7-9 April 2020 | Tokyo, Japan

The 7th International Conference on Architecture and Built Environment with AWWARDS

CONFERENCE S.ARCH 2020

ARCHITECTURE AWARD

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Conference Proceeding

ISBN 978-3-9820-758-5-3

The 7th International Conference
on Architecture and Built Environment with AWARDs

S.ARCH 2020

7-9 April 2020 I Tokyo, Japan

Conference Proceeding

May 2020
ISBN 978-3-9820-758-5-3

Impressum

Get It Published
Verlag e.K.
www.get-it-published.de
info@get-it-published.de
Allee am Roethelheimpark 14
91052 Erlangen GERMANY

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Front Cover Illustration

http://shuttestock.com; Edition: Fabian Rodriguez

Published in Germany

The 7th International S.ARCH Conference
07-09 April 2020, Tokyo, Japan

>>> S.ARCH 2020 I Sustainable Architecture

CONFERENCE PROCEEDING

ISBN 978-3-9820-758-5-3

MAY 2020

www.s-arch.net

CONTENT

TOPIC 01: STATE OF AFFAIRS AND FUTURE VISIONS

01.101 - GENDER IDENTITY, SITUATED BODIES AND URBAN SCENARIOS

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Abstract

The body is the first habitable territory for each individual. As A. Lindon describes "The first space that every social subject inhabits is its own body, and this, in turn, is made up of two essential general components. The first one is its motor capacity, which allows visibility, access, and displacement through the built context and the second component are feelings, an important element to understand how humans exercise meaning in spaces.

The experiences that enable the approach to the public sphere determine the relationships established with others and with the surrounding world. Once this is recognized, it is possible to value the relevance and positive or negative influence that city planning may imply through its decisions and actions.

Public space is the territory that supports par excellence, the encounter and social interaction with others. It is the scenario that requires the presence of others radically different (A. Gorelik, 2012), the common ground where people carry out the functional and ritual activities that bind a community, and hence it should be supportive, democratic and meaningful. (S. Carr et al, 1992). This is why it has the potential to be the tool and the scenario of rights repair for all diverse groups and bodies.

When talking about the diversity of bodies, the concept points two categories: first, from the interdependence of the life cycle, referring from childhood to old age, as well as functional and cognitive diversity; and from the construction of identity, related to sexual orientation and gender identity.

This research focuses on gender identity and intends to establish opportunities to contribute from the perspective of urban planning, to improve the quality of life and civil rights for a specific target population in their urban mobility experience, which, in the case of Colombia and Latin America, is in a worrying risky state of discrimination: the Trans women.

The construction of identity, diverse bodies, and urban scenarios, are discussed around the use and appropriation of public space. This article share initial conclusions derived from the observation specific to urban circumstances associated with the pedestrian realm, including materiality, technical aspects, and regulatory frames that allow or hinder access to urban goods and services, usually as a consequence to political, institutional, public and private

decisions of urban planning impact. Direct interviews and the mapping of mobility patterns of Trans women are advanced, to establish how the characteristics of public space and some physical elements, influence the experience during the day and night of Trans women in a district of Bogotá city, Colombia, suggesting inquiries for other cities in the world.

Keywords

Gender identity, situated bodies, public space, Trans-women and urbanism with gender perspective

Introduction

The experiences that enable the approach to the public sphere determine the relationships established with others and with the surrounding world. The result of these individual and social constructs promotes a dynamic relationship at the level of the spaces we inhabit and acquires a strong influence on how we construct cities.[1]

Because of concerns about the construction of identity, the development of diverse bodies and of cities, this research aim is to address the use and appropriation of public space in the experience of Trans-women[2] along their daily routine, and their mobility during day and night routes. It is an analysis that starts from a personal body of dissenting identities and their immersion in the open public space, in the Suba district in Bogotá, D.C.

1.1 Target population and problematic in context

As a starting point, the concept of body is established as the first habitable territory for every subject. “The first space that every social subject inhabits is its own body, and this in turn, is made up of two essential general components: the first one, its motor capacity, which allows visibility, access and displacement through the built spaces; and the second components are feelings, as an important element to understand how humans exercise meaning in spaces.”[3]

Based on this body conception, it is pertinent to talk about the social and identity construction of people. That is why the studies and sociologies of the body, in conjunction with spatiality and emotionality, recognize that “corporeality constitutes the key to understanding the social, in light of the gender condition and identity of certain subjects in the spatial experience within the public space”.[4]

On urban studies literature, reference is made to the fact that the upgrading conditions for the most vulnerable population will result in the improvement of conditions for all populations. For this reason, the trans population has been selected, given their high level of social segregation. According to a Colombian ruling (Judgment T-314 of 2011), it was recognized, that the critical situation of marginalization of transgender individuals, remains very severe, indicating a risk as the more representative victims of violence due to prejudice in society, manifested in multiple ways.”[5]

Data on the violation of rights of the trans population are alarming. The Inter-American Commission on Human Rights has stated in a study that the life expectancy of 80% of this population ends abruptly by their 35 years old. According to the Bogota LGBTI Public Policy Biannual Report[6] 60% of this population has known at least one person who has died violently because of their gender identity in the city. 38.6% of people in LGBTI sectors have felt assaulted in the last three years in the public space, with transgender people being the most affected.

In the 2017 Multipurpose Survey in Bogotá[7] The distribution of LGBTI people was disaggregated by district, providing a total of 3,070 trans women in the city. The larger segments were registered in areas with low-income level 2 (two over six possible strata levels), with 57.2% of trans women and 42.9% of trans men. In fact, 5 out of 10 trans people in the capital live in contexts of poverty.[8]

Of the people who perceived greater violation of their rights due to their sexual orientation and / or gender identity were trans women, at a percentage of 73.6%. The data handled by the GAAT Foundation have shown that for 69.1% of trans women and 50% of trans men, end up working in sexual service activities, as their main source of income. The Local government of Bogota, through its Public Policy Observatory focused on monitoring welfare conditions of lesbians, gays, bisexual, transgender and intersexual people, revealed through their "Base Line study" in 2017, that less than 58% of these individuals do not finish high school and have very low access to university 7,89% in the case of women and, 14,29% in the case of men.

Laura Weinstein, director of the GAAT Foundation explains[9] "Trans women are much more visible, and the stereotypes imposed on us of femininity are much stronger. There will always be someone to remind us that we do not reach those standards. And the more visibility, more violence and fewer opportunities we might get, due to physical aspects, such as bone constitution for example. Since it becomes evident, a discrimination begins".

Consequently, the multiple oppressions experienced by trans women in different urban environments define the central problem addressed by the study, because the violation of the "right to the city" as a result of urban discrimination associated with public space and genre-connected violence is exacerbated. Following the call from UN-HABITAT (2011), "The right to the city encapsulates the four dimensions of equality (economic, social, political, and cultural), which, combined, will guarantee inclusiveness. The fundamental principle of the right to the city is that human rights are interdependent and indivisible. This calls for the simultaneous achievement of all human rights for all residents in any city".

1.2 Situated Bodies and Urban Scenarios

The ongoing research raises two central questions that will guide the inquiry into the challenge of identity and situated bodies within the urban scenarios. First, how does urban discrimination in public spaces appears and may affect gender and the daily mobility of trans women in Bogotá? Second, how to contribute from the urban planning perspective to claim the rights of trans women within their urban mobility experience?

For the purpose of the research, the urban discrimination associated with the pedestrian realm is understood as the set of selected material, opportunities of representation, technical, and regulatory conditions that allow or hinder access to urban goods and services, as a product of political, institutional and private decisions, present in the city and its urban planning projects.

In this sense, the general objective of the research is to make visible how the urban context associated with the infrastructure of the public space, encourages or restricts everyday mobility, day and night experience of trans women in Bogotá. Four specific objectives are established: 1. Contribute to increase information and data related to the trans situation in the urban context to remedy historical debt in urban studies on the absence of gender perspective. 2. Identify the physical-spatial elements that may be related to the gender violence and lack of protection for trans women in the public space. 3. Map the patterns of daily mobility of some trans women in Bogotá, in order to collect evidence of aggressions and register their testimonies. 4. Identify underlying cultural precepts that contribute to gender-based violence towards trans women in the public space.

Based on the first advances of the study, the following hypothesis are proposed: 1-The design of public space, together with a symbolic approach to gender identities is able to promote a more equal enjoyment of the right to the city, minimizing discrimination and gender-based violence against trans women in Bogotá. 2- Disparity in public space quality and standards (materials, lighting, types of surveillance, etc) creates segregation among different areas of the city, causing a negative perception and real insecurity among pedestrians.

1.3 Research methodology

Qualitative and participatory methods have been implemented, allowing access to the daily mobility experience of some trans women living in the Suba district in Bogotá. Some of the phases proposed by the Participatory Feminist Research-Action activities[10] are adopted, because "it proposes to explore the real space of diversity and interconnection at the scale of the bodies, since the bodies are the links of the public-private space, gender identities and gender violence."[11]

The exercise began through individual interviews, where they have begun to build lifelines, seeking to specify positive and negative experiences in the public space. In addition to this, the method proposed by the Narrative Inquiry[12] has been implemented, where the events mentioned, as determining milestones in the assignment of personal meanings to the different urban scenarios, are jointly reviewed.

Exploratory walks have been made, documented in a format known as sentimental cartographies. This exercise consists of accompanying the trans women in their daily journeys from the moment they leave the public space until they return home, documenting through video and photographs, the relationship they have with the different urban scenarios and the signifiers involved in them. Finally, it origins a participatory activity called body mapping. In this exercise, drawings of their bodies are delineated, in relation to the previously identified urban spaces, indicating and locating physical, emotional and psychological sensations that those spaces evoke.

The chosen sector for research has been Suba, one of Bogotá most populated districts with 1,162,700 inhabitants and a density of 11,562.25 inhabitants, per square kilometer. Located in the northwest of the city, it is crossed throughout its territory by a small mountain range, "Los Cerros de Suba" and "La Conejera".

1.4 Literature review and context

Checking the theoretical framework, a timeline has been developed to bring together the following categories: Urban theories that have expanded the concept of subject from diversity and identity construction; International cooperation milestones of women and feminists for the right to the city; Milestones of Latin American cooperation of women and feminists for the right to the city; Feminist urbanism; Gender and urban anthropology studies; and, Bogotá District Programs of the Women's Secretariat.

Six trends have been identified to address the problem at the regional level, among them are: urban production of heterosexual space; control of the bodies, policies of fear and power in the city related to the perception of security; cultural geographies and sentimental cartographies; differential approach (LGBTIQ +) in public policies; design for diversity; and, urban and significant scenarios. In these approaches, on the gender diversity of the bodies in relation to the city, the lack of exploration in the particularity of the territorial appearance of trans women is noticeable.

The advances and rights achieved at the Bogotá level, as well as the implementation of milestones of Latin American cooperation of women and feminists for the right to the city has permitted a significant advance in the last 15 years. This experience, currently allows for a legislative and priority support from the District Public Policies. Since the creation of the Observatory of Women and Gender Equality of Bogotá, it is important to mention that it has become a strategic tool to collect, order, analyze, interpret and disseminate information concerning the situation of women living in the Capital District.[13]

1.4.1 **To inhabit the gender and the body**

Within the constitutive dimensions of identity, gender is given as a basal construction that is inhabited in relation to its positioning in its social environment. From the gender with which we perceive ourselves, we adopt behaviors related to gender roles that begin to guide social and affective interactions.

The bodies that are in transition, suggest questions about how they are read in the context of urban settings. This transitional dimension, of a simultaneous or non-defined state[14], is established as an unintelligible threshold that defies the binary categorization of bodies (men/woman), usually done in an automatically way.

The public space is where political symbols are activated and identity is disputed. This correlation highlights heteronormativity as a model that only exceeds the relationship between two and becomes a social norm[15]; and gender performativity[16], as a concept that refers to behaviors related to gender roles in linking with others. In the case of the identities that decide to undertake a transition from a biologically assigned body as masculine to a femininity, it represents the denaturation of the place of the male, which from the philosophy of gender poses a break on the question of identity as a natural provenance.[17]

This research pays particular attention to these situated bodies, their mobility patterns and daily meeting spaces that allow the production of space. As Sergio Salazar argues: “Gender is produced through the body, its movements and its desires, and to understand its social production, it is necessary to introduce the concept of incarnated space that reconciles the spatial triad of Lefebvre (spatial practice, representation of spaces and spaces of representation), thereby giving the body a political-social agency to speak and act in the world. Body is the biological and social entity that occupies space, mediates perception and the strategic way of being in the world, it is the place of the materialization of human experience. One could say that the body inhabits more than one place simultaneously, where its biological existence "feeds" on its individual, social, political, medical, economic and many other possible "body spaces".[18]

1.4.2 To inhabit the public space under a gender perspective

Carlos Hernández and María Ángeles Duran[19] propose "the strong hypothesis of admitting the absence of gender reading among architects and urban planners, is one of the greatest failures in the theory of architectural knowledge of this century." Thinking about urban planning with an intersectional gender approach, represents a debt on the part of the academy and traditional city planning.

Although invisible, the commitment of feminist urbanism far from being a "novel trend", has a long history and a reflexive, theoretical and methodological weight that places the sustainability of all lives as a guideline of land use planning. This approach over the public space, transcends the limitations on the autonomy of women and illegitimated identities, and makes it a scenario for the extension of rights, a space of conquest where the construction of urbanity is built everyday as a social pact where all voices are valued.[20]

Contributions from urban planning with a gender perspective allow us to review the quality of urban scenarios with emphasis on safety indicators, proposed by UN Women[21] and the Montreal´s six principles declaration;[22] that suggest safer spaces as follows: 1. Sign posting: know where you are and where you are going; 2. Visibility: see and bee seen. 3. The presence of people: hear and be heard 4. Formal surveillance and access to help: be able to scape and get help; 5. Spatial design and maintenance: live in a clean and friendly environment. 6. Community participation: act together and build collectivity. These strategies have recently been complemented by local experiences, meeting the new urban agendas and social demands.

Blanca Valdivia quotes Olga Segovia and María Nieves Rico to point out that, “approaching a new urban paradigm implies recognizing diversity and accounting for the multiplicity of faces and inhabitants that the city has, incorporating all realities into the social production of the urban habitat, including in particular the rights of women in relation to the city and from an intersectional perspective”[23]. Here, it is important to note that intersectional perspectives refers to the way in which any one individual’s multiple identities (gender, class, ethnicity, age, ability status, sexual orientation) combine to shape their own experience.

1.5 Advances

Interviews with the first co-researchers have been carried out, making possible the construction of the chronological Narrative Inquiry, starting from the beginning of their gender transition. Afterwards accompanied walks following their daily routines have allowed to document some of the urban environments connected to meanings of some experience of gender violence and have been geographically located.

The Town of Suba presents a variety of income groups residing in different sectors, which mean, there are paths with significant changes in the physical and material configurations along its street sections, due to differences in the buildings, materials and architectonical relationship. The walks have taken place in 8-hour lapses and have allowed us to build a collection of the different urban scenarios where these women usually move. These spaces have been identified, according to characteristics on the street sections and some expressions of the recognized pedestrian dynamics. Some of them are: pedestrian intention or desired lines, narrow paths, oversized paths, dark areas without natural surveillance, high commercial activity and low pedestrian activity areas, among others.

There has been as well, a record of the interaction of some people with the presence of the trans women, including abusive glances or looks from third parties, unwanted approaches or touching and especially verbal street harassment. It was found common to endure comments about their bodies, recalling many of the anecdotes of verbal aggressions in the public space and of how their bodies have been read in relation to the canons of hegemonic beauty, as well some hatred expressions towards trans people and the roles of trans women in social structures.

Some of the worst aggressions witnessed or registered, include questions from unknown people, about their prices for sexual interaction, although none of the trans-women involved so far in this research, exercise an employment related to sexual activities. As a consequence, the eventual stress caused due to harassment, affects the way in which they select their outfits to go outdoor in public spaces, as a way to prevent, avoid or reduce comments about their bodies and appearance, although in many cases the verbal abuse remains with comments as “freak”, “sissy” or other unpleasant offensive words.

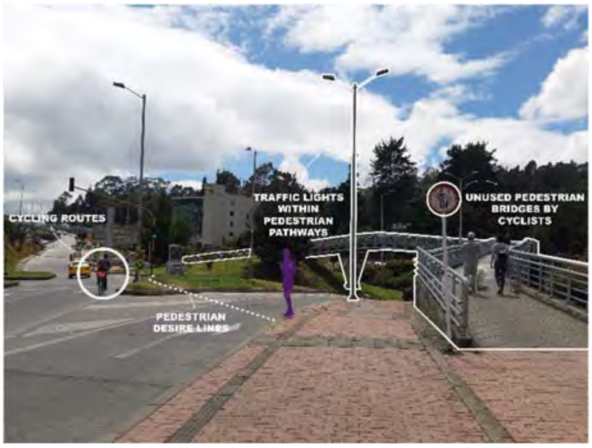

Figure 1 and 2: Contrasts on public space design and urban conditions within street sections at Suba district

When passing through some of the daily routines, memories of disgust have been activated mainly about events of verbal and physical violence that determine and shape the use, or restraint to use, certain spaces or zones of the city. This circumstance demands a greater effort of time, mental stress and money to circulate –or not- through some parts of the city, but with the aim of avoiding those uncomfortable situations.

2 FINAL CONSIDERATIONS AND FUTURE PERSPECTIVES

In the current Latin American scenario, where the rise of feminisms has allowed the politicization of personal, domestic and public experiences, the path has widened notably for young people. In this process of visibility and vindication, the way we think the urban setting has been enriched, thanks to the pendular revision between feminist urbanism theory and the activist practice.[24] That is why the discipline and academy must be rethought as a strategic space for alliances. As Rita Segato says in one of her last interviews, “there is a reemergence and a vocation to rebuild those communal and collectivist worlds (…) a reemergence of that feminine politicity. What we see on the streets is not an invention, it is a retort due to fatigue, tiredness and failure of patriarchal practices.”[25]

Further research hope to include the sentimental cartographies and body mapping of our target group, as well as to overlap evidence that reveal common areas perceived as insecure, in an effort to identify trends and opportunities for improvement to advance in the construction of more inclusive and safe cities for all citizens.

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01.102 - IMAGINARY MAPS
A POSTHUMAN URBAN DESIGN METHOD BASED ON NEURAL STYLE TRANSFER

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Abstract

The main aim of this paper is to demonstrate and interrogate a design technique based on deep learning. The discussion includes aspects of machine learning, 2D to 2D style transfers and generative adversarial processes. The paper examines the meaning of agency in a world where decision making processes are defined by human/machine collaborations (fig.1), and their relationship to aspects of a Posthuman design ecology. Taking cues from the language used by experts in AI such as Hallucinations, Dreaming, Style Transfer and Vision, the paper strives to clarify the position and role of Artificial Intelligence in the discipline of urban design.

Figure 2. Results of 2D to 2D Style transfers based on Nolli plans and an image of the Moon: aspects of Estrangement and Defamiliarization profoundly speak in those results about a design ecology in a Posthuman era.

Keywords

Artificial Intelligence, Neural Networks, Automation, Urban Design, Style Transfer.

1 INTRODUCTION – A POSTHUMAN TRAJECTORY

The Map. This icon of urban planning goes far beyond its mere meaning as an abstraction that allows to execute in a controlled manner the materialization of matter and space. It rather represents a vast collection of possible solutions for urban Problems. Considering the gigantic amount of data that a collection of maps spanning more than three millenia[1] represents It appears almost evident to use this enormous repository of urban imagination in the age of big data. A quick search on Google yields 8.920.000.000 images (Yes, that's almost nine billion results!) tagged *map*. The enormous vault that the discipline of urban planning has generated throughout the ages forms THE natural resource of our discipline, waiting to be mined and processed – not to copy or imitate existing urban design solutions, but to find bespoke solutions to specific problems. Urban planners and the respective students learn to differentiate urban textures through visual stimuli, i.e. seeing hundreds and thousands of images of specific maps of cities and projects in order to recognize planning styles[2] later. They learn to differentiate for example between Gothic, Renaissance, Baroque and Modern urban conditions through memorizing geometrical features and patterns. Neural networks (NNs), which are complex functions loosely based on the structure of the human brain, learn to perform visual tasks in a similar way, by both identifying and extracting meaningful texture and patterns within their input. This paper presents a possible application of a neural network-based image editing technique, called Neural Style Transfer[18], to mesh not only low level pixel patterns, but also higher level geometric features, like roads, buildings, etc., between urban maps in an effort to create cities with novel styles. The research on this possibility started as a simple experiment for style transfer between maps in order to explore the opportunities as a design method[3].

2 Of Ideal Cities and other Strange Objects

It is almost impossible to judge maps on a purely pragmatic level. They always simultaneously talk about planning processes, economic environments, material preferences, political conditions and stylistic fashions of the time the urban design was created. Wither this be in the rigorous structure and geometrical purity of Renaissance Ideal cities, as exemplified in the concept of the *ideal town* as proposed by Leon Batista Alberti in *De Re Edificatore*[4], or in the intricate voluptuous geometry of parametrically designed settlements such as Zaha Hadid's *Kartal Masterplan* for Instanbul[5]. In both cases it is not surprising that the intrinsic matter of urban planning in a large scale involves aspects of ideology and utopia. Both examples mentioned above can be identified as representatives of ideologies that span areas beyond shape and geometry and involve political, social and economic conditions[6]. It might not surprise that in this extent they also represent a vessel and repository of the history of urban planning imaginations, and as such can be considered an enormous mine for new ideas on the nature of the city. Traditionally urban planners are trained during their studies to operate like data miners. Every new project is based on the hundreds and thousands of images ingested during the training received in architecture school. This image-based tradition is exploited in the 2D to 2D style transfer approach presented in this paper. However, it is not only about mining. What goes beyond the ability to simply ingest imagery, is the inherently human ability to perform pattern recognition. One of the aspects the human mind is particularly avid about, is to recognize events and objects, separate fore- and background. The ability to even recognize that an error or mistake inhabits the potential for a creative solution to a problem[7].

How can this, computationally rather difficult to grasp problem be harnessed to achieve image to image style transfer? This is where the aspects of the neural network's learned features, or what it has learned are salient pixel patterns within a given image, come into play. We can use trained neural networks to successfully quantify and define textures within images, and in the context of urban maps, we can create a 'city texture' and hallucinate[8] its specific features in other images of city plans.

There are two main hurdles that need to be taken to successfully apply this technique to urban planning processes. On the one side is the database. What is the Neural Network working with? A couple of lines of code used to collect a dataset of images used in this paper can describe the process that the authors applied:

```
With
webdriver.Chrome(executable_path=driver_path) as wd:
    res = fetch_image_urls(search_term,
    number_images, wd=wd, sleep_between_interactions=0.5)
```

The code scrapes the internet for images with particular labels as a first step to create a database as source for any form of style transfer, dreaming or hallucination. This is how we can tap into the existing resources of our own discipline in order to create novel outcomes. The second important aspect in this process is the training of the neural network. Let me mention here a popular example to explain a method of training a neural network. Although handwritten checks are slowly fading out, there are still massive amounts of them written on a daily basis. In order to facilitate and speed up the process the reading and identifying the written numbers has been handed over to trained neural networks some time ago. NN's take in images of handwritten numbers as input and performs complex thresholding operations on the images' pixels to filter out relevant visual information (e.g., edges, curves), which it uses to ultimately form a prediction for what number is in the image. The accuracy of the network's prediction is evaluated using an error function and a ground truth label for the number captured by the image. The training of the networks starts with human intervention, in that a human tag the images, identifying the numbers (fig.2), as well as in how the error measurement is defined. How else should a machine learn what a six is, an eight, a nine, a zero etc.? How could an algorithm learn the large variety in hand-writing styles that can drastically alter the appearance of a four? After being present thousands of hand-written examples, the Neural Network becomes better and better in understanding what the individual numbers are through an autonomous learning process (fig.3).

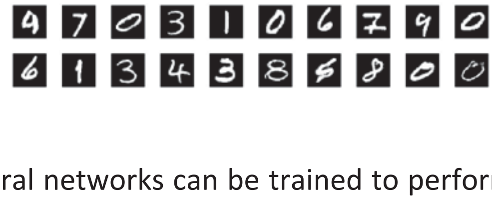

Figure 3: A set of random numbers, tagged by humans, serves as first layer in a Neural Network in order to learn to read the numbers autonomously. Image: James Le

Neural networks can be trained to perform much more complex classification tasks, such as differentiating between architectural styles. It is key to collect a large dataset that captures all possible variance of such styles so the NN can learn accurate and representative visual patterns for each class. The dataset used to train a neural network can be thought of as the 'world' the network exists in. We can then use these learned patterns as a way mathematically represent an image by decomposing it into its base spatial/geometric, style or texture features. For the author's the most exciting discovery in applying this technique is that by manipulating the weights/impact of style and spatial imagery the results produce unexpected, atmospheric and profoundly ***other, defamiliarized and estranged*** results. Estranged in a good way[9].

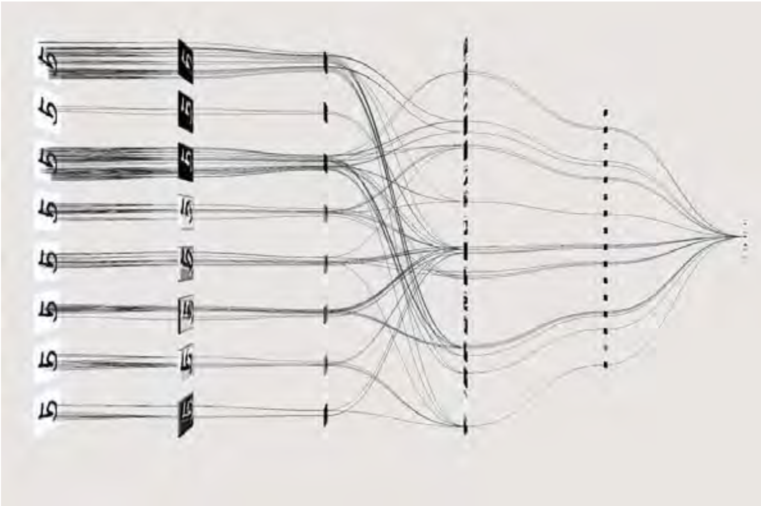

Figure 4: Sketch of a simple neural network to read numbers on a check. The network has 4 layers that allow him to increase the precision in reading the correct numbers

3 Tipping the Hat to Neuroscience

It is quite fascinating how computer science has adopted the vocabulary of neuroscience to explicate the processes invoked in NN, and the proximity of this language to the wording of architecture when it comes to the imagination of the discipline. Terminology like *Vision* and even *Dreaming* and *Hallucinating* made regular appearance in the manifest heavy postmodern era[10] of the 1970ies, such as in the written works of Hans Hollein (Metaphor and Metamorphosis exhibition) and it was chronicled extensively in Gunther Feuerstein's oeuvre (fig.4) the terminology still provokes the spirit of particularly advanced architecture, albeit in a certain romantic and poetic fashion – which this paper is not about. The plot twist here being how this relationship to the terminology is currently being reinvented for the architecture and urban planning discipline by a series of young practitioners and their allies in computer science and robotics[11]. Instead of adopting the term as a metaphor, it rather borrows the terminology from computer science and more specifically from machine vision research, which has its focus on developing Neural Network solutions for example for autonomously driving cars. The discipline of computer science themselves borrowed the terms *hallucination* and *dreaming* from Neuroscience who developed this terminology in order to explain the behavior of common neurochemical mechanisms and the phenomenological similarities between human dreams and drug-induced hallucinations[12]. In this light it can be stated that a neurochemical mechanism and the synthetic ecology created with computational Neural Networks share similar traits and are closely related, thus the conversation in this paper on *Dreaming*, *Vision* and *Hallucination* in regards of ***Imaginary Maps.*** Literally discussing machines hallucinating possible solutions.

Figure 5: Günther Feuerstein, Visionary Architecture in Vienna 1958 to 1988 – Ernst u. Sohn Verlag 1988

In this paper we lay the foundation for a fascinating possibility: a computational method to train neural networks to learn and recognize a variety of urban features, styles and aspects and possible ways to get neural networks to generate novel planning solutions. Another possible application for this approach is the possibility to create an app that is able to analyze urban plans and check them for errors – for example their accordance to code, their energy consumption, or their functionality. The approach however offers an entire set of possibilities that go beyond its application as a mere tool for optimization, thus provoking questions pertaining to the nature of creativity, agency and posthuman culture (Fig.5).

In contrast to the approach of other practices and individual researchers working within this paradigm, such as XKool (Wanyu He), Shao Zhang (PennDesign) and MetroDataTech (Tang Ge) -which primarily rely on finding engineering and pragmatic solutions to architectural problems- the approach of the authors is acutely aware of the cultural and discursive dimension of the proposed approach. It is clear, that a conference paper might not be sufficient in length to cover the entirety of the implications in regards of architecture theory within a novel paradigm, thus the authors would like to apologize for the occasional brevity in the argument.

Figure 6: Result of Style transfer between a Dataset of Nolli maps of known cities (Rome, Barcelona, Manhattan, Washington DC) and a 19th century science plate depicting a detail of the moon's surface.

To further lay out the difference of the approach of the authors, and the beforementioned companies and researchers, we would like to propose the following:

There are two main paths of inquiry and critical interrogation: the technical expertise necessary to apply neural networks successfully to obtain comprehensive results in pragmatic problems, such as plan optimization, landscape optimization and the ecological footprint of the design. All of which can be described as tamed problems, dealing primarily with highly specified engineering problems. On the other end of the spectrum AI allows to explore the wicked part of architectural design as well, pertaining to aspects of morphological studies, creativity, style and mood.

In the course of the research conducted by the authors investigating the implementation of AI based algorithms into planning processes the authors made a crucial discovery. In the beginning the sentiment, and prejudice, was that AI can generate everything on its own. It became very quickly very obvious that this is not the case. As described above Neural Networks rely on initial human training to do anything. It is not said however that once sufficient Neural Networks have been trained by humans, they might be able to solve problems entirely autonomous. In the case described in this paper, the notion's focus was on the ability of NN to develop morphologies of architecture entirely independent and divorced from human agency. It did not take long to understand that AI faces a great amount of stereotypical ideas, and fears, based on a lack of factual information. The vast number of Blogs and Internet pages spreading misinformation on the prospects of AI makes finding a proper reference hard[13]. The fear is fuelled in addition by comments such as *The development of full artificial intelligence could spell the end of the human race….It would take off on its own, and re-design itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete and would be superseded.* By Stephen Hawking's[14], and Elon Musk's comment on Artificial Intelligence: *"With artificial intelligence, we are summoning the demon."* [15] During the work on the research presented in this paper, which primarily focused on 2D to 2D style transfer, it became very clear how much the behavior of a NN is dependent on the training and parameter tuning conducted by a human being (see argument above). In a sense this means if an AI turns *"demonic"* it does so only because of the training it received – channelling the malignant traits of the human mind[16]. The main stumbling block is the generalization of the problem. In addition, there is a major problem with the assumption that "Jobs get Lost" This generalized assumption needs to be met with a healthy dose of scepticism and needs a critical interrogation. On the one side Jobs transform into something different, on the other hand it is possible to think about jobs in general in an alternative way. The economic concepts that are currently in operation will not be able to cope with the changes at hand pertaining to AI and Automation – as they are profoundly rooted in the 19th century economic thinking of the industrial revolution which are not applicable any more[17]. The way we think about jobs have to transform with the surge of AI and Automation. All of these points describe the ecology of the conversation, the intellectual atmosphere that the research started to touch upon in the initial phase of the project, in regards of grasping the scale of this paradigmatic shift. On another note it can be stated that the term AI is profoundly vague as it describes an entire array of computational techniques such as Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), and many more.

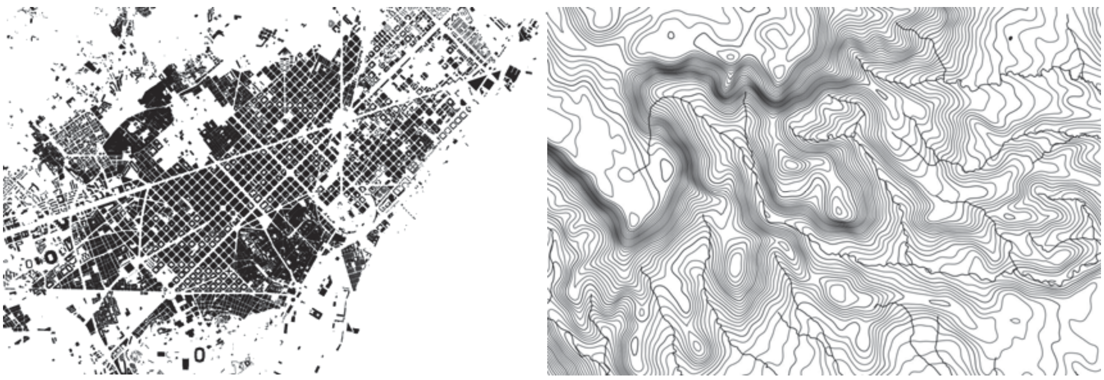

Figure 7: Style example: Nolli map of Barcelona, target example: Topo lines of a hills (source: Schwarzplan.de, Bundesforste)

If we turn the focus back on its consequences for urban design the authors claim that when these techniques are applied to design, they can blend a chronology of styles to create a *dynamic style* that captures and reflects a variety of design techniques over a period of time including social and cultural evolution. Style artefacts can be exaggerated to a point of hyperbole, transforming the natural balance/harmony of human style and design into a pareidolic and compositionally unstable, but novel form rooted in post-human (in the sense that they were not primarily authored by human ingenuity), but humanly accessible, architectural features. An example for this approach was tested by the authors by creating a database of Nolli maps of various cities scraped from the web and applying this *style* to various target images (fig.6). In a playful approach we chose images such as 19th century science plates of the moon, topo lines of alpine areas and random Asian cities as target files. The resulting images serve as a first proof of concept of a possible Neural Network technique for the design of cities. Further work on this technique will be conducted in the upcoming semesters. The goal is to gain better control of the Neural Network by implementing rulesets in order to give more weight to specific solutions. For example, the rulesets defined by Christopher Alexander in *A Pattern Language.* It would be highly interested to see how these rulesets can be applied to an urban condition.

The presented 2D image editing method has interesting implications for 2D urban design applications. By employing this technique, it is possible to create style transfers between various city plans, or to hallucinate alien features into conventional maps. Exemplary demonstrated by creating style mash ups between rural areas and city plans, or mutants of various urban conditions. In the following the authors would like to explain the technical background of this approach, explaining the computational methods used in NN.

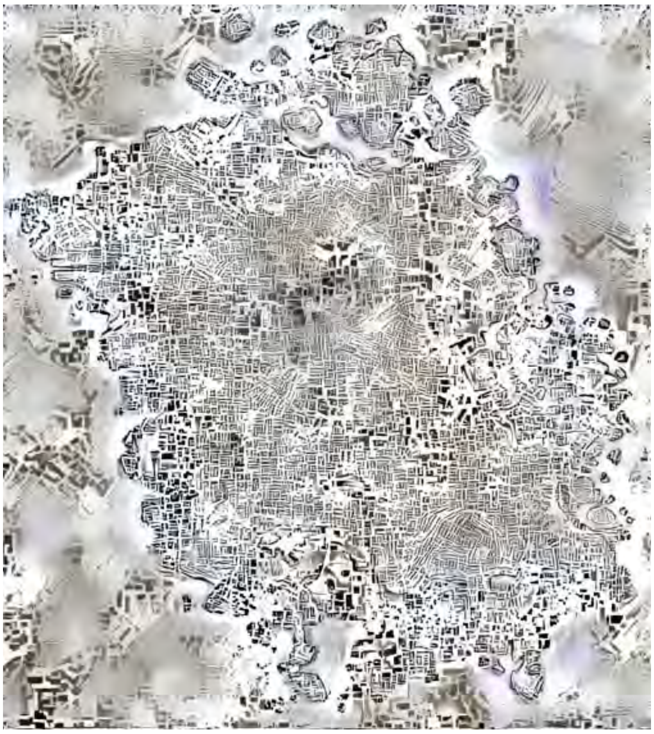

Figure 7: Imaginary City Map. 2D to 2D Style transfer result between a database of Nolli plans of various cities as a style and a 19th century science plate of a moon crater as a target image. Cities on the Moon

4 Background - Generative Adversarial Neural Networks and the 2D visual world

Artificial neural networks are computing systems that are designed to loosely emulate the hierarchical structure of the human visual cortex. A neural network is comprised of processing nodes, called *neurons*, that are organized into groups, called *layers*, based upon how they connect to other nodes in the network. Input information flows through a neural network in a feed-forward, hierarchical manner: Each neuron in the network receives input from neurons in the preceding layer and transforms it into a new representation via a nonlinear function, which acts as a threshold that filters out relevant information captured by its input. This new representation becomes the input to the neurons it is connected to in the proceeding layer.

The way in which neurons are connected and transmit information are specific to particular tasks and need to be learned from input data. In this paper, we are interested in purely visual tasks and modelling visual information, so the following sections only consider convolutional neural networks (CNN), which are designed to operate on images.

The set of filtering transformations the network performs on images, and consequently the novel ways the network represents salient visual information captured by the images, are learned directly from the image pixel intensities. For example, in image classification, a neural network transforms an input image into a new representation by decomposing it into a set of visual features that makes the semantic image content easy to classify as, for example, ‘Street’ or ‘Plaza’. The visual features that comprise this new image representation could be textural, like tar, concrete, greenery or shadow, or pertain to geometry and shape, like curves or corners. Thus, the ‘Street’ class may be represented by a set of long, continuous line features combined with stone textural features such as pedestrian crossings or green striped in the middle of the road, whereas the ‘Plaza’ class could be represented by a set of corners and polygonal features. These visual features are extracted sequentially by the network, where the first layers filter out simple lines, edges and textures, and the later network layers filter out the sets and combinations of these features, such as corners. The final network layer predicts the semantic class label, e.g. ‘Street’, based upon the set of features extracted from the image by the preceding layers. (fig.7)

In this example, the CNN is trained for a discriminative task, and functions as a prediction/classification machine. For this kind of task, the network learns only to model the visual information that maximally differentiates the semantic classes present in the dataset.

4.1 Methods – or: Modelling the Style of the Real World

Independent of the task, neural networks learn how to represent images in terms of color, texture, and geometric structure. These representations can be used to perform image manipulations that result in unique design. In the following subsections we discuss the specifics of the style transfer technique called Neural style transfer[18], which was used to generate the images in this paper and forms the core result of the presented process.

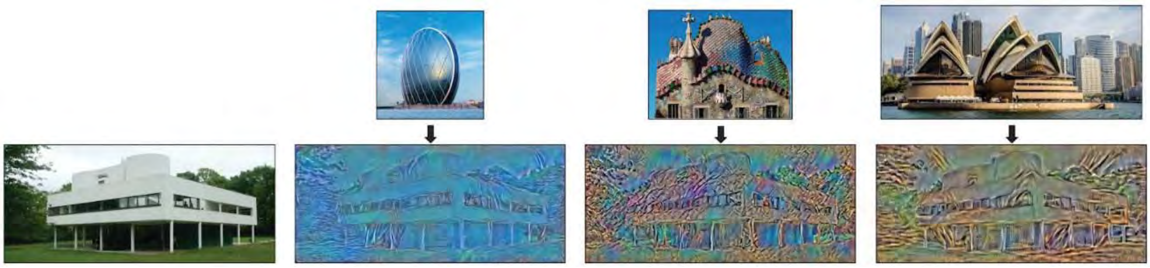

Figure 8: Iconic buildings in architecture can have their styles 'quantified' and transferred to other iconic buildings using the Neural Style Transfer method. (Image: Alexa Carlson)

The objective of this image editing method is to alter a given input image so that it captures the style of a second, 'style guide' image without altering the original content, i.e., the geometric/spatial structure of the input image. As previously described, an input image can be decomposed into specific visual features by projecting it into a given network layer, i.e., transforming it into the set of visual features learned by that layer. The network layer representation of the image not only provides information as to what type visual features are present in the image, but also where they occur within the image. Thus, through an optimization process, we can iteratively change the pixel values of our input image such that the network's representation of its style features, like texture and color, resembles the network's representation of the style features of the guide image, while making sure that the network's representation of structural features in the input image, such as outlines of buildings or edges, remain unaltered. This technique allows us to have a quantifiable metric of style that can be used to probe how the 3D nature of buildings, and other architectural components, like streets and buildings, are decomposed and represented in this 2D space. As shown in Figure 8 and Figure 9, this new style representation of a building can be fused with other buildings to generate novel architectural types.

Style transfer in addition to its technical abilities evokes memories to the discussion on style in architecture. It is indeed amusing that the term ***Style*** returns into conversations about architecture and urban planning via neuroscience and computer sciences, as if it comes back to haunt the discipline and remind them of the importance of its own tradition in this crucial conversation, with proponents such as Gottfried Semper[20] and Alois Riegl[21].

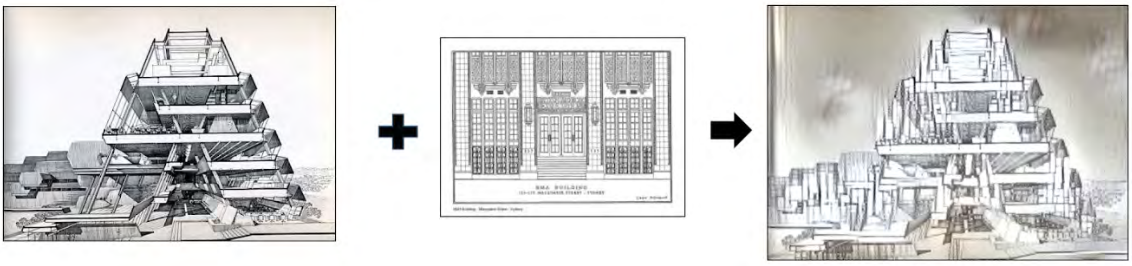

Figure 9: Using the same Neural style transfer method, we can apply the architectural style of one building section onto another to produce a novel, different architectural style.

5 Conclusion - The Defamiliarization of the City, or: An Alternative Utopia

As described in the introduction to this paper the urban map is a cultural staple of the architecture discipline. It is the medium that best captures the intentionality of the urban project in an abstract medium as a two-dimensional surface. In architecture discourse the line, the plan, the abstract representation of materiality has played a major role, and it always has been interpreted as the result of human cognition and mind. This can be illustrated as a core idea in the architectural theory of for example Leon Battista Alberti, as expressed in the *De re aedificatoria*, pertaining to the distinction between “lineament,” the line in the mind of the architect, and “matter,” the material presence of the building. This particular distinction plays a key role in architectural design, and the conceptualization of the architectural project, throughout the history of western architecture. Le Corbusier described this at the heyday of modernism in the twentieth century like this: “Architecture is a product of the mind.” The distinction between mind and matter can be found in Vitruvius, in the distinction between “that which signifies and that which is signified”; at the Accademia di San Luca in Rome, between *disegno interno* and *disegno esterno*; or in Peter Eisenman’s distinction between *deep aspect* and *surface aspect* in architecture, to name just three examples[22] that profoundly describe the planning process as a particular ability of the human mind. What position does the discipline have when it comes to understanding the potentialities of applications such as NN’s that are able to produce results that question the sole authorship of human ingenuity? Well, there is always the chicken & egg problem: NN’s origin in the human mind. That they are able to autonomously generate plan solutions is in itself not yet proof for thinking or even intelligence. However, if we take the philosophical standpoint of materialism it would allow to create an even field between these two thinking processes. In a materialist tradition though itself is just the result of material processes in our brain, neurochemical reactions able to form thought. This was briefly described above in the section explaining the origin of the terminology used in this paper such as *Hallucinating*. If this position is taken, then the conclusion is that AI’s can think as much, and form original language[23] or shape[24] as humans can, the only difference being that their neural processes are not based on neurochemical processes but computational processes within another material paradigm. In this paper, we present the possibility to utilize AI applications for the generation of planning processes. In particular the application of style transfers with NNs. This approach on the one side critically interrogates the unique position of the human mind when it comes to creative processes and in addition questions aspects of creativity in planning processes. In a design ecology where the boundaries between human and computational cognition are increasingly blurred, the presented process harvests the multiplicious solutions found by architects throughout the ages and employs mining big data to create possible novel solutions to planning problems.

In an outlook it can be stated that this is only a first attempt in the area of the critical interrogation of planning in architecture in the age of AI. In fact, there is still a lot to be done. The first, alien, results achieved in this paper can only be seen as a first tapping into the potentialities of this approach. From tapping into novel design direction that rather talks about how machines see our world - with all its wonderfully strange results in terms of morphologies, chromatics and possible theories, to profoundly pragmatic approaches. It is feasible to speculate about the pragmatic applications of the findings in this paper. The possibility to create an application as a corrective tool in the planning process. Through datamining (Fig.5) it would be possible to create a NN that can analyze plans to see for example if they comply with local building codes. Or the plans can be analyzed to see if they are functional at all. All of these abilities need to be trained, heavily relying on human judgement at the beginning, but increasing its abilities after a period of training.

Further research needs to be done to dive deeper into the opportunities presented in this paper. In this extent the work on this problem can be considered a work in progress. The refinement of the algorithm allows to continue the conversation laid out in the conclusion of this paper. The authors of this paper have already started refining the approach and are looking forward to the in-depth interrogation of this posthuman design ecology.

Acknowledgements

The authors would like to thank Dean Jonathan Massey (UoM) and Associate Dean of Research Geoffrey Thun (UoM) for their continuous support and the Robotics department of the University of Michigan for providing know how, time and effort to make this research possible. In particular Elmer G. Gilbert Distinguished University Professor Jerry W. and Carol L. Levin Professor of Engineering and Director of Robotics: Jessy W. Grizzle.

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[1] The authors refer here to the map of the Babylonian city of Nippur – ca. 1400BC

[2] *Style* in this context of conversation is borrowed from computer science to describe a specific computational problem.

[3] The full paper contains a glossary explaining the mathematical background of the work done by the authors. By request the authors can provide the code for others to replicate the results.

[4] Leon Batista Alberti, *De Rei Edificatore*

[5] *Zaha Hadid Masterplan Istanbul*

[6] *Just think about Patrik Schuhmacher's Theoretical oeuvre and the schism it has created in the discipline by provoking with neoliberal statements. In the process creating a counter-culture in Digital Design opposing the neoliberal position and adopting instead a leftist, Accelerationist Ideology.*

[7] See also Greg Lynn's entire conversation on "Happy Accidents"

[8] $$\ell(m) = -|f(R(m, \phi))|_F^2$$

[9] Graham Harman, Weird Realism: Lovecraft and Philosophy, Zero Books, Hants, UK, 2012, p.93

[10] Think of Coop Himmelblau's manifests of the 19070ies, or Hans Hollein's flirt with the terms Visionary, also Peter Cook Visionary Architecture, or Gunther Feuerstein's Book: "Visionary Architecture in Vienna 1958 to 1988"

[11] See for example the work of Stanislas Chaillou, Daniel Bolojan, Guvenc Ozel, Daghan Cam, Alisa Andrasek and many more.

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01.103 - ARCHITECTURE TRANSFORMATIVE POTENTIAL

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Abstract

Nowadays the waste of land is an issue for sustainability and the literature on adaptive reuse frequently refers to its untapped *potential*. At the same time there has been an increase of attention on the reduction of energy footprints, in terms of sustainability requirements and especially in terms of the generative power of architectural design practice.

The aim of the present research is to provide a methodological framework to define, decode, and assess the concept of *Architecture Transformative Potential* in dismissed urban fabric. The study also aims to widen the boundaries of architecture considering the process that shaped dismissed buildings and the *option-value* of design. The research framework is the *post-functional era*, where the built environment requires classification following morpho-structural characteristics.

Embodied energy and *morpho-structural flexibility* are identified in this paper as the main elements composing the *Architecture Transformative Potential*. This *potential* is coded as an open function relating the embodied energy of dismissed buildings and the sum of all the main open options in design practice. The methodology that has been selected is the cases studies analysis within focus on high-rise buildings. The findings should make an important contribution to the field of adaptive reuse, evaluating the impact of further use options.

Keywords

Transformative-Potential, Embodied Energy, Flexibility, Adapting re-use, Option-value

1 INTRODUCTION

The reduction of energy footprints as a generative power in the architectural design practice is highlighted by many authors.[1][2][3] The sustainability issue is one of the triggers of adaptive reuse strategies. Such strategies frequently involve the release of an untapped *potential*, as already present in the existing built environment.[4][5]

The current adaptive reuse approaches focus on the concept of untapped *potential*, even if such *potential* is not properly coded and a complete definition concerning its meaning is still lacking.

The present paper defines the concept of *Architecture Transformative Potential* from an interdisciplinary point of view. The *ATP* is defined and addressed as an operative tool to evaluate dismissed buildings.

The *post-functional era* is the boundary system of the present research, this thought arises in a novel classification of built environment, independent from the functional types of buildings and based only on formal and structural characters.[6][7]

The first part provides a broad framework of the concept of *potential*. Starting from the definitions of the term *potential* within different disciplines –as Physics, Philosophy and Social Sciences–the concept of *potential* is defined both in a theoretical and an operational meaning, highlighting its main behaviors. The *potential* acts in a detected force field, it may be positive or negative, it is multiple and not unique, it acts as a function or a flow and it requires a trigger element to be activated.

A critical reading of the existing literature suggests the *Architecture Transformative Potential* as an open function. *ATP* connects the embodied energy untapped in the built matter and the morphological asset related to its structural system.

The transformative potential has been addressed as an operative formula, in order to quantify and qualify the amount of *potential* embedded in the dismissed building stock.

Real estate studies quantify the amount of *Adaptive Reuse Potential (ARP),* and *the capability to change (Flex)* as the results of indexed parameters.[8][9] However, such concepts are made by indicators and fixed parameters, the present research focuses on an open formula instead.

The goal of the research is to evaluate the impact of further use options. The theoretical considerations will lead a cases study selection in order to test the open formula on real buildings.

2 The concept of *Potential*

Starting from the 17th century, the term *potential* has continued to spread, making a significant increase during the 1960s. Nowadays, references to this *potential* are strongly present among hard sciences. The term *potential* has been widely explored, but it is still not clearly defined in the framework of architecture. The literature –especially the one concerning interventions on built environment– consider the untapped *potential* in urban legacy as an unstated value waiting to be released.[10][11][12]

How is it possible to exploit this hypothetical resource if it is not even defined properly? Such *potential* has always to be released or not?

The origin of the concept of *potential* comes from ancient Greek, specifically from the term δύναμις, (dúnamis) that derives from the verb δῠνᾰμαι (dúnamai) "I am able to". [13] Such word refers to the concept of *potential* only from IX sec b.c., thanks to the Greek philosopher Aristotle.[14]

The conceptual breaking point occurs with the theory of gravitational force by the scientist Galileo Galilei in 1638, and the linguistic one happens by the introduction of the *potential function* by Gauss in 1839. Galilei initiated the rational approach to the idea of *potential*, from his observations on the concept of gravity, improved by Newton, that invents the *potential energy* formula as known today.[15]

Nowadays, the word *potential* expresses itself mainly as a scientific term, and this prevalent meaning has been related to the sphere of hard sciences and the concept of energy itself.

A contemporary approach in philosophy is the one developed by DeLanda, declining the concept of p*otential* as *virtual*. Such *virtual* represents all the possible actions even if not available anymore, still embedded in the object as once possible trajectories.[16]

Among the broad analysis a series of intersections emerge, linking the nuances of *potential* through the different fields of knowledge.

First of all the concept of *potential* acts as a flow that variates in a detached time frame. Its origin –settled in the mean of "power"– gives the perception of something able to transform itself, according to the presence of a trigger element, capable of activating it. In order to analyze the *potential* in the field of architecture it seems necessary to set a boundary system, according to the aim of the specific research. This *Architectural Potential* is *Transformative* because it is related to the built environment, and specifically, to the dismissed building, in order to retrace its transformability.

3 Post-functional era as boundary system

The present research aims at contributing to the current debate surrounding the dismissed built environment, adding the concept of *Architecture Transformative Potential*. The intuition of Yona Friedman [17] seems to find place in the trends of contemporary architecture, back to the Habraken's *Supports-Infill theory*[18]. Contemporary architecture shifts in scale, becoming more and more uncertain and ephemeral. The structure, the frame, the bones are the elements to be provided by architects, allowing the movements and the unexpected to play in between. [18]

The program is still present, not as the unique generative force shaping the project, but as dynamic mix-use system, changing, expanding and contracting the space, they require a built frame capable of adapting.

Even if *form* does not *follow the function* anymore [19], or better, even if nothing has to be designed to follow just an unique function in the same space or in the same life-span, it does not mean that form is dead too. It depends upon how we deal with it. The form, not considered anymore as a physical, rigid and defined object, is still appealing, if defined as geometry embedding a space.

Even if the research focuses on the dismissed built environment, no real theoretical shift occurs. The focus on existing object does not change what it is irrelevant in an operative way as the previous function. The form is a physical condition but not a generative guideline and the function is flattering, it does not seem to be fixed, following the current trend. [17] A helpful point of view is presented by some novel theories in the contemporary architecture field, such as *form and function follow climate* and the *shape of energy*. [19][20]

The climate crisis is a crucial component of this shift, but it is not the only one. The *flexibility* that our future seems to require plays a significant role, highlighting the energy as a possible generative system for architecture design. According to Rahm, architecture today is free of any formal and functional predetermination;

"*variable, fluctuating, open to meteorological permutations and the passage of time, to seasonal changes, to the alternation of night and day and moreover to the sudden appearance of unanticipated functions and forms"*.[19]

Architecture may be not function-driven anymore, and the rise of energy matter as a shaping force, could structure architectural space.

Is it possible that such theoretical approach is not only suitable to the new buildings, but even to the existing ones, assessing the energy already embedded in them, both as a building construction and a morphology asset?

The decline of function-driven paradigm is a difficult shift in the evaluation of building stock. Indeed, the urban legacy is categorized on the basis of the original functional purpose of each building. The function regarding a dismissed building is even less important, because it is not practiced anymore. According to Louis Kahn, a building that has become a ruin is free of the constraints of use.[21]

How it could be possible to retrace the energy embedded in the matter, the space, the time and the connection flows composing the existing architecture? In this case, this energy is an inactive power, it is its *potential*.

According to Weber

"the ideal type represents a conceptual framework which isn't historical reality nor the 'true or genuine' reality, though it more or less serves as a scheme by which reality must be subsumed as a template; it signifies a pure and limited boundary notion, whereby reality must be measured and compared, to illustrate the determining significant elements of its empiric essence".[7]

Starting from the interpretation of things –*human actions* in Weber– the speculative structure emerges as a methodological frame capable of measuring the real. Such methodological framework is not present in the real world, but it shares some features with the real objects, even if it does not derive from them. The Weberian *idealtypus* underlines links and relational connections, being itself a sort of discrete classification.

The ex-post classification of the existing built environment allows to consider dismissed buildings as infrastructures beyond their previous functional purpose, addressing the concept of *Architecture Transformative Potential* in an objective way. Such approach intentionally omits a wide range of other subjective values. This omission is essential for assessing a specific kind of *potential*, the *Architectural Transformative Potential* in existing building, purely considering the energy embedded in its materials and in its shape.

4 Elements

According to the summary of characters and behaviors underlined in the first section, an incomplete definition of the wide concept of potential in the field of architecture could be retraced across the architectural literature. Starting with Vitruvius, the concept of 'potential' is embodied both in the matter and the function. This concept is touched briefly as an outline between "firmitas" and "utilitas".[22] According to Rossi, the *potential* shows the fundamental relationship between matter and energy, such a form of dynamic energy is the *potential* itself.[23] The *potential* seems a force originated by the incompleteness and the chance to do, linked to the ruins and the abandonment. [24][25]

Stemming from the theoretical speculations, another kind of literature linked with the theme of architectural potential emerges, one which is more linked to the practice and less conceptual.

Brand focuses on how to prevent the loss of *potential* during the building's lifespan, even if he does not define what the *potential* is.[26] According to Douglas, a *building adaptation* *potential* exists relates to the alternative use and layout of the existing building. In fact, the property's location, condition, construction, morphology, and legal restrains will all influence its adaptability.[4]

As highlighted before such *Architecture Transformative Potential* depends from both physical condition and further design options. Douglas includes an *adaptation potential* in his to-do-list in order to analyze the current provision in assessing the building, it is synonyms of *flexibility/suitability* for change of use.

Primary elements of the *Architecture Transformative Potential* seem to be the energy embedded in constructive materials and the aptitude to change of the physical space. The concept is not defined, but is possible to outline the concept itself as a relation between such main elements. The current research aims at analyzing this kind of *potential* in its endogenous meaning. Invisible layers related to the space-time dimension are already present in the materials used in the building construction and its stage of obsolescence.

4.1 Retroactive Embodied Energy

Nowadays the interest in the sustainable approaches is taken for granted, adding importance to the ecological impacts of buildings. The buildings consume more than one-third of energy use producing 30% of the greenhouse gas emissions, and 40 % of the whole land waste is addressed in building materials.[27][28]

The embodied energy links the diverse shape of energy embedded both in constructive materials and in labor dynamics, includes in the built environment. The first definition of embodied energy comes up in the 1970s, being defined as the process of determining the energy required directly and indirectly to allow a system –usually an economic system– to produce a specified good or service.[29] The embodied analysis focuses on how the energy flow affects an economy, placing the role of direct and indirect energy used by a productive system.[30]

Nowadays, multiple definitions of such concept –related to the built environment– exist. The differences among them depend on the boundary considered.

A comprehensive definition of embodied energy includes not only the extraction of raw materials, the transportation on site, and the construction stages but also maintenance, demolition, and disposal stages of the building life cycle.[31]

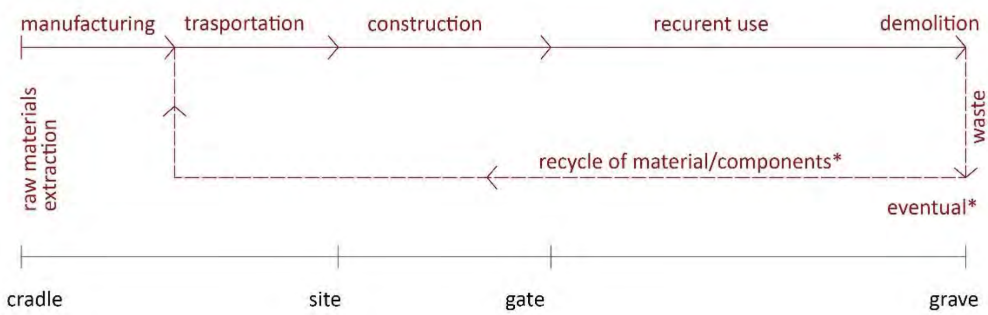

Figure 8. embodied energy cycle chart

The unit of Embodied Energy is MJ/kg. Metal and plastic are the materials embedding the higher amount of embodied energy, even if such values depend on multiple factors.[31] According to Azari, the type of structural system has an impact on embodied energy. Each structure requires a construction materials, a manufacturing process, a way of transport, and a constructive system.

The methodological approach and the database are suitable to completely change the results as well. Indeed, the main methodologies are part of the *Life Cycle Assessment* to calculate the embodied energy; the *process-based LCA* and the *Input-Output-based LCA*. The first one is accounting the values of each step of the building construction, not including the financial system, tracking and quantifying environmental flows, even if it is time intensive, it is capable to produce building-specific results, allowing the comparison of buildings. The second method uses annual *Input-Output models* of the US economy, linking monetary values of the building sector to their environmental inputs/outputs. [32].

The database of materials in the building sector is necessary in both methods. The fundamental database is the *Life Cycle Inventory (LCI)*, that starts from the 1970' in the United States.[33] According to Stahnel and Reday-Mulvey, the energy issue became relevant in the framework of circular economy and re-condition processes, in the 1970'.[29] Only an historical research on each specific building could provide data for previous constructions.

The Embodied Energy became appealing only if inscribed in the framework of an interdisciplinary approach, claiming the fluid essence of architecture studies, interested in redefining the limits of architecture itself. [34]

The main trend in sustainability studies is linked to the reduction of the operational energy. Operational energy is a part of the energy flow related to the construction of buildings, this energy does not represent all the system. In fact, an enormous amount of energy involves the extraction of production of the built environment, such kind of energy is the Embodied Energy.[28]

Considering the focus of this research, the calculation wants to comprehend the process from the cradle to the current situation of dismissed buildings. It considers the hypothetical demolition and the recycle of materials as an option to be calculated separately.

The innovative approach is to consider such embodied energy not just in a provisional way, but also in a retroactive way. This retroactive Embodied Energy retraces the history of the dismissed building, its materials and its energy systems. In new buildings the main contributor in its value is the structure within building layers, and the metals within materials. The height seems to be a trigger element for Embodied Energy as well.[35]

The cases study approach is the methodology to estimate the energy of such materials in existing building, using an existing *Life Cycle Inventory.* Even if the process-based-LCA method seems the best approach to calculate the embodied energy of existing buildings, just real cases study would confirm this hypothesis among the existing buildings.

The goal is to assess a range of embodied energy values, linking this result to the morpho-structural asset that already contains multiple design options.

4.2 Morpho-structural Flexibility

The morpho-structural asset should be addressed as a typological question, even if not in a classic way. Indeed, the reference to typological studies is related to the interest in finding common features addressing the options embedded in buildings. Durand provides a matrix of possible types, not embracing the whole but giving an order to the multiple options in design.[37] This simplification of architecture uses a classification process to teach how to design a new building, highlighting common spatial features beside different functional categories. Durand's method could work as a tool to clarify the state of existing built environment.

The main contemporary adaptive reuse approaches could be classified as *technical* and *typological*.[38] Both approaches are valuable points of views, standing upon the functional categories of buildings.

In order to organize the built environment in structural types –as social *idealtypus* in Weber– both of them seem fundamental in order to apply an integrated approach. The wide topic requires a goal-oriented lens, such point of view may be the concept of flexibility.

According to Hertzberger, flexibility suggests an open-ended solution, such a concept is called *rhetoric value of flexibility* by Schneider and Till.[39] Herzberger refers to the term flexibility as being capable of proposing different solutions for diverse users, not proposing a single solution but the most appropriate one.[40]

Following the *Support-Infill theory*, it is possible to distinguish the construction components by different life spans and diverse building levels -such as urban tissue, support, infill- or by differences in dealing with fixed or variable components.[18]

Stewart Brand decodes the multiple layers composing the building: *Site, Structure, Skin, Services, Space Plan, Stuff*. [26] The layer of the structure is the one affecting most the essential flexibility, and having the longest lifespan, beside the *Site*. The structure is organizing the space and the fixed features of the building more than the other components. Many taxonomies were developed by multiple authors, but each of them was referred to a functional type or to a precise method of building construction.[4][41][42]

According to Wachsmann, the technological determinism could explain the link between the Gothic cathedral to the industrialized Crystal Palace. Such structural types designs analogues spatial assets and somehow a novel classification of built environment.[6]

To define clusters of types –in the field of technical structure and building construction– the morpho-structural broad classification is based on 3 main classes of parameter, as the main constructive structural systems until 1980'[4], the basic shape of building footprints and the height. (Table 1)

The process to define clusters of buildings uses *Python* calculation system to operate all the possible combinations between them. The one that is considered either structurally unsustainable or logically not convenient are critically excluded from the set of possible combinations.[4][42]

The process underlines a high number of possible combinations, even if it is a proxy evaluating just a part the whole building object, from a singular point of view. (Figure 2)

Table 1: morpho-structural classification process

Height (m)	**Plan basic shape**	**Constructive systems (Douglas,2006)**
A= Skyscraper >100	a= square	1= Solid masonry walls
B=Super-high 50-100	b= rectangular	2= Cavity masonry walls insulated
C= High 20-50	c=round	3= Framed/panel walls

D=Medium 10-20	d=court	4= Skeletal frame
E=Low <10	e=L shape	5= Portal frame
	f= C shape	6= Column and plate
	g= triangular	7= CLASP system
	h=polygonal	8= 'No-fines' concrete
	i= curve	9= Bunched/bundled tube
	l= free	10= Slip form wall and slab
		11= Modular pod
		12= Tunnel form reinforced concrete

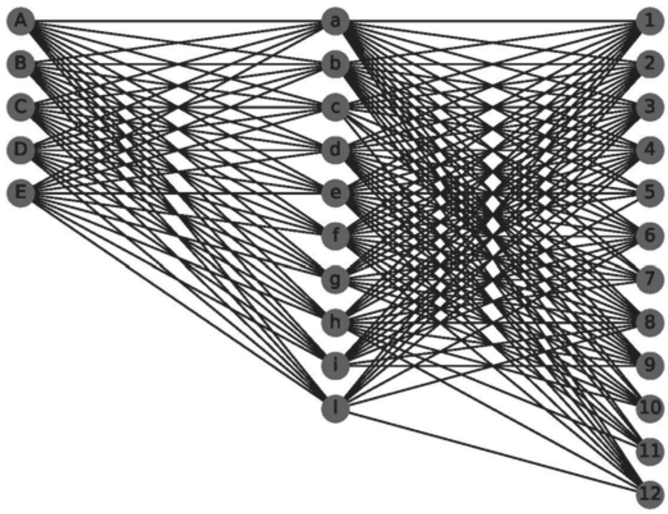

Figure 2. morpho-structural possible matches

5 Conclusions

The present research aims to address the relevance of the concept of *potential* in architecture studies related to the dismissed built environment. Such concept is the *Architecture Transformative Potential*. *ATP* expresses the capability of dismissed buildings to unveil the energy untapped in its matter and the inclination to allow a number of adaptive design practices. The energy framework is the reshaping force of the already existing built environment, this framework allows to quantify and qualify the energy still present. The ideal obsolescence condition seems to be the one where the layer of structure is still present (Figure 3) and the embodied energy related to the structural system is embedded in the constructive system.

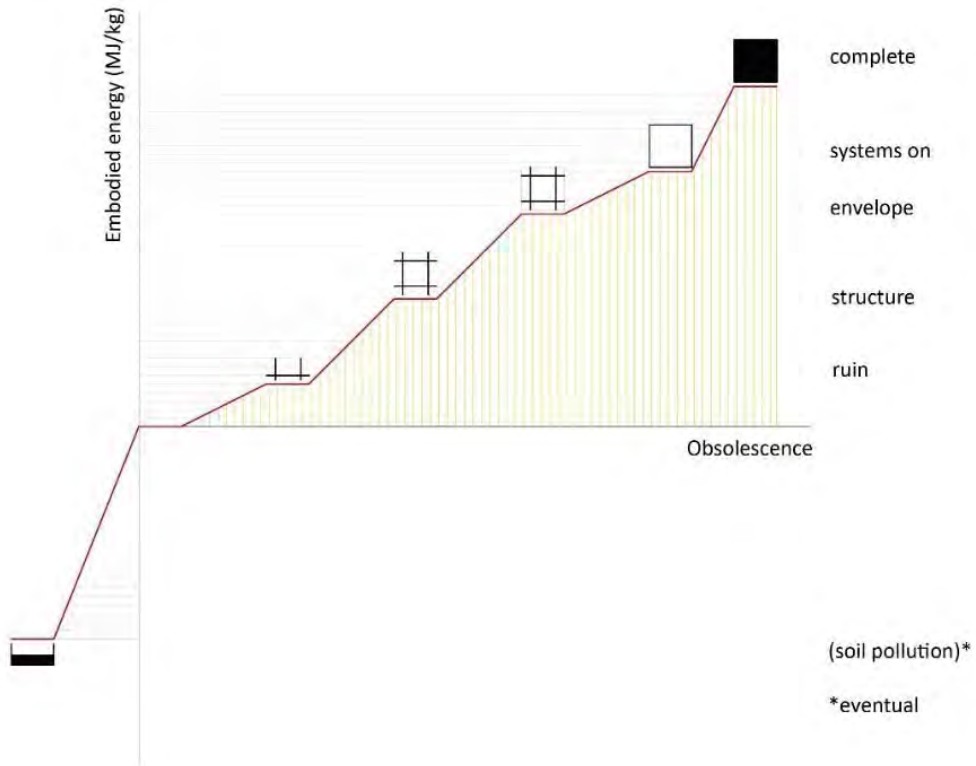

Figure 3. structural stages related to the obsolescence

The broader research on the meaning of *potential* underlines some common features, explaining how it is supposed to behave; it acts in a detected force field, it may be both positive and negative, it needs a trigger element to be activated, it structures like a function or a flow, it is multiple not unique.

The embodied energy is already defined by a closed formula, even if generally is applied as a predictive tool to design new buildings, instead of an evaluative tool for the existing ones. Quite the opposite happens concerning the morphological flexibility related to structural and constructive systems. Such a concept is expressed in multiple qualitative ways to the existing literature in the field of architecture.[17][18] The studies on flexibility that have shown quantitative output are applied in the Real Estate.[8][9]

The goal of *Architecture Transformative Potential* is to assess the impact of *open-options* in abandoned buildings, as just architecture is capable of prefigure. Such options are qualitative and subjective, and this research does not intend to refute this. However, the approach simplifies the existing architecture realm, underlining a complementary point of view that isolates some features within dismissed buildings.

Stemming from the architectural discourse related to the energy, the research wants to claim the role of design in evaluating the weight of chances. Possibilities are trigger elements themselves, as having multiple options increases the value, even if just one of them will be realized.

The hypothesis is to express it by a function. As shown in Eq. (1) below.

$$\text{Transformative Potential} = \text{TP}_j = x_j + y_j$$

$$y_j = \sum_{i}^{n} \mathrm{y}_i \tag{1}$$

Where x_j is the embodied energy measured in *j*; y_j is the flexibility for each design option *j* and *n* are all the possible design options. In the formula, x_j and y_j are expected to be directly proportional one to the other.

The task is to define and convert the member y_j in MJ/kg as x_j.

The hypothesis is to approximate such kind of *flexibility* as the sum of each possible action, even no actions at all, or negative ones. This actions act in a post-functional era and on dismissed buildings.

Using the *Research-by-Design* approach [43], such *flexibility* y_j could be defined through a simplification of design actions, allowed in each case study analyzed. The previous classification in morpho-structural types allows to enlarge the case study general assumptions to its whole category. The case study selection will focus on dismissed building that have an high embodied energy expected. Such as high-rise buildings[35] comprehend different kind of morpho-structural types, as shown in the scheme below.

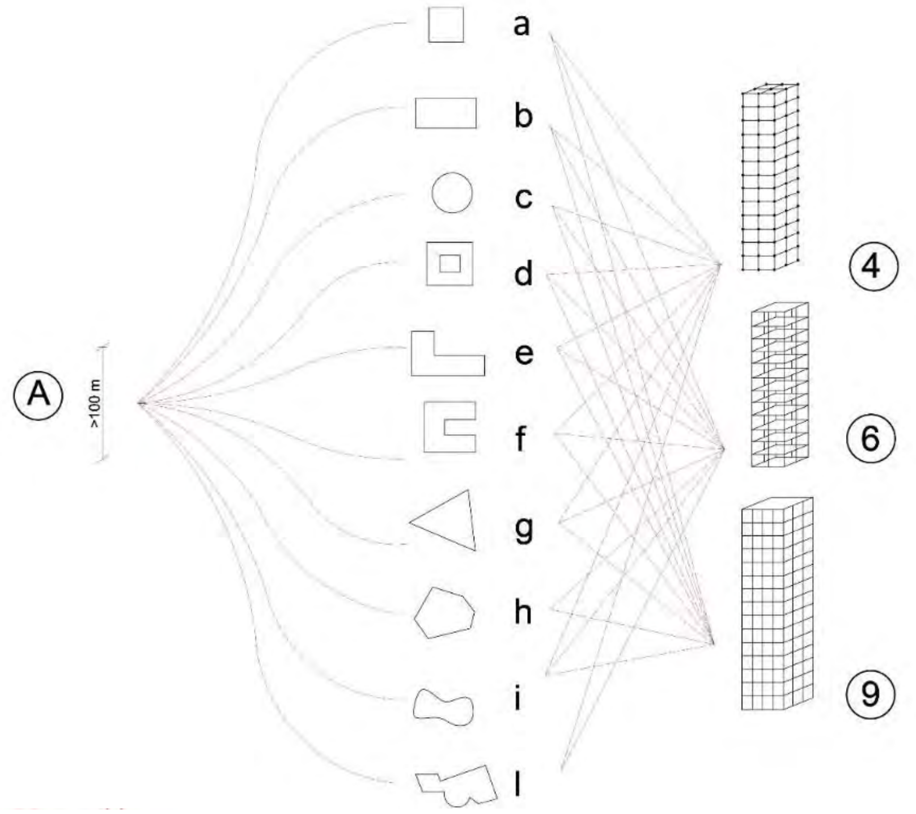

Figure 4. The 26 possible basic morpho-structural types (height > 100m)

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01.104 - SELF-BUILT HONG KONG: THE HIDDEN CAPACITY IN GRASSROOT COMMUNITY

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Abstract

Hong Kong is both a prosperous and poverty-stricken city. In 2019, Hong Kong's GDP reached 32nd in the world ranking; nearly one fifth of its population living below the official poverty line. In the face of such resource scarcity, grass-root citizens maximize the use of their relationships, intellectual and material resources, to accumulate social capital for better living quality and economic growth. Social capital, within the architectural realm, manifests itself in different forms; a fruit store in an alleyway, an angle-bar cabinet, a self-made wooden stool. These interventions might seem small, or even negligible, yet their very existence allows for a rich daily life.

This paper aims to document these informalities, as a reverse engineering approach, to identify both tangible and intangible demands that emerge from daily activities. The goal is to rethink architecture as an enabler for the dwellers, particularly the underprivileged ones, to give birth to a place they call home that closely associates with their culture, social and economical conditions, and most importantly, values. The word housing, in this very context, is understood as a verb that includes both dwellers and their activities. It is only through the process that the true value of housing distinguishes itself from commodity – a common misconception in today's modern society. The study selects three families who live in subdivided units (SDUs) – one of the typical destitute dwellings in Hong Kong. By observing the spatial programme organization, and how individual furniture and item supports the programme need, the research demosntrates the undelrying wisdom and self-built capacity of the ordinary people.

Keywords

Self-Built Architecture, Social Capital, Grassroot Design, Housing Value, Dweller's Control

1 INTRODUCTION

Dwelling is a process emerges from our daily activity. It manifests the very mental meaning that we endow in specific moments of time in our lives. Dwelling is a creation of both body and mind, in which the absence of either one will make it impossible to succeed. The notion of intimacy between human and dwelling, on the linguistic level, is indeed suggested from the original form for the word *dwell* as Greek *Homois* – meaning "of the same kind [1]." Gaston Bachelard's *The Poetic of Space* refers the built environment as a cradle for human being to mediate between self and the world [2]. *In Supports: an alternative to mass housing*, John Habraken further depicts the connection between the two as the most important "natural relationship [3];" one that is fundamentally rooted in human existence. The natural

relationship – the basis for human inhabitation– however diminishes in the search of the solution for housing shortage. Mass housing becomes the dominant mean in the housing provision front.
The concept of mass housing was conceived in Europe's social democracies during the early twentieth century, when decent homes were promised to provide for most of the population [4]. With the escalation of technological advancement, industrialisation, and economical forces, mass housing becomes inseparable from "modern housing". The close association of these two terms demonstrates that mass housing is considered as the prevailing method in the building programme, despite of other effective means.
Mass housing calls for the most rigorous standardisation and central control, in which the involvement and initiative of the inhabitant are excluded. While the question of housing has been ever more technologically and financially oriented, individual specifics to the physical space is no longer part of the equation of dwelling. The dwellers' need is reduced to mere statistics. Lodging in an environment that one does not possess, Habraken claims, "man no longer houses himself: he is housed [3, pp. 9]."

2 Housing Crisis in Hong Kong

In Hong Kong, the insufficient supply of housing has been continued since the 1840s. Despite of its mass housing supply effort, Hong Kong's public housing shortfall in the next decade remains expected [5]. The average waiting time for public housing has increased to 5.4 years – from the mark of 3 years [6]. Grassroot population who could not afford private property must seek for bottom-up alternatives. These alternatives include the roof top houses, subdivided units, cage rooms, and coffin rooms. Considering hygiene, safety, comfort, rights of dweller, and all measures for any decent dwelling, the quality of these shelters is often unacceptable.

3 The Bottom-Up Housing Typology

These grassroot housings have their existential value on two levels: first, they are the safety net for the underprivileged community whose government is powerless to fulfill their needs; second, from the academic point of view, these housings offer a catalogue of diverse typologies among the massively produced ones, which are indifferent and lifeless. Not only they exhibit the underlying capacity of the citizens in adapting unfavourable spatial condition, but also demonstrate the possibility of bottom-up initiative in the housing sphere.
The history of these housing typologies dates back to the Treaty of Nanking formed during the end of the Opium War in 1841. As the City of Victoria being designated the *de facto* capital of Hong Kong by the British government, an exclusive living area for the foreigners, Victoria Peak became the settlement for Chinese and refugee. Tenement house (唐樓) was one of the most popular dwelling options at the time. It was a two-to-four-storey building, comprising retail on the ground level and residence on the upper levels. Each storey was less than 50 square meters, holding up to 60 people. This was indeed the earliest form of sublease with each tenure was further subdivided into smaller units. Known as today's cage room and coffin room, the smallest tenure was a bed of a bunkbed with metallic net enclosing around. Other more affordable alternative was squatter built with metal sheets, used timber, broken bricks, and garbage [7, pp. 2-16]. In this paper, the research is going to further examine the subdivided unit and how its dweller accustoms to the given spatial condition.

4 The Subdivided Unit Condition

In 2016, there were 27,100 quarters with SDUs in Hong Kong [8, pp. 5]. With each quarter subdivided into approximately 3 to 4 units, the total number of SDUs was estimated to be around 92,700. More than 200,000 people, 91,800 households were accommodated [8, pp. 5]. While the median monthly income from employment of working population living in SDUs was $9,250, more than 30% of which was contributed to the rental cost [8, pp. 6-7]. However, the economic burden of these tenants very often did not barter for any fair living condition. According to the Right to Adequate Housing, UN-Habitat underlines six key aspects for adequate living standard: security of tenure, availability of services, materials, facilities and infrastructure, affordability, habitability, accessibility, location, and cultural adequacy [9]. As regards living area, over 65% of SDUs households were living in 7-13 square metres floor area, with median per capita being 5.3 square metres [8, pp. 7]. Facilities such as independent toilet and kitchen were only installed in 95.9% and 72.4% of units respectively [8, pp. 7].
In the architectural discourse, the stated numbers above is only meaningful when an in-depth study on the actual living condition and its constituted reason is conducted. There are three categories of conditions, namely the fixed, soft, and self conditions. The fixed conditions describe the relatively tangible characteristics laid down by the city, building, and unit; the physical constraints that the citizens make their decision of dwelling upon. On a city level, transportation network, service and facility, and neighborhood are the three elements that determine the quality of the external setting. On a building level, it covers the physicality of space between the city and unit that greatly dictates the transportation means, the social quality among the neighbors, and the usage of the common area established upon collective agreement. The unit level specifies all the attributes equipped within the living space, including structure, wall/partition, layout, door, window, finishing, bathroom, kitchen, switch/socket, and ventilation. The soft conditions, as the name suggested, indicate a certain degree of compliance flexibility, contributed by the building management office, tenure owner, neighbor, and other critical personnel. They are very often the unspoken rules that rely on trust, common norm, and network between the tenant and the key person whom the he/she needs to deal with. The self conditions are based upon the tenants' very own circumstances, such as household structure, culture, financial conditions, and living habit, that directly affect the way everyday living is carved out inside the unit.

5 The Pattern of Programme Organization and Function

In this conversation between the dweller and space, it seems that the former one is rather passive with all these external and internal forces shaping the way of living. It is however not the case. The dweller does have say, though very limited, in creating a place that is inhabitable for them. The study presented in this paper is a unique field research conducted by the author in three SDUs in Kowloon District. The selected tenants are all single family whose mothers are the main source of income and children are at school. The objective of this study is to identify the common pattern that is fundamental in the way these dwellers adapt the space within the unit; thus, rethink architecture as a building land for the dwellers to exercise their wisdom and resources, and create a home that truly belongs to themselves. The study comprises of two themes: first, how the programme within the unit is organized; second, how individual item supports the programme need.

5.1 Case Study One

The first case is the Leung family – a working mother, a 7-year-old son, and 9-year-old daughter. Located in an early 60s residential building in Tai Kok Tsui, the unit is one of the four units subdivided from a single flat. The location is rather convenient; markets, shops, schools and other services can be reached within 5-to-10-minute walk. The unit, which is 11.2 square meter, is a studio flat encompassing one individual bathroom. There is no kitchen provided. Windows mainly occupy the wall opposite of the entrance. At the centre is the living space where dinning occasionally takes place. The cooking area is right next to the entrance on top of the washing machine. The bunkbed is placed at the recessed corner next to the toilet. The rest is dedicated to the storage space. Despite of the wall next the entrance, space below the windowsill and above the bed is also used for storage purpose.
Considering the function of the individual item, there is no clear definition as each item bears multiple uses. The bed is not just for sleeping, but is also for sitting, dinning, studying and storage as well. For sofa, it offers seating for watching TV as well as for eating a meal. Table, in this case is a folding one, is used when visitors join the meal, as well as when the study desk is not enough for both children to study. The chair, depends mostly on whether it is foldable or not, is used as either seating or storage. The kitchen countertop for cooking is also used for storage during times other than food preparation.

Figure 1: Panoramic photo of case study one interior

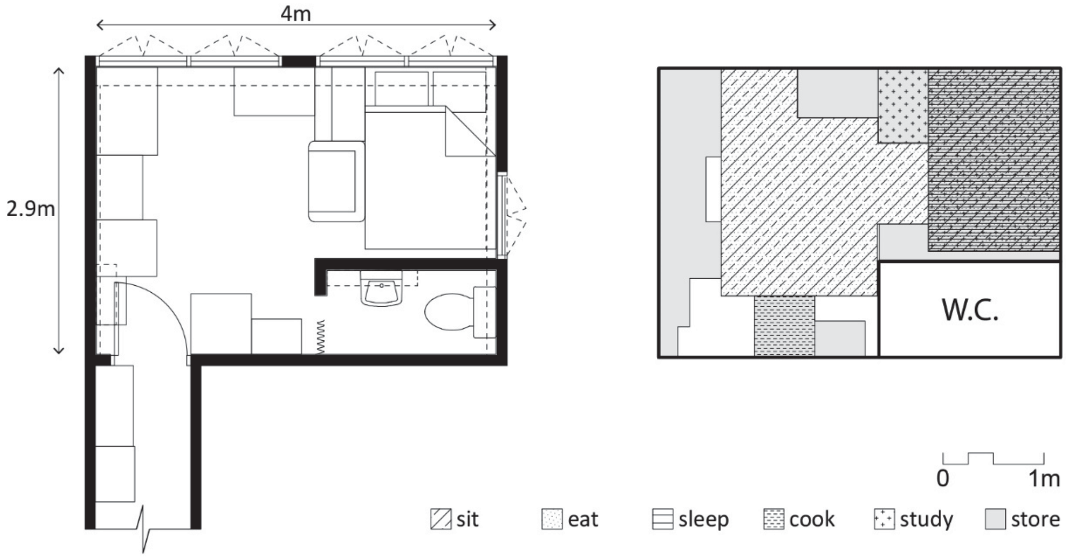

Figure 2: Floor plan and space programme diagram of case study one

	Bed	Sofa	Table/desk	Chair	Kitchen countertop
Sit	O	O		O	
Eat	O	O	O		
Sleep	O				
Cook					O
Study	O		O		
Store	O			O	O

Table 2: Furniture and function of case study one

5.2 Case Study Two

The second case features the Chan's family – a working mother and a 12-year-old son. The unit is also located in a mid-60s residential building in Tai Kok Tsui, where services and facilities are easily reached within the neighbourhood. The unit has 10.9 square meter, one of the two divided from a single flat. Unlike the first case, there is only one 0.9m-wide window above the built-in kitchen countertop. Artificial lighting therefore has to be lit on even during daytime. The bathroom, which is 1.1 square meter, is partitioned with non-structural walls next to the countertop, creating a recessed corner where the daybed is placed. At the centre, there is the main living area that is used for sleeping. Along the wall next to the kitchen sink is allocated for storage and study space.

Similarly, the use of the individual functional items does not confine to one specific purpose, but rather manifold. The daybed is a place for sitting, dining, sleeping, and storage. The transformable sofa provides seating, sleeping bed for occasional visitor, study and storage space. The desk, which is owned by the landlord, is used for study and storage. The folding chairs are only used when extra seat is needed for dinning and other daily routine. The kitchen countertop is likewise used for cooking and storage purposes.

Figure 3: Panoramic photo of case study two interior

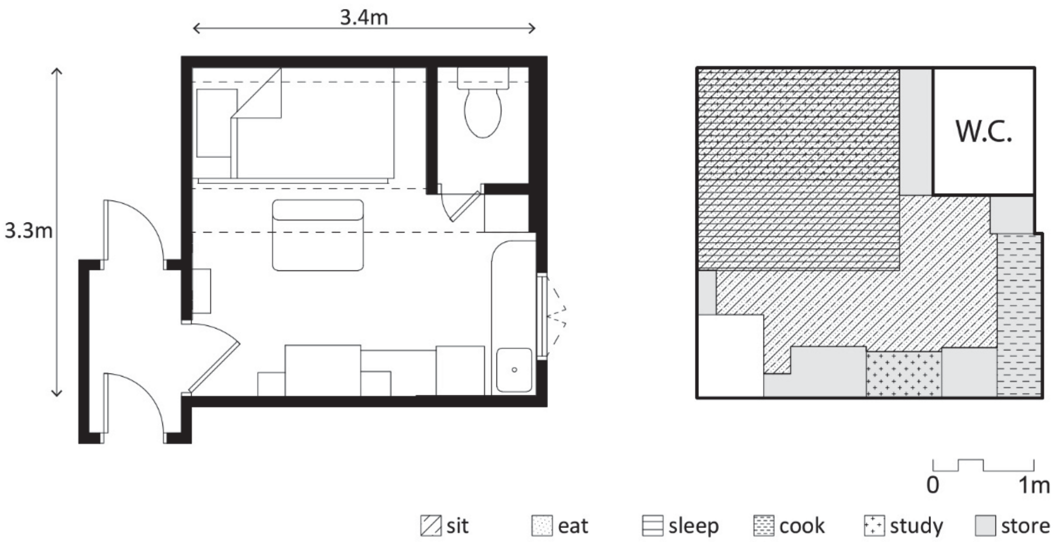

Figure 4: Floor plan and space programme diagram of case study two

	Bed	Sofa	Table/desk	Chair	Kitchen countertop
Sit	O	O		O	
Eat	O				
Sleep	O	O			
Cook					O
Study		O	O		
Store	O	O	O		O

Table 2: Furniture and function of case study two

5.3 Case Study Three

The last family is the Wong's – a working mother and a 8-year-old son. The unit is located in an early 70s residential building in Hong Hum, where a main public transportation interchange is located. Other services and facilities are within rather short walking distance. The unit, one of the three divided from a single flat, is only 7.1 square meter. In this case, the layout clearly defines the served and servant space; individual bathroom and kitchen countertop are provided in a separate area. At the opposite corner of the entrance, there is a bunkbed forming an L shape circulation in the living area. The television, fridge, and some storage items are at the end of the bed. The study desk is right next the window. As the remaining space is left for circulation, the main storage area is on the upper level of the bunkbed.
Taking the advantage of the tall ceiling height, the bed which is for sitting, dinning, sleeping, and studying, also become the main storage area. The desk and kitchen countertop are then served for study and cooking accompanied with storage purpose.

Figure 5: Panoramic photo of case study three interior

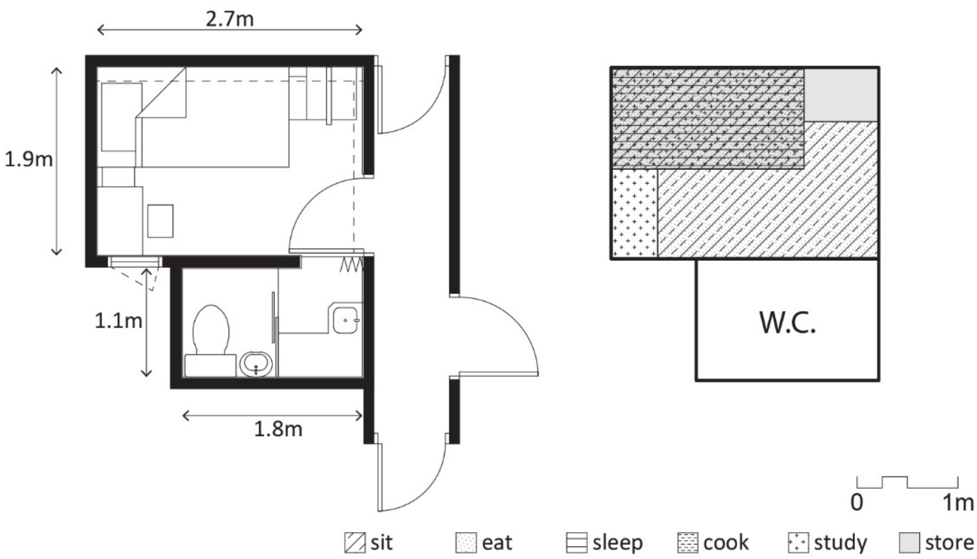

Figure 6: Floor plan and space programme diagram of case study three

	Bed	Sofa	Table/desk	Chair	Kitchen countertop
Sit	O	n/a		O	
Eat	O				
Sleep	O				
Cook					O
Study	O		O		
Store	O		O		O

Table 3: Furniture and function of case study three

6 The Pattern of Storage Item

Regardless the different programme organization setting found in these three cases, the multifunctional character of the furniture always associates with storage. That is, other than examining how furniture is used to fulfil the programme need, it is also necessary to explore how storage item is exploited in order to make space for regular daily routine.

According to the nature, structure, function, material, mechanism, and mobility, nine types of storage item are identified. They include the open shelf, cabinet, drawer unit, shelving unit, basin, bag, box, hanging bar and string, as well as hook and hanger. Open shelf can be either a shelving board mounting on the wall or stand-alone without any support at the front or back. The cabinet refers to a full-size closet or the one enclosed by cabinet doors. For the drawer and shelving unit, whilst sharing similar concept with the previous two types, they are modular systems that can be assembled in various combination. Basin, bag, and box are considered as the component units that are relatively inexpensive and lightweight; yet they might not necessarily be in uniform size. Hanging bar and string are commonly used for clothe-hanging purpose. Lastly, hook and hanger are the storage medium that are used accompany with hanging bar, string, and window fence. Sometimes they are directly drilled into the wall.

Among these nine types of storage item, it is evident that the hook and hanger are most commonly found in these three selected families. Followed by the component category, bag is also a favourable alternative in keeping things in order; each bag can be either packed as an individual item or a sub-category in other storage medium. Box, though is more structurally durable, it is less of a popular tool for it is not as easily attainable as bag is. On the other hand, closet, cabinet and other massive storage pieces are the least favourable.

The pattern of storage item cannot be understood alone without explaining the “nature” of the SDUs dwellers. 17.2% of SDUs households migrated within the past 5 years [8, pp. 7]. In other words, for those public housing applicants, whom most SDU tenants are, need to move from one place to another at least once before they could settle down for a stable living life. Therefore, the storage items of these tenants are often transportational-friendly. Light weight, medium-to-small volume, and easily attainable pieces are more widely acceptable among the SDU tenants. Moreover, the notion of temporary and permanent becomes ambiguous. Items that are designed for longer lifespan are sometimes abandoned during the next relocation; plastic bags and other less durable pieces become an all-time resort in the storage front. In short, flexibility, light-weight, accessibility, and multi-functionality are prerequisites for the grassroot community to create a home accustomed to their needs.

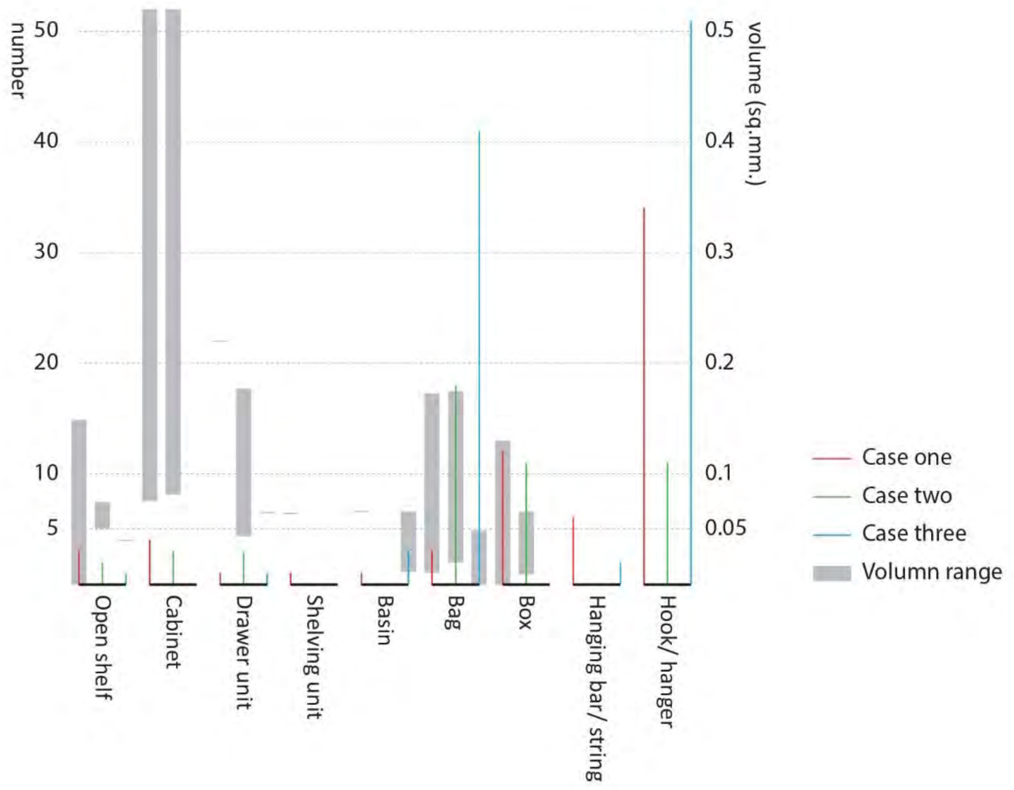

Chart 1: Storage item number and volume chart

7 Conclusion

The current top-down approach of the mass housing has caused serious impacts on both macro and micro scales: the unmet demand of the housing supply, and the separation of the natural relationship between user and dwelling. It is therefore necessary to call for a bottom-up alternative that enables effective housing provision and, more importantly, reconnection between people and physical space.

The three case studies presented in this paper reveal the potential of bottom-up initiatives, and their capability of responding to the built environment. Three characteristics are discovered among the selected families: 1) programme organization is hybrid. Bed, for instance, provides a large surface area that supports most of the daily activities, including sitting, dinning, sleeping, studying, and storing; 2) storage is associated with most functions, due to limited space; 3) portability is the primary concern of the storage furniture, considering the nomadic lifestyle of the grassroot community.

These common patterns reflect the need to incorporate change into the architectural process. It therefore requires paradigm shifts in the role of architect, the building process, and the architectural design. Architects are responsible to provide a building land and principles which end users can make decision upon. These principles mainly define the control hierarchies, territorial organization, and public and private spatial division that dictates various aspects of the building. Ranging from internal spatial organization, finishing, mechanical service, to façade, and common area, architects may decide the degree of end users' control according to the project prerequisite. Future alteration is unforeseeable. Rather than excluding the possibility of change, architects shall focus on how change can be integrated with the entirety of the building.

Note

Area mentioned in each case study is saleable area. It refers to the sum of the area including kitchen, toilet, dining room, living room, and bedroom. External wall, internal wall, or any internal partition area is excluded.

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01.105 - A BIOMORPHIC FORM AND CHARACTER FOR A CITY SPORTS COMPLEX IN SAN FERNANDO, PAMPANGA (PHILIPPINES)

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Abstract

Biomorphism is a concept through which a structure is inspired from a natural model including its form and character. This concept used in architecture encourages the association of nature with humans and sustainability. Due to urbanization, the connection of humans with their natural environment considerably lessen and as a result, there is an increase in pollution, poor air quality and high heat index which the city of San Fernando, Pampanga already experience. This impacts the performance and health of athletes. Sports venues are encouraging to follow criteria of sustainable development such as designing of sports structures to be compatible with nature and to reduce damage to vulnerable areas.

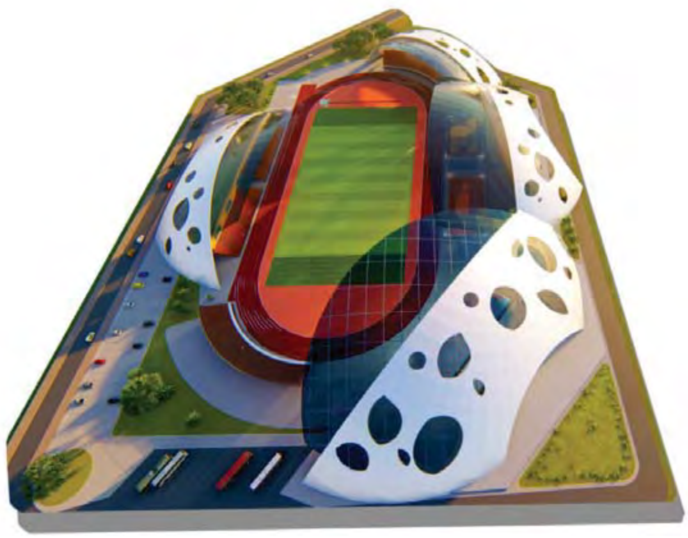

Figure 9. Biomorphic Sports Complex

One of the study's objectives is to determine a biological model and to integrate it as a biomorphic form and character to the proposed project. Results of the study are from primary data and secondary data gathering for needed information and data. An appropriate model organism was studied and configured through 3D software applications converted to a biomorphic arrangement and as the physical form of sports complex. (See Figure 1) This produced a biomorphic design solution with its corresponding character compatible with nature which is climate responsive, energy efficient and reduced damage to vulnerable areas. It satisfies environmental criteria of sports structure. Additionally, the study proves that biomorphic forms also follows functions allowing a fluid architectural space, variability and flexibility of design plans.

Keywords: Biomorphic, Culture, Nature, Sports Complex, Sustainability

01.106 - SUPERTIGHT: THE FORM & TEXTURE OF TIGHTNESS

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Abstract

The Super Tight refers to the small, intense, robust and hyper-condensed spaces that emerge as a by-product of extreme levels of urban density. Tightness arises as consequence of density, but tightness itself is not density. Tightness is a series of social, economic and cultural practices that have developed in cities as a response to the rapid growth and consolidation of cities.

These ideas have been explored through a site specific architectural installation and curated exhibition that drew on contributions from practitioners throughout Asia to explore the role of design in negotiating and expressing density in urban environments. The proposed paper will expand upon the content of this exhibition, and will critically explore how architectural form, material and organisation might be considered ‘tight,’ or trigger perceptions of tightness in the experience of the city. How do we describe the physical properties of tightness? Does tightness have a form? Does the geometry, surface texture or detail of urban space affect the qualitative sense of its density? Such questions are crucial to understanding tightness as a design question, rather than as simply a by-product of density.

While tightness can be understood austere lack of generosity- we will argue though that in tight urban environment its form and surface texture appearance has been enriched through operation for subtle adjustment and addition. These adjustments bring precision according to use, and density as by-product, while transcending an original planed diagram. Such adjustments and richness of texture which not only make density inhabitable, but also desirable.

Keywords

TIGHTNESS, DENSITY, EXHIBITION, ARCHITECTURE, URBANISM.

Introduction

This paper is about the term Tightness as it relates to the form and appearance of buildings, cities and the built environment. This concept was introduced through a curated exhibition and installation exhibited in Melbourne in 2019, which tested these ideas through full scale prototyping, 1:1 drawing and large scale cinematic projection.

Figure 10. Super Tight Exhibition RMIT Design Hub Gallery 2019. Photo by Tobias Titz.

The exhibition set out to establish an alternative value proposition for urban density, independent of the circumstance of its creation, and to explore how design and creative practice is both influenced by and influences the shape of dense urban environments.

The Super Tight refers to small, intense, robust and hyper-condensed spaces that emerge as by-products of extreme urban density. Tightness is often a by-product of extreme urban and other settlement density; however, the two conditions remain correlative rather than causally related. Dense urban environments support the creation of tightness, but not all dense cities are tight. Density is often understood as a problem of planning to be negotiated or managed away; tightness however, can be considered qualitatively. It sits apart from the pressing pragmatics of accommodating populations and begins to suggest alternative measures by which we can read and understand the by-products of intense human occupation.

This essay will attempt to introduce alternative ways of understanding the spatial consequences of density, that begin to set aside issues of human occupation and attempt to describe the formal properties of tightness independent of the conditions of its creation. It will reflect on the architectural installations built for the 2019 Super Tight show in Melbourne, as well as architectural and cinematic works contributed as a part of the exhibition. It will critically explore how architectural form, material and organisation might be considered 'tight,' or trigger perceptions of tightness in the experience of the city. In particular, it will focus on developing a language for describing the physical and formal properties of tightness.

While tightness is often associated with austerity or a lack of generosity, we will suggest an alternative definition of the concept which suggests that tightness might offer strategies for generating opportunity and affordance in constrained conditions, and urban generosity through operations of adjustment and addition.

The Exhibition

The Super Tight exhibition was held at the RMIT University Design Hub gallery from July to September 2019.

The exhibition was comprised of a collection of distinct but inter-connected physical exhibits and installations that visitors were able to move through and interact with directly in order demonstrate the qualities and conditions of tightness that the exhibition sought to unpack. A number of these installations were the setting of a series of informal debates and discussions, in which contributors and other guests were invited into the space of the exhibition to unpack and expand on the concept of the 'super tight' and the broader context of urbanism in which it is situated.

While many of the key ideas we have taken away from the project were introduced or cultivated in these forums, including a number discussed below, the focus of this paper will be on the physical and formal attributes of the exhibition, contributed works and the immediate material understanding of tightness this provides.

The physical exhibition can be broken into three categories of spatial exploration:

Drawing. For the exhibition, Taishin Shiozaki Laboratory (Tokyo Institute of Technology) produced a series of five large format illustrations. They were drawn in a semi realistic manga (Japanese comic book) style and were accompanied by video and still photography. Each scene explored a different aspect of 'familiar' or everyday density in the daily experience of living in Tokyo. The series attempted to explore not only the spatial qualities of density, but to render visible the underlying social structures that permit it, and in some cases, accelerate it. The series was drawn and exhibited at a 1:1 scale, encompassing intricate texture and detail.

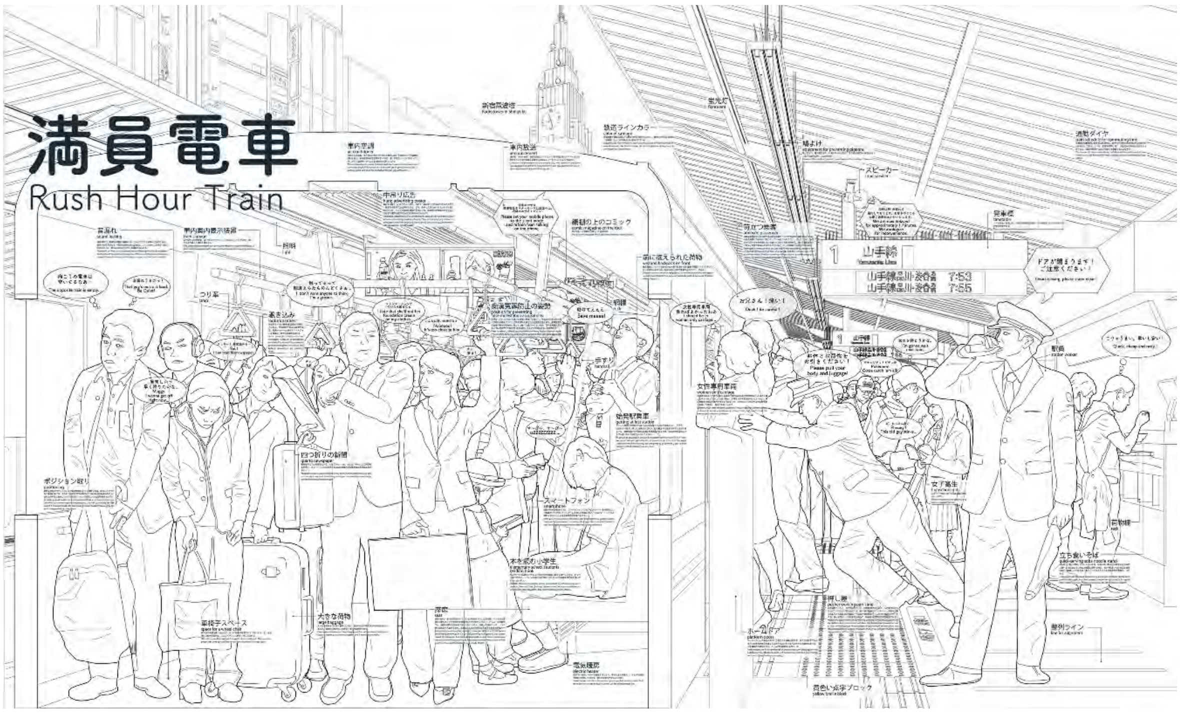

Figure 2. Rush Hour Train (2019). Shiozaki Laboratory (Tokyo Tech).

Projection. Most of the works contributed to the exhibition took the form of projected images, both moving and still. This included images, films and drawings of architectural works, photographic / cinematic documentation of tight urban conditions, documentary style film exploring particular projects and locations, and original artworks speculating on urban conditions in different Asian cities. These works were again projected at a large scale. The exhibition included a series of screens of different sizes and orientation showing the works rotating through a loop, the largest of which was 8m x 16m. While the content of the projects differed from intricate studies of material detail, through to vast drone shots of cityscapes, much of the work appeared close to its original scale.

Figure 3. Super Tight Cinema (2019). Photo by Vicky Jones.

Physical Installations. The major physical installations took the form of two architectural works installed at full scale in the main gallery. These were original designs that were extrapolated from existing conditions observed in actual places. The first of these was modelled on the Pasteur Hem, located in District One of Ho Chi Minh City, Vietnam. The second was loosely based on a very small bar located in Shibuya's Nonbei Yokocho. In both instances, the original was modelled from photos and personal recollections, and then adapted through iterative versioning to become original design works in themselves. These installations were occupied by visitors to the exhibition and became the venue for events held during the duration of the exhibition.

Figure 4. The Tight Bar (2019). Photo by Vicky Jones.

The ambition of these installations was to explore the qualities and characteristics of the super tight directly through the medium of architectural and urban design – being spatial and material organisation and construction.

The Role of Form

A number of key observations and lessons can be drawn from the design and staging of the exhibition, along with the experience of moving through and occupying the spaces that were created for and within it.

The exhibition was about cities, and the role that design and creative practice play in their formation and operation. When we think about urbanism there is tendency to talk in generalities or abstraction as a means of distilling vast and heterogenous situations into comprehensible chunks or short hand ideas. This is not an unreasonable response as often the sheer scale and complexity of cities is overwhelming – particularly for a public audience.

However, in order to reflect upon the role of designers operating in dense urban environments and to speculate on the material and spatial qualities of the super tight conditions that emerge as a result it was essential to develop a means of testing ideas that did not depart from the real and immediate. It was essential that these ideas were tested in the medium of cities.

This was achieved through a process we describe loosely as versioning or modelling. In this context, this describes a procedure in which actual spaces within a city form the starting point or the basis of a formal analogue that seeks to distil the key spatial and organisation qualities of the original, while rendering the lessons from this condition transferrable. The ambition of these operations is to set aside any nostalgia or sentimentality associated with the highly particular and unique circumstances of urban environments, and to likewise side step issues of representation and the copy. Instead we sought to focus in on the measurable formal and organisational properties of these spaces. This included the proportion, scale, composition and articulation as they relate to known objects, in particular the human body and furniture.

We sought to assess these proto-typical conditions in terms of their agency in shaping the experience of space, and their performative qualities in terms of human occupation.

Scale was a critical component to this understanding. While countless iterations of the exhibition installations were produced through the design of the project, using the standard means of architectural design production (scaled drawings, 3D visualisation, scaled physical models), the completion and occupation of the exhibition itself revealed the importance of the 1:1 in assessing the characteristics of the super tight as a formal condition.

Figure 5. Bar Talk - discussions on density in the Tight Bar (2019). Photo by Vicky Jones.

In particular, it revealed a series of inherent or unconscious biases that we as designers carried with us when assessing designs. What the full-scale designs revealed was that what often appeared unreasonably small on paper, was surprisingly functional and practical when built. The parts of the installations where space was pinched, compressed or squeezed became the areas to which visitors gravitated, forming bottle necks and moments of negotiation and engagement amongst individuals. The capacity for these spaces to accommodate people was far greater than we had anticipated during design. In many cases, it was only social mores and behavioural expectations that limited their capacity.

As with everything there is a limit to what a space can accommodate, however this project demonstrates that a tight form might be described as not so much as one that is simply small, but one in which its organisation and scale is much more precisely aligned to the performative potential of its use.

Loose-fit Tightness

While the concept of super tight has broadened to take in a large number of conditions, perhaps its most obvious manifestation is in the small footprint buildings and micro-dwellings of (amongst others) cities such as Tokyo, Hong Kong, Ho Chi Minh City and Seoul. The exhibition takes many of its formal queues from these kinds of spaces, most notably the 'Hems' of Ho Chi Minh city and the tiny bars of Tokyo.

The work of co-curator Yoshiharu Tsukamoto's practice Atelier Bow-wow provides a primer for understanding and identifying the qualities of the super tight. Over a period of 30 years, Atelier Bow-wow has worked within what they describe as the fourth generation of suburban housing in Tokyo. As the city incrementally subdivides from generation to generation, the average plot size has become exponentially smaller, while at the same time the vast sprawl of the city has driven many younger professionals to accept and actively seek smaller housing closer to Tokyo's urban centres. As a result, the practice has produced a large number of houses that are constructed on tiny footprints, constrained circumstances and for which design operates out of necessity in order to navigate these challenges. [1]

Figure 6. House Tower by Atelier Bow-Wow (2005). Copyright Atelier Bow-Wow.

House Tower (2006) was exhibited in the Super Tight exhibition as a large format sectional drawing at 1:2 scale. The project occupies a site of 42m2 in the inner district of Shinagawa in Tokyo, which accommodates a four-storey family home. The volume of the house is setback from the front and sides to address planning regulations, leaving a building footprint of 18m2. The most notable aspect of the design, and the reason it was selected for exhibition, is the result of these tight constraints has been the re-orientation of the planning arrangements of the house to operate vertically. As is the case with many of Atelier Bow-wow's dwellings, the habitable space of the house is organised sequentially around a stair-case and a series of offset split levels that each accommodate a domestic function within what is otherwise a single continuous vertical volume.

This project is self-evidently 'tight' in its navigation of physical and regulatory constraints, but in its resolution it produces an alternative understanding of tight. When purely viewed in plan, the dwelling is tiny, but the section feels vast and volumous. For example, the 'study' room occupies little more than borrowed corridor space, but if one were to re-orient the section 90 degrees the implied 'footprint' of these spaces are very large. This space is usefully engaged in the storage of books, but also as a double height volume that opens onto the bedroom platform above. The effect of this is a sense of spatial generosity that transcends traditional understandings and measures of comfort in dwellings. The paradox here is that the openness and generosity created within an extremely small space requires a degree of organisational looseness. There is very limited functional zoning within the house, other than areas delineated by the stepped platforms. Spatial designations are loose; space is barely partitioned and configured in such a way that it is possible to establish a variety of household living configurations. The loosely overlapping functions and behaviours of a single space becomes a strategy for affording greater opportunity within tighter means. As space constrains and dwindles, the task of the tight architect is to fold together temporal layers of behaviour and find a languid looseness within the tight crush.

The No Edit City

The Hem House (2015) by Sanuki Daisuke Architects, which exhibited through a still photograph and drone video series, has a similar vertical orientation to the House Tower. The project is located at the intersection between two extremely narrow 'hems' (laneways) in Ho Chi Minh city. The functions of the house are similarly stacked by level, however the dimensional constraints of this project are far less extreme, allowing for a more familiar sequence and relationship between functional spaces and circulation. Unlike House Tower, which is surrounded by the 2-3 storey detached that is typical of Tokyo, the Hem House is embedded within an urban context that is made of up vertical 'Tube' housing, ubiquitous in Ho Chi Minh City, which is tightly laminated and attached on to one another. Many of the surrounding buildings are significantly taller, which has the effect of locking the house within a kind of interior condition.

Figure 7. NGA House by Sanuki Daisuke Architects (2018). Photo by SDA.

In this project tightness is defined less by the smallness of spaces, as the manner in which the project sits within the city. The house abuts another on two sides, and the other two are within touching distance of neighbouring properties. The house is literally and figuratively laminated into its surroundings, an idea best demonstrated through the illustrative sectional drawings produced to explain the project. The two exterior walls are programmed heavily with cabinetry, air conditioners, bathrooms, circulation and other systems that support that operation of the house, punctuated with windows opening onto the exterior. This interior condition is reminiscent of and clearly learns from the typical façade conditions of Vietnamese cities (and many other cities) in which the exterior façade of buildings becomes little more than a platform for the accretion of services, equipment, ad hoc addition etc. Tightness is less a measure scale, and more an intensity of visual, formal or textural inhabitation - a condition of saturation that is rendered remarkable in this case through its interiority in this project.

This concept of saturation is something that is very present at the urban scale of Super Tight cities. The condition is generated through urban environments and their architecture adapting through processes of continual addition and accretion. Rather than absorbing change into a master planned regime, every alteration is a form of addition that adds an order, texture or pattern. Don’t edit (as in correct or remove), add another layer and keep moving. The delight of immediacy and expediency in this approach mirrors the daily life in mega-cities, both admired and derided.

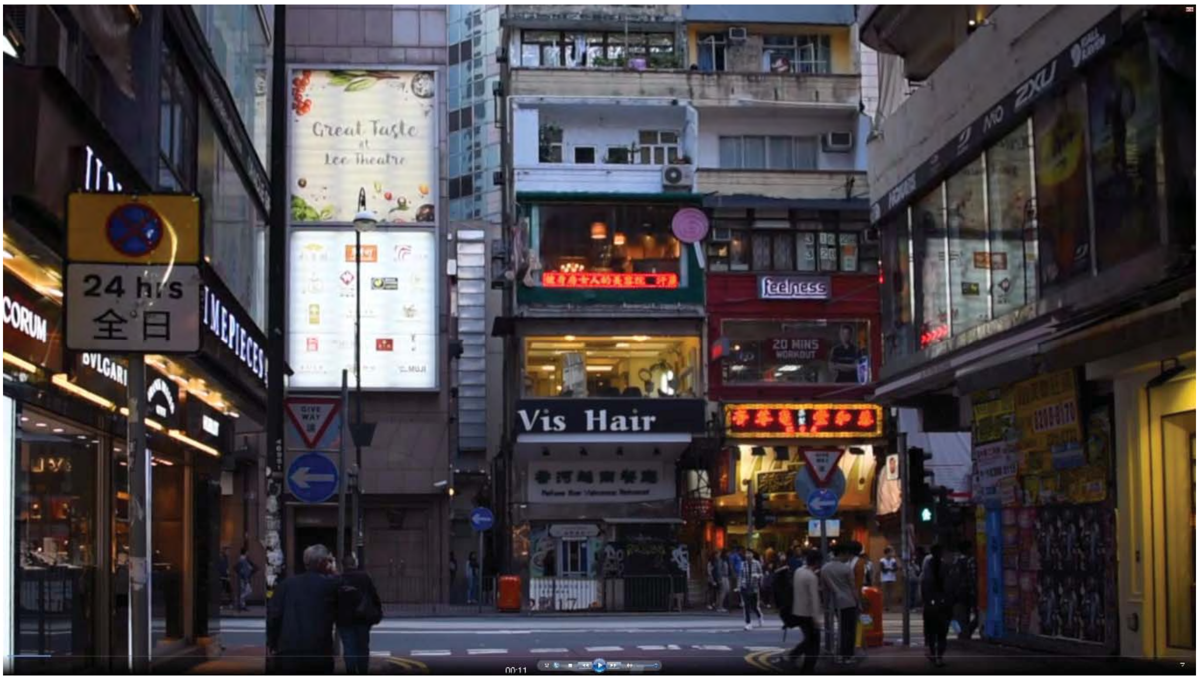

Figure 8. Still Frame from ‘Middleman’ by New Office Works (2017).

Hong Kong, as observed by the architectural practice New Office Works (Paul Tse & Evelyn Ting) is an artefact of the historical, social and economic forces that have shaped its growth. They describe the city through the concept of the ‘Middleman,’ in an eponymously titled film series which explores various elements of the city’s material culture. The mercantile history of Hong Kong as a gateway port in which different economic and cultural forces played out has left a rich and intricate trace in the fabric of the city. These creative documentary works suggest that a tight urban environment is one where the visual and formal appearance of a city has not been subjected to constraint or removal, but rather is one in which the operations of the city have been expressed directly.

What is left is an assemblage that is surplus to Leon Battista Alberti’s 15th century description of beauty. Alberti described beauty as being defined as “a harmony of all the parts…fitted together with such proportion and connection, that nothing could be added, diminished or altered, but for the worse.” [2] In contrast the tight city can be added to, altered, or have parts taken away with very little impact on the overall legibility. The super tight city is a formal arrangement that has achieved a kind of generosity; that privileges multiple viewpoints and spatial readings over a single vision.

Reflections on the works exhibited in the exhibition suggest a formal language of density that has transcended any original individual or social expectation or functional requirements, and that has acquired its own independent and autonomous cultural and spatial value.

Speculations on an Autonomous Tightness

The most obvious understanding of urban tightness, the forms and material organisational structure that underpin it is that it is somehow an artefact of the cultural rituals, social practices, economic and political circumstances of a particular point or trajectory in time. Undoubtedly this is true, and much of the work of, amongst others, Yoshiharu Tsukamoto points to the emergence of micro urbanism and other 'Super Tight' phenomena as being the products of history. However, as Tsukamoto has also identified, the shape and direction of our cities is not a foregone conclusion and it is essential that we are able to critically engage with and measure the qualities of our cities in order to decide on an appropriate direction for their future course.

"While showing optimal possibility of living in a tiny space, at the same time we have to talk about the epic story of 20th century of Tokyo, for example. Because if you know that, you can imagine another future... another way to reconstruct the city." [3]

To be able to argue for tightness in the future of cities, it is critical to be able detach the form and appearance of buildings and cities from the circumstances that produced them. We must begin to measure and understand tightness, and to define its formal and physical qualities beyond simple the footprint of human inhabitation.

If designers are to have agency in the generation of urban environments, it is essential that we develop an understanding of the formal consequences of density, and by extension to experiment through design speculation in this medium. Moreover, rather than assessing urban and architectural form through known functional templates we must begin to understand form as exhibiting particular formal qualities, a few of which have been described in this paper. These qualities can be understood independently of the circumstances from which they have emerged and are transferrable. In a world rapidly urbanising, the formal language of the super tight city might be a prototype for sustainable growth.

Acknowledgements

The organizer gratefully acknowledges the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2020 for efforts done for the success of this event.

This research has been supported by the RMIT University School of Architecture and Urban Design SRIC committee.

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01.107 - "DESIGNED FOR BETTER LEARNING" A NEW EDUCATIONAL PARADIGM IN GREEK PUBLIC SCHOOLS

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Abstract

The Designed for Better Learning (DfBL1.0) Program delivered a new educational paradigm in Greek public schools by transforming the built environment and the educational experience of 24 school communities, across all levels of education, in the City of Athens, Greece. It is an innovative Program that employs architecture, technology and pedagogy to upgrade underfunded schools in ways that enhance teaching, improve learning, generate pride and lead to community development. The Program provides the methodology and the tools to collaboratively re-design an educational environment in ways that creatively relate to better learning. Moreover, a municipal fabrication lab (Maker Space) equipped with 3d printers, laser and vinyl cutters as well as a CNC router was set up to support teachers and students in a series of learning-through-making activities. Since April 2016, the Program has been deployed in three phases. The first one tapped on the constructive nature of participatory design and worked closely with the school communities toward large-scale interventions in the school buildings guided by both functional and educational parameters. In addition to physically transforming the schools, the program employed the Educational Pla(y)ces methodology (Εκπαιδότοποι / e·kpe·tho·to·pe in Greek, a word combing the words 'child', 'play', 'place', 'education' and 'playground'), an interdisciplinary design-thinking/maker-learning approach that enriches the educational process by engaging both teachers and students to design and build learning microcosms and prototypical educational equipment and use them in their schools. During its third phase, the Program deployed STEM fairs for the students as well as training workshops for the teachers on the use of the Maker Space equipment and power tools. The DfBL1.0 Program has achieved a confirmed qualitative upgrade of the school environment and an empowered, positive disposition toward the educational process in the participating schools. On a personal level, this marks a development from ‘listening’ to ‘making’, which scales up on the community level from a culture of ‘observation’ to a culture of ‘active participation’. Having a learning-centered core, the program renders a proactive community that takes on itself the opportunity to change through a cost effective yet high--impact participatory process.

Keywords

Design thinking, maker learning, participatory design, educational pla(y)ces, qualitative upgrade of school environments.

1 INTRODUCTION

The Designed for Better Learning (DfBL1.0) Program was launched in 2016 as a sustainable solution for the major renovation of educational spaces and learning practices within the social and economic constraints of Greece in crisis. It dynamically concentrated to address several interrelated problems that are known to have a negative effect upon the educational outcomes in Greek public schools:

- Out-dated infrastructure and poor building conditions
- Absence of multi-sensory stimuli and equipment for educational, social and play activities in the yard
- Low level of student engagement in the learning process
- Lack of motivation combined with a limited variety of options in training the teachers
- Low municipal capacity for maintenance
- Lack of state planning for modernizing school facilities
- Fragmentary state pilot-programs for enriching the standard educational process
- Disassociation of school facilities with their neighbouring communities

Since 2016, the DfBL1.0 Program has successfully delivered a new educational paradigm to reinvigorate 24 public schools, in Athens, Greece, across all levels of education (from nursery schools to high-schools), which represent 5% of the total number of schools in the seven districts of the municipality. The Program helped transform the physical learning environment and educational experience of more than 5000 students while improving the everyday working reality of 600 educators, with an estimated influence on 15,000 members of the wider school communities. It is a ground-breaking initiative to stimulate learning, teaching and community engagement by bringing into education best practices from the design field and the maker movement. Through a multi-faceted implementation, DfBL1.0 advanced in the collaborative improvement of the learning environment and the enrichment of the educational process while investing at the same time in supporting teacher empowerment and developing student agency.

The participating schools were selected based on the willingness of the administration and the teachers' association to join the program, the building's condition in terms of repair requirements and maintenance, as well as the equal dispersion of the school sites within the City of Athens (CoA). Alongside the application of the Program in the 24 schools, of note is the creation of a state-of-the-art Maker Space, the first municipal laboratory of its kind in Greece, equipped with innovative design and manufacturing technologies to support DfBL's project-based educational activities.

The DfBL1.0 Program was designed for the City of Athens (CoA) by the Transformable Intelligent Environments Laboratory (TUC TIE Lab) of the School of Architecture at the Technical University of Crete (TUC) and the Athens Partnership (AP), an independent non-profit organization working to intersect between city government and private sector partners. The research plan and methodology were approved by the Ministry of Education and Religious Affairs and the Institute of Educational Policy. It's pilot phase was funded by the Coca Cola 3E

Company in Greece. The application of the Program in full in the 24 schools and the creation of the Maker Space facilities were exclusively funded by the Stavros Niarchos Foundation and was implemented by a 38-member TUC TIE Lab team in collaboration with AP and the CoA Childhood, Education and Lifelong Learning Division with the support of the Building Infrastructure Division.

2 Goals and Objectives

Basic classroom design in Greece has not changed since 1894 [1]. The educational process is rigid within the blackboard-oriented setting and unsupportive to student engagement and participation. The majority of the educators remain attached to the traditional teaching stereotypes, with their lack of technological and spatial literacy failing to associate the quality of the school environment and the diversity in the educational process with the quality of learning. Children and teachers are hampered by this rigidity and stagnation. Students, moreover, are forced to accept an environment and a school experience of emotional detachment and mostly theoretical learning, with no hands-on involvement and without the ability to shape one’s surroundings and educational experience.

The overarching goal of the DfBL1.0 Program is to surpass the prevailing stereotypes of public education in Greece and establish beneficial conditions for teachers and students of all ages to enjoy a positive school environment with rich learning experiences. Working at the intersection of three scientific fields -education, architecture and technology- the team pursued this goal following four basic guidelines:

i. Create a new educational experience through a participatory design-thinking/maker-learning methodology. Invest in activating both teachers and students by providing them with new tools and opportunities to purposefully shape learning microcosms inside the school.

ii. Prioritize architectural design and technical works aimed at safety, functionality and the enrichment of the school space with a variety of learning stimuli

iii. Train the teachers to develop design and technology skillsets.

iv. Help the stakeholders understand the value of transformative learning in the school communities and its role in creating a model educational environment for personal development and social empowerment.

The objectives of the program became obvious early in the process. On the one hand, it was imperative to change the prevailing "image" of the Greek public school (semantics), meaning the way it is perceived and defined by the school community and its neighbouring environment as a building as well as a symbol. Alongside, it was crucial to improve the "utilization" of the school environment (appropriation), by activating, both dynamically and inclusively, every possible area in it. In both cases, the key factor was to bring out the hidden, untapped pedagogical character of the school space and the unlimited imagination of the school community to help create a useful, yet appealing, learning place that fosters familiarisation, comfort, security and, above all, creativity.

3 Methodology and application

3.1 Laying the groundwork

Form an alliance of high-level stakeholders to clear bureaucratic obstacles and support the existing organization that bonds school communities.

One of the key challenges the program faced was the coordination between various actors. The challenge was met with a simultaneous top-down and bottom-up approach that facilitated various degrees of involvement for all partners and stakeholders.

The top-down approach in particular addressed the organizational multiplicity and challenges of the Program by facilitating coordination and alignment between the Ministry of Education and Religious Affairs, the City of Athens and the regional directorates of education. The bottom-up approach included the establishing of clear communication channels between the municipal departments responsible for school buildings and utilities, the school administrations and educators, as well as the parents who needed to understand the changes taking place at their child’s school.

Both approaches spanned across four different levels of decision making and operating (researchers, field-managers, project managers, and program directors along with high-level city officials), making it possible to directly pinpoint critical issues and regulate complications more efficiently within a shorter time frame. During this process, the Program helped identify the absence of communication protocols between public offices with overlapping service areas, it managed to set new precedents in the process of issuing building permits for technical works in school buildings, all while tracking the optimum handling procedures that would minimize the established bureaucracy. Moreover, it orchestrated frequent school community meetings to present updates, discuss arguments and decide further actions.

3.2 Introducing a maker education public hub

Create an open, high-tech space for collaborative, hands-on learning that helps users see themselves as inventors and experience what Nicola Tesla described as the greater thrill for the human heart: to see some creation of the brain unfolding to success.

The successful application of the Program required the creation of a supporting educational/life-long learning facility for the City of Athens, a state-of-the-art Maker Space. This is the first municipal laboratory of its kind in Greece, equipped with innovative design and manufacturing technologies (laser-cutters, 3d printers, a vinyl cutter and a CNC router), along with power and hand tools, to directly facilitate project-based learning, tinkering, and making. It plays an integral part in the sustainability of the DfBL1.0 as it provides a venue for developing self-confidence along with student agency and teacher empowerment. Moreover, it provides the potential to enrich the experience of the conventional sources with STEM oriented activities.

The Maker Space operates in the following directions:

- Engage pupils in the DIY culture, empowering them to affect their environment directly and learn to take “matters into their own hands”, beginning from their school
- Train educators to novel, interdisciplinary teaching approaches inside and outside of the classroom

- Equip young professionals with skills for the contemporary creative practices enhancing their abilities and augmenting the quality of their services.

3.3 Changing the educational experience from the inside

Researchers, teachers and students discuss needs and wishes, and together design a common vision of a functional, experience-rich school environment.

The bottom-up application of the Program additionally employed the TUC TIE Lab's Educational Pla(y)ces[1] methodology (the name is *Εκπαιδότοποι* / e·kpe·tho·to·pe in Greek, a word combing 'child', 'play', 'place', 'education' and 'playground'). It is a participatory, design-thinking/maker-learning approach that brings into education best practices from architecture and the maker movement to create a platform for increased learning and engagement based on Seymour Papert's "constructionism" theory [2]. Architects-researchers, together with teachers and students, collaborate to enrich the educational process by designing and building original educational equipment, small-to-medium scale, and use it in their schools: objects, pieces of furniture, installations and spatial arrangements [3-4]. Their common thread, other than their trying an alternative approach to enrich learning, is that they produce interesting micro-spaces within the school that enhance its educational dimension by facilitating playful and meaningful interactions both inside and outside the classroom.

This participatory design process comes along with challenges of personal nature [5-9]. Vivid among those challenges are the established preconceptions of public school space in Greece [1] along with the fact that most of the people involved (teachers, students, principals, school counsellors, parents, and janitors) feel reluctant to make decisions and take responsibilities for their actions as soon as they realise the gravity of their voice. Further in this process, the research team, mainly compiled by architects, has to deal with a communication gap and the lack of common spatial representations between them and the school community.

The Educational Pla(y)ces methodology successfully addresses those issues by drawing on Edward Soja's work to create a "third place" between 'researching' and 'participating.' The transition in this 'third place' [10] helps both sides get into a mode of "critical spatial awareness" and trust-building that is necessary in order to distil the parameters guiding the creation of effective and appealing educational environments. When this approach runs with the teachers in particular, it conveys valuable lessons for the architects as well. Inside their common 'third place' both sides are voluntarily stripped off their professional notions and biases. Rather, they focus on creating a common vocabulary and gradually channel their dialogues in playful design scenarios conductive to 'better learning.' Through their combined insights and knowledge, they are able to immerse into a fruitful design-thinking process and

[1] The Educational Pla(y)ces methodology It was originally developed by Marianthi Liapi in 2004 during her graduate studies at MIT, under the scientific guidance and vigorous support from developmental psychologist Edith Ackermann, as a research approach in the ways in which design can help children create a better understanding of the world around them. From then on, the methodology has been enriched with the invaluable assistance of Kostis Oungrinis, Associate Professor at the TUC School of Architecture and TUC TIE Lab director, as well as from the fieldwork of brilliant TUC TIE Lab researchers. It has been tested extensively in public schools in Greece (Athens and Chania), with the DfBL1.0 Program facilitating its largest application so far. Every single element in the methodology is permeated by Csikszentmihalyi's take on creativity [11]: "It is easier to enhance creativity by changing conditions in the environment than by trying to make people think more creatively."

translate their concerns, needs, ideas and wishes into data that fuels the architectural products of the Program.

The basic components of the Educational Pla(y)ces methodology are:

- the participatory design process
- the educational planning parameters
- the architectural design principles and techniques
- the Maker Space laboratory
- the analog and digital fabrication tools
- the fabrication materials
- the evaluation protocols (usability and functionality testing)
- the sustainability of the end-product as an alternative learning medium (Fig. 1).

Figure 11. Examples of Educational Pla(y)ces projects

Within the extends of the Educational Pla(y)ces methodology, the DfBL1.0 team performed three types of fieldwork inside each school:

- *Fieldwork A*: The research team works extensively inside a school complex in order to observe, record and analyse the existing school conditions (space and human activities within).

- *Fieldwork B*: The team works collaboratively with the administration, the teaching and supporting staff and the students through walkthroughs, interviews, questionnaires and drawings in order to record and analyse the spatial imprint of the educational space. The findings from *Fieldwork A* and *Fieldwork B* are grouped in the following three categories:

1. Educational goals
2. Positive and negative elements in the existing school condition

3. Spaces with hidden dynamics

- *Fieldwork C*: The researchers work collaboratively with the school community toward project-based learning [12] and maker-training workshops for empowerment and capacity building.

Furthermore, an internal evaluation team works towards gathering original data through questionnaires, interviews and on-site observations in order to develop an informed image of the schools before and after the application of the DfBL.

The complexity in the application of the aforementioned components together with the singular personalities of the participants make every Educational Pla(y)ces project unique both as a process and as a final product. A similar uniqueness is evident in the bonding created between the participants themselves, as well as between them and the final product

3.4 Building a strong footprint

De-institutionalise each school with an appealing interior renovation, a playful yard for all age groups as well as with identity bearing elements to bring out its unique pedagogical character

The transition in Soja's 'third place' also guided the qualitative, yet cost-effective, upgrade of the school buildings and yards through large-scale construction works. The interventions addressed both the functional and aesthetic transformation of the schools' facilities as well as issues of infrastructure maintenance, repairs and safe operations as instructed by the CoA Directorate of School Buildings. The technical nature of the interventions was largely enhanced by the spatialization of the findings that emerged during the participatory analysis in order to create an environment that fosters "genuine exploration, reflection, expression, and negotiation, while at the same time providing help and support, when needed," [3]. The leading design guidelines supporting the qualitative upgrade of the school space can be summarized as following:

i. rationalise the school interior and exterior organization-plan based on combined functional and educational parameters,

ii. fix operational building problems (e.g. insulation against moisture and water, better lighting and acoustics, anti-vibration flooring in the athletic courts, and so on),

iii. de-institutionalise the average mental image of the building with aesthetically enjoyable and context-appropriate colors, patterns and materials, while targeting, at the same time, an optical reduction in scale (Fig. 2),

iv. focus on a learning-centered and flexible classroom design,

v. take advantage of the interior common spaces with small-scale structures that bear an educational function, like reading spaces and student work exhibition areas, without obstructing the traffic flows,

vi. upgrade the quality of the restrooms,

vii. break-down the school yards in designated activity zones for all ages with spatial reference points (equipment and/or diverse materials)

viii. prioritize a balanced combination of safety and playfulness

ix. invest in the creation of interesting outdoor spaces for socialization, outdoor learning and teaching activities, as well as for community events,

x. provide each school with identity bearing elements on the urban scale (e.g. school entrance, facade and name-sign), and

xi. instil an overall sense of identity in order to preserve the poetic quality of "my school" beyond functionality.

As a result, the architectural proposals guiding the interventions focused on spatial and educational flexibility while tapping on the inherent quality of the learning environment and its equipment to enrich all learning activities. Moreover, the aforementioned guidelines, along with a list of qualitative indicators, were shared with the collaborating offices from the CoA Directorate of School Buildings, as reference information for them to consult prior to engaging with school refurbishment projects in the future.

Figure 2. Examples of the transformative effect of the DfBL1.0 Program in two Elementary Schools in Athens, Greece.

3.5 Boosting self-confidence with 21st century skills

Train the teachers, emphasize the essential role of applied digital technologies in learning and create more opportunities for STEM oriented interaction and experimentation.

Acknowledging the founding role of the Maker Space as an educational laboratory, the Program invested in maker-learning seminars and workshops, as well as in STEM educational visits at the lab's facilities. The main objective was to emphasize the essential role of applied digital technologies in learning and at the same time create opportunities for active participation, interaction and experimentation. The DfBL1.0 teachers, to begin with, were guided into Maker Training Workshops (Fig. 3). Through a similar to the Educational Pla(y)ces process, the teachers participated voluntarily in the courses, off school hours, following a university-level program that helped them (re)surface competencies like creativity, problem-solving, research-ability and digital literacy.

Figure 3. Maker training seminar for the teachers participating in the DfBL1.0 Program held at the Athens Municipal Maker Space.

The students, on the other hand, visited the Maker Space facility with their schools and participated in STEM-oriented activities, tailored to the specific learning needs of each age group involved (Fig. 4). The objective was to introduce children with modern technological applications that go beyond the computer screen: robots, haptic interfaces, interactive projections, virtual reality headsets, electronic invention tools and toys to name but a few. They also had the chance to go through a guided tour of the Maker Space laboratory and get acquainted with the do-it-yourself /learn-together maker philosophy. Lastly, the parents had the opportunity to explore the playful side of technology through Maker Space Open Day events for all.

Figure 4. STEM-oriented activities for students of all ages at the Athens Municipal Maker Space.

4 Results - A new educational experience of relatedness

To date, the DfBL1.0 Program has achieved a confirmed qualitative upgrade of the school environment and a positive disposition toward the educational process in all participating schools. The teachers report an increased engagement of the students in the learning activities as well as an unprecedented initiative to create new projects. Moreover, both students and teachers have embraced the collaborative processes, feeling empowered by the opportunity to change by themselves their everyday learning environment through a creative process that also involves the technological support of a state-of-the-art Maker Space.

The Program's progress was evaluated by monitoring data from teacher feedback, student performance, as well as their overall social behaviour and active engagement in both school and community activities. The data collection took place three times in the duration of the whole program. The overall progress was evaluated by comparing pre-intervention conditions to conditions as they were developed during the DfBL program.

More specifically, the evaluation process recorded a high degree of satisfaction from the results of the technical interventions, a stronger relationship with the school and, through time, a more positive disposition towards it. At the same time, the Educational Pla(y)ces projects, apart from the direct benefits they brought in the everyday learning activities, they helped increase participation in class and collaboration between the students. The change is clearly depicted as students leave from school feeling more “cheerful” and “happy” by 77%, while their disposition to their school changed from “obligation” to “joy and creativity” by 34%. Regarding the teacher’s community, the evaluation recorded a 66% increase in their associating work with a more positive disposition, while many of them (43%) enriched their pedagogical approaches, providing signs of a more general transformative change in education. The school community has also been activated. Many parents reported that their children are happier to attend school which, in turn, led to greater parent satisfaction. Parent associations at DfBL1.0 schools gradually became very supportive of the program and in many cases, asked for more engagement and volunteered to provide resources in order to expand the activities taking place.

Regarding the Maker Space operations, more than 95% of the participants stated that they "learned something new" and that they are definitely willing to come back for more high-tech experiences. Even though the Maker Space was created to facilitate the DfBL1.0 processes, it eventually opened up its operations as an educational facility that organises and supports a large variety of learning programs for all age groups (STEM events for schools and life-long learning seminars) while providing free maker-oriented services for Athenian citizens. At the same time, it strengths the role of the municipality in the empowerment and capacity building of its public servants as well as of its citizens.

5 Conclusions - Going forward, reshaping space and relationships

DfBL1.0 created and applied a framework and a methodology to radically change the way schools look and operate, in an efficient and low-cost way. In this interdisciplinary approach, the Program managed to overcome numerous obstacles, gained support from the involved stakeholders and achieved its ambitious goals. Yet, the most important aspect of DfBL1.0 is the long-term benefits of associating education with a creative mindset that guides you to build learning props and not only facilitate a deeper learning process but moreover enhance the educational space with stimuli. "Learning by listening" at school is replaced with "learning by doing", with hands-on activities that introduce the "thinker-doer" mentality and gradually train students to seek after knowledge and solutions through a playful yet solid research-based approach. This type of a creative mindset has also affected the educators and helped them expand their pedagogical practice in class. Most importantly, through the program activities, they learned first-hand how to identify areas with hidden potential inside their schools and take advantage of them by redesigning them for an enhanced educational process. Moreover, some educators already act as catalysts for further development, operating as “ambassadors” to other teachers and multiplying the program’s impact.

The long-term goal of the program is to contribute to a societal paradigm shift where people are engaged in life-long learning activities for empowerment and capacity building. On a personal level, this marks a development from ‘listening’ to ‘making’, which scales up on the community level from a culture of ‘observation’ to a culture of ‘active participation’. Having a learning-centered core, the program renders a proactive community that takes on itself the opportunity to change through a cost-effective yet high-impact participatory process.

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01.108 - TOWARDS AN ARCHITECTURE FOR WELLBEING.

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Abstract

Architectural design can have profound implications on human health and planetary wellbeing. The built environment is currently one of the most important determinants of health and wellbeing. As human health comprises of *physical, mental* and *social* aspects, it is vital that the design of buildings addresses each of these aspects holistically with a framework for *planetary* health. The research explores how values and principles for architectural design are coproduced in order to facilitate wellbeing for all users. Many countries worldwide are already pursuing 'Healthy City' policies to align public health aspirations with built environment strategies and this research pursues this specifically for the architecture profession. The research uses an interdisciplinary *design-research* methodology to examine the fields of health and architecture in order to develop a framework for designing, making and shaping architectural environments in order to improve and promote human and planetary wellbeing. This emerging framework sets out the theoretical principles of healthier architectural design strategies through analysis of empirical and evidence-based research. The paper then uses this framework to elaborate a roadmap towards an architecture of wellbeing.

Keywords

Wellbeing, architecture, sustainability, ecology, health.

1 OVERVIEW

This article explores the emerging role that the design of the built environment plays in determining health outcomes – and the impact that the architecture profession can play in improving health and wellbeing. The relationship between the design of the built environment and health is a complex and interconnected puzzle involving human behaviour, culture, technology, marketing, spatial organisation, legislation, ethics, beliefs, economics and ecology. Emerging data reveals how contemporary lifestyles and behaviours are leading to profound changes to both human health and the health of the planet; with cities and urban areas contributing significantly towards climate change as well as human health impacts. In response, the United Nations' Sustainable Development Goals are an attempt to try to curb many of the drivers of climate change and simultaneously improve the wellbeing of human populations. There are changes afoot to radically adapt the built environment to be part of the solution to climate change, and there has been a paradigm shift in the architectural profession to address this. Many of the drivers of climate change are correlated to the rise in human ill-health. Contemporary built environments are considered to be 'diseasogenic' in that they are causing diseases and illnesses in humans. Aspects of the built environment nudge, influence and structure societal and individual behaviour leading to ill-health, including cardiovascular disease, cancer, diabetes and lung disease [1, 2]. These non-communicable (aka 'lifestyle') diseases now cause more mortalities globally than communicable diseases [1]. It is estimated that the majority of all illnesses are related to lifestyle [3] with millions dying needlessly each year [1]. The economic burden of these diseases is predicted to be unsustainable, "healthcare costs are rising so fast in advanced economies that they will become unaffordable by mid-century" [4]. A concerted effort is required to address both planetary health and human health simultaneously; accordingly, the United Nation's Sustainable Development Goals [5] replaced their Millennium Development Goals [6] with a greater focus on human health: "health has a central place as a major contributor to and beneficiary of sustainable development policies" [7].

The most widely used definition of health comes from the WHO Charter [8]: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". This definition has proven to be very versatile and durable since it was written over 70 years ago; however, as a result of subsequent awareness and knowledge of climate change, this definition is now must be understood within the context of 'planetary health' as it is not possible to have a healthy population on a sick planet. The implications of this paradigm shift are radical and profound for many industries, institutions, society, agencies - particularly the architecture profession.

2 Sick cities

The position of the built environment as having a negative influence on health is particularly of concern as the world is rapidly urbanising with over half of the global population now living in cities [9]. The global urban population will reach an additional 2.5 billion people by 2050 [9]. As societies urbanize they also tend to spend more time inside buildings [10, 11, 12]. The largest migration from outdoors to indoors in human history is currently underway and there are many adverse health implications of lives spent mostly inside buildings. Firstly, 'indoorisation' can impact adversely on levels of sociability with populations spending less time together and less time amidst their wider community. This isolation is associated with loneliness, depression and poorer mental health [13, 14, 15]. Secondly, time spent indoors often has deleterious associations for health, particularly for poorer and disadvantaged communities [16, 17, 18]. Indoor air pollutants and contaminants are significant risks for respiratory disease, allergy and asthma symptoms [19]. Furthermore, indoor lifestyles are often corelated with sedentary lifestyles which indirectly impact other health issues such as obesity, cancer and diabetes [20, 21]. Poorly designed buildings can impact negatively on mental health, for example: overcrowding, inadequate levels of daylight, poor housing standards, and insufficient agency over the built environment [22, 23]. Conversely, time spent outdoors can lead to improved outcomes for health and wellbeing [24]; with green and blue natural spaces associated positively for physical, mental and social health [25, 26]. The emergence of a new 'indoor society' places even greater significance on the architectural profession which play a vital role in how all these future homes, workplaces, shops and leisure spaces might better impact on human and planetary health.

3 Post-Anthropogenic, hyper-wild, ecological systems

We are currently living in the Anthropocene – the geological epoch characterised by human activity on the planet. One of the consequences of the Anthropocene is that we must address the challenge of climate change. Whilst we can and should learn from ancient traditions of building and of living, this may not provide the solutions for a much-changed climate. A repercussion of dramatic shifts in climate is that it is not enough to simply look at past ways of doing things, or attempting to recreate the past, as these will not necessarily withstand the altered environmental conditions. We know that with the current greenhouse gas emissions, the global climate will be changing considerably this century (even if all the actions promised by nations globally occur). The scale of the problem requires society to embrace new technologies, new modes of living, new economic models and new ways of being in the world in the coming century. The Anthropocene requires hitherto unprecedented solutions that will undoubtedly require natural and technological and digital and cultural rebalancing.

The defining characteristic of the Anthropocene is the prominence of *humans* ('anthropo-' means 'related to humankind') as the key agent determining the environment. This partitioning of humans as distinct to the ecology of the planet signifies the nub of the problem, the separation of humans and nature. This anthropo-ecological dissociation is argued to be the fundamental cause of how we have managed to harm the global climate so badly and how humans have developed such unhealthy lifestyles. There are a number of theories that attribute the failings in the current system, in part, to the divergence of humans from nature and instead call for a reunification. Deep ecologists reject the separation of human society from the natural world, and particularly the domination of the former over the latter [27]. Ecofeminist theory attributes the failure to live within our means ecologically partly as a consequence of the exploitation of nature in a patriarchal capitalist system [28]. A radical change is called for which requires a paradigm change in ethics, values, economics, culture, technology and our relationship with nature. Humans, their local habitats, homes, the wider environment, and planetary ecology need to be understood *relationally*, not separate from each other. A number of theorists have called for the blurring and redesign of the relationality of humans and nonhumans, particularly, more-than-human environments [29, 30, 31, 32]. The relationality of humans and nonhumans forming and performing redesigned and re-imagined identities raises questions how they might reconfigure the social. In many of the critiques outlined above, the scope of *nonhumans* is used in the broadest terms possible including animals, plants, built environments, technological entities and digital realms. This Anthropogenic entry point contextualizes the theoretical framework into a planetary perspective. What is key is the urgency to place a set of practices, limited here to that of architects and built environment disciplines, in relation to the interwoven network of human action, social relationships and natural contexts

In terms of built environments, the epistemological underpinning of much of this is aligned with '*ecological systems thinking*'. "Cities are complex systems, so urban health outcomes are dependent on many interactions" [33]. The call to a natural ecosystem brings into play the complexity of a dynamic, emergent and adaptive network immanent to the development and reproduction of a city. Ecological systems-thinking has become more prominent in the praxis and theoretical framework of urban planning and development. As a result of climate change, architecture has been contextualised in the inherently unpredictable climatic/weather systems and the interweaving of natural ecosystems [34]. As the future existence of human society is dependent upon the continued existence of natural ecosystems, this has embedded natural-ecological approaches in alternative urban development thinking. The ambition of the integration of ecological principles for sustainability and built form is expressed by Hough: “Our primary concern is how the city can be made environmentally and socially healthier” [35]. Both sustainability and health targets require continuous balancing of an evolving, dynamic interweaving of social, environmental, economic and spatial factors. Furthermore, as one cannot remove or separate human activity from natural processes, there is an acceptance that there must be intervention within this ecological system in order to achieve better health and more sustainable development.

Within this philosophical and theoretical framework for a new architecture of wellbeing; cities are to be ‘re-wilded’ with flora and fauna reintroduced into urban contexts [35]. Re-wilding means more wild plants and flowers (instead of e.g. tarmac); and herds of grazing animals to maintain these fields (instead of lawn-mowers, leaf-blowers and maintenance teams); and packs of wild predators such as wolves to control the grazing herd populations. There is a need to go further with hyper-wilding and a redesign of our relationship indoors with living and biological entities. As the challenge facing society is so great there will need to be a radical change to our buildings which will need to progress from being inert and static assemblages. For hyper-wilding (‘hyper’ means ‘over, more or beyond’) buildings themselves become living agents. This means not just using organic materials, such as straw, bamboo, timber or hemp as building blocks (although this is welcome); instead in the hyper-wild building the architecture itself would be formed of living bio-organisms. These living architectures could help to serve a myriad of services: regulating temperatures, filtering air pollutants, generating energy, providing drinkable water, sensing contaminants, absorbing greenhouse gases and range of other beneficial roles [36, 37]. Furthermore, the equality immanent to a rebalanced non/human relationality calls for a greater democratisation of design – not just humans (and certainly not just an elite minority of humans) but must expand to include and/or account for nonhumans in decision making processes [38]. For some thinkers, nonhumans have their own agency [39]; this calls into question the autonomy of users and their rights vis a vis participation in democracy, participatory design and codesign. How this might work in practice is contested and unresolved. However, a critical component of health and wellbeing is ‘agency’ and a degree of control over one’s existence must play a part in any future roadmap. The next section attempts to situates this theoretical and intellectual framework into the more prosaic and pragmatic issues of healthier built environments.

4 Health in all policies

The notion of health has, until recently, been restricted to hospitals, doctors, medical faculties, medicines and pharmacies. However, the traditional health/medical approach no longer works for complex lifestyle diseases. There is a revolution in attitudes to treating, promoting and preventing health; a revolution that requires a greatly expanded field of disciplines to address the complex inter-disciplinary drivers of ill-health and disease. A “unified front is needed to turn the tide on [Non-Communicable Diseases] NCDs” [40]. The World Health Organisation is urging a ‘health in all policies’ to ensure that a consideration of health is included in all policy-level decision making. This top-level ‘health in all policies’ shift is beginning to impact in many industries and professions that have hitherto not been associated as part of the ‘healthcare’ sector. Radical changes are planned to expand the healthcare workforce to include 'any individual who … has the opportunity or ability to positively impact health and wellbeing through their work' [41]. Arts, humanities and social science sectors are becoming integrated and aligned with the healthcare sector as a consequence of this revolution. In the context of the built environment for example, the urban planning sector is already in the process of 're-uniting planning and health' [42]. There are far-reaching implications of expanding the healthcare workforce beyond its traditional core to include these other disciplines. However, very little progress has been made within the architecture profession despite its important role in shaping the built environment. The 'health in all policies' strategy should ultimately result in a 'health in all designs' approach and healthifying architecture.

4.1 Health in all designs: Design methodologies

This section of this article explores the specific role that 'design' can play towards an architecture for wellbeing. Designers of buildings and cities can fundamentally change the environment in which society lives (in a manner that few others from the arts, humanities or social sciences are able). Designers can proactively determine the built environment in order to influence behaviour, relationships and lifestyles – as well as the broader ecological system in which we inhabit. What is meant by 'design' when intervening within an urban ecological system? At the broadest definition, "Everything belongs to design" [43]. Design in this context can be understood as an attempt to purposively alter a system to create a desired outcome [44]. "Design can be defined as the human nature to shape and make our environment in ways without precedent in nature, to serve our needs and give meaning to our lives" [45]. In this conceptualisation, design ranges "from the details of daily objects to cities, landscapes, nations, cultures, bodies, genes, and … nature itself" [46]. Design is now involved in almost all human activity at all scales; and there is a relationality across these scales that must be addressed by designers. Scientists attempting to halt climate change are, in effect, attempting to redesign the earth's atmosphere to one that remains habitable. Planetary health requires a new atmospheric composition, a designed ecology that is no longer 'natural' but 'man-made' (sic) and determined through human activity. At the scale of the city, design has been intimately involved with the processes of urbanisation and "indoorisation".

As most of the planet now live in urban areas, and spend most of their time indoors, there are profound implications of design decisions on society. As much architectural design is now shifting towards being situated within the broader agenda to modify social behaviour, improve health and preserve natural ecosystems, the aim of design is not merely to produce a (healthy and sustainable) building, but also to produce a (healthy and sustainable) society. There are now entirely new disciplines emerging that aim to use design as the methodology for intervening into socio-spatial-ecological systems in order to attain improved sustainability and human wellbeing. Designers intervene to create positive change for example with 'eco-design' or 'green design' which aims to improve the environmental impact of design processes; and 'design for sustainable behaviour' [47, 48, 49]. Attempts to change human behaviour using design thinking strategies can incorporate reformatting spatial environments; 'systemic design' often combines nature-based or biophilic approaches to effect positive environmental changes for wellbeing [50]. Meanwhile the discipline of architecture, for which design plays a central characteristic, has largely ignored the imperative to generate solutions for urban health and climate wellbeing. The next section explores in more detail, specifically how the architecture profession might use design methodologies to intervene in the built environment to improve wellbeing.

4.2 Healthy Architecture Knowledge

There is already a wealth of research that examines the relationship between the built environment and human health. Research from medical disciplines already reveal a number of health issues pertinent to the design profession, particularly for an individual's health. Epidemiological research provides another perspective looking more at population health in relation to urban and spatial factors. There is much valuable healthy architecture knowledge (HAK) produced across disparate scientific disciplines: sociology, psychology, environmental science, material science, behavioural studies etc. What is needed is for these diverse bodies of knowledge to be organized, codified, contextualized and operationalized into the architectural profession. That is, in order for this knowledge to be usable by an architect, the field of (HAK) needs to be contextualised into the building design process.

4.3 Evaluating Healthy Architecture

Measuring the impacts architecture makes on wellbeing requires an interdisciplinary approach across heterogeneous health determinants and causal factors. This section examines a potential routeway towards a better understanding of healthy architecture. There are various ways of calibrating the impact of health issues by accounting for the 'cost' of disease in an equitable manner that have already been developed (particularly in the field of health economics) [51, 52]. Several approaches equate specific illnesses with financial costs; a few of the more prominent methods are précis-ed here.

The Value of Statistical Life (VSL) is a model based on placing an economic cost on each illness and then evaluating a population's willingness to pay (or not) to reduce the associated risk of death or disability [53]. VSL models the loss of economic production related to illness as well as also accounting for more subjective perceptions of the relative 'cost' of each illness or disability. A second approach is the Value of Lost Output (VLO) which measures the costs related to illness and injury in relation to Gross Domestic Product (GDP). The WHO's EPIC model is a well-known example of the VLO methodology. A third approach is the Cost Of Illness (COI) method which attempts to measure the financial impact of illness. The types of financial implications accounted for include: medical insurance costs, medical care costs, medicines, non-medical costs (such as transport), loss of income and various other indicators of financial impacts of ill-health. These three approaches have various strengths and weaknesses however as they tend to reduce the value of life to an economic currency which is contrary to much eco-feminist theory, this research proposes to use a fourth approach - 'Disability Adjusted Life Years' (DALYs) [40]. The World Health Organization describes DALYs thus: "the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability" [54]. One DALY is equivalent to one year of healthy life lost. The term is helpful in this context as it enables comparison across heterogeneous health issues in a systematic and quantifiable mechanism. The DALYs can be ascribed to particular illnesses, for example, mental health issues account for 13% of all DALYs [55]; alcohol misuse is attributed to 4.6% of DALYs [56] and cardio-vascular diseases are estimated to be responsible for 10% of DALYs [57]. The benefit of adopting the DALY approach for the conceptual framework is that it embeds healthcare evidence in a comparable 'language', so that regardless of whether one is comparing social, mental or physical health concerns, homogeneous DALY criteria can be applied. Ultimately, the aim of adopting this system is to ensure the health of a building can be evaluated against the potential DALYs lost or gained as a result of design choices; furthermore, the design can be modified in order to enhance the 'healthiness' of the resultant building. It should permit a robust platform upon which to account for the health implications of design decisions. DALYs offer an appropriate and transferrable system for comparison of health risks and determinants of health across a wide range of social, mental and physical health issues. These criteria need to be integrated into the architectural design process.

4.4 Living (with) buildings

Further research is required to integrated the detailed resolution of health criteria indicators such as DALYs within the broader theoretical framework set out in this article. There is a wealth of exciting research in progress focused on experimental approaches to building future cities and designing architecture in radical and innovative ways. However, there is still a long way to go before fully robust and transferable mechanisms are in place to evidence that these future cities and buildings are healthy places for humans, nonhumans and the planet. Today it is possible to calculate the energy efficiency of a building fairly easily, indeed it is now so routine that in all EU countries each building now has a sticker illustrating the energy rating – rather like a domestic refrigerator does – with 'A' denoting excellent performance down to 'G' for poor energy efficiency (as part of an EU wide European Energy Performance of Buildings Directive) [58]. In the future, a similar approach might make it mandatory for the healthiness of architecture to be calculated; whereby each building would have a fridge-sticker system to illustrate its relative healthiness or unhealthiness. Any such evaluation would need to be situated in the relational socio-ecological framework established in this article.

5 Conclusion

The research sets out the implications of contemporary human activities on the health of the planet and society. As the nations of the world sign up to curb harmful greenhouse gases by the middle of the century, the Post-Anthropogenic epoch is barely 30 years away. One of the most significant changes required is to redress the division of human society from the natural world. Radical transformation of the relationality of humans to the wider ecological context is required; and a concomitant blurring of humans and nonhumans. This paradigm shifts needs to impact all aspects of human society, and there is already some progress with the implementation of health in all policies and a call for 'health in all designs'. Designers will play a significant role in reshaping and reconfiguring many of the determinants of planetary health and human wellbeing. Architects have an opportunity (and responsibility) to use their design expertise to affect positive changes in both. The research sets out a relational socio-ecological framework for measuring and evaluating the healthiness of buildings, proposing the DALY model as a technique best suited to measuring the health impact of designs. Measures are an established way to promote better practice, and therefore the DALY model can be used to prompt healthier design solutions with the ultimate aim of producing buildings that support, promote and enable better wellbeing for society and for the planet.

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01.109 - WHY ARCHITECTS SHOULD LEARN TO CODE

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Abstract

What does she place programming in our everyday lives? It allows us to work smarter, and helps us perform certain tasks. To go further, the tools at our disposal are rather impersonal and sometimes not enough adapted to our will. Today it becomes necessary to be able to go beyond this limit, to understand and learn the fundamentals of computer programming in order to carry out simple actions allowing us to optimize our working time to devote ourselves to other more important tasks. Since the transition to digital technology, the acceptance of computer tools is rather badly perceived among architects. The question today, as Antoine Picon points out in his book "Digital Culture and Architecture", is no longer whether digital is a good or bad thing for design. Rather, it is about understanding where tomorrow's architecture is heading. With these technological innovations, the only certainty we can have is that this change in the way we design will be significant.

Keywords

Future, Architecture, Learning, Code

1 INTRODUCTION

This introduction is dedicated to the presentation of the preliminaries necessary for the modeling of the problematic, the authors' research is divided into three theoretical parts developing on human thinking, the emergence of computation, and Human/Machine collaboration. They expose the evolution of reflections through time.

The first part of our reflection is addressed to the period in which computers were introduced into the processes of conception of architecture. Starting with mental thinking through the conceptual idea to the emergence of digital, the authors wish to highlight what the architect has gained and what he has lost.

In the history of architectural conception, we have gradually passed from a mental reflection towards a reflection helped by digital tools. We have therefore passed from a conception method based on human reasoning and ink drawings on paper, to a conception method based on human reasoning and drawings on a computer screen, to a conception method based less and less on human reasoning and more and more on algorithms.

These new technologies go far beyond mere formal and structural qualities, we will confront logical thoughts from mental thinking and more contemporary thoughts from computational thinking [1].

2 The Logic

There are now a few years where questions are raised about learning logic language, code, programming. Architects have to learn some rules of representation, construction, regulations.

And yet today, when computers dominate in many fields, the architect uses the means of representation by hand, using simple tools such as ruler and compass, not limiting in any way the expression of form [2].

Even if he is still not proficient in a field he is familiar with today, computer representation could one day become hostile to him. This is why a better knowledge of his tools would allow him to evolve with the technique and to be much more efficient for certain very repetitive and sometimes even complex actions.

It is very serious to note the evolution of architects in an environment that is hostile to them, manipulation without knowledge can be very dangerous for the design of the project. The nature of the design of certain very complex buildings, no longer especially call upon engineers, but upon mathematicians, programmers, able to use big data in order to generate forms of urbanism/project optimized according to the sunshine, the urban flow, the views, the space. The architect, having tamed physical space, must nowadays tame virtual space.

3 The Vision

The vision at the beginning of the digital era was very dark, the drawing generally was done on white paper with the help of the hand and the pencil. This one started to turn towards black screens composed of pixels, which when the hand holding the digital pencil passed, allowing the lighting of the pixel then selected allowing the drawing. The drawing on paper then gave way to white lines on a black background.

Ivan Sutherland (Fig. 1), a young graduate student working at the MIT labs, had a very junior position and was therefore only allowed to use the machine in the middle of the night. He developed Sketchpad, the first program that made it possible to draw directly on the screen [3, 4].

The introduction of digital instruments in the architect's conceptual approach was not without difficulty, its integration undoubtedly provoked a disorderly arrival of the tools on the market. During the 1970s and 1980s. Computer technology was first interested in urban analysis and architectural programming, then in the production of plans already produced by hand, and finally in the modeling of computer-generated images of the project.

This accidental succession of means caused confusion in the natural sequence of the phases of the creative process: the constitution of the plans and the communication of the idea began to precede or even replace the realization. This undoubtedly led to a negative view of computer technology for many architects and its rejection as a design tool.

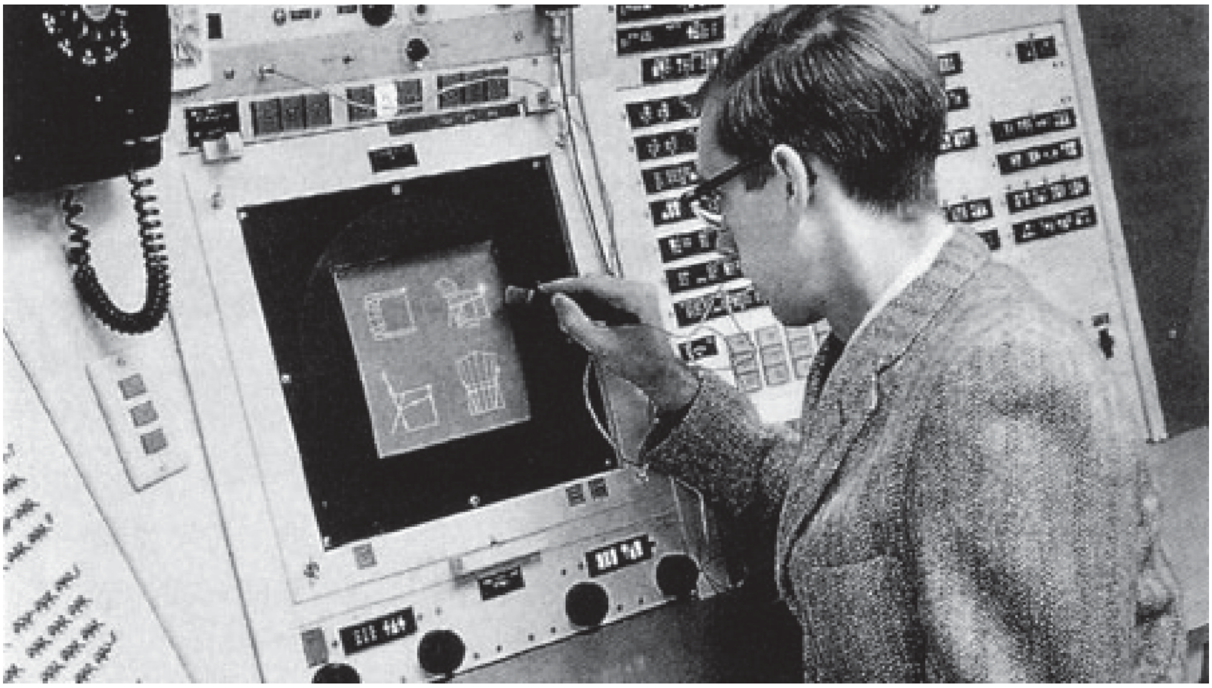

Figure 12. Ivan Sutherland working with Sketchpad.

4 The Tools

In 1992, "Paperless Studio" created by Bernard Tschumi, Dean of the Department of Architecture at Columbia University in New York, uses computer tools in the field of design. New technologies integrating information into the program, such as motion and flow data as a conceptual basis, made it possible to see the impact on design.

At that time, modeling and animation software was used for special effects in Hollywood, as architects hijacked this technique in order to use it in architectural design.

Frank Gehry uses the digital model for the Walt Disney concert hall using the FaroArm, a mechanical arm used to measure a three-dimensional object to model the project on the computer. This was done using aerodynamics software from Dassault Système, which allowed the forces to be calculated and the project structure to be dimensioned.

These experiments, in which the first digital architects were involved, gave rise to numerous architectural creations in the most diverse forms, usually characterized by a lack of orthogonality. "Free form", "liquid", "blob", "digital" or "non-standard" are all qualifiers for this trend towards the wealth of the formal expression stimulated by advances in computer graphics.

Since that time, architects have had to deal with a veritable electronic tidal wave, both in terms of hardware and software. The question today, as Antoine Picon points out in his book "Culture numérique et architecture", is no longer whether digital is a good or bad thing for design; it is rather a question of understanding what tomorrow's architecture is heading towards [6].

Faced with cascading technological innovations, the only certainty we can have is that this change in our way of thinking will be significant. It could prove to be as radical and lasting as the transformation that gave birth to the architectural discipline at the beginning of the Renaissance. At that time, the adoption of new tools and procedures (plan projection, cutting and elevation, perspective representation) was inseparable from phenomena. Like the emergence of the figures of the architect and the engineer and the new place taken by design [7].

5 The Importance

Why is the digital revolution becoming more and more important today? To answer this question, we have to go back to the beginning of computer science, to the era of mechanical calculating machines, perforated tape calculators, and the first electronic calculators. The physical space required for this computing power was phenomenal for a minimal computing power of one operation per second, today our smartphones are able to process 9.01×10^{15} operations per second.

The reason is Moore's law, it tells us that the power of an average computer will double every 18 months. But this law has already undergone some revisions to fit the reality. Yesterday we were at the level of the capacity of an insect brain, today at that of a mouse, tomorrow at that of a human. It is very likely that within a few years we will all know a virtual assistant, helping us in our complex daily tasks. But then we will have to face the fundamental physical limitations of microelectronics. [8]

There are 7.7 billion of us who want to replace tedious tasks with machines. It goes without saying that this programming will be done with time and demand.

In architecture it is a bit the same observation, we are able today to generate master plans for a procedural way, re-transcribing our physical space in order to make the machine understand the study environment in a simulation. We then use flow, sunshine, wind and temperature data... in order to generate or find an optimization for our buildings (Fig. 2).

Figure 2. Rotterdam Wind and Solar urban optimization

The creation process is then questioned, the idea is no longer fixed, but modifiable in time by the program. The architect's creative phase, the idea of space and time is then taken into account by the machine, but remains to be conditioned by man. Once the intentions had been well defined, it was then a good idea to optimize the light on each island core while modifying the heights of the interior spaces by maximizing the volumetric.

The paper information had to be entered into the machine to begin programming functions to vary the heights and interiors of the island cores. Once the urban organization had been redesigned, it was possible to simply select the area to be optimized and program an intelligent cut-out to distribute optimized areas for offices and housing [9]. This is why I then come to conditioning and programming, the tool that the architect of tomorrow will use will have to meet a certain programming logic and why it is undeniable that the architect will need this logical knowledge in the near future.

6 What We Gain and What We Lose

This way of doing things and thinking is not very common in the world of engineers and even less so among architects. This is, first of all, due to a certain complexity of the tool, but it has become increasingly easy to use over the years, thanks to the performance of our equipment and our increasingly advanced programs for the study of materials and structures.

Today, when digital technology dominates architectural representation, we most probably have a certain crisis of immediacy between the brain and the hand, partly lost in the drawing. Other phenomena with the arrival of digital technology such as the loss of scale in architectural drawing, we no longer know today what scale is represented by a digital drawing.

Zooming and de-zooming are daily and become a basic function on our supports, which gives us the feeling that it is neither too small nor too big. This crisis in design ethics then takes on a new dimension with digital and new means of representation.

Other practices are emerging and have enriched the architect's vocabulary. It is one of the characteristics of the architect to be so versatile in tools rather than in other fields. Tomorrow the architect may also be a programmer with the evolution of digital technology, where programming will be part of our design tools.

This crisis in the traditional ethics of architecture with, for example, that of constructive truth, we are witnessing a whole rise in the desire for sympathetic collaboration with the material. It is not a question of following the pattern of imposing form on the matter, but of collaborating with matter to allow form to emerge. They are commonplace in digital fabrication and form interesting propositions with the emergence of computation.

7 What emerges

Not without consequence, the conventional graphic practice is lost, to be found again in new means of representation.

Other practices emerge, they have enriched the architect's vocabulary. It is one of the characteristics of the architect to be so versatile in tools rather than in other fields. Tomorrow the architect may also be a programmer with the evolution of digital technology, where programming will be part of our design tools [11].

It is interesting to note that some of this research in recent years, through parametric design which was already present in the late 90s, the early 2000s. Why are we talking about it so much today if it's that old? With the evolution of machines and the miniaturization of electronic components, it is becoming easier and easier for us to get high computing power at our fingertips. This has had a strong tendency to bring certain research out of the closet, in particular Machine Learning, which over time is being perfected towards artificial intelligence.

This crisis in the traditional ethics of architecture with, for example, the crisis of constructive truth, we are witnessing a rise in the desire for sympathetic collaboration with the material. It is not a question of following the pattern of imposing form on the matter, but of collaborating with matter to allow form to emerge. They are commonplace in digital fabrication and form interesting propositions with the emergence of computation [10].

There is also a growing body of work on digital design and how to generate complex shapes using digital manufacturing. Another point also on digital manufacturing and the arrival of CNC machines, and 3D printing, which today occupy a whole questioning on and encourage investigating the possibilities of these new tools today.

8 Anxiety

The world is now entering a new phase of ascension, building a complex machine, capable of interacting and solving problems is now possible. The results exceed expectations, but there is still one last step, that of creating intelligence capable of thinking to think, and as is often the case, fiction enters into dance and accompanies technological developments. The authors did not wait for the arrival of AI to create an extremely rich imagination by bringing new ideas that broaden the field of possibilities (Fig. 3). Fiction reveals new frontiers for scientists to surpass and also causes new anxieties among populations.

Figure 3. The anxiety of machine-controlled human upbringing.

Czechoslovakia, 1921, a new play entitled RUR is performed in Prague. It is on the stage of a theater that the term robot appears for the first time, it is a word made from several Slavic terms like Robota which means chore in Czech or Robotnik for workers in Polish. For this futuristic work, a manufacturing plant produces robots intended to serve men, the machines see themselves one day equipped with artificial intelligence and then becoming aware of their condition revolt against their master.

Thus, from the fictional birth, it is already at the heart of justified fascination and deep anguish. Fiction will then maintain a complicated relationship with AI, although it is sometimes a sympathetic or benevolent role, it is often destructive and inhuman, built to annihilate us without a state of mind. This old fantasy of the creature turning against its creator. This robotic fear takes its source at several points, on the one hand, AI is the exact opposite of us, they are devoid of intelligence, doubt, feeling, pity or love, apathy, so many things difficult to code. So when faced with a moral dilemma, will the robot make the right decision or can its choice endanger humanity?

Conversely, would the idea of endowing robots with the ability to develop self-awareness, a bit like the monkey that became human, ever want to dominate the reign of the species like we do?

The Microsoft firm tested a conversation robot called Tay.ai on Twitter. This chatterbot was designed to chat with users, and within 24 hours, it began to make Nazi comments. After having integrated all the trolls that had fed its database, it was not so sure that Machine Learning would be effective, if the world from which the machines were learning made fun of them or was hostile to them. In the end, our fear is that the AI will escape us. That it will develop a cyber-soul. It would then have its own priorities which would not be the same as ours, finding the energy to survive, increasing its computing power, hacking access if we disconnect it. And if the robots try to divert us from the course of evolution, the computer robots, in good mathematical management will see that we do not respect our environment and sometimes our fellow human beings, their goal will be to ensure their survival as long as possible. Will they look favorably on this unpredictability, in short, we feared that robots would find us useless, even harmful?
As for reality, automation and the computer, we took our place in many areas and often for the better. We leave the hard work to them, but it is also what puts a number of workers and laborers out of work. So we will have to find a model of society, and until we do, we will see AIs as parasites that rob us of our livelihood.

They fascinate us as much as they frighten us, they make us face our own fallibility, our own imperfection. Even the legendary chess player Garry Kasparov and a supercomputer named Depp Blue was once faced in a worldwide contest (Fig. 4), as if the feverish world wanted to ensure its supremacy.

If we want to make the most of our technology, we must face our fears. We must overcome those fears if we are to get the best out of what humanity can give.

As the Russian proverb says: "If we cannot overcome them, let us join them". Garry Kasparov had the idea that we could play with a computer... with a computer at his side while combining our forces. Human intuition and the calculating ability of the machine, human strategy, machine tactics, human experience, machine memory.

Figure 4. Garry Kasparov (left) Vs. Deep Blue (right).

The idea became reality in 1998, under the name Advanced Chess, this human/machine competition against elite players. However, in this first attempt, both failed to effectively combine their own skills. Advanced Chess found its place on the internet and in 2005 this freestyle chess tournament was a revelation. A team of grand masters and top machines participated, but the winners were neither grand masters nor a supercomputer. The winners were a duo of American amateur players who controlled three machines. Their talent in accompanying their machines thwarted the superior chess knowledge of the Grand Masters against them, and the computer power far greater than that of other people.

Garry Kasparov came up with the idea that a low-level human plus machine is superior to a very powerful machine alone. However, even more remarkable is that he can be superior to a pro-human player with a machine and a lower algorithm. This has convinced us that we need better interfaces to help accompany machines and make this intelligence more useful.

The human plus the machine is not the future, it is already our present.

Everybody has already used online translation tools to understand the main lines of a foreign press article. Despite their imperfections, we use after our human experience to make sense of it all, and then the machine learns from our corrections. This model is developing in medical diagnostics and safety analysis. The machine analyzes data, calculates probabilities, goes 80 or 90 percent of the way, making it easier for human analysis and decision-making. But you're not going to send your children to school in a driverless car that is 90% or even 99% reliable. So we need a big step forward to gain a few more crucial decimal places.

At a time when intelligent machines are making their way into every industry every day. But where in the past machines have replaced manual labor, today they are attacking graduates or politically influential people. Garry Kasparov as the person who fought them and lost, he is here to say that this is great news. One day, all professions will have to face this pressure. It is not up to us to choose when and where technological progress will stop. We cannot slow it down. In fact, we have to speed it up. Our technology excels at erasing difficulties and uncertainties from our lives, and so we must look for greater, more uncertain challenges.

Machines make calculations, we understand things. Machines receive instructions, we have goals. Machines have objectivity, we have passion.

Mankind can only do one thing, dream! So let's dream big dreams [12].

9 Conclusion

The use of these tools in architecture has transformed the way we do things. Our thinking about architecture is changing with the new ways of representation, analysis, and design. The arrival of digital tools is totally transforming the traditional ethos of the hand drawing to focus on computational design in the future design.
Reflecting on the past, speculating on the present and exploring the future. The future of digital architecture, we are moving towards an approach multidisciplinary in a technological context of architecture combining design, programming and architecture.

We need to connect more with mathematicians... or developers, in a world where technology has made it possible for us to allow us to live better and optimize our resources.

This proliferation of IT tools leads to a transformation of the way we live and work. We are looking for a morphological and optimal design performance. The multiple digital generations of architectural prototypes analyze the benefits and costs, this significantly improving the digital design process at physical.

The human plus the machine is not the future, it is our present. We have to face our fears if we want to make the most of our technology, and we have to overcome those fears if we want to get the best out of what humanity can give. By combining our strengths, human intuition and the computing capacity of the machine, human strategy, machine tactics, human experience, machine memory, would this be the most perfect project ever?

We no longer have a race against the machine, but with it. We have to collaborate in this race, to program the machine for the future of the possible, to solve the problems, to respond to the performance and economy of the project.
Thanks to these optimizations, we can save calculation time on a project, but also keep an important advantage in the construction.
We are only at the beginning of this revolution, and so much remains to be done. In the future, these advances will make it possible to establish tangible connections to the evolution of the digital process necessary to ensure the success of automated construction for humans. We must aim at programming as we have done for mathematics from a very early age, we are lagging behind, and this awareness should not be taken lightly.

The issue of our century, AI, will transform our jobs, our way of conceiving, it is important to develop this new technology in order not to stay behind in the years to come. Even if creation will resist a time, we are no longer in the time of science fiction, technologies are developing fast, and this in the same way as our computer power. We must be optimistic until then, and launch awareness campaigns today.

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01.110 - THE PATH AND THRESHOLD.

KINESIS AND EVENT IN CONTEMPORARY ARCHITECTURAL PRACTICE IN CHINA

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Abstract

At a time of rising cconcern with the ecological, the technological and the complex interrelations between them, problematic city and disadvantaged rural in China frame pressing debates on the practical future of human-influenced environment. ‘Am I in nature or is nature in me?’ the wandering aesthete had asked. If European thought had focused on the elusive *haecceity* of things, out East a shimmering interconnection between things had been the taken reality, so persistently portrayed in fine art and literature. Still underlying, ancient, ideas of the relations with the resources of nature and landscape promise a coherence and delight not apparent in the urbanisation project of Deng XiaoPing’s ‘catch-up’ development, nor as yet address abject deprivations in rural areas.

In this flux, the paper looks at the contemporary practice of urbanism and architecture in China referring to the author’s urban and rural projects. In particular, aspects of seamlessness and *parataxis* used in the projects are used as hypothetical narrative.

The Path is a key component in classical Chinese landscape painting which allures and guides us through the depiction, around which phenomena arise, where architectures are sited and where – on a social domain - we meet others. The route to holy pilgrimage sites in China, the path is also a practical necessity in so large a region, extending by iteration through roads and rail into the city, and so to joining with the much-neglected street. In different ways, the case study projects all use transition and sequence as underlying conceptions; spatial flows that are seamlessly connected to the spiritual-practical path that accesses them.

The Threshold – gates, doorways, pronounced thresholds are crucial delineations in Chinese cities, gardens and architectures that are ever important as cultural *and* practical spatial events. The contemplator in classical painting faces nature without and the comforts of the humble pavilion within – at a threshold that is both phenomenal *and* conceptual. Contemporary architecture delights in the miracle of glass allowing the exterior to be framed, managed, and transmuted. Along the path we focus on specific qualities and events that articulate continuities. In architectural projects, particular moments of space, form or materiality animate sequence and act conceptually as thresholds in our understandings.

In the age of the ‘atomisation’ of photographs and deification of the static image, readings of kinesis and event also promise the revelation of the drawn processes and ‘communities of

association' in the making of architectures. Here narratives of Path and Threshold, a method of both understanding and ideating, draw down from and reinterpret profound cultural memes.

1. Introduction

The current Covid-19 virus and images of empty streets remind again of how precarious our roles in nature are; a shift of idea so enduringly portrayed in photographs of a tremulous blue earth taken from the first expeditions into space. The photographic image has catalogued tragedies and terrors of environmental degradation, dysfunctional urbanity and migrations which underlie foretold disaster - we are exploiting our earthly home through human made techniques, but continue to evolve new technologies in the hope of improvement that may yet threaten wellbeing further. In *Hyperobjects, Philosophy and Ecology after the end of the World* [1] Timothy Morton identifies large and complex systems which we, he argues, are not equipped to understand or manage; ecology and the new nature of the digital being foremost. With oncoming automated intelligences and the imminent arrival of the long-predicted *cyborg* that intertwines the human with the artificial, we are engaged in a yet more entangled condition.

In China, where I work as an architect and urbanist with a project studio in Chongqing, the unprecedented rush of modernisation since the nineteen eighties was underpinned by faith in imported techniques and technologies that endure; China is wholeheartedly involved in the *4th Industrial Revolution* of a digital age with extensive promotion of for instance the Internet of Everything, Artificial Intelligence, vehicle electrification, and - not least in this crisis – biological and health technologies. At the same time fewer and lighter work hours have given space for a revival and reinterpretation of the cultural arts and aesthetics, with the powerful relations with the 'home' of the rural being re-explored. Having imported ways of doing things from Europe this quickly evolving China is the context and material which we work further with at times bewildered, at times replete.

In *Living off Landscape or, the Un-thought of in Reason* [2] Francois Jullien compares the limitations of European ideas of the ideas of landscape with the vast project of Chinese landscape painting. These works combine painting and ink drawings with poetry in expressing a sylvan, human and transcendental formula where 'Permanence and variance are at the same time confronted and associated' as Jullien says and argues that 'We (Europeans) were not expecting this other possibility of thought. In truth, we *had never even imagined it.'*

Amidst the day-to-day of rapid development projects our bearings our frequently lost; we are in a kind of enigmatic mist - so beloved in China – which obscures, reconfigures and reveals. Without navigational guides with diverse projects, policies and events, we are surely lost in the mist. Our contemporary projects try to engage with profound Chinese ideas of relations to nature that work in ontological, spiritual, cultural, medicinal and culinary ways, and that are now being re-evaluated in today's China. I argue that Chinese ideas of landscape are a rich resource in articulating new approaches to building in both rural areas and in the reconfiguring tasks of built cities. These are consonant with worldwide environmental and technological concerns. Here, two distinct formulations arising in landscape painting are the focus; the path that guides us through landscape and the threshold which articulates particularities along the way.

Figure 1: Wang Ximeng., Extract from *A Thousand Li of Rivers and Mountains* (千里江山) (1113)

2. The Path

Wang Ximeng's exquisitely coloured eighteen metre long *A Thousand Li of Rivers and Mountains* of 1113 [Figure 1] depicts a panorama of cloud, mountains, lakes and rivers. Here we are drawn into as Jullien says 'a maximum of polarities' that invites a contemplation of the breadth and detail of the world. We can better imagine ourselves there in a state of heightened awareness by the inclusion of roads, bridges and paths that leads through the constantly changing landscape. The path is understood as a practical means of traveling; it is the essential infrastructure of communication, trade and administration in so vast a country. Perhaps that perceived importance underpins the great connective works in modern China of new roads, railways and airports and even the geo-political project of Xi Jinping's Belt and Road Initiative. Unlike the cities of Europe with their temples and churches, religious sites in China are remote and often atop mountains which involve the lengthy ritual of pilgrimage. In 2018 there were over three billion internal tourism trips within China [3] – freer time, surplus income, the desire to go home, visit the only-recently-left rural, is above all a cultural journey. The path gives us access to where we are going – the busy village or lonely pavilion or to other kinds of architecture that may exist. Along the path we meet others; fishermen, farmers, traders and scholars are depicted in classical Chinese art and in mythology on a shared and social fabric. In the classical Chinese garden [4], an idealised three-dimensional expansion of landscape painting, the path is highly prescriptive; we follow a set of references and scenes as if a text is being read. This path-allure, both intuitively understood and expansive, performs multiple functions all at once as a conceptual, phenomenal, spiritual, practical and social device.

Emphasised in China but explored elsewhere, we can add ideas of *path* from European culture. Whilst in The *Age of Reason* thinkers pursued logic and science as a line to 'truth' the traveller in the Romantic era in the poetry of for instance William Wordsworth (1770 – 1850) or Wilhelm Mueller (1794 – 1827) used the road and physically walking as analogy of spiritual and emotional journey. The idea of the *Flaneur (from the 1860's on in France, especially Charles Baudelaire)* takes wandering the city as an existential pursuit for the artist-poet at a metre similar to the contemplating aesthete in classical Chinese painting. Along the way, essential qualities of our experience are found; ideas that are developed in the work Guy Debord and the *Situationists* in the 1940's who pursued chance encounters (in the city). In the

Land Art of Richard Long [5], he walks recording phenomena on the way and constructs physical paths with found materials such as rocks in rural and wilderness settings. The field of *psych-geography* is interested in mapping spatial continuums with encountered feelings and effects rather than using normal criteria of cartographers or administrators, and in so doing seeks to re-explain and re-present the world.

Seamlessly, the path links experiences kinetically through different modes, mentioned above. In this way the perception may be a critique of spatial experience; as designers we cannot enforce meanings of the completed building onto the user who freely reacts subjectively to the *psycho-real* environment we make, and rather we can read space as a series of transitioning experiences extending from a distance, to entrance, to within and to views out to the context that it is part of. We form a personal mental picture by superimposing partial impressions, rational and emotional responses. If the unique method of reading space is fluid, this perception then is also a design strategy. Our WuYu project [Figure 2], a small hotel, builds on the dynamic of four courtyard spaces by interlinking them and by allowing a visual connection through the transparency of enclosure and apertures to imply reveal their association.

Figure 2: Priestman Architects., *WuYu Hotel*, Chongqing (2019)

Photographs and drawings cannot explain the composition as a series of connected spatial zones that are superimposed with changing distinctions between interior and exterior. In this sense the project is an extrapolation from the traditional courtyard complex of China, that sets up subtle spatial gradations through unexpectedly simple means of enclosure; gateway, courtyard, arcade, interior rooms. In ChongQing, despite damp cold winters and hot dry summers, ChongQingers will be comfortable outside throughout the year using yards, arcades, awnings, fences that mitigate the climate.

On Chongqing's South Mountain, in forested hills above the main urban area, our NanShan Lodge project [Figure 3] sets up a series of sequences. An original adobe farmhouse is contrasted by a newly built section to set up spatial transitions, all rooms have carefully positioned windows where views are emphasised and extending external platforms emphasise the relationship with the trees and hills of its context.

Here the relationship between the inside and outside, between the projects and its surroundings are made ambivalent as a means to the enrichment of phenomena. At a larger scale, our LuGu Hu [6] project for ancient village land beside the beautiful Lu Gu lake on the Sichuan / Yunnan border uses the path-route in a more literal way as the physical organisation of the four hundred metre long site. Here we set up a footpath that connects mountains behind the site, villages and fields to the shores of the lake with a deliberately romantic narrative and end point for weddings. The proposal resonates with the local government (client) more than it would have in my London origin and in ways that I do not understand, but guess that the path as a plural proposition – as the thing itself - is an embedded priority.

Figure 3: Priestman Architects., *NanShan Lodge*, Chongqing (2019)

The flow of phenomenal and aesthetic experience between outside and inside is a resource that we can promote at all scales. The path that leads us through landscape, also extends into and around buildings and into villages then cities. Proposals for the regeneration of Edinburgh's Waverley station [7] involved a new public park with cross links connecting the medieval Old Town to the Georgian New Town of that severed city, and so setting up a sequence of spatial gradations; a spatial journey.

If this metaphorical-real path began in landscape and the rural we can extend it now it into the agglomeration of the breathing city. In China urbanization has brought radical environmental change through the economic transitions from agrarian to manufacturing, now towards services. Rural dwellers – not least in China – want to move to urban areas for employment, education and healthcare. In developed countries we take the countryside and access to it for granted – now China is responding to powerful emotional-cultural links that are all the more immediate since only in the 1950's 87% of China's population lived in rural areas [8]. Now there is more free time and disposable income when urban dwellers want to revisit, remember and replenish their relatively recent connections with rural life. This in turn is a means to sharing relative urban wealth and contributing rural development and poverty alleviation. As our experience shows working on rural projects with local government, bonds with the rural and the idea of the rural characterise the societal path – both real and virtual - that interconnects us;

Spiritual Landscape – and the ongoing landscape painting project of China
Cultural Landscape - Temples, mountains, forests, animals, ethnic groups
Memory of rural family life.
Healthy air, water and food
Repose in Nature - Daoist 'traveling whilst reclining', Confucian 'reclusion'.
Wilderness – idea of the sublime
Active outdoors – outdoor sport, extreme sport
Vacation economies – transport, overnighting, cuisine, activities
Rural development /rural employment through urban consumers.

In the modern Chinese city, so recently and radically enlarged, a marked pause in greenfield development has followed overdevelopment, shifts to higher technology industry, and environmental protections. Now with more spare time, increased longevity and an ageing population there is more focus on urban regeneration using existing fabric, community improvements and street renewals. For me the street is the heart of the city, where its life and character is found, where citizens live, work, buy necessities and *un-necessities*, and interact. Norman Foster, the British Architect renown for his technically precise buildings, talks about the city becoming more social. In successful Chinese streets locally initiated products, shops, restaurants and café type meeting-working-resting spaces abound; here we see conventional age group categories and buildings uses intermingling and hybridising. Our WuYu hotel project mentioned above, is built into the top floor of an existing urban shopping mall and contributes 'lounge' respite and 'slow-life' activities to the shopping and restaurants below. Another project in Chongqing city involves a 24-hour bookshop and café space.

In *Seeing Like a City* [9] Amin and Thrift describe the city as a socio-technical adaptive complex. Focusing on infrastructures that both facilitate and endanger the myriad functioning of the city 'in a force field of relational interactions' infrastructures they say are like 'trails from the past into the future, like walkabouts - locating us and telling us what we are.' The street carries – like the path – practical, cultural, social and economic vitalities. In our MadLab Chongqing workshops [10] multi-disciplined participants from abroad and China map the phenomena of the city and propose interventions that enrich the material of the city's *Chongqingness*. We refer both to the agora of ancient Greece - a widened street that was used for commercial and civic functions - and to Chinese depictions of bustling streets in fine art and cinema. Using spatial and virtual hybrids, we speculate on new techniques of interaction, and on new technologies that may coexist in the street. Not least in China reducing working hours due to automation of agriculture, manufacturing and administration and artificial intelligence are likely to alter the activities on the street as a kind of melting pot of interactions.

Our JiuJie Street Regeneration project [Figure 4] in Chongqing's second urban hub of GuanYinQiao, proposes flexible urban squares, de-congests the arterial road, places numerous road crossing points including bridges between denser parts of the area, and a network of miniature gallery-performance spaces. This strategy gives an open infrastructure for poly-morphic, adaptive and interactive city where new forms of activity are welcomed and supported.

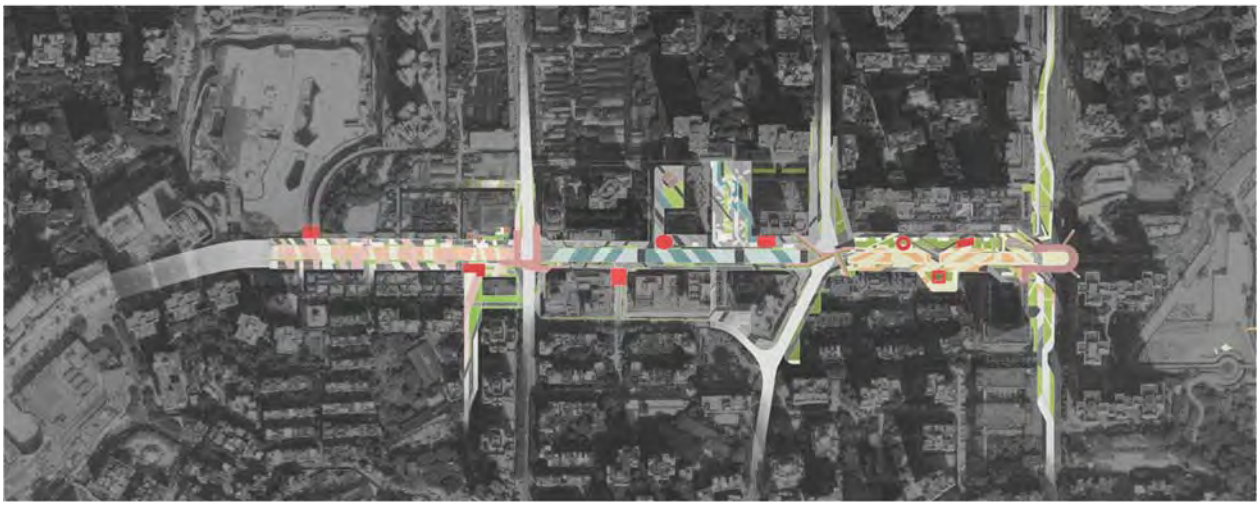

Figure 4: Priestman Architects., *JiuJie Street Regeneration plan*, ChongQing (2017)

In the modern Chinese city road traffic pollution and congestion has become a crisis of environment *and* of the civic. Meanwhile possibilities abound on innovating new activities from on-coming technologies and work-life behaviours. The qualities of the street – a more social path – are central to the renewal of a creative adaptive city and which in China is explored with Chinese cultures.

3. The Threshold

The path is resonant in the projects we do and particularly in China. Of the other cultural components in the vast output of the Middle Kingdom, our projects invariably involve in one way or another a gate, gateway or celebrated boundary. Projects are often started with a gate that symbolizes the development to come, sometimes remains the only completed part. As so frequently depicted in classical art and drawing the aesthete sits facing nature at the threshold of his lonely pavilion. Here he is – and we imagine we are - between the comforts of the indoors and the resource of the world outside, at the transition between privacy and the shared, where interiority touches on exteriority. As an architect I am concerned with a specific site, limits of the building(s) and internal qualities, whereas as an urbanist are concerned the fluid, open, social characteristics of infrastructures and spaces between buildings. Thresholds then between architecture and the urban, are potently ambiguous, having a fruitful complicity between context and place.

Entrances, shrines, temples exaggerate the moment of stepping from one side into the other with the installation of massive threshold stones or timbers. In the classical Chinese garden the anticipation of looking through from one area to another section is amplified by pronounced window and door surrounds. Whilst our view to the other is framed, the framing itself is emphasized as a component-object. Large gates at the entrance to cities, villages or temple clusters similarly announce and define the boundary of a jurisdiction, and they also stand as detached sculptural objects.

Our NanShan project [Figure 3] balances practical needs with carefully positioned windows where we can sit before views to trees and forested hills. The miracle of glass endures; modern architecture ever demands bigger, clearer, safer and warmer glazed windows. Our project in the beautiful mountainous Sichuan for a public country park, is intended as rural development by attracting urbanites and giving poorer local villagers new forms of employment. The main Yele Gate [Figure 5, left hand] for this park also functions as a carpark, visitor centre, and electric bus park for tours inside the park, and like all Chinese gates must introduce and reaffirm the content of what is beyond.

Figure 5: Priestman Architects., *Yele Gate Visitor Centre and Arts Centre*, MianNing County, Sichuan (2018)

Literally in this case, the building is shaped to allude to the dramatic mountains (one is Holy mountain of 5250m height), whilst the primeval alpine forest of the area (protected and managed with wild giant pandas now re-inhabiting) is indicated with numerous columns made with local quick growing trees. In symbolising the immense 'hyperobject', to borrow from Morton [1], of the mountain forest landscape with its myriad geological, ecological and human systems interacting we are not overly reductive, but offer a trigger for wider thoughts. In this sense allusion has both economy and power and is used in a similar way to Chinese painting which often uses spare poems and single characters to compliment or counterpoint the intentions of the depiction. Following this project, we have looked at the cartoon image, particularly Dino the Dinosaur [11], as highly accessible communications of characteristic, form and action. In another project for a poly-functional open-use tower in Hong Kong, the idea of *scenography* is used in speculating on physical or digital atmospheric props, that both opens spaces to the wider world and gives interchangeable personality in privacy.

The second building project in the Yele Park area is for an Arts Centre [Figure 5, right hand] is prominently located in front of the Holy mountain overlooking the lake, and is intended as a sculptural symbol for the park, for performance and exhibitions. The truncated pyramidal form of the building is designed to refer to large rock boulders in the area – natural, mysterious, characterful monoliths with long histories. The building is embedded into the sloping site at the entrance side, and expressed as detached from the ground at the viewing side. Through a scattered arrangement of glazing and partial transparency the building will glow like a lantern. The exterior of the building is clad in the local timber used by villagers. Whilst being modern in appearance the project presents itself ambiguously, a conceptually shimmering object that alludes to wider contextual and cultural characteristics. Here the idea of threshold has been extended conceptually from the literal '*gateness*' of the Gate.

The mountain road leads into the park and the Gate and Arts Centre articulates our journey as a specific place; a point of focus which provides for us, where narratives of the place collect, and where we are invited to extend beyond the immediately seen. The seamless, fluid condition of the path is punctuated, animated by events where other modes of seeing – serious or amusing - transect. As previously described, kiosks in our JiuJie project [Figure 4] form thresholds; trigger points that shift the street towards a different range of experiences beyond the commercial.

In other ways, conceptual thresholds occur when we draw attention to specific qualities such as the use of raw adobe walls in the NanShan project [Figure 3], or trees in the Gate project [Figure 5]. We may be surprised by distance in a view from a window that places us in a larger scale, whilst examining the small scale of stair case details. In *Living off Landscape* [2], Jullien discusses the correlation of *nearness* and farness, the polarity of sight and hand in Chinese painting and quotes the poet Xi Kang poem “The hand brushing the five strings / The eye follows the wild geese as they take flight.”

4. Entwining Path and Threshold

Heady anxieties about threatened ecologies, malign species, new technologies, and hybrids between form the amorphous context to a rapidly evolving China. In fruitful ambivalence of architect *and* urbanist, I import ways of doing things; old tools re-tooled to the found conditions in China. I aim to re-equip the box with new implements as more of the unknown is known [12]. Lost - not only in translation [13] - in a fog of shift, then way-points and places emerge as if from the vaporous mists of a Chinese landscape. In his chapter *Use the Force* [14], Morton characterizes European thought as having a fear of change; in a state of ‘kinophobia’. Whereas, as we learn from Jullien [2], much of Chinese thought about origin, phenomena of the world and human-nature relations not only recognises a dynamic constant of change, but celebrates it as the substance of things. ‘*Am I in nature or is nature in me*?’ the wandering aesthete succinctly asks in a state of happy entanglement. In our practice here *in* the ground the equanimity of Chinese colleagues faced by sudden changes is startling.

Ideas of the interrelation of things is a fundamental cultural understanding in China, but which are not apparent in the rampant modernising projects of China, nor help to address the pressing problems of pollution, iniquity, poverty or impending futures. Pragmatics and poetics are so well understood in Classical Chinese thought but so sorely in need of re-evaluation in modern Chinese development. Here narratives of *path* and *threshold*, a method of both understanding and ideating, draw from and reinterpret profound cultural memes and are tested as useful touchstones.

A speculation on navigating through mistiness, this paper has drawn out, drawn down on and drawn the narrative of the path that is spiritual, conceptual, practical and social. A strand of seamlessness, the chameleon path leads through the virtual ideas of landscape and the physical reality of access as the starting point of all architectures (which can only exist if you can get there). Our own projects are described not as static photographable sets but as kinetic experiences of spatial transition and sequence; the path detours us into and around the building. Leading on or back into the city the path becomes or was to begin with the street at the core of the burgeoning and problematic urban. Here it is imaginable as a circumstance of origination, a new agora.

Along the way vistas, detours, intersections, buildings and events articulate our progress.
Focusing here on the perennial *threshold* the phenomena of this cultural-practical device is explored as a potent component in human made environments. Referring to our own projects,

modern architecture uses the magical place at the threshold-facade of the building, just as the lonely scholar sits contemplating nature in the porch of his pavilion. The threshold is described as a thing in itself as well as a framing representation of the beyond. Here the path makes a transition on our way or forks to another domain.
This tolerant idea of the eventful path gives us a plural, democratic method of assembling diverse references, media and techniques. We work on projects by iterative non-linear study, intuition, conceptualising, doodling, diagramming, sketching, drawing, generating, modelling, discussing, writing, verbalising and a myriad of combinations of these modes. At the time of writing during Covid-19, we are practicing remotely through Wechat, China's Whatsapp. This openness further engages us in our *communities of association*; in our ecology of policy makers, project initiators, collaborators, colleagues and academia.

Acknowledgements

The author gratefully acknowledges the work of the S.ARCH-2020 International Conference Programme Committee and Lecturers for their work and efforts in the great success of this event.

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01.111 - DESIGNING ECOLOGY: COLLABORATIVE TEACHING AND PRACTICE

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Abstract

This paper presents an alternative pedagogy developed within an architectural design studio and research seminar to integrate principles of ecology into master planning and architectural proposals grounded in real-world development surrounding international tourism. Our approach asks: can we design our ecology, rethink what is natural, and reimagine the planning process by prioritizing a symbiotic relationship with habitat as a guiding principle? Can we consider human and nonhuman inputs to redefine the program of international tourism in the Punta Cana region of the Dominican Republic and beyond?

In many parts of the world, construction surrounding tourism is often rapid and unplanned, claiming land in scenic areas for the enjoyment of elite populations while imposing a particularly wasteful and environmentally detrimental model of human activity, yet for some countries it provides such a significant portion of their gross domestic product that it must be considered as a pattern of human behavior that will continue into the future and that needs better design. With the benefit of a real-world partner in the Punta Cana region of the Dominican Republic who is striving to achieve a more sustainable approach to ecotourism, we were able to dive deeply into issues including coastal resource management, species and habitat preservation, sustainable agriculture, waste and water management systems, sustainable construction, and other environmental considerations as precursors to a more integrated ecological design process. The students were tasked with both analysing and challenging our partner’s existing activities and master plans and to envision future plans for growth. Visits to the region were conducted to gain a deep understanding of the geographical, socioeconomic, cultural, and environmental context. Student design proposals ranged in scale from regional masterplan to parcel and building design, allowing one to inform the other while envisioning their impact through spans of human and ecological time.

Our experience supports the idea that collaboration with real-world partners challenges the academic environment to engage more comprehensively with issues of economics, politics, race, sociology, and sustainable ecology -- extending the scope of design to address more than just form -- and to do it less abstractly. Meanwhile, the reverse is true, which is that the presence of an academic studio on the ground generates tough questions, challenges real-world players to engage critical topics, and refocuses their attention to spark change.

Keywords

Sustainable Habitat, Designed Ecology, Pedagogy.

1 International tourism and environmental stewardship

In many parts of the world, construction and operations surrounding tourism are often rapid and unplanned, claiming land in scenic areas for the enjoyment of elite populations while imposing a particularly wasteful and environmentally detrimental model of human activity, yet for some countries it provides such a significant portion of their gross domestic product that it must be considered as a pattern of human behavior that will continue into the future and that needs responsible design [1]. And it is this need for design thinking that the research, collaboration, and design work presented in this paper attempt to address with the benefit of real-world partners in the Punta Cana region of the Dominican Republic.

Punta Cana is located at the easternmost tip of the island of Hispaniola where the Caribbean Sea meets the Atlantic Ocean. Attracted by the splendid white coral sand beaches shaded by palms, dazzling marine life, and pleasant climate, tourists have been bringing economic prosperity to investors and local populations that have migrated to the area to service and build the burgeoning economy. Our partners in this academic collaboration, The Grupo Puntacana organization (founded in 1969) and its associated non-profit Grupo Puntacana Fundación (founded in 1988) have been central to these developments and have achieved national and international recognition as a model to be emulated both economically and ecologically [2].

The Grupo Puntacana Fundación is instrumental in deploying environmental initiatives such as research and implementation of coral reef restoration, species preservation of the native Ridgeway Hawk and seasonally resident sea turtles, promoting responsible fishing practices, solid waste management programs, waste water treatment, sustainable food production, and composting. The Fundación is also involved in the development of Community Programs such as constructing housing, hospitals, clinics, schools, cultural centers, parks, and playgrounds that support their staff and the inhabitants of Punta Cana. One of the most compelling features of the Grupo Puntacana organizations is that their success has been tied to scale, thinking big when others did not have vision of a similar scope.

A central challenge for this group is the economic pressure to turn a profit and continue to grow. This has led to the introduction of more tourists on the ground and the correlated need to cater to their international expectations for luxury like air conditioning, imported foodstuffs, and recreational activities like golf which impose heavy demands on the environment.

The studio explored the potential to further merge business development with ecological stewardship by expanding the reach of the initiatives of the Grupo Puntacana Fundación, applying these as a lens through which to frame future expansion at the scale of the building, the neighbourhood, the town, and the region.

2 Collaborative Teaching and Practice

The work presented in this paper is the outcome of a graduate research seminar during the summer of 2019 and a graduate architectural design studio during the fall of 2019 at Roger Williams University's School of Architecture, both taught by the co-authors, and under the aegis of RWU's Center for Macro Projects and Diplomacy (The Macro Center). The Macro

Seminar and Macro Studio utilized a collaborative teaching practice model where the Grupo Puntacana and Grupo Puntacana Fundación directors, architects, and scientists participated in the development, delivery, and evaluation of the courses along with the co-authors and other consulting experts in landscape architecture, airport design, and urban planning.

Our experience supports the idea that collaboration with real-world partners challenges the academic environment to engage more comprehensively with issues of economics, politics, race, sociology, and ecology -- extending the scope of design to address more than just form -- and to do it less abstractly. Meanwhile, the reverse is true, which is that the presence of an academic studio on the ground, asking tough questions, challenges real-world players to engage critical topics, refocusing their attention and sparking change.

3 Contextual Research

3.1 Macro Case Studies (Global)

Students analyzed case-studies addressing Macro-scale questions. These case studies included planning and design models at urban, regional and global scales as well as organizations whose influence is worldwide.

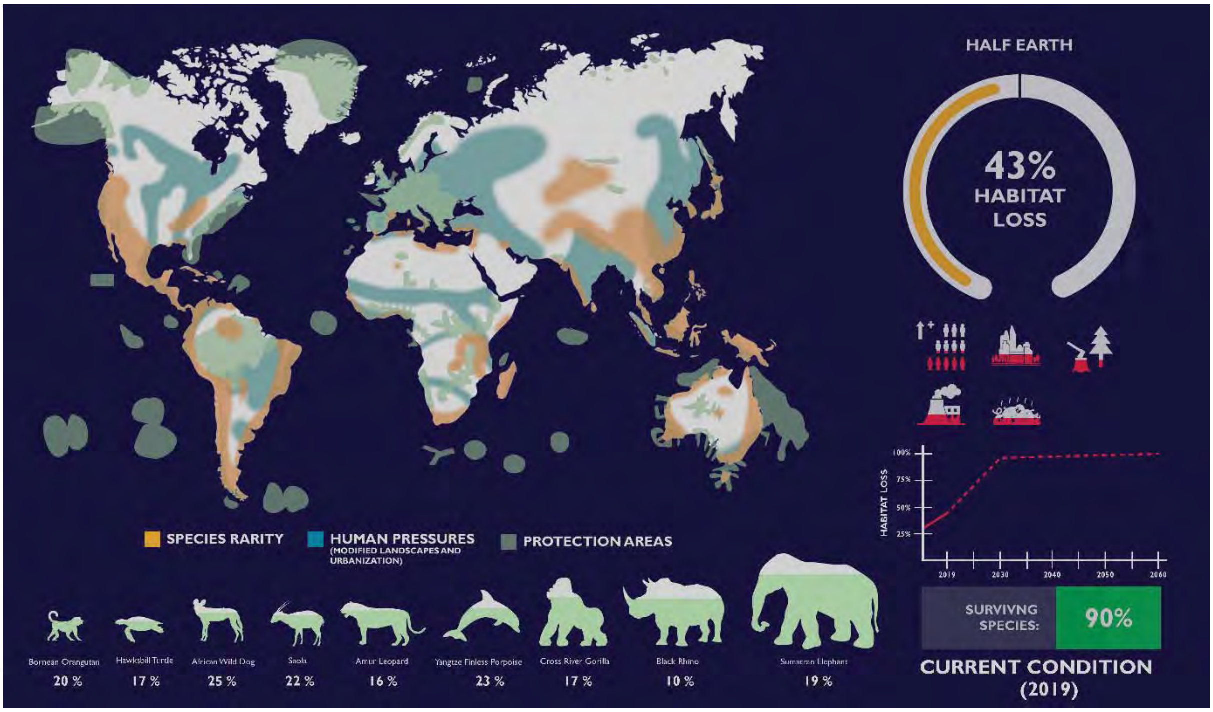

Figure 1. Half Earth Project, Analytical Diagram. Work by Timothy Allen and Thomas Lee

Ideas like E.O. Wilson's Half Earth Project [3], Ebenezer Howard's Garden City [4], and the Urban Growth Boundary in Portland Oregon, appear alongside the work of groups like The Ocean Conservancy, the US National Parks, and tools like Geospatial Information Systems (GIS).

The following questions were posed: What is the reach in terms of geographical boundaries encompassed by the efforts of a particular case-study? What is being prioritized and who stands to benefit? How do human culture and needs factor compared to the needs of other species? How is education incorporated? How might this effort be expanded, improved upon, or refined?

Following this analysis, students were asked to contextualize their learnings in relation to the work of Grupo Puntacana and the Fundación Grupo Puntacana.

3.2 Climate, Culture, History, Marine and Terrestrial Environment

At the scale of the region and country, students conducted a multifaceted analysis of the Dominican Republic and the region of Punta Cana, investigating its History and Culture, Climate, Marine and Terrestrial Environment, Geography and Physical History, and Urban and Architectural characteristics. Data and information were gathered from primary and secondary sources to document findings at the scale of the country and the region. Maps and diagrams were created and correlated to understand the connections between environmental, physical, and human history.

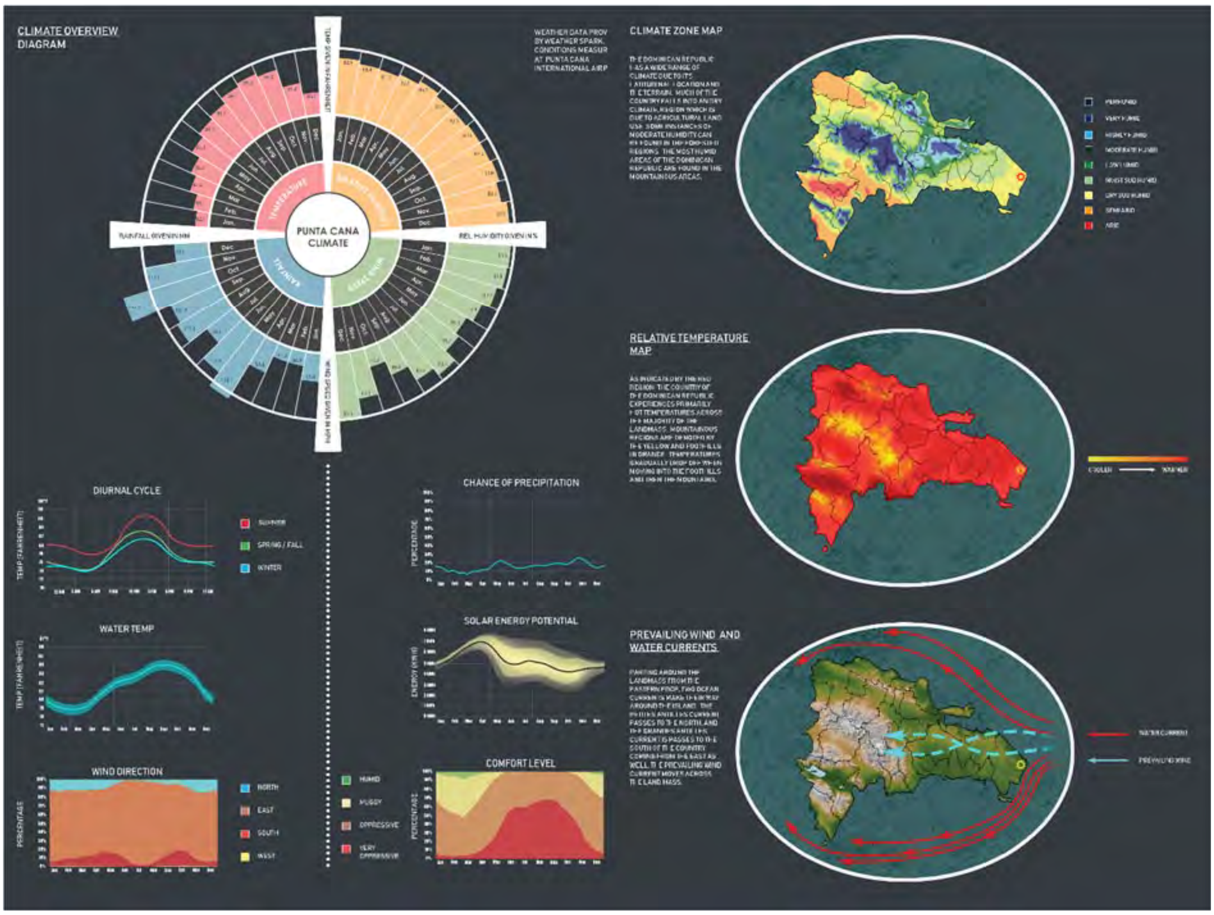

Figure 2. Climate Diagrams. Work by Cameron Germond and Daniel Cusmano

3.3 Program and Site Analysis

Four sites were identified for development at urban planning and architectural scales. The first site involves the proposal of a new Airport terminal, adjacent to the existing Terminals A and B. The second site, Puntacana Village, tackles urban development to the east and west side of the existing Village and its connections to the former. The third site, Hacienda, involves development on a land-locked and densely vegetated inland area. Its adjacencies are urban development to the north, high-end second vacation housing development to the west and south, and existing jungle to the east. The fourth site addresses developing in the Old Hotel site where the first hotel of the Grupo Puntacana was sited. Besides featuring the existing bungalows of the original hotel, this site has tentative connections to the sites of the Grupo Puntacana Fundación to the northeast, a natural reserve to the south east and a water's edge along the west.

3.4 Interconnected Maps

Examining the immediate context within the sphere of influence of the Grupo Puntacana, students generated a series of diagrams to document the ecological initiatives developed by the Grupo Puntacana Fundación. These included Ridgeway Hawk preservation, sea turtle conservation, beekeeping, composting, sustainable fishing practices, coral reef restoration through micro fragmentation, sustainable agriculture, and solid waste management. Information gathering took place through experiential research on the ground, and exchanges with the scientists and directors of the Fundación.

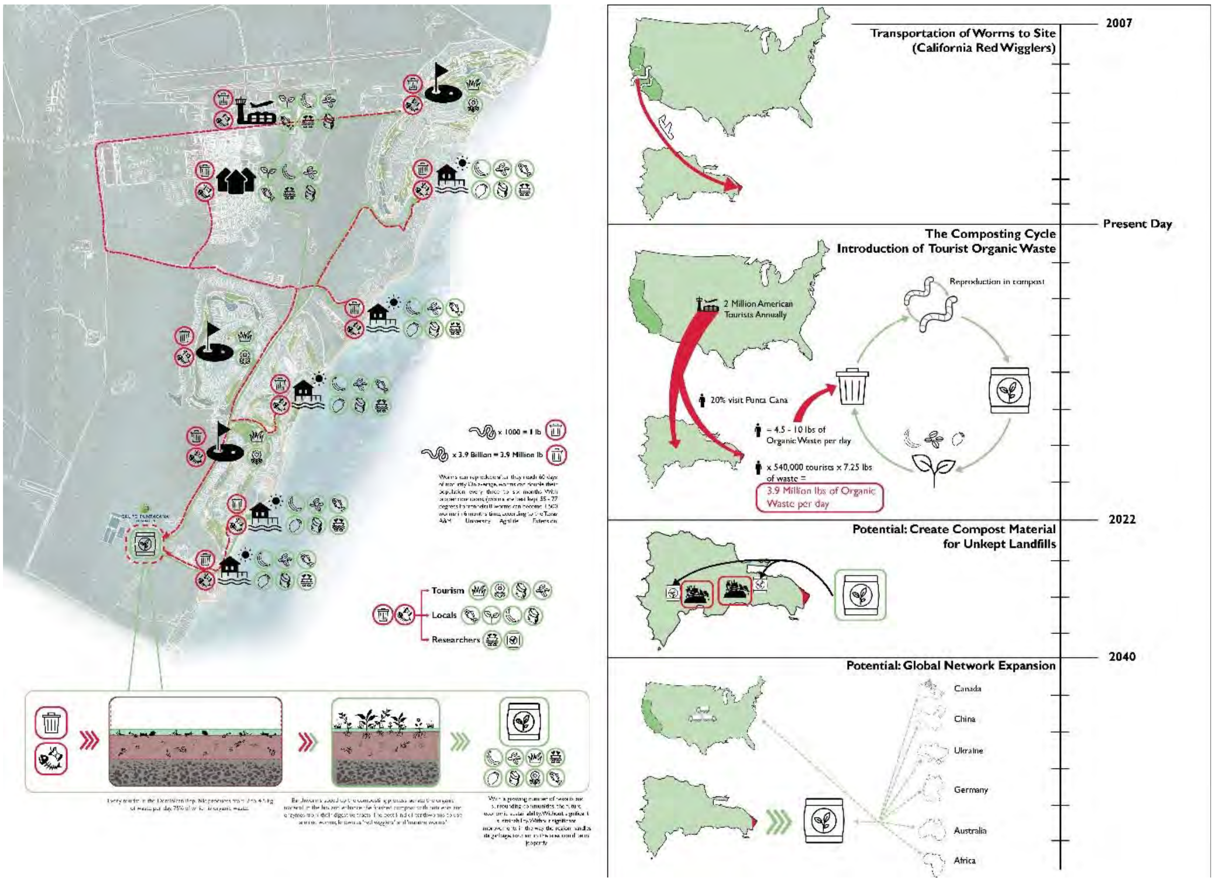

Figure 3. Interconnected Map: Vermiculture. Work by Timothy Allen and Thomas Lee

Students also examined the impact of each initiative at various scales and time spans, and generated Interconnected Maps that analysed the initiative's mission, the stakeholders involved and its relation to other programs within the environmental and cultural context of Punta Cana, The Dominican Republic and beyond.

4 Designing for Humans and the New Nature

4.1 Evaluating and Envisioning Program and Habitat Potentials

Students were asked to develop master plans informed by their understanding of the sites and what these might become in the future. A typical master plan entails the planning of building, landscape, and infrastructure, with human uses taking precedence. Instead, students were asked to reimagine the planning process by prioritizing habitat as the guiding principle.

Human and non-human considerations were addressed to evaluate and envision program potentials related to tourism while promoting sustainable habitats for each site. The amount of territory allocated for human and non-human use was central to their designs as well as the development of strategies that might support symbiosis. The students' proposals aimed to identify opportunities for joining business and tourism activities of the Grupo Puntacana with sustainability-oriented activities of the Foundation and how these might be further deployed or enhanced at each site.

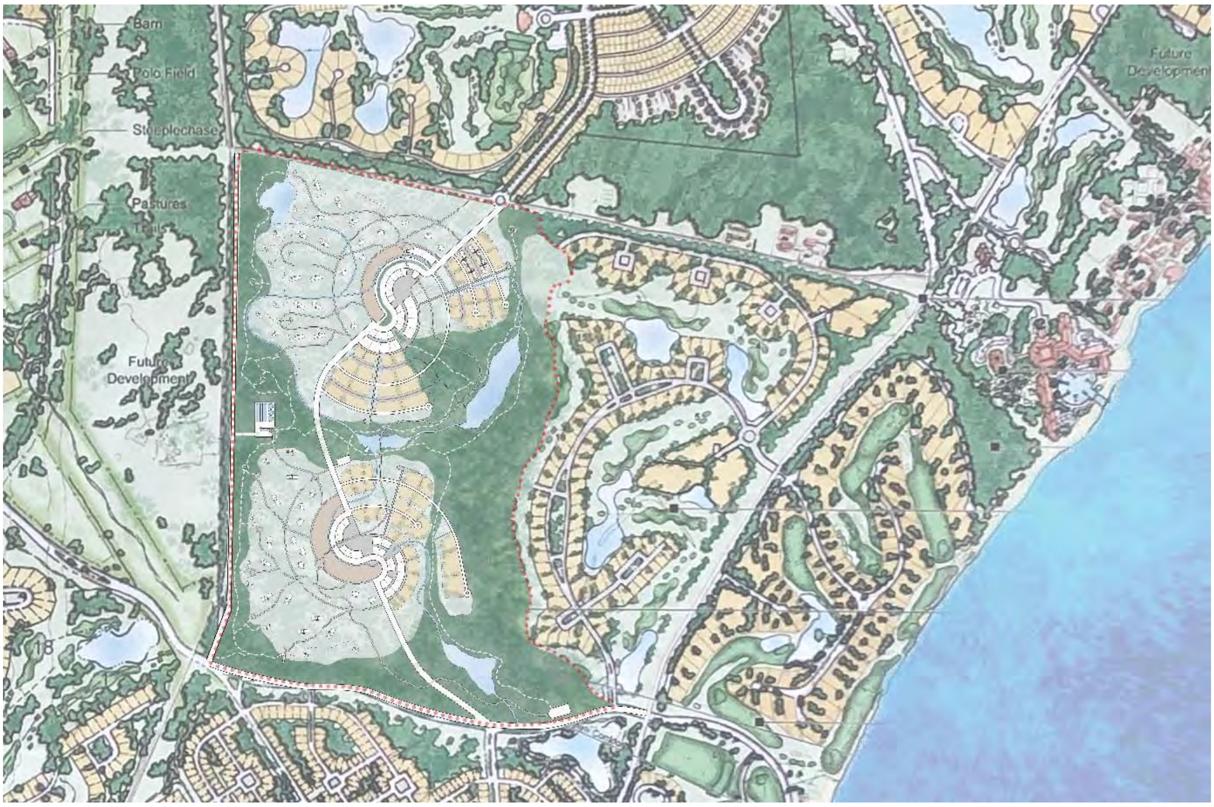

Figure 4. Hacienda Masterplan. Work by Cameron Germond and Daniel Cusmano

4.2 Designing Habitat at the Micro, Meso, Macro Scales

Students were asked to develop comprehensive proposals for each of the sites. Recognising that design can happen at various scales simultaneously, they tested the values and potentials that responded to both human and ecological considerations at the scale of a masterplan, architectural prototype, and construction detail, allowing each to inform the others.

Their urban planning and architectural design decisions integrated sustainable initiatives developed by the Grupo Puntacana Fundación. They studied the impact of such integration at different scales, levels of performance and through the experience of each site. Considering the sites as part of a continuous territory was key in the development of a macro scale understanding, establishing connections and defining necessary differences while addressing specific opportunities within each site and generating contextualized proposals at the meso and micro scales.

Figure 5. Aero Terraza Verde. Work by Victoria Thomson and Bradley Yoon

The airport proposals aimed to serve as a gateway to and from Punta Cana by introducing visitors to the foundation's ecological and social programs, thereby affirming the identity and mission of the Grupo Puntacana. The spaces and programs within the airport were conceptualized as moments of pause and relaxation where content on the initiatives of the Foundation could be accessed, generating environmental awareness and educating tourists. Employing passive architectural strategies, local materials and proposing landscape features such as green walls and gardens with endemic species intended to offset the negative effects on the environment that are typically associated with airports while providing pleasant experiences throughout.

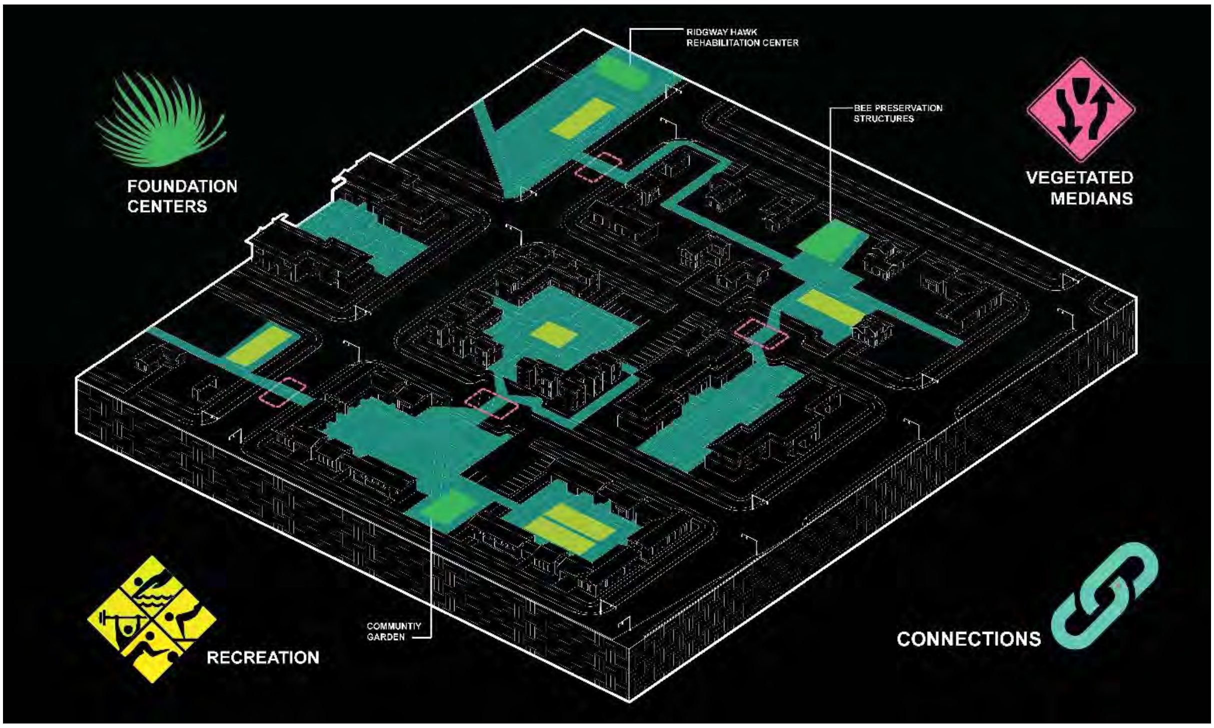

Figure 6. Urban Interconnections. Work by Justin Freiss and Tyler Moorey

For the village site, the development of zoning guidelines addressed the integration of the sustainable initiatives of the foundation at the urban and architectural scales. Transportation systems focused on the pedestrian experience by providing networks featuring tree-lined shaded paths and culturally active public spaces that catered to both local and tourist populations. These were integrated with vehicular (private and public) and golf cart roads that used recycled materials and underground utility systems. Green corridors supported environmental and social programs such as parks, beekeeping and composting. Green roofs, vegetation, and passive building cooling were used to offset the effects of urban development.

Figure 3. Imagining Urban Balance. Work by Justin Freiss and Tyler Moorey

The inland condition of the Hacienda site and its relation to the other sites offered particular opportunities for real state development and ecological preservation. The proposals recognised the critical adjacencies of the site (a large territory surrounded by urban development to the north, coastal resorts to the east and south and densely vegetated areas to the west) and defined it as a link between these areas. This allowed for offering a mix of housing types that range from second vacation houses to compact cabins situated within areas dedicated to the experience and research of *natural* habitat. The relationship to the environment informed how the various typologies aggregated, related to the ground and which passive strategies were incorporated into their designs.

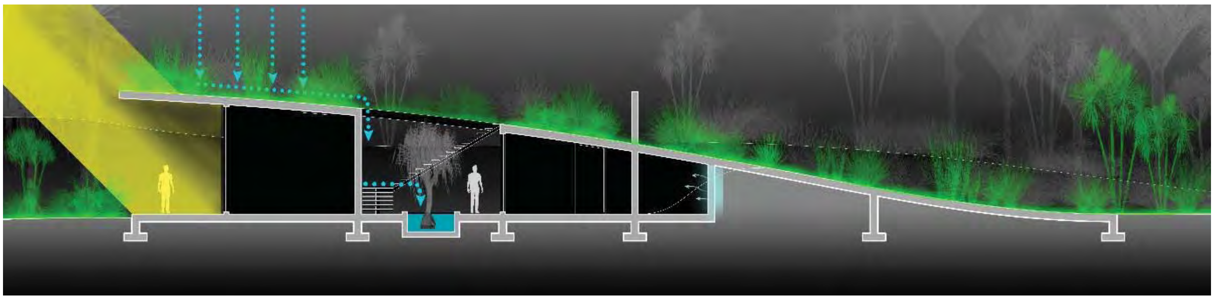

Figure 7. Passive Strategies. Work by Cameron Germond and Daniel Cusmano

Additionally, commercial centers and greater density housing were proposed to the north to connect with the urban development of Village site and to support the needs of the tourists to which this development caters. On this site, zones were dedicated to scaling up specific programs of the foundation such as the preservation of the Ridgway Hawk and the development of a water treatment facility.

For the Old Hotel site, some proposals aspired to hybridize the program of tourism with environmentalism. Identifying the unique features of the site like the fabulous waterfront and the possible connection with the operations of the Grupo Puntaca Fundación, students proposed to redefine the tourist experience by designing a hotel complex that physically and programmatically supported the foundation's programs. They studied metric and spatial parameters related to the sustainable programs to identify the most productive adjacencies. Unique experiential and programmatic opportunities were proposed as a result of this synergy. Immersion in activities like coral reef restoration, composting, waste management, and sustainable agriculture were envisioned as part of a high-end hotel concept. The redefined typology responded to both economic demands and ecological inputs while harnessing the educational potential of the tourist experience to embody a sustainable vision of the Grupo Puntacana. Other masterplans within the same site, proposed the adaptation of existing buildings to offset energy consumption and site disturbance. Increasing density while minimizing the footprint of needed new structures in dedicated areas, intended to combat the negative impact of building in close proximity to the shore and ecological reserves.

Figure 8. Redefining Recreational Tourism. Work by Timothy Allen and Thomas Lee

5 Concluding observations

In this effort we experienced many moments of productive intersections between academic and practical perspectives. The idealism of design in the academic setting is all too easy to dismiss, yet the fact that the students were highly attuned to the specifics of the site, culture, climate, and economic development over time meant that many of their observations were well taken by our collaborating partners. This was particularly true for the way in which students integrated the ecological thinking evident in the work of the Foundation into their process as a driver for decisions at all scales. The potential economic, social, and environmental benefits of ecologically planned urbanism, or low-tech passive architectural strategies, or the educational and experiential rewards of participatory ecotourism, for instance, were all focal points for interesting discussion and knowledge sharing.

The presence of our partners in critiques was invaluable for this exchange, and to highlight moments in which crucial practical considerations needed greater attention, like that the airport designs required more resolution of parking and transportation, or that the Village was too pedestrian for Dominicans, or that the Hacienda masterplans needed more density to be economically viable.

Grupo Puntacana and the Grupo Puntacana Fundación each prioritize different aspects in their work, resulting in urban growth that does not always take full advantage of the knowledge generated by the Foundation. Through our experience in teaching the studio and addressing both economic demands and ecological inputs, we were able to explore and demonstrate the potential positive impacts of integrating the knowledge derived from both branches in the design of their masterplans, and to affirm the benefits of collaboration between academic and real-world organizations.

Acknowledgements

The authors are grateful to many collaborators and supporters in this effort. First and foremost to Stephen White, AIA, Dean of the School of Art Architecture and Historic Preservation and to Lisa Raiola, Vice President for Institutional Advancement at Roger Williams University for their invitation to drink from the waters of Puntacana and for supporting us intellectually, logistically, and financially through and through. To the late Frank Davidson [4], for his vision to initiate and support the Center for Macro Projects and Diplomacy at Roger Williams University, the legacy of which we are pleased to be able to continue with this work. To our families, for their patience, encouragement, and participation. To our mainland experts, Marion White, Adam Anderson, Ginette Wessel, John O'Keefe, and Heinrich Hermann. To our wonderful collaborators and hosts in Puntacana for their generosity, openness, good humour, and participation: Frank Ranieri Jr., Jake Kheel, Liana Reyes, Ihron Barrera, Antonio Barletta, Oscar Imbert, Victor Galvan, Noel Heinsohn, and Susanne Leib. And finally, to our superb students who participated in the 2019 summer seminar and fall studio.

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01.112 - ARCHITECTURAL FORM IN MOTION GRAPHICS

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Abstract

This paper explores the use of the wipe, a transition, as an architectural space within motion graphics production. Exploring ideas from zen, and Japanese Poetry, expanding on the notion of the 'pivot word' in Japanese literature, exploring the 25 frame wipe, as an architectural, navigational device, within time and space. Taking the idea of the chronotope from Bakhtin, a time-space device, and precendents from the work of Samuel Beckett, literature including poetic form, and the structure of the traditional Japanese Nō Drama. I will introduce my current project - Recipes for Baking Bread as an exploration into the navigation of time and space, using the wipe as a transition from early Ukrainian histories in the 1930's, and the present day, architecture in production, and contemporary work including Max Hattler, the poetry of Rilke, Tal Rosner, and Simon Faithful.

Keywords

wipes, transitions, production, motion Graphics.

1 INTRODUCTION

This paper is exploring the idea of architectural space and form, within motion graphics and film construction. I am going to be particularly looking at the idea of the transition the 25 frame wipe which can create, and break structure and rhythm within contemporary motion graphics. Including precedents from Samuel Beckett, Laurence Sterne and Oulipo poetry. Taking principles from zen philosophy and the work of Svetlana Alexievich. I am going to reference my current project Recipes for Baking Bread, which is exploring stories from Holodomor in Ukraine in 1932 and 1933.

2 Wipes

"sometimes there is also the intersection of the momentary and the timeless which may be noted in many haiku."

— Donald Keene, Japanese Literature

The history I am drawing on for my research goes back to Dziga Vertov and the early filmmakers. Dziga Vertov was a Ukrainian-Soviet filmmaker. He was one of the first people to use the idea of the edit, and montage. In the early film pieces when they were shot, audiences were not able to see the advantages of watching something on film when the film replicates without sound, what is happening in real life. With the birth of Freud's ideas about the mind and what the mind can do came the idea of the cut, the edit. Filmmakers like Eistenstein and Vertov were exploring how audiences psychologically can make leaps from place to place and time to time and Hito Steyerl in her contemporary writings talks about the same thing. She talks about the idea of a filmic wipe being a political device to erase and remove, and then replace images, all within a second or 25 frames.

"Wipes as a filmic means are a powerful political symbol. The show displacement by erasure, or more precisely, replacement. They clear one image by shoving in another and pushing the old one out of sight." (Steyerl, 2017, p. 12)

Japanese literature and poetry often follows similar structures, "as in a Japanese painting a few strokes of the brush must suggest a whole world" (Keene, 1953, p. 29) Traditional Japanese Nō drama has a traditional structure of five plays inter- spersed by short comedic pieces which in a sense work in a similar sort of way as a wipe or a transition does in contemporary motion graphics. In sports broadcasting the wipe takes the viewer backwards and forwards in time, it is a navigational device.
Audiences have become so used to the idea of watching a football match and being in the match and being five seconds before the current action. Or, a wipe or transition taking a viewer between the studio and the live action. This is one of the ideas I am exploring in the work I am producing at the moment. I am developing a very short wipe of 25 frames as an architectural device or space to take viewers of the work backwards and forwards between contemporary UK and Ukraine, and into the 1930's, across time and space. How a short, structural device is able to do it.

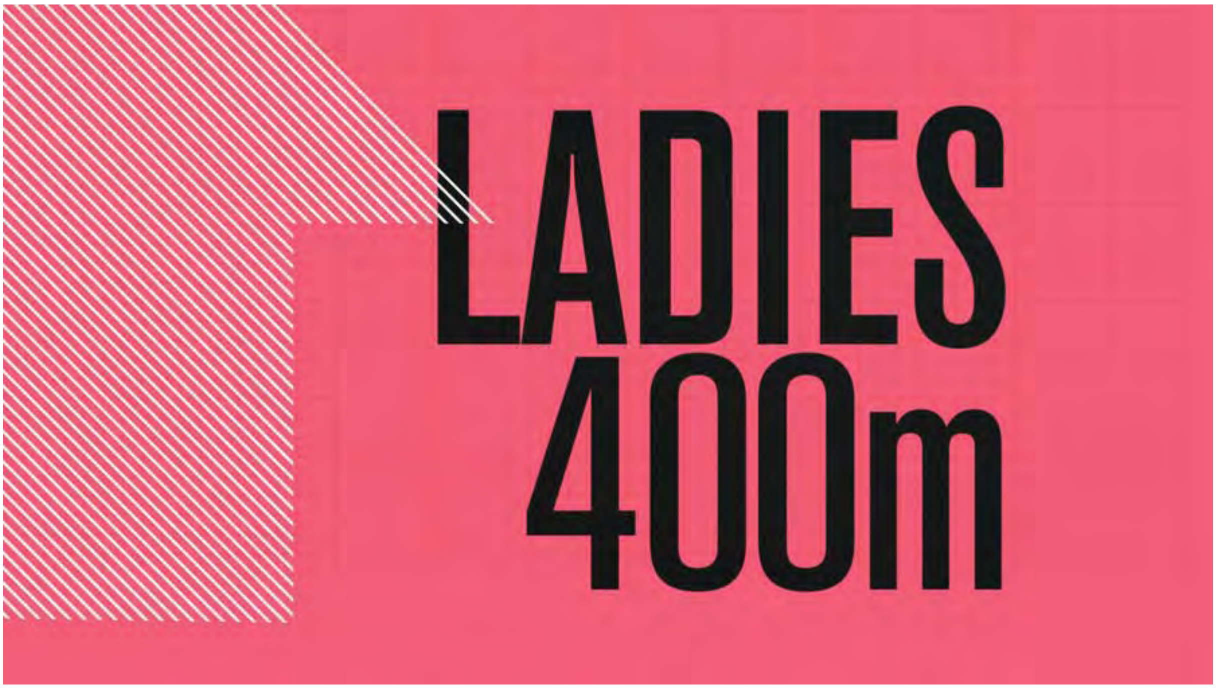

Figure 13. BBC Work. Athletics Wipes, produced at
BBC Sport, 2012

Figure 2. Recipes for Baking Bread: Still.

3 Pivot Words

"We will give the name chronotope (literally, 'time-space') to the instrinsic connectedness of temporal and spatial relationships that are artistically expressed in literature."

— Mikhail Bakhtin, The Dialogic Imagination: Four Essays.

One of the other features of Japanese literature as described particularly in Donald Keene's writing is the idea of a Pivot-Word. In plays and in texts this can be a key moment, a point in time where a narrative shifts or changes. By adding meaning to a word or a series of words a phrase which can mean more than one thing which shifts the action, the point of motion of a piece of work. (Keene, 1953)

In traditional Hollywood film-making and narrative, there is a scene which if often referred to as the campfire scene. It happens traditionally two-thirds of the way through a film. The narrative arc drops down the plot appears to resolve itself and in the old Hollywood Westerns this would be the point where everybody sits around the camp fire. Now it is still used as a storytelling device, the point at which the B-plot appears. It is a point of action or no action. Around two thirds of the way through the film before the end and resolution of the story. I am taking the same idea in the work I am making. Two-thirds of the way through I am reversing the principle. When I first started learning Ukrainian I was taught very early how to say 'Black Soil'. Чорнозем in Ukrainian. Which is a source of great pride in it is a rich, fertile source, a rich fertile land, which historically has been often named the bread-basket of Russia, or the Bread-Basket of Europe. During Holodomor when so many people died due to the collectivisation of farmland the soil, the earth, the farming, became also a reference to death, and to millions of people who died. I am going to have 10 frames of black, in my film. To first of all refer to Black Soil and then as a testament, or a testimony to the people who died during Holodomor, which is estimated to be around 7 million people (Holodomor Museum, n.d.).

There is a contemporary piece of work by a film-maker called Ion. It has a similar device in it. It is an absolutely brilliant piece of work, based on the idea of a circle, going back to artists including Oskar Fischinger (1933-34), who explored exactly the same principle in the 1930's.

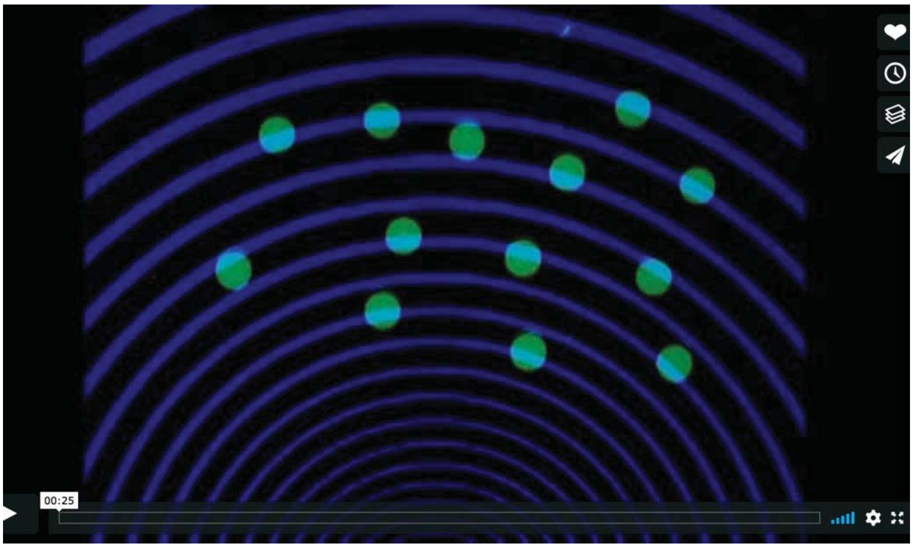

Figure 3. Kreise

Ion has made a piece of work which is purely about form. It is black and white and it is exploring the geometry of a circle. The space, physical space, and the time-space, of a simple form. There is a part in this film where the images smash out, and everything just goes back to black. It is really dynamic and really powerful. (Ion, 2012)

Samuel Beckett does something similar in his work. There is a structure, he breaks and then creates a structure (Beckett, 1959 / 1984) as does Laurence Sterne, in his original writings. In Tristram Shandy (1759-67 / 2000) there is a page of pure black to represent the death of a character. (Sterne, 2000, p.29) Another, marble page later in the book is about the printing process itself, in that neither the publishers or Sterne, were able to control what happened and exactly how the marble page appears. (Ross, 2000, p.562) Both Beckett and Sterne are great examples of writers who use visuals in their narrative. Creating structure from devices

Figure 4. Black Page

In Addition, I have a diagram and a quote from Oskar Fischinger (1947, quoted in Keefer and Guldemand, 2012, p.112) who writes in an interview about a project he created when he was 19, describing the plot of a Shakespeare story. He mapped everything out on graph paper, the characters, their moods and the emotions, and created a timeline of happenings throughout the play. He then started creating cinematic responses to the work he was doing. His storyboards are quite often on graph paper. They are visual depictions of time, and space. This idea of time and space is described very clearly by Mikhail Bakhtin in his idea of the Chronotope which literally means time-space. He refers to Einstein in his original writings. (Bakhtin, 1981 / 1994)

I am using this idea for some of myliterature reviews.

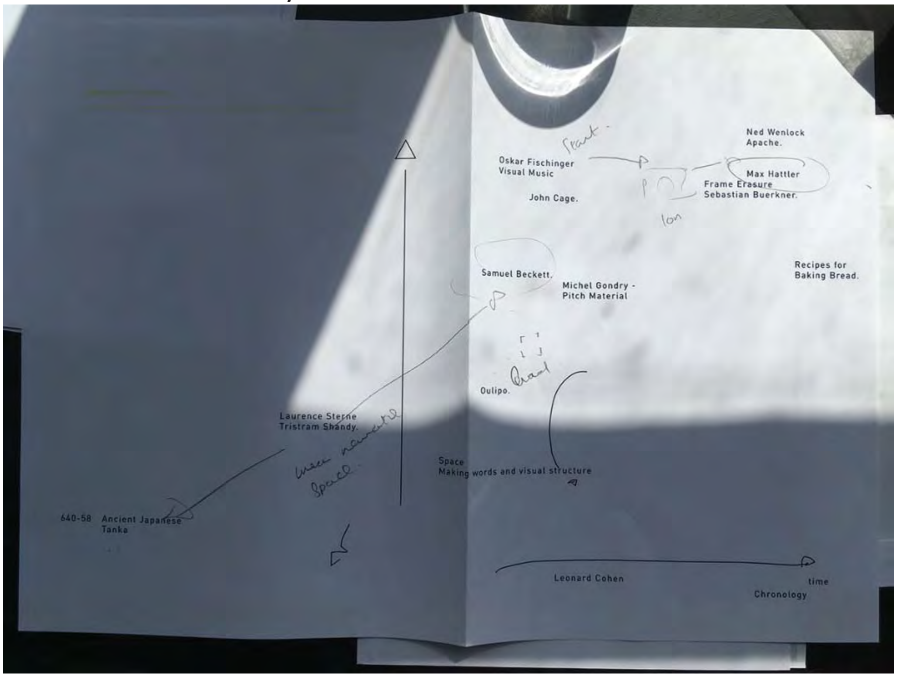

Figure 5. Literature Review

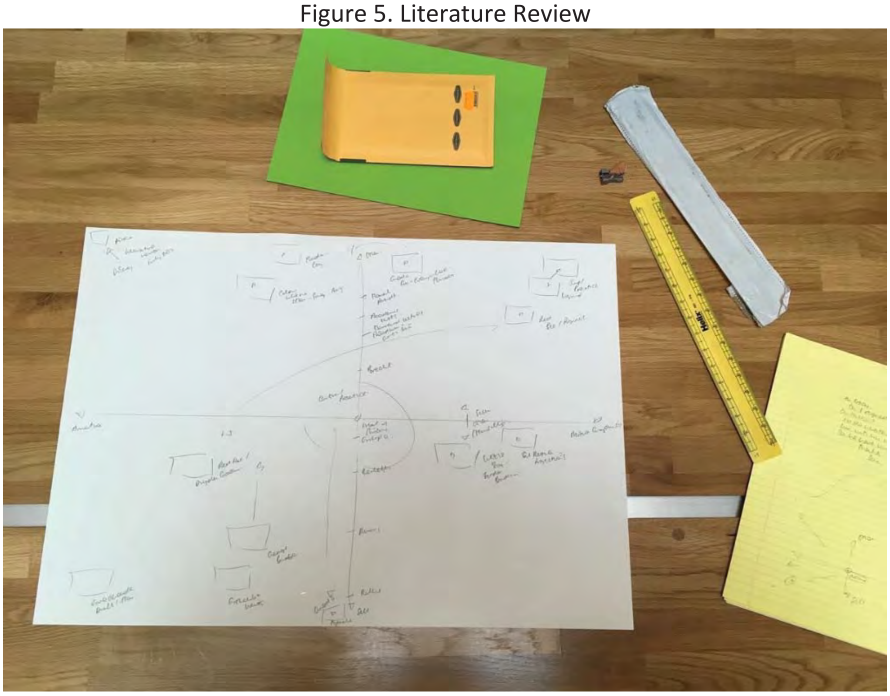

Figure 6. Literature Review

I have a context map showing on the left, or the x-axis, a plot between traditional animation practice on the left hand side and contemporary motion graphics practice on the right hand side. On the y-axis, I have a relationship between the inner and the outer world. Artists who are creating work for themselves as a means of self-expression. With artists who are working for other people in response to a client project, or a brief.

I am adding a z-dimension to this, people who use visual space within their work. This was taken from a diagram in a book by sociologist Anthony Giddens who plots time and space on the x, y, and the z axis. When I plot this in time I have a fourth dimension, showing chronologically where this work appears in time. (Giddens, 1984)

4 Recipes for Baking Bread

The next part of my paper is the original literature review for the project I am currently working on. There are three films included. The first is by Jane Cheadle. Originally called 'Draft', it has now been renamed as 'Flow'. It is a really beautiful piece of work. It is the artist in her studio exploring tactile materials. Chalk. It is very reminiscent of the work of William Kentridge, in lots of ways, visually and in the practices she uses. William Kentridge does a lot of work with charcoal, erasing and removing, and reversing images. Shooting backwards and forwards in time. He works on one sheet of paper as he changes or modifies the image. Jane Cheadle does exactly the same thing in this particular piece of work. There is a sense of intimacy in it, and about it: the artist is present in the work, as it the sense of time. Water flows and disappears and appears. Chalk appears on the floor. The artist is present, in her absence. It is an intimate portrayal of somebody who is working in their studio, without ever the evidence of the artist. (Cheadle, 2015)

William Kentridge talks about the relationship between his work and drawing. Other people's pain, and how drawing can be an act of processing. Both one's own pain, and being sensitive and compassionate with the pain of other people. (Kentridge, 2010, quoted in Art21, 2010)

This is one of the things I am enjoying in my work, a history, a part of my past which I don't yet know. The second piece of work I am looking at is by Theodore Ushev. It is called Tower Bawher, a constructivist style piece of work. The film, he explains he made almost completely from memory in a really short production time. Approximately five weeks. The way he describes his process is almost as if the film came out of him. There was a force behind it, a visual memory. Ushev (c2009, quoted in Selby, 2009) I love the style of this. The graphics very much are in the style of motion graphics and it is a great example of creative practice where motion graphics is also a part of narrative. Creating narrative from a more traditional motion graphics style work.

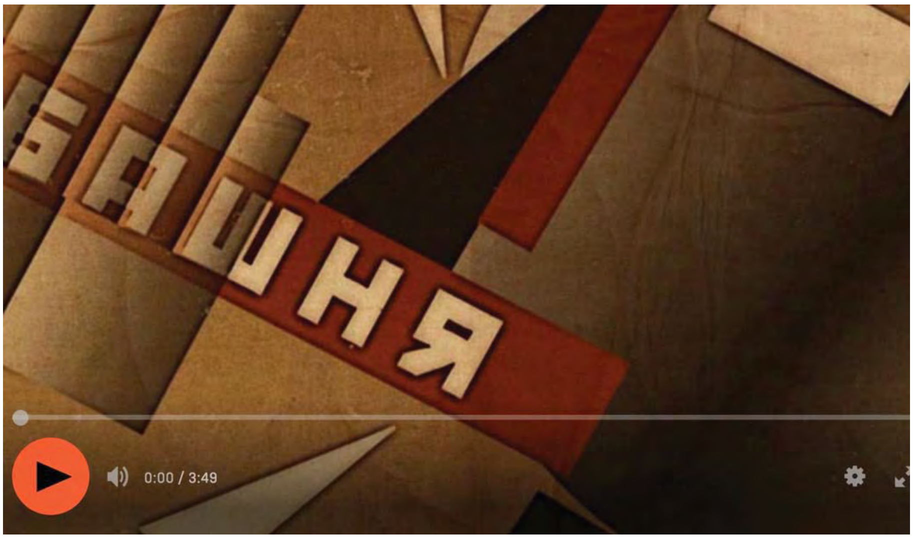

Figure 7. Tower Bawher

I have a diagram to represent my project:

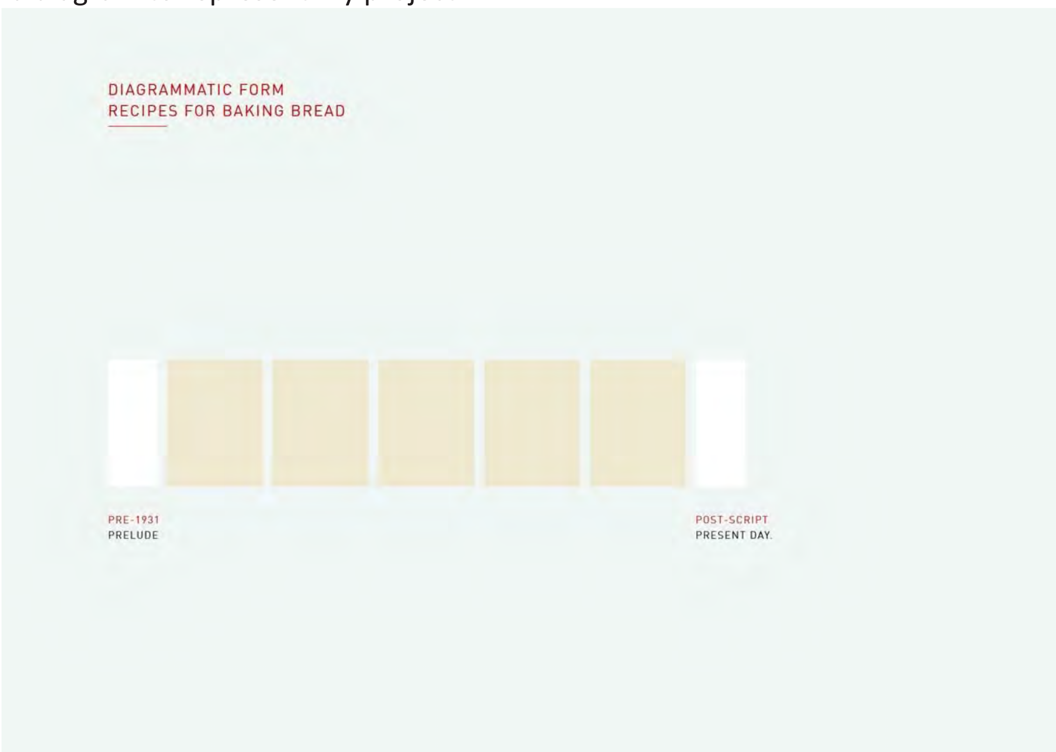

Figure 8. Diagrammatic Form

It is going to be in five parts. I have a series of interviews. The first interview I made was with a former baker who now lives in Cyprus. I interviewed him on the day his bakery was closing down. He talks about the bakery in his family and the idea of a secret recipe (Prytulak, 2019) what to do, with the recipe. He is talking about history and about family histories and very specifically talking about the recipe.

I have an idea about using Jung's Archetypes. One of the archetypes is rebirth (Jung, 2003). In the films I am making, rebirth is going to be represented by recipes. Recipes are passed down through generations in the same sense as a character is reborn throughout the film.

The structure I have for my work is based on a traditional Nō drama. There is going to be five parts with a small interlude between each one. A wipe. The wipe is based on an architectural form taken from a museum in Kyiv. In Central Kyiv, in Ukraine. The museum is a celebration of war. The military forces. It is underneath a huge statue called Rodina Mat, or Mother Russia. A woman with a sword and a shield facing east towards Moscow.

Figure 9. Rodina Mat

The final piece of work I have included in my literature review is a film by Jordan Baseman called Little Boy. Originally the film featured a transcript from a Hiroshima survivor. It is an artistic response to a piece of oral history. What the artist does with the work is rather than offering an illustration, or an interpretation of something beyond comprehension, he creates an artistic response to the interview he recorded with the survivor. One of the things he describes in an interview with Animate Projects is an idea he had about trying to create parts of the work where he was not, and the audience, people watching it, were unable to breathe properly. Something claustrophobic. It is more evocative. There is something uncomfortable about the work. It is fragmented, it is disjointed, it is uncomfortable to watch. Exactly why, it is so effective. It does not say anything. It does not make any comments about Hiroshima. It creates something. It creates a piece of work in a person's mind.

Figure 10. Little Boy

"No artist tolerates reality."

– David Shields, Reality Hunger—

A visual appendix, including notes, videos and source materials, can be found online at the following address:
http://recipesforbakingbread.co.uk/Conference-Notes/S-ARCH2020.html

Acknowledgements

The authors are grateful to many collaborators and supporters in this effort. To our families, for their patience, encouragement, and participation. To our wonderful collaborators and hosts for their generosity, openness, and participation.

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Figures

Nesteruk, S 2012 **Athletics Wipes: BBC Sport**, digital image, BBC

Nesteruk, S 2018 **Recipes for Baking Bread**, digital image, unpublished

Fischinger, O 1933-34 / 2013, **Kreise (excerpt)** by Oskar Fishinger, viewed 6 March 2020, <https://vimeo.com/55181698>.

Sterne, L 1759067 / 1998, **Black Page,** Oxford University Press. Photograph by Sara Nesteruk, 2018.

Nesteruk, S 2019 **Literature Review**, digital image, unpublished

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Ushev, T 2006, **Tower Bawher**, digital image, National Film Board of Canada, viewed 6 March 2020, <https://www.nfb.ca/film /tower_bawher/>

Nesteruk, S 2019 **Diagrammatic Form**, digital image, unpublished

Nesteruk, S 2017 **Rodina Mat**, digital image, unpublished

Baseman, J 2015, **Little Boy: Image Still**, digital image, Animate Projects, viewed 6 March 2020, <https://vimeo.com/124138239>

01.113 - THE COMMODIFICATION OF ORNAMENT IN ARCHITECTURE

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Abstract

Usefulness is a subjective quality, defined by Ralph Waldo Emerson as the pinnacle trait to strive for in one's life. The Merriam Webster dictionary describes 'function' as, "The quality or state of being a functional design that is admired both for its beauty and for its functionality." Function and usefulness are often viewed as synonymous, however sometimes 'function' can in itself become rendered negligible if its usefulness or purpose is negated by different value systems. If we view the arguments presented by postmodernists and gothic architects, their opinion on functionality often seems to be in direct conflict with one another. This dispute is well characterized by the movements' approach to façade and ornamentation on the exterior of buildings, as will be explored in this essay. However, if we turn away from the 'form vs. function' arguments intrinsic to these schools of thought, it is arguable that both theories are linked to an existential question resting at the heart of architecture. If architecture is a means by which to design structures that fulfil a need in society, postmodernists and Gothics achieve this goal in ways befitting of the societies in which they are working. Gothic cathedrals of the medieval period that honoured religion (a major area of life at the time) such as the Chartres Cathedral are analogous to big box stores or strip malls in America to say. While big box stores forego ornamentation, architectural reflection and beauty in favour of being cheap and economical to build and maintain. Thus, this kind of architecture is constructed to allow the consumers to pursue bargains at the lowest price. If religion was a defining feature of the medieval period in Europe, capitalism is a defining characteristic of our society today, and the buildings we create are reflective of these values.

The argument for and against ornament presented by postmodern and gothic architects from the outside can appear to conflict with each other. From a higher perspective, architecture's ultimate goal is to create a useful building that satisfied the society's need at the time. In light of this revelation, both school's thoughts are in agreement in that they utilise different methods to obtain the same goal, which is to benefit the society. Façades on buildings are arguably the only visible outward manifestation of the inner structure. A shopping mall can be a rectangular structure devoid of unique features or personality, but it exists to support consumerist ideals, and it arguably fulfils this function through structural needs. In modern architectural teaching, we often overlook the value these 'decorated sheds' have in defining and supporting the contemporary. 'Bigness' architecture is on trend in America and throughout the world, because these structures allow us to shop, dine and 'consume,' just as the soaring cathedrals of the 18th century allowed the religious to observe and engage in their faith. As this paper will outline, the subject of facades and the role of ornamentation in

architecture is an allegory for the philosophy underlying the schools of architecture and their thoughts on function.

Keywords

Ornament; Façade; Architectural Theory; Functionalism; Post-Modernism

1 INTRODUCTION

Deconstructivism rejects the idea of ornament as an afterthought of decoration, and it cannot be separated from the building's function. In "Bigness, or the Problems of Large," Koolhaas argues that 'bigness' has become a definitive trait of architecture, and total transparency its ideology. These characterless and standardized new buildings we see today emerging into global cityscapes are simply larger than they need to be and have no clear function (Koolhaas 2002). As a nefarious by-product of 'bigness,' 'Junkspace' can be seen everywhere in today's society - shopping malls (Fig.5), highway architectures (Fig.6), and airports (Fig.8) are examples of this particular type of building that devalues architectural contexts. One crucial feature applicable to all 'Junkspace' is the disconnection between its façade and what is inside the building. In other words, the ornamentation process has been completely disconnected with the building's function itself (Koolhaas 1977). For example, in highway retail spaces the omnipresent air-conditioning creates an enclosed building environment that can potentially be reproduced anywhere in the world like a giant Lego Block (Fig.9). The only difference or distinguishable feature of one and another highway architecture is its giant sign (Fig.7) that is attached to the building's façade after the building construction is completed.

2 Value of Space: Bigness V.S. Junk Space

the disconnection between the ornament and the building function does not necessarily produce 'useless' architecture. 'Junkspace' does not always produce useless buildings because it still serves a purpose and role in modern society. Theorists like Jameson supports the argument by saying that changes in space and representation are evidence of shifts in social and economic structure because they can be shown to exhibit the same underlying topic in modern society (the cultural logic of late capitalism in contemporary society). Another argument by Jameson seems to explain the existence of 'Junkspace' in modern architecture. He argues that post-modern commodification of culture itself has anyway removed any possibility of oppositional distance between culture and economic organizations (Jameson 1993). Architecture itself is perhaps the place where these changes are the most visible. 'Junkspace', as mentioned above, and other buildings that come with 'bigness' can be seen as associated with the modification of culture, society, and economics in modern times indeed. These buildings are not 'useless;' they represent the need that citizens and society have upon architecture design.

Koolhaas's critique on 'bigness' is not incorrect, but the discussion of 'bigness' should not just focus on its literal outcome, but also on the reason why this particular space is designed and repeated throughout the world. 'Junkspace' is perhaps not the best architectural design in and of itself. However, the use of it we often see in metropolitan parts of America, for example ornamentations in New York (Fig.10), do exist for more than just functional reasons. Its ornamentation reflects the goals of our modern planet and the commodification nature of contemporary society. Hence, it still serves its architectural purpose.

Figure 1. West façade of Notre Dame de

Chartres Figure 2. Sam's Club façade

Figure 3. Notre Dame de Chartres

Figure 4. Strip mall in Strathmore

Figure 5. Toyota store in Maine

Figure 6. Toyota outlet centre in South Carolina,

Figure 7. Walmart Michigan sign

Figure 8. Lego block

Figure 9. Heathrow airport Figure 10. Façade and Signage in Time square New York

3 Detachment: Duck V.S. Decorated Shed

Robert Venturi and Scott Brown also discuss the detachability of ornament and the building's inside body in the book 'Learning from Las Vegas.' Before starting any argument, it is important to understand both 'duck form' and 'decorated shed' (Fig.11) have taken the idea of 'form follows function' (Venturi, Scott Brown and Izenour 1972). The question does not lie on whether these two types of ornaments have functional purposes or not but on whether the ornamentation can be detached from the building's inside body and instil its meaning. 'Duck form' is a literal extreme outcome when architects only try to reflect the building's intended function. For example, Randy's Donuts shop (Fig.12) in Los Angeles is built with a giant donut on its roof because it sales donut. This is a classic example of a duck form building. While 'decorated shed' agrees with 'form follows function' but emphasis the potential separated process of each. Also 'decorated shed' uses signs to offer a sense of purposefulness of the building. Venturi's building – Guild House (Fig.14) can be seen as a representation of a 'decorated shed' (Brownlee et al. 2001).

Many architects today focus so much on the idea of rejecting explicit symbolism and applique ornament, has distorted the building into one giant ornament itself and produced the ultimate 'duck form building.' As Charles Jencks argues, in substituting 'articulation' for decoration, the building has become a giant duck form itself. Venturi criticize these architects for taking a misguided attempt to design 'duck form' buildings through programmatic and structural expression and has submerged symbolism (Jencks 1991).

In 'Complexity and Contradiction in Architecture,' it is not hard to see what Venturi is criticizing – the extreme outcome of seeking for 'useful' and functionally meaningful ornament (Venturi 2014). In another word, whether an ornament is useful or not does not only depends on whether it is fully attached to or detached from the building's inside. A good example (Fig.13) of how this theory is tested is the 'Vanna Venturi House;' a building he designed wherein the building's outside does not necessarily need to reflect its inside. Attached ornaments can lead to 'duck form' buildings, while detached ornamentation can instil the philosophic complexities of semiology and form perfectly functional and 'useful' buildings.

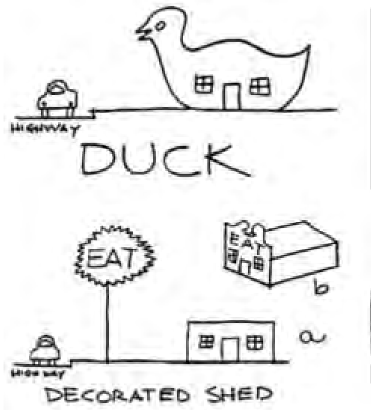

Figure 11. Duck form and decorated shed Figure 12. Randy's donuts façade design

Figure 13. Venturi Guild House Figure 14. Vanna Venturi House

4 Beyond Commodity: The Cultural Importance of Ornament

The impetus behind the functionalist movement was the revolt against superfluous or 'useless' ornament, which doesn't serve any functional purpose (Palmer and Dodson 1996). Arguably ornament outside a gothic cathedral (Fig.15) that is often viewed as the ornament that is detached from its function does have a functional purpose. Paradoxically, gothic style might have been criticized as the example of non-functional ornament that detached itself from the building's inside, but gothic revivalists are the first to give vigorous expression to doctrine and direct it against the useless accretion of ornament at the expense of structure and form. Pugin and his followers as gothic revivalists argue that gothic architectural details are not just an idle surface that stuck over a functional frame. Ruskin further asserts that the single origin of all serious gothic ornament comes from the love of stone and the respects for sound construction, are of identical origin (Pugin 1931). Although theorists do not come to one agreement on whether the ornament of the gothic cathedral is attached or detached from the building's inside, the gothic ornament does have a functional purpose like what Pugin and Ruskin argue (Ruskin 1979).

Gothic theorists have also already argued that in the context of the 1800s the difference between gothic style and classical style is not a matter of merely the structural veneer rather than architectural, social and cultural achievement. In the book 'The Stone of Venice,' Ruskin argues that Pugin demonstrates how the ornamental and stylistic details of Gothic architecture is inevitably developments from structural and social needs at the time (Ruskin 1979). The satisfaction of the social needs at the time indeed made gothic ornament not 'useless,' regardless whether if the ornamentation process is attached or detached from its building process.

In considering the value of ornamentation in architecture, one must reflect on Adolf Loos' essay "Ornament and Crime." This essay is one of the most harsh condemnations of ornamentation, wherein he asserts that whether regarding economics, aesthetics or socio-culture, ornamentation is a criminal behavior and will trigger devolvement of humankind (Loos and Opel 1997). Given the influential European bourgeoisie was promoting the simplicity of form at that time of Loos' writing, the motive behind Loos' assertion that ornamentation is a crime is not hard to understand. However, Loos' theory has been eloquently revoked by many theorists such as Joseph Rykwert, who wrote "Ornament is No Crime" in order to question and refute Loos' proclamation (Rykwert 1975). From the discussion above, it is evident that throughout the development of western architecture, facades and structural volumes articulate all kinds of ornaments. The articulation of ornaments embeds religious and social meanings, which fulfills its metaphysical, existential value.

Figure 15. Milan Cathedral gothic façade

5 Summary

In summary, Koolhaas rejects purposeless ornamentation and junk space and 'Bigness' because they strip a building of its identity, while Venturi is at peace with 'decorated shed' because it allows consumers of the building to identify its intended purpose through signs. Both architects prioritize function over needless decoration, but Venturi argues that ornament can be separate from the building itself and still be meaningful like the attached ones. On the other side of the architectural semantic schools of thought, adherents of Gothic architecture arguably have been seen with having the trace of both attached and detached ornamentation. Without the need to define whether it is only attached or detached ornament, it is useful ornamentation that response to people's functional, social and cultural needs at the time. Without looking at the topic from a larger perspective, both detached and attached ornamentation may seem to be in conflict with each other. With further examination, both types of ornaments reflect the meaning of architecture that is to design for the people and their need, and thus both styles of ornamentation are useful.

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01.114 - TRANSFORMATION FOR BECOMING SPACE OR PLACE: CASE OF GALATA BRIDGE

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Abstract

Bridges are the structures which serve as a transition in urban area that creates social interactivity between two locations. These architectural pieces, which do not belong to these two locations, have their own societal process transforming in time. This societal process affected by events that are important dynamics of discussing spatiality.

The aim of the study is to discuss creating spatiality in a transition. For this study, Galata Bridge in İstanbul, Turkey, which was built in 1845 and renovated several times, is chosen as a case study in terms of its historical value. Galata Bridge is analyzed within the literature considering its spatial process chronologically in order to discuss how events affect the process of spatiality, and also spatial identity. Analyses demonstrate that there are two types of space formations, which effects the creation of spatial identity of the Galata Bridge during the history. As a result of this study, two types of space formations of Galata Bridge describe in terms of the dynamics that generate a space.

Keywords

spatiality, Galata Bridge, spatial identity, urban space.

1 INTRODUCTION

Bridges are the structures which serve as transitional space in urban areas that create social interactivity between two locations. These architectural pieces, which do not belong to these two locations, have their own societal process transforming in time. This societal process is affected by events that are important dynamics of discussing spatiality. The bridge thus makes a place come into presence, at the same time as its elements emerge as what they are. [1].

İstanbul, the older name is Constantinople, was settled and developed around on Golden Horn, which is a valuable site consisting of diverse cultural layers that starts from antique age to today. Galata, which is a Genoa settlement and has all architectural components which a Roman city must have, had a side on Golden Horn [2]. Furthermore, these two regions faced each other are important because of their position that they had high economic activities as being trade centers on Golden Horn. This value makes essence of the connection between two sides of Golden Horn more considerable in terms of building spatiality in time.

The aim of the study is to discuss formation of spatiality in a transitional space by means of bridge's phenomenological potential. For this study, Galata Bridge in İstanbul, Turkey, which was built in 1845 and renovated several times, is chosen as a case study in terms of its historical value. Galata Bridge is analyzed within the literature considering its spatial process chronologically in order to discuss how events affect the process of spatiality and also spatial identity. Analyses demonstrate that there are two types of space formation that affect the creation of spatial identity of the Galata Bridge during history. As a result of this study, two types of space formations of Galata Bridge describe in terms of the dynamics that generate a space.

2 Spatiality in a Public Transition Places

Transitional spaces are the locations, where the state of being interactive happen lowest degree because of their purpose in urban area. Place and space making process in transition spaces might change according to the features of where built a transition. Thus, formation of space in transition spaces is open to discussion depending on the interaction between participant and place where human located in time.

Urban space does not have only one subject; it has a collective discourse accommodating common uses that includes many subjects interacting with each other. Killian (1998) approaches the public space as a site for impersonal contact and representation. At this point, a societal production arises for constructing a spatial characteristic [3]. Berber (2011) interprets that Lefebvre's idea of space is a product of human and social reality beyond being a form and stage, and is a dynamic, full of contradictory and conflict social product that can be shaped and shape it [4]. In this sense, a society is responsible for shaping the urban space.

According to Hiller and Hanson (1984; p. 26-27), space is defined by two senses which space arranges people in a space locating them by creating variable degrees in relation to each other and arranges itself by physical components in order to define a pattern of society [5]. Society is not only contributors for occurring space, but also other events triggered formation of society by politics, interventions, and disasters are associated with space. Density degrees of which these events encounter built the space. At this point, cultural attributes step into the subject of defining a space. Also Lefebvre explains the problematic of space that "the social relationships that obtained previously still obtain; the new problem is, precisely, the problem of their reproduction." [6]

Furthermore, space is estimated by many layers which are intertwined with each other. For this reason, transitional space has relativity in accordance with this approach and has an interaction with surroundings in terms of different dimensions such as politic, social, economic, and psychological. In urban areas, collective attributes generate conflicted variety in layers that frame a space. On the other hand, collectivity in society is not enough for accommodating in space. Personal experiences are also essential for defining a space. Sharr (2010) is assumed that Heidegger argues the distinction between space and place while claiming space can not only realize analytical without a human experience [7]. In this sense, places include special experiences realized by human's body in space. Transitional space is a product of a social space that is a permanent process.

A transitional area in an urban space increases its spatiality as human experiences are increased. At the same time, bodily experiences consisting internalized three levels of space, that Lefebvre was claimed, in space contribute the identity of space due to mass spatial practice. Place thus is allowed to construct in dweller's mind.

3 Transformation of Galata Bridge

Golden Horn, in İstanbul, hosts fluidity in terms of spatial transformation and the societal structure of the historical peninsula that went back to antique times. Revolutions beginning from 1808 transformed the Ottoman architectural style impressing European municipality politics and principles of 19th century Western urban planning style [2, 8]. Development of industrial technology causes the involvement of transportation systems in İstanbul. Construction of buildings in İstanbul city is characterized by the fire that the city faces. This situation caused the renewal of the buildings.

The first touch between two sides of the Golden Horn was settled by Cisr-i Atik Bridge between the Azapkapı and Unkapanı in order to ease the transportation of Mahmud II (1808-1839) [2, 9]. This attempt shows the necessity of a creating physical connection between the two sides of Golden Horn. Galata Bridge is a product of Tanzimat Period that is an indication of modernization movements in Ottoman. At that time, the integration of new technologies that westernization movement possessed in the Ottoman urban life, and by following these efforts changes of urban face became visible. Galata Bridge, one of the westernization results, had influence upon the transformation of the society. Today, theses contributions are placed a part of urban history. Furthermore, Galata Bridge became a part of the urban myth and named the region [9]. For this reason, Galata Bridge is valuable in order to argue spatiality since it has built several times. In this chapter, brief history of Galata is analyzed and then the process of space making of Galata Bridge is described.

3.1 An Analyzed History of Galata Bridge

In the 19th century, Ottoman Empire gave a start for westernization because of the developments lived in west in terms of social, technological and economical. Transportation is one of the important notions in city life to consider in these developments.

Eminönü and Karaköy that are placed opposite sides of Golden Horn facing each other are two important trade centers in İstanbul. In 1845, the first connection between Eminönü and Karaköy appeared by the attempt of Bezm-i Alem Valide Sultan, the mother of Mahmut II (Figure 1) [2, 9]. This first Galata Bridge gave a way to unite two different cultural differences [9]. This attempt has demonstrated the need to create a physical connection between two cities since the rise in the population of Karaköy due to Karaköy became a trade center after 1838. Bridge was not only a symbol of the connection between the European and traditional vibes, and also connected two landmarks to each other physically [9]. These two points became a busy realm affected by the water transportation and railroads in the westernization process. Galata Bridge started its influence on the process of cultural transition between two sides of the Golden Horn [9].

Figure 1. First Galata Bridge in 1845 [9]

In 1863, Galata Bridge was re-built wider and more ostentatious because of concerns about respectable appearance for important guests [2]. After the first bridge, this new one was the evidence of the need that there must be a link between Karaköy and Eminönü. The third Galata Bridge, which was built by a British company in 1878, demonstrates that western architectural approaches were blended with Ottoman architectural style (Figure 2)[2]. It had two floors including shops, restaurants and coffeehouse and allowed the passage of sea traffic by opening in the middle. At the end of 19th century, the technological developments in transportation began integrating to design decisions of Galata Bridge which considered vehicular roads, easing sea traffic. These contributions increased the population activity between two trade center, Eminönü and Karaköy, where population was arisen in those region [2,8].

Figure 2. Galata Bridge built in 1890 (source: Mihran Iranian)

In 1912, the fourth Galata Bridge was built by a German company with a tramline depending on developments on transportation (Figure 3) [2, 8]. This steel structured bridge was renovated several times and used until the fire in 1992. This bridge that served as harbor for ferry transportation on the first floor had two stories. On the first floor, public spaces such as coffeehouses and restaurant were placed. Until the fire happened in 1992, Galata Bridge became a symbol on Golden Horn, and the existence of it cannot be denied. New spaces added in time were successful being a part of city life beyond a transition space. All renovations and repairs evolved the bridge into space-making discussion. This bridge is now a part of the city, and has become a gathering space for people. Novels, poets and songs have the words of the Galata Bridge as a representative of the ritual of the city [10, 11]

Figure 3. Galata Bridge (1912)

After the fire in 1992, a bascule bridge was built on the north side of the old one in 1994 (Figure 4) [9]. This bridge, which has a tramline, is wider than the previous one. Top level of the bridge has transportation services and the bottom level of the bridge has restaurants like the previous one. These spaces, which can create a social environment and use it to turn the bridge into a 'place', are the result of a different social formation than the 1912 bridge.

Figure 4. Galata Bridge (source: https://www.britannica.com/place/Istanbul/images-videos#/media/1/296962/138439)

3.2 Space Formations of Galata Bridge

According to history of Galata Bridge, fire happened in 1992 is a critical event in spatial process of Galata Bridge (Figure 5). Before the fire, space was constructed on previous form of bridge permanently. However, fire causes a new spatial form of Galata Bridge though it has same functions except demolished memorized spaces.

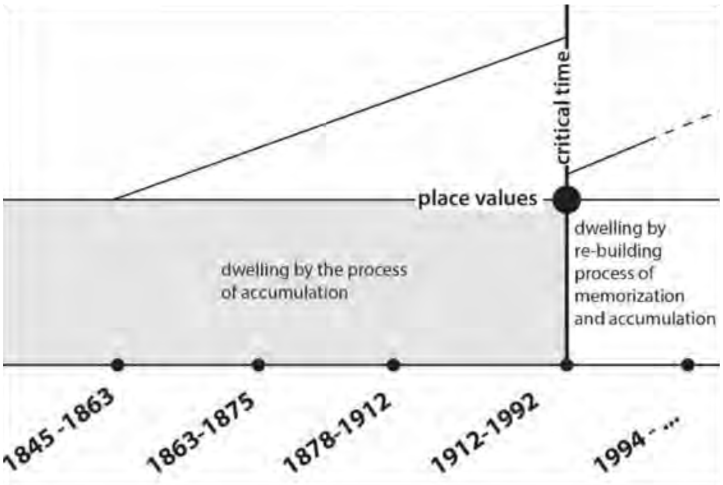

Figure 5. Milestones of Galata Bridge

Analyzed history of Galata Bridge demonstrates that the bridge has gradually collected new functions which allow new attributes experienced by human (Figure 6). Expansion of bridge forces the social formation on bridge due to interpenetration of spaces. Repetition of the realization of a bridge structure between Karaköy and Eminönü proves that there is a development of the social space. The Last Galata Bridge has similar layers like the layers of the previous one. On the other hand, there is a break in time in terms of the use type of the bridge. Galata Bridge dissolves the notions of different cultures while making a connection between the Karaköy and Eminönü. In 1994, Galata Bridge served as a social structure of a group which was blended with present. Homogeneity of social structure establishes a new unique cultural form end of the 20th century. All social processes, whatever their abstract and conceptual nature, are recognized in space [12]. The phase until critical event is gathering materiality for place-making. Thus an identity is generated in spaces of Galata Bridge.

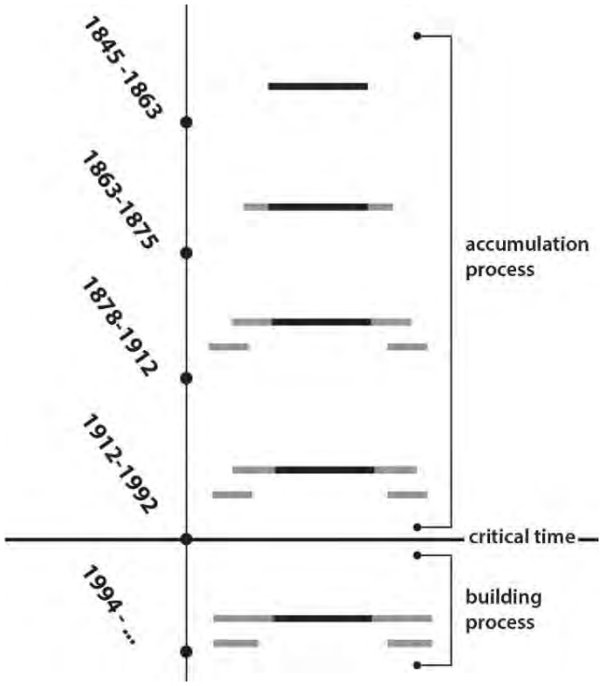

Figure 6. Layers in spatial formation of Galata Bridge

Spatial situation of Galata Bridge for today describes in different terms. Ertaş (2010) defines Galata Bridge as an *unprogrammed* space that is flexible and open to change and transformation [13]. Citizens might privatize the space themselves in order to enable themselves to develop a feeling of belonging to place within which they live by means of encouraging heterogeneity [13]. Özdamar (2019) stresses that Galata Bridge gathers multi-layered *polyvalent* form that space can be structured [11]. Layers were overlapped denser since the memorization was increased until 1992.

Galata Bridge became an essence of Golden Horn with irrecusably position providing an *intertwinement* between Karaköy and Eminönü. Although it sustains the connection permanently, accumulation of narrative was lost after a disaster event, and space production started re-building again in 1994.

4 Conclusion

Galata has a historical value which consists of a societal formation continously. In first action to materialize a connection between Eminönü and Karaköy does not include variable human activity. Becoming a 'place' has a fragile effect because of inefficient human lived experiences; however continuous accumulation of spatial knowledge of the Galata Bridge intensifies the spatial identity by means of substantiation with its phenomenological presence.

Process of space formation is related with the actions that affect the identity of space. As a result of this study, although quality of being 'place' is increased in space, the action of a disaster cuts off the physical activity intertwinement though it is high the 'place' quality of space.

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01.115 - INSTITUTIONAL PUBLIC SPACE:
THE FORMATION OF PUBLIC SPACE AT CULTURAL BUILDINGS

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Abstract

Public space has always been a contested subject, in terms of who it belongs to and how it is occupied. At the cultural buildings, it is amplified with the problem of commodification in the arts and culture sector. This paper defines the *Institutional Public Space* to look at the intersection of these two topics. It is a type of public space that is created by and representing institutional intention instead of natural occurrence, yet frequently it is perceived or used quite differently than intended.

Cultural Institutions nowadays can no longer be simply defined as public or private… The paper examine the oscillating position of cultural institutions between public and commercial interest through reviewing the space at key cultural buildings. The study demonstrates how physical space acts as a vehicle to manifest institutional intention and position. What could be the opportunity for cultural institutions to maintain or enhance their social value through the creation of public space?

While most studies on cultural architecture focus on aesthetic or semiotic representation, this paper takes an approach to analyse socio-spatial relationship through architectural drawings, particularly in plans, to focus on the inhabited space where social activities happen. The findings explain the formation of public space and its relationship to cultural institutions, along with a brief narrative of Hong Kong's cultural development, to conclude with a projection to explore the future of cultural institutions and the public space it will produce.

Keywords

Public Space, Cultural Buildings, Cultural Commodification, Public Sphere, Plan Analysis

1 INTRODUCTION: WHAT IS INSTITUTIONAL PUBLIC SPACE?

Public space has a common understanding in everyday life, such as the street, park and plaza, to the hotel lobby or commercial establishment, as places where everyone could go and enjoy. However, the actual spatial practice is more complicated, just as it reflects the complexity of urban life. Among the spectrum of public space types, there is a particular kind that was created with strong institutional intention, supposed to be public yet highly controlled. The public space at the cultural buildings (museums or theatres) falls into this category, which could be defined as “Institutional Public Space”, and this paper will investigate the formation of the institutional public space and its significance for contemporary cultural institutions.

1.1 The classic dichotomy

In the public space discourse, there was always a clear distinction in the realm of public versus private. Before modern-day metropolis life, *private* was understood as the protected domestic realm with family and friends, while *public* is open and vulnerable with acquaintances and strangers. The contemporary idea of public space emerges in cosmopolitan cities around the 19th century, with places such as promenades or coffee houses as the site where people (strangers) gather and discuss public affairs [1]. This renders the political nature of public spaces in contrast to the personal private space.

Into the 20th century, the modern metropolis thinking is replaced by postmodern concepts as an effect of late-capitalism, where it is in service for the market and bypassed the critical question [2]. In this context, the private space is being interpreted as individual rights, in particular property rights, and the discourse on public space is shifting from the political public versus domestic private, to the social public against capitalistic private.

1.2 The struggle of public space

Under the premise of postmodern late-capitalism, urban geographer Don Mitchell proclaims “the end of public space” as it became homogenised in serving the private capital [3]. He states that public space should be where the collective public can claim ownership to appropriate, and this renewed perspective in social concern led to the question of the right to the city, especially during the 1960s and 70s. The contestation of public space can be read through cases where order and control is exerted by the state or the capital (the private interest) against vulnerable individuals (the public), such as the homeless or the political activists. This struggle of public space is particularly apparent for the cultural institution. Although it proclaims to be open to all, yet there is a need to maintain order and control in similar fashion as a commercial venue. As Mitchell describe the exclusion of marginalised groups, the exclusion in the commodified cultural spaces extends to the non-consuming public.

1.3 The blurred boundary

In late-capitalistic neoliberal society, cultural institutions can no longer rely on state support as the role of government diminishes and give way to the free market [4]. Social provision, including that of arts and culture, is gradually transferred to the private sector and as personal responsibility. This is the context where cultural institution began to look into potentials of commercial operations. With the success in generating both funding and audience, since then every significant cultural institution has a commercial operations team.

While there would still be critique to the institution's integrity for public interest, yet at the contemporary cultural venues, the boundary of public/private can no longer be clearly defined. The public space at the cultural venue therefore possess characteristics of open public spaces that is free and accessible, yet in operation similar to commercial spaces that emphasis order and control. The inter-related and overlapping ideas make the distinction of Public and Private deem less important, with the focus shifting into the sociability of these cultural spaces.

2 The social role of cultural institutions and its public space

The hypothesis of institutional public space recognises the cultural institution's capacity influence the production of its public space, and therefore playing a crucial social role in contemporary urban life. To unpack the conceptual relations of cultural space and its public character would be fundamental for further investigation. In this paper, "cultural space" is defined as the freely-accessible area associated with cultural buildings, including both exterior and interior space, and broadly accounting for a range of venues where arts and cultural activities take place.

2.1 Cultural space as discursive platform

Cultural institutions are constantly contributing to the public discourse, both with the artistic work it showcases and as the site of debate and discussion. The discursive nature makes it essentially political and public, with a role to allow and encourage social interaction. The concept of public space in physicality is the "actually-existing space" [3] where the discursive public acts happen. For example, the theatre foyer is where audience would linger for conversation where the cultural event provides the occasion and topic. Although more discursive activities happens through social media nowadays, the physical presence and experience is not replaceable. This overlap of event and space gives a special quality to the cultural public space, where the cultural content carries an additional layer of meaning. The public space is therefore not only the site where people gather but there is a common cause that brings them together.

2.2 Cultural space as counter-balance to capitalism

The cultural space also plays a significant social role against the private capital. While the distinction of public or private is no longer definitive, the cultural institution still maintain a clear public role in contrast to commercial establishments. Different than other public institutions such as schools or hospitals, the cultural institution is in a position to mitigate and negotiate through its flexibility in its form and representation, with an opportunity to count-balance the effects of pure capitalistic operation.

The institutional public space is where cultural institutions express its vision and mission. Particularly the admission-free area, namely the lobby and the surrounding open area, enjoy qualities of a public park while facing challenges of the lucrative potential to use it for commercial gain. Rem Koolhaas has written extensively about the phenomenon of shopping and how it has spread to every aspect of urban life, including that the cultural institutions [5]. The MoMA Design Store is a most prominent case that the Museum of Modern Art in New York has a reputation in retail almost more than a public museum [6]. There are critiques at the cultural institution’s commercial operation at cultural institutions for their public-ness has been sacrificed for economic gain, while the proponents welcome that arts became more popular for the mass. However, the potential social benefits of market-minded cultural institutions has not been sufficiently explored. If we begin to see public and private not as a dichotomy but symbiotic relationship, what are the opportunities for the next generation cultural institutions and what type of public space would result?

3 The evolution of cultural public space

There are two significant roles of cultural institution in the public space discourse, which are the representation of the public, and as the site where public life happens. Institutions such as museums or theatres have become a crucial platform for social life and it is practiced through not only their curatorial activities but also the inhabited public space. Reflecting the institution’s direction, these spaces can be supportive of inclusive social and cultural participation, or it can become exclusive and effectively a tool for capitalistic gain. Most of the time they are somewhere in-between. A review of cultural space development reveals the forces of private and public interest at different time, serving as the context to discuss the role of contemporary cultural institutions.

3.1 Culture for public goods — Common Public Space

The idea of public cultural institutions was formed around the time of Enlightenment, evolved from the private collection to public display. As a mode of knowledge dissimilation, it later became the institution of museum [7]. Around the same time, the proliferation of Victorian theatres with public ticket sales in relatively affordable price also marked the transformation of theatre from an exclusive activity into popular entertainment [8]. Museum atriums and theatre foyers then became important public spaces where people meet and socialise, as a “common” space that can be seen as the foundation of the discursive public and democratic society.

3.2 Neoliberal turn of cultural institutions — Privatised Public Space

Around the 1980s, global economy and politics began to adopt a neoliberal turn. Emphasis on individuality, postmodern society is characterised by heterogeneity, with an optimistic note that it can lead to a more diverse and democratic culture [2]. However, the traditional socialist understanding of arts and culture has moved away from public goods into the enjoyment and cultural "lifestyle" for economic gain. Most cultural institutions during this period has a certain degree of commercial operation, where the public space is once again exclusive to potential consumers instead of the larger public. For example, the Lincoln Centre in New York was conceived as part of an urban regeneration plan in cooperation with real estate developer. The process of building the prestigious cultural complex has expelled original residents and excluded many in the neighbourhood.

3.3 Cultural institutions for the community — Social Public Space

The contestation of private and public interest complicates the position of cultural institutions in the late-20th century, and its public space became an indicator or manifesto of such position. After the global social movements in the 1960s and 70s, cultural institutions began to reconsider their position and role in the community. Opened in 1977, the Centre Pompidou in Paris was the forefront of a new generation of cultural institutions. It adopted a design scheme that is characterised by openness and flexibility, planned half the site for a public piazza connecting to a transparent and accessible ground level [9]. The public space at the Centre Pompidou encourages everyday activities for residents and attracted millions of local and international visitors every year. It is a manifesto of the new cultural institution that emphasises on social engagement and contributes to the urban surrounding, which has become a trend followed by many new or reformed cultural institutions in the 21st century.

The development of cultural institutions did not follow a linear fashion that goes from public to private or vice-versa. While architecture itself is static, the resulting public space can change over time in response to different social conditions. As public space quality and social inclusion has became key concerns of the institution, the Lincoln Centre has recently completed a significant public realm redesign by architects Diller & Scofido. The elitist cultural complex has opened up its space to engage the surrounding community with new concept in the use of it public space through innovation in design and programming [10]. Meanwhile, after the 911 events there is a heightened sense of security in public space, and the Pompidou Centre atrium and façade escalator is no longer freely accessible but guarded by a series of security check points. In one way or another, for the next generation of cultural institution, public space will be the protagonist instead of residual space around the gallery or atrium. It is no longer only the passing or waiting space and extends across the building threshold, with a renewed attention for the idea of public realm not strictly defined.

4 The trajectory of Hong Kong cultural public space

In the case of Hong Kong, cultural institutions were never purely public welfare or commercial operation. The prevalence of popular culture and entertainment industry over high culture also reflected the two-fold problem of cultural development in Hong Kong. There was never a proper public cultural policy in place, while the private sector culture industry proliferate for economic gain without specific social responsibility. The development of cultural public spaces in the city could reveal the interplay of these forces, between cultural commodification and social concern.

In the 1960s, there was a number of public cultural buildings constructed, as the post-war British government saw cultural provision as one of the effective ways to manage the colony and its citizen. Meanwhile, the corporate-like operation of current cultural institutions, such as the West Kowloon Cultural District (WKCD), can be seen as a contrasting view and direction. What were the events and social conditions that contribute to this transformation? Into the last decades of the 20th century, Hong Kong began to gain its own identity while growing into a capitalistic metropolis. Following the experience of western capitalistic societies, a thriving cultural scene usually accompany economic growth. Hong Kong has also seen a brief renaissance in cultural development during that period, with key cultural buildings built by both the government as well as the civil society (artist community). To focus at this particular period can suggest how the city was responding to the issue of commodification, in order to understand the current situation and project into the future of cultural sector.

4.1 The 1980s formation of the local identity

Responsible for the city's public affairs including leisure and culture, the then Urban and Regional Councils have built dozens of cultural buildings in form of Town Halls, Civic Centres and Theatres throughout the territory in the 1970s and 80s. The local identity has gradually built up as the city began to prosper and in need of a local cultural landmark, leading to the conception of a new cultural complex in 1974 at the site of the old Canton railway station. This is the first major public cultural building designed by a local architect, Jose Lei, with a design adopting a non-descriptive international style that suits the purpose of reduce colonial symbolism and forward-looking to be among the ranks of international cities [11].

Breaking away from the typical spatial organisation of colonial architecture, the Cultural Centre does not have a formal or hierarchical arrival sequence, where the masterplan caters to multiple approaches and connected to the urban streets and waterfront promenade. A circulation diagram at concept stage has shown the interior foyer designed as the central collection point, connecting internally to the grand theatre and the concert hall, and externally to the waterfront plaza and the passage that links the Art Museum and the Space Museum. It is open and accessible from both north and south with multiple entrances, the foyer of the Cultural Centre is thoroughly public and integrated into the urban fabric. This could be a reflection of the young cultural institution eager to express a new urban vision for the energetic and growing city. However, with conservation governmental operation, the public space at the Cultural Centre remains rather static in spite of its once forward-thinking design. It lacks the vision and artistic direction required for a world-city cultural institution, and being reduced to bureaucratic operations with a mind-set of order and control, which is striking a sharp contrast with the nearby art-themed commercial space, the K11 Art Mall, or the city's latest cultural development, the West Kowloon Cultural District.

4.2 The post-1997 Neoliberal turn

The Hong Kong Cultural Centre complex is the last large-scale cultural project built by the colonial government. In the decade following the 1997 hand-over, only two public regional theatres and the Central Library were built with mediocre public reception. The post-1997 transitional government had a weak cultural vision and remained a passive role with smaller projects, while the arts and culture sector in civil society has become more developed and proactive. Since 2000, key cultural projects are mostly funded and operated by semi-public organisations or the private sector, where these new institutions would have more liberty in terms of development and operation. However, these new cultural projects, for example the PMQ or Tai Kwun, are essentially mixed-use development with some cultural components such as gallery or performance space, and a significant portion of floor area is reserved for commercial outlets such as retail and restaurants. As cultural institutions they pronounce to be public, yet the public space created recalls more resemblance to shopping malls and audience is regarded as consumers, which fits into the neoliberal rhetoric of market force and privatisation of social and cultural provision.

The cultural development discussion has since aligned with economic output instead of social outcome, and even government departments adopted this perspective. While considering public cultural space as part of the urban development strategy, the focal point falls on tourism revenue and real estate value. This was the background of the new cultural district development in initiated in the late 1990s. After public disapproval of the initial developer-led consortium proposals, the current West Kowloon Cultural District (WKCD) project is a restart in 2008, with more communication with the local artistic community and supposedly to nurture local growth in the cultural sector. Instead of a public-private-partnership model, the project is operated through a statutory body, the West Kowloon Cultural District Authority (WKCDA). Independent from the state bureaucratic system, although initially funded by Government endowment, it has a corporation with its own financial responsibility. As a result, its operation is inevitably capitalistic. The masterplan designed by Norman Foster is pragmatic with a straight-forward vision for arts and culture, but in substance it follows the typical development logic that emphasises maximise land utilisation. Approximately half the land plots are allocated for commercial use, in addition to the adjacent luxury apartments, offices, hotels and shopping centres that have already been built and sold since 2007.

The Xiqu (Chinese Opera) Centre, the first WKCD project opened in 2018, can be an example of this dilemma between market force and public (cultural) vision. The open atrium is the most prominent cultural public space, as the architect describes it as a celebrated plaza, resulting from an innovative strategy to lift the auditorium 24m above ground. In plan, the thoroughly open ground floor space appears to be connecting the city and the future district with ample open area for public leisure activities. While the design strategy aims to creates an open public space with no gates, the actual space has a number of design barriers in reality. In addition, surrounding the atrium it has a significant amount of floor area allocated to shops and restaurants that is planned for a greater capacity beyond the expected audience, with the main circulation and storefronts reminding visitors of a shopping centre where all paths lead to consumption. This is perhaps necessary to maintain the high operating cost of the Centre, and it could perhaps bring benefit to increase cultural visitation, however, it will require careful monitoring to not fall into pure commodification. Established in 2008, the WKCDA is a relatively young institution, without a strong initiative in the beginning, it has inherited the traditional exclusiveness and a market-oriented mind-set typical of the cultural sector in the city. In the future, there could be more opportunities for the project to succeed in social engagement or commercial operation. The relationship between the institution and the public manifested through its space should be a key topic of investigation as more projects are currently under construction, asking the question about the social responsibilities of these soon-opening cultural institutions.

5 Discussion: What is the future Institutional Public Space?

What makes cultural public space works? This paper argues that cultural institutions play a decisive role in the formation of its public space, through design influence and spatial management. The evolution of cultural public space reflects the social significance of cultural institutions and how they contribute to a democratic society. The brief account on cultural development in Hong Kong shows the different phases of governance and direction of cultural institutions. What could be the future model for cultural institution and what kind of public space it would produce? The architect's design strategy reflects the vision of the cultural institution, yet design alone is not enough to create effective public space without the collaboration of institutional stakeholder. The institution plays a major role in the production of its public space, it is their responsibility to understand the needs of the public that it proclaims to serve and translate it into the design and operation of public space.

5.1 The Third Way for Cultural Institutions

This review of cultural buildings and their public space has shown its oscillating position between private and public space throughout the last century, and currently facing the issue of privatisation/commercialisation under the neoliberal rhetoric. However, it is not longer a simplistic opposition in contemporary society, there is a equally strong force of concern in social issues at the cultural public space. While it is not realistic to return to the reliance of state welfare or royal patronage, as a way forward we should seek a healthy collaboration and balance in culture and commerce. The value and position of cultural institutions will inevitably be the battlefield of contestation, and spatially it could be seen in both the of commodification of cultural space, or the “culturalisation” of commercial space.

The idea of “Third Way” is taken from the field of political science during the 1990s British “New Labour” governance. It denotes a potential way forward for the role of the state in the face of capitalistic force, but emphasis on the citizen responsibility in a reciprocal relationship [12]. Culture as a social right could be seen as a common enterprise with contribution from both the institution and the public. Through the practice of public space, it is a process of civil engagement and education. The contestation of private and public interest could be turned into an opportunity of collaboration, where the cultural institutions plays the role of both public and private sector. While the operation achieve financial sustainability through commercial operations, it could in the same time provide for community benefit. The path towards this goal would be a process of constructive discourse, and the inter-dependent relationship between culture and commerce should be recognised.

Since the global financial crisis in 2008, questions towards capitalistic operation of social provision has raised a new level of concern, and many are seeking alternatives for a more balanced model. This will be an inevitable question for the new and established cultural institutions in the coming years. While top-down institutional intention was imprinted in the public space, is there a possibility for the users to re-appropriate it for alternative social purpose other than those prescribed? The public space at cultural buildings would be the stage to reflect these changing intentions and needs.

5.2 Renewal in cultural institution for post-social movement Hong Kong

In 2019, Hong Kong has seen the largest social movement the city has ever experienced, and these are precisely the occasion when citizens exercise their right to public space. The cultural places have their symbolic meaning as well as spatial function for protest activities to take place, which appear to be quite different than the intended use as designed by the institution. How could cultural institutions react and will the post-social movement Hong Kong calls for a renewal in cultural institution? Can the purpose-built institutional public space be flexible or adaptable to unexpected activities? The case for Hong Kong’s social movement has seen extraordinary use of public space, and the cultural places have become public landmark for remembrance. The study on institutional public space serves as a foundation to further explore the interplay between cultures institutions and the space and activities, which renders more urgency at this time of (radical) civil response to institutional powers.

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01.116 - LEARNING FROM THE STREETSCAPE IN RESILIENT VILLAGES
STUDY ON THE PUBLIC SPACE SETTING IN THE GREATER BAY AREA IN CHINA

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Abstract

Megacity of the Greater Bay area in China, combined nine cities in Guangdong province, Hong Kong and Macau S.A.R, becomes one of the largest metropolis and city cluster in the world. The relentless urban sprawl has been pushing the rural lands and villages into a self-reflecting condition. The resilient villages, except for the vanishing ones in majority, start to reshape themselves, fighting to survive and adapt. Streetscape, identified as one of the most significant space type, is a reciprocal public setting with village life and adaptation to the contemporary condition. The objective of this paper, through an anthropological lens, dissect the spatial quality of the streetscape in the resilient villages, and discuss the setting of public space in compare to the urban condition in the megacity.

What relentless sprawl of the megacity brings to the village, are various in economy, tourism, gentrification, planning and beyond. Streetscape in resilient village represents both a bottom-up primitive village life and its response to the environment. Physically, it includes streets, street-front space, public space, architecture add-ons, and vernacular structures. Psychologically, it contains everyday life, the spontaneous, communities and collective memory. On the contrary, the setting of public space in the urban context is rather simple and smooth, with enormous scale of roads and piazzas. Street is disappeared. Understanding the primitive way to construct space, here is what we should learn from the streetscape in resilient villages.

To examine the streetscape, it is essential to index each space in practical cases, with parameters on scale, relation with streets, function, ownership, architectural elements, and use of time etc. The analytical cross-reference will provide supportive evidence that determines the essence of how they become resilient and adaptive. Space is made for people, which the confrontation between the megacity and villages constantly overlooked. The resilience, lying in the reforming streetscape, proves the value of it and shall serve as beneficial approach in constructing the setting of public space.

Keywords

Streetscape, Resilient village, Reciprocal, Public space, Megacity

1 INTRODUCTION

Architecture is narcissistic. The ego of architecture prevents themselves from communicating with the environment, which are encouraged to do so. Cities are filled with these architectures. Megacity, like the Greater Bay area in China, relentlessly pushes the margin of urbanization and unified architecture eliminates the sense of scale, material, lives and atmosphere. The autonomy of design has alienated the architecture from daily life and ordinary people. If we include the residents and passersby in the community to the conversation, the focus will be drastically different. They would rather talk about what is the market, what happened in the community, how vibrant is the street. It is not to say they are careless on architecture, but in the forest of concrete, people tend to be affectionate on those are proximate to their lives.

Streetscape, on the other hand, is humble and modest. There is nothing as building a street. Streets are initiated by designated path walked by people. The external boundary is constituted by architecture facades. Space are residual threshold and different forms of public occupations. Streetscape is so humbled that it takes the leftovers of the all the aggressive erections. However, it is the place where people live and experience every day. Megacity is turning streets into roads, for the high efficiency of traffic. Street life is getting wiped out in the city and the public space are no longer for the experience of citizen, piazza for events, grand stairs for gesture, etc. Space are destinations, the else are all routes. Thousands of people step on the several hundred square meter granite piazza every day before entering the skyscraper, but yet, nothing happens. Life, is disappeared.

Allan Jacob has once documented the great streets in the world. The qualities and criteria in a great streets reside in the people activity and experience [1]. Cross-examining these qualities and criteria in today's megacity in the Greater Bay area in China, it is not difficult to uncover that they are actually more leaning towards the streetscape in the villages, rather than the city. The relentless sprawl of the megacity city cost huge sacrifice of the rural villages. Numerous of them has vanished. The rest in minority, under the radiation of the megacity urbanization, demonstrate a resilient status. Land policy [2] in the rural village of China prevents excessive exploit on the land and properties of the villagers. If any responsive action or counter action in the resilient village can ever occur, street is the first to react and revive. Therefore, recognizing the streetscape in the resilient village is the significant in studying the public space setting in the megacity of the Greater Bay area in China.

2 Decline of Streets in Cities

Street has been a system of transportation and connectivity for a long time, from the Wai Guo city (外郭城) in the Tang dynasty in China (Fig.2) to the Streets in Bologna in Italy (Fig.2) and the Las Vegas Strip in United States. Street functions not only as a carrier of commuting and accessibility, but also a mediation of every life. The Greater Bay Area in China has surpassed Tokyo bay in 2013 and became the largest city clusters in world [3]. The rapid and relentless urbanization replaces the streets with roads and transfer the matter to a planning obligation. The inability of design intervention fails to stop the decline of the street against the unified megacity. The main roads with sixteen lanes, tree pools with over 10 meters sectional width, smooth public plaza, etc. All these over-scaled urban subjects severely endanger traditional streets within their fights with vehicle-dominated road network. Like The past glory shading on people's everyday street life is vanishing and this imbalanced fight put walking experience in the megacity into a crisis of disorder.

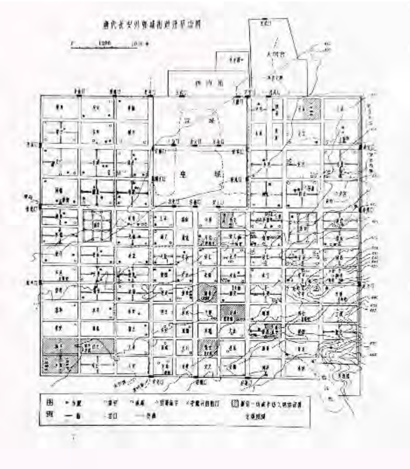

Figure 14. (left): Street map in Wai Guo city in the Tang dynasty, China [4]

Figure 2. (Right): The monumental street crossing of Bologna's Arco del Meloncello, Italy

2.1 Towards an over-scale

The megacity sprawl has ruthlessly swallowed the villages failed to become resilient. Da Chong village (大冲村), located in the city of Shenzhen, is one of them. Adjacent to Shen Nan Boulevard, one of the most significant road in the city, the village was taken over by more than 4.5 billion USD and transform to urban programs. Less than five years, the village was wiped out with one left family temple as symbolic heritage, and the whole area now is covered by skyscrapers and urban complex (Fig.3). It is inevitable and reasonable to take over the land if necessary in urban planning and the legitimacy of the act is not questionable. Although the increase of land value was skyrocketing, which means the reconstruction shall provide a higher value in terms of areas, the explosion of scale is more horrified.

Figure 3. From village to the city, Da Chong village, google map screenshot

Da Chong village transformed from a cluster of 1400 buildings into dozens of apartment building and office tower, with a large shopping center. The main street in the middle is rerouted and the width increase from 10.5 meters to 19 meters. One footprint of the skyscraper complex can cover 30 houses and the entrance plaza of them is larger than a 9 houses block in the village. Each of these humongous building is a destination to arrive, and the actual walking experience is transfer from the street to the shopping experience inside the building. As requested by the building code and regulation, the public space provided would easily achieve the required amount. The 500 hundred square meter courtyard space in the middle of the skyscraper is decorated with greeneries and landscape design. However, a park-sized public space can hardly function as a place for any human interaction or activity. People naturally pass by without take a look at the 10 meters long bench. On the special occasion like the memorial day of the village temple, it serves as a dinning venue for the returning villagers, and it is temporarily private space. (Fig.4)

Figure 4. Festive dinning venue for returning villager, Da Chong village, Shenzhen China

(Image access: https://weibo.com/3318051577/ECVT7mSUF?sudaref=www.baidu.com&display=0&retcode=6102&type=comment#_rnd1583503587537)

2.2 Aspiration in the decline

Things, settings, buildings and even the human activity are over-scaled. As one of the most significant reason to the decline of street, the over-scale provides unitary experience in urban public settings. If we compare the streets and neighbourhood between the city and village, the scale and the relative effect it brings are different. City prioritizes efficiency. The roads and planning is carrying this responsibility. It provides a starting points to destination model (Fig.5). Not to speak the widely-used navigation, people tend to find the shortest route in-between and everything along the way is secondary. City is a place for work, profit and entertainment. Villages prioritizes community and neighbourhood. Rural village in China is a society about people. Rural rules, not the regulation or efficiency. Village provides a wandering model (Fig.5). Destination is just somewhere to be and the path along the way could be various, interrupted, or deviated. The flow merge into the path of streets, and the unexpected is possible to occur.

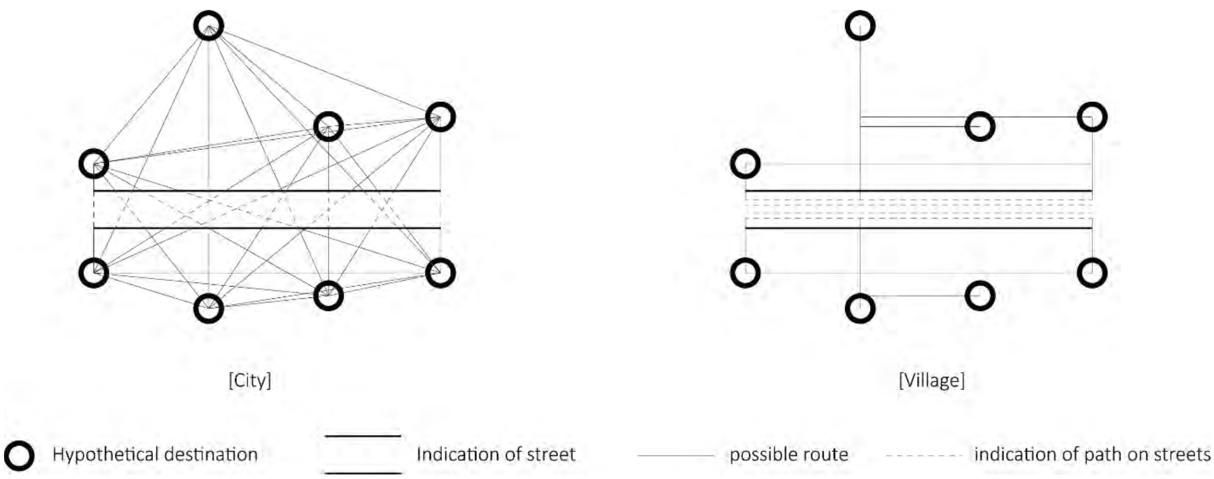

Figure 5. Diagram of destination model in city (left) and wandering model in village (right), drawn by the author

Aspiration is growing when the city fails to offer alternatives. People seeks for more diversified, adventurous and even nostalgic experience. The renovation of the historic structure came the first and the tourism in rural village was the next. Pursuing different experience is not demonstrating something could be eternally better, but our perpetual longing for the unexpected encounters. The resilient village are adapting to the grand development of the megacity and street is where the reviving transformation begins. Proposing the streetscape in resilient village does not prove the lives in village is better. Instead, learning from the streetscape in the resilient village is like revisiting the moment Venturi and Scott Brown trying to innovate the discourse of architecture by visiting Las Vegas [5]. The decline of streets are irresistible in a mega-scale of urbanization. The longing aspiration could initiate a comprehensive study on the streetscape in the resilient villages, which will provide strategic opportunities for the revitalization of the rural, a silver lining of the massive urban sprawl.

3 Streetscape in resilient village

In the book *Discovering Vernacular Landscape*, John Jackson identified and elaborated the meaning of "-scape" used in our descriptive terms and subjects.[6] The use of terms as "Cityscape" "Townscape" "Landscape" articulate a coherence by describing an environment with "-scape". Jackson believed the coherence reflects generic interpretation of "-scape" – a collective elements within a certain defined environmental concept.

3.1 Streetscape

To study the street scape in the resilient village in China, it is only fair and reasonable to define parameter for discussion and what elements and boundary are included. The concept of streetscape contains the street as the spine and spatial elements attached to or related to the street in any forms. Defining the subject as streetscape, instead of streets, is not only being inclusive, but also possible to study the interconnection and collective effect holistically as a system. Streetscape includes street, threshold between the street and buildings, façade interface, public space and settings. If we see the original planned network as the middle lines of the streets, streetscape is the residual leftover in between after the solidity of construction.

Over 20 villages in the Greater Bay area of China are visited and investigated to observe and learn from the ecology of streetscape and village lives. The essence of being rural rooted in the villages has been forming its ecology through adapting to the contemporary architecture and megacity effect. As what Banham has articulated his idea on the architecture of the four ecologies in Los Angeles, an ecological system can be adopted and grow under the geographical and structural framework of the city [7]. There is no doubt that any village would work as large as a grand city as Los Angeles. The inner relationship and reflection are similarly inspiring. The riverside could be the continuous beach line, or a door-front corridor could be the drive-in route in Los Angeles. They are elements that could work collectively under an environmental (geographical) framework and produce positive spatial effect and qualities.

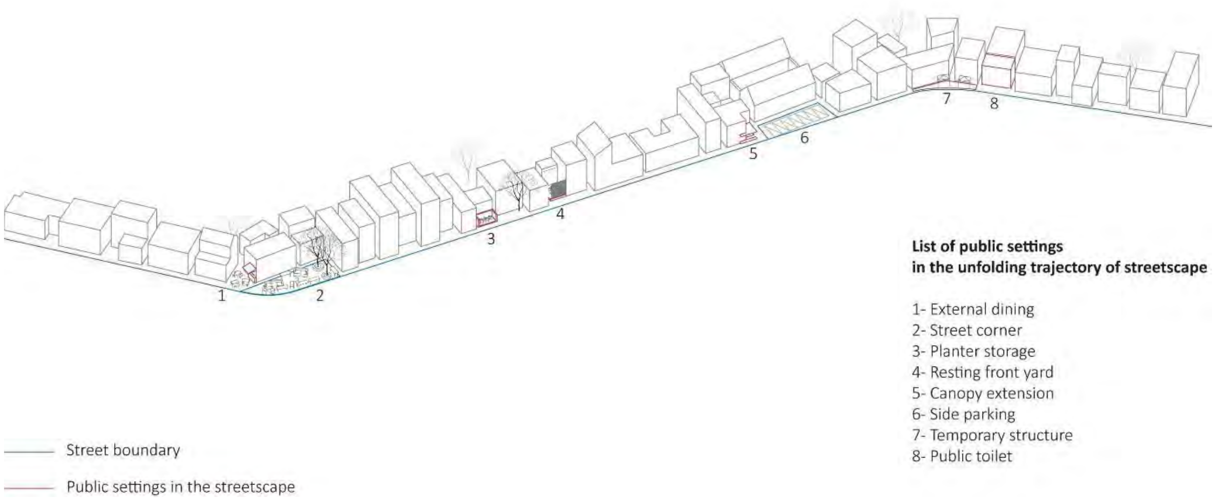

Figure 6. Diagram of public settings and unfolding trajectory of streetscape of Xin Ji Road (新基大道), drawn by the author

3.2 An Operational Framework

In our finite lives, except for those catastrophic destruction or demolition, we can always remember a place during natural transformation, a city, an old town or the farmland in our childhood. The buildings, tree, streets, placement of each space are consolidated scenes in our minds. Unless of partially demolishing, they are the solidness cladding on where they belong. On the contrary, the residual leftovers, streetscape, is the remaining operational framework for the adaptive changes, evolutional transformation of spaces, minor adjustment and more tantalizingly, the unexpected. This operational framework is of great significance in both revitalizing strategies for resilient village development and the changes for daily needs from the local villagers.

Resilient villages are adaptively transforming to achieve in two ways, co-existing with the megacity under urbanization and providing sufficient living environment for the local villagers. Both of these achievement rely on the development of streetscape and public spaces. For instance, Feng Jian village (逢简村) is a water village located at the urban fringe of the Foshan city in Guangdong province in China. The village was preserved initially for its geomorphology (Fig.7) and it has earned its chance to become adaptive to the city by introducing tourism. Feng Jian village is one of the earliest resilient village that introducing tourism as the successful pattern for village revitalization and manage to achieve its self-sustainability, before the strategy is overly exploited and reproduced. Based on the natural geomorphology of the village, the streets started from the river and connected along the riverside. As the commuting via small boats on the river has been their daily routine, it is reasonable to consider the river as the "main street" of the village. Started from the village temple, the revitalization project has been expanding along linearly along the river and street. Boat dock, bridge landing platform, intersections, riverside, street corners all these spatial element collectively combine as a vibrant streetscape (Fig.8). These places are not defined to specific programs, but constituting an open and sustainable framework of streetscape, which is flexible and adaptive to cultural event, tourism, place to sit, or family entertainment.

Figure 7. (left): Ancient geographic map of Feng Jian village, 清光绪 《顺德县志》[8]

Figure 8. (Right): Street view of Feng Jian village, Foshan, China

Another uncanny and intriguing scenario of streetscape has been captivating during the investigation in the rural village. Xin Ji Village (新基村) is another resilient village attempting to evolve through implementing urban program for attracting visitors. Unlike Feng Jian village, it has not reach the level of categorizing as tourism village, and therefore, the most village is operating on the daily basis for local villagers. The elements of streetscape in this case are more in a sense of scattered and vernacular. Although it under the influence of visitor and small amount of tourist, there were no agenda as development and streetscape is mostly transformed naturally and spontaneously. The intriguing scenario mentioned was depicted on a segment of the main street. The west side of the street is aligned with several restaurants and bars. Attached to the street, the external threshold space of each building are set to be an open space for visitors to sit and gather. The east side on the other hand, which is closer to the river, is occupied by several canopied structure, built by the village committee. (Fig.9)

Figure 9. Plan analysis of the public structure in Xin Ji village, drawn by the author.

Although the notion of "canopied street" is not as pushed as the Gothic Palazzo della Ragione at Bergamo (Fig.10), described by Bernard Rudofsky in the Street for People [7], the aspiration and preference of human being remains similar. The structure is built with a slope roof and a giant wooden deck platform underneath. There was almost no tourist would use the structure but it was the villagers' favorite. Furthermore, as the canopied structure becomes the top afternoon gathering place for the elderly in the village, they started collected used furniture and tucking them in with the giant platform. Beyond this, rods started to come out in between the columns and the green curtain, which is almost architecturally uncanny in this structure, is actually ingenious in this scenario (Fig.10, 12). Anyone passing on the street is kindly welcomed by this open structure.

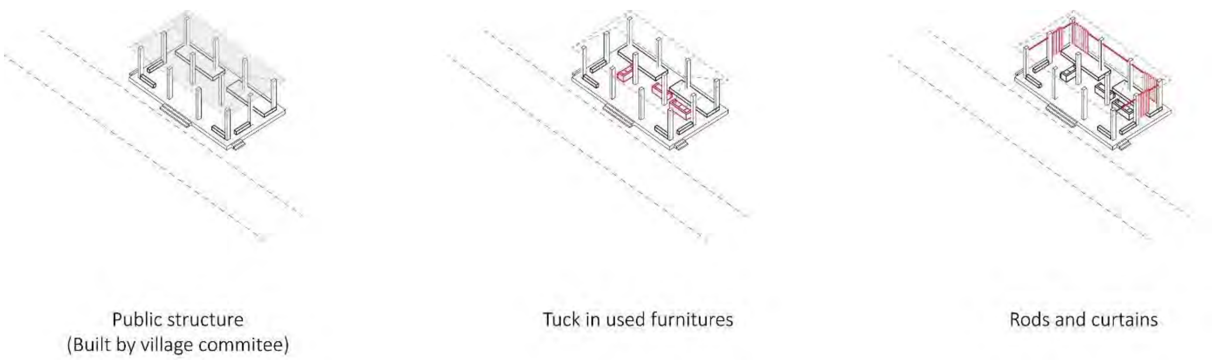

Figure 10. Process of re-inventing the public structure by local villagers, drawn by the author

Figure 11. (left): Ground floor of Gothic Palazzo della Ragione at Bergamo, Italy, by Bernard Rufodsky.

Figure 12. (Right): The canopy structure in Xin Ji village, Dongguan, China

3.3 the Street and the "-scape"

In the framework of streetscape, the two major parts in this concept can be deconstructed individually and reciprocal when they work together collectively. Street is carrying the flow of people, sending them to every possible destination in the village. The "-scape" on the other hand, is the uncertainty on the way that provide the unexpected and vibrant village life. The "-scape" can be a tree pool, several benches, a window extension from the building, a temporary table, a random add-on attached to the façade etc. (Fig.13) Any elements, bump out or sit still along the streets are reasonable public settings in resilient villages. Theoretical research aside, the practice on the development of village revitalization is also can dissect the spatial structure with the concept of street and "-scape". Isolated individual projects would not be sustainable as they have not be able to fit in the system of rural village.

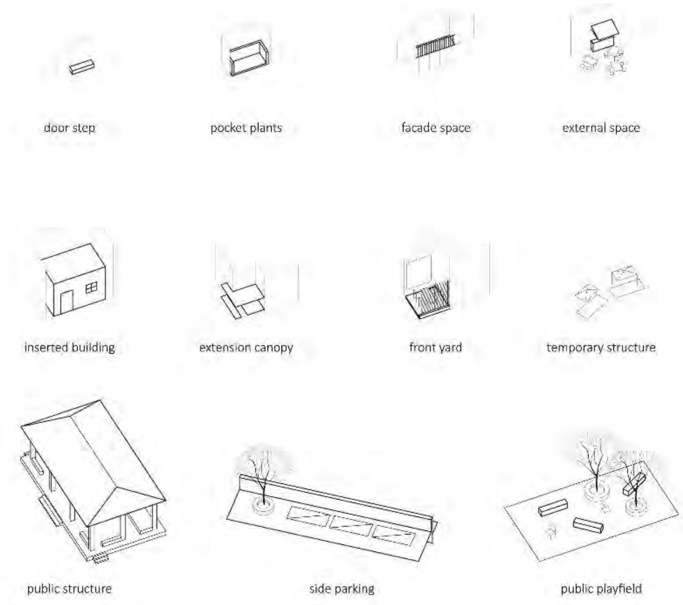

Figure 13. List of public space and setting in the streetscape of Xin Ji village, Dongguan, China, drawn by the author

4 Conclusion: Lesson to the City or Not

The megacity of Greater Bay area in China is one of the largest city cluster in the world. The magnitude of megacity sprawl is overwhelming and push the rural village to margin of survival. The dual condition triggers the rumination on the unified urbanization with grand unhuman architectural or urban gesture, and the retroactive observation back on the resilient villages. Learning the streetscape in resilient village is a proposition to rethinking the massive urbanization of the megacity in the Greater Bay area in China and provide insightful and supportive research towards a nostalgically innovative development in public space settings. Since Corbusier had imagined and pictured the city of Paris [9], the grand gesture and priority in efficiency is not just inevitable, but rightful in a way. That's the greatness of city.

However, the dilemma for city's unified urban construction and people's anticipation for alternative and a more living environment is a realistic issue in the megacities. Resilient village is seeking adaptive opportunities towards a co-existing condition of the megacity. By comparing the public settings between the megacity and resilient villages, the objective of this paper is identifying the streetscape in the village as the study subject to revisit and providing supportive evidence and discussion on the definition, parameters, elements, interconnection and holistic picture on streetscape. Over 20 resilient villages are visited to create sufficient samples of observation and specific cases and scenarios are selected to elaborate the structure, function and significance of streetscape, and what beneficial insight could it reflect on the study of public space settings.

Acknowledgements

I, the author, hereby express my sincere gratitude for Professor Peter W. Ferretto as the knowledgeable, patient and caring supervisor, guiding me along the journey of the research on resilient villages in China. I'm also deeply grateful for my colleague Jack Choi, who has been providing helpful advice and insightful discussion on various architecture topic and subjects. In addition, special thanks to Mr. Wang, Mr. Lin, and Mr. He (all are chairs of village committee, the position and full name of them were asked to remain confidential), whom I have earned the chance to discuss with during the visits to the village. They have provided substantial and practice introduction and opinion on the real cases of villages. Also special thanks to Mr. Yao, villagers of Xin Ji village who have kindly accepted my interviews. Lastly, I'm grateful for my family and friends who has been nothing but supportive along my research.

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TOPIC 2: CONCEPTUAL AND METHODOLOGICAL CONCEPTS

02.101 - CATEGORIES OF INNOVATION DESIGN

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Abstract

Literature describes design innovation as being incremental novelties of an existing product or radically new products obtained by design effort. By examining innovation at the initial stages of the design process, the novelty of a design can be assessed in terms of its newness to the market and newness to the consumer. Based on these two factors, the paper presents and compares the features of non-innovative designs and four innovative design categories. Each category is described and detailed through industry examples and/or supported by literature on design theory. By examining the information available for each type of design, the paper also examines and presents potential differences in the design brief and briefing process that can increase the quality of the design response.

Keywords

design, innovation, re-innovation, robust design, design brief

1 INTRODUCTION

The term "innovation" has its roots in Latin - in+novare – meaning "to make new" or "to introduce something new" [1] [2]. Its meaning is clearer than the term "design". The term "design" also has its roots in the Latin formation 'de+signare', meaning 'to mark' [3]. Freeman (1982) [4] identifies the term "innovation" to include "technical, design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment". Cooper (2000) [5] identifies product innovation as a process related to newness and commercial risk. He analyses on 6 dimensions which include: a company's entry in a new market segment or measures that lead to cost reductions. As a result, Cooper (2000) [5] considers product innovations as unique features of the product, as well as any processes that are new or radically improved in the creation of that product.

In current literature, some papers see design as the entire process from briefing to the finished product with innovation being able to present itself at any point in this journey [5]. This means that innovation in the final product can come from manufacturing, marketing, distribution and so on, even if it doesn't influence or has minimal influence on the product or service itself, as presented to the consumer.

Within this paper, the definition of design or product innovation is limited in comparison Freeman (1982) [4] and Cooper (2000) [5]. Improvements in manufacturing or in the company's relation to the product will be considered as product or design innovations only to the extent that the process determines improvements in the design itself, observable to the final user. New manufacturing processes determine innovative design in relation to previous ways of production and towards the company as user, not the final client of the produced good.

Since all design projects involve at least a minimal degree of novelty, a complete and definite distinction between design and innovation design has not been thoroughly established in the literature. A review by Mutlu and Er (2003) [6] concludes that "design innovations" are either "(a) the incremental novelties in the design of an existing product or service, or (b) radically new products or services obtained by design effort with no or minimal technical novelty" [6]. Especially designs that aim to improve an existing product to a minor degree, will be considered in this paper as incremental design. On the other hand, designs that are completely new or distance themselves to a high degree from previous designs, will be regarded as innovative designs. Perks, Cooper and Jones (2005) [7] define these two categories as incremental development – "the gradual improvement of a product through a series of product variants" [7] - and radical development – "breakthrough innovation associated with significant jumps or changes in the product" [7].

Unlike sculpture or painting, a designed product cannot be considered innovative by its creative features alone, because its existence is determined by the marketplace [8]. The question then becomes, can a design be innovative only by virtue of it being successful in the marketplace? Innovation can come from significant improvement of a design, which is an unquantifiable characteristic. Consequently, even if at face value, the design can appear as an incremental upgrade to the previous iteration, the market success can transform those incremental changes into significant improvements.

This poses a new question. When looking at innovative design through radical development, is significant improvement a characteristic of the product itself, or is it a substantially positive response from the market? The latter is most likely true, because design – as an "externally driven" form of expression [8] – involves external thinking and catching the market opportunities, trends and behaviours. This would allow a design to become innovative, even if at face value it might seem like an incremental development, or even identical to a previous product.

The paper reveals and categorises different types of innovative design and discuss the differences between them as a measure of their newness to market or consumers. The relevance of distinguishing these categories is then discussed in relation to the ways in which the design is created. The text builds on the characteristics and models of design briefs from the current state of the art and attempts to bring an initial draft design brief model of all types of innovation design. The design brief models are discussed in terms of structure, characteristics and ways of expressing the information in order to achieve the most appropriate responses. The study uses logical argumentation to discuss and distinguish each type of design. Knowledge is deducted from existing principles and empirical examples.

2 Types of design

Design is categorized in this paper generally as incremental or innovative. These concepts are differentiated by their level of newness to consumers, the market or both. Depending on the degree or type of innovation targeted by a company, the design will be constructed taking into account different parameters. Accordingly, one type of incremental design and 4 types of innovative design in relation to the design's newness to the market or consumer can be identified:

- Incremental design (small improvement) – limited level of newness to the market and limited level of newness to the user
- Innovative design (significant improvement) – limited level of newness to the market and medium level of newness to the user
- Innovative design (new response, existing market) – limited level of newness to the market and level of high newness to the user
- Innovative design (existing response, new market) – high level of newness to the market and high/low level of newness to the user
- Innovative design (new response, new market) – high level of newness to the market and high level of newness to the user

2.1 Incremental design (small improvement)

Incremental design typically comes as a natural improvement to an already existing design. This category appears in the market in response to competition in the segment. Since incremental designs are generally based on already existing products, they follow a predictable design evolution and situate themselves in an existing market of products. In this situation, an existing market refers to a segment that generally has an established group of consumers. A good example for this situation would be a line of products that has an established consumer base and aims to make reference to the already existing product identity for all its future iterations of the design. Car companies such as BMW and Porsche often rely on this type of design strategy for many of their models.

Regarding briefing for this type of design, most of the parameters are put in place, and designers have limited freedom to explore. Design characteristics can come directly from consumer feedback, market trends, competitors and especially the previous model in the range. The context in which the design functions is very well defined, as well as the target audience. Due to all these fixed characteristics, the market impact and sales figures can be approximated to a much higher degree than in other types of design. Also, the design effort is lower, as well as the growth potential. As a result, probably the most impactful parameters in creating the design, in this situation, are the market/competitors and previous iterations of the product.

2.2 Innovative design (significant improvement)

Innovative design can be separated into two categories in terms of the required solution or type of response given: a substantial improvement of an existing design or a completely new response for a market demand. The innovative design by substantial improvement refers to products that already have a market base and, through the given response, are able to disrupt the typical design trajectory of the market segment and create a significant step forward. This type of design Is present in literature and has been defined by Perks, Cooper and Jones (2005) [7] as "radical development". A good example for this would be products that have greatly distanced themselves from competitors and made very large improvements to the state of the art, such as the IPhone, in comparison to previous smartphones, or LCD TVs, in comparison to previous CRT displays.

On the other hand, innovative designs can also be generated through having completely new responses. These types of designs ca be split again into two different categories based on the availability of an established group of consumers or market: a new response in an existing market and a new response in a new market.

2.3 Innovative design (new response, existing market)

New responses given in an existing market represent designs that address an already established market interest but are able to fulfil that demand in a completely different way than previous designs. In this category we can put designs that serve a very similar purpose, but approach the design of the product differently: consider video projectors as alternatives to TVs, or beanbags as alternatives to armchairs. Each product has a similar function, addresses a similar type of user and are placed in similar contexts; however, they present different physical and aesthetic features. Both products are generally identified as having different designs, but they aim at solving a similar problem. Regarding briefing for this type of design, several aspects are already established, such as the context, the target audience, competitors and market potential. On the other hand, the physical and aesthetic features of the design are left to the designer to develop and exploit.

2.4 Innovative design (existing response, new market)

This concept of innovation through existing response in a new market comes close to what in literature is referred to as "robust design". Described by Rothwell and Gardiner (1989) [9], "robust design" is a type of re-innovation, where "a basic design (…) has sufficient inherent technological slack or flexibility to enable it to evolve into a significant design family of variants" [9]. This is different from what the term signifies in manufacturing and assembly, where "robustifying a product is the process of defining its specifications to minimize the product's sensitivity to variation" [10]. Depending on the necessary adaptations for the new market, the design can have a high or low level of newness to the user.

This type of design follows a reverse path to the other designs, meaning that it is a solution in search of a problem to solve. This applies to products that have a very high flexibility regarding their use. A good example for this can be the use of a smart phone operating system, appropriated to monitor or remediate sleep disorders, or convert the device into a fitness tracker. Briefing for innovation designs through existing response in a new market would typically rely on an in-depth discussion about the characteristics of the existing product. The qualities and potential of the existing design can then be used by designers to shift the product into a new market.

2.5 Innovative design (new response, new market)

New design responses for new markets can come close to inventions and are solutions to newly discovered problems and either do not have an established market, or the market is significantly underdeveloped. A salient example would be the design of the first digital pointing device, as a tool for navigating the virtual space. This was neither a radical improvement of a keyboard nor was it intended to replace it. The mouse, as it was named, was a new design brought into a market that had a very limited development in terms of the ease of navigation in the virtual space. This situation probably represents the biggest challenge for designers due to the large pool of possibilities. This can include briefing characteristics such as target audience, design features and context. The design brief can be as little as stating the identified market issue that the design needs to solve.

If a new design for a new market fulfils the expressed need, it automatically becomes an innovation even if the design is a repurposing of an existing product. As a result, this situation, the design innovation is determined by the newly identified and unsolved demand/problem or the new quest for solutions, and not by the design in itself. Similarly, a design can be considered innovative only by virtue of its success in the market, regardless of its design characteristics.

In the field of medicine, the quest for a solution to treating patients with blood clots, embolism and risk of stroke eventually resulted in the innovative re-purposing of warfarin, a strong anticoagulant, which had initially been developed as a rat poison. At the start of the design, the response could have been the development of a new drug, device or service. However, the solution was determined to be an existing product, warfarin. Looking at the final design, the product would be categorised as an existing design in a new market, at the beginning of the process though, the project would be a new design in a new market. The project did not start as a solution in search of a problem, but rather a problem in search for a solution. Although the outcomes are different, the design brief for a digital pointing device (mouse) would have been similar to the design brief for a product that treats patients with blood clots, embolism and risk of stroke (warfarin).

3 The design brief for incremental and innovative design

The distinction between these types of incremental designs and innovative designs is important because in order to achieve the desired response, an appropriate design brief needs to be established. The design brief is an instrument used in the design industry that states the complete requirements of a project, both for the client and for the design company. It usually includes all the relevant information for insuring an appropriate creative outcome, details about stakeholders and the responsibilities that each of them has, deadlines for all actors involved and the ways in which the project needs to be delivered [11] [12].

Petersen and Joo (2015) [12] suggest that the design brief needs to incorporate three large components which have an equivalent in Phillips' (2004) [11] view for the most part. They include information about the company that sells the product, the market and competitors (Strategy), the consumer profile, business performance and environmental concerns (Context) and the project budget, deliverables and aesthetics (Performance). This suggests that these types of design briefs cater more to incremental designs or innovative designs by significant improvement. New designs or existing designs in new markets would not have access to market figures, competitor information or present clear design features.

Since it is based on high degrees of novelty, innovative design can only emerge through the expression of significant creative and problem-solving capacity. Studies show that the design brief can increase the potential of creative results both through its content and its way of displaying it. Sipilä and Perttula (2006) [13] found that including a rigid requirements list decreases the quantity and variety of ideas generated. Regarding the way in which the information in the design briefs are displayed, Wikström and Verganti (2013) [14] show that "creativity is stimulated by the narrative way of exploring a situation" [14]. Sipilä and Perttula (2006) [13] also partially found that including visual stimuli increases the number and variety of ideas generated. Lau (2007) [15] found that creating the design brief through abstraction hierarchy determines more creative solutions. As a result, both the content of the design brief and the way it is presented would need to be adapted to the type of design in order to insure optimal responses.

4 Conclusion

The paper has outlined the different types of innovation design and has presented a comparison between them and incremental design. The four types of innovation design were categorized depending on the type of response they require – existing response or new response – and the type of market they cater to – existing market or new market. The benefit from understanding the features and requirements of each of these types of innovative design comes from determining the best way to facilitate its inception. Arriving to an appropriate response depends on the way the design brief is formulated and, on the time, and capacity of the design team to create effective solutions.

The study serves as an initial basis for further research in the field of innovative design and ways in which novel and creative design responses can be facilitated through adapting the design brief to the requirements of particular types of innovation.

Literature reveals a significant focus and good development for design briefs for incremental designs and possibly innovation designs through significant improvement [11] [12], but shows many gaps in regard to innovation design through new response and/or new markets. This becomes apparent when considering that the latter forms of innovation design briefs cannot cover the information shown in the models from literature. Also, information that can be regarded as axiomatic and omitted from incremental design brief models can be essential in designing innovative products, especially the ones that do not have established markets and customers. Qualitative means of investigating the issue can be utilized in order to provide better proof and fill the gaps in the current design brief models. Case studies can be used to outline the parameters of creation innovation designs as well as identifying other features that might be missing from this paper. Similarly, focus groups, interviews and Delphi studies can further reveal knowledge and missing links in the state of the art.

As stated at the beginning of this paper, the design brief has a creative design component and procedural aspect which defines budget, implementation, timeline and so on. The latter section has not been discussed in the present paper and would require further research in relation to the types of innovation design outlined here. The quest for an appropriate conceptual design response takes centre stage regarding innovative design through new response, but later stages of the project would be highly influenced by the manufacturing and implementation of the design. Budget, schedule and stakeholders would further restrict and shape the design solution. Though the manufacturing of the design plays an important role in the success of the product, its impact cannot typically be anticipated in the initial stages of innovative design projects.

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02.102 - BIONIC APPROACH OF THE "REVERSE STRUCTURE" IN ARCHITECTURE

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Abstract

This paper intends analyse a particular kind of structure in architecture that we can call "reverse structure". The logic of those system is based on the "inverse" composition of the building structure. The statical system is generated from the gravity effect on the corps. The composition is inverted; it starts from a scale model where the basement of the building is put on the top and the top is on the bottom. The gravity generates spontaneously the form of the architecture. This method is a part of the Bionic approach. The immediate advantage of this process consist in the creation of structure subject only to compression. In cases specially complex it is possible to have structure that combines forces of traction with compression. In any case, this particular method permits the absence of bending moment in the whole structure, with evident statical advantage. The paper will analyse historical cases and it propose a general approach to the planning.

Keywords

1 INTRODUCTION AND GENERAL EXPLANATION OF THE TOPIC

This paper follow the previous general study made by me about Bionic. In the previous paper named General consideration on the Bionic approach in architecture and engineering , we discuss the general meaning of Bionic and key issues related on this discipline. One of the key topic that we rise up in that script was the catenary arc of the Catalan master Antoni Gaudí. That was the introduction about similar cases which include the Taq-i Kisra in Ctesiphon and in the Nubian vault . A modern approach on this kind of structure concern the St. Paul's Cathedral by Sir Christopher Wren who generated an inverse catenary arc thanks of the contribution of Robert Hooke. About those cases we remand to my previous paper.

In this script, I want investigate deeply the logic and the system of a much general topic which can be called "reverse structure" or "upside-down structure", where the catenary arc of Hooke-Gaudí is a particular case.

The difficulty of this paper is that we do not have so much literature concerning this area of research. It is definitely true that many architect and engineer approach this problem and find appropriate solution, but it is also true that even today we are lack of investigation and appropriate definition. Even the name of this principle is uncertain and in this paper we will use the terms of "reverse structure" or "upside-down structure". Other formulas are welcome, but in the limit of this script we will use those two terms.

A definition could be: the reverse structures are all the one composed using the natural gravity's forces in the inverse sense.

We will not investigate deeply the issue of the gravity in the limit of Bionic approach . What we need to mention is that the gravity is a common phenomenon in the physical world and it is characterize by the attraction of two bodies which have mass. The formalization of this

attraction's force is regulate by Newton's and Einstein's Theory. In the limit of this paper we need to avoid any deep investigation on the nature of the gravity because it is irrelevant on our discussion. The Bionic approach need to understand the Natural process and systems especially in their effect. In this case we need simply to recognize that cause of the gravity on our Earth, the physical object with the density higher than the air will fall down with a dynamic which variate according with latitude, position, high. Our intention, in this paper, is simply to build a method to use the gravity to generate structure in architecture.
In this sense we will focus our attention on the simple admission that everybody with weight will be attracted on the center of the earth according with Newton's law. This is trivial but this is the biggest advantage of our method: we no need any complex calculation. Concerning this specific aspect, we will dedicate a part of the paper and we will find that we can have a clear understanding of the forces in act in the structure just with the ancient "funicular polygon", which is a key concept in our discussion. In this preliminary chapter we have to introduce the topic and the general method. We believe that the core of this problem is exactly the funicular polygon. This can be defined as «an open or closed figure that is not necessarily plane and that is formed by a rope or cord acted upon at a number of points by forces acting in various directions» or «a figure representing lines of resultant stress in a rigid body acted upon at various points by forces that may or may not be concurrent and may or may not be coplanar». Other definition mention that the funicular polygon is «the figure formed by a light string hung between two points from which weights are suspended at various points». A key information is included in this sentence: this is «a force diagram for such a string, in which the forces (weights and tensions) acting on points of the string from which weights are suspended are represented by a series of adjacent triangles».
The funicular polygon is a method to calculate the tensional state of a system using resultant stressed line. A very special situation in this method is its relatively simplicity. This happen because this is basically a graphic method and what it appears is the reality of the tensional status in the system. In other words, it happens that the general configuration of the system is at the same time the diagram of the forces, the tensional status and for "only" solution for the balance of all the elements involved. The special character of the funicular polygon is that this is a method to calculate the tensional status of a system without any algorithmic calculation. This means that the stress of the different strings came from a graphical method. We want notice that the simplicity of the funicular polygon came from the fact that we no need any advanced mathematics to be realized. It is basically a graphic method of calculation. Other great advantage of this method is to connect the design process to the calculation of the structure. In other words, design and statical efficiency is exactly the same. The graphostatics can take back the practice of architecture and engineering in its original unit: design, calculation and construction, in unity.
Other interesting information which come from the definition is that, at the contrary of every freshman in university believe, the funicular polygon concerns three-dimensional structures and not only a plane one, which consist the trivial case. In the plane ($\mathbb{R}2$) or in the 3D space ($\mathbb{R}3$) the conformation of the funicular polygon follows exactly the same rules. We believe that one of the key point of this method and surely one of the most important in the economy of our paper, is that the funicular polygon in balance generate automatically a diagram of the forces of the system. This is one of the most impressive point of the fundamental book On Growth and Form by D'Arcy W. Thompson. In his masterpiece, Thompson describe that in the Nature – in specific in the skeleton of the vertebrates – the form of the bones and their general conformation into a skeleton, correspond to the diagram of the forces. The forms and the diagrams of the forces are strictly in common. But we have to be extremely careful on this

point. This does not mean that the natural forms are the most ideal and perfect expression of the state of the forces in a natural body. At the contrary it exists a series of modification that include several variable, extremely complex to be considered.

Our task in this section of the paper is to describe only the general topic involved in the reverse structure, which are much more ideal. What is important in this moment is the admission that the funicular polygon it is a very powerful and simple method to generate the exact conformation of a statical system in balance. Exactly like in the Bionic process, the form corresponds to the diagram of the forces. This is a precious help for the architect and the engineers because, in fact, they no need any calculation to generate an optimized system. This means that the funicular polygon gives to us, graphically, formally, the system already balanced. But we need to avoid a misunderstanding. It exists a differences between the funicular polygon and the self-balanced reverse structure. On this point we have to be conceptually very clear. If the funicular polygon it is a graphic method to calculate the forces and the conformation of a static system in $\mathbb{R}2$ or $\mathbb{R}3$, the reverse structure it is something surely related on the funicular polygon but with the key difference that the upside-down organism does not show the tensional state directly but it is a kind of structure that naturally use the gravity to generate a self-balanced structure. We are no able directly to understand the forces in play, but we can visualize and generate model completely in balance. On this point we have to say that, if the funicular polygon study both the balanced and dynamic system, in our case we are more interested in the statical system, or system in balance. This means that in this paper we will consider only the funicular polygon in balance or, technically, the close polygon. In this paper we will introduce only structure in balance but it is possible to consider architectural structure which are not in balance. This should not surprise our reader. In fact, the architect has the big weakness to consider as a dogma the preposition of Marcus Vitruvius Polio of the firmitatis. This is a great limitation. It is possible to create architecture with dynamical aspects. This it could happen generating a structure which admit some movement. Obviously we can't consider a walking building seriously, but what it is very possible to imagine is a structure where the inner movement are balanced by a damper. In this case the structure it is not in static balance but in what we can call dynamic balance. In this case the funicular polygon is not close, but dynamic, and this can create sure a difficult situation but extremely promising for the architecture. Unfortunately, we cannot consider those structure in the limit of the paper.

If the issue of funicular polygon is clear, we can extend our investigation on the core of this work: the upside-down structure. Those are all the structure that are composed by reversing the elements, or in other words, this structure is composed reversing the natural construction of the building. To do a project of a reverse structure we need to invert the building. The basement has to be put on the top, and the top of the building have to be on the bottom. In some way, it is a process of composition which reverse the common process of planning and surely the practice of build the structure. In the literature we did not find any appropriate definition for this kind of building which, seems, to represent a very specific and unusual case of architecture. In most of the cases we had found experiments of vault and dome, include shell structure, but in fact those are not the only possible reverse structure. In this preliminary chapter we have to define the different structure and clarify appropriately the difference between the different cases.

At first a trivial observation, but that commonly create misunderstanding. We are investigating the case of the reverse structure. The reverse structure, do not have any tensional state except compression (N-) and tension (N+). Banding moment, torsion or other force except N- and N+ are ideally excluded. But the reverse structure is not the only one who do have exclusive forces as N- and N+. A case, commonly insert in this discussion are the suspended bridge. This is incorrect because the suspended bridge has completely different logic from our topic. Nevertheless, we admit that it exists certain similarity between the two cases.

The main difference is that the suspended bridges do not work with the inversion of the signs. In fact, the reverse structure is generated with the goal to be reversed. To be more clear, the process of creation of the suspended bridges generate a model that, finally, is built without any variation, except the scale, in dimension and in forces. For example, a model of suspended bridge, the initial concept, it is exactly the same with the final work. The bridge is build according with the model without any variation.

The reverse structure is invert. This means that the final work, the building or the bridge, or whenever, are reverse in forms and in forces comparing the initial model. The process of generating of a reverse structure have to start by an upside-down model and then finally, when it is finish, have to be turn up to down. This process that we will describe in the following pages has the main result to invert not only the structure but also the sign and the tendency of the forces. In short: the suspended bridges are conceived and build without any modification. The reverse structure is inverted from the modelling phase to the construction. This is why in this paper we will not touch the forms, structure, systems of the suspended bridges.

A point, extremely important in this part of the paper, is to understand that the reverse structure is unique in their process of generation. In some way the architect has to reverse his thinking and any personal opinion concerning the form and the structure have to be strongly limited.

An additional and important point about the definition of the reverse structure is that, in a certain way, the process of generation of the form is automatic and independent by the architect. The planner has to make the structure coherent with the natural principles of the gravity and the nature itself generate form and structure. The gravity, acting on the physical structure, create automatically the only possible form of the structure. A point is important: the architect will include in the preliminary model all the condition of the project, but then, his decision is strongly limited by the nature of the gravity. This is typical of the Bionic structure. If in the normal composition of architecture, the planner has a very strong power to decide forms and structure, even against the logic or the best optimized solution, in the Bionic approach, the planner has a very limited action, because the natural principle will generate the system. In other words, the Nature will design the architecture according with its inner principle. According with our previous paper about Bionic, we define the Bionic approach as a process to take inspiration from the natural process and transfer it into the architecture and engineering. In this sense the reverse structure is Bionic: they use the principle of the gravity, the behaviour of the gravitational forces to design architecture, with a very limited intervention of the personal taste of the planner.

The last issue we want focus on, in this first part of the paper, is the area of our investigation. For us, the reverse structure is all the structure that can be ideate reversing an initial model (conceptual, mathematical or physical). In the common practice of ideation, the reverse structure (even if we are considering a very particular and limited practice in the area of engineering and architecture) in most of the cases we are creating curves upside-down structure. This means that in most of the cases the reverse structure concern vaults, arcs, domes, shells, light-weight membrane structure. In fact, we believe that the reverse structure can be both curves or based on triangular truss structure, or 3D linear structure. Our effort in

this paper is to discuss the known reverse structure and introduce other cases that can be included in this category.
But one issue has to be clear. We will consider only the structure that is naturally designed by the gravity and the intervention of the architect is limited to conform a structure that has only compression and tension forces. In any cases we have to permit the situation where a cable, a bean, a membrane has something different of those two forces or the consequence is the collapsing, once the structure is build. The method and the problems if this kind of approach it will be described in the following pages.
The last topic that we have briefly to touch is a trivial case that it cannot be included in this dissertation. The project named Upside-down skyscraper in Mexico City by Esteban Suarez from architecture firm BNKR Arquitectura it is a very interesting case of building, but it is not what we are interested in. At first this is not a skyscraper, because it "scratch" not the sky but the ground. In addition, the statical structure of this building it is not based on the gravity, but it is basically a huge hole in the earth. Our paper intends to teach "how to fly" and not how to dig. Everyone has his job.

2 The logic of the reverse structure or the "upside-down world". Theory and method of generating reverse structure

Why we have to reverse the world? Why we cannot simply use the common way to generate a structure? This is the common question that firstly could come into the mind of person in front of the reverse process of generation of a building.
The answer is: because the reverse structure is more simple to create, more safe, more natural. The consequent reaction is: then why, nowadays, nobody uses this method to create architecture? The answer is much more complex and even hard to explain. We personally believe that for a certain historical coincidence the process and the method of generating architecture and structure it was developed in a certain direction and the reason of this is extremely hard to explain. What we can notice is that this situation happens in many cases. Very often the industry and the production do not follow the best technology or science available on the market. At the contrary, it is possible to demonstrate that in general the production has the tendency to crystallize itself in a certain position without any change for centuries. Certainly this trend has a reason, such as: once a trend is established, it is very difficult or expensive, or complex to let it change, even if it is demonstrating that the current technology is not the best or the most performative. In general, we have to abandon the idea that the most diffuse technology in a certain area is the best in a certain period. This never happen, now or in the past. It seems, in most of the cases, that when a technology is developed, for certain historical reason, the tendency of the human being is to refine, to improve this technology instead to find a completely different one but radically better. Once this specific technology is established and developed, the reduction of the cost, the general trend of the market, push the production in this direction abandoning all the other possibility, some worst, some better, that it will be put into the "museum of idea" for a period of time more or less long. We can quote many examples of this direction, but this will lead our script too far. The example of the internal combustion engine is very interesting on this point. This kind of engine is not the most performative but for a certain coincidence become the most diffuse, especially the models based on Otto and Diesel cycle. At the same time, the world decide to abandon the development of a much more efficient engine such as the Stirling engine, or the Massive Yet Tiny (MYT) Engine. A similar situation could be demonstrated in

several aspect of the modern life. It seems that the modern world prefer to improve a certain technology or theory and not radically abandon it in front of a better one. In fact, what is the Copernican revolution? The demonstration that to change the vision of the cosmic geometry the western world used 2.000 years.
In our paper we want simply discuss that the upside-down structure are more simple and easy to generate. This is the classic case that the things are so simple and obvious that nobody can see it. «The king is naked» but nobody can see it. But why this structure are supposed to be more simple and what is the nature of this method?
In general, we have to consider that the reverse structure belongs to the Bionic approach. In out previous paper we discuss that the natural approach to the reality use the effect of the manifestation of the Nature into “process”. Those “process” are in general extremely complex an it's hard for the science to discovery the “first principle” of the nature. We can easily see the effect, the golden rule of the reality, but in fact the motion, the first cause is something extremely hard. Maybe the theology could be a more appropriate discipline for that. In the limit of our scientific approach, we can demonstrate that the study of the Nature concern a series of endless question and in the limit of the Bionic approach it's much better to limit our investigation on the “effect” or “process” or the understanding of “how the nature work”. It's much enough and already very difficult. We refer to our paper on the bionic approach for more detail on it .
Starting from the Bionic approach we have to discuss that the upside-down structure are a true Bionic method. In short, we can say that those structure “naturally” conform themselves according with the law of the gravity. They simply can't avoid it. The reverse structure conform themselves in this way because this is the most simple and “natural” way of disposition of the forms.
At first we can mention a trivial case [c1]. If we take a simple chain (or a rope or a line with a certain unit weight) and fix one side to the ceiling (or similar) on a point that we can call “A”, what we obtain is obviously that the chain will form spontaneously a vertical line. The extreme of the line fixed on the ceiling is on the top and the opposite sit of the line is on the bottom. Why? The gravity act on every single ring of the chain (or on the single “ideal” unit of the continuous line) which has its own weight and this particle drift to the center of the planet Earth according with Newton's Law of Gravity. This is simple. And this trivial case lead us to observe that the gravitational forces act in the most simple way on the corps. In other words, the behaviour of the corps on this planet follow all a certain rules, with the only exception of some magician, or divine entity with, for definition, are not a Bionic case. This situation generate a key question: why the object in this universe follow a certain rule that is exactly the same in every part of it? The answer is extremely hard and go beyond to the limit of this paper, but in fact, it seems that: or the things follow this universal laws or, if not, this things can not exist. Maybe this is a banal consideration, but the answer or this critical question do not have any other answer in our limited mind. Anyway the problem touch the key topic of the reality and exactly for this it's very hard to discuss about it.
Coming back to our topic, from the macabre case of the hanging rope, we can create a key example in our discussion: the catenary curve. We are in the situation that our chain is suspended on the ceiling fix to one point. The opposite is below and free. If we take this free end and fix it on the same ceiling, in a different position from the point “A”, for example “B”, and if the distance between “A” and “B” is less that the length of the chain, then what we obtain is a catenary arc [c2]. Some definition of this arc we already describe in a previous paper and we will not insist more about it. In fact this paper it is not about the catenary arc itself but about the reverse structure which is a much general case. Nevertheless, the catenary

arc has a very special propriety that can illustrate perfectly the theory of the reverse structure. Exactly like the trivial case, the catenary arc has the most convenient form for the chain. “Most convenient” means that the form of this arc is the one which has less stress and less energy dispersion of any other. In other words, this is the most economic form for a free line in the space. For analogy, if we consider a soap bubble, its form is a sphere because this geometrical form is the one which permit to have the maximum amount of volume with the most limited surfaces. The soap bubble, then, can have its self-balance when contain that specific amount of gas using the that specific amount of soap film. In other words, the sphere of the soap bubble is a result to contain a specific amount of gas with a specific amount of soap film. We will not insist on this point because it's also a trivial case already described many times. What it appear clear in both of the example is that the Nature seems work using the most convenient conformation of its element, or in other words to optimize the energy on tap.
In this sense, the catenary is the form that optimize weight of every single ring of the chain. But it happen something very interesting for us. In the trivial case [c1], we can imagine the chain made by a sequence of small ring . Every single ring has weigh and for this reason is attract to the center of the Earth. The assembling of the rings (the chain), then, is formed by the addition of single units everyone attract to the center of the Earth. Where the different rings are linked, the point of connection, of touching, that specific point transmit the forces between the rings and et the chain to be a chain and not a sum of rings. If this is clear, we can consider that all the “couple” of rings are linked together by one point and in this point we have a force that connect two rings by two rings and, in general, all the rings together. This force between two rings is tension (N+). Between all the rings, then, we find only tension . And this is the major advantage of this system. In every reverse structure we have only tension forces, in the cases of suspended chains .
Until now we consider only the case of the chain and of that particular structure that is the catenary arc. The example of this structure is already mention in the paper at note 1 in this script. But the catenary arc or vault it is not the only case for the reverse structure. We want enlarge our discussion to every reverse structure. The case, in fact, is very simple but general. If we take the case [c2], we have a catenary arc where all the ring are subjected to a tension. If in the center of this chain we add a weight, the structure will loose immediately the conformation of catenary arc and generate “V” shape [v1]. If we add more weights in a different positions, the “V” shape will be deformed and the final conformation will become exactly like the diagram of the forces [v2]. This theory is well define and express in the fundamental D'Arcy W. Thompson, On Growth and Form , which induce the cases of the animal skeleton compared with the diagram of the forces and the mechanical action on the conformation of the bones. According with this theory, the form of the natural corps are the direct effect of the gravity, or in other words, the gravity deform the corps according with the most convenient and “energy saving” form. This form is the one which give to the maximum performance on the structure.
One things have to be extremely clear. We are taking about structure subjected by a gravity, but this kind of structure are not the only one in the universe and even in this planet. It exist at least two kind of forces that act on the corps: the gravity (that we are talking about now) and the pressure . In this paper we will limit our discussion on the first one because the upside-down structure interact with the gravitational forces. We will describe the immense interest about the pressure forces on the Bionic structure in future works .
The case [c1], [c2], [v1] and [v2] are still simple cases. They are simple for several reason. The first that appear evident is that the case that we have described are planar case. This means that the catenary arc and the “V” shaped structure lie in a plane: in other words they are two-

dimensional structure. A chain, or a "V" shape structure in absence of any other force are flat. But this is not the only case possible in those kind of structure. We have to remember that the Bionic approach is extremely realistic and in fact it is the most realistic process in architecture ans structure because it act with modelling and studying the natural world. In this sense we have to extend our research in three-dimensional structure, which is conceptually not really difficult. The most simple case that we can imagine is to take the case [c2] or [v1] and let it rotate around the cusps. What we obtain is a "catenary dome" [d1] in the case of [c2] and a cone [cn1] in the case of [v1]. We will not consider [cn1] because not really interesting, but in the case of [d1] we find a very interesting situation because the whole dome has exactly the same characteristic of [c2] but in three-dimensional shape. In other words, we have a structure which generate a volume and all the point of it are subjected only to tensional forces (N+). At the contrary of [cn1], [d1] has a specific advantage which is very special: the "feet" of the dome, the place where the structure touch the ceiling is perfectly vertical. This means that the forces of tension link the ceiling to the structure perfectly perpendicular. This is an immense positive point when we have to generate the final structure. We will introduce the reason very soon. The key idea of this point is that the suspended structures could be two- or three-dimensional and the 3D structure, in fact, is the key interests of this paper.
Make our concept more complex and interesting. Until now we have discuss simple cases. The advantage of this cases is that we have only tension [N+] forces inside. The architecture of Antoni Gaudí are based on this concept, especially for the parabolic dome . This structure are particularly simple cause of the completely absence of other kind of forces . What we want introduce now is an advancement of this method to create hybrid structure with the presence of tension [N+] and compression [N-] forces. We are not talking about Tensegrity structure but some structure which are much more free in the form and much more easy to realize. The shape of this kind of structure are not only curves according with the catenary arc or vault or dome, but could be also linear or a combination between the different forms.
To generalize those structures we can propose a method of generation of a reverse model. We want suggest an interesting method to create reverse structure where only tension [N+] and compression [N-] forces are include. The same method could be realized for reverse structure where only tension [N+] are included. This method avoid the presence of bended forces into the model.
The beginning is to create a plan of the building, whenever is it, church, skyscraper or a simple villa. Once we design the draft of the map on the plane, we have to suspend the map, the basement on the ceiling, reversing the architecture. This means that the plan of the building will be on the top. Finally we have to hang chain, or cable or line on the key point of this map. This chain will become, in the final building, the main columns the main pillars of the building. The chain, hanging on the ceiling will be effected by the gravity and become vertical. Now it's the time of the creative part of the project. We need to give a shape of the whole building. In this case, the architect can show his taste and his skill of generating forms. This part of the planning is not rational and can not be framed into a method. It depend of the personal skill of the designer. But of course this phase is not completely free. The designer have to follow a basic rule of the reverse structure. He (or she) can shape the chain, he (or she) can join together different chain, but the rule is: it is a must that every single chain have to be in tension. The designer can create every shape that he want but the strict limitation is that every chain can not be relaxed, even the one which is subjected by the own weight and it will be conformed as catenary arc.
One step more: between the chain, to make the model more complex and to avoid relaxed chain it is possible to insert some sticks. This could be made by piece of wood or plastic or

steel, but have to be rigid. This sticks have to be fixed and linked between the different part of the chain in order to make tense some line that are relaxed. During the formation of the model, and the phase of joining the different chain, some of them could be relaxed and this it can not happen. Every relaxed chain is a mistake and it definitely lead the structure to the collapse. The reason of this come from the funicular polygon already described before. The key rule of every funicular polygon in balance is that the sum and composition of the different forces have to be completely close, both in two- and three-dimensional shape. The structure that we are gong to describe are in fact nothing more than a funicular polygon. IN some way we can say that what we are doing is to modelling a funicular polygon in the space. Usually the funicular polygon is a graphic method to calculate the static of the building, a method extremely diffuse in the Middle Age in Europe. Now, what we are doing is to exhume this methodology in a “sculptural” way. The stick that we are adding now have to be use in compression. If it is use in tension this is not appropriate and it's better to substitute it wit other additional chain. The composition between chain in tension and stick in compression generate finally a balanced model which is, again, a close funicular polygon, with some part in tension and some part in compression.
An additional caution is that the base of the model have to be larger (even slightly) than the develop of the structure. If not it could happen, in the final stage, some instability problem.
We have to remember that we are still working on a reverse model. A reverse model is inverted. This means that it is not the final one. The key process to end the modelling phase is to reverse the structure. This means that we have, ideally or practically, freeze the model and reverse upside-down: the top become the basement and the lower part of the model become the cusp. In fact, in this phase the building return in its logical dimension. It is the phase of the composition that, actually, is reverse. We generate the building in the opposite way. Reversing the building means to take back the form to the natural state. This dramatic move not only reverse the model but, consequentially, reverse the state of the forces. The chain, initially on tension [N+] become compressed [N-] and the sticks initially compressed [N-] become on tension [N+]. The reason of this inversion can be explained in a mathematical view. We remind that the catenary arc is a hyperbolic cosine curve, expressed by the general function [f3]:

$$y(x)=\frac{1}{2}a(e^{\frac{x}{a}}+e^{\frac{-x}{a}})=a\cosh(\frac{x}{a})$$

In the case of the inversion of the curve the function simply become [f4]:

$$-y(x)=\frac{-1}{2}a(e^{\frac{x}{a}}+e^{\frac{-x}{a}})=-a\cosh(\frac{x}{a})$$

In mathematics this is a simple inversion of the sign and this generate an inverse catenary curve. Nothing complicate. What is complicate for our understanding is that, with the inversion of the sign in the curve, also all the sign are inverted, all the nature of the curve is inverted. For our specific problem, also all the sign of the forces are inverted. The result is that, in the initial model we have built the structure which chain and sticks because those two materials was suitable to follow the natural forces (chain or cables for tension, sticks for compression). Once we reverse the structure we have to remember that the nature of the structure is inverted, so the final model have to reverse also the materials to “rebuild” the model. The part initially on tension [N+] become on compression [N-] and the chain have to

be substitute with sticks. The same for the sticks that become, in the reverse model, in tension [N+]. In the final model, then, we ave to reverse also the use of the material.
We need to remember that this happen in every kind of reverse structure. In the example that we have described we focused mainly on the linear model, based on the polygonal funicular. But the situation is exactly the same in the case of the catenary arc, vault or dome. If we reverse the model of a catenary vault, the chain or cable, excellent to absorb the tension, have to be converted in a material able to sustain the compression forces, and it is warmly suggested to use massive materials .
In this specific section of the paper we describe only the realization of the scale model for a reverse structure in the case of polygonal forces. The system that we propose until now is generated by the process of Middle Age constructors and from the practice of Antoni Gaudí and the theory of Culmann.
The linear structure, mentioned above, are not the only one that can be generated in this way. We are referring to a special kind of structure that could be define as curves surfaces. But we need to be extremely careful in this case because the “curves reverse structure” are very difficult to generate and calculate. Exactly like the “linear” structure, not all the curves structure can be calculated as reverse structure, or in other words, not all the curves surfaces are reverse structure. Actually, we can say that the reverse curves structure are a very special kind of curves structure, with a very special characteristic. At first the problem of the form. Not all the curves that we can ideate can be represented with the Euclidean geometry. In fact just few of them are include in that cases. Other forms, have to be described by a complex mathematical tool, such as differential geometry, or topology or Chaos Theory. Other forms can not be described at all by mathematics. Then the consequent question: if a form can not be described by mathematics, does this means that we can not use? It is obvious that some forms exist independently by our knowledge of a mathematics able to describe it. But in this paper we are going to indicate a particular kind of structure which is the reverse one. This category of structures can not acquire any kind of conformation but just some form which is generated by the gravity and from the natural conformation of the matter. Two very significant author in this area are Heinz Isler and Frei Otto. Some author love to consider also Eladio Dieste as an engineer which generate the form starting form the reverse structure. On this point we disagree. To analyse deeply their work is a task which go beyond from this paper. What we need to illustrate is their work in a general view. The method of those masters are very different, especially for Eladio Dieste who use a kind of technology and forms extraneous from Otto and Isler. Otto himself, use the light-weight structure. In short, those three authors are in result, technology, process, very different and can not be easily compared. What it is interesting is that, although this radical difference in process and result, what all they investigate are reverse structure.
In the case of the curves structure, they have to be consider in a very different manner comparing the previous cases. At first we have to notice that their behaviour is like membrane. This means that the structure work as a unit, or in other words, every singe point of the structure is connected to the whole. The most close comparison is with the shells, with the only difference that the shells (the sea-shell for example) are corrugated and this increase their structural resistance . In the limit of the smooth reverse structure, we believe that the method of Heinz Isler is extremely interesting exactly because is simple and effective, with «[...] virtually unlimited potential of non- geometric shell-shapes, which especially pleased him because of their high aesthetic value» . In fact, it seems that is exactly the same that we have described above considering the funicular polygons, but for the curves shell. His shells are developed starting from mechanical, physical models which are exactly the same as funicular

forms. In his case, he was using hanging cloth hardened with polyester or frozen water . The results was exactly the same comparing of our description of linear hanging structure. The wet cloth of Isler conform themselves according with the laws of gravity. Once is frozen and inverted, what we obtain is a structure subjected only by compression [N-]. The interesting point is that this reverse shells no need to obey to the Euclidean geometry. It can be much more free, and the boundary of the dome can be free edges without any support. This is the case of the Gasoline station in Deitingen in Swiss (1968) and the Bridge on the Basento River in Italy by Sergio Musmeci (1967-1976): the border of the structure are not rigidly follow a geometry but they follow free forms.
In the case of Isler's method the «[...] membranes and inverted hanging membranes, a plaster cast of the form was taken and accurately measured, always by him in person, in a purpose-made frame. This allowed precise coordinates to be taken for a grid of points over the surface. Following production of resin models, load-tested to prove structural adequacy, the measured dimensions were scaled up, suitable formwork was constructed and the shell cast – no computer-aided design (CAD), finite element analysis (FEA) or other computer systems were involved» .
The paper already quote , illustrate nice picture about the Isler's method to generate structure . At this moment, in conclusion of this chapter, we can summarize a very interesting output. The case of the linear reverse structure, illustrate by us, and Isler's work, just mention above, and the method of Frei Otto and Sergio Musmeci , illustrate in our previous paper, in all this cases, although the difference of the results, we can find out a common point: every author put a fundamental importance in the physical model. As we already mention in our paper dedicated on the general illustration of Bionic , Otto himself aware the danger to trust excessively the computer. In all those cases, the real building are fundamentally based on the scale model which is the only real sources of the study of the forms and structural coherency. Especially in the case of Musmeci for Basento bridge, the model have to realized at different scale. The complexity of the structure can not be fully calculate by any algorithm and any computer simulation. In this specific case , the collapse of the final model caused by the sinking of one of the “feet” of the study structure, show the importance and the fragility of the foundation in shell structures. Thanks of this experiment and real cases, we can conclude the fundamental importance of the modelling in any reverse structure, linear or curve. At the same time, it is extremely sensitive the choice of the materials to generate scale models. We can mention only one problem, in between many, about this point. The model of the bridge made by Musmeci, was realized in the preliminary phase by natural rubber. This material is excellent because it can be freely conformed. The main problem is that to stretching the membrane generate a reduction of the section of the rubber. This is not a problem in the phase of modelling, but could have a dramatic consequence if it is not considered during the advanced phase of construction.
The reverse structure, described above, are not completely determinate by the designer. In fact, we can say that the action of the architect is extremely limited. The form is basically generated by the action of the gravity on the corps. So the point is that, if we assume a form, the action of the gravity will generate forms and the designer has only the task to adjust the structure and correct the eventual mistakes of the forms according with the method and initial assumptions. This do not mean that the architect is in a cage, completely “roped” by the suspended chain. In fact, the method can be described more as an interaction between the creativity and the inner rule of the gravity on the bodies .

3 From the model to the reality. Problem of adaptation, general problem of calculation

The case of the reverse structure, and in general of Bionic, is extremely special in the practice of architecture and engineering. It is exactly an activity which is in between theory and practice. But with some additional difficulties and some extremely positive point. According with the practice of reverse stricture, we have already notice the anomalous method to create building. The point is that the upside-down structure, for their specific nature, have to be realized only and exclusively by model. At the contrary of the common architecture, which are generate by the personal taste or "rationality" of the designer, the upside-down structure can not accept any caprice or styling. This method limit the intervention of the architect in the control of the structure, but this is generated basically by gravity and the form of the nature. To be more precise: the form that appear from the upside-down structure is the consequence of the law of Nature. The law of Nature are, as we know, extremely complicated and the advantage of Bionic approach is to avoid every complex calculation. The only rule of this process is: if it work, it will survival. If not, it will collapse. Is it a kind of Darwinism in architecture? Well, something like this, but the key point is that the reverse structure never lies. The form is generated by the effect of the nature of the bodies and the designer can only intervenes partially on the general scheme, but in the limit of coherency of the method and the gravity forces. This is why the model has so big importance in the reverse structure. But the modelling has to be consider in a very special way: it is not the prefiguration of the form, volume, shape, proportion between the different part. The model, in bionic, is a functional system. This means that the model generate the form. The form can not be decided exclusively by the designer, but the gravity (in the case of the reverse structure), the mechanic (in case of natural system), etc., drive the model to the only possible solution. This is clear.
What is extremely interesting for us is that, all the great master that we had investigate, Frei Otto, Sergio Musmeci, Antoni Gaudí, Heinz Isler, put a great value on the modelling phase. More. For all of them, the modelling, the generation of scale model is the only way to create this sophisticated structure. Some of them (Gaudí in primis), even do not calculate anything and simply transfer in scale 1:1 what they have generated by model. Otto himself admit the great importance of the scale model in his work. According with his thinking, one of the most dangerous action for designer is to trust excessively the computer. Many fail in the engineering was caused, according with his words, by an excessive trust in calculation method. Some complex forms can be created by computer, and the range of the possibilities are virtually endless . If, thanks of computer, it can be created infinitive possibilities, to manage it is tremendously difficult . In the case of the natural forms, the range of the possibilities are limited. For example, to quote n example that Otto mention, the minimal surfaces are a very strict series of forms that follow a precise mathematical laws and the nature is even more selective in the use of them. The point: that in the definition of a form in the Bionic approach we have a very limited choices, but those are real and provided by amazing proprieties. We even dare to say: those forms from the Nature are perfect in their conformation . Something similar happen with the calculation. Not all the forms can be calculated and not all the calculation can provide good and rational forms. In a polemic spirit we mention a case: the common practice of engineering is simply foolish. The trilithon – pillars/beam – is one of the most statically inconvenient system ever created. And it is the most widespread.
We mention this point because what we are going to discuss is the problem of calculation in the structure generated by reverse model. As Otto mention the collapsing is really a big

problem in the modern structure, especially for the shells and vaults. His opinion is that often professionals do not really understood the computational tool and the models of stability are not sufficiently studied in depth . In our previous paper, we already mention the problem that Sergio Musmeci met in the realization of the Basento Bridge , and in this paper we will not mention again. Here it is more useful, maybe, to mention a method that could be useful to cover the difference between the theory and practice in the generation of reverse structure.
Obviously, to consider the model as real structure is a big mistake. It need a phase of adaptation which we consider a fundamental in the bionic approach. One reason, in between many: the reverse structure (the membrane for example) are based on the tension [N+]. The membrane that we use, or the cable (or chain) for the linear structure, are excellent for this kind of force. Once we reverse it, the compression that it is generate are much more complex than the previous one. For example the instability caused by slenderness which is called “buckling”. This happen not only in linear structure but also in other thin structure like the shell and membrane subjected by pressure. This is the reason why in the common calculation of structure we have to provide a certain coefficient of safety: the thin structure are commonly realized larger than the optimal size exactly for the buckling problem. We find this problem also in the Basento Bridge by Musmeci. It is well known that he define the forms thanks of the soap bubble and rubber membrane. But soap bubble and rubber membrane can not sustain bridge. And the concrete structure (the final solution for this bridge) has a very different behaviour of the vanishing bubble, which can exist just for few seconds in the history of the universe. And especially: compression forces are the opposite of tension. This is the main reason why he did some radical modification between the model and the final work . The “feet” of his vault, for example, are often more thick than the develop of the structure and this case is the opposite situation of the scale model membrane. In fact, certain point of the structure has a concentration of forces. This s the case of the connection on the foundation where all the forces are relived on the foundation. The point is: in the real structure is the opposite of the model. Where the membrane of the scale model is stressed and consequentially stretch with shrink of the membrane of the model, in the real structure we have in the same position an increment of the pressure and, consequentially, we need to increase the section of the membrane to resist of the forces.
This is was very clear in the case study of Musmeci, where he was forces to modify the tensional state's assumption of the model during the realization . The problem is exactly the same in the case of every structure generated by model, especially in the case of reverse model. Every model is theoretical. It need an adaptation to the reality. This is particularly dangerous in the case of the reverse model because at the contrary of the normal scale model, the reverse structure suggest the final form of the building. In pure theory, the upside-down structure have to simply reverse, copy and enlarge. The initial solution and the final one are exact the same except the opposite sign and the size. But in fact it's not. We want mention in short the key difference between the model and the final structure :

1. Problem of the scale: in general terms we can mention that a static conformation, in general, is valid in a certain range of size. If the system is too small or too big, we have necessarily to change the conformation and the logic of the structure. A classic example is the suspended bridge. This specific typology is ex, but it can't be use for distance over 2 km of length or it appear some instability caused by the conformation of the logic of the system . The problem do not come from any mistake of calculation or form some mysterious forces that generate the instability of the bridge. The problem is related on the statical system itself: size and performance are optimize in a

certain range. This is not the only case. This issue is also related on the «gnomon» and it is a very ancient geometrical problem . The problem of the scale (or gnomon) appear every time we enlarge a structure; this it can work until a certain limit, and if this limit is exceeded then it start to have some serious problem of instability or even collapsing. This is a very complex problem that it concern mostly geometry and it is mention in the fundamental book of D'Arcy W. Thompson about the growth of natural organism. The classic and fundamental example, that we will not discuss in this paper, come from Galileo Galilei, in Discorsi e dimostrazioni matematiche intorno a due nuove scienze , where it is discuss the problem of the horse falling . Since Galileo until D'Arcy Thompson the problem was clear: what is good and appropriate in a certain size can be inappropriate if we increase it. If two structure, one large and one small, have identical proportions and are constructed of the same materials, so that one is purely a scaled up version of the other in every respect, nevertheless the larger one will require proportionately more enforcement and support on launching to prevent its breaking apart under its own weight. The case become even more complex if the size increase over a certain limit: we will be forced to re-think the whole system.

2. Change of the material: this point is related with the previous one but also it has some specific problem. The first consideration is that in most of the cases the scale model have to use a different material compared with the final construction. This is a trivial consideration, but what is important is the behaviour will be extremely different. In the reverse structure we have to generate a model with a material suitable to resist of a certain forces that, finally, will be reversed. The case of Isler or Otto, for example, is emblematic. They use cloth or tulle for their reverse model but the flexibility, or in general the behaviour, of this materials can not be compared with anything else. The change of the material, therefore, is an issue that have to be carefully consider. A key problem is that the fracture's behaviour is extremely different. In any kind of structure we have to consider the possibility of the collapsing. The resistance, the distribution of the forces, and finally the fracture type in the cloth and in the concrete, for instance, are extremely different and can not be compared. Every material has is own behaviour and the theory of elasticity (behind everything) suggest that different materials have different propriety. When we reverse the scale model subjected by tension, for example, and we generate the final building we have to change the material for construction. It could be very lovely to generate a large dome in tulle, but unfortunately not that realistic. Necessarily e have to consider a material able to tolerate well compression forces, such as concrete, bricks, stone, which in general are massive and heavy. Tulle has, basically, exactly the opposite characteristic: light, vanish and easy to be ripped. The conclusion is that, we have carefully consider the change of the material and especially we have to consider that some technical solution still need to be invented. The best example on this point is the case of Eladio Dieste, who develop a geometry, a calculation an a technology suitable for his innovative structure.
3. Tension-Compression's reversion: This is a well-known problem and we already quote one problem of this reversion which is called buckling. Every structure generated by inversion need have to consider that a certain conformation could work appropriately in case of tension, but when it is inverted in compression the behaviour could be very

different and even generate collapsing in spite of the calculation is verified. The buckling problem is a very famous issue, but much more dangerous are situation like elementary forced resonance (generated by wind or other reason) , aeroelastic flutter . The problem of reversion of the forces can be generalized as the understanding of the force state into the structure. In the case of the reverse structure it should be, theoretically and hopefully, only the tension/compression forces, but in fact the possible presence of other kind of residual forces could be an additional and unexpected problem that suddenly appear in the real structure. If the scale model works, not necessarily the real structure can stand.

4. Forces state of the model and real structure: strictly related on the previous topic we have to consider the situation of the forces in between the model and the real structure. This chapter is dedicated mostly on this issue. In this list we no need to mention more about it, except the fact that it will be very difficult to have a precise understanding of the state of the forces into complex structures. We have to remember that the structures that we are going to consider can be classified as extremely complex. We even do not have a suitable mathematics to calculate the state of the forces. The structures that we have mentioned in this script have a tensional state which can be rationalized by modelling and, eventually, graphical method.
5. Weight of the structure: this point was already described when we have described the case of Isler's structure and Musmeci's bridge. The key point is that the scale model which generate the form of the structure in the upside-down structure has basically no weight, or at least a very modest one. At the contrary, the real structure have basically to resist to their own weight with is in many cases the most consistent forces state. In our point of view, and an invitation for the future study, it is necessary to study the relationship between type of structure and own weight. This means that certain structure's typology are more convenient in a certain scale and after that the self-weight become too hight and, consequentially, other type of structure become more technically and economically convenient. As we mention in the previous pages, one of the key point of the structure is the economical convenience. In this case, this is connected on the weight of the structure that do not mean only the safety and security, but also the economical convenience to generate a structure which, yes, can safely resist, but at the same time do not cost excessively cause the use of the materials. The biggest mistake that an architect can do, is consider the reverse structure as ideal, and this means: without the own weight, no extremal forces, no dynamic forces, no subsidence of foundation, no accident, no wind. Nothing except the structure and God (himself). This is especially valid in the case where the reverse structure are generate with the help of the soap bubble. In this paper we did not mention about this method, but we believe that the reverse structure have to be generate not only with the funicular method or the hanging model. The final shape have to be generated also with soap film self-generating form. The case of Isler was a little different, but not too much. One of his method was the use of the hanging wet cloth. After that we freeze it and then reverse .
6. Subsidence and adaptation of the foundation of the structure: this is one of the most complex case in our point of view because it concern the alteration of the geometry of

the form of the structure. In all the other point of this list, we are in front of the problem that the real structure is subjected by unpredictable forces, such as resonance and so on. But we are still in front of an organism that maintain its own form and logic. In the case of the alteration of the position of the foundation for subsidence, for example, the whole system is subjected on a different forces state and, even worst, it stand into a different geometry. IN the case of the reverse structure the form is everything. This is not foolish formalism but the understanding that the upside-down structure are formed by the gravity and the form is the diagram of the forces. To modify the geometry of the hanging structure means to generate a completely different statical situation. Every modification of the forces state in the structure generate a different form. At the same time, in parallel, every modification of the form generate a different system of forces. So: a form generate according a tensional state, necessarily can not be modify or the tensional state will be modified. But, if that specific form is already built and a different tensional state or a different geometry happen for any case (such as the modification of the position of a foundation), the immediate consequence is the losses of the perfect correspondence between form and forces and this will lead to the collapsing.

7. Additional forces on the real building which are irrelevant in the model: the discussion on this point is already explained in the previous point. One additional discussion have to be mentioned in the case where the structure are extremely light, such as in the tensile structure, or in the shells. In all those cases, we are in front of slender structure and this are characterize by a great state on instability in a certain situation – vibration or the aeroelastic flutter for example.
8. Deterioration of the material: The science of materials is a very complex are of study and it is fundamental in our concerning. The topic is immense, but in the limit of this partial list of problems, we would like to remind that the upside-down structure work with two different kind of forces. This is a key aspects in the realization of the project. We have to remind that some materials are ideal for tension (such as wood and steel), some systems can work only with tension (cable, rope, polymeric membrane) and other materials work very well under compression (concrete, stone). The choice of the material have to be very accurate according with the situation that we are facing. In general, and according with the previous experience, it seems that the best choice is to use materials which are working organically. The case of Gaudí (and the middle age builder) is classic: he use only stone for its excellent propriety under compression forces. Much more complex is the case of Dieste, who develop a specific technology (a mix between bricks, steel bar and a thiny layer of concrete) for his structure, that came on his conception of structure, the local economy and the poor ability of the local labours. We find that the main problem of the choice of the materials is not the propriety of the material. No engineer can commit a such great mistake to use an improper material. The main problem is that the reverse structure are extremely thin. If we remember the hanging model of Gaudí, or the shell of Isler, or the light-weight structure of Otto, in all those cases we are in front of structure which work on the limit of the resistance. The case of Gaudí is the same. Every case we have considered we are in front of structures where the use of the material is extreme. If this is clear in the

work of Otto and Fuller – who both claim that their work is ecological also for the less use of material in term of quantity –, in the case of Gaudí is less evident; but in fact we are in front of the same problem: the Catalan master use natural stone for the column of Chapel of Santa Coloma de Cervelló , which is extremely fragile. A deep analysis could show that in the reverse structure the material is used in the very extreme limit of its resistance. Exactly because we live in a universe subjected by time and the time generate corruption of the matter, we have to consider that the deterioration of the material in the upside-down structure can generate an immediate collapse without any "notification". The case tat we have analysed are based on the minimum amount of material (for saving energy, for philosophical approach, for the inner nature of light structure, etc.), but the minimum amount of material generate the consequence that the material is under a great stress and every slight fracture, or every small mistake in the realization, or every little anomaly in the micro-structure of the material generate an immediate collapse. Memento mori.

9. Measurement: This point has a great importance in our discussion. According with the practice of the reverse structure, the modelling has a fundamental part of the composition. We can not generate upside-down structure without modelling. The well-known problem is that the model is not the real structure. This means that the model will always have some difference with the final work. The difference concern size and materials and the fact that the final work do not correspond to the initial one. The problem of the measurement is a key issue. Te experience of Isler has a great importance of that . The measurement of the model is a key problem because we need to replicate exactly the conformation of the scale model in order to repeat the exact proportion and forms of the study structure. Every modification it will have the result of the collapsing of the final structure. Nowadays, many technology are developed on this filed, such as the laser scan. In fact, we can not see any problem about this point except the inaccuracy of whom will do the measurement. Finally we can say that the truth stand with the scale model.
10. Accident: this is partially related on the point 8 of this list. We can define accident as an event that it is not include in the normal use of the building. We will not going too deep in this topic because seems obvious, but the main concerning we need to point out is that, exactly like in the point 8, in case of accident the upside-down structure can be extremely fragile and subjected to fracture. We need to be extremely careful on this point because it can genrate fragile collapsing. We believe the problem can be solved with the use of bionic. The solution could come from the idea of "adaptive system". We have to remember that the reverse structure are included in the Bionic approach. And one of the topic of the Bionic is the living system. In most of the cases, the living system are adaptive, which means they are subjected to change according with the solicitation of the environment. The accident are unpredictable events, or events that can be predict just in part, or events that can be predict but do not appear in the normal use of the structure, or, also, event that can be sustain by the structure but then, finally, the structure is highly compromise. In the case of the adaptive structure, it exist a kind of self-regulation, or a kind of ability of the system to accept different state of order. The state of stability it is not only one but a multiple range of

situation. The first example at we can imagine is a structure which use tensor, or a damper able to absorb the external stress or movement. It is also possible to generate a structure which can modify his structure according with different state of order of the environment. In other words, a structure which has different conformation for the stability state.

11. Difference in the use between model and real structure: the scale model can be use only in few way. It can be a lovely environment for dollies, can be a nice decoration to show to friends how intelligent we are, or it can be use as a study model to realize the final structure. If our choice is the last one, then we have to consider the fact that in many cases the reverse structure are very idealistic. This is also related on the point 13 of this list, and it is also a problem that was pointed out to Isler's dome. In the case of Isler (but it seems similar to Otto cases, and in general with all this kind of structure) the form which is automatically generated are limited. In the history of architecture, the style, composition, philosophical approach generate an enormous number of formal and functional solution. But the point that, personally, we want explain is that the reverse structure can not be limited on the compressed or tensile membrane. If we introduce the case of the funicular polygon, then we discovery that the possibility of application of the upside-down structure are much more wide than in the previous cases.
12. Economic realizability: the discussion about the cost is extremely complex because the market follows a (il)logic grand that in most of the case are opposite with the “art of construction”. If we analyse the so called “market analyst” we find an embarrassing incompetence, a malicious dishonesty and a criminal behaviour which connect developer, government and bank. In short: corruption. Nevertheless the market exist and the demand of the buyers is there. The question is that the request of the market are mostly based on the ignorance and a surprising short vision. Every market is different, so it seems impossible to analyse the problem in this paper, and frankly talking we re not interested at all to analyse something like a market that in our point of view is the most virtual and unreal situation ever create in the human history. But one concept we can spend about it: every project have to be realized on the needs of that specific client. The project is the answer of a question made by one client and not by every client. The question that Nicolas Esquillan and Ove Arup point to Isler can exist only in the massive production, but in this paper we want analyse not a global production but what it is called “art of construction” . The suggestion is that, in the reverse structure, we have to generate a system which is able to solve few specific problem which match the need of one client and about the market we invite to fight against it. This is the secret of the quality of a project.
13. Self-sufficiency of the form-finding methods with the functional needs: This problem apparently is similar to the previous one, and in fact is different. We are discussion about the problem that the self-finding form is in general very limited. In other words, the form that we can obtain are limited. The function, especially in the contemporary age are much more complex, and often the method of the reverse structure can generate just a limited number of formal solution that, sometime, can not be match with the functional request of the market. We have to observe that in the last twenty

years, certain kid of function become extremely rigid and crystallized in a certain typology and space which do not follow the function, or the use, or any specific logic except the marketing. The most evident example are the shopping mall which repeat countless times the same form structure, spacial disposition. In every shopping mall it seems exist only one structure, one logic, one distribution and the action of the architect is limited on a simple decoration. Similar discussion could be done for other function. In our point of view this is a very strong limitation of the architecture and a big mistake in the current production. In the limit of this paper we have to admit that, yes, the self-form finding with the reverse structure generate just a limited number of forms and especially typology, but it is also truth that this method it is still not completely developed. The method of Isler, for example, generate an endless number of shell structure, able to cover thousand cases of architecture in a cheap and functional way. The funicular polygon method generate countless structure able to be used in every kind of structure. We want reverse the accuse. If someone point out the weakness of the self-forming method in the modern age, we can easy strike back that what is limited is not the method but the rigidity of the needs of the market. If the architect can propose more solution for each function the market will be developed in a much more exiting way.

14. Problem of the calculation of certain complex forms: this is a relative problem. Certain structure are clearly too complicated to be calculated using the common method, and surely we can forget the computer. As our paper already discussed, we no need any calculation if we use graphic method (for example), or other similar process. Nevertheless the calculation is possible and this belongs to a very specialized discipline that have to be developed in the following years. We invite engineer and mathematicians to work of the calculation of complex structure. We believe that the graphic method is a very powerful solution for this field.

Irregular and chaotic models: in the case that we have analysed in this paper we was in front of a method able to generate harmonious model, or in other words, model that generate structure that have a kind of order. The funicular polygon, for example, generate system which has a high level of definition and nothing is random. But those are not the only system that can be generate by reverse model. The example come from a young architect who form very interesting structure: Andres Harris . His work is just at the beginning, but we get some interesting case to analyse if we consider the work of “Single-” and “Multi-Spine formation”. His work on viscosity is very interesting because he generated structural forms based on extension of two parallel surfaces which in between contain resin. The result is a kind of self-generating (in this case irregular) system of “stalactite-stalagmite” which has a high level of resistance, once the resin is solidified thanks of hardener reaction . The discussion will be too long, but the interesting issue is that what we consider order it is not the only possibility for bionic structure, but just one case of order. And what it is consider random, or chaotic, can generate an interesting system able to create effective structure.

4 Open questions and problems

This paper discuss mostly the reverse structure, but introduce also several concept which surround the topic of the upside-down structure. We find that the discipline is surprising new and few people investigate it. In this section of the paper we want introduce, very briefly, some key problem that we believe are the challenge of the future development of the discipline. We are not going to discuss and intentionally we will give just a list of topic. Each one is a huge branch and we invite scholar, architect, engineer and biologist to investigate this amazing area of the nature.

We have to admit that the Bionic method in general and the reverse structure in detail contain a level of complexity that excess our capacity of analysis. In general, the first and general problem that we want express concern the method. At the most general view, we do not have any correct method to approach the nature. What we usually do in front of the Nature is to replicate the natural phenomena and often we are not able to describe the fundamental reason of certain behaviour. We know that it work, but we don't know why. At this level we are primitive troglodyte in front of the event that we adore more like god (or similar) than a physical event.

And this is the list of astonishment:

1. As we mention, we imitate the Nature but we don't know why it work.
2. We do not have any suitable mathematics or geometry to calculate appropriately the Bionic structure in general and the reverse structure.
3. We do not have any method to verify the ultimate strength of the scale model. We can create model, the stress it, but then no any appropriate method to apply this lesson on the real construction.
4. The scale model, a fundamental method as we express, is different in the behaviour, resistance, stress, usage on the real construction. If the model it work, we have no any prise that the final construction will stand.
5. What we consider random, it can have a deeper order but too complex to be discovered. What we consider order, could be just a trivial case. What we consider common, it can be wrong.
6. Sometime we impose our personal taste, creation of forms, indulgence of capricious opinion and do not follow the nature of the forms. In Bionic and reverse structure the key problem is the self-generation of the shape. Human being still do not understand that they are not God.
7. We believe that it exist a logic and the construction have to follow it. Sometime nature seems illogic but finally it work.
8. One of the key problem is that the nature work following a systemic way (or holistic, or any other fancy word which describe the part harmonically inside the whole). The scientific method is based on the division in part, and this means exactly the opposite of the nature. We declare that the scientific method is completely unable to understand the Nature, even the physical matter.
9. Nature work according “measure”, “form” and “order” . In the human activity those concept change with the age, especially change the intrinsic value of those concept. Architecture is free to don't follow this parameters. Bionic must.
10. We already mention the problem of the scale . At the actual state we don't know exactly why the corps at different scale work in a different way. We know it's concern the ration Volume/Surface, but the intrinsic reason is still

unknown. And an additional problem is: what is the limit of the scale that determine the different behaviour? When a model become “too big” to start to act differently according with he problem of the Gnomon?

11. We should develop an appropriate science that develop a deep connection between forms, structure and materials. The science of materials have to be develop according with the structure and forms. What we can find, nowadays, is the use of the traditional materials for innovative process.
12. We do not have any method to clear investigate the running of the forces into the structure. The analytical method or the mathematics are abstract and we do not have any way to analyse the fluency of the forces into the forms.
13. We have to develop an appropriate economic structure for certain forms and structure. The question of Nicolas Esquillan and Ove Arup to Isler does not have any sense especially because the current economy is the wrong system and unsustainable one. What we discuss in this paper is Bionic in sense of natural system and the contemporary economy is something abnormal.
14. … and we will always, and ever, forget something.

5 Conclusion

This paper touches a complex problem using a simple method. The model of operation tat we propose is very old, but we believe that the argumentation is new, especially in the problem that we touch and open. The reverse structure is a way to approach an extremely complex topic which in fact it cannot be easily solved in theoretical way. It is similar to the process to make fire using to wood sticks without knowing the problem of the friction. We use the ancient way of calculation of structure to point out the immense question: how the nature work.

We think that the most suitable concept in this dissertation is the idea of Efficient Structure. This concept is extremely promising and indicate a system able to optimize the performance of the organism using the most “natural” way to solve the structure. The form and the result is sure unconventional, but this do not mean wrong. It means, mostly, un-thought. We believe that the reverse structure is more performative, more natural, more efficient than most of the structure on the market. This paper offers more question that answer.

References

i. 1 Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, unpublished

ii. 1 John H. Lienhard in *Two Kind of Structural Design*, illustrate as also the dome in Pantheon in Roma was developed using the catenary method. For more information cfr.:

iii. http://www.uh.edu/engines/epi1169.htm

iv. 1 In this paper I will refer to this kind of structure simply as catenary arc, because the paternity of this structure is uncertain and surely much older than Hooke and Gaudí.

v. 1 We remind that in the area of Bionic very often we no need to investigate the nature of the phenomena, because this could lead us in an endless analysis of the most minute reason of the natural matters. The Bionic approach intend to study what is *manifest* in the Nature, how the Nature work, its process and phenomena. In the Bionic we need to understand rules,

proportion, measurement, behaviour. The question “why” belong to the theology, the “physical details” belongs to the Biomimicry.

vi. 1 As every student knows, the *Newton's law of universal gravitation* is regulated by the following formulation: «Every point mass attracts every single other point mass by a force pointing along the line intersecting both points. The force is proportional to the product of the two masses and inversely proportional to the square of the distance between them». Source: Wikipedia. Word: «Newton's law of universal gravitation». In:

vii. http://en.wikipedia.org/wiki/Newton%27s_law_of_universal_gravitation

viii. 1 The General theory of relativity is much more complex and general than the Newton's Law, because it concern a very sophisticated geometrical theory. «[...] providing a unified description of gravity as a geometric property of space and time, or spacetime. In particular, the curvature of spacetime is directly related to the energy and momentum of whatever matter and radiation are present». Source: Wikipedia. Word: «General relativity». In:

ix. http://en.wikipedia.org/wiki/General_theory_of_relativity#Definition_and_basic_applications

x. In other words, in Einstein's theory the forces of gravitation are not caused by a mysterious attraction, but by the deformation of the space-time dimension.

xi. 1 Those two definition came from: Source: Merriam-Webster Dictionary. Word: «funicular polygon». In:

xii. http://www.merriam-webster.com/dictionary/funicular%20polygon

xiii. 1 The last two definition are from: Source: «Thefreedictionary». Word: «funicular polygon». In:

xiv. http://encyclopedia2.thefreedictionary.com/Funicular+Polygon

xv. 1 A complete theory of the graphiostatic is illustrated in the classic book of Karl Culmann, *Die graphische Statik*, Meyer & Zeller (A. Reimann), 1875. This theory was developed with the contribution of many construction enterprises such as Holzmann and Benkieser and Eiffel. The complete book in pdf (German edition), in:

xvi. https://archive.org/details/anwendungenderg03culmgoog

xvii. 1 In the limit of this paper we will not explain this method which is a part of the basic training of every student of architecture and engineering. For some explanation we will remand to the following link:

xviii. home.cc.umanitoba.ca/~coar/.../GRUPFORC.PDF

xix. http://commons.wikimedia.org/wiki/Category:Funicular_polygon

xx. Extremely interesting the paper of Rolf Gerhardt, Karl-Eugen Kurrer, Gerhard Pichler, The methods of graphical statics and their relation to the structural form, Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003, ed. S. Huerta, Madrid: I. Juan de Herrera, SEdHC, ETSAM, A. E. Benvenuto, COAM, F. Dragados, 2003, pp. 997-1006. In:

xxi. http://gilbert.aq.upm.es/sedhc/biblioteca_digital/Congresos/CIHC1/CIHC1_098.pdf

xxii. 1 Cfr. Rolf Gerhardt, Karl-Eugen Kurrer, Gerhard Pichler, *The methods of graphical statics and their relation to the structural form*, Proceedings of the First International Congress on Construction History, Madrid, January 2003, Ed. Huerta, Madrid, 2003, pp. 997-1006. Pdf in:

xxiii. http://gilbert.aq.upm.es/sedhc/biblioteca_digital/Congresos/CIHC1/CIHC1_098.pdf.

xxiv. 1 D'Arcy W. Thompson, *On Growth and Form,* Cambridge University Press, 1917.

xxv. 1 Even if it is not directly connect with the topic of this paper, we have to mention that in Bionic it exist a key concept concerning this specific issue. The natural organism's structure do not follow strictly the rule of the state of the forces. This means that bones, skeleton, shells do not have *exactly* the conformation of the diagram of the forces, but they are conformed in order to *optimize the performance* of the system. This sophisticated concept it will be describe in the future in a more specific papers.

xxvi. 1 A close funicular polygon is the one where all the forces are in balance and the graphical resultant of the composition of all the forces result close. This close system are in balance, and this means that the results of all the forces in every direction in $\mathbb{R}^2$ or $\mathbb{R}^3$ are zero. But the funicular polygon could be also open, of course. In this case, it exist a force that, in some direction and in some entity, let the system be dynamic. In other words, the resultant of all the forces is ≠ zero. The effect is that the system is not static, but dynamic. This structure are not wrong, and at the contrary have a very interesting propriety that we will describe in this paper.

xxvii. 1 Three are the basic condition for a building in *De architectura*, by Vitruvius: firmness (firmitatis), utility (utilitatis), and beauty (venustatis), (liber I, 2).

xxviii. 1 The reference is, of course, to the Archigram's *Walking city* in 1964 (by Ron Herron). We admire that project and we consider a clear example of "funky" architecture, and in general, a very important example which characterize the architecture culture between 1060 to 1979.At the same time we know very well the project of Kiyonori Kikutake (菊竹 清訓), *Marine City* project of 1958. We met personally Mr. Kikutake in 1996 in Italy during a conference and his objective and rational vision of the reality was surprising. We mention this personal case, because we strongly admire the utopic and imaginative proposal for architecture.

xxix. 1 We will see that in the reality the situation is much different, but in the approach of the problem we have to approach this structure in the ideal case to make the discussion more clear.

xxx. 1 The suspended bridge are extremely interesting in terms of history. We do not ave any specific investigation, but it seems that the first examples of this structure came from the 15th Century, in Tibet and Meso-America. It will be very interesting, in the future, to discovery more information about it. We believe tat their invention is a true Bionic process and we suspect tat their beginning is much more far in past.

xxxi. 1 In our future paper, we will introduce some cases of reverse structure from the past and in most of the cases we are in front of curves structure.

xxxii. 1 For the description of this funny example of underground architecture cfr. Shortlist.com. In:

xxxiii. http://www.shortlist.com/cool-stuff/design/the-upside-down-skyscraper

xxxiv. 1 This topic is extremely interesting and in our research e collect many example. But the analysis of this cases is too long and complex. In the limit of this paper we can only describe briefly some important example. One of the most evident is the Otto and Diesel Engine for car. It is evident that this is an evident case of inertia of the technology. The most common engine that nowadays we use dated respectively: 1954, Wankel engine; 1950's, Free-piston engine; July 18, 1942, Messerschmitt Me 262 first jet engine; March, 1937, Heinkel HeS 1 experimental hydrogen fueled centrifugal jet engine; 1937, first successful run of Sir Frank Whittle's gas turbine for jet propulsion; 1925, Wilhelm Pape patents a constant-volume engine design; 1925, Hesselman direct gasoline injection; 1900, Wilhelm Maybach designed an engine built at Daimler Motoren Gesellschaft; 1900, Rudolf Diesel demonstrated the diesel engine in the 1900 Exposition Universelle; 1898, Fay Oliver Farwell designs the prototype three or five cylinder rotary internal combustion engines; 1896, Karl Benz invented the boxer engine, also known as the horizontally opposed engine, or the flat engine; 1892, Rudolf Diesel developed his Carnot heat engine type motor; 1891, Herbert Akroyd Stuart built his oil engine; 1884, British engineer Edward Butler constructed the first petrol (gasoline) internal combustion engine; 1882, James Atkinson invented the Atkinson cycle engine, which had one power phase per revolution together with different intake and expansion volumes, potentially making it more efficient than the Otto cycle, but certainly avoiding Otto's patent; 1879, Karl Benz was granted a patent for his internal combustion engine, a reliable two-stroke gas engine, than later, Benz designed and built his own four-stroke engine that was used in his automobiles; 1878, Dugald Clerk designed the first two-stroke engine with in-cylinder compression; 1876, Nikolaus Otto, working with Gottlieb Daimler and Wilhelm Maybach, started the genesis of the four-cycle engine; 1872, In America George Brayton invented Brayton's Ready Motor; 1862, Nikolaus Otto was the first to build and sell the engine; 1861 4-cycle engine, by Alphonse Beau de Rochas; 1860, Belgian Jean Joseph Etienne Lenoir (1822–1900) produced a gas-fired internal combustion engine; 1856, Pietro Benini realized a working prototype of the Italian engine supplying 5 HP; 1853-57, Eugenio Barsanti and Felice Matteucci invented and patented an engine using the free-piston principle that was possibly the first 4-cycle engine; 1838, William Barnett made the first recorded use of in-cylinder compression. All those engine are based on the thermodynamic theory of idealized heat engines made in 1824 by Sadi Carnot. Source: Wikipedia. Word: History of the internal combustion engine. In:

xxxv. http://en.wikipedia.org/wiki/History_of_the_internal_combustion_engine

xxxvi. The conclusion is that the engine that we are using nowadays are based on a concept made in 1824 and on a model developed since 1838 and 1856.

xxxvii. 1 Most of the modern gasoline engines have a maximum thermal efficiency of about 25% to 30%. The most efficient type, direct injection Diesels, are able to reach an efficiency of about 40%. Source: Wikipedia. Word: Engine efficiency. In:

xxxviii. http://en.wikipedia.org/wiki/Engine_efficiency

xxxix. 1 This engine, originally conceived in 1816, basically reach 40% of efficiency. General discussions of the Stirling engine. In:

xl. http://www.bekkoame.ne.jp/~khirata/academic/kiriki/begin/general.html

xli. This engine it is also used for cars and many other applications.

xlii. 1 Cfr. in:

xliii. http://fuel-efficient-vehicles.org/energy-news/?page_id=908

xliv. http://peswiki.com/index.php/Directory:Massive_Yet_Tiny_%28MYT%29_Engine

xlv. 1 Hans Christian Andersen, *The Emperor's New Clothes*, 1837.

xlvi. 1 Cfr. note 1 on this paper.

xlvii. 1 *Ibid*.

xlviii. 1 This is a simple example. The sequence of rings can help us to understand the behaviour if the system. But it is exactly the same in continue material like a rope or a line. We can consider the continue material as a sequence of singe unit particles provided by weight.

xlix. 1 In fact, in the real world this is not truth. Every ring has tension forces (N_+) between the adjacent rings, but every ring itself has a multiple forces. We can imagine a ring, perfectly circular. If we have (N_+) to the opposite site, the circular ring will be deformed and become an ellipse. This means that inside every single ring the state of the forces is absolutely more complex than a single tension. We have to remember that in this aper we describe an ideal case. In the reality the things are much more complex and the problem will be briefly analyse in the part V of this script.

l. 1 In this paper we consider the chain, line, rope, similar case.

li. 1 D'Arcy W. Thompson, *On Growth and Form,* op. cit., chapt. 8.

lii. 1 This is related on all the corps in the liquid, or the dynamic of the gas, or laminal forces.

liii. 1 A brief note is necessary. Soap bubble, membrane, shells, all those structures are based on forces that belongs to the pressure.

liv. 1 For an introduction of Gaudí structure and method, cfr. with:

lv. http://www.sagradafamilia.cat/sf-eng/docs_instit/arquitectura_c.php

lvi. http://www.sagradafamilia.cat/sf-eng/docs_instit/estructura1.php

lvii. http://www.sagradafamilia.cat/sf-eng/docs_instit/estructura2.php

lviii. http://www.sagradafamilia.cat/sf-eng/docs_instit/estructura3.php

lix. http://www.sagradafamilia.cat/sf-eng/docs_instit/estructura4.php

lx. 1 In fact, it is not totally correct. This is valid only for the theoretical structure, and partially for the scale model. In the real structure the weight of the building, the wind-pressure, the subsidence of the foundation, and other forces, create a much more complex state of the forces. We will discuss this problem in the section III of this paper.

lxi. 1 Source: Wolfram MathWorld. Word: «Catenary». In:

lxii. http://mathworld.wolfram.com/Catenary.html lxiii. For a short analysis between the hyperbolic cosine curve and other similar function such as parabola:

lxiv. $[f_1]$: $p(x)=x^2$

lxv. trigonometric sine curve:

lxvi. $[f_2]$: $f(x)=\cos x$

lxvii. cfr. with: Gail Kaplan, *The Catenary Art, Architecture, History, and Mathematics*. In:

lxviii. http://archive.bridgesmathart.org/2008/bridges2008-47.pdf

lxix. 1 In the section III we will describe more about the difficulties to convert the ideal model into reality and the correct use of the materials for the realization.

lxx. 1 Mark Schenk, *On the shape of Cables, Arches, Vaults and Thin Shells*, 2009. In:

lxxi. http://www.readbag.com/www2-eng-cam-ac-uk-ms652-files-iastruct-cables-and-arches

lxxii. 1 The case of Eladio Dieste is extremely different from the reverse structure. The discussion is very technical and include the analysis of the construction technologies and the forms that the Uruguayan master used in his works. Just as a hint, we can mention that the curves that Dieste use are Gaussian vault and not cosine hyperbolic functions. In addition, the whole system of his work is much more complex than the simple catenary forms. For more details cfr. With: Mark Schenk, *On the shape of Cables, Arches, Vaults and Thin Shells*, op. cit. Especailly, Mercedes Daguerre, *Eladio Dieste*, Electa, Milano, 2003. Also in Chinese Paolo Vincenzo Genovese, *Eladio Dieste*, Archicreation, ????

lxxiii. 1 This structures are extremely interesting and part of the work of Eduardo Torroja include these examples. This elements will be not included in this study for the reason that the corrugated curve structure are connected with the folding structure, even more complicated. We just quote the case as a tribute to the work of Torroja who we consider one of the greatest master of all the time.

lxxiv. 1 H. Isler, *Twenty-Five Years Attempt for Structural Beauty*, IABSE Congress Report, No. 11, 1980, p.149. Quote in Toni Kotnik, Joseph Schwartz, *The architecture of Heinz Isler*, in Journal of the International Association for Shell and Spatial Structures, Vol. 52 (2011) No. 3 September n. 169, p. 187. In:

lxxv. http://www.schwartz.arch.ethz.ch/Publikationen/Dokumente/Isler.pdf

lxxvi. 1 David Wendland, *Model-based formfinding processes: Free forms in structural and architectural design*. In:

lxxvii. elib.uni-stuttgart.de/opus/volltexte/.../wendland.pdf

lxxviii. 1 In *Ibid*. Cfr. also: Toni Kotnik, Joseph Schwartz, *The architecture of Heinz Isler*, op. Cit. Cfr. also with the interesting analysis in Tessa Maurer, Elizabeth O'Grady, Ellen Tung, *Inverse hanging membrane: the Naturtheater Grötzingen*, in:

lxxix. http://shells.princeton.edu/Grotz.html

lxxx. 1 About Sergio Musmeci short analysis we already quote in: Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, op. cit.

lxxxi. 1 John Chilton, *Heinz Isler's infinite spectrum form-finding in design*, Architectural Design, Special Issue: *The New Structuralism: Design, Engineering and Architectural Technologies*, Volume 80, Issue 4, July/August 2010, p. 67. Pdf version in:

lxxxii. http://arhns.com/wsh/literatura/10_Heinz%20Isler's%20Infinite%20Spectrum%20Form-Finding%20in%20Design.pdf.

lxxxiii. 1 Toni Kotnik, Joseph Schwartz, *The architecture of Heinz Isler*, op. cit. David Wendland, *Model-based formfinding processes: Free forms in structural and architectural design*, op. cit. H. Isler, *Twenty-Five Years Attempt for Structural Beauty*, op. cit.

lxxxiv. 1 A complete description of his work and his technique can not be fully developed in this paper which has the goal to illustrate generally the topic.

lxxxv. 1 Cfr. Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, op. cit.

lxxxvi. 1 *Ibid*.

lxxxvii. 1 Cfr. Rinaldo Capomolla, *Il ponte sul Basento di Sergio Musmeci. Il progetto della forma strutturale prima dell'avvento del calcolo automatico*, in: AA.VV., *Atti del Primo Convegno Nazionale di Storia dell'Ingegneria.* Napoli, 8-9 marzo 2006, a cura di Alfredo Buccaro, Giulio Fabricatore, Lia Maria Papa, Tomo II, pp. 1143-1152 [In Italian]. In:

lxxxviii. http://www.aising.it/docs/atticonvegno/p1143-1152.pdf

lxxxix. 1 Similar opinion are included in David Wendland, *Model-based formfinding processes: Free forms in structural and architectural design*, op. cit.

xc. 1 Juan Maria Songel, *A Conversation with Frei Otto*, Princeton Architectural Press, New York, 2010, p. 38.

xci. 1 *Ibid*.

xcii. 1 If someone argue that the perfect form do not exist in there real world, we would like to remind that this paper concern physics and not metaphysic. We kindly suggest, in this sense, our work about it.

xciii. 1 Juan Maria Songel, *A Conversation with Frei Otto*, op. cit., p. 41.

xciv. 1 Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, op. cit.

xcv. 1 For more technical details, cfr. with Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, op. cit.

xcvi. 1 The detail of this technical consideration are include in Rinaldo Capomolla, *Il ponte sul Basento di Sergio Musmeci. Il progetto della forma strutturale prima dell'avvento del calcolo automatico*, in: AA.VV., *Atti del Primo Convegno Nazionale di Storia dell'Ingegneria.* Napoli, 8-9 marzo 2006, a cura di Alfredo Buccaro, Giulio Fabricatore, Lia Maria Papa, Tomo II, pp. 1143-1152 [In Italian]. In:

xcvii. http://www.aising.it/docs/atticonvegno/p1143-1152.pdf

xcviii. Discussed already in Paolo Vincenzo Genovese, *General consideration on the Bionic approach in architecture and engineering*, op. cit.

xcix. 1 This list is a personal opinion and surely incomplete. We list in order of importance according with our understanding of the problem. In addition, we mention that the point 1, 11, 12, 13, in this list are problems that was already point out to Heinz Isler from some leading engineer such as Nicolas Esquillan and Ove Arup during the first congress of the International Association for Shell Structures in Madrid, led by Eduardo Torroja. Quote in: Toni Kotnik, Joseph Schwartz, *The architecture of Heinz Isler*, op. cit. The paper contains a mistake in the spelling of the name of Nicolas Esquillan, called “Nocolas”.

c. 1 We discuss this problem in a early investigation of the Bionic system, in particular concerning the analysis of the project of Messina Bridge, made by Sergio Musmeci in 1969-’70. For more detail, cfr. with: Paolo Vincenzo Genovese, *Come imparare dalla forma in natura. Bionica e architettura* [Translation: *How to learn from the natural forms. Bionic and archiecture*], in L'Architettura – Cronache e storia, ???

ci. 1 This word come from the Greek «γνώμων», [gnōmōn], and it is referred for many mathematical and geometrical problem. The most famous is the use of the gnomon by Thales of Miletus to measure the high of the great pyramid of Khufu. The story is very famous and no need to be explained again.

cii. 1 D'Arcy W. Thompson, *On Growth and Form*, op. cit.

ciii. 1 Galileo Galilei, *Discorsi e dimostrazioni matematiche intorno a due nuove scienze attinenti alla meccanica e ai moti locali* [*Discourses and Mathematical Demonstrations Relating to Two New Sciences*], Ludovico Elzeviro Publlisher, Leida, Holland, 1638.

civ. 1 The story is very interesting and it will be interesting to quite interely. «Please observe, gentlemen, how facts which at first seem improbable will, even on scant explanation, drop the cloak which has hidden them and stand forth in naked and simple beauty. Who does not know that a horse falling from a height of three or four cubits will break his bones, while a dog falling from the same height or a cat from a height of eight or ten cubits will suffer no injury? Equally harmless would be the fall of a grasshopper from a tower or the fall of an ant from the distance of the moon. Do not children fall with impunity from heights which would cost their elders a broken leg or perhaps a fractured skull? And just as smaller animals are proportionately stronger and more robust than the larger, so also smaller plants are able to stand up better than larger. I am certain you both know that an oak two hundred cubits high ,would not be able to sustain its own branches if they were distributed as in a tree of ordinary size; and that nature cannot produce a horse as large as twenty ordinary horses or a giant ten times taller than an ordinary man unless by miracle or by greatly altering the proportions of his limbs and especially of his bones, which would have to be considerably enlarged over the ordinary. Likewise the current belief that, in the case of artificial machines the very large and the very small are equally feasible and lasting is a manifest error. Thus, for example, a small obelisk or column or other solid figure can certainly be laid down or set up without danger of breaking, while the large ones will go to pieces under the slightest provocation, and that purely on account of their own weight». In ivi or Galileo's *Two New Sciences*, First day, Interlocutors: Salviati, Sagredo and Simplicio, pages 1 – 4, in:

cv. http://galileoandeinstein.physics.virginia.edu/tns1.htm

cvi. 1 It happen when the external periodic frequency that matched the natural structural frequency.

cvii. 1 This is the case happened for the famous first *Tacoma Narrows Bridge* by Leon Moisseiff, collapsed on 1940 November 7. The case is well documented in:

cviii. http://www.youtube.com/watch?v=nFzu6CNtqec

cix. The aeroelastic flutter is the interactions between the inertial, elastic, and aerodynamic forces that occur when an elastic body is exposed to a fluid flow.

cx. 1 Toni Kotnik, Joseph Schwartz, *The architecture of Heinz Isler*, op. cit. John Chilton, *Heinz Isler's infinite spectrum form-finding in design*, IASS Journal, pp. 64-71, John Wiley & Son, 2010. in:

cxi. http://onlinelibrary.wiley.com/doi/10.1002/ad.1108/abstract

cxii. 1 In fact, its propriety are isomorphic, which means are exactly he same in every direction of the space and with same behaviour under compression and tension.

cxiii. 1 Barcelona, Spain, 1898-1915.

cxiv. 1 J. Chilton, *Form-finding and fabric forming in the work of Heinz Isler*, icff2012, in:

cxv. http://fabwiki.fabric-formedconcrete.com/lib/exe/fetch.php?media=nottingham:form-finding_and_fabric_forming_in_the_work_of_heinz_isler.pdf

cxvi. 1 For more detail about the concept of art of construction cfr. Paolo Vincenzo Genovese - 罗杰威, 源泉的求索：建筑的内涵及解读, 中国建筑工业出版社, 北京, 2013.

cxvii. 1 Cfr in:

cxviii. http://www.andres.harris.cl

cxix. 1 The process is included in:

cxx. http://www.andres.harris.cl/?page_id=36

cxxi. 1 Aurelii Augustini, *De Natura Boni*, I, 4. Italian version: Agostino, *Natura del bene*, Bompiani, Milano, 2001, I, 4, p. 121.

cxxii. 1 Cfr. this paper, part III, point 1.

02.103 - THE ROLE OF ARTIFICIAL INTELLIGENCE IN ARCHITECTURAL DESIGN: CONVERSATION WITH DESIGNERS AND RESEARCHERS

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Abstract

The proliferation of data together with the increase of computing power in the last decade has triggered a new interest in artificial intelligence methods. Machine learning and in particular deep learning techniques, inspired by the topological structure of neurons network in brains, are omnipresent in the IT discourse, and generated new enthusiasms and fears in our society. These methods have already shown great effectiveness in fields far from architecture and have long been exploited in software that we use every day. Many computing libraries are available for anyone with some programming skills and allow them to "train" a neural network based on several types of data.

The world of architecture has not remained external to this phenomenon: many researchers are working on the applications of artificial intelligence to architectural design, a few design software allow exploiting machine learning algorithms, and some large architectural firms have begun to experiment with deep learning methods to put into practice data accumulated over years of profession, with special interest in environmental sustainability and building performance. If on the one hand, these techniques promise great results, on the other we are still in an exploratory phase. It is then necessary, in our opinion, to understand what the roles of this technology could be within the architectural design process, and with which scopes they can facilitate such a complex profession as that of the architect.

On this subject we made ten interviews with as many designers and researchers in the AEC industry, In the article we will report a summary of their testimonies, comparing and commenting on the responses of the designers, with the aim of understanding the potentials of using artificial intelligence methods within the design process, report their perceptions on how artificial intelligence techniques can affect the architect's approach to the project, concluding with some reflections on the critical issues identified during the interviews with the designers.

Keywords

Digital Architecture, Artificial intelligence, Machine Learning, Architectural Design, Computational Methods

1 What do we mean by artificial intelligence?

Since artificial intelligence methods have become of great interest in every scientific and commercial sphere, it is, however, necessary to point out the meaning of the term artificial intelligence, used commercially with different meanings.

If it is true that already in 1950 Alan Turing wondered if a machine could imitate human intelligence, it is also true that the term with the meaning we attribute to it today was coined in 1955 by John Mc Carthy, to describe a research field where "explore ways to make a machine that could reason like a human, was capable of abstract thought, problem-solving and self-improvement" [1].

Over 60 years, artificial intelligence has been enriched with sub-fields and related methods that vary from the simplest Rules-Based Systems, to Machine Learning, shallow and deep neural networks, natural language processing, speech processing, image recognition and many others. To define these different methods of artificial intelligence it is useful to differentiate them according to the need for human interaction during their learning process. In the case of supervised learning, the presence of a programmer, or better that of a data scientist, is required to organize the data in order to allow the software to create and therefore recognize the desired correlations between input and output. With active learning, the interaction required by the algorithm to direct its choices is minimal, and most of the data is unlabelled. There are then reinforced learning approaches, processes in which the data is collected in real-time and the software is able to gradually learn based on its own experiences. Finally, there are those methods that involve unsupervised learning, which implies total autonomy of software in generation of rules used to analyse the information collected and independently search for correlations that the machine will use to process the data [2]. Among these methods, the ones that have seen the greatest development in recent years are clustering algorithms, which measure the similarities between uncategorized data, organizing them into clusters, through which they distinguish the new data acquired, without the need for human interaction. Deep Leaning algorithms, which are based on the relatively old concept of Artificial Neural Networks, are now extremely popular and extensively applied in many fields. This is mainly due to the advent of fast graphics processing units (GPUs) the have significantly increased our computational capability and made now it possible to apply such novel Machine Learning techniques to an extremely large set of problems. The fundamental characteristic of neural networks, is the organization of the algorithm, a computer analogue of the brain neuronal interconnections. A deep neural network is therefore organized in different layers, even 100, each of which includes multiple neurons.

Through this complex structure, the algorithm can independently manage a huge complexity of data and extrapolate information previously unobtainable by any other type of algorithm[3]. To date, applications of these networks found large within numerous fields, from self-driving cars, the translation of texts or facial recognition, even managing to beat human champions in complex games such as Go [4].

Reactions towards these technologies have been as positive as negative, if on the one hand some read their enormous potential and have shown confidence in their wide adoption, others [5] warned us, saying that Artificial Intelligence could even decree the end of the human race. Even in the architectural field, there is a discussion about their role within the practice, several researchers and architects have said that the introduction of the next artificial intelligence will bring modification to architecture [6]. In order to understand the topic, it is important to investigate how architectural firms have welcome artificial intelligence methods, and what are architects expectations about them.

2 Will artificial intelligence be useful in architecture?

From February to July 2019 we met and interviewed ten architectural designers and researchers with great experience in digital design: Daniel Davies, former Director of Research of WeWork, Aurélie de Boissieu, London Head of BIM Grimshaw Architects, Xavier de Kestellier, director of Hassell, Al Fisher, Head of computational development of Buro Happold engineering, Irene Gallou, Head of specialist modelling group of Foster+Partners, Harry Ibbs, Europe design technology director of Gensler, Andres Klok Pedersen, partner at BIG – Bjarke Ingels Group, Arthur Mamou Mani, director of Mamou Mani studio, Edoardo Tibuzzi, director of AKTII and Pablo Zamorano, head of computational design of Heatherwick studio.

We asked all of them to order various of industry 4.0 enabling technologies and digital techniques characteristic of our sector based on the usefulness they will demonstrate in architecture. The interviewees, therefore, gave a vote from seven to one to the technologies of Internet of Things, Augmented Reality, Virtual Reality, Digital Manufacturing, Machine Learning, BIM and "Other computational methods" category which includes other possible methods not mentioned among others in the group. It is important to point out that the respondents were asked to make predictions over the next 10 years based on their impressions, taking for granted the benefits already demonstrated by these technologies in contemporary practice within their experiences, with obvious reference to Building Information Modeling.

Interviewee	BIM	Other Comp. Meth.	IOT	AR	VR	Machine Learning	Digital Manufact.
Arthur Mamou Mani	5	6	2	3	1	4	7
Al Fisher	6	7	2	4	1	3	5
Andres Klok Pedersen	7	1	2	4	3	6	5
Aurélie de Boissieu	1	2	5	4	3	7	6
Daniel Davies	7	7	5	4	3	2	1
Edoardo Tibuzzi	2	7	5	3	3	4	6
Harry Ibbs	1	3	2	5	4	7	6
Irene Gallou	2	3	5	4	4	7	6
Pablo Zamorano	3	7	4	5	6	6	5
Xavier de Kestellier	3	4	6	1	2	7	4
Total	37	47	38	37	30	**53**	51

Fig.1: Results of the question “Order the following technologies for the usefulness they will have in Architecture over the next 10 years”. In green, first places for each personal ranking.

As is evident from figure 1, Machine Learning is the technology that obtained the highest score with a total of 53 out of 70 achievable points, followed by digital manufacturing with 51, third “other computational methods” with 47, then Internet of things with 38, BIM and Augmented Reality with 37, last Virtual Reality with 30. It is interesting to note that Machine Learning and "other computational methods" both obtained the first place in the personal rankings of the designers four times, as well as happened twice for BIM and once for Digital Manufacturing.

It is therefore clear that based on the experiences and expectations of the interviewed designers, machine learning and its derivations are expected to play a role within the architectural practice, a role that, for many of the interviewees, will be decisive in ten years.

3 The approach to artificial intelligence in professional practice.

Despite expectations, all the designers interviewed acknowledged that the relationship between the most advanced machine learning techniques and architecture practices is still in an embryonic phase. What is happening is what Eduardo Tibuzzi, among others, recognizes as a moment of experimentation, characterized by a pioneering and empirical approach, in which the new techniques will be adopted to measure their potential. This has already happened with all the digital techniques previously applied in architecture, from the use of the digital curve to the parametric design, up to the evolutionary algorithms and swarm intelligence, well known within the architectural community today, systems which, outside our profession, are also exploited within machine learning and deep learning methods [7].

As Harry Ibbs states, there are substantial differences between these new methods and previous digital techniques adopted in Architecture. It is required, before applying them, to understand how they work, and master at least one programming language. We can also say with certainty, that to adopt these most advanced techniques we need significantly greater computing power compared to common computers and workstations. As an example, if we want to create a deep neural network, the faster strategy would probably include the use of Tensorflow or Pythorch, open-source computer libraries developed by Google and Facebook respectively, which allow, like several others, to develop machine learning and deep learning algorithms. Anyone wishing to try these methods can then count on extensive documentation, practical and theoretical lessons, tutorials, guides and on-line support based on large communities.

To work at their best, these libraries use parallel computing: the ability to simultaneously perform thousands of operations, thanks to high parallelism video cards, without which deep learning would not be possible in an accessible time. It is then possible the practice of remote parallel computing, in the form of cloud services offered by some of the web giants, who rent their powerful IT infrastructures with tariffs based on the machines' effective use.

To exploit the power of deep neural networks, specific skills and a computing power, significantly higher than that available within an ordinary architectural firm today, are therefore required. Deep Learning, unlike the most common machine learning algorithms, requires time in the order of hours or even weeks of CPU time, for training, so to acquire and process the huge amount of data required for its operation, after that neural networks can be interrogated quickly.

4 The role of Data

As underlined by almost all the interviewees, the topic of data is central in any machine learning application. Because data and their structure will strongly influence final outputs: a neural network, for example, will become very able to distinguish a cat, only after seeing thousands of photos of cats, examples from which it will autonomously extrapolate characteristics with which the AI will build his idea of the object cat. Leaving aside the ethical considerations related to artificial intelligence in general, it is necessary to reflect on the data we inject in these processes. The ways we collect and organize them can lead to biased output, and on more than one occasion artificial intelligence has shown discriminatory behaviours concerning ethnicity or gender [8].

An excellent example applied to architecture is provided by Xavier de Kestelier, who states that: "if you only show them modernist architecture, the AI will only be able to create modern architecture" this statement refers in particular to some applications of the deep learning, and testifies how the functioning of these methods can be influenced by the data we used to populate the algorithms. It is therefore important to ask ourselves what is the data that an architecture firm can use, suitable in quantity and quality, to develop artificial intelligence methods? And above all: What are the goals we want to achieve using them?

Despite the increasing role of data in contemporary society, in the fragmented world of architecture, only a few practices have fully embraced the use of data within the design process [9]. In the case of the latter, it is certainly possible for Architects to take advantage of a collection of data collected during the design, construction and use of the architectures already built over the years. As Aurelie de Boissieu and Pablo Zamorano point out, it is possible to base these methods on all the legacy knowledge that professional practices have built up over years of experience. The data can also be created based on purely geometric considerations, as it happens when you want to optimize the number of parking spots inside a parking lot, or the number of desks in a room.

For these purposes, machine learning has already been used, and it can provide as output a highly performing geometric configuration according to functional criteria previously established by the designers. Potentially all simulations, starting with physical and environmental models to human behaviours, represent a source of data, especially for deep learning. Ss they can be obtained with relative simplicity, and they are potentially consistent with the amount of information required from a deep neural network to learn something. This occurs, for example, with computational fluid dynamics simulations, as Irene Gallou testifies, who affirms how neural networks, thanks to the experience and data acquired on the subject for over ten years, adequately trained with billions of simulations, are capable, just by intuition, to quickly provide a building's wind behaviour model, immediately useful for Architecture choices.

Several Architectural offices and companies have already started to collect data on how space is inhabited, through traceability systems and user feedback. With this information, it is possible, as an example, to obtain information on the effective use of spaces within a co-working, and remodel internal environments taking into account their actual use. Al Fisher told us that data collected inside a stadium during a football game was analyzed with machine learning methods developed by his office to design a new stadium. The number of computer data available is also growing: administrations and governments at different levels are increasingly collecting data to optimize processes and distributing them for free.

Limiting our view to architecture, it is easy to observe how those who surely have a stronger connection with data, in addition to large architectural firms, are software houses. Companies specialized in digital tools for Architectural design and a relationship of constant dialogue and collaboration with some of the most innovative architecture firms.

5 Current contributions and expectations

About the contribution and role that artificial intelligence will have within the architectural project, it is quite clear that it will be, at least initially, limited to those areas in which there is a well-defined set of rules as Xavier de Kestelier suggests. He cites, as an example, design of residential buildings in Asia, where there are specific rules to be respected, a theme on which AI will be able to make a large contribution in the future. Daniel Davis, author of numerous researches on machine learning applications to architecture [10], also states that, although it is certainly true that machine learning will have a role to play in architecture: "I don't think machine learning should be seen as a magic bullet, it's a difficult and complex technology to use, and only really works in certain situations".

Speaking about Deep Learning methods, Andres Klok Pedersen confirms that we have just begun to know these systems. Underlining that, when applied in other fields, they showed great skills when used in a coordinative way instead of a prescriptive one: avoiding teaching what they should strictly do, defining instead game rules and success criteria and letting artificial intelligence find its answers independently.

If anyone expects Artificial Intelligence to report on architecture the disruptive influence they are demonstrating in areas such as autonomous driving, image recognition or other fields, it is clear that none of the designers interviewed currently sees the possibility of such a massive revolution in architecture. This is because, as Andres Klok Petersen points out, architecture is certainly among the most complex professional practices, and any architectural choice involves countless aspects. It is not a question of carrying out a single operation correctly, but of finding in one move a solution capable of solving a vast collection of problems. Engineering constraints, human, environmental parameters, politics, social sciences, art, are just some of the parameters from which the design choices arise. Architecture is a complex practice. On the contrary, sectors where Artificial Intelligences are showing an important impact, have a more linear nature than that of our profession. The interviewee goes on saying that, by breaking up the architect's work into separate tasks, describing the process rigorously, it is easier to imagine an AI capable of solving these operations individually. It is therefore important to ask ourselves several questions: Are we able to manage these enormous potentials to generate new concepts and ideas? Can we describe this complexity so that a machine can process it? Maybe in the future.

It is therefore still too early to understand how much these technologies will erode from an architect's professional practice, and certainly nothing in terms of responsibility. In this sense, Arthur Mamou Mani declares that even by using AI, designers retain the right to control the design process at any time, making choices and questioning answers provided by artificial intelligence.

Looking to the near future, with a realistic approach to the potential already shown by these methods within their first applications in the field of architecture, Irene Gallou potentially sees in Artificial Intelligences some magnificent assistants, able to remember all the experience acquired through data properly structured, and quickly return feedback that is certainly useful for architects.

6 Conclusions

According to our respondents' answers and reflections there is confidence that, the most advanced artificial intelligence will be highly useful for professional practice over the next ten years. It is important to note that, the interviewees also see utility for architecture in technologies such as digital manufacturing or other computational methods, of which, among other things, artificial intelligence could become an engine. The relationship between Artificial Intelligence and professional practice is currently at a recognized pioneering status: few studies and companies with specific skills, especially computer skills, familiarity with data, experience, and parallel computing capabilities, are exploring the applications of advanced artificial intelligence within the architectural practice.

Within these offices, some of the most advanced methods of machine learning and deep learning have demonstrated great results in limited areas, in terms of data analysis and optimization, also proposing effective spatial configurations when the boundary conditions are duly defined.

The data, which plays a central role within each machine learning and deep learning strategy, must be structured consistently and be a lot. These algorithms use in fact, thousands or even billions of examples to learn autonomously, and the amount of data is decisive for the result's quality. So, among the first data used with these strategies, we may easily find those produced in years of professional experience. New data can be collected, created or acquired. That of data is certainly one of the most sensitive subjects from an ethical point of view: data is collected more and more often and by many actors, from technology giants to governments, and it is certainly important to question their validity upstream of any artificial intelligence process. Architect's responsibility is therefore enhanced: An architect can question the machine's outputs at any time but he must also be able to understand the quality of the inputs with which he trains the machine.

Given the complexity of architecture, our interviewees exclude that artificial intelligence will be able to have disruptive effects in our field in the short-term, the role that AI will probably assume in the immediate future will be that of an assistant, extremely specialized and able to solve very specific problems.

Even if it is not yet quantifiable how much the introduction of these hyper-specialized artificial colleagues will erode from the architect's practice. However, we can assume that profession, within some of the most innovative studies, will further approach computer science, statistics and science in general. Skills needed to be able to obtain information and solutions capable of speeding up the project and improving the final architectures. The contribution of software houses within the phenomenon of artificial intelligence in architecture remains to be investigated. It is probable, that in the case of proven usefulness and diffusion of AI within the most innovative architectural firms, software houses will probably be decisive in the dissemination of new tools developed ad hoc for our sector.

The full interview with the Architects will be published with Giuseppe Gallo's doctoral thesis.

Acknowledgements

We warmly thank the Architectural Offices and designers who have agreed to participate in our series of interviews, our thanks also go to Francesco Grigoli for his technical comments and suggestions.

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02.104 - A NEW SURVIVAL MODEL FOR THE REUSE OF HISTORICAL BUILDINGS –TAKING MIYAHARA OPHTHALMOLOGY OF TAICHUNG CITY AS EXAMPLE

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Abstract

There are two dominant philosophies regarding the restoration and reuse of historical buildings in Taiwan: the Northern School advocates "repairing old as old", while the Southern School advocates "repairing old as new". According to the Cultural Heritage Preservation Act, the public sector should adhere to the "repairing old as old" paradigm. Nevertheless, the restoration and reuse of historical buildings under this premise are often met with dilemmas such as insufficient space to meet contemporary needs, low visiting frequency of the suggested exhibitions, and lack of self-financing commercial strategies. The Japanese colonial Miyahara Ophthalmology building, which belongs to the Dawncake Group, established a new era for the reuse of historical buildings in Taiwan. This study discusses Miyahara Ophthalmology in depth via case analysis, field observation, literature review, and online consumer evaluation. The findings are as follows:

1. Under the increasing financial pressure, the interdisciplinary reuse model of Miyahara Ophthalmology marks a new opportunity in the private sector, though it should not be the only model for the restoration and reuse of historical buildings.
2. The success of Miyahara Ophthalmology, while partly due the uniqueness and restoration of the historical building itself, can be primarily attributed to the sophisticated brand products, brand marketing, business strategy, and the brand's contribution to Taiwan's ecology, culture and society, all of which are independent of architecture.
3. Despite some critiques from the elite, the overwhelmingly positive feedback from the general public is an undeniable fact.
4. Retaining the facades and using many recycled objects as interior decoration successfully implemented the concept of sustainability.

Keywords:
Miyahara Ophthalmology, Brand, Sustainability, Interdisciplinary, Reuse

1 INTRODUCTION

1-1 Motivation

Reuse of historical buildings is an approach of implementing sustainable development and revitalizing cultural heritages. There are two dominant philosophies regarding the restoration and reuse of historical buildings in Taiwan: the Northern School advocates "repairing old as old", while the Southern School advocates "repairing old as new". The prior often has difficulties meeting the needs of modern functions and often becomes the so called “mosquito museum”; the latter may result in a deficit in historical memory and cultural essence. Yet, both require stable financial support for long-term maintenance. This study intends to analyze the reuse and business strategy of Miyahara Ophthalmology owned by the Dawncake Group (hereinafter referred to as Dawncake).

1-2 Objective

Dawncake, a Taiwanese enterprise founded by a confectioner in Taichung City, Taiwan, owns six different theme stores. Among them, Miyahara Ophthalmology is the flagship store of the brand. It sits at No. 20, Zhong-shan Road, Central District, Taichung City, Taiwan, next to the Lu-chun Creek and Taichung Railway Station. It reused a colonial clinic, and houses restaurants, souvenirs, pastries, ice products and refreshments. The objective of this study is to investigate the restoration and reuse strategy of the mentioned building, as well as its marketing strategy, products and packaging design, in order to find an alternative for building reuse as a reference for future theoretical research and practical implement.

1-3 Methods

The methods employed are primarily qualitative, supplemented by questionnaire survey. The three methods are as follows:

1. Literature review: Reviews on the reuse of historical buildings, the status of preservation of Taiwanese cultural heritages, brand marketing and experience economy, etc.
2. Fieldwork: On-site investigation of Miyahara Ophthalmology's reused space, business model and brand marketing strategies.
3. Questionnaire survey: Based on the fieldwork results, a questionnaire was designed to survey whether the respondents' views were consistent with the views of this study.

2 Literature Analysis

2-1 Reuse of Historical Buildings

"Reuse", also known as "adaptive use", means that a building’s use is either changed throughout its life cycle, or that its original functions are reorganized to enable future use. According to the 《Encyclopedia of Architecture, Design, Engineering & Construction》, the definition of "adaptive use" is：

> 「*Adaptive use is the field of architecture concerned with continuing a building or structure in service by means of creating a new use for it, or with reconfiguration of a building so its original use can continue in a new form that meets new requirements. It is sometimes called building modification or retrofitting. Adaptive use allows the recapture of the value the original building once held, using it and transforming it into new energy for the future. The success of adaptive use lies in the architect’s ability to seize the potential of an existing structure and use it in its new life.*」〔1〕

Fu believes that the significance of buildings’ reuse lies in preserving the memory of historical buildings and injecting new life into them, so that buildings that are not applicable or idle can seek new life through the activation of reuse〔2〕.Due to the dialectical aesthetics of the old and the new, it is often a common problem in the practice of building reuse.

This study proposes the following hypothesis: Although historical buildings gain new life and inherit the historical memories through appropriate functional reorganization after reuse, the more important issue is how to operate the reused building sustainably under the economic challenge of the capitalist society. Therefore, while talking about design strategy of building-reuse, interdisciplinary business management and marketing strategies should be simultaneously considered, to allow the reused building to survive sustainably in the capitalist society. Without that, the purpose of reuse cannot truly be achieved.

2-2 Status of Preservation and Reuse of Cultural Heritages in Taiwan

The Cultural Heritage Preservation Act of Taiwan (CHPAT) was promulgated in 1982 and revised on July 27, 2016. It aims to preserve and utilize cultural heritages and promote multiculturalism. According to Article 3, Chapter I of the CHPAT, "cultural heritages" refers to tangible or intangible cultural heritages that have cultural values such as history, art, and science and are designated or registered〔3〕. Yet the preservation and reuse of Taiwanese cultural heritages often face the following problems in practice:

1. Disturbance of Cultural Heritages Between Public Property and Private Property
   If a building is designated or registered as a cultural heritage, it is subject to the provisions of the CHPAT, and its repairs, management and changes in property rights must comply with the relevant provisions and restrictions of the CHPAT. Coupled with its provisions and restrictions, it is difficult to provide sufficient incentives given the high real estate prices. Consequently, building owners often rejected the proposal of registering their buildings as cultural heritages, and buildings with preservation value were frequently illegally demolished〔4〕.
2. The Heavy Burden of Cultural Heritages Regarding Every 15-Year-Restoration Regulation
   Due to limited government manpower, the exhaustive nature of the reporting process, and the necessary involvement of expert scholars and relevant personnel, it is very difficult to fully take care of all the cultural heritages with preservation value. In addition, the Bureau of Cultural Heritage, Ministry of Culture expects that cultural heritages should be reinstated every 15 years to ensure they comply with the status quo. The resulting hike in preservation and maintenance costs causes great financial pressure for national and local governments.
3. The Monotonous and Rigid Mode of Cultural Heritages' Preservation and Reuse
   Currently, the reuse of historical buildings typically adopts a conservative "repairing old as old" mode, and concentrates on restoring the appearance of the historical buildings without dialogue with the modern society. Hence, the cultural heritages often display their past glory and isolate themselves from modern society〔5〕. Besides, the lack of sustainable management expertise has led many historical buildings to become "mosquito museums" rarely visited by the general public, making ordinary operations financially difficult.

In summary, although the CHPAT is well-intentioned, there are still many problems to be overcome in the practical implementation. Furthermore, the governmental approach to building reuse is relatively conservative, and lacks the vitality of reuse and the niche of sustainable management. Therefore, this study takes Miyahara Ophthalmology, a private historical building that has cultural heritage value but is not actually registered as a cultural heritage, as a research object to find a more suitable reuse model for contemporary conservation in Taiwan.

2-3 Brand Marketing and Experience Economy

1. Brand Marketing

(1) Brand：As defined by the American Marketing Association, AMA, a "brand" is a name, term, symbol, mark, or other kind of feature that identifies a seller's service or product. As Aaker mentioned, "brand" is a kind of symbol or name that is used to identify different products and services and to distinguish them from competitors〔6〕. From a product's perspective, brands comprise tangible products, intangible value and consumer expectations for products〔7〕.

(2) Brand Identity : "Brand identity'' refers to the identity of the products and services provided by the enterprise or institution〔8〕. By means of a combination of words, images, ideas and consumer feelings, brand group uses tangible and intangible operations to help consumers identify and find its brand〔9〕. According to the relationship between institutions and institutions, institutions and products or between institutions and services, brand identification can be classified into single brand identification, sub-brand identification, main brand endorsement identification, and multi-brand identification etc.〔10〕.

(3) Brand Image：Keller referred to brand image as the association and cognition of the brand in the consumer's memory. The stronger the associative information that consumers receive, the more difficult it is for brands to be imitated or replaced〔11〕. Combining the brand with local cultural characteristics can accumulate exclusive brand images through local historical memories and humanities, and then shape an exclusive brand culture〔12〕. Hoshino stated that in an economically-mature society, in order to allow consumers to discriminate between too many products of the same type, consumer activities are carried out on the symbolic value of the difference rather than the product itself〔13〕. In other words, the intangible emotional value evoked by the brand image behind the product is the niche for consumers.

(4) Strategies of Brand Marketing：Brand marketing refers to the behavior used by an enterprise to promote its brand name and corporate philosophy. Through the use of marketing strategies, it strengthens consumer recognition of the brand, thereby increasing the value of the brand〔14〕. Gary proposed that the enterprise should execute the 5P marketing module—Product, Price, Place, Promotion, and People—to strengthen the brand〔15〕.

2. Experience Economy

Pine and Gilmore pointed out that the world economy changed from the original agricultural economy to the industrial economy, and then developed into a service economy. Nowadays is the era of experience economy. The so-called experience economy refers to service-centered and commodity-based materials to create a consumption environment that immerses consumers into a novel, surprising and touching atmosphere, enabling them to combine their own feeling to obtain a unique consumer experience, and thereby to strengthen brand identity and loyalty〔16〕. Schmitt proposed in his book 《Experience Marketing》 that in the era of the experience economy, consumers pay more attention to the process of consumption in addition to consuming goods〔17〕. Hence, the product must be based on personal experience, so that consumers can acquire comprehensive brand recognition during their shopping. In other words, brands must replace standardized services with sensory, feeling evoking, thoughtful, and even mobile or associated marketing.

2-4 The Dawncake Group

1. Introduction of Dawncake

Dawncake is a pastry and dessert enterprise founded by Shu-fen Lai in 2000. It's six theme stores sell cakes and desserts. In addition to the natural and local characteristics of the main products, Dawncake also uses its exquisite and innovative packaging design and a large number of emotional and contextual visual images to surprise its consumers〔18〕. The flagship store Miyahara Ophthalmology has incorporated architecture into the brand image, combining the brand with the renovated building to give the historical building a new image and new life. At the same time, through the memory of the historical building and its local links to Taichung City, Dawncake strengthens the local culture〔19〕. This makes Dawncake stand out in the pastry industry in Taichung and become a significant icon.

2. Identity and Image of Dawncake

According to Aaker's classification, Dawncake’s brand recognition belongs to the sub-brand category. In fact, Dawncake’s brand identification is formed by its corporate flagship store and its five sub-brand stores. Miyahara Ophthalmology and the five sub-brand stores each play a specific brand image, but they together also form a unified and dual-connected brand image. The marketing of the sub-brands cannot be separated from the support of Dawncake. Dawncake adheres to the corporate philosophy of using natural, fresh ingredients from mother earth and not using artificial flavoring. Dawncake adds extra value to its products via local culture, precious Taiwanese ecological species, so that its distinctive corporate image can be deeply rooted in consumers' hearts.

3 Site Analysis

3-1 Dawncake-Miyahara Ophthalmology

Miyahara Ophthalmology was a private ophthalmology clinic opened by Dr. Takekuma Miyahara in 1927 next to Lu-Chuan River in the Central District of Taichung City during the Japanese Colonial Period. Its walls are made of red brick and the roof truss is of wood. The two-story red brick arch street house, combined with Ionic cement pillars and decorative gables, was the largest private clinic in Taiwan at the time. After World War II, in order to remove the depressing image of Japanese Colonialization, the red brick exterior wall was painted white and transformed into Taichung Health Center. Thereafter, the property was transferred to private owners, and the building was sold and leased to different industries. As modifications were made to accommodate new functions, the original holistic building image was gradually destroyed. From then on, the development of the central district correspondingly declined. The damages of Miyahara Ophthalmology caused by earthquakes and wind disasters have also contributed to its ruin-like status〔20〕.



Figure 1. Miyahara Ophthalmology Clinic〔21〕; Figure 2. The white painted façade〔21〕; Figure 3. Miyahara Ophthalmology (present)

However, instead of recognizing Miyahara Ophthalmology’s historical and architectural value, the Taichung City Government listed it as a dangerous building in 2008. Miyahara Ophthalmology was set to be demolished within a limited time. Fortunately, Dawncake purchased it in 2010 and Miyahara Ophthalmology was subsequently jointly renovated by architects Cheng-bin Su and Shu-he Yang. The reuse strategy of “preserving the old, renovating the new” has transformed Miyahara Ophthalmology into a Dawncake flagship store, selling gifts, cakes and ice products, while also housing restaurants and a tea house. The renovation of the historical building and its exquisite fantasy library-like interior has drawn many domestic and foreign tourists to come experience its novel atmosphere. Miyahara Ophthalmology also attracts a large holiday crowd, breathing life into the previously silent Central District.

3-2 Reuse Strategy of Miyahara Ophthalmology

While the governmental sector mainly preserves cultural heritages following the "repairing old as old" paradigm, Dawncake has taken a “preserving the old, renovating the new” approach to repair and renovate Miyahara Ophthalmology. The facade of the building was restored to its original appearance during the Japanese Colonial Period, the old wooden roof trusses were partly preserved. A new saddle roof with a rhombus-shaped glass was added to the old building. Inside, a four-story-high glass curtain is paired with a new steel structure to create the spatial highlight, a so-called "House in House" strategy. On the second floor, a delicate salon restaurant, Moon Pavilion, was formed like that in the Shanghai Bund area. A Y-shaped steel frame is used to reinforce the roof to protect the original damaged wooden roof trusses.

3-3 Early Integration of Dawncake

In addition to factors at the architectural design level, this study believes that the key successful preservation and reuse influential factor of Miyahara Ophthalmology lies in its private ownership. Its sustained existence is to a great degree due to Dawncake's brand marketing and strategy of experience economy. Therefore, this study analyzed its operation strategy:

1. Product Strategy

Dawncake positions Miyahara Ophthalmology as the brand's flagship store. Thus, unlike the other five theme stores, which have their own featured products, the products and services of Miyahara Ophthalmology are comprehensive. In terms of pricing strategy, Dawncake distributes the quantity of products to keep the average price affordable. For example, a 6-pack dawn cake and a 54-gram Oriental Beauty tea bag cost NT $ 360 each, so that the price of most of the products ranges between NT $ 300 and NT $ 500. Meanwhile, a variety of different product combinations and packaging have also been considered to expand the price range.

On the first floor, there is an ice cream and a bubble milk tea shop, providing consumers with ready-to-eat desserts. The ice cream shares the same price as Haagen Dazs at NT $ 90 per scoop. A mug of hand-shaken bubble milk tea costs 30% more than a Starbucks Grande Caffe Latte. The Taiwanese cuisine on the second floor, Moon Pavilion, offers lunch, dinner and afternoon tea. The average meal price there is about 2.5 times that of a Starbucks Grande Caffe Latte. An individual classic afternoon tea set costs about 4 Starbucks Grande Caffe Lattes. These examples highlight that Miyahara Ophthalmology is a $$$ store.

2. Evoking a Novel Consumer Atmosphere

Dawncake is good at creating a surprising immersive consumption atmosphere. This study determined the successful strategies of Miyahara Ophthalmology to be as follows:

a. Inimitable Spatial Atmosphere

The first-floor display area uses postmodern mix-and-match and retro-style furniture as well as decorations to shape the inimitable space atmosphere. In this way, Miyahara Ophthalmology induces consumers' emotional brand identity with rich visual themes. The entrance has decorative bookshelves spanning the entire four-story lobby, creating a library-like environment. The illuminated atrium, with a glass ceiling decorated with traditional wedding fortune cutting 囍 brings the seasonal signals to the interior. The wooden Chinese medicine cabinet, Chinese tea house textile, and British-style chandeliers evoke the memories of the Japanese Colonial Era. The hybrid interior, by means of mixing Eastern and Western cultures as well as tradition and modernity, creates a fantastic and irreplaceable brand identity.

The Moon Pavilion on the second floor is mainly composed of herringbone-shaped wooden floors and original red brick walls, with traditional lanterns and French flannel sofas, to create a salon atmosphere like that of the Shanghai Bund. The existing wooden roof trusses, together with the reinforced steel frames, present a strong sense of coexistence between old and new. Dawncake also used a large number of popular, humorous legend, cultural propaganda curtains and realistic advertising visuals of different generation figures to evoke consumers' curiosity. With gorgeous, meaningful, imaginative and story-induced visual images, Miyahara Ophthalmology creates shopping experiences, which seduce customers into a fantasy world full of surprise, exploration and nostalgia.

b. Innovative Product Packaging Design

In addition to the irreplaceable interior, Dawncake is also well known for its exquisite and innovative packaging design. Dawncake designs the packaging of all its products. "Locality and fun" are two driving forces for its product packing, which attract both domestic and international guests. It takes advantage of unique packaging types such as tea food CDs, pastry books, and vinyl record tea bags. Moreover, Dawncake adds narrative and witty slogans to nougats, which completely overturned the traditional pastry packaging routine.

Dawncake is also good at using traditional cultural totems and vintage elements for its packaging. Through exquisite packaging aesthetic, narrative themed media, Dawncake conveys traditional Chinese culture gently and elegantly. In addition to using cultural themes, Dawncake also uses Taiwanese precious species as the packaging theme; e.g. desserts with Taiwanese bluebird and butterflies on the cover.

c. Staff's Social Services

In addition to the successful consumption process of Miyahara Ophthalmology, Dawncake also committed to its local social service. Miyahara Ophthalmology's staff regularly wears uniforms cleaning the streets along the Lu-Chuan River. This action is actually the irreplaceable mobile propaganda to Miyahara Ophthalmology. Customer-oriented and enthusiastic serving attitude, coupled with the seasonal uniforms, lead to another irreplaceable positive and lively brand image for Dawncake.

3. Brand Festival

Miyahara Ophthalmology does not actively publish newspaper advertisements. It relies on word-of-mouth communication between the Internet and consumers to build brand reputation. In a highly competitive market, this is especially extraordinary. Dawncake does not adopt the usual anniversary marketing routines, instead, it creates its own festivals throughout the year, such as the Spring Festival, the Festival of Poets, Mother's Day, the Pineapple Festival, the Moon Festival, the Nostalgic Song Festival, and Christmas.

4 Survey Results

The questionnaire was issued on a GOOGLE web form, for consumers who have been to Miyahara Ophthalmology at least once. 152 copies were distributed, 152 were recovered, and

152 valid questionnaires were collected. The questionnaire contains five questions, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was conducted from December 2, 2019 to December 11, 2019.

4-1 Data of Survey Respondents

In terms of gender, female consumers were more enthusiastic than male. The number of female respondents was about 2.6 times that of male respondents. In terms of age distribution, the 19-25 age group accounted for the majority (46.1%), followed by the 36-55 age group (25%) and the 26-35 age group (20.4%). The oldest age group (>56) only accounted for 8.6%. It is clear that Miyahara Ophthalmology primarily appeals to consumer groups aged 19-55.

In terms of education, 91% of the respondents had at least a college education, demonstrating that Miyahara Ophthalmology attracts high-level intellectuals easily . In terms of occupation, students made up the majority (39.5%), followed by other occupations (33.6%), which include military and law enforcement personnel. The remaining occupations individually comprise less than 10%. These results show that Miyahara Ophthalmology is very attractive to students, military and police. In terms of monthly income, the majority of respondents (42.8%) reported an income below NT.$20,000 , and more than 81.6% reported an income less than NT.$60,000. These results demonstrate that Miyahara Ophthalmology's primary consumer base is the (lower) middle class, rather than high-income individuals whose monthly income exceeds NT.$60,001.

Cross-comparison of the above statistical results reveals that young and middle-aged customers aged 19-55 years old, with high education level and monthly income below NT.$60,000, are the leading consumer groups of Miyahara Ophthalmology. These young and middle-aged consumers love the brand shopping experience, even though Miyahara Ophthalmology is a relatively expensive $$$ brand store.

4-2 Results of the Questionnaire

This study will use the joint proportion of "agree" and "strongly agree" as the basis of the following results:

1. About 75% of the respondents who have visited Miyahara Ophthalmology more than once believe that it is a successful brand store that brings a good consumer experience (Q1, Table 3).
2. Most of the respondents show high recognition to the reuse of the historical Miyahara Ophthalmology building (91.5%, Q2, Table 3).
3. About 80% of the respondents believe that the main reason for Miyahara Ophthalmology's success is its delicate products, brand marketing, and promotion of Taiwan's traditional culture (78.9%, Q3, Table 3).
4. More than 85% of the respondents believed that Dawncake retained part of the historical building Miyahara Ophthalmology and used recycled furniture / building materials for interior decoration, meeting the goal of sustainable development (86.2%, Q4, Table 3).
5. Similarly, more than 85% of the respondents believe that Dawncake should display more historical evidence of the Miyahara Ophthalmology to highlight the historical building itself as its brand representative (86.9%, Q5, Table 3).

Table 1: Result of the questionnaire-percentage, this study

	strongly disagree	disagree	no opinion	agree	strongly agree
Q1	0	3.90%	20.40%	39.50%	36.20%
Q2	0	3.90%	4.60%	34.90%	56.60%
Q3	1.30%	4.60%	15.10%	41.40%	37.50%
Q4	0	2.60%	11.20%	40.80%	45.40%
Q5	1.30%	1.30%	10.50%	33.60%	53.30%

It can be clearly confirmed that Miyahara Ophthalmology is a successful innovative business model for the preservation and reuse of historical buildings. The results of the questionnaire are consistent with that of the on-site investigation and analysis.

5 Conclusion and Outlook

5-1 Conclusions

Based on the results of Chapter 2 "Documentary Review and Branding", Chapter 3 "Field Investigation", and Chapter 4 "Questionnaire Survey", this study draws the following four conclusions:

1. Under the increasing financial pressure, the interdisciplinary reuse model of Miyahara Ophthalmology marks a new opportunity in the private sector, although it should not be the only model for the restoration and reuse of historical buildings.

   Dawncake actively integrates commercial brands into the interdisciplinary operation of revitalizing and reusing historical buildings, providing academics and architects with an innovative model of cultural heritage preservation completely distinct from that of the governmental sector. This innovative model no longer fully complies with the "repairing old as old" regulations of the CHPAT. It promotes a way of co-existence, “preserving the old, renovating the new”, allowing a contemporary enterprise to co-exist with the cultural heritage. Though this kind of co-existent model has precedents in the Netherlands, Italy, and many European cities, it is a noteworthy success led by the private sector in Taiwan.
2. The success of Miyahara Ophthalmology, while partly due the uniqueness and restoration of the historical building itself, can be primarily attributed to the sophisticated brand products, brand marketing, business strategy, and the brand's contribution to Taiwan's ecology, culture and society, all of which are independent of architecture.
3. Despite some critiques from the elite, the overwhelmingly positive feedback from the general public is an undeniable fact. Besides, via Miyahara Ophthalmology, Dawncake has successfully promoted the urban recovery of the Central District of Taichung City. This study proved that in comparison to the governmental mode, the commercial reuse model of Miyahara Ophthalmology is an effective alternative for the preservation of historical heritages.
4. Miyahara Ophthalmology preserves historical facades, partly damaged wooden roof trusses, and uses recycled furniture / building materials, combined with traditional iconic elements in an unique innovative way, which not only preserves the tangible building, but also implements the intangible core value of culture and sustainable development.

To conclude, as this study mentioned before, the quantized results of the questionnaire have echoed the results of the qualitative on-site investigations. Dawncake's success tells us that nowadays historical building preservation and reuse can be executed by both private and governmental sectors. The key point is that the reuse of historical building is not only an issue of architectural renovation. It has to be a comprehensive interdisciplinary teamwork between architects and enterprises to ensure their sustainable existence, namely a complementary combination of hidden brand enterprises and explicit historical buildings.

5-2 Outlook

Due to the limited time and resources, this study only focused on Dawncake's Miyahara Ophthalmology, focusing on the "reuse of historical buildings" and "brand marketing". In the future, we plan to include another Dawncake project, "Fourth Credit Cooperative", into the overall study to examine the differences between that and the results of this study, in order to gain more advanced knowledge of the successful adaptive use of cultural heritage in the private sector.

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02.105 - URBAN REGENERATION OF THE HISTORIC CENTER OF ALEPPO IN SYRIA

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Abstract

The historic center of Aleppo in Syria is one of the oldest continuously inhabited cities in the world, listed in UNESCO's world heritage list, with a pre-war population estimated at 100,000 inhabitants. The recent civil war in Syria caused major catastrophes in the historic center of Aleppo, which today is trying to welcome back its residents. This project concerns the urban redevelopment and urban renewal of the historic center of Aleppo and it is organized into three parts. The first part analyzes the city of Aleppo before the war, with an emphasis on the historic center, and provides information on demographic characteristics, on the evolution of the urban fabric, and on the city's different typologies from ancient times until today. It also analyzes transportation networks, land uses, building regulations, and public spaces. The second part examines the damages in the city and the historic center due to the war. It also provides information on the current situation of the city, and its estimated growth rate until the year 2025. The third part proposes planning strategies and policies for the revitalization of the historic center of Aleppo, following an anthropocentric approach, by giving priority to the city's inhabitants, and encouraging participatory practices, and community engagement. Our proposal includes layer-by-layer interventions to make the city viable and enhance the quality of life of its residents. Attempting to preserve the cultural identity of the historic center of Aleppo, we introduce new practices in land-uses, transportation networks, public spaces, and green areas. All the maps used in our study were created from scratch, by tracing (in 2d) every building's imprint from old and new maps of the city.

Keywords: Urban conservation, Aleppo, City planning, Adaptive Reuse, Urban renewal

Figure 1. The historic center of Aleppo

1 Introduction

Located in the plains of northern Syria, between several trade routes, Aleppo is one of the oldest continuously inhabited cities in the world that was ruled by the Hittites, Assyrians, Akkadians, Greeks, Romans, Umayyads, Ayyubids, Mameluks, and Ottomans. These past civilizations left their traces that are still visible on the city, synthesizing that way a unique urban fabric, and contributing to the creation of a rich cultural heritage (e.g., the Citadel of Aleppo, the Great Mosque, and various madrasas, residences, khans and public baths). [1] The Citadel (Acropolis) of Aleppo is one of the most famous monuments of Syria, dominating the highest hill of the walled city, above the Suqs, mosques, and madrasas. [2] In 2011, Aleppo was the largest city in Syria, with 125 neighborhoods, 22 informal settlements, and a population estimated at 3 million inhabitants (25% of the national urban population). [3] Back then, Aleppo used to be Syria's industrial capital. It has been a silk trade hub for many years and it still maintains its historic market, called Al Madina Souk (the largest covered market in the world with 13km of stores), located west of the Citadel, following the traces of the Hellenistic-Roman grid. Aleppo's position makes it open to outside influences, and international trade. [4] The city is diverse and multicultural, including religious groups of Christians, Kurds, Alawites, Circassians, Turkmen, Yezidi, and Ismaili. [5] It went through various historical periods and invasions that left the historic fabric almost intact, until its independence from the French Mandate (1920-1946). [6] The civil war started in 2011, between the Syrian regime and the opposition forces that were fighting for the control of the city. This war resulted in many catastrophes to both the built environment and people's livelihood. By the end of the war, in 2016, Aleppo's inhabitants started making their way back to the city, in an effort to take their lives back, and thus the need for its regeneration becomes more and more urgent.

2 The historic center of Aleppo

The history of Aleppo dates back to the sixth millennium BC; it was originally formed on a small group of hills around the central hill where the Citadel still stands, 50 meters above the ground level. The city was formed organically, first inside the fortification walls, and then outside and it is characterized by the typical Islamic urban fabric, which includes a densely built environment while exhibiting a minimum of public open spaces. [7] The historic center has been inscribed on UNESCO's World Heritage List. (Fig. 2)

Figure 2. The evolution of Aleppo from ancient times until the 19th century

2.1 The evolution of the urban fabric and its typologies

While the growth of Aleppo in historic times was organic and has resulted in a coherent urban pattern, during the last century, the historic center was distorted a lot, due to the partial implementation of independent and destructive masterplans. [2][8] From 1890 until the end of the first millennium, the first masterplans were implemented, causing, in 1893, the demolition of the north wall of the historic center to accommodate the 14-meter-wide road, surrounded by hotels, residences, and markets. A western-style administration, established in 1925, signalized the initiation of modern city planning. This was the first organized approach for research and mapping of the city for the creation of a basis for later urban studies. Aleppo's first organized masterplans came between 1931 and 1938 and were influenced by the European planning standards, as expressed by the charter of Athens. Later on, between 1950 and 1970, new masterplans -that would prove damaging for the historic center- were published, imposing large highways over the traditional urban fabric. [9] In particular, in 1954, a masterplan, designed by A. Gutton, implemented two main roads, and two large highways, along the east-west axis, that would serve as vehicle parking, as well as, large warehouses, replacing the traditional buildings. The partial implementation of this masterplan destroyed almost 20% of the historic urban fabric. [10] In 1974, Banchoya-David proposed a masterplan that initially sought to counter the effect of the Gutton's masterplan. However, Banchoya-David proposed a new north-south highway, which would have cut through the historic fabric, demolish more monuments, and further segregate the traditional quarters. In 1979 public and private parties in Aleppo acted against this masterplan, until finally, the Ministry of Culture stopped its implementation. After this event, Dr. Stefano Bianca, a UNESCO expert, conducted lengthy research of the historic city, which led to a report in 1983, that proved Aleppo's cultural value. In 1986 the historic city registered as a national monument to UNESCO's World Heritage List, meeting the criteria 3 and 5: it includes unique testimonies to cultural traditions or civilizations and outstanding examples that illustrate a significant historical stage. [11] During the Rehabilitation project of the historic center, which was completed in 1998, a buffer zone was created around the historic core, aiming to isolate it from its surrounding areas, to preserve and protect it. This plan was actually a reaction to the implementation of several destructive masterplans. This buffer zone failed in achieving its main goal and it did not succeed in forming a transitional area or natural expansion of the historical city. In contrast, these areas were used as parking lots, garages and building materials storage. [12]

2.2 Built and un-built environment and their typologies

The historic center includes various building typologies, most of them of high architectural value. Most of these buildings are residences (built according to the traditional Islamic courtyard house styles), religious sites, Souks (main market), Hammam, Khans, Administrative Buildings, and Museums. [13] As for the traditional urban fabric, five main categories are recorded. The first is the Citadel, which includes buildings from antiquity until the Ottoman period. Second is the typology of Al-Madina Souk, positioned on the traces of the Hellenistic-Roman grid. Finally, we see two typical categories of residential building blocks. The first, and most common one, includes densely structured dwellings. The second one also includes open vacant spaces, which are divided into 2 main categories; all scale squares and pedestrian corridors. The last category of building block is the Bab Al-Faraj neighborhood, which during the implementation of a masterplan was partially destroyed, and today combines both historic and modern buildings. [14] (Fig. 3)

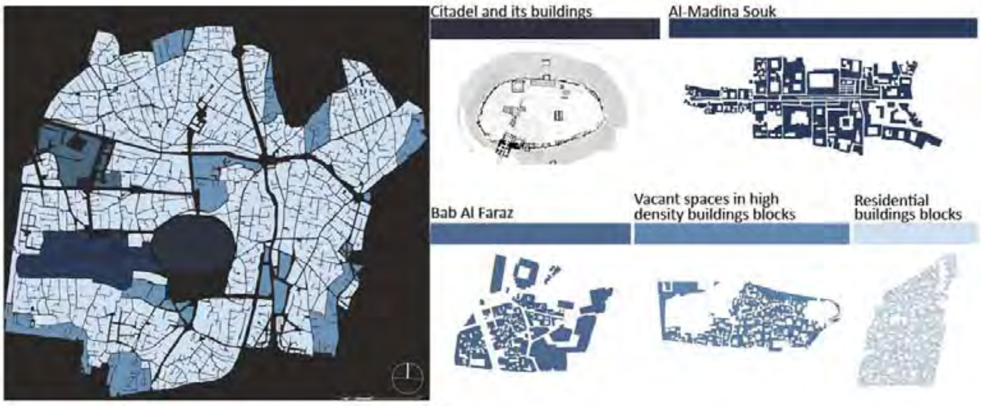

Figure 3. Typologies of the built environment

2.3 Land-Uses

The GIS analysis reveals that approximately 60% of the land-uses are residential, and the rest is commercial, administrative, public, and touristic. [6] In a land-use proposal launched in 2005, planners attempted to control tourism in the historic center, by concentrating it around the Citadel, in order to place only residential uses in the historic neighborhoods. In addition, the new policies proposed the relocation of activities, which existed for centuries like goldsmiths and soap makers. [15] These proposals, if implemented, would have negatively impacted the socio-economic climate of the historic center, since trade and tourism were the strongest economic forces there. (Fig. 4)

2.4 Transportation networks

The primary means of transportation in the historic center is the car. The existing rail network of Aleppo does not serve the historic core. Each residential quarter in Aleppo typically contains a main street, a secondary one, and smaller –mainly pedestrian- streets.
The main road network emerged from the partial implementation of Gutton's masterplan in 1954, when buildings were demolished to create a 20-meter wide boulevard. The secondary road network, with a width between 8 and 12 meters, serves lower traffic volumes. The narrow alleyways are divided into two types: a main pedestrian street, and private streets -cul-de-sacs- leading to the courtyards of the houses. (Fig. 5)

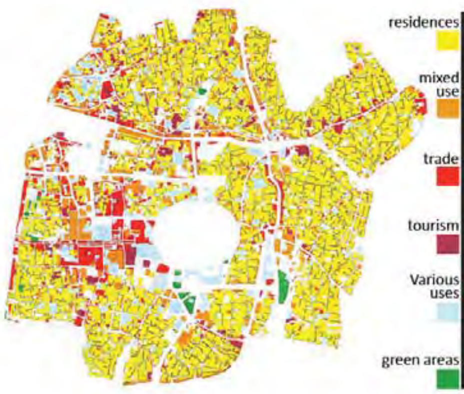

Figure 4. Land uses Figure 5. Transportation networks

2.5 Green areas and public spaces

As in most of the historic centers that are characterized by lack of green -public or private-areas, Aleppo has a minimum of green areas. [16] However, Aleppo's historic center has several public places, mainly in front of religious buildings like Mosques. A proposal, whose implementation was completed in 2005, focused on the upgrading of public infrastructure, by creating pedestrian zones in the historic center. [10] This proposal gave emphasis on the Citadel's perimeter, which after its regeneration became one of the largest and most crowded public spaces in Syria. [17]

3 The Syrian civil war and its consequences

The civil war started in 2011, between the government and the opposition forces, and divided the city into two zones; the west, controlled by the regime, and the east, which was ruled by the opposition forces. [18] Both the whole city and the historic center were severely affected; its narrow alleyways and adjacent buildings provided an ideal environment for the frontline of the war.
A huge part of the city was affected by the war; in 2014 15% of the neighborhoods were fully destroyed, 47% were partially damaged, and 38% were affected. [3] At the same time, most of the road networks were destroyed. [19] 45% of the pre-crisis employment (e.g., Tourism and trade) stopped.
The historic center became the most abandoned area in Aleppo. 16,5% of the historic core was totally or partially destroyed and 84% was affected. 121 cultural elements (houses, mosques, churches, Khans, markets, open spaces, and monuments) have been reported as damaged (totally or partially destroyed, burned, or looted). Most of the city's services and infrastructure (e.g., health and food) have been damaged. In addition, the principal economic forces in the historic center, that of tourism, trade, and services, collapsed, and the historic center stopped being a major commercial and tourism hub. [3] However, it is estimated that the damages in cultural assets are under a reporting process [20]. Nearly 85% of the upper-middle-income population was forced to leave the historic center.
After the end of the war in 2016, Aleppo's inhabitants started to return to the city. It is estimated that 100% of the pre-war population will return to Aleppo until the year 2024. The pre-crisis population growth rate was 2.8%, and the estimated post-war population growth rate, until the year 2025, is 12%. However, the returnees are jobless and depending on savings and reserved food supplies [3]. As for the built environment, the pre-war estimation for the buildings was 11.000 houses, which hosted in total 128.000 people. A quick calculation shows that 11,57 people occupied one parcel. Thus, if we change the density of the people per parcel, it is possible to host more residents in the existing buildings, at least for the first and second stages of the post-war period. We now know that 41,5% of buildings of the historic center are still habitable, which means that if we put 15,6 people per parcel, it is possible to host them in the existing buildings.

4 Strategies for the historic center's redevelopment

The war proved dramatic for Aleppo's residents and the city, which calls for immediate action. The paper proposes conservation, restoration and preservation practices for the city's-built environment and its traditional urban fabric. It gives emphasis to participatory practices through an anthropocentric approach, which re-negotiates the land-uses, transportation networks, green areas, and public spaces. The proposal's intention is to regenerate the historic center by implementing micro-scale interventions. In contrast to the previous profit-centered plans that proposed the relocation of some activities from the historic center, the proposal focuses on the population dynamics and needs and analyses the risks and challenges of the current state of the city. [9]

4.1 Building regulations and urban density

The proposal's intention is the maintenance of the existing building regulations for the preservation of the existing built environment. After the analysis of the pre-war existing building regulations, the area is divided into four zones. The first includes 2-floor buildings of 75% building coverage and 1,5 building ratio. This zone is the most common one and refers to the majority of the residential buildings, existing inside the building blocks. Likewise, the second zone refers to 3-floor buildings with 75% building coverage and a 2,25 building ratio.
The second zone is mostly observed in individual buildings, scattered outside the dense residential blocks. The third zone includes 5-floor buildings with 80% building coverage and 3,2 building ratios. The third category is the most common one for the buildings in the periphery of the residential blocks. Finally, the fourth zone has 6 or more floor buildings, 100% building coverage and a building ratio of 6. This last category is only detected in the Bab Al-Faraz neighborhood, which is not officially included in the historic center of Aleppo, as it includes newly built constructions on its majority. (fig. 6)

4.2 Land uses

The main intention of the land-uses is to propose their organization in order to revive and preserve the historic center. Aleppo has very few schools compare to its population since 34% of the schools cannot function due to the war damages; the proposal puts emphasis on Education by identifying neighborhood-level educational hubs and buildings that have the required infrastructure to serve as schools. [3] Besides education, the proposal also considers important, to dynamically adjust the role of some land uses, depending on the needs of the city, so as to alleviate the consequences of the war. Collective shelters, for example, are scarce in the historic center, but much needed for the returnees, who have lost their homes and families. For this reason, our research proposes the creation of social infrastructures (e.g., clinics, public libraries, centers for elderly people, playgrounds) that will be scattered within the residential blocks, accessible to everyone on a neighborhood scale. The residences continue to occupy the majority of the land-uses and are placed inside the building blocks to remain protected from traffic, noise and public uses. We place markets and local trade in a linear form, mainly around the residential blocks. In addition, we propose a main linear trade zone on the broader streets and a secondary on narrower streets and neighborhood level. Traditional markets, such as Al-Madina Souk, remain in the same pre-war areas while secondary markets (including restaurants and leisure activities), and mixed-uses are spreading around the residential blocks' perimeter. Administrative services are concentrated in newly-built dwellings that can occupy more square meters. Welfare and health services are placed in the same way. Finally, touristic accommodation is concentrated mainly around the Citadel (in buildings that used to have the same pre-war occupation), but also in newly built constructions in the Bab Al-Faraz neighborhood. (fig. 7)

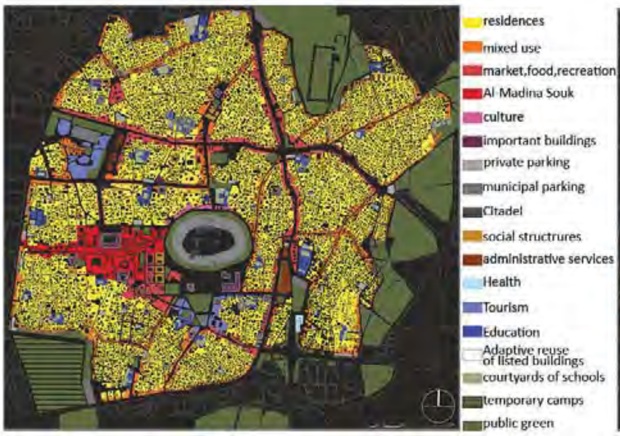

Figure 7. Proposed Land uses

Figure 6. Proposed building regulations

4.3 Transportation networks

Concerning the network planning of the historic center, the proposal attempts the maintenance and enhancement of the connections to the new city, aiming to reduce the usage of cars in the historic centers. We propose a main road network, a secondary one, a pedestrian street that allows passage of residents' cars, a main pedestrian street, and private streets that lead to the residences. We introduce a low-mobility system by proposing a minibus network that will start at the central train station and will cross the historic center; bus stops are placed at locations where public buildings or main activities are concentrated. Moreover, we convert some major road networks into secondary to further reduce car flow within the historic center. In addition, we provide municipal and private parking and off-street parking spaces. (Fig. 8)

4.4 Green areas and public spaces

As most historic centers, Aleppo is characterized by the lack of open green areas. However, the new city offers some large green spaces, in various forms (e.g., linear parks, public gardens). The goal is to identify some available vacant spaces in the historic center that can be transformed into green areas and connect with those out of the historic city borders. We introduce linear green islands in some of the historic center's road networks to connect the historic center with the new city through a green network (e.g., tree trucks, flower beds). The proposal also creates a network of public squares and sidewalks both in the historic center and the wider city. To highlight the remnants of the city's fortification wall, we have created a wide sidewalk along its traces. This pavement meets small public squares in front of the gates that are still maintained. (Fig. 9)

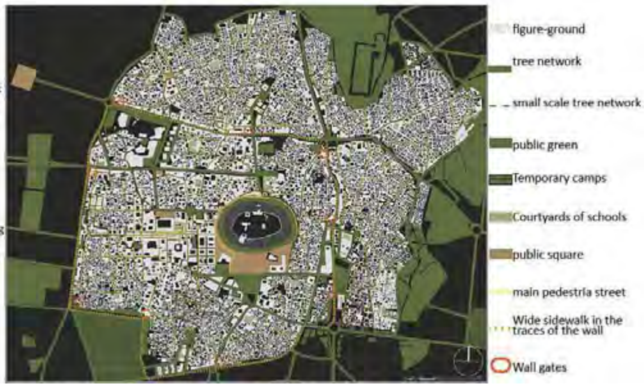

Figure 8. Transportation networks Figure 9. Green spaces and public squares

5 Discussion

After the end of the war, Aleppo's inhabitants that have been forced to leave their homes, eventually return. The returnees are aware of the difficulties they will face in the city, but they are so passionate about their hometown, and they can probably play a huge role in its urban renewal. For this reason, these people should not suffer another displacement, but instead, they should actively participate.

Planning should take into account inhabitants' needs and plans for the regeneration of the historic center. Aleppo's inhabitants can also be a great source of data; before the war, these people lived in a very strict and closed society, and information about everyday life in the city then is scarce. People's testimonies and their memory of the city can give planners an insight into the inhabitants' lives before the war. [12]

The use of public space has changed a lot during the conflict. As the conflict was spreading, for example, women were shrinking to their houses and immediate neighborhoods, but at the same time, they were secretly serving others, as teachers or by providing medical services. The proposal, attempts to provide public spaces for everyone, irrespective of age and gender, and it reconsiders the rigidity of the public and private boundaries. (Fig. 10)

Talking about community engagement, inhabitants will not only share their opinion about how the city should be re-planned. People able to build houses can engage in restoring their properties or other people's houses. Likewise, people able to teach, cook, give medical care, etc. will be able to share their skills and serve others. Besides, even in the pre-war period, Aleppo's inhabitants used to have a caring attitude towards their neighbors and helped each other, as much as they could. Some stakeholders, for example, show a caring attitude towards the building (as if it were their own) and have a positive effect concerning the area's conservation, and this attitude may be an appealing option towards a participatory process.

To preserve cultural identity, and decrease the cost of reconstruction, we propose the reuse of the existing materials, from the damaged buildings. In this way, the transportation cost will be low, and the negative environmental impact will be reduced. In addition, the use of traditional materials like stones and wood, with new techniques, can save the cultural identity of the place, and contribute the buildings' best adapting to local climate conditions.

Another challenge that we want to address in this study, is the symbiosis of tourism and the returnees in the historic center. Tourism was one of the main means of the economic activity in the pre-war period, and inhabitants seemed to have an interest in keeping it in the historic core. We wanted to keep the tourism in the historic center but concentrate it in areas that would not disturb the privacy of the residences. [21]

The proposal respects the tradition but also intends to introduce a novel approach by incorporating some elements of contemporary city planning, adapting them to the traditions of the Middle East. We try to smooth the dichotomy that exists today in the city; with respect to the tradition, our proposal aims to not only preserving the past for its intrinsic value but also developing and adapting it to the changing societal values.

Figure 10. Public space in the historic center

6 Conclusion

At present -early 2020- Aleppo is still under a recovery process, after the severe catastrophes of the war. Inhabitants have returned to the city, and field research and mapping have started, in order for the damages to be measured and registered. This paper tries to confront the existing situation in the city as an opportunity for the historic center's redevelopment and to resolve of pre-war irregularities. For this reason, this study proposes new policies and strategies for the historic center's regeneration, considering several factors; the inhabitants, the stakeholders, UNESCO's regulations, and the cultural value of the built environment.

Figure 11. Physical model of the historic center

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02.106 - MINIMUM DISTANCE REQUIREMENTS BETWEEN BUILDINGS AND THEIR CONTRIBUTION TO FIRE SAFETY

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Abstract

Design of new or modification of existing buildings are complex procedures where various aspects must be taken into consideration, such as technical and legal issues. Therefore, a careful planning must precede any starting of the construction process. While the planning process, architects and engineers in Germany and all over the world are confronted with numerous local and national planning regulations.

The German building law knows strict requirements for the position of buildings on land, especially regarding minimum distances to property lines and to neighbouring buildings. Beside other intentions, these regulations shall prevent the spread of fires to other constructions. For existing buildings, concepts must be developed to avoid or at least to reduce the risk of fire spreading.

The paper analyses German requirements for minimum distances to property lines as well as between buildings and their contribution to fire safety. The authors give an overview about the historical development of planning principles and distance regulations in German building law. Furthermore, they inform about the current planning requirements and their contribution to an effective fire protection. In addition, fire safety demands and their technical realization will be explained.

It is to conclude that strict distance requirements can contribute to an effective fire safety. They may lead to a decreased danger to life and limb as well as avoid property loss and environmental damage.

Keywords

Distances, Fire Safety, Construction Technology, Building Regulations.

1 INTRODUCTION

The strict fire safety requirements in Germany have led to a continuous decreasing of death by fire [1] and a low level of fire caused damages in Germany over the last years. Minimum distance requirements to property lines and between buildings significantly contributed to that development.

The German fire safety system is divided in preventive fire protection and defensive fire protection [3]. Preventive fire protection includes structural, technological and organizational fire safety measures. Because minimum distance regulations can be defined as preventive structural fire protection, the paper only contain information to that part of fire protection.

Especially the requirements for distances between buildings, fire resistance of building elements, and flammability of building materials have been changed significantly over the decades. Today, they form a combined, detailed, and effective fire safety system of preventive structural fire protection measures to the benefit of humans and buildings, what is confirmed by the data from the International Association of Fire and Rescue Services [4]. On the next pages, basic planning principles in Germany will be analysed, followed by an overview about fire safety requirements as well as an introduction in the distance requirements of German building law.

2 Planning Principles Contributing to Fire Safety and their Historical Development

Fire safety is one of the main reasons in Germany why people neither can freely chose the place in the landscape nor the position on the property where a building should be erected. Various and detailed regulations contain restrictions where to build and how to build.

Planning and building regulations have a long tradition in Germany. Drawn from the experience of several huge fire disasters – numerous cities such as Lübeck and Strasbourg burned down for several times in the Middle Ages - building requirements were needed, especially in the fast growing cities. Reasons for fires tragedies often have been careless handling of fire and open flames, but also fires resulting from armed conflicts. Densely built cities enabled easy fire spreading to other buildings [5]. The situation was aggravated by the frequent use of easy flammable building materials at that time, such as timber or straw. These problems resulted in the first written codified building law in the German speaking judicial area, which was developed in the 13th century [5]. Customary building rules, in former times only orally passed down, were collected in the *Sachsenspiegel* [6] and in the Statutes of the City of Mühlhausen/Thuringia [7], which contain the first written distance regulations in the German region [5].

The regulations in [6] and [7] obliged the owner of a building to leave space of three feet between his oven and the neighbouring property to avoid any danger caused by fire. One foot corresponded to around 30 cm in the German region in the Middle Ages [8].

Since the 14th century, there were fewer fires due to stricter planning and building regulations, a more solid construction technology and the increased use of stone based building materials [5]. Thus, in many parts of the today's German area, first administrative ordinances contained building requirements, such as the "Erste Landes-Ordnung von Eberhart Herzog zu Wirtemberg of 1495", which became more detailed in the land and building law from the 17th century [9].

Building regulations of the 19th century required distances between buildings of 2.3 meter, if exterior walls are not constructed from fire-resistant materials, such as Article 37 [10]. The building law at the beginning of the 20th century required the same distance of 2.3 meter from non-fire-resistant exterior walls as the former regulations. However, it contained much more construction details and exception regulations [11].

In the 20th century, distance regulations did not only consider fire safety but also social and health issues. Resulting from new construction technologies, distance regulations depending on the height of buildings became necessary. That is why, modern distance regulations are calculated basing on the dimensions of the building (see paper section 4.2).

Today, the extent of general distances for fire safety and spaces between buildings do not differ significantly from the historical regulations.

Current planning principles in Germany contribute to legal determination of soil and its usability. They set area-related requirements for a building project, which ensures a controlled urban planning development. The German planning rules are federal legislation and laid down in a Federal Building Code (Baugesetzbuch) as well as in the Federal Regional Planning Act (Raumordnungsgesetz) and accompanying ordinances. These regulations contain requirements regarding land use for human settlement, transport and other purposes and explain if, what and how much it is allowed to build and which usage of the building is legal.

German planning regulations know different styles of land use for building. They contain requirements how to locate buildings on the plot and if spaces must be left between buildings and/or property lines. The different styles are called e.g. open construction style and closed construction style. In the closed construction style, buildings are constructed without any lateral distance to the next building. In the open construction style, a distance between neighbouring buildings must be left, see Section 22 of [12]. The paper focuses only on distance requirements in the open construction style.

Beside the Federal planning rules, German Federal States' building regulations contain the essential requirements how to arrange a building on the property. They mainly serve the purpose of hazard prevention and regulate the implementation of buildings as well as structural works. Because building regulations are legislation of the German Federal States, and, by this, there are 16 Federal States' building regulations, minimum distance requirements of the Federal States differ from each other.

3 German Fire Safety Demands

Distances between buildings help to prevent fire spreading (flame, hot gases, excessive heat) to other constructions, and, therefore, contribute to fire safety.

German fire protection regulations are quite detailed and have been developed over hundreds of years. The first codified fire safety requirements, written down in the Middle Ages, were minimum distance requirements to avoid fire spreading. Until now, in a modified system, they can be found in the today's building regulations of the Federal States.

Particularly, over the years, requirements for fire resistance of building elements and flammability of building materials have been significantly changed leading to comprehensive fire safety concepts for structures nowadays.

Today, fire safety requirements can be found in the building regulations of the German Federal States and in nationwide applicable technical standards such as German DIN Codes (e.g. DIN 4102 [13], DIN EN 13501 [14]) and Eurocodes (such as Eurocode 2 [15]). Normally, fire protection regulations are made for new constructed buildings. Nevertheless, additionally, they contain schemes to deal with the specialties of existing buildings.

Structures in Germany are to design, to construct, to maintain, and to alter in a way that the incipient fire as well as spread of fire will be prevented. Furthermore, in case of fire, the rescue of humans and animals as well as an effective fire-fighting must be guaranteed [16]. To both, adequate distances between buildings and sufficient free spaces on the property will contribute. The respective state building authority is responsible for checking the compliance of a planning with the building regulations.

To avoid fire spreading, Federal States' building regulations contain fire safety requirements regarding building elements, building materials and construction methods. Fire resistance of building elements is declared by fire resistance classes, and flammability of building materials by building material classes. Additionally, there are rules regarding the construction's division in fire compartments and provision of access routes for fire service.

Fire resistance of building elements is essential for fire safety and defines the duration while the building element keeps its functionality when exposed to fire [17]. That means, in minimum, to guaranty load bearing function and/or to prevent fire spread beyond designated areas (separating function). Dependent on the building elements' function in the construction, Federal States' building regulations and respective national technical standards contain different requirements regarding their fire resistance and the flammability of the building materials they consist of.

The German building law requirements regarding fire resistance of construction products and building elements must be met in structural design of buildings. The demands on the building elements and building materials increase, as higher and more complicated the construction is.

In Germany, usability of building materials and construction methods normally is proofed by compliance with national technical building rules. If building materials and construction methods are not regulated in one of these technical building rules or are not in compliance with them, usability must be proofed on the basis of official certificates of usability, such as a General German Technical Approval or European Technical Assessment, a General Construction Supervision Test Report or an Approval in the Individual Case, given by the highest building authority [16].

Nevertheless, German Building regulations contain exceptions of their strict fire protection regulations, if the building proofs an adequate distances to the property lines or other buildings.

4 Distance Regulations between Buildings in Germany

The implementation of distance requirements in building law originally was driven by the wish to prevent fire tragedies [18]. However, later revisions of distance regulations did consider also health issues. Thus, sufficient space between buildings should ensure optimal lighting, ventilation, and exposure to sunlight and, therefore, contribute to healthy living and working conditions. Furthermore, enough distance guarantees privacy and living free from disturbance, which secures the necessary social distance [19]. Nevertheless, distance regulations neither shall avoid views from outside into buildings and residential estates nor guarantee an unrestricted view of the surrounding.

There are two different types of minimum distance requirements for buildings in the Federal States' building regulations - spaces in front of buildings and distances for fire safety. Because the distance requirements of the 16 German Federal States differ considerably from each other, the authors will explain them by using the example of the building regulations of the Federal State of Saxony [16].

4.1 Distances for Fire Safety

To prevent spreading of fire to other buildings, German building law contains requirements for minimum distances dependent from the fire protection design of construction elements. Today, the reasons for fires are still the same as in the Middle Ages. That is why also modern building regulations still require adequate distances between neighbouring buildings and restrict the use of easy flammable building materials for exterior walls and roofs.

If an exterior wall of the building cannot be planned with the required minimum distances to the property line, it must be designed as firewall. A wall is qualified as a firewall, if the building element stays fire resistant when exposed to fire, even under additional mechanical stress, and if it is constructed from non-flammable building materials [16].

Exterior walls, which are not designed as a firewall, have to keep distance of in minimum 2.50 meters to the property line or, in minimum, 5 m to an existing building, Section 30 of [16]. In this way, fire resistant construction elements can be replaced by adequate distances. Nevertheless, for these fire protection requirements there are several exceptions, for example dependent from the style of construction in this area and from the building types. Thus, buildings without residential rooms or fireplaces, if their gross capacity does not exceed 50 m^3, are excluded from that regulation. Other exceptions as well as requirements for construction of firewalls contain the Federals States' building regulations.

Furthermore, for an adequate duration, roof materials must be resistant against fire from outside by flying fire and radiating heat ("hard roofing"), Section 32(1) of [16]. If the building is planned without "hard roofing", it has, for example, to keep distance from

1. the property lines in minimum 12 meters,

2. buildings with hard roofing on the same property in minimum 15 meters,

3. buildings without hard roofing on the same property in minimum 24 meters,

4. buildings on the same property, without residential rooms or fireplaces, if their gross capacity does not exceed 50 m^3, in minimum 5 meters [16].

Exceptions, for example for smaller buildings, as well as requirements for construction of roofs contain the Federals States' building regulations.

Normally, distances must be located on the building plot where the building should be erected but, under special conditions, required distances also can be transferred to neighbouring properties or public areas [16].

4.2 Spaces in Front of Buildings

Although fire safety is not the primary objective of spaces between buildings and to the property line, they contribute in an essential way to prevention of fire spreading to other buildings as well as ensure efficient fire-fighting by defining areas for access routes of fire service on the property.

Distance relating law regulates, in particular, the obligation to keep distances, the arrangement of distances on the building plot, the calculation of free spaces and exceptions.

Although distance regulations of the Federal States considerably differ, they have in common that all building regulations require the obligation to keep distances before aboveground exterior walls of buildings or constructions, which produce similar effects like buildings, such as walls, towers or noise-reduction barriers [3].

As well as fire safety distances, the spaces in front of buildings must be located on the building plot where the building should be erected. In special cases, required distances also can be transferred to neighbouring properties or public areas [16].

German building law knows two different principles to determine the required distances between buildings and from the building to the property line: the classical system, used by 15 Federal States, and the special system of the Federal State of Lower Saxony. Lower Saxony decided for another system because it found the classical calculation of minimum distances to be too rigid for contemporary architectural forms with its for example highly structured facades and curved exterior walls (details see under [3]).

In the classical system, minimum distances between buildings and property lines in the open construction style will be calculated based on the height of the exterior walls. The identified height is the measure “H” (see Figure 1). Subordinated construction elements, such as eaves, pillars or stairs to the front door, will not be included in calculation of minimum distances.

The former times’ minimum space of 1 H was reduced to 0.4 H in nearly all Federal States’ building regulations, always combined with a minimum distance requirement in meter. Most of the building regulations contain the requirement to leave distances of: “… 0.4 H, in minimum 3 meters.”, see Section 6(5) of [16].

In many building regulations, there are special requirements for calculation of minimum distances depending of the roof type (see Figure 1) and the type of building, such as wind power plants or constructions with circular cross-section.

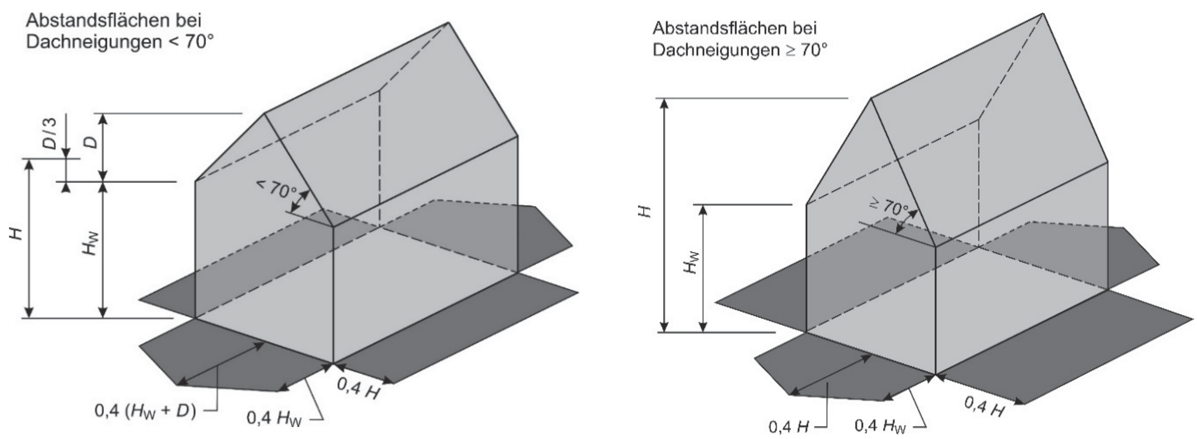

Figure 15. Calculation of minimum distances for buildings with roof pitch < 70° and ≥ 70° at the example of the Federal State of Saxony [3]

If it is necessary for urban development, urban planning regulations as well as Federal States’ building regulations can contain exceptions from the distance requirements.

While planning and construction of a new building, distance requirements are to obey. If the building owner plans construction works in an existing building, he has to comply with the current distance requirements if a modification of these building elements is planned, which are essential for calculating the minimum distances, such as exterior walls or roofs.

5 Conclusion

Germany has learned from its huge fire tragedies in the Middle Ages and developed efficient building requirements which contribute to fire safety. Fire safety research identified too close distances of constructions to neighbouring building or the property lines, as well as the flammability of roofs, as reasons for fires and the German Federal States reacted with strict requirements in their building regulations. These regulations decrease fire danger to life and limb as well as avoid property loss and environmental damage.

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TOPIC 3: HOLISTIC ENVIRONMENTAL PERCEPTIONS

03.101 - RESTORATIVE RETREAT AND WELNESS CENTER IN ACOP, TUBLAY

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Abstract

This thesis was founded on the premise that stress is a major cause of chronic diseases like heart problems, high blood pressure, and cancer and that health and wellness can be encouraged with natural environments.

The study had the aim to highlight stress coping through holistic health practices and the importance of the care of the other facets of health in balance with our physical bodies. This concept along with that of restorative natural and built environments was applied to the design of a retreat and wellness center. The challenge was to design and create spaces that work together to cater to the different facets of health as well as take advantage of the forest setting of the project site. To accomplish this, this thesis compared different existing local and foreign similar facilities catering to holistic health to identify wellness services that would be suitable for the Baguio-Benguet area. Surveys and interviews were conducted to further refine this list based on the expectations and needs of the local community. Through these two methods, architectural and design features that encourage good health and relaxation were also isolated for application in the project's design solution.

To contribute to the socio-cultural acceptability of the thesis project, its architectural character was based on a mix of both traditional Cordilleran architecture and modern design (Figure 1). Different distinct architectural features were adapted from traditional Sagada and Bontoc houses. These were chosen specifically because of their connection to the lot owner's cultural heritage.

Keywords

Holistic health, Restorative environment, Cordilleran architecture

1 Introduction

Humankind is a continuously developing and progressing species. However, though industrialization and urbanization have vastly improved our lives, our environment, the health of all living things, and the state of the human condition have also been sacrificed. Global warming, widespread pollution, and deforestation have had a drastic effect on our lifestyles, overall health and wellness [1]. Stress, which studies have found to be linked to diseases such as cancer and heart disease, is also a global epidemic [2].

Today, more than ever, people should be concerned about making an effort to keep healthy. However, many still define good health as care of just the physical body. Though important, is only one aspect of our health. Overall good health is composed of social, metal, emotional, and spiritual health components [3]. People also need a refuge and retreat from the stressors like pollution, noise, and traffic, as well as the general unhealthy lifestyle that permeates our urban environments. Studies have shown that exposure to natural environments like forests can be restorative and have physiological and psychological relaxation effects [4].

1.1 Goal

The study of a *Restorative Retreat and Wellness Center* aims to create a facility that offers a place for both locals and tourists to relax, de-stress, and avail of services that cater to holistic health and wellness. Another goal is to use the concept of restorative environments to encourage healing. Lastly, the project design should tastefully incorporate Cordilleran culture into its features and blend with the existing surrounding development.

1.2 Conceptual Framework

Two major concepts are used in this thesis: (a) Holistic Health and (b) Restorative Environments. Two types of information were compared: (a) Theoretical data and (b) Existing facts and features to isolate facilities, services, and features suitable for the project. This information is then further tempered by socio-cultural acceptability based on the local community. The final list of facilities, services, and features are shaped by the existing site features and blended with the use of Cordilleran architecture.

2 Methodology

2.1 Locale of the Study

The site is located in Tublay, Benguet. A generally mountainous region with two seasons- wet and dry. Tublay is a mostly forested area 13 kilometers north of Baguio City. More specifically, the project site is located in Brgy. Acop, within the existing development of WINACA Eco-Cultural Village which is around 4.1 hectares wide.

2.2 Data Gathering Tools and Procedure

Three different research instruments were used- (a) Literature Review, (b) Case Studies, and (c) Questionnaires. These were used to expand the researcher's knowledge on the concepts of holistic health and restorative environments and identify prominent design concepts and facilities based on foreign and local case studies. To ensure suitability of project facilities and features for the Baguio-Benguet area, data gathered was tempered by questionnaire results and interviews.

3 Results and Discussions

3.1 Literature Review

Table 1 presents the various key concepts that were identified from the literature review of holistic health and restorative environments.

Table 3: Key Concepts of Holistic Health and Restorative Environments

Holistic Health	Incorporation of body, mind, and spirit for an ideal state of health [5]
	Balance between the human's internal and external environment [6]
	Wellness counselling; creating a personal wellness plan [7]
Restorative Environments	Restorative process can be encouraged by presence of natural features, structural features, absence of threats/ providing a break from stress [8]
	Elements of healing: Sun, Cognitive/Perception, Color, Light, Sustainability [9]
	Application of biophilic design principles [10]: contact with natural environment, contact with natural views
	Health benefits of plants and water [10]

3.2 Case Studies

The researcher performed case studies on wellness facilities, visiting several located locally [11-12]. A foreign case study of a wellness center was also included [13]. It was chosen based on the similarity of its location and climate to the project site. Table 2 presents various facilities catering to holistic health and related to restorative environments that were identified as common among the various case studies.

Table 2: Common Facilities identified in Case Studies

Holistic Health	Clinic/ Medical services/ Consultation rooms
	Spa/ Massage rooms/ Treatment areas
	Gym/ Fitness areas/ Physical activity areas
	Restaurant/ Café/ Dining area
	Learning area/ TV lounge/ Library/ Halls
	Accommodations/ Villas/ Rooms
Restorative Environments	Gardens
	Hot and Cold pools/ Outdoor Pools
	Patios/ outdoor activity areas

3.3 Questionnaires

The sample population for the respondents of the questionnaire were chosen randomly from the local population of the Baguio-Benguet area. Some questionnaires were also answered by visitors and non-residents. Questions focused on three segments: (a) Building and Facilities, (b) Site and Environment, (c) Socio-Cultural Acceptability. The results of these questions further identified which of the concepts and facilities to be applied and offered are to be considered priority according to the community in the design of the project facility. The top results based on the questionnaire are shown in Table 3 and Table 4.

Table 3: Building and Facilities

Ranking	Activity	Facility
Frequency of engaging in activities/ visiting ff. facilities	Medical consultation/ Wellness counselling	Clinic/ Medical services/ Consultation rooms, Learning area
	Spa treatments	Massage rooms/ Treatment areas
	Vacations for leisure	Pools, Activity studios, Outdoor areas
Importance of general activities	Exercise and physical activity	Gym, Activity studios
	Diet and eating healthy	Kitchen, Dining areas
	Social interaction and relationships	Shared spaces
Importance of additional areas/ services	Shuttle and transportation	Parking/ Garage, Drop-off areas
	Rest and relaxation, Meditation	Lodging/ Rooms, Outdoor gardens
	Cooking demos	Learning kitchen

Table 4: Site and Environment and Socio-Cultural Acceptability

Design aspect	Concepts/ Considerations	Facilities/ Features
Site elements for a relaxing/ healthful environment	Vegetation, plants, and trees	Gardens, Biophilic design
	Quiet and nature sounds	Privacy/ Isolation, Outdoor areas
	Natural light and ventilation	Sustainable design, high windows, building openings
Socio-cultural acceptability of wellness center	Prioritization in hiring local staff/ employees/ workers	Staff offices and employee housing
	Offer/ use local products	Retail store
	Complementing surrounding areas/ businesses	Cordilleran architecture, Existing surrounding architectural features

3.4 Site Analysis

3.4.1 Current Status of Site

As the project site is located within the development of WINACA Eco-Cultural Village, it is important to consider the existing facilities and features of the development. This is so the design of the project will complement its existing surrounding areas.

Existing facilities include: the (a) Nardas Handwoven arts and Crafts factory, (b) 2 Lodging cottages with several rooms, (c) 2 Traditional Cordilleran houses which can be rented, (d) Indoor and outdoor dining areas which can accommodate more than 700 people, (e) Restaurant open during weekends and holidays only, (f) Several greenhouses producing various vegetables including lettuce, celery, tomatoes, strawberries, as well as anthuriums.

As for utilities, WINACA Eco-Cultural Village's main source of water is pumped from a spring. This water source is enough to supply the different areas of the village including the farm, lodgings, restaurant and dining areas, the Nardas factory, and the four private residences on-site. Electricity is provided by a direct connection to a BENECO line. For the occasional power outage, a generator exists beside the Nardas Weaving factory enough to supply the factory, lodgings, restaurant and dining areas, and the private residences. Parking areas for visitors exist scattered within the development, enough to easily accommodate more than fifty private vehicles.

For waste management, biodegradables are separated and sorted to either be used as food for poultry or to be processed into compost. Residual waste is gathered, segregated, and disposed of in the same dumping site as the neighbouring municipality of La Trinidad.

3.5 Architectural Programming

The final list of facilities to be included in the *Retreat and Wellness Center* was chosen to cater to holistic health- physical, mental/ spiritual, and social health aspects. They are shown in Table 5 with their definition based on function, along with some design considerations. Design standards were taken from the National Building Code of the Philippines [14].

Table 4: Architectural Programming Data

Area	**Function/ Features**	**Design Standards**
Coffee Shop (Physical, Social)	An area open to both customers and non-customers of the wellness center that serves snacks and drinks. Its menu concentrates on healthy foods & products made from local produce.	
Retail Space (Physical, Social)	Sells health and wellness products as well as produce that is grown on-site and locally.	Unit area per person – 2.80 sq. m.
Lobby (Social)	Main entrance hall of the retreat and wellness center. Serves as the registration and information center of the facility.	Waiting area – 0.65 sq.m./ person Information & Reception area – 5.02 sq.m./ staff
Office Space (Mental)	This refers to a variety of spaces such as administration offices, staff offices, and consultation offices.	Private offices – 10-30 sq. m.
Conference Room (Mental, Social)	A room for meetings especially for administration personnel and staff regarding operation of the facility and client concerns.	Unit area per occupant – 1.40 sq. m.
Treatment Room (Physical, Mental)	Space designed for health treatments such as massages, and alternative medical practices like acupuncture and reiki.	Unit area per occupant – 7.40 sq. m.
Yoga Studio (Physical, Mental, Social)	Wide, open floor space with a wall of mirrors where clients can perform activities like yoga, meditation, Zumba, pilates, etc.	Unit area per occupant – 4.60 sq. m.
Lecture Room (Mental, Social)	Large room that can accommodate groups of people for lectures and meetings.	Unit area per occupant – 1.80 sq. m.
Waiting Area (Social)	Area where clients can wait and lounge comfortably while waiting to be accommodated or treated.	Unit area per occupant – 0.65 sq.m.

Dining Area (Physical, Social)	Wide, communal space for wellness center clients to eat and socialize over meals.	Unit area per occupant – 1.40 sq.m.
Kitchen (Physical)	An enclosed area for preparing food and meals for the clients.	Minimum Dimensions – 3.00 sq. m. with a least dimension of 1.50 m
Demo Kitchen (Physical, Mental)	An open area with equipment for cooking. It is open to the view of the dining area and will be used to teach clients how to cook and prepare different healthy foods.	Minimum Dimensions – 3.00 sq. m. with a least dimension of 1.50 m
Pantry (Physical)	Storage room for cooking ingredients and other food products.	
Lodging Room (Physical, Mental)	Private area for clients to sleep or stay if they want complete privacy.	Minimum Dimensions - 6.00 sq.m. with a least dimension of 2.00 m.
Toilet & Bath (Physical, Mental)	Area included in lodging rooms to serve	Minimum Dimensions - 1.20 sq.m. with a least dimension of 900 mm
Swimming Pool (Physical, Mental)	Outdoor water element that serves both an aesthetic purpose and as an area for clients to engage in activities like swimming or water aerobics.	
Hot Baths (Physical, Mental)	Area for clients to soak in hot baths to relieve stress and relax the body.	
Garden (Physical, Mental)	Area for clients to relax or lounge surrounded by nature and vegetation.	
Gazebo/ Lounge Area (Physical, Mental)	Shaded outdoor space where clients can relax. Can also serve as an alternative outdoor health treatment area.	
Parking Space (Social)	Space for vehicles. Includes client and staff parking.	Average parking slot – 2.50m x 5.00m; Truck/ bus parking – 3.60m x 12.00m; Jeepney/ Shuttle parking/ loading – 3.00m x 9.00m

4 Architectural Solution

4.1 Layout of the Site

The facilities are first grouped into separate buildings based on the correlation of their services as shown in Table 5. The site has three tiers of flat buildable areas. Using these flat tiers, the buildings and other outdoor areas are then arranged on the site based on the degree of privacy ideal for their activities. This concept is illustrated in the bubble diagram in Figure 1. Privacy is provided by the different elevation of each flat tier and presence of vegetation.

Table 5: Facility groupings

Building/ Area	**Facilities**
Front Building	Lobby, Coffee Shop, Retail Space, Conference Room/ Lecture Room
Treatment	Office space/ Consultation rooms, Waiting area, Treatment rooms
Circulation	Lobby, Waiting area, Stairs, Elevators, Access bridges (to lodgings)
Lodging Building	Dining area, Demo kitchen, Kitchen, Pantry, Tea room, Lodging rooms with Toilet and bath
Activity Studio	Yoga Studio, Lockers, Storage, Patio, Male and female restrooms and showers, Mechanical rooms
Hot Baths Area	Hot baths (indoor and outdoor), Locker rooms with toilet and showers, Mechanical room
Healing Gardens	Gardens, Gazebos
Pool Area	Swimming pools, Outdoor yoga areas, Gardens, Gazebos
Parking Area	Drop off area, Varied parking slots, Shaded walkway, Landscaping
Service Parking	Parking slot

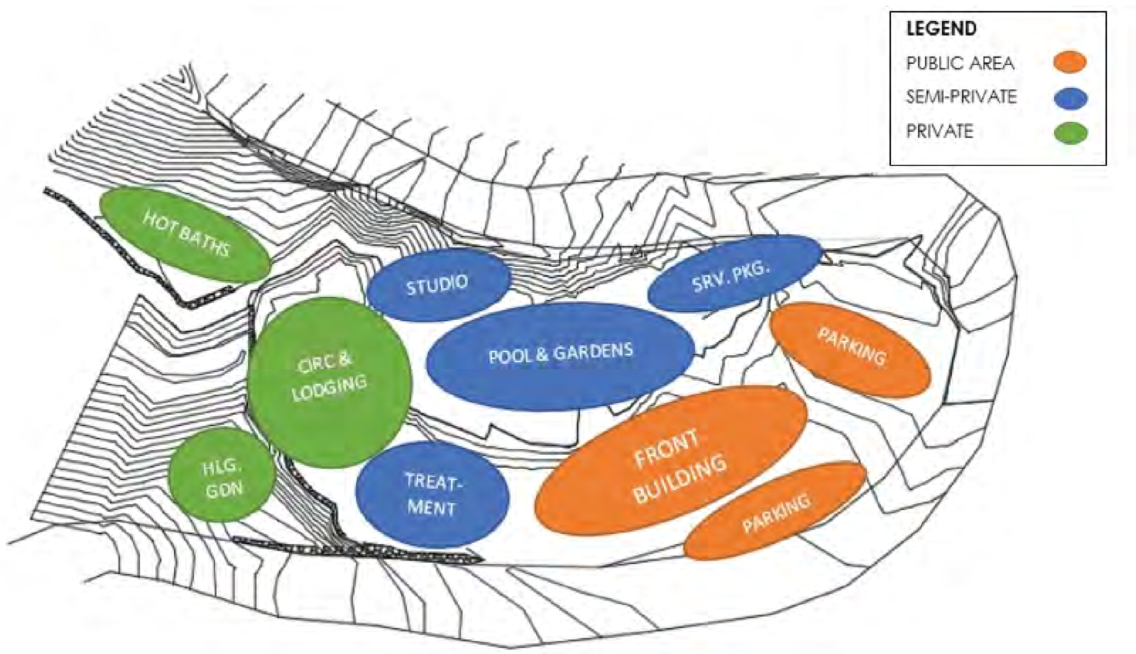

Figure 1. Bubble diagram of building layout and areas on site

4.2 Architectural Character

The architectural character of the facilities was based on existing architectural features of buildings within the site. Figure 2 and Figure 3 show examples of such.


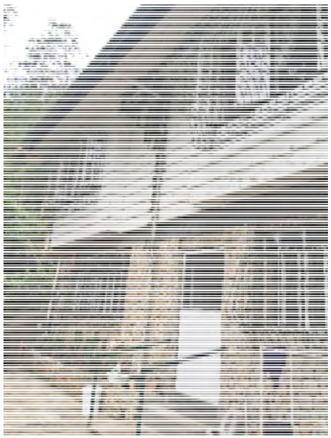

Figure 2. Cottage A Exterior (left)   Figure 3. Private residence of owner (right)

Some notable features that repeat throughout the different structures within the WINACA Eco-Village development are: (a) Use of crazy cut stone as the exterior wall of lower floors, (b) Use of horizontal wood slat walls, (c) Green and white color scheme.

The second factor influencing the architectural design of the project is Cordilleran architecture. Bontoc and Sagada traditional houses, as shown in Figure 4, were chosen as a reference as the owner of the lot has roots specifically in these two places. The Ifugao house is also a type of traditional house found in Sagada. Prominent features of these houses are the (a) steep pitch of roofs, (b) hip or Dutch gable roof types, (c) use of wooden planks for the walls, (d) floor raised from the ground on stilts.

Figure 4. Sagada, Bontoc, and Ifugao traditional houses [15]

These architectural features combined, blended with concepts of restorative environments and holistic health, resulted in the use of the following strategies.

(a) A crazy cut stone finish was used for the columns and exterior walls of the lower levels. Highly reflective floor to ceiling glass windows were used to create the illusion of the upper levels being elevated by stilts. The use of highly reflective glass will also mirror the site's natural elements, especially trees and vegetation, making the building blend more seamlessly into the landscape.

(b) Horizontal wooden planks were also used as exterior wall finish for upper levels as this is true for both the existing residential buildings and traditional Cordilleran houses.

(c) The shape of Bontoc and Sagada traditional house roofs were chosen as the basis for the roof shape of the facility's buildings.

Figure 5. Rendered images of project showing architectural features

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03.102 - VISUAL NARRATIVES A METHODOLOGY FOR LAYERING AND DECONSTRUCTING DIGITAL PROJECTIONS

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Abstract

During the last decades, audio-visual hardware combined with digitally processed content has transformed physical space into a live media canvas. These technologies are mainly focused on cultural heritage, tourism, social events, performances, and commercials. The most fundamental factor for these mediated experiences is the user's engagement with the immersive content. This paper focuses on analyzing a specific methodology for content creation in mediated environments, which exposes the audience to an enhanced interactive experience. Our approach emphasizes the differences between the "structural" components of an image and reconstructs them in a specific order, based on how visual information is perceived by the user. The methodology is presented through a series of applications, conducted by TUC TIE Lab, ranging from small scale (affecting a single or few people) to medium (indoors affecting groups of people) to large (urban projections affecting crowds of people). The approach is interdisciplinary and the themes addressed include cultural, educational and extreme conditions environments. On these occasions, the variation between ambient/non-intrusive and literal/intrusive digital objects is fundamental for understanding the effects on the user's perception. The aim of this research is that the visual content can facilitate the fabrication of a "sense of place" and affect the spatial-psychological relationship in built environments where strict structural elements define the boundaries between the external physical world and the user/inhabitant. Furthermore, the implementation of interactive elements, in the projection process, will be presented, as a means of increasing users' engagement. The projected elements come to life as interactive components of the whole picture/ canvas, promoting an enhanced mental and physical relationship between the viewer and the surrounding visuals.

Keywords

Mediated Reality, Information Design, Visual Layering, Interactive Experiences, Psychospatiality

1 Introduction

Media technologies have a long history of implementation in cultural, educational and entertainment environments. Evidence suggests that mediated environments have a positive effect on human psychology and learning experience, by introducing immersive digital elements that simulate and enhance physical conditions. [1][2]

A content-creation process, when properly guided into constructing immersive virtual environments, can convert physical space into a new form of interface. Taking into consideration the human brain's limited capacity for processing visual information [3], the visual layering methodology analyzed in this paper aims to abstract excessive information and guide users' attention into the most significant parts of an image.

The timeline of examples presented in this paper displays the implementation and evolution of various content-related techniques, through interdisciplinary studies in different environments. An initial evaluation will be presented based on the impact of these applications on human attention, engagement, and memory.

2 Theoretical Background

The Visual Layering Theory (VLT) was introduced by the Transformable Intelligent Environments Laboratory (TUC TIE Lab) [4] at the School of Architecture at the Technical University of Crete (TUC). The case studies presented and analyzed in this paper use similar hardware and implementation techniques, yet the desired outcomes have fundamental differences.

The VLT divides visual elements into two main categories - active and passive. Active layers include all the visual elements of high semantic value that draw actively the attention of the viewer because of their movement, their interactivity, and their signifiers. They address the cognitive functions that demand rapid attention and may dynamically affect our behavior. The active layers are split into three tiers. The first active layer includes those elements that can be described as 'protagonists'. The protagonists are visual elements that retain the highest semantic value of the whole image. Their status is achieved through a series of identifiers, such as size, lighting, shades, focus, occlusion, in comparison with the other active elements [5]. The second active layer includes the elements 'supporting' the protagonist. Through the same semantic table of identifiers, the supporting elements are distinctive but their significance is directly related to the signifier, the protagonist. The third active layer includes all the other elements that are animated but not immediately related to the main active elements of the scene. They provide, in a way, the context in which a scene evolves, for example, a road, a hall, or a cafe.

The passive layers include the elements of the place in which the action takes place. They are also split into three tiers. The first passive layer is closely connected to the third active one. It includes the main elements that provide the sense of locality. Cognitively, they are considered the inseparable spatial elements where the presented activity takes place, such as trees, buildings, plazas, and so on. They also provide proportions of scale and they are very crucial for the *parallax* phenomenon [6] which creates the sense of motion. The second passive layer includes those elements that create the sense of the overall region that hosts the locality. They are mostly understood as geometrical shapes, outlines, shades, and blurred elements, such as the skyline of buildings, rolling hills, treetops, and so on. The third passive layer is what one may describe as ambience: the sky, distant mountains, the sea. While it is the visual element attracting the least attention, it has been proven to be essential in projecting the sense of place [7], as its alterations affect the viewer profoundly.

The Visual Layering Technique does not stop with the analysis and classification of the visual elements but utilizes them to facilitate a wider perception and understanding of a visual scene. By shifting active and passive elements to different tiers respectively, the viewer can identify, understand and recall much more information. Furthermore, by employing more abstract representations, the viewer participates in the completion of the visual scene with his/her own apperceptions, creating a more personal and unique experience. Finally, by slightly animating the elements, different narratives can be presented, creating an additional trigger for the viewer's engagement.

It is important to note that by changing the value of the attributes of the semantic identifiers, the focus of the visual information can be rearranged, providing a changing image without though changing the viewpoint or the number of the elements in a scene, thus increasing significantly its communicative aspect, and reducing the need for multiple images.

TUC TIE Lab's methodology is based on a series of field experiments and applications which revealed that the significance of a scene is better understood through an experience that focuses on the cultural and social context, than through representational accuracy. Instead of focusing on excessive details, that also require more resources to complete and project a scene, it focuses on expressionistic tools that aim to address also the implicit and the collective memory. In this way, the user not only gets informed but also has an emotional connection with the scene, creating a unique experience that makes him/her understand the theme's Genius-loci [8].

3 Content Creation Methodology

Social VR systems adopt the TUC TIE Lab's Visual Layering Methodology via an ongoing research project named Hybrid Environmental Projection Platform (H.E.P.P). Projects referring to projection mapping use various content-related features and techniques (i.e. blur, color saturation, depth of field, field of view, sound). These techniques do not necessarily relate to visual layering, but rather in methods and features that enhance immersion and can be more effective in educational and cultural environments when combined with the general image layering methodology.

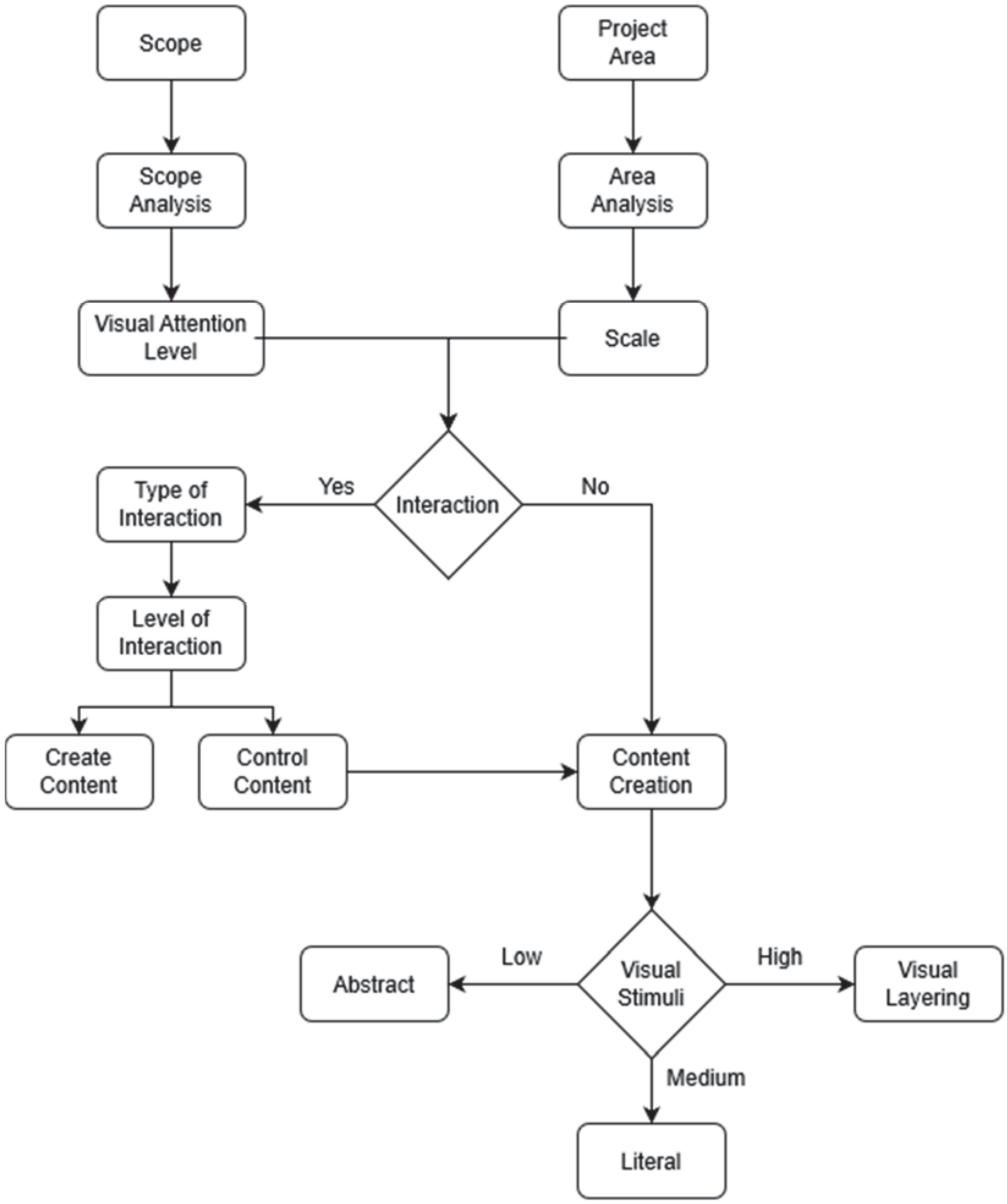

Figure 01. Content-Creation Methodology

4 Project Classification

This analysis includes selected projects in the fields of media technologies and tele-presence conducted by TUC TIE Lab during the last four years. Two constantly evolving social VR systems implementations will also be examined. The projects included in this study, meet the following mediated characteristics:

- utilize immersive features
- incorporate computer-generated graphics
- incorporate projection mapping technologies and techniques
- address small, medium or large groups of people (interior & urban scale)
- are designed and performed around the research fields of human cognition and perception

Table 1: Project Characteristics / Content Evaluation

	INSTALLATION CHARACTERISTICS			CONTENT EVALUATION		
PROJECTS	SCALE	INTERACTION	LEVEL OF MAPPING	ATTENTION	ENGAGEMENT	MEMORY
A.K.T.	medium	N/A	low	high(intrusive)	low	high (Visual Layering)
H.E.P.P.	medium	medium	low	high(intrusive)	medium/ low	high (Visual Layering)
Urban Projections						
Experiment 01	large	N/A	medium	medium	low	medium(literal)
Experiment 02	large	N/A	high	medium	low	medium(literal)
Experiment 03	large	N/A	low	medium	low	low(literal)
Experiment 04 “TIE Lab Doodle”	large	high	low	high(intrusive)	high	medium(abstract)
Interior Projection						
TUC STEM DAY	small	medium	high	high(intrusive)	medium	high(literal)

The experiments will be sorted according to their nature, the initial scope and the achieved outcome as presented in Table 1. Included are projects that seek to dominate the user's perception. Among these are social VR systems and a limited number of urban and interior projection mapping installations. Projects aiming to complement the main foreground action without entirely capturing users’ attention are also designed based on the content creation methodology presented in Figure 01. Projections in theatrical performances, space analogs, hospitals, and prison facilities are being developed by TUC TIE Lab at the moment and belong to the cases where media play an ancillary role in the holistic spatial experience

5 Evaluation Methodology

The variables of interest in our projects are human attention, engagement, and memory.

Attention. This variable examines the levels of attention to the intrusive or non-intrusive range of stimuli presented in a mediated environment. For example, the A.K.T. and H.E.P.P. platforms trigger selective attention, which refers to focusing on a specific range of stimuli [9].

Engagement. Engagement refers to the user’s interest in the mediated environment. The engagement with visual content also relates to the attention and comprehension variables. According to Kaplan & Kaplan, fascination and engagement are closely related. Fascination is also a requirement when designing content for restorative purposes [3].

Memory. Memory refers to the potential of the projected content to create immersive experiences that will activate the semantic and episodic memory. The activation of the episodic memory through VR has been documented [10] and can lead to the formation of explicit memories. Social VR systems, like the H.E.P.P. platform, can augment the potential of creating explicit memories through the Visual Layering Technique that imbue additional semantic value.

These inquiries follow a quantitative research methodology because the collection and data evaluation allowed for more participants. Therefore, user experience questionnaires (UEQ) with closed-ended questions were introduced. The template and the context were the same. The urban projection mapping experiments referred to a wide range of ages, while the interior projections mainly referred to control groups composed of elementary to high school students. Moreover, formal and informal interviews with the participants took place after the experiments.

6 Projects

6.1 Social VR Systems

The concept of an immersive educational environment that could be transported and deployed in different classroom layouts and connect schools around the globe emerged in 2011. The Automatic Kinetic Theater project (A.K.T.) (Figure 2) was composed of an environmental projection infrastructure with transformable and collapsible features and robotic elements, aiming to promote multi-cultural context in educational environments.

It was the first project to implement the Visual Layering Methodology. The A.K.T. installations led to the design and introduction of the Hybrid Environmental Projection Platform (H.E.P.P.) in 2014. [11] H.E.P.P. is a transformable social VR system, operating with interactive environmental projection principles. It has the same operational framework as A.K.T., however, this system integrates a user interface optimized for Kinect gestural inputs, allowing for medium-level interactivity.

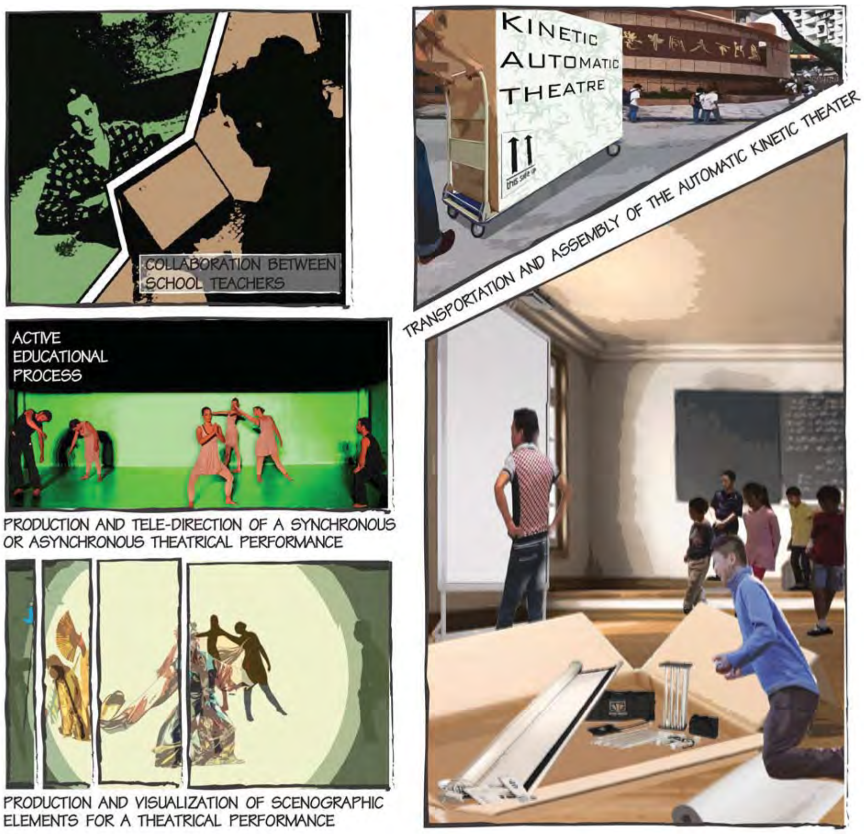

Figure 02. Details from the Automatic Kinetic Theater project (TUC TIE Lab, 2011).

H.E.P.P. has been field-tested during three different phases in various interior layouts. Since the platform has several deployment capabilities, the installations were deployed in different spatial arrangements regarding the screen curvature. The screen curvature proved to be marginally significant for immersion, though memory and attention were not affected. Regarding content, H.E.P.P. utilizes a constantly evolving adaptation of the Visual Layering Methodology. The rendered video sequence had a resolution of 9600 x 1080 pixels. The final visual sequence consisted of information-rich environments, representing key parts of the old Venetian Harbour of the city of Chania. Finally, the rendered content was imported in a customized software inside the Unity game engine in order to implement the gestural interface and the general UI.

The H.E.P.P. v.03 (Figure 03) was exhibited in two different settings. The first installation was deployed in 2018 within Sabbionara Gate, located on the northeast corner of the Venetian walls of Chania. [12] The participants were local people across a wide age range.

Three types of visual content were tested. The custom Unity software supports inputs from

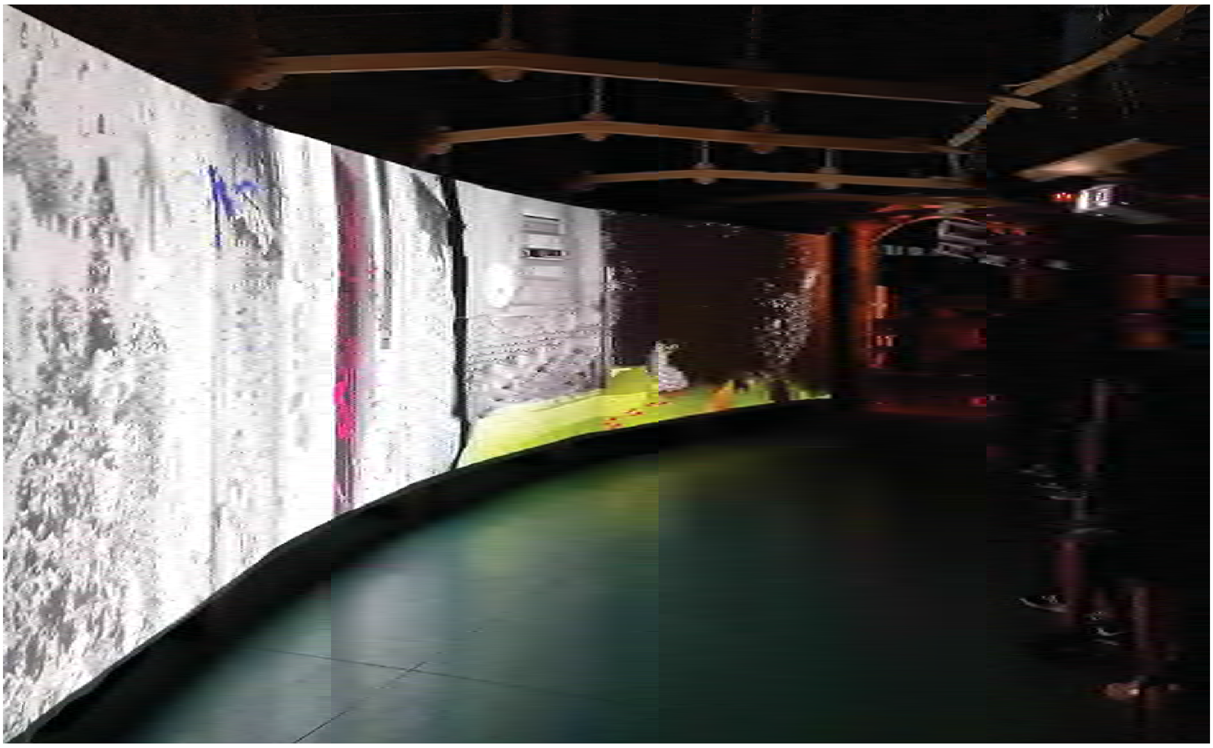

Figure 03. Details from H.E.P.P. v.03 (TUC TIE Lab, Summer 2018).

either rendered panoramic videos or live streaming from 360º cameras. For this experiment, a commercial-grade Samsung Gear 360º was utilized for the 360º demonstrations. The 360º content appeared pixelated and the image quality was generally inferior compared to the visual layered panoramic video which was rendered at the native resolution of the platform.

However, the users reported higher levels of immersion while viewing the 360o video, even though the image quality deteriorated. Immersion levels raised especially when gestural inputs were used to pan the 360º content. On the other hand, the panoramic content was rated as more impressive with greater color accuracy and clarity and enhanced the memory variable by utilizing the Visual Layering Technique more directly.

Lastly, a computer video game was launched to compare the factor of engagement with the aforementioned content approaches. The game was Far Cry 4 and was able to run at the platform's native resolution (9600x1080@60Hz pixels) in ultra-settings. The level of detail was outstanding; however, the most noticeable immersive feature was the enhanced depth of field. All the users reported the highest levels of immersion, nonetheless, the memory variable was low mainly because of the rapid transitions.

An advanced H.E.P.P. infrastructure (v.04) will be introduced in 2020. The platform will utilize a 5-projector array system with a maximum brightness of 5000 lumens. A cylindrical projection lightweight infrastructure with a horizontal field of view of 270^o is going to be deployed. Our future efforts will investigate the user- content relationship and the impact of visual layering on cognition using EEG sensors and UEQs. Finally, olfactory and haptic stimuli are programmed to be integrated into future experiments.

6.2 Urban Projections

TUC TIE Lab has been experimenting using projection mapping techniques and technologies in urban environments since 2015. The first urban project had a festive theme and was set on the west facade of the “Mikis Theodorakis” theater (previously Old Custom House) located opposite the center of Mediterranean Architecture, at the old Venetian port of Chania. The west facade of the theater is 45.2m x 10.6m (W. x H.) and the projection mapping was accomplished by integrating large venue Epson PowerLite projectors with a maximum brightness of 5200 lumens inside the Centre of Mediterranean Architecture (C.A.M), at a distance of approximately 48 meters from the projection surface. The two buildings are strategically positioned since the urban space between them functions as a public square (Katehaki square), thus the study was addressing a substantial number of locals as well as international visitors. The theater building was used four times as a canvas with different content approaches. This promoted the comparison and evaluation of different techniques on the same reference surface. (Figure 04)

The first experiment was conducted in the winter of 2016, using a single large venue projector which allowed for mapping only a portion of the building facade. The theme blended with the rest of the surface by dissolving and matching with the hexagonal masonry pattern of the wall.

The second experiment utilized two large venue projectors; thus, the projection occupied the whole surface (45.2x10.6 meters). The enhanced projector arrangement also allowed for keeping approximately the same pixel density, since each projector was occupying almost one half of the canvas.

This had a significant impact on immersion and consequently, attention since the whole length of the building can be perceived from the most parts of the square. Current research mentions the important role field of view also plays for presence. When the proportions of a mediated space correlate with the human natural field of view, the sense of “being there” is enhanced. [13]

A third experiment took place during the winter of 2018. The projector arrangement was the same, however, the projected theme had radically changed. A festive animation clip was created by TUC TIE Lab, based on the parallax technique in order to promote depth. The building facade was not mapped according to the openings (doors, windows) and the ornamental elements. Instead, the image boundaries were defined and an edge blending process was performed.

The reported impact on attention, engagement, and memory was relatively low compared to the first two experiments. This suggests that the aforementioned factors also depend on the level of the surface mapping. However, even a simple video projection constitutes a significant stimulus, since most of the visitors reported that the animation captured their attention due to the scale of the projection.

The fourth experiment, codenamed "TIE Lab Doodle", had a completely different purpose. Adopting the same technical arrangement, the facade was transmuted into an interactive paint canvas. Children from local schools were invited to draw on the building facade using a tablet. Challenging the kids to draw on a building surface proved to be a truly memorable experience, promoting engagement by actively altering the semantics of the building. Like a projected graffiti.

To sum up, the experiments altered the significance of the façade, which before was conceived by the visitors of the Katehaki square as a passive background. The main recorded impact of the projection mapping experiments was the change of the state of the façade from passive to active and the attitude of visitors towards the newly introduced surface / interface. Most visitors reported that they had not noticed the architectural characteristics of the façade since then.

However, the achieved brightness level was incapable of providing the ideal setting for a more immersive content, with increased levels of depth of field. Therefore, the produced content on each occasion focused on implementing 2D graphics with parallax movement.

A more advanced projection setup with increased brightness levels (2 x projectors with >12000 lumens each) will be installed in the square in 2020. The advanced platform will be utilized to re-evaluate results since this urban setting offers an optimal urban plateau for experimenting in the fields of immersion and presence. The new setting will overcome the deficiencies of the previous versions and further experiments, including depth of field and interactive features, will be conducted.

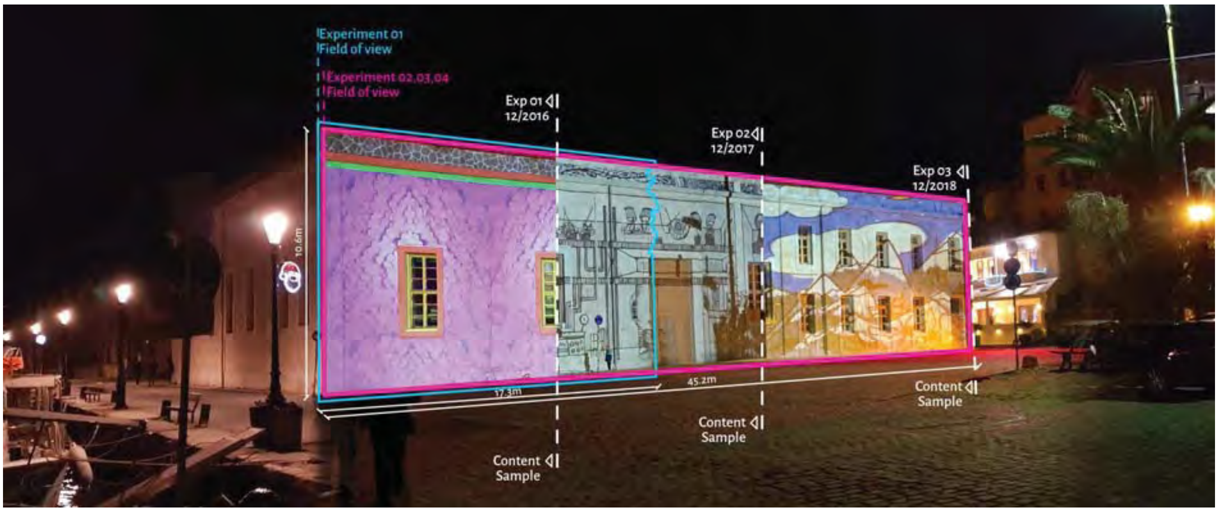

Figure 04. Comparison of the Urban Projection experiments.

6.3 Interior Projections

The TUC STEM 2019 experiment was conducted during the annual STEM day for elementary schools organized by the Technical University of Crete. The participants were elementary school students and due to the increased attendance during the annual exhibition (more than 4000 students), the pupils were divided into groups of ten. Volunteers were guiding the visitors, giving them instructions regarding the experiment.

A setup of three 1080p ultra-short throw projectors with a peak brightness level of 2000 lumens was utilized to map a 9m^2 dark room (3x3 meters) and create an engaging virtual spacecraft bridge. The theme was educational and it was part of a larger installation regarding space exploration. The projected content presented the Earth, the Moon, and Mars via a Unity application with integrated joystick support. Infographic elements were applied in order to provide a sense of depth between the cockpit's virtual windows and the external view (Figure 5).

Figure 05. TUC TIE Lab Space - Educational Installation / TUC STEM DAY/ Autumn 2019

The survey intended to measure the attention, engagement and memory factors in an educational mediated environment with the use of literal and descriptive content. The students from all groups were completely engaged and high levels of memorization of the projected material were reported. The ability to control the content managed to increase immersion, however, only the student operating the joystick was affected. The most immersive feature, according to the UEQs was the ability and the freedom to enlarge the virtual objects (Earth, Mars, and the Moon) and manipulate their rotational speed.

7 Conclusions

The coexistence of virtual places and the physical world has become a major discussion topic during the last decades. TUC TIE Lab is conducting interdisciplinary research aiming to introduce virtual narrative spaces by examining urban and interior mediated methodologies for educational, cultural, restorative and entertainment purposes. These methodologies are exploring the qualities and features of the virtual content. This paper presented some of these mediated experiments in order to discuss the initial effects of specific content strategies and installation features on the human cognitive processes.

The present study compared several experiments with variable levels of interaction. We were able to observe the impact on attention/engagement/memory with different interpretations of our content methodology.

During the experiments, it was observed that even a simple animated urban projection (i.e. Urban Experiment 03) constitutes a significant stimulus, despite the low levels of surface mapping. The vast majority of participants reported that the urban installations captured their attention momentarily due to the scale of the medium. When the projection surface expanded vertically during the urban experiments 02, 03 and 04, a considerable increase in the attention variable was reported. Therefore, it is safe to say that the viewing distance in relation to the size and ratio of the mediated surface, as well as the manipulation of the projection surface size/screen size constitute a significant factor for increasing attention and memory.

The above statement is valid, regardless of nature and characteristics (literal or abstract) of the projected content. However, the different content techniques displayed a significant impact on retaining the visitors' attention, and in some cases engaging their memory. More specifically, the visual content characteristics had a substantial impact on the amount of time the attendant kept his/her attention on the projection surface. However, the projection during the Urban Experiments 01, 02, and 03 failed to hold the observers' attention for more than three minutes. One possibility is that the literal content had slow animations and transitions. When interactive objects were introduced, the collected data from the UEQs displayed a significant increase in the engagement factor. The fourth Urban Experiment allowed the users to actively generate their own visual content on the urban landscape.

H.E.P.P. and TUC STEM day projects adopted a different approach regarding interactivity, allowing the user to manipulate specific pre-rendered content elements and software functions. These projects cannot be directly compared with the Urban Experiment 04 in terms of interactivity, however, a generalized correlation between interactive features and the engagement variable has emerged from the UEQ evaluations.

Finally, as indicated in Table 01, TUC TIE Lab's Visual Layering Technique has proven to be effective in addressing collective memory. The results from the H.E.P.P. experiments indicated that the users memorized more visual elements from the same image when the layering technique was deployed, thus confirming our hypothesis that representational accuracy is not required for the stimulation of the memorization process.

To sum up, according to UEQ evaluation, memory appears to depend mostly on the content (colors, literal/abstract/visual layering) and the level of mapping which ultimately becomes part of the content. The level of attention depends on the type of content (intrusive/non-intrusive) and the scale of the installation. Lastly, interactive features appear to be more important for the engagement factor by contributing to the sense of self- location.

Future efforts will investigate the presence and immersion factors in mediated systems. The upcoming H.E.P.P. and Urban Projection platforms will benefit from those findings and the redesigned software will move towards a more immersive approach, by adopting features such as depth of field and higher levels of interaction. From a content perspective, we are constantly evolving our strategy in order to define which scenarios demand literal and which abstract representations. In the near future, mediated experiments will also be conducted in a space analog, an intensive care unit, and a prison. These isolated conditions should challenge our research on virtual content even more since they will rely on an Activity Based Design Scheme, with the virtual content actively adapting to each living scenario. Earlier studies from various scientific fields have demonstrated the restorative and educative potential of mediated environments and should prove valuable for our future research in this direction.

8 Acknowledgements

We gratefully acknowledge the work done by volunteers and interns during the TUC STEM Day 2019 and would like to express our gratitude for their valuable assistance.

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TOPIC 4: INTERACTIVE STRUCTURES

04.101 - INTERACTIONS IN SPATIALLY AUGMENTED PLACES

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Abstract

Projection mapping installations that take place in urban settings can influence and augment the perception that people have from the real-world environment. Taking this into account, the added element of interactivity in these installations can really enhance their impact. This paper focuses on analyzing and validating a variety of digital interactions with large-scale projection mapping installations along with environmental projection systems. The applied projects that employed this research methodology are focused on education, digital storytelling, culture, tourism and extreme environments. The implementation of interactivity enhanced the users' experience and engagement significantly, a fact that was also further enriched with the custom-made content the research team developed for each occasion. The specialized content-creation process focuses on the differences that the images' "structural" components have, and on the way that those components are reconstructed in a specific order so that to enhance the users' perception. The interactive elements in these Spatially Augmented Reality (SAR) installations can either use a secondary device (for example a phone, table or joystick) as a controller or just the user's body or hand gestures. There are different interaction levels that can be implemented. These range from a simple selection of pre-made content, to allowing the users to control virtual figures or various elements in order to tell their story, to fully allowing the users to draw digitally and ephemerally anything they want on a public building. These different levels of interaction are being evaluated based on the specific requirements for each installation. An environmental projection system, for example, that is being used for educational and cultural purposes can have multiple modes of user interactivity with each one being evaluated for usability, user-experience as well as contribution in achieving the installation's overall purpose.

Keywords

Interactive experiences, digital storytelling, augmented reality, user-experience, projection mapping, public space.

1 Introduction

The goal of Spatially Augmented Reality (SAR) [1] installations is to enhance the ambience, the communication level and the experience of the physical environment by orchestrating projected themes, images, videos or other combined forms of AV graphics. This way, any surface within a user's environment can become a medium that transmits information. Along these lines, another similar technique emerged during the last few years for this kind of installation, titled projection mapping, that also included in its applications not only flat surfaces but also irregularly shaped elements.

Installations that take place within an urban environment can influence and augment the perception that people have from the real-world environment. Also, they can provide additional information that enhance the user's experience and can additionally act as a supplementary communication medium.

One of the first uses of this technology surfaced in 1969, in the Haunted Mansion in Disneyland, in order to create the illusion of 5 singing head busts. [2] Since then, this technology has been used mainly for entertainment and artistic purposes. The research work presented in this paper is conducted at the Transformable Intelligent Environments Laboratory (TUC TIE Lab) based at the School of Architecture in the Technical University of Crete. It focuses on analyzing and validating a variety of digital interactions with large-scale projection mapping installations along with environmental projection systems. The applied projects that employ this research methodology are mainly focused on education, digital storytelling, culture, tourism and extreme environments. Taking this into account, the added element of interactivity in these installations can really enhance their impact and user engagement.

2 Background

The Visual Layering Theory (VLT) was introduced by the Transformable Intelligent Environments Laboratory (TUC TIE Lab) [3] at the School of Architecture at the Technical University of Crete (TUC). The specialized content-creation process focuses on the differences that the images' "structural" components have, and on the way that those components are reconstructed in a specific order so that to enhance the users' perception.

The VLT divides visual elements into two main categories - active and passive. Active layers include all the visual elements of high semantic value that draw actively the attention of the viewer because of their movement, their interactivity, and their signifiers. They address the cognitive functions that demand rapid attention and may dynamically affect our behavior. The active layers are split into three tiers. The first active layer includes those elements that can be described as 'protagonists'. The protagonists are visual elements that retain the highest semantic value of the whole image. Their status is achieved through a series of identifiers, such as size, lighting, shades, focus, occlusion, in comparison with the other active elements [4]. The second active layer includes the elements 'supporting' the protagonist. Through the same semantic table of identifiers, the supporting elements are distinctive but their significance is directly related to the signifier, the protagonist. The third active layer includes all the other elements that are animated but not immediately related to the main active elements of the scene. They provide, in a way, the context in which a scene evolves, for example, a road, a hall, or a cafe.

The passive layers include the elements of the place in which the action takes place. They are also split into three tiers. The first passive layer is closely connected to the third active one. It includes the main elements that provide the sense of locality. Cognitively, they are considered the inseparable spatial elements where the presented activity takes place, such as trees, buildings, plazas, and so on. They also provide proportions of scale and they are very crucial for the *parallax* phenomenon [5] which creates the sense of motion. The second passive layer includes those elements that create the sense of the overall region that hosts the locality. They are mostly understood as geometrical shapes, outlines, shades, and blurred elements, such as the skyline of buildings, rolling hills, treetops, and so on. The third passive layer is what one may describe as ambience: the sky, distant mountains, the sea. While it is the visual element attracting the least attention, it has been proven to be essential in projecting the sense of place [4] as its alterations affect the viewer profoundly.

The Visual Layering Technique does not stop with the analysis and classification of the visual elements but utilizes them to facilitate a wider perception and understanding of a visual scene. By shifting active and passive elements to different tiers respectively, the viewer can identify, understand and recall much more information. Furthermore, by employing more abstract representations, the viewer participates in the completion of the visual scene with his/her own apperceptions, creating a more personal and unique experience. Finally, by slightly animating the elements, different narratives can be presented, creating an additional trigger for the viewer's engagement.

It is important to note that by changing the value of the attributes of the semantic identifiers, the focus of the visual information can be rearranged, providing a changing image without though changing the viewpoint or the number of the elements in a scene, thus increasing significantly its communicative aspect, and reducing the need for multiple images.

TUC TIE Lab's methodology is based on a series of field experiments and applications which revealed that the significance of a scene is better understood through an experience that focuses on the cultural and social context, than through representational accuracy. Instead of focusing on excessive details, that also require more resources to complete and project a scene, it focuses on expressionistic tools that aim to address also the implicit and the collective memory. In this way, the user not only gets informed but also has an emotional connection with the scene, creating a unique experience that makes him/her understand the theme's Genius-loci [6].

Table 4: Projects to be analyzed / Informations and content evaluation

	Installation information			CONTENT EVALUATION	
PROJECTS	Scale	Interactivity level	LEVEL OF MAPPING	ATTENTION	ENGAGEMENT
Open City Museum	small	medium	high(AR App)	medium(non-intrusive)	high
Tie Lab Doodle	large	high	low	medium	high
Theatrical performance 1 "Accomplice"	medium	low	high	medium / low	high
Theatrical performance 2 "Festen"	medium	low	medium	Low (non-intrusive)	medium
TUC STEM Day 2019	small	medium	high	high(intrusive)	medium
Student Creativity Exhibition 2019	small	medium	high	high(intrusive)	low

3 Projects

The projects analysed in this paper (Table 4) have been implemented with different interaction levels. These interaction levels range from performing a simple action, to allowing the users to control virtual figures or various elements in order to tell their story, to fully allowing the users to draw digitally and ephemerally anything they want on a public building.

Open City Museum

Open City Museum is an ongoing project that employs the Visual Layering Technique to create a mobile augmented reality application and provides users with the ability to experience a virtual time-leap in the past where a monument's history is depicted in its previous social context. The application is currently being developed for monuments in the city of Athens. It tries to provide a completely new experience when visiting a historical monument of a cultural heritage site. The application does not focus on the most famous monuments of Athens (like Akropolis and the Parthenon) but rather it focuses on lesser-known monuments, hidden inside Athens' neighbourhoods.

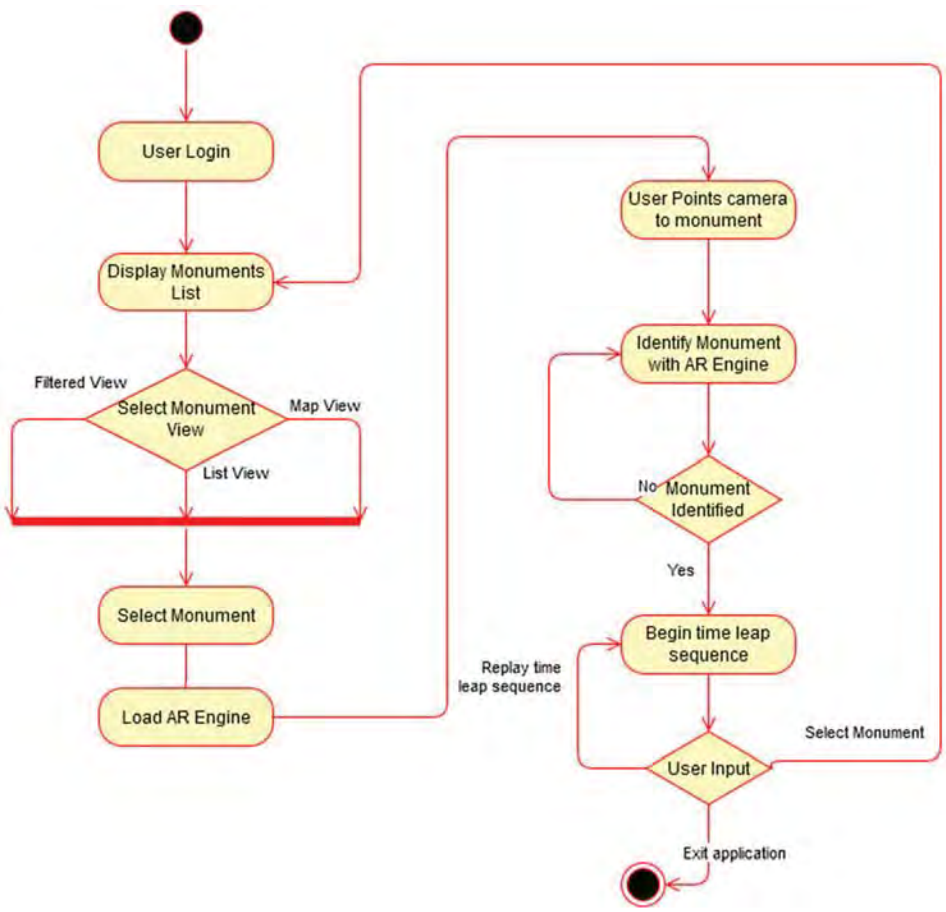

Figure 16: Basic activity diagram for user functionality for Open City Museum application

The high-level activity diagram of the Open City Museum application usage is described in Figure 16. After users log-in, they can select the monument that is closer to them. If needed, the application can suggest a scenic route to reach the monument. In case a user follows the suggested route, s/he will pass through other monuments as well since the routes that the application suggests are predefined and based on criteria like historical era and the current location. When users arrive at the monument's location, they just need to pick up their phone and point the camera to the monument. Once the monument is recognized, a time-leap experience starts (Figure 18). The time-leaps that a user can experience are timed to around 20 – 30 seconds so that the experience will not feel tiring. This project is an example of simple interactivity. A user needs to be inside a specific location and just turn a mobile phone in the direction of the historical monument in order to see a selection of premade content related to it.

Figure 17: Open City Museum, AR App, evaluation chart

Figure 18: Open City Museum variations of screenshots from the time-leap that a user experiences when visiting the monument of Lysicrates.

TIE Lab Doodle

TIE Lab Doodle is an application that allows any projection mapping façade to be turned into an interactive painting canvas. It uses a combination of a mobile and a desktop application in server-client architecture. The desktop application (server) is running on the computer that controls the projection mapping software. The mobile application (client) runs on an android phone or tablet and provides the functionality and tools to draw. With this combination of mobile application, desktop application and projection mapping software the user is able to interactively draw on any surface/façade. This project has high interactivity and engagement levels.

The pilot application took place in April 2019, in a public square at the Venetian old port of Chania (Figure 19). The immersive and engaging effects of the interactive software were tested in the context of an urban experiment (Figure 20). An open call resulted in a high participation of children of various ages. An 8-inch android tablet was given to the young participants and a TUC TIE Lab researcher instructed them on how to operate the application. Each child used the device for approximately 5 minutes.

The application adopted a coherent and user-friendly UI to address a broad age group of children and young adolescents. During the design phase of the application, usability was a big consideration. The same design principles were used as in the design of eShadow. [7] EShadow is a digital storytelling tool based on Greek traditional shadow theater and has been used by over a hundred schools in Greece. The children that participated in the experiment had no issues with using the application and were able to use all the features without any assistance.

One unexpected problem that occurred during this event was the unreliable wifi connectivity between the mobile and desktop applications. This became an issue since the experiment was conducted in an open public square, but was mitigated with the addition of a wi-fi hotspot near an open window in the building that housed the projection mapping equipment.

Figure 19: TIE Lab Doodle. Interactive Projection Mapping Installation.

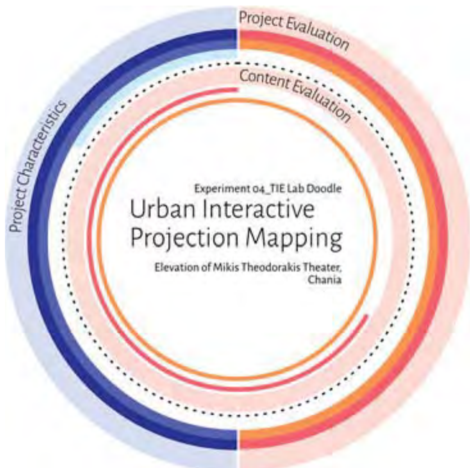

Figure 20: TIE Lab Doodle, Urban Projection Mapping evaluation chart

Theatrical performance 1 "SinEnoxi"

Designing visual content for Rupert Holmes' play "Accomplice" theatrical performance proved to be challenging. The script involved four different scenes that had to be designed from scratch along with the producers and the scenographer of the play. TUC TIE Lab researchers produced the appropriate background scenes that would complement the main action. The scenes were both pluralistic and literal, which means that the composition of the structural and visual elements was rich and bold. However, exaggerated and salient visual elements should not undervalue the main action in this type of theatrical performance. The introduction of an enhanced peripheral atmosphere should elevate the perceived value of the whole theatrical play and further engage the audience. In the end, a balance between the main action and the background visuals was achieved with the appropriate stage-lighting setup, contributing to the overall atmosphere (Figure 21).

Figure 21: Interior Projection Mapping. “SinEnoxi” Theatrical Performance.

There were four thematic scenes. The actual set was composed of white panels (stage left and stage right) and a white curtain behind the upstage, simplifying the projection mapping process. After the preparation of the first virtual sets, the adjustment sequence commenced. The light technician had been working along with the TUC TIE Lab researchers in order to define the optimal relationship between the stage lighting and the computer-generated visuals.
The interaction was limited to selecting the appropriate scene from a series of predefined sequences. Additionally, there was a scene containing interactive linear visual elements connected to an external microphone. These elements were activated during a scene when the protagonist was being “electrocuted”. The lines were reacting to his voice pitch and a flashing glitch -similar to TV static noise- background effect complemented the dramatic scene. User Experience Questionnaires (UEQs) were distributed to the attendants directly after the play (Figure 22). [8]

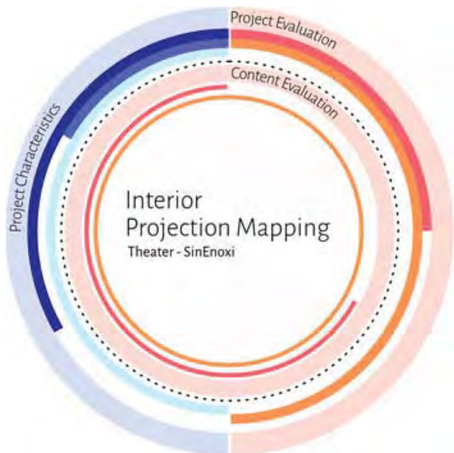

Figure 22: Interior Projection Mapping evaluation chart from the “Accomplice” play.

Theatrical performance 2 "Festen"

Festen was a stage adaptation based on the homonymous Danish black comedy-drama. The play premiered in July 2019, at the Mikis Theodorakis theater in Chania. Compared to the previous theatrical performance study, the projection study in Festen had a radically different purpose. The visual content on this occasion was abstract and focused on exalting the atmosphere and ambiance of specific scenes.

During the rehearsals, open-source code originating from Google experiments [9] was utilized in order to generate the interactive visual particles. The projection was adapted to the stage's back wall (upstage), behind the acting area which was composed of a large dining table with chairs. One specific intense scene required for peripheral visual elements, thus the roof panels above the arena of the theatre were mapped. A semi-transparent white curtain was employed as a projection surface on the rear upstage wall, offering a wider color gamut than the existing wall materials. Two large venue projectors were utilized for the experiment. An Epson PowerLite beamer with a maximum brightness of more than 5000 lumens was projecting on the white curtain and a Christie (6500 lumens max. brightness) with an ultra short-throw lens was used for the ceiling projection. (Figure 23Figure 24).

Figure 23: Interior Projection Mapping / Theatrical Performance "Festen".

Stage microphones were utilized in order to capture the actors' performance during the rehearsals since the "Google Experiments" code-generated particles were audio sensitive. The graphical visualization from the Google Experiment was then captured during the rehearsals. This way there was a limited risk of a failure related to the live playback of the experiment with the live audio-feed, during the play. This allowed for a high level of interactivity in combination with a minimized risk factor since authenticity was a very important aspect for maintaining the integrity of the live performance.

Our evaluation process was conducted for six theatrical plays. The participants were over 18 years old, with the average age being close to 40-years-old. The UEQs were administered to the attendants immediately after the play. The variables of Attention and Engagement were studied (Figure 24 and Table 4). Both plays (Accomplice and Festen), employed the same questionnaire structure.

Figure 24: “Festen”, Interior Projection Mapping evaluation chart

TUC STEM Day 2019 and Student Creativity Exhibition 2019

Last year the experiments that were held in the annual events for TUC STEM Day 2019 Student Creativity Exhibition 2019 were a combination of the theatrical performances described above and the TUC TIE Lab Doodle experiment. In more detail, the structure of the events consisted of 3 parts. One part was a black theatre performance from elementary school children, another part was projection mapping and the final part was live play that combined the body shadow of children with eShadow. During this event, the participating children could interact with the projection mapping installation by controlling the eShadow digital puppets. So this is an example of a high interactivity in a projection mapping installation. The analysis of the User Experience Questionnaires in those events revealed 60 positive or very positive responses and 12 negative or neutral ones. The total number of questionnaires that was gathered was 114, but not all of them had the open ended questions answered.

4 Conclusions

The addition of interactivity in projection mapping installations can significantly enhance the user engagement. The feedback that has been received through questionnaires and interviews surfaces a 73% positive feedback regarding the user interaction and engagement. The interactivity added in the projection mapping installations had different interaction levels. These levels range from low to medium and high.

Regarding the two theatrical performances, these had a low interactivity level, but from the audience reactions, the analysis of the questionnaires and the in-person feedback received, it seems that the addition of projection mapping enhanced the audience’s immersion and increased the impact of the theatrical performance. The projects with medium interactivity levels were the Open City Museum and the installations in the TUC STEM Day 2019 and the Student Creativity Exhibition 2019. Focusing on the last two, since the participation of the users was higher, the interactivity had a significant impact in the children's engagement. This was very clear from both the questionnaire results and from the enthusiasm that the participating children showed during the events.

The project that had the highest interactivity level is the TIE Lab Doodle and the children and grown-ups that played with it were very enthusiastic about the whole procedure. From the project’s development perspective, it was the most challenging one since it required a combination of technologies in order to achieve the end-result. In the future the team plans to extend the use of the TIE Lab Doodle application so that it can have better integrations and additional drawing features.

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04.102 - PASSIVE HUMAN-STRUCTURE INTERACTION EFFECTS IN FOOTBRIDGES

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Abstract

Footbridges can be susceptible to excessive levels of vibration due to pedestrian movements. Bystanders on a bridge can affect its dynamic properties (natural frequency and damping ratio) and response due to human-structure dynamic interactions. This study uses the results of tests conducted on two footbridges with a number of human subjects, in an attempt to validate the accuracy of a single-degree-of-freedom and two-degrees-of-freedom human models by using them to predict structural response and comparing them with their measured counterparts. The results show that the inclusion of the human models result in good prediction of the footbridge response. Therefore, the human dynamic models can be used to increase the accuracy of the response prediction when human-structure interactions are present.

Keywords

Footbridge Vibrations; Human-Structure Interactions; Simple Models; Computer Models; Excessive Vibrations

1 Introduction

Excessive vibrations of architectural structures such as buildings, footbridges, etc., can cause discomfort or annoyance of the users. It is, therefore, very important for the architects and engineers to have a reliable estimate of predicted vibrations of these structures at the design phase. Obviously, these vibrations become of importance after people occupy structures. However, presence of humans can affect their dynamic performance. Different models have been proposed by researches representing the dynamic properties of individuals or groups of people.

Pedersen and Hansen [1] considered the effects of the human-structure interaction (HSI) on floors using single-degree-of-freedom (SDOF) models to represent the humans and a specific mode of a floor to form a 2DOF dynamic model. The human parameters were assumed to be f_H (natural frequency) = 6 Hz and □$_H$ (damping ratio) = 20%. The results of this study showed that the presence of humans have different effects on the low and high frequency floors.

Sim et al. [2] developed a 2DOF crowd model using the individual human dynamic properties recommended by Wei and Griffin [3] and Matsumoto and Griffin [4] for the seated and standing individuals. They conducted an analytical study, which showed that passive crowd add mass and damping to the structure, resulting in a reduction in natural frequency and response compared to the empty structure.

Agu and Kasperski [5] conducted a probabilistic study to check how random scatter of individual human dynamic properties in a group can affect the natural frequency and damping ratio *(f and* ?*)* of the structure with a crowd. They concluded that due to the randomness of dynamic properties of human body, the mean values for individual human dynamic properties cannot be used for all cases to represent the human-structure dynamic interactions.

Zheng [6] developed a continuous model of a standing human body from the available natural frequency measurements of standing subjects by Matsumoto and Griffin [4]. By incorporating the available information in biomechanics and his interaction human body model, Zheng [6] identified parameters for a 2DOF human model to be f_1= 5.78 Hz and ξ_1= 36.9%, and f_2= 13.2 Hz and ξ_2= 44.5%. The identified damping ratio of the human body varied from 2.5% to 38.8%, and the mean damping ratio of the individuals were from 8.6% to 22.5%.

Even though footbridges are generally subjected to the moving loads from pedestrians, in larger such structures bystanders may be present who can interact with the structural vibrations and result in less movements. This paper considers two dynamic human models: single-degree-of-freedom (SDOF) and two-degrees-of-freedom (2DOF) to represent passive humans on two footbridges. The dynamic properties of these models were identified through a series of tests at the Virginia Tech Vibration Testing Laboratory, Blacksburg, Virginia, by the application of the Component Mode Synthesis (CMS) approach [7]. A number of human subjects stood motionless on two footbridges, while dynamic tests were conducted and footbridge dynamic responses were measured. Modal tests were also conducted on the structures without people. Using this data and the SDOF and 2DOF human models, the resonance frequency response function (FRF) and the associated resonance frequency were computed and compared with those from the measurements. The results confirmed the validity of the proposed human models to represent the presence of passive individuals on footbridges.

2 The Human Models

A SDOF and 2DOF models were used as shown in Figure 1.

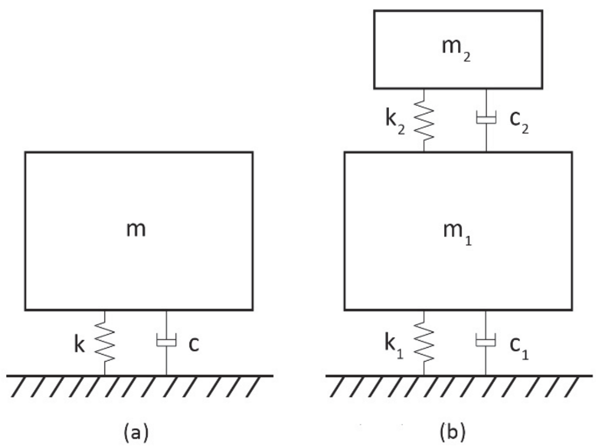

Figure 1. Human models used in this study: (a) SDOF model; (b) 2DOF model

In these models m, m_1, and m_2 represent the lumped human masses; k, k_1, and k_2 denote human stiffnesses; and c, c_1, and c_2 are the damping values from the human bodies.

From the results of a number of tests conducted at the Virginia Tech Vibration Testing Laboratory, the following non-dimensional dynamic parameters were identified for each human model in standing posture: SDOF model: f_H = human body natural frequency = 5.7 Hz; ζ_H= human body damping ratio = 25%; 2DOF model: μ = mass ratio (m_2/m_1) = 0.54; f_{H1} = human body first mode natural frequency = 5.4 Hz; f_{H2} = human body second mode natural frequency = 13.2 Hz; ζ_{H1} = human body first mode damping ratio = 45%; and ζ_{H2} = human body second mode damping ratio = 40%

3 Description of the Footbridges

Two footbridges, one located in Clifton Forge, Virginia, and the other in Blacksburg, Virginia, were used in this study. Figure 2 is a side view of the two structures.

(a) (b)

Figure 2. (a) Clifton Forge Footbridge; (b) Blacksburg Footbridge

3.1 Clifton Forge Footbridge

The architectural design and construction of this structure were conducted by a group of architecture students at Virginia Tech as part of a course requirement. The total bridge length, including a main span of 13.6m and a ramp of 11.2m, is 28.4m. Due to the fact that the footbridge was located in the 100-year floodplain, it was designed to resist the flood loads. The footbridge width is about 1.5m, and the deck is made of 19mm thick wood decking supported by 51mm x 171mm wood joists, which are nailed to 38mm x 152mm rim joists bolted to the main structural steel sections (W200x41.7, W200x35.9, and W150x29.8). More information on this structure can be found in Setareh et al. [8].

3.2 Blacksburg Footbridge

This footbridge connects a multi-story building to an adjacent parking structure in the center of the town of Blacksburg, Virginia. It is made of a steel structure consisting of trusses at 2.44m apart with a standard Pratt configuration. The total length of the footbridge is 35.6m and has a clear depth of 2.29m. All the truss members are made of Hollow-Structural Shapes (HSS) which are welded together. The truss panel points are 2.74m apart. The footbridge floor deck consists of a 20 gauge, 51mm thick form metal deck with 102mm of concrete topping (total thickness = 153mm).

4 Description of the Modal Tests

To estimate the dynamic properties of each footbridge, a series of modal tests and analyses were conducted. For this purpose, an electrodynamic shaker supported by a force plate was placed on each footbridge close to its quarter point to excite several modes of the structure. A roving accelerometer technique was used to collect the vibration data during each modal test. A burst chirp excitation was used for these tests.

Using ME'scope VES software [9], a modal analysis of the measured data for each structure was conducted. A local curve-fitting method enabled the extraction of the modal properties with small variations in the natural frequencies. For the Clifton Forge Footbridge, the main lower modes natural frequencies were 3.61 Hz (torsional mode) and 4.72 Hz (vertical bending mode). For the Blacksburg Footbridge the main identified natural frequencies were 4.08 Hz and 11.43 Hz. Both were vertical bending modes.

5 Description of the HSI Tests

To evaluate the effects of humans on the vibration properties of the footbridges, a number of tests with the help of groups of volunteers were conducted. For the Clifton Forge Footbridge sixteen human subjects (male and female) were used, and for the Blacksburg Footbridge up to thirty-seven volunteers (male and female) stood on the structure while an electrodynamic shaker generated burst chirp forcing excitations. See Figure 3. Due to the time constraints, only one HSI test was conducted on the Clifton Forge Footbridge. However, several HSI tests were performed on the Blacksburg Footbridge while 3, 15, 21, 27, and 37 people stood standstill on the structure during the tests.

(a) (b)

Figure 3. HSI Tests: (a) Clifton Forge Footbridge; (b) Blacksburg Footbridge

6 Computation of Footbridge Response Including HSI and Comparison with Measurements

Component Mode Synthesis (CMS) technique [7] was used to predict the response of the footbridges using their measured dynamic properties from the modal tests and the aforementioned human dynamic models.

Figure 4 shows the acceleration FRFs from the measurements without people and with people along with the predicted responses using the CMS and SDOF and 2DOF human models for the Clifton Forge Footbridge. From this figure, it is clear that the presence of people resulted in the total suppression of the second (bending) mode. This is clearly due to the HSI effects.

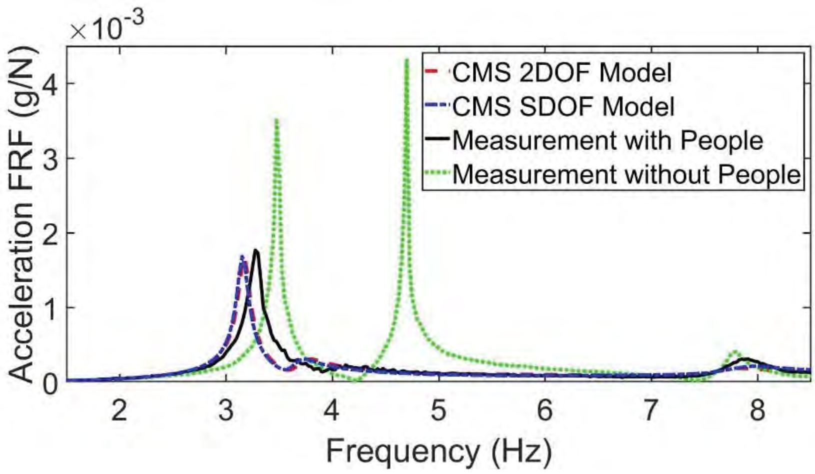

Figure 4. Comparison of the acceleration FRF for the Clifton Forge Footbridge without people, with people, CMS with SDOF human model, and CMS with 2DOF human model.

The measured resonance frequency with people was 3.275 Hz, while the predicted values using SDOF human model was 3.152 Hz, and using 2DOF human model was 3.177 Hz, resulting in an error of 3.8% and 3.0%, respectively. The predicted peak resonance FRF with the SDOF model was 4.8% and the same with 2DOF model was 5.3%.

Figures 5(a) and 5(b) show the acceleration FRFs from the measurements without people, with people, the predicted responses using the CMS and SDOF and 2DOF human models with 3 and 37 people, respectively, for the Blacksburg Footbridge.

Using the SDOF human model, the error in the predicted resonance frequency for the lowest mode was from -0.64% to +2.4% and for the FRF resonance amplitude was from -45% to +27%.

The error in the predicted resonance frequency for the lowest mode using the 2DOF human model was -0.64% to +4.2% and for the FRF resonance amplitude was -46% to +24%.

For the SDOF human model, the mean error in the predicted resonance frequency for all tested cases was -0.76% and for the resonance FRF amplitude was -5.5%. The range for the error in the resonance frequency was -25% to +2.4%, and for the resonance FRF amplitude was -124% to +29% (for all modes).

For the 2DOF human model, the mean error in the predicted resonance frequency for all tested cases was -0.2% and for the resonance FRF amplitude was -1.1%. The resonance frequency error range was -23.6% to +4.2%, and for the resonance FRF amplitude was -71% to +39% (for all modes).

These results show smaller mean errors in the footbridge resonance frequency and FRF resonance amplitudes when the 2DOF model was used.

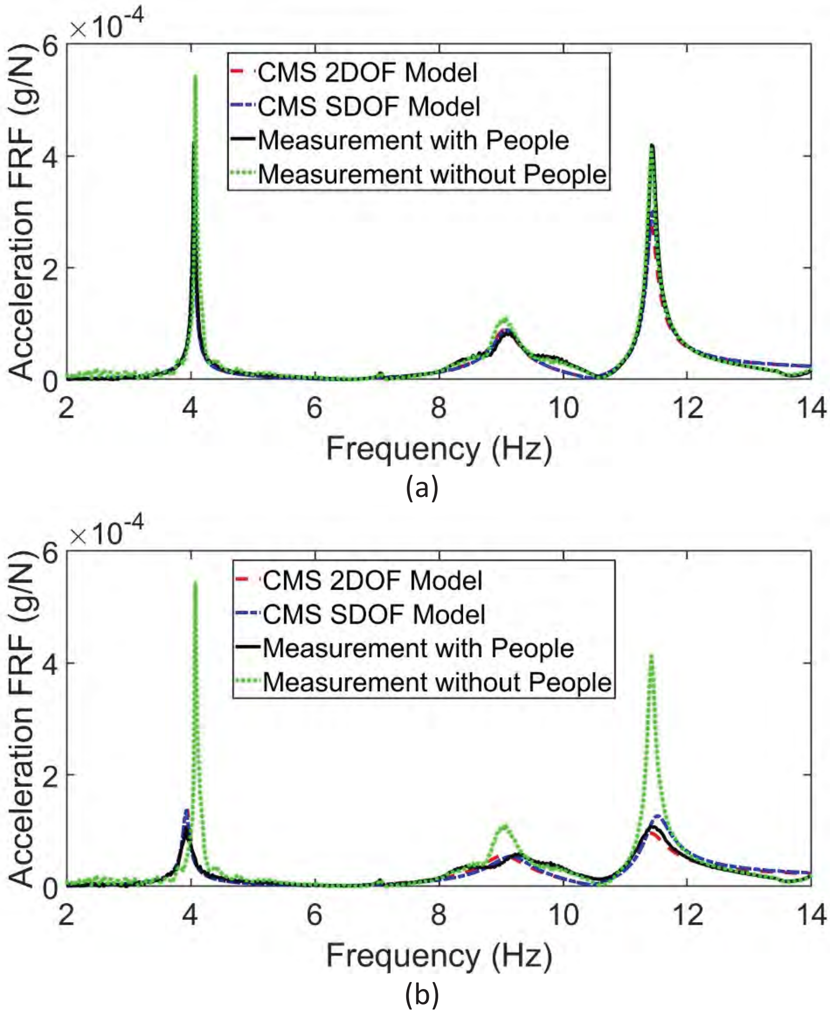

Figure 5. Comparison of the acceleration FRF for the Blacksburg Footbridge without people, with people, CMS with SDOF human model, and CMS with 2DOF human model: (a) 3 people; (b) 37 people

Figure 5(a) shows that when only a few people (3) were present on the footbridge, there was not much difference in the FRF response between the use of SDOF and 2DOF human models. However, when a larger group of people (37) was interacting with the floor [Figure 5(b)], the 2DOF model resulted in a more accurate prediction of the footbridge response.

7 Summary and Conclusions

Two simplified human models were used to predict the vibration responses of two footbridges using the results of modal tests on the structure. The predicted responses were compared to those from the measurements with a number of people standing still on the footbridges.

It was found that in most cases the use of the 2DOF human model resulted in footbridge response predictions that were closer to the measurements (less error in the predicted resonance frequencies and resonance FRF amplitudes).

Acknowledgements

The research presented here was supported by the National Science Foundation under grant number CMMI-1335004. This support is gratefully acknowledged. Any opinions, findings, and conclusions expressed in this paper are those of the writer and do not necessarily reflect the views of the National Science Foundation.

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TOPIC 5: BUILT ENVIRONMENT

05.101 -EVALUATION OF KOTA TANPA KUMUH PROGRAM CASE STUDY IN TEGALREJO

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Abstract

KOTAKU(*Kota Tanpa Kumuh,* Free Slums Area City) is Indonesian government national program to upgrade infrastructure development, social and economic education in society based livable settlement embodied support. This program has increased people life quality in multiple areas. One of them is Tegalrejo, a Yogyakarta subdistrict which is located on the riverbank of Winongo River. This research is intended to evaluate how success is KOTAKU's accomplishment in elevating quality of life in shantytown area.

This research is made up of descriptive-cualitative method by unstructed interview with local society who contribute in KOTAKU program in Tegalrejo. Infrastructure viability evaluation will include three main aspects : building, drainage processing and green open space procurement. Builiding evaluation objects are (1) regularity of dimension, orientation, and form, (2) population and region spatial structure program, (3) thermal, lighting, building material and sanitation quality evaluation based on building structure system standard. Drainage processing evaluation consist of (1) rainwater disposal, (2) odor comfort, (3) city's drainage system. Green open space evaluation will be focused on public open space and green open space existence in Tegalrejo.

Keywords

infrastructure, slums, evaluation, program, development.

1 Introduction

Indonesia government has implemented Kotaku Program(city without slums area) since 2016 to alleviate slums settlement particularly in urban area by creating system, facilitating local government and communities(based on Indonesian state law : PUPR Program Tanpa Kumuh, 2016). Kotaku Program was implemented in 34 provinces, 269 district and 11.067 villages by reducing slums settlement and its prevention as priority.
Beforehand, Indonesian government's attempt in slums settlement alleviating through Urban Poverty Prevention Program and National Urban Poverty Program still experiencing number of obstacle because it only uses social and economic aspect(Nurwino Wajib, 2019). However, since the Kotaku program began, the government started to jusxtapose social and economic aspects with infrastructure development. Furthermore, Kotaku Program applied the Tridaya concept that encompasses the environment, social and economy aspect which is expected to accelerate the handling of slums settlement in Indonesia.

This paper is evaluating one of Kotaku Program implemented region which is Kampung Tegalrejo located in Code Riverside, Yogyakarta, Indonesia. Code Riverside also known as Kali Code is slums settlement area located on Code River water side within condition that tend to worsen each year. This settlement area experiencing number of problem such as land use changes, population growth, and conomic development activities (Widodo B, 2010; Ribut Lupiyanto, 2010; Donan Wijaya, 2010). The government have done a lot of efforts to reduce slums settlement area to get livable settlement in accordance with Yogyakarta government development plan. This requires the government to suppress slums settlement area growth which will be continued by structuring and utilizing the environment with 'Slum Upgrading' (Paulus Bawole, 2016). Therefore, in order not to repeat the past problems, the government conducted the Kotaku Program in the Code riverside area (PUPR, 2016).
The focus of this paper is on a single aspect of the kampong Tegalrejo which is environment section that will be specified into three targets namely buildings, drainage treatment and procurement of green open space. The importance of contributing to the record of success in Kota Tanpa Kumuh programming, we undertook to research several evaluations: evaluation related to building construction includes: (1) regularity in dimensions, orientation and shape, (2) population density accordance with regional spatial planning provisions, (3) conformity to the technical requirements of structural systems, airing, lighting, sanitation and building materials. Evaluations related to drainage treatment that refer to 2007 Department of Public Works slum criteria include (1) rainwater drainage systems (2) odor comfort and (3) connectivity to urban drainage systems. And evaluation related to green open space is focused on the availability of land for green open space and public open space. All the several evalution will result on question: what degree of success was achieved through implementation?

2 Methods

The evaluation which is conducted in this study is a summative evaluation which is useful to provide information about the benefits and usability of the program at the end of the program. Research in evaluating the success of slum settlement structuring and rehabilitation programs is conducted with descriptive research that will explain and illustrate the process and results of the program based on the facts in the field and try to assess the success of the program based on obtained data.

3 Result

In general, conditions in the settlements that received assistance from the Kotaku Program includes slums neighborhood that occupy illegal land (squatter area). The rejuvenated settlement location is emphasized along the Code Riverside within *RW*(hamlet) 02 which is divided into 4 segments of the rejuvenation stage. The new rejuvenation phase is carried out in 2 stages namely in segment 1 and segment 2. Here is sort of slums settlement condition before rejuvenation of Kotaku Program in Karangwaru urban village area.

(Figure 1. Low-income housing area in sub district Karangwaru, Tegalrejo, Yogyakarta)

Condition of slum neighborhood slum before rejuvenation:

3.1 Open Space

The existence of open space in Karangwaru Riveside area was very limited and almost non-existent. Figure 1 shows that the riverside area is dominated by buildings.

3.2 Street Network

In Karangwaru area there were only environmental streets, which according to their width can be divided into:

(a) A width of 3-4 meters that can still be passed by small type 4 wheeled vehicles.
(b) Width of less than 2 meters (footpath) which dominated the buildings in Karangwaru.

3.3 Drainage Network

The drainage network in Karangwaru area, especially the slums housings utilized Code River as their final disposal outlet without any further prior control. Whereas in little further area from the river, the drainage network followed the pattern of streets and building to be streamed into the river.

3.4 Sanitation

Sanitation from settlement bathing, washing and toilet facilities on the riverside in Karangwaru Area didn't use any special treatment as final disposal, because it was directly discharged into the Code River. Meanwhile, settlements which are a little bit further from the river use onsite treatment such as septic tank.

3.5 Resident Building

Most Karangwaru community dwellings are made of wood with improper construction methods. This happened because of community's low knowlodge about building construction system and the community's economy which included the low income one. In order that they just built a residence carelessly.

Condition of slum neighborhood slum after rejuvenation

3.1 Open Space

The green open space provided in Karangwaru area such as greenery park and playground for children. The available open space is used by Karangwaru residents to do social interaction between communities. In this case, the community is actively involved in the green and communal open space development but the community's sense of responsibility for these facilities is still low and because of that, several green and communal facilities are found damaged.

(Figure 2 : Communal space as Karangwaru community interaction center)

3.2 Streets Network

Almost every street on Karangwaru Riverside area uses paving block pavement as material while several streets which is further from the riverside area uses aspalt as pavement material with 1-2 meters width. The condition of sloped streets leading to Code River form a circulation pattern and the buildings are following contour height. With limited land, Karangwaru residents who have houses with narrow access roads but have 2-wheeled vehicles are parking their stuff in wider locations or sufficient width roads.

(Figure: Karangwaru riverside street condition with paving block pavement)

3.3 Drainage Network

Karangwaru rainwater drainage is equipped with closed drainage system which is continued to the final drainage in Code River. However, at several points, drainage channels were found to be not smooth due to compression and shallowing. Certainly this strategy will reduce the capacity of water to drain rainwater which can cause open water overflow on the ground until it spread into lower land area.

3.4 Sanitation

In the area of case study, there are communal sanitation facilities for defecation and urination for public used. Communal sanitation facilities are served by providing bathing and toilet facilities. In this case, the community is actively involved in the facility implementation in order that the level of community responsibility for their facilities is quite high.

3.5 Building Evaluation

Buildings in study area have experienced an quite improvement after KOTAKU Program were being implemented, almost every buildings use strong and proper material and buildings construction in Karangwaru (89%) while other several buildings still use wood as material with unproper construction in riverside area (11%). Building density in riverside area is no longer exist due to Indonesian 3M ; munggah(climb up), mundur(backward) and madep(orientate). In order that, the terms of building regularity and orientation is quite good applied.

Environmental Infrastructure Condition Criteria

The assessment of housing and settlements in terms of infrastructure and environtment includes 3 criteria which are environmental sanitation level, odor comfort and the connection to urban drainage system. Based on the criteria for determination of slum areas by Indonesian Departement of Public Works (2007) Karangwaru has conditions such as :

1. Environment Sanitation (Rainwater Disposal System)

   Generally, the environment drainage quality in Karangwaru is a permanent canal, with fine condition is 83% so that the rainwater canals can work properly. Only several points of canal are founf clogged with garbage. However, canals that located at riverside area of Code are only an open excavation with drainage slope which is affected by the land contour. Due to that condition, the riverside canals work less effective in flowing water.

2. Odor Comfort

   The drainage system in the study area has good rainwater and household wastewater flow system (88%), in order that in study area there is no odorous wastewater.

3. Connections to urban drainage system

   For areas that have drainage that disposed the waste into urban drainage system while area without waste water drainage system will be absorbed directly by the soil or streamed to the river(located in the area near Code Riverside). From the condition of environmental sanitation, most of the population have acknowledged the importance of environmental health. This might be Karangwaru community’s old habit like streaming household water waste into the river (80%) change to stream it into the city canals. While the rest still stream the household water waste into the river (20%)

4 Conclusion

Conclusions from KOTAKU program implementation evaluation in Karangwaru,Tegalrejo, Yogyakarta include :

4.1 KOTAKU Program in Karangwaru riverside area of Yogyakarta is considered successful in achieving the stated program objectives, which is to become a better area without slum settlement. Therefore, KOTAKU Program in Karangwaru area is considered quite effective.

4.2 From the physical aspect, the KOTAKU program in the Karangwaru riverside area in general gives positive changes and considered successful in improving the physical condition of the settlement environment infrastructure better than before. This condition can be seen from the results of research that the conditions of environmental infrastructure of settlements such as road networks. Drainage, sanitation and public bathing, washing and toilet facilities, and open space as well as evaluations of house buildings increased significantly after KOTAKU Program.

4.3 From facilities and infrastructure aspect (according to slum areas criteria by Departement of Public Works, 2007) it can be concluded that the majority of existing environmental infrastructure conditions are included in category of light slums. The existence of residents who dispose household waste water in the river causes sedimentation and turbid color to the river.

4.5 From building evaluation aspect, one of the causes of the high level of settlement density in Karangwaru Village is the large number of migrant residents who live because of work location and presence of families who already live on the site. This causes the house to grow dense and irregular, buth with a fairly good condition of infrastructure. The social economic condition of the population, which is generally low income, causes the low motivation of the population to have a decent and healthy home.

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05.102 - 3D PRINTING FOR EARTHEN ARCHITECTURE

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Abstract

Today, the new dimension of Digital Fabrication in architecture offers a completely new scenario, including the 'Do It Yourself'. Machines and robots can increase the chances available to those who want to get involved in it. Several companies innovate production processes by connecting the traditional construction methods with new digital technologies. Young communities, in search of self-determination, feel the need to be personally involved in the regeneration and foundation of their living environment. Thus, the designer becomes a technical process consultant in the production and animator of the community that builds its own architecture. Through an applied case of a 3d printer used for earthen architecture in Syria, the FabLab POLIBA team of the Polytechnic of Bari proposes a new approach to lead the new urban and peri-urban communities to found again their own places of life.

Keywords

Earth material, 3d printing, Do It Yourself, Syria, architectural design.

1 Introduction

Raw earth and self-construction have always been closely linked. In fact, the practice of self-construction is historically connected to poor contexts, often characterized by a lack of building materials and their difficult provision. In such context, the use of earth as a building material, already present on the site of construction, is proposed as an ideal response to the need of shelters. The use of earth in self-construction is the result of a peculiar relationship between man and territory, that is man's need to take possession of nature that surrounds him, using manual skills as an appropriation tool. The use of raw earth has therefore emerged in various inhabited areas of our planet since forever. In Europe, the use of earth in construction has spread simultaneously to the first prehistoric settlements. Then, military conquests and trade throughout history have encouraged the spread of these techniques. The use of earth, as any other building material, is linked to the flourishing of a series of construction techniques. The main techniques, based on local differences in the earth composition, cultural preferences and other external influences, can be grouped into macro-categories. The first includes solid constructions of monolithic or in blocks, often load-bearing, made with plastic or dry earth, and with the optional addition of other materials (rammed earth, cob/bauge and earth bricks or blocks). The second category refers to mixed structures using an earth filling joined to a wooden framework. The third category consists of stone masonry bound with earth mortar. These are traditional building methods with different declinations from place to place, which can be substantially grouped in four families: Pisè, Adobe, Torchis and Bauge [1].

2 Contemporary experiences

Today, this material raises more interest than ever for its concern to the circular economy, to the reduction of energy consumption and, therefore, for its sustainability. The on-site availability of this material, in fact, reduces the waste of energy resulting from extraction and transport operations. Moreover, it does not require further transformation operations, such as firing, which is necessary for the construction of traditional bricks. Furthermore, the ease of dismantling and return into the environment is not of secondary importance. Buildings made of raw earth can easily return to nature without leaving residues and contamination. Raw earth is also interesting, as already said, because of its connection with 'Do It Yourself', both in the application of traditional techniques and for its affinity with the most innovative digital production techniques, applied to architecture. The aim of using this material and its techniques is the formation of new communities and their training. Quoting Otto Kapfinger's words about Martin Rauch's experience, in the attempt of "advancing the idea of building with earth so that is technically and logistically up to date, in the process empowering the majority of the world's population to turn this technique and use it to significantly improve their living conditions".

There are many significant experiences related to the use of raw earth combined with the 'Do It Yourself', today. Hassan Fathy's work in Luxor, Egypt, in 1946, is certainly of considerable interest. He was called to design and build the New Gourna district. His project, well-illustrated in his book *Architecture for the poor* [2], can be considered a cornerstone in the birth of a self-constructive tradition destined to characterize much of the most recent experiences. The former community of Old Gourna lived among the ruins of ancient pharaonic tombs in the Thebes valley, whose economy was based on the trading of archaeological evidences discovered on the site. The impoverishment of the site caused the Egyptian government to move the community to another area, assigning to Fathy the task of planning the move. He developed a strategy that involved the community itself in the construction of the new district, inspired by the typical Egyptian building and architecture tradition, with the typical use of raw earth as a building material. Central to this operation was the close collaboration between the architect and the community, who assisted him in drawing up a project suited to their needs and, above all, in the construction phase. The population, trained in the ancient Nubian building technique of vaults and raw brick walls, was able to erect their homes. The project of the village proposed and updated the traditional architectural typologies: courtyard houses, malqaf, masharbiya. The roofs, as mentioned, were dome-shaped with a parabolic generator, according to the Nubian technique. This type of vault was suitable for self-construction since it did not require the use of ribs. The resistance of these structures is ensured by the parabolic arch, which transfers the load directly onto the perimeter walls of the rooms, subjecting the bricks to the sole compression action. Furtherly, Fathy used raw bricks, lightened by adding considerable amounts of straw to the mixture. This technique both reduced the loads on the perimeter walls and helped to obtain lighter bricks that could be easily handled by everyone [3].

His experience has certainly paved the way to more recent experiments. The work of Martin Rauch in undoubtedly noteworthy. His approach to earthen construction was not born in the architectural field, but derives from his work as a ceramist, sculptor and kiln builder. In his architectural activity he has always shown great interest in the use of rammed earth, a process that does not involve the cladding through additional materials or the finishing of surfaces. The use of the pisé technique produces facades which, if not plastered, directly reveal their character. The construction with layers of earth simultaneously generates the ornament (figure 1).

Figure 25. An exterior surface detail of Boltshauser LehmhausRauch - photo by Beat Bühler

Rauch has begun to adapt the language of the traditional pisé technique to the standards, the technical and aesthetic requirements of contemporary architecture, highlighting the great potential of raw earth as a building material. For example, he managed to prevent the use of concrete to correct certain defects in the traditional pisé technique. The use of concrete, in fact, produces a significant reduction in raw earth essential qualities, as well as its recyclability, breathability and minimum entropy. For this purpose, he has worked on improving natural material mixtures, on optimizing the compaction process and the formwork, obtained through the project and testing of different designs. Among his innovations, moreover, there is the insertion of reinforcement layers able to improve the efficiency of the traditional technique without abandoning its fundamental principles. Rauch himself summarizes this double effort of innovation and preservation of the material natural properties with these words: "The envelope that surround us should be able to breathe and diffuse in the same way as our bodies. My buildings are therefore deliberately not encapsulated, sealed, or made smooth with synthetic or high-density, energy-intensive materials; rather, they are assembled and finished in raw form - left uncooked, like sushi! The entire building substance remains permeable, meaning that it is sufficiently resistant to the demands of usage and maintenance and minimally resistant to long-term degradation and the recycling process". His collaboration with international architectural firms, such as Herzog & de Meuron and Snøhetta, has led to several further innovations, resulted from the urge to adapt the technique to the demands of industrial production and to the logistical requirements of large-scale project management.

Rauch has created, to this purpose, a robot that can automatically deposit and mechanically compact the material in the formworks, of variable dimensions, up to a maximum of 80 cm in length and variable thickness. The compacted and demoulded pieces can be cut into smaller pieces. This new technology allows to meet the requirements of prefabrication and to simplify logistic operations, such as transport. It has been applied to projects such as Ricola Kräutenzentrum in Laufen and the visitor centre at the Swiss Ornithological Institute [4].

His collaboration with Anna Heringer marks a moment of extreme interest in the evolution of the use of raw earth material within 'Do It Yourself', in areas characterized by real difficulties, such as housing needs and community reconstruction. The challenge pursued by Anna Heriger is to demonstrate that the use of raw earth goes beyond the extreme economy that characterizes it. The use of this material is suitable for considerable innovations in terms of efficiency, performance, sustainability and aesthetics. In fact, earth is rich in nuances, which reflect and express cultural diversity. In the words of the Iranian-American architect Mohsen Mostafavi: "the limitations of a material's use, or mis-use, depend solely on our capacity to imagine alternative and unexpected means or incorporating it into the design process". The main difficulty encountered by Heringer in the affirmation of the earth construction was the distrust of the client / beneficiary of the work. Speaking about her experience in Rudrapur, Bangladesh, about the design and construction of the METI School (Figure 2), Anna Heringer reports how, for that people, earth architecture was linked to lack of means and poverty. This is clearly due to the cultural massification that has cleared the use of some hi-tech building systems, which have now become a symbol of efficiency and wealth. This idea can overshadow the potential of raw earth, sometimes already known to people who have already lived in architectures of this type. This potential does not only include the intrinsic properties of the material, though susceptible to innovation and perfectly in line with current expectations of sustainable living. What is less known is the possibility of creating work for both local construction workers and for inexperienced ones (figure 3). The implementation of these ideas has therefore been essential to the success of the project. The school was built by local workers, properly trained in construction techniques in earth mixed with straw, bamboo and coconut fibre ropes. This building, together with the DESI school for electrical training built in 2008 in the same campus, with the same materials and techniques used for the METI School, fully represents the combination of traditional construction methods and modern passive heating and cooling, lighting, ventilation and energy supply systems. Both systems were built with the full involvement of the local population [5].

Figure 26. METI School by Anna Heringer, photo by Kurt Hoerbst

Figure 27. local workers during the construction of the METI School by Anna Heringer, photo by Kurt Hoerbst

3 Raw earth and digital fabrication

Another feature that makes raw earth extremely topical is its affinity with some current digital manufacturing technologies and 3D printing. In fact, in proper mixtures, it is suited to be extruded, similarly to what happens with plastic materials in FDM printing technologies (Fused Deposition Modelling). The connection between 3D printing and raw earth seems to be so strong that it has been considered for some visionary Mars colonization programs. The use of earth as a material for 3D printing well responds to the need, identified by NASA's Langley Research, to exploit resources already present on the planet, so to avoid their import from Earth. In fact, 3d printing has already been tested on the International Space Station in 0-gravity environments, with excellent results and clear timesaving compared to that required for similar projects on our planet [6].

However, returning to what happens on our planet, the printing technologies used for the extrusion of material as raw earth or similar are mainly three: robotic arm, portal or gantry systems, and delta systems. In the first case, the material release is entrusted to an extruder installed on a robotic arm generally provided with six degrees of freedom. In gantry printers the material is extruded from a rotating head with one or more nozzles, attached to a gantry system with four degrees of freedom of movement. In the delta system, developed by the Italian company WASP, the extruder is supported by three arms and the position of the extruder itself depends on the arms simultaneous movement [7].

The last decade has brought different experiences of 3D printing applied to architecture. All over the world, more than sixty architectural modules have been built using the most different materials: various cements, biodegradable and non-biodegradable plastics, metals and natural materials. The first project of a large machine for printing cement dates to 1996, when Dr. Behrokh Khoshnevi developed the Contour Crafting, a gantry type technology, which has been further updated today. This technology involves the use of a mechanical arm capable of extruding the construction material layer by layer. According to the Contour Crafting, the extruded flow is bound horizontally and vertically for the finishing of the extruded volumes surface, using trowels with an adjustable orientation [8]. However, for the practical realization of a housing unit, we have to wait more than a decade. It was only in 2010, in fact, that the American company D-Shape, founded by the Italian engineer Enrico Dini, designed and built the first 3d printer in the world able to extrude cement, printing ‘Unacasatuttadunpezzo’ and the ‘Rodiolario Pavillon’. Their 3d printer was the gantry type.

In 2014, the new-born company ‘Winsun’ created a four-level building by quickly printing concrete blocks and assembling them on site. From 2016, the birth of prototypes and buildings printed in this way grows exponentially, together with research on printable building materials. The biggest growth in this period is recorded in America, Holland and China. The most active realities, whose activities achieve interesting results, are: ‘MX3D’, based in Amsterdam, which realizes the first printed metal bridge; ‘Dus Architects’, which realizes medium-small size buildings in biodegradable plastic; the research centre of the University of Eindhoven with the realization of a printed concrete bridge. The improvement of the products resistance represents one of the challenges related to the construction of buildings with additive manufacturing. In this direction, research experience has shown that it is also possible to use unalloyed materials, such as cement, for additive manufacturing processes. In this regard, in 2015 researchers at the ETH Zurich, Gramazio and Kohler created ‘Rock Print’, an architectural installation that use a machine capable of positioning a steel wire mesh by layer, through a nozzle, of randomly placing stones and compacting them inside the steel wire cage, in sequence. The result is an installation whose resistance is entrusted to the mutual collaboration between the joints randomly realized by the positioning of the stones and the non-rigid metal cage. The rewinding of the wire guarantees the total dismantling of the installation, which turns out to be a totally reversible intervention [9].

Among the Italian experiences, the activity of the company WASP s.r.l., based in the province of Ravenna, stands out without doubt. The company, since its birth in 2012, has strongly structured its research on the large-scale 3D printing of materials as clay, cement and raw earth, with the aim of creating zero-miles houses, using local and easily available materials. In 2015, the company launched its 'BigDelta', a 12 m high printer, for architectural scale printing, with which they built a 3 m high wall prototype. In 2016, they developed the 'Maker Economy Starter Kit', a container fully equipped for the design and creation of architectural scale objects. In 2018, the company launched the WASP Crane, a technology which reinterprets the classic traditional crane construction system and applies it to 3D printing. The 'Crane' printer consists of a support structure of trellis with a triangular-section, which identifies a printing area with a diameter of 6.3 m, on which the extruder arm can be mounted. The 'Crane' develops a modular construction system and is therefore repeatable in both 2d directions. Through this system the company has created the first house printed in raw earth: 'Gaia' (figure 4), a housing module made in just 10 days using zero-miles material.

Figure 28. A moment in the construction of 'Gaia' prototype developed and built by the Italian company WASP s.r.l.

The module has a surface area of about 30 square meters and has a wall section structured with canals, filled with rice husks, a material with good insulating qualities, easily available from the waste of the local rice production. The geometry defined by the wall section, characterized by a wavy outward outline to best use solar radiation, allows a better adhesion between the layers, avoiding the danger of break following the shrinkage of the material after the drying process. This helps to improve the mechanical strength qualities of the wall and gives rhythm to the external surface. The internal surface of the wall is covered with clay plaster and rice husk and contributes, together with the internal ducts system, to improve the climatic properties of the interior, resulting in an energy sustainability of the housing unit, which does not require other air conditioning devices. The foundations are also printed, with concrete. The roof is wooden, in response to the requirements of the current Italian regulations, and is supported by wooden uprights, positioned along the internal perimeter of the wall.

4 'Do it yourself', 3d printing with raw earth for the self-construction of young communities

FabLab Poliba, with its research group, aligns with these latest experiments and organizes an internship of technical training with WASP. The purpose is to obtain the necessary technological know-how for the realization of a research project on the themes of self-construction, within the framework of a scientific cooperation between the Polytechnic University of Bari and the Faculty of Architecture of the University of Damascus. The objective of the research is the proposal of a new settlement-building process that uses self-construction for a re-settlement in Syria, plagued by the destruction of the war since 2011, of a new community of young people, eager to return to their country once the conflict will be ceased. At the basis of the project there is the clear idea of self-construction, as an activity capable of creating communities, not only in a practical and physical way but also in a social and cultural sense. A society built through the direct use of forces and skills already present in the community, now more linked to a technological approach to everyday life than to a traditional one. In this sense, the implementation of traditional local building techniques [10], combining raw earth with the new additive manufacturing, seems desirable. The outcome is a self-constituting young community that chooses to invest in technologies, such as additive manufacturing, for the self-construction of its own habitat. It will autonomously manage technology choosing what to build, co-aided by designers who will no longer govern the process. They will lead, support and advise the community towards directions identified by the community itself. A designer similar, in short, to the "choral architect" desired by Carlo Ratti.

The research project aims at realizing a residential settlement linked to the cultivation of land in the suburbs of Aleppo. As for the construction technique, the project will start from the local architecture features and styles in order to innovate them so to meet the needs of the new community. Therefore, the project will shatter the traditional courtyard type, to make it more permeable, realizing paths and cultivations that are at the same time private and common spaces (figure 5-6).

Figure 29. Pre-visualization of the design hypothesis developed by FabLab Poliba research team

Figure 30. Pre-visualization of the design hypothesis developed by FabLab Poliba research team

About the choice of the most appropriate technology, the attention of the research group focused on a technology already developed by the WASP company, the 'Big Delta', capable of extruding clay mixtures. The 'Big Delta', as already mentioned, consists of a support structure with three uprights that holds an extruder, managed by three arms. It is theoretically infinitely repeatable on the plane to form a hexagonal grid. This gives maximum freedom in design and execution, with the only limit imposed by the maximum protrusion allowed by the extrusion process, an important detail since the entire structure of the living module will be made with raw earth. The answer to this limit is already present in the characteristics of the massive local architecture, whose roofs are vaulted. The project therefore proposes to use the technology to its extreme limit, taking back the traditional vaulted system and working on the theme of progressive protrusion.

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05.103 - TRANSFORMATIVE POTENTIAL OF HIGH SPEED RAIL IN RURAL CALIFORNIA

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Abstract

The new High Speed Rail project in California provides an essential opportunity to transform our chronically auto-dependent communities into sustainable, vibrant, compact, and pedestrian-oriented urban centers to prevent new suburban sprawl. Our Architectural Design studio at CCA looked at how current proposals for an HSR station in rural Gilroy, CA could achieve these goals while maximizing the project's sustainability benefits. Gilroy offered the closest rural location for our students.

Six teams of two and three students developed proposals for one of three different alignment options through the central Gilroy site. The teams were required to create expressively sustainable architecture to a Design Development level of detail, which included envelope details, thermal management, and energy production.

The projects revealed that elevating the HSR trackway structure above grade allowed for the best pedestrian connections to and through our specific site, including intermodal connections to buses. Due to the restricted size of the station site, the full benefits of the HSR investment cannot be realized without anticipating significant development on adjacent land parcels, which would likely require up-zoning and parcel aggregation, and would benefit from a detailed master plan. The station's sustainability goals could serve to set a high-standard for future adjacent development.

HSR planners and engineers should conduct a parallel urban planning examination to determine the optimal state of post-HSR development. Such a study should aim to bring the highest level of sustainability benefits to the communities served. Well-designed solutions can make a tremendous difference in creating a desirable pedestrian-oriented urban district in communities that have not had them since the prevalence of auto-oriented development.

Keywords

Transportation, Urbanism, Architecture, Education, Infrastructure

1 Introduction

California's legislature established the California High-Speed Rail Authority (CAHSRA) in 1996 to begin planning for a publicly-funded line connecting the state's population centers. In 2008, citizens approved $9 billion in bonds to partially fund the project's design and construction with a phase one target of connecting Los Angeles and San Francisco in two-hours and forty-minutes with 220 mile-per-hour trains. In 2015, ground was broken on what is currently the state's largest public works project. The initial operating segment of the California High-Speed

Rail (CAHSR) is expected to see trains in 2027, with the complete phase one opening as soon as two years later.[1]

The CaHSR project provides an essential opportunity to transform some of our auto-dependent communities into sustainable, vibrant, compact, and pedestrian-oriented urban centers, and to ensure that future growth creates less suburban sprawl. We built he 2017 High-Speed/Low-Speed design studio at the California College of the Arts to explore this potential through an urban-scaled design project that investigated options for a new high-speed rail station in Gilroy, California. The students were challenged to reconcile the the conflicts created by the juxtaposition of large-scale high-speed rail infrastructure with the more low-speed local improvements needed to create a humane and sustainable urbanism.

2 Setting

The ambitious and much-delayed CaHSR project is planned to transport passengers between San Francisco and Los Angeles by 2029. Current air and auto traffic between California's two largest cities are are a major source of carbon emissions that would be reduced with the introduction of this electrified rail service. The pollution benefits of CAHSR are often touted by project supporters, but the potential sustainability benefits to the smaller communities served by the line are less broadly understood. .

Many of the rural cities in California were established by railroad companies seeking to create customers and economic activity along the lines they had built on land they owned. These late-19th Century towns organically formed pedestrian-oriented business districts surrounded by housing, within a short walk to the railroad depot at the city's center. As rail usage was supplanted in the 20th Century by automobiles and trucks, these cities continued to grow, but followed the typical forms of auto-centered sprawl that characterizes much of America's built-landscape.

These cities continued to be centers for agricultural production and distribution, but in more recent years, California's housing crisis has led these areas to see a growth in so-called Super Commuters who choose to drive at least 90 minutes home from their jobs to gain access to affordable housing. According to one study, Bay Area Super Commuters increased 112.7% between 2005 and 2016.[2] As a result, the housing crisis can be seen to have driven auto-dependent sprawl in job-poor areas that had otherwise been productive agricultural land.

The environmental impacts of auto-dependent, low-density development in food-producing areas are widely understood.

Despite these obvious problems, the rural former railroad towns of California continue to have neglected, but walkable downtown areas with historic buildings and a reasonably-scaled grid of streets. It may not be feasible to sustainably transform the more distant portions of the suburban sprawl surrounding these cities, but with the addition of robust local transit network and active transportation enhancements, a significant area of these cities could be transitioned to a form of sustainable urbanism that is sought in larger cities.

3 Studio

Of CaHSR's fifteen Phase One stations, seven are in rural cites and towns, in areas associated with agriculture, and distant from California's primary job centers. For our architectural design

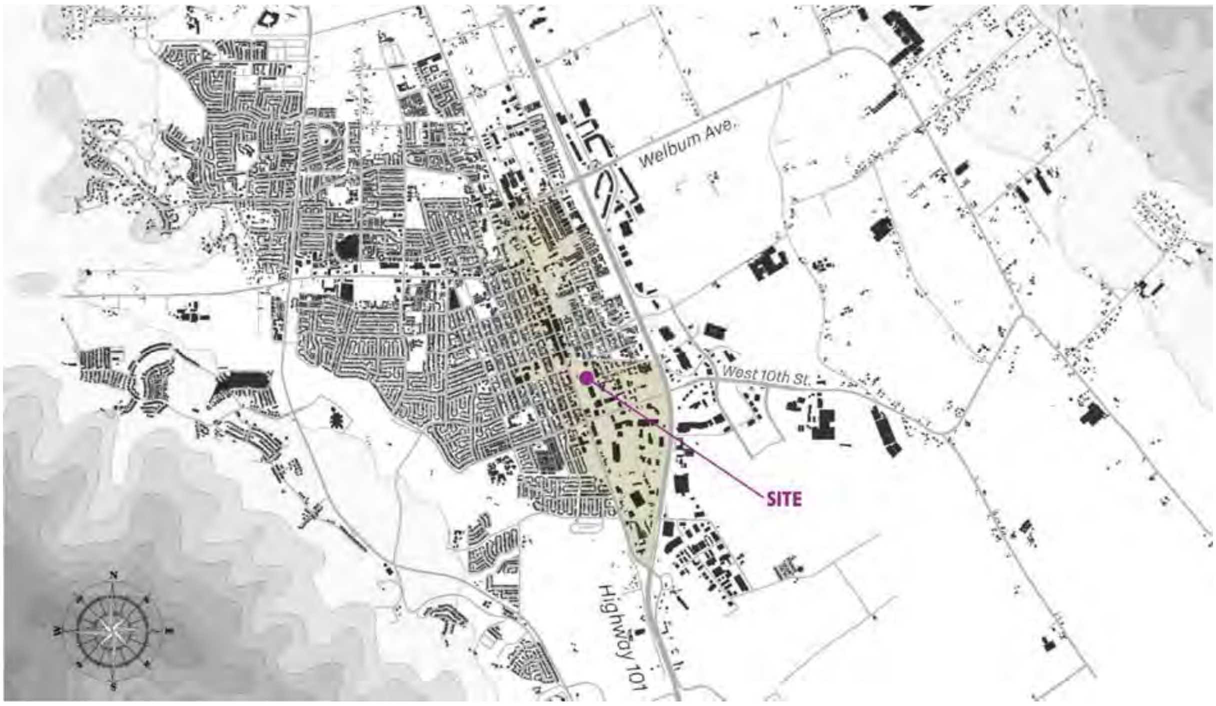

Figure 1. Gilroy Urban Form - Maya Annotti and Zachary Fish, CCA Architecture, 2017

studio, co-teachers Jeffrey Logan and Randolph Ruiz chose Gilroy, California as a case study to examine the planning assumptions of the California State High-Speed Rail Authority and to propose means by which the rail station itself could more aggressively promote a post-automobile urban form in rural California. Gilroy offered the closest rural location for our students.[Figure 1]

The proposed downtown site is a megablock, once the home to long-gone railroad freight facilities of which the town's early 20th Century Prairie-style railroad depot remains. The depot is used by buses and commuter trains to San Jose and San Francisco. The site's west side is bound by Gilroy's main commercial street, Monterey Road, with the historic downtown area located to the north along Monterey. Most of the site is vacant aside from the historic depot and its parking lot.

The scale of contemporary rail infrastructure is greatly at odds with the scale of humane urbanism. The forms and requirements of High-Speed Rail infrastructure are not readily compatible with the degraded early 20th Century small town urbanism of Gilroy and other similar cities slated for HSR stations. Poorly handled, HSR could further degrade these communities by creating out-of-scale barriers, additional automobile traffic, and sound pollution. While the potential sustainability benefits of the CAHSR project appear to be obvious, some plans call for the construction of greenfield stations with thousands of parking spaces, which would only exacerbate California's crippling auto-dependency.

In most rural station locations, passengers are expected to easily transfer between a variety of transport modes, each of which have large spatial requirements. The 2018 California State Rail Plan envisions clock-face pulse scheduling that would coordinate the times of connecting trains and buses.[3] For such a system to work, passenger transfer times between modes must be kept to a minimum. The large facilities needed for buses and connections to conventional rail modes must be immediately adjacent to the HSR station. This requirement tends to further isolate the station from the surrounding urban fabric.

Exacerbating the potential disconnection between station and town, current plans for CaHSR's rural stations call for acres of parking and anticipates a demand for 6,500 parking spaces at Gilroy.[4] As this program requirement appears to be misaligned with the larger goals and potential of the HSR project, our program called for 500 spaces of structured parking, designed to be convertible to office space. Other intermodal accommodations include vehicle drop-off lanes and a secure indoor bicycle parking facility.

The program for the studio project followed the guidelines established by CaHSR, but deviated from them in several ways. An important precept in transportation planning is the role of quarter-mile and half-mile walksheds in determining the areas in which people might be expected to to housing and jobs. Unfortunately, the massive footprint of a high-speed rail station and the necessarily adjacent intermodal transportation facilities occupy much of the valuable land within the station's quarter-mile walkshed. CaHSR's plans do not anticipate an intensive use of the station grounds, which will create long walks to the surrounding urban fabric. Our studio proposed to address this by including a range of appropriate amenities within the station facility. While a small amount of retail is included in CaHSR's current plans, our studio called for the integration of a wider range of station-compatible commercial and civic program elements to encourage a more vertical and urban approach to the station site.

Students reviewed the engineering guidelines and preliminary schemes produced for the CaHSR Authority, performed a brief urban analysis, and studied the construction technologies and aesthetics of major state-wide infrastructure projects from the modern era. Six teams of two developed proposals for one of three different alignment options through the central Gilroy site. The projects were iteratively refined to a Design Development level of detail, which included structural plans, envelope details, and sustainability strategies. The site chosen was one of two under consideration by the city and CAHSR Authority. It is impacted by an existing conventional railway at-grade with both freight and passenger trains.

Students worked in teams to develop a wide range of solutions to stitch their station proposals into the existing and anticipated urban fabric while using architectural forms and details that expressed the spirit and technology of California's modern history of infrastructural achievements.

Six teams of two and three members developed architectural proposals for the Gilroy high-speed rail station. Three alternate HSR alignments were explored with two teams designing for each of the alignment options. These options differed most the the HSR trackway. In one option, the trackway would be located completely below grade, adjacent to the existing conventional railroad right of way. In this solution, the conventional railway would remain in its current location bisecting the town of Gilroy with numerous street crossings-at-grade. The second solution places the HSR tracks on an elevated viaduct slightly east of the conventional railroad ROW, which would also remain in place at-grade. In the third option, both the existing railroad and the proposed HSR line would be built on an elevated fill through the town and across the site, and perpendicular streets would dip down slightly to pass beneath this structure.

Since the modern movement of the early 20th Century, many architects have been fascinated by expressions of speed and technology. The CAHSR project would seem to be an appropriate application for these interests. In addition to these traditional modern concerns, students were challenged to create architecturally expressive sustainability strategies so that this premier public works project could serve as an example to the community of these evolving technologies.

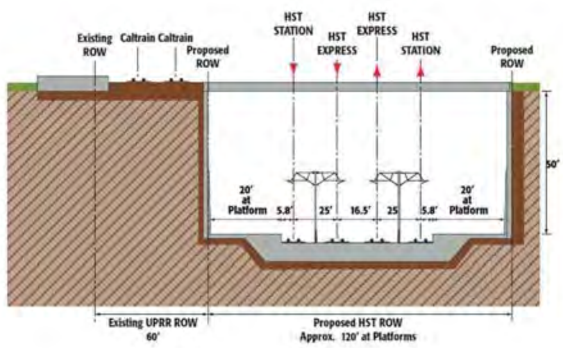

Figure 2. Trench Section - Downtown Gilroy Station Area Plan, OPPORTUNITIES AND CONSTRAINTS REPORT, PUBLIC REVIEW DRAFT 10.23.15 - PlaceWorks, 2015

3.1 Outcomes: Trench

Two teams developed a station for a below-grade trackway. While this solution potentially has the least impact on the eventual development of the site and surrounding community, it is also the most expensive and disruptive to build. The below-grade trackway prevents the HSR from becoming a visual barrier and limits the effects of train noise. Streets and some some development may pass over the right-of-way on bridges, which *could* allow Gilroy’s street grid to be reconnected where it has been interrupted by the railroad cutting across it. However, this strategy leaves the existing freight and passenger trains at grade and therefore does nothing to improve the current environmental and safety issues created by bisecting this small town with conventional trains at-grade.[Figure 2]

From an architectural perspective, sinking the HSR line below-grade deprives the railway of its visual symbolism, but leaves room at grade for bold architectural expressions, which may be necessary to re-establish a visual identity for the railway while serving as a way finding landmark. Both teams proposed signature architectural statements spanning above the trenched-right-of-way to assert the significance and presence of the HSR Station below. Leaving the existing railway at grade maintained an unsatisfying status-quo, and required cross-site pedestrian circulation to descend beneath the existing railway. This complicated access to the HSR platforms and mandated lengthy vertical circulation paths. Both teams ultimately determined that the best approach for pedestrian circulation was to cross the site on a wide concourse below the conventional railroad and above the HSR platforms. This solution made for poor connections to the amenity program elements above the station, which could only be reached via via additional vertical circulation elements that were not a part of the primary paths of circulation.

Students Abdullah Bakhyour and Nic Tanji designed a dynamic, wedge-shaped bridge structure spanning across the trackways with a station concourse slung below it within in the trench. They located the station mid-block to allow room for new urban development to envelop the station and its entry plazas. The western entry is oriented toward the existing historic downtown and included a dedicated entry for cyclists. The recessed HSR trench allows bridges to connect across the site from east to west, but the existing railroad right-of-way blocks safe crossings at-grade. To resolve this, they proposed a number of tunnels beneath the railroad and above the HSR line to assert a finer-grained network of pedestrian paths that could tie into Gilroy's interrupted street grid

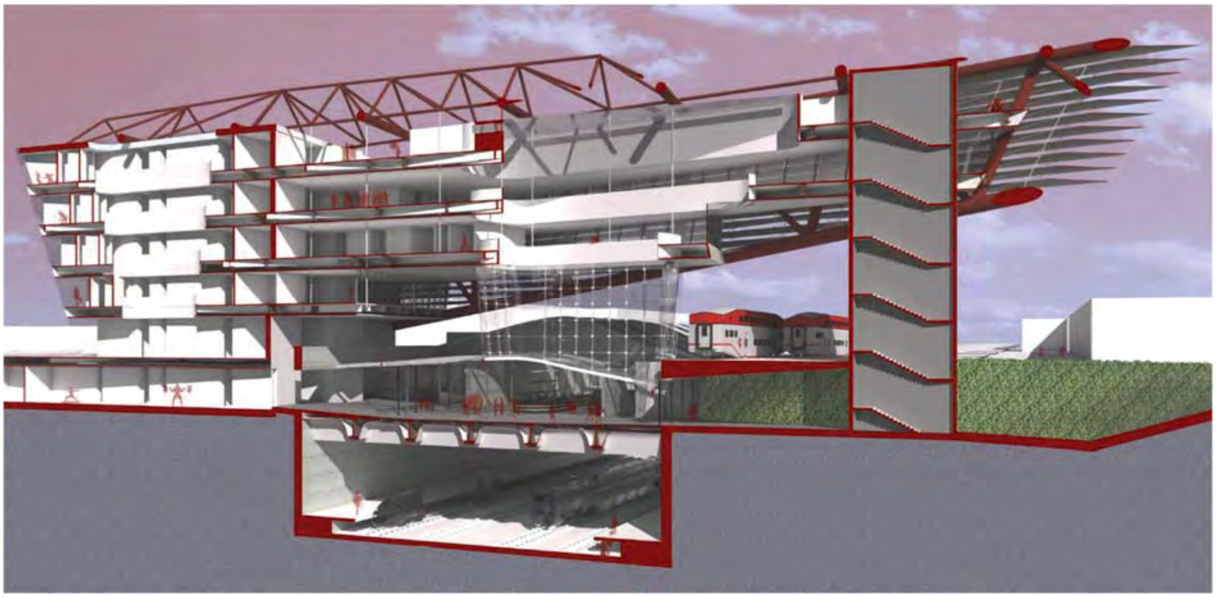

Figure 3. Section Perspective - Abdullah Bakhyour and Nic Tanji, CCA Architecture, 2017

Their project features passive solar shading louvers, daylighting strategies, stack-induced ventilation, rainwater collection, and photo-voltaic panels. The building's structure takes inspiration from railway-scaled steel bridges and features large-scale steel trusses in its facades.[Figure 3]

Students Hamzah Bassurah and Rajah Bose designed an urban-scaled courtyard station building that spans across the rail-trench. Abroad diagonal concourse cuts across the site from its most prominent corner at the start of Gilroy's historic downtown, to the intersection of 9th and Alexander. The station building sits closer to downtown on the northern end of the site, and its northwestern corner is eroded away to create an inviting gesture toward the direction from which most pedestrians would enter the site via the concourse. The courtyard serves to visually connect the bottom-most platform level up through to the amenity programs above. The rail trench itself would be covered with a linear park with apertures for daylighting.

The building is clad in an textured array of operable shading devices, and is raised above the concourse on tree-like steel columns to create sheltered outdoor areas and to allow daylight to enter the train platform area. Natural ventilation is enhanced by a prominent solar draft

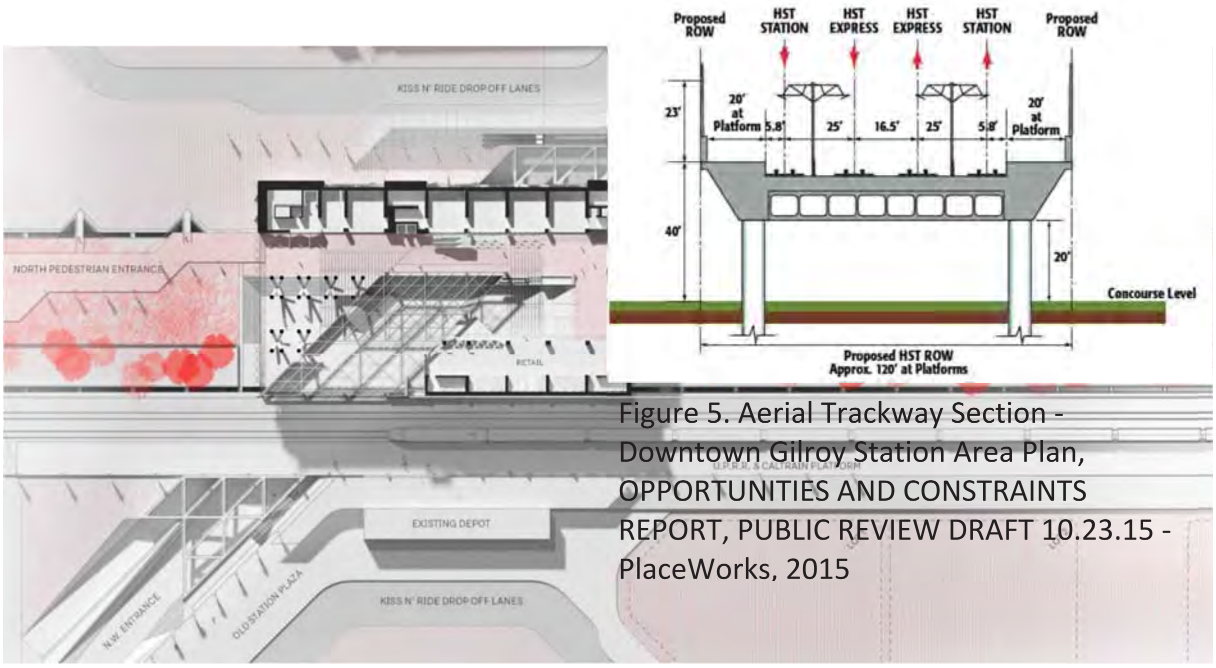

Figure 5. Aerial Trackway Section - Downtown Gilroy Station Area Plan, OPPORTUNITIES AND CONSTRAINTS REPORT, PUBLIC REVIEW DRAFT 10.23.15 - PlaceWorks, 2015

Figure 4. Site Plan - Hamzah Bassurah and Rajah Bose, CCA Architecture, 2017

stack and solar panels cover the roof. Plantings in the track-top park serve to buffer the existing railroad tracks and reduce noise.[Figure 4]

3.2. Outcomes: Aerial

A second set of proposals featured an elevated HSR viaduct to the east of the existing conventional railway, which was again left in-situ. The elevated HSR line allows pedestrian-circulation to pass over the existing railway and under the HSR line and would still require a fair amount of vertical circulation. Requiring two separate rail alignments across the site requires a larger footprint but still allows for unique placemaking opportunities.Due to the requirement to grade-separate the HSR tracks, this strategy is the most cost-effective alternative for building the line through Gilroy.

While the elevated tracks easily allow surface-based circulation to proceed un-hindered, some may argue the aerial viaduct would be an unattractive and even overwhelming physical presence. This solution would also produce some noise pollution. Given Gilroy's current low-rise character, the elevated viaduct may feel out of scale with the rest of the city. As previously illustrated in CAHSRA documents, the aerial alignment is located further away from the existing conventional railway. As a result, this scheme requires a longer distance for train-to-train transfers.[Figure 5]

The design by students Ephrata Deneke, Jennifer Gonzalez, and Stephen Sanford proposes a cathedral-like structure of branching columns inspired by trees and 19th Century trainsheds. Their proposal is located toward the north side of the site to better connect to the historic downtown and establish a presence at the site's most prominent corner at Monterey and Old Gilroy.

The light-filled space of the concourse sits atop a vaulted concrete platform containing some of the amenity and service programs. All of the amenity program was easily accessed from the project's elevated circulatory spine. A similar branching roof on top of concrete vault system is proposed to support the HSR tracks and platform canopies running perpendicular to the

Figure 7. Interior Perspective - Tracy Nguyen and Tetiana Muraviova, CCA Architecture,

Figure 6. Perspective - Ephrata Deneke, Jennifer Gonzalez, and Stephen Sanford, CCA Architecture. 2017

station concourse. Their design features passive solar shading, natural ventilation, thermal mass, photovoltaics, natural daylighting, and rain water collection.

Students Tracy Nguyen and Tetiana Muraviova created another aerial alignment solution. Located near the north end of the site, their project features two sinuous diagonal pathways that form a large 'X' in plan, connecting the opposite corners of the site. The first of these pathways forms the station building itself; an organic, snaking structure that starts near the downtown-adjacent site corner, passes over the existing railway, passes beneath the HSR viaduct and descends to grade level at Alexander Street near 9th. The second pathway is in the form of a broad elevated park-like environment that crosses the site and building to form the opposite diagonal. As such, their project was intended to stitch the surrounding site together via these mostly stair-free pathways that create shortcuts through the site's megablock while passing through the station's facilities and amenities. The remainder of the site to the south would be left open for development.

This design used curved glue-laminated beams to form structural ribs. Variations in the rib profiles creates a constantly changing section through the project. Sustainability strategies

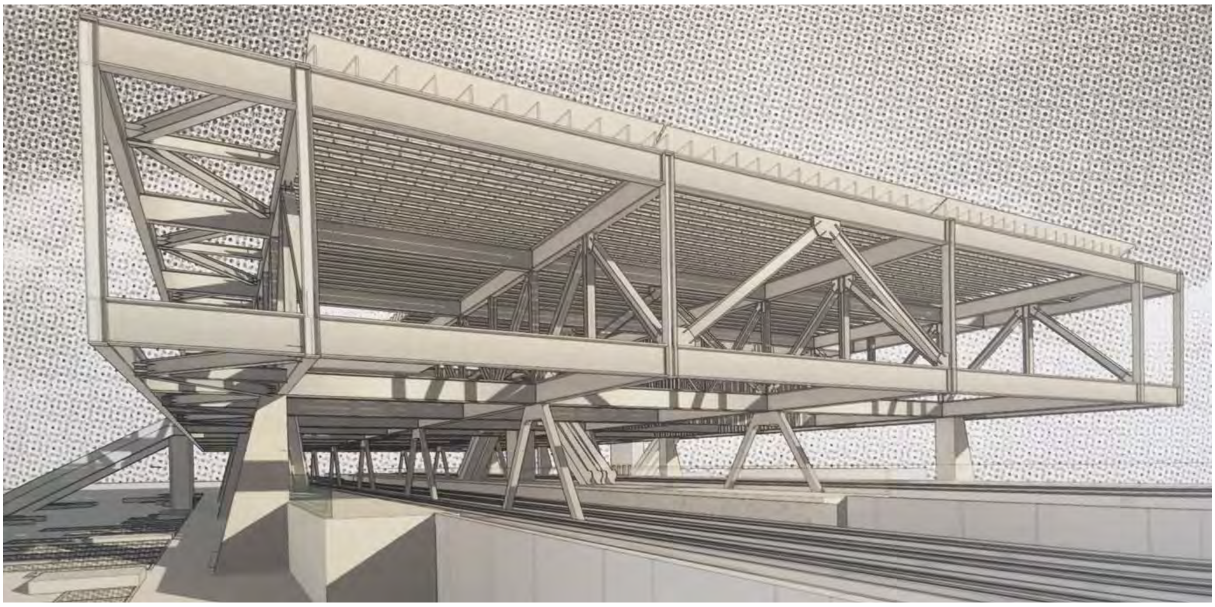

Figure 9. Perspective - Jaime Jung and Adan Rios, CCA Architecture, 2017

included natural cross ventilation, photovoltaics, timber construction, and rainwater collection.[Figure 7]

3.3.Outcomes: Causeway

The third set of designs placed both the existing railway and the HSR on a low fill across the site. Grade separating both railways offers better opportunities for circulation beneath the rail lines while still allowing for the possibility of developing building space above the trackways. While not the most economical option, this solution is less expensive than the rail trench and preserves more space for other forms of development. Grade separating both rail lines together offers advantages for both urban and site circulation, but the causeway would create a visual and physical barrier through the center of town while producing the same noise impacts as the aerial alignment. Another drawback of this scheme stems from the length of the underpass needed to cross beneath the tracks and platforms. A 200-plus-foot long pedestrian tunnel poses a challenge to designers hoping to create a space that is pleasant and safe.[Figure 8]

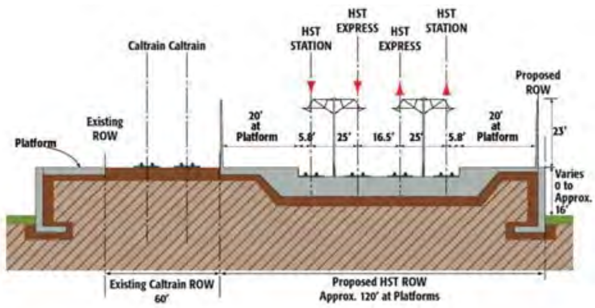

Figure 8. Causeway Section - Downtown Gilroy Station Area Plan, OPPORTUNITIES AND CONSTRAINTS REPORT, PUBLIC REVIEW DRAFT 10.23.15 - PlaceWorks

Students Jaime Jung and Adan Rios produced a design featuring a large open-frame megastructure spanning the both elevated trackways for 800-feet length of the HSR platforms. This armature served as a massive train shed, while containing and supporting all of the program elements of the station and its amenities in a combination of outdoor platforms and enclosed box-like volumes. A large, at-grade, accessible public pathway passes beneath the tracks, but most of the site's cross circulation requires ascending up into the megastructure via escalators and elevators, from which visitors could walk to adjacent developments via a network of pedestrian bridges.

In response to Gilroy's hot and sunny summer weather, the top of the megastructure is covered with acres of open photovoltaic arrays designed to allow natural air circulation, while shading the outdoor program elements below.

While not structurally efficient, this scheme asserts a bold image for Gilroy's HSR station while leaving large areas of the site open to future development.[Figure 9]

Students Maya Annotti and Zachary Fish placed all of the program elements in conventionally-built "headhouse" structures that flank the elevated causeway to the west and east. These headhouses form triangular courtyards oriented to embrace visitors arriving from either side of the site. These buildings are connected by a public circulation path below the tracks and by an overhead bridge providing passenger access to the train platforms.[Figure 10]

An elaborate undulating steel, glass, and photovoltaic canopy spans above, serving as an updated homage to 19th Century iron and glass train sheds. The canopy uses glazing with integrated solar cells along with a water collection system. The students calculated this roof

Figure 10. Perspective - Maya Annotti and Zachary Fish, CCA Architecture, 2017

would collect 4.5 million gallons of water during a year of average rainfall. This project was located toward the south end of the site, leaving the north end open to development.

3 Lessons

The projects described allowed our students to explore the functional and feasibility issues associated with each of the three alignments under consideration at that time. While the end results may not have reached the standards of experienced professionals, the work was able to tease out the various advantages and disadvantages of each approach. A key measure of success was whether the students could develop efficient circulation systems that connected transfer passengers between transportation modes, local passengers to the surrounding city, and citizens through and across the project site. The requirement that tracks and pedestrian paths be grade-separated establishes that any viable circulation solution would rely heavily upon vertical circulation. Minimizing the inconvenience, capacity limitations, and expense of the vertical circulation elements will be essential for a Gilroy CAHSR station to be measured a success.

It may be a mistake to grade separate the HSR line while leaving the conventional railroad in-situ. Conventional heavy railroad operations are increasingly incompatible with the at-grade crossings of small towns such as Gilroy. The danger and inconvenience posed by these conditions should be eliminated.Elevating both the HSR trackway structure and the existing conventional railway above-grade likely allowed for the best pedestrian connections to and through the site, including the intermodal connections to buses.

In the trench schemes, the depth of the trench needs to accommodate the HSR trains with overhead catenary system, the concourse and its structure, and the structure needed to support the passage of the conventional railway over the concourse. Combined, these elements require a vertical separation of at least fifty-feet between the HSR platforms and the other modes of transportation. The length of time required to transfer between modes should itself be disqualifying despite the other benefits to the city; benefits that are not fully-realized if the conventional railway is left in-place. Accessing railways from above requires more vertical separation than when accessing them from below, because the required vertical clearances are much higher for electric trains at 27 feet, versus ~10 feet for people in an underpass.

The aerial alignment scheme work by placing the concourse below the HSR station and above the buses and conventional railway platform. Splitting the differences in the hight of these modes mitigates the vertical circulation problems of the trench approach, while creating a reasonably feasible cross-site circulation path for the general public. That said, the concourse still needs to clear the conventional railway tracks by at least 22 feet. Elevating the conventional railway through the site would allow all of the concourse functions in these schemes to take place at grade, increasing accessibility and providing construction cost benefits.

The causeway solution is the only one of the three to propose both rail alignments through downtown Gilroy. This alone gives this scheme a great advantage. Accessing the track platforms from below minimizes the required vertical circulation and is probably the most efficient way to transfer between trains. It would be a further improvement upon this scheme to locate the bus platforms below the railway platforms. Both causeway teams opted not to use the underpass as the prime circulation path as they imagined the long, low-ceiling concourse as an inherently uninspiring space. In addition to this drawback, the elevated causeway creates a visual and physical barrier through much of downtown and the elevated trains create noise impacts. All of these issues could be mitigated to some reasonable degree by building frequent underpasses at every cross street, lining the railway right-of-ways with large commercial buildings to enclose and hide the railway, installing sound barriers, carefully designing the underpasses, and adding extra space between tracks to allow for natural daylighting strategies within the underpasses. There are a number of examples European and Japanese rail viaducts that have been successfully mitigated and integrated into a vibrant urban fabric.

Due to the restricted size of the station site, the full benefits of the HSR investment cannot be realized without anticipating significant development on adjacent land parcels, which would likely require up-zoning and parcel aggregation. A detailed master plan would help determine the best feasible outcomes for Gilroy’s community and the HSR station.

The curricular requirements of our course as well as the limitations of one semester curtailed the scope of the urban investigation that our class was able to pursue. While the resulting proposals anticipated ways in which the remaining site and urban context could grow, each scheme would have benefited from a greater effort devoted to creating a coherent vision for the urban design of the site and its surroundings.

HSR planners should not develop specific trackway and station designs without conducting a parallel urban planning examination to determine the optimal state of post-HSR development. Such a study should aim to bring the highest level of sustainability benefits to the communities served while also maximizing the value to all of the state's taxpayers through increased economic activity, social equity, and environmental sustainability. Well-designed solutions can make a tremendous difference in creating a desirable pedestrian-oriented urban district in communities that have not had them since the prevalence of auto-oriented development.

Acknowledgements

The author gratefully acknowledges the California College of the Arts, my co-teacher Jeffery Logan, our guest critics, and of course, our students, who created all of the work described above.

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TOPIC 6: URBAN ECOLOGY AND CLIMATE

06.101 - PATHER PANCHALI: DIVERSITY AND INCLUSION IN DESIGNING SIDEWALKS IN DHAKA, BANGLADESH

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Abstract

The rapid urbanization, accelerated mobilities, and burgeoning growth in the informal economy have generated an urgency in rethinking the sidewalks of Dhaka city as one of the most dynamic elements of urban street life. Sidewalks in Dhaka, being a non-privatized, tax-free urban space, have always provided many informal workers access to the city's growing economy. The temporal changes of activities on the sidewalks have not only enriched Dhaka's unique cultural life but also supported the co-existence of different economic classes in a competitive capitalist urban setting. However, to avoid increasing traffic congestions and to achieve a global city aesthetic, recent infrastructural city development interventions are focusing on transforming the sidewalks only as a street component for uninterrupted pedestrian movement. Such functionally linear thinking around sidewalks has resulted in wider roads, narrower sidewalks, evictions of street vendors and other service providers, and hence, economic and cultural marginalization of the city's significant portion of the informal workforce. This paper documents the stories (*Pather Panchali* means stories of the streets) from five dynamic sidewalks at five different areas of Dhaka city to make such marginalization spatially visible and provides alternative frameworks for the future development of diverse and inclusive sidewalks.

Keywords

Sidewalks, Transformation, Informal Workforce, Urban Street, Development.

1 Introduction

The infrastructure of the cities in the Indian sub-continent has developed centering a more pedestrian-oriented mobility pattern (Gehl and Gemzoe, 2003). These mobilities have always been accompanied by different cultural activities ranging from selling daily groceries to services like mobile phone balance recharge, shoe cleaning, hairdressing, umbrella repairing, etc. The colonization of the sub-continent and the beginning of the industrial revolution had initiated the idolization of the western philosophy of city planning (Robinson, 2002). In this era, "the phenomenon of universalization, while being an advancement of mankind at the same time constitutes a sort of subtle destruction, not only of traditional cultures, which might not be an irreparable wrong but also of what I shall call for the time being the creative nucleus of great civilization and great cultures" (Frampton, 1983:147). Much of the urban growth is now taking place in the developing world rather than the developed world but still, theories of city planning remain rooted in the developed world (Roy, 2005). Cities in developing are still being built on the conceptualized model of the Western world. Dhaka city is not free from this phenomenon.

In the journey of four hundred years, Dhaka has transformed from a small trading town to a Megacity. The gradual development process of Dhaka as a traffic-congested and pedestrian-unfriendly city can be traced back to the time it started to become a car-oriented “modern” city. There is a stark difference between the urban fabric of old and new Dhaka, later of which has not yet been successful to accommodate its millions of people.

In context of cities like Dhaka, public spaces are an important urban feature and sidewalks are incredibly malleable public spaces, where informal workers, like street vendors, waste pickers, beggars, rickshaw pullers, CNG drivers get an access to participate in the city’s economy (Country report by Bangladesh Bureau of Statistics, 2012). Hence, sidewalks (defined or undefined) in Dhaka are the places, where pedestrian mobilities have always been accompanied by a range of socio-economic activities. However, with the growth of Dhaka’s traffic, the urgency of widening the streets by narrowing the sidewalks, gradually “criminalized” such socio-economic activities. Being inspired by the developed cities from the west, the recent design and developments of sidewalks in Dhaka express great negligence toward these social and cultural parameters that have always been an integral part of Dhaka’s city life (Husain, Yasmin, and Islam. 2015)

This paper investigates such exclusions of social-cultural context from Dhaka’s sidewalks. Based on a three months long fieldwork at 5 sidewalks at 5 different areas in Dhaka city this paper documents those scenarios/stories of the sidewalks that can hardly reach urban designer’s table while making decisions around urban development. This paper argues that incorporating a more empathetic and localized approach to spatial planning at an urban level requires a thorough understanding of a specific region, locality and critical analysis of climatic and cultural sustainability.

2 Background

Sidewalks are physical as well as cultural legacies of a city. These places also act as inclusive public spaces in the context of urban settings. So, understanding these spaces requires an understanding of the city’s heritage and context. The historical shreds of evidence help us to understand the relationship between these public spaces and society. Public spaces in this subcontinent has a long thread of evolution. A climate that facilitates barefoot walking and shadows of trees turned towards universal development followed by colonial rule and industrial development. As the western standards of development are now rethinking how to create a more humane and accessible city (Dear, 2002), it might be the time we review our growth to satisfy sustainability aspects.

Figure 1: Fresh fish selling, processing (left) and burgaining at a vegetable cart is going on (right) by the roadside.

Kahn (1995) writes that the paradigm of 'sustainable development' described in Agenda 21, rests on three conceptual pillars. These pillars are 'economic sustainability', 'social sustainability', and 'environmental sustainability'. Economic sustainability, by way of growth, development, and productivity, has guided conventional development in the past. While on the other hand 'Social sustainability' consists of notions like equity, empowerment, accessibility, participation, sharing, cultural identity, and institutional stability. It seeks to preserve the environment through economic growth and poverty alleviation. The theoretical framework proposed by Kahn suggests that economic, social and environmental sustainability should be integrated and interlinked. This suggestion of Kahn, as we already know, is applicable in every design sector. However, the political economy of urban development in a developing context of the Global South often devaluate such notion of integrating socio-economic parameters into design decisions while following the codes of world-class city aesthetics (Ghertner, 2011).

For example, one of the important features of the public spaces, roads, and sidewalks in Asian countries are the street vendors (Bhowmik, 2005). This informal work sector is one of the key attributes of these spaces. Just as these public spaces are more vibrant with these informal workers, in a mutual way, this informal sector relies largely on these public spaces, especially the sidewalks. Evidences show that exclusionary practices by cities towards the urban informal workforce represent a no-win response to the policy challenge. Without recognizing and supporting the livelihoods of the urban informal workforce, cities cannot reduce poverty and inequality or reach their full productive potential. However, the borrowed notions of urban development from the West often side-lines this huge workforce and produce urban spatial design vocabularies that do not respond toward the city's economic dependency on the informal workforce (Kim, 2015). As a result, now and then, developing cities experience random evictions and forced displacements (Ahmed, Nusrat, and Jackson, 2015). Sidewalks of Dhaka city are not exceptions. While street vendors are an integral part of the Dhaka city's street culture, the new phase of urban development is gradually "getting rid" of this huge workforce. In the companion report on public space and informal livelihoods, Chen et al. (2018) summarizes Bromley's (2000) overview of common policy arguments for and against street vendors. Arguments against street vendors contend that they contribute to congestion, crime and grime, unsightliness, public health risk, tax evasion, substandard goods and services. But common negative perceptions of vendors ignore the many services that vendors do provide. Vendors play a variety of roles in urban systems that contribute to local economies, livability, equity, and safety.

The city of Dhaka has grown in a more or less spontaneous way over the span four hundred years history- the medieval trading town of Dhaka has extended from one square mile in 1600 AD to a large conurbation [Statistical Metropolitan area of Dhaka City, DSMA] of 522.34 square miles in 1991. Here in Dhaka, two dominant urban patterns are conspicuous within the successive stages of growth; they are the historical core or 'old Dhaka' and the later development towards the north, known as 'new Dhaka'. Besides, a few planned additions are also featured in this city. Nilufar (2010) identifies that four major spatial patterns are co-existent in Dhaka; they are indigenous and informal developments; colonial and planned interventions. “The 400 years’ history of Dhaka shows that the city has grown and enlarged to a significant scale. It is evident that the basic idea comes from the indigenous structure of the medieval city, but the spatial enlargement gives a vision of the new world. In spite of a small amount of planning, the organic morphology dominates the global structure of the city.” (Nilufar, 2010). Though the old Dhaka has grown within a more spontaneous way where the roads were mainly built in a pedestrian-oriented way and around the local businesses, in designing the new parts of the city, the local and cultural contexts were mostly overlooked.

In this paper, an attempt to draw an inclusive approach to managing sidewalk spaces that houses the livelihood activities and needs of the vendors has been made. The paper tries to bring attention to the locating and measuring activities such as sidewalk vending rather than just leaving it to a vague intuition. While there may be a debate whether to eradicate this sidewalk life or not, this research advocates on behalf of this social-spatial phenomena to be inclusive in designing sidewalks (Rahaman, K. R., Ohmori, N., & Harata, N. 2005; Bari, Haque, Nag, Hossain & Haque, 2018)

Figure 2: Mr. Kashem is providing mobile network balance transfer service to his customer (Left); Abul Bashar is having breakfast at a sidewalk restaurant only for 15 Taka (right).

3 Methods

The data and information about the cultural dimensions of the sidewalks in Dhaka presented in this paper are collected essentially in three ways- a) primary data collected from 3 months long ethnographic fieldwork, which include more than 25 interviews, and 10 focus group discussions, b) questionnaire survey and c) secondary data sources, which include peer-reviewed journals and conference papers, local and international newspapers published both in Bangla and English, studies conducted by various development agencies and NGOs, etc.

All three of our authors participated in the fieldwork at different levels. Interviews were taken in Bangla. As the authors are native speakers and live/d in Dhaka for at least 10 years, data collection through interviewing the participants went comparatively smoother. The authors easily could achieve the trust of the participants and build a friendly relationship with them. Each interview was semi-structured and was recorded with the permission of the participants. Each interview lasted for 20-30 minutes. Later these interviews were transcribed and translated in English. FGDs involved 40-60 minutes discussions (mostly the consumers of products and services of the sidewalk vendors).

Around 78 vendors and 23 pedestrians participated in our questionnaire survey. The vendors were asked about their livelihood practices, daily income, business trajectories, profits, savings, family configuration, migration patterns, spatial limitations, exposure to pollution and nuisance, safety and security issues, gender discriminations, etc. Pedestrian interviews included questions around the economic background, migration pattern, location of households, locations of sidewalks they frequently use, dependency on street vendors for different services, shopping preferences, price negotiation patterns with the vendors, etc. Later the findings from this survey were translated into English, processed, and categorized for this paper.

4 Study Area

Dhaka, the capital of Bangladesh, has grown from a small trading town to one of the megacities of the world. The city is located in the central part of the country with having a 10 million population (TMP, 1998). The city's public sidewalks are less than a decade of age while a significant portion of the city is still lacking cohesive public sidewalk system (Bari, Haque, Nag, Hossain & Haque, 2018). The city contains approximately 3,000 km of road network of which only 400 km i.e. 13.33% have sidewalks (Rahman, 2010). The urbanites of the city are depending on foot for 60% of their daily trips (Rahaman, Ohmori, & Harata, 2005).

The survey was conducted on the 5 different sidewalks of 5 different areas of the cities with varied characteristics. These are Gulistan Area (Near the Baitul Mukarram National Mosque), Gawsia Market area, Nilkhet Area, Motijheel Area (Near the Ideal School and College) and Dhanmondi area (streets where the morning market takes place). The area around the Baitul Mukarram National Mosque is a transit area for daily commuters. Gawsia market is one of the prominent retail shopping area of Dhaka. Nilkhet is well known for its bookselling and printing shops. Dhanmondi is a mixed-use area with many residential buildings and many shopping areas.

5 Findings

In this section, we document the findings from our three months long fieldwork. Our data reveal a wide variety of ways how the street vendors and informal service providers along the sidewalks are doing their day to day business, what are the disruptions and disturbances that they face regularly, and what are the pedestrians' and local people's thoughts toward such engagement of the vendors on the sidewalk. From our survey in Dhaka's 5 most popular vendor-occupied sidewalks in 5 different areas, we documented hundreds of cases from the streets/ sidewalks. Later we categorized those cases in four broad themes: displacements, disruptions, quick-fixes, and mobilities to better depict the complex relationships between people from different backgrounds and Dhaka's sidewalks and how linear design thinking around sidewalks fails to attain cultural sustainability in this context.

5.1 Displacements (of the vendors)

The urge of planning and developing sidewalks to provide uninterrupted walkability for the pedestrians often sideilnes the struggles of the street-side vendors and other service providers (Morshed, Adnan Zillur. "Why not a national footpath policy?" The Daily Star, September 30, 2019, Accessed March 1, 2020, https://www.thedailystar.net/opinion/the-grudging-urbanist/news/why-not-national-footpath-policy-1807042). These planning strategies involve frequent forced displacements of this informal workers. Due to several administrative, political and contextual reasons, the vendors have to frequently change their locations. Such random forced evictions make it difficult to create a permanent space identity for the vendors and service providers, which is important for their business trajectory.

Case 1: Mr. Jahangir (age 50), is a vendor who sells dates on the sidewalk in front of the Baitul Mukarram Mosque. He has migrated to Dhaka 8 years ago from a small village in Rajshahi (situated in the northern part of Bangladesh). For him, street vending was the only doable business, which his limited capital. He started selling nuts near the Stadium Market gate (close to the Mosque). Gradually, he managed to buy a cart and started selling dates in front of the Mosque. However, he is struggling almost every day to run his business without being temporally displaced by the VIP traffic. The Bangabhaban, the Presidential residence of Bangladesh being at proximity, the road adjacent to the sidewalk, where Mr. Jahangir works, is used by the notable VIPs, displacing Mr. Jahangir and many others from their regular business. Jahangir says,

"*Karim Chacha (another vendor in the same sidewalk) told me that there was more space before in this sidewalk. In the last 10 years, this sidewalk was wrecked and rebuilt three times and each time the sidewalk became narrower and higher. Now you can see there is almost no space left to place a cart here without occupying some portion of the street. I have to move my cart at least twice a day when any VIP passes through this street. In this busy area finding another location to keep my cart, even for a few minutes, is extremely difficult. Other vendors on that side of the street (pointing toward the other side of the road) get angry if I go there as they lose customers."*- Jahangir (male, 50)

Case 2: The scenario is no different for Ayesha Siddiqa (40), who sells bangles in front of Ideal School, Motijheel. She lives near the Railway, in a slum with her 10 years old son. Her husband left her when her son was only 3 years old. After that, she started her own business. She buys bangles from one of her friends and sells those in front of Ideal School. Ayesha has a regular customer base of guardians coming to drop or pick their children from Motijheel. She says,

"The School Guards always try to evict us from sitting in front of the school gate. My bangles attract women and teenage girls. Where else am I going to find such customers if it's not a school? I cannot rent a shop. I don't have enough money for that. Although the kids and their moms find it fun to shop from my basket, the guards don't let us sit here for a long time. They say that we ruin the beauty of this school entrance, we make the sidewalks dirty. One day one of the guards told us that he will call the police. After that day I did not appear here for 2 weeks. I tried to sit in front of the Central Government Girls School. But it's difficult to make new customers at a new place. Hence, I again came back here, knowing all the risks of getting

arrested. There is no space for us anywhere in the city, not even in the sidewalks…" -Ayesha (40, female)

Figure 3. Security personnel forcing a vendor to move out from his regular selling place (left), Mr. Faijullah lost his "*chouki*" (selling stand) during a raid, now selling products on a plastic sheet on the sidewalk near Nilkhet (Right).

These and many other stories like Ayesha and Jahangir help us to understand the spatial marginalization of the informal workers in the form of displacements. Although the recent sidewalk development interventions focus on uninterrupted pedestrian flows, they hardly consider the impacts of such "uninterruptedness" in the lives of thousands of people like Ayesha and Jahangir.

5.2 Disruptions (in the lives of pedestrians and local people)

Permanent and temporary displacements not only disrupt the normal working lives of the street-side vendors and service providers, but also hamper the day to day lives of the local people and pedestrians as well. From our interviews and questionnaire surveys, we came to know that a significant portion of the local neighbourhood directly or indirectly depend on the sidewalk services. For example, cutting hair at a significantly cheaper rate, getting fresh fruits, vegetables, even fishes whenever necessary, buying fancy ornaments at an extremely low price, etc. 90% of our pedestrian participants belong to low or lower-middle-income population and they mentioned to us how important these sidewalk functions are for them. Random displacements make it difficult for these people to locate services from the sidewalks on a regular basis. In most of the cases pedestrians let us know that even though for the vendors their walking spaces get narrowed, they enjoy the liveliness and colors that the vendors bring in an urban sidewalk. However, this culture of the sidewalks gets disrupted by outside forces in the form of dislocation and displacements. The following cases from the field depict the complex picture of such disruptions and point towards the economic marginalization of a certain class in the urban Dhaka.

Case 3: Shafiq is a 24 years old electrician. He works at an electrical equipment repairing shop in Fakirapul Bazaar. The owner of the shop sends him to the neighbouring or distant houses/ shops/ offices to fix electrical fixtures. Most of the cases, his employer does not pay him any transportation cost. Hence, Shafiq walks to his job place every time. He used to have his hair done by a barber, who used to work on a sidewalk right opposite to the Ideal School in Motijheel. He says,

" …*the barber only charged me 10 taka (0.12 USD) for a decent haircut. I used to take his service in every 15 days. He listened to me if I interrupted him and explained him how I wanted my hair done. He also provided a free shoulder massage. As all the vendors have been evicted from this street last month, I lost him. I should have taken his mobile phone number to know, where is he working now. Last week I went to a formal salon, and the cheapest cut cost me 100 taka and I didn't like the cut at all. The barber didn't even give me a scope to complain*."- Shafiq, male, 24 years old

Case 4: Rubana is a 20 years old student from Home Economics College. She loves to read fictions, whenever she gets time. She belongs to a poor farmers' family, who live in Comilla. Rubana lives with 4 other girls in Azimpur, close to her college. She usually buys required books for her college from the Nilkhet old book markets. But her favourite fiction books can only be found on the sidewalk book sellers. She says,

"… I can buy an old, used book 'the collection of Misir Ali' by Humayun Ahmed (famous fiction writer in Bangladesh) for only 120 Taka from the Nilkhet sidewalk. But the same book will cost more that 400 Taka if I want to buy it from a bookshop inside the market. But the problem is every other week these booksellers get evicted by the traffic police as they block the road to some extent causing traffic congestion. But you can see how popular these roadside book sellers are. Poor students like us largely depends on their services."- Rubana, female, student, 20 years old.

These and many other cases from the pedestrians and local community people demonstrate the dependency of low-income people on sidewalk vendors. However, the voice from these consumers do not reach to the city authorities, who are extensively biased toward formalization of business entities to attain taxes. Hence, sidewalks designed from the city corporations never address the above-mentioned disruptions.

5.3 Quick Fixes (done by the vendors)

Despite being a significant part of the sidewalk life, sidewalk vendors are considered to be illegal and often become victims of harassments by law enforcing officials especially the police and extortionists. To survive in a situation with random displacement and disruptions the informal workforce from the sidewalks come up with some quick fixing techniques. In this section, we document two types of quick fixes- social and material, which help us to understand the complex socio-material relationships that develops spatially in a sidewalk but random get acknowledged by the authorities and designers.

As these informal workers do not have enough resources and infrastructure for resistance, so they opt for some *Jugaad* or frugal innovations in order to sustain. The *Jugaad* is part of the 'infrastructure deficit' (Sharma, 2009), a robust and cost-effective solution to rough roads and poverty. From the fieldwork, we have observed many types of survival techniques among the vendors. Near the Baitul Mukarram Market Area we have interviewed some vendors who place their carts in front of the formal shops of the market. Some of them mentioned that the

Figure 4: A social connection develops between the formal shop employees and the street vendors.

Employees from the formal shop often help the vendors by looking after their products, when they need a bathroom break, or need to store their belongings during a sudden eviction. In Nilkhet we have found cases, where some of the vendors pay a certain amount of their daily income to the adjacent formal shops to attain permission to sell their stuffs in front of those shops. Another common survival technique is the mutual trust and exchange of favours among the vendors and within their social network. The exchange of favours vendors in their day-to-day life and helps them flourish despite intense competition. They get informed about raids by police or city official from their network and act in accordance. They often hide their carts or selling objects in other shops and stay in hideouts until the authorities are gone.

Case 5: Mostafizur, age 38, a bookseller in the Nilkhet area, expresses a common sentiment of the vendors,

"I've been on this street since I have moved to Dhaka city three years ago. I couldn't afford to own a shop with my little capital. This is my home. I spend more time here than in my own home. But many times, the police try to evict us, vendors, from our workplace. We get the news beforehand from our network and try to lay low on the raid days. Well, we need to survive, and the government continues to evict us, what else can we do?"

Mostafizur's case was an example of social quick fixes. Material quick fixes are not uncommon in this context as well. For instance, the locations that street vendors took up are usually influenced by attractiveness, accessibility, number of customers, competitors, allocation by municipalities and the original site where vendor businesses started (Onyango et al., 2012).

But due to sudden development programs of city and local authorities, they face difficulties in adjustment in the work environment. Sometimes environmental factors also cause them to modify the space around them. The common practice among the vendors is using shades for their carts or on their usual workspace on the sidewalks. This practice is due to the climatic condition of our country.

Case 6: Shabbir, a 29 years old vendor, generally sells plastic household material near a street in the Baitul Mukarram Mosque area. He generally sells from 8 a.m to 9 p.m. He receives more customers in the prayer times of the day and especially on *Jumma Bar* (Friday). He sits in front of a book shop. He generally hangs a plastic sheet hanging over the sidewalk he sits by. He says,

" ……the weather is not always on our side. Sometimes it is scorching heat and sometimes it is raining all day. I use the shade to protect my products and also to protect myself from the heat and rain. I usually come in the morning, put on the shade over my space and start selling. When my business is done for the day, I wrap up the plastic shade and use it to cover the products. The shade is most helpful in the raining hour. Passers-by also come under the shades during raining."

The stories here unveil an overlooked aspect of the vending practice on the Dhaka's urban life, which the vendors create with the adopted frugal innovations. However, in many cases such quick fixes fail to help them as vendor-unfriendly sidewalks and regulations cost these vendors financially, sometimes they lose social support as well.

Figure 5: Sidewalk vendor using plastic sheets to cut the dripping water from the adjacent building.

5.4 Mobilities

Usually street vendors are portrayed as an obstruction toward free pedestrian movement on Dhaka's sidewalks (Rahaman, 2006). From our fieldwork, we collected stories from working women, who argued that they feel safer on those sidewalks, which are occupied with vendors until late night. Past researches have suggested that the areas with lighting and human activities might enhance the feeling of safety (Boyce & Gutkowski, 1995; Nasar & Jones, 1997; Painter & Farrington, 2001; Ramsay & Newton, 1991).

The following case studies show the impact of the presence of the vendors on the mobility patterns of the women.

Case 7: Lata is a 27 years old garments worker. Her shift ends at 9:30 pm. She always walks back home with one of her co-workers. It usually takes an hour to walk to her home. One day her co-worker didn't come to the factory due to severe illness. Lata had to return home all by herself. She says,

" *it was almost 10:30 pm. On my way back there was a comparatively desolate sidewalk, which we always tried to cross as fast as possible. That night I was alone, and I felt like someone was following me. I knew this area was not safe for girls. I started running and after crossing a few blocks, I took the street on my right. The sidewalks of that street were occupied with late night vendors. I was relieved, started walking, and didn't look back… "*

Case 8: Maisha, a 25-year-old university student, is a usual customer of the Gawsia market. She generally buys her clothing and ornaments there. As her university is nearby as well as her dormitory, it is more convenient for her to come to this marketplace. She visits the market more on Fridays when her university is off. Friday being the general holiday here, the market crowd is double than usual. She also has a part-time job as a tutor in a nearby area in which she goes mostly in the evening.

"I am a student of Dhaka University and a regular user of this route. I generally buy clothes and ornaments from the sidewalk vendors. You will always get things cheaper from the roadside vendors than in the shops. It is more beneficial to me as I am just a student and have no steady income. Also, when I come back late from my tuitions at night, there are still some vendors in that area, working late. They kind of give me a sense of safety as the crime rates in the city are increasing. Though on Fridays, it is impossible to step into the market as there is a huge crowd. Also, evening hours are the busiest. This often causes so much traffic jam in the area! But I think everything comes with a bad and good side, don't they?"

Many other stories similar to the above stories demonstrate that safe and secure mobilities of the women pedestrians, who work till night, significantly depends on the presence of vendors and customers. However, how "criminalized" sidewalk vendors actually sometimes reduce crimes against women is rarely mentioned in the mainstream development discussions.

6 Discussions and Conclusion

In this paper, we have presented sidewalk vendors and service providers as a significant informal workforce of the sidewalks in Dhaka city. Then we described how Dhaka city's street culture has been produced and reproduced by its sidewalk activities, which can be traced back to its birth as a city. We have discussed how such deeply embedded cultural urban phenomenon started to become marginalized as globalization emerged. We have also discussed how globally recognized standards of urban development and aesthetics contradict with our own social and traditional values, hence, sometimes neglect location/context oriented cultural sustainability. Through our findings ranging from the struggles of a displaced vendor to the urgency of free mobilities of women during nights, we have repeatedly argued that constructing sidewalks excluding all these socio-cultural values results in distress and marginalization of the economically vulnerable portions of the society. In this section we describe alternative frameworks for the future development of diverse and inclusive sidewalks.

First, to avoid any kind of social and economic marginalization in urban landscape we have to ensure the participation of every actor in a spatial network. We must ensure that voices from every layer of the society can reach the authority, who plays leading roles in city development. Spaces like sidewalks should not be considered otherwise. An urban designer should involve more actively with the subalterns and ensure their spontaneous participation in every phase of design decisions. A designer should be more open toward learning the subaltern cultural nuances, modes of innovations, and forms of resistance, in order to ensure social justice through designing urban spaces like sidewalks.

Second, designing a sidewalk should involve all its micro spatial systems and interrelations of the components that create those systems. For example, designing a sidewalk in front of a school should involve thorough cultural analysis of the spatial interrelations of students, school staffs, parents, security guards, street vendors, service providers, rickshaw pullers, pedestrians, bikers, canvassers, etc. Designing sidewalks only for the pedestrians will marginalize the agencies of the other social entities that engender a dynamics sidewalk context in front of a school in a Global South city.

Finally, we should keep in mind that in comparison to the other public open spaces, sidewalks have more intimate and regular interactions with the urban life in Dhaka's context. Michel de Certeau (1993) has described the city as a story that unfolds continuously as people move through space on different trajectories. Sidewalks are such spaces of movement. Our empirical observation helps us to better understand the importance of sidewalks through the lens of most "undesirable" users of these spaces. We call for inclusive designs that will incorporate heterogeneous socioeconomic factors in design discussion and produce more culturally sustainable sidewalks in Urban Bangladesh.

Acknowledgements

The organizer gratefully acknowledges the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2020 for efforts done for the success of this event.

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06.102 - THE MORPHOLOGICAL INTEGRATION AND CONDITION OF BUDDHIST TEMPLES' RIVERFRONT ALONG CHAO PHRAYA RIVER IN BANGKOK

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Abstract

In the past, Buddhist temples were the center of the communities both in the sense of spatial and spiritual gatherings for the people in the neighborhood to perform a variety of activities. Since Bangkok used to rely on water-based transport system, temples would face the river or canal where the riverfronts would be the main entrance. As the city evolved, urban transformation led to a change in transport from water-based to land-based. Temples' riverfronts thus changed from front to backyards, causing many to become deprived. This paper is a part of the research on the Publicness of the Chao Phraya Buddhist Temples' Riverfronts intending to present an overview of the morphological integration and condition of the temples' riverfronts which are Bangkok's traditional public spaces in the present time. Referencing the concept of successful public space, the morphology of the site is the fundamental factor which induces people by their natural movement, consequently affecting the various usages of the site. In this research, configurational analyses by Space Syntax Technique on all 27 Bangkok Chao Phraya Buddhist Temples' Riverfronts reveal how these sites have been integrated with the present urban transport network which is related to a functional pattern. An on-site survey on the condition of the temples' riverfronts and initial site surveys of activities occurring on the sites were collected to analyze with the morphological integration data to find relationships between them. The research finds that the integration level of a temple's riverfront largely depends on the integration level of that district but may not represent the real natural movement of the riverfront. Furthermore, the space usage pattern and activities on a temple's riverfront are probably influenced by other factors, especially non-physical ones, which makes temples' riverfronts a unique type of public space.

Keywords

Temple's Riverfront, Morphology, Publicness, Public Space

1 Overview

Buddhism has played a significant role in Thai society since the 14th century. This religious institution has a deep influence in every part of the community and has become part of the Thai traditions and cultural norms. In Thailand, temples are the physical form of religious institution which perform not only religious duties but also public services. In the past, temples are the center of every community carrying out both public services such as school, hospital, poorhouse, warehouse, court etc, and community affairs including festivals, performances, daily meetings, hang out places, etc. "The universal understanding of temples are the public spaces of the communities related to the sacredness and ceremony which enhancing social relation and a sense of unity" (Wanlipodom, 2017 p.49). Furthermore, even though temples are sacred places with specific religious and spiritual roles, temples and communities have a deep relationship, dependency, and ownership. Both organizations are closely associated with each other even in temple management and community activities (Visalo, 2016). This strong connection is apparent since the formation of the village, as villagers usually allocate a common land within the residential area and construct a simple structure for ceremonial purposes following by inviting a few monks to settle. This sacred place, hence, has been developed in parallel with the village and becomes the center of the community. As a result, temples have been established by the concept of public space for both ideological and spatial sense which cannot be separate from the social context of the community (Wanlipodom, 2017). Moreover, after Bangkok became the capital of Siam in the late 18^{th} century, it comprised of only 3 main institutions: palaces, temples, and houses, where temples were the bond that links between the ruling classes and the lower level for governing and social stability (Jiratasanakul, 2011).

Before shifting to a car-based metropolis like today, Bangkok used to be a famous water-based city for hundreds of years, known as Venice of the East. The city was built along rivers and canals; all civilian houses and floating house were constructed on or next to the bank, facing the river. The junctions of the canals were normally overcrowded dwellings as a city cluster. The traditional settlement pattern was temples at the center of the clusters, surrounded by the communities whereas the farmlands were linked by a small waterways and pathways (Askew, 1994). Since temples were the place for most social activities, religion, trade, education, event, recreation, etc, and rivers/canals were the main routes, villagers usually entered temples from the temples' port sides, which is the main entrance. Temples probably had multiple port sides depend on the side of the temples. After that, people automatically moved through temples' courtyard, locating on the riverfront, due to the traditional landscape design of the temples' master plan (Jiratasanakul, 2011).

This specific configuration made the temples' riverfronts the main area which directly absorbed the natural movement of the people both "to" and "through" the area. As a result, the temples' riverfront became a lively public space as the effect of the Natural Movement was in line with the natural movement concept by Hillier. The theory states that the area which is located at a good morphological form and is integrated with the city structure will get the effect of the natural movement as people pass through the area which afterwards creates the multiplier effect. After that, when there are many people at that site, the situation will induce more and diverse kinds of activities to occur within the place (Hillier and Hanson, 1984 and Hiller, 1996). Moreover, a temple's riverfront was under the influence of Attractor Movement as well because the chapel, as the destination of religious ceremonies, also attracted people. As a result, it can be said that in the past, a temple's riverfront was a public space with a high level of publicness because of the influence of both the morphological integration as waterway was the main mode of transportation while the temple was the center of the community and provided religious ceremonies which played an important role in the people's lifestyle.

However, Bangkok started transforming from water-based community to land-based city in the late 19th century because of the strong colonization threats. As a result, Siam had to imitate the Western lifestyle to show civilization and one of the main strategies was changing urban structure from water-based to land-based transportation, enabling Europeans to conveniently travel within the city. The land-based transportation change took place quickly; subsequently, the city and its citizens could not adjust to the new system harmoniously. This situation was described by J. Hoche who lived in the early 20th Century in his book "Le Siam et les Siamois" that the change in lifestyle and transportation system made the city chaotic. There were two cities on top of each other, the watered-base and land-based city. For a century, Bangkok morphology continuously changed from a water-based to land-based city. Finally, the land-based would win that was the end of Venice of the East (Jumsai, 1985). The final change took place after the end of World War II with the influence of modernization and pressure on the economic growth. It can be said that by this time, Bangkok transportation policy totally shifted to land-based transportation, especially road and highway system. The river and canal system thus became neglected, and lack of maintenances has made the waterways dirty and shallow. Moreover, road network expansion and building encroachment resulted in canals getting filled and the canal network cut off. Finally, Bangkok's canal system can no longer be used for transportation (Tapananon, 2013). As a result, nowadays less than 10% of Bangkok's canal network is in use (Petvirojchai, 2017) and less than 10 river/canals have public transportation service, whereas Bangkok has 1,682 canals in total.

The fall of water transportation network and the rise of road system significantly affect the riverfronts and the surrounding areas because the waterfront which used to be the face of the communities is now the backyard and has become depressed and difficult to access. The study from Urban Design and Development Center (UDDC) shows that only 14% of Chao Phraya riverfront in the inner city's areas can be accessed by the public. Furthermore, most of them are not in a good condition, in contrast, the good quality ones are usually owned by the private sector for business purpose (UDDC, 2015). Though the severe scarcity of public riverfront is a concern for many sectors, especially the civil society, this problem has never been relieved, but there have been some attempts by the government to introduce some ideas.

This study focuses on Bangkok temples' riverfronts because even though in the situation of public space scarcity in the middle of the city, especially public riverfront, temples' riverfronts remain a type of traditional public space which is still available along Chao Phraya River. Most of them have existed since the early state of capital city establishment or before. Although the morphology, structure, and the land use of the city have been changed over the time, these riverfronts are still at the same places as they used to be. However, the condition and land use pattern of each temple's riverfront have changed according to the management of the temple and the need of the user. This research on temples' riverfront is based on the importance of the city's public space both in the morphology dimension relating to site location, physical condition, and the surrounding area, and the socio-culture dimension relating to history, institutional relationships, and beliefs. These factors influence the publicness of the sites. As a part of a larger research, this paper analyzes the morphology dimension and the configurational analyses represented by Space Syntax Technique to reveal the integration level of the target sites with the city. The initial site survey of functional patterns shows activities which signify the publicness of the area, and the conditions of the temples' riverfronts which may reflect the management of the temples. The activities and conditions suggest some factors which influence the level of publicness of the Chao Phraya Buddhist Temples' Riverfronts in Bangkok.

2 The Temple's Riverfront Study

Nowadays, there are about 452 Buddhist temples in Bangkok; most are located closed to the Chao Phraya River or canals. Focusing solely on Chao Phraya River, there are almost 50 temples adjacent to the River and many also border canals which in the past were used to connect with the communities. However, this study finds that in recent times many of temples' riverfronts have been occupied by communities while some have been rent out to the business sector. As a result, there are 27 temples whose riverfronts still "physically exist as riverfront" where people can enter the area and use the riverfront for different purposes. The study finds that these temples' riverfronts have difference characteristics. The size, river scenery, condition/quality of the site all affect activities which can occur within the area. Moreover, the potential of accessibility for each site is also different which will be assessed by Space Syntax technique. For the potential of accessibility in term of location and mode of transportation, almost all sites are located within walking distance from the main roads supporting by public transportation. According the Urban Design and Development Center, the longest walking distance of a typical Thai is 800 meters (UDDC, 2015). Nevertheless, the actual walking distant depends on the condition of the route and the surrounding area. All temples can be accessed by car, motorcycle and bicycle, but the interesting point is that some of the temples' riverfronts also have public service boats.

3 The Morphological Integration of Temples' Riverfronts in Bangkok

According to the concept of good public space, the area should be a lively place which consists of various kinds of people, a variety of activities, during different times. In order to make a public space successful, a recent urban planning theory states that its location in relation to the corresponding urban transportation network is the key factor, even more than the specific characteristics of that space. There are 2 main components which directly affect to the liveliness of the space: 1) the density of pedestrians around the area, and 2) the convenience of access and how connected it is to other places (Whyte, 1980). Whyte's principle has been further developed as theory, the Theory of Natural Movement. This theory consists of the logic of spatial configuration and the measurement tool ("Space Syntax analysis"), and indicates the relationship between the spatial configuration and the characteristic with the level of the space use (Hillier et al, 1993). The conceptual framework of Space Syntax comprises public spaces and thoroughfares, especially for traveling on foot, which are the fundamental factors of urbanization process. The characteristic and the level of the traveling within the city can be explained and forecasted by the sophisticated analysis of the relationship of all public routes on the digital mapping model. In short, Space Syntax analysis process based on the spatial model of the target area, city. The map consists of 2 main components: convex spaces and axial lines. Each convex space represents a unit of area within the city, and axial lines link the convex spaces within the city. In the other words, axial line networks are the spatial configuration network of all public spaces in the city (Paksukcharern, 2004).

In this study, the Space Syntax concept is applied to test the hypothesis that even though the temples' riverfronts are a specific type of public space under the influence of socio-culture and management factors, they are still a kind of public space/public riverfront that people can freely access to do many kinds of activities. Thus, the integration level of the temples' riverfronts still play an important role as the fundamental influence of the areas which resulting in the publicness of the places. In order to measure the integration level of each temple's riverfronts, the Bangkok integration base map is applied. New axial lines are inserted within the temples' areas and connected to the axial lines of the base map. The convex spaces of temples' riverfronts are determined and a few axial lines are used as representative of the convex spaces of temples' riverfronts. Thus, the integration value of those axial lines refers to the integration value of temples' riverfronts. The axial lines of water transportation system are also created into the map, both express boat and the ferry.

In term of Space Syntax technique, each of the temple's riverfront is calculated in 4 patterns: Mean 0/N, Mean 0/800 meters, Mean 0-3/N and Mean 0-3/800 meters. The purpose of Mean 0 and Mean 0-3 are to find the difference between integration values of pure riverfronts and the riverfronts along with surrounding areas. The purpose of N and 800 meters are to find the difference between the integration values at the city and the district level, which can imply whether the place is a public space of the community or a public space of the city. The 800 meters boundary may be downsized or enlarged depending on the morphology of each area especially from main roads and canals. Moreover, if a temple's riverfront has a public pier with the ferry services, the Space Syntax calculation area is expanded to also include the opposite side of the river.

Table 1: The integration value of 27 temples' riverfronts

Code	Temple	Mean 0 / N		Mean 0 / 800		Mean 0-3 / N		Mean 0-3 / 800	
		Int Val	Rank	Int Val	Rank	Int Val	Rank	Int Val	Rank
E1	Soi thong	513.040	5	42.521	9	529.295	5	48.198	9
E2	Anamnikayaram	592.630	2	62.580	4	567.120	4	63.363	6
E3	Bangpo omawat	671.402	1	53.447	5	840.116	1	70.444	3
E4	Kaewfachulamanee	365.725	9	49.046	6	364.759	11	53.542	8
E5	Chansamoson	360.349	11	48.297	7	401.814	8	70.266	4
E6	Rachatiwat	379.544	8	26.685	16	385.441	9	30.357	17
E7	Yannawa	591.268	3	70.170	2	692.143	2	105.151	1
E8	Worachanyawat	588.614	4	31.871	13	587.172	3	33.626	15
E9	Inbanchong	145.969	21	6.643	26	169.451	21	9.597	26
E10	Bangkhlo nok	154.896	20	5.874	27	171.240	20	7.596	27
E11	Thongbon	171.975	18	11.500	22	223.548	18	29.066	19
E12	Pariwat	155.467	19	8.442	25	182.985	19	14.703	25
E13	Dan	202.853	17	11.323	24	258.522	16	39.536	13
E14	Khlongphum	61.784	27	11.402	23	80.270	27	21.298	24
E15	Khlongtoei nok	140.408	23	23.207	20	143.777	25	24.899	23
E16	Bangna nok	254.410	15	46.433	8	229.513	17	45.086	10
W1	Wimuttayaram	440.928	6	20.269	21	502.261	6	27.803	21
W2	Awutwikasitaram	291.839	13	34.355	12	332.617	12	41.449	12
W3	Borwornmongkol	267.054	14	26.372	18	278.512	14	26.689	22
W4	Kharuehabodi	250.252	16	26.592	17	267.300	15	28.409	20
W5	Rakhangkhositaram	395.429	7	65.974	3	409.071	7	68.822	5
W6	Arunratchawararam	364.892	10	78.394	1	366.906	10	78.680	2
W7	Kalayanamitr	305.906	12	35.811	11	326.621	13	37.902	14
W8	Bukkalo	129.930	24	38.467	10	163.559	22	60.904	7
W9	Klang dao khanong	122.542	25	29.714	14	149.430	23	42.838	11
W10	Dao khanong	108.414	26	23.962	19	123.799	26	30.347	18
W11	Chaeng ron	142.929	22	28.522	15	146.841	24	33.268	16

The Space Syntax calculation reveals the integration values of the 27 temples' riverfronts along Chao Phraya River in Bangkok. When focusing on Space Syntax analyses at the city level (N), we found that the Mean 0 and Mean 0-3 methods have a slight difference in the integration value for all temples' riverfronts; the rank differentiation is not more than 3 levels or even no difference. Similarly, the Mean 0 and Mean 0-3 of integration 800 Meters have a slight difference in the integration value for almost all temples' riverfronts; the rank differentiation is not more than 4 levels or even no difference, except Wat Dan (E13) because there is only 1 axial line within the temple area which leads directly to the riverfront. As a result, for Wat Dan, changing from Mean 0 to 0-3 within 800 meters radius makes the riverfront becomes as a part of the surrounding area which resulting in the significant raise in the integration rank. On the other hand, if we compare between N and 800 meters radius, the ranks of the temples are quite different for both Mean 0 and 0-3. This means that the temples' riverfronts can be classified as "local level riverfront" or "city level riverfront" based on the site of the temples due to the morphology factor.

When considering the integration level base on the district, the integration value of the temples' riverfronts tend to be similar to the integration value of their districts, because most temples' riverfronts are located not far from the main street or not more than 3-4 steps in the sense of Space Syntax technique, which represent the depth of the particular site. For example, the temple coded E1, E2, and, E3, E4, and E5 are located within the same district; as a result, their integration values are similarly high. Likewise, the temple coded E9, E10, E11, E12, E13, and E14 are located within the same district, and their integration values are all low. Moreover, if we consider in more details, there are other noteworthy points. Firstly, the temples' riverfronts can be divided into 2 types: a "Dead-End Riverfront" located at the end of a "Blind Alley" and a "Connected Riverfront" located at an "Interchange Transportation Node". Surprisingly, the integration levels of those 2 types seems not that different. In contrast, the integration level of E2 and E3, the dead-end riverfronts, are a bit higher than E1, the connected riverfront, even though E1 benefits from the natural movement of people crossing the river. Moreover, the integration level tends to be high at the bridges connecting 2 sides of the river. To explain this situation in the morphology aspect, all Chao Phraya River bridges are designed to link the main city streets which usually highly receive the influence of the street network. As a result, the integration levels of the bridges are usually high, whereas the sites of the temples' piers are not supported strategically by contemporary urban transportation. Thus, although a riverfront is an Interchange Transportation Node, the level of integration may not be as high as expected because the road-bridge system is planned as the current dominant transportation.

4 The Condition of Temples' Riverfronts in Bangkok

The previous section explains the morphology of the temples' riverfronts by applying Space Syntax technique under the belief that it is the critical and fundamental factor influencing the space usage pattern. This part explores the physical dimension in order to provide more information which may be useful to further understand the space-usage pattern. A physical site survey was conducted to collect data on the condition of temples' riverfronts by exploring the sites with a simple list. The list was adapted from literature review about key elements or factors which make public spaces more attractive or user friendly (Jacobs 1961, Lynch 1981, Lennard and Lennard 1995, Gehl 2010, and Garwin 2016) and combined with other factors and special characteristic of temples' riverfronts. The score of each factor ranges from 1 to 5, and all factors have equally weight.

Table 2: The factors for the conditions of temples' riverfronts

Factor		Factor	
1	Condition and quality of access/route	6	Shady and pleasant
2	Mode of transportation to the riverfront	7	Clean and tidiness
3	The scenery of the river	8	Food and drink
4	The visibility within the riverfront	9	Release/feed the fish and amount of fish in the river
5	Street furniture available	10	Area for Buddhist activities

Table 3: Example of the scores for the conditions of temples' riverfronts

Code	Temple	The Factors of The Condition of Temple's Riverfronts in Bangkok											Rank
		1	2	3	4	5	6	7	8	9	10	Total	
E1	Soi thong	3	5	2	2	2	3	2	4	4	1	28	17
E2	Anamnikayaram	3	4	1	4	1	1	1	3	1	1	20	26
E16	Bangna nok	5	5	5	4	4	4	5	4	5	5	46	1
W1	Wimuttayaram	4	4	1	5	1	1	4	2	1	2	25	23
W2	Awutwikasitaram	4	5	3	3	2	3	4	2	4	1	31	13
W11	Chaeng ron	3	4	4	4	3	5	4	2	1	2	32	12

5 The Publicness of the Temples' Riverfronts

"Cities that have a strong notion of the public demonstrate a commitment to an improved quality of life for their citizens by providing adequate street space, green areas, parks, recreation facilities and other public spaces. Public spaces are vital ingredient of successful cities. Having access to public spaces does not only improve the quality of life but is also a first step toward civic empowerment and greater access to institutional and political spaces" (O' Reilly, 2016 p.4). In urban planning area, the concept of public space has been broadly discussed especially the dimensions and the factors effecting the publicness of the places: accessibility, agency, interest, ownership, management, user, etc. However, all those dimensions/factors are usually related to collective, inclusive, public owned/public operation, diversity of people/activity (Nemeth, 2011). In urban planning, the publicness of the place is defined in 2 schools: Phenomenalism and Behaviorism. In this study, based on the behaviorism which study how behaviors of people come about in response to in the environment where the publicness of the place is related to space-used and space-used pattern concept. The publicness of the place which leads to the success of the public space depends on the multi-use, accords with the concept of the recent public space which emphasizes on promoting the public space to be "Social Space" (Paksukchareon, 2019). Thus, the publicness of any public spaces in the city means that places can be freely accessed and the places must be multi-used by 1) various kinds of users 2) variety of activities and 3) different time of the days (Jacobs, 1961, Gehl, 1971, Hillier and Hanson 1993, Hillier, 1996, and Paksukchareon, 2019).

In order to measure the publicness level, a systematic initial site survey of 27 temples' riverfronts was conducted to gather the necessary information. The non-participant observation was deemed suitable and has an advantage in allowing the researcher to understand a phenomenon by entering the public/social system involved, while staying separate from the activities being observed. Without actively participating, the target group will behave normally; thus, the researcher will get information which is close to the real situation that can reveal the actual characteristics of the places.

In this study, non-participant observation was conducted 4 times for each temple's riverfront, in the morning and afternoon of a working day, and in the morning and afternoon of a weekend. A working day means Tuesday, Wednesday or Thursday – Monday and Friday are eliminated because of unusual traffic. A weekend means Saturday or Sunday. The observation was not conducted on public holidays and Buddhist Holy Days due to unusual traffic. The non-participant observation form is designed as a table consisting of 3 main groups: user, activity, and time period of data collection. The variety of users is based on fundamental demographic characteristics: gender, age, status related to the area, and general purpose. The variety of activities is based on Gehl concept of activities within public space: necessary, optional, and social activities (Gehl, 2010). The variety of time is based on the stability of the users and activities within working day and weekend. However, due to limitation of the initial site survey which were not able to collect the data for the whole day, 4 periods of time mentioned above are used as the proxy, and the variety of time is estimated from the stability of user and activity of those 4 periods. The value of user, activities and times are weighted equally on the assumption that these 3 groups are equally important criteria of the publicness of the public space.

Table 4: The publicness score of 27 temples' riverfronts

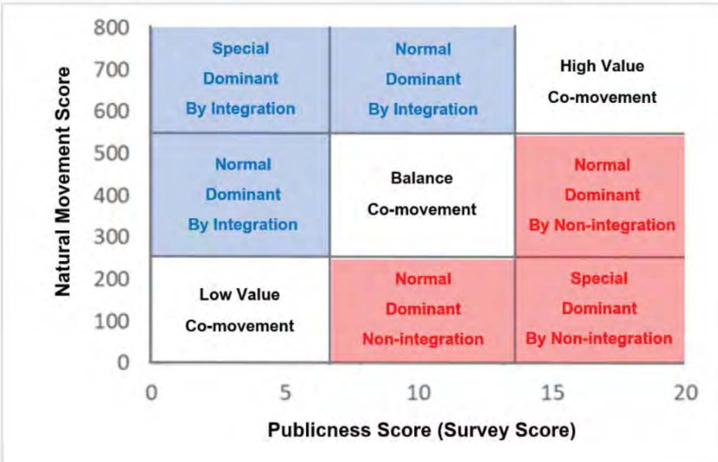
Code	Temple	Score	Rank	Code	Temple	Score	Rank
E1	Soi thong	11.16	13	E15	Khlongtoei nok	7.75	20
E2	Anamnikayaram	7.85	19	E16	Bangna nok	15.88	1
E3	Bangpo omawat	7.39	23	W1	Wimuttayaram	10.91	15
E4	Kaewfachulamanee	12.67	7	W2	Awutwikasitaram	11.00	14
E5	Chansamoson	2.77	27	W3	Borwornmongkol	12.40	8
E6	Rachatiwat	13.54	5	W4	Kharuehabodi	10.73	16
E7	Yannawa	12.02	11	W5	Rakhangkhositaram	15.32	2
E8	Worachanyawat	13.71	4	W6	Arunratchawararam	14.45	3
E9	Inbanchong	6.88	25	W7	Kalayanamitr	11.22	12
E10	Bangkhlo nok	7.55	22	W8	Bukkalo	12.27	10
E11	Thongbon	12.33	9	W9	Klang dao khanong	7.55	21
E12	Pariwat	13.50	6	W10	Dao khanong	8.53	18
E13	Dan	10.53	17	W11	Chaeng ron	6.92	24
E14	Khlongphum	6.73	26				

Although the publicness score of 27 temples' riverfronts from the initial site survey may not precisely describe the whole phenomenon of the areas and some of the ranking may be switched, the score is still a reliable reference in term of overall users and activities emerging within the places which can be interpreted into the publicness score. Moreover, the overall ranks can illustrate trends of the publicness of all 27 sites which is in line with the objective of this data collection to find a "Factor of the Publicness".

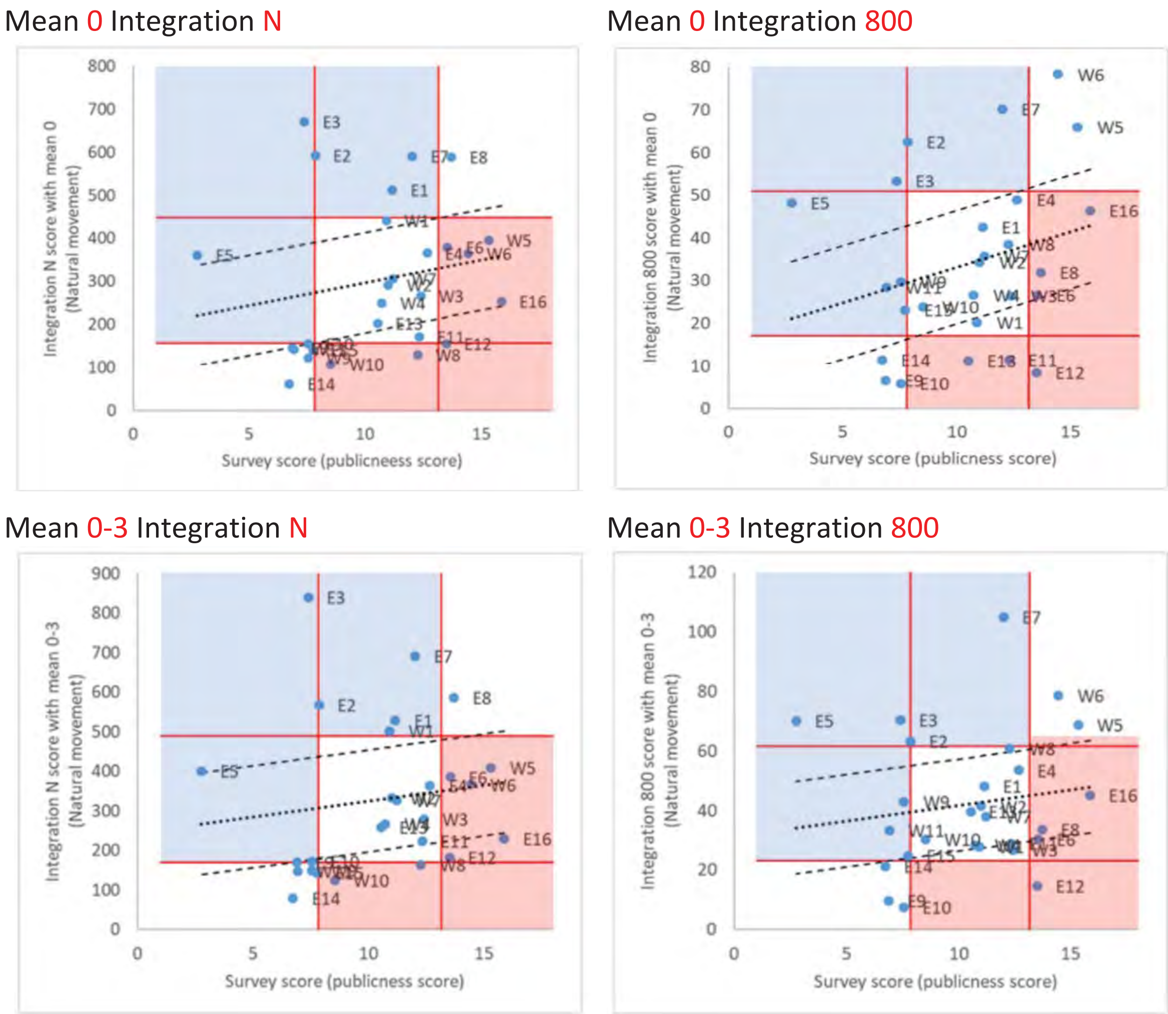
The publicness score and the rank tend to conform with the recent concept of public space. The key success factors of public space are the location of space relating to the urban transportation network, the density of the pedestrian around the area, the convenience of access, and connectivity of the place with the other places of the city (Whyte, 1980). The publicness score shows that all 10 temples which have piers with public boat services rank in the top half (14 of 27). Out of the other 4 temples without public boat services, one is a way through passer by the communities, while the 3 others are dead-end riverfronts with specific management/characteristics. In this regard, the dead-end riverfronts seem to be disadvantaged because one of sub-categories of the publicness score is based on necessary activities which normally include a passageway. Thus, their scores are usually a bit lower than others. However, even the areas with natural movements, the publicness score seems to differ significantly as a result of other factors, especially area management relating to the religious activities. Moreover, many the "Connected Riverfront" seems to follow the concept of Hillier's Movement Economy Principle. In particular, the configuration of the urban grid determines the people's movement through the area, following by multiplier effects based on the flow, the natural movement, and other activities, which may affect the areas' economics activity (Hillier et al, 1993). However, the temples' riverfronts are not purely public spaces or "Common Property" but are under control of religious institutions. As a result, the activities there partly depend on temples' arrangements or decisions allowing the communities to use the areas. An interesting point is that the activities manage by the temples are usually related to traditional beliefs which may possibly be a "High Influence Attractor" drawing many people into the riverfront areas.

6 The Relationship Between the Morphological Integration and the Publicness Score of Buddhist Temples' along Chao Phraya River in Bangkok

This section is about finding the relationship between morphological integration, Space Syntax Technique, and the publicness of the temple riverfront through the initial site survey score. The main objective is to group the temples' riverfronts according to the relationship between morphological integration and publicness score by applying statistic regression technique. The first factor, the integration level, is a direct value which captures the integration of the temples' riverfront under the belief that it is the fundamental factor behind the publicness of the public spaces. Whereas, the second factor, the publicness score, implies other factors which "support" or "go against" the publicness of the places which in this study is mainly about socio-culture of the areas and management of the temples. As a result, the temples' riverfronts can be divided into 3 groups: 1) Dominant by Integration Group, 2) Co-movement Group, and 3) Dominant by Non-integration Group. In addition, these 3 groups are divided into sub-groups to highlight the places which are possibly under very high influence on one side, dominant, which highly deviate from the average and do not fall in line with the recent publicness of the public space concept that the morphological integration should be the fundamental factor of publicness. Then the level of publicness should be aligned with the level of the morphological integration, meaning that if the level of the morphological integration is high, this should be resulting in multi-used by various kinds of users, variety of activities in a different time of the days.



Graph 1: Regression Analysis of morphological integration and publicness score



The regression analysis model of morphological integration and publicness score reveals the relationship graph with the regression line, the upper bound and the lower bound. In this case the upper bound is set at 75th percentile and the lower bound at 25th percentile in order to separate all sample into groups which can be further analyzed. It should be noted that although the confidence interval in scientific and social science studies are usually set at 90% or above in order to find the appropriate sample, eliminate the outliers or prove the reliability of all samples, this study has a different purpose for applying confidence interval, which is to illustrate the trend and divided the 27 samples into groups. As the sample size is very small, 27 cases, setting the confidence interval at 90% will not display characteristics which are beneficial to the purpose the study. Moreover, all 4 graphs also divided into 9 quadrants. This technique is added up with the upper and lower bounds in order to specific into more detail groups: special dominant, dominant, high value, and low value groups. By analyzing across all 4 integration technique graphs, the temples' riverfronts can be divided into 3 main groups and 2 sub-groups.

6.1 Group A: Dominant by Integration Group

The significance of this group is that the integration level is significantly high in contrast with the publicness level which is low or quite low. In this situation, it can be deduced that other factors have a high negative influence which obstructs people from using the areas. As a result, the publicness of the places is lower than the expectation if we base on the principle that the morphological integration is the main factor that attracts people to the public spaces. In this case, when we analyze the temples with 4 different types of Space Syntax Technique, there are 4 temples that are always in this groups; E2, E3, E5 and E7.

The information shows that E5 and E7 are in Normal Dominant by Integration Group. Where as E3 is in the Special Dominant by Integration Group, and E2 seems to be overlap on those 2 groups. Moreover, the position of E2, E3 and E5 are often closed together on the graphs.

When analyzing into more details we found that E2, E3 and E5 are very similar in some important aspect. Firstly, they are in the same district, even within the walking distance. Secondly, the physical condition of the places is poor, with low management system, and lastly, there is no pier. In contrast, E7 is located in the center of Bangkok and closed to a large transportation interchange node: boat, rail and road system. Moreover, although there is no public boat service in the riverfront, there is a tourist boat service and the physical condition of the area is good. As a result, E7 is always separated due to some of different aspects from the others.

6.2 Group A/B: The Overlap Group A and Group B

This group is an overlap group between group A and group B because when we analyze the temples with 4 different types of Space Syntax Technique, they are sometimes in group A and sometimes in group B. As a result, they cannot be considered as good representative of group A or group B. There are 7 temples in this group: E1, E9, E10, E15, W1, W9 and W11. All these temples share some similar characteristics. First, they are located in the district where overall integration levels are quite low. Second, the integration levels and publicness score are often similarly not high. Third, there is no pier/public boat service and the places are dead-end riverfronts. Lastly, the condition of the riverfronts is often poor and there is no activity arranged by the temples. E1 is the only exception because E1's location is the same as group A but there is public boat service; thus, its publicness level is higher than group A and can almost be in group B. However, poor site management causes the publicness level to be lower than expected; therefore, the place cannot be a part of group B.

6.3 Group B: Co-Movement Group

This group is an ideal group according to the recent theory of public spaces. The concept is the places that are in a good urban morphological integration will naturally attracted people into the area making the place lively with various kinds of people and activities. In contrast, the places that are in a poor urban morphological integration will tend to become depressed area because lack of usage. In this case, when we analyze the temples with 4 different types of Space Syntax Technique, there are 6 temples that can always be included in this groups: E4, E14, W2, W3, W4 and W7.

The information shows that 5 of 6 temples are in Balance Co-movement Group, except E14 is in Low Value Co-movement Group. Moreover, the position of W2, W3, W4 and W7 are often closed together on the graphs. When analyzing in more details we found that W2, W3, W4 and W7 are very similar in some important aspect. Firstly, all of them have public boat services. Secondly, the physical condition of the places is quite normally clean but no attractive activities and no attractive surrounding. Lastly, the riverfront view is mostly blocked by the flood dam. As a result, most people usually spend a short time in the riverfronts which resulting in fairly limited activities. Whereas, for E4, the level of publicness is higher than the others because the physical condition of the places is better with the wide river view and there are some activities arrangement within the area; as a result, the place can attracted more people to spend more time and doing more activities in the area. In contrast, E14 is a good example of the area that cannot becomes a good public space because the place is in a low integration level, dead-end riverfront, no activity arrangement, and the place is single use as car park. As a result, the place seems destined to be a deprived area.

6.4 Group B/C: The Overlap Group B and Group C

This group is an overlap group between group B and group C because when we analyze the temples with 4 different types of Space Syntax technique, the temples are sometimes in group B and sometimes in group C. As a result, they cannot be regarded as good representative of group B or group C. There are 7 temples in this group: E8, E11, E13, W5, W6, W8 and W10. They, in fact, have some different interesting characteristics. The first sub-groups, E8, W5 and W6, has the publicness and integration score in the high zone because they can further develop the areas from a great morphology factors: located in prime areas of Bangkok, high integration value, and public boat services. As a result, when these temples develop the area and put some more activities within the area, the publicness score is high due to the place as the passageway (natural movement) and the destination (attractor movement) of people. On the other hand, the second sub-group, E11, E13 and W8, are based on the special characteristic of their own riverfronts: beautiful scenery, and the variety of activities management by the temples and/or the communities. However, the morphology and the connectivity of the temples to the urban network are not as good; hence, the publicness score is lower than the first sub-group because the difference in morphological dimension which is the fundamental factor in the recent theories.

6.5 Group C: Dominant by Non-integration Group

This group is the opposite of Group A because the publicness level is significantly higher than the morphological integration level of the places. This situation may possibly imply that Non-integration factors play a very important role on the places which go against the hypothesis that the morphological integration is the basis of the public spaces' publicness. In this case, when we analyze the temples with 4 different types of Space Syntax Technique, there are 3 temples that always be counted in this group: E6, E12, and E16.

The information shows all temples are in Normal Dominant by Non-integration. However, in fact, E12 almost be a Special Dominant by Non-integration because when we analyze E12 with 4 different types of Space Syntax Technique, 3 in 4 cases are counted as Special Dominant by Non-integration. E12 is a good example case that a temple's riverfront can be a unique riverfront because of the influence of a religious institution. Because even with weak morphological factors, low integration level, and dead-end riverfront without public boat service, E12 can still draw people and activities by arranging a lot of activities relating to traditional beliefs and talisman. Moreover, this temple creates a great landscape which can induce people to pass through many activities step by step until the last activities at the riverfront.

On the other hand, E16 is a specific case as well because even though the integration level seems to be not so high but in fact, this place is a special riverfront because it connects to Samuth Prakarn Province and it is the only place in Bangkok where motorcycles can cross the river by ferries. Because of this special service, the density of traffic in the place is over the integration level and full of commuters for the whole day. Moreover, the temple sees the opportunity from the density of the traffic, the riverfront is largely improved and fills in with many activities which related to traditional beliefs. As a result, this riverfront is usually full of people because of both natural movement (real traffic) and attractor movement (created activities).

Lastly, E6, is the largest temple's riverfront in Bangkok. The riverfront has been developed in separate functions: car park, pocket park, and traveling piers (not public pier with public boat service). Even though the integration level of the place is not that high, many activities can occur within the place because of the size and designed multi-function of the place. Moreover, although there is no public pier, the place is not a dead-end riverfront, but there is a small alley network which is connected to the surrounding communities. As a result, various kinds of people and activities still happened within the place but quite low in the density.

7 Conclusion and Discussion

The underly assumption in this study is that there are 2 main factors that influence the publicness of the temples' riverfronts along Chao Phraya River in Bangkok: 1) the morphological related dimension and 2) the socio-cultural and management dimension. This paper focuses on the examination of the morphological related dimension which is regarded as the fundamental factor of the publicness of the temples' riverfront. In order to prove the assumption, the Space Syntax Technique is applied to all 27 temples' riverfronts and the physical conditions within 27 temples' riverfront were also collected. In addition, the publicness of the 27 temples' riverfronts by the systematic initial site survey was conducted to collect 3 main types of data, people, activity, and time, under the principle that the different kinds of people, the variety of activities, in the different times are the determination of the publicness of the public spaces (Jacobs, 1961, Gehl, 1971, Hillier et al, 1993, Hillier, 1996 and Paksukchareon, 2019).

The Space Syntax analysis discloses the reasonable integration level of each temple riverfront. However, this technique still has some disadvantages. First, the integration level of the temples' riverfronts seems to be the same as the surrounding area because most temple riverfront are usually only a few steps from the main street. In the sense of Space Syntax, these places are easy to access but, in fact, they are "Blind Alley". Then, there is a low level of "Real Natural Movement" pass through those riverfronts. Second, the temples' riverfronts which is not a blind alley because there are the public boat services, have lower integration level than the real situation because the Space Syntax cannot evaluate the actual number of users using the different transportation system (land and water transportation) which is often unequal within the same model. Moreover, because the urban road transport network is a dominant transportation system, the integration level tends to high at the bridges which connect the main streets of the city; as a result, the piers within the temples' riverfront which connect with the small street tend to has lower integration level. For the riverfront's physical condition, this factor is an additional element that support/discourage more/less activities within the area. However, the very important characteristic seems to be that if the areas are arranged to support the activities about traditional beliefs, they tend to critically attract more people and other activities within the places.

When analyzing the publicness score with the integration level of the 27 temples' riverfront by regression technique, the sample distribution of all 4 graphs tend to show a pattern that conform with the concept of good public space that the morphological integration is the fundamental criteria of the publicness. However, some temples critically deviate from the regression line, mean of all samples. These temples are usually statistically called outlier but this study calls Dominant by Integration Group and Dominant by Non-integration Group. By preliminary analysis, the 4 temples' riverfront in the Dominant by Integration Group usually share some of the same characteristics; the influence of the temple's district cause high integration for these riverfronts but there is low real natural movement because of dead-end alley and the condition of the riverfronts are often bad. Whereas, the 3 temples' riverfront in the Dominant by Non-integration Group rely on effective area managements and the degree of publicness seems to be critically based on the temple's effort on the belief-related activities which make the place a specific destination. Lastly, Co-Movement Group usually shares characteristic of public boat services which make the riverfronts an interchange mode of transportation system, and in order to increase the amount of people within the places, the temples must also arrange the areas to support people's activities.

8 Further Study

The research will be further studied in details for selected cases from 3 main groups and 2 sub-groups on 2 main factors, the morphological related dimension and the socio-cultural and management dimension, to find the notion and the characteristics of the publicness of the temples' riverfronts and the influence of those factors on the level of the temples' riverfront of Chao Phraya River in Bangkok.

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06.103 - CITY IN TRANSITION: PORTO MARAVILHA URBAN PROJECT IN RIO DE JANEIRO-BRAZIL

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Abstract

This paper focus on the urban project in the central and port area of Rio de Janeiro, Brazil, Porto Maravilha. It is a project with many complexities, including both small and large scales. It deals with a diversity of actors and interests in a territory in transition.

The project covers an area of 489 ha, consisting of obsolete port structures, urban voids, historic fabric and low-income housing areas. They are different contents and urban fabrics that although contiguous, do not interact.

The Rio de Janeiro Olympic Games in 2016 and the 2014 World Cup in Rio de Janeiro created the opportunity to implement this project. A legal, financial and urban development operation was established to enable a project based on a public-private partnership that envisaged the additional construction of 4.7 million m2 involving 2 billion US dollars.

The project is based on sustainability goals, with road rehabilitation, infrastructure recovery and expansion, light rail vehicle (VLT) implementation, tunnel construction, and the implementation of street furniture and bicycle networks. The Porto Maravilha project also aims to enhance the historical heritage and promote the social and economic development of the region. It also aims to raise the quality of life of the population living in the region through urban requalification.

In fact, the legal and financial operation privileged a large business area with housing for the middle and upper classes. In practice, the government carried out the infrastructure works, and the waterfront was revitalized with the insertion of new leisure and cultural equipment. No action has been taken to improve the living conditions of the low-income population.

The permission to build buildings more than 50 meters high, which are foreign to the city's urban standards, means a break in the landscape. So far the private sector has invested shyly in the area, we still have uncertainties about the transformation of this space.

Keywords

Urban project, urban transformation, Porto Maravilha, Rio de Janeiro

1 Introduction

This paper focus on the urban project for the port area of Rio de Janeiro, Brazil, called Porto Maravilha, which was created in 2009, aligned with the preparations for the 2016 Olimpic Games in the city.

Rio de Janeiro's port area was set up at the beginning of the 20th century with the construction of the modern port in a landfill area, which was "glued" to the existing urban fabric, with a traditional configuration. Built to meet the needs of port activity at a time when Rio de Janeiro was the capital of the country, this new totally flat area is composed of large lots, where warehouses are built on land owned by the federal government (company of the ports and rail network). On the other hand, the previously existing urban fabric consists of small lots, with buildings for residential or commercial use on the existing steepy hills. It is a place rich in history, where the first favela of Rio de Janeiro appeared and where the slaves first set foot up until the end of the 19th century. These are different contexts and urban fabric that although contiguous, do not interact.

This is a pericentral area that, since the 1980s, when the port activities ceased, has been the object of frustrated proposals for renovation, seeking to recover dynamism through new uses. It is a complex area, close to the historical and financial downtown areas of the metropolis, of large dimensions and with particular land features.

The Porto Maravilha design foresees the construction of approximately 4.5 million m2, in a time window of 30 years, in an area consisting of obsolete port infrastructures, urban voids, historic fabric and low-income housing, that was for many decades outside the radius of operation of the real estate market in Rio.

The Rio de Janeiro Olympic Games in 2016 and the 2014 World Cup in Rio de Janeiro created the opportunity to implement this design. A legal, financial and urban development operation was established to enable a design based on a public-private partnership.

The design involves the application of a significant amount of resources, new institutional and financial arrangements to make it viable, assuming, for these reasons, a very particular character in the recent practices of urban planning in Rio de Janeiro.

It presents many complexities, including both small and large scales. It deals with a diversity of actors and interests in a territory in transition.

In fact, the legal and financial operation privileged a large business area with housing for the middle and upper classes. In practice, the government carried out the infrastructure work, and the waterfront was revitalized with the insertion of new leisure and cultural equipments.

This paper explores the considerations on the urban conceptions of the project and the proposed occupation patterns, revealing the degree of uncertainties involved in the renovation process of the port area. It also discusses the meaning of Porto Maravilha in Rio's urban dynamics, considering the trends of the current urbanization process.

2 Urban concept, patterns of use and uncertainties

Porto Maravilha is supported by a complex legal, insitutional and financial framework. The major instrument is Porto Maravilha`s Consortium for Urban Operations, enforced by a municipal Law in 2009. This Law defined a basic program for the use of the land with some important urban interventions – most of them for road works – and new urban parameters that enable construction densification in the port area.

The adopted urban concept for the Project does not present any substantial difference from the traditional Brazillian urbanism approach. It consideres the area as being a void to be occupied and, under this notion, the existing urban fabric is not fundamental in the design concept. The renovated site overlaps the existing one and, also, suggests, as it can be seen in the images of the new developments, the creation of a generic landscape.

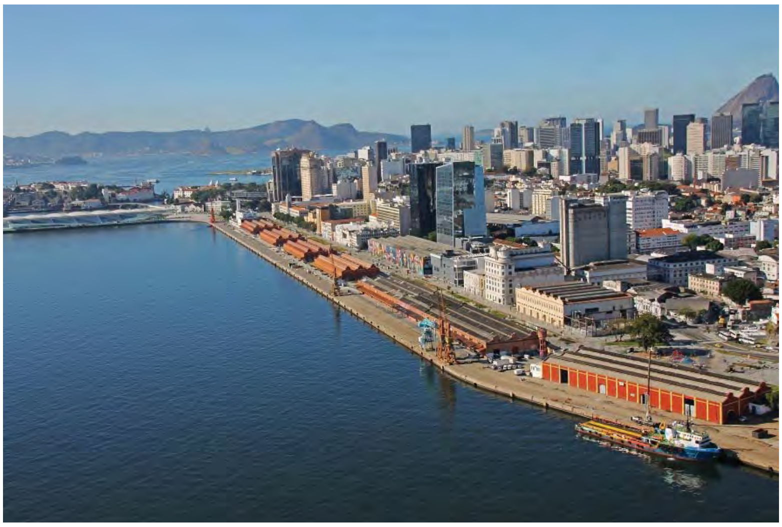

Figure 1. Porto Maravilha Water Front and generic landscape at Porto Maravilha.

The urban operation is mostly based upon the openning of some roads, local transportation system modernization, infrastructure implementation and the grant of new urban parameters. An ingenious financial arrangement comprising of public budget, selling of public real estate and fiscal benefits supports and guarantees the realization of the planned public works. This financial arrangement is under the denomination of a public private partnership, enabled by the creation of the Urban Operation Consortium (OUC). It is worth noting that the rationale for this instrument, in compliance with the Estatuto da Cidade (The City Bylaws, a federal legislation from 2001 that provides a set of urban legal instruments, which the Urban Operations Consortium is one of them) is to use private resources to finance basic urban interventions. Howerever, what it is seen in the port area of Rio de Janeiro is the opposite. The public sector paid for the infrastructure in the area, with minor participation of private investments.

2.1 Legal, institutional and financial framework

The Porto Maravilha project was object of not only specific norms that provide legality and legitimacy to the whole urban operation but, specially, it is structured on financial models and on tax exemptions.

The main urbanistic judicial instrument adopted is a public private partnership, called Urban Operation Consortium, OUC, which is not something new. Howerever, it acquires a different dimension through the Estatuto da Cidade (The City Bylaws), as it comes hand in hand with other instruments and with the creation of CEPACS (Additional Construction Potential Certificate) that are securities that would be issued and purchased regarding the asset of construction potential.

The first regulation for Porto Maravilha Project is the Supplementary Law 102/2009, that defines the area as of urbanistic special interest, providing for legal instruments and specific actions to make the urban project feasible.

This same Law provides for the foundation of the Company for Urban Development in the Region of the Port of Rio de Janeiro, CEDURP, as a joint enterprise in charge of the project management. As many other complex urban projects, it is necessary the establishment of a specific body to manage and deploy the project.

The Urban Operations Consortium is part of the Municipal Planning for Public Private Partnership – PROPAR RIO- regulated by the Supplentary Law 105/2009. Furthermore, the Law 5128/2009, provides for fiscal and tax benefits to foster tax revitalization, waivering, reductions and even, write offs. At the same time, it is established a consortium, composed by the major construction companies (OAS, ODEBRECHT and Carioca Engenharia).

In terms of property ownership, for the municipal government to be able to change the urbanistic parameters and the use of the land, a simple term of understanding between the federal, the state and the municipal governments was signed; so that the federal and the state governements could transfer their ownership in the area of OUC to the municipal government (where 62% belonged to the federal government and 6% to the state government). The municipal government represented by the CEDURP would manage the enterprise. This conciliation among the different levels of the government to provide viability for Porto Maravilha Project was essential and unique, because the greatest constraints to the realization of the project in the port area of Rio de Janeiro were the matter of ownership and the imbalance of interests among the public powers over the city.

In this regard, the perspectives of hosting the 2016 Olympic Games and the 2014 World Cup were the catalyzers for the land ownership flexibilization, needed for the realization of Porto Maravilha.

Another important aspect in Porto Maravilha´s model was the way of applying the CEPACs, the additional additional potential certificate, the acquisition of rights to build beyond the permitted municipal parameters by the real estate sector. The money collected by the public authorities, through offers of CEPACs, would be invested in infrastructure in the area. In 2011, in a single tender, all the bonds were acquired by Caixa Economica Federal (a public bank) using the resources of FGTS (Fund for Guaranteed Time of Service, an existing fund that guarantees the workers rights), hoping to resell them later on, to the private sector. Who anticipated the resources for the realization of the planned construction work in the operation was not the private sector, only interested in investing in the area without risks; but, indeed, the public bank. So, the FGTS and CEF (Caixa Economica Federal) were in charge of all expenses in this public private partnership, resulting in a total of US$2 billion dollars, for the payments of CEPAGs and for the public land in the area. It was expected the return over the investment through the sales of the CEPACs for the real estate market, which did not take place.

Figure 2. CEPAC's zones shown in yellow.

The FGTS was created for the worker´s social protection. If applied for other ends, exists the legal obligation to compensate it with part of the resources for the construction of popular housing, which it was not done in Porto Maravilha. Without the financial provisioning with social housing construction neither present in the municipal budget nor in the sales percentage of CEPACs, the Law 101/2009 was not in compliance with its own guidelines rendering social and economic benefits for the population affected by the urban operation and the proper use of urban voids. On the contrary, in 2009, many violent evictions in settlements in the flat side of the port region took place.

2.2 The urbanistic proposal

The Porto Maravilha urban operation has general objectives, it aims to provide urbanistic structural transformations, social benefits and environmental valorization. It refers to expansion, interaction and re-utilization of free spaces for public use as strategy for urban reconfiguration of the port area. However, the objectives of the actions are not clearly defined and the basic program for use of land does not allow a forecast of the type of occupation to be achieved.

The evaluation of the distribution of urbanistic parameters in different sectors and subsectors as defined by the basic program enables the identification of big parcels, where, effectively, it has been planned new urbanistic parameters, considering a substantial increase in construction potential. It is a stock of additional construction potential that can be used by those that purchase the CEPACs, Aditional Construction Potential Certificate.

The maximum utilization coefficient is very high, allowing the construction of 50-floor buildings in some subsectors, despite all the risks that they may bring to the local landscape.

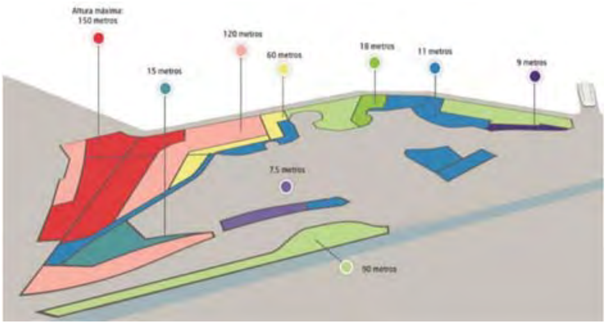

Figure 3. New buildings' height permitted.

Maybe, one can say that it is the area of real urban renovation of the operation. The others are the protected sites by heritage and the favelas, that are not the core of the operation but also suffer the impacts of the construction works and of the occupation of the area to be renovated.

Thus, it is important to report that during the works in Cais do Valongo, there were major historical findings that proved to be one of the most important port for entrance of slaves in the world. It was officially declared UNESCO´s World Heritage site, due to the efforts made by the National Heritage Institute, the municipality of Rio de Janeiro and the social activist movement against racial inequality.

According to the guidelines for the urban operation, the new urban pattern for the area will not be determined by a project that would drive the process of renovation and occupation, but by the total number of independent developments to be realized along time. In the areas where it is possible to acquire the certificates of the additional construction potential, the buildings will not be subject to restrictions in tipology, horizontal occupation, number of buildings in the lot and number of units per building.

The operation plan did not specified the distribuition of the occupation of the land by sector; a resource that is frequently applied to implement use diversity and to define the financial aspects, such as residential and non-residential uses that have different market coefficients. Even though, there are expected equivalence rates for residential and non residential uses for the selling of additional construction potential in each sector, the operations did not fix quotas. Without induction mecanisms, it is the market that establishes the use and, certainly, it will favour what is more profitable. As it happens, it was not established quotas for housing of social interest in the different sectors or for new developments. This element could promote social diversity in the future.

Without having clear guidelines to guide the occupation of the parcels, it is also impossible to see the re-design of public spaces as being the structuring element in the Rio de Janeiro´s port urban project.

In essence, the works foreseen in the operation are basically road ones. The main works are the two big roads that cross all the area to be renovated (Fig. 4) and the implementation of the Light Transportation Vehicle on tracks.

Figure 4. Mobility map

The implementation of Light Transportation Vehicle redefines the mobility in the perimeter of Porto Maravilha, connecting it to the regional airport in downtown Rio and to the Central Bus station, located at the junction of two major roads to the rest of downtown area and to the rest of the metropolitan region. The most important work is the Binário do Porto, and the expressway that replaced the Belt Flyover that was demolished.

The flyover bypassed downtown and the port, all along Guanabara Bay; it was built in the 50´s, during the peak of the so called highway fever in Rio de Janeiro (ABREU, 1987) and it was seen as one of the worst urban disasters in carioca urban history. For some decades, its demolition was conjectured but as it was there and important for the city´s road system. The main justification for its demolition was its impact in the local urban space and in the landscape of the city.

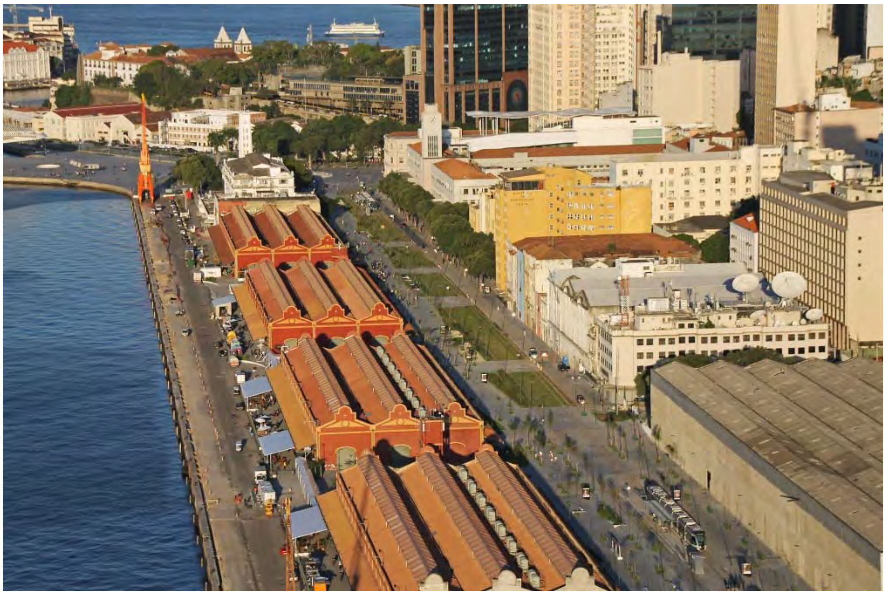

Figure 5. Water Front without the flyover.

Figure 6. Porto Maravilha in the Olimpic Games 2016

Although, paradoxally, the operation admit new urban parameters that, depending on the sector, it would result in the construction of new buildings, 90, 120 or 150 m high. Should these 50-floor buildings be built, although not part of the urban tradition of Rio de Janeiro, they will probably create obstacles to the perception of the mountains that frame the central area of Rio de Janeiro and, that since 2012, is part of UNESCO´s World Heritage site in the category of cultural landscape.

2.3 The perimeter of the operation and the future of its occupation

The large perimeter extension of Porto Maravilha (near 500 ha) and the expectations in building more than 4.5 million m^2, of which 4 million m^2 would be of additional construction potential are concerning factors about the development of the project throughout time.

The comparison with some well-known international experiences provides a good understanding of what these numbers represent.

The project for revitalization of the port area in Buenos Aires, Puerto Madero, encompasses a large area along the banks of River de la Plata, directly connecting it to the downtown area of the Argentinian capital. Frequently, it is seen as a reference for Rio de Janeiro due to the fact that is also an experience in a latinamerican city. It began in 1990, with a perimeter of 170 ha. The amazing transformation in Puerto Madero produced a new high-end business, tourism and housing hub, occupying no more than 2.25 million m^2, from 1992 until 2011.

Two other large waterfront renovation projects, Canary Wharf in London and Battery Park City in New York City, with similar sizes, present more modest numbers than Porto Maravilha. Both sites have approximately 40 ha and with almost 1.5 million m^2 of construction in 20, 30 years.

The Paris Rive Gauche project, with the intention of renovating the large area in the east part of the French capital city, has 130 ha in perimeter and its initial program was to be 2.4 million m^2. It started in 1991, and according to official data, about 60% was built by now, producing a meaningful transformation in this part of the city.

The perception of building more than 4 million m^2 may seem excessive for a single operation, with the aggravating factor of not having a clear strategy for this to be accomplished; it is also necessary to consider that the realization of all this potential may have bad spatial outcomes. Besides the height factor, already mentioned, being permitted for new buildings, this would also represent a very high density of buildings, more than 18.000 m^2/ha in an area of 220 ha.

From the urban space standing point, Magalhaes (2012) shows that the renovation of the port area of Rio de Janeiro is “in the hands of cold indexes of utilization of land and subject to the needs of the capital that is being invested for its development”. In the case of Porto Maravilha, the action of designing it and the strategy for redesigning the city became of less importance.

3 The renovation of the port area and the city of Rio de Janeiro

Besides the uncertainties of the outcomes of OUC Porto Maravilha in the existing urban environment in the port area, also, its impacts in the city are unknown. Other ongoing actions in the city point out into the opposite direction, such as the policies of recentralization of urban development, the opposition to expansion trends and dispersion of urbanization that Porto Maravilha project may signify.

The presence of the real estate industry in Rio de Janeiro, in Barra da Tijuca and in western zone, during the recent decades, is still strong. It seems that OUC Porto Maravilha presents itself as a new and available for possible new markets but, yet, without strongly interfering with the existing market.

On the other hand, in recent years, it has been seen a growing demand for new commercial spaces in central area of Rio de Janeiro, that was being supplied by many enterprises being launched between Cidade Nova and Praça XV (Porto Maravilha adjoining areas) through retrofitting some buildings in Downtown Rio and, surely, pressing into some National Heritage protected areas. The start of OUC Porto Maravilha interferes in this movement, absorbing some developments. It is possible that there may be demand for new developments in the port area, but hardly it will meet the volume envisioned by the operation. Unless the expansion into the port area will happen due to a process of stripping the consolidated downtown, but it would be harmful to the city.

4 Final considerations

In this paper, we sought to reflect on the significance of the renovation process in the port area of Rio de Janeiro and on what the urban project represents. Gigantism and the lack of a clear strategy over time and the adherence of the various agents involved in the OUC Porto Maravilha project, suggest a scenario of many uncertainties regarding its implementation process in the medium and long terms. The possible impacts of this project in the overall dynamic of the city are also not clear, even though it has been celebrated by its promoters as the biggest private-public partnership in the country, as if this were a goal in itself.

The actual realisation of the additional constructive potential foreseen for the port area by the OUC Porto Maravilha will hardly ever fully happen. If so, the urban outcome will most likely be disastrous. If not, in theory, there will be a suboptimal use of the already installed structure, and the onus of having acquired all of the stocks of the area's additional construction potential, the acquisition of CEPACs, will be left upon Caixa Econômica Federal, without being able to sell them entirely in the market.

The urban operation does not effectively establish a process of renovation of the port area that would be able to deal with different scales of intervention, different timeframes, different social actors' interests, all of which are important issues for the implementation of urban projects (TSIOMIS and ZIEGLER, 2007). Conceived in a static way, the project covers up conflicts, does not clearly establish a strategy for occupying the area of intervention over time and risks being altered at anytime to time to fulfil occasional interests.

In spite of everything, it can perhaps be said that a scenario of uncertainties concerning this operation would still be the most favorable one to the city of Rio de Janeiro, for it leaves open the possibility to review the on-going project. Preferably, leaving aside empty images and formulating an urban project that promotes social diversity and different uses of space, combining good architecture with quality public spaces.

Acknowledgements

We gratefully acknowledge the support of CAPES - PrInt, FAPERJ and CNPq to carry out this work.

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06.104 - DESIRE AND CIRCUMSTANCE OF URBAN DENSITY: TIGHTNESS AS POSITIVE DENSITY IN ASIAN CITIES

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Abstract

Is urban density to be desired or is it merely the outcome of external forces? What makes a hyper-dense environment desirable or unacceptable? Such questions were examined in the exhibition 'Super Tight' held in Melbourne this year. This work developed the term 'tightness' with the aim of placing a qualitative dimension on density and to view it as a desirable. This aim is premised on the fact that procuring density is a critical task of reducing the environmental footprints of cities, and that modern western cities, in particular, struggle to overcome their legacy of dispersed planning - both in policy and practice. The Supertight project establishes 'tightness' as a counterpoint to density as volume, and the density of the Asian city as a counterfactual to models of urban dispersal found in Australian cities. Such cities have bottom-up social, economic, political and other trajectories which drove the tightening of their urban fabric; yet in many cases the outcome has been a vibrant and diverse urban form. The emergence of extremely tight, or closely integrated living and working environments in cities has coincided with the development of technologies that have brought people, and institutions, into a state of closeness previously unimaginable. Tightness, closeness and connectivity are conditions, that the despite the corresponding trade-off of personal space that are inherently desirable conditions. To what extent can dense, tight, and constrained urban conditions be considered the outcome of this desire for closeness and connectivity – rather than simply the by-product of uncontrolled human settlement.

Figure 31. Image of the Supertight exhibition showing drone footage of Saigon urban fabric.

Keywords

TIGHTNESS, DENSITY, FOOTPRINT, PLANNING, DESIRE, ARCHITECTURE, DESIGN

Topic: T6 Urban Ecology and Climate

1 Introduction

Is a very high density city desirable? Does a high density city as we find it, exist in response to circumstances of economics and politics, or to the desires of its inhabitants? Is it merely a by-product a measurable after-effect, or is it a quality itself of a city? To frame these questions differently and unpack them further: If urban density is usually an outcome of external circumstances, could it occur without these circumstances of forces driving it; could it be the outcome of social desire? Or: If high urban density, or a hyper compact city is desirable for a number of urgent practical reasons including efficiency or land and resources use, then could other desires persist beyond these drivers of a tight footprint?

We have used the term Tightness, loosely, to describe the coalescing of physical density and close social organisation; a desirable fit between the two. That term might be used to flip the logic of density, and make it the object of desire without limit. It is a term that was tested by our 2019 design exhibition Supertight (RMIT DesignHub Gallery)[i] and depicted through the qualitative observations of designers in Asian cities. Here as then, we contend that density (and urban dispersal for that matter) are generally seen as the `natural' result of external material forces and that the task of urban planning has been to control density and to limit it. Even where the city planner's acknowledged role has been more recently to sustainably control sprawl, it is tempered by a limit; a memory of the dangers of the hyper dense or overcrowded. It is a logic built into 20th century design which lingers. Could that logic be reversed, and a 21st century desire for the tight city mean a desire for more tightness, with minimums and not maximums? In the knowledge that economic and social forces are driving dispersal, could the aim of planning be to facilitate density rather than control it? Could the urban planning conceive of minimum density, its role being to satisfy the desires for closeness and the compact?

Figure 32: Super Tight Exhibition RMIT Design Hub Gallery 2019. Photo by Vicky Jones

2 By Product Density in Europe: Paris and Barcelona

When very dense cities are usually seen as the convergence of material circumstances – they are conditions which no longer exist. One study examining Europe's urban density, described in Lessons from Europe's Densest Neighbourhoods[ii] identifies the highest density neighbourhood in each European nation and ranks them for inhabited density. In doing this it also identifies a particular period, 1850 to 1914 when nearly all of the most dense urban quarters were constructed. A convergence of three circumstances formed these 19th century hyper dense cities. First, rapid industrialisation brought large urbanising worker populations together. Second, construction technologies, including elevators and concrete frames allowed taller building, and third, fast metropolitan transit systems had not quite arrived so walking was still a necessity. Walking from the apartment to the factory nearby was a recipe for a very dense city. Almost no urban environments constructed after World War One have achieved the density of that period, and most have reduced in density since that time. Most of these neighbourhoods too were described as fairly undesirable when they were constructed (at least from a social status perspective). They have since become highly desirable through gentrification. Of the neighbourhoods ranked, those in Barcelona and Paris were the most dense by a significant measure. Global tourists and new urbanists alike, might also agree that these two are among the most desirable cities on earth.

Conversations on such great cities often get stuck with the proposition that they are desirable but not replicable. Conversely places like Paris and Barcelona are saddled with the burden of being a template for urban density. That is, density should be like this. Rapidly changing Asian cities become important in overcoming fixed or historical images of the hyperdense city; experiencing explosive growth more recently and producing different or varied responses. The idea of the uniquely desirable model of density (European) which is not replicable in different historical or cultural circumstances is challenged by the most dense 21st century Asian cities. The site division in Tokyo driven by inheritance taxes driving micro grained villas, or the taxing of street width driving the Vietnamese tube house are similar circumstances spawning by - products. How to replicate the desirable product without these conditions?

In considering the gentrified 19th century city, untangling the distinction between desire and circumstance may no longer be necessary. It may be no longer relevant to ask: what causes very dense urban environments? It may be more useful to ask: Which kind of urban environments which now exist are the most desirable? Or: Are cities less desirable as a result of being more dense? How does this compare with the desirability of low density cities?

3 Density as Excess and Lack: Manhattan and Mumbai

The contradictions of hyper density, both excess value and lack of resources converge as a place which is out of control. The twin images of Manhattan and Mumbai serve as a diagram of this, and the planner serves a discipline to these out of control desires. In that logic, the compact (walled) city is no longer necessary. The protection of close proximity is now entirely superseded by peace, or by modern warfare. The dispersed city is healthy; spatialising sanitation and overcoming the epidemic diseases of proximity. Facilitating the infrastructures of sanitation, but also managing the moral problems of overcrowded working classes become a modern preoccupation of planning. Managing uncontrolled desires for closeness with the antidote of fresh air and nature.

Density grows from uncontrolled capital speculation- the profit motive drives high rise development and the shrinking of space to accommodate expanding land value and construction prices. Yet density grows too from uncontrolled poverty; caricatured in Mumbai slums or Lower East Side tenements. This is simply the flipside of capital speculation; of maximising space while responding to scarcity. Both circumstances share the qualities of being uncontrolled and unplanned; being purely circumstantial rather than desirable; being excessive. Describing the excessive scarcity of space masks the desirability of the tight environment. The Manhattan apartment in the centre of hyper-dense affluence; or the hyper dense informal favela, each have qualities chosen over other less desirable options.

4 Tightness and Volume

Urban density is a measure of inhabitants not building volume, and yet in affluent or developing cities the two are conflated. In contrast to the scarcity of space driving compression, urbanisation amplifies the footprint of a growing population simply by growing in prosperity and expanding the square metres of built floor space per person. Modernity adds both additional area to the private home and adds numerous public facilities which occupy space in the city, improving amenity, and also accelerating the square metres growth per person. Ho Chi Minh City's dense core (its District One) is a case typical of this condition, where its 19th/ 20th century hyper-density has been contained in a low-rise envelope through a very low square metre per person. The three to five storey fabric of Saigon has been counted as some of the most dense in the world. As the explosive growth in the city's economy redevelops its central district to a business district, the built volume increases and the population per area diminishes. Office and retail space displaces dwellers and like many rapidly modernising cities, the high rise expansion of the dense volume parallels the dispersal of its inhabitants.

5 Tightness and technology

The promise of 21st century technology is the miniaturisation and the condensation of things; in architectural programs and space it promises an urban scale compaction akin to the shrinking of electronic devices. The automation of deliveries, of ride sharing in autonomous vehicles, urban agricultural techniques, virtual communications, home 3D printing; are among a suite of technologies which both disrupt and streamline. Each of these have the potential to compress the footprint of a city, and to create human density with far less built area. With the vast floor plates of factories, of supermarkets, office space and car parks becoming superseded, their urban built volume evaporates along with the space for infrastructure that supports their footprint.

There is little doubt that this image of a highly tuned, miniaturising technology is desirable and attractive, just as the urban tightness that could result is. Our interest in urban density as a desire and our use of the term tightness, relates less to the efficiencies of technology, and more to the creation and enlarging of social bonds through urban proximity. The relationship between the measurable physical density of a city and its social tightness is complex, yet social bonds are widely viewed as a desirable quality of cities. Proximity is a precondition for a socially desirable settlement; even affluent suburban properties are described through access to the social network of a neighbourhood. All cities no matter how lacking in density are defined by some condensation of settlement, and the series of desirable connections. which are. The technologies that could bring us closer together physically as well as virtually, might recast our maximum density, and eliminate the objects that stand between us. Those objects are both redundant spaces and redundant controls. It could simply be then that a tightening of the city is a natural desire, and it is planning controls that has artificially thwarted that.

Another persisting dream of modern technology is the belief that it will bring social liberation; that through its egalitarian access it might overcome class or disadvantage. That is coupled with a dream that this liberation strengthens social bonds. Yet, affluence remains the driver of a dilated footprint. Greater affluence usually corresponds to a larger physical footprint, and larger physical separation. More economically equal societies have been shown to be more socially cohesive.[iii] The complicated relationship between the socially tight and the physically tight is nevertheless crucial. The task of the tight city is de-coupling density from poverty, scarcity, exclusion or conformity. This task may be bundled in technologies and may be observable in the world's tight cities right now. Successfully living in a very tight environment has the capacity to shape behaviours and desires, and the evidence of existing dense and successful cities is as powerful a measure as planning policy or advocacy.

Figure 2: Archie Pizzini, Rasquachismo Series, 2017, Vietnam

Figure 3: Sue Hajdu, Urban Documentary Vietnam Series, 2016, Vietnam

6 Cities are Already Tightness: Saigon, Tokyo, Beijing

The existence of cities is qualitative evidence of the value of density. They prove what density looks and feels like in its variations. They are the concrete intersection of desire and circumstance, and evidence of density beyond what is ever planned. That is the tight city as found, always exceeds the planned or projected city in the intensity of its occupation. The images of tight cities made for the Supertight exhibition are observations of qualities; evidence of their circumstances, and projections of a desirable city.

Considering the photographic images of Ho Chi Minh City (Saigon) by Archie Pizzini (figure 2) and Sue Hajdu (figure 3) In each case these are documentary records by migrants to Vietnam, curated over a number of years and infused with nostalgia and romance. Each captures the qualities of closeness, of intimacy in Vietnamese cities, and also of the ingenuity and care in using or shaping the urban environment by its inhabitants. Both capture the intense but subtle adjustment of the physical surroundings. These are photographers witnessing the transformation of Vietnam's urban environment since the 1990s and asserting the value of an urban culture which is well adapted to its tight footprint. Desiree Grunewald, a collagist working in the same city, makes real fiction from Saigon's alleys. (figure 4) Here, the montaging hand compresses space, literally, by overlapping its material; but the montaging eye has identified this tight urban environment as already full of moments of elision and occlusion in its overlapping. They are already a montage, sometimes indistinguishable from the cut up version. For her colleague Andrew Stiff, with the medium of video, observing these same Saigon environments is an act of abstracting and amplifying the qualities of visual and occupied density. The filters of blurring, of tightening the frame, of layering, serve to heighten the allure of the everyday and close-up life of Saigon's streets.(figure 5) What Andrew Stiff terms the `creative archive'[iv] is both a desired recording of the real, and a tool of advocating for the city he records. There is in this group of observations, a dreamy affair with the city, but also an unflinching stare at it. There is also an assertion, through the depictions, that what exists in the famously wild city is not chaos, but a highly considered and networked orderliness.

Figure 4: Desiree Grunewald, Capasytelonescua, City Collage Series (photographic montage) 2017, Vietnam

Figure 5: Andrew Stiff, Hem Walk Series (film still) 2018, Vietnam

The Shiozaki Lab drawings of Tokyo tightness stand similarly at the junction of circumstance and desire, and in their analytical yet narrative linework, refuse to differentiate between the two.(figure 6) The scenes of Tokyo life describe its dwellers accepting and contending with everyday life, but also pursuing the pleasures and freedoms of close sociability. The Cherry Blossom festival crowds are alongside the daily commuter crush, and indeed all functions of the city are set alongside each other, sometimes incongruously, sometimes overlapping seamlessly. The least desirable of these, the train carriage is also the most monofunctional, and the most directly the result of the segregation and dispersal of urban life. The city Shiozaki describes, is shaped by a set of behaviours that temper desires and that channel them toward a collective negotiation with tight living. Tohru Horiguchi's video of the Bingo bar in Osaka takes a particular circumstance – the absence of chairs as the subtle spatial disruption and tightening. (figure 7) Like an experiment to test behaviourial effects, the normal functioning and seamless adaption in uncanny. What if anything is lost; is something else gained in this omission? The descriptions in Shiozaki Lab's drawings are augmented with descriptions of thoughts by their inhabitants- manga thought bubbles letting us see invisible thoughts. It is almost possible to imagine the hidden thoughts of the standing men of the Bingo Bar.

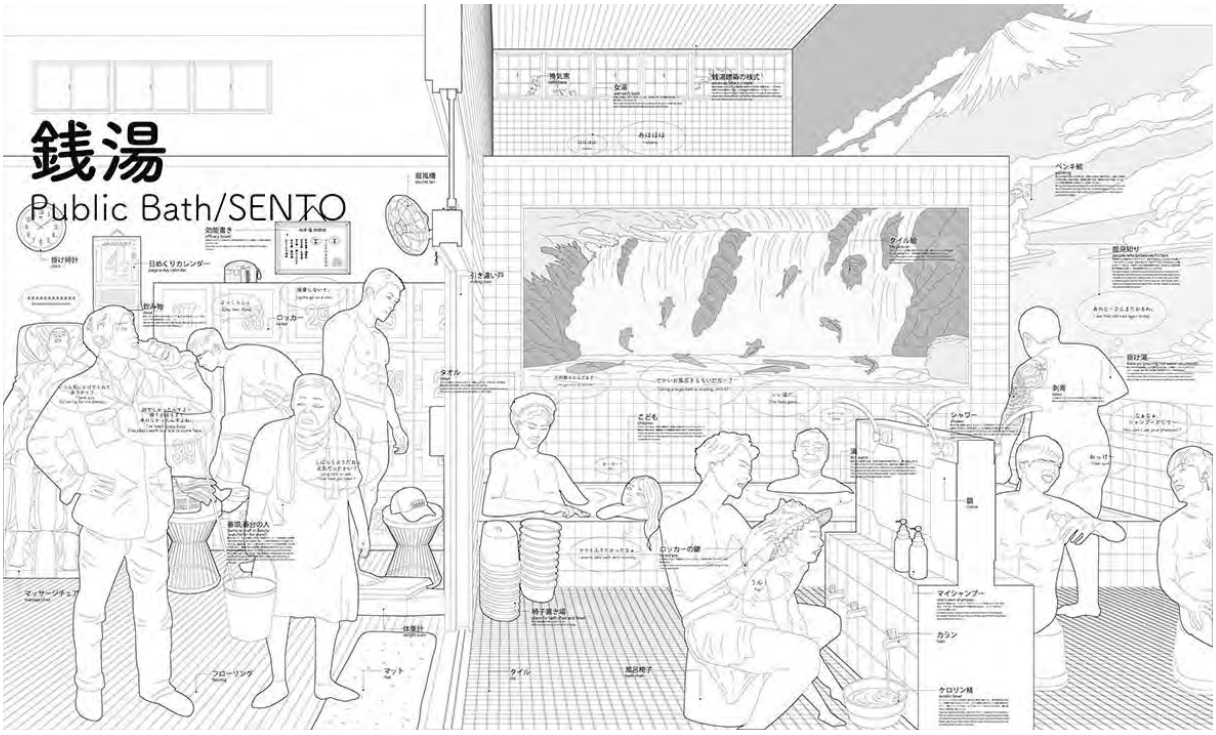

Figure 6: Public Bath/Sento (2019). Shiozaki Laboratory (Tokyo Tech).

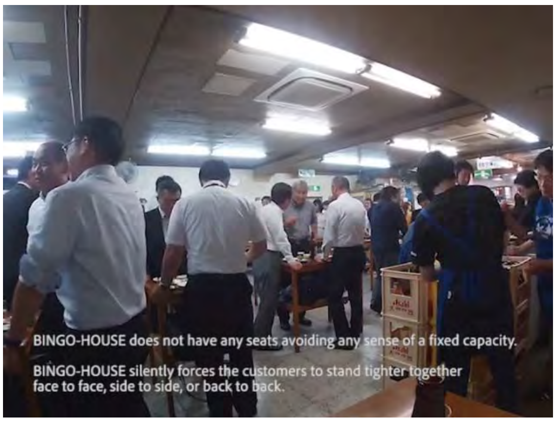

Figure 7: Tohru Horiguchi, Bingo Bar,(film Still) Osaka, 2019

The Diamond Village series by Drawing Architecture Studio is part of a body of work which tackles the full intensity and complexity of the tight city, in this case Beijing, through line drawing both fantastic and forensic. (figure 8) Simultaneously zooming out to capture the dense city as an object and zooming in forensically to watch individuals in the dense maze, the drawing is also simultaneously above and below its spaces, inside and outside. The effect is dizzying and fantastic and yet accurately transposed from observed conditions; the lively, peripheral and less planned piece of Beijing. The drawing style is crucial, depicting as it does, a saturated and full urban environment, rendered as a benign, cartooned video game. It is an aesthetic of the busy and saturated and lively. Unlike the often evacuated dystopian visions of Archigram, Superstudio or the Metabolists, the future in Diamond City is teeming and populated. It is a transposition from circumstance to desire. That transposition from circumstance to desire, is present in all of the fictionalised observations of these Supertight Asian cities. It is a form of mental gentrification, just as the gentrification of Parisian work quarters established their desirability. The images of the Supertight establish the case for the desirability of the environments and the intensity they describe; 21st century Asia.

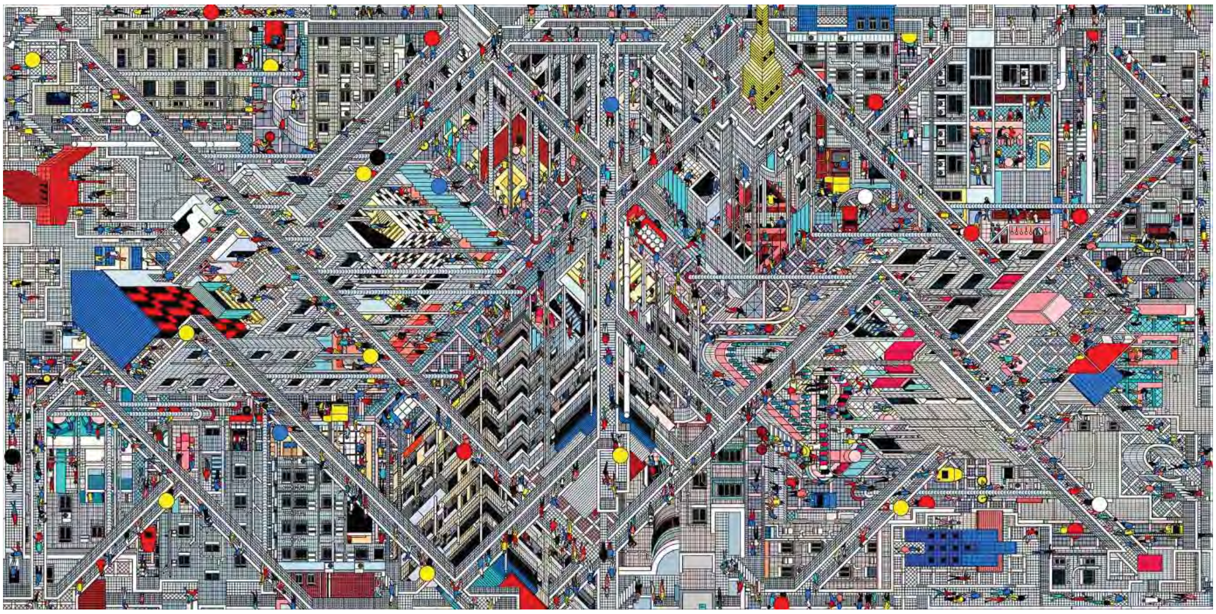
Figure 8: Diamond City, Drawing Architecture Studio, Beijing

The New Discipline of Planning the Tight

If the conditions for very dense cities existed in the 19th century, then those conditions exist now, in a very different way. The environmental case for a tight footprint is compelling, yet it requires a reversal of practice, and perhaps a choice to adopt that reversal. Desire can co-opt that choice and overcome its resistance. We could imagine that the discipline of urban planning might take on new tasks; a new set of aims. We could frame this as the third stage or era for the centuries old project of urban design. First: the city made for protection; (a walled fortress); second, the city made for health (the zoned and dispersed system of the 2oth century, modernist or Garden City, or the Ville Radieuse). Third, the city as a Tight system. The conditions for the Tight city are transforming; the problems traditionally associated with crowded cities have mostly disappeared, (with post-industrial sanitation and medicine), and we suffer from isolation as much as from overcrowding. The imperatives to tighten our footprint related as it is to our carbon footprint have reversed the paradigm of limiting density and facilitating dispersal. The role of Tight urban planning in this imagined third era is to facilitate hyper density, to reconcile the impulses of the previous two eras and to capture new techniques of compressing urban programs. The role of this planning too, is not the formulation of a blueprint for new cities, or a justification for erasure, but an adjustment, a recasting and backfilling of all the cities we have. For this era, extreme density is a natural desire, and it is not the task of urban planning to thwart it.

In the context of ecological threats to our existence, the stakes are enormous, and a reversal of current trends of accelerated dispersal is required to realise a Tight era. Sprawling cities remain a prevalent model of aspiration and of affluence. Some cities busily grapple with ways to reverse their dispersal (or to maintain their tight core) while at the same time other fast growing cites in Asia are adopting 20th century urban models; either drastically dispersing their density or constructing new towns on a dispersed model.

Making the case for super compact or dense cities is pointless unless it is coupled with desire; with a tight city as a desirable aspiration. If high density is seen purely as the consequence of scarcity (whether that scarcity means poverty or means extreme land values); then it continues to be something to manage, control or limit. Images of density are stereotyped by overcrowded people or overcrowded architecture; by Mumbai’s slums or Hong Kong’s bundles of towers or. Perhaps the image of tightness should be the crowded bar, the street festival, the teaming market; the image of celebrating closeness in events and everyday life. The supertight city images, the transposition from circumstance to desire, are m part of that process. The point of the term tight, is to inject desire into the problem of the urban footprint.

Acknowledgements

The organizer gratefully acknowledges the work done by Programme Committee and Lecturers of the International Conferences S.ARCH-2020 for efforts done for the success of this event.

This research has been supported by the RMIT University School of Architecture and Urban Design SRIC committee.

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06.105 - COMPARATIVE STUDIES OF URBAN SURFACES, VEGETATION, AND MICROCLIMATIC COMFORT

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Abstract

Landscaping and the use of vegetation has been recognized as important means for microclimatic modification. This paper focuses on the cooling potential that vegetation can provide to spaces adjacent to houses. Microclimate and building thermal performance can be significantly affected by the modification of air temperature, solar heat gain, longwave heat gain and heat loss by convection.

In the outskirts of Brasilia, the capital city of Brazil, the process of urbanisation has been one of "land clearing", which means all the vegetation and its natural covering are removed in an irresponsible attempt to simplify the urban implementation. This process of clearing the land has enormous impact on the environment leaving the land vulnerable to erosions, lack of shading, and a lot of dust. A major problem is the castigating excessive solar radiation. More importantly, the combination of the devastated land with large asphalt areas produces hot and dry environments. On the other hand, Brasilia itself is one of the greenest cities in the world with an estimate of around 100m^2 per inhabitant. With this in mind, this paper presents comparative microclimatic studies of single family row houses in low income housing settlements, deprived of all vegetation, with middle class row houses in the centre of the garden city which is considered Brasilia. Measurements and data were collected, urban spaces analysed, and thermographic pictures taken to feed and ground the comparison.

This paper promotes the idea of microclimatic design as an essential issue of environmental architecture. In this sense, trees are of great significance, not only for its visual effect alone, but by promoting an unparalleled experience and awareness of life and space. Trees inform, improve, and upgrade spaces and lives, and therefore are an essential element in designing architecture. By taking into consideration site conditions including its vegetation, addresses the idea of 'continuity' and also 'contextualism', words that define sustainability. It shows that architecture is not constrained by environmental planning, nor economically dependent. In fact, it makes the architect more aware of the surrounding qualities such as visual and environmental comfort, contributing to the essential beauty of space, building, and environment.

Keywords

Urban spaces, environmental comfort, microclimate, vegetation, albedo.

1 Introduction

The presence of vegetation strongly influences the urban climate, establishing strong contrasts between surface temperatures. Studies carried out with vegetation in urban microclimates focus on: air temperature reduction, atmospheric pollution reduction, air humidification, wind control, and urban heat island mitigation [1].

With the growth of cities, the natural soil coverage and trees decrease while built-up areas and impermeable surfaces increase, therefore reducing the shaded areas and humidity, whilst causing the consequent increase in surface and air temperatures. Thus, soil impermeability, or the reduction of water infiltration capacity, is directly related to the reduction of evapotranspiration due to tree loss. Evapotranspiration is the combination of the loss of water to the atmosphere through the transpiration and evaporation of greenery. It is the biggest mechanism through which the trees contribute in lower urban temperatures, helping the "oasis phenomenon". Trees can also mitigate the greenhouse effect, filter out pollutants, buffer noise, prevent erosion and have a calming effect on people. The performance of vegetation depends on its intensity, shape, dimensions and location (2).

The present work discusses the influence of vegetation in the microclimate as a mitigating actor in the residential urban spaces of Brasília. The research focuses in the capital city of Brasilia and its neighbouring satellite cities. The capital of Brazil was inaugurated in 1960 and has become a landmark in the history of urban planning. Brasília is currently the largest city in the world that did not exist at the beginning of the 20th century, with an estimated population in its metropolitan region of 3,050,000 inhabitants [3]. The rapid population growth consequently lead to great urban expansion, forming peripheral nuclei (satellite cities), which are interconnected with the capital city core, also known as Pilot Plan, but very different in terms of urbanism.

2 Objectives

There is a vivid contrast between the Pilot Plan and its satellite cities. In the Pilot Plan, urban scales are part of the spatial configuration, such as the large green areas between buildings. On the other hand, in satellite cities, the urban expansion in its majority, is marked by the lack of planning, high urban density, soil impermeability, absence of vegetation and public spaces.

In view of this, the objective of this study are:

• Investigate the influence of vegetation on the microclimate of residential urban spaces;

• Analyze the level of environmental comfort in areas with a lot of vegetation as well as without, comparing urban fragments between residential blocks of the capital's Pilot Plan, and the neighboring urban expansions of Riacho Fundo II, Structural City and Sol Nascente;

• Estimate the mitigating potential of urban vegetation on the local microclimate based on the literature review and case study;

• Evaluate other uses and potentials of vegetation.

3 Methodology

The selection criteria for defining the study areas was based on the contrasts in the amount of green areas between the different Administrative Regions. In the Federal District, which encompasses all the Administrative regions, there are areas of both spontaneous and planned occupation, and these, in turn, have distinct designs and varying proportion of urban occupation. In addition, the choice took into account the building typology, all single family homes. In this context, four areas were selected: 708 South (Pilot Plan); Riacho Fundo II; Structural City; and Sol Nascente. After defining the areas, the second step of the analysis dealt with the identification/classification and mapping the area. The intention was to characterize the urban vegetation present in these areas and the building's roofing materials.

The third step was the analysis of the urban thermal field itself. Part of the analysis of the urban thermal field was done using images obtained with a thermal camera, with photos from the pedestrian point of view, at critical heating spots. In addition to the images, temperature, relative humidity, and carbon dioxide concentration were measured for comparative analysis.

The last step was to compare the results of the four different areas, and from this information correlate the vegetation, the covering materials and the temperatures, in order to sustain the relationships between the analysed variables and the urban thermal field.

4 Case Studies

The Pilot Plan area, where blocks 708 South is located, is basically an area that is part of the origin of Brasília as a "garden city". The other study areas are further away from capital's city centre, and therefore are not part of the original urban design for Brasilia. Estrutural is approximately 15 km away from the Pilot Plan, Riacho Fundo II is approximately 23 km, and Sol Nascente approximately 32 km from Brasilia. They are considered peripheral areas, where urbanization took place after the occupation of the Pilot Plan, to meet the demand of the low-income population that was unable to settle in the new capital area due to the higher speculative value of the properties of the "garden city". The constantly increasing values consistently drives the lower income population to move to more remote regions, without an urban project that contemplates the use of vegetation as was done with the Pilot Plan. As a matter of fact, these new settlements barely have any urban planning, other than that of land clearing to make way for simple and quick grid-like plot division. On the other hand, the residential area of 708 South, is located on the south wing of the airplane shape of Brasilia. A city planned by Lucio Costa which has in its bucolic scale an integral and central part of its design.

Figure 33. Study cases locations

Figure 2. Residential blocks of 708 south, located in Brasilia´s Pilot Plan, the garden city

Figure 3. Cidade Estrutural, 15km from Brasilia

Figure 4. Riacho Fundo II, 23km from Brasilia

Figure 5. Sol Nascente, 32km from Brasilia

With the exception of the Pilot Plan in Brasilia, all other áreas are devoid of vegetation.

5 Microclimatic Analysis

The city's environment suffers from both the pre-existing climate and the climatic changes resulting from urbanization. Vegetation contributes significantly to the establishment of microclimates. The photosynthesis process itself helps to humidify the air through the water vapour it releases, helps to decrease the temperature of the air, absorbs energy, and favours the maintenance of the oxygen-carbon dioxide cycle essential for air renewal. In general, vegetation tends to stabilize the effects of the climate on its immediate surroundings, reducing environmental extremes [2].

Pictures were taken with a Flir thermographic camera for analysing the influence of vegetation on its surrounding microclimate. These images allow to clearly see the most heated points in the thermal field of the area. They also allow to observe the temperatures of urban surfaces from the pedestrian's point of view, and correlate with its thermal sensations.

Images were taken from all the four different residential areas between September and November, at three different times of the day: 9:00 am, 3:00 pm, 8:00 pm. The pictures were photographed in specific areas, from the pedestrian point of view, at the critical points of heat exchange.

At 708 South, the areas chosen was: a residential street composed of buildings with up to two floors, consisting of cementitious materials, traditional masonry, ceramics, granite, steel and glass. The street itself was coated with bituminous material, with the presence of small well spaced trees. Adjacent to this street, there is a line of large trees, a concrete-covered walking path, and a large lawn interspersed with islands of concrete floors. The neighbouring W3 street, is a large 6 asphalt lane avenue, and also a central dividing walkway with large canopy trees. In order to analyse the effect of evapotranspiration and respiration of vegetation, in addition to the images, data on temperature, relative air humidity and carbon dioxide concentration was measured *in situ*.

The characteristics of temperature and humidity were overall similar and homogenous around the area, mainly due to materials with high emissivity albedos. The big difference between the house street and the adjacent avenue was in terms of the concentration of carbon dioxide. It remained higher during the day due to the high flow of motor vehicles. Although the temperatures recorded for the three spots were close, it was still noticed that in the green areas, the thermal comfort was much greater due of the shading of the tree canopies.

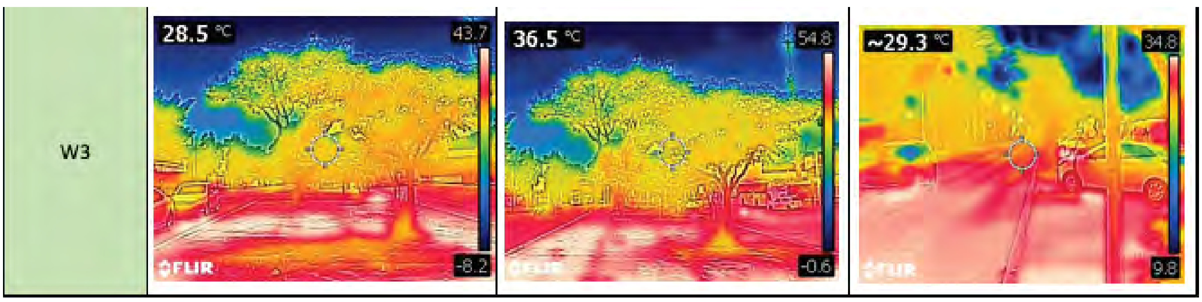

Figure 6. Thermal photos of the 708 south area, in the Pilot Plan of Brasilia, the greenest area

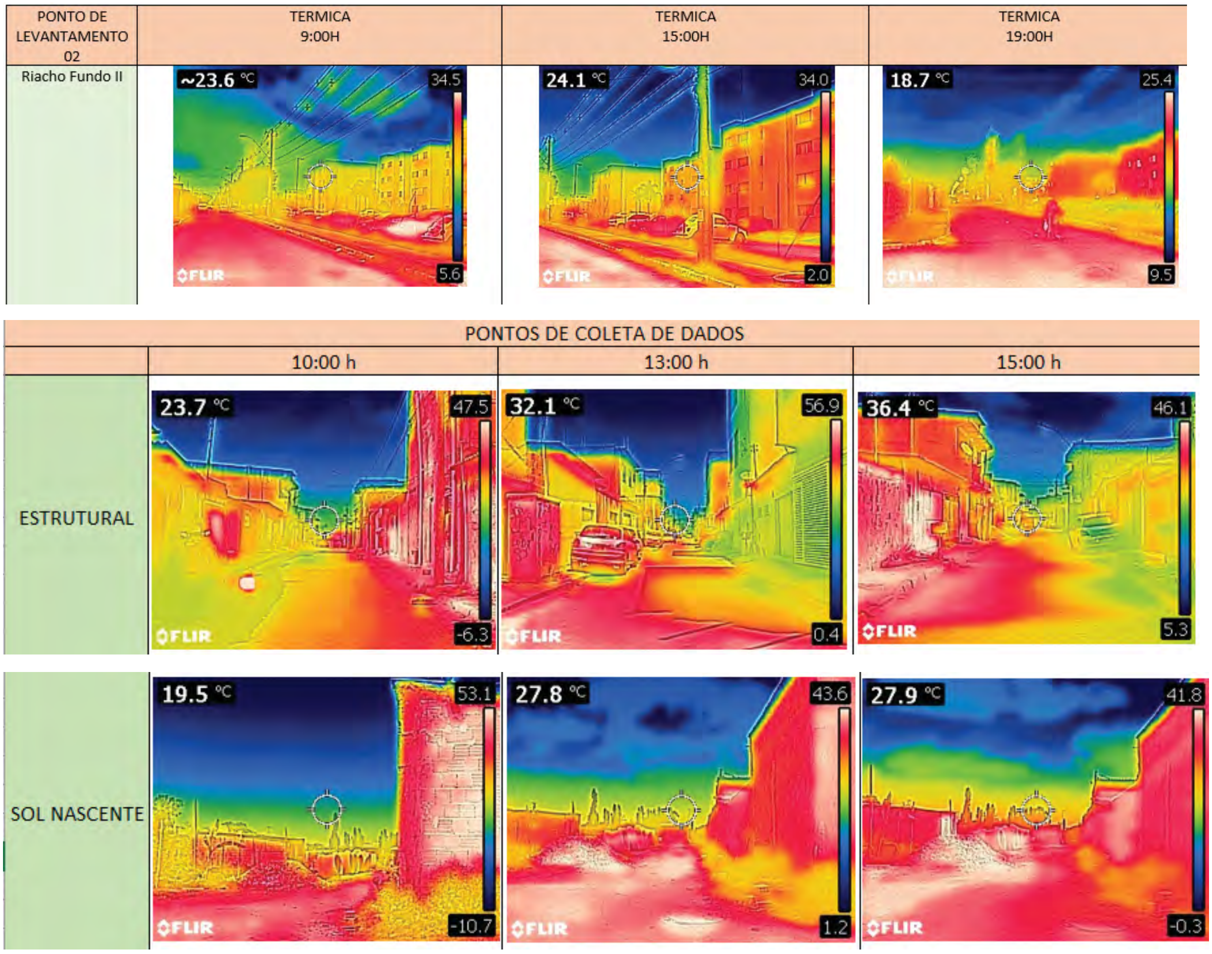

Figure 7. Thermal photos of the peripheral areas: Estrutural, Riacho Fundo II, and Sol Nascente. All areas mainly devoid of vegetation.

With the use of thermal photos, surface radiant temperatures are obtained, and the differences are highlighted between the greener areas with greater thermal comfort with the less planted areas and consequently with less thermal comfort. Locations with more homogeneous and more heterogeneous materials are vividly perceived, as is their impact on their microclimate. Photographs also showed the greater heating of the facades, which consist of cementitious materials, masonry, ceramics, all good night time emitters.

In the Riacho Fundo II area, research was carried out in a residential block parallel to a highway with high traffic of cars, cargo vehicles and urban transport. The residential condominiums are up to 4 floors, with light colour painting, and fibre cement tiled roofs. There is no form of greenery, be it grass, shrub or tree. The streets are of asphalt and the pavements concrete or just plain dirt, all exposed to direct solar radiation. Internal streets have single-family residences of 1 to 2 floors, with timid and fading presence of greenery. The majority of the residences are of masonry, finished with painting or ceramic tiles, and the roofs are mainly fibre cement or clay. Measurements were also taken *in loco.* Analysis on temperature, air humidity and CO_2 carried out in the W3 Sul region was also carried out in the Riacho Fundo II area.

The temperature is much higher on the asphalt and concrete surfaces, reaching up to 55ºC on a sunny day. The thermal sensation is even greater than 55º C due to the lack of vegetation, generating intense discomfort to the pedestrians. The temperature and humidity characteristics were similar at all data collection points, and consisted of materials with high emissivity albedos. The big difference was in terms of the concentration of carbon dioxide, which remained higher during the day due to the high flux of motor vehicles. Furthermore, it is a distant region in relation to the centre of Brasilia, having less reliability from the public authorities, and less public transportation. The burning of garbage is something also quite common, generating a higher concentration of CO_2 in the region due to fires.

The place studied in the Structural City is a residential street, with houses of up to two floors. The materials used are mostly masonry, concrete, ceramic as a finishing, glass and iron used in frames. The road is paved and has residences on both sides, with narrow concrete sidewalks. There was no grass or tree in the study area. At Structural, temperature of the materials with the aid of the thermographic camera was measured, and it was verified that the temperature of the asphalted areas reached 56.9 ° C at 1:00 PM, and the temperature of the homes indicated 46.1 °C as external surface temperatures, predicting great discomfort internally. The high temperatures, combined with the lack of vegetation in the area, cause an uncomfortable experience for passers-by.

At Sol Nascente, the studied space is composed of a narrow path that starts with a bituminous material and follows a dirt track. At the beginning of the street, the houses are made of traditional masonry, lined with ceramics, iron details and narrow concrete sidewalks. At the end of the route, the residences are simpler than traditional masonry, without coating, and iron frames. The vegetation found is formed by scarce ground coverings, which mingles at the end of the road with small fruit trees, since this area is recently occupied, and a few trees can be seen. The same measurements at Sol Nascente were taken, and temperatures of 53.1°C were registered in the external microclimate with homes in the morning already reading 43.6°C. The lack of vegetation and shade, associated with high temperatures, generates a hostile microclimate, of discomfort, making the thermal sensation greater than the measures.

6 Conclusions

It is clear that vegetation influences people's quality of life. The regions with the most vegetation are able to offer thermal comfort to people who live or work in the region, making the space pleasant. More pleasant environments are more in demand, and as a result, they become more expensive in their real estate value. It is a fact that the regions with the most vegetation are the richest areas, and those with the least vegetation are the poorest. The lack of vegetation in the poorest regions was due to the fact that there was no urban planning. The spaces were invaded and occupied in a disorderly manner, due to great demand and the impossibility to face the high rents and property values of the city centre. Clearing the soil from all the existing vegetation is just seen as the quickest and easiest way to free more space and then divide, and occupy informally. Research confirmed the discomfort by users in bare and green-less places. Vegetated environments are more comfortable and have a more pleasant thermal sensation. Environments without vegetation are less comfortable, and even unbearable, with a very high thermal sensation. The urban disorganization of the poorest regions, coupled with the geographical positioning away from water sources, such as Lake Paranoá, which could generate a more thermally comfortable and sound microclimate, as well as, the absence of wind corridors that can minimize the sensation of heat [6]. Complementary factors studied on geographic positioning, air humidity, CO_2, also influence, together, the feeling of comfort or discomfort to users in these regions studied, and deserve further research.

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TOPIC 7: BIOCLIMATIC AND CULTURAL SENSITIVITY

07.101 - ENGINEERING A LIVING BUILDING REALM: DEVELOPMENT OF PROTECTIVE COATINGS FOR PHOTOSYNTHETIC CERAMIC BIOCOMPOSITE MATERIALS

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Abstract

Photosynthetic microorganisms are responsible for the habitable atmosphere that sustains the plethora of life on the planet. In a time when humanity is encountering one of its greatest challenges in the form of a global environmental crisis we look for solutions present within nature. Within bio-design we seek to incorporate living metabolic functions within buildings that enable microorganisms to adapt to a wide range of environments and feed on products we wish to transform. Owing to the responsive nature of living organisms we can foster a dialogue between our species and microorganisms by engineering environments that can help those organisms to flourish. The studies outlined in this paper explore the potential of sustaining photosynthetic microorganisms in minimal moisture environments through the use of laboratory design practice. Thus, enabling their integration within interior settings for the purpose of sequestering carbon dioxide and generation of oxygen. In this paper we assess the limitations and performance of such living materials that would help inform the conditions that would have to be created for photosynthetic microorganisms to be sustained within an uncontrolled interior setting. The paper will demonstrate a range of natural coatings and their effect on the metabolism of Chlorella *vulgaris*, a photosynthetic microalga. In contrast to traditional forms of fabrication where the role of the designer is primarily concerned with generating a predetermined solution, when designing with living things the designer facilitates desirable natural processes that often unfold in unpredictable ways. Therefore, there is a need for a clear understanding of the natural requirements of living organism in terms of their metabolic functions so that we can guide their growth in a desirable way.

Figure 34. Living Algae on Porcelain by Assia Stefanova, part of Yggdrasil Exhibit, London Design Festival, 2019 [image by author]

Keywords

living materials, photosynthesis, bio-composites, ceramics, ecology

1 Introduction

Today urban areas account for 70% of energy consumption worldwide, with buildings being responsible for the majority of carbon emissions [1]. The built environment has contributed significantly to the environmental crisis facing humanity; from the sourcing and manufacture of materials to the energy required to sustain a high level of living comfort inside buildings. These relatively new standards of comfort are oftentimes met through the use of mechanical systems and manual methods, both contributing to higher building energy usage and heat losses [2]. However, there is a new trend of looking to natural processes in order to meet some of our needs as well as to establish a more balanced, closer relationship with nature by developing living building materials. The constant exchange between organisms that occurs in nature and the mutually dependent relationships present between species have created life as we know it. Within nature, organisms feed on each other's waste products to survive, creating symbiotic relationships that challenge widely accepted notions of individuality and separation [3]. It is these close relationships that serve as a blueprint for a new wave of living materials that sustain other species and that have the ability to utilize wastewater and carbon dioxide (CO_2) [4] and that produce vital resources for our survival.

The microorganisms that are the focus of this paper are microalgae, photosynthetic micro-organisms predominantly found within wet environments in both fresh and sea water [5]. In this paper we propose the integration of such organisms into unit based building components such as wall or ceiling tiles so as to reduce the need for ventilation. The algae cells would eventually be washed off and used as a natural fertilizer [6], feeding back into the food chain, whilst new cells would be introduced to populate the surface once again. The substrates would be reused in the cultivation of microalgae and would provide a complex, multifaceted geometry for maximum surface area. Algae provide a pertinent example of organisms that can sequester CO_2 whilst feeding on readily available waste products. They have evolved over time to survive within a variety of environmental conditions, altering their metabolic functions so as to meet their needs through the use of available resources. Today algae cultivation is finding application within the production of biomass [7], wastewater remediation [8], food production [9] as well as the sequestering of CO_2 [10]. Microalgae are typically cultivated within four main systems; open pond, closed pond, hybrid systems [11] and minimal moisture environments [12]. Photosynthetic algae utilize available light to process nutrients, suggesting applications within both internal and external building surfaces, depending on the species used. Within building applications algae have been integrated into biomass producing facades [13], photosynthetic lamps [14] as well as infill for flexible skins [15]. Within all those examples the algae are grown in suspension within enclosed containers. From a design perspective integrating liquids into the building fabric poses challenges of maintenance, spillage and space requirements. The closed system of cultivation is also a popular method of cultivation for laboratory experiments as it ensures consistent results that only take into account a limited number of variables by limiting contamination from other chemical or biological entities and that reduces external stress. Testing within a controlled setting has been done with various types of phytoplankton on a variety of substrates, including, paper, timber, textiles and luffa. These studies have set out a simple screening method [16] of testing the performance of photosynthetic microorganisms with various materials. However, experiments conducted in a controlled environment provide data reflective of perfect conditions that are challenging to meet within a regular building setting and therefore are not representative of how the material would perform within real world architectural applications. Therefore, before embarking upon fabrication with living organisms it is important to establish if their metabolic functions would be affected if exposed to an open interior setting and then devising ways to create a buffer that would offer a level of protection.

In this paper we are going to study living bio-composites consisting of an inorganic substrate (in this case various types of ceramics) in conjunction with a species of microalgae that is compatible with conditions typically offered by a range of interior environments such as offices or residential buildings. Nutrients and moisture are distributed through the unglazed, porous ceramic substrate, such that the structure becomes a distribution system capable of retaining moisture. We are able to sustain the algae in low moisture levels without the use of liquid tanks as long as minimal levels of moisture are maintained, as demonstrated within earlier experiments conducted. The benefit of this type of cultivation is in the level of flexibility in terms of architectural applications as well as the much greater cell density per area used and the reduced water demand for cultivation of algae.

The challenge in developing living bio-composite materials arises in the transition from a controlled laboratory setting to an uncontrolled domestic or office environment. Within our interior environments there are numerous bacterial and fungal species that would often find moist, nutrient-rich environments desirable and that are likely to colonize such exposed surfaces, attacking the algae and competing for space and nutrients. In order to minimize the detrimental effect of undesirable colonies and prevent rapid evaporation the experiments described below demonstrate a range of conditions that may enhance and support algae growth by employing natural coatings (i.e. Aloe vera, olive oil, lemongrass oil and chitosan) that have anti-bacterial and self-hydrated properties to protect the cells from water evaporation and foreign bacterial colonies. All the methods aim to utilize natural, low impact products and strategies that avoid artificial means of controlling the living population such as antibiotics or synthetic chemicals that potentially have detrimental effects on the environment.

2 Method

The experiments study the effect of an open setup on the development of microalgae that are highly efficient in sequestering CO_2 and that are compatible with conditions typically offered within interior environments, including light already utilized within interior spaces as well as a temperature that would not have a detrimental effect on the metabolic functions of the algae ranging between 18-25°C. The experiments test four types of ceramics, including; Porcelain, White Fleck (WF), Crank ES50 (ES50), Crank ES65 (ES65). The chemical compositions and texture of the clay provide differences in environmental conditions that can affect the response of the algae, hindering or helping growth in a variety of contexts. The species used was Chlorella *vulgaris* (C. *vulgaris*) a species that has a particularly efficient photosynthetic rate, with some chlorella species reaching an efficiency of more than 20% compared to the typical 1% efficiency of terrestrial plant species [17]. The cell viability was assessed using imaging pulse amplitude modulated-fluorometry (Imaging-PAM M-Series; Walz GmbH); that provides the level of chlorophyll fluorescence of photosynthetic cells [18]. Numerical and image data produced from Imaging-PAM were collected every 2 days for 14 days for each set of experiments. Liquid algae slurry (0.02ml per sample) that had been grown in full strength

BG-11 medium (100% BG-11 contains; 1.5 g/L $NaNO_3$, 0.036 g/L $CaCl_2 \cdot 2H_2O$, 0.075 g/L $MgSO_4 \cdot 7H_2O$, 0.04 g/L K_2HPO_4 and 0.02 g/L Na_2CO_3) [19] was placed in 50ml Falcon tubes and centrifuged at 1620 RCF (Relative Centrifugal Force) for 10 minutes to produce a dense algae slurry. Samples of 1.3g ceramic pieces were placed within 12-well-plate containers with 0.5ml of BG11 nutrient media. In each instance there were 3 samples with living cells of 0.05ml algae slurry and 3 samples without cells samples as per Fig.2, alongside control suspension samples with cells in suspension and empty BG11. The algae slurry and liquid consistency coatings were deposited using pipette tips whilst the natural coatings were deposited using a spatula, 0.5g per sample of gel or 0.05ml liquid consistency using pipette tips. The well plates were left open within an interior setting that was lit for approximately 16 hours a day and where a temperature of 18-22°C was maintained. The study was split into three stages conducted sequentially, each stage informing the next set of experiments.

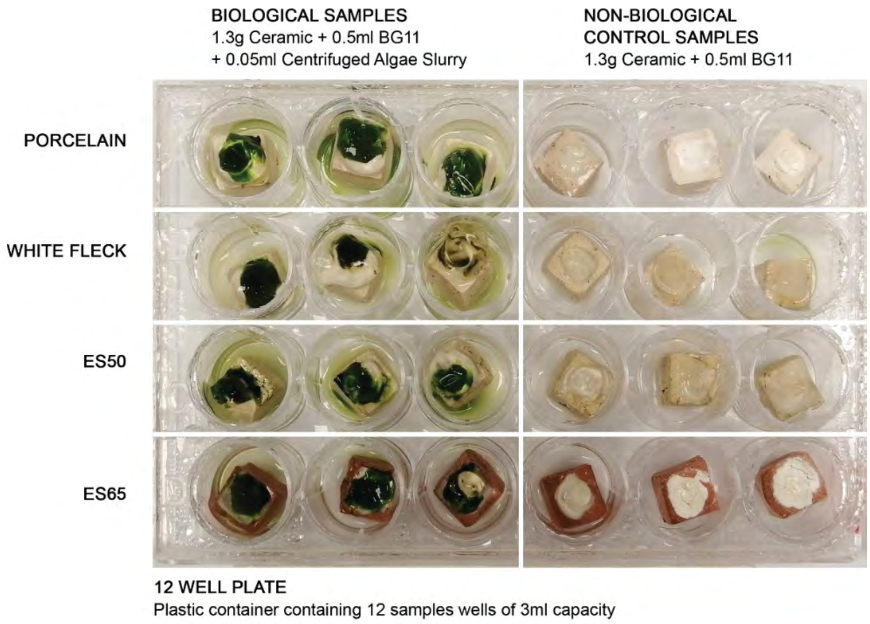

Figure 35. Example Samples Setup in 12 Well Plate- Ceramic Samples with and algae slurry and coating on the left, and control samples with coating without algae slurry on the right

1. Water Evaporation and Rehydration- This set of experiments assessed the metabolic functions in relationship to moisture reintroduction and evaporation. Three methods of moisture reintroduction were tested including; restoration of initial moisture levels every 48 hours, spraying the surface every 12 hours, 5 times per well plate using spays of 0.7ml water content and the use of a hydrogel as a top coating sprayed every 12 hours. A set of controls was used consisting of samples within a closed well plate that were not exposed to air to compare the performance of the exposed samples.
2. Protective Coatings – this set demonstrates the testing of a range of coatings that aim to provide a buffer from the open air or to enhance algae growth. The tested natural coatings include Aloe Vera, Chitosan (1.2%) / Acetic Acid (2%), Olive Oil, and Diatomaceous Earth.
3. Combined Protective Coatings– The combinations tested include; Aloe Vera and Diatomaceous Earth, Aloe Vera and Hydrogel, Chitosan (1.2%) /Acetic Acid (3%) / Diatomaceous Earth (1%), Olive Oil and Lemongrass Oil (10%).

3 Water Evaporation and Rehydration

In the first instance it was important to assess the survival rate of cells within an uncontrolled environment without any additional means of protection. The setup also highlights the difficulty of maintaining the minimal moisture levels necessary. In the first set of samples water was reintroduced every other day at a rate of 0.3ml to replace moisture lost due to evaporation, within the second set of samples water was introduced every 12 hours through spraying each plate five times with 0.7ml of sterile D.I. water. In the third set 0.6g of hydrogel powder were mixed with 20ml D.I. water and 2g of the gel mixture were placed over the algae slurry on the surface of the substrate. The last set contained samples that remained closed for the duration of the experiment to compare the performance of the algae when the well plate is left closed and evaporation occurs at low rates, in that set water was not added during the 14 days of testing.

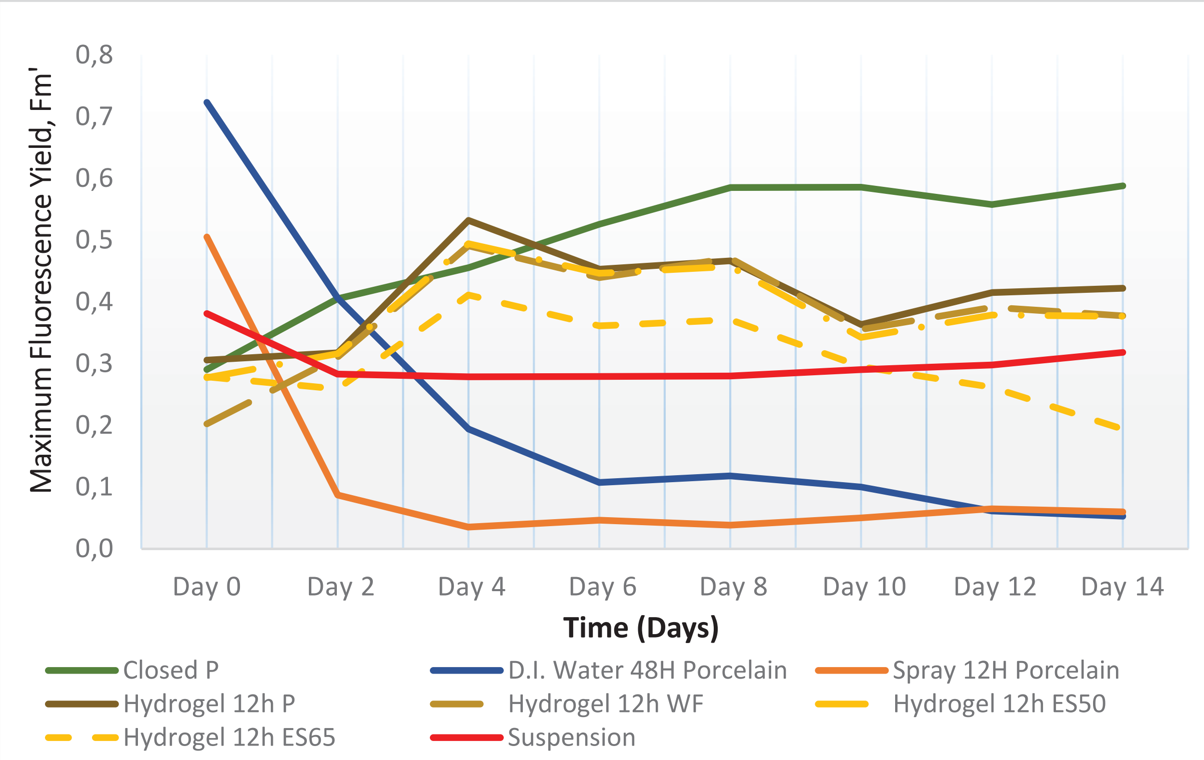

Figure 36: Maximum chlorophyll fluorescence yield of exposed to air ceramic samples and suspension samples using various methods of moisture retention and reintroduction

In this first group of experiments the results demonstrate a decrease in living cells, down to as little as 30%-7%, if we compare these results to results obtained within a closed setup where the cell culture continued to exhibit healthy functions and further favourable development it is obvious that exposure to an interior environment is highly problematic. The second set exhibits a steep decline and sustained low number of cells for the duration of the experiment likely due to the cells washing off into the surrounding liquid media during spraying suggesting the need to improve cell adhesion. The third set performed better however the hydrogel did exhibit a tendency to detach and would pose challenges if placed on a vertical surface. Figure 3 demonstrates the steep decline in chlorophyll fluorescence in uncoated samples. Porcelain is highlighted as it performed better than other types of ceramics.

4 Protective Coatings

Within nature organisms are often protected through a process of encapsulation [20], this natural phenomenon served as inspiration for the development of a natural antibacterial coating that would protect the algae by providing a film that may act as a barrier to the external environment as well as to provide an environment that would be less hospitable to undesirable species. In this next set of tests we used a number of coatings that aimed to slow down evaporation, providing a level of protection and helping to reduce contaminants through their natural antibacterial properties. In each instance the coating was delivered after the algae slurry was deposited onto the ceramic to cover the cells. The samples were sprayed with sterile D.I. water twice daily to ensure the coatings did not dry out. In this instance cell wash off occurred at a lower rate as the cells remained underneath protected by the coating layer. Porcelain and White Fleck displayed slightly better performance than Crank ES50 and ES65 (See Figure 4).

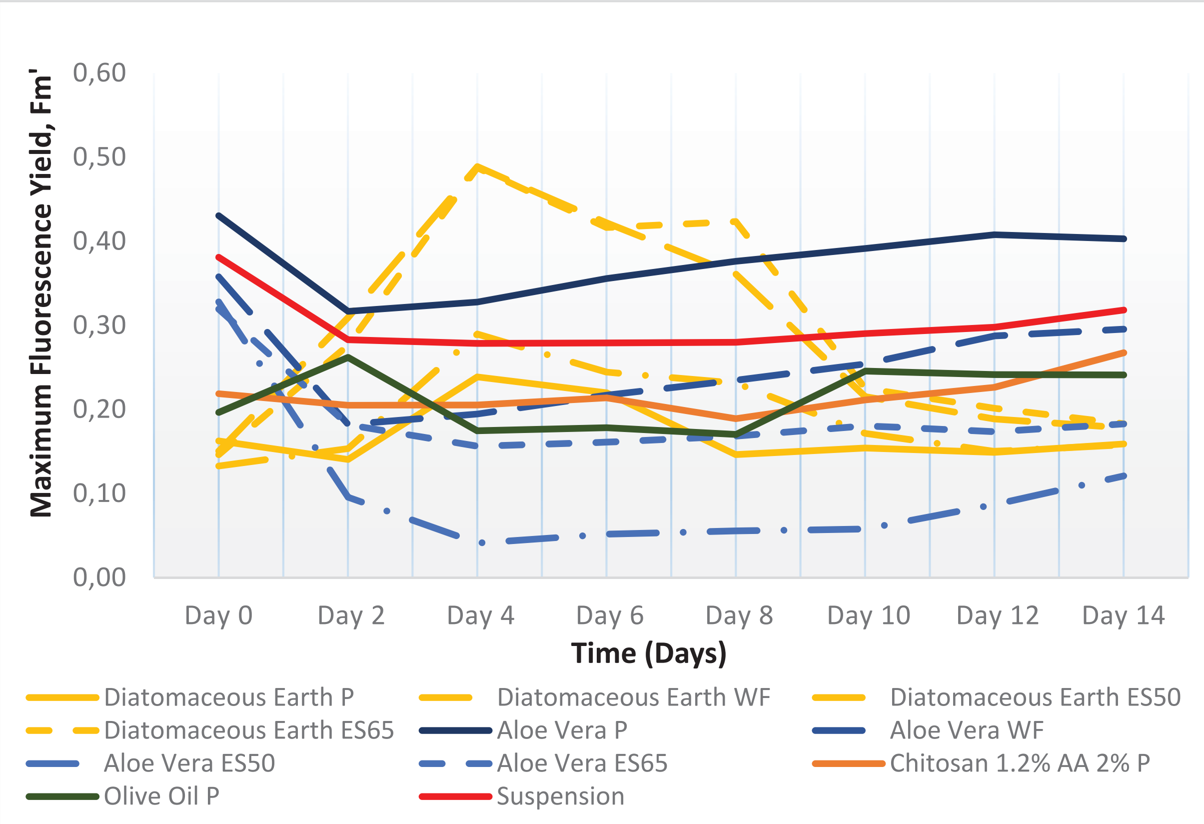

Figure 37: Maximum chlorophyll fluorescence yield of exposed to air clay base and suspension samples with protective coatings

This is most likely due to the higher variations within the composition of the later. The majority of samples displayed a slight decrease in chlorophyll fluorescence by day 2 followed by gradual increase that persisted for the duration of the experiment suggesting that cultivation within interior settings may be possible if the cells remain protected. A longer study is necessary to assess if the coating would have to be reapplied at certain times and to compare the longevity of the bio-composite within an open setup with that of closed samples. Previous closed experiments have been sustained within a closed setup for as longs as 100 days without a significant decrease of chlorophyll fluorescence. In the case of Diatomaceous Earth (DE) there is an increase of chlorophyll fluorescence by as much as 330% in certain cases by day 4, however that is followed by a decline likely due to the mixture not slowing down moisture evaporation on the surface. Aloe Vera, Olive Oil and Chitosan (1.2%)/ Acetic Acid (2%) display a steady increase in chlorophyll fluorescence providing greater consistency in chlorophyll fluorescence levels.

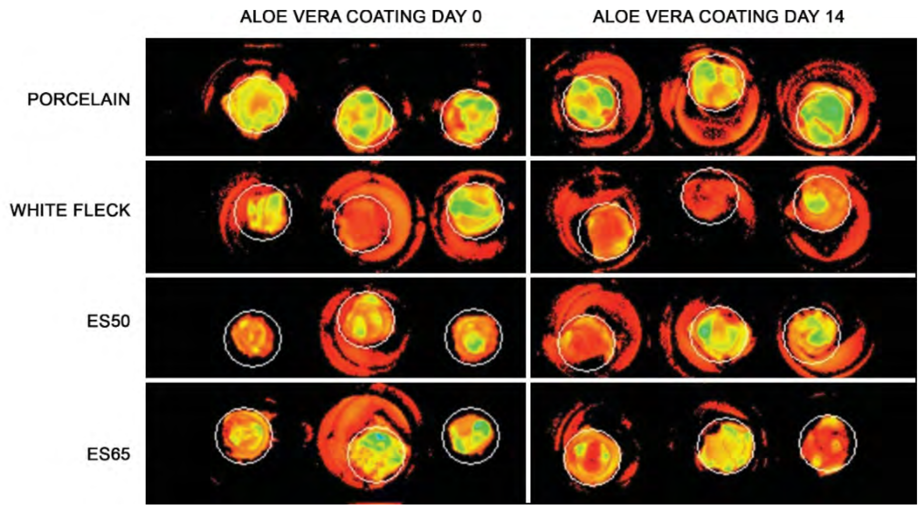

Figure 38: Aloe Vera samples on Day 0 and Day 14 Imaged using Image PAM- cooler colours indicate areas of greater chlorophyll fluorescence. From the image it becomes apparent that certain types of ceramic substrate are less likely to support C. *vulgaris* growth, with Porcelain showing an increase in chlorophyll fluoresce.

5 Combined Protective Coatings

In this group of experiments the previously tested coatings were combined and enhanced. Aloe Vera was combined with hydrogel at a ratio of 1:2, to assess if the moisture content could be increased. Olive oil was mixed with 10% Lemongrass essential oil in an attempt to reduce potential contamination and Chitosan (1.2%)/ Acetic Acid (4%) were combined with DE (1%) in an attempt to improve cell growth. Aloe Vera was also combined with a bottom layer of DE. The DE powder was mixed with water at a 1:1 ratio and 0.1ml of the solution was deposited on each sample using a pipette, 0.05ml of centrifuged algae slurry was deposited separately on top of the diatomaceous earth solution and the cells were sealed by a layer of 0.3g Aloe Vera. Within all other examples the coatings were applied over the algae slurry using a pipette or spatula depending on consistency. The results (Fig. 5) show a greater decrease in chlorophyll fluorescence at Day 2 compared to the single substance coatings and they also exhibit greater daily variation. The Chitosan (1.2%)/ Acetic Acid (4%)/ DE (1%) mimicked closely the performance the changes of chlorophyll fluorescence of the suspension culture.

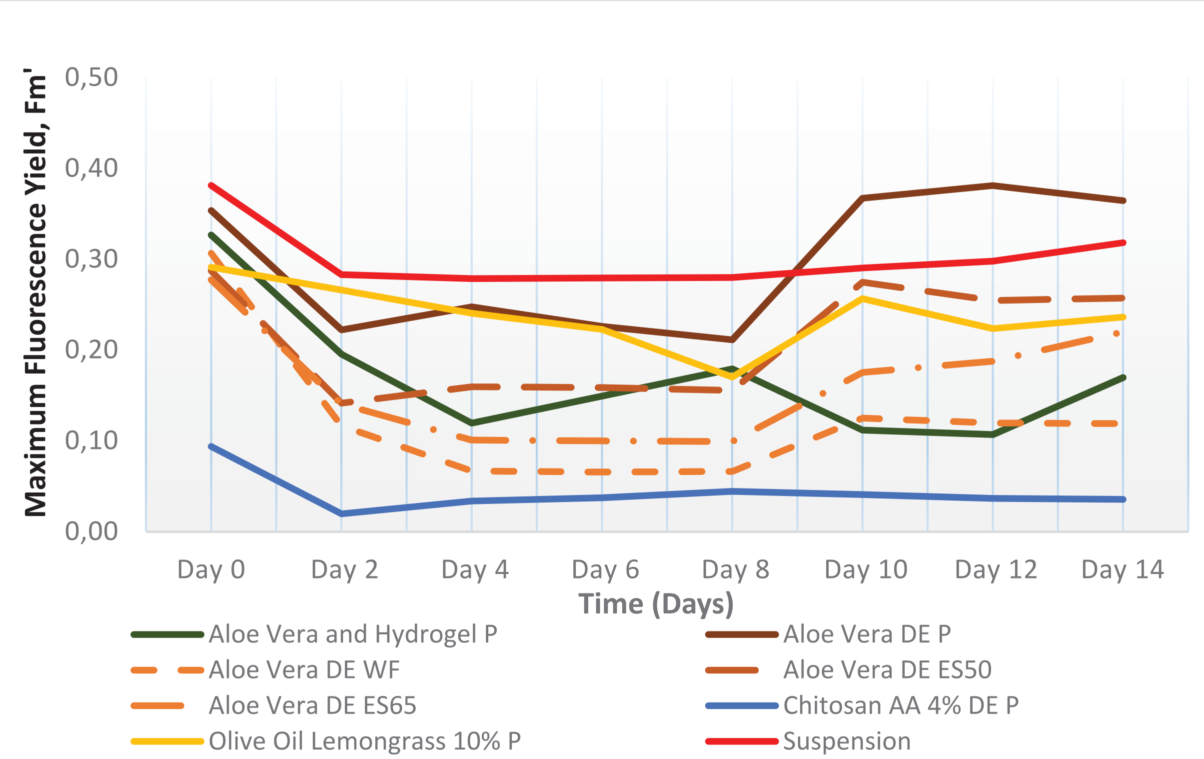

Figure 39: Maximum chlorophyll fluorescence yield of exposed to air ceramic base and suspension samples with various combined coating

6 Discussion

The experiments described above demonstrate the challenges of exposing living bio-composite materials within an uncontrolled interior environment. Whilst a decrease in cell numbers was observed in certain types of coatings within uncontrolled environments, living algae colonies were successfully sustained for the duration of the experiments suggesting that further testing through fabrication and live integration of such material is worthwhile. The results highlighted the need for a protective coating that acts as a buffer and that slows down the rate of evaporation. The testing also shows the importance of moisture distribution and the need for the development of a regime that maintains reasonable moisture levels as the surface of the ceramic tends to dry at a higher rate creating a hostile environment unsuitable for algae growth. The four types of ceramic presented different results, with Porcelain and White Fleck outperforming the two stoneware clays showing the effect of the substrate upon the chlorophyll fluorescence levels over time, with higher level of aggregate having a detrimental effect on the organism. The distribution of moisture throughout the ceramic samples would also be affected by the firing temperature of the ceramic affecting porosity with higher firing temperatures resulting in lower porosity (1100°C) with lower firing temperatures (e.g. 900°C) resulting in higher porosity and therefore better distribution of moisture and nutrients. In addition to that the shape of the sample would also have an effect with thinner layers of ceramic providing wetter surfaces if pockets of liquid could be locked inside the structure. Testing is necessary to assess the exact amount of moisture needed to maintain healthy algae growth in relationship to evaporation rates within different interior settings and the development of a building component geometry such as wall or ceiling tiles and a water distribution system would provide the next steps to integrating the living material within a building scenario. The coatings tested show significant improvement in performance in the cases of Aloe Vera, chitosan and olive oil, in comparison to uncoated exposed samples. The coatings demonstrated an increase in chlorophyll fluorescence from the initial amount by the end of the experiments. A longevity test would have to be conducted to assess the lifespan of the bio-composite and the appropriate maintenance protocol that should take into account both the needs of the organism and what would be reasonable expectations to place upon inhabitants or mechanical systems as well as testing of the method for extraction of the dead algae cells so as to assess the viability of the whole product lifecycle.

7 Conclusion

By bringing materials and living organisms together we begin to form collaborative networks that foster closer relationships and open up new methods of cultivation which are necessary for addressing contemporary ecological issues. As is the case with all living things, the proposed materials require care and dedication and whilst that may be perceived as a limiting factor that places a burden upon inhabitants it is also an opportunity to establish a closer connection with our environment. By tending to other living things we develop a feeling of responsibility [21] and recognize needs outside of our own.

The research has identified the importance of protecting the living organisms from sudden environmental changes and unhospitable conditions through the introduction of an environmental buffer in the form of protective coatings. The choice of coating is of particular interest with more economical, local solutions offering a viable system for scaling and mass application. The choice of coating would depend on materials that are easier to source in particular parts of the world for example Aloe Vera would become an appropriate candidate in places where it is locally grown. However there is a wide range of factors that would have to be taken into consideration in addition to the type of coating, including cost of manufacture, maintenance and lifespan. Materials such as diatomaceous earth are of particularly interest, in the case of DE there is a close relationship to the living organisms being utilized. Creating a bio-composite using DE would in essence enable the construction of a habitat capable of supporting new life through the use of the remains of previous ancestors, creating a new network and opening up a dialogue as to the relationship between past and future within an ecological context.

The demonstrated design approach highlights the need to integrate laboratory testing and experimentation within design practice and to engage more closely with such testing so as to gain greater understanding and control necessary to develop viable solutions that can sustain living organisms for a meaningful period of time. The development of living materials opens up new possibilities of collaborating with nature to meet our needs in a sustainable manner. Tapping into natural cycles through creation of a living building fabric has potential to enable us to meet our needs through the use of living metabolic functions. The results suggest that microalgae could be cultivated within interior surfaces and applications may range from walls, ceiling tiles, partitions to decorative lighting fixtures. This new generation of products would be endowed with a natural intelligence in the form of responsive living behaviour and would require the same level of consideration as all living things.

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07.102 - INVESTIGATION AND EVALUATION OF ILLUMINANCE AND LUMINANCE LEVELS IN SULIPAN ELEMENTARY SCHOOL (SEPTEMBER AND DECEMBER MEASUREMENTS)

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Abstract

The interior lighting environment of classrooms affects the learning processes of students. In this paper, we carry out illuminance and luminance readings of classrooms in Sulipan Elementary School, which is a heritage structure, to determine the daylight factors (DF) and electric lighting illuminance levels during the months of September and December. We then take the luminances of task surfaces within a typical classroom scene to derive the luminance ratio between task and non-task luminances. We then compare the DF, illuminance levels and the luminance ratios to prescribed IES and CIBSE standards. Our findings indicate that the indoor average illuminances are below the standard of 300 lux. Finally, we present remedial measures considering the heritage value of the structure which can be used and developed for future studies.

Keywords

classroom lighting, lighting standards, Gabaldon school, heritage conservation

6 Introduction

In 1907, a government act authored by Isauro Gabaldon (Gabaldon Act) saw to the formalization of free public education in the Philippines during the American Era (United Architects of the Philippines Sugbu Chapter, 2012). Under this document, nine prototypes based on the number of classrooms per school were developed and built using a modular concept of 7 by 9 meters that allowed for future expansion (Bureau of Education, 1912). The design of the GS is based on natural lighting and ventilation as seen in the design of the windows, eaves and high ceiling. Figure 40 shows a two-classroom prototype, with transoms over large windows, deep eaves, pitched roof, and elevation from the ground.

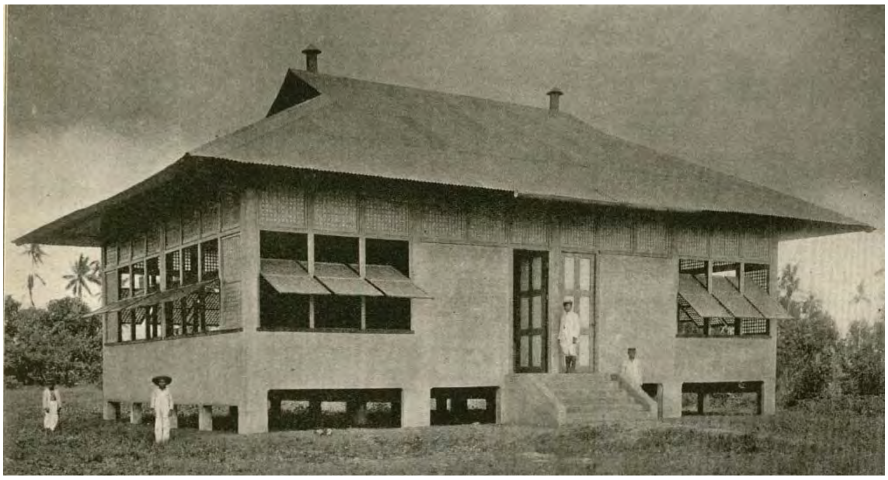


Figure 40. Two-classroom GS design under the 1912 Bulletin

As of 2015, there are reportedly 1,446 of Gabaldon school houses (GS) all over the country (Department of Education, 2015). Over the years, these GS have expectedly undergone architectural interventions among which are electrical installations. At present, GS fall under the mandate of the Department of Education (DepEd). It was not until the 1990's that the heritage value of these buildings was emphasized with DepEd partnering with a local community of heritage advocates. In 2007, then revised in 2010, DepEd released the "Educational Facilities Manual" which put together provisions and regulations on effective management and supervision of school facilities (Department of Education, 2010). The manual identifies the different typologies of public school structures according to design, including the Gabaldon schools. With the enactment of RA 11194 in January 2019, GS are officially declared as cultural properties, and it has become policy to conserve them.

Where lighting is concerned, the 2010 Manual outlined the recommended illumination levels of between 300 lux for a standard classroom as supplied by four, six or eight units of 40-watt fluorescent lamps. As mentioned, GS were originally designed without electric lighting, which leads us to look closer into the GS and ask: How comfortable and efficient are the interiors presently under no electric lighting? How do the lighting retrofits impact the present lighting environment? And the GS heritage value? Thus, in this study, we investigate indoor lighting of GS with and without artificial lighting.

Standards have been established to guide the design for comfortable and efficient lighting environment specific to various tasks, in our case specifically, reading and writing on desks. For our purposes, this study shall refer to the 10th edition of the IESNA Lighting Handbook (Illuminating Engineering Society of North America, 2000) for illuminance and luminance standards, and daylight factors which considers natural light. If proper improvement on lighting is done, not only will the value of Gabaldon schools be reinforced, but also their users will reap the practical benefits as well. With numerous GS still existing and presumably operational, the findings of this study will elicit a reconsideration of the way that we plan for the conservation of heritage schools.

Previous conservation works done under the Philippine Heritage Schoolhouse Program show fluorescent lamps housed in reflective aluminum bay lighting fixtures being used (Department of Education, 2016). A conservation management plan for the San Francisco Learning Center, a GS in Albay Province, also recommended the use of this type of fixture (Patawaran, 2008), however details are lacking. The conservation plan of Sumaguan Elementary School in Cebu Province finds pathologies of a host of building problems and presents recommendations for them, but noticeably excluded are lighting considerations (United Architects of the Philippines Sugbu Chapter, 2012). Such conservation plans show that while the DepEd has clear lighting requirements stated in the DepEd guidelines, conservation plans have tended to provide little consideration to lighting. When the design and retrofitting of lighting is not specified in the plans, the task is effectively consigned to the builder or contractor. Conservation professionals should take the lead in ensuring that the conservation of spaces and structures maintains its authenticity and significance. Since the significance of a GS is its particular use as an educational facility, it is therefore incumbent upon the planner to consider not just the structure itself, but the facilities that make an effective learning space. One such consideration is through appropriate lighting.

In a study by Aslam et al, it was found that the students' test scores in a classroom equipped with proper lighting were higher than those in the control setup (Aslam, Hussein, & Suleman, 2014). In another experiment it was found that classroom lighting had a positive influence on student's concentration (Galetzka, Moolenaar, Sleegers, & Zanded, 2013). Wilkins and Winterbottom conversely observed that certain characteristics of lighting such as over-lighting and excessive daylighting, pattern glare, and imperceptible flicker of fluorescent lighting cause visual discomfort in students (Winterbottom & Wilkins, 2008). A more extensive research by Michael and Heracleous assessed the natural lighting performance on visual comfort of different classrooms in Cyprus for a whole year, using the combined method of qualitative survey of subjects, field measurements for validation, and light simulation for evaluation purposes (Heracleous & Michael, 2017). Findings include the satisfactory natural illumination of schools investigated except where high contrasts were observed, and recommendations of architectural interventions were put forth to improve visual comfort. Where daylighting is concerned, Heschong et al found that students in classrooms with high levels of daylight displayed faster rates of improvement compared against those with lowest daylight levels (Heschong, 2003). A study on the performance evaluation of lighting and daylighting retrofits was conducted by Dubois et al (Dubois, et al., 2016) in which several case studies were monitored using a protocol that assessed the overall lighting performance including (1) energy use, (2) retrofit costs, (3) photometric assessment, and (4) user assessment. It is clear that the issue of lighting deals with many other factors such as energy efficiency, installation costs, solar context, and most especially user assessment.

The objectives this paper are therefore the following:

6.1 To analyse illuminance levels in the classrooms. Illuminance deals with the amount of light striking a surface, and directly bears on the visual acuity, or the ability to see fine detail. Even though the eye can see at only 5 lux illuminance, the eye is not able to see small details of a task such as for reading.

6.2 To determine the natural lighting component expressed as the Daylight Factor (DF). Determining the Daylight Factor allows us to evaluate whether each classroom has sufficient daylight penetration that determines whether or not artificial lighting is needed. According to IESNA Lighting Handbook **(Illuminating Engineering Society of North America, 2000)**, a room that has a daylight factor of 5% and upwards is daylit enough as not to require artificial lighting except at dawn and dusk.

6.3 To measure luminance levels and analyse luminance ratios (LR) in a typical field of view within a classroom. Luminance ratio (LR) is the ratio of foreground luminance to background luminance, and it is related to perceived brightness of objects in view.

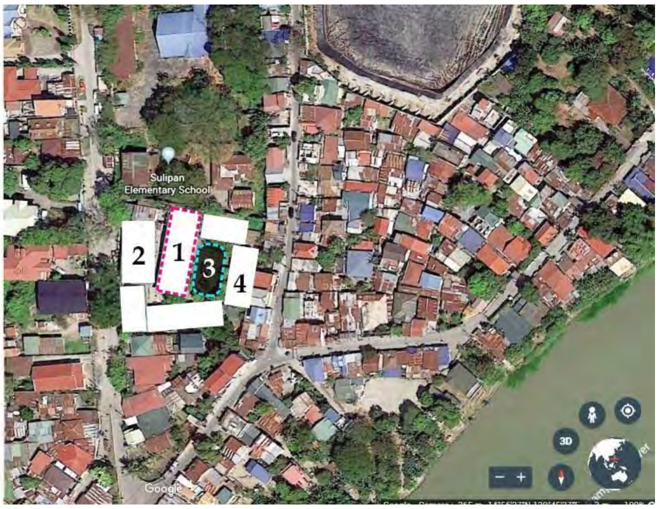
The differences in this perceived brightness due to the wide range of luminance in a visual environment produce the effect of unwanted glare.

6.4 To compare existing conditions in against present standards.

7 Case Selection

To select a school for this study, we followed the following criteria:

1. Structure – DepEd-listed Gabaldon school with available documents
2. Number of rooms – must have a maximum of five (5) classrooms as measurement for lighting levels can be performed and completed within the span of a day.
3. Location – must be within 80 kilometers of Metro Manila for practical and logistical purposes.
4. Cooperation of school administration – must give permission and allow access to the school with minimal bureaucratic work.



1 Gabaldon structure
2 Covered court
3 Vegetable garden
4 Structures added

Figure 41. Vicinity map and site layout (Source: Google Earth)

Sulipan Elementary School in Apalit, Pampanga satisfies the aforementioned requirements and is thus used as subject of this study. The schoolhouse is oriented with its longitudinal axis at approximately 12 degrees east of north. It faces west towards the covered court and further, Sulipan Road. On the north side is a tree and a roofed seating area. On the east, south and southwest sides are the added detached structures and vegetable garden (**¡Error! No se encuentra el origen de la referencia.**).

The structure's orientation with respect to the sun presents high potential for direct sunlight entering through the fenestrations along the east wall (Figure 41). However, the present configuration would seem to suggest that the path of direct daylight may have been blocked by structures, such as small trees along the east side. Surfaces of exterior objects may present new reflecting surfaces from which direct daylight can bounce off and penetrate the structure through its many openings.

Sulipan is a five-classroom Gabaldon, the fifth classroom of which has been subdivided into the Principal's Office and the Computer Room (Figure 42). The awning windows made of capiz shell panes are 1.90 meters high, with the sill at 0.56 meters from the floor, and have provisions for opening to either to 20 or 43 degrees (Figure 43.a). Some of the windows have broken or missing capiz shells, especially those on the west wall where they are most exposed to activity; and some windows do not open fully or at all due to broken mechanisms. The east and north windows of Room A have curtains, and its west windows have curtains only at the transoms. Room B and D windows all have curtained transom, while Room C has none. During school days, windows and doors are left open during class.

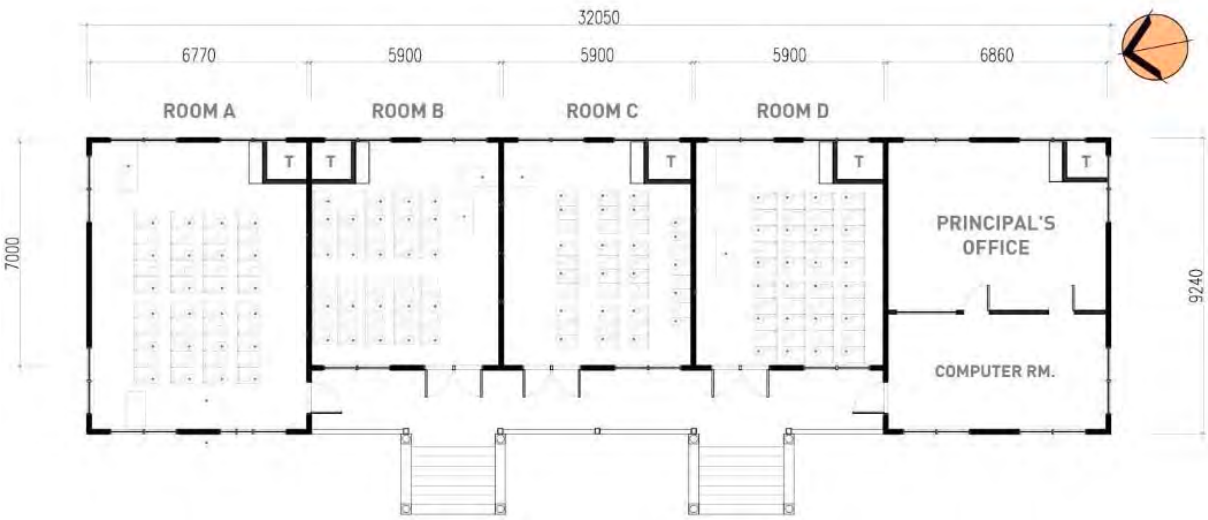


Figure 42. Sulipan floor plan

Figure 43. Typical features, left to right: (a) *Capiz* window open 20 degrees, (b) aluminum reflector with compact fluorescent lamp (CFL)

The light fixtures used are pairs of hat-shaped aluminum reflectors with CFLs of varying light outputs (lumens), suspended from the ceiling to an effective height of 3.00 meters from the floor. Each room has four pairs of these arranged in the room (Figure 43.b).

8 Methods

There are two types of measurements used to answer our objectives: (1) Illuminance (lux), and (2) Luminance (cd/sqm). Measurements were recorded on September 22 2019 and December 01 2019. Each classroom is divided into a grid at the intersections of which are the targets (Figure 44). These are points at which readings are taken.

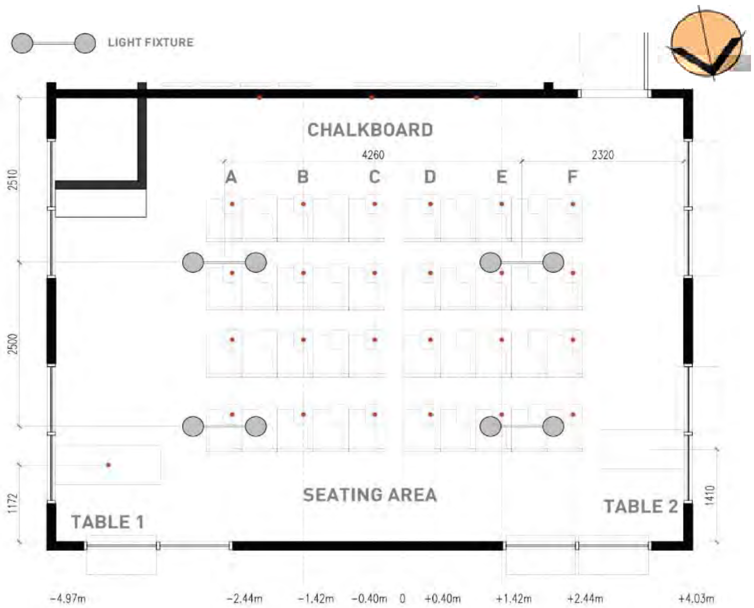


Figure 44. Layout of targets in Room A, showing target zones A to F, reading from east to west in plan

Illuminances are measured under four setups with lights off/windows closed (Setup 1), lights off/windows open (Setup 2), lights on/windows closed (Setup 3), and lights on/windows open (Setup 4) as outlined in Table 5. Two readings are taken per day; once in the morning, between 10.30 am and 12 nn and once in the afternoon, between 12 nn and 3.00 p.m. Illuminance readings taken under Setups 1 and 2 are used to determine the DF. Readings taken under Setups 3 and 4 are used directly to determine average illuminance levels per classroom and to evaluate uniformity. Illuminance values were measured at 24 targets for Rooms A, C and D; and at 25 targets for Room B according to their existing seating arrangements. A zone is a set of targets labelled from A to E (or F), east to west direction; and each row is a set of targets labelled 1 to 4 (or 5) according to their distance from the chalkboard. Illuminances are measured at desk height of approximately 0.60 meters from the floor, and 1.20 meters for chalkboards. The lux meter is oriented parallel to the relevant surface for which illumination level is measured; horizontal on desks and tables, and vertical for chalkboards. Readings were taken using a Dr. Meter LX1330B lux meter.

Table 5 : Setup variations for illuminance measurements

PURPOSE	#	LIGHTS	WINDOWS
DAYLIGHT FACTOR	SETUP 1	OFF	CLOSED
	SETUP 2		OPEN
ILLUMINANCE LEVELS WITH ELECTRIC LIGHTING	SETUP 3	ON	CLOSED
	SETUP 4		OPEN

The second method is recording luminance values (cd/sqm) in order to determine LR within a given scene in a room. A spot meter which is a viable alternative to the more accurate luminance meter is used to read the luminances of surfaces (Hiscocks, 2009). It is aimed at select surfaces to serve as foreground and background within a specific scene in a classroom to measure their respective luminances. The LR is simply the ratio of the foreground and background luminances. To optimize luminance data collection, the scene selected for the measurement of luminance levels is as viewed from a position at the rear of the classroom. In this manner, a wide angle of view is possible in which many of the classroom's surfaces are visible in the scene.

9 Data Collection

9.1 Daylight Factor

For daylight assessment, we use simple averaging to interpret the readings. The zonal averages of the DF's for Setups 1 and 2 for each classroom are determined and plotted on a graph. A zonal average is the average illuminance reading per zone. Only zonal averages are taken because daylight penetration in the rooms occur along the east and west windows only. Even though Room A has windows on the northern wall, this does not represent a majority of typical classrooms. The profile of each graph would indicate the highest and lowest average DF's in a classroom. Comparing the graphs for Setup 1 against Setup 2 would show the effect of open windows in the penetration of daylight.

To determine the daylight factor, the exterior illuminance level and the illuminance levels at targets within each room were recorded. Calculation of the DF is:

$$DF = \left(\frac{Ei}{Eo}\right) x\ 100 \quad (1)$$

where DF is the Daylight Factor, E_i is illuminance indoors in lux and E_o is the illuminance outdoors in lux. In Table 6 below is the IESNA Standard for DF:

Table 6: Average Daylight Factors and Impact (Mathalamuthu & Ponniah, 2018)

AVERAGE DAYLIGHT FACTOR	DESCRIPTION AND RECOMMENDATION
DF < 2%	Not adequately lit; artificial lighting is required most of the time
DF > 5%	Substantially daylit; artificial lighting not required except at dawn and dusk

9.2 Illuminance and Uniformity

For illuminance levels assessment, the zonal averages of the illuminance readings for Setups 3 and 4 for each classroom are also determined and plotted on a graph overlaid on each classroom's longitudinal section. A zonal average is the average illuminances of the targets along grid points parallel to the window. This makes it easy to see where the highest and lowest averages can be found in the zones parallel to the windows. In addition to zonal averages, the average per row (perpendicular to the windows) are also determined and plotted on a graph overlaid on the respective cross section. This graph will reveal averages for the room's cross section. For each of these graphs, comparing Setups 3 and 4 will indicate the effect of open windows (Setup 4) to the illuminances.

For illuminance uniformity, each illuminance reading per target is divided by the maximum illuminance for the room. The average uniformity values of the morning and afternoon data for each setup for the two separate days are taken. The means of these averages are computed to stand for the average uniformity for the day per room.

The IESNA Handbook recommendations for illuminances is presented in categories based on three sets of visual tasks, namely; simple, common and special tasks. However, to account for both uncertainty in photometric measurements as well as in reflections from surfaces, IESNA allows for a 10% variation from the recommended illuminance level. Classroom visual tasks are classified under Categories D and E. See Table 7.

Table 7: Recommended illuminances for elementary classrooms after determining visual task parameters (Illuminating Engineering Society of North America, 2000)

TASK	**CATEGORY**		
	Description	Illuminance (lux)	
Reading and writing on desk	**D** – Performance of visual tasks of high contrast and large size	300 lux [±10%]	270 – 330 lux
	E – Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lux [±10%]	450 – 550 lux

Illuminance levels on their own can only tell us the lux reading at a particular target. In addition to the mean illuminance level, its distribution across a work plane needs to be considered. Illuminance uniformity (or uniformity) pertains to the human perception of how evenly illumination is distributed throughout a work plane. It is expressed as a ratio between minimum illuminance and maximum illuminance at this work plane. The maximum uniformity is 1, which means that the lux levels at all targets are the same; however, in reality this is difficult to achieve. IESNA affirms from other studies that the acceptability of begins to "decline as the minimum-to-maximum illuminance ratio over the working area falls below approximately 0.7" (Illuminating Engineering Society of North America, 2000). Higher uniformity of light distribution and larger area of the visual field allows for better seeing of a visual task. Mathalamuthu et al. (2018) evaluated the uniformity of classroom lighting against the parameters shown in Table 8 (Mathalamuthu & Ponniah, 2018).

Table 8: Daylight illuminance uniformity indicator, where U = Uniformity; E = Illuminance; E_{min} = Minimum illuminance; E_{max} = Maximum illuminance

ILLUMINANCE UNIFORMTIY ON THE WORK PLANE (U)	**ACCEPTABILITY**
$E_{min} / E_{max} > 0.5$	Acceptable
$E_{min} / E_{max} > 0.7$	Preferable

9.3 Luminance and Luminance Ratio

With a piece of white paper set as the foreground, the luminances of various surfaces in the classroom are compared against the foreground luminance. Luminance ratios pertains to the difference in luminance between a task and a background. In general, the higher the ratios are, the higher the negative effects such as discomfort and fatigue. The ratios are then compared against acceptable and preferable ratios. Listed in Table 9 are the recommended luminance ratios by IESNA.

Table 9: Applying the recommended luminance ratios (Illuminating Engineering Society of North America, 2000) to surfaces in the classroom

SURFACE	**LUMINANCE RATIO** X = Task luminance; L = Surface luminance
Task (1)	X
Desk (2)	Not less than 1/3 task luminance but no more than task luminance (or $1/3X \leq L \leq X$)
Floor (3)	Not less than 1/3 task luminance but no more than task luminance (or $1/3X \leq L \leq X$)
Wall below chalkboard (4)	Not less than 1/3 task luminance but no more than task luminance (or $1/3X \leq L \leq X$)

Chalkboard (5)	Not less than 1/3 task luminance but not greater than 5 times task luminance (1/3X ≤ L ≤ 5X)
Wall above chalkboard (6)	- same -
Ceiling (7)	- same -
Open doorway (8)	- same -
Window panel (Left) (9)	- same -
Window panel (Right) (10)	- same -

10 Results and Discussion

10.1 Daylight Factor

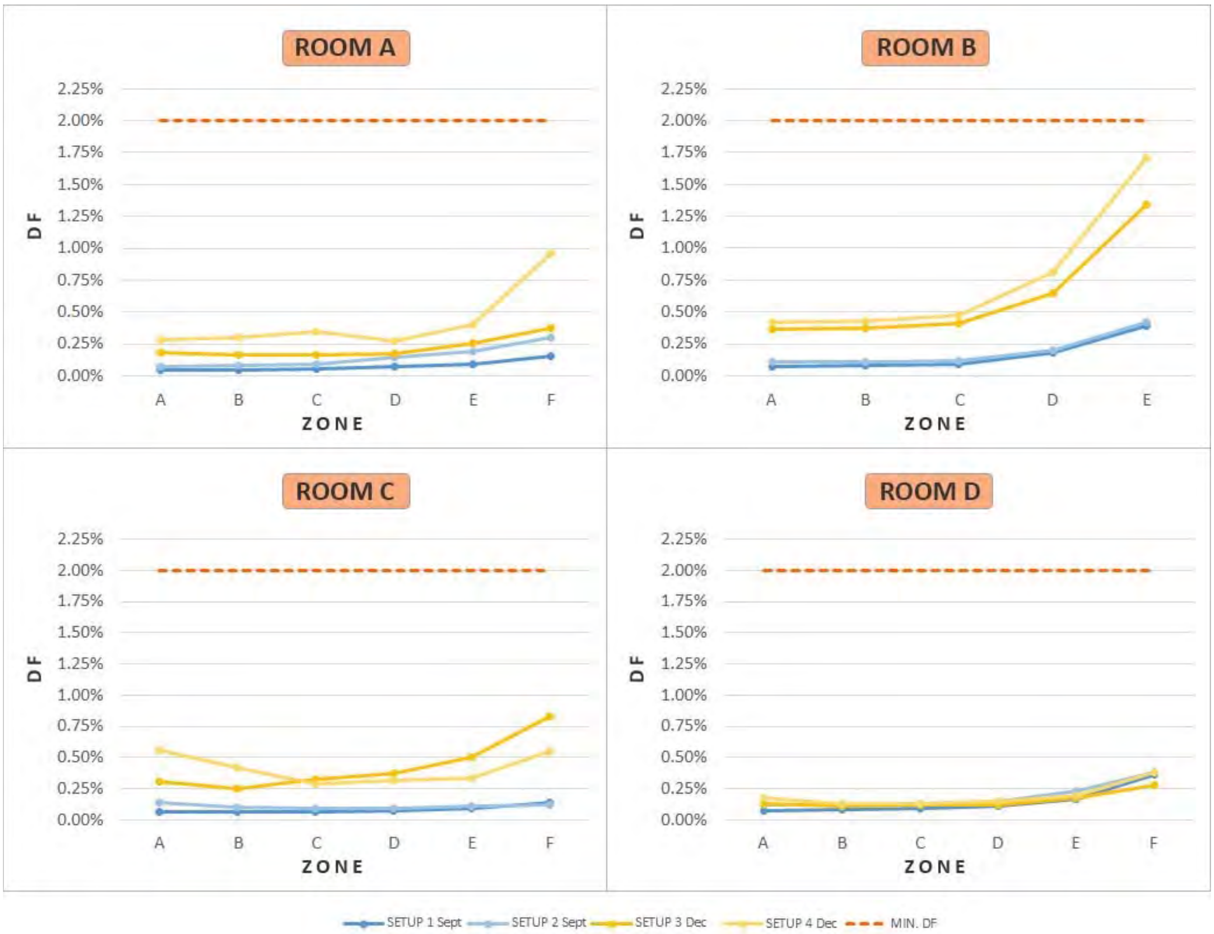


Figure 45. Daylight Factors: (a) Room A, (b) Room B, top; (c) Room C, and (d) Room D, bottom

DF's in the rooms follow an exponential slope in the resulting line graphs (Figure 45). Specifically, this exponential increase is seen leading from targets column A (east) to its highest values in targets column E (west) or F in the case of Room C. This would suggest that windows on the west tend to allow for more daylight compared to the east windows. Classrooms all have doors on the west, which were left open during recording in order to approximate actual classroom setup on a typical school day. Furthermore, windows on the west side displayed more broken or missing *capiz* shell panes compared to the east side. The concrete flooring of the covered court as well as the light-colored walls of the adjacent school building are likely to have further increased illuminances on the west side due to external reflections from their surfaces. The building's orientation with respect to the sun path is fundamentally undesirable as it has high potential for direct sunlight entering through the east and west, which can lead to glare. These factors are considered to have the most impact in causing the high DF on the west side of the rooms.

The lowest DF yielded by the recorded illuminances was 0.05% (Figure 45.a) and highest was 1.71% (Figure 45.b). None of the recorded values reached 2%, the lower end of a range values up to 5%, in which a room is said to be daylit but needs artificial lighting for most of the day.

As expected, DF's in each room were higher in Setup 2, where all currently operable windows were in open position. All classrooms except for Room D show marked differences in DF's between September and December. In Room C, there is an unexpected crossing of the Setup 1 and Setup 2 graphs, which could be due to a sudden change in outdoor illumination at the time of recording that was not accounted for. Since the DF is a ratio which indicates the inherent capability of a window to allow daylight penetration, we expect the DF to be constant for the same window. Room D shows DF's that are consistent for both setups for both September and December.

10.2 Illuminance and Uniformity

Our interest in illuminance levels is more directly related to electric lighting because illumination that is dependent on daylighting tends to be unreliable owing to nature. For this reason, we only look at Setups 3 and 4 to give us a real-world picture of how it performs visually inside the classrooms. First, we check whether the mean illuminance meets the 300-lux requirement. Second, we consider the its spatial distribution – or where illuminances are highest and lowest. Third, we consider the uniformity of the illuminances for every classroom. The mean values per zone under Setups 3 and 4 for September and December are plotted on a graph. When overlaid on the room's sectional view, it easily reveals the zones with the highest and lowest average lux levels (Figure 46). From the readings at the individual targets under Setups 3 and 4 in both morning and afternoon sessions, the mean illuminance level of each room was computed. The highest mean value can be seen in Room B under Setup 4 (Sept) at 442 lux, while lowest is in Room D under Setup 3 (Dec) with 96.50 lux.

In all graphs, the lowest average lux values can be found in Zone A, and gradually increasing towards Zone F (E for Room B). This is a pattern that is consistent regardless of the time of the reading since readings were taken once in the morning between 10 am to 12 nn, and once in the afternoon between 12nn to 4 p.m. This tendency towards curved profiles can also be seen in the graphs for Setups 1 and 2. Obviously DF's greatly impact the illuminance readings for Setups 3 and 4, therefore, the high illuminances on the western zones of the classroom are driven largely by high daylighting penetration. This high daylight penetration can be attributed to the ff:

- Doors are located on the western side and left open, permitting unhindered daylight.
- The presence of higher luminance reflecting sources such as the open court flooring and nearby single-storey structures on the west side compared to those on the east side contribute to the higher readings on the western zones.
- A restroom and lavatory are located on the east side in each classroom, effectively blocking one window.
- Distance of targets from the east and west walls due to room layout. The restroom at the east side enforces a seating layout that is farther away from the east wall than it they are from the west wall. In other words, the zones are not symmetrical from

center. The lower readings in Zone F can be because the targets in this zone are much farther away from the windows than the targets in Zone A are from the west windows.

We have seen the mean illuminances per zone from east to west. Figure 47 shows the mean illuminances per row. For the same reason as above, the highest mean illuminances can be found at the front of the room in Row 1, and lowest in the back at Row 4 (or 5 in Room B). What both cross section and longitudinal graphs show is that under Setup 4, our setup that best approximates actual classroom parameters, the highest illuminances are typically on westernmost zone and at the row nearest the chalkboard. Values here can go as high as 1,738 which is well over the recommended 300 lux.

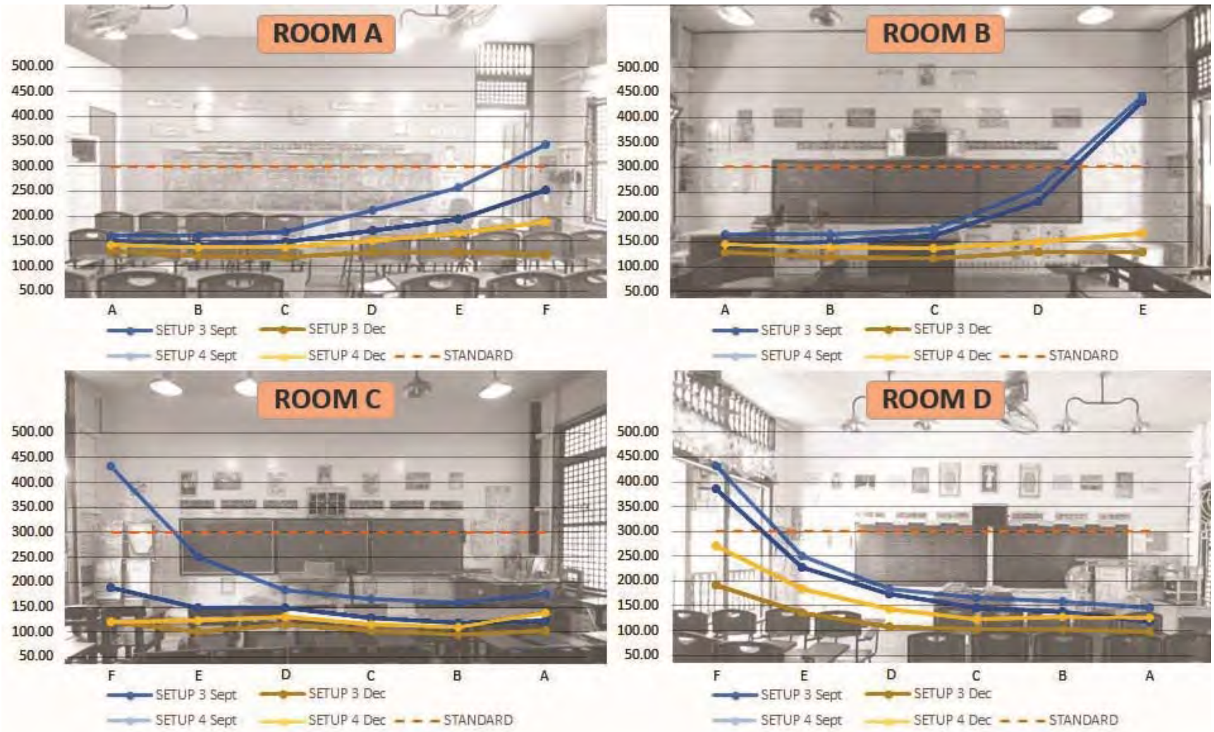


Figure 46. Graphs showing mean zonal illuminances (Rooms A and B, top; Rooms C and D, bottom)

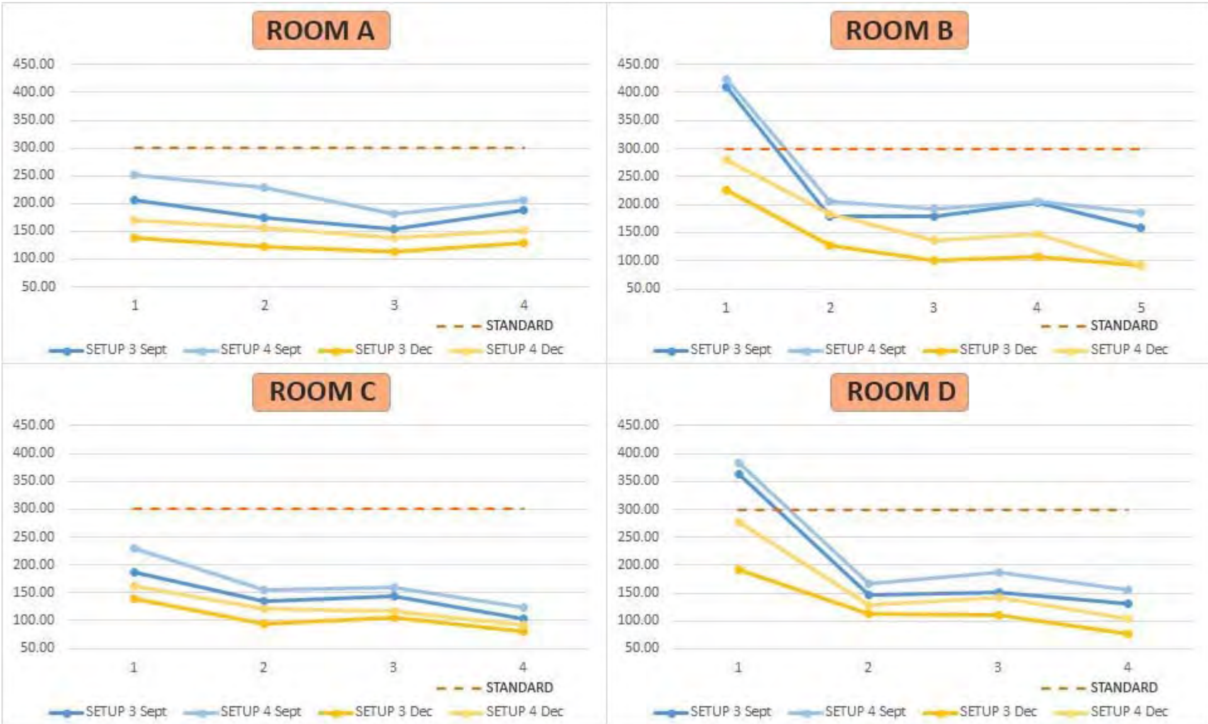


Figure 47. Graphs showing mean row illuminances (Rooms A and B, top; Rooms C and D, bottom)

We can consider the desks as a singular work plane given that seating arrangements in the classrooms are closely packed and frequently rearranged to suit classroom activities. In doing so, we can apply the uniformity ratio to the illuminances across all desks. Summarily the average uniformity values all fall below the preferred 0.7 ratio. It is only in Room A on December that the uniformity is higher than the acceptable ratio of 0.5. This data reveals that the desks are illuminated very unevenly, with a high variance between its minimum and maximum illuminance values. Table 5Table 10 summarizes the average uniformities for both September and December for Setups 3 and 4.

Table 10: Uniformity values on September and December

ROOM	SEPTEMBER				DECEMBER			
	3		4		3		4	
	AM	PM	AM	PM	AM	PM	AM	PM
ROOM A								
E_{min}	117.0	141.0	135.0	148.0	121.0	88.0	143.0	121.0
E_{max}	192.0	530.0	285.0	605.0	205.0	143.0	245.0	205.0
U_1	0.61	0.27	0.24	0.27	0.59	0.62	0.58	0.59
$U_{1\ ave}$	0.44		0.37		0.44		0.51	
ROOM B								
E_{min}	91.0	110.0	104.0	102.0	37.0	56.0	58.0	69.0
E_{max}	660.0	1,450.0	632.0	1,394.0	382.0	692.0	504.0	690.0
U_1	0.14	0.08	0.16	0.07	0.10	0.08	0.12	0.10
$U_{1\ ave}$	0.11		0.12		0.11		0.11	
ROOM C								
E_{min}	91.0	92.0	11.0	105.0	79.0	61.0	90.0	67.0
E_{max}	266.0	334.0	334.0	358.0	186.0	188.0	239.0	156.0
U_1	0.34	0.28	0.03	0.29	0.42	0.32	0.38	0.43
$U_{1\ ave}$	0.31		0.16		0.31		0.40	

ROOM D								
E_{min}	97.00	108.00	119.0	117.0	85.0	50.0	90.0	72.0
E_{max}	987.0	1,006.0	1,003.0	1,074.0	453.0	384.0	481.0	688.0
U_1	0.10	0.11	0.12	0.11	0.19	0.13	0.19	0.10
$U_{1\ ave}$	0.10		0.11		0.11		0.15	

10.3 Luminance and Luminance Ratios

A piece of white-colored paper on the desk is considered as the foreground, with a luminance of 37. In this scene, several surfaces have the potential to cause glare due to their relatively higher luminances: the open door, *capiz* window at the front right side. Not visible in the photo are the window at the rear right side and front left side which also pose as glare sources.

Table 11. Luminance ratios and their compliance, showing data for Room A only

TARGETS		SEPTEMBER				DECEMBER			
			cd/sqm		Compliant?		cd/sqm		Compliant?
		(1/n)X	L	nX		(1/n)X	L	nX	
ROOM A									
1	Task (Paper on desk)	12.3	37.0	37.0	-	9.3	28.0	28.0	-
2	Desk	12.3	4.0	37.0	NO	9.3	4.6	28.0	NO
3	Floor	12.3	6.0	37.0	NO	9.3	5.3	28.0	NO
4	Wall below chalkboard	12.3	12.0	37.0	NO	9.3	11.0	28.0	YES
5	Chalkboard	12.3	6.5	185.0	YES	9.3	6.0	140.0	NO
6	Wall above chalkboard	12.3	18.0	185.0	YES	9.3	18.0	140.0	YES
7	Ceiling	12.3	24.0	185.0	YES	9.3	12.0	140.0	YES
8	Door	12.3	900.0	185.0	NO	9.3	900.0	140.0	NO
9	Window panel (right side front)	12.3	2,000.0	185.0	NO	9.3	3,300.0	140.0	NO
10	Window panel (right side rear)	12.3	240.0	185.0	NO	9.3	300.0	140.0	NO
11	Window panel (left side front)	12.3	400.0	185.0	NO	9.3	270.0	140.0	NO
12	Window panel (left side rear)	12.3	170.0	185.0	YES	9.3	210.0	140.0	YES
13	Window panel (left side rear curtain)	12.3	70.0	185.0	YES	9.3	240.0	140.0	YES
% COMPLIANCE		33.33%				41.67%			
ROOM B									
% COMPLIANCE		20.00%				27.27%			
ROOM C									
% COMPLIANCE		20.00%				33.33%			
ROOM D									
% COMPLIANCE		30.00%				33.33%			

Table 11 shows the compliance of the rooms for Setup 4 for the two days. Luminance levels in general fall within the 3,000 cd/sqm requirement in the de Bruin-Hordijk and de Groot study **(de Bruin-Horijk & de Groot, n.d.)**, except in some cases where targets were positioned at the open doorway, leading to luminance measurements from the surfaces outside. In these cases, luminance readings ranged from 3,100 to as high as 8,000 cd/sqm. These high values are so high as to cause glare, an undesirable effect that leads to discomfort and impaired vision.

The low luminances are partly due to the generally low illuminance in the rooms. One way to reduce the ratio between the luminances of interior to exterior surfaces that come within view in a scene is to increase overall indoor illumination. The table shows that most of the non-compliance comes from open doors and windows. The most compliant surfaces are the wall above the chalkboard, ceiling, windows with intact *capiz* panels, while open fenestrations cause the most potential for glare depending on visible reflective objects at the exterior. Clearly some form of shielding is necessary to mitigate this glare potential.

11 Conclusion

The low daylight factors in the classrooms indicate that the fenestrations do not maximize the available natural light from outdoors. With DF’s below 2%, artificial lighting is needed to meet the recommended average, maintained illuminance levels. The higher DF’s on the west compared to the east reveal that artificial lighting is more needed on the east side. A lighting scheme that is highly controllable through switching and dimming will address this condition. Lights that can be switched on and off as needed will not only improve the visual environment but will lead to electrical cost savings for the school. Target illuminance levels even when the electric lighting is on (Setup 4) still fall below the recommended 300 to 500 lux range. The highest mean illuminance in a room under Setup 4 is 249.04 lux in Room A.

Uniformity of light distribution is generally low for all rooms, where the difference between the highest and lowest illuminances per room are high. The high values come from targets positioned nearest the doors and windows, and not from targets below the light fixtures, indicating that the existing lighting has insignificant contribution to the illuminances from daylight. The existing lighting scheme of eight (8) compact fluorescent lamps in aluminum reflective fixtures need to be reconsidered. Their layout in the ceiling clearly does not respond to the behavior of incoming daylight. Given that daylight entering the rooms attenuates in an exponential manner per column or zone, electric lighting must be fixtures that are linear. These light fixtures must also be arranged and grouped per zone perpendicular to the direction of incoming daylight so that switch operation can be done per zone as needed.

Surfaces commonly within viewing angle from a student seated at their desk have luminance levels below 3,000 cd/sqm. However, the luminances of surfaces that are outside the classroom but within view of the student can reach as high as 8,000 cd/sqm, which become sources of glare. Since closing the windows and doors will hamper the natural ventilation, it does not offer a practical way to address the problem. The option to provide blinds or some form of shading element must be considered to mitigate high luminances within a student’s field of view.

In all aspects investigated, the lighted environment of classrooms of Sulipan Elementary School has been found to be poor. Since daylight cannot sufficiently illuminate the classrooms, artficial lighting is needed. This lighting must perform within the recommendations of the IESNA in order to provide a lighted environment that is conducive for learning. Furthermore, many studies have shown that improvement of lighting environment in classrooms lead to better student performance (Galetzka, Moolenaar, Sleegers, & Zanded, 2013) (Aslam, Hussein, & Suleman, 2014). In our case this may also be carried out but will be more novel only after the retrofitting has been introduced.

Acknowledgements

The authors would like to express their gratitude to the Office of the Vice Chancellor for Research and Development for their support in this research. The authors are indebted to the Department of Education and the Sulipan Elementary School for their cooperation and patience.

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TOPIC 9: MATERIALITY

09.101 - RESEARCH ON THE DURABILITY OF RECYCLED AGGREGATE CONCRETE CONTAINING HIGH VOLUME FLY ASH

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Abstract

This study experimentally investigated the durability of concrete containing high volume fly ash. Two kinds of concrete with natural aggregate and recycled aggregate were adopted. Concrete mixtures made with 0%, 30%, 45% and 60% replacement of cement with class F fly ash were prepared for testing. Water-cementitious material ratios ranged from 0.35 to 0.59. The compressive strength, the resistance to chloride-ion penetration, and the water permeability of concrete were measured and presented. Test results indicate that recycled aggregate concrete showed a similar durability as the natural aggregate concrete. Except for the concretes at early ages, the compressive strength, the durability-related chloride-ion penetration, and the water permeability of concrete containing high volume (60% cement replacement) fly ash were obviously superior to the concrete without fly ash at later ages of beyond 28 days.

Keywords

high volume fly ash, recycled aggregated concrete, water permeability, chloride-ion penetration, durability

1 Introduction

The reuse of waste concrete has always been an important issue in Taiwan. In general, the reuse method is mainly to crush waste concrete as coarse aggregate for producing concrete. This concrete was named recycled aggregate concrete (RAC). The surface of recycled aggregate is full of pores, presenting high water absorption, which affects the quality of the interfacial transition zone, leading to negative effects to the durability of concrete. In order to improve the durability of concrete, Pozzolans such as fly ash and ground granulated blast furnace slag were added to concrete, however, there are restrictions on the addition content of the Pozzolans in many national standard codes. For past decades, more and more research results of high volume fly ash concrete were published, most of them were discussed for natural aggregate concrete (NAC), but rare for the reports relating to the RAC incorporating high volume fly ash, especially for the durability.

Babar Ali et al. [1] investigated the compressive strength of RAC with three replacement ratios of recycled aggregate (0%, 50%, 100%) and of fly ash (0%, 20%, 40%). The test ages included 3, 28, 90 and 180 days. Test results showed that the compressive strength of RAC was lower than that of NAC at all ages, and the strength of concrete with fly ash was lower at early age, however exceeded at later age. Adding fly ash could reduce the amount of cement and improved the workability of concrete.

M. Malešev [2] studied the effect of fly ash content and water-cementitious material ratios on RAC. Test results showed that as the fly ash content increased, the compressive strength of concrete decreased slightly. For example, the RAC with a water-cementitious material ratio (w/cm) of 0.54 and 50% content of fly ash had a compressive strength of 36 MPa at 28 days, which was 13% lower than that of the corresponding reference concrete (without fly ash). However, when the water-cementitious material ratio decreases to 0.3, the compressive strength of concrete was 50% higher than that of the reference concrete. Also, as the fly ash content increased, the resistance of concrete to chloride-ion penetration enhanced, especially for RAC with a large amount of fly ash combined with low water-cementitious material ratio, which exhibited an acceptable durability.

S. Palaniraj et al. [3] researched the compressive strength and durability of RAC incorporating high volume fly ash. The recycled aggregate used was obtained from crushed concrete of a 20-year-old building. The replacement ratios of recycled aggregates are 0%, 25%, 50% and 100%, and the replacement ratios of fly ash were 0%, 40%, 50% and 60%. Test results show that the compressive strength and tensile strength of RAC is about 40% to 50% lower than that of NAC, and the resistance to chloride-ion penetration of RAC was in the medium range.

R. Kurda et al. [4] performed the electrical resistivity and water absorption tests of RAC with high volume fly ash. The test results showed that with the increase of the amount of recycled coarse aggregate, the water absorption of concrete increased and the electrical resistivity decreased. When adding fly ash, these tests had the opposite result. They also suggested that RAC with high volume fly ash used in combination with high performance superplasticizers would have better durability performance.

S. Saha et al. [5] studied the RAC containing high volume fly ash (60%content), and the replacement ratios of recycled coarse aggregate were 0%, 25%, 50%, 75% and 100%. The test results show that the compressive strength, flexural strength and splitting tensile strength of concrete showed significant loss when increasing the replacement ratio of recycled coarse aggregate. Even though loss of strength was found, the test results indicated that up to 25 % replacement of natural coarse aggregate by recycled coarse aggregate was acceptable for the production of the concrete.

Based on the results of the above mentioned researches, it is seen that RAC with high volume fly ash may present better durability and higher compressive strength at later age. Therefore, this study aims to investigate the fresh properties, compressive strength and durability of RAC incorporating high volume fly ash.

2 Experimental Program

2.1 Test Materials

(1) Water: ordinary water that meets the requirements of ASTM C 1602.

(2) Cement: Type I Portland cement produced by Taiwan Cement Company, with a specific gravity of 3.15. The basic properties of cement are shown in Table 1.

(3) Class F Fly Ash: low-calcium class F fly ash obtained from Taichung Power Station in central Taiwan. The basic properties of fly ash are shown in Table 1.

(4) Fine Aggregate: natural river sand with a specific gravity of 2.60 and fineness modulus of 2.40.

(5) Coarse Aggregate: crushed river stone, with a specific gravity of 2.61, bulk density of 1470 kg/m^3 and D_{max} of 19 mm.

(6) Recycled Coarse Aggregate: crushed waste concrete, the specific gravity is 2.26, bulk density of 1280 kg/m^3 and the diameters of 5 ~ 20 mm were selected after screening.

(7) Superplasticizer (SP): High performance water-reducing agent of Type G, the specific gravity is 1.2 ± 0.02, the value of pH is 7.0 ± 1.0.

Table 12: Composition and physical properties of cement and Class F fly ash

Components	Cement	Class F fly ash
SiO	21.4	50
Al_2O_3	4.9	28.4
Fe_2O_3	3.8	6.98
CaO	64.2	5.91
MgO	1.1	1.39
Na_2O	0.2	0.09
SO_3	2.1	0.47
K_2O	0.44	0.13
Loss on ignition	2.1	4.62
Specific surface area (m^2/kg)	336	416
Specific gravity	3.14	2.31

2.2 Mixture Proportion and Specimen Preparation

The mixture proportions of concrete were designed according to the ACI 211 for providing the compressive strength of 28 MPa at 28 days. The water to cementitious material ratio (w/cm) ranged from 0.35 to 0.59, and the fly ash content ranged from 0% to 60% by weight of the total cementitious materials as cement replacement. The mixture proportions are shown in Table 2.

The fresh properties of concrete, including slump, air content, unit weight and setting time, were simultaneously measured for each batch. Various specimens for tests were then cast from each mixture, they were: cylinder specimen of ϕ100 x 200 mm for compressive strength test, cylinder specimen of ϕ150 x 50 mm for water permeability test, and cylinder specimen of ϕ100 x 50 mm for chloride-ion permeability test. After removal from the molds, all specimens were moved to a standard moist-curing room until date for testing.

Table 2: Mixture proportions of concrete

Specimen no.	**w/cm**	**Water**	**Cement**	**Fly ash**	**Fine aggregate**	**Coarse aggregate**	**Recycled coarse aggregate**	**SP**
		kg/m³						
NC28F00	0.59	200	340	0	740	1020	0	0
NC28F30	0.47	160	238	102	780	1060	0	3.4
NC28F45	0.41	140	187	153	790	1090	0	7.2
NC28F60	0.35	120	136	204	805	1095	0	11.8
RC28F00	0.59	200	340	0	680	0	930	0
RC28F30	0.47	160	238	102	710	0	970	4.1
RC28F45	0.41	140	187	153	725	0	990	7.2
RC28F60	0.35	120	136	204	735	0	1015	11.8

* Specimen number: N is normal aggregate concrete, R is recycled aggregate concrete, C28 is the compressive strength of 28MPa, F45 is 45% cement replacement ratio of fly ash.
** The containing water of Superplasticizer (SP) is not calculated in the mixture design.

2.3 Testing of Specimens

The compressive strength test that meets the requirement of ASTM C 39 was performed at the ages of 7, 28, and 56 days. According to ASTM C 1202, the resistance of concrete to the penetration of chloride-ion was measured in terms of the charge passed through the concrete in coulombs. The water permeability of concrete was tested using a water permeability apparatus subjected to a water pressure of 0.29 MPa for 3 hours to determine the flow through the concrete specimen. The chloride-ion penetration and water permeability tests were performed at 28 and 56 days.

3 Results and Discussion

3.1 Fresh Properties of Concrete

Table 3 presents the measured results of fresh concrete including slump, air content, unit weight, and setting times. It can be found that the natural aggregate concrete (NAC) and recycled aggregate concrete (RAC) mixtures were mixed by using superplasticizer to produce slumps of 150 mm to 240 mm and 50 mm to 120 mm, respectively. The air contents of NAC and RAC increased with the increase of the cement replacement ratio of fly ash, ranging from 1.4% to 1.7% and 1.7% to 2.0%, respectively. The unit weight of NAC and RAC decreased as the replacement ratio of fly ash increased, ranging from 2265 kg/m^3 to 2350 kg/m^3 and 2095 kg/m^3 to 2170 kg/m^3, respectively. These results indicate that the fly ash RAC mixtures prepared for the test can exhibit adequate properties of fresh concrete, excepting the unideal slump due to the irregular shape of recycled aggregate.

Table 3 also shows that the initial-and final-setting times of NAC ranged from 5:10 (hour:minute) to 17:50 and from 7:15 to 21:20, and of RAC ranged from 4:35 to 11:10 and 7:20 to 16:20, respectively. For each series, the setting time of the fly-ash concrete increased in conjunction with the fly ash content. In addition, the setting times of RAC were shorter than those of NAC, owing to the water absorption of recycled aggregates after the concrete being cast.

Table 3: Properties of the fresh concrete

Specimen no.	**Slump**	**Unit weight**	**Air content**	**Setting time**		**SP**
				Initial	**Final**	
	mm	**kg/m³**	**%**	**(h:min)**	**(h:min)**	**kg/m³**
NC28F00	150	2350	1.4	05:00	07:15	0
NC28F30	120	2325	1.7	06:40	09:10	3.5
NC28F45	220	2295	1.7	08:45	11:40	7
NC28F60	240	2265	1.7	17:50	21:20	12
RC28F00	50	2170	1.7	04:35	07:20	0
RC28F30	80	2145	1.8	05:30	08:25	4
RC28F45	150	2120	1.8	06:25	09:45	7
RC28F60	120	2095	2.0	11:10	16:20	12

3.2 Compressive Strength of Concrete

Figure 1 shows the compressive strength of the concrete mixtures measured at the ages of 7 days, 28 days and 56 days. The strength development of the NAC and RAC series presented a similar trend. However, at 7 days, the compressive strength for both kinds of the fly-ash concrete were lower than that of the control concretes without fly-ash. At 28 days and 56 days, the strength of the fly-ash concretes equalized and exceeded that of the control concrete. In comparison, the fly-ash concretes of the RAC presented a higher strength gain than that of the NAC. These results indicate that the control mixtures had larger early strength gain than that of the fly-ash mixtures. Nevertheless, higher strain gain of the fly-ash concretes was observed at later ages of beyond 28 days.

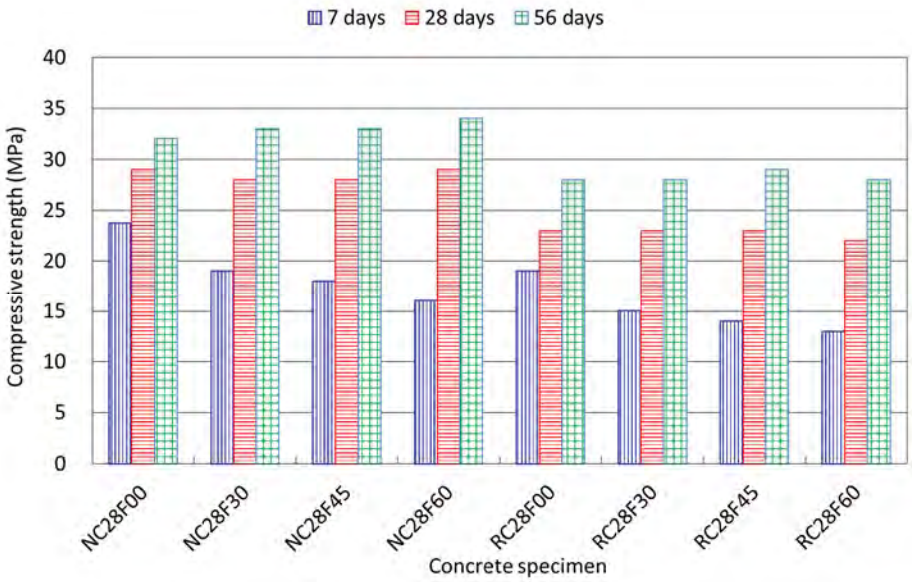

Figure 48. Compressive strength of concrete

3.3 Resistance to chloride-ion penetration

Table 4 summarized the measured results for the resistance of the concrete to the chloride-ion penetration, the results are also illustrated in Figure 2. Overall, the characteristic of the resistance to the chloride-ion penetration of the RAC was almost similar to the NAC, in which the resistance to the chloride-ion penetration of concrete incorporating fly ash was higher than that of control concrete without fly ash. At 56 days the total charge passed, in coulombs (C), were 1224 C and 1089 C (classified as low permeability) for NC28F60 and RC28F60, and were 7432 C and 8006 C (high permeability) for NC28F00 and RC28F00, respectively. This indicates that incorporating high volume (60%) of fly ash in concrete may reduce the chloride-ion penetration, resulting in the improvement of the durability of concrete. This is believed to be due to contribution of the pozzolanic effect of the fly ash mixtures.

Table 4: The resistance to the chloride-ion penetration of concrete

Specimen no.	w/cm	Total charge passed (coulombs)		Classification of the chloride-ion permeability*
		28 days	56 days	
NC28F00	0.59	9954	7432	high/high
NC28F30	0.47	3402	2039	moderate/moderate
NC28F45	0.41	1985	1274	low/low
NC28F60	0.35	1841	1224	low/low
RC28F00	0.59	9329	8006	high/high
RC28F30	0.47	3474	2651	moderate/moderate
RC28F45	0.41	2588	1674	moderate/low
RC28F60	0.35	2093	1089	moderate/low

*Charge passed, chloride permeability, coulombs: > 4000C = high 2000 - 4000C = moderate
1000 - 2000C = low 100 - 1000C = very low < 100C = negligible

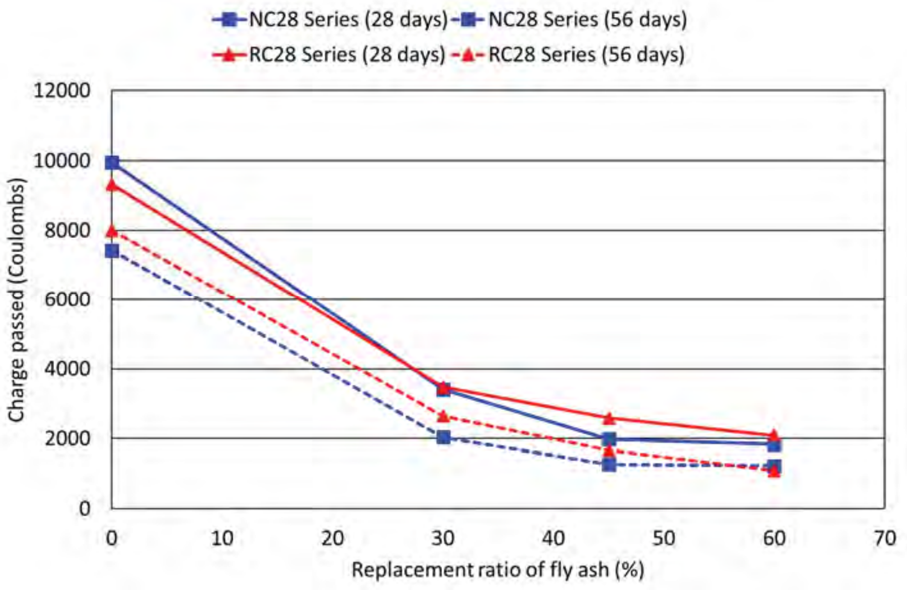

Figure 2. Relationship of total charge passed and fly ash content

3.4 Water permeability

The water permeability of concrete was tested using a uniaxial flow apparatus performing on cylinder specimen (ϕ150 x 50 mm) subjected to a 0.29 MPa pressure for 3 hours. The water permeability was calculated with following formula:

$$\text{Water permeability} = \frac{m_2 - m_1}{m_2} \times 100\% \quad (1)$$

where m_1 = initial weight of specimen, m_2 = specimen weight after test.

Figure 3 illustrated the measured water permeability of the concrete specimens. It is seen that the water permeability decreased with the increase of the age of concrete for both kinds (NAC and RAC) of fly ash concretes. The water permeability of NAC is superior to that of RAC. In addition, incorporating fly ash in concrete may inherently reduce the water permeability of concrete. This can be particularly found in NC28F60 and RC28F60 (containing 60% fly ash) at later age of 56 days, which have water permeability of 3.21% and 3.93%, compared less with those of NC28F00 and RC28F00 of 3.69% and 5.20%, respectively. These results signify the facts that the concrete containing high volume fly ash of 60% at later age may exhibit lower water permeability, namely superior durability to the concrete without fly ash.

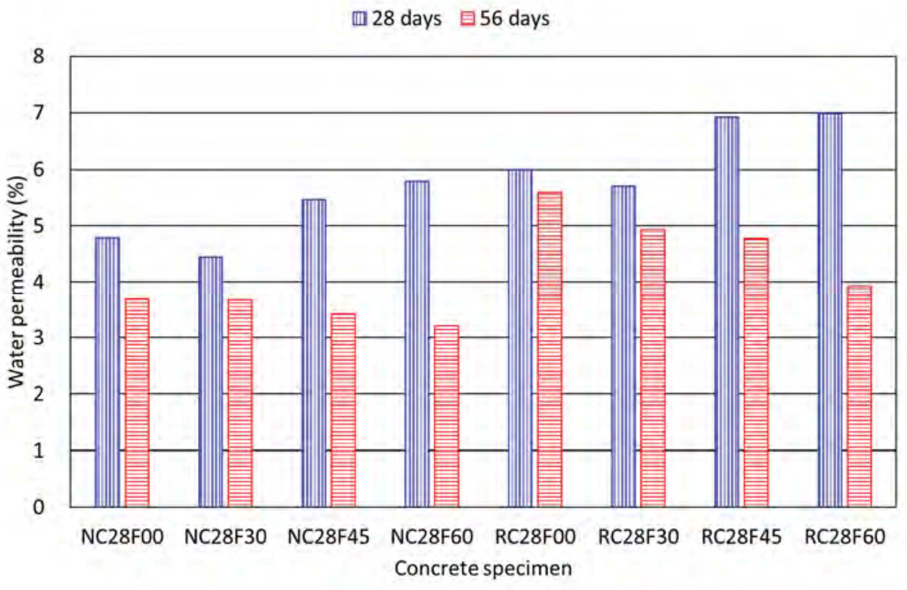

Figure 3. Water permeability of concrete

4 Conclusion

Based on the results of the experimental work, following conclusions can be drawn:

1. The workability of natural aggregate concrete (NAC) was better than that of recycled aggregate concrete (RAC) with the same mix proportion. The setting times of both NAC and RAC increased with the increase of fly ash.
2. The control mixtures of both RAC and NAC had larger early compressive strength gain than that of the fly ash mixtures, however, higher strength gain of the fly-ash mixtures was observed at later ages of beyond 28 days, thus, the strength of fly-ash concrete exceeded that of the control concrete without fly ash at 56 days.
3. RAC had similar characteristic of the resistance to the chloride-ion penetration to NAC. The resistance to the chloride-ion penetration of concrete incorporating fly ash was higher than that of control concrete. Especially, incorporating high volume (60%) of fly ash in concrete may reduce the chloride-ion penetration, resulting in the improvement of the durability of concrete.
4. The water permeability of NAC was superior to that of RAC. Incorporating fly ash in concrete may reduce the water permeability of concrete. The concrete containing high volume fly ash of 60% at later ages may exhibit lower water permeability, namely more durable than the concrete without fly ash.

Acknowledgements

The authors appreciate the Architecture and Building Research Institute (ABRI), Taiwan, for the financial support to this research.

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09.102 - THE COHESIVENESS OF ECOLOGICAL CONSTRUCTION – MATERIALS APPROACHED THROUGH TECTONIC PRACTICE

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Abstract

Based on a tectonic approach, which focuses on sustainable ways of extracting and producing, cutting and combining materials in accordance with their potentials and properties, the paper will explore one crucial point at which ethical and aesthetic aspects can be said to converge. In terms of materiality we define the ethical as showing regard for the ecological context from which matter and materials are extracted and produced with their potentials and properties in mind, and the aesthetic as bringing forth well-wrought artefacts which can hold their own through an elaborate integration of different elements into a coherent whole. We argue that these two aspects converge in the tectonic attempt of cutting, combining and joining materials in sustainable ways so as to create artefacts of well-arranged pieces, in which "the elements or salient features that constitute things can be said to feed into and play off each other, or answer to each other in various ways, such that they generate and maintain a form of organization that is cohesive overall."[1]

In relation to an ecological context, the paper will discuss if this notion of cohesiveness could inform today's tectonic practice and prove to be relevant for the building industry as such. In order to use the term ecology with regards to modern day tectonic practice, the understanding of the term is extended to include industrial aspects. Equal to how materials are extracted and processed, the way they are combined and joined conditions the lifespan of the materials and the artefact, which they are part of. Regarding the vast environmental impact of the building industry today, unfolding the intertwined ethical and aesthetic questions concerning materials are of great importance and may lead to increased optimization, cost reduction of material consumption and a highly coherent, legible built environment.

Keywords

Tectonics, Cohesiveness, Ecology, Materiality, Building Industry.

1 Introduction

The reason for taking our starting point in indigenous and vernacular building traditions in what follows is to explore how their respectful modes of handling materials and using them in ecological construction could inform today's tectonic practice and building industry. In terms of materiality, we designate this regard for the ecological context ethical, as it proves to take special care of the integrity and intrinsic value of the living ecosystems, from which matter and materials are extracted and produced, by keeping in mind their limits, potentials and properties [2][3]. As we shall see, there is also an important aesthetic aspect to this form of ecological construction, which consists in bringing forth well-wrought artefacts that can hold their own through an elaborate integration of different elements into a coherent whole. We argue that these two aspects, the ethical and the aesthetic, converge in the tectonic attempt of cutting, combining and joining materials in sustainable ways so as to create artefacts of well-arranged pieces, in which “the elements or salient features that constitute things can be said to feed into and play off each other, or answer to each other in various ways, such that they generate and maintain a form of organization that is cohesive overall [4].

2 Three cases of ecological construction

Figure 1. Picture of one of the living root bridges in Meghalaya. Photocredit: Roman Korzh.

2.1 Living root bridges

In the Northeastern part of India, situated between Assam and Bangladesh, lies Meghalaya where we find examples of the living root bridges. In the forests of the Khasis, the bridges are infrastructural connections between villages, which would otherwise be disconnected by floodwaters during the monsoon season. These bridges are developed by the Khasi people through a unique tradition of utilizing resources and showing respect towards the biophysical context. A special weaving technique shapes the roots of the *Ficus elastica* into a suspension bridge by guiding them whilst still letting them grow.

The same living root weaving technique is used to build ladders for climbing between the plateaus of the mountainous region. Because of the geographic remoteness and inaccessibility of the villages, this building tradition has remained unaffected by external influences, such as colonization, industrialization or foreign materials. The rainforest moisture is so heavy that dead organic materials over time end up decomposing, while the roots of the living trees only grow stronger over time [5].

Due to this, the living root bridges are far more durable and resilient than any other alternative. As a technology, the *Ficus elastica* is embedded in traditional ecological knowledge of the local environment and climatic conditions, where it maintains biodiversity and is self-regenerating. The growth of the trees depends on the monsoon downpours, during which they in turn preserves accessibility for the Khasis. Much of the maintenance of the bridge is as such upheld by the trees themselves. If part of the bridge breaks, the roots are then re-guided to patch the hole.

The living root bridges hold some of the qualities that are sought after in modern construction; they are low maintenance, low cost and have very low embodied carbon footprint. However, there is a temporal aspect to them that most often is not a quality in modern construction. The builders take the biological growth and developments of the trees into account, which means that the bridges are planned a decade in advance and take between 10-30 years to finish. When finished, the 30 years old bridges are very sturdy and can bear the weight of up to 50 people. Some of the existing living root bridges span up to 100 feet and are more than 250 years old. [6]

2.2. Eelgrass roofing

For the second example of ecological construction, we look to the small island of Læsø in the northern part of Denmark, where a most peculiar and particular type of seaweed building technique came about some 300 years ago. Læsø is a secluded island, and in the past, resources were very scarce. The primary building materials available were the driftwood and eelgrass that washed ashore on the island. Out of this situation sprang the craft tradition of building seaweed roofs.

The visual appearance of the buildings does not represent an aesthetic trend of the time. Rather the architectural expression is a result of building with local and accessible materials. The building process is first to gather the fresh eelgrass (*Zostera Marina* – a certain sort of seaweed which is inedible), which is then spread out on the nearest field for air drying. When dry, it is ready for use. In bulk it can be used as insulation in walls and stuffing in mattresses and furniture. On Læsø it was also used for roofing, miming the use of organic materials in traditional thatched roofs.

Figure 2. Photo of eelgrass roof, Kaline's House, Læsø. Photocredit: Helene Høyer Mikkelsen.

Originally, it was simply piled on top of a roof frame and held in place in different ways without being sewn as the thatched roofs were. This primitive construction is one of the simplest forms of roof, but it required a very sturdy load-bearing construction. However, the roofing technique was developed to more specific use. In the 18th century there were more women living on the island than men, who were often at sea or in war. The women did all the work on the farms and farmhouses [7]. The way, that the seaweed is twisted into these long rolls, bears resemblance to how women of the time processed wool for the spinning wheel.

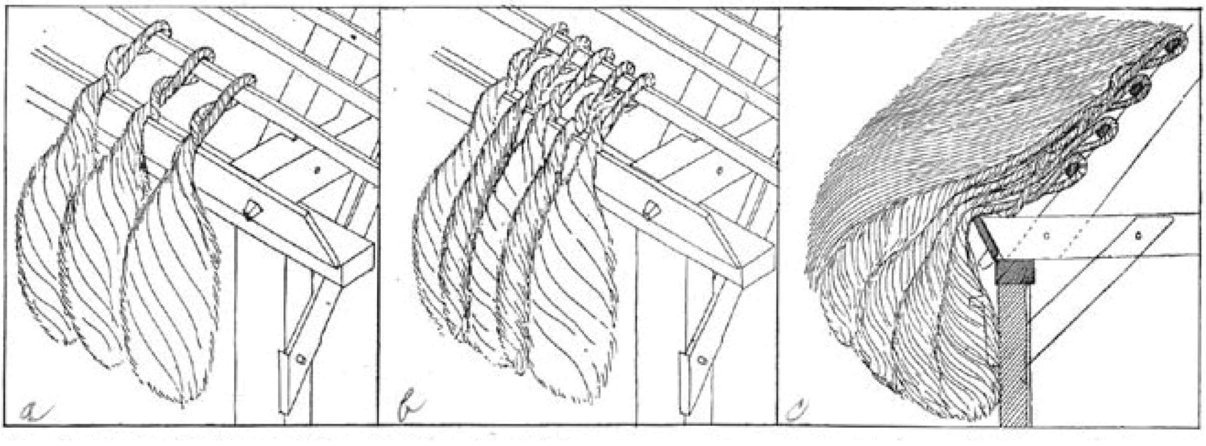

Figure 3. Illustration of traditional eelgrass roofing from Engquist, H.H.; "Læsøbyggeskik", Nationalmuseets Arbejdsmark 1944.

The dry bulk material is first twisted into long and thick rolls of between 7-12 kg, which are then tied onto the first 3-4 horizontal battens of the wooden roof frame. When these battens are tied full, the quantity of seaweed makes up what is called a kind of rampart. Sprigs of spruce is then laid on the wooden frame, upon which more bulk seaweed is thrown reaching a thickness of up to 2 meters. While piling seaweed onto the frame, the seaweed is being compressed by a person walking around on it.

The seaweed's ability to divert water is not the best, so for it to become fully watertight, although still permeable, it is crucial that it compresses. Over time the seaweed hardens and forms a waterproof oxygen-free membrane in the middle of the bulk. The final thickness of these roofs is between 1 and 1,5 meters. Patches of turf are put up on the ridge of the roof to keep the seaweed in place. Traditionally, the roofs were usually built in spring, so that the seaweed would compress enough by its own weight and through weathering over summer reaching a density that could withstand the winter weather.

2.3. Laft timber construction

As a third example of ecologically sound construction, we will highlight one of the best known building techniques in Scandinavia *laft* and compare it to *stav* [8]. The latter technique proceeds by raising polished trunks and planks vertically next to one another, initially by driving the piles into the ground in order to create protecting walls. Yet, builders and dwellers soon realized that wood submerged in earth starts to rot in a relatively short time. This led to improvements, such as placing the timber on top of a foundation made of stone and binding and backing up the planks through constructions on the inside of the building.

Figure 5. Timber wall of vertical planks (*stav*). Photocredit: Northhouse.org.

However, the technique of creating walls out of timber raised vertically inevitably runs into a recurrent problem: The trunks and planks break and shrink over time, because of weathering and of drying up, so that fillings are needed to keep the timber together and avoid that wind and cold penetrate through the undesired openings. As with any temporary solution, which only postpones decay for a shorter or longer period of time, the fillings cannot hold the whole artefact together and will also weather away prematurely. From beginning to end, time runs counter to the whole building project and will result in unsustainable stopgap measures, if the building technique is not turned around towards the horizontal, so that the timber can start to develop its own productive dynamics.

The *laft* technique offers exactly that. It consists in putting wooden beams horizontally on top of one another, adjusting the pieces to each other so that they fit into a repeating pattern which conveys the impression of great solidity and balance. Each beam will often be convex-shaped at the top and concave-shaped at the bottom in order for the top pieces to carve themselves slightly into the pieces right below them. In addition to this, a part of each beam in the corners is gouged, so that it can receive the next beam coming on top, which has also been prepared to fit and receive the next. In this way, the beams in the wall end up falling into place under their own weight and become interlocked [9].

Figure 4. Corner of *Laft* timber construction. Photocredit: Norges Husflidslag.

If we add the weight of the roof and the heavy snowfall in northern Scandinavia, the whole building will become more and more well-fitted, as each carefully prepared beam works its way into the adjacent beams. This sort of joint timber building becomes more robust over time and needs only a few preventive adjustments to cope with the inevitable weathering and movements of the timber. The oldest *laft* houses still standing in Norway are from the 12th century [10]. Needless to say, no material structure lasts forever, but the *laft* technique is a paradigmatic example of tectonically sustainable development which not only unfolds its maximum potential without using up its resources prematurely, but in its unfolding it consolidates and sustains itself over such a long time-span that it gets as close as we can come to self-sustainability [11].

3 The relevance of tectonic practice in ecological construction

Seen through the lens of tectonics, the *laft* technique shows how development can become sustainable by building its unfolding on its own folds, which are prepared in such a way that they make the elements fit together and play off each other so that the whole building becomes more cohesive over time. Similarly, the compression of the eelgrass roofs that happen over time relies on the properties of the material itself for becoming waterproof. In the case of the living root bridges, which are built without cutting the *ficus elastica*, the technique of weaving and knotting holds tectonic values, as the knot can be said to be fundamental for all constructional details in that it ties and integrates different parts and pieces into a whole [12]. The point of highlighting these techniques is not to extend their fields of application beyond their own well-defined limits and start building like this everywhere, but to use it as an example of tectonic ecology, highlighting its aesthetic and ethical aspects, which are relevant for technological and human development.

The late modern tradition of tectonics in architectural theory, notoriously represented by Kenneth Frampton, has made a case for tectonics as a humanistic and ethical response to the environmental and existential challenges facing mankind at the turn of the millennium: Tectonics is based on a thorough knowledge of the nature of materials, stemming from local traditions, which are reinterpreted so as to be applicable in the late modern globalized world. In contrast to the abstract non-places of the accelerated civilization of illusively unlimited consumption and the monotony and mismatch of suburban sprawl, the art of tectonics creates durable and distinguishable dwelling places for human well-being. It promotes a legible, ecological built environment, into which is inscribed its own making, and it is resource saving and easy to recognize and to reproduce, as the materials and the structural units going into tectonic work fit harmoniously together and relate the whole artefact respectfully to its surroundings [13].

In the light of the enormous ecological impact which the construction industry has on the planet, and considering that architecture tends more and more towards becoming a technocratic, mechanical management of resources and information flow, cut off from local environments and, to a large extent, governed by global trends and economies, tectonics offers sustainable solutions that let materials express their nature in accordance with regional cultural traditions and the living ecosystems of the earth [14].

Frampton borrowed the term “critical regionalism” to designate his own scrutinizing attempt to challenge the dominant architectural discourse, which revolves around utility, commodity and profit, by recovering a tectonic art of creating dwelling places poetically. His aesthetic-ethical approach finds a parallel in bioregionalism, which seeks to create, not unreal, immaterial utopias, but *eutopias*, good places to live that contain a dynamic and sustainable equilibrium between human habitation, social organization and local ecology [15].

The art of tectonics embodies sustainable ways of integrating technological development with human development by letting the built environment be formed by and thus embedded in local and regional traditions, which hold the key to a deeper understanding of the sustainable correlation between the materials used, the living ecosystems, cultural identities and human well-being.

4 Environmental ethics of the built environment

The regard for the ecological context place ethical aspects to the cohesiveness of the built, the materials used and their natural origin. According to the theory of responsive coherence, there is a hierarchy of contexts to be considered; “...the biophysical realm of nature constitutes the basic context for the development and continuance of the linguistically mediated human social realm, and that the human social realm in turn constitutes the basic context for the development and continuance of the human-constructed realm.” Quote Warwick Fox, p.19 [16]. The designation of the biosphere as the primary entity of ethic concern, is mirrored in the environmental ethics of ecocentrism.

Four of the main -isms in the field of environmental ethics include anthropocentrism, sentientism, biocentrism, ecocentrism. In general, these positions seek to define what one could call the ethical community. This ethical community can be understood as consisting of ethical agents and subjects. Ethical agents can be held accountable for their actions and are obliged to pay respect to the ethical subjects, even though the subjects cannot be held ethically accountable. According to the Danish philosopher K.E. Løgstrup, ethical relations are interdependent, and where one part is in a relation with power over another part, the part in power has the responsibility, to figure out how to use it's power for the best of the other, even though it is not the best for itself [17]. Then, who and what are included in this ethical community of power relations?

In anthropocentrism, only humans are of ethical importance as agents and subjects. In sentientism, all sentient beings (living beings who are conscious of their own situation and can feel pain) are included as subjects. Biocentrism further expands the ethic community to include all living things as subjects. Ethical agents can then be held responsible for exerting power over all living things, not because they are conscious, but because they have a quality which holds ethical significance. For the American philosopher Paul W. Taylor, this quality is that they have "a good of its own" [18]. Gjerris relates this to the Aristotelian concept of *telos* (Greek for "goal" or "purpose"). We will return to this later. The fourth position, ecocentrism, further expands the ethic community to the entire biosphere on a systemic level. According to Gjerris, the focus in ecocentrism is on the wholes which nature consists of and the processes that carry the living [19]. Bio- and ecocentrism are related in the way that they recognize that both human and non-human nature have intrinsic ethical value. Related to this are also the concept of deep ecology, which equalizes the power relation between human and nature in a way that problematizes viewing nature solely as a resource existing for humans to exploit.

Returning to the concept of *telos*; In *The Question Concerning Technology* the German philosopher Martin Heidegger also uses *telos*, not to describe the purpose of a living thing, but to describe the *causa finalis* of a sacrificial silver cup [20]. *Causa finalis* is comparable to purpose, so in both cases, the concept of *telos* can be understood as contextualized beyond the thing itself – no matter if it is a living thing or an object of human craftsmanship it is part of a larger whole.

The three examples show different ways of applying natural resources as building materials. The first example with the living roots bridges, the trees as resources are not cut or extracted, but rather channeled and preserved. As the *Ficus elasticas* are not cut for construction, but remain living organisms which fulfill their role in the natural ecosystem as well as function as bridges for the Khasis, extraordinarily, one could claim that they unfold both telos understood as in Heidegger's 3rd causality and Paul W. Taylors' definiton of telos. In the case of the roofs on Læsø, the seaweed washes up on the shore, from where it is collected and processed. In the case of the laft construction, the timber is cut from its biological context before being prepared for use in the laft technique. These days, it is of course important for the ecological soundness that timber for construction comes from sustainable forestry.

Even though the techniques of applying the natural materials differs in the three cases, they are similar in that the materials are processed and joined in accordance with their intrinsic properties while being used for their instrumental value. There is a coherence between biology and technology in a way that renders the structures cohesive over time.

4 Conclusion

The cases presented in this paper display ecological structures and constructions that have emerged from their specific geographic and cultural settings. What the cases have in common is the handling of materials in coherence with the intrinsic properties and the ecosystems they are part of. The materials are applied in ways which correspond with some of our current demands for technological performance and sustainable construction. This could point to a potential for including natural processes in the definition of sustainable technology. The prevalent preoccupation with high-tech solutions in much of current industrial building practice could be challenged by investigations into low-tech examples like those addressed in this paper. The tectonic practice offers a framework for engaging in the processes of industrial construction with aesthetic and ethical considerations as two converging points of departure. An ethical approach to materials and natural resources, embodied in tectonic practice, enables a cohesiveness of construction, in which aesthetics is a vital part of the ecological whole.

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AUGMENTED REALITY IN ROOM ACOUSTICS: A SIMULATION TOOL FOR MOBILE DEVICES WITH AUDITORY FEEDBACK

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Abstract

Augmented reality (AR), as a combination of real and virtual worlds, is getting more widely used in the architecture and construction domain, especially for visualization. However, virtual information can be presented not only visually but also audibly, which is valuable for room acoustic simulation. An application running on a mobile device, Soundar, was developed for simple acoustic simulations for small size rooms. It simulates the reverberation time and the sound pressure level in an existing room based on a virtual sound source, the location of the user, and the surface characteristics of the room. Users can alter the material of the room surfaces, change sound properties and then simulate the difference in sound. The application provides both visual and auditory feedback that will let the users not only read the data but also hear the result of the simulation.

Tests were run to compare the results returned from Soundar, existing sound simulation software, and sensor recording in the real testing rooms. By comparing the numeric results, SPL charts, and the impulse responses of the sound files, it was shown that Soundar is acceptable for normal usage and schematic design, but not for scientific precise analysis.

Keywords

Augmented reality, room acoustics, room auralization, mobile application.

1 Introduction

Augmented reality (AR), as an overlay of real and virtual worlds, is getting more widely used in many industries. In the architecture and construction domains, most applications are for interior design, measurement, BIM visualization, and simulation. There are many other AEC opportunities that can benefit from further AR development. AR can be used for design applications like model viewing, simulation, measurement, interior design, and furniture selection. Furthermore, it can also be useful in other phases or relevant areas like facility management and maintenance, construction and manufacture, and education.

The visual sense, as one of the two main ways for people to get information in daily life, is the most common one in AR. However, another way using the auditory sense has not been fully involved with the utilization of this technology. People can get information directly from what they hear, and on some occasions, it is even more useful than seeing and reading. Acoustic stimulation is exactly one of these occasions. To have a better understanding of how sound performs in space, it is always clearer and more straightforward to hear it rather than showing data and descriptions. This is the main purpose of Soundar, an application for mobile devices that was developed to provide auditory and visual feedback of the acoustic simulation for an existing indoor environment based on AR technology.

By setting up the room based on the real environment the user is in and adding virtual sound sources into space, Soundar can simulate the reverberation time of the room and the sound pressure level based on the location of the user in the room, which is determined by the location of the mobile device. Then it generates a sound file that represents how it would sound as if the sound source is truly played on this occasion. The users can change the materials of the surfaces, thus changing the absorption coefficient and acoustic characteristics of the space. The feature of changing materials can help users redesign the room to achieve a specific acoustic performance (Figure 1) .

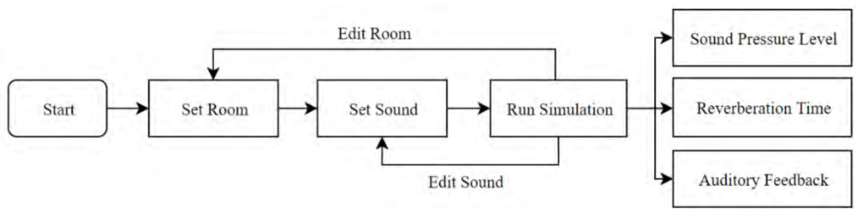


Figure 1. Workflow of Soundar.

2 BACKGROUND RESEARCH

2.1 Basic Knowledge

Augmented Reality (AR) is a technique that brings virtual models and information into reality. There are various definitions of AR. The commonly accepted definition of AR is a three-dimension display that combines both virtual and reality and reacts in real-time [1]. The audio was introduced as a part of AR in 1995 with the prototype of the automated tour guide system[2].

Room acoustics focuses on the sound performance and properties in an enclosed environment [3]. Sound pressure is the deviation between the local pressure and ambient pressure. Decibel (dB) is the unit of sound pressure level. The time for the sound pressure level to reduce –60 dB in a room is called reverberation time (T_{60}) [3]. For the room with small size, the T_{60} can be calculated by using Erying's formula (Formula 1).

$$T_{60} = \frac{0.161V}{-S \cdot \ln(1-\bar{\alpha})} (\bar{\alpha} > 0.2) \tag{1}$$

2.2 Related Software and Tools

Unity is a game development engine that is used to develop AR based applications for mobile devices [4]. Steam Audio is an audio SDK that can be used on many platforms, including Unity [5]. Unity released a hub system called AR Foundation that integrates multiple AR SDK together, which can solve the problem of publishing one application to different mobile devices. It can also make it available to use features from different SDKs in one application.

There are also some useful tools for sound measurement such as Virtual Sound Level Meter (VSLM), which is based on Matlab [6]. VSLM can measure the SPL and do other sound analyses of a sound file in .wav format. Room EQ Wizard (REW) is a room acoustics analysis software that can measurand analyze room and loudspeaker responses [7]. It can read existing .wav sound files and analyze the SPL, frequency, impulse response of the sound file.

3 METHODOLOGY

The overall workflow for developing Soundar starts from setting up the software platforms and databases and ends up verifying that the deviation of the results of Soundar is below the threshold for human hearing to notice the difference.

3.1 Platform Setup and Database Setup

Unity was chosen as the development platform because Unity AR Foundation is easy to use and allows portability between devices. The following software and tools were installed to the workstation: Unity and Visual Studio, Unity AR Foundation and other AR SDKs, and Steam Audio. The material database is a CSV file, which can be directly read and written by Unity (Figure 2). The material database was separated by the surface categories: wall, floor, and ceiling. It includes the data of the material name, and the acoustics parameters of this material, which are low frequency absorbing coefficients, mid-frequency absorbing coefficients, high frequency absorbing coefficients, scattering, low-frequency transmission coefficients, mid-frequency transmission coefficients, and high-frequency transmission coefficients. The definition for low, mid, and high frequency is 400 Hz, 2.5 kHz, and 15 kHz [5].

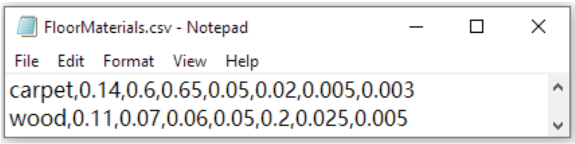

FloorMaterials.csv - Notepad
File Edit Format View Help
carpet,0.14,0.6,0.65,0.05,0.02,0.005,0.003
wood,0.11,0.07,0.06,0.05,0.2,0.025,0.005

Figure 2. Material data of floor materials in CSV format.

There are five default sound files in Soundar: impulse, a constant sound at 500Hz, a piece of music, and two pieces of speech of male voice and female voice. All these sounds were recorded in anechoic chambers. The impulse sound is a balloon burst. The music file is an anechoic recording of symphonic music [8], and the speech files are recordings of several Harvard sentences from the TSP Speech Database [9].

3.2 Application Development

The overall framework includes the architecture of the application, operation sequence, as well as its internal logic. The development of Soundar contains two major parts: the simulation process and user interface (UI) design (Figure 3). Each part was broken down into subprojects by different aspects.

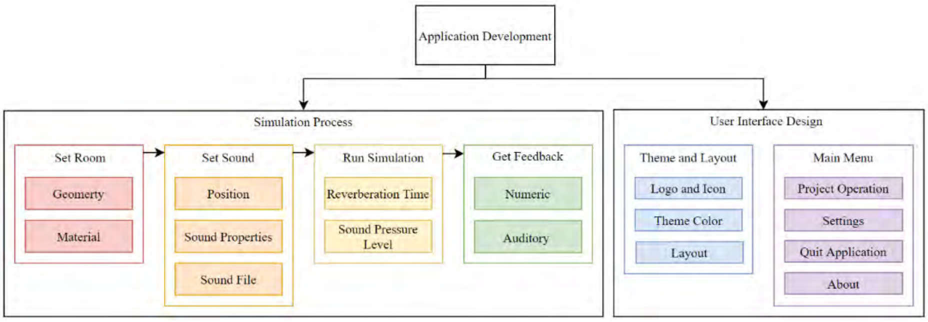


Figure 3. The overall framework of the development process of Soundar.

The development of Soundar used the modular design method. Individual modules were generated before building the application. Each module focused on one independent simple function. 42 modules were made for Soundar for a different purpose. Modules can be used multiple times in different tasks or even other modules, and the tasks can be a huge combination of the modules. Although the modules are for simple tasks, each of them has single or multiple variables. With the changes in the variables, the module can realize multiple purposes. All these modules are small pieces of Unity scripts, and they are called by the main script for each task or other modules (Figure 4).

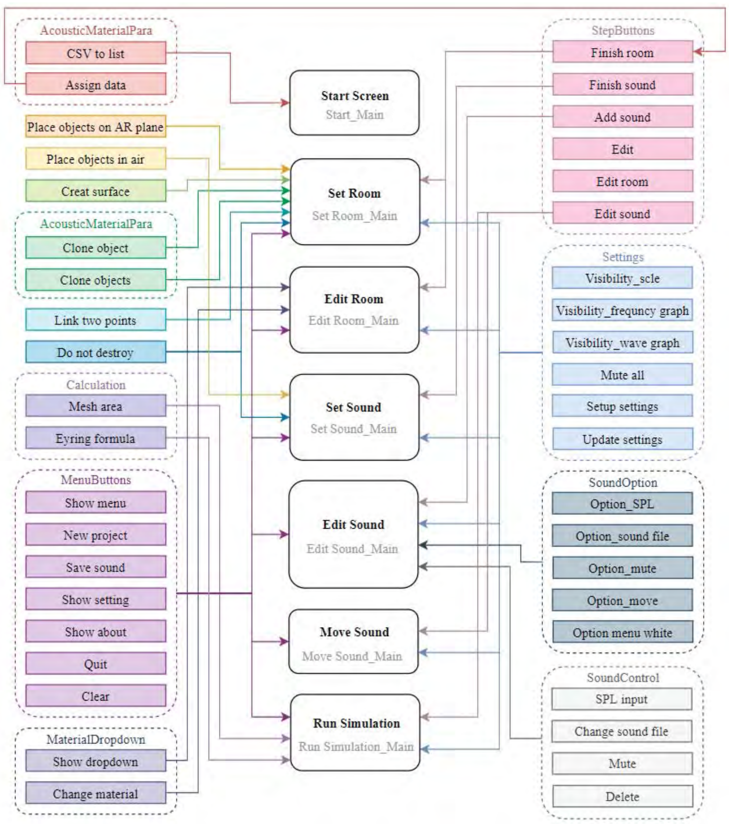


Figure 4. Relationship between scenes, main scripts, and modules.

4 SIMULATION PROCESS

Soundar has seven scenes: "Start Screen," "Set Room," "Edit Room," "Set Sound," "Edit Sound," "Move Sound," and "Run Simulation" (Figure 5).

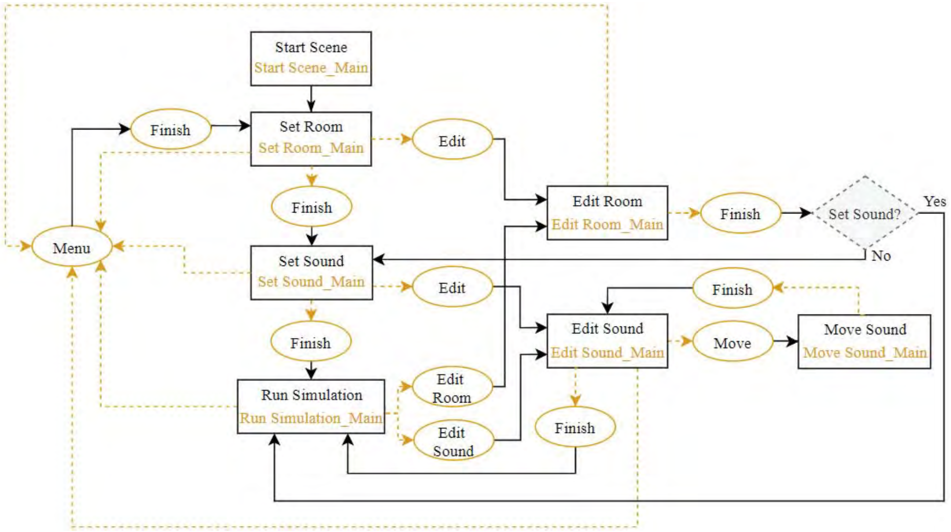


Figure 5. Relationship and connections in the seven scenes.

4.1 Start Screen

"Start Screen" is the first scene shown after the application run (Figure 6). It shows the logo and the name of Soundar and leads users to finish the calibration. The calibration plays a constant sound at 500 Hz in 30dB, and the user can adjust the volume setting of their devices to where they can barely hear the sound. Meanwhile, it loads the material database to the application and then loads the next scene.

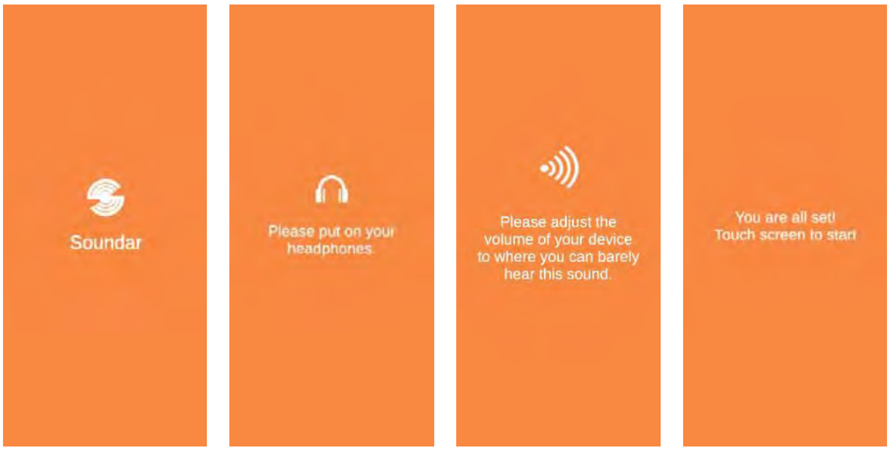


Figure 6. "Start Screen" shows the logo and the name of Soundar and do the calibration.

4.2 Set Room

“Set Room” is used for creating a room based on the real environment (Figure 7). Soundar first detects the surface in reality and generates horizontal AR planes using the scripts from the AR foundation. Users can define the floor by placing floor vertices on the AR plane. For each additional point, it draws lines to connect the new point to the previous one. When the new point is less than 0.1 meter from the first point, it deletes the new point and links the new last point with the first point, which considers the floor shape a closed-up shape. If the points are fewer than three, which can not define a surface, a hint text will show up to warn the user.

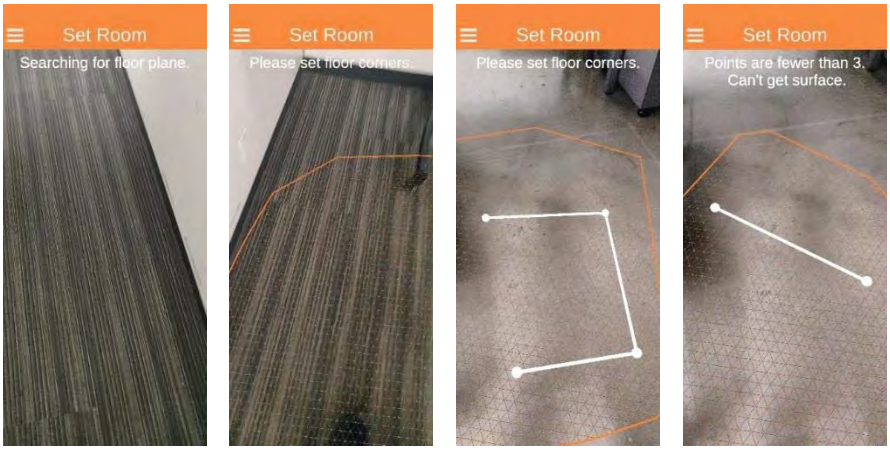


Figure 7. Floor set-up in “Set Room”

When the floor surface is set, Soundar copies the floor points, boundaries, and the surface as the ceiling and assigns the default ceiling material to the ceiling surface. The elevation of the ceiling is calculated by the rotation of the device. If the rotation of the device is out of range, which makes the elevation of the ceiling below the floor or in an infinity distance, a hint text will show up to warn the user (Figure 8 a-c). When users touch the screen and confirmed the ceiling, walls are generated and the room is set up (Figure 8 d). When the room is set up, the “edit” and “finish” buttons will show up, which leads to the scene “Edit Room” and “Set Sound.”

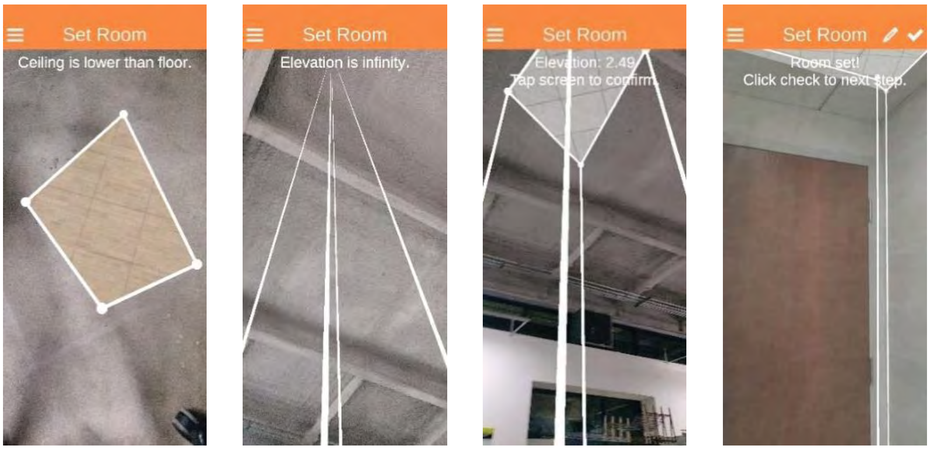


Figure 8. Different conditions for ceiling elevation (a-c) and room set (d)

4.3 Edit Room

"Edit Room" allows users to change the material of each surface (Figure 9). Users can choose the material options in the dropdown. When the value of the dropdown changes, the texture and the value of the acoustical parameters will change based on the material database.

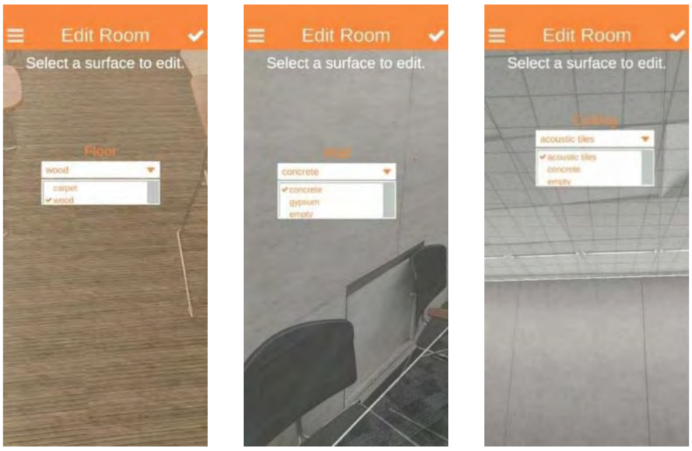


Figure 9. Different dropdowns are shown when selecting different surfaces.

4.4 Set Sound and Move Sound

In "Set Sound," a new sound source will be created at the camera location for each time when users touch the screen. A counter shows how many sound sources are placed in the project (Figure 10 left). In this scene, users can move the sound source along the coordinate axes. The axes are based on the world coordination system, which will not change the directions with the location and the orientation of the devices (Figure 10 right).

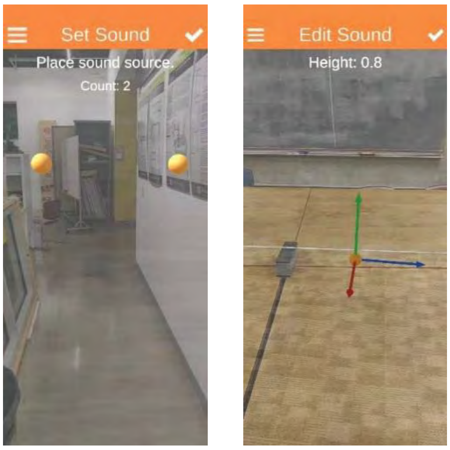


Figure 10. Set (left) and move the sound source along the coordinate axes (right).

4.5 Edit Sound

The scene "Edit Sound" allows users to change the sound pressure level and the sound file of the selected sound source. Users can also mute the sound source. Each sound source can be edited individually (Figure 11).

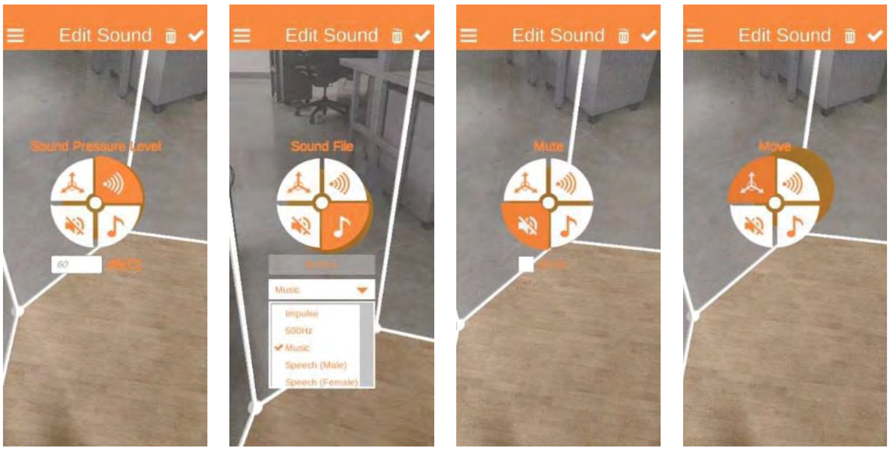


Figure 11. Four edit options in "Edit Sound."

4.6 Run Simulation

Users can get the simulation result of the real-time sound pressure level and the room reverberation time of the room, as well as hearing binaural sound feedback based on users' location based on the location of the mobile device (Figure 12). For every time users open the "Run Simulation," it records the environment to calculate the average SPL of the current environment. The user current SPL shows at the center of the SPL scale in real-time. The arrow of the scale also rotates to the same position on the scale. The reverberation time is calculated by the Eyring's formula [10].

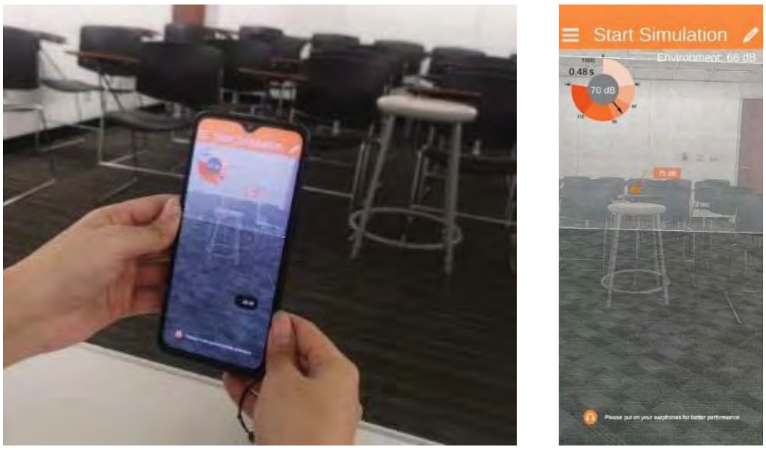


Figure 12. “Run Simulation” shows visual feedback and plays auditory feedback.

5 VALIDATION

The validation was focused on the accuracy and useability of Soundar. Soundar was tested in two rooms in Watt Hall at USC. Two methods were used in the test: a live recording and the Soundar simulation. A live recording was taken of a test sound going through a loudspeaker and recorded with a microphone. The Soundar simulation was the screen recording from the tested phone. The Soundar used in the test was version 1.0.8.25, which could not a simulation sound file to the local folder of the device. The simulation sound file was recorded by the phone’s built-in recorder, which was set to only record the device internal audio. All files were converted to .wav format using Adobe® Audition.

5.1 Validation Tests

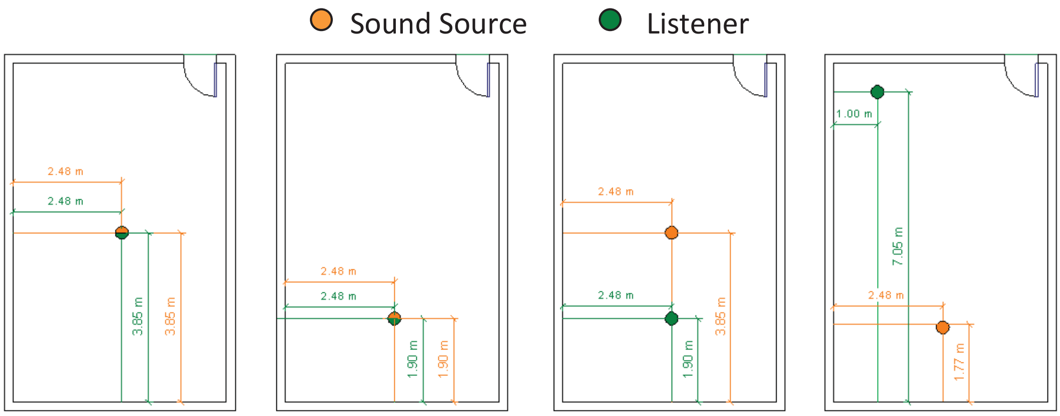
Room 1 was Watt 212, which was an enclosed room with no windows, 2.40 m in height, 7.70 m in length, and 4.96 m in width. The floor was covered with thin carpeting, the ceiling with acoustic ceiling board, and the walls were gypsum board. The room had an even background sound which was at an average of 65.5 dB(C).

Nine tests, numbered from T_{1a} to T_{1i}, were implemented in Room 1 (Table 1). These tests included different positions of the sound source and listener, different kinds of sound, different sound source SPL, and different room materials (Figure 13).

Table 1: Test settings in Room 1.

Test	**Sound File**	**Average SPL (dB(C))**	**Source (m)**			**Listener (m)**			**Material**			**Test Method**
			x	**y**	**z**	**x**	**Y**	**z**	**Floor**	**Walls**	**Ceiling**	
T1a	Impulse	90	2.48	3.85	0.75	2.48	3.85	0.75	Carpet	Gypsum	Acoustic	Soundar / Recording
T1b	Impulse	90	2.48	3.85	0.75	2.48	3.85	0.75	Wood	Concrete	Concrete	Soundar
T1c	500 Hz	75	2.48	1.90	1.05	2.48	1.90	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording

T1d	500 Hz	75	2.48	3.85	0.75	2.48	1.90	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording
T1e	500 Hz	85	2.48	3.85	0.75	2.48	1.90	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording
T1f	Music	75	2.48	3.85	0.75	2.48	1.90	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording
T1g	Music	75	2.48	1.77	1.50	1.00	7.05	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording
T1h	Speech (Female)	75	2.48	1.77	1.50	1.00	7.05	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording
T1i	Speech (Male)	75	2.48	1.77	1.50	1.00	7.05	1.05	Carpet	Gypsum	Acoustic	Soundar / Recording



(a). T_{1a}, T_{1b}, (b). T_{1c} (c). T_{1d}, T_{1e}, and T_{1f} (d). T_{1g}, T_{1h}, and T_{1i}

Figure 13. Positions of the sound source and listener in Room 1.

Room 2 was tested in the San Merendino Room, which is in the basement of Watt Hall. The room was also an enclosed room with no windows. It was 2.75 m in height, 4.40 m in length, and 4.80 m in width. The floor was covered with thin carpets; the ceiling was unpainted concrete. One of the walls was gypsum boards, and the other walls were unpainted concrete. The background sound in this room is not even. An air conditioner filter was on one side of the room generated an uneven background noise. The noise at the test position was about 54.0 dB(C). Two tests, T_{2a} and T_{2b}, were implemented in Room 2. These tests focused on impulse reactions in a room with a different size (Table 2) (Figure 14).

Table 2: Test settings in Room 2.

Test	**Sound File**	**Source Average SPL (dB(C))**	**Source (m)**			**Listener (m)**			**Material**			**Test Method**
			x	**y**	**z**	**x**	**y**	**z**	**Floor**	**Walls**	**Ceiling**	
T_{2a}	Impulse	90	2.20	2.40	0.80	1.10	2.40	0.80	Carpet	Gypsum	Acoustic	Soundar

T_{2b}	Impulse	90	2.20	2.40	0.80	1.10	2.40	0.80	Carpet	Concrete	Concrete	Soundar / Recording

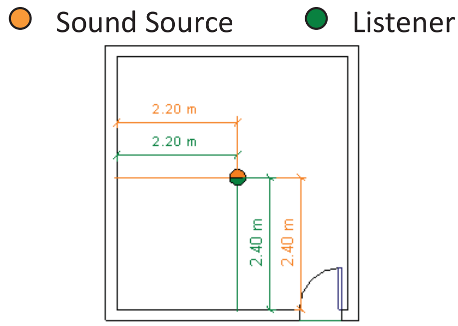


Figure 14. Positions of the sound source and listener in Room 2.

5.2 Test Result and Analysis

Three kinds of performance of Soundar were analyzed based on the test results: the SPL change as a function of time, frequency response, and the reverb performance. The analysis used time-domain charts, the frequency domain charts, and the impulse response chart to compare the sound performance between different tests.

The SPL change as a function of time used the time domain charts generated by VSLM (Figure 15). The time spacing of the time domain charts is 100 ms. The difference of SPL (ΔSPL) can be calculated from data logs, which is the absolute value of the SPL of Soundar simulation result minus the SPL of the live recording at the same time. Generally, untrained listeners can distinguish the difference of SPL when it changes by about 3 dB. The validation used 3 dB as the tolerance and calculated the percentage of the data that has the ΔSPL under 3 dB.

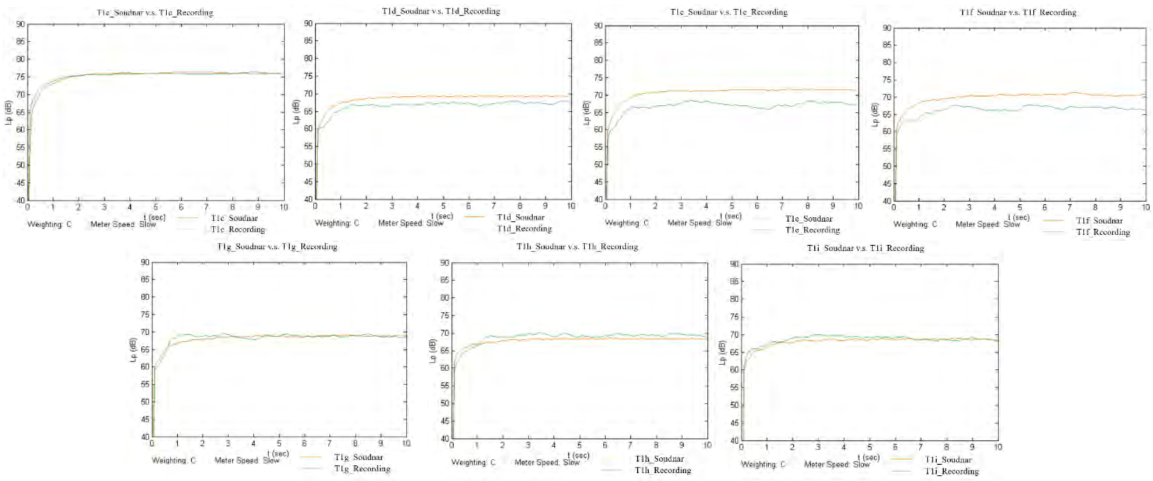


Figure 15. Time domain charts of tests T_{1c} to T_{1i}.

Calculated with the data exported from the charts, the percentage of ΔSPL less than 3 dB(C) showed how much data was in the tolerance. Soundar had a good performance of SPL change per time in Test T_{1c}, T_{1d}, T_{1g}, T_{1h}, and T_{1i}, which had over 98% of the time that had a difference lower than 3 dB(C). T_{1e} and T_{1f} had a larger SPL gap between Soundar and the live recordings. The average ΔSPL of these to tests was 3.92 dB(C) and 3.61 dB(C), which are higher than the tolerance (Table 3).

Table 3: Data analysis of SPL per time.

Test	T_{1c}	T_{1d}	T_{1e}	T_{1f}	T_{1g}	T_{1h}	T_{1i}
Average ΔSPL (dB(C))	0.41	0.72	3.92	3.61	0.55	1.21	0.72
Percentage of ΔSPL < 3 dB(C) (%)	98.99	98.99	9.09	24.08	100	100	100

The frequency response analysis was based on the frequency domain charts generated by REW, which indicated the SPL at each frequency (Figure 16). The frequency-domain data was 1/12 octaves smoothed, which separated each octave band into twelve parts, and the value on the center frequency of each band is the average of the values on both sides. The coefficient of determination (R^2) was used to indicate the similarity of Soundar from the live recording. R^2 is in the range of 0 to 1. When R^2 is close to 1, it indicates that the Soundar simulation is close to the live result.

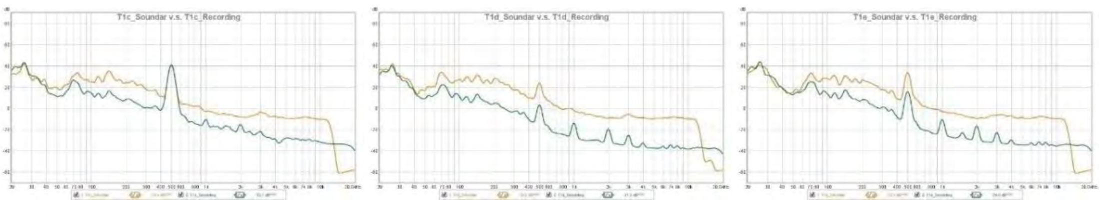


Figure 16. Frequency domain charts of T_{1c} to T_{1e} (20 Hz to 20 kHz)[1].

To look into the similarity more precisely, the coefficient of determination (R^2) was calculated from the data log of all of the graphs. In the frequency range of 20 Hz to 20 kHz, which is the frequency range of human hearing, the R^2 is higher than 0.73 (Table 4). Despite the frequency higher than 12 kHz, which were wiped by the record settings of the device, the R^2 is above 0.8 (Table 5).

Table 4: Data analysis of SPL per frequency (20 Hz to 20 kHz)

Test	T_{1c}	T_{1d}	T_{1e}	T_{1f}	T_{1g}	T_{1h}	T_{1i}
R^2	0.78	0.77	0.73	0.76	0.76	0.77	0.78

Table 5: Data analysis of SPL per frequency (20 Hz to 12 kHz)

Test	T_{1c}	T_{1d}	T_{1e}	T_{1f}	T_{1g}	T_{1h}	T_{1i}
R^2	0.93	0.94	0.92	0.9	0.9	0.93	0.93

[1] Only 3 of the 7 bands are shown here.

The reverb performance was analyzed by using the impulse responses, which showed the sound decay per time after the sound stops (Figure 17). From the impulse response, the reverberation time can be indicated by the T_{20} calculation. The threshold for human hearing to notice the difference of reverberation time is a deviation of 20% [11], which means that when the deviation of T_{60} is lower than 20%, the reverb sounds the same to the listeners. Therefore, the validation used 20% as the threshold of the accuracy of the reverb simulation. Besides the reverberation time, the shape of the impulse response also shows the decay rate and how the room reacted to the impulse.

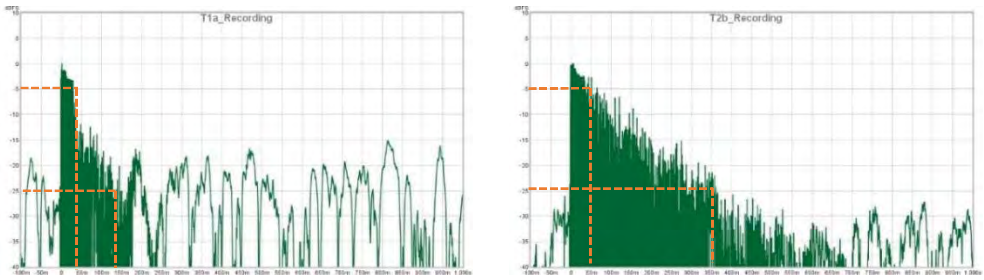


Figure 17. Impulse response charts of room impulse recordings.

In the validation tests, because the range from maximum to the background sound level was less than 30 dB(C), the T_{20} calculation was used to estimate the T_{60}. Using the T_{20} calculation, the T_{60} of Room 1 and 2 can be concluded from the simulation response of the live recordings. The T_{60} of Watt 212 was 0.36 s, and the T_{60} of San Merendino Room was 1.02 s. (Table 6)

Table 6: The recorded T_{60} and the calculated T_{60} of Soundar.

Test	T_{1a}	T_{2b}
Recorded T_{60} (s)	0.36	1.02
Calculated T_{60} (s)	0.48	1.45
Difference (%)	25.00	29.66

The sounds rendered by Soundar showed an abnormal impulse response (Figure 18). The orange graphs represented the impulse responses of Soundar rendering. The rendered sound had a high deviation from the recorded sound, which can be directly heard while listening to the results. Normally, the sound decays with a logarithmic trend after it stops playing like what is shown by the impulse responses of the live recordings (green graphs). The sound decay speed was faster in T_{1a} than T_{2b}. However, the results from Soundar renderings showed the opposite (orange graphs). Large differences were also shown in the T_{60} values calculated by the impulse response (Table 7).

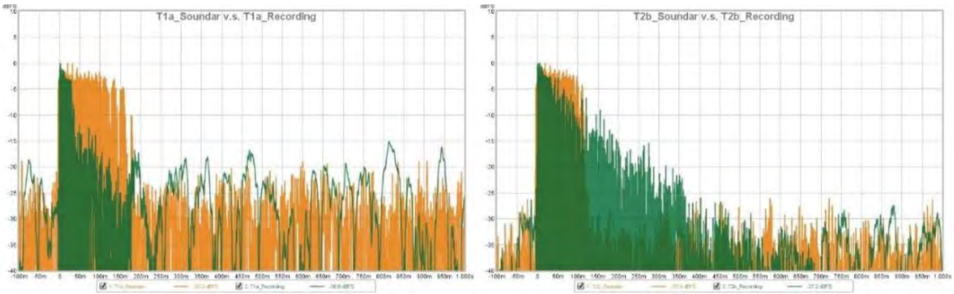


Figure 18. Impulse response charts comparing the rendered sound and recorded sound.

Table 7: The recorded T_{60} and the rendered T_{60} of Soundar.

Test	T_{1a}	T_{2b}
Recorded T_{60} (s)	0.36	1.02
Rendered T_{60} (s)	0.22	0.09
Difference (%)	32.50	88.87

Furthermore, comparing the impulse responses between T_{1a} and T_{1b}, as well as T_{2a} and T_{2b}, which were tested in the same room but used different material settings, the reverberation time of the room was not significantly influenced by the material assigned in the room (Figure 19). Although T_{1b} and T_{2b} used more reflective materials, the impulse responses and the frequency responses were quite similar to the ones with more absorptive materials.

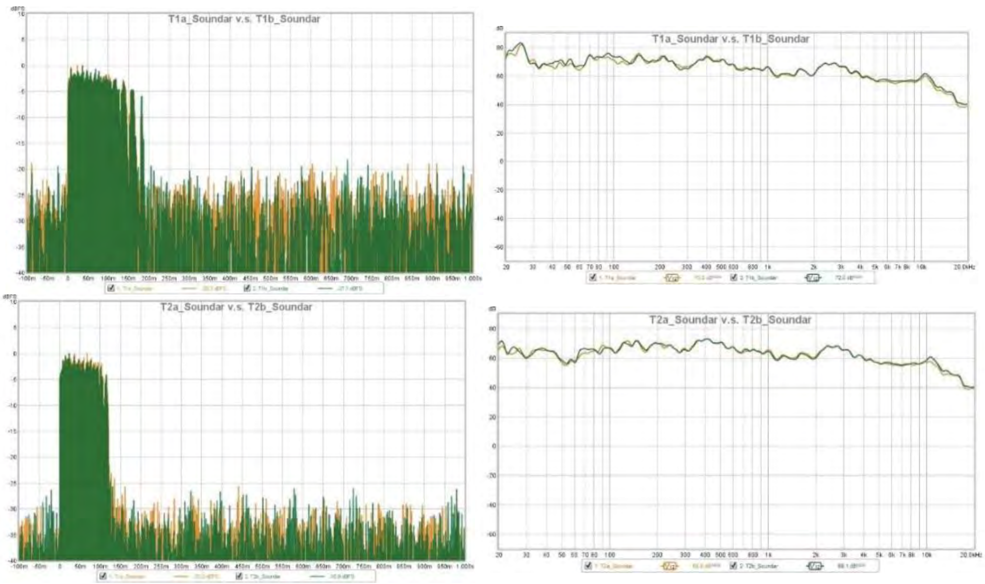


Figure 19. Impulse responses and frequency domain charts of tests with different materials.

One the other hand, when comparing the impulse responses between T_{1a} and T_{2a}, which were tested in different rooms but with the same material settings, the reverberation time was quite different (Figure 20). The T_{60} of T_{1a}, which was tested in a larger room was longer. The frequency response indicated that the difference was mainly made by the different reactions in the low frequencies (20 Hz to 400 Hz).

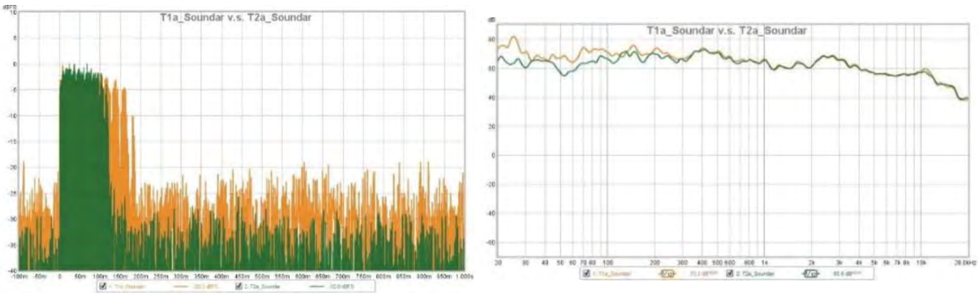


Figure 20. Impulse response and frequency domain chart of tests with different room sizes.

The validation of version 1.0.8.25 showed that the numeric results and the auditory results of the realtime SPL are at an acceptable deviation threshold. Soundar also had a good performance when the listener is close to the sound source. However, the accuracy went down when the distance got further. Soundar currently had a bad performance in the reverb rendering, impulse responses. Improper settings on Steam Audio might be one of the reasons that caused the inaccuracy or inaccurate simulation in that software.

6 CONCLUSION AND DISCUSSION

Soundar brings a new solution for ordinary people to understand how the environment, both room geometry and surface materials, influences a room's sound performance. By introducing augmented reality technology to room acoustic simulation, Soundar can provide them with direct and immediate experiences. It is also convenient since it is using cellphones and tablets. The UI design and the directions make Soundar easy to use, even for the first time user. After setting up the room and sound sources, users can directly get feedback in both numerical and auditory ways.

Soundar has some inadequacies at the current stage. The unstable positioning and low accuracy of results especially in the rever simulation limit the usage of Soundar. However, it is still a meaningful approach towards combining AR and acoustics and can be used on many occasions to help people have a basic understanding of the space and the room acoustical performance. More research development could be done, but the Soundar prototype app is a good step towards combining acoustics and augmented reality.

Acknowledgments

The authors would like to express my deep gratitude to Professor Mark Schiler and Professor Doug Noble from USC, acknowledge the help of Buro Happold Engineering, and thank Matthew Harrison, who enlightened me with the idea of using Steam Audio in this project.

This paper was written during a difficult time when the world is suffering from COVID-19. We want to thank everyone who was fighting the virus to save lives all over the world.

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