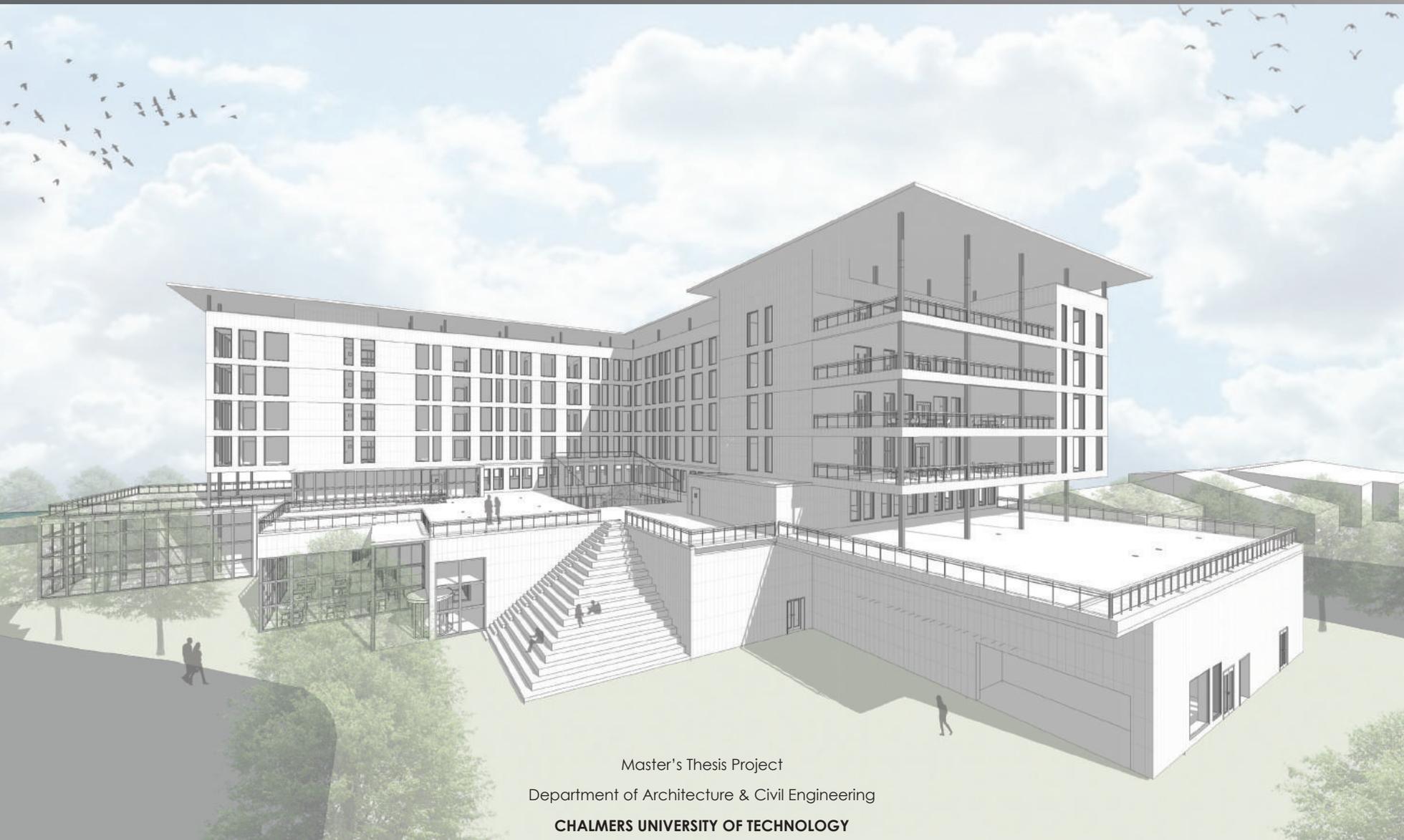


TRANSLATING WITH OPTIMISM

Exploring Flexibility in Design for a Positive Future

SRIPRIYA MANOHAR



Master's Thesis Project

Department of Architecture & Civil Engineering

CHALMERS UNIVERSITY OF TECHNOLOGY

Autumn 2017

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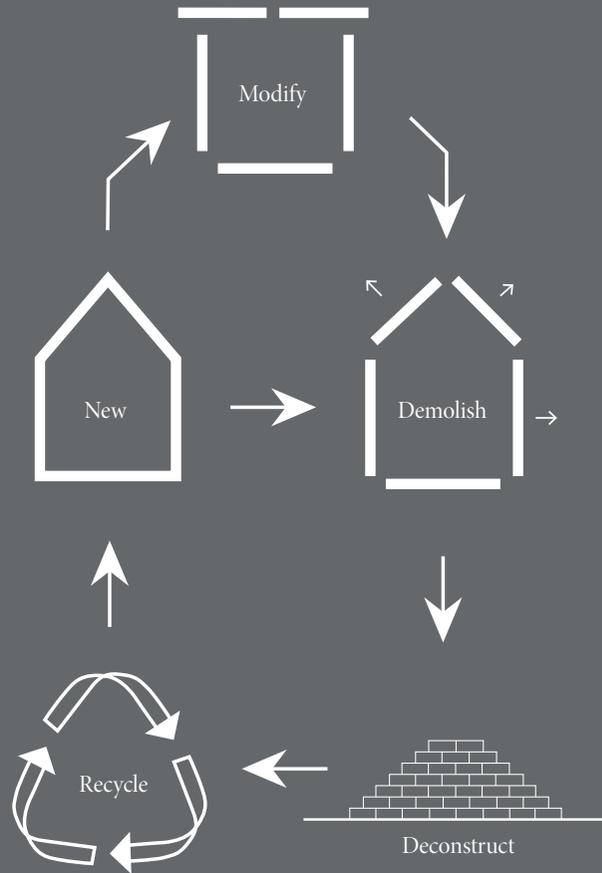
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A 30 credits Master's Thesis written within the Masters Programme:
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Department of Architecture and Civil Engineering,
CHALMERS UNIVERSITY OF TECHNOLOGY
412 96 Göteborg, SWEDEN

*"The world will not evolve past its current state of crisis by using
the same thinking that created the situation."*

- Albert Einstein



Designing flexible buildings to facilitate circular future with integrated closed loop economy, resource strategies and life cycle design.

Abstract

Today, over-consumption of resources in all the sectors explains *the way we face our global resource crisis*. Adding to that, the demands and changing requirement of human needs make the future uncertain. In such scenarios, the impact of conventional building techniques in the construction sector is prodigious and a radical change is needed in the planning and design approaches as soon as possible for a positive future. These challenges create the point of departure for this master's thesis.

The local context of Norrköping is presently in the phase of expansion with both growing population and the access to the employment market. This thesis is focused on cradle to cradle perspective to support the sustainable development approach in Norrköping which is currently undergoing major spatial transition due to demands. This master's thesis seeks to study and understand the impingements of construction sector on the environment and explores how the concept of flexibility in planning and design approaches can contribute its part in *healing the environment*.

The work is based on literature studies, empiric qualitative data from contextual analysis, dialogues and meetings with the municipality, besides synthesis and design. Flexibility in design is explored through theory and reference projects. With the help of the findings, a shared and mixed environment is developed in Norrköping's Inner Harbour area to strengthen the resilience of the neighbourhood and to increase the awareness of regenerative circular systems in the building industry.

The outcome of this thesis is a design proposal with simple interventions and design strategies in two different planning scales. It is an attempt to showcase how the concept of flexibility could enhance the opportunity of creating a circular future without any significant loss of resources.. Lastly, it highlights the potentials of designing with flexibility and discusses the further possibilities and suggestions for improvements in development approaches.

Key words: *Sustainable Development, Flexibility, Flexible design, Generic design, Circular thinking, Recycle, Reuse, Reduce*

The Author

The author, Sripriya Manohar was born and raised in a small village in the state of Tamil Nadu, India. She has completed Bachelor of Architecture (B.Arch.) and then worked at a practice for a couple of years in Tamil Nadu, India before moving to Sweden to pursue her Master's degree in Architecture at Chalmers University of Technology.

“During my bachelor’s education, a lot of emphases was given on Sustainable Development in Architecture. What was understood was that it is a vast subject and has infinite ongoing researches. While pursuing Masters in Architecture and Planning Beyond Sustainability at Chalmers University in Sweden, I have been exposed to a lot of global and local issues and how to deal with them with a sustainable approach. After being educated in two different zones with varied culture, climate, environment and society, being an architect, it is concerning to look at the environmental issues which affect the possibilities for a positive future in a greater extent. Before starting my Master’s Thesis term, I did an internship for an architectural firm called AG Arkitekter in Norrköping. During that time, I was introduced to the Inner Harbour site and it’s new development plans which have interested me to develop a flexible space that can be adapted over time without leaving behind any hard impacts. My intention towards choosing the particular subject for my Master’s Thesis is to unfold the knowledge on the regeneration of circular systems in the building industry that sets up an optimistic impression to evolve past the current state of crisis. There is always a new chance to start over. So let us not be afraid to rebuild what we want which will eventually create a ripple effect on a larger scale.”



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Preface

This Thesis project was developed as a result of seeing the ongoing new Urban and Spatial Planning developments to meet the current demands for spatial needs in Norrköping, a growing city in Sweden. Also, my prolonged thinking in building an environmentally friendly world for our future generations played a crucial role in formulating the research questions for the project. I was engaged in researching and writing this thesis from September 2017 to January 2018.

I would like to extend my sincere gratitude and thankfulness to my supervisor Nils Björling (PhD & Senior Lecturer, Chalmers University of Technology) for his excellent guidance and support during the process. I would also like to thank my examiner Kristina Grange (Professor, Chalmers University of Technology) for her keen involvement and constructive advice.

I extend my earnest thanks to Fredrik Wallin, Linda Gärln, Per Haupt and others from Stadsbyggnadskontoret, Norrköping Municipality for giving me their time and providing me with the required data.

I thank all my dearest friends who supported me and stood by my side when I needed most. I also want to thank AG Arkitekter AB for showing the warmheartedness and their accompaniment in my process. And last but not least, special thanks to my ever so loving family and especially my elder sister without whom my Master's degree would not be possible.

Sripriya Manohar
January 2018, Norrköping

Booklet Outline

This Master's Thesis booklet consists of seven chapters on the whole. This page is intended to provide clear reading instruction for the readers in order to facilitate those who want to study something particular among the seven chapters. Each of the chapters are defined with specific colour to help with the orientation.

Chapter 1 - Introduction

The first chapter provides an outline for the thesis framework with a short background.

Chapter 2 - Theoretical Framework

This chapter explores the present linear state of construction sector and its associated problems and showcases the overview of flexibility in the circular thinking systems.

Chapter 3 - Reference Studies

In this chapter, relevant case studies of both architectural and urban scales are presented.

Chapter 4 - Contextual Framework

This chapter describes the local context of Norrköping and its related analysis.

Chapter 5 - Conceptual Framework

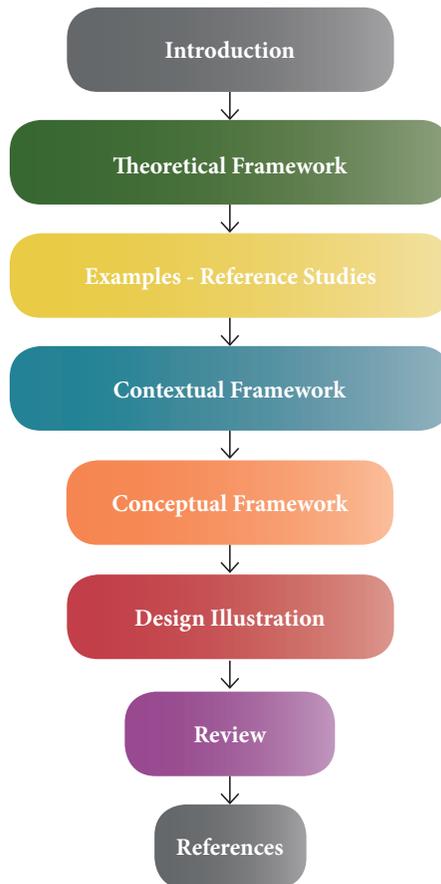
This chapter demonstrates the design strategies with the concept and programme which eventually is forming a base for the design proposal.

Chapter 6 - Design Illustration

In this chapter, the various design strategies are exhibited in two different planning scales and outlines the idea of flexibility on the whole.

Chapter 7 - Review

Lastly, this chapter concludes the whole project by discussing and reflecting upon the results.



Terms & Definitions

Flexibility

Ability to modify something. For example, in the manufacturing industry, Flexibility can be defined as the ability to change the volume of the product.

Flexible Design

Flexibility in Building design is a concept which allows the modification of spaces by considering the demands and changing requirements of human needs having future uncertainties in mind.

Generic

Generic design is a concept focused on functionality referential to the location and not dependent on socio-economic condition, hence are ignorant to changes on certain cases. Generic is often considered more vernacular rather than contemporary.

Cradle to Cradle

A holistic design approach which establishes the closed loop systems without producing waste in its processes thereby creating a sustainable environment for the life of future generations.

Regenerate

Produce new out of waste with a closed loop input or improve the existing that does not affect the environment.

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CHAPTER 1

Introduction

BACKGROUND

Overview

In today's society, over consumption of resources is leading way to the graveyard by the end of its life. The building industry has some important issues, one of which is high amount of waste that comes from producing new building materials, from demolition and even from building new structures. The most important is the fact that the natural resources are wiping out, we are still reaping the left-over resources that this planet has to offer. *(This is illustrated in Figure 1. which explains the conventional system boundaries in the building industry.)*

Also, people are depopulating from their original place to the areas which have closer access to their workplace. This gradual increase in the population of cities is because of the growth of knowledge attractors such as education and service sectors. This eventually increases the demand for housing and new infrastructure facilities in the cities resulting in construction and demolition of structures. These challenges in today's environment has lead way to resource depletion.

In order to economize material usage and to bring forth a new designing approach to achieve Sustainable resource management in building industry, it is essential to necessitate the municipalities to focus on creating a Circular future and reduce the environmental impact.

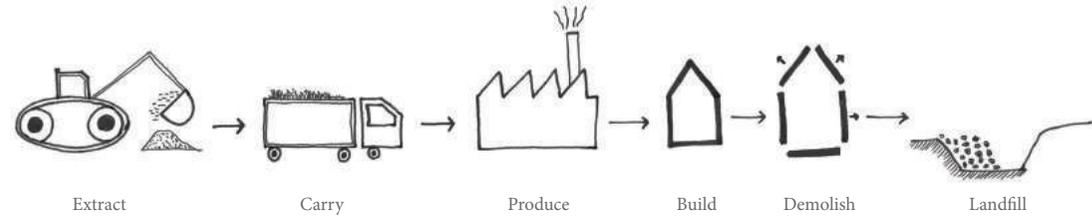


Figure 1. Conventional system boundaries in building industry

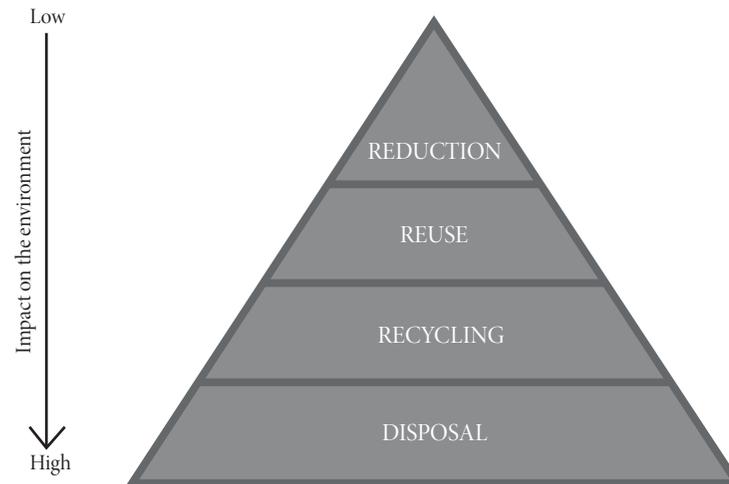


Figure 2. Waste Hierarchy
(reinterpretation based on Yuan & Shen, 2011)

Construction and Demolition Sector

In general, the construction industry is one of the industrial sectors which leads to the growth of socio-economic status of that particular country. By contrast, the construction industry plays a primary role in the environmental erosion by means of depletion of non-renewable resources. The works in the construction industry imparts to the emission of dust, generation of enormous quantity of solid waste, depletion of land and energy consumption. The wastes produced from the construction industry is one of the most prominent waste flows in Europe, estimated both in volume and weight. Construction waste constitutes to almost one-fourth of the European waste and only small quantity is recycled or reused (*Figure 2. explains existing Waste Hierarchy where the disposal of materials is at high end and reuse and reduction on the low end*). The construction industry also produces significant amounts of hazardous waste, almost 40 percent of the Swedish hazardous waste is generated in the construction sector (*IVL svenska miljöinstitutet, 2016*).

Another negative effect of this sector is that, 5% of Green house gas emissions are produced by making building materials (*Circular construction, 2014*).

“In 2012, 7.7 million tonnes of Construction and Demolition Waste (CDW) were officially reported as generated in Sweden” (europa.eu).



Image 1. Down-cycled materials in the Demolition site
(Retrieved from <http://gxn.3xn.com/>)

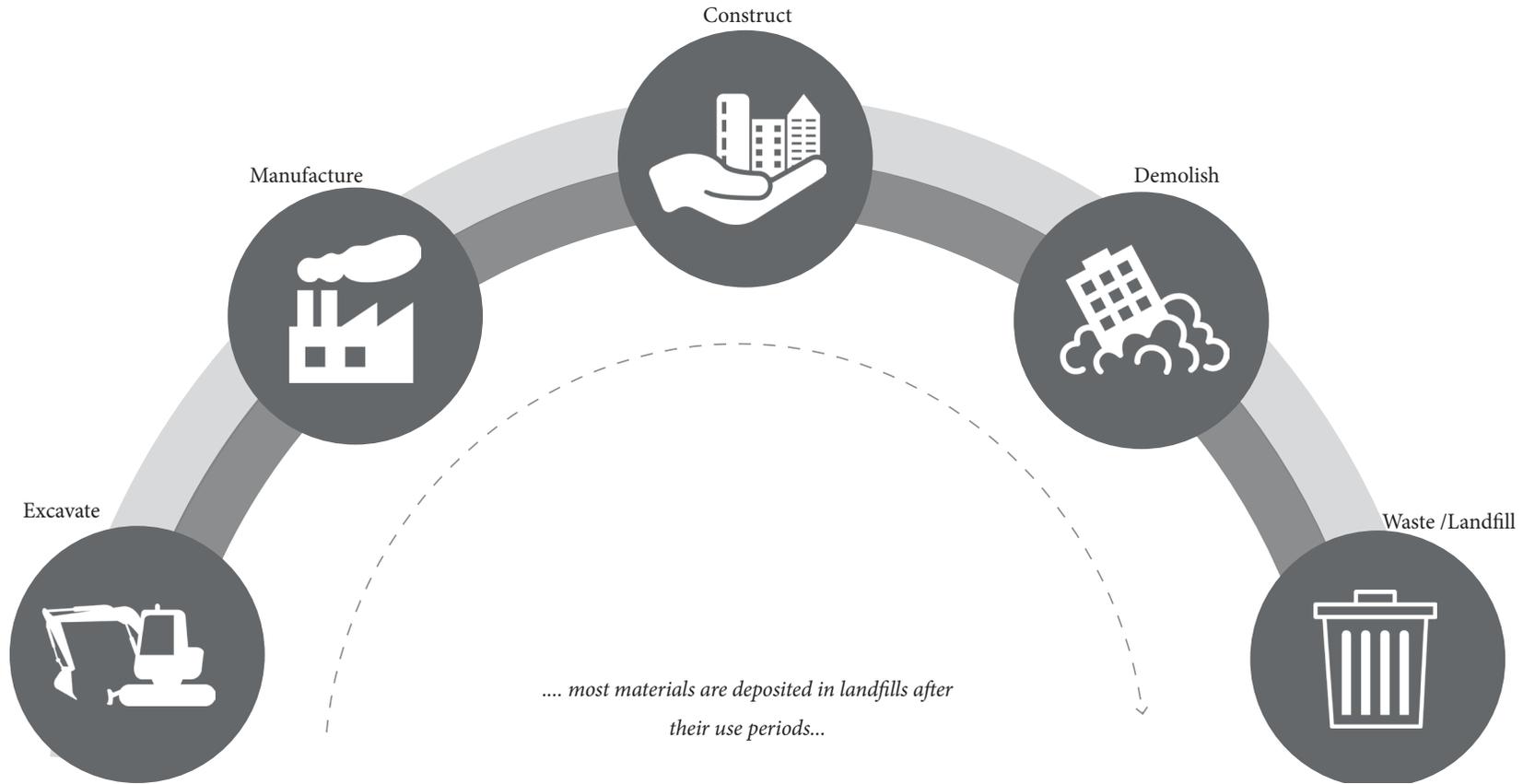


Figure 3. Cradle to Grave Model
(reinterpretation based on *Cradle to Cradle in the Built Environment*, 2013)

Linear Approach

Today, either the lifetime or the quality of the product does not last longer and are becoming obsolete in a short time. Instead of fixing the product again to its original state, it is economically substantial to purchase new one of its kind. Thus, once the building materials reaches its full lifetime, they are either down-cycled or simply ends up as building waste. In this, the material's value which was generated in the process of extraction and production is lost (see Figure 3). This showcases the linear flow of conventional building materials, otherwise called as Cradle to Grave model. (C2C, 2002).

The construction sector is highly dependent on fossil fuels and the raw materials like sand, clay, iron, wood, etc. The large scale use of these raw materials is strongly dependent on natural resources. The harvesting and processing of these resources are complex in nature and also has noticeable consequences for the environment as they are using energy from finite sources for the process to take place (Circular Construction, 2014).

Population growth

The global population is increasing rapidly and nearly all the countries are experiencing the economic growth. There is a remarkable connection between the economic growth and the consumption based on the amount of waste that is being generated (SEPA, 2012).

Population growth is posing a increased pressure on the Earth's resources and the threat is set to affect all the inhabitants on earth, not only those in the construction industry. By 2050, the population of our world will increase to 9.7 billion, of which two-third of the population will live in urban centers, otherwise called 'mega-cities' (UN, 2015).

Rapid growth of population and the urbanization is increasing the demand for infrastructure and facilities regardless of uncertainties of future. When the population increases, the productivity in the construction sector also increases (see Figure 4). It was examined already that globally we, humans are consuming 1.5 times more the resources than the planet can provide. And in Sweden, the consumption rate is 4.2 times than the Earth can sustain (WWF, 2016).

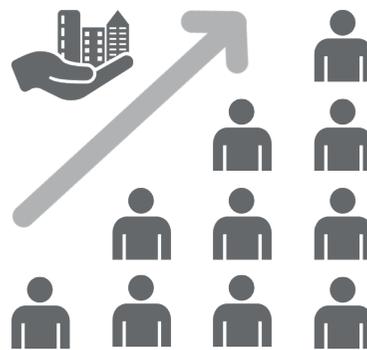


Figure 4. Population growth and the increase of construction productivity

The Path to Circularity

“The use of natural non-renewable resources has grown dramatically particularly since the mid-20th century, so that we are endangering the key environmental systems” (WWF, 2016).

The Cradle to Grave model is setting a greatest threat to our ecosystem. The current conventional practice in the construction sector is not economically feasible since the recovery of the materials from the demolition site is complex. Materials like steel, aluminium and copper are often contaminated with concrete and only 30% of the used metals are recycled globally today. In addition, the process of recycling requires progress with the material separation and transportation and the process is expensive too (Circular Construction, 2014).

Though there are concerns and practices regarding Sustainable development is taking place, it is not up-to the scale and there is a clear demand to change the conventional way to preserve the resource bank (see Figure 5.).



Figure 5. Goodbye Grave, Industrial Ecology (admins, 2016)

RESEARCH RELEVANCE

Why Flexibility?

There is a famous quote said by the Greek philosopher, “Change is the only constant”, which is unquestioned and does not require any further explanation in this dynamic world. Having said that, it is really essential to adapt to the changes, so, the ultimate goal is to endure a solution for a long term that can balance the wheel of productivity to ensure environmental sustainability.

Being one of the prominent impactor on the environment, the construction industry sets a new era on the innovative productivity. As one of the innovations, the construction industry is currently looking at infinite and instant flexible options that can fit into varying situations.

Flexible solutions work mainly based on the concept of reuse and recycle. By doing so, the demand for extreme productivity is reduced which in turn cuts down the rate of impact on the non-renewable resources of our environment.

Why Norrköping?

Norrköping is an attractive city with historically rich cultural & industrial heritage. Today, the municipality is in a phase of expansion with both growing population and access to employment market. The local context of Norrköping - is presently facing housing shortage issues

and on the other hand transformation and transition of industrial areas to residential and public space have been initiated.

The city is planning now for how they can grow and develop into a more attractive and sustainable city and has plans for mixed use developments. The city planning office of Norrköping municipality is mainly focusing on Sustainable development approaches to reuse the land centrally located in the city rather than extinguishing large areas of green land and creating thinned settlements in the outskirts of the city (see Figure 6.) (based on Vision 2035, Norrköping municipality).



Image 2. Industrial Landscape of Norrköping
Retrieved from <http://www.upplev.norrkoping.se/sv/item/industrilandskapet>



Image 3. Sustainable city development
(Carlsson, 2014)

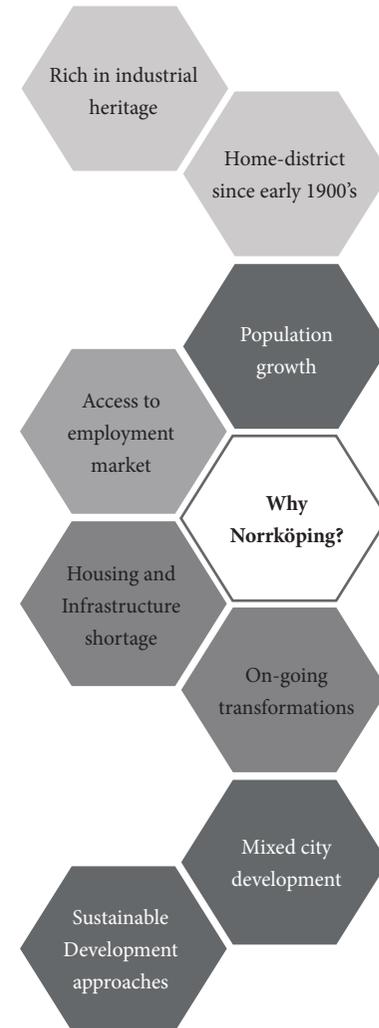


Figure 6. Reasoning for choosing Norrköping

PURPOSE

As an overall vision, the purpose of this master's thesis is to explore the possibilities of extending the life span of the built environment to cut down resource depletion considering the future uncertainties that can add to the Sustainable development approaches being carried out in Norrköping.

AIM

The aim of the project is to develop design strategies with the main focus on the concept of flexibility and cradle to cradle theory. The design strategies are then illustrated through a design proposal that can contribute in creating a circular future. The potential of the design strategies are highlighted on the design proposal and provides perspectives on efficient usage of the site potential, building space and the material usage. Also it will discuss about the shortfalls and further exploration required in the particular subject. Along with analyzing the concept of flexibility, the thesis also investigates on other related literatures about Building a Circular Future. It will also look through the Future visions and Comprehensive Planning of Norrköping which facilitates in getting a better understanding of the new development strategies (see Figure 7.).

RESEARCH QUESTIONS

The important research and design questions connected to the purpose of the project that could drive the thesis in a right direction are as follows:

Question 1

What values and qualities does Flexibility add to the buildings?

Question 2

Which are the challenges of Flexible Design and how can they be managed in the local context of Norrköping to facilitate a circular future?

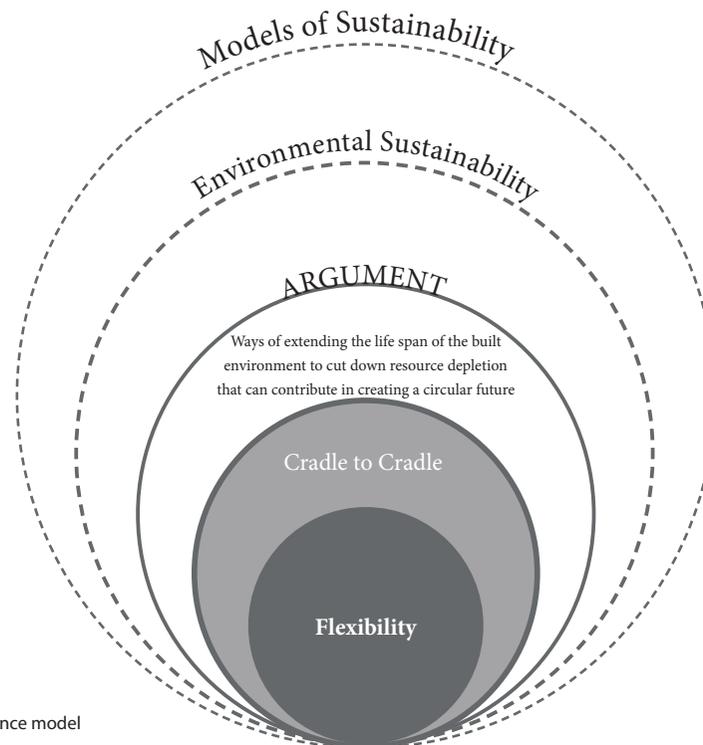


Figure 7. Research Relevance model

METHOD

This thesis is carried out as a 'Research for Design' project which implies that the research would stand as a base knowledge in the execution of design. Research is to be conducted through empirical studies about the area and its development plans and collection of qualitative data through statistics, interviews and site visit observations. Literatures in the form of books, articles and journals supporting cradle to cradle design and the flexibility in architecture are studied. Along with the literatures, meetings with the municipality and interviewing the local inhabitants are to be conducted. The project also looks at few interesting reference projects in both urban scale and the building scale. These collective base knowledge is then expressed in the Design Phase strongly (see Figure 8.).

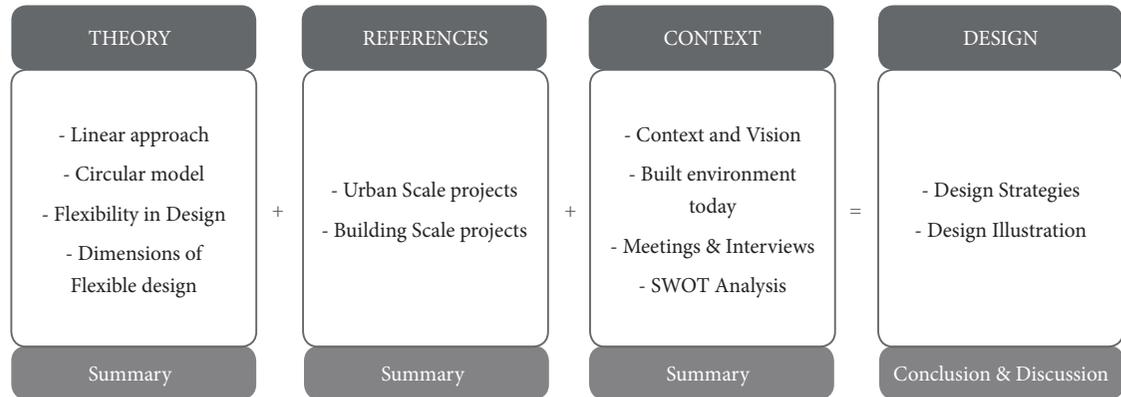


Figure 8. Illustration showing the Research and Design approach

PROCESS

The first half of the project period is completely a knowledge building stage where the research on theory and the area is conducted, on-going development plans are analyzed and dialogue with the municipality is set. Then the second half will be focusing on articulating the research through design strategies and then illustrating through the design proposal (see Figure 9.). Schedule is made with weekly goals, evaluating the weekly work at the beginning of the next week and critically reflecting upon them based on the questions: "Am I going in the right direction? Am I moving in the right speed? Why I have to do it? What was good and bad? Why?"

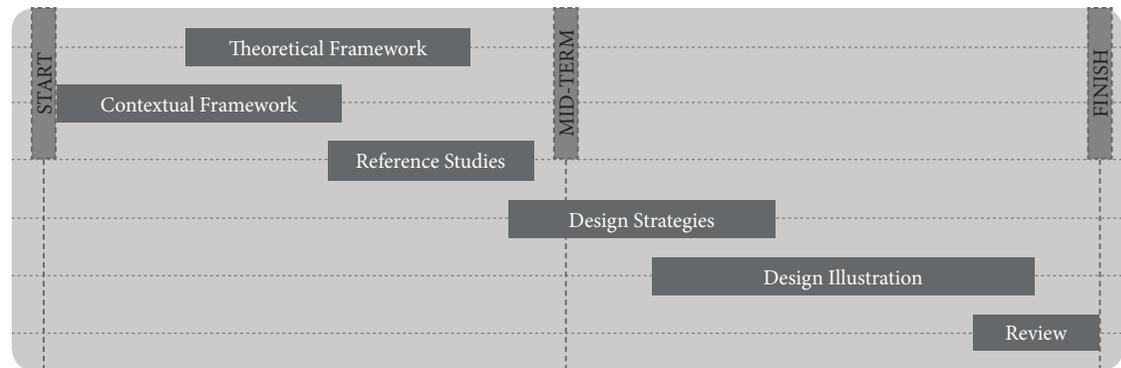


Figure 9. Illustration showing the time scale of the different methods that are included in the process

FOCUS & LIMITATION

The project focuses on enhancing the long-term sustainable solution in planning and design approach in the construction sector. The context is set to the industrial node of the city that is to be transformed soon which is currently being an unfriendly zone. This project would also help to activate the time dead space to create synergy effects (*refer to Figure 10. for the focus and delimitation diagram*).

- Considering the *research part based on Flexible design and cradle to cradle concept* as the main focus for this thesis, the project delimits itself into the building proposal that would benefit and inspire the Municipality of Norrköping. The thesis will not focus on detailing the Master Plan of the site in order to show the activation of the area.
- The project does not focus on the economic aspects rather *focuses on the environmental aspects* in relation to the physical expression of the area.
- The project does not focus on technical solution in construction rather focuses on life cycle and aesthetic aspect of design.
- Considering the limited time for MT, the thesis will not question or critically reflect upon the newly proposed developments for the areas, rather formulate new design approach.

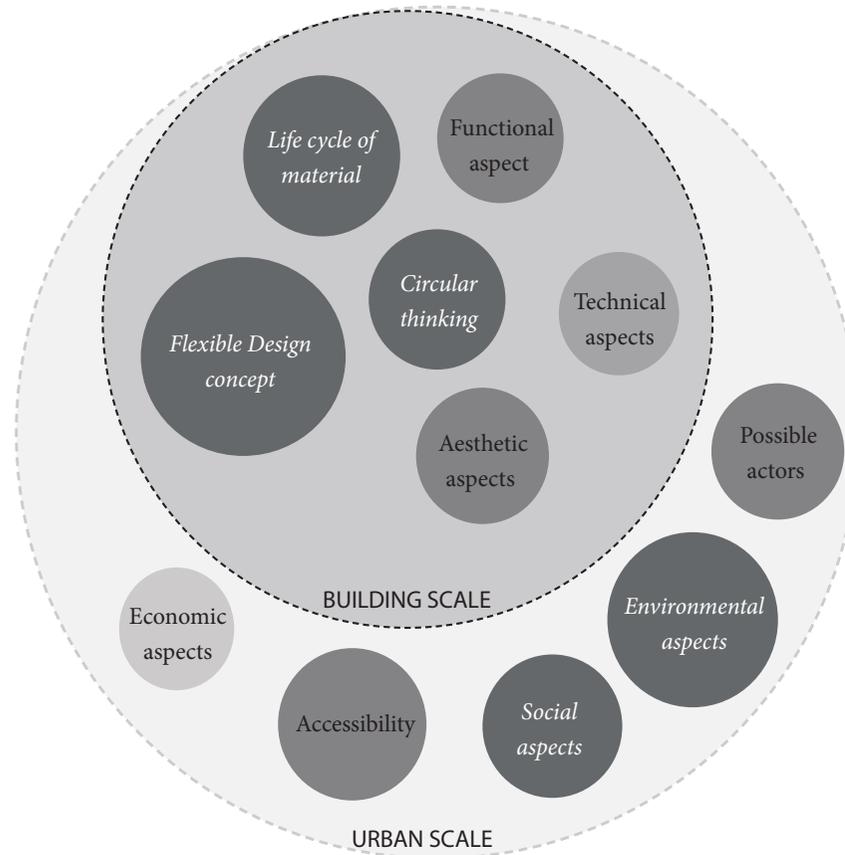
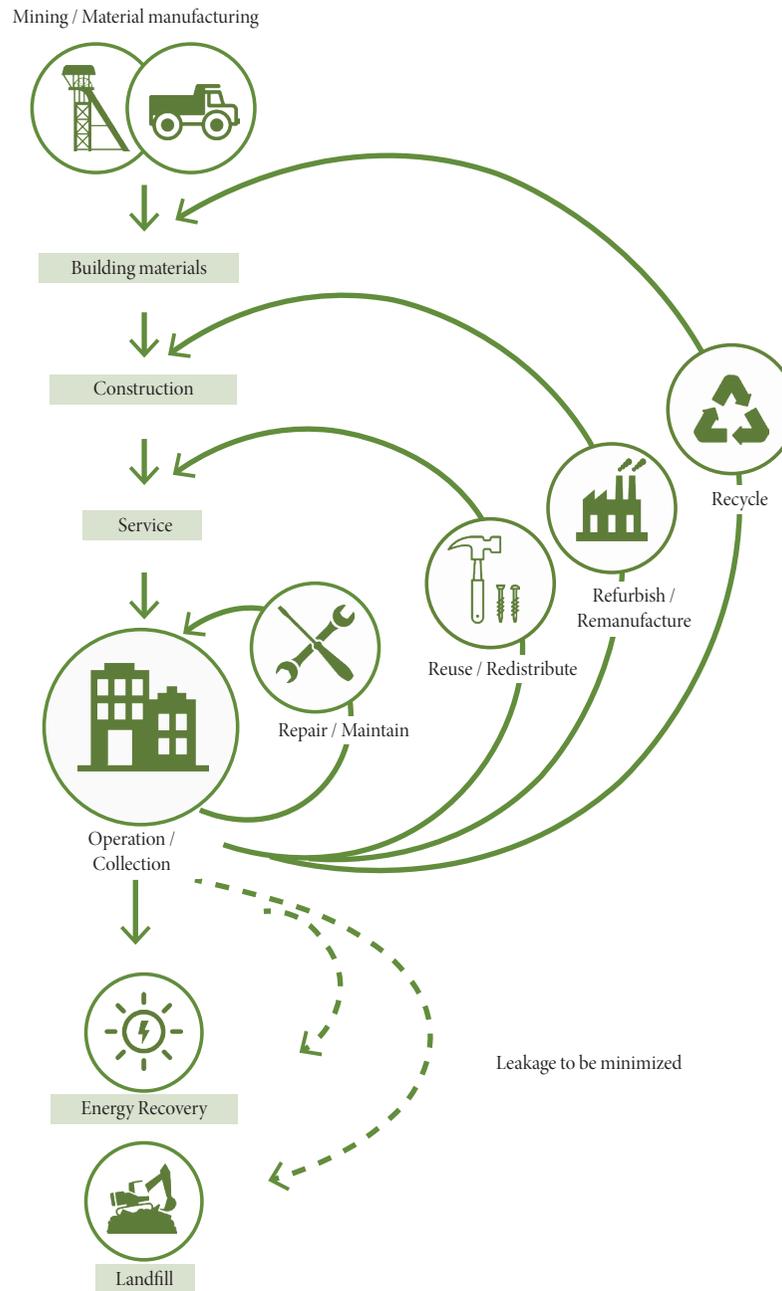


Figure 10. Focus and Delimitation Diagram

CHAPTER 2

Theoretical Framework



This illustration explains the Cradle to Cradle design strategy in the construction sector, where most of the used materials are either repaired or reused or refurbished or recycled and are used again. In the end, the amount of waste generated becomes lessened because of the closed loop cycle of materials.

Figure 11. Cradle to Cradle strategy - in the Construction sector (reinterpretation based on Ellen McArthur Foundation, 2012 & WEF, 2016)

CRADLE TO CRADLE - PACE OF INNOVATION

Normally, the success of the Sustainable Design can be defined as the heightening of the livelihood without the impingements on environment (Stephen McKenzie, 2004). However, today the construction industry is like a 'one-way' road for the materials used and they impact upon the environment in various ways. "Today a building truly becomes a material graveyard at the end of its life." (*Building a Circular Future - Jensen, 2016*)

It is demanding how can the construction industry tackle the uprising challenges to facilitate a circular future. In order to build a circular future, the municipalities have to start working with circular economy. Linear thinking has to be changed over with circular thinking.

Cyclical Thinking

As a reaction to the linear approach followed in the production and consumption of products, a design paradigm called Cradle to Cradle (C2C) was introduced by chemist Michael Braungart and architect William McDonough. The definition of C2C model is as follows:



Image 4. Cradle to Cradle brand model

(retrieved from <http://www.mcdonough.com/cradle-to-cradle/>)

"Cradle to Cradle is a holistic approach where all the system boundaries seeks not only efficiency but also essentially waste free environment."

This design strategy explains the circular flow of nutrients in two cycles: biological and technical, in which waste is converted into a useful nutrient for another new purpose while using the energy from the renewable source for the production process. The basic philosophy for this design approach is to preserve the value of the material during its lifetime. Thus, by closing the loop of the cycle, the emission of polluting agents are reduced, building waste is lessened and at last the use of resources is minimized (*Building a Circular Future, 2016*)

The materials that has been turned into a waste will end being a waste not only if they undergo a recycling treatment but also meets the necessities considering the further use complicated by the uncertainties about the future (*SEPA, 2012*).

Regenerative Development

It marks a substantial evolution in the concept of circularity. This design strategy was introduced by Professor John Tillman Lyle, in which he discusses the core issues concerning environment and ecological footprint.

It is a self-healing or self-evolving process where the design system regenerates instead of degenerating the supporting systems and resources in socio-ecological relationship. In this process, the value of the consumed resources are either maintained the same or increased as compared to the origin. Thereby, the quality of the place is improved and the lifespan of the design system is extended (*Mang & Reed, 2012*).

Design for Disassembly

Design for Disassembly (DfD) is a holistic design approach of Circular thinking approaches because it provides the used design components with the quality of either to be reused or to be recycled or to be reassembled by fitting into the closed loop cycle. The main purpose of DfD is to disassemble all the used jointed construction components into its individual components and can be used in any degree of scale and complexity (*Building a Circular Future, 2016*).

The important rule followed in the Design for Disassembly is that the connections of the design components must be reversible to allow for easy deconstruction. For decades, the concept of DfD has been used only by conscious choice in small scale projects but not out of necessity. Therefore it is essential to implement the Disassembly concept in large scale projects as well.

BEYOND SUSTAINABILITY

Today, the trend of Sustainable development is elevating in the construction sector and it is still encountering many challenges that are upcoming though. Having these Pace of Innovation in the construction sector, it is still demanding to think Beyond Sustainability.

As it is discussed in the previous segments, there are a lot of ways of promoting Sustainable development that are followed today. From recycling and sorting of waste into recyclable and non-recyclable, reusing of waste materials as a potential resource, new technological improvements in construction techniques, energy-efficient techniques accommodated in buildings, nature influenced designs, bio-elements used in the buildings, the use of alternative materials in the construction, smart buildings, deconstruction and material passports and so on (see Figure 12.).

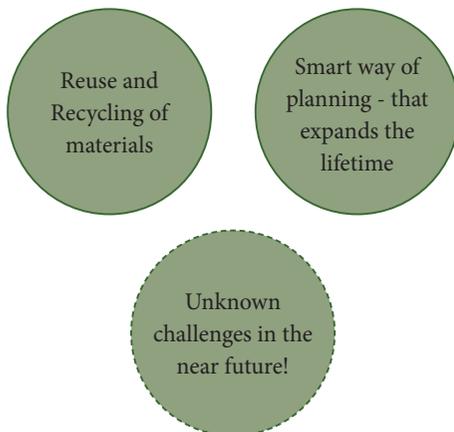


Figure 12. Sustainable approaches and the unknown forthcoming challenges

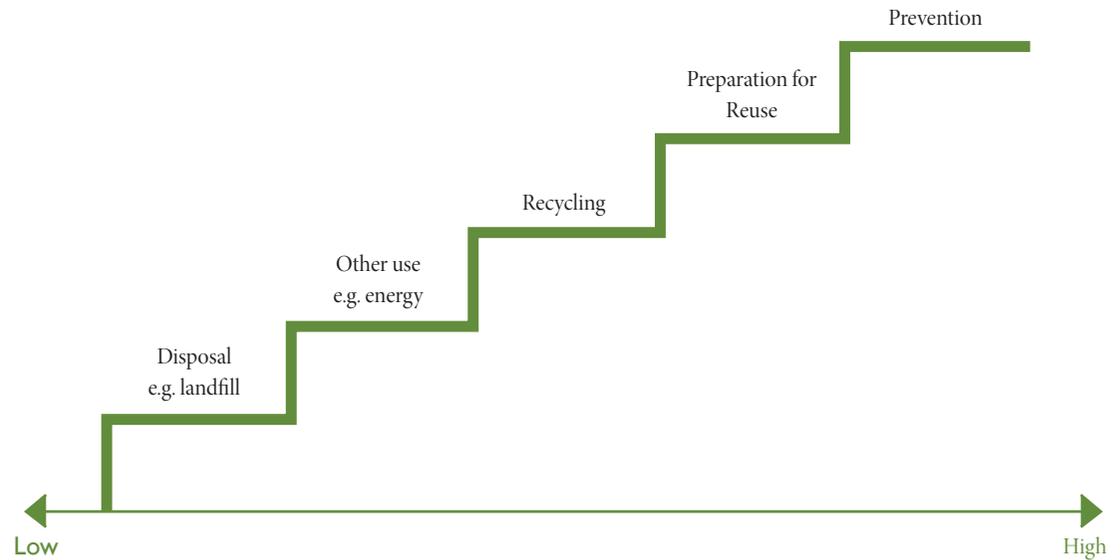


Figure 13. Waste Hierarchy (based on SEPA,2012)

Life-cycle approach

The use of the building is modified over time because of the constant change in the number of users, change of owner or of new trends. So, when there is a change in the use of the building, there will always be a need for rebuilding (Brand, 1994).

The lifespan of both the materials and the building is taken into account in the circular model where the value of the material is preserved along with extending the life time of the building (Figure 13. explains the expectation of Waste Hierarchy Ladder, where Disposal is on the low end, recycle and reuse are on the high end. Prevention or reduction is also taken in to account on the highest end).

OVERVIEW - FLEXIBILITY

“Almost no buildings adapt well. They’re designed not to adapt; also budgeted and financed not to, constructed not to, administered not to, maintained not to. But all buildings (except monuments) adapt anyway, however poorly, because the usages in and around them are changing constantly.” - *Brand, 1994*

Flexible planning is an immense field of study and is represented in Sustainable Development in various design directions. The involvement in designing the adaptive spaces and flexible buildings has been escalating with time as a result of the varying requirements of the occupants. In John Habraken’s definition of Open Buildings, he states that the built environment is the outcome of a persevering design process where the environment transforms part by part. Therefore flexibility can be empathized as an ability to adapt to the changing needs of the built environment. It includes adapting with the changing demographics, the possibility of incorporating new technology or even opportunity to change the function or configuration of the building (see Figure 14.). However, modification of one function to some other has more often been witnessed as unmanageable, hard and expensive.

The extent of flexibility can be determined in two ways: firstly, the in-built opportunity for adaptability, identified as capable of various social uses, and secondly, the opportunity for flexibility, identified as capable of various physical arrangements (*Schneider & Till, 2007*).

Then again, regardless of the numerous attempts, the tendency to design flexible buildings is normally expected for a short term where it relates to a specific program for a particular point of time. Therefore, it is demanding to accept the necessity for a long term building reflecting on the uncertainty of the future demands and occupation.

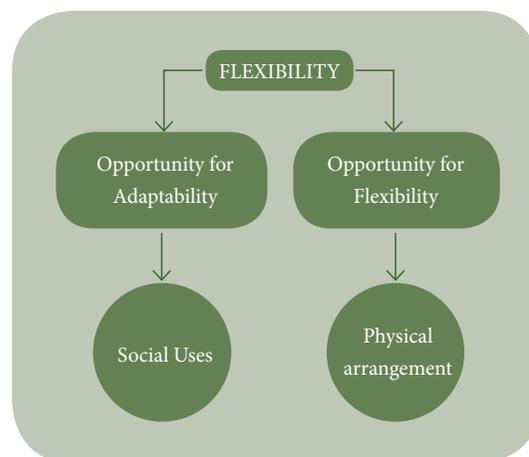


Figure 14. Flexibility in Building Design
(based on Schneider & Till, 2007)

The future of a building can be measured in respect to its sustainability, adaptability and flexibility where such structures can be easily altered based on the requirement. Other crucial aspects are minimizing the waste production, reducing the use of materials and the ease of dismantling the services.

Contrarily, inflexibility of a design portrays that occupants have no choice but to leave when their needs changes. Such considerations have an optimistic view in the real estate market since the buildings will continue to subsist on demand.

Presently, the growth of flexible planning and design represents a universal happening. Many investors and government supervisors have started to acknowledge few of the issues that the building sector still faces. It includes the vitality of the extended lifespan of the buildings compared to the short span of its functions, the vacancy of the structures due to its inability to meet the current requirements and the rapid change in user demands. Hence, the modern technological solutions about how to build in flexibility are being industrialized in order to improve the responsiveness of the buildings for the users, as well as increasing capacity for change, efficiency and sustainability, thereby dramatically extending the life of the buildings.

There is an ongoing research and experiment project Positive Footprint Housing, where the main focus is given on achieving long-term sustainable solutions for housing and a part of the research is focused on Flexibility and its attributes in housing design.

FLEXIBLE CITY - NEED FOR SUSTAINABLE SOLUTIONS

Cities in Transition

Transition of countries and cities has marked significant reflections on the spatial challenges which the cities, towns and villages are facing right now. When the demand for housing and other facilities are growing, the demand for healthy heterogeneous living environment is at risks by means of further urban growth. This forces us to think about re-use and area transformation.

Sustainability, in general, means handling with care all conditions, features and goods that are scarcely available. So, a sustainable living environment is one which not only makes responsible use of energy and raw materials but also with the available open space and greenery. The existing urban areas are adjusted with infills where necessary by means of redeveloping the existing structures and plots that have become vacant (Bergevoet & Tuijl, 2016). The scale of flexibility in planning determines how well the cities and building will be able to cope with the future requirements.

The goal of the current set of system is to expand the urban areas which has resulted in the system failure since, today, there is a growing demand for the quality than the quantity of space. This has provided an effective answer of redeveloping the vacant spaces in the existing urban areas such that the countryside lands will still be surplus.

As said by Bergevoet & Tuijl (2016), the existing set of design instruments are not flexible enough to react to the new situations in a satisfactory way. Also, the design instruments must cope with the unpredictability rather than shaping long-term objectives (refer to Figure 15. For *Flexible development framework*). The required design instruments are sorted into three levels of flexibility as follows:

1. Local flexibility

The local residents are always attached to the existing local situations and they fear the change. The entire street or individual buildings may lists particular status or interest. Hence, reusing of the existing plot is difficult and it depends on the local situation and the energy available. Indeed, flexibility at the local level is one important driver for the development of flexible city.

2. Time based flexibility

The objective of today's spatial development is often seems to be built to last for ever. This strong focus on long-term solutions excludes time from the system. The reason behind the long-term developments turns out to be the fear of financial loss due to unexpected future situations. But now, due to environmental concerns, the developments are not taken for granted and requires time-based flexibility to produce results which are open to change.

3. Use-driven flexibility

Urban development in the past centuries was initiated by the public authorities, housing companies, investors and the institutional developers. At that time, the production and supply were not based on actual demand counting the user's actual requirement. When the users have the benefit over their own living environment, supply and demand will be more coordinated. Therefore, flexible city is also being shaped through use-driven flexibility.

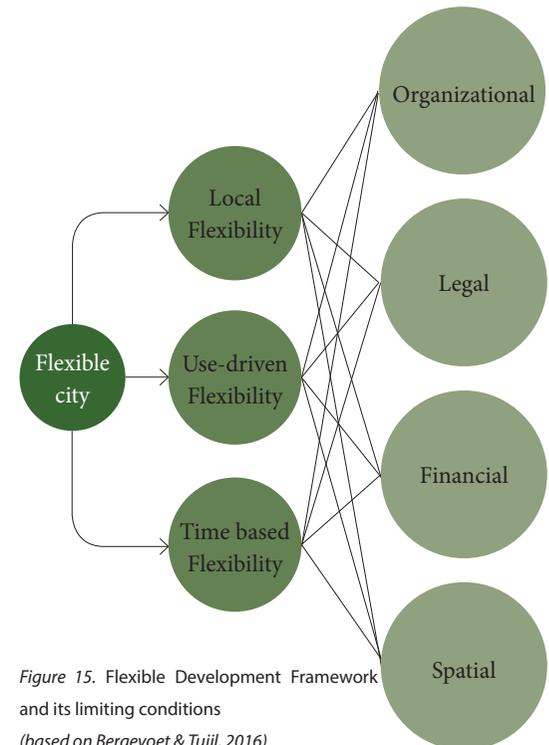


Figure 15. Flexible Development Framework and its limiting conditions (based on Bergevoet & Tuijl, 2016)

Example

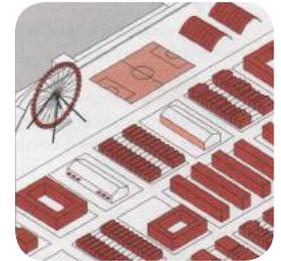
Here is an example to illustrate how flexible planning work.

Mono-functional new building projects and large scale projects are often lack the attraction from the existing urban fabric. The urban fabric becomes diverse in the forms of usage and types of building when parts of the building are preserved during the process. This is achieved only when temporary and semi-permanent building structures are added. Temporary programs always encourages the new development in the place when there is a demand.



Illustration of the flexible functions

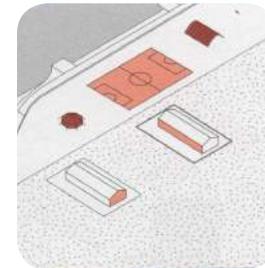
Image 5. Urban Pioneers, from static town planning to multi-speed town planning (scanned pages, based on Bergevoet & Tuijl, 2016)



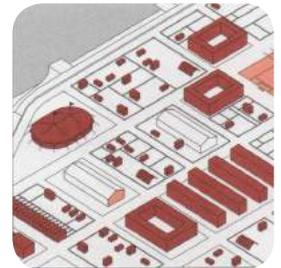
3a. The temporary intervention is successful; new permanent investments are made further along



1. A vast building site is derelict



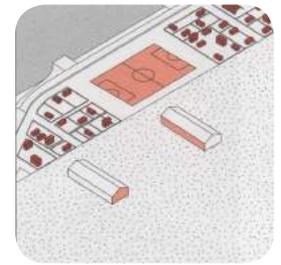
2. Part of the site is put to use temporarily



3b. A mixed area emerges with temporary and permanent functions



The existing situation



3c. The temporary zone evolves further; the adjoining site remains undeveloped (as yet).

DEFINING FLEXIBILITY AND ITS ATTRIBUTES

Flexible Building

“A sustainable building is not one that must last forever, but one that can easily adapt to change” - *Graham, 2005*

Flexibility in architecture is defined as the domain of architecture that enables the changes in space planning over time, thereby extending its lifetime (*Kronenburg, 2007*). Flexible building can be demonstrated in multiple ways:

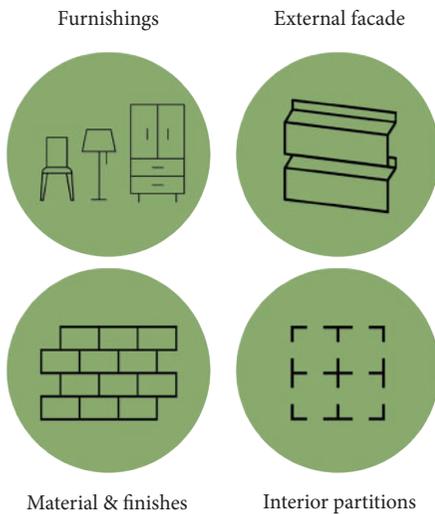


Figure 16. Ways of showing Flexibility
(based on Kronenburg, 2007)

For example, Flexibility can be shown in the usage of construction materials by the Design for Disassembly strategy. The deconstruction of building encounters the effective usage of building materials where they are removed completely and equipped into some other efficient building (*see Figure 16.*).

Dimensions of Flexibility

The Flexibility in design is articulated through four important attributes (*see Figure 17.*). These attributes form the basis for adapting to the changes with respect to the uncertainties. They are represented below:

Interactive - Buildings that are responsive to all the influencing factors both internally and externally. They react to the shifting requirements through their usage, operations and envelope either automatically or intuitively.

Adaptability - Buildings that are reconfigured to fit the specific usage of the space. These kind of changes are responsive to the specific user's requirement and they respond readily with respect to the fixed fabric of the building.

Movability - Buildings that are portable and are relocated from one place to another to accomplish its purpose in a better way. These kind of changes possible based upon how the superstructure of the building is assembled.

Transformability - Buildings that are altered physically by means of its shape, form, size and appearance. They are responsive to the changing needs by contracting, expanding, opening or closing.

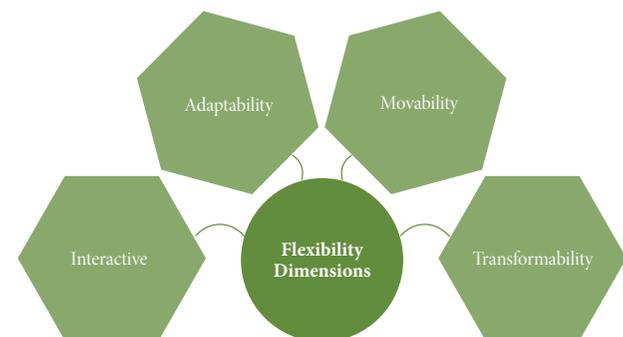


Figure 17. Flexibility Dimensions
(based on Kronenburg, 2007)

Layers of Change

A building is conceived with several layers of longevity of built components. Some layers endure long life than other layers and some layers are resistant to change than other layers. The concept of shearing layers as explained by Stewart Brand (1994) plays a major role in establishing flexibility concept (see Figure 18.).

Foundation - buried in the ground, hard to access and can withstand considerable number of buildings. This layer is eternal.

Structure - backbone of the building, joints are accessible to the smaller extent, has long life and can be reused in another building. Further alterations to this layer should leave it unaffected.

Facade - easy to change and are changed at least once in its lifetime because of its exposure to the weather.

Partitions & Systems - flexible layers because of its adaptability to the constant changes in its lifetime. Partitions include interior walls, ceilings and floors. Systems should be installed independently with optimal freedom, keeping the structure physically distinct.

Things - that has a short lifetime and does not hinder the building process. This layer includes interior furnitures and fit-outs.

The different layers of a building gives an insight about how a building can be persistent for a change by associating it with both the building's components and time (see Figure 19.). The change in building is encountered at various degrees of time and also the different layers provides an image of required total effort (Schmidt, 2010).

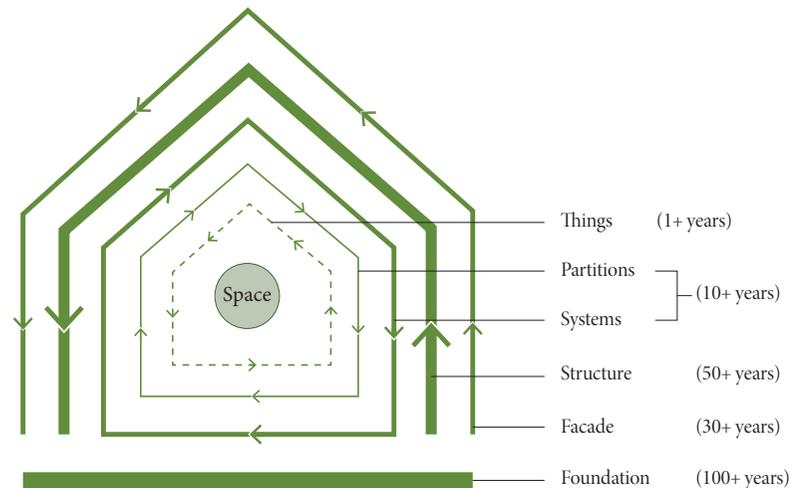


Figure 18. Shearing Layers of Building - in relation to lifetime (reinterpretation based How Buildings Learn, 1994)

Dimensions	Strategy	Type of Change	Layer(s)	Rate of change
Interactive	Refitable	Change of performance	Partition, System, Facade	Moderate
	Adjustable	Change of task	Things	High
Adaptability	Versatile	Change of space	Things, Partition	High
	Portable	Change of location	Structure, Foundation	Low
Movability	Convertible	Change of function	Partition, System, Facade	Moderate
	Scalable	Change of size	Partition, System, Facade, Structure	Moderate

Figure 19. Flexibility Dimensions and Layers of Change (based on Schmidt III, 2010 & Kronenburg, 1997)

The following table provides example organized by building layers to reduce the effect of change (see Figure 20.).

Building layer	Design Parameter	Tactic examples
Space	room	standardization, big-volume and clusters
Things	furniture systems	standardization, modular, movable
Partition	partition walls	sliding, demountable, non-load-bearing, glass
	flooring	raised floor systems, carpet tiles
	organisational solutions	planning grids for electrical outlets, lighting and partitions
System	access	exposed, gridded systems, removable panels, clear zones
	capacity	20% surplus
	zoning	user and area control
Facade	facade	demountable, standardized
Structure	wide spans	6 - 10.8m
	high storey height	4 - 7.5m
	increased load capacity	oversized foundations, floor loadings
	prefabricated members	trussed rafters, cross-laminated timber

BENEFITS OF FLEXIBILITY

The following are few among the benefits of designing with flexibility:

- Efficient usage of space
- Increased life time
- Improved functional operation
- Accommodative
- Economically viable
- Environmentally viable
- Reduces waste
- Minimizes energy loss

Figure 20. Example of design tactics for different building layers (reinterpretation based on Schmidt III & Austin, 2016)

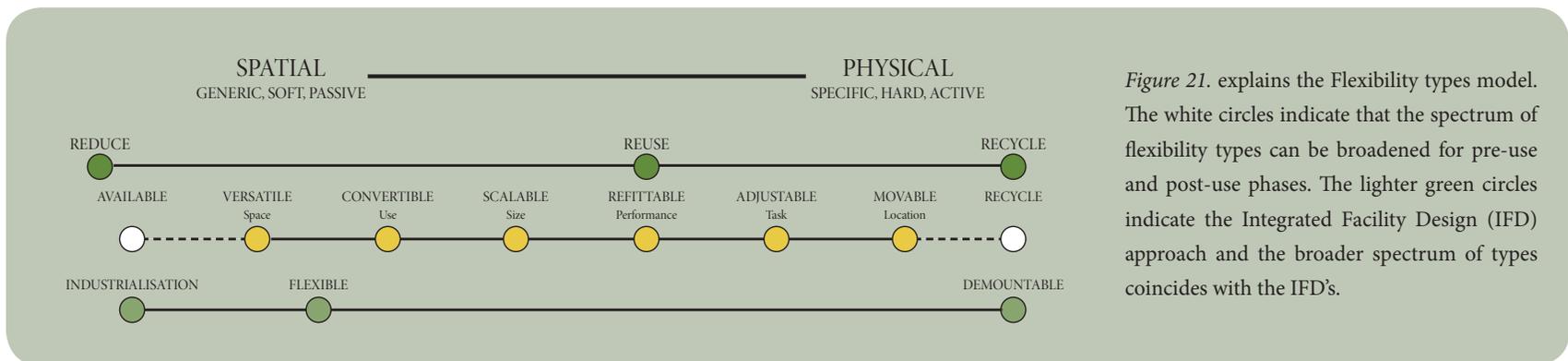


Figure 21. explains the Flexibility types model. The white circles indicate that the spectrum of flexibility types can be broadened for pre-use and post-use phases. The lighter green circles indicate the Integrated Facility Design (IFD) approach and the broader spectrum of types coincides with the IFD's.

Figure 21. Flexibility Types Model (reinterpretation based on Schmidt III & Austin, 2016)

SUMMARY

To summarize, this chapter gave a perception about Sustainable development in connection to Flexible planning which can face the approaching uncertainties. Flexibility includes Generic solutions but not all generic buildings are considered to be flexible, i.e., grid structure being generic is considered to be a flexible design solution but convertible structures are not generic in nature. Generic planning is often more denotive to the location and is focused on the functionality and the budget, hence are ignorant to changes on certain cases. Generic solutions are almost vernacular in type and significantly loses value through cultural shifts. Generic structures are raw spaces and are more commercial related that suggests nothing in particular thus allowing it to adapt for any number of changes. For example, buildings that exhibit characteristics particular to law offices, museums, restaurants, galleries, offices, bookstores, etc. Currently, it is believed that the multifamily residential structures with double loaded corridors and central circulation are also generic buildings since they are functionally or spatially the same. Flexibility dimensions except adaptability reorganizes and breaks the typical pattern of generic structures.

To state evidently, the concept of flexibility is a complex phenomenon complimenting to the other Cradle to Cradle design models like Design for Deconstruction. But flexibility, focuses however in the feature of change where adaptability takes into account the future context and provides with the instruments that would make a building or a site in itself ability to keep up with the present situation also. In this process, the local residents of the city along with the investors play a crucial role in the development depending on the financial conditions. Hence, the need for adaptability that can balance the supply and the demand is the driving force behind flexible planning which although considers the current situation, yet take into account the ever changing context. Flexibility on the other hand, is the concept that formulates the building's future and their further stages of development in a viable way. Therefore, transformation and development needs the notion of flexibility in order to ensure adaptability and eventually durability.

To summarize the theoretical chapter, the different types of Flexibility dimensions are ordered based on the level of rate of change associated with various layers of the building.



The above types of Flexibility dimensions are briefly explained with example in the following page.

Adjustable

The building is defined adjustable by making certain that the ‘things’ layer inside the building which includes furnitures, equipments and other fixtures can be reconfigured well to adapt with the changing tasks. Adjustable solutions not only makes the spaces more efficient but also increases the user comfort level because of it’s configurability. Thereby, it increases the user’s control over their space and cuts down the demand for new fit-outs for the various tasks. The adjustable design can be established well in residential and commercial functions.



Image 6. Configurable working units - adjustable
(retrieved from the book, based on Schmidt III & Austin, 2016)

Versatile

Versatility is the most common among the adaptability types and it is about changing the spatial layout of the room. However, these changes are imparted by the altering activities, tenants and the organizational structure.

Spaces can be rearranged either for different activities (i.e., after hours and special events) or for the change in the number of users. For example, Versatility can be shaped by the movability of interior walls, things and other fixtures. Versatility and its associated changes mainly affects the ‘things’, ‘partitions’ and ‘systems’.



Image 7. Large open interior space - versatile
(retrieved from the book, based on Schmidt III & Austin, 2016)

Refitable

Refitable solutions increases the performance of a building by modifications in it’s partitions, systems and facade. These modifications are imparted by the changes in environmental conditions, materials, new technologies, rules and regulations. In order to access those layers, temporary changes of things and partitions usually takes place. To avoid complication, the systems layer must be built independent of structure layer. The refitable solutions in future establishes spatial and organizational flexibility depending on how the owners can easily replace and change the energy performance of the buildings.



Image 8. Exterior view of cladding surface - refitable
(retrieved from the book, based on Schmidt III & Austin, 2016)

Convertible

Convertible solutions are actually assisted by changes in the ownership of building, social demands and the tenancy. For example, the conversion of offices into other commercial functions and residences requires consideration on both the present and the future ownership, tenancy and market demands, thus causing very moderate level of rate of change.



Image 9. Exterior view of SEGRO Energy Park - convertible
(retrieved from the book, based on Schmidt III & Austin, 2016)

Scalable

Scalable solutions are related to changes in the size of building based on different social requirements, economic factor, space constraints and the ownership. The size of the building can be altered either vertically or horizontally depending on different associated layers such as structure, foundation and systems and also by means of circulation in a building. As this type is constrained with basic structure of the building, the rate of change is expectedly low.



Image 10. Addition of circular structure - scalable
(retrieved from the book, based on Schmidt III & Austin, 2016)

Portable

Portable solutions are the least common type and it completely depends on the project location and environmental conditions. Usually Portable structures are light in weight and number of occupancy is comparably less to other commercial projects. In addition to that, the facade layer is usually made temporary for easy and quick removal.



Image 11. Movable Foundations - portable
(retrieved from the book, based on Schmidt III & Austin, 2016)

Because of the time constraint for the thesis project, this thesis will not study deeper about the dimensions Portable and Scalable as they have low level of rate of change and involves intense exploration in order to combine efficiently with the other Flexibility dimensions. For example, as Portability works with the basic structure and foundation of the building, the different contexts should be taken into account as it might affect the functional aspects of the building. And to attain exterior facade Scalability, again the surrounding neighbourhood with respect to the directions should be examined well as that might affect the interior qualities of the building.

Also, this thesis will not study about the financial and legal flexibility as explained in Delimitations in the Introduction chapter. Instead, the project will focus on testing the other flexibility models such as Spatial and Organizational Flexibility that are associated to Legal, Use-driven and Time based Developments.

According to Schmidt III & Austin (2016), there is no hindrance between the various types of flexibility dimensions when they are implemented in the building. However, due to the combination of one or two types, some tensions may still occur in the building. For example, versatility of a space will be hindered by the refitable design because of the change in the performance of the space (e.g. Reconfiguration of floor plan affects underfloor heating and its associated pipe lines).

Dimensions related to various types of changes that are carried forward further to test and witness in the design phase are:

Adjustable

Versatile

Refitable

Convertible

And the Levels of flexibility models that are carried forward further to test and witness in the design phase are:

Spatial flexibility

Organizational flexibility

CHAPTER 3

Reference Studies

INTEGRALEN 6

Location - Vallastaden, Linköping
 Architect(s) - Staffan Schartner, Omniplan
 Year - 2017

Integralen 6 is a massive wooden house in which durability and flexibility has been penetrated. It has 22 apartments having completely uninterrupted floor plan that allows the apartments to be rebuilt as the needs change. There is a green house on top floor which is installed on Eco-perspective.

- All installations are in the shaft of the house's gables as well as in the cavities underneath the floors.
- The kitchen and bathrooms are prefabricated removable modules and they can be placed in different places in the apartments.
- The facade is also designed and constructed with changeable feature. The windows and doors on the facade can be moved around if there arises other needs.
- All floors has common entrances and the stairwell and elevator are located at the common entrance terraces.

Highlights

- Wood as the main building material
- Residence and office functions
- All materials can be recycled and replaced
- Stone wool insulation to prevent fire from spreading
- Spatial change w.r.t. Adaptability and movability
- Standardized construction units



Image 12. Prefab units being assembled on-site



Image 13. Simple construction with reversible joints



Image 14. Combination of wood and steel construction

HABITAT 67

Location - Montréal, Canada
 Architect(s) - Moshe Safdie
 Year - 1967

Habitat 67 is a Brutalist building and one of Canada's National Heritage sites. This building consists of 354 identical prefabricated concrete modules and are stacked in different combinations to form a 12-storey complex. Originally, there were 158 residences, but then some of the units are joined together to make larger modules totally comprising 146 residences.

- Units are arranged in a way to create suspended private terrace for each residence.
- Each residence has got skylights of varying angles .
- Interiors are designed simple yet futuristic to allow for various usages.
- There are pathways at different levels connecting groups of modules. They serve as a primary circulation streets between different units instead of having corridors.

Highlights

- Concrete as the main building material
- Residence
- Removable and alterable units
- Possible change of physical arrangement
- Standardized construction units
- Concept of Densification is exemplified



Image 15. Prefabricated modular units stacked upon one another
 (retrieved from <http://www.archdaily.com/>)

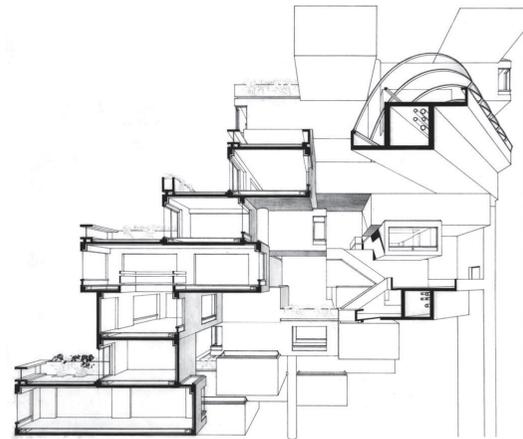


Image 16. Prefab concrete construction giving sturdy look - brutalist style
 (retrieved from <http://www.archdaily.com/>)



Image 17. Private terraces and connecting pathways at various levels
 (retrieved from <http://www.yankodesign.com/>)

SEGRO

Location - Slough
 Architect(s) - Langley Hall Associates
 Year - 2015

This building owned by SEGRO based in UK is designed for disassembly. A 10 year old two storey building which was a out-of-town style had to be demolished and reassembled in a new site 2 kms away for office and warehouse purpose.

It was efficiently examined to see how much of the materials can be economically recycled. The steel frames, cladding materials, lift and most of the services have been reused in the new building. But all the concrete structures like foundation, ground slab and first floor slab needed to be replaced as there were water leakage problems.

Totally, 70% of the material was efficiently reused. The interior and exterior of this building typology is designed in such a way that it can typically adapt to multiple uses such as industrial, leisure and retail.



Image 18. An example standing to showcase Design for disassembly model
 (retrieved from <http://www.segro.com/media/>)

Highlights

- No organic waste
- Easy to reassemble at any place
- Concrete and steel frames as main construction material
- Covered by glass cladding
- Optimization of materials and energy
- Short life span like 20 years after which the fabric need to be discarded for recycling.



Image 19. Steel and aluminium frames covered by glass on the external facade
 (retrieved from <http://sturgiscarbonprofiling.com/>)

MANCHESTER METROPOLITAN UNIVERSITY

Location - Manchester, UK
 Architect(s) - Feilden Clegg Bradley Studios
 Year - 2012

Metropolitan University building accommodates multiple functions including business school and student hub. The building is located in a prominent location close to the city center and are designed for anticipated future changes.

The spaces can be reconfigured without moving any installations as the services are installed on the floor voids and the ceiling soffits. The floor plates are column free from the lectures and seminar rooms with floating rooms connected by open platforms and wide connecting bridges. Three floor plates are placed at standard intervals enabling standardization and ease of changeability in the interior design.

A series of formal and informal social spaces are created on the intersections on different floors which can be altered for any other purpose.



Image 20. Open interior that can adapt to any social function
 (retrieved from <http://www.archdaily.com/>)

Highlights

- Open and transparent interior
- Adaptable for multitude usages
- Concrete and glass as the main construction material
- Good daylight and views to the outside because of the openness and transparency
- Transformable facade with pleating refracting and reflecting fins.

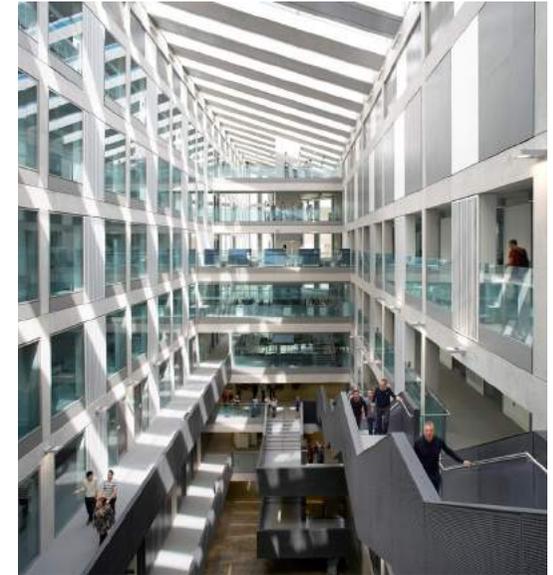


Image 21. Allows maximum daylight because of the transparency
 (retrieved from <http://www.archello.com/>)



Image 22. Column free interior with floor plates at standardized interval allowing ease of interior changeability
 (retrieved from <http://www.archello.com/>)

VALLASTADEN SQUARE

Location - Vallastaden, Sweden
Year - 2017

The space between the student housing in Vallastaden has been given a new meaning with temporary structures. These structures can be replaced or reconstructed any time and can be reassembled at any other place as wanted. They serve as social space and currently accommodating different functions: one is cycle parking and the other is open meeting place.

These temporary wooden structures are placed in a way that they can even be covered with some fabrics as a roof cover. Between each wooden unit lanes at regular intervals, runs greenery where installation pipes for lights and water are placed.

The purpose of this kind of structure in the courtyard space is to create a stable place where students can meet other students and form new relationship, make friends with other students.

Highlights

- Wood as the main material
- Public use
- Social space
- Temporary structure
- Removable and replaceable structures
- Flexible square between buildings



Image 23. Pop-up spaces and Temporary structures for outdoor social activities



Image 24. Multi-purpose structure, serving both as parking place and also as a meeting place

ALBERTOPOLIS

Location	- London
Architect(s)	- redesigned by Dixon Jones
Year	- originally 1851 redesigned in 2012

Albertopolis, named after Prince Albert is London's first cultural quarter and has showed that it is adaptable over time in an exceptional degree. This quarter is planned in axial grids, includes several educational institutions and many famous museums.

The plan of the buildings were designed with futuristic thinking in order to make use of the open space along the pedestrian road by changing the street hierarchies.

The strong identity of the place brings various people together with a clear intention and creates a sense of place for the area itself.

The Exhibition road is redesigned to accommodate shared space features and now functions as the principal pedestrian route. The area is lively all the time because of its flexible ideas over landscape and architecture of that place.



Image 25. Pedestrianized street where open public squares are provided with temporary exhibition installations often (retrieved from <https://en.wikipedia.org/>)

Highlights

- Landscape of the city
- Public use
- Temporary exhibition installations in public squares
- Shared social space
- Flexible open spaces and pedestrian pathway
- Vibrant and active area
- Ease of movement
- Strength of identity



Image 26. View of the street before redevelopment (retrieved from <https://en.wikipedia.org/>)

THE WHITE MEAT CITY

Location - Copenhagen, Denmark
 Year - redeveloped in 2007

The meat packing district in Copenhagen was established as a cattle market in 1671 and then the district was sub-divided into three parts called brown, grey and white named after the dominant colour of the buildings. The Brown meat city is the oldest and has been changed into a creative cluster of different public activities since 2000. Only the white part is still serving some businesses related to meat. Most of the industrial activities are left and the entire neighbourhood became barren. In order to stimulate economy in the area, in 2005 the city council decided to stimulate 24x7 activities related to gastronomy.

These kind of industrial parks are often isolated but the Meat district in Copenhagen stands as an outstanding example to allow the influx of new functions. The district itself is the nation's cultural heritage symbol and since 2005 it has become an attractively mixed district with creative businesses and activities.

Along with the indoor functions, the open squares hosts pop-up markets and activities such as races and carpentry workshops. Since then, the district has grown into an extremely popular place in such a short period of time.



Image 27. Pop-up markets in the open square of the White meat district engaging the existing businesses too
 (retrieved from <http://www.visitcopenhagen.com/>)

Highlights

- Mixed functions
- Public use with 24x7 activities
- Temporary markets in open squares
- Shared social space
- Flexible open spaces and pedestrian pathway
- Vibrant and active area
- Possible developments for new building volumes
- Attractive neighbourhood



Image 28. Social events and market spaces on the pedestrian streets
 (retrieved from <http://www.visitcopenhagen.com/>)

SUMMARY

This part presents the learned aspects from the reference studies related to the considered flexibility dimensions presented in the theoretical chapter such as: Adjustable, Versatile, Refitable and Convertible. The most intriguing things are:

1. Temporary spaces
2. Pre-cycling
3. Public spaces
4. Generic program
5. Diverse Functions

These aspects would stand as an inspiration for the Design phase.



Generic program

All the building scale projects have used Generic programs like commercialized functions which are highly adaptable and refitable in future with respect to the context as mentioned in the theoretical chapter.



Diverse Functions

The building scale projects except Habitat 67 have diverse functions that makes those buildings versatile in changing different interior spaces. Also, all the building scale projects are convertible in connection with Systems layer of the building.



Temporary spaces

The urban scale projects have used temporary installations. They satisfies the temporary demands and also provides the spaces with the adapting quality. If the temporary utilization of a place inspires users to stay, then they can be made more permanent to attract new investment or else other new function will pop up there.



Pre-cycling

The building scale projects and temporary installation spaces have used Precycling approach. This means to anticipate the recycling of used materials in the design phase to avoid the risks of deterioration in the future. Such that, the components are available for reuse after the end of its operation thus enabling material flexibility.



Overlapping Public spaces

Most of the developed public spaces in the urban scale level and in the Manchester University building project have overlapping activities that can share and collaborate with the connected spaces. Shared and collaborative themes enables social interactions and are highly adaptable for future changes.

CHAPTER 4

Contextual Framework

VISION 2035

Norrköping is an attractive city with historically rich cultural & industrial heritage. The Municipality is currently expanding and many areas have been given a face-lift which makes it even more attractive to live in. The city is constantly growing due to the increase in the demands for housing and other infrastructure facilities. The city planning office is mainly focusing on Sustainable development approaches to reuse the land centrally located in the city rather than extinguishing large areas of green land and creating thinned settlements in the outskirts of the city.

Inner Harbour

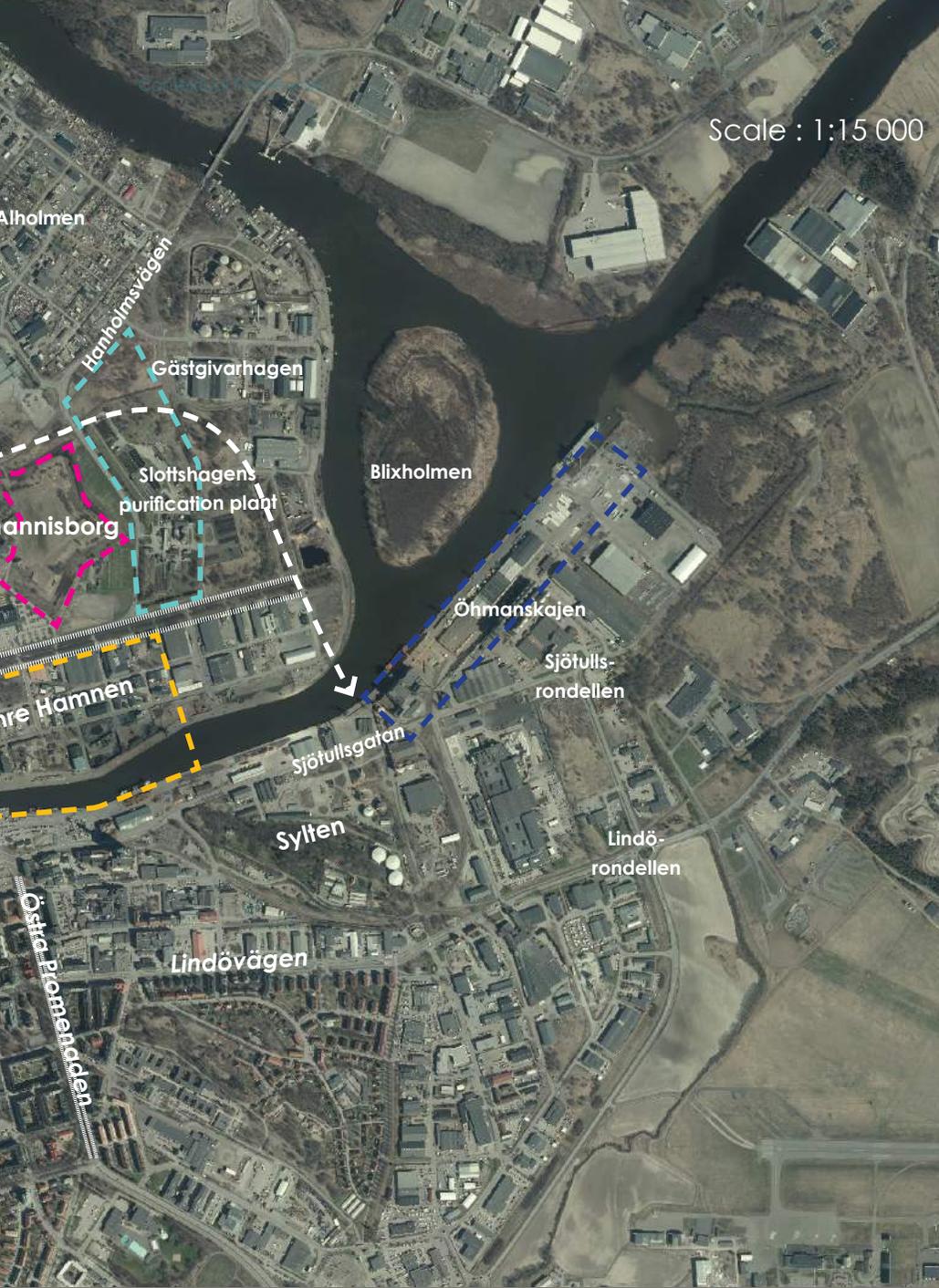
The chosen area is located in the Inner Harbour area to the south of Saltängen at Motala river's quayside and to the east of Norrköping city centre. The distance to the city centre is less than 1 km. **The chosen area is a vase barren land as considered under flexibility concept** and are currently used as open parking area .



Image 29. Aerial photograph of the Inner Harbour area, 2017 (collected from Norrköping Municipality)



- Ostlänken's approximate line
- Need for new road line
- Södra Butängen
- Inre Hamnen



Scale : 1:15 000



Image 30. Aerial view of Butängen & New Resecentrum



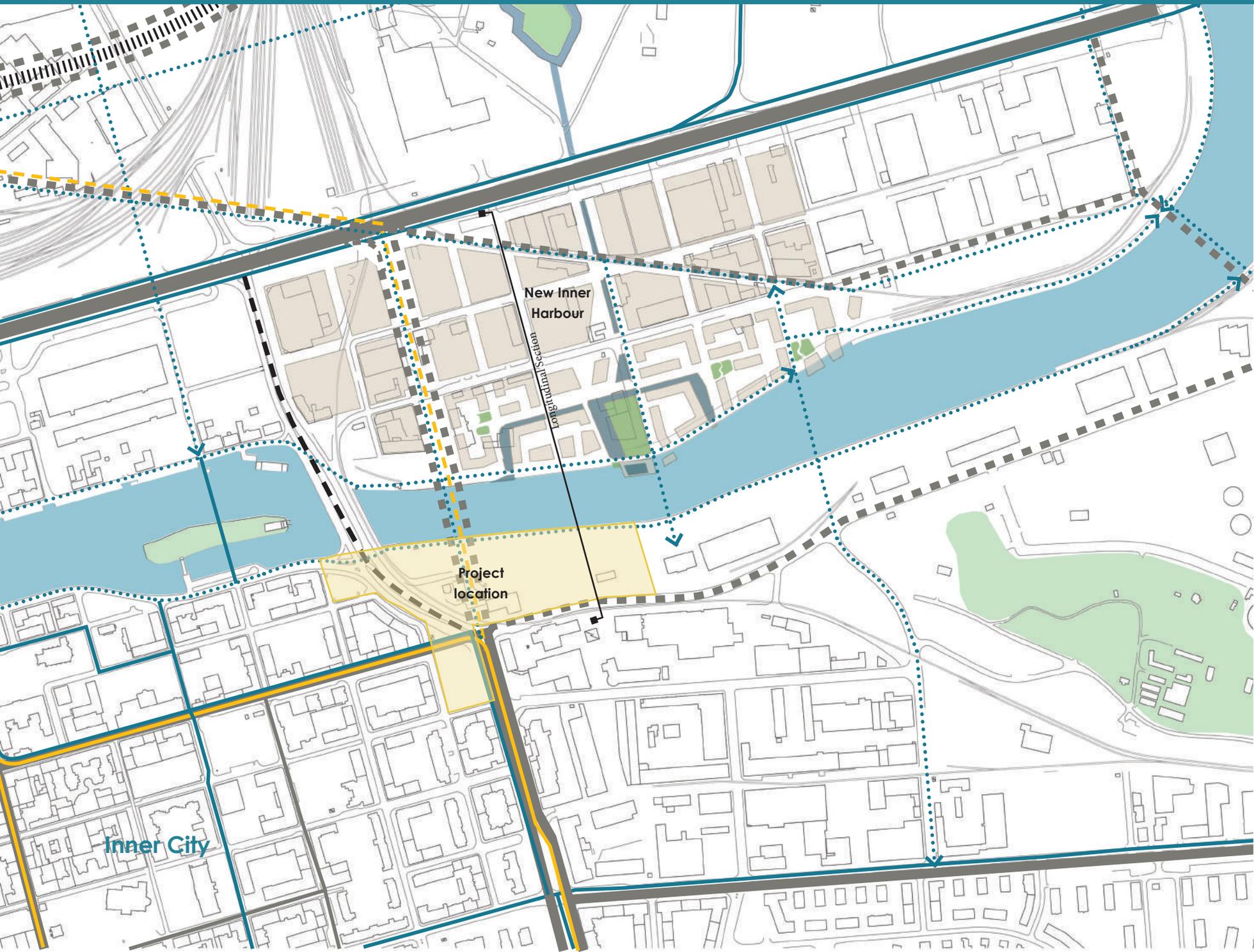
Image 31. Illustration of Johannisborg



Image 32. Tram station at Resecentrum

(All the visualizations are collected from Municipality's website page. www.next.norrköping.se)

- - - - - Johannisborg memorial
- - - - - Slotshagens Purification plant
- - - - - Öhmanskajen
- Main road networks



New Inner Harbour

Longitudinal Section

Project location

Inner City

LEGEND

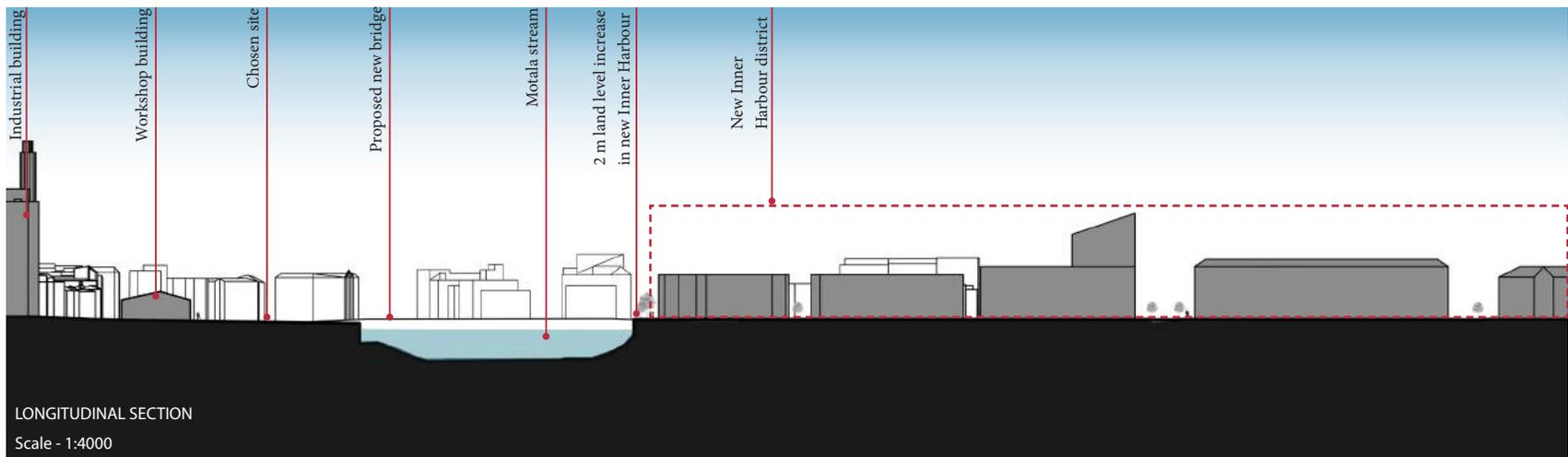
	Existing building
	New development
	Green structure
	Proposed greenery
	Water
	Proposed water channel
	Main road line
	Sub road
	Proposed road line
	Tram line
	Proposed tram line
	Pedestrian & Cycle path
	Proposed Pedestrian & Cycle path
	Road - to be demolished
	Ostlänken line
	Site

PLANNED CONNECTIONS

Public Movement

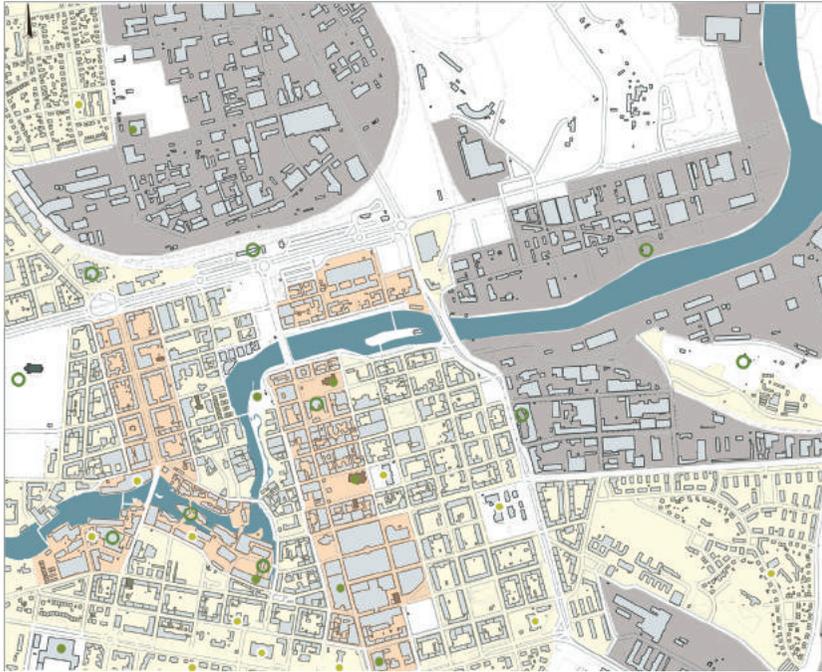
After having a condensed Dialogue with the Municipality regarding the development of Sylten area, it is understood that the City Planning Office wants to sub-divide the blocks into more compact blocks, taking into account of newly planned bridges. As a result, planned public movement has been studied and speculative studies has been done in order to visualize the possible forecast scenario of the context and its development on the southern side since there are no plans yet made for the south.

As mentioned in the findings, the main intention of the municipality is to preserve the grid pattern of the Inner city bordered by the main road lines on all four sides. With that idea, the southern side which is currently being an industrial zone has been visually divided into grid blocks allowing the street lines to connect through. The Östra Promenaden (The East road) is running through the chosen site and thus resulted in dividing the chosen area into three blocks. All the three blocks are different in sizes with varying areas.



BUILT ENVIRONMENT - TODAY

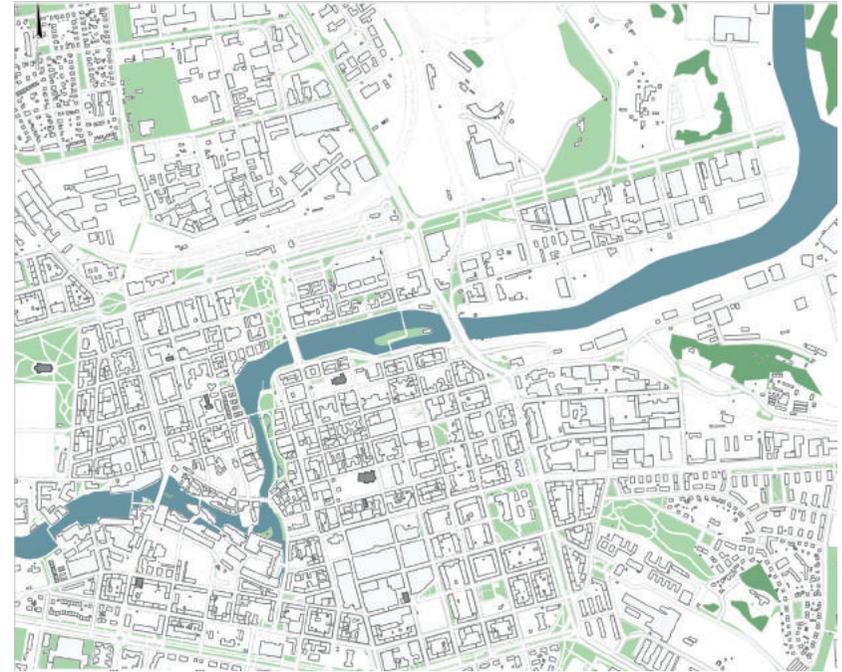
Existing functions



- Residential area
- Retail / Residential area
- Industrial area
- Water
- Culture / Entertainment
- Schools
- Landmarks

The analysis of the existing built environment explains that the inner city is surrounded by main road lines on all four directions, Motala stream that run across the city and there are important landmarks like cultural heritage buildings within the city. The educational buildings are spreaded all around the city at certain limits.

Green and Blue Structures



The cultural and entertainment buildings like city museum, theatres, concert hall and shopping center are all located within the inner city limit. Also, it explains that the industrial areas are excluded from the inner city and the inner city is mixed with various private and public functions. Though the functions are mixed, yet they are segregated because of the mono-functional arrangement of different functions. The green structures like parks and outdoor garden around the cultural buildings are spreaded and there is a small mound on the southern side of the stream very close to the chosen site.

FINDINGS

Findings represents municipality's strategies which are drawn from the studies of both the existing functional analysis and future development plans. It is understood that the Municipality has certain Strategies to take into account for the spatial development on the South following the Development of New Inner Harbour area.

(Note: These strategies are few among municipality's ideas for future Sustainable city development.)

Future scenario will be the intensification of this area, complimented with housing and working spaces where there will be increase of Public accessibility. The housing blocks will be complimented with retail spaces along the streets on the ground floor.



Inner City Grid pattern

Protect and establish the 17th century grid pattern of the Inner city that connects to Östra Promenaden.



Mixed development

Creating a mixed use development where different functions overlap and co-exists to densify the Inner core.



Strengthen the Promenads

Public accessibility and Transportation around the Promenads are to be strengthened to create a strong inner core.



Intensification

By enhancing and strengthening the inner core, the city would be intensified with both spatial and functional qualities.

LOCATION SELECTION



Image 34. View 1 - adjacent to the water

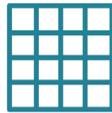


Image 35. View 2 - Heritage Building next to the site



Image 36. View 3 - Service road in the front

Inner City Grid



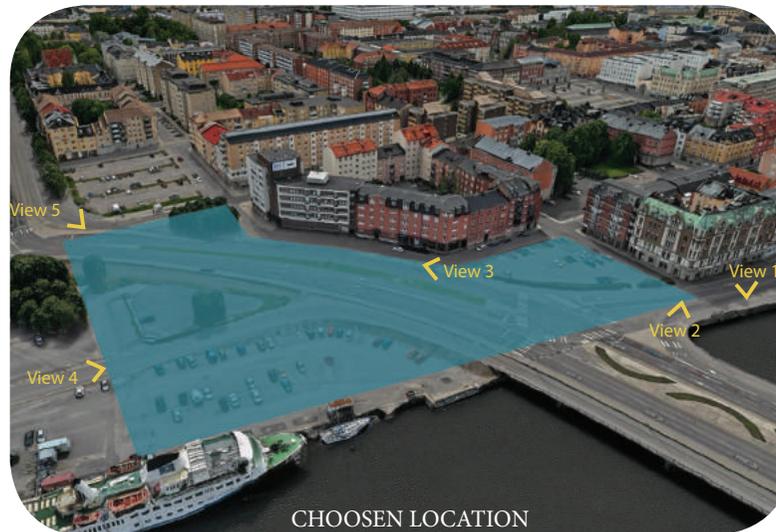
Target location



Water front



Public space possibility



CHOSEN LOCATION

Image 33. Aerial View of the chosen site



Image 37. View 4 - from the Workshop on the other side



Image 38. View 5 - Tram line in-front of the site

(All images are retrieved from <https://www.google.se/maps/>)

From the context analysis, the exhibited plot has been chosen for the building design proposal as it is within the inner city grid limit and will be the next targeted location for the future development to fortify the inner core. And because of the waterfront, it has the possibility for public space development which connects with shared and collaborative spaces of flexibility. Also this can be a compliment to the surrounding residential neighbourhood. Moreover, the context for the project will be set with the New Inner Harbour Development which is starting its Phase-1 development in 2018.

SWOT ANALYSIS

SWOT analysis is a tool used in planning and design to identify the site's current Strengths (S) and Weaknesses (W), as well as the Opportunities (O) and the Threats (T) that may be provoked. The data used here are provided through the site analysis and the other mapping elements. The site visits, interviews with the local inhabitants and the meetings with the municipality also has imparted information. This tool helps to shape the objective of the project further into strategies.

- Closeness to the Central station and the Inner city.
- Closeness to the existing and the proposed residential areas demands a place for supporting program.
- Located in a nodal point.
- Good accessibility with public transport.
- Active interest from the stakeholders for future development.
- Rich waterfront
- Open ground of the site creates a possibility to experiment the flexibility concept in all scales.

- Lack of mixed use environment and no public activities after business hours.
- Lacking greenery and green connections.
- Disconnected from city life.
- Mono-functional surrounding for a long time.
- The site is very close to the industrial zone.

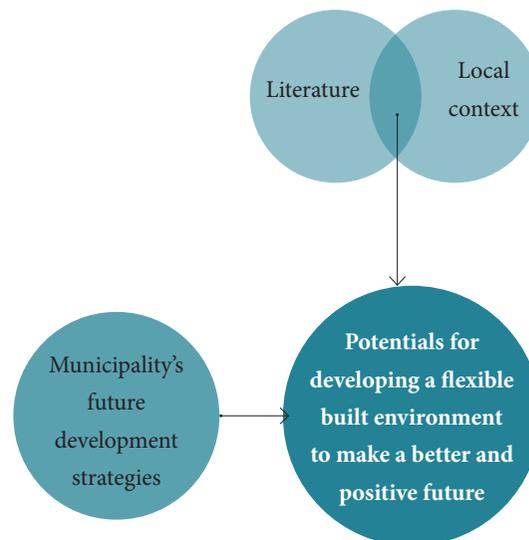
- Maximum height level for structures (because of robust and unique surrounding).
- Unwelcoming area due to mental and physical barriers.
- Possible threat of pollution of ground soil because of surrounding industries.
- Unclear vision for the Urban spatial transformation on the southern side.
- Possible chances of gentrification due to the homogeneity of proposed development on the northern side of site.

- Utilize openness and empty nature of site.
- Development of Inre Hamnen – Saltängen area.
- New meaning of the place (Mixed use).
- Complement the existing openness with Flexible functions.
- Use the accessibility to connect with the Inner city in order to attract people.
- Positive attitude towards Area development.
- Use the waterfront for outdoor activities and Pop-up spaces.
- Activate the parking and urban leftovers.

SUMMARY

To summarize, the City Planning Office in Norrköping Municipality wants to *reinforce the central nucleus* rather than wiping out the green lands in the suburbs. As a part of new developments, Inner Harbour area is on the priority to initiate the reinforcement of the city. So, there is already an acceleration or necessity of change in that area. It is important to *reintroduce the potentiality* of the historically important Urban areas. The chosen area has been part of the city's identity as Industrial land since 17th century. So, there is a need to reintegrate these obsolete space into the city with the appropriate programs. The existence of diverse activities and functions with a well established connection to the surroundings are the most important for a successful urban spatial development. By taking municipality's strategies for development into consideration, *Intensification of the city should be sustainable* in order to confront the effects of ecological footprint. *Presently, the existing unused buildings are more conventional rather than flexible to maximum extent because of its industrial and commercial nature.* Hence the life-cycle of buildings are much shorter and they have been constructed to serve a specific purpose, either housing or businesses. **So there is a necessity to witness the usage of adaptive spaces with material flexibility.** Though there are developments and research on flexible planning are undergoing, yet they are not spreaded into a wider scale because of the risk of financial crisis fearing the future is not certain.

The theoretical knowledge on the concept of flexible design was useful in exploring how Norrköping municipality can support a transition into a more sustainable future. For example to understand, choosing the project site close to the New Inner Harbour area can be taken into consideration as one of the potentials for the project development in terms of different flexibility dimensions where disposal of used construction materials and building components are seen as valuable resources. Municipality's strategies for the future Sustainable city development could be seen as a supporting element in taking potential conclusions from the context.



The following are the Stand-alone aspects concluded from the contextual study. These conclusions are developed as a result of studying how the flexible city development should take place and how a building can become flexible based on different dimensions associated with various layers. The concluded aspects are seen as a great potential in developing a flexible built environment.



Being a Barren Land



Need for multi-funtional space

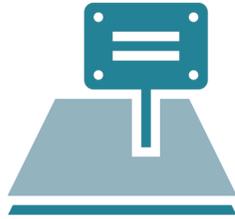


New Inner Harbour as a potential



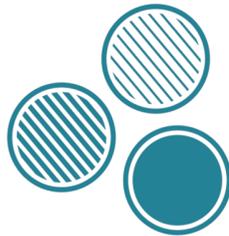
Supply and Demand satisfaction

The calculated risks considering future uncertainties are necessary and it should be taken both by the municipality and the local organizations in the development of flexible built environment for a circular future. The above aspects are carried further forward along with the considered flexibility strategies in order to create a strong resilient neighbourhood.



Barren land

The chosen site is currently a open barren land in the nucleus of the city which is one of the suggested flexible city development solutions. Because of it's vacant nature, the site has got the potential to develop and test both the temporary and permanent flexible spatial solutions associated with different flexibility dimensions.



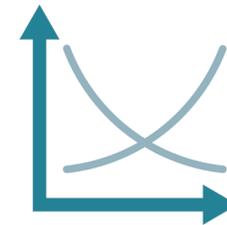
Multi-functional use

Because of the water front view, the chosen location has got the potential to develop a multi-functional space with diverse activities that can compliment to the surrounding mono-functional neighbourhood. Multi-functional spaces are usually more public friendly and will create the possibilities of developing shared spaces.



New Inner Harbour Development

The chosen site is very close to the New Inner Harbour Development. So, there is a great potential to reuse and recycle some of the qualified torn down building materials and components from the Inner Harbour construction site. This will ultimately help in extending the life span of both the building material and the built environment for the future use.



Supply and Demand satisfaction

Along with satisfying the needs of building materials and components from the New Inner Harbour site, the city in itself could also compliment the site with commercialized functions that are highly in demand currently. So, the demand for the functional and material needs in the project's development could be satisfied respectively.

CHAPTER 5

Conceptual Framework

DESIGN FRAMEWORK

Throughout this thesis, the motive of witnessing the flexibility dimensions in design has developed stronger that focuses on showcasing the ways to extend the life span of the built environment.

The collective knowledge from theoretical studies, contextual studies and reference studies is condensed to well-define the design framework for testing various dimensions of flexibility in the chosen context.

In the process of developing the design framework in other words is expressed as conceptual aspects, a large number of possibilities and challenges were discovered. From this, ten design strategies were developed to address the opportunities of extending the life span of the built environment as well as to manage some of the current functional demands in the context. **While these design strategies are general, nevertheless it has to be conceived that they are developed for the studied context.**

The Design Strategies along with the programs will then assist the building capable of adaptive changes for the future use. Thus it adds value to the building and makes it fit for the purpose in the context. The program describes the functional features that should be included in the building in order to support the design framework. In the following pages, the ten strategies are presented and the functions are described briefly on why it is essential. *The illustration in Figure 22. shows the general strategical diagramming of the framework.*

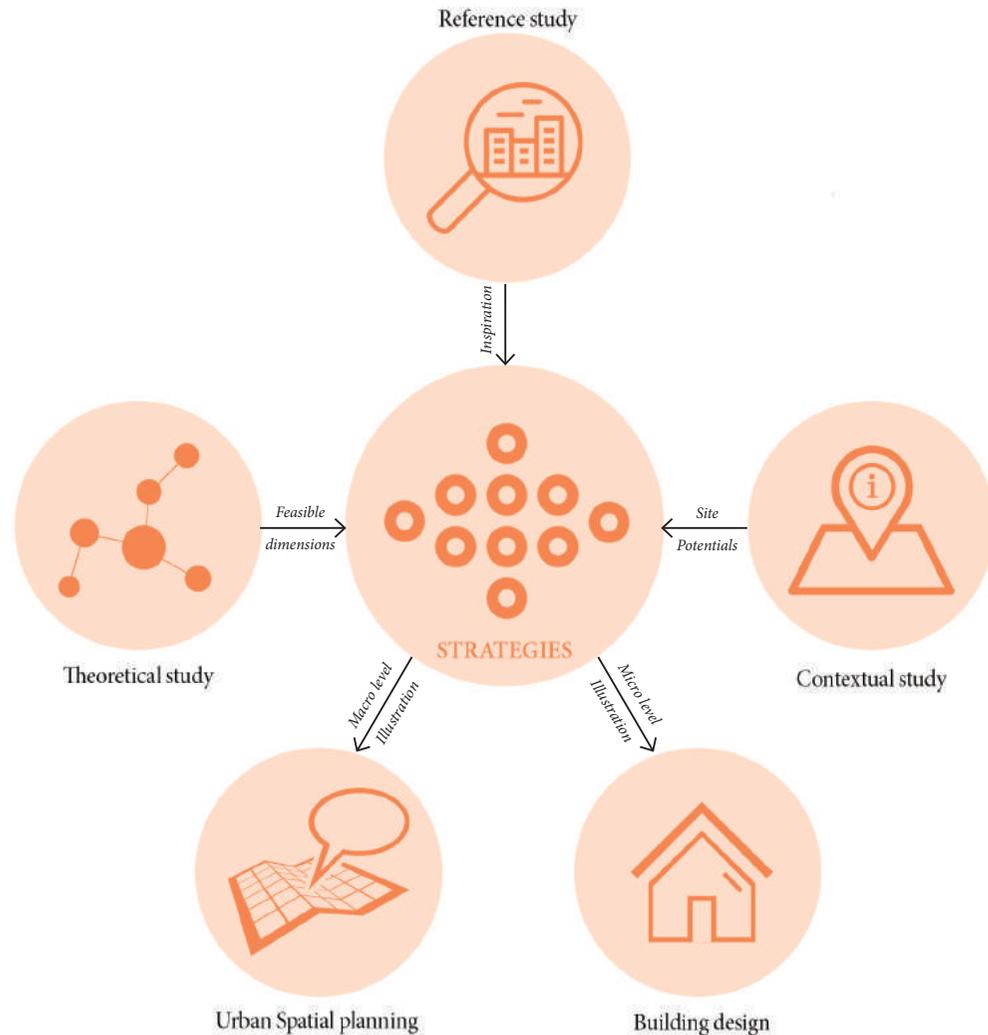
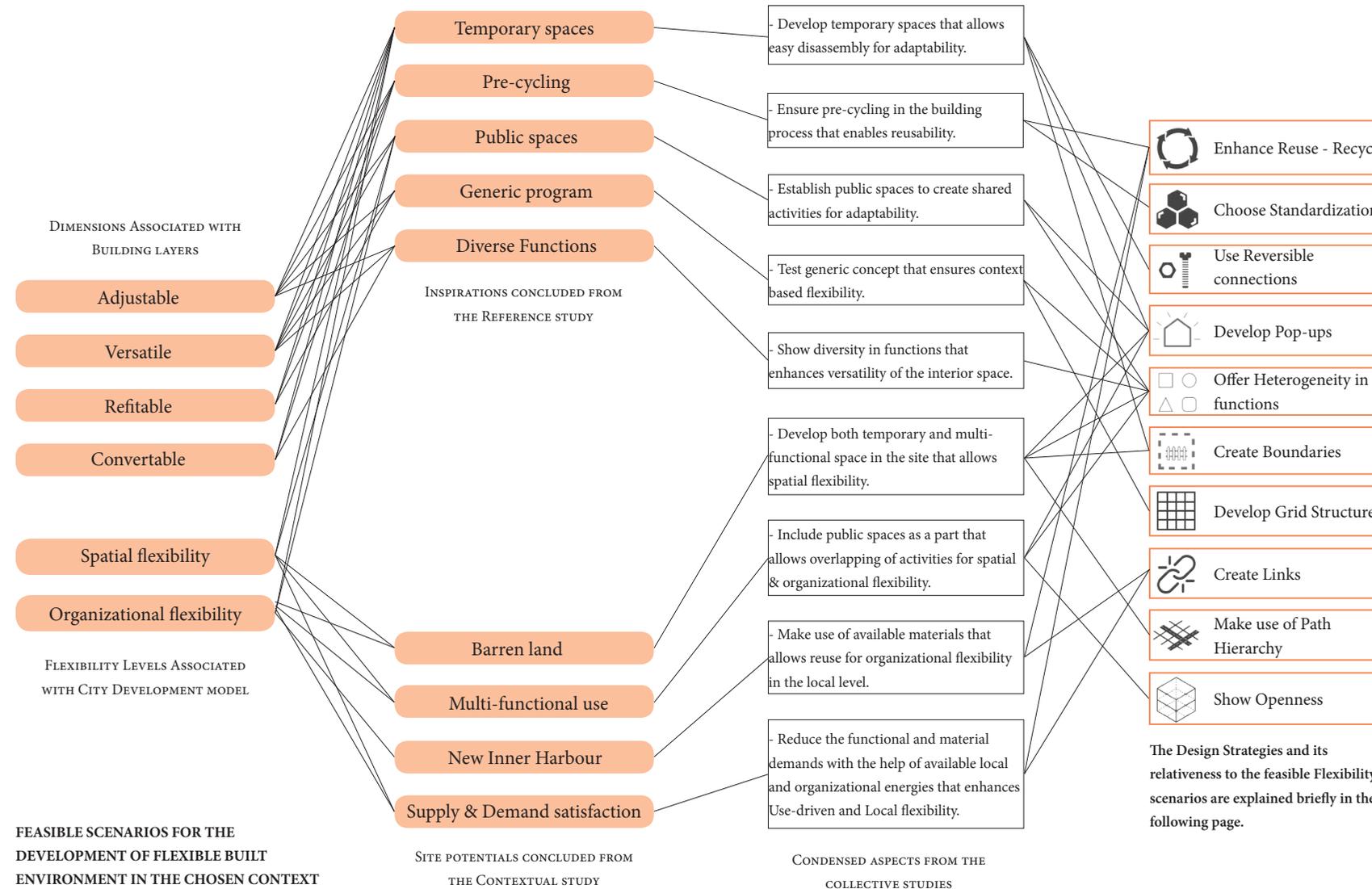


Figure 22. Illustration showing the conceptual framework of Design Strategies for the implementation of Design proposal

This page explains the synthesis of the collective knowledge from the studied chapters such as Theoretical framework, Contextual framework and the Reference studies. The concluded perspectives from all the three chapters supports in reasoning out the condensed aspects that are to be developed as Design Strategies.

The findings concluded from the reference studies become inspirations for the development of flexible built environment and are related to both flexibility dimensions associated with building layers and flexibility levels in city development model. The findings concluded from the contextual studies stands as the site potentials and are solely related to the flexibility levels in city development model. The inspirations along with the site potentials provide an idea for this project on how the development of flexible built environment should take place. Some of the concluded aspects condensed from the collective studies are mentioned below.



Relationship between flexibility concept and the condensed aspects from the collective studies:

As Adjustability involves working with furnitures and other interior infills, it is likely to adapt with all temporary spaces and multi-use spaces by means of easy to fix connections. As Versatility involves working with partitions, it is likely to adapt with different kinds of functions and programs but with temporary partitions assembled using easy to fix connections. As Refitability involves working with the performance of the building associated with system layer, it is important to highlight the generic concept which significantly portrays the functionality and its performance with respect to the context. Along with that, to be refitable, the built-in units must also be of temporary type which does not disturb other associated layers much. As Convertability involves working with different organizational and social needs, along with developing temporary spaces using reusable materials, it is essential to develop multi-functional space which meets the above mentioned needs.

As Spatial and Organizational flexibility are the limiting levels of various flexible city development models, it is really important to make use of all the site potentials. Thus, including soft spaces which acts as temporary space becomes crucial. By prioritizing the existing circulation routes, the possibility for future development is heightened as the temporary paths does not include any hard spaces which eventually enables spatial flexibility. And it is more crucial to connect the site to other parts of the city that satisfies functional and material needs.

DESIGN STRATEGIES



1. Enhance Reuse - Recycle

Choose materials and components used in building construction which has high reuse potential - they fit in the closed loop system of cradle to cradle model allowing them to reuse, recycle, redistribute and reassemble. These reusable materials can be used in different layers of the building and altogether their life-time will be extended for another useful purpose in future.

By enhancing reuse-recycle, along with extending the value of the product, spatial adaptations are also made possible as it reclaims the use of product which is connected to adjustability, versatility, reusability and convertability dimension.



2. Choose Standardization

Select modular and prefabricated simple design units - they facilitate integration anywhere in the building as they are similar. Standardized units are likely to be reused both today and in the future allowing them for maximum adaptability. However, standardized materials can be still considered as difficult to fit easily in various contexts as they are monotonous.

By choosing standardized design elements, it again reclaims the use of product again which is connected with different dimensions of flexibility.



3. Use Reversible Connections

Make the joints and connections that are reversible and easily accessible - they endure for material assembly and disassembly both on short and long terms without damaging the other parts. Also this type of connections make the building effective to adaptivity in all possible ways by respecting the nearby buildings, people and nature in connection with the building's stability.

By using reversible connections, it establishes internal spatial alterations and easy disassembly of the whole building. So, this defines the various dimensions of flexibility accompanied by spatial flexibility. As internal alterations are associated with the supporting functions, this establishes organizational flexibility as well.

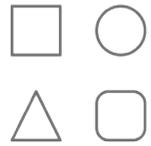


4. Develop Pop-ups

Construct temporary installation structures on the open areas in front of the building and also inside the building - these pop-ups are highly flexible concerning the changing urban spatial structures and satisfies the temporary demand. However, pop-up structures inside the building correspond with the organizations in the case of multi-functional shared spaces.

By developing pop-ups which are temporary structures, again remarks spatial alterations because of its easy disassembly nature. This explains the possibility of various flexibility dimensions together with spatial and organizational flexibility

DESIGN STRATEGIES



5. Offer Heterogeneity in functions

Provide inhabitants and context the multi-functional space - they are highly flexible with shared and collaborative themes in adapting to the changing needs. Rather than defining each quarter of the city with specific function, emphasize heterogeneity with sequence of interconnected spaces that avoids social disintegration by opening up the area for all the inhabitants of the city.

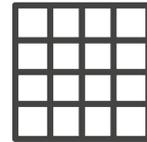
By offering heterogeneity in functions, it demonstrates the development of interconnected spaces within the building. The interconnected spaces usually have shared and collaborative themes which defines the versatility and adjustability of the space in addition to organizational flexibility.



6. Create Boundaries

Demarcate the borders and boundaries between soft spaces and hard spaces on site - they enhance the possibilities of future adaptation of the site and its circulation. In general, soft spaces are flexible to the greater extent considering new developments both today in the future.

By creating boundaries spatially and visually, it defines clear margins between developed and undeveloped spaces. The undeveloped spaces are temporary in nature but the developed space can hold either temporary structure or permanent structure. The temporariness defines various flexibility dimensions together with spatial and organizational flexibility.



7. Develop Grid Structure

Follow and extend the grid pattern of the city into the site and the building - they are more generic and are effectively adaptable for future changes when it comes to commercialized functions. However, grid pattern is difficult for use in wide open service cores and overfull public spaces like cinemas. Also it lifts difficulties in regards to various contexts as they are monotonous.

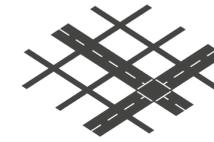
By developing grid structure, it enables generic quality within the building allowing spatial alterations in the commercialized functions. As this explains the internal changes within the building, it affects the performance of the space. It defines refitability dimension together with adjustability and versatility dimensions.



8. Create Links

Establish a functional link between the abandoned urban area and the other zones of the city in order to activate the vast barren land and make the place lively as they attract more people. These synergy effects can then be genuinely spreaded to the surrounding neighbourhoods which enhance the usage of the place.

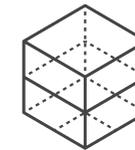
By creating links of the developed and undeveloped spaces to the other parts of the city, it establishes collaborative and shared themes between different organizations holding the functions. Thus, it entirely related to the spatial and organizational flexibility for the flexible city development.



9. Make use of Path Hierarchy

Distribute the circulation and access routes in and around the site based on the hierarchy of pathways which limits the perception of broader flexibility. This enables adaptivity and provides with more alternatives for the future such that they extend the life span of the built environment.

By making use of path hierarchy that has been established in site surroundings, it prevents collapse of the sustainable city development by limiting the broader flexibility. With the determined spatial development it provides future spatial and organizational flexibility.



10. Show Openness

Establish openness and transparency in the ground floor of the building by means of glass walls - they visually connect the building with the street and create accessible interaction with the surroundings. Also the public functions inside the building respecting their spatial arrangement should be kept transparent to create strong visual connection with the surroundings.

By showing openness which explains the use of public spaces that are a part of heterogeneous functions, it defines the spatial and organizational flexibility.

Hierarchy of Design Strategies

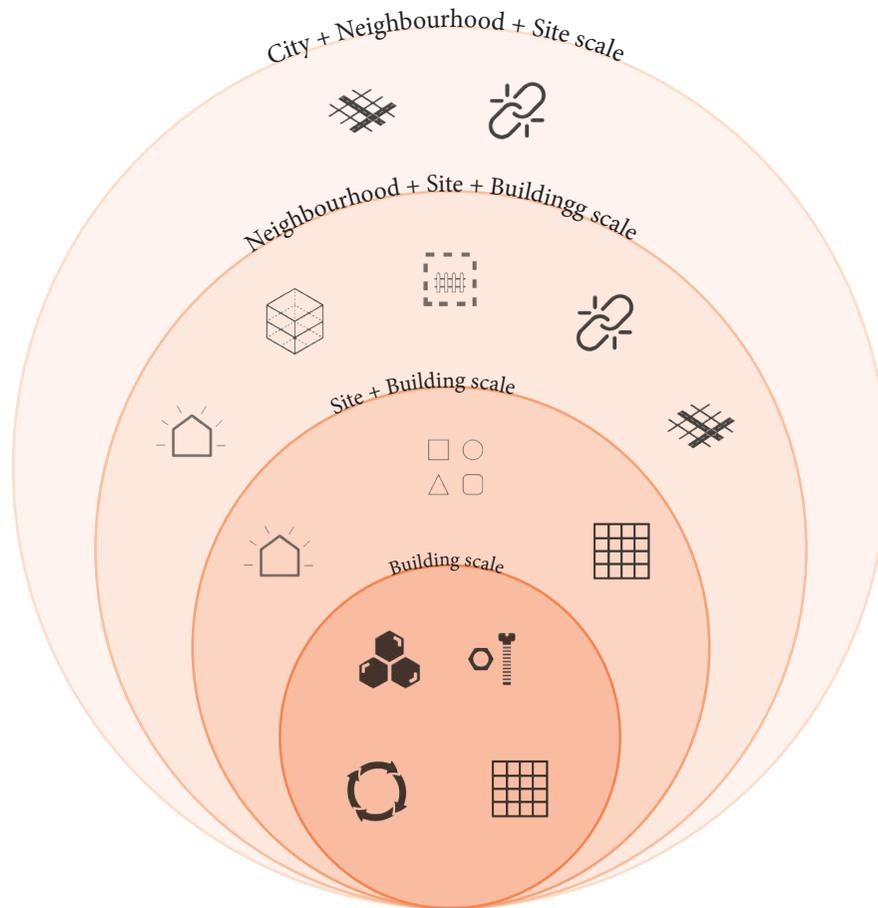


Figure 23. Illustration showing the Hierarchy of Design Strategies

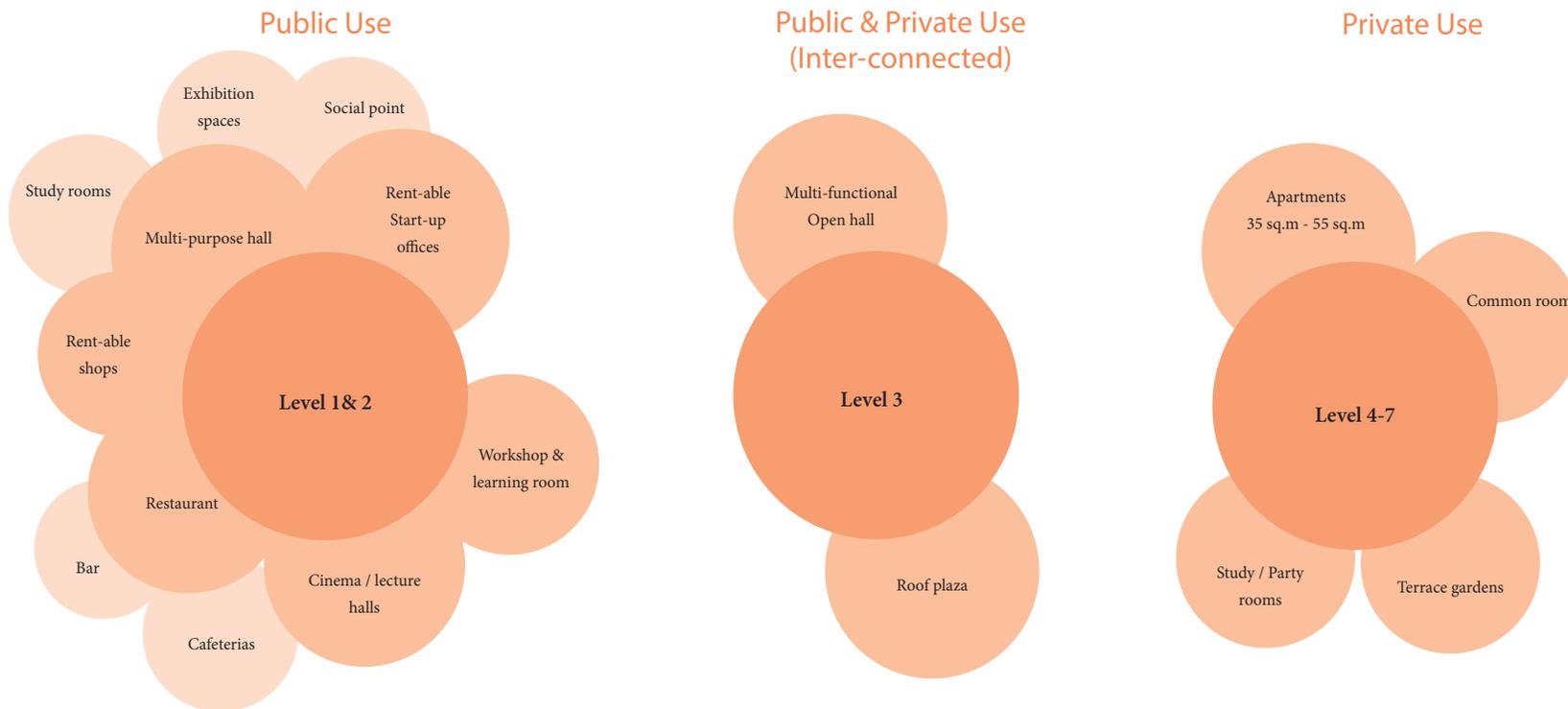
The design strategies that are inferred from the collective knowledge stand as a guiding principle in the design implementation step. For that, it is absolutely essential to organize the strategies as the ordered groupings. The hierarchy represents the most significant notions that prompts to attain flexible design solutions in different scales (see Figure 23.). Enhancing Sustainability to extend the life span of the built environment turns out to be the core focus in all planning scales.

The defined strategies are connected to the various levels of flexibility and different flexibility dimensions based on how well the strategies could demonstrate them and provide with optimal results. Not all the strategies have individuality, while few possess similarity and few holds contravention.

For instance, strategies that feature similarities are: Reversible connections and Standardization - as both are highlighting easy deconstruction process. As an example to define the strategies that feature contravention are: Heterogeneity and Grid Pattern - as the later is more generic which works well with commercialized functions rather than multiple use.

PROGRAM

Following the design strategies, focusing on flexibility and to support the context needs, both Public and private use is emphasized in the building. Specific programs and functions are chosen both to establish a collaborative public space and to provide private residential units that are prone to gentrification issues respectively. They are generic programs and are chosen based on the functional requirements and to attract local residents to that abandoned area. Open areas surrounding the chosen site suggests certain temporary functions to activate the area in order to attract locals. Later, these temporary functions can be either made permanent or changed into various other functions depending on the needs.



- The ground floor is a double height level enclosing Public functions that can overlap and collaborate with each other.
- Level 3 with interconnected spaces allow for sharing and enables flexibility.

- Level 4 to 7 with common rooms enables interactions between residents. Spatial and use-driven flexibility is shown through partitions, systems and things.

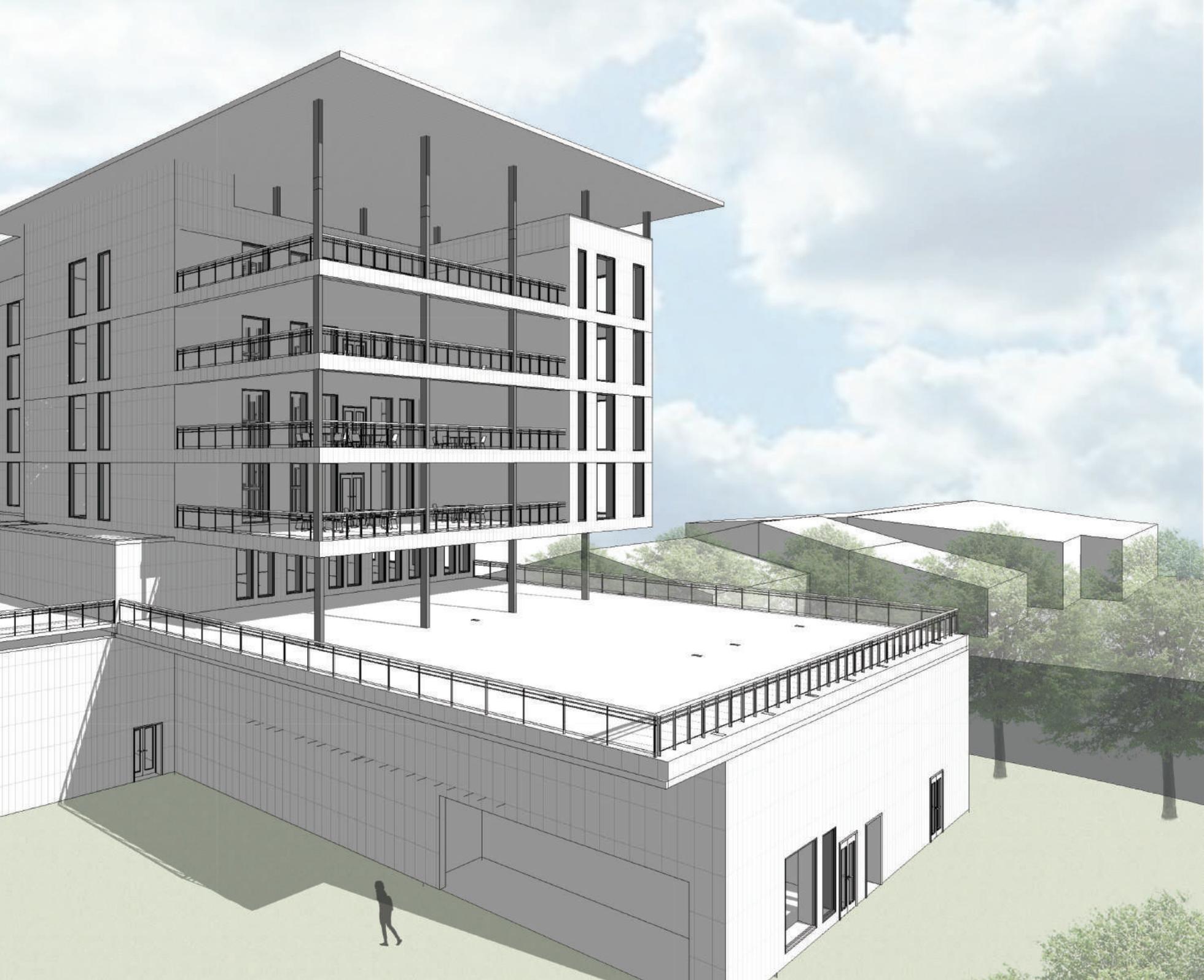
Cinema Halls have low rate of change considering the

spatial flexibility. Yet they are included in the program as they are considered one of the highly attracted public space. Taking context requirements to make area public friendly, it is crucial for this thesis to have cinema halls as a part of the design program.

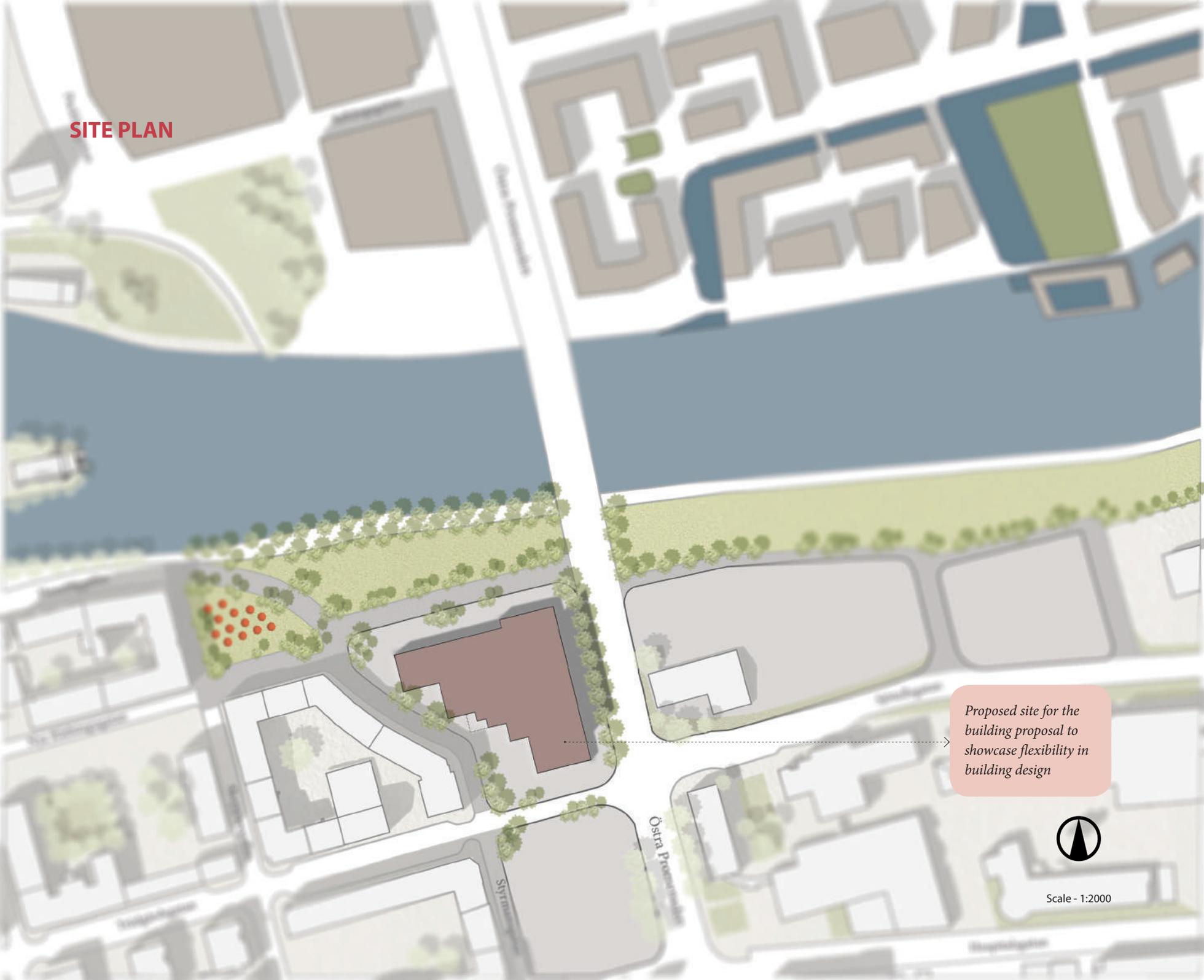
CHAPTER 6

Design Illustration





SITE PLAN



Proposed site for the building proposal to showcase flexibility in building design



Scale - 1:2000

Temporary programs - Alternates for the Open grounds

The building is developed in a way to integrate it with the surrounding neighbourhood. For example, building and plot boundary follows the Grid pattern of the city and thus by **developing grid structure** it extends the pattern into the building. By **making use of path hierarchy** in connection with traffic, the already existing service road which has less traffic will provide the main public entrance into the site - this encourage pedestrian circulation for the public entrance. The other two entrances adjoining the vehicular roads is provided with vehicular access. And by **creating boundaries** spatially, the plot facing the waterfront is demarcated as soft space which will include temporary functions by **developing Pop-up** structures until further development.

Adaptable outdoor open ground for temporary exhibition installation during summer season and can serve as Christmas market area during winter season.



Image 39.



Image 40.

Corner triangular plot can be turned into a pedestrian plaza with urban street furnitures to provide opportunities and desires for the changing context.



Image 41.

Open ground can function as an outdoor play area for small kids and also landscape barrier acts as an Urban furniture - bordering soft space and hard space.



Image 42.



Image 43.

Open public ground to accommodate adaptive functions such as flea market, ice skating, outdoor movie screening and other pop-ups for different seasons.



Image 44.



Image 45.



Image 46.

NYA RÅDSTUGUGATAN
GROUND FLOOR PLAN

Public use - Level 1-2



TRÄDGÅRDSGATAN

Entrance

ÖSTRA PROMENADEN



Scale - 1:500

Workshop

Sjötullsgatan

Ground floor is a double-storey structure by **offering heterogeneity in functions** which is generic in nature - being referential to the location it provides flexibility in terms of adapting to the future needs of commercial functions. To **show openness**, most part of the ground floor is made transparent with glass walls to create a strong visual connection to the surrounding neighbourhood. So, the more active rent-able shops are placed facing the streets adjacent to the residential blocks.

The other public functions are spreaded to interlink with the multi-purpose hall in the middle of the floor that can support different sharing activities. To **create links** to the already existing functions in the inner city, the start-up office spaces are included which are rent-able and allows collaborative structure. The workshop hall, study hall and the audio-visual hall is also provided to **create links** with the local cultural and educational facilities that can work stand-alone or as rentals when there is a need.

Relevant Strategies

-  Grid Structure
-  Openness
-  Heterogeneity
-  Links
-  Boundaries
-  Path Hierarchy

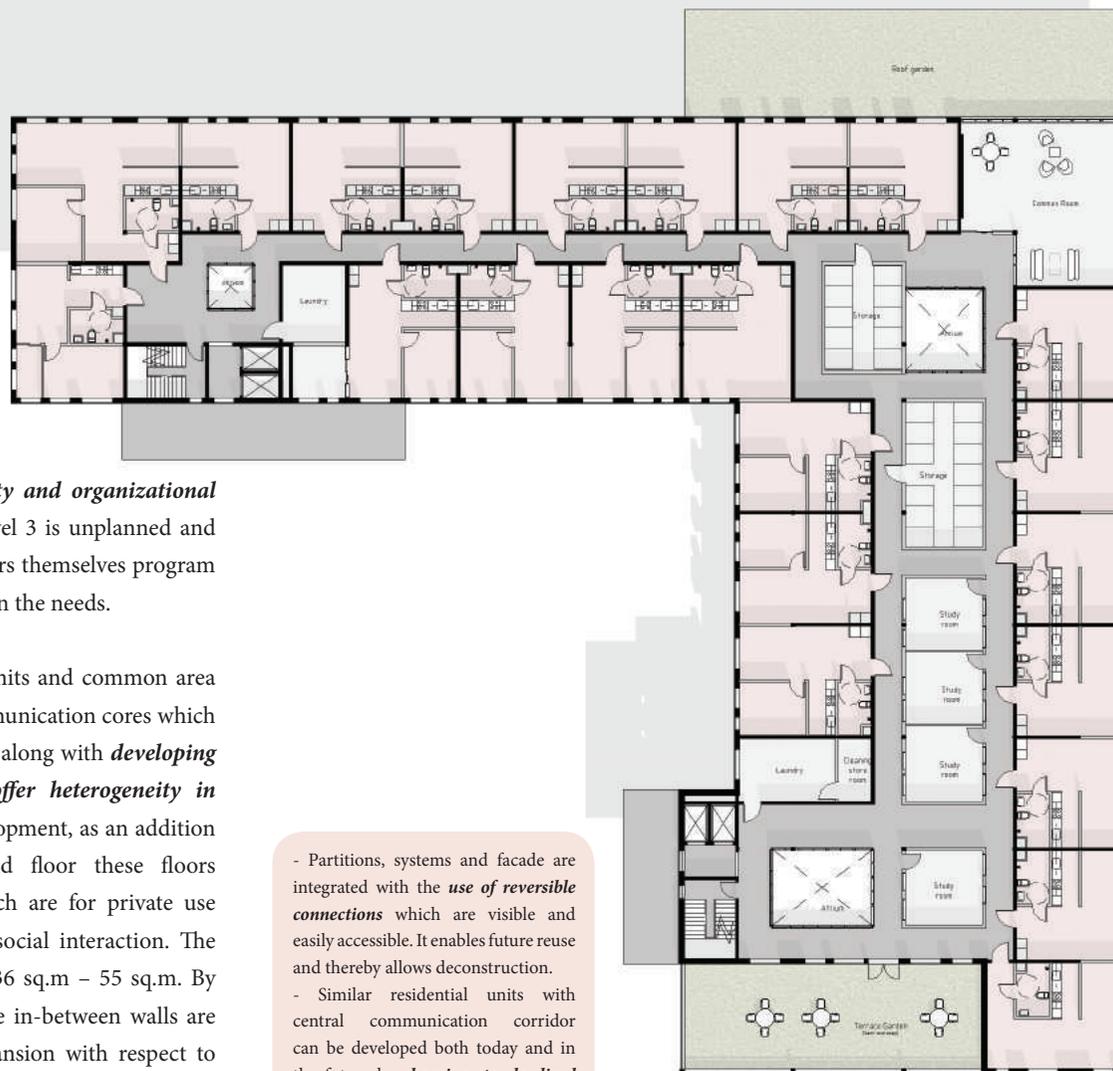
- Glass facade **shows openness** and creates visual connections to the surrounding.
- Provided functions **creates links** to already existing programs in the city and in future would possibly turn into a connecting hub because of its location.
- Also by **offering heterogeneity in functions**, the public space compliments to the surrounding monotonous and residential neighbourhood.
- The provided multi-functional activities establishes sharing and collaboration with other users or organization.
- Circulation routes around the site **makes use of the path hierarchy** that is the order of the roads in connection with traffic.
- **Creating boundaries** between soft spaces and hard space (building plot) establishes demarcation for future developments.

TYPICAL FLOOR PLAN

Private use - Level 4-7



Scale - 1:400



To *enable user-driven flexibility and organizational flexibility* in the local level, Level 3 is unplanned and left as an open hall where the users themselves program the required spaces depending on the needs.

Level 4-7 includes residential units and common area with central corridors and communication cores which is one form of generic planning along with *developing grid structure*. In order to *offer heterogeneity in functions* for the building development, as an addition to the public friendly ground floor these floors includes residential units which are for private use with a common hall to allow social interaction. The apartments vary in sizes from 36 sq.m – 55 sq.m. By *using reversible connections* the in-between walls are made adjustable to enable expansion with respect to user requirement in future. The terrace garden are semi-enclosed spaces, again creating adaptive sharing spaces.

- Partitions, systems and facade are integrated with the *use of reversible connections* which are visible and easily accessible. It enables future reuse and thereby allows deconstruction.
- Similar residential units with central communication corridor can be developed both today and in the future by *choosing standardized* building materials and units which allows generic functional changes.

Relevant Strategies

- Grid Structure
- Reversible connections
- Heterogeneity
- Reuse - Recycle

Steel Framework

Being a generic model *developing grid structure* allows Commercialized functional changes in the future in addition to present spatial alterations. It is in a way flexible with respect to the changing needs. By **choosing standardization**, a modular grid made of prefabricated individual units of steel columns and framings are assembled on-site with prefabricated hollow core concrete flooring. This is light weight and with the **use of reversible connections** deconstruction is possible. Also, it **enhance reuse-recycle** and reassembly in other parts of the building or in different construction site in the future along with preserving the material value. Thereby, it assists in extending the lifetime of the used product.

The grid is standardized but it is not determined to all parts of the building. Because some of the parts are supporting more specific functions to enable service core like big kitchen and overfull public activity like cinema hall .

Steel structure

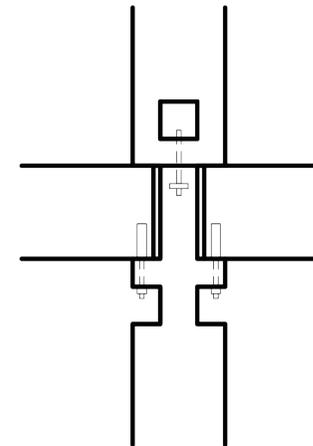
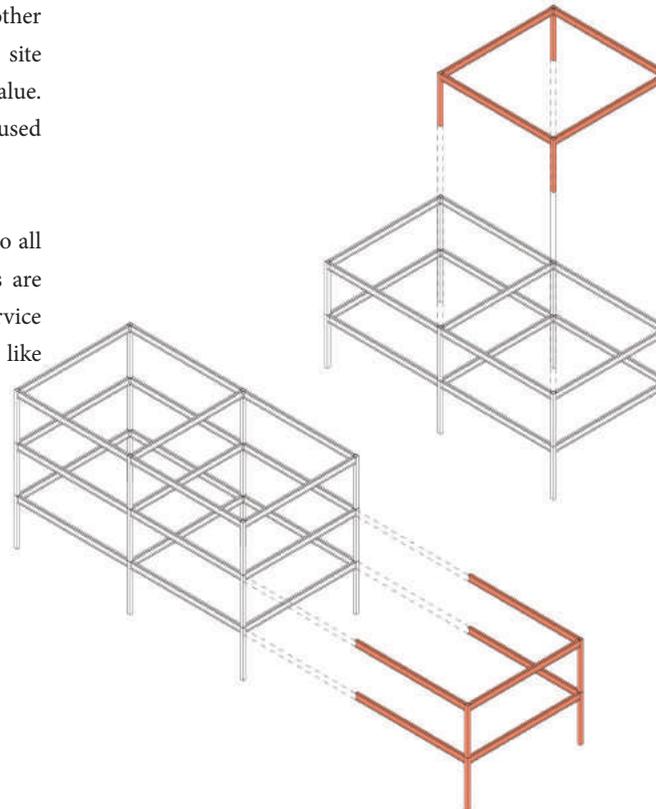


(retrieved from <http://www.oldcastleprecastspokane.com/>)

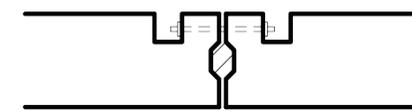
Hollow core concrete slab



(retrieved from <http://www.architectureanddesign.com.au/>)



Reversible joint connections between Column and Slab for easy demounting and reassembling.



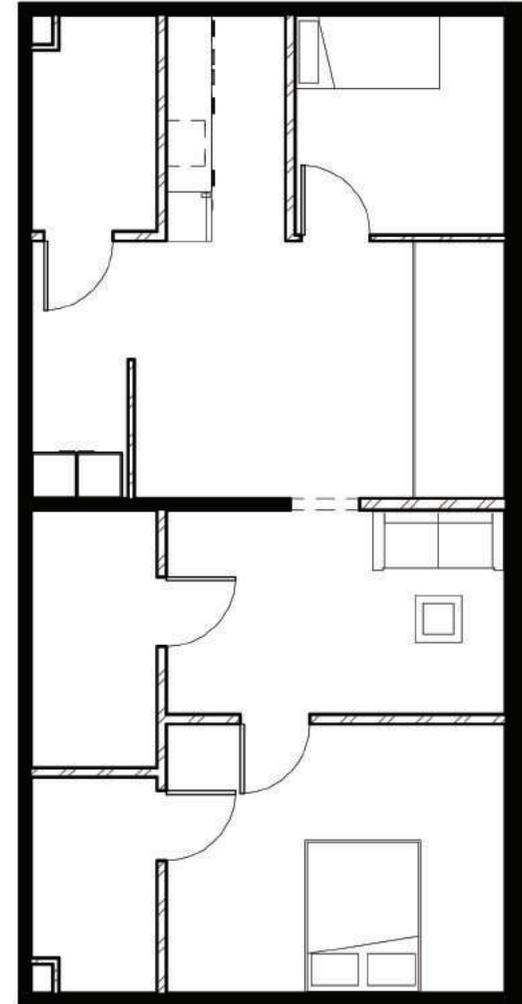
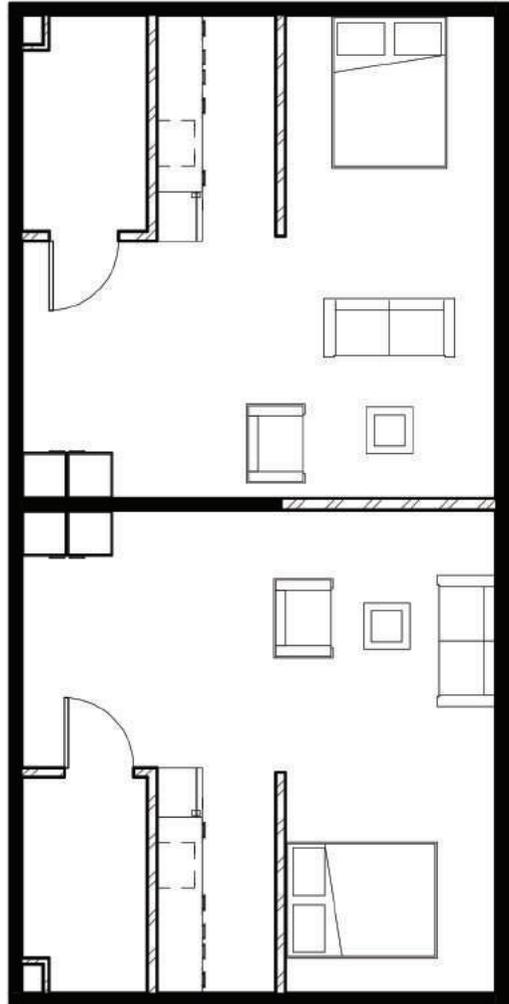
Slab to Slab connections are made with reversible joints and the gaps are binded with grout

Relevant Strategies

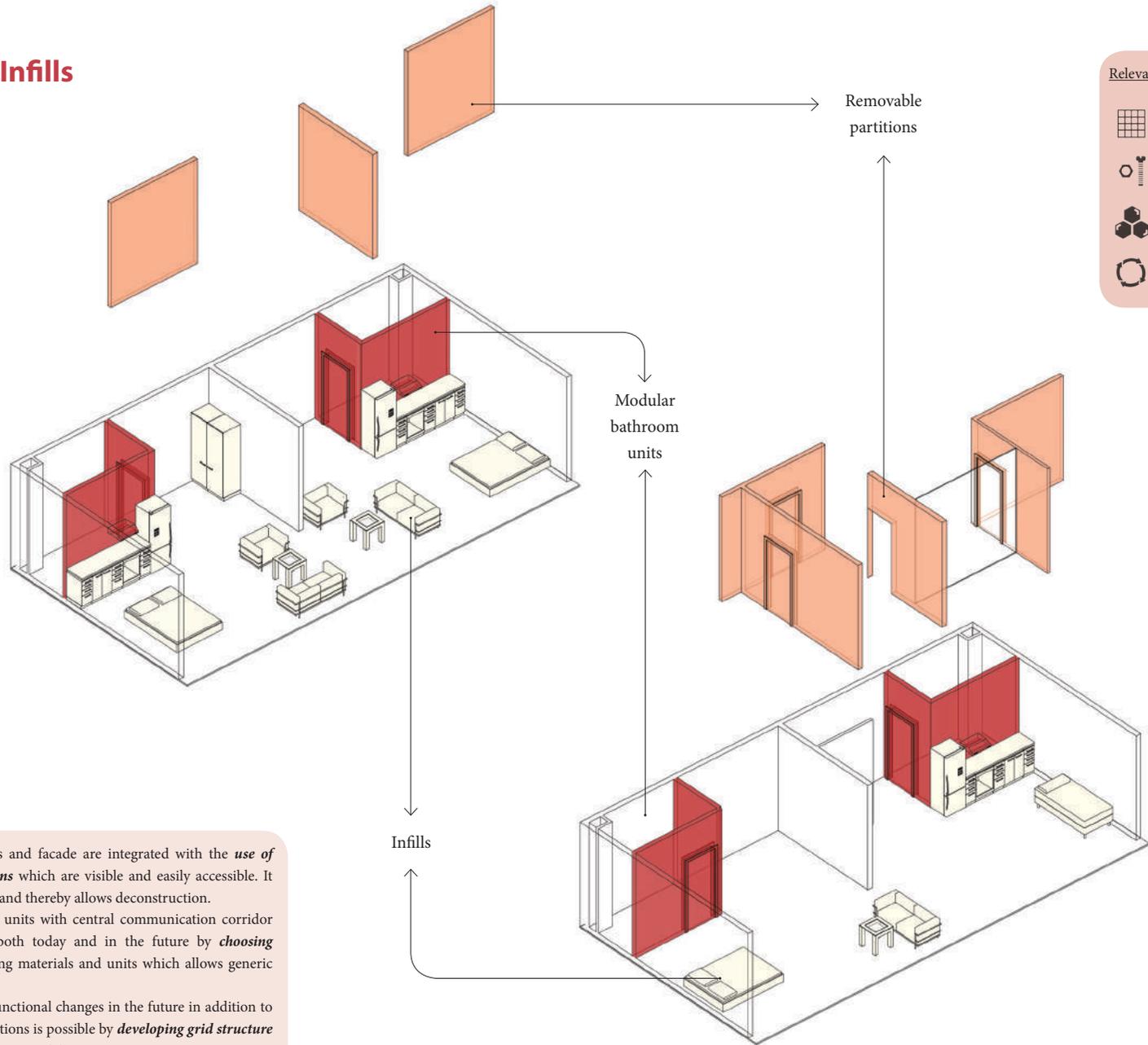
-  Grid Structure
-  Reversible connections
-  Standardization
-  Reuse - Recycle

Alternative option - Residential unit

Here it is illustrated, how the apartments could create an opportunity for physical arrangement based on the increased number of users. A studio apartment can possibly be altered to a three room apartment with temporary and easy to disassemble partitions. The allocated partition walls emphasize on individual expansion and the infills associated with the systems can also be altered without damaging the interiors as the system lines are independent from the main structural framework. The bathroom units are modular and are made refitable too with respect to the support level. Hence they can be removed at any point of time in relation to the spatial modifications.



Partition - Infills



Relevant Strategies

-  Grid Structure
-  Reversible connections
-  Standardization
-  Reuse - Recycle

- Partitions, systems and facade are integrated with the *use of reversible connections* which are visible and easily accessible. It enables future reuse and thereby allows deconstruction.
- Similar residential units with central communication corridor can be developed both today and in the future by *choosing standardized* building materials and units which allows generic functional changes.
- Commercialized functional changes in the future in addition to present spatial alterations is possible by *developing grid structure* which is being a generic model.

SECTION - AA'

Compressed wood fibre panel



Eco-active mushroom insulation



Mineral fibre ceiling tiles

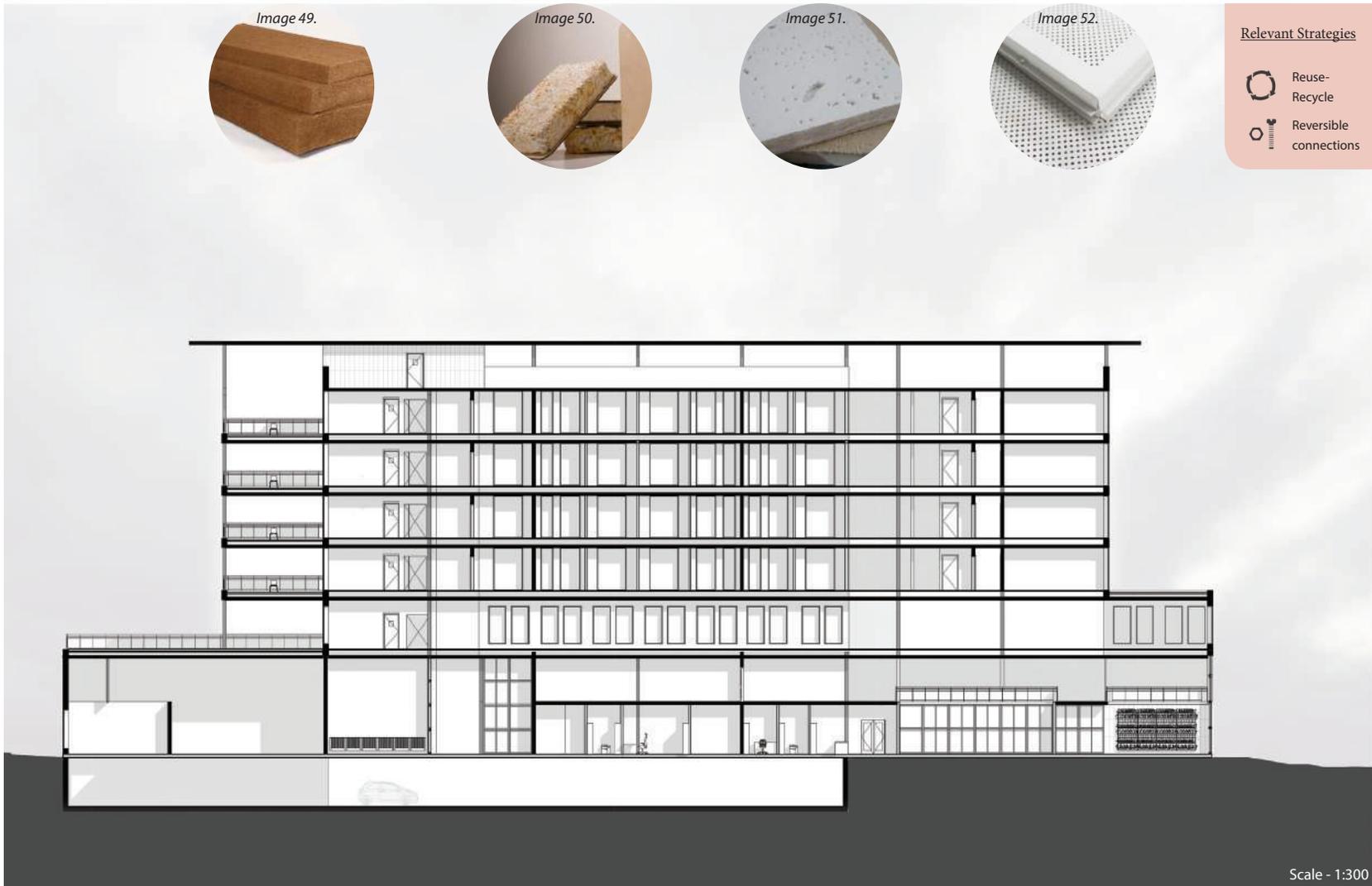


Metal work ceiling tiles



Relevant Strategies

-  Reuse-Recycle
-  Reversible connections

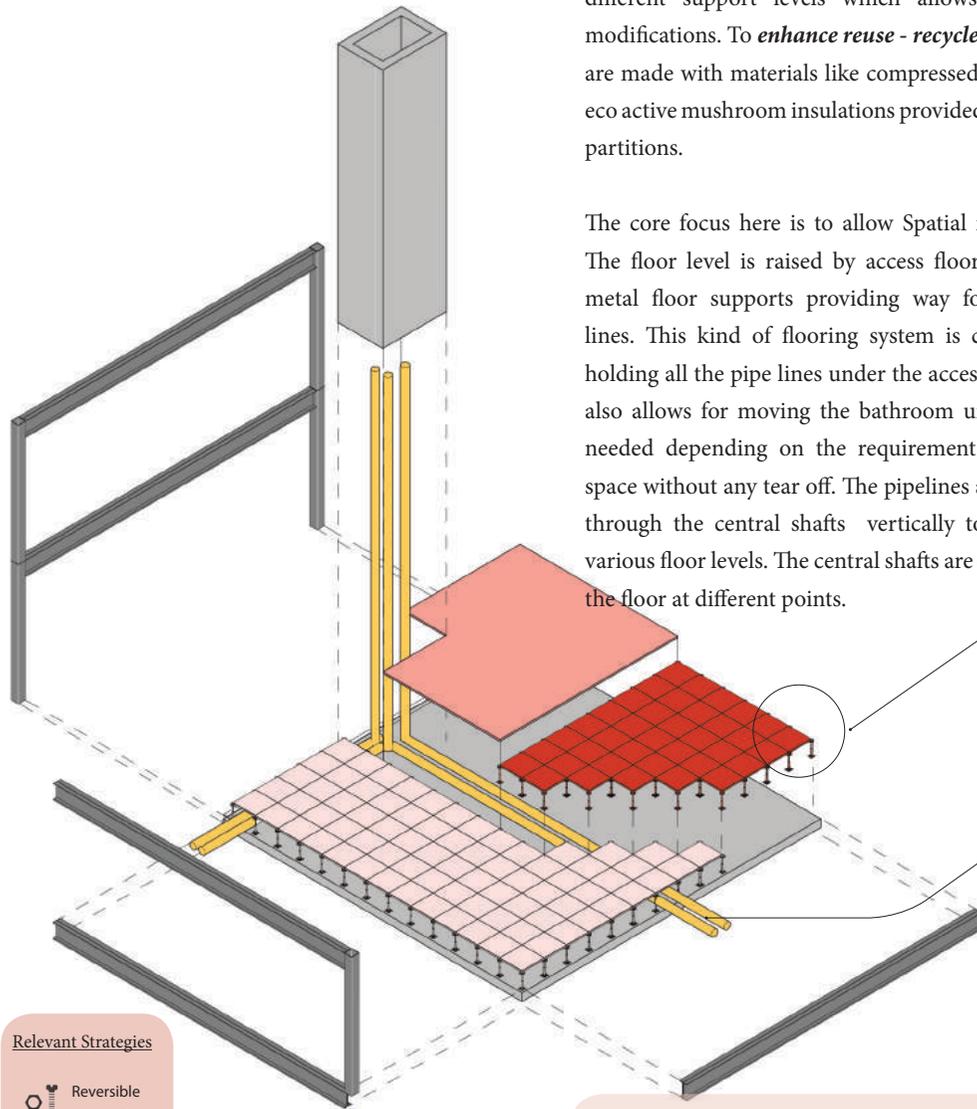


Scale - 1:300

Partition & System

Section AA' shows the floor level provision in two different support levels which allows easy spatial modifications. To **enhance reuse - recycle** the partitions are made with materials like compressed wood panels, eco active mushroom insulations provided with wooden partitions.

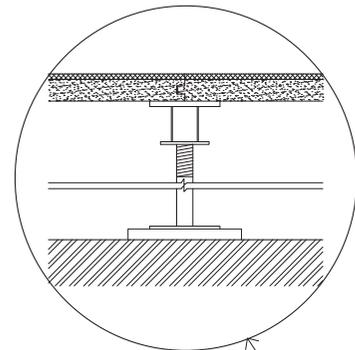
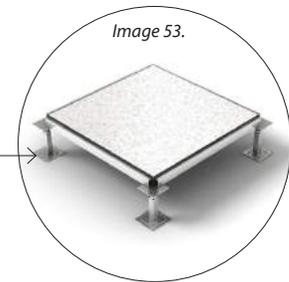
The core focus here is to allow Spatial modifications. The floor level is raised by access floor panels using metal floor supports providing way for the service lines. This kind of flooring system is cooperative in holding all the pipe lines under the accessible level and also allows for moving the bathroom units anywhere needed depending on the requirement of the room space without any tear off. The pipelines are then taken through the central shafts vertically to connect the various floor levels. The central shafts are distributed on the floor at different points.



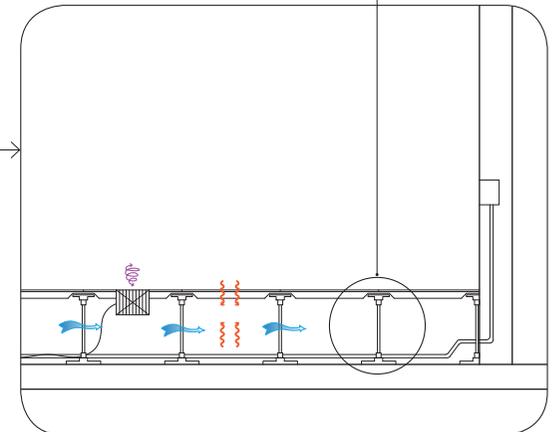
Relevant Strategies

-  Reversible connections
-  Standardization

- Partitions and systems are integrated with the **use of reversible connections** which are visible and easily accessible. It enables future reuse and thereby allows future deconstruction.



Raised access floor



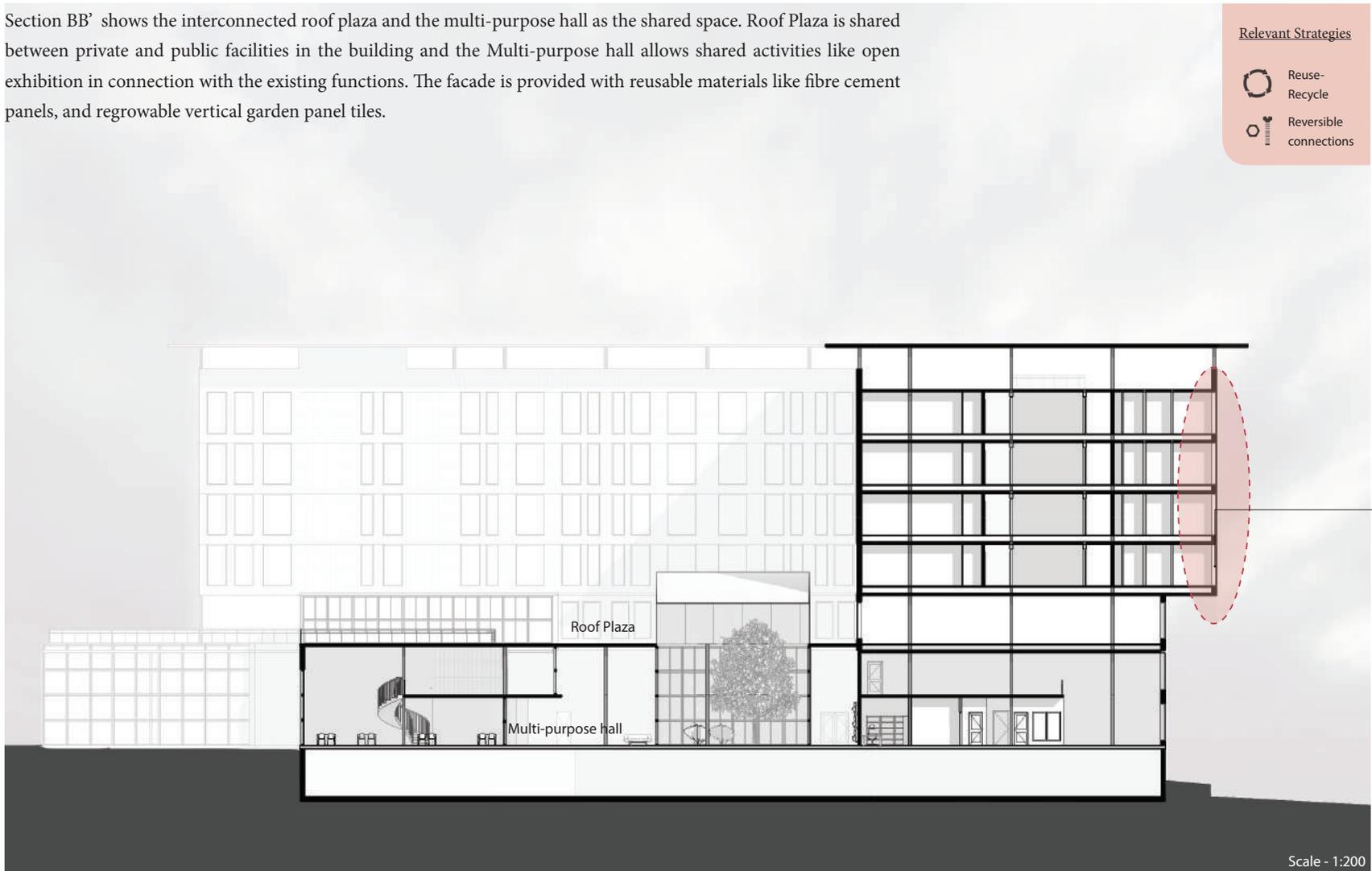
Pipe lines and heating system taken underneath the floor

SECTION - BB'

Section BB' shows the interconnected roof plaza and the multi-purpose hall as the shared space. Roof Plaza is shared between private and public facilities in the building and the Multi-purpose hall allows shared activities like open exhibition in connection with the existing functions. The facade is provided with reusable materials like fibre cement panels, and regrowable vertical garden panel tiles.

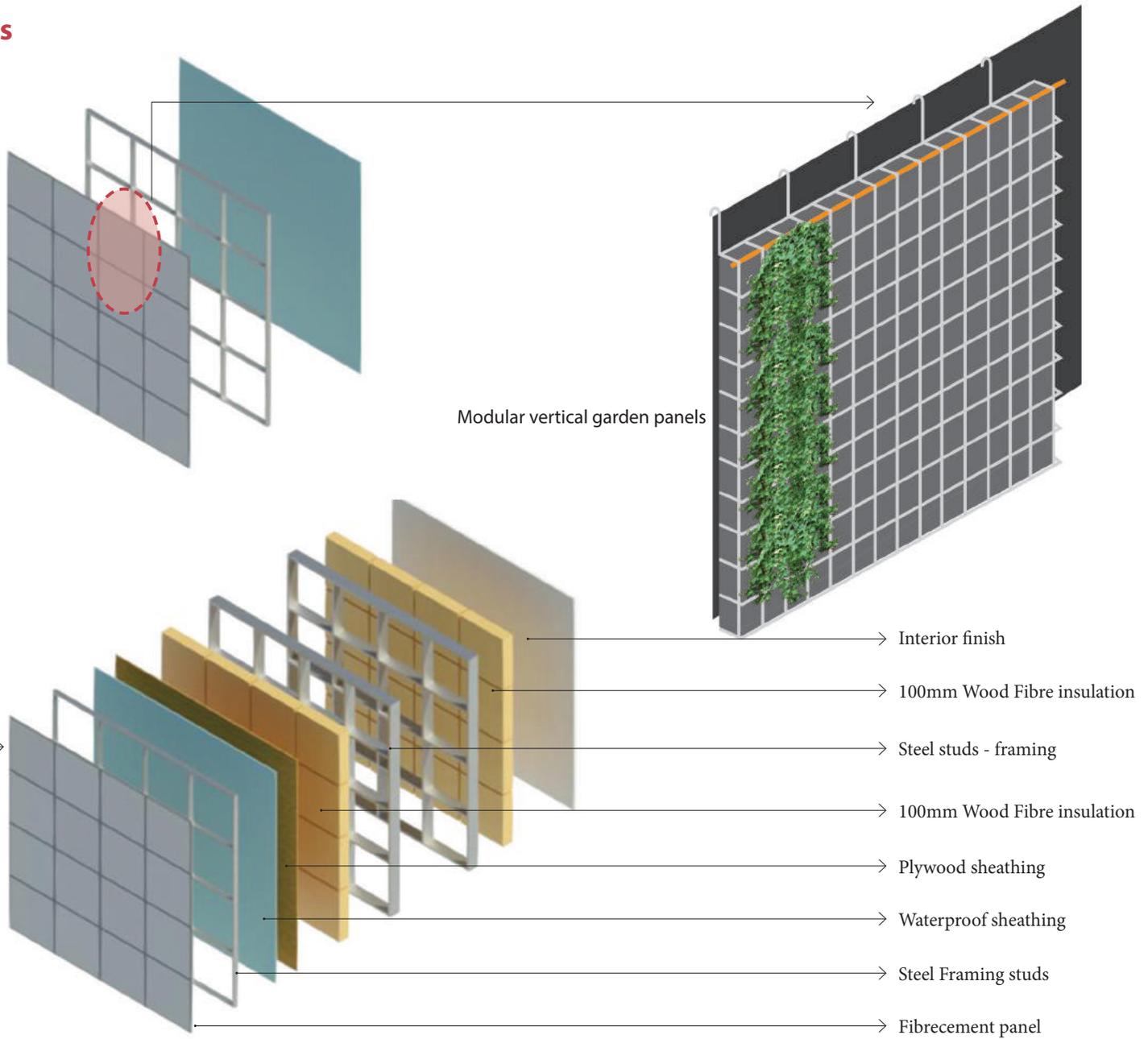
Relevant Strategies

-  Reuse-Recycle
-  Reversible connections



Scale - 1:200

Facade Layers



Relevant Strategies

 Reversible connections

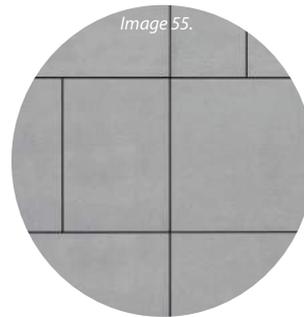
 Standardization

EAST ELEVATION



Vertical garden panel tiles

The green façade that acts as a renewable energy source is a great regrowable element and also purifies the air and protects against heat and cold.



Fibre cement panels

These panels have a reuse potential. Standardized units along with easy to disassemble joints facilitate future deconstruction.



Wooden Panels

Recycled wooden panels and recovered panels from New Inner Harbour site are mainly used for the roof and other interior partitions to facilitate reuse.



Scale - 1:300



CHAPTER 7

Review

DISCUSSION

Research questions have been considered as guiding rules for the thesis in developing the design part (1. *What values and qualities does Flexibility add to the buildings? and 2. Which are the challenges of Flexible Design and how can they be managed in the local context of Norrköping to facilitate a circular future?*).

Various questions have arisen and several thoughts and reflections have come across during the process of development of this Master's Thesis. It was quite clear from the beginning of the thesis to work on adaptive spaces to find out more about what is a flexible design and how following this design concept can add more value to a project. In this section, the thesis is concluded with a design outcome based on the design strategies and the research questions are addressed through reasoning based on descriptive scenarios and gained knowledge. Some of the holistic discussions that are to be addressed and taken forward further are also presented in this section.

Values and Qualities

The flexible design has revolutionized R&D (Research & Development) recently despite the limited amount of its development in the construction sector. Flexible designing is the most practical solution to do justice to the transitioning world. However this technique of construction costs money. According to the theoretical studies, the shearing layers of the building are the biggest part in establishing different flexibility values and qualities in a building construction such as sharing and collaborating. This shared spaces always brings the people together and create the possibility for social integration than social disintegration which is more common in mono functional developments.

At the same time, flexibility should have a bordering limit on everything. When there is too much flexibility, there also arises too many conflicts. The project has attempted to identify the necessity of the limiting conditions on different levels of flexibility. From the reference studies in relation to the theoretical studies, it was identified

that commercial buildings adapts quickly, whether to success or failure. Domestic buildings change most steadily. Institutional buildings change reluctantly and rarely, at great expense. Although the used functions and programs are generic in nature, those flexible functions and its adaptive nature to certain extent enable users and operations to establish the quality of shaping the experience of provided space. Shared and collaborative spaces increase the utilization value which eventually heightens the market and property value.

And through heterogeneous spatial development, investment costs may not be affordable by individual users. For example, the unplanned and open floor plan of Plan 3 allows less constraints at the floor plan level as the users can accommodate more to the building. The level of how change can be accommodated provides the users with more freedom to adapt the spaces at the 'things' layer level (usually interior furnitures and fit-outs). This establishes the Use-driven flexibility at the organizational level by making the users to understand the limits of what they can do. Safety and security in heterogeneous environment may be improved through showing openness in the structure with increased circulation and visual communication rates.

Establishing adaptability in the spatial alterations for the future provides the users a motivation of increased physical and mental activity. This in turn give long term health benefits for the users with improved quality of life. Also, flexibility in design could establish a sense of belonging, freedom of redefining the spaces and tolerance level among the various user groups. This is one of the important goal for sustainable city development followed by many municipalities. Recycled materials reduces the demand for new resources, cuts costs related to the production and transportation of new materials and eliminates the need to send waste to landfill sites. Furthermore, it could satisfy the demand and supply through efficiency gains of existing links. So, Flexibility in design is vital for a move towards circular future.

Challenges of Flexible design in the local context

Flexibility is always context specific. There is no specific formula for implementing such adaptive spaces. The result is often the mixture of built-in characteristics and remarkable strategies to produce a desirable level of flexibility where the outcome is often a mixture of organizational (actor based) and financial (cash flow based) forms of convenience.

The conducted research on Flexibility explained that the social context always has influenced the physical characteristics of a place. The gained knowledge from the contextual study in relation to the theoretical study explains that programs are context specific. Having said that, spatial flexibility in terms of program interchangeability becomes a great challenge. Spatial flexibility which was not discussed more enough in this thesis should have limited conditions on what kind of programs and functions could be interchangeable and become adaptive to the change. A further study on different functions and social spaces are to be made to find out on **what scale they can become flexible and how much of flexibility is possible to enable?** For example, private spaces like Residential units can become flexible and adaptive for office and institutional use after a decade or so and it is vice versa. Furthermore, studies should be made on enclosed public spaces like theaters and service areas like big kitchens in order to find out the possibility and rate of change of flexibility in those spaces.

Through this project, it has been found why designing with flexibility is not been given importance in the dynamic context though the design allows for more positive values. When there is a demand for change of function once the use period of the specific function in heterogeneous development is over, there arises the question of **“where does all the unneeded used building components go after its use period?”** In addition to the spatial flexibility, material flexibility also stands as a challenge. For this, it is furthermore essential to learn about the local landfills and recycling regulations in order to enhance reuse-recycle. For example, there are few organizations in Canada,

the US, Australia and New Zealand that buys or sells the reused construction materials and building components. The **processing and disposal of used building materials** needs temporary warehouses and processing points at accessible points in the local context which are yet to be established.

CONCLUSION

In this project, the possible values and qualities of designing with flexibility have been explored and thereby the subsisting and the uprising challenges related to the subject have been figured out. This thesis is an attempt to showcase the possible design aspects of flexibility and the answers proposed through this thesis project has not been used as a standard set of strategies by the organizations today. Rather, it has begun to frame the problem of material disposal and shorter lifespan of the built environment by the inefficient process and by that emphasizes their potential role in a Sustainable development approach. In order to achieve that, ten design strategies were developed from the gained knowledge of theoretical framework.

With the additional time and research knowledge, this project could be developed further to explore the shortfalls that has been discussed above and produce even more alternatives on the design proposal. With this thesis project, it was clearly understood that even a single room could be considered a flexible space if at least the value of some of the used elements is preserved during the project period or available for reuse, thereby extending the lifespan of the element.

The exhibited theories are evident admitting the critical discussions clearly pointing out that there is a clear challenge for the construction industry and the municipalities to alter the course of consumption of resources that does not leave a hard impact on our ecosystem. And also in implementing sustainable construction techniques by operating within the limits of our environment in order for our planet to preserve and restore resilience. As the quote in the beginning of booklet says, there is an actual call for an optimistic and different way of thinking towards a positive future in planning and design approaches to overcome the current state of resource crisis. Hopefully, Designing with Flexibility should be seen as an inspiration that can be planted in every local context and grown bigger in the future as ripples throughout the planet to make the life of the Earth much longer for our future generations.

So... Let us work towards transforming our place positively with OPTIMISM!

“ *Optimism is a duty. The future is open. It is not predetermined. No one can predict it, except by chance. We all contribute to determining it by what we do. We are all equally responsible for its success.* ”

*- KARL POPPER,
Austrian and British Philosopher*

PERSONAL REFLECTION

General Learning Outcome

First of all, I'm happy with my master's thesis and how it has turned out. Having the necessary means, the work process was consistent throughout the project time though it was very limited, and I would say that it acted as the main constraint as the entire work was produced in one study term. Until before I have moved to Sweden, I have been living in India and have come across design developments and constructions which are entirely different by means of material usage, climate, culture and obviously regulations. During this Master's programme and thesis, I learned a lot about the social and environmental sustainability-related issues. This is also what has fascinated me the most to look back at the very alarming issues globally.

Before starting this thesis project, I had a great interest to work with social sustainability subject and I still do have. But after moving to Norrköping to do an Internship for an architectural firm, my focus has changed slowly towards the global environmental issues. Along with seeing the city development plans, I have developed a strong belief that the global issues can be challenged on a local level and it would always stand as an initiating point in bringing a change towards a major cause.

Design Process and Challenges

The thesis work and process has brought insight that adaptive spaces and flexible planning constitute a complex topic which has proven to involve several diverse aspects and potentials. The scope of the thesis has hence changed and has grown over time. The aim of this master's thesis was to develop design strategies focusing on the concept of flexibility and to highlight its potentials through design illustration along with discussing the shortfalls and further exploration required in the subject.

Though the topic sounds interesting, it has truly been challenging and developing with a lot of gained knowledge from the studies in addition to my own experience and

opinions from the practice area. Testing the strategies through design illustration was the difficult part that I faced, and I believe that the aim was achieved well as in overall.

Originally, I planned to do a more detailed design proposal with sections and details showing both urban level flexible strategies and the building level strategies. However, time didn't allow for that, so then I chose to concentrate on more abstract master plan and *generic floor plan* with closer studies on an elaborative scale in order to clarify the thesis aim. Strategies, however, have been considered important for the entire project phase and supported the research and development of design proposal to a large extent.

The research part had to be carried out in a critical way, as the term 'Flexible design' was difficult to define and is often confused with the definition of dynamic architecture. The reference projects were crucial in guiding the theoretical research. At the same time, these case studies served as a part of the toolbox in evolving the design strategies. Several design strategies on various design scales had arisen in this process but decision making on choosing the most provoking ones was another difficult part that I had faced. Since importance was given to design strategies, the design proposal should be seen as one design alternative. Given more time, the project should have been further explored with more alternatives.

CHAPTER 8

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APPENDIX - I

Public Interview

Appendix-I presents the public interview questions and the answers. As mentioned in chapter 4, interview questions are framed by the municipality to know the public's interests on new Inner Harbour area development. Few among the same set of questionnaires are used in this thesis project after-all the chosen location is very close to the new Inner Harbour site and inhibits nearly the same inner and outer qualities.

It is essential to acquire more knowledge on what the residents of Norrköping city value most which will facilitate on what to prioritize and how to work on it further.

With the help of couple of my friends who speaks Swedish, I got the chance to interview the inhabitants who were randomly passing around the site. The

questionnaires and the answers obtained from the Dialogue with the residents are taken into account. Most of the answers are the inhabitants' expectation and wishes for the area on how they want the place to be in the future. There are five questions in total and the answers that were received from the inhabitants are slightly modified by using the architectural terms in order to provide a clear connection to the project.

Q1. What is the first thing you think of when you hear about Inner Harbour and the open land on its southern side?

- *Great potential on sustainable developments on the ugly part of Norrköping that people passing through have seen in many years.*
- Newly building gentrification project that attracts certain type of residential consumers.
- *Do not want to go there.*
- *Water is always a living ingredient.*
- Water.
- Waterfront café.
- Industries.
- *Graveled parking areas.*
- Outdoor meeting area.
- *Walk along water.*
- Boats / Shipyard.

Q2. How do you see the area around the harbor today?

- Good location – use the water!
- *Dark and do not want to be there late at night.*
- *A garbage dump, dirty, inaccessible.*
- Bad buildings, refugee creativity.
- *Cultural values, robust.*
- Pollution, toxic air.
- Scandal.
- *Industrial zone.*

Q3. What do you think is important for the Municipality to invest in, to feel welcoming and attractive for the future?

- Take advantage of the water, beach café, activities around or in the water, barbeque by the water, kayaking.
- Connect with the heritage buildings to take advantage of them.
- Mixed houses – large, small and various forms.
- *Roof gardens, sky bar, very green areas.*
- *Market square.*
- *'Affärsliv'.*
- Walking / Jogging tracks.
- *Meeting places.*
- *Clear identity for the place.*
- *Something unique to the area!*

Q4. Do you see any risks for new development around Inner Harbour?

- 2000 luxury apartments in Inner Harbour – for people only who can afford, is giving an indirect message of Trespassing prohibited!
- *Too expensive to live – water front developments.*
- Division of the city – gentrification.
- Flooding in future.
- Toxic ground.
- Heavy traffic.

Q5. Is it important to prioritize the environment and sustainability around Inner Harbour? And if so, how and in what ways?

- *Everyone considered that it is crucial to have an environmental thinking rather than a hygiene factor*
- Self-benefitting from the energy, e.g. to have control over water and heat.
- Social sustainability, apartments even for lower-economy groups.
- Quality without luxury.
- Pedestrian friendly, Bike paths.
- Private farming.
- *Solar panels on the roofs.*
- Durable materials used for construction, e.g. wood.
- *Recycling, Closed ecosystem, reuse.*

APPENDIX - II

Dialogue with Municipality

- | | |
|------------|---|
| 2017-09-01 | Personal Meeting with Fredrik Wallin & Linda Gårlin, Project leader for New Inner Harbour area development, City Planning office, Norrköping Municipality |
| 2017-09-11 | Personal Meeting with Per Haupt, City Planning Architect, Norrköping Municipality |







CHALMERS