

Conference Paper

Sustainable Architecture for Future High Density Cities: An Applied Design Approach

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Abstract

This paper presents a series of speculative, research-driven architectural design proposals addressing sustainability in the high-density urban contexts of Shanghai and Hong Kong. The projects each address specific urban problems arising from the site contexts while also developing and utilising innovative ideas generated from architectural and technological considerations. Design results include speculative mid-rise buildings that employ innovative sustainable design approaches ranging from the social to the material dimension. While findings confirm the general notion that an integrated architectural approach must address social, ecological and economic issues to ensure sustainability and viability, this paper further informs researchers as well as practitioners in the creative disciplines with regards to the short- and long-term priorities we have established amongst these issues through the discussed investigation.

Keywords: Sustainable Architecture, High-density cities, Research-driven design

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1. Introduction

1.1. New Visions for Architectural Sustainability

By 2030, the majority of the global human population will be residing in cities [9]. As many cities around the world are growing into metropolises, some are presently developing into future meta-cities characterised by dense interwoven and interconnected networks of industrial, urban and social organisations. Urban centres in the greater China region such as Shanghai and Hong Kong, subjected to mass migration, and land scarcity, are no exception. At the same time, these Chinese metropolises like are characterised by high rates of consumption of natural as well as non-renewable resources [9]. With urban density comes an increasing necessity to use resources in more sustainable ways. Contributing to nearly 50% to the factors that drive climate change, the construction industry is a key to improving the long-term impact of cities on the environment [25]. At the same time, the call for sustainable urban development has

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expanded beyond ecological and economic aspects to also encompass social aspects. Promoting social, ecological and economic processes, the sustainability movement has raised awareness of the interwoven nature of these aspects [28]. In architectural design practice, a unified response to this new perspective is still under development.

While *sustainability indices* (such as LEED, BREEAM, The Three Star System, etc.) of buildings [21] tend to be available only after completion, this paper presents a series of speculative design proposals that seek to maximise sustainability beginning at the initial design process stages. The research-driven projects develop new architectural and urban visions in the context of Chinese metropolises by addressing key issues of sustainable development, from the social to the material dimension [15]. The resulting design proposals offer a conceptual positioning of architecture as a mediator between environmental and urban pressures of the future.

The three proposals present mid-rise buildings to be located in the urban centres of Shanghai and Hong Kong. While each of the projects addresses unique urban challenges, they were designed as parts of a sustained, design-driven enquiry over the course of three years, with each proposal building on the insights gained from the previous ones. In this context, mid and high-rise towers are understood to offer the most viable response to urban needs due to their ability to successfully integrate “complex systems” [1] such as ventilation mechanisms, architectural components, structure and many others. While tall buildings tend to offer economic benefits, they do not guarantee sustainable development. In particular, high-rise and high-density urban settings require careful integration in social terms.

2. Background: Dimensions of Sustainability

2.1. Sustainability in the Context of High-Density Cities

The term sustainability has gained much significance over the course of recent decades due to increasing awareness of the need to protect our bio-physical environment and economy [27]. While often been misinterpreted for being synonymous with nature [13], different ideological underpinnings have been developed in conjunction with this term [15]. After the introduction of the Brundtland Report back in 1987, the term *sustainable development* was coined to incorporate the dimensions of ecology, society and economy [5] – thus further extending its focus beyond energy considerations [15].

2.2. Ecological, Social and Economic Dimensions of Architectural Sustainability

For the purpose of this study, three aspects of sustainability are considered as outlined in the following sections.

Recognised as the world's major cause of environmental degradation and pollution, the construction industry has been criticised for depleting natural and non-renewable resources, leading to adverse effects including global warming and climate change [2]. As a consequence of these effects, low-lying cities like Shanghai and Hong Kong are not only affected by global environmental pressures but also challenged by rising sea-levels. *Ecological sustainability* thus arises as a key challenge of future high-density urban architecture.

In the context of the built environment, social sustainability has been defined as "social equity and sustainability of communities" [9]. *Social equity* and *communal sustainability* are both multi-faceted and mutually interwoven. They have been described as the "quality of life, social integration and cohesion of different parts of society" [9]. The relevance of high-density urban settings to social sustainability is significant as cities [9] like Shanghai and Hong Kong are facing housing and public infrastructure challenges.

Most commonly defined as "the need to maintain a permanent income for humankind, generated from non-declining capital stocks" [27], the economic sustainability dimension is a key to the sustainable growth of future urban societies, especially in high-density metropolitan areas. Linear consumption and related economic models will have to be re-examined [11]. As pointed out by McDonough and Braungart, the main cause of urban challenges such as different types of pollution and unsustainable linear consumption models are primarily design related problems [21]. The *Circular Economy* paradigm involves the adaptation and utilisation of circularity in our consumption models focusing on strategies to recycle and recover materials to feed them back into the supply chain [10]. This approach involves systems thinking, viewing challenges as sub-systems of larger systems to minimise the impacts of societal growth and development on the environment [10].

3. Design Research Process

This study comprises a series of studio design research projects carried out by the first author over three years, extending across both undergraduate and graduate studies.

Each project adopted an applied design approach [15] generating opportunities for reflection and theory-building as well as proposals in the process of designing. Applied design can be regarded as a reflective practice in which the designer engages in reflection-in-action [24]. The process of action and reflection occurs as a sequence of iterative cycles of “framing”, “moving” and “reflecting” [24] while navigating constraints effective and arising during the process of designing [12]. While each design proposal discussed below builds on the previous one(s), the three dimensions of sustainability summarised above have been navigated as de- facto design constraints (ibid.) through a process of recurring externalisation of thoughts and ideas in sketch, diagrams, model making, and so on, and their subsequent evaluation [14].

For the purpose of this paper, the design process is understood as comprising the three stages of analysis, synthesis and evaluation [16], paralleling Schön’s reflective cycle stages of “framing”, “moving” and “evaluating”. The initial steps of each of the three design processes involved defining and understanding the respective projects’ aims. This process was addressed through a critical analysis of case studies and literature on the topic at hand. In subsequent stages of the processes, syntheses of ideas were developed through applied design (i.e., navigating design constraints through framing, moving and evaluating). At this stage of designing, novelty was generated in the form of applied design and also through explicit reflection. Throughout each design process, proposals were subjected to different types of evaluation employing amongst others, self-reflection, peer discussions as well as reviews from both academic and practitioner critics.

4. Scope and Limitations

From the early design stages, the three proposed design projects – *New Shanghai Habitat*, *Networking Tradition and Future* and *Reef Towers* – focused on sustainable design for the context of high-density urban settings. Addressing current urban challenges in the greater China region, the proposals not only respond to the constraints arising from their specific localities. They also serve as prototypical visions that raise questions regarding short- and long-term urban priorities. Carried out within the time frame of 4–5 months for each studio project, the proposals remain unbuilt, limiting the range of insights that can be derived from each project accordingly.

5. Brief Introduction and Critical Evaluation of Design Proposals

Overall, this study generated a broad spectrum of speculative design ideas. Despite their multi-faceted nature, the dimensions of sustainability presented in this study draw on designerly approaches to sustainability. In order to fit the scope of this paper, this listed projects are presented in excerpts, each focusing on one of the three dimensions of sustainability discussed in the preceding sections.

5.1. The New Shanghai Habitat: Retaining a Sense of Belonging in Fast Globalising Cities

Located in the historical Shanghai district of Huangpu, the *New Shanghai Habitat* is a mid-rise tower designed as a part of the first author's BEng Architecture final year project at XJTLU. The overall project brief called for the innovative interpretation and application of concrete as a key building material in the Chinese construction industry. The following paragraphs document the implementation of the social sustainability dimension within the context of an applied design approach.

In recent decades, China experienced unprecedented processes of globalisation. As a consequence of fast urban growth, towers of different heights and scales continue to mushroom throughout Chinese urban centres. To accommodate such towers, a significant percentage of low-rise traditional settlements is being demolished to provide developable space, such as the traditional *Lilong* housing units in Shanghai [3]. Introduced in the late 19th century, these residential building types consist of Western-influenced row houses which represent the city's historical and cultural heritage of its industrialisation and urbanisation periods [3]. Characterised by their distinct urban form, these settlements create a strong sense of place and community – aspects criticised to be lacking from newly constructed modernist residential towers. The juxtaposition of high-rise and low-rise buildings throughout Shanghai has become well-known as a “paradoxical pattern of unevenly developed urban fabric” [3].

Responding to these challenges, the *New Shanghai Habitat* (Figure 1) proposes the (re)interpretation of traditional *Lilong* settlements in a 100 meters tall mid-rise tower with 25 floors. The building aims to retain and amplify the unique sense of community present in and around the site. Understanding the essence of this sense of community as the mutual exchanges and social interactions of a group of individuals living within a certain proximity [20], the *New Shanghai Habitat* identifies the *Lilong* alleys as main

vectors capable of sustaining communal life in the vertical dimension. Through the integration of pocket spaces within these transitional spaces, the tower balances the ratio of interior and exterior spaces to generate encounters as well as hosting diverse communal activities. By fostering and nurturing social bonds among its inhabitants, the *New Shanghai Habitat* proposes to create a variant of the vibrant street life found in and around the *Lilong* settlements.



Figure 1: *New Shanghai Habitat* – renders and plan showing (re)interpretation of Lilong streets.

Since its beginning, the local construction practices underlying the Chinese economic boom have been dominated by the use of concrete as the primary building material [15]. With the speed of construction occurring throughout China, “concrete structures have become characteristic of unimaginative and architecturally lacking buildings” [15]. Whereas the emphasis on speed and quick financial returns have contributed to unsustainable developments in cities like Shanghai, the future use of concrete needs to balance between innovative architectural and construction approaches to positively impact future societies. The *New Shanghai Habitat* explores the potential of concrete both structurally and spatially, employing the unique nature of different material compositions contributing to invoke the tactile richness of the *Lilong* settlements. Through experimentation with various concrete aggregates and surfaces, the project uses a variety of concrete treatments and finishes to mark different zones of inhabitation, implicitly distinguishing public and private spaces in the building.

5.2. Networking Tradition and Future

Shanghai has seen a large-scale expansion both horizontally and vertically in the past decades. While the city has successfully decentralised major industrial zones to reduce coal consumption and the associated pollution [29], the metropolis also witnessed a significant increase in different types of infrastructural constructions – shrinking greenbelt areas to accommodate boulevards, motorways, financial districts, residential zones and many others [29]. Despite the positive economic and social

influences brought about by these developments, their associated effects have also had repercussions for the city's urban dynamics. With challenges like social inequalities, propagation of urban heat island effects, heat waves and pollution of diverse types bound to increase in coming decades, urban developments in Shanghai need new approaches to develop sustainably for the benefits of future urban communities.

Forming a part of a larger masterplan comprising a group of nine networked towers, the *Networking Tradition and Future* (Figure 2) proposal comprises two interconnected mid-rise buildings originally developed as part of an MArch Architecture studio project. It was further developed and presented as a team work for an award-winning competition entry at the *Council on Tall Buildings and Urban Habitat* (CTBUH) conference in 2017. Located in Shanghai, the two interconnected towers address, amongst others, new high-density urban pressures such as urban heat island effects, which are predicted to impact on the city's urban centres in the foreseeable future [7]. As these pressures hamper urban liveability due to their negative consequences on temperature, wind speed, air pressure, rainfall and so on, the *Networking Tradition and Future* project seeks to create and maintain urban microclimate within its proposed masterplan. The proposal reaches out to its surrounding environment by weaving a tensile network of nano-polymer membranes equipped with solar cell fitted ETFE between the towers and existing contextual elements (Figure 2, right). The tensile membranes are host to Amphidium moss which consumes toxic gases and binds with particulate matter from the atmosphere. Creating a 3- dimensional landscape, these adaptive tensile networks not only generate green energy but also form a series of interconnected urban umbrellas acting as shading and cooling devices. Through the spraying of water vapour, these urban umbrellas regulate the urban microclimate to foster outdoor communal activities for both its inhabitants and visitors alike.



Figure 2: *Networking Tradition and Future* – renders and section through tensile membrane network.

Beyond employing various approaches to address ecological sustainability, the *Networking Tradition and Future* project seeks to inform and sensitise its inhabitants to the consequences of their actions on the environment. With environmental challenges

being essentially rooted in social problems [18], the two interconnected buildings aim to encourage low-tech sustainable activities such as like gardening, planting and waste management in their shared communal spaces to raise awareness towards a green environment.

5.3. Reef Towers: An Alternative Model to Urban Growth in Hong Kong

The intense pressures of contemporary megacities offer both challenges and opportunities for future architectural design. High density, speed of change and closely interrelated economic, political and social dynamics result in environments where the artificial becomes a new natural, and humans live in completely manufactured surroundings that offer limited opportunities for individual choice or expression. The urban areas of Hong Kong are unique places where such conditions are in the process of generating new forms of architecture.

Characterised by a unique, yet complex topographic condition, Hong Kong is one of the densest places on Earth with a permanent population of more than seven million inhabitants. Reclaiming more than 7,700 hectares of land from the sea since 1887 [22], the city's urban expansion practices have predominantly pushed waterfronts further into the sea. This practice is considered unsustainable both in terms of ecology and social heritage. While these urban developments have been criticised for favouring economic benefits over sustainable developments [6], the city struggles to cope with key challenges like the excessive production of waste as well as air and water pollution. Furthermore, with current research predicting a 4-degree increase in temperature and an associated minimum 10-metre rise in sea levels [17], urban expansion practices in Hong Kong have to be reconsidered. Responding to the key challenges of urban and economic growth models in Hong Kong, the *Reef Towers* (Figure 3) proposes an alternative approach to current land reclamation practices in Belcher Bay, located on the northern shore of Hong Kong Island. The project, forming a part of an MArch final year thesis, aims to create a systemic urban growth model by merging the sea and the city, resulting in a new way of building on the water at the urban scale.

The *Reef Towers* project acknowledges both the site's historic organic fabric as well as its more recent, reclaimed and orthogonal urban layout by extending a network of platforms into the sea. Aligned with the existing streets, the proposal generates new types of urban connections, which link to and sustain the diverse flows present on the site. The overall masterplan employs various strategies to retain local heritage

and to amplify urban life – by creating and activating publicly accessible waterfronts which are host to the existing urban functions like street markets, open public spaces, recreational areas, green strips and many others. Responding to the expected sea level rise, the extended dendrite-like platforms (Figure 3) are designed to sprawl both horizontally and vertically, forming sheltered lagoons and new waterfronts at each growth interval, thus extending the waterfront heritage. Host to a series of interlinked and interdependent mid-rise buildings, the *Reef Towers* draw an analogy to natural coral reefs where the towers regulate themselves and, in mutual exchange, that of its long-term as well as transient inhabitants – with the aim to contribute positively to the surrounding environment socially and

environmentally for a holistic sustainable economic growth. On the scale of an individual tower, the proposal integrates and coordinates diverse functions with dynamic spaces reflecting Hong Kong's topography. Particular attention was given to the façade, which was inspired by the House N designed by Sou Fujimoto. Blurring conventional boundaries, the façade comprises adaptive thin steel rods weaving in and out of the towers, acting as variable thresholds to promote and host various inhabitation zones for activities, vegetation and organisms alike.

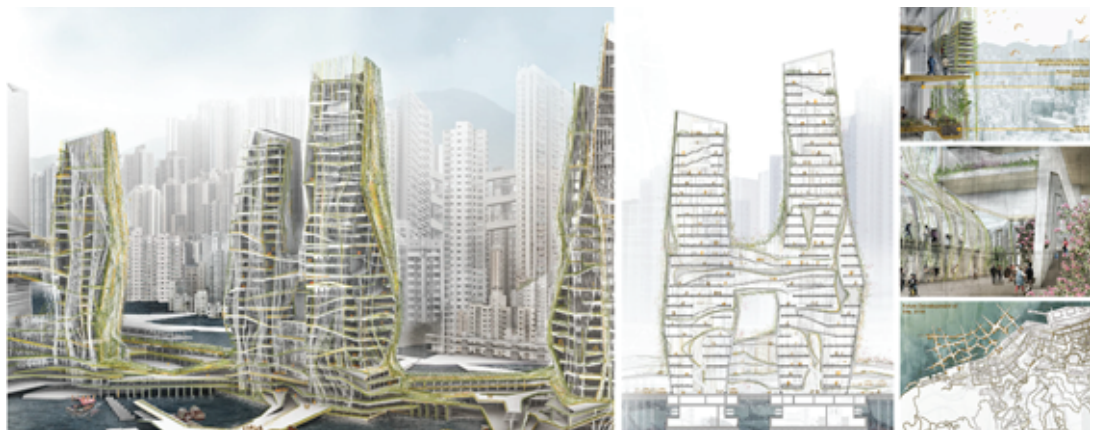


Figure 3: *Reef Towers* – renders, section and masterplan illustrating new urban growth model.

6. Summary and Outlook

In response to the soaring demand for high-rise construction in Chinese cities, this paper presents a series of critical and speculative mid-rise towers of around 100 meters tall (25–30 floors). The research-driven proposals present new approaches to sustainable development of high-density urban environments for the immediate future of Shanghai and Hong Kong. Each design proposal adopts various approaches and perspectives

to address the question of sustainability in high density urban contexts, some focusing more on broader social aspects while others concentrate more on technical issues. Together, the projects offer a broad vision for future urban life in which technology supports a socially driven approach to long-term sustainability.

Among the aspects explored – sense of belonging, material, microclimate regulation, urban growth model – social sustainability has emerged as a viable primary design driver. Receiving the support of numerous reviewers and critics, the social dimension generates several insights and raises critical questions with regards to short- and long-term urban priorities. These questions provide foundation for further investigations by both researchers and practitioners in the creative fields. The key issue raised is: How can new technologies integrate and support social sustainability for creating long-term viability? This issue finds its relevance in fast-developing and developed cities where technologies are gradually influencing social norms, thus affecting urban communal life. In a human oriented architecture, social sustainability provides a framework into which the other dimensions are accommodated. In that sense, it also guarantees an architecture which responds to the local context. In practice, focusing on social sustainability can serve as a testbed to address key urban issues and contribute towards a sustainable future. However, despite many designers' social aspirations, current pressures and economic mechanisms hinder their intentions and thus, new innovative thinking. Design proposals are often 'optimised' to increase financial benefits – for instance, in many residential tower projects across China, the number of shared open spaces are reduced as they are not rentable. Despite the three proposals remaining unbuilt and questions regarding their feasibility, this study underlines the need for designers to find new visions from other sources like universities, think-tanks, government bodies, in order to avoid any critical state of our urban environments – for design is a “one-shot operation” [23] where the consequences are irreversible.

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