

DESIGN STRATEGIES FOR RESIDENTIAL HIGH RISE BUILDINGS  
THROUGH OPEN BUILDING PRINCIPLES

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To my family and friends.

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## **ABSTRACT**

Current high rise living trends view apartments as rigid inflexible structures. People are dynamic, progressive and adaptive. Our living spaces should be able to adapt to our changing needs, expanding families, tendency to migrate and fast-paced oriented lifestyles. We are constantly upgrading our building stock with new systems and technologies to meet current social, financial and technological demands. However, high-rise housing has been slow to adapt due to its rigid form. Not only does it directly affect the inhabitant, but it also poses greater problems in the future when these buildings become obsolete due to its inflexibility, despite being in good working order. This dissertation looks at approaches to increase flexibility and adaptability in residential high rise architecture. It determines the best design strategies for high-rise living using open building principles. Data collection and analysis was done through comprehensive literature reviews, analysing case studies and field research. Open building case studies were primarily used to compare and contrast various approaches and summarise the best design strategies for high rise living. There are many recommendations highlighted in this dissertation, listed according to system level, building level, unit level, room level and layout level. This study is essential because the implementation of these design strategies and the Open Building principles tackle issues on changing household composition and income; mass housing, loss of individuality and exclusion of the end user; inflexibility and obsolescence; preventable construction waste; entanglement and finance.

## ABSTRAK

Pangsapuri sering dilihat sebagai struktur yang tidak fleksibel dan tegar. Manusia adalah dinamik, progresif dan adaptif. Kediaman kita perlu ada kapasiti untuk menyesuaikan dengan keperluan kita yang berubah seperti perkembangan keluarga, kecenderungan untuk berhijrah dan gaya hidup yang pantas. Kami sentiasa menaik taraf bangunan kami dengan sistem dan teknologi baru untuk memenuhi tuntutan sosial, kewangan dan teknologi semasa. Walau bagaimanapun, bangunan pangsapuri yang sedia ada, lambat untuk menyesuaikan diri kerana bentuk yang tegar. Ini menimbulkan masalah yang lebih besar pada masa akan datang apabila bangunan menjadi usang kerana tidak fleksibel, meskipun berada dalam keadaan yang baik. Disertasi ini melihat pendekatan untuk meningkatkan fleksibiliti dan keupayaan pangsapuri menyesuaikan diri kepada kehendak semasa individu. Ia menentukan strategi reka bentuk yang terbaik untuk hidup bertingkat tinggi menggunakan prinsip *Open Building*. Pengumpulan data dan analisis dilakukan melalui kajian literatur secara menyeluruh, menganalisis kajian kes dan kajian lapangan. Kajian kes *Open Building* digunakan terutamanya untuk membanding dan membezakan pelbagai pendekatan dan merumuskan strategi reka bentuk yang terbaik untuk hidup bertingkat tinggi. Terdapat banyak cadangan yang diketengahkan dalam kajian ini, yang disenaraikan mengikut peringkat, dari tahap system, tahap bangunan, tahap unit, tahap bilik dan tahap susun atur. Kajian ini adalah penting kerana pelaksanaan strategi reka bentuk dan prinsip-prinsip *Open Building* mengatasi isu-isu perubahan komposisi isi rumah dan pendapatan; perumahan besar-besaran, kehilangan identiti dan pengecualian pengguna akhir; isu bangunan tidak fleksibel dan usang cepat; sisa pembinaan boleh dicegah; pembinaan secara pertindihan serta isu kewangan.

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background Studies**

Change is the only constant in our society, as we as people are constantly evolving and adopting new lifestyles. Our view of buildings as static objects is changing rapidly. We see it in the open plan office which allows for maximum changes in layout and commercial outlets which see rapid change in tenants. However, this view hasn't made its way into mainstream housing. A dwelling being the primary living space, needs to accommodate life cycle changes; increase/decrease in family size, aging, change in occupation etc.

People are dynamic, progressive and adaptive. Our living spaces should be able to adapt to our changing needs, expanding families, tendency to migrate and fast-paced oriented lifestyles. With globalisation and seamless transfer of information, it is important to recognise the bottlenecks posed by rigid and static architecture, especially in the urban context.

Buildings should not only address the needs of current users and changes in their lifestyles, but also address the needs of future users. This not only includes the cyclical changes in occupants over time, but also includes meeting needs in the far-future which cannot be predicted with our current knowledge.

High-rise living remains very static and unchanging. The typical residential high-rise comprises of lofts, 2 or 3 bedroom units, Soho units, etc. These do not allow for changes in terms of layout, expansion or reduction of floor area. Heavy renovation works are not advised as it affects the integrity of the building structure. The noise and reverberation from hacking would affect not only immediate neighbours, but neighbours beyond them. Repurposing typical residential high-rise buildings would be a challenge as it is built in unique units and grids and therefore may have irregularly spaced columns, narrow but long load bearings walls and other structural components which would be difficult to work with.

When older commercial buildings are ‘revalued,’ demolition exposes the existing building shell, which is then retrofitted with upgraded facade and interior systems. In ‘build-to-suit’ office facilities, base building construction is made as generic as possible: its long-term value is increased by providing capacity for changing requirements, including eventual tenant turnover and future sale. What happens then to buildings which fail to adapt? They become obsolete.

Obsolescence occurs due to physical deterioration, wear and tear, technological advances, changes in the economic conditions, user requirements, design, appearance, taste, legal, and social needs. For example, air-conditioning systems have evolved over the years. Many older buildings are simply not equipped for these needs and therefore lose their appeal and relevance. In the industrial building segment, structures comprised of harmful materials and low clearances have become undesirable.

The design strategies developed in the course of this dissertation were used to make informed design decisions in the design studio. The implementation of the design strategies are seen in the plans listed under appendix C.

## **1.2 Problem Statement**

People are dynamic, progressive and adaptive. Our living spaces should be able to adapt to our changing needs, expanding families, tendency to migrate and fast-paced oriented lifestyles. We are constantly upgrading our building stock with new systems and technologies to meet current social, financial and technological demands. However, high-rise housing has been slow to adapt due to its rigid form. Not only does it directly affect the inhabitant, but it also poses greater problems in the future when these buildings become obsolete due to its inflexibility, despite being in good working order.

## **1.3 Aim**

This dissertation focuses on developing the flexibility of residential high-rise buildings to create variety and give the end user more options in an effort to cater to their dynamic lifestyle and needs. It also looks at flexibility at building level to ensure the building stays relevant, can be repurposed and has the capacity to adapt to future needs.

Residential high-rise buildings should be flexible at all levels; system level, building level, unit level, room level, and layout level. Open Building offers solutions by dividing the vertical housing into the base building and infill. This dissertation will look at alternative grid systems, parcellation methods and layout options using Open Building principles. Therefore, the research aim was to find out:

What are the best design strategies that can be used in the field of architecture which focus on flexibility in terms of size and layout?

## **1.4 Research Questions and Objectives**

This research acknowledges that the inflexibility of residential high rise buildings is the main issue in tackling multiple problems. In the course of writing this dissertation, various design strategies and approaches to residential high rise buildings have been analysed specifically for its short term and long term flexibility (You may delete). The aim of the study led to ask two basic research questions.

- i. What are the context specific users' demands for flexibility in high rise apartments?
- ii. What could be the best design strategies that can meet those demands?

These two questions were further focused down to two objectives as follows.

1. To identify context specific users' demands for flexibility in high rise apartments
2. To determine best design strategies at different levels that meets the demands

## **1.5 Significance of Study**

Household composition changes every five to ten years. How people use the space changes as well. The current trend in housing is to move from one home to another, which better suits our spatial needs. However with soaring property prices, this is not always a feasible option. Flexibility at unit level is definitely required when time is factored into design.

Flexibility is not only valued for short term tenancy, but is also valued in the long run. What happens when buildings become obsolete? Cities have few options available to them to remove dilapidated buildings. When private property owners refuse to take responsibility for their property, it becomes a town's burden to remove a dilapidated building by using scarce taxpayer money. As a rule of thumb, demolition roughly costs  $\frac{1}{3}$  of the cost of construction. Often, cities cannot afford to remove dilapidated buildings, prolonging the suffering and decline of surrounding properties.

Let's step back and see the bigger picture. According to the U.S. Department of Energy, the average office building's lifespan in 2008 was 73 years. Imagine the projected future of cities, especially in developing countries where the construction boom sees rapid development in cities over short periods of time. Many buildings would be repurposed to meet demands of the day, but there will also be many which would no longer be in use due to its inability to adapt. Residential high-rise buildings will easily become obsolete.

## **1.6 Research Methodology**

This chapter decides the research direction through the understanding of the existing research and literature review. The overall basic research framework will be divided into four different stages; to identify the research problem, data collection, data analysis and lastly, conclusion. The research problem is generated from preliminary literature review. The research questions, aim, objectives and scope are then finalised. Data is then collected through literature reviews, case studies and field survey, which is then analysed. The findings are then discussed and recommendations specific to residential high rise buildings are detailed. Discussion regarding the adopted methodology and the breakdown of the research will be further elaborated in Chapter 3. Primary data will be collected through literature reviews,



case studies and a questionnaire. This research will take a qualitative approach, meaning that a formal, objective, systematic process will be used to analyse the data in order to achieve the research objectives.

## **1.7 Expected Findings**

Towards the end of the research, the author will be able to list down the strategies that may be implemented in a residential high rise building. These architectural strategies act as a guideline for architects designing high rise buildings for residents. It is unique due to the open building concepts used throughout the construction and lifespan of the building. In answering the research questions stated above, open building strategies will be explored and scrutinized specifically for designing residential high rise buildings. These concepts and approaches are very different from the conventional approach to high rise living. Thus, the questionnaire is used to assess the Malaysian public's interest in such methods, and their willingness to buy apartments which use open building concepts. From the analysis of the data collected, it is believed that a list of architectural strategies will be produced, which will be socially accepted by people.

The design strategies developed in the course of this dissertation were used to make informed design decisions in the design studio. The implementation of the design strategies are seen in the plans listed under appendix C.

## **1.8 Structure of Thesis**

The research structure is generally divided into five main chapters. Chapter 1 provides an overview of the study. This comprises of the background study, problem statement, thesis statement, research aim, research questions, research objectives, scope of thesis and research methodology. Chapter 2 provides a comprehensive background study on the Open Building system and relevant literature. It also includes case studies of Open Building projects from around the world. These case studies are studied in terms of concept, layout and structure. Chapter 3 presents the methodology chosen to conduct this study. This chapter provides research paradigm and research procedure and the outline of overall research framework. Chapter 4 discusses the findings based on the literature review, case studies and questionnaire. Data assembly in this study is for the purpose of analysis. The data analysis is used to suggest relevant design approaches or strategies to achieve the research objectives. . It also discusses the questionnaire used to determine the social acceptance of open building concepts and systems. Lastly, Chapter 5 summarizes the research and significance of this study. In addition, this chapter also elaborates the limitations and outlines the aspects with potential for further studies regarding this subject.

## REFERENCES

- Alter, L. (2015, July 6). *In 35 years America has cut its energy intensity in half, getting exactly nowhere*. Retrieved May 5, 2016, from treehugger:  
<http://www.treehugger.com/environmental-policy/35-years-america-has-cut-its-energy-intensity-half-getting-exactly-nowhere.html>
- Battisto, D., & Franqui, D. (2013). A Standardized Case Study Framework and. *ARCC 2013 | The Visibility of Research, Sustainability: Visualization Sustainability and Performance* , 406-414.
- Dolan, T. (2012). *Live-Work Planning and Design: Zero-Commute Housing*. Hoboken, New Jersey: John Wiley & Son, Inc.
- Habraken, J. (1998). *The Structure of the Ordinary*. Cambridge, Massachusetts: MIT Press.
- Habraken, J. (2002). The Uses of Levels. *Unesco Regional Seminar on Shelter for the Homeless* (p. Vol. 27 no. 2). Seoul: Open House International.
- Hans Drexler, S. E. (2012). *Holistic Housing: Concepts, Design Strategies and Processes*. Germany: Walter de Gruyter.
- Kendall, S. (2016). *Infill Systems US*. Retrieved May 2, 2016, from Infill Systems US:  
<http://infillsystemsus.com/>
- Stephen Kendall, J. T. (2000). *Residential Open Building*. Padstow, Cornwall: TJ International Ltd.
- Wilson, L. (2013). *How big is a house? Average house size by country*. Retrieved May 2, 2016, from Shrink That Footprint: <http://shrinkthatfootprint.com/how-big-is-a-house>