UNDER ONE ROOF

Hybrid Architecture for Auckland

Explanatory Document by
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The exponential growth of the human population globally has directly resulted in urban sprawl in many cities around the world. Trying to accommodate this ever-increasing growth gives rise to an unsustainable living solution. A shortage of obtainable land for expansion and an escalation in real estate prices has steered planners to mixed-use buildings to solve multiple issues currently faced by the 21st-century city. In architecture, the mixed-use building is a typology that existed since the formation of the city-states. With the utilization of zoning plans in the 19th century, due to the beginning of the industrial era and the introduction of modern town planning, the mixed-use building was used to supplement the limitations of an indisputably limited land base. The thought behind it was that the vertical expansion would help in saving energy resources, support the ever-increasing population and prevent the further eradication of farmlands, nature, and recreation thereby ensuring sustainability.

The development of mixed-use buildings gave rise to an exploration of the potential and the opportunities that these types of structures can provide in relation to their placed context. This research, therefore, investigates the process of hybrid typology analysis in the context of the city as a first principle aid to produce mixed-use architecture. Through the research of related literature and precedents, a defined methodology with a focus on analysis and synthesis will assist in the development of a series of mixed-use interventions that go beyond the current understanding of mixed-use building development and how it can be sustainable. Hence this proposition of a productive and powerful mixed-use development is a beneficial point of research. However, this unification of variety as far as “form and function” should be situated in a comprehension of history, hypotheses, and points of reference of pertinent typologies. The aims and objectives, the philosophy and eventually the exploration question, which will be outlined in this explanatory document.

This project is an attempt to answer the question: how can the design of a mixed-use high-rise building provide a solution to urban sprawl and increase sustainability? The project can technically be located in any definitive urban area in the world facing this issue, but an area of downtown in Auckland.
New Zealand was chosen as the site for this research. Ultimately this research provides insights into how a productive and powerful mixed-use development with a focus on sustainability can contribute to the urban fabric of contemporary 21st-century cities.
02 | INTRODUCTION
2.1 | **Background**

The skyscraper, a man-made marvel which defies gravity by reaching the sky, is one of the most dominating structures of any city. It symbolises firm human ambition to build higher and higher which raises several questions in our minds. One of the most frequent and basic question being "**Why skyscrapers?**" This thesis is an attempt to answer the same by exploring the use of mixed-use high-rise building and also examine the function of hybrid typology and its contribution towards sustainability. The research also presents a brief explanation of the historical and current innovations in terms of skyscrapers.

The fact that cities globally as well as in Auckland continue to expand horizontally over a large area in an irregular manner is also touched upon. To protect the city against this sort of expansion which eventually would reach a saturation point, a skyscraper as a building structure is a possible solution by vanquishing vertical space through intensification and agglomeration. Auckland being a metropolitan city attracts a large number of people and undergoes mass migration every year resulting in a shortage of homes and inflation of rents. As per a Business Insider article, Auckland is currently at
the third position among 23 cities with the best quality of life in the world and is touted to be one of the best cities to live in the future\(^1\). Its downtown area is where all the high-rise construction has taken place and these properties being valuable, it’s sensible to use the land to its utmost level by having mixed-use purposes in the high-rise building. As seen in the past, it indirectly contributes to sustainability at a lower magnitude.

Open spaces add to the working of urban areas and improve their imperativeness, be it open courts, green parks, or shaded foyers, or even the avenues used by public every day. It gives respite from the condensed urban setting. As communal places, open spaces too help to reinforce social character, and in addition offer open doors for group-holding and bonding between social comprehensions. In the meantime, open spaces help to improve the urban setting by encouraging life outside buildings. They bring along monetary returns not just by attracting more people for neighbouring trades, but also by making Auckland more appealing city to live, play and work in. As Auckland is set to be more populated in future, open spaces would turn out to be significantly vital in keeping up a decent personal satisfaction and feeling of prosperity.\(^2\) \& \(^3\)

The growing shortage of accessible land for building, combined with rising land costs for both commercial and residential properties, has forced restrictions on living and working conditions for both the present and future tenants of downtown areas. This has further complicated the formal and practical knowledge of building typologies, as it identifies with family life, offices and workforce in the urban setting. This has prompted the fervour for hybrid designs, which tend to satisfy the numerous needs emerging from such situations. Keeping this as a core part of this thesis, it proposes to have a mixed-use sustainable high-rise building in Auckland CBD area to cater to the shortfall of residential and commercial spaces and make-shift serviced spaces along with public amenities.

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In the process, references and extractions of some recently built multi-use skyscrapers are examined with a reason in order to explain their position in the respective cities. By accentuating skyscraper’s technological, sustainable and growing nature, this proposition tries to dismiss any judgment about skyscrapers as mere mammoth exhibits of architecture. The aims and objectives, briefly the methodology and ultimately the research question, which will be considered throughout the entirety of this document.

2.2 | **Outline**

The project explains the current urban sprawl in Auckland. Sprawl, which is a by-product of the population growth and rapid development has led to unsustainable living conditions. To support this, research on statistical data for Auckland City was conducted focusing on the supply of housing for the ever-increasing population of Auckland as mentioned in section 3.1.1.

The project experiments with a mixed-use typology in the city centre because the typology can be utilized effectively to meet the demands of urban intensification. It is an attempt to combine different functions at one given place thus contributing towards sustainability.

This architectural proposition focuses on the co-existence of public open spaces and private areas such as residential apartments and commercial offices. This is demonstrated in detail in design document section 4.2.
2.3 | **Aims & Objectives**

The research project aims to design a mixed-use skyscraper which:

- Contributes to a sustainable environment along with providing well-organized facilities and amenities to meet needs of urban community
- Configure spaces that improve the social and visual collaboration and decrease confinement
- Comprehends the eventual fate of urban communities, the difficulties the communities might confront, understanding the developing ideas and advancements from around the globe

To achieve the outlined aims, the following objectives are established below:

- Data collection and review of related literature and case studies relating to the aims mentioned above
- Derive and describe from concerning case studies the methodological concept of “under one roof”
- Check the parameters of under one roof concept and implement it to the selected site
- Create a good public realm in the Auckland CBD by introducing multiple functions under one roof
2.4 | **Research Question**

From the preceding segments, the articulated research question is mentioned below:

“How can the design of a mixed-use high-rise building provide solution to urban sprawl and increase sustainability?”

This research question focuses on concisely addressing the defined aims and objectives. The question is also the concern to be addressed by the resulting proposed design and it’s relating brief.
2.5 | **Scope & Limitations**

The project is not just a mere glass box of skyscraper as the bling in the city but a functional disposition catering to the site and human affiliation.

The project mainly focuses on inter-relations of the below-mentioned topics:

- The correlation between the functions of the project and the site
- The Mixed-use typology in urban context
- Form of the building responsive to climatic and material challenges

These concepts narrate the introduction in segment 2.1 and aims, objectives of the proposition in segment 2.3. Above mentioned topics’ impact on the project and the integral complications, the project faces would be discussed in the paper in an urban setting of Auckland city. This is described more in-depth in segment 3.1.
2.6 | **State of Knowledge - Literature**

- **Urban Intensification**

  Urban intensification means habitable communities accommodating growth, people-focused and energized city hub accompanied by striking urban design and esteemed legacy. In layman’s term, it is nothing but basically planning for growth and keeping or making the urban area attractive and accessible. If strategically planned and implemented this can lead to successful cities. Managing such cities is crucial.

  The thought of urban intensity summarises the idea that is obtained within qualitative aspects of urban density. Numerous researchers assert that it is insufficient for density alone to determine what a city needs. Instead, a city is built upon these boundless facets of urban density, by letting mixed and multi-functional spaces to establish itself as the driver of the sustainability of the urban texture.

  Intensification is endorsed as a means to attain several benefits. First, if population growth can be accommodated at higher masses, or within existing urban areas, or both, less rural that is green land will be required for new housing. Thus, not encroaching on greenland for housing which is a huge plus point. Second, research shows that when the population of the masses increases beyond a certain level, automobile use declines in favour of transit, walking, and cycling as everything required is literally just around the corner. Third, where surplus infrastructure capacity exists in developed areas, adding more people to these areas makes more proficient use of public urban infrastructures such as water and sewer pipes, as well as “soft” infrastructure such as public schools and social services. A comprehension of the local specific (e.g. site advancement costs, acquisition costs etc.) and wider economics (e.g. relative market competitiveness with traditional greenfield) of the area are essentially crucial. In short, vertical expansion in already urbanized areas plays to the city’s strengths rather than spreading its resources over an ever-wider terrain.
Timber being sustainable

The first and most obvious advantage of glulam is that its fundamental constituent, timber, grows out of the ground and does not require mining or for that matter rigorous manufacturing processes that steel or cement need. Thus, we can guarantee that it is an ecologically sustainable material. Types of timber, varieties of adhesive and preservatives and method of application are all the reasons to determine the strength of glulam. Given the appropriate specification, it can be utilised for the most challenging of conditions. One case where glulam is opted over other materials for its robustness is in the swimming pool area – this is a particularly corrosive environment with high humidity and chlorine levels and glulam provides a durable and cost-effective solution. Glulam is designed to last for years together with the least amount of maintenance issue. This is profoundly suggested for humid weather conditions.

Another advantage is that smaller foundations are needed for a reduced structure weight. Glulam beams are very efficient to produce. The energy required to produce a glue-laminated beam from the log is only a fraction of the energy required to produce steel or concrete. Glulam has superior earthquake resilience and noteworthy protection to fire than any other structural construction material.
Mixed-use typology as Social Condenser

Social condenser is an idea that was conceived from the Soviet Union’s constructivist movement. It was first penned by Organisation of Contemporary Architects (OSA) which is an architectural association in the Soviet Union in light of the socialist movement at that time. The main idea of the social condenser is that architecture is not only an inanimate object but also an instrumental tool to transform the nation’s way of life, changing the ordinary man to a new social creature. To achieve this mixed-use building layout, it is configured in such a way that circulation becomes the most important space to fit in the spaces alongside it so as to increase chances of interaction and meeting, accelerating collectivism across the population.

Each function is thought out not to create intensity and vitality in the city, nor to attract a flux of external users, nor even to foster mixing and interdetermination but rather to achieve a self-sufficient and complete building that can isolate itself from the conventional city.
3.1 | CONTEXT RESEARCH

3.1.1 Urban Sprawl

Auckland was fairly abandoned by Maori and the early Europeans unless it was made the capital of New Zealand in 1840.4 But it has grown rapidly since then mainly around the commercial ports of Commercial Bay, as well as some parts of Onehunga due to its proximity to the port and few spots of the harbour. The populous was mainly centred around these ports as walking was the only means of transport and soon the areas started getting crowded.5 This initiated the means of streetcars (trams) and railway transportation which allowed people to settle in different localities around the railway and tram stations. As a result, Auckland grew in western and southern direction along the railway line.6 All these factors made Auckland a favourable place to live and invited even more people to the city which required more living space and hence the expansion started towards Great North Road, New North Road, Sandringham Road, Dominion Road, Mt Eden Road, Manukau Road and Remuera Road, forming a new arc of suburban

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6 J. Barr, (1922) Municipal and Official Handbook of the City of Auckland, New Zealand, Wilson and Horton, Auckland
development in Auckland by 1915. The intervention of automobile had become an integral part of the life for many people before World War. Possession of automobile meant accessing any parts of the city at our ones’ convenience and not to be dependent on the streetcars line or stay nearby it. The number of automobiles in New Zealand skyrocketed from 37,500 in 1922 to 261,850 in 1938, at that stage the second highest rate of vehicles per capita in the world after the United States.\footnote{Bloomfield, The Growth of Auckland, 12.} It was during 1951 that the Auckland Metropolitan Planning Organisation’s \textit{Outline Development Plan} proposed the development of Auckland focusing on the car based mode of transport for a population of around 600,000 compared to the actual population of 328,479 in 1951.\footnote{Auckland Regional Growth Forum, (1997) A Place Sought By Many: a brief history of regional planning for Auckland’s growth, Regional Growth Forum, Auckland.} This was the first step towards urban sprawl and after the WWII there was the ‘baby boom’ which just fuelled the demand for more new housing. Efforts were taken by the authorities to shift the population to other parts by shifting few ports to other parts of New Zealand and emphasising on family planning in a hope to reduce the pressure on public facilities. After realizing that the population can’t be controlled and Auckland grew even richer for people to live in this city, authorities started looking out for other option of ‘where and how’ the growth would take place. This at later stage leads to acquiring the valuable and fertile farmlands on the

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure4.jpg}
\caption{Field’s development near Papakura}
\end{figure}
outskirts of the city for further development to accommodate the ever-increasing population.\textsuperscript{9} This had led to Auckland being what it is today with city landscape identified by vehicular congestion, low quality of air, tainted water bodies around the region, damage to the environment and increasing infrastructure costs.

3.1.2 Housing

The demand for housing hasn't stopped since 1970's due to the increasing population. the 2013 Census figures according to the data distributed by the stats.govt.nz online demonstrate that Auckland has a populace tally of 1.42 million and is relied upon to develop to around 2.2 and 2.5 million over the coming 30 years. Around 400,000 extra houses will be required by the year 2040, which implies that at least 13,000 extra houses must be constructed every year.\textsuperscript{10} As of now there is a deficit of around 20,000 units even though the present levels of the building are significantly less than a

\begin{figure}[h]
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\includegraphics[width=\textwidth]{average_annual_absolute_population_growth_2001_2013}
\caption{Average annual absolute population growth, 2001-2013}
\end{figure}


Large portion of the volume required. Just, 5,000 approvals for new homes are issued every year in Auckland, and not all of these are fabricated to reality. The Commission predicts it will hit requirement mark of 60,000 units by 2020. House costs in the city have been going up by nearly $3000 in seven days!! That implies a middle Auckland house is acquiring $150,000 a year, which is considerably more than what house owners earn through their normal jobs. The shortfall in supply to meet the demands has also resulted in an exorbitant rate of houses and that has, in turn, inflated the housing rents which are increasing at the rate of 2.3% every year.

The city faces housing crisis due to the following reasons:

- A persistent under-supply of housing to meet demand
- A lack of housing choice
- Poor-quality, unhealthy and overcrowded housing
- Declining affordability and home ownership.

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12 Rents for urban properties reach all-time high, 20 Sep 2017, retrieved from https://property.trademe.co.nz/market-insights/rental-price-index/rents-for-urban-properties-reach-all-time-high/

13 Auckland Council, Auckland’s Housing
There is no single solution, nor a single sector to address these issues, and urgent, large-scale, bold, multi-sector action is required to:

- Increase housing supply to meet demand
- Increase housing choice to meet diverse preferences and needs
- Increase the quality of existing and new housing

Figure 7 Increase in weekly rents for various typologies
https://property.trademe.co.nz/market-insights/rental-price-index/rents-for-

Figure 8 Annual change in rental price index
3.1.3 Commercial

Auckland city is well connected with rail and motorways which make it efficient for the businesses to run in the city. This good connectivity allows about 90,000 people to come to the city every working day. This figure is expected to rise to 140,000 working people coming to Auckland CBD by 2032.\(^\text{14}\)

This figure makes CBD the economic hub of the region. 60% of New Zealand’s top companies are based in Auckland which makes it the largest commercial centre, tertiary education centre and wealth creator with an annual output of about 60 billion dollars. This region hosts up to 31% of NZ’s businesses and about 32% of NZ’s employees.\(^\text{15}\) The industries that employ the most people in the Auckland region are business services such as legal and accounting, marketing and management services, food and beverage manufacturing, health, hospitality, telecommunication services, building construction, machinery and motor vehicle wholesaling.\(^\text{16}\)

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http://temp.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/theaucklandplan/Pages/theaucklandplan.aspx  
\(^\text{15}\) Ibid.  
\(^\text{16}\) Auckland is New Zealand’s commercial hub, New Zealand now, accessed on 15 Sep 2017 retrieved from https://www.newzealandnow.govt.nz/regionsnz/auckland
Despite Auckland being identified as the economic hub of New Zealand, it still falls short of commercial vacant spaces for rent. Auckland region’s 2.4% vacancy rate is the lowest since late 2007. CBD retail vacancy has reduced from 3.0% in late 2014 to 2.5% as at June 2015. The additional demand for CBD office and residential space will boost retail significantly over the next five years. The current supply could increase from 124,000 sq. m by an additional 50,000 sq. m by 2021, with NDG Auckland Centre providing just under half of the additional space.

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17 Chris Dibble, “Vacancy rates - same same but different,” accessed 03 March 2017 
http://www.colliers.co.nz/news/2016/vacancy%20rates%20-%20same%20but%20different/

18 Colliers International, ‘Retail Reality Check’ NZ Retail Report 2015 page 02, accessed 15 March 2017 
http://www.colliers.co.nz/find%20research/retail/nz%20retail%20report%202015/
3.1.4 Context Inference

As from the above context, it can be concluded that the constant influx of human population to Auckland city has caused an urban sprawl which will have ramifications on natural resources. The city continues to fall short of meeting the demands of the housing as the booming economy of Auckland attracts more people to this region which also has side effects on commercial retail/office spaces which the city is falling short of. The answer to this could be urban intensification of Auckland region which the Auckland Council emphasizes on.

Urban intensification at times leads to congestion of the cities which needs to be balanced with sufficient open spaces and pedestrian-friendly routes for the city, which has been already identified by Jan Gehl in his urban analysis for the city ‘Auckland Public Life Survey 2010’. As this project focuses on curbing the urban sprawl, a high-density scheme could be a solution for the city with the means of a high-rise development.

For instance, the development of 422,600 M² piece of land on Fred Taylor Drive near the Westgate shopping Centre provides 1500 houses. Which is roughly 280 M² area of land utilized per house. This in comparison to One Central Park, a mixed-use typology in Sydney on-site area of 6060 M² provides with 623 apartments in addition to 625 car parking spaces. The apartments occupy less footprint and give more living units whereas the houses occupy

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larger footprints and give less living units. There are pros and cons of each case like apartments are low on maintenance as compared to houses but are also smaller in area than the other.22

3.2 | Literature Review

3.2.1 History of Skyscrapers - World & Auckland

The need for building super tall and uber tall structures continues to be a challenge to designers and civil engineers to design and reach new heights. Tall structures have been an answer for urbanization and overpopulated urban areas for a very long time together. The tall structures that we know today ended up plainly conceivable with the creations of lifts, more up to date assembling materials and auxiliary building frameworks, multi-storey development goes back to the Roman Empire.23 In this manner, we can presume that vertical inhabitation has been around for quite a long time.

The inventions of elevators, building materials, and structural engineering systems have cleared the way for the construction of high-rise buildings. From the findings, it can be established that high rise buildings have been around since the Roman Empire and the concept of the vertical city isn't novel. Thus, we can understand that vertical inhabitation has been around for centuries.24 At some point in time, most extensive streets will also prove to be inadequate to cope with the influx of the ever-growing population. Hence, there is a need to go vertical & tall structures have been a solution to urbanization and populated cities for ages together.

24 Ibid.
How the wonder of building tall structures started

The high rise is a result of 19th-century American industrialism, spirit, and calamity. The Great Chicago Fire of 1871 was a disaster that required dense and quick remaking, both of which the tall building facilitated. The coincidental discovery of this new typology always showed signs of changing the contemporary urban natural surroundings.25

![Figure 12 Scene of downtown Chicago, after the Great Fire of Chicago in 1871](image)

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At the end of the 19th century, Chicago was one of the most prosperous cities in the United States. Located between the unknown West and the civilized East, Chicago played an important role economically and politically. The rapidly growing city was struck by a massive disaster in 1871 when a fire broke out which ended up destroying nearly 3.3 sq. miles of downtown Chicago. The prosperity came to an abrupt halt, with many of its buildings destroyed and with thousands of citizens abandoned on the street homeless and helpless. The city had to rebuild itself quickly from scratch to meet the immediate demands and efficiently fulfil the capacity. This gave rise to a new style in building typology to build a denser, faster and safer habitat for people in order to prevent any destruction from future fires. This resulted in the birth of a high-rise structure.

City zone of New York and Chicago in North America were expanding & developing at an enormous rate due to social, economic and technological advancements thus giving rise to an appropriate setting for the construction of contemporary multi-storey structures.

The effect of this episode on the development of the up and coming structures

In 1885 post the destruction caused by the fire, the Home Insurance Building in Chicago, 10 storeys high, was the first that demonstrated the utilization of the steel framed gravity system. It was a tall structure to reinforce both internally and externally a fireproof metal frame. This caused the implementation of huge windows on the lower level of elevated structures.

This laid a pattern for steel frame system in tall structures, as the load bearing system used during that era was extremely incompetent monetarily beyond 15 storeys. Such sort of confinement is clearly visible in the 17 storey high; Monadnock Building of 1893 in Chicago which was the highest and the first one to make use of a portal system for wind support. However, owing to its load-bearing masonry system, it had walls up to 1.8 meters wide on street level. This made the ratio of its “net-lettable-area” to its total built area very minute to be economical. In 1889, the Eiffel Tower multiplied the stature of the previously tallest Washington Monument, transcending 300 m with the use of pre-assembled iron components.29 This new building idea gave an incredible boost and provided confidence in the vitality of tall metal compositions.

The Ingalls Building, established during 1903 in Cincinnati in the United States of America, is believed to be the foremost “reinforced concrete skyscraper.” This structure comprising of 16 storeys was constructed monolithically by casting the columns, floors, and walls using concrete of relatively low strength by current standards. Elzner & Anderson designed what was considered a landmark in architecture at that time and was also feared that the building would collapse under wind loads but or because of its own weight, but the success of the building led to the team creating the tallest reinforced concrete structure.30

During the 70s era, incredibly innovative and technological progression took place that empowered designers and architects to try more eminent structures and that led to more experimentation with respect to the height, shape and capacity of the structure. These sorts of upgrading resulted in the use of high-strength bolts replacing hot-driven rivets, the use of electric arc welding in shop fabrication and the compressive strength of concrete catapulting.31

30 Kayvani, Tall buildings, 24
31 Ibid.
The evolution of the structure of high rise buildings

These technological advances, consolidated with a more profound knowledge and practical understanding of structural behaviour more specifically wind loads, gave a push to the advancement of super high structures being constructed in Chicago amid the 1970s. The framework and type of unique tall structure used to be structurally determined, like in the case of, the John Hancock Centre built in 1969 that had structural steel as a major component of the plan. These super tall structures were brought about by architects as “tubular” plans where the whole building was conceived as a cantilevered “tube” John Hancock Center, 1969 or a heap of tubes in Willis Tower, 1974.
Today, architects and builders have more liberty to explore and experiment than any other time in the recent history. The architect’s unique design is then implemented by the engineers to build the structures because of progress in technology. This would not have been achievable 20 years ago. Though complex structures would timely bring about an expansion in development cost, a watchful and modern building approach is required to accomplish the engineering vision without surplus costing. Regardless of whether it is in the decision of the horizontal load-opposing structure and/or floor frameworks, or opposing breeze loads.\textsuperscript{32} & \textsuperscript{33}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{skyscraper_timeline.png}
\caption{Skyscraper timeline}
\end{figure}

\textsuperscript{33} Ibid.
in the approach for integrating the structure in the general geometry and design of the building, the choices made by the architect or structural engineer profoundly affects the cost, amenity, constructability, and sustainability of tall buildings.

Thin high rises aren't conceivable all over and this has more to do with the location and the objective behind it, than structural and framework capabilities. As design advanced, architects began to utilize the idea to motivate the types of the structures they composed. Cases like the incorporate Bank of China Tower in Hong Kong which during the time of its development set the record of the tallest commercial structure outside North America and Gherkin in London, where civil engineers along with architects adopted versatile strategies in comparison to the diagonalized framework structures in order to create magnificent high-rise buildings of proficiency and style.34
3.2.2 **Purpose of high-rise**

The primary motivation and reason behind building high rise is to use the minimum amount of land in a restricted territory by working in a vertical heading attain maximum output. Its architects and engineer’s obligation to design high rises that are decisive, sustainable and receptive to their urban setting. The high rises with architecturally brave in design with notable height is hardly noted until the functioning of the building and its density is beneficial for the people in that local setting.

“One of the greatest difficulties is altering the previously established assumption that high-rise structures are fabricated only for being tall. A lot of people think of skyscrapers as being a bit egotistical, which can be true in some instances, but with the direction in the way the world is heading with regards to population growth and people wanting to be closer to their CBD centers, it’s something we definitely need to consider more of and get past that preconception. For a super tall building to work, there needs to be that right mix within the building and ample amenities provided,"  

As per Council on Tall Buildings and Urban Habitat (CTBUH), a hybrid high rise must have at least more than two functions to be called it as a mixed-use building. When a tall structure has a blend of lodging, residential, commercial, business and personal space in the same structure, it is basically a small vertical town. It is a building where individuals can live, work, mingle, eat, all under one roof, you truly need to make it as comfortable as possible and a

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knowledge of the right blend is very essential. Creating a feeling of a group is a developing urban need as urban communities wind up noticeably denser. To summarize, high rises try to achieve community strategy vertically rather than on a level plane.

Other than just getting people to socialize, there is also a financial benefit of mixed-use high rise, each function creates a tide of investment growing economic activity for both the occupants and the people in that building. This makes building high rise essential that makes urban places more accessible, that cater the rising population and provides reasonable housing. While high rises are actually a productive use of land, smart design through systems including mechanical ventilation, vertical gardens, lighting, glazing and highly efficient heating and cooling enable the buildings' inhabitants to live greener.37 Using these measures makes skyscrapers greener than sprawl, and they host social, economic and aesthetic senses.

As per the studies by Jane Jacobs and Jan Gehl in the 1960s, the interaction of building edges, public streets, and social interaction, created some of the classic analysis of working of an urban public realm. 38

37 Gaal, Skyscraper Ambitions, 30
3.2.3 Relations with Technology and Economic Conditions

There was a reasonable movement from tall to super tall to uber tall with the assistance of driving innovation. The extensive pace of urbanization during the last few years has caught an accelerated rise in the development of high-rise structures around the world, especially in the rising economies of the world.

A major financial purpose behind the development of tall especially private structures is because of the shortage of land in the densely populated urbanized parts of the nation. In the previous two decades, the race for creating the tallest has been stretched out for creating the most notable high-rise building rendered in complex geometries and tilting frames. Over the years, CTBUH has been jotting down information of high-rise structures. The following is a bar graph diagram depicting the various courses of events and stature of tall structures, concluding at the Burj Khalifa in Dubai in 2008, which is 828 m-tall and is currently the tallest structure in the world.39

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39 Kayvani, Tall buildings, 24
Over the years the definition of 'high-rise' has evolved. Council on Tall Buildings and Urban Habitat coined a 200 meters + building as ‘tall’, 300 meters+ as 'supertall' and 600 meters+ to be ‘uber tall’.\textsuperscript{40}

\textsuperscript{40} Kayvani, "Tall buildings," 24
The tallest structures on the planet, the capacity of the structures and the materials used to develop these structures, are quickly evolving. A couple of decades ago, 75% of the tallest buildings were situated in the Northern region of America and starting at 2014; this figure is under 25% with the move happening overpoweringly to the Middle East region and Asian countries.

The capacity of tall structures has likewise changed altogether in the previous five years. Before, the capacity of the 100 tallest structures on the planet moved far from the transcendent office structures that have commanded the tallest records for a long time to more private and mixed-use capacities. Growing population and fast urbanization in rising nations clarify why such huge numbers of tall structures are being produced for private and hybrid purposes rather than solely for business office utilize.\(^1\)

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\(^1\) CTBUH Journal, 2008 “Tall buildings past and present trends,” accessed Aug 28, 2017
http://www.ctbuh.org/LinkClick.aspx?fileticket=M7nXrLx8g0M%3d&tabid=1108&language=en-GB
Deciding the appropriate structural materials and driving monetary plan

The basic materials utilized as a part of tall structures are single or mixture of structural steel, concrete and composite frameworks. Basic structural frameworks for high-rise structures are usually chosen considering architectural, economical and site factors. The financial drivers vary by geography as the relative expenses of material, labour, time and space vary from location to location. Different elements to consider in picking the structural material include:

- Local Market Preference/Availability
- Building Form General vs Complex
- Project Estimate Size/Height
- Site Location/Access and Speed of Construction
- Design Considerations (Fire Performance, Adaptability)
- Climate and Location

Inclinations and the financial practicality of the distinctive basic materials that are utilized as a part of tall structures’ development are evolving. World’s tallest structures were all-steel structures making for about 90% in the year 1970. Complete steel structures represent fewer than 15% in comparison to concrete or composite structures. The cost of the material, technological expertise and how tall structures are being fabricated all impact this adjustment in the material selection of tall structures.\(^{42}\)

\(^{42}\) Kayvani, Tall buildings, 24
\(^{43}\) Ibid.
3.2.4 Hybrid Typology

The concept of a hybrid use structure is not recent. It was conceptualized in the medieval times, where there was a desperate need as the population was increasing tremendously and there was a shortage of land for future development. More and busier roads, streets, and service lanes resulted in building structures being vertically developed containing both household and work offices in the same region. The most widely recognized instance of such a scenario would be of the house over a store, where the merchant stacks his goods on the lower level where he can easily get noticed and interact with potential buyers, whereas at the same time he and his family could have their personal space on the upper level.

In the 19th and 20th century, the mixed-use structure focused on progress and augmentation. With regards to building typologies, this development is a shift in style and adaption to advancing planning regulations.

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45 Martin Musiatowicz, Hybrid Vigour and the Art of Mixing, Hybrids I = high-rise mixed-buildings (2008), 5.
46 Martin Musiatowicz, Hybrid Vigour and the Art of Mixing, Hybrids I = high-rise mixed-buildings (2008), 5.
In 1916, New York Zoning resolution presented the thought of correct inclination of the sun to the midway of the road. This resulted in minimum setback rules applicable for all high-rises in New York City, which also constrained building masses to be set back from the streets, with respect to their stature. Designers were needed who would follow the thoughts of the Ecole des Beaux-expressions, which overlooks the conventions of the past. Accordingly, sufficiently lit spaces, logical necessities for building structures and economy were more significant than outlined French cornices. Urban cities in North America, for example, New York are based on grids, which delivers both orderliness and restriction to development and extension. Hybrid use architecture stands for expanding the limitations of a city based on grids. The Downtown Athletic Club (1930) and the Equitable Building (1919) were instances of this sort of disruption, which intended to overlay functions like retail on the lower floors, workplaces on the intermediate floors, and entertainment spaces on uppermost floors. The two structures are vertical cases of the physical analysis of the zoning laws of the time and each boosts the potential utilization of accessible land.

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Going by this, architect Raymond Hood had a feeling that “every businessman in the city must have realized the advantage it would be to live in the Building where his office is located”. Hood recommends a vision of constructing a “City under a Single Roof”.\(^5\) This approach collaborates workplaces, apartments, enterprises, organizations, lodgings, and theaters in an enormous volume such that all day to day activities can occur in the same building; and the best case of this are the Unit Buildings (1931).\(^5\) It was a very detailed variant of a hybrid complex and a prelude to a mixed-use development in architecture.

The term Hybrid is characterized as “a substance derived by combining two unique components”. The term goes about as an analogy in architecture that hoists the act of mixed-use into a more cohesive outcome. The mere difference between a typical mixed-use building and a hybrid depends on the nature of multi-functional unification with the single building mass. Hybrid building developments are geometrically scaled with regards to the city is generally done in two ways: horizontal and vertical.\(^5\) The vertical cycle overlays functions with the goal that one function is laid over another; while horizontal development is dealt with on-floor additions, for


\(^{51}\) Ibid.

\(^{52}\) Javier Mozas, This is Hybrid, Spain, a+t editions, (2011).
example, expanding the number of activities per floor. In the twenty-first century, hyper-urbanization has seen nations like China cultivating a sprawl targeting a more viable and productive development in both the geometrical ways. Devoting a chosen area just for a single task isn’t productive any longer. The ever-expanding population, resulting in increase of activities, is tended to by the “floor-area-ratio” method.\textsuperscript{54}

With reference to my thesis project, the mixed-use typology will be put to test as far as tending to these present issues in the city and will also observe how it can impact its analysis, pre-assuming future advancements.

\textsuperscript{54} MVRDV. The Vertical Village, Rotterdam (2012), 13
3.2.5 Climate and Environmental Factors

Climatic conditions and natural elements can affect the design and development of a high-rise building and consequently it is one of the prime factors that are thought about.

For a high rise, the lateral wind loads acting on the structure varies from place to place. These wind loads can be countered with use of bracings in structure and strengthening the core structural system of the building. Same goes for the seismic forces as well. The use of timber proves beneficial for seismic considerations as the timber is lighter and doesn’t cause vast ramifications on the building.

The positioning of the sun path during the whole season plays a vital role in arranging the public and private places. Public open spaces are usually aligned towards the northern sunny side. The damp and dark spaces of the site like the southern region are beneficial if designed for service cores of the high rise. In terms of hybrid construction of concrete and timber, the damp southern side of the site could be made of timber and the northern side can be assigned for concrete construction as concrete has more heat retaining capacity because of silica content in it which keeps the room warm in the winter.\(^5^5\)

3.2.6 Sustainability

Architects and engineers need to be more watchful of the worldwide impact of the buildings as they have certain effects on the environment. Globally, man-made buildings are the reason for 40 percent of energy use, 30 percent of waste produced and 15 percent of water use.\textsuperscript{56}

Even though the demand for good economical designs for high rise hasn’t changed drastically, the demand for tall sustainable buildings is growing rapidly. High-rise buildings consume more energy and material and that’s the reason new innovations in the use of material become even more viable. The key component of a building is its structure and it’s the main source of energy consumption which leads to substantial building costs as well.\textsuperscript{57}

Sustainable design goals can be achieved by addressing the following three objectives: reduce, reuse and recycle. The use of three R’s namely: reuse, reduce and recycle can assist the project to achieve sustainable targets. Use of alternative industrial by-products like slag, fly-ash can severely reduce the inbuilt resources spent on concrete production.\textsuperscript{58}

‘Reuse’ in architectural projects could be achieved by the means of the adaptive use of existing materials. The adaptive reuse of material can be achieved fully by means of flexible planning. A simple form of structural network in design phase solves many complicated future problems in terms of structures. Future tall buildings could be designed keeping in mind the recyclable nature of the structural members with new materials like fibre reinforced


\textsuperscript{57} Kayvani, Tall buildings, 24

concrete and engineered timber. At present timber tower as high as 18 storeys in Canada has been built.\textsuperscript{59} With proposals for 44 storey tower in London being researched on using steel reinforced timber.\textsuperscript{60} As timber construction is pre-fabricated off-site and assembled on site, the labor and machinery costs for timber construction drops down drastically as compared to concrete and steel construction.

**Timber**

The most sustainable construction material in today’s world is wood, but just not any wood. Studies have predicted that in coming 36 years the world's urban growth will double up, in turn, increasing the need for taller structures in urban areas. In such situation, it is very important that Architects and Engineers are made aware of the benefits of timber construction and also the contribution that they could make towards Earth’s health.\textsuperscript{61}

“It allows us to think about managing our forests in a way that allows us to do more with what we have,” Maness says. “We can use diseased or low-quality smaller trees that are grown for production instead of going out and harvesting from our national forests”.\textsuperscript{62} The towers strength and mass rely on highly engineered materials like Cross-laminated timber, Glue laminated timber, Laminated Veneer Lumber, and Poles.

\textsuperscript{59} Lloyd Alter, “Students move in to the world’s tallest timber tower,” accessed on September 14, 2017

\textsuperscript{60} Warren Cornwall, “Would you live in a wooden skyscraper?” accessed on August 25, 2017

https://oregonclt.com/the-worlds-most-sustainable-high-rise-construction-material-is-wood-2/

\textsuperscript{62} Ibid.
CLT (Cross-Laminated Timber)

A research program was funded in the mid-1990s, by the Austrian government to develop a new and stronger form of “engineered”. The outcome was cross-laminated timber. A lightweight and robust material, which could be pre-assembled and custom, cut.

The simple magnificence of CLT is its orthotropic quality. Typical wood is solid toward the grain however weal in the cross course. Cross-laminated timber are enormous panels up to half a foot thick, which are glued together by the layering of parallel beams on top of each other perpendicularly, making it strong in two directions. This gives it steel like strength. According to research by Waugh Thistleton, CLT is economically beneficial as the construction is about 15% cheaper than conventional steel and concrete.63

Production of concrete and steel generates a ton of carbon dioxide as it requires huge measures of vitality to deliver and transport. On contrary, engineered wood like CLT, which requires extra vitality to cut into sections, is much more environmental friendly. When a high-rise tower is constructed using CLT, the carbon saving would be huge.

As stated by an organization Wood for Good, which promotes sustainable wood construction says that wood acts as an excellent insulator, five times more than concrete and 350 times more than steel. As a result, timber buildings require less energy to heat and cool.64

“Wood is the new concrete,” says de Rijike, of dRMM. “Concrete is a 20th-century material. Steel is a 19th-century material. Wood is a 21st-century material.”65

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64 Joeleena Corbin, (2015). The World’s Most, 50
65 Clay Risen, Cross-Laminated, 51
Anatomy of a Timber Tower

1. Whereas steel or concrete structure is skeletal, using columns to carry loads, CLT towers distribute weight over the entire, solid vertical panel.

2. Steel or concrete L-brackets fix the horizontal and vertical CLT panels together.

3. The horizontal spans between vertical CLT elements can be significantly longer than with steel or concrete beams.

4. Interior walls are usually fireproofed by applying a layer of gypsum paneling on top of the mass timber panels.

5. Panels come made to order with windows cut out, sometimes piping and electrical installed. Construction is as easy as screwing the panels together.

6. Elevators have a double wall with insulation sandwiched between them for fire safety and soundproofing.

Four groups have been derived based on the structural system of timber structures namely; portal frames, surface structures, arches and a final group of post-and-beam systems.66

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Portal Frames

Portal frames consist of three different forms. In a few cases, the entire portal is curved while in others it’s been fabricated from glue-laminated timber. All remaining portals utilize LVL. As timber is a cost-effective and a very efficient material it has revolutionized the forms and detailing of structures. The 1200mm max depth of LVL billets appears to define a practical max beam depth which, for a light roof without a ceiling, can span up to 32m. Such a span to depth ratio of 26.7 compares closely to the ratio of 30 for two-pinned frames according to the rule-of-thumb estimates of the “Timber Design Guide”.

Nailed gussets are used to provide rigidness and strength where rigid joints are not achieved by bending laminates around a curved knee joint and apex joints. The base connections of a portal column are always pinned; Steel hardware is bolted to the foundations and forces from the timber columns transferred into them by bearing and either by bolts or screws. As far as the lateral load resistance of all the portals is considered they depend on the frame action to resist athwart wind and earth tremors. To achieve longitudinal stability, tension-only steel bracing is provided in roof and wall planes.67

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67 Ibid., 42.

Figure 23 Portal frame structures (Charleson & Perez, n.d.)
This kind of structures exemplifies the distinctiveness of contemporary long-span surface structures. In a few of the contextual analyses, steel members are used in the structural system to withstand tension forces. The structural forms are quite diverse and vary from a regular geodesic dome to freer forms that maximize surface actions like tension and compression. Sawn or glued-laminated timber is used to achieve curvature in surface structures. However, a curved or a shell form can be achieved by interlocking short lengths of LVL.\textsuperscript{68}

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\textsuperscript{68} Ibid., 43.
Arches

None of the arches are utilized as a standard two-dimensional framework spanning transversely to encase a vaulted volume. The greater part of these curves frames intricate 3D curved surfaces that seem, by all accounts, to be shell or surface structures. Timber arches can span over a range of (20m to 157m) and outline how arches can empower some interesting structural forms.69

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69 Ibid., 44.
Post and Beam

Post and beam are basically cantilevering canopies, in which all the timber posts are circular. These structures are notable for their use of timber poles, mainly as vertical elements, and their significant variation in their architectural forms given similar structural systems.\textsuperscript{70}

Conclusion

The timber structural materials widely used are LVL (laminated veneer lumber), glulam and poles. The less utilized materials are plywood and sawn timber. The usage of LVL was restricted to light-industrial portal frames but it has the potential to be consolidated into other structural systems as well. Poles were found exclusively in post and beam and cantilever structures. Glue-laminated timber was prevalent in all structural categories.\textsuperscript{71}

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\textsuperscript{70} Ibid., 45.

\textsuperscript{71} Ibid.
**Timber as sustainable**

Sustainably harvested wood buildings store carbon for the life of the building and beyond when a wood fibre is recycled or recovered. In addition to these factors, wood’s lower energy depletion during production results in lower greenhouse gas releases in comparison to the production of other building materials. Mass timber products are versatile and high-performance building materials, particularly where ecological targets are concerned.\(^1\)

One of the biggest drawbacks of wood construction in comparison to concrete and masonry industries is the fact that wood can flare up. Hence, wood isn’t as safe as concrete amid a fire. But the recent tall wood buildings are made from Cross-Laminated Timber (CLT) that doesn’t burn very well by any means. When solid wood is exposed to fire the outside of it burns, which really gives a protecting layer; this has been known for a long time, which is the reason substantial timber structures were composed of larger members than were simply required for structural motives. Cross-Laminated Timber works in the same fashion.

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\(^1\) Lyod Alter, *Students timber tower*, 40.
Figure 29 Fossil fuel energy used in manufacture of building materials

Figure 28 Carbon released and stored in the manufacture of building materials

Source: timber in ecologically sustainable development, retrieved
There is another advantage of working with wood in an earthquake zone as it is a lot lighter. The lower mass results in less inertia and therefore lower resistance to overturning during an earthquake. The concrete foundation and ground floor provide a counterweight to resist overturning forces. Concrete is not an ideal approach to build with, in an earthquake zone, where light-weight and flexible joints making buildings much safer.\textsuperscript{73}

This has generated a new inclination towards tall wood buildings. And the tallest of the tall wood buildings is Brock Commons Tallwood House, which is an innovative tall wood hybrid building at the University of British Columbia. It's a student abode and has just been given possession. It features mass timber as a practical building material in a high-rise application and demonstrates a novel and sustainable way to enhance the performance of buildings. The innovative mass timber-hybrid structural system is economically feasible, adaptable and repeatable to other building types and uses. Incorporating wood, a renewable substance that stores carbon, into its buildings, reflects UBC’s pledge to sustainability and revolutionary new building technologies.

We can conclude that if we want to reduce our carbon footprint, we need to make a conscious effort to quit using concrete wherever possible.

\textsuperscript{73} Ibid., 47.
3.3 | **Precedents**

3.3.1 **Analysis**

**MARKTHAL (MARKET HALL)**

- **Project**: Markthal (Market Hall)
- **Location**: Rotterdam, Netherlands
- **Architect**: MVRDV
- **Type**: Mixed-use / Hybrid
- **Programme**: Public Market, Apartment 228 units
  - Restaurants, Underground Supermarket
  - Underground Car park.

Since early 1990’s the site in Binnenrotte, Rotterdam was originally used to host an open-air market. In 2004, unfortunately, the changes in health regulations prohibited the sale of fresh food in open air. As a result, Markthal started in 2014 was the first unique hybrid building of the Netherlands featuring a covered public market. The huge arch consists of apartments and space underneath is utilised as a market floor. The height of the arch-shaped building and its

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colourful interior makes it visually striking. Unique is the combination of an apartment building covering a fresh food market with shops, restaurants, supermarket and an underground parking. More unique is the way in which all these different functions are combined.\textsuperscript{75}

Markthal has made strong contributions to the urban economy and its surroundings. Markthal with its day to day fresh food market, shops and housing units, creates coherence and connections in the neighbourhood which will reach a new centrality. The apartments in this hybrid building also fulfil the high demand of residential density in the inner-city area.\textsuperscript{76}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{interior_view}
\caption{Interior view (Scagliola & Brakkee, 2014)}
\end{figure}

\begin{footnotesize}
\begin{enumerate}
\item Markthal Rotterdam / MVRDV. (2014). Retrieved from \url{http://www.archdaily.com/553933/markthal-rotterdam-mvrdv}
\item Ting, People’s supermarket, \url{http://www.archdaily.com/553933/markthal-rotterdam-mvrdv-5431b19cc07a809a0e00054a-markthal-rotterdam-mvrdv-photo}
\end{enumerate}
\end{footnotesize}
The horseshoe-shaped structure creates a void through the building where the market is situated. This 40-meter arch shelters the new market and the arch contains 228 apartment units. To engage the public the building was designed to be as open as possible. Simultaneously, the Architect had to bear in mind the new regulation of ‘no fresh food in open air markets’ and also tackle weather condition. MVRDV tackled the problem using cable net structures, with glass mounted facades. The two large glass facades and light wells on top of the arch provide invincible amount of natural light, giving a feeling of outdoors within the market.\(^7\)

It comprises of 96 fresh-food stalls, 20 specialist food stores and restaurants, 228 apartments and parking for 1200 cars. The locations and size of the market within the quieter part of the inner city attracts a lot of population from neighbourhood, however, to attract tourists MVRDV collaborated with local artists to fill the 11000m\(^2\) ceiling with a panoramic artwork. A visual connection is made between the public and private spaces with windows in every apartment overlooking the market hall and vice versa.\(^7\)

\(^7\) Ibid., 51.
\(^7\) Ibid.,
BRYGHUSPROJEKTET – COPENHAGEN

Project: Bryghusprojektet (Danish Architecture Centre)

Location: Copenhagen, Denmark

Architect: OMA

Type: Mixed-use / Hybrid

Programme: Office Commercial Residential Restaurants
and Café Urban Park and playground

The design by OMA makes the existing playground facility a part of the project and extends it with new typologies for mixed age groups split all over the site – facing the city as well as the waterfront. The building is a hybrid development, which consists of residential and commercial spaces, restaurants, shops, parking, playground and the important DAC’s headquarters. At the transition point between landscape and building is a playground linked to the academic spaces of the DAC.

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81 Ting, People’s supermarket,

82 Basulto, Bryghusgrunden mixed use, Copenhagen
This urban project sits in between the city centre and the waterfront acting as an ‘urban mortar’ which links the city to the waterfront by a pedestrian walkway going under the existing motorway.\textsuperscript{83}

Despite it being a hybrid building, its primary program is still the DAC’s headquarters. So, to integrate all the DAC’s components, alongside other programs, OMA organized each facility in a vertical arrangement from subterranean and positioned each facility in a way that it provides a view over the city of Copenhagen. Overall, the Bryghusprojektet will transform a dead and hard to access space, into a new engaging public place. A development with a mix of activities all in one place\textsuperscript{84}

The building is designed to comply with the highest standards of the new Danish energy code. It uses environmentally sustainable systems such as using the sea water for cooling, a system which uses both mechanical and natural ventilation and a high-performance glass facade. During winters the public spaces will be kept warm by utilizing the heat gained from the building itself.\textsuperscript{85}

\textsuperscript{83} Ting, People’s supermarket,
\textsuperscript{84} Ibid.,
\textsuperscript{85} Basulto, Bryghusgrunden mixed use, Copenhagen
PONSONBY CENTRAL

Project: Ponsonby Central

Location: Ponsonby Road, Auckland

Architect: Jones Architects

Type: Mixed-use development

Programme: Markets, restaurants, and retail

Ponsonby Central is a fresh approach to a mixed-use development which was established in 2012. The initial plan was to develop the site into a residential complex with four-tower apartments. But later, the new owner came up with idea of the community-centric concept, which was welcomed by all.

Initial plans were drawn by Jones, to create two central axes. One from Ponsonby Road to the car park, and another from Richmond Road through to Brown Street. “This would create a cross to link all the storefronts together,” Jones says.86

It was organized in a way that three zones namely produce market, a chain of food and retail would be created. The idea was that the produce from the market converted into meals at the front. A series of retailers line the Ponsonby road which is the third zone.

The rustic look of the place is created using wood, concrete, and steel followed by all. The earlier plan of apartments is still in discussion and soon would be a part of this community-centric concept making it more hybrid.
LINKED HYBRID

**Project:** Linked Hybrid

**Location:** Beijing, China

**Architect:** Steven Holl Architects

**Type:** Hybrid complex

**Program** - 750 apartments, public green space, commercial zones, hotel, cinematheque, kindergarten, Montessori school, underground parking

This is a twenty-first-century iconic urban development in China which creates an open urban space, accessible to the public from all sides. The 220,000-square meter pedestrian-oriented Linked Hybrid complex sited adjacent to the site of the old city wall of Beijing. Filmic urban public space; around, over and through multifaceted spatial layers, as well as the many passages through the project, make the Linked Hybrid an "open city within a city". It is designed in a way that public encounter varies interactive spaces in between commercial, residential, and educational to recreational. The structures underground, on the ground and over the ground are fused together to create a holographic urban space.87

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There are open passages on the ground floor for both residents and visitors to walk through generating a micro-urban space. Around the large reflecting pond are shops activating the surrounding urban space. On the ground level, there are also other public spaces such as restaurants, hotel, schools, kindergarten, and theatre. All these public functions are linked with surrounding and penetrating green spaces.\textsuperscript{88}

On the intermediate level of the lower buildings, public roofs gardens offer tranquil green spaces, and at the top of the eight residential towers, private roof gardens are connected to the penthouses. The elevator displaces like a “jump cut” to another series of passages on a higher level. The multi-functional sky bridges from twelfth to the eighteenth floor include swimming pool, gymnasium, café, gallery and auditorium connecting the hotel and eight residential towers, which offers picturesque views of the city. The base-loop and the sky loop were designed with a hope to create random relationships and function as social buffers for both residents and visitors.\textsuperscript{89}

Geothermal wells (660 at 100 meters deep) provide Linked Hybrid with cooling in summer and heating in winter and make it one of the largest green residential projects in the world (aiming at LEED Gold rating).\textsuperscript{90}

\textsuperscript{88} Ibid., 57.  
\textsuperscript{89} Ibid.  
\textsuperscript{90} Ibid.
3.3.1 Inference

The selected case studies in its own specific manner exhibited its hybridity, but the similarity in between these four case studies is that they are all effective open spaces. Each of the four projects has in some way or the other uplifted the neglected sites in the city area.

<table>
<thead>
<tr>
<th>Markthal</th>
<th>Bryghusprojektet</th>
<th>Linked Hybrid</th>
<th>Ponsonby Central</th>
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</thead>
<tbody>
<tr>
<td>Hybrid building</td>
<td>Hybrid building</td>
<td>Hybrid building</td>
<td>Hybrid building</td>
</tr>
<tr>
<td>Public markets, restaurants and residential</td>
<td>Offices, cultural community centre, residential and other public spaces</td>
<td>Residential and commercial, hotel, theatre, schools and open public spaces</td>
<td>Markets, restaurants and retail</td>
</tr>
<tr>
<td>Vertical layering of programs</td>
<td>Stacked but scattered layering</td>
<td>Vertical towers connected with loops</td>
<td>Horizontal development</td>
</tr>
<tr>
<td>Clearly defined circulation pattern</td>
<td>Overlapping of public and private circulation</td>
<td>Base loop and sky loop act as social buffers</td>
<td>Two defined central axis</td>
</tr>
<tr>
<td>Separate public and private spaces</td>
<td>Common spaces in between for unexpected encounters</td>
<td>Public and private spaces linked with the green surroundings</td>
<td>Common cross link to all store fronts</td>
</tr>
<tr>
<td>Visually connected</td>
<td></td>
<td></td>
<td>Visually connects to the city</td>
</tr>
<tr>
<td>Urban permeability achieved by large openings at both ends</td>
<td>Urban permeability achieved by connecting the city and the waterfront</td>
<td>Urban permeability achieved by walk through accessible from all sides</td>
<td>Urban permeability achieved by produce-convert-create</td>
</tr>
</tbody>
</table>
4.1.1 Site Selection

As the project mainly focuses on urban intensification, two sites were considered for the project in Auckland’s CBD region.

**Site A: Wynyard Quarter-Tank Farm**

A reclaimed land also known as Western Reclamation on the Waitemata Harbour was constructed by Auckland Harbour Board. Mainly used for timber trade initially, later it gradually changed to bulk petrochemical storage. With the lease for bulk chemical storage ending in 2011, this vast piece of land is currently available for development.

**Site B: City Works Depot (CWD), Wellesley Street**

Historically this site was used as a workshop for Auckland city development. CWD flanked by streets on three sides is positioned at an important motorway interchange.

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Figure 42 New Zealand map with Auckland demarcated & Auckland CBD map indicating the selected sites
The Chosen Site - Site B (City Works Depot)

Context - The site sits to the west of Queen-street, and is mainly surrounded by the commercial office or retail buildings. Its geographical position makes it a striking spot right in the heart of the city. Its proximity to Victoria Park supports the residential as well as the social settings for the design proposal. The proposed Aotea square station falls within 5 minutes of walking distance from the site. Adding to its prime location is the key motorway interchange within 2 minutes reach. It is also accessible by public bus from Wellesley Street. All these factors brand the site as one of the prime locations for commercial businesses to flourish.

Figure 44 Context Map
4.1.2 Site Analysis

**Site Conditions**

**Access** - The site is flanked by streets on all three sides. Single-way Nelson Street running towards north aligns in a North-South direction on the eastern side of the site. Wellesley Street (northern side) and Cook street (southern side) run parallel to each other in East-West direction. Vehicular access to the site is from Wellesley St. and Cook St. and pedestrian access is from all three streets with a dedicated pedestrian access from Nelson Street.

**Topography** - The site sits on the edge of the horseshoe-like topography of Auckland city. The highest point of the site being 31 meters and the lowest being 18 meters. The site slopes down in two directions from the highest point at the junction of Nelson St. and Cook St. One side falls towards West and the other falls towards North. The natural setting further divides the area into three levels as shown in Fig. 54.
Figure 52 Image indicating slope of the Contours

Figure 53 Wind Analysis for the Site

Figure 54 Site divided into two different levels as on site
**Existing Site**

The site has a shed with multiple functions within. The current portal structure which spans (100 x 60) meters are made of thinly pressed steel portal frames and tilted glass, to maximise the natural light entering the building.  

As per the first-hand report, the site comprises of cafes, restaurants and commercial office spaces. The open area around the building is mainly used for open parking space which is not pleasing in an urban fabric. Out of the total site area, only 20% of the site is open for public use and the rest is privately and semi-privately owned.

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*Figure 56 Existing Site Scenario*  
*Figure 55 Site with 20% public use*

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Site Images

Figure 57 Panorama of site
Figure 58 Panorama of site
Figure 59 Sun Path Analysis

Summer

08:00 AM  10:00 AM  13:00 PM  16:00 PM

Winter

08:00 AM  10:00 AM  13:00 PM  16:00 PM
**Sun Path Analysis**

As the site is surrounded by high rise commercial/residential buildings on the eastern side and the topography on eastern end being high, the direct morning sun reaching the site is low in summers and almost no direct sunlight reaches the site in winters.

The topography on the western side of the site slopes down further and therefore the site receives ample amount of light throughout the day even in winters. While the evenings remain the more or less same in summers, the winters as expected receive low light towards the end of the day.

The northern region remains well-lit throughout the day and the southern region relatively remains in the darker zone which needs to be dealt with in the design process further.

**Human Foot-fall**

The southern end of Nelson Street and the western end of Cook Street leads to motorway exits; hence the major pedestrian traffic approaching the site is from the north-western and north-eastern side of the site.

Considering the site to be more public friendly, supporting design approach needs to be adopted for the same.

![Figure 60 Human Footfall](image)
4.1.3 Site Inference

- The shed is an enclosed building with cafes and restaurants sectors of it open to public and the rest of the shed been privately owned which isn't open to public
- This expensive land in the CBD is majorly used as an open parking lot. With Auckland Council focusing on limiting cars to the city and making Auckland CBD pedestrian friendly, its viable to reverse the ratio of the existing parking to public friendly spaces on the site.94
- Due to its unique geographical location over the topography, the effect of sun path on the design is vital as the south-eastern region receives the least sunlight due to the neighbouring towers
- The main pedestrian approach to the site is from north-eastern side and north-western side as the motorway exits area are on the southern side

4.2 | Design Process

4.2.1 Program

What Design Methodologies should be adopted to create a harmonious place for different sectors of the society to work in tandem in Auckland city?

Before the design development is flagged off, it is important to recognize the key drivers of this project. The ideas arise from the first section of the document where many problems faced by Auckland city have been discussed.

- Urban sprawl engulfing Auckland city
- Shortage of homes
- Shortage of commercial office spaces

Figure 62 Auckland Skyline
Program

- Residential Apartments:
  One important physical realm for a successful market to respond to its surrounding neighbourhood and integrate with its community group. The project will include two apartment buildings that will adapt to its surroundings. These blocks will be composed of mid-rise buildings to ensure intimacy, life, and activity at street level. The most important entity of the project

- Public Space:
  One of the main entities of the design proposal. The proposal would focus on engaging public to the optimum level with the site and along with different functions of the building.

- Commercial Office Space:
  The design attempts to cater the shortfall in supply of commercial office spaces in Auckland CBD. This sector would help generate revenue for the maintenance of the public spaces.

- Open Green Space
  It adds to the value of the site and acts as a breather amongst the concrete and glass jungle of the city.

Figure 63 Program Bubble Diagram
4.2.2 Design Strategy

Zoning

- The major pedestrian approach to the site is from the north-eastern and north-western end, thus the open plaza of site happens to be from this end.
- Nelson Street is above ground level by 6 meters, idea is to have a podium at the base block for the design and a direct connection from Nelson street to the building over the podium.
- The site which admasures about 190 x 100 is divided into parts with introduction of pedestrian walkways running through the site.
Ideas

*Base Idea 1 -*

- Twin towers, one dedicated for Residential, other a mix of serviced apartments and commercial office spaces
- Both the towers connected by amenities block at the base
- Northern wing preferred for commercial office space to generate more revenue from rents
Conceptual Render Idea 1-

Figure 69 Conceptual 1
Base Idea 2 -

- Singular tower with all functions segregated at different levels
- Public access to the podium of two levels as it is stepped down to the ground level
- Additional vertical transportation with ramps on external façade to different levels apart from conventional vertical cores
Conceptual Render Idea 2 -

Figure 72 Conceptual Render 2
**Base Idea 3** -

- Singular tower with all functions segregated at different levels
- Public thoroughfare through the street connecting the Cook St. and Wellesley St. W
- Shops flanked on two sides of the through street to keep the street active
Conceptual Render Idea 3 -

Figure 75 Conceptual Render 3
4.2.3 Testing the Idea’s

- Twin Tower

- Dedicated tower for two different functions
- Public access to base of towers up to 3 levels including podium of 2 levels
- Pedestrian access spirals along the façade of the tower with help of ramps
- Retail shops alongside ramp
- Proposed plaza on northern side for social gathering and main entry for the site
- Introduced new vehicular access for the site, dissecting the existing lower level parking space
- 45 storey high towers
Connecting Blocks

- Two towers spread over the site with a possibility of the third tower as future proposal
- Blocks interconnected with bridges one storey which would act as public functional space
- Gaps between the tower blocks to let light penetrate and wind flow through the building
- Open market space in front of the tower blocks and an open plaza near the junction of Wellesley St. and Nelson St.
- 10 storey high towers
• Stand Alone

- Single tower 45 storeys high on the southern end of the site to open more space for pedestrians on ground level on northern end
- Pedestrian way flanked by retail spaces, pedestrian walkway spirals up the tower via ramp to open to a viewing deck
- The topography of northwestern region of the site gives an opportunity for pedestrian landscape
- Ramps to basement parking (underneath podium) from lower level of site to upper level of site
• Splitter Stand Alone

- Splitting the site with pedestrian walkways
- Connection to Nelson St. by means of the splitter walkway
- Pockets formed due to spiral ramps alongside tower used as public plazas on the northern and southern end of site
- Parking space is hidden under the activated pedestrian friendly podium level

Figure 84 SSA Ground Floor Plan

Figure 83 SSA First Floor Plan (Nelson St. level)

Figure 85 SSA Schematic Section through site
4.2.4 Test’s Inference

- The design should focus on being as public-friendly as possible and be more porous to welcome the city crowd.
- Amenities block which is at the base of the high rise needs multiple entries and exits inviting people to take shorter routes through the site thus creating a good public realm.
- Urban intensification focuses on using minimum land with high density, one tower block should be a viable option.
- Due to its height, the tower block would create dark and damp spaces on the site which should be avoided by aligning the tower block at the south-eastern end of the site.
- The ‘site splitter’ pedestrian walkway should not be enclosed and can be open facing the setting sun on western end.
- Cut down on the ‘pancake’ styled podium’s, rather invite people on ground level from Nelson St. via ramp and activate the ground floor.
- The green buffer on the site would add to the cityscape and would be an asset to the project and act as a calming entity to the site considering the proximity to the busy Nelson St.
4.2.5 Design from Tests

Public Space (Outdoor)

- Using the site’s topography to create an open plaza for the crowd which would also act as the main entrance to the site.
- Walking guides on floor with the help of difference in materials.
- Creating streetscape wherein people can enjoy the open views on western side.
- Designing a green belt between Nelson St. and the main building, along with a jogging track open for public.

Figure 87 Form evolution of Plaza on the northern end

Figure 88 Public Outdoor space arranging
Public Space (Indoor)

1. Starting off with a simple rectangular form for the building complimenting the open plaza

2. Tweaking the rectangular form with curves to invite crowds from Nelson St.

3. Introducing sharp angles to create green public space between Nelson St., building and on the western end to enjoy open sunset views

4. Since the south-eastern end had less to no sunlight, the floor plate was tilted to close off the south-eastern end of the site which opened up the open public space on the north-eastern front
Circulation (Indoor)

1. Starting off with straight and simple corridors for the retail strip

2. Modifying the straight corridor to curved one for the circulation

3. Straight aligned corridors with full visibility till end creates one-point perspective which gives a feeling of a long passage and is generally boring while walking. Rather slight gentle turns while walking keeps a person interested and alert while walking. The corridor of smooth curves as in Fig. 93 contradicts the internal space with the external space. The form depicted in the Fig. 95 compliments the design.
Assigning zones as per their functions

Figure 96 Zones as per their Function
Roof Moderation

1. Starting from the simplest, strongest and oldest forms of Long span, A Dome.

2. Changing the basic dome shape to allow sunlight to enter the long span structure.

3. Maintaining a visual distance for the Nelson St. pedestrians. But the sunlight entering the building is reduced.

4. Modelling a smooth finish which is pleasing to eyes from Nelson St. end.

5. A form which allows enough sunlight to enter the building and which is smooth at the same time. The roof climbs up from the Nelson St level giving an impression of direct connectivity to it from Nelson St.
Roof Inspiration

**Slater Bugs**

- Slater bugs have a heavy shell made of calcium carbonate which acts as an armour for its soft body inside.
- The profile of the shell is smooth and rounded. The thorax is the major part of the body and is consists of seven segments, which is protected with seven wide overlying dorsal plates.
- They usually have projections on the sides. Beneath each plate are couple of legs for mobility. They are called isopoda as the legs are similar in lengths.
- Individual plates spanning approximately 50 meters in length covering the public space beneath. Rather than having one whole roof over such a huge span and create another shed, the design focuses on splitting the roof in different segments of 6 meters.

- The design was further explored to create a sense of integration between the roof and the building. The roof replicates the gradient of contours which are rising towards the south-eastern end of site where the high rise is.

- Instead of inclining the roof in straight line towards the high rise, the roof was staggered in its inclination to allow afternoon sun seeping in the public building. The Glulam long span beams also create double heighted ceiling in the internal space which gives a grand experience.
Integration between Horizontal and Vertical

Figure 107 Design Concepts for Elevational Integration
• The roof with inclined stepped profile was given a curved path towards the high-rise building for form integration
• Roof over public market space rises towards southern direction and roof over auditorium inclines in eastern direction
Hybrid of Timber + Concrete

Having top 20 floors of timber construction and bottom 24 floors as concrete, wind loads at top would cause lot on stress at the junction of concrete and timber.

Learning from the case study of Brock Commons which is the tallest 18 storeys tower in world right now, few hybrid schemes for the proposed 44 storeys high are tested as shown in the figure.
05 | DESIGN OUTCOME
Figure 110 Ground Floor Plan
Figure 112 Longitudinal Cross Section
Figure 114 View showing plaza
Figure 116 View showing indoor restaurant place
Figure 117 Restaurant at upper level getting Harbour bridge views at night
6.0 **Conclusion**

**THE RESEARCH QUESTION**

This research aims to respond to the question “How can the design of a mixed-use high-rise building provide a solution to urban sprawl and increase sustainability?” This question gave rise to four main objectives.

The first objective was to arrest the urban sprawl happening in Auckland region over the fertile lands. In doing so, the second objective was to create a design which caters to the needs of the community in a confined space thus saving carbon emissions from their respective vehicle as is seen in the suburbs scheme. The third objective was to improve the social and visual collaboration of a public space and create a good sense of public realm.

**RESEARCH**

As a part of the process, contextual research of issues concerning Auckland were first considered which are as mentioned below:

- Urban Sprawl
- Housing
- Commercial

The review of contextual research indicated how the city has suffered urban sprawl and the by-products of it getting built. To cater this a strategy of urban intensification was suggested to be undertaken in which a site in CBD area could be intensified by mixed-use high rise building as a supporting solution to lack of housing and rentable commercial spaces.

After taking into consideration the conclusion of the contextual research, further studies were carried out on the below-mentioned topics:

- History of Skyscrapers
- Purpose of skyscrapers
- Hybrid Typologies
- Sustainable material for high rise building
The study on these fields helped the research in understanding the exact cause and use of skyscrapers. The complexities involved in designing a multifunctional high-rise building in an urban context were looked upon. An understanding of creating a good public realm amidst a busy city was studied. Use of timber material as a sustainable option as compared to steel and concrete was established.

**DESIGN PRECEDENTS**

Four precedents with different characteristics were discussed. The arrangement of the different functions in one consolidated building plays a vital role in all of them. The main elements of the building included vertical or horizontal layering of the functions, the overlap of public and private sectors, visual connectivity in the urban fabric with a distinct feature.

**THE SITE**

Since the proposal was to curb the urban sprawl and take measures to intensify Auckland cities, various sites in CBD were considered. The Tank Farm at Wynyard quarter and the City Works Depot site were analysed. The City works depot site was selected given its contextual location which is well connected with the public transport and the motorway.

In-depth analysis of the City Works Depot site mentioned revealed that the site had a distinct topography. A high point of 31 meters and a low point of 18 meters. The site being accessible from three sides made it even more interesting in terms of creating connections to the neighbouring streets of Wellesley, Nelson, and Cook. The existing site hosts cafes, restaurants and commercial office spaces. Out of the total site area, only 20% is accessible for public. Most of the site is used as a parking space.
DESIGN

The design aspires to reinvent the site and be more public friendly giving back more footage to the public. The project sets out not just to design a mixed-use high rise but an experience of the good public realm. Thus, the public realm is one of the main aspects of this project.

The design was mainly site oriented as per the topography and the access streets. As the project was proposed over an existing public space, it was rightful to give back to the community with abundant public facilities. The aim of this project was to densify urban core maintaining a good public realm at lower floors, along with modular residential units for the residents and commercial office space for Auckland city.

The form for integrating all the functions under one roof was driven by the site conditions. The junction of Cook St. and Nelson St. formed the anchor point for the site and the form gradually flowed onto the site from that high junction. Such interesting topography defined for public use along with open green spaces designed for the city with views to Harbour bridge makes for a good urban connect.

DESIGN OBJECTIVE

- A supporting solution to the urban sprawl and housing shortage, providing densification along with a good public realm
- Encourage efficient use of valuable CBD land and give most of the land back to the people of the city
- A hybrid design focused on engaging various sects of the society to co-exist under one roof
THE LAST WORDS

This proposal symbolizes an effort to design a hybrid building in an urban context involving various groups under one roof. It is a project for the people of the city to enjoy the design spaces and functions proposed under one roof. It is a gradual attempt to decentralize the focus from the crowded Queen street and spread the concentration around the city making use of the proximity of City rail link and the future proposed underwater motorway and rail link to Northshore.

The design makes use of the natural topography of the site and creates open green spaces in the middle of the city for the people to engage along with the apartment residents and office goers of the commercial building. This design attempts to offer a viable alternative for a multi-functional society while addressing the problem of urban sprawl in Auckland.
07 | BIBLIOGRAPHY


Auckland is New Zealand’s commercial hub, New Zealand now, accessed on 15 Sep 2017 retrieved from https://www.newzealandnow.govt.nz/regionsnz/auckland


Barr J., (1922) Municipal and Official Handbook of the City of Auckland, New Zealand, Wilson and Horton, Auckland


Colliers International, ”Retail Reality Check” NZ Retail Report 2015 page 02, accessed 15 March 2017
http://www.colliers.co.nz/find%20research/retail/nz%20retail%20report%202015/

http://www.ctbuh.org/LinkClick.aspx?fileticket=M7nXRLx8q0M%3d&tabid=1108&language=en-GB


Gehl Jan, Auckland Public Life Survey 2010, pg. 58 accessed from


Green Education Foundation, “Fly Ash Concrete,” accessed on July 12, 2017 


https://thesheet.ng/you-need-to-see-this-tall-buildings-past-and-present-trends-by-professor-kourosh-kayvani/ 


Musiatowicz Martin, Hybrid Vigour and the Art of Mixing, Hybrids I = high-rise mixed-buildings (2008), 5.
MVRDV. The Vertical Village, Rotterdam (2012), 13

Mozas Javier, This is Hybrid, Spain, a+t editions, (2011).


Kayvani, Tall buildings, 24

Rents for urban properties reach all-time high, 20 Sep 2017, retrieved from https://property.trademe.co.nz/market-insights/rental-price-index/rents-for-urban-properties-reach-all-time-high/


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