# Beneath the Tracks

by

Calvin Liang

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Master of Architecture
Waterloo, Ontario, Canada, 2025
© Calvin Liang 2025

# Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

# Abstract

As of 2025, Vancouver is facing a worsening housing crisis, with homelessness rising sharply each year and vacancy rates remaining critically low. Given the city's limited available land, it is essential to explore alternative spatial strategies. One such looked opportunity, lies beneath Vancouver's elevated SkyTrain tracks - a space in which hundreds of commuters pass over everyday yet remains underused. This thesis explores the untapped potential of these areas, reimagining them as prime locations for affordable housing that is targeted at young urban residents such as students, recent graduates and young professionals.

To understand the viability of this housing strategy, four categories of international case studies relating to under-SkyTrain communities are explored: [1] Reclaiming Elevated Spaces, [2] Prefabricated Units, [3] Tiny and Flexible Spaces, [4] Communal and Landscape Engagement. Many of these categories overlap, with the central case study encompassing all four categories being the Chūō Line in Tokyo. It is a project that most closely parallels the thesis vision, which successfully integrates housing with community and commercial life beneath elevated rail infrastructure. As a fully realized and active project, it offers an example of what an under-SkyTrain development in Vancouver could become. Other examples from dense cities like Hong Kong and Paris show innovative responses to limited land, many of which are becoming increasingly relevant in a rapidly growing city like Vancouver. The thesis also examines local cases to see how these strategies might actually play out in reality. By examining the range of both global and local projects, the thesis identifies key design and planning strategies that may be applicable to Vancouver's own spatial context and housing challenges.

The following section considers how these spaces could be integrated in Vancouver, and what it means to build so close to transit infrastructure.It explores topics such as the Transit-Oriented Development (TOD) strategy, historical context of the SkyTrain and sound mitigation.

The research, case studies, and context studies are ultimately synthesized into two design ideas that test how prefabricated housing and community can be integrated beneath the SkyTrain. The first explores co-living and retail near Metrotown Station (a high-density area), while the second looks at live-work housing around Royal Oak Station (a medium-density area). A lower-density site isn't proposed, since those areas still have room to grow without needing to build under infrastructure like the SkyTrain. This thesis challenges the idea that dense cities like Vancouver have run out of space. It doesn't claim to solve homelessness overnight, but it argues that under-bridge spaces shouldn't be dismissed as leftover gaps. With a shift in perspective, they can become seeds for community.

# Acknowledgements

To Terri Boake, thank you so much for your guidance and mentorship, always bringing in fresh ideas while keeping my thesis grounded and precise. Your deep knowledge and well-travelled perspective have been invaluable, and I appreciate your dedication and even reading my thesis even during a ski trip or before a packed conference. You gave me a guiding light when I felt unsure about how to move forward, and I'm incredibly grateful for your support.

To John McMinn, my committee member, thank you for your strong enthusiasm and expertise in prefabricated housing. Your thoughtful feedback added another layer of feasibility to my project, and you opened my eyes to possibilities I wouldn't have considered otherwise.

To Philip Beesley, my TRD-1 professor, thank you for your unwavering encouragement from the start to the finish of this thesis journey. I know I took my thesis in a million directions, and I appreciate your patience through it all. Your questions and support helped shape my interest in modular design and flexibility, which have become central to this project.

To my friends and classmates, thank you for the inspiration and support throughout this process. During moments when I felt lost, your encouragement and ideas kept me going. The late nights in the studio and online, the shared struggles and breakthroughs, and I couldn't have done this without you.

Finally, to my mom and dad, thank you for your patience, hard work, and constant support. Taking on this master's wouldn't have been possible without you. Even after long days working late, you still did everything you could to support me, and I'm endlessly grateful for that.

# Table of Contents


**Author's Declaration** ..... ii
**Abstract** ..... iv
**Acknowledgements** ..... vi
**List of Figures** ..... viii
**Chapter 1 | Introduction** ..... 1
1.1 Overview of Vancouver's Housing Crisis ..... 2
1.2 Under-Skytrain Spaces ..... 5
1.3 Research Question and Objective ..... 6
1.4 Competition ..... 7
1.5 Framework and Design Approach ..... 7
**Chapter 2 | Case Studies** ..... 11
2.1 Case Studies Around the World ..... 13
2.2 Reclaiming Elevated Spaces ..... 16
2.3 Prefabricated Structures ..... 49
2.3.1 Reusing Shipping Containers ..... 71
2.4 Tiny and Flexible Living ..... 85
2.5 Communal and Landscape Engagement ..... 96
**Chapter 3 | Reframing Under-Skytrain Spaces** ..... 104
3.1 Under-Skytrain Spaces ..... 105
3.1.1 History of the Line ..... 106
3.2 Spatial Conditions of the Skytrain ..... 110
3.2.1. Beyond Transit-Oriented Development ..... 114
3.3 Land Economics ..... 116
3.4 Prefabrication in Practice ..... 117
3.5 Noise and Vibration ..... 133
3.5.1. Source of Noise Pollution ..... 134
3.5.2. Passive Noise Mitigation Strategies ..... 136
3.6 Shared and Public Spaces ..... 138
**Chapter 4 | Design Implementation** ..... 140
4.1 System 1: [Box-Link-Box] ..... 142
4.2 System 2: [Core-Spine-Pod] ..... 150
4.3 Sample Site A: Metrotown Station ..... 168
4.4 System 3: [Base-Extender-Face] ..... 184
4.5 Sample Site B: Royal Station ..... 198
**Chapter 5 | Conclusion** ..... 214
**Bibliography** ..... 216

# List of Figures

**Figure 1** Image retrieved from https://council.vancouver.ca/20231031/documents/regu20231031p1_2023_Homeless_Count.pdf, modified by Author

**Figure 2** Image retrieved from http://hdl.handle.net/2429/82110

**Figure 3,4** Drawn by Author

**Figure 5,6** Image retrieved from https://www.khanacademy.org/humanities/renaissance-reformation/late-gothic-italy/florence-late-gothic/a/the-ponte-vecchio-old-bridge-in-florence

**Figure 7** Image retrieved from https://www.leviaducdesarts.com/en/the-viaduc-des-arts

**Figure 8, 9, 10, 11** Image retrieved from https://dsrny.com/project/the-high-line

**Figure 12, 13** Images taken by Author

**Figure 14 - 18** Image retrieved from https://chuolinehouse.com/plan/plan_l.html

**Figure 19 - 23** Image retrieved from https://chuolinehouse.com/plan/plan_h.html

**Figure 24 - 29** Image retrieved from https://chuolinehouse.com/plan/plan_c.html

**Figure 30 - 32** Image retrieved from https://chuolinehouse.com/plan/cafeteria.html

**Figure 33** Image retrieved from http://www.earthscape.co.jp/works/landscape_design/chuolinemall_project/

**Figure 34 - 38** Image retrieved from https://c.re-write.co.jp/works/kazoku-bunkasai2016/

**Figure 39, 40** Image retrieved from https://www.homes.co.jp/cont/press/rent/rent_00944

**Figure 41** Image retrieved from https://tachikawa.keizai.biz/headline/3115/

**Figure 42** Image retrieved from https://chuolinehouse.com/plan/

**Figure 43** Image retrieved from https://hyperallergic.com/437845/james-brittain-revisited-habitat-67/

**Figure 44** Image retrieved from https://www.archdaily.com/404803/ad-classics-habitat-67-moshe-safdie

**Figure 45** Image retrieved from https://hyperallergic.com/437845/james-brittain-revisited-habitat-67/

**Figure 46** Image retrieved from https://www.tokyotimes.org/inside-the-nakagin-capsule-tower/

**Figure 47** Image retrieved from https://www.archdaily.com/1006528/where-are-the-23-modules-saved-from-the-demolished-nakagin-capsule-tower-now

**Figure 48** Image retrieved from https://recollective.ca/project/monad/

**Figure 49** Image retrieved from https://www.naturallywood.com/projects/monad/

**Figure 50** Image retrieved from https://www.thinkwood.com/construction-projects/brock-commons-tallwood-house

**Figure 51** Image retrieved from https://vancouver.housing.ubc.ca/residences/brock-commons/

**Figure 52, 53, 54** Image retrieved from https://www.archdaily.com/919886/dyson-institute-of-engineering-and-technology-wilkinsoneyre

**Figure 54** Image retrieved from https://www.canadianarchitect.com/durham-modular-supportive-housing/

**Figure 55, 56, 57, 58** Image retrieved from https://www.canadianarchitect.com/durham-modular-supportive-housing/

**Figure 59** Image from R. Smith, Prefab Architecture: A Guide to Modular Design and Construction, Wiley, 2010

**Figure 60** Image retrieved from https://www.trinitybuoywharf.com/architecture/container-city-2

**Figure 61, 62** Image retrieved from https://livinspaces.net/design-stories/ls-tv/inside-londons-container-city/

**Figure 63** Image from R. Smith, Prefab Architecture: A Guide to Modular Design and Construction, Wiley, 2010

**Figure 64** Image retrieved from https://www.fanzo.com/en/bar/17067/boxpark-shoreditch

**Figure 65** Image retrieved from https://www.archilovers.com/projects/58115/boxpark-shoreditch.html

**Figure 66** Image retrieved from https://newcastlemagazine.com/the-top-shipping-container-shopping-villages-in-the-uk/

**Figure 67** Image retrieved from https://themanc.com/eats/food-and-drink-hub-hatch-confirms-reopening-date-for-april/

**Figure 68, 69** Drawn by Author

**Figure 70** Image retrieved from https://www.cca.qc.ca/en/articles/issues/2/what-the-future-looked-like/32737/1964-fun-palace

**Figure 71** Image retrieved from https://doi.org/10.3351/ppp.2024.4785923692

**Figure 72, 73, 74** Image retrieved from https://www.archdaily.com/497357/lt-josai-naruse-inokuma-architects

**Figure 75, 76** Image retrieved from https://www.archdaily.com/949150/nano-scale-gary-chang-explores-compact-living-and-the-future-of-dense-cities

**Figure 77** Image retrieved from https://architizer.com/projects/176-square-meter-apartment/

**Figure 78** Image retrieved from https://medium.com/@kagoleung/pet-architecture-6effeb4fd115

**Figure 79** Image retrieved from https://www.5050travelog.com/camera-and-lens-reviews/nikon-z7-ii-review

**Figure 80 - 83** Image retrieved from https://good-design.org/projects/caulfield-to-dandenong-level-crossing-removal-project/

**Figure 84, 85** Image retrieved from https://www.archdaily.com/995133/powwowwow-commercial-centre-all-zone

**Figure 86** Taken by Author

**Figure 87** Image retrieved from https://www.thecanadianencyclopedia.ca/en/article/SkyTrain

**Figure 88** Drawn by Author, overlayed transit map from https://www.TransLink.ca/schedules-and-maps/SkyTrain, and site conditions analyzed from Google Earth, modified by Author

**Figure 89, 90** Image taken by Author

**Figure 91** Image retrieved from https://globalnews.ca/news/3765443/track-work-has-TransLink-warning-weekend-commuters-of-SkyTrain-delays/ https://globalnews.ca/news/3765443/track-work-has-TransLink-warning-weekend-commuters-of-SkyTrain-delays/

**Figure 92, 93** Drawn by Author, overlayed transit map from https://www.TransLink.ca/schedules-and-maps/SkyTrain, and site conditions analyzed from Google Earth, modified by Author

**Figure 94** Image retrieved from https://www.burnaby.ca/recreation-and-arts/events/parkway-alive

**Figure 95** Images taken by Author

**Figure 96** Image retrieved from https://www.mckinsey.com/capabilities/operations/our-insights/modular-construction-from-projects-to-products

**Figure 97** Image retrieved from https://www.socma-forklift.com/other-equiments/reach-stacker-container.html

**Figure 98** Image retrieved from https://webthesis.biblio.polito.it/23233/1/tesi.pdf

**Figure 99** Image retrieved from https://www.mckinsey.com/capabilities/operations/our-insights/modular-construction-from-projects-to-products

**Figure 100, 101** Image retrieved from https://leckiestudio.com/portfolio/triptych/

**Figure 102** Image retrieved from https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/bc_std_des_catalogue_v1.pdf

**Figure 103** Image retrieved from https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/voices%20on%20infrastructure%20scaling%20modular%20construction/gii-voices-sept-2019.pdf

**Figure 104 - 168** Drawn by Author

# [Introduction]

With Vancouver's growing housing crisis, it is important to think creatively and come up with solutions that make efficient use of the city's limited space.

Beneath the SkyTrain lies a continuous zone of overlooked land that holds promise to support a new way of living and bring together community.

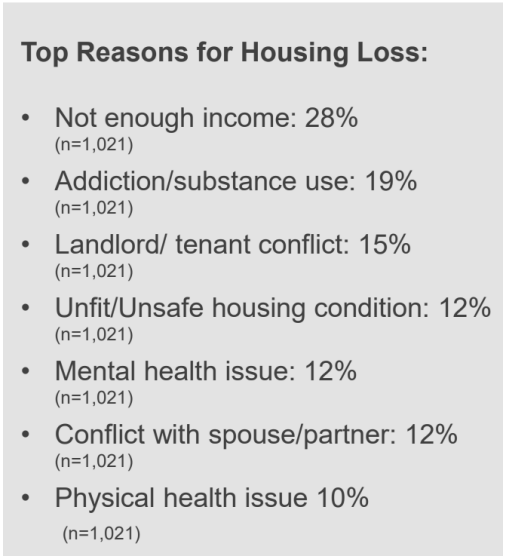
## 1.1 Overview of Vancouver's Housing Crisis

Vancouver, a city consistently ranked among the world's most liveable cities for its natural beauty and quality of life[1], is facing a severe and deepening housing crisis. Over the past decade, the availability of bachelor and one-bedroom units priced under $750 has declined significantly, creating a rental landscape where demand far outpaces supply. [2] Between 2012 and 2016, applications for subsidized housing in Metro Vancouver rose by 15%, with notable increases from people with disabilities (8%), singles (2%), and families (3%).[1] More recently, in the 2023 Homeless Count in Greater Vancouver, individuals who were identified as experiencing homelessness has increased by 32% compared to 2020 from 3,634 people to 4,821 people.[3] The number speaks for themselves, as the population continues to grow and urban density intensifies, housing has become increasingly scarce and unaffordable.

1 Singer, C. R. (2025, June 19). Canada's cities rank highly in Global Liveability Index despite Calgary drop. Immigration.ca. https://immigration.ca/canadas-cities-rank-highly-in-global-liveability-index-despite-calgary-drop/

2 Mauboules, Celine, and Dustin Lupick. "2023 Homeless Count, Vancouver." 2023 Homeless Count: Vancouver, October 31, 2023. https://council.vancouver.ca/20231031/documents/regu20231031p1_2023_Homeless_Count.pdf.

3 Homelessness Services Association of BC. (2023, October). 2023 homeless count in Greater Vancouver: Final data report. Reaching Home's Community Entity for Greater Vancouver. https://hsa-bc.ca/_Library/2023_HC/2023_Homeless_Count_for_Greater_Vancouver.pdf




**[Fig. 1]** "Not enough income" was listed as the top reason for housing loss

The 2023 Homeless Count study also identified the most common reasons for housing loss in Vancouver (see figure 1), with the leading reason being lack of income.[1] In recent times, wages have not kept pace with housing prices and a closer look at the rent / income data makes this gap even clearer. Looking at the income scenario for a typical male aged 31-50 in 2016, considering several scenarios (earning Minimum Wage, Receiving Persons with Disabilities and Receiving Basic Income Assistance) reveals that a typical single male aged 31 - 50 would scrape by with a remaining income of merely $335. Those identifying as receiving persons with disabilities and receiving basic income assistance will typically be in debt by the end of the month based on whether they paid the median rent for a bachelor's apartment.[4] Income assistance has remained unchanged for 9 years, while average market rent has continually increased year by year since 2010. Additionally, even for those who can scrape together the rent, the available options are scarce, with the most affordable bachelor suites (under $750/month) in Vancouver being only 0.1%.[4] These numbers reveal is that there is a systemic failure within the city to even meet the basic human necessity of shelter.

4 Pauly, B., Cross, G., & Weiss, D. (2016). No Vacancy : Affordability & Homelessness in Vancouver [R]. doi:http://dx.doi.org/10.14288/1.0416187

| Table 7 - Income-Food-Rent Calculation<br>Single (Male 31-50 yrs) earning Minimum Wage[19] | | |
|---|---|---|
| Data Category + Year | 2015<br>$10.45/hour<br>40 hours /week[20] | 2016 Forecast<br>at $10.85/hour<br>40 hours /week |
| Monthly After-tax Income ($)[23] | $1590 | $1639 |
| Bachelor Apt. Median Rent ($)[24] | $920 | $920 |
| Average monthly cost of Food in Vancouver[25] | $335 | $335 |
| Remainder for monthly expenses ($) | $335 | $384 |

| Table 8 - Income-Food-Rent Calculation<br>Single (Male 31-50 yrs) Receiving Persons with Disabilities | | |
|---|---|---|
| Data Category + Year | 2014 | 2015 |
| Average Assistance Paid ($)[26] | $880 | $891 |
| Median Rent of Bachelor Apartment in Vancouver CMA ($)[27] | $897 | $920 |
| Average monthly cost of Food in Vancouver[28] | $320 | $335 |
| Remainder for other monthly expenses ($) | -$337 | -$365 |

| Table 9 - Income-Food-Rent Calculation<br>Single (Male 31-50 yrs) Receiving Basic Income Assistance | | |
|---|---|---|
| Data Category + Year | 2014 | 2015 |
| Average Assistance Paid ($)[29] | $544 | $552 |
| Median Rent of Bachelor Apartment in Vancouver CMA ($)[30] | $897 | $920 |
| Average monthly cost of Food in Vancouver[31] | $320 | $335 |
| Remainder for other monthly expenses ($) | -$673 | -$704 |

**[Fig. 2]** Income-Food-Rent Calculations for Single (Make 31-50 yrs)

Among the most affected are young urban adults aged 25–44. This group, which comprises of students, recent graduates, and early-career professionals, has seen a rising share of renters, increasing from an already high number of 45.1% in 2016 to 47.7% in 2021.[5] This thesis focuses on this group because they are particularly vulnerable to these economic trends and being priced out of the city. There is a growing urgency for housing solutions that are both affordable and accessible to this population, a part of the population that is both mobile and contributes significantly to the economic growth of

5 Metro Vancouver. (2022, December). Metro Vancouver housing data book. Metro Vancouver. https://metrovancouver.org/services/regional-planning/Documents/metro-vancouver-housing-data-book-2022.pdf

the city. They are also more likely to be receptive and benefit from more experimental forms of urban housing, including modular, compact dwellings beneath existing infrastructure such as the SkyTrain. Elderly or disabled populations may require quieter and more stable environments, but young adults may find the central locations and affordability as an acceptable trade-off.

## 1.2 Under-SkyTrain Spaces

The term “under-bridge” has long carried connotations of marginalization and neglect. These spaces evoke imagery of people being pushed to the periphery of society to places that are physically and symbolically associated with homelessness and abandonment. Even the phrase “water under the bridge” implies something meant to be forgotten. Despite being unideal and never intentionally designed, these spaces offer something essential.

Homelessness is often viewed in negative terms, but it also reflects on a human survival instinct to adapt and be strategic with limited resources. Spaces underneath bridges weren’t intentionally thought of or designed for living. They emerged as byproducts of infrastructure as leftover zones as the city created more overhead paths for methods of transport such as cars and trains. However, one day, faced with limited living options, someone, somewhere approached the underside of a bridge. They found the space fairly dry, tolerated the sound, and found that it offered a level of privacy and protection from above. What would it mean to approach these same spaces not with indifference and neglect, but with care and deliberate design? Could these spaces of survival that are carved out by necessity be instead designed as places of belonging?

## 1.3 Research Question and Objective

Given Vancouver's growing housing shortage, spaces should be examined in more creative and strategic ways. This thesis explores an overlooked opportunity, the area beneath the SkyTrain rails which run through some of the city's most populated neighborhoods, yet many sections remain largely under used.

The central research question is:

***How can housing be integrated beneath Vancouver's SkyTrain infrastructure to support affordable residential development while enabling community life in these overlooked spaces?***

Note that the research question touches three key elements - [1] SkyTrain infrastructure, [2] integration of residential development and [3] community - all three are part of an interconnected and mutually beneficial system. The elevated SkyTrain concrete infrastructure that supports its rails create an urban spine that passes through Vancouver's densely populated neighborhoods. While the spaces beneath are often dismissed as brownfields or neglected green strips, their location makes them prime candidates for affordable housing. The area is especially promising for young urban residents like students, recent graduates, and early-career professionals looking for more connected and transit-oriented lifestyles. This concept goes beyond just housing and when thoughtfully designed, these in-between spaces can also serve as communal zones that can stitch together fragmented neighborhoods and create new opportunities for gathering and creating a sense of community beneath the rails.

## 1.4 Competition

The inspiration for this thesis was from the 2024 “Underbridge” competition organised by Buildner, in which I participated as a framework for the research. The competition’s mission was to find innovative solutions to transform underutilised spaces beneath bridges with considerations for scalability, affordability and eco-consciousness.[6] By studying competition objectives and analysing winning and shortlisted entries, the thesis draws on my design approach and can learn from these entries that can offer ideas that can be used for under-bridge projects.[2]

## 1.5 Framework and Design Approach

For clarity, the thesis defines two terms: “**under-bridge**” refers to the general concept of spaces under bridges, while “**under-SkyTrain**” refers specifically to the expansively long space that exists underneath Vancouver’s SkyTrain elevated rails.

The thesis is structured into two major parts. The first part builds the case for why under-SkyTrain housing should be explored as a legitimate urban strategy. Under-bridge developments are not a new idea, and there are real examples of similar ideas successfully built internationally with existing case studies in major cities around the world. These case studies exist in cities such as Tokyo, Paris, and have already reimagined these spaces for housing, commerce, and public use. There will be an exploration of precedents in four categories which are [1] Reclaiming Elevated Infrastructure [2] Prefabricated Units, [3] Community Engagement, [4] Tiny and Flexible living,  all of which are strategies that are synthesized together that ultimately lead to lessons and ideas that are building blocks for the final design.

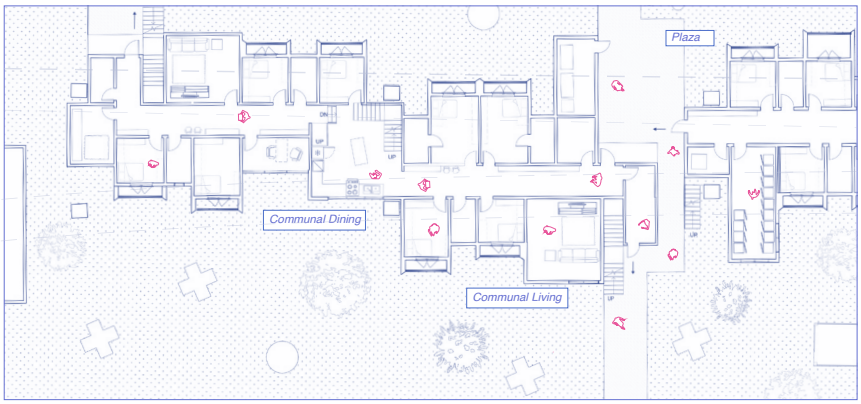
6 Buildner. (n.d.). Under Bridge architecture competition: Affordable housing series 17th edition. https://architecturecompetitions.com/underbridge/brief

# MOS
# A I C

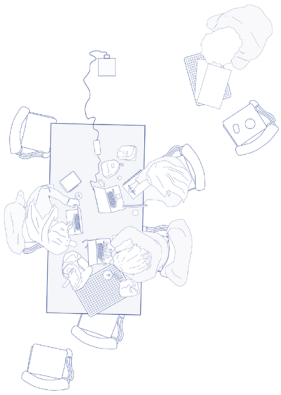
As Canada prides itself on being a cultural mosaic, this project addresses the disconnect often felt by young international adults and students, offering them a sense of belonging and flexibility for cultural integration. By activating the site with adaptable communal spaces that encourage openness and porosity, “Mosaic” catalyzes social interactions and cultural activities, allowing individuals to engage in their personal (ie. cultural and religious) practices, creating a deeper connection with their community. Situated near British Columbia’s busiest mall and a major bus terminal, the project takes advantage of this by creating a vibrant hub of activities, making it an ideal setting for newcomers to feel at home and connected in their new environment. Through its focus on **flexibility** in design and **community** building, “Mosaic” aims to enrich the lives of its diverse population.g the urban landscape.







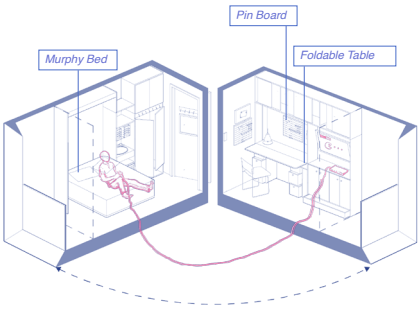

**Typical Residential Module I** Level 1



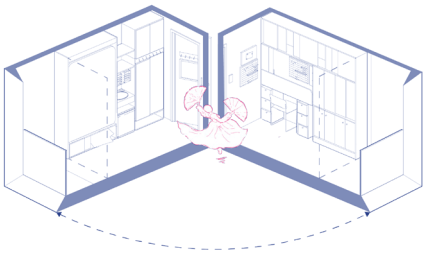
A variety of communal spaces, such as shared living dining and work areas, help newcomers feel include in their new community. These spaces can creat new collaborations and serendipitous encounter that can lead to the formation of new friendships

N

In Vancouver’s diverse cultural landscape, flexibility in space usage is crucial. The flexible furniture can be folded so that the unit becomes a rectangular form that is efficient and versatile that can accommodate a variety of needs, from cultural to religious activities, giving occupants the freedom to use spaces in ways that best suit their diverse requirements.

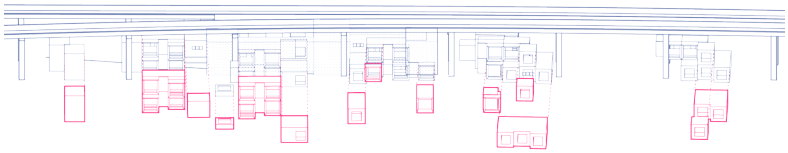



**Typical Flexible Unit I** Open

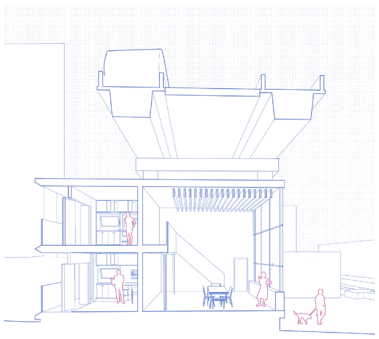


**Typical Flexible Unit I** Closed

**[Fig. 3]** My competition entry board submitted for

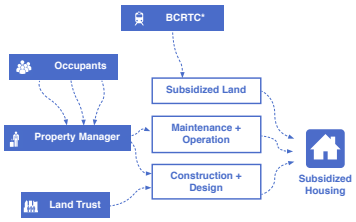


Inspired by the plug-and-play metabolic architecture system, the system consists of a central communal kitchen core, that has 2 central corridor spines that extend from each end. Units and amenities stem out from the corridor spine, that have different dimensions to create a variety of undulations that can be repeated throughout the line without looking repetitive. This can be repeated throughout the Skytrain system. Current design is a study of one particular site at Metrotown Station.



**Section I** Communal Kitchen + Units

## Funding Flowchart




*The land beneath the skytrain tracks is owned by BCRTC (BC Rapid Transit Co Ltd). It is mostly underutilized green space and parking that has potential to be used to redevelop for housing.

## Symbiotic Relationship

### Metrotown Station to Occupants

- While many vehicular bridges pose issues such as **carbon monoxide** and other harmful substances emitted by vehicles - these electric vehicles do not omit any harmful by-product

- Residents coming from other countries may have feelings of **loneliness** and being marginalize, being in a high activity area can create a sense of vibrance and community in the area

### Occupants to Metrotown Station

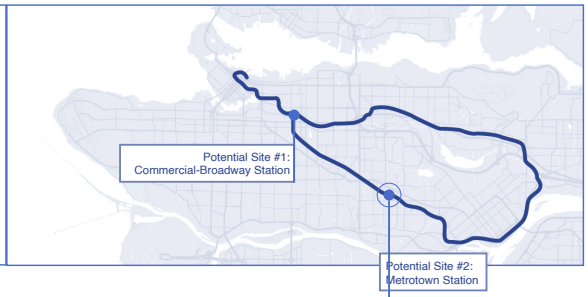
- Residents have convenient access to public transit, reducing congestion and **lowering emissions** and carbon footprint

- Currently the City of Vancouver has new initiatives that incentivises Transit-Oriented Development

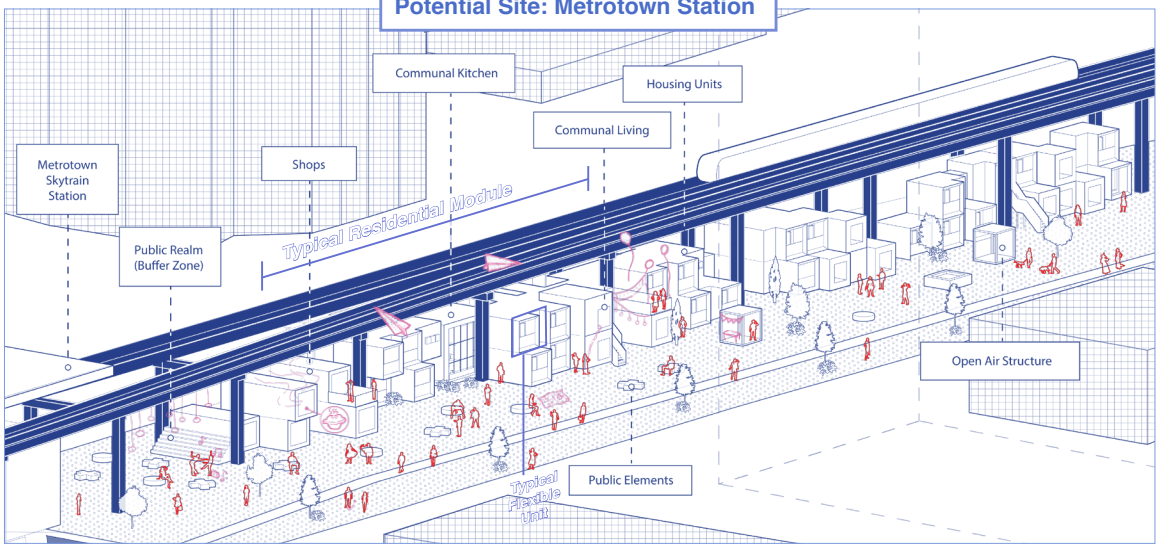
- Metrotown station in particular is connected to the 2nd busiest bus loop in the province, meaning ease of **access to amenities** - for foreign students, bus routes including direct paths to many post-secondary institutions.

- Housing revitalizes station areas and create vibrant communities in otherwise underwhelming green spaces
- Stimulates surrounding **businesses** and economy in a high traffic area.

79 KM of Underutilized Space Beneath the Tracks




## Potential Site: Metrotown Station




the 2024 Underbridge Competition, hosted by Buildner.

# [Case Studies]

This section presents precedents from around the world that explore similar typologies and ideas such as developments around elevated infrastructure, flexible and prefabricated systems, and shared living models that support community engagement. These design strategies respond to constrained sites and aim to improve affordability and social connection. Many of these case studies shown here are real world examples that serve as evidence that this approach is viable and offer lessons that can inform the Vancouver context.

The next part of the thesis then turns to the practical realities of integrating housing into Vancouver's under-SkyTrain spaces. It takes into account the city's site-specific factors that include its history, policies, spatial factors and how the space deals with noise and vibration. This would prove that the under-SkyTrain housing is a potentially viable strategy for the city rather than a purely speculative exercise.

The final part of the thesis presents how three typologies - co-living, live-work and retail that are models that can be implemented under the SkyTrain. These three typologies are then tested across two sites, Metrotown Station and Royal Oak Station. These locations were selected to reflect differing urban contexts, Metrotown being high-density and Royal Oak being medium-density and examining how different interventions can adapt to the varying conditions found along the SkyTrain corridor. Each site offers unique spatial and social aspects that allow the thesis to explore how modular housing systems might respond to local needs.

Through case studies and design proposals, this thesis proposes a prototype for Vancouver which can leverage its existing SkyTrain infrastructure to meet its housing demands.

## 2.1 Case Studies Around the World

While proposing modular housing under the SkyTrain may seem like an unconventional idea in the Canadian context, similar strategies have been realized throughout the world. This thesis studies and draws ideas from a range of both built and conceptual case studies, offering strategies and lessons, as well as proof that similar ideas have worked (or not). Four key design ideas emerge from these case studies and serve as lessons and a foundation for the design proposal:

1. Reclaiming Elevated Spaces

*Given that the thesis studies the area beneath the SkyTrain rails, these precedent studies look at how similarly elevated structures such as bridges/viaducts/elevated rails were reimagined for new uses such as for housing and community. These examples show the potential for SkyTrain-adjacent spaces that can be similarly repurposed to become multi-use infrastructure.*

2. Prefabricated Systems

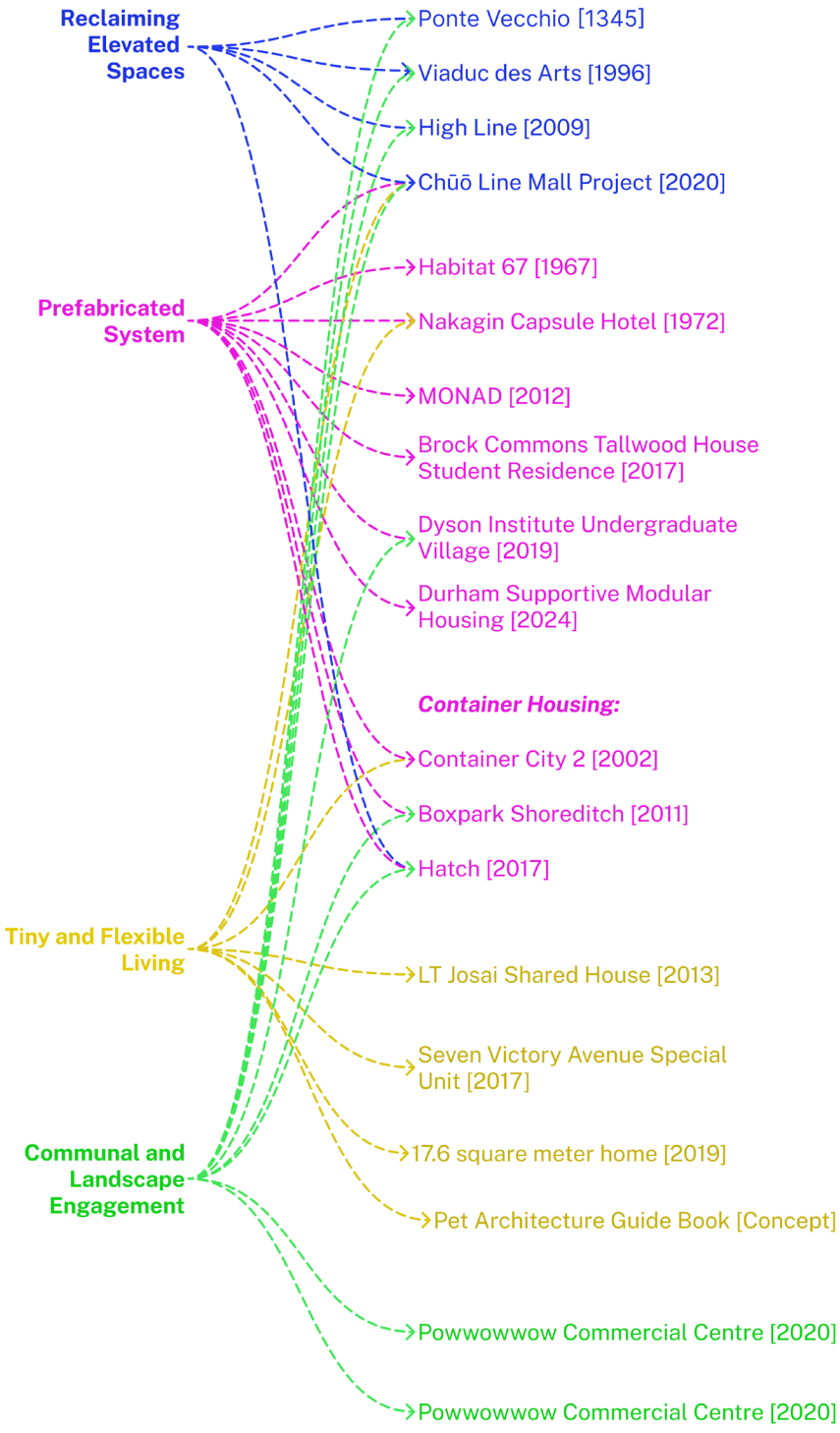
*The site conditions beneath the SkyTrain is undoubtedly precarious, with its narrow widths and its limited overhead and lateral clearance because of the elevated structure and its columns. Prefabricated systems are a practical solution that allows much of the construction to take place off-site, making it less prone to on-site troubles. While affordability and scalability often cited advantages of prefabrication, those trade-offs will be discussed further in Chapter 3. This section focuses on precedent studies that demonstrate how modular or prefabricated approaches have been applied in similarly constrained or urban contexts.*

## 3. Flexible and Tiny Living

*Given that the SkyTrain runs through dense urban environments and awkward spaces, flexible design approaches, having a flexible and adaptable space beneath the SkyTrain allows it to make the most out of the footprint to increase livability. Examples of this include transformable interiors, furniture that has multiple uses and  layouts that can reconfigure and adapt to a wide range of daily activities. When space becomes limited underneath the SkyTrain, adaptability allows to make the most out of the footprint to increase livability. While the upfront costs are greater, it does offer long-term value.*

## 4. Spaces that Bring Us Together (Communal and Landscape Areas)

*SkyTrain station proximity offers convenience and gives these underused spaces the potential to become more active and connected. While accessibility get people to come, the design gets people to stay. Through greenery, gathering spots, and informal public uses, infrastructure can be softened into places people to gather and enjoy. Landscape and communal programming are key to turning these neglected areas into spaces of connection for both livability and public acceptance of this experimental housing typology.*




**[Fig. 4]** List of categories relevant to the thesis and their respective case studies presented in chronological order

## 2.2 Reclaiming Elevated Spaces

While elevated spaces such as bridges and walkways are often built for vehicles to pass through and life happening above, the spaces beneath them are often in North America, considered awkward leftover spaces. These spaces are often marked by shadows, noise, and odd geometries and are often disconnected from the rest of the city. However - through examining cities like Tokyo and New York - where similar conditions have been successfully reimagined, one can see how these once challenging and interstitial spaces can be reframed for public use that becomes a corridor for activity or housing.  This section looks at the first category of case studies: existing elevated infrastructure that has been readapted for new uses. These precedents give insight on factors such as, dealing with noise and privacy through strategic layout to finding ways to bring in light and greenery to an otherwise darker space, these projects show how narrow or constrained sites can still offer good quality of life. Some even introduce shared courtyards or public programs on the ground floor which could bring life and colour into spaces that once felt invisible. These examples are a starting point for thinking about how under-SkyTrain development could feel part of the city.

### The Ponte Vecchio

Location: Florence, Italy

Year Built: 1345 (Rebuilt)

Elevated Infrastructure Strategies | Communal Engagement

In many modern cities, elevated infrastructure such as highways, some bridges and rail lines are often seen as noisy spaces with little public value and disconnected from surrounding neigbourhoods. The Ponte Vecchio show a contrasting historical example of how this is not always the case, and it can instead host a more vibrant urban life. These spaces produce excessive noise and are spaces to be avoided. However,

historically there were many cases where similarly elevated structures integrated with urban activity and filled with life.

Although not an “under-bridge” development in the conventional sense, the Ponte Vecchio is one of the oldest and most iconic examples of using infrastructure as more than just circulation. More than just a bridge,it was designed as a commercial corridor lined with small shops.[7] These businesses include butchers, barbers and goldsmiths, all of these shops are lined across the bridge and integrated directly to the structure creating a continuous streetscape suspended over the river. It was nicknamed the “Bridge of Gold” [7] for its concentration of jewelry shops - and eventually - the Ponte Vecchio became a centre of economic activity and a civic destination. It remains in use today and continues to attract visitors from around the world, demonstrating how infrastructure can evolve into a layered, multifunctional public space.



**[Fig. 5]** Built-in Amenities at the Ponte Vecchio Bridge

As the introductory case study, the Ponte Vecchio shows that infrastructure doesn’t have to be neutral or dead space. Instead, it can be activated with program and identity. While the structure is considered technologically obsolete by today’s standards, it’s continued use and cultural relevance show that strong ideas can outlast technical limitations. In the context of under-SkyTrain sites, this precedent shows that leftover

7 Flanigan, T. (n.d.). The Ponte Vecchio (“Old Bridge”) in Florence. Khan Academy. https://www.khanacademy.org/humanities/renaissance-reformation/late-gothic-italy/florence-late-gothic/a/the-ponte-vecchio-old-bridge-in-florence

urban spaces can be transformed to have lasting meaning given the right programming.




**[Fig. 6]** Storefronts that are integrated to the Ponte Vecchi

### Viaduc des Arts

Location: Paris, France

Year Built: 1996

Elevated Infrastructure Strategies | Communal Engagement

In Paris, Viaduc des Arts is a successful example of adaptive reuse, where the space under the bridge were transformed to become retail spaces. The originally building constructed in 1859, was part of the Vincennes railway line that connects Paris to its eastern suburbs. It was decommissioned in 1969 and left unused for many years. Eventually, the City of Paris opted to preserve the structure as part of a larger revitalization plan and so the structure became readapted, with an elevated linear park above the rails and the spaces underneath the vaults were retrofitted to fit a 1.5 km line of artisan shops, galleries and cafes.

Architect Patrick Berger led the redesign of the vaults, sealing them with custom designed curtain walls. The glazing is supported by a wood and metal structure that is embedded within the brick arches. Such design allowed for transparency that

created a visual connection from street to interior and admitting natural light into the otherwise dark vault space and maintaining the original vault's unique brick and stone infrastructure. Viaduc's adaptive reuse model offers placemaking ideas that can inform Vancouver's approach to under-SkyTrain development in its retail aspect.[8]



**[Fig. 7]** Rows of developments lined beneath the bridge at the Viaduc des Arts

8 Ghida, D. B. (2024). Revitalizing urban spaces: Ten key lessons from the "Viaduc des arts" adaptive reuse and placemaking. Frontiers of Architectural Research, 13(5), 1095-1112.

### High Line

Location: New York, USA

Year Built: 2009

Elevated Infrastructure Strategies | Communal Engagement

Located in New York, the High Line project by Diller Scofidio + Renfro is an elevated linear park that has repurposes an abandoned railway into a greenway.[9] While it is not classified as an under-bridge project, it has done an effective job of transforming a long neglected linear and elevated infrastructure into a public precession. Through its reclaim of disused infrastructure, the High Line offers a place of respite within the dense and active city. As users move along its path, the experience is carefully sequenced, through framed views, material shifts, and programmed pauses create a sense of rhythm. This is achieved through landscaping, seating, sculptures, and lookout points that support both circulation and quiet reflection. [10]

9 Diller Scofidio + Renfro. (n.d.). The High Line. https://dsrny.com/project/the-high-line

10 Cilento, K. (2009, June 9). The New York High Line officially open. ArchDaily. https://www.arcdaily.com/24362/the-new-york-high-line-officially-open



**[Fig. 8]** The High Line greenway acting as a place of respite for its visitors contrasting the busy New York cityscape it cuts through



**[Fig. 9]** Landscape design with meandering pathways in proximity to tall apartment buildings






**[Fig. 10,11]** The sunken seating areas takes advantage of elevated space to be a viewing platform area for the some of the spaces beneath the high line have buildings located beneath it.

Additionally, the underside of the High Line supports secondary uses. Buildings adjacent to or beneath the structure make use of the overhead massing for lighting and mechanical infrastructure for some cases. This approach shows how similar elevated transit structures like Vancouver's SkyTrain could support similar integrations, which can support any infrastructure below.



**[Fig. 12,13]** Heaters and Lighting Is held by elevated ceiling structure of the High Line

### Chūō Line Mall Project

Location: Tokyo, Japan

Year Built: 2020

Elevated Infrastructure Strategies | Modular/Prefabricated Housing | Communal Engagement

Of all the precedents examined, the Chūō Line Mall Project comes closest to mirroring the thesis proposal, both in spatial logic and programmatic intent. Located in the dense urban context of Tokyo, Japan, the project transforms nearly 9 km of

underutilized space beneath the elevated JR Chūō Line between Mitaka and Tachikawa. What was once originally to parking and storage transformed to become over 72,000 sq m. of mixed-use development, integrating housing, pedestrian walkways, local shops, and community amenities which were all carefully stitched beneath a major rail corridor. [11] As a large-scale example of redeveloping the space underneath an elevated transit rail, with the Chūō Line Mall Project offers a direct spatial and programmatic precedent for Vancouver's SkyTrain. Because of the similarity of the precedent to under-SkyTrain proposal, it is proof that such residual infrastructure can be truly built, given the right conditions.

**Historical Context**

In the 1960s, the Chūō Line ran at grade through major metropolitan areas, leading to frequent traffic disruptions due to "closed-crossings" - barriers that would remain down for up to 40 minutes to an hour. To alleviate this, tracks between Nakano Station and Mitaka Station were elevated, eliminating 24 crossings and allowing for freer vehicular and pedestrian flow below. From 1995 to 2014, further elevation efforts were carried out across six cities. This strategy parallels the history of Vancouver's BCER (BC Electric Railway) tram system to elevated SkyTrain systems, in which the grade-level trams were decommissioned in the 1950s (refer to 'History of the Skytrain' section in Chapter 3).

11 百瀬伸夫. (2018, February 7). 高架下の新たな商空間からはじまる「沿線まちづくり」!!〜JR中央線「中央ラインモール構想」〜 [New commercial spaces under elevated tracks spark transit-oriented development: JR Chūō Line "Chūō Line Mall Concept"]. 日経メッセ JAPAN SHOP. https://messe.nikkei.co.jp/js/column/cat454/137268.html

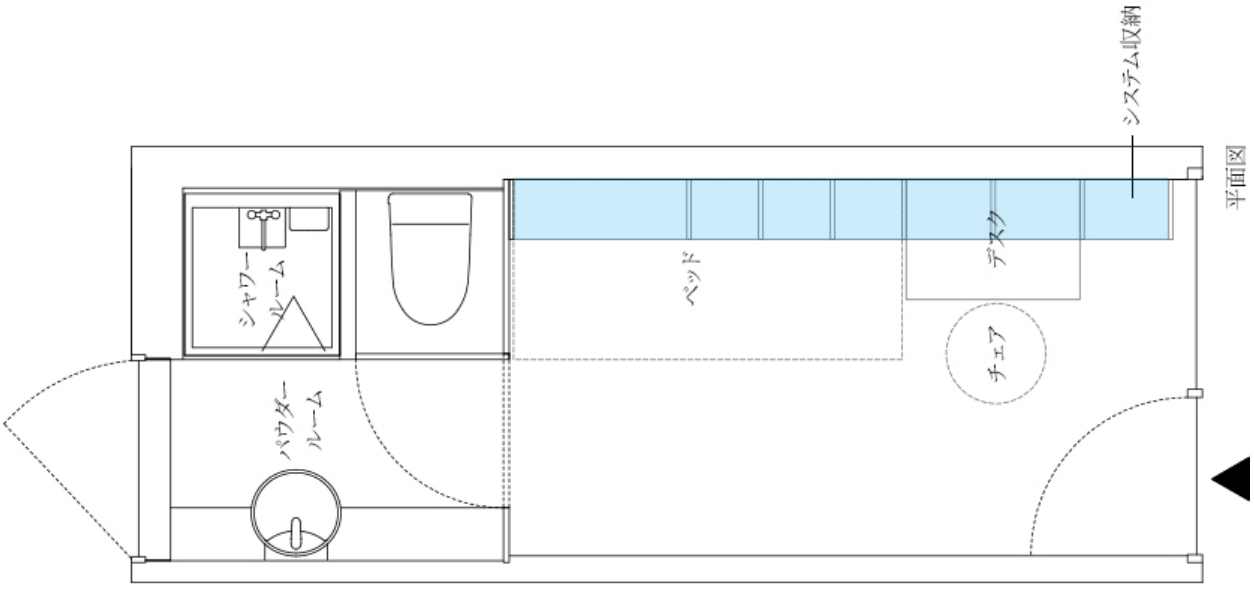
**Housing Typologies**

One of the sub-projects relevant to the current thesis is the Chūō Line House (Koganei) which is a student housing complex that is developed between Higashi-Koganei and Musahi-Koganei Stations. It is designed by three architects (Koh Kitayama, Akio Taniuchida and Michio Kinoshita) that features three residential types: Plans L, H, and C - each are situated beneath the elevated rail and accompanied by communal buildings and amenities.

Note that though the spaces designed are situated directly beneath an active train, the housing units are structurally detached from the concrete structure above, reducing direct vibration transmission. Train noise is almost not noticeable. The open layout and breaks between buildings allow natural light and air to filter through, while also creating community courtyards and shared outdoor decks.The following part are several typologies that exist along the line as they were introduced in this development:

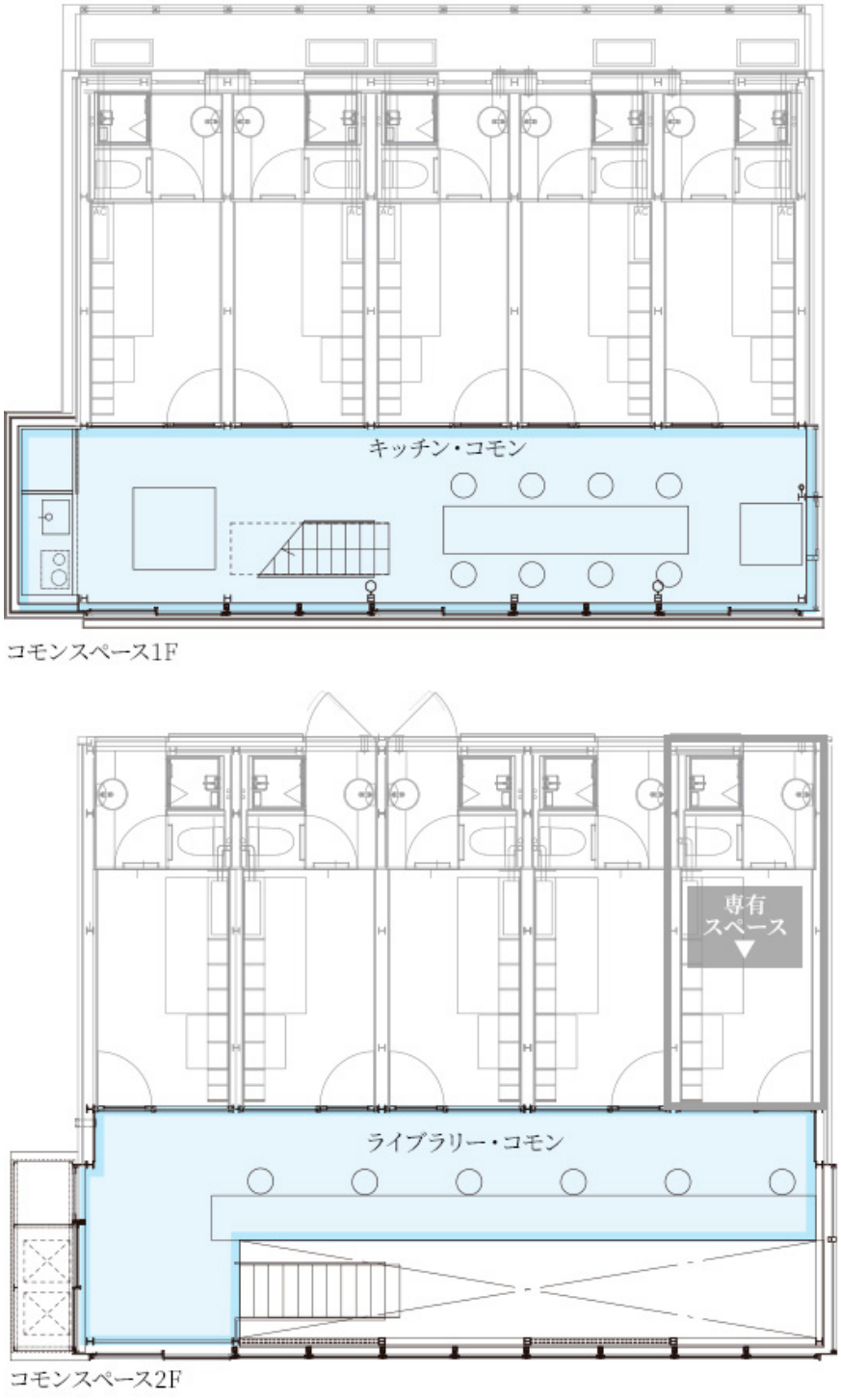
***Plan L***

There are several types of unit plans in this case study. One such unit plan type is Plan L, which features compact private units (10.62 m²) connected by common corridors furnished with seating and tables. The plan is minimalistic and reverses conventional North American layouts. While many North American layouts place bedrooms on the side with most sunlight, while having a washroom hidden away, this plan flips the concept around by placing the washroom at the outer edge to bring daylight deeper into the corridor and allow privacy for compact bedrooms placed further inside. A clever double-door system allows the washroom to either be separated off completely for private use or opened to function as an accessible sink area that shares light with the bedroom. While this design might not directly comply with North American codes or furnishing standards, it shows how sometimes breaking the rules sometimes allow for more creative and efficient designs.[12]




**[Fig. 14]** A shot of the second floor of Floorplan L's typical unit plan

12 JR Chuo Line Community Design Co., Ltd. (n.d.). Plan. Chuo Line House. https://chuolinehouse.com/plan/




**[Fig. 15,16]** These are the first (top) and second (bottom) floor plans of Floorplan L. Highlighted in blue are the shared common areas which serves the tighter private units.



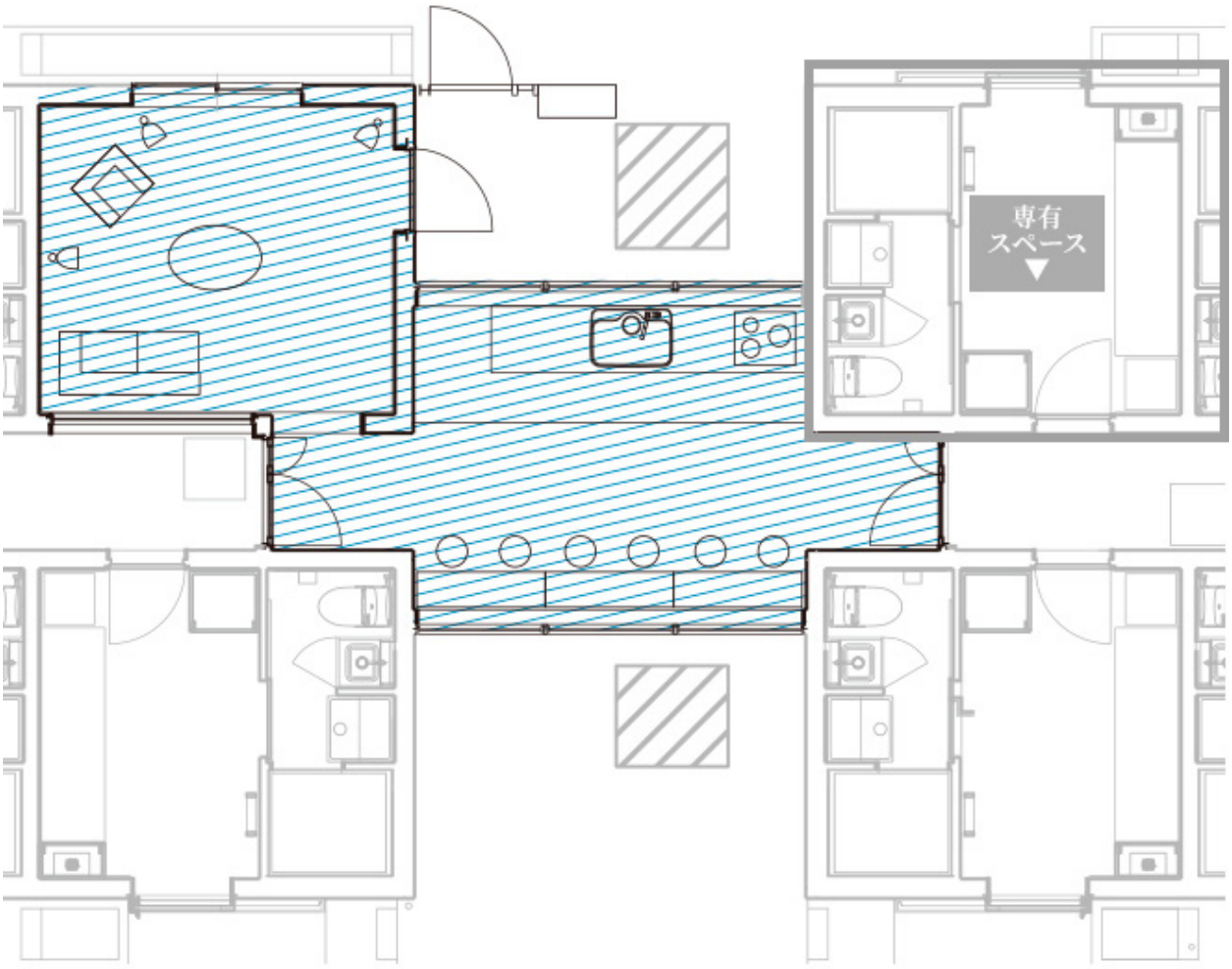
**[Fig. 17]** A shot of the second floor of Floorplan L's common area



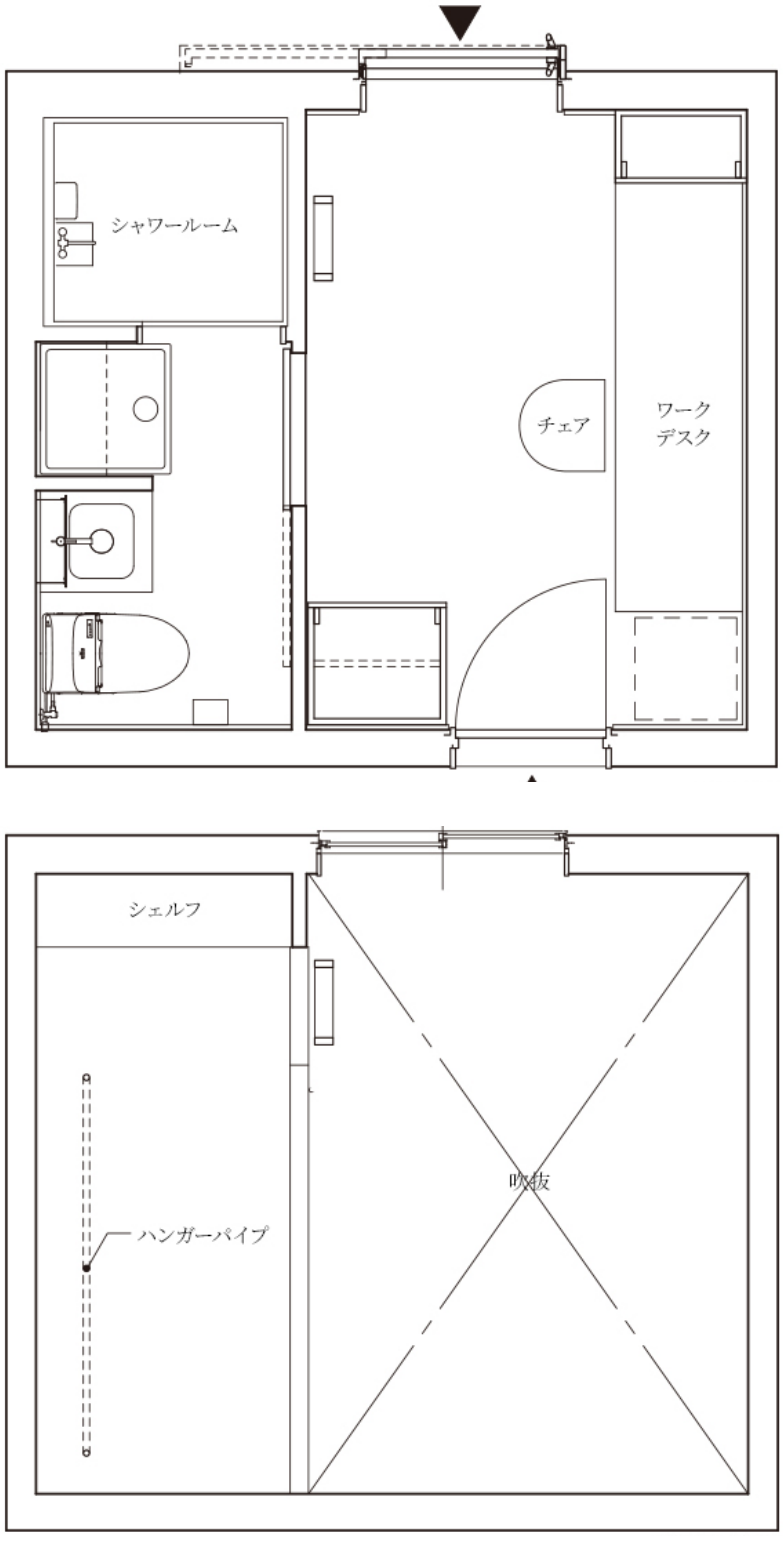
**[Fig. 18]** A shot of the ground floor of Floorplan L's common area

### *Plan H*

The H-type plan introduces a central communal lounge situated between structural columns, shared by three private bedrooms. These units are slightly more spacious (11.59 m²) and take advantage of vertical headroom by placing sleeping areas above enclosed washrooms.




[**Fig. 19]** Overview of Plan H, highlighted in blue hatch are the communal area including the central kitchen/dining area and the living area on the top left section of the photo




[**Fig. 20,21]** A shot of the Plan H first floor (top) and second floor (bottom), which shows a double height area with the bed above the washroom area



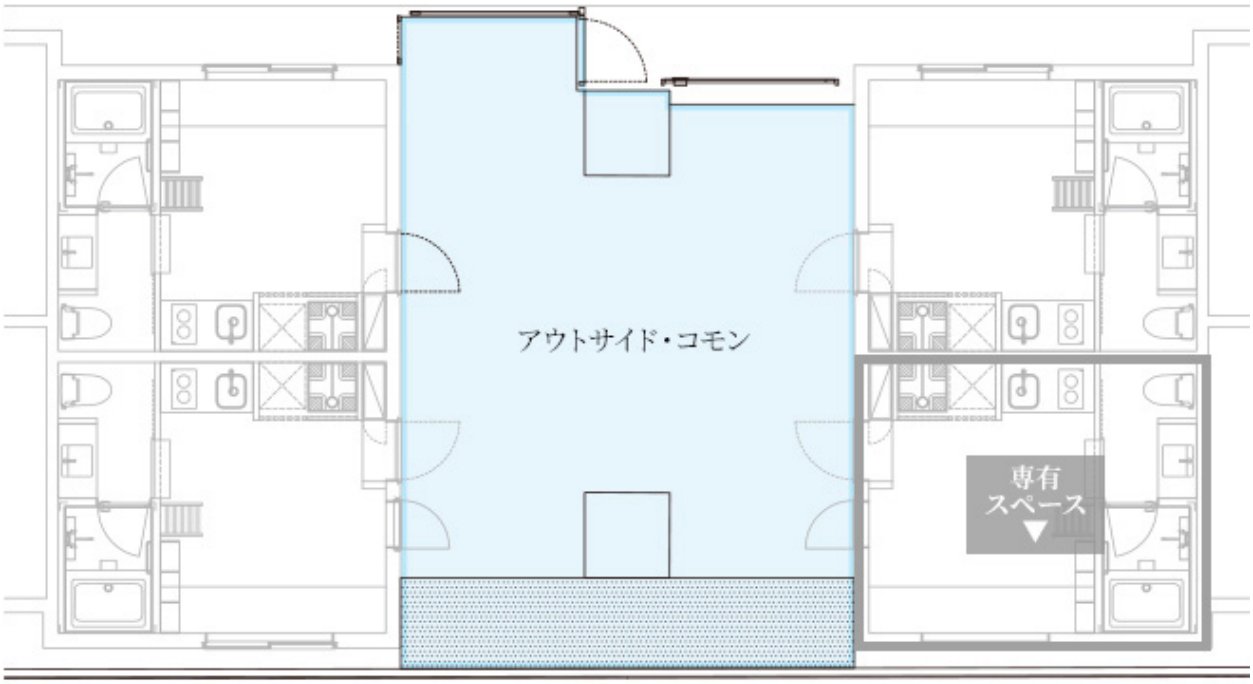

[**Fig. 22**] A shot of the ground floor of a Floorplan H bedroom



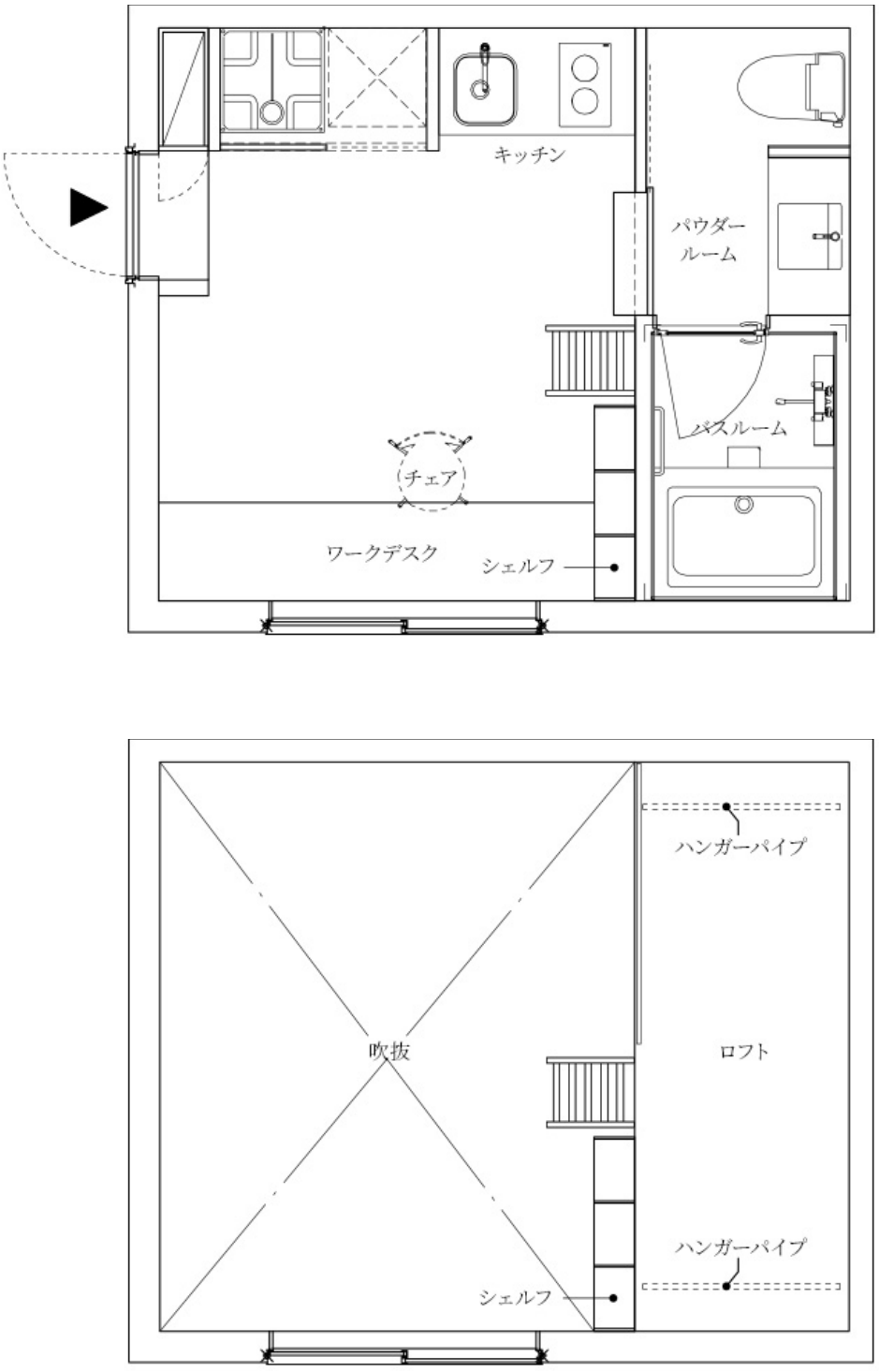
[**Fig. 23**] A shot of Floorplan H central kitchen area

***Plan C***

The C-type units are the most generous in size (15.94 m²) with ceiling heights of 3.5 metres. These rooms maximize vertical space, with beds above washrooms and ample built-in storage throughout.




**[Fig. 24]** First floor of the C-type unit, with a work area, a small personal kitchen area and a washroom - highlighted in blue is its common outdoor area




**[Fig. 25,26]** First floor (above) of the C-type unit, with a work area, a small personal kitchen area and a washroom and the Second Floor (below) of the C-type unit show the extent of the double height space for the work-kitchen area, as well as the stairs leading up to the bedroom area




**[Fig. 27]** C-Type units making use of all the vertical amount of space, including placement of the bedroom above the washroom area.



**[Fig. 28]** C-Type units bedroom top view



**[Fig. 29]** The in-between spaces between the residential units of C-type units give its tenants their personal open-air space.

### Community Philosophy and Shared Spaces

The overarching philosophy of the project is to build a “connected society” that links people to place and to one another through shared greenery, culture, and informal interactions. An example of the connectedness, is through its open-air communal zones such as community gardens, community terraces, and micro-plazas such as the “Musako Terrace”. These micro-parks are outfitted with long shared tables, benches, and deck-like platforms under the viaduct. What was originally leftover space was transformed to become areas for various reasons for gathering including reading, playing, and dining. Long communal tables were implemented as a strategic design choice to encourage strangers to share space.

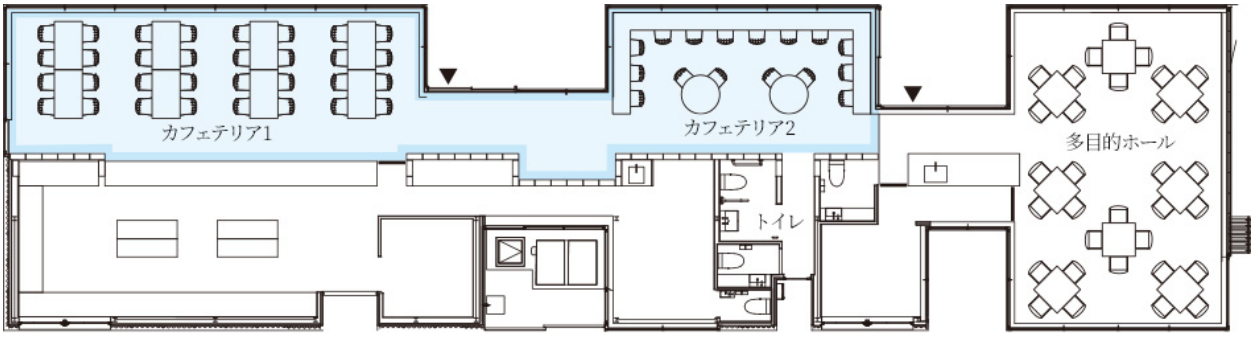
While there is little shared communal spaces within the residential buildings, this development includes communal facilities serving as a cafeteria, study space, and workshop area in which residents can share together. These spaces encourage daily interaction among student residents and includes a “Knowledge Room” open to the wider community.



**[Fig. 30]** Common Area/Cafeteria that encourages daily interaction among student residents



**[Fig. 31]** Cafeteria is equipped with a sink, tables and chairs for gathering




専用カフェテリア平面図

**[Fig. 32]** This communal area has a long floorplan to conform to the shape of the underside of the long concrete elevated structure, and rectangular bump recessed inwards to accommodate the concrete columns




**[Fig. 33]** Makeshift mats allow people to gather and share books




**[Fig. 34]** Temporary structures such as tents and carts activate and create new program for communal activities.

## Public Areas




**[Fig. 35]** Open air areas still included seating and microgardens that let visitors of all ages settle down under the concrete cover

Beyond just buildings, the open spaces are designed with seating and tables and public spaces to gather and populate the space. The result of this is an urban corridor filled with activity, making the spot a welcoming space.

“Community Stations”, which were multi-purpose spaces that brought together people beneath the line. One example of this, is the Community Station Higashi-Koganei, a 100-meter-long, open-layout space that contain small shops, co-working areas strung together by shared lounge-like interiors. What makes it distinctive is its intentional lack of partitions, turning what would normally be isolated commercial

units into a shared environment. Events like zine markets, musical performances, and seasonal workshops take place here regularly. On rainy days, the covered arcade remains accessible, reinforcing the sense of it being a continuous yet welcoming street. In 2016, this typology was awarded the Good Design Award (Community Design) and was praised for being “a place that connects the town and its people”.[13]




**[Fig. 36]** Family Culture Festival in 2016, drawing in community

13 アーバンライフ東京編集部. (2019, November 29). 中央線「ラインモール構想」現地レポート ベンチャー魂とローカル人情の融合を見よ [Chūō Line “Line Mall Vision” field report: A fusion of venture spirit and local warmth]. Urban Life Tokyo. https://urbanlife.tokyo/post/24494/



**[Fig. 37]** People of all ages gather together to watch music performances and to celebrate the event



**[Fig. 38]** Performers and vendors bring colour and vibrancy into the space



**[Fig. 39]** Commercial programming located beneath the line.

**Urban Activation and “Nonomichi”**

Adjoining the different programs is the “Nonomichi”, which is an active continuous 2-meter-wide pedestrian walkway that threads together stations and programs. This walkway is well-lit with lantern-like fixtures and punctuated by seating, greenery, and programmatic “nodes” such as cafés, clinics, childcare facilities, and galleries. Rather than feeling like a leftover passage, it has become an east-west urban spine that is an  active walkway.



**[Fig. 40]** The Nonomichi, paved walkway along the station, with lights that allow for better sight at night

### Design Consistency and Identity

To maintain consistency along the 9 km stretch, a comprehensive Design Code Book was established early in the project. It coordinated architectural expression, materiality, lighting, signage, and landscape elements. Each station node had a unique design theme to create variety and an identity for each place, while still adhering to a common visual and spatial language. Examples of these themes include “Tradition × Innovation” (Kunitachi) or “Family Gathering” (Musashi-Koganei).[14]

### Relevance for Vancouver

Though rooted in Tokyo’s cultural and infrastructural context, the Chūō Line Mall offers transferable strategies for Vancouver’s SkyTrain-adjacent sites in many ways, including: tight spatial constraints, layered programs, and building community through small-scale interventions. Under-SkyTrain areas are often treated similar to the space the Chuo Line once was, as often overlooked. In addition to the plans and details shown in the aforementioned plans, Chūō Line provides many high-level strategies that can help inform a similar development by SkyTrain: Mainly it would include integrating:

[1] Modular housing that works within constrained footprints

[2] Layered programs like co-working, workshops, and micro-retail

[3] Pedestrian connections that turn infrastructure into a spine of movement

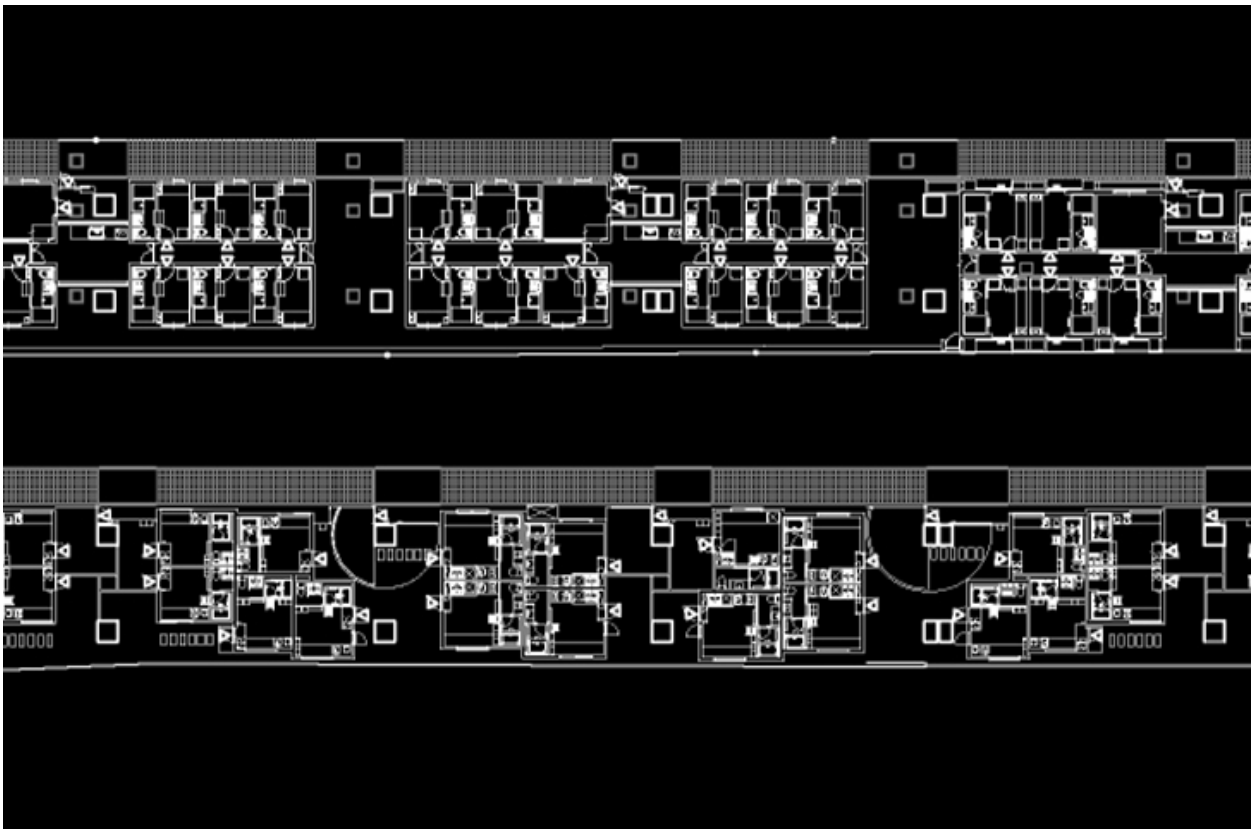
[4] Community-oriented amenities like gardens, terraces, and gathering areas

Ultimately, the elevated infrastructure in both cases can act as an urban scaffold that supports a socially engaging and activated space.

14 山下PMC. (2017). 中央ラインモールプロジェクト [Chuo Line Mall Project]. CMAJ Digest, 1. https://cmaj.org/templates/cmaj_new/member/pdf/2017/digest/01_digest.pdf




**[Fig. 41]** Residential units which have a more private character than the commercial units, with secured gates and more opaque features.



**[Fig. 42]** Floor plans of different modular student housing configurations assembled together under the Chūō Line

## 2.3 Prefabricated Structures

There are two major reasons why prefabricated structures are used in the context of under-Skytrain affordable housing: [1] With the growing housing shortage in Vancouver in recent years, prefabricated structures have gained popularity. [2] The strength of factory-assembled buildings lies in their ability to be built quickly and off-site, which in many cases makes them cause fewer on-site disruptions and potentially prefabrication can be cost-effective. These two factors are particularly beneficial to this thesis, which focuses on affordable housing beneath the SkyTrain: Vancouver's expensive real estate makes cost-effective construction essential, and the constrained, dense urban context beneath the SkyTrain benefits from minimizing construction

impacts. In short, prefabrication offers both economic and logistical advantages that align well with the challenges of under-SkyTrain development. This section presents built examples of prefabricated structures and highlights what worked, what didn't, and the lessons that can be applied to the design proposal. Further exploration of prefabrication as a building method will be explored in detail in Chapter 3.

### Habitat 67

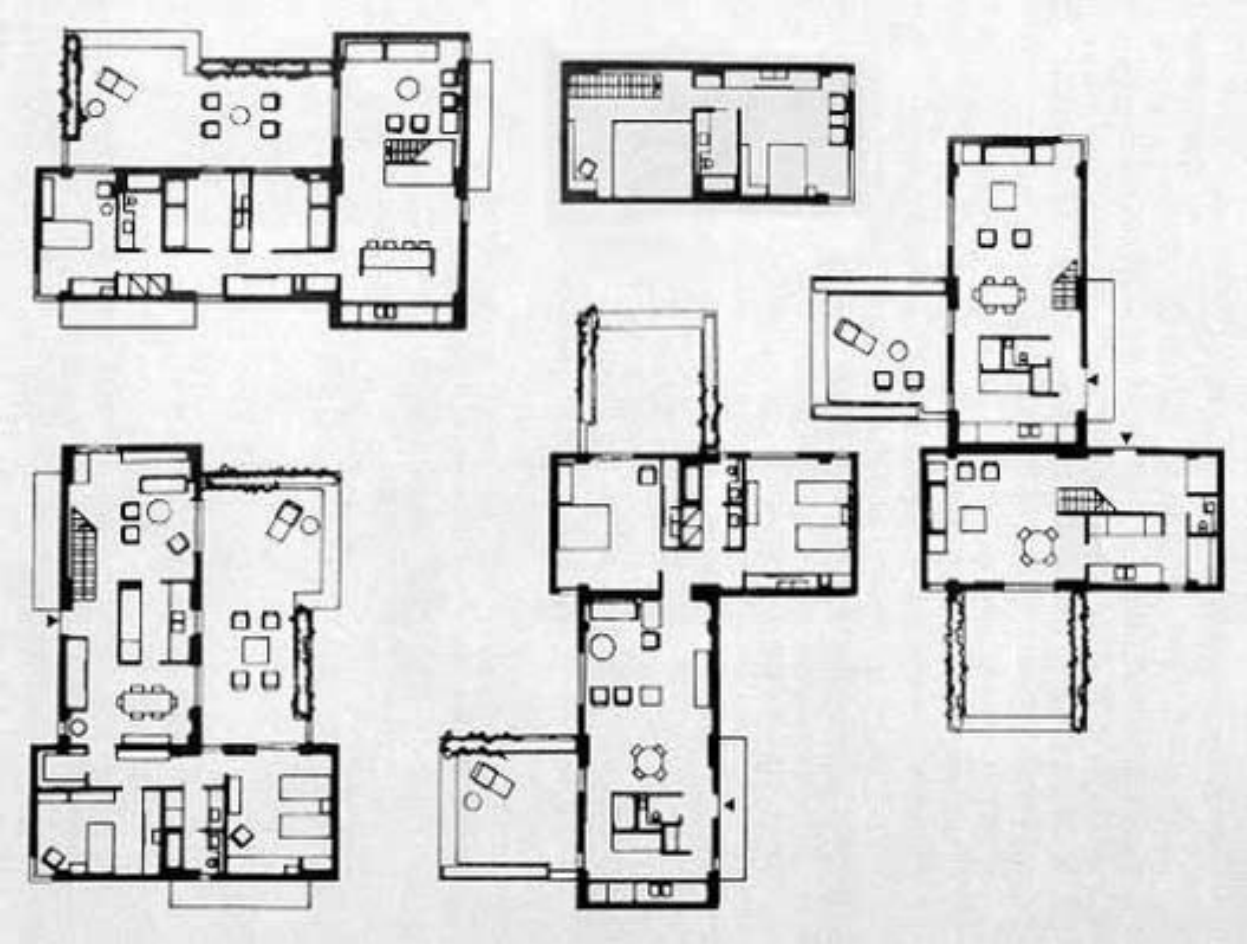
Location: Montreal, Canada

Year Built: 1967

Modular/Prefabricated Housing | Communal Engagement



**[Fig. 43]** Habitat 67 has modules that follows a predictable and structured arrangement but the staggered placement of units creates a visually dynamic form.



**[Fig. 44]** Habitat 67 uses 17.5 ft by 38.5 ft concrete modules through rotation and translation create 15 unique combinations of 1 to 4 bedroom spaces

Habitat 67 was a modular housing designed by renowned architect Moshe Safdie for his masters thesis titled titled “A Case for City Living” and described as “A Three-Dimensional Modular Building System” at McGill University, later built for Expo 67 in Montreal after his thesis advisor invited him to submit his project for the World Exposition in 1967.[15] Unlike the much smaller units of the Nakagin Capsule Tower (discussed as the next case study), Habitat’s modules were relatively spacious with each module measuring around 17.5 ft by 38.5 ft. To make these units not appear

15 Merin, G. (n.d.). Architecture Classics: Habitat 67 / Safdie Architects. ArchDaily. Retrieved February 27, 2025, from https://www.archdaily.com/404803/ad-classics-habitat-67-moshe-safdie

repetitive, each of these modules were combined one to eight concrete modules at a time which were then mixed, mirrored, and rotated to form 15 distinct housing typologies. These units were then arranged in three clusters to create an assemblage of 158 residential units arranged in a Jenga-like fashion consisting of a total of 354 units all together. While it was significantly scaled down from its original Master's thesis proposal of  final result was porous, for a variety of vertical and horizontal connections, with each unit gaining access to light, ventilation, and private outdoor terraces.

The staggered placement of the units and open configuration made the structure appear porous and open. This was an intentional design move by Safdie, who aimed to combine the privacy of suburban housing with the density and infrastructure of urban living. Each unit was meant to feel like a house with a garden that was stacked in a way that maintained openness and visual variation.

Internally, the modular logic extended to the fixtures through using pre-manufactured fiberglass bathrooms, standardized kitchens, and plastic-framed windows that followed similar geometric logic of the outside. Note that, while prefabrication was originally intended to lower costs, the irregularity of stacking and the need for reinforced structure drove material and labor expenses far beyond initial expectations. Structurally, the building relied on a mix of high-tension cables, post-tensioning, and welded joints to hold the modules together - all of which adds to the technical difficulty and cost of construction.[16]

Over time, the maintenance of the exposed concrete, waterproofing issues, and general upkeep added to the complexity. Residents have also modified their units over the years to better suit changing needs. These combined challenges ultimately limited

16 ArchEyes. (2025, March 8). Habitat 67 by Safdie Architects: A visionary experiment in modular housing. https://archeyes.com/habitat-67-by-safdie-architects-a-visionary-experiment-in-modular-housing/

Habitat 67's potential as a scalable model of architecture, and is now considered more of an experiment rather than a precedent to be repeated.

Despite its issues, Habitat 67 offers lessons for modular housing today especially for projects beneath elevated infrastructure. Through strategic stacking, it gives space that allows for integration of private green space, light, and air. It's a design that shows how density doesn't have to mean uniformity or compromise on livability. Its shortcomings demonstrate the importance of balancing design ambition with durability and cost-effectiveness. These considerations are especially important for affordable housing designs where every additional expense matters.



**[Fig. 45]** Interior shot of a typical unit at the Habitat 67 that highlights its spaciousness living environment, it is decorated with artwork, stylistic furniture, ample natural light that create a lived-in quality of space.

## Nakagin Capsule Hotel

Location: Tokyo, Japan

Year Built: 1972

Prefabricated Structures | Tiny and Flexible Living

The Metabolism movement emerged in post-war Japan as a radical rethinking of architecture, imagining cities as “metabolic systems” where buildings could grow and evolve over time through modular components. [17] While many proposals remained unbuilt due to infrastructural complexity, the Nakagin Capsule Tower (1972) by Kisho Kurokawa remains the movement’s most iconic experiment.

Nakagin was made up of 140 prefabricated capsules, each about 2.5 m × 4 m × 2.5 m, attached to two large concrete service cores. The idea was that each unit could be replaced every 25 years, through a “plug-and-play” system which was like Lego, where one can remove and attach pieces in a customizable manner. Each capsule came pre-fitted with a fold-out desk, bed, storage, and a tiny all-in-one bathroom. [18] A single circular window (1.3 m wide) would let in light and air. In theory, it was a flexible, high-efficiency solution for urban living. However in practice, the units were cramped and repetitive, with the interiors being too rigid to personalize. The interior floor area was just 10 sq m. per unit and was far smaller than even today’s micro-unit standards (which are usually around 25 - 30 sq m.), and this tightness left no room for adaptability. Unlike Habitat 67, which encouraged variation through stacked arrangements and allowed larger spatial combinations, Nakagin was locked into a rigid system in which each capsule identical, with a fixed footprint and no way to combine or expand units.

17 Gardner, W. O. (2020). The metabolist imagination: Visions of the city in postwar Japanese architecture and science fiction. University of Minnesota Press.

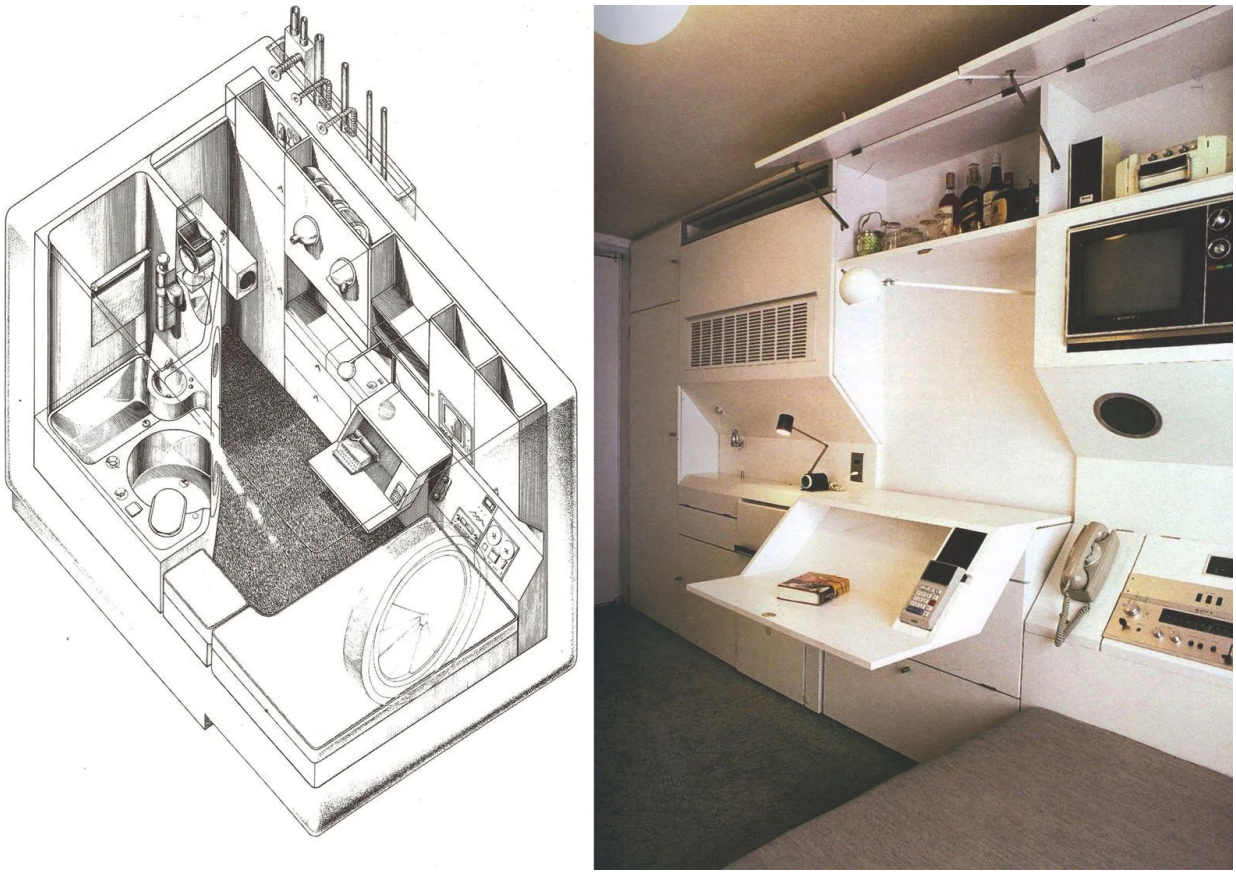
18 Block, I. (2021, July 16). Nakagin Capsule Tower to be dismantled and turned into rental accommodation and exhibits. Dezeen. Retrieved February 27, 2025, from https://www.dezeen.com/2021/07/16/nakagin-capsule-tower-dismantled-news/

While the idea was adaptable in theory ended up rigid in practice, and not a single one of the units were ever taken out or replaced.  The cost and effort to lift one out in the middle of Tokyo with cranes, permits, and disruption was just too high.With so many logistical hurdles, the “plug-and-play” dream never moved beyond paper architecture. Over time, the tower started to visibly deteriorate. Water damage caused black streaks to appear on the facade, and the steel joints aged badly, making the structure that was meant to be future-proof become obsolete. Nakagin was officially decommissioned in 2022, and only 23 of its capsules were salvaged for display or preservation, while the rest were demolished.

Fumihiko Maki, one of the original Metabolists, was critical of these limitations. He wrote in his essay *Investigations in Collective Form* that warned that megastructures (much like the large, centralized systems like Nakagin) often were too rigid to evolve like the Metabolist ideals promised. Although the capsules were technically modular, the whole building relied on a fixed service core that couldn’t adapt. Maki proposed “group form” instead: a more decentralized system where smaller parts could grow, shift, or be replaced over time without needing the entire structure to change. It was a model based less on formal unity and more on systems that allowed change to happen in scale of units and clusters.[19]

That said, there’s still a lot to learn from it. Its compact logic, prefabricated strategy, and unit-based design are still useful today, especially in places with awkward leftover spaces like under Vancouver’s SkyTrain. If applied with better servicing, repair access, and more adaptable cores, the same logic could work, but this time in a way that actually supports flexibility over time.

19 Maki, F. (1964). Investigations in Collective Form. Washington University in St. Louis. https://doi.org/10.7936/3R0Q-4715



**[Fig. 46]** Interior shot of a single pod, left shows an artistic rendition as an overall axonometric view, while the right shows the foldable table opened up for use.



**[Fig. 47]** Nakagin Capsule Tower, showing visible signs of weathering, including black streaks on the façade that indicate water damage

Nakagin's floor plan had ultra-compact, repetitive units and lack of internal flexibility made it not very livable which ultimately lead it to its decommissioning. While the concept of efficient micro-housing still holds value, Nakagin pushed compactness and standardization too far. Maki's critique of megastructures pointed out that when servicing and adaptability are too centralized, leading to the systems become too brittle that they can't respond to change without disassembling the whole building. In the case of modular infill, especially under constrained conditions like the SkyTrain, flexibility has to happen not just at the unit scale but across the whole system. This can mean

decentralized cores or independent clusters of units which make the ability to replace or modify parts without affecting the entire system.

**MONAD**

Location: Vancouver, Canada

Year Built: 2012

Prefabricated Structure

The MONAD building is a four-storey prefabricated infill project that was developed through collaboration between LWPAC (Lang Wilson Practice in Architecture Culture) and its sister company Intelligent City (specializes in using robots to automate manufacturing custom mass timber panels), both companies co-founded by Oliver Lang. While LWPAC directed the architectural design, Intelligent City handled the off-site fabrication and delivery of the building's volumetric wood-frame modules. It includes three storeys of residential space and a ground floor retail space. The residential units were programmed vertically, with each apartment programmed like a vertical townhouse with own private entranced and their own outdoor space and a shared roof garden on the top level. Internally, each unit wraps around an open central courtyard and light wells.

Structurally, MONAD is built offsite through prefabricated construction using wood-frame modular units, with exceptions of a few major beams and columns implemented that were made of engineered wood using LVL (laminated veneer lumber) and PSL (parallel strand lumber) to bear the structural load. Prefabrication off-site allowed for quick onsite construction. [20] The residential portion of the building (2nd floor and above) were built as a series of volumetric modules in a factory. The preassembled units were lifted onto site in mid-January of 2012 and completed with drywall, wiring and

20 Naturally:Wood. (2024). MONAD. https://www.naturallywood.com/projects/monad/

plumbing in April the same year. The building's core and structure first-storey and below (foundations, basement, retail level, parking and elevator structure) were constructed on site. In an article, Oliver Lang says "What I've created here, is an urban model that can be transplanted anywhere".[21] This first Monad building was intended to be a prototype that is generative and adapted and optimized to work in various infill sites. As of 2025, there is plan to deploy three more Monad projects including Monad Granville, Monad Rupert and Monad Clark with each having their own unique scale and personal character. As MONAD is a prototypical model for modular infill, it offers ideas of creating a prototype that can be plugged into the leftover spaces underneath the SkyTrain rails, something that can repeat and adapt along that spine, yet is still site-specific.




**[Fig. 48]** Volumetric light-frame wood modules getting craned into place, a process that took a single weekend.

21 Recollective Consulting Inc. (2023). MONAD. https://recollective.ca/project/monad/



**[Fig. 49]** Interiors of a residential unit of the MONAD, from lifting modular units to furnished in less than four months

### Brock Commons Tallwood House Student Residence

Location: Vancouver, Canada

Year Built: 2017

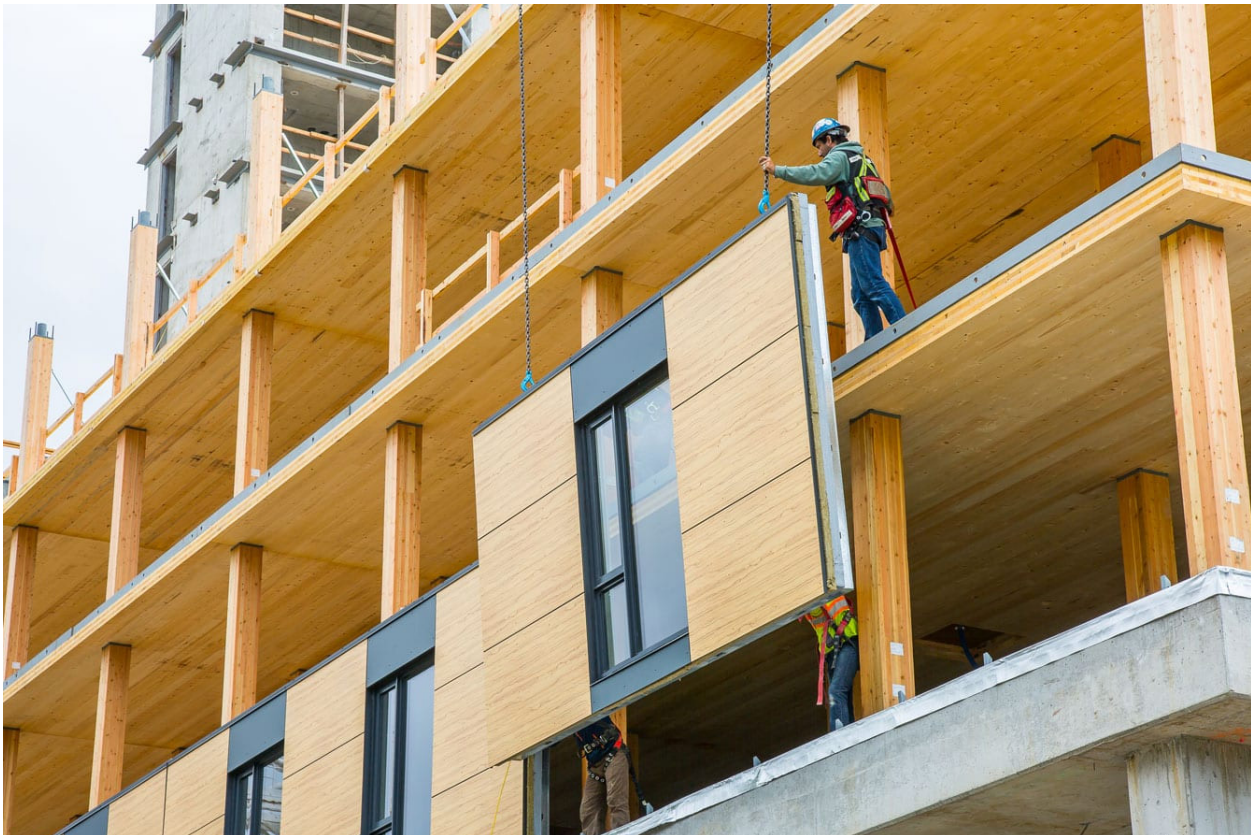
Prefabricated Structures

Brock Commons is a heavy timber student housing at the University of British Columbia. The floor plates are made up of Cross-Laminated Timber (CLT) and Glulam columns. Due to many of its panels and fitted pieces manufactured off-site and meticulous coordination through 3D modeling, this 18 storeys high-rise of 404 student units was constructed on-site in only 70 days[22] which was a much shorter timeframe

22 Naturally:Wood. (n.d.). Brock Commons Tallwood House. Retrieved December 27, 2024, from https://www.naturallywood.com/projects/brock-commons-tallwood-house/

needed to build a similarly sized off-site concrete building. It is also economically viable, as prefabricated timber elements can be produced off-site and assembled quickly, reducing labor costs and time. Additionally, timber buildings sequester carbon, making it an environmentally friendly alternative to traditional construction methods. Given that the building is designed and built in British Columbia, a place with abundant wood, CLT buildings have gained massive popularity in recent years.

However, there are a few drawbacks to the this type of CLT-glulam system, mostly in detailing and code issues that have yet to be resolved. An issue is water exposure, which is especially an issue in wet climates such as Vancouver. It is rare to see exterior facade that is wood especially if exposed to the rain unless covered by roof because rain can affect it a lot.  If not detailed properly and mass timber like CLT panels are exposed to moisture for extended periods, they can suffer from dimensional instability, rot, and mold. To prevent damage, mass timber buildings will need proper detailing practices, such as sealing panels and ensuring proper ventilation. Additionally, given the fire safety reasons from the BCBC (British Columbia Building Code), many parts of the Brock Commons building hides its timber structure behind drywall and concrete, which was done for fire safety reasons but might detract from the natural wood aesthetic.



**[Fig. 50]** Brock Commons prefabricated facade panels are being installed, 14 storeys assembled in 70 days with minimal wasted material.



**[Fig. 51]** Common area that showcases interior wooden walls and column materiality palette

**Dyson Institute Undergraduate Village**

Location: Malmesbury, United Kingdom

Year Built: 2019

Modular/Prefabricated Structure | Communal Engagement

The Dyson Institute Undergraduate Village, designed by WilkinsonEyre, is a case of prefabricated housing that is designed for students - pods are usually stacked 2-3 stories high, surrounded by gardens and including communal amenities and a central learning hub[23] that makes the place much like a village.



**[Fig. 52]** CLT structure is exposed to give a warm, clean look that also provides individualized spaces for live and work.

23 Pintos, P. (2019). Dyson Institute of Engineering and Technology / WilkinsonEyre. ArchDaily. Retrieved February 27, 2025, from https://www.archdaily.com/919886/dyson-institute-of-engineering-and-technology-wilkinsoneyre

The use of prefabricated pods manufactured off-site for rapid assembly, reducing time and site disruptions that may be a key advantage for potential under-SkyTrain housing which is an advantage for potential under-SkyTrain housing where the site and its proximity to transit lines can be constrained and require minimal interference. Additionally, the use of exposed CLT in the units, gives the units a warm clean feel to the interiors. The unit itself is quite spacious spanning 8x4 m in area accommodating a bed, seating, study/living areas and a bathroom. Each pod was manufactured off-site, fully fitted before being transported and craned to the site.



**[Fig. 53]** Staggered stacking of the modular pods to create variety and to break down the form to be more human-scaled.

Modular housing often works best when there is a standardized unit that can be repeated, which in turn can limit customization. Looking at the Nakagin Capsule hotel, the repeated units ended up creating monotonous, gridded boxes that lacked variety. However, Dyson Institute Undergraduate Village is successful in the way that, while it still uses the same repeated units, they are staggered and varied in its modular layout that breaks away from the rigid and repetitive pattern that's often associated with prefabricated housing, creating more visual interest and a design that feels more organic and interesting. The shared pathways and shared greenspaces - with the orientation glazed residential facade facing towards these areas which create a sense of openness and connection that allow for subtle dialogue between the residents and other passersby, which blur the boundaries between private and public space and make the development feel more inviting and inclusive rather than closed off from its surroundings.



**[Fig. 54]** Shared pathways spaces in-between units allow for gathering and community

### Durham Supportive Modular Housing

Location: Toronto, Canada

Year Built: 2024

Prefabricated Structure



**[Fig. 55]** Facade of Durham Supportive Modular Housing. Its warm facade dispels the original notion that modular housing only has an industrial look.

The Durham Supportive Modular Housing project by Montgomery Sisam Architects benefitted form modular housing because it allowed for a rapid assembly of units, completing the process from design to occupancy in just twelve months a significant time saving over traditional methods. Speed and affordability were key goals, and off-site indoor manufacturing helped reduce both cost and timeline. The onsite

control meant mitigating risks such as weather-related time day, material waste and unexpected cost overruns. These advantages make modular construction particularly relevant for under-SkyTrain housing, where site access is limited and minimizing on-site disruption is crucial.

Each residential module was tailored to fit a flatbed truck, measuring approximately 66 by 14 feet which streamlines transport and on-site assembly. The process also allows the construction season to be extended, helping meet urgent housing demands without compromising quality.[24] Beyond speed and efficiency, the Durham project dispels the myth that prefabricated housing must look like impersonal industrial structures that don't feel like home.  Montgomery Sisam's website describes the facade as being inspired by its surrounding context, with its dark cladding, wood accents, and sloped rooflines harmonizing with the surrounding neighborhood.[25] The final structure looks and feels like a home, - it has a visual modern and elegant aesthetic that does not usually associate with supportive housing. Also, its shared amenities such as dining areas, wellness spaces, and bike storage create a more communal and human experience for its residents.

For sustainability, the building contributes to energy efficiency and reduced greenhouse gas emissions by use of rooftop solar panels, airtight construction (another advantage of being built off-site), and optimized window placement.

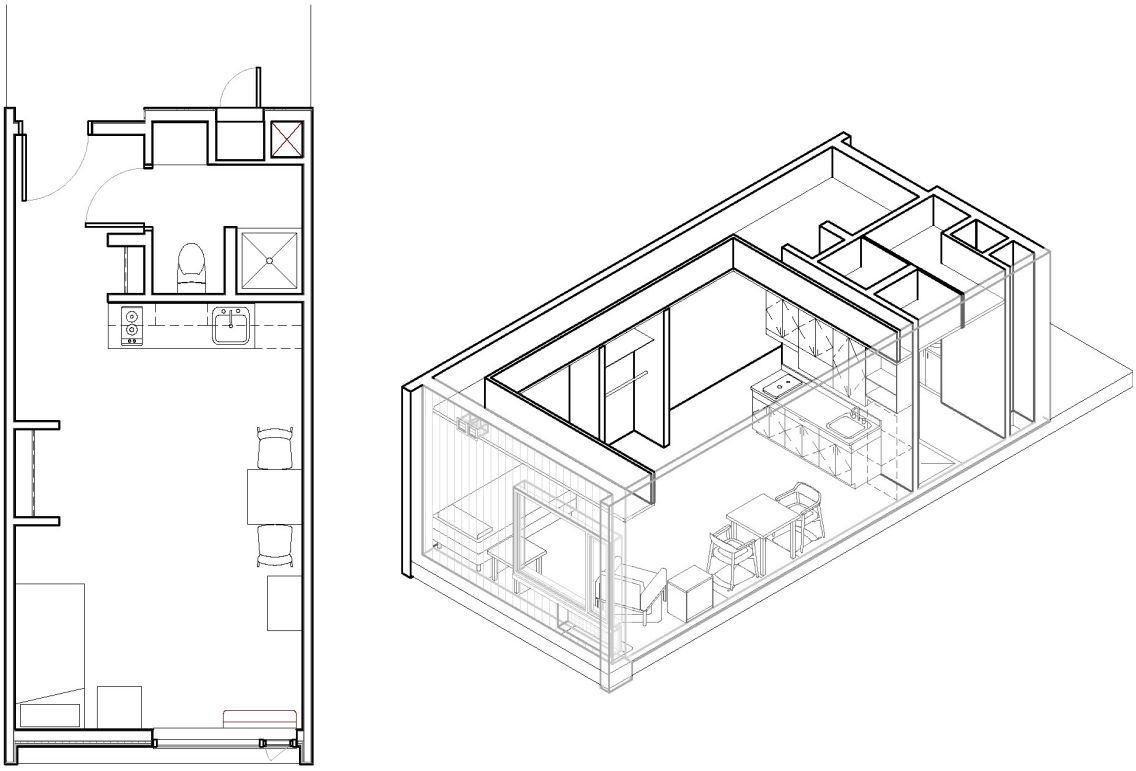
In terms of layout, there are two distinct sections with one being private and the other being more public. This typology balances privacy with community, providing

24 Canadian Architect. (2021, November 29). Durham Modular Supportive Housing. https://www.canadianarchitect.com/durham-modular-supportive-housing/

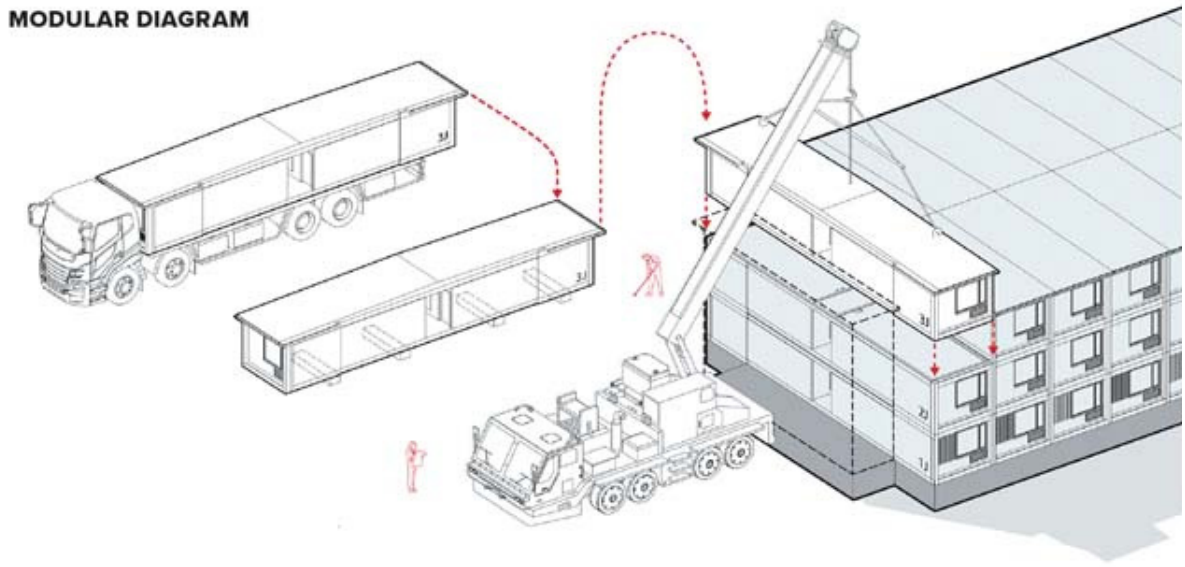
25 Montgomery Sisam Architects. (2024). Durham Modular Transitional Housing. Retrieved February 27, 2025, from https://www.montgomerysisam.com/project/durham-modular-supportive-housing/

shared spaces that encourage social interaction while maintaining personal space. It demonstrates that modular housing can support both functional and social dimensions, evolving into a more community-oriented and context-sensitive form of urban living.

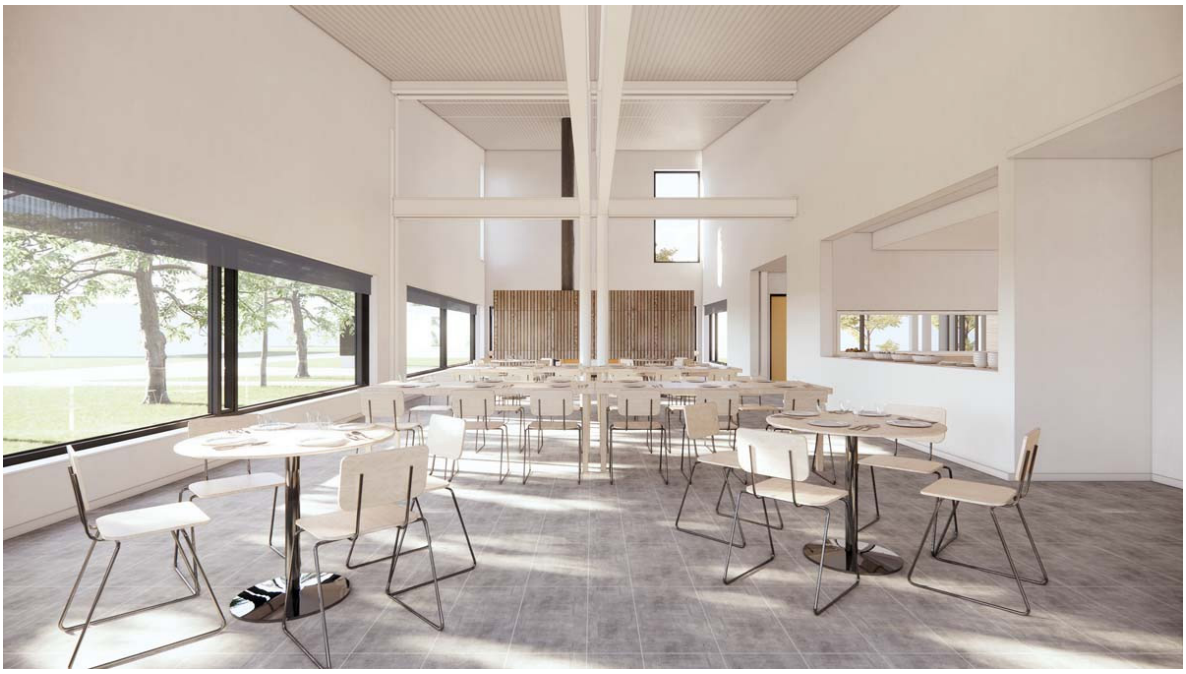
Overall, the Durham Modular Supportive Housing is an example of how modular construction can meet the urgent needs for affordable, transitional housing while fostering a sense of community for its residents. Its use of sustainable materials, rapid assembly, and customization to blend with its surrounding context gives lessons on design for the SkyTrain-adjacent housing proposal.



**[Fig. 56]** Each residential module is approximately 66 sq ft. by 14 sq ft, and tailored to the size of a flatbed truck.




**[Fig. 57]** Each residential module is approximately 66 sq ft. by 14 sq ft, and tailored to the size of a flatbed truck.



**[Fig. 58]** Interior shared common area, creating a communal gathering area that supplements the residential units

## 2.3.1 Reusing Shipping Containers

In 1956, Malcolm McLean pioneered containerized shipping to improve freight efficiency, ultimately prompting the adoption of the ISO (International Organization for Standardization) container standard by 1970 to streamline global trade. The ISO shipping container revolutionized global freight transport and now carries 90% of non-bulk cargo via ship, rail, or truck. Eventually, due to trade imbalances, hundreds of thousands of surplus containers sit unused, making them a viable resource for architectural reuse. Also known as International Standard Building Units (ISBU), these containers are structurally robust and ideal for prefabricated construction with minimal modification. These units have a stacking capacity of 5 to 15 stories[26] easily without additional reinforcement and come in the following dimensions:

| | 40 Foot Typical | 40 Foot High Cube | 20 Foot Typical | 20 Foot High Cube |
|---|---|---|---|---|
| Ext. Length | 40' – 0" | 40' – 0" | 19' – 10 ½" | 19' – 10 ½" |
| Ext. Width | 8' – 0" | 8' – 0" | 8' – 0" | 8' – 0" |
| Ext. Height | 8' – 6" | 9' – 6" | 8' – 6" | 9' – 6" |
| Int. Length | 39' – 4 13/64" | 39' – 4 13/64" | 19' – 4 13/64" | 19' – 4 13/64" |
| Int. Width | 7' – 8 33/64" | 7' – 8 33/64" | 7' – 8 33/64" | 7' – 8 33/64" |
| Int. Height | 7' – 10 3/32" | 8' – 10 3/32" | 7' – 10 3/32" | 8' – 10 3/32" |
| Doorway Width | 7' – 8 3/64" | 7' – 8 3/64" | 7' – 8 3/64" | 7' – 8 3/64" |
| Doorway Height | 7'– 5 49/64" | 8' – 549/64" | 7' – 5 49/64" | 8' – 549/64" |
| Int. Cubic Capacity | 2,390 cu. ft. | 2,698 cu. ft. | 1,170 cu. ft. | 1,320 cu. ft. |
| Empty Weight | 8,070 lbs. | 8,470 lbs. | 4,755 lbs. | 5,070 lbs. |
| Maximum Payload | 59,130 lbs. | 58,730 lbs. | 62,445 lbs. | 62,130 lbs. |

**[Fig. 59]** Typical and High Cube Shipping Container standard dimensions, which allows for more otpions for different programmatic needs depending on the building use

26 Smith, R. E. (2010). Prefab architecture: A guide to modular design and construction. John Wiley & Sons.

For transport, shipping containers were initially intended for transport by truck and ship; therefore, they should fit legal trucking dimensions. The current legal trucking dimensions in British Columbia (legal maximum is 4.15 m (h) x 2.6 m (w) x 12.5 m (l)) without additional oversized permit charges. [27] One major advantage is its ability to repurpose existing structures (the shipping containers), which makes it quite cost-effective. It also provides speed of construction due to the prefabricated nature of the modules, which can be assembled quickly on site. However, there are still drawbacks to container housing. The shipping container dimensions are usually predetermined, making it less flexible in terms of design and spatial configuration. Modifications to the structure, especially when cut horizontally against the grain of the corrugation (for adding doors and windows on the side of the container for example), would cause a loss in the corrugation's structural strength and making modifications difficult can results in increased costs.

Additionally, the primary purpose of the container is to act as a structural shell, meaning other aspects of the wall including  insulation, waterproofing, and soundproofing are to still be added, leading to further construction expenses. Container housing also has issues with thermal regulation, as the metal containers tend to retain heat or cold, requiring more extensive insulation to make these environments livable. While reusing shipping containers as infrastructure can be cost-effective, it is important to weigh these factors and determine whether the sacrifices in flexibility and increased costs for modifications justify their use in large-scale housing developments beneath Vancouver's SkyTrain.

27 Consolidated Regulations of British Columbia. (2025). Commercial Transport Regulations, B.C. Reg. 30/78. Consolidated Regulations of British Columbia. https://www.bclaws.gov.bc.ca/civix/document/id/crbc/crbc/30_78

On a sustainability note, shipping container housing and shops that reuse disserviced shipping containers - are questioned by some environmentalists if high-energy steel because they are taking it out of the recycling cycle. However, it can be argued that recycling itself takes energy to process the steel to become something recyclable. [28]

Residential conversions of shipping containers are technically feasible, especially with taller shipping containers that could meet the BCBC's Part 9 (2024) 2.3 m minimum ceiling height. However, once added insulation, fire separations, and HVAC systems, the interior space becomes tighter especially with the wall and ceiling components in place. While, it is still sufficient space, it does make the design process more limiting and less forgiving. However, commercial uses such as popups or seasonal retail are more adaptable due to it having less constraints. They usually have lower servicing needs and have more flexible layouts. There are also fewer regulatory constraints that are a factor in long term habitation. As a result, the thesis will be exploring container architecture that are commercial rather than residential as a way to support the surrounding housing community. The commercial modules can host food vendors (much like the Chuo Line precedent) or up and coming businesses (upcoming precedent in the thesis called Hatch).

28 BC Housing, Manufactured Housing Association of BC, & Real Estate Institute of BC. (2014). Modular and prefabricated housing: Literature scan of ideas, innovations, and considerations to improve affordability, efficiency, and quality.

## Container City 2

Location: London, United Kingdom

Year Built: 2002

Prefabricated Structures



**[Fig. 60]** The bold colours and form of the exterior facade and circular windows of Container City 2



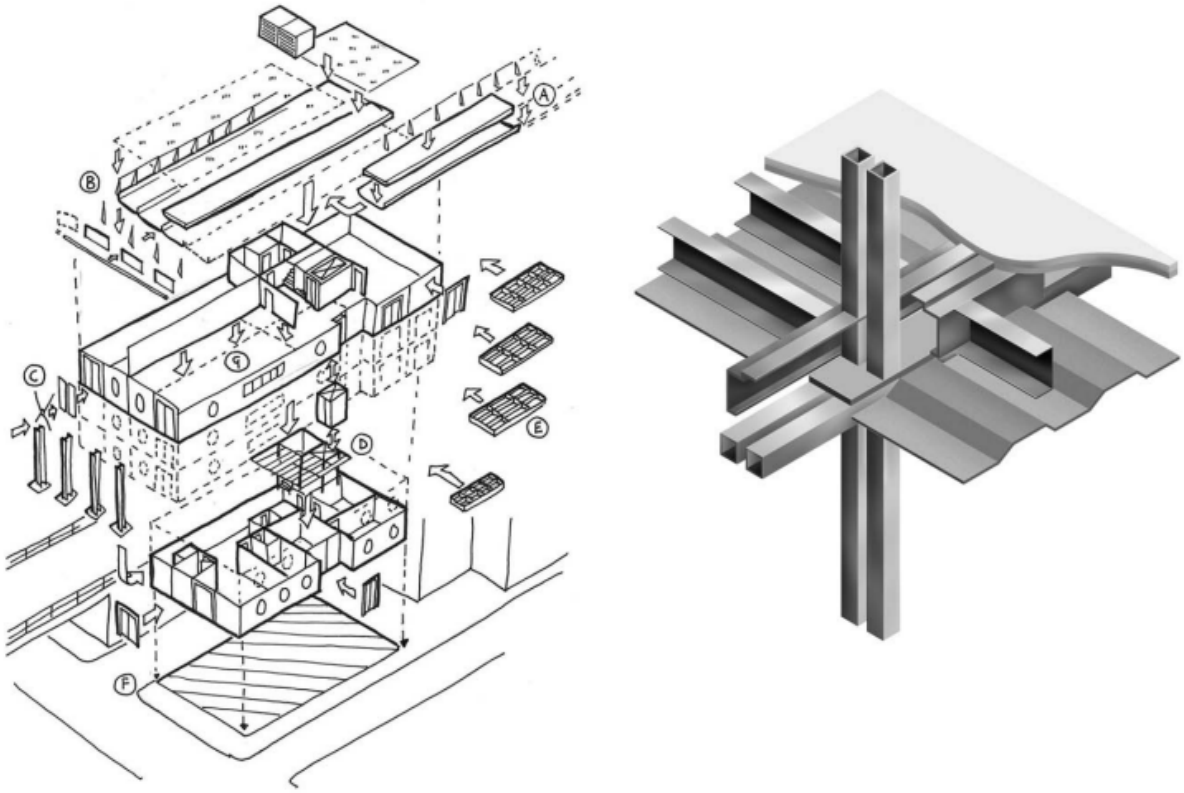
**[Fig. 61]** *Right* Incorporating retrofitted balconies that creates a personal outdoor space

**[Fig. 62]** *Left* Interior view of the container homes that are made up of two modules

In London, England - the project Container City 2 contains 5 storeys of office space and is a successful piece of architecture that adopts principles of modularity and adaptability but in a contemporary way that uses the principles for more efficient assembly, transportability, and its adaptability to varying urban conditions, making it more suitable to the various conditions beneath Vancouver's SkyTrain. The shipping container modules can be reconfigured in many ways and are in a variety of colors that it can scale up while still having variation. These principles address the unique challenges of creating affordable, flexible housing in varying urban spaces.

Shipping container construction has become more popular in the recent years. Container City stacks and configures modules in a unique way that breaks down the monolithic nature often seen in mass-produced housing. The entire complex was installed in days with minimal site disruption which is an approach that can align with the constraints of SkyTrain-adjacent sites, where construction access is limited especially in high-density areas where land scarcity makes traditional development infeasible.There is also an economical argument to be made. In London, container housing costs 60% less per square foot than traditional buildings, making it an ideal candidate for addressing affordability crises. Buro Happold Engineers and George and Harding Construction developed technology for the Container City projects (shown in the precedent is one example of a series of projects.) The 12 ft x 42.65 ft module was used as a base unit in order to accommodate the dimensions of  hotel unit. Compared to typical onsite construction methods, it saved 25 percent on construction time and 10 percent on construction costs. [29]

29 Smith, R. E. (2010). Prefab architecture: A guide to modular design and construction. John Wiley & Sons.




**[Fig. 63]** Buro Happold engineered a system for shipping container architecture since 2000s in which more than a dozen have been completed, including housing, retail, office space and daycare facilities. The left diagram is an early diagram by Buro Happold Engineers that identify elements of the system and on the right is a connection detail of one shipping container module connected to another.[30]

However, there are also limitations of using shipping containers as a shell for buildings. The rigid dimensions of shipping containers and their requiring extensive modifications to make them livable in terms of acoustics, thermal and required dimensions for its intended program makes it not ideal in many cases.[31] For the Container City projects, although the interiors were finished out in China, the cladding and structure were less coordinated and made on different schedules. The cost and time saved were not substantial because of the amount of onsite work to coordinate the

30 Smith, R. E. (2010). Prefab architecture: A guide to modular design and construction. John Wiley & Sons.

31 Equipment Management Services. (2019, May 7). The pros and cons of building a shipping container house. EMS. https://ems-llc.com/the-pros-and-cons-of-building-a-shipping-container-house/

structure and skin of the building. Shipping containers make sense when it is a project that is for more confined sites, more temporary and have more flexible interior program.

### Boxpark Shoreditch

Location: London, United Kingdom

Year Built: 2011

Modular/Prefabricated Structure | Communal Engagement

Another example of shipping container architecture is Boxpark Shoreditch - a pop-up retail space made from shipping containers. Designed by Waugh Thistleton Architects, it was assembled in just a few months, showing how modular construction can quickly activate leftover spaces in the city. The stacked containers create a commercial strip, with glass storefronts that keep it visually open to pedestrians. On the second level, an open-air deck with seating and food vendors turns what could have been just a retail row into a casual gathering spot. This kind of efficient, adaptable setup is exactly the kind of thinking needed for under-SkyTrain housing, where space is tight, and construction needs to be quick and low-impact. One of Boxpark's biggest strengths is how it makes modular design feel engaging instead of rigid. Instead of just stacking boxes, they integrated social spaces, making it feel active and inviting. The second level acts as a buffer between private and public space, which is something modular housing under the SkyTrain could use, whether through shared terraces, balconies, or elevated courtyards. Another takeaway is how Boxpark is in proximity into transit-oriented development (TOD). Its location near Shoreditch High Street Station means high foot traffic and built-in customers, proving that small-scale retail can work well alongside transit infrastructure. Note that these retail spaces are smaller-scale and more low-maintenance rather than full-blown operations due to the limit of the shipping containers. A similar mixed-use approach with housing + retail under the SkyTrain could make

these spaces feel more connected and economically viable. That said, Boxpark's model has limitations with its shipping containers materiality requires heavy insulation, proper ventilation, and soundproofing, especially near a train line. Either way, Boxpark with its shipping container and proximity to transit, gives solid ideas for how SkyTrain-adjacent housing could be used to activate the streets with small shops and public spaces. It is a project that had its own spinoffs and similar projects such as Stackt (Toronto) and many places around the world in different contexts and environment.




**[Fig. 64]** Public Gatherings and activities that take place on the platform above the first floor shops.




**[Fig. 65]** Glazed Doorways that showcase the storefronts of a variety of vendors

### Hatch

Location: Manchester, United Kingdom

Year Built: 2017 (Decommissioned 2023)

Reclaiming Elevated Spaces | Prefabricated Structure | Communal Engagement

While Boxpark in London is an early example of reusing shipping containers to create a shopping and food hub, Hatch was inspired by this project, and was adapted to the a new site, which was at a highway underpass. It is located along a corridor with heavy foot traffic but had limited retail options, with the underpass being a dark leftover void. Hatch emerged as a way to strategically activate the space, and acted as a micro-village and incubator space for independent businesses that offer short-term leases in repurposed shipping containers. There were several tenants that eventually scaled to permanent locations.

The project launched in 2017, and Hatch expanded rapidly. By Phase 2, it grew from 2480 to 11840 sq ft., with adding stacked container units, open-air terraces, creative workspaces and music stages that transformed the space into a multipurpose node. By 2019, Hatch hosted 30 vendors of retail that include food stalls to retail, and during events is layered in festive grounds, live music and other informal gatherings that create a lively space rarely found below an underpass.[32] On a broader scale, Hatch was part of a broader urban development strategy, Bruntwood's Circle Square project that was a 1.2 million sq ft. mixed-use masterplan, and Hatch acted as a testing ground to small vendors to potentially "hatch" to the larger and more permanent neighbourhood. In 2023, Hatch was sold to new developer which plans to invest and grow in the coming few years.[33]

This deliberate urban intervention aligned with Manchester's infrastructure and development strategy and ultimately turned a negative space into a positive asset. This is directly applicable for Vancouver's under-SkyTrain spaces, its broader Vancouver Transit-Oriented Development strategies and independent business culture - for the high-traffic areas beneath the SkyTrain that acts as public buffer for the more private residential areas, the space can be prototyped as retail modules.[30]

32 Confidentials. (2019, October 23). Newer bigger Hatch: What a crate idea. https://confidentials.com/manchester/hatch-oxford-road-manchester

33 Whelan, D. (2023, September 1). Bruntwood sells Hatch to STACK. Place North West. https://www.placenorthwest.co.uk/bruntwood-sells-hatch-to-stack/

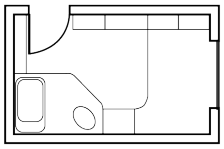



**[Fig. 66]** Shipping containers bringing vibrance and colour beneath the bridge

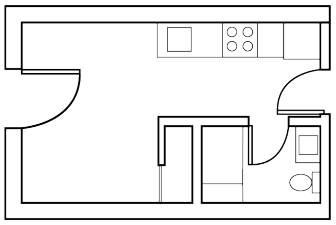


**[Fig. 67]** Beneath the concrete structure hosts an active space with vendors and activities

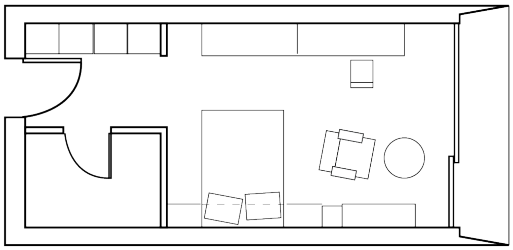
Nakagin Capsule Hotel Typical Unit



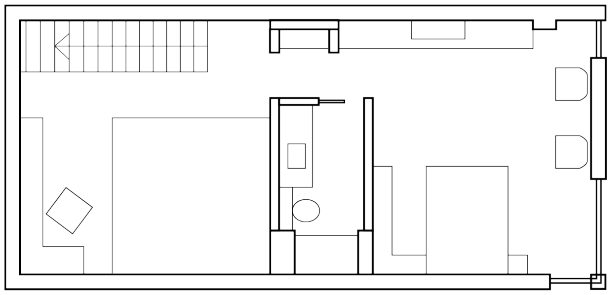
Brock Commons Typical Unit



Dyson Institute Undergraduate Village Typical Unit



Habitat 67 Typical Unit (1)



**Dotted Line Units are proposed units for the thesis. The size proposed include exterior walls.**

**Residential Pod (High-Density Site)**

While Nakagin capsule hotel is efficient, it is not the most livable or comfortable as a unit.
The size of the pod for the thesis design between the sizes of Brock Commons Units, as it is roughly the size of a student unit and a smaller microunit given that it is temporary space targetted towards a mix of young professionals and students.
Each unit includes 1.2 m of outdoor space

Op 1:
3.0 x 5.4 m

Op 2:
3.0 x 6.0 m

WR:1.5
x 2.6 m

**Live-Work Unit (Medium-Density Site)**

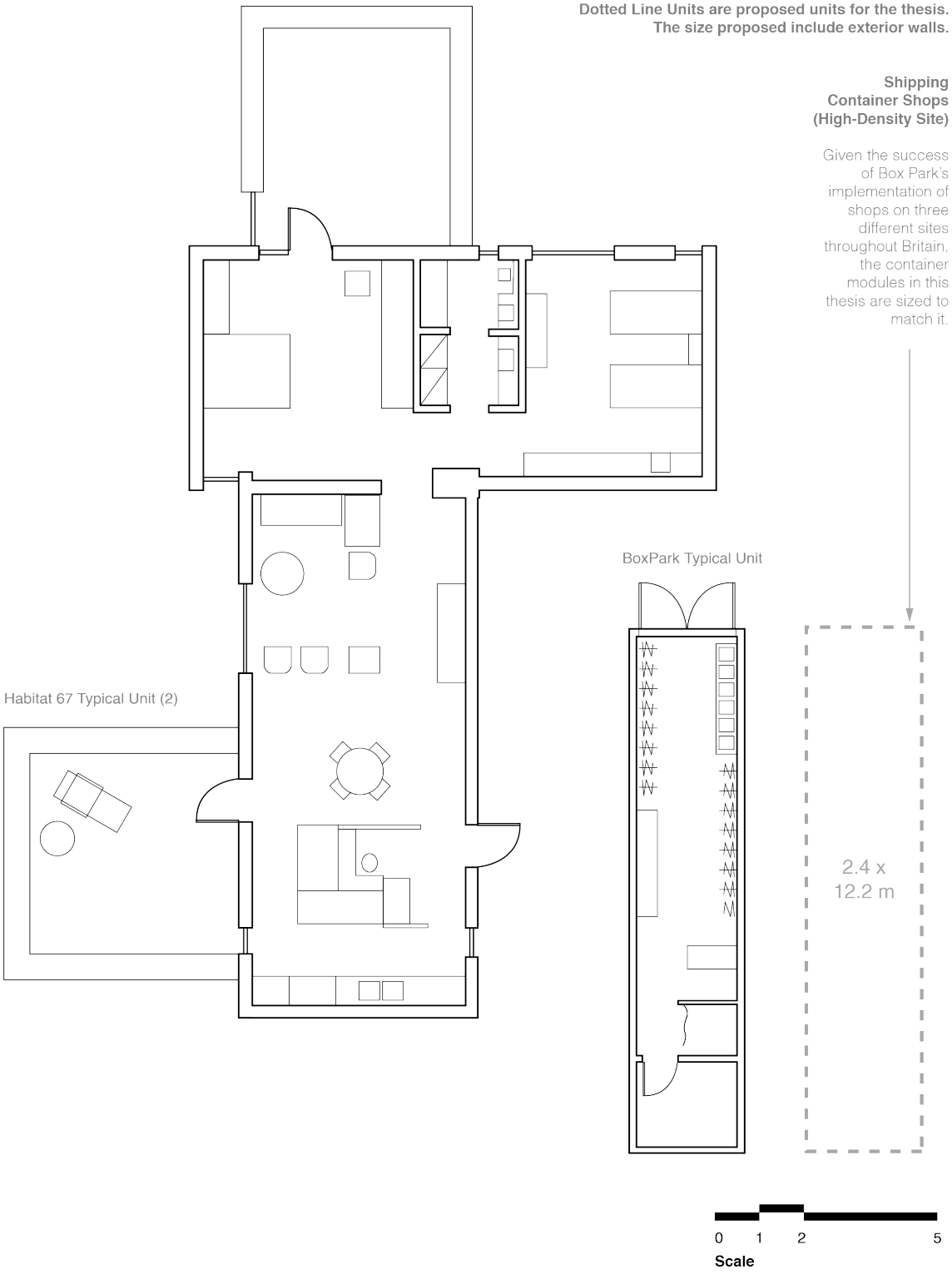
Live-Work Units are sized to match the footprint of a single Habitat 67 typical unit given its programmatic similarities and comfortable yet efficient floorplan.

6.2 x 9.0 m

0 1 2 5

**Scale**

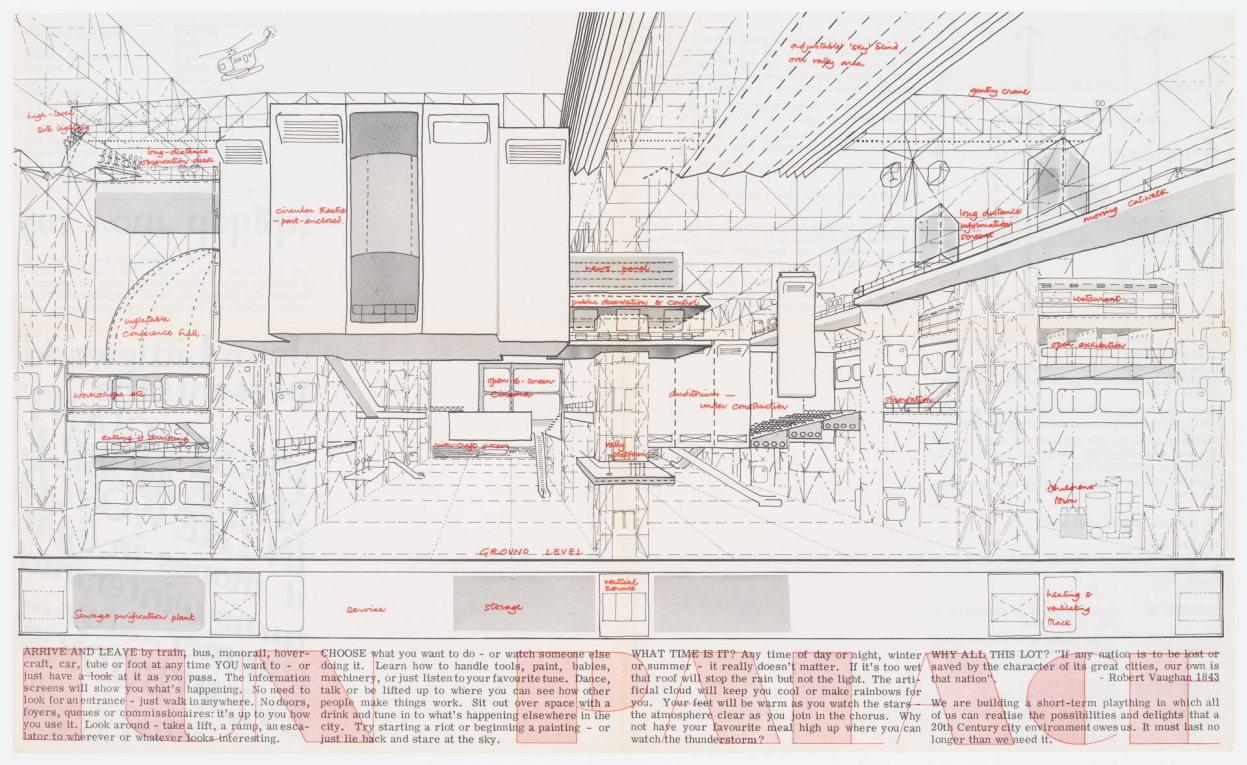
**[Fig. 68]** Comparison of different unit sizes of prefabricated modular living, compared to the unit design sizing in the design portion of this Thesis




**[Fig. 69]** More examples of pre-fabricated units

## 2.4 Tiny and Flexible Living

Cedric Price, a pioneer of adaptive architecture, provides further insight into how flexibility can be applied to urban housing. One of his famous works, the Fun Palace, illustrates how architecture can serve as a flexible structure that changes based on how people interact with it.[34] Inside this speculative structure was an ever-evolving space where structures could be moved, reconfigured, or adapted to accommodate a variety of activities and needs.[32]




**[Fig. 70]** Cedric Price's Fun Palace as pioneer of viewing architecture rather than a permanent structure, instead something that is flexible and adaptable to the everchanging needs of its occupants.

The spirit of flexibility that was originally envisioned at the scale of social infrastructure is seen commonly today but in a different context, where it is proven to be crucial in terms of designing constrained housing in dense urban sites. In high-density

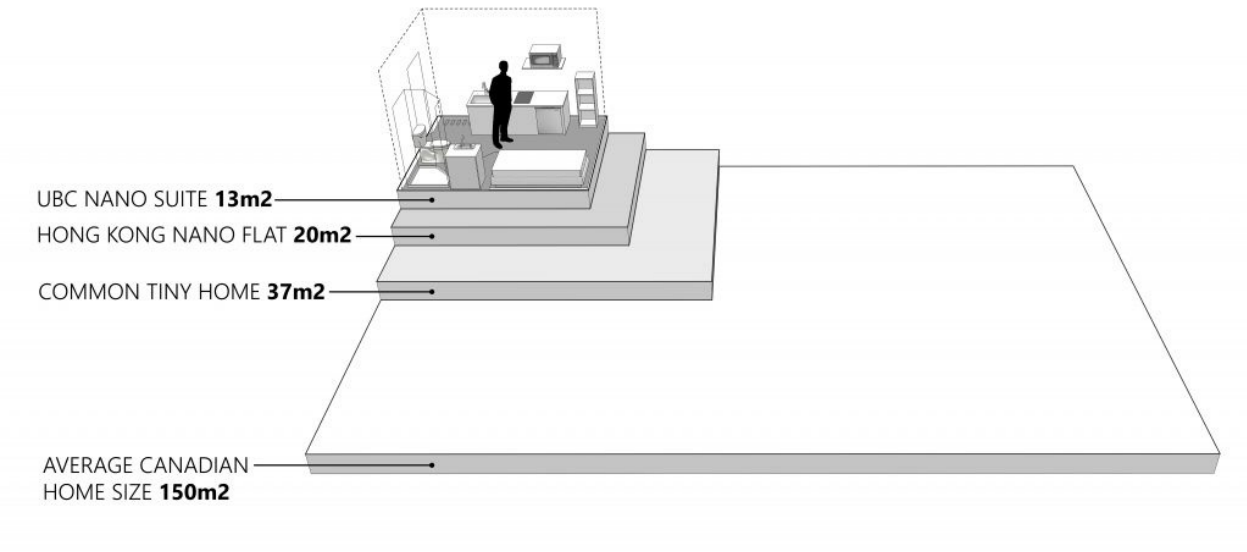
34 CCA (Canadian Centre for Architecture). (2016, February). 1964: Fun Palace. https://www.cca.qc.ca/en/articles/issues/2/what-the-future-looked-like/32737/1964-fun-palace

cities such as Tokyo, Hong Kong and increasingly Vancouver, micro-units and nano suites have emerged as solutions to affordability in a place where land is scarce.[35],In Vancouver, their “Micro Dwelling Policies and Guidelines” define such dwellings as new self contained as units under 320 sq. ft. with some exceptions down to 250 sq ft.. These units are intended for single occupancy and must meet livability standards including natural light, ventilation and access to outdoor space. A strategy used in order to maximize spatial efficiency is through flexible furnishing systems such as multi-use or foldable furniture. However, such design usually comes with a premium, which raises the question of whether flexibility is truly democratizing or branded as “affordable” for the sake of it. Each case would require a careful cost-benefit analysis.

With such a small floor area, a key concern is whether these spaces are livable for its occupants. According to a 2023 University of British Columbia study, after analyzing student experiences on the 13 sq m. UBC Nano Suite (a unit that is smaller than the 37 sq m typical microunit size found in Vancouver) found no statisically significant decline in well-being after living in the nano suite for seven months. [36] While this may suggest that tiny living spaces can be tolerable in the short term, the findings are limited by demographic scope - students that are in transitional life stages rather than long-term residents or working professional. It is relevant for the design portion of the thesis which mainly serves students and young professionals.

35 City of Vancouver. (2025, April 1). Micro dwelling policies and guidelines. https://guidelines.vancouver.ca/guidelines-micro-dwelling.pdf

36 Shulman, L., & Honey-Rosés, J. (2024) How small is too small? Assessing the well-being impacts of nano suites on university students. People, Place and Policy, 18(1), pp. 26-47. https://doi.org/10.3351/ppp.2024.4785923692



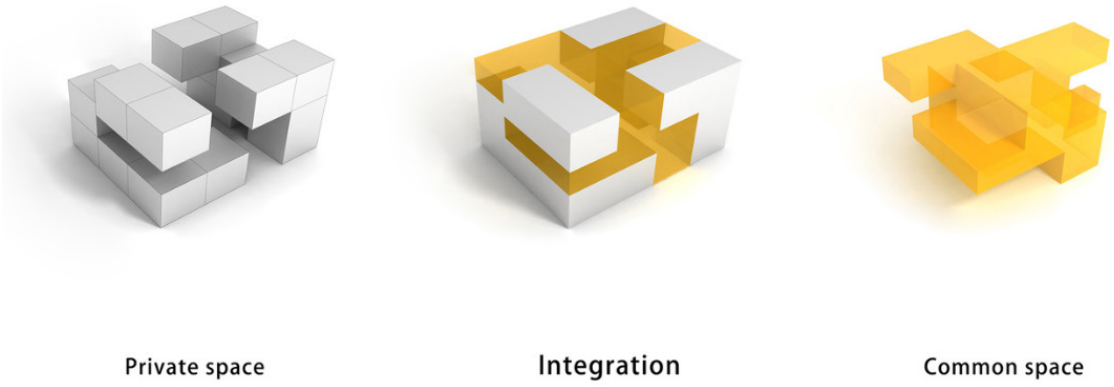

**[Fig. 71]** Nano Suite at UBC that is used for the survey in the study - which is smaller than Hong Kong Nano Flats and common tiny homes.

## LT Josai Shared House

Location: Japan

Year Built: 2013

Location: Tokyo Japan




**[Fig. 72]** Diagram explaining how the private and common spaces are intertwined

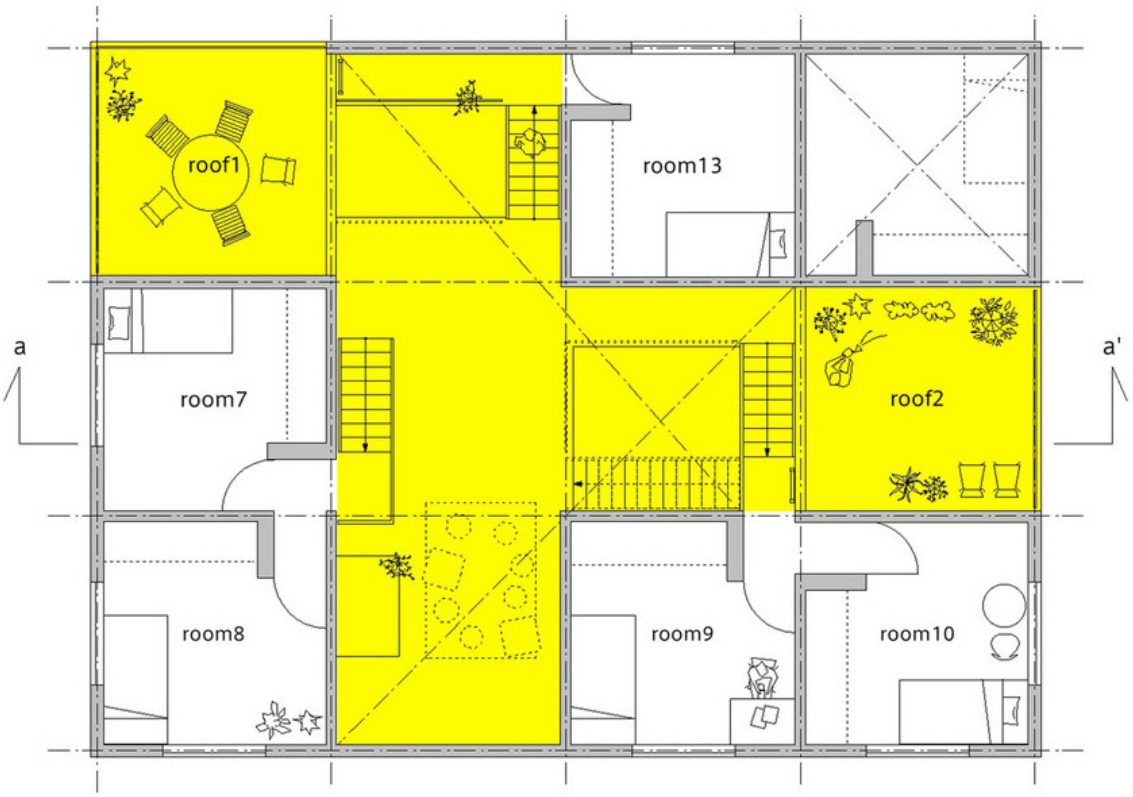
This co-living housing project by Naruse Inokuma Architects offer a clever exploration of balancing spatial efficiency with shared housing. Designed in response to the growing demand for communal living, the building accommodates 13 residents, each with a private bedroom of only 12.4 sq. m.. Although compact, the units have more generous shared spaces including kitchens, living areas, and bathrooms. When dividing the total building floor area (including circulation and services) by the number of residents, each person effectively occupies only 23 sq. m. which may seem fairly efficient and a small area. [37] However, the architects designed it with spatial voids and ample natural light that makes the space feel more spacious and mitigates the feeling of confinement.

``



**[Fig.73]** Common space and different pockets of shared activities

37 ArchDaily. (2014, April 18). LT Josai Shared House / Naruse Inokuma Architects. https://www.archdaily.com/497357/lt-josai-naruse-inokuma-architects




**[Fig. 74]** Floorplan of a typical level, highlighted in yellow are the common spaces

### Seven Victory Avenue Special Unit

Location: Hong Kong

Year Built: 2017

The corridor-like unit is only 15 sq. m. in area double-loaded with functions and the foyer also works as a laundry room and walk-in closet, both of which can fold back into the wall. A living room can turn into a bedroom or a dining space depending on the time of day or the person's routine. According to the project description, seven strategies were used to aid in optimizing space and mitigate any claustrophobia within the narrow space[38]:

38 EDGE Design Institute Ltd. (2016). Seven Victory Avenue Special Unit. https://www.edgedesign.com.hk/2017-seven-victory-avenue

1. Maximizing Surface and Volume Space: Every surface and vertical space (2780mm height) is used. It integrates many concealed storage components such as cupboards behind boards.
2. Thin and Strong Material: Honeycomb aluminum panels (albeit expensive) are used to reduce bulk
3. Blurring Spatial Zones: Functions overlap throughout the flat, allowing multipurpose and flexible use of space.
4. Time-Based Transformation: The space adapts based on routines - with sliding partitions and compartmentalization, the whole space can shift between different uses (full cooking or full bathroom)
5. Multi-purpose Furniture: Self-explanatory, examples include seating-storage hybrids, grill that doubles as balcony table
6. Mobile and Concealed Elements: Visually, furniture such as camouflaged tables and projector blinds can act as dividers/screens that offer use without visual clutter
7. Prefabrication and Modularity: Modular furnishing allows for quicker and more cost-effective construction

Given the long, linear space around SkyTrain stations, with some areas having tight constraints this study provides a masterclass on creating livability in narrow constrained spaces.




**[Fig. 75]** Multifunctional spaces - how a narrow foyer corridor



**[Fig. 76]** Flexible furnishings to accommodate various everyday activities

### 17.6 Square Meter Flat

Location: Taipei, Taiwan

Year Built: 2019

Flexible Structure

The 17.6 square meter house by studio, A Little Design is an example of such work that emphasizes flexibility concept at work are of housing with flexible furniture - creative use of its furniture millwork in unexpected places. The place behind the stairs become unexpected storage, and the crevice on the wall can open up to become a desk for the bed and seating. The design of the space goes beyond simply plan, but makes use of all of the limited 17.6 square metres of space and 3.4 metres in height. Through thinking 3-dimensionally, in every notch and every nook and cranny within the design.[39] In the case of housing under the SkyTrain, where units might have height or width limitations, this kind of furniture can help people make the most of a small space. To reiterate the previous section, these solutions may be more useful in tighter and denser areas where land is limited but the flexible furnishing comes as extra cost.

39 Architizer. (n.d.). 17.6-square-meter apartment. https://architizer.com/projects/176-square-meter-apartment/



**[Fig. 77]** Open and Closed position of the flexible space

### Pet Architecture Guide Book

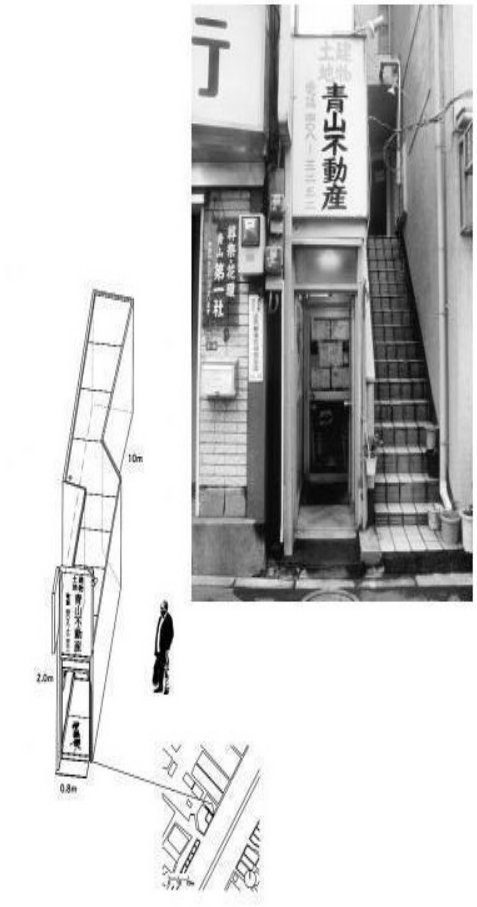
Location: Conceptual

Year Published: 2002

Location: N/A (Typology rather than an individual building)

Pet architecture is a concept coined by Atelier Bow-Wow that categorizes small or micro buildings that can squeeze into left-over urban spaces. While these infill spaces may be awkward due to obstructions and having odd geometries,it results in many interesting and playful forms that adapt to the site's irregularities. [40]

40 Shinada, K. & Tōkyō-Kōgyō-Daigaku (Eds.). (2002). Pet architecture guide book. World Photo Pr.




**[Fig. 78]** An Example of “Pet Architecture”, how a building can still fit within a narrow jagged floor area.

Like Tokyo, Vancouver also has many irregular spaces and sites and Vancouver can learn from these creative use of unconventional spaces for housing or other programs, which are commonly found beneath the SkyTrain tracks given the number of unconventional conditions that exist beneath the SkyTrain given the hilly terrain and the bends and turns of the SkyTrain rails itself. While modular design is a scalable option for most of the Under-SkyTrain spaces and is what is being proposed , it would be quite difficult, if not impossible to create a standardized system that can accommodate all the varying spatial conditions across the span of the elevated tracks. By considering strategies such as Pet Architecture, it encourages designers to be open to unconventional sites as more than just a challenge to create something truly unique.

## 2.5 Communal and Landscape Engagement

Community and landscape are essential elements that shape how people gather and live with place. In a multicultural city like Vancouver, it becomes necessary for architecture to respond with nuance. A one-size-fits-all approach flattens this diversity. Instead, the proposal embraces a “fill-in-the-blank” system: a modular framework that encourages local adaptation. By enabling community members to shape parts of the design. Whether through cultural expression, landscape strategies, or programming the architecture becomes a living system that reflects its context.



**[Fig. 79]** Basketball courts and playground space beneath the bridge which protects it from the rain and shine by Cooper Park by the False Creek in Vancouver.

Note that not all the “blanks” will need to be filled with infrastructure. Like rests in a musical composition or negative space in a painting, the overall system should allow for porosity with its building form that can be used for outdoor amenity spaces and thorough ways to allow people to pass through and even engage with the public spaces of the buildings. The porosity allows for articulations on the facade, which is visually permeable rather than a monolithic wall. It is a fine balance between structured infrastructure and unstructured areas that allow for more flexible programming for various events.

**Caulfield to Dandenong Railway & Linear Park (aka “The Underline”)**

Location: Melbourne, Australia

Year Built: 2019

Communal/Landscape Engagement | Reclaiming Elevated Spaces

Although this thesis focuses on the potential for housing beneath Vancouver’s SkyTrain, it also examines how its adjacent open spaces can be important for creating an active community life.This Australian case study shares a similar spatial condition - a linear corridor under rail infrastructure - but in this instance, the space has already been converted to communal open areas such as basketball courts, playgrounds and public amenities that under-SkyTrain spaces has potential to become. The Caulfield to Dandenong Railway & Linear Park project (colloquially known as “The Underline”) runs through three distinct communities in its city: [1] Carnegie, Murrumbeena, [2] Hughesdale, Clayton and [3] Noble Park that reclaim the space beneath the elevated rails as a continuous public park. The success of the project is that it could create a cohesive activated space while maintaining the character of each neighbourhood. [41]

41 Good Design Australia. (2019). Caulfield to Dandenong Level Crossing Removal Project. https://good-design.org/projects/caulfield-to-dandenong-level-crossing-removal-project/

The linear park is made up of a series of activation nodes, which are small pockets designed for communal activities such as gathering spots, fitness zones, varied seating, playgrounds, picnic areas, dog parks and larger areas for sports, skating climbing, bouldering and other activities. Each node is designed to be inviting and well-used that draws together community through these shared programs.[42]While the original goal was to simply remove level crossings and build new stations, the project went further, into turning leftover land into 22.5 hectares of open space and 17 km of bike and pedestrian paths. Instead of treating the underside of rail as dead space, the design created multi-use zones that serve different generations with different activities, as shown visually in the figures below. The project went through extensive community and council consultation to ensure that the project contributed back to its local communities. by connecting previously fragmented parts of the city, tying together shops, adding transport hubs and public services. For Vancouver's under-SkyTrain spaces, a similar attitude can be taken - by listening to the site, listening to the people, and shaping public spaces that speak to the communities who actually move through them.

42 ASPECT Studios. (n.d.). Caulfield to Dandenong Railway & Linear Park. https://www.aspect-studios.com/projects/caulfield-to-dandenong-railway-linear-park




**[Fig. 80]** Aerial view of a basketball area beneath the elevated concrete structure



**[Fig. 81]** Various fitness and play elements between the tracks




**[Fig. 82]** The spaces are well-lit during evening hours



**[Fig. 83]** Pedestrian trail runs along the corridor of the trains

## POWWOWWOW Commercial Centre

Location: Bangkok, Thailand

Year Built: 2020

Modular/Prefabricated Structure | Communal/Landscape Engagement

The Powwowwow development in Thailand is an example of well integrated communal and landscape engagement. With Thailand only having 6.9 square metres of green public space per capita (which is 2.1 square metres below WHO standards). As a result, the project aims to create a model for sustainable urban living that maintains a green oasis condition. While Vancouver has ample parks and greenspace, and has a different climate than Thailand, there are many urban design strategies and programming strategies in this project that is useful for undercover spaces (or Under-SkyTrain in Vancouver) and how to design them. There are foliage that are distributed around the building, throughways that permeate through the first floor building that open up the market for public access, and allowing light and sights into the shops. The second floor acts as a patio area for people to settle and gather - just an open flexible space that has seating and tables, that can allow for countless outdoor activities.[43]

43 ArchDaily. (2023, January 19). POWWOWWOW Commercial Centre / all(zone). https://www.archdaily.com/995133/powwowwow-commercial-centre-all-zone



**[Fig. 84]** Upper Floor is flexible open space with flexible chairs and tables for various activities



**[Fig. 85]** Porous and Open Space well integrated with its surrounding foliage

# 3

# [Reframing Under-SkyTrain Spaces]

The city is a living system that is constantly growing and shifting. Design doesn't happen in a vacuum, especially within infrastructure heavy sites such as under-SkyTrain spaces.This chapter outlines the physical, regulatory and systemic constraints that shape both the bounds and opportunities of the projects that can coexist within the context. A context that responds to and moves with the city's growing metabolism.

## 3. Under-SkyTrain Spaces

Vancouver's SkyTrain system is a key component of the city's transportation network, with over 233 million journeys taken annually as of 2023 [44] across 79.6 kilometres of track.[45] Despite its importance in connecting the city, much of the space beneath the elevated tracks remains underutilised - often used as parking lots, brown spaces, underused green spaces with limited access to sunlight, or simply neglected. These areas represent missed opportunities for urban development that can address Vancouver's housing demands. By transforming the under-SkyTrain spaces, the city could increase its density along key transit corridors and provide affordable living options with easy access to public transit



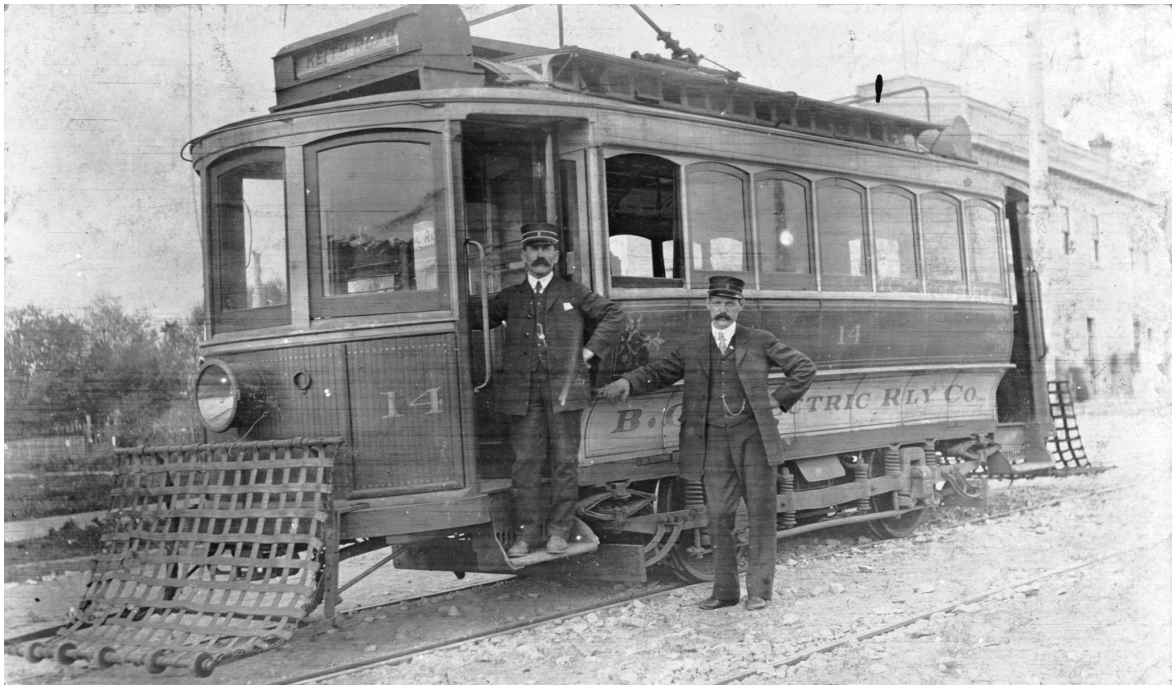
**[Fig 86]** Two living tents set up beside the SkyTrain rails in Central Park, Burnaby

44 TransLink. (n.d.). Ridership. https://www.TransLink.ca/plans-and-projects/data-and-information/accountability-centre/ridership

45 CityNews. (2016, December 2). Evergreen extension opening today. https://vancouver.citynews.ca/2016/12/02/evergreen-extension-opening-today/

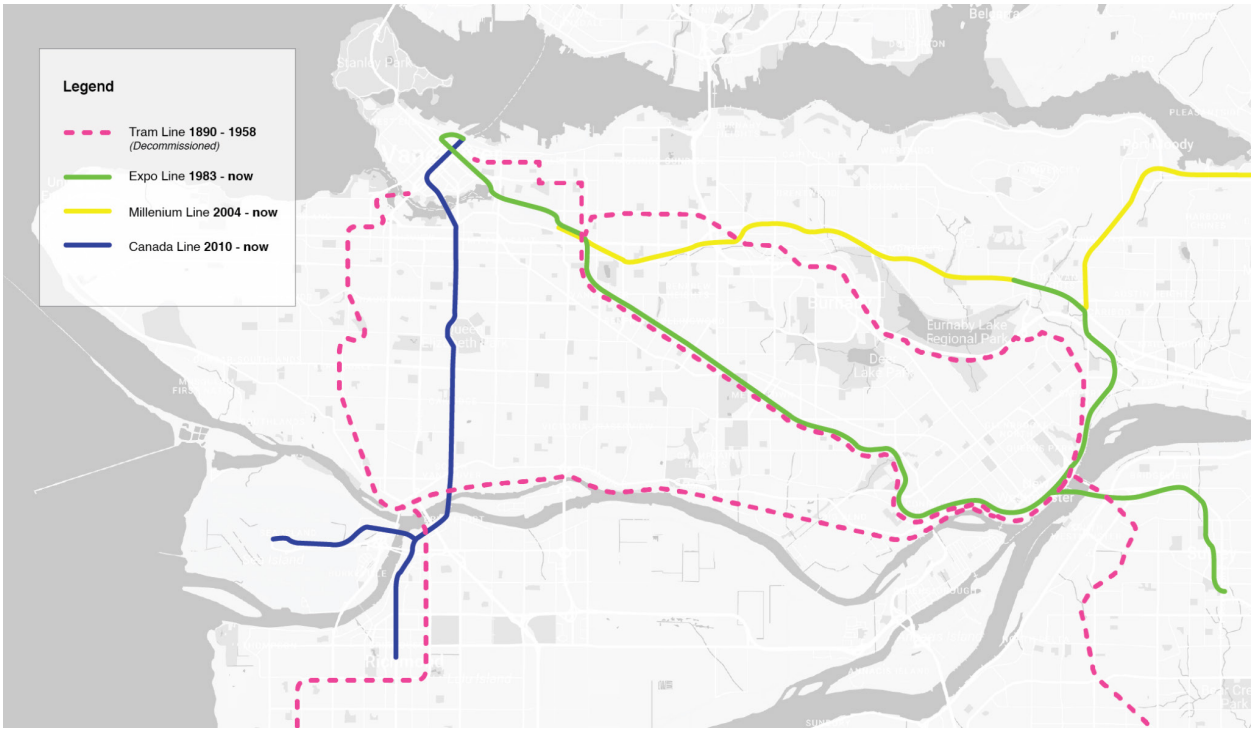
### 3.1.1 History of the Line

With the coming of Expo 86 in Vancouver, the theme was transportation: “World in Motion, World in Touch.” To celebrate such a momentous occasion, the city updated its transportation system, the “SkyTrain” that was opened to the public on December 11, 1985.[46] This original Expo Line ran a mere 22-km from downtown Vancouver to New Westminster., much of it built along the decommissioned streetcar line.[13]




**[Fig. 87]** North Vancouver’s first streetcar in 1907

46 Russwurm, L. (2016, March 10). SkyTrain. In The Canadian Encyclopedia. Updated by N. Baker, December 16, 2019. https://www.thecanadianencyclopedia.ca/en/article/SkyTrain




**[Fig. 88]** Modern SkyTrain map, in which many parts of the elevated tracks followed the old streetcar tracks overlaid with the 1953 map that highlights the street car rails

The system has since expanded with the Millennium Line (2002) and Canada Line (2009), and further Expo Line extensions (2016).[13] Although the tram lines are no longer in use, remnants can still be found along the path of the current SkyTrain lines.



**[Fig. 89]** Remnants of former railway tracks near Metrotown Station



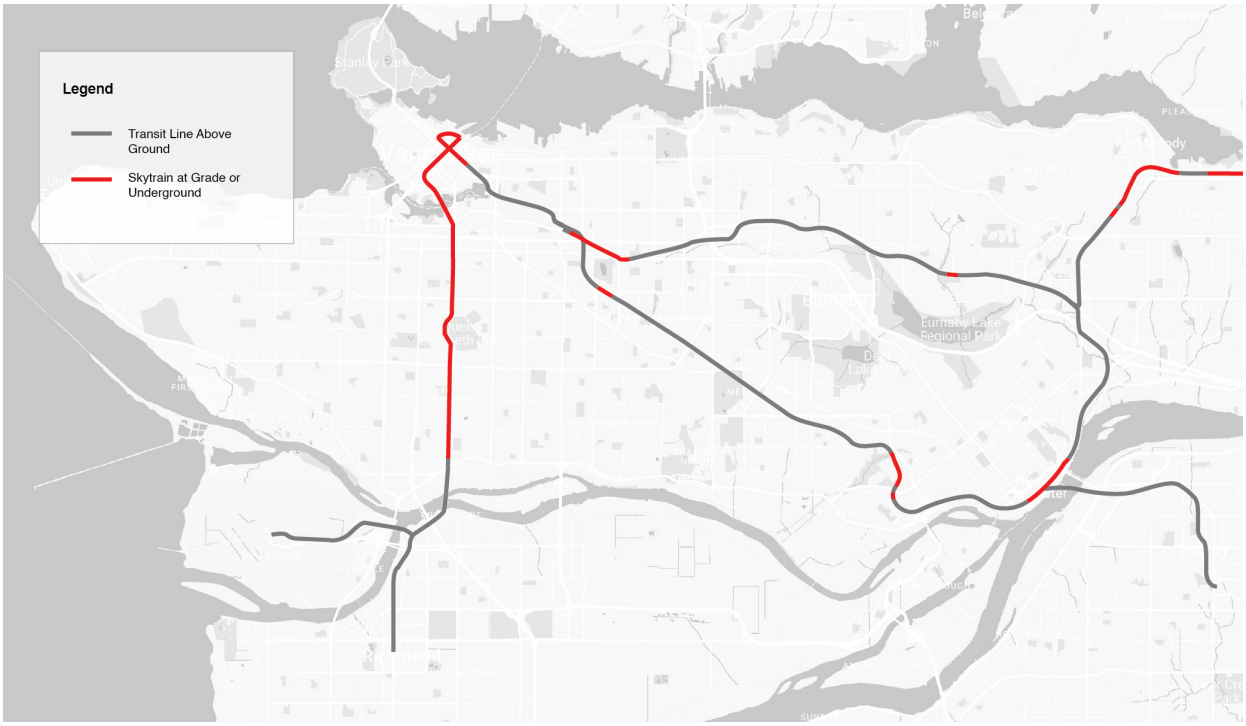
**[Fig. 90]** Remnants of former railway tracks near Patterson Station

## 3.2 Spatial Conditions of the SkyTrain

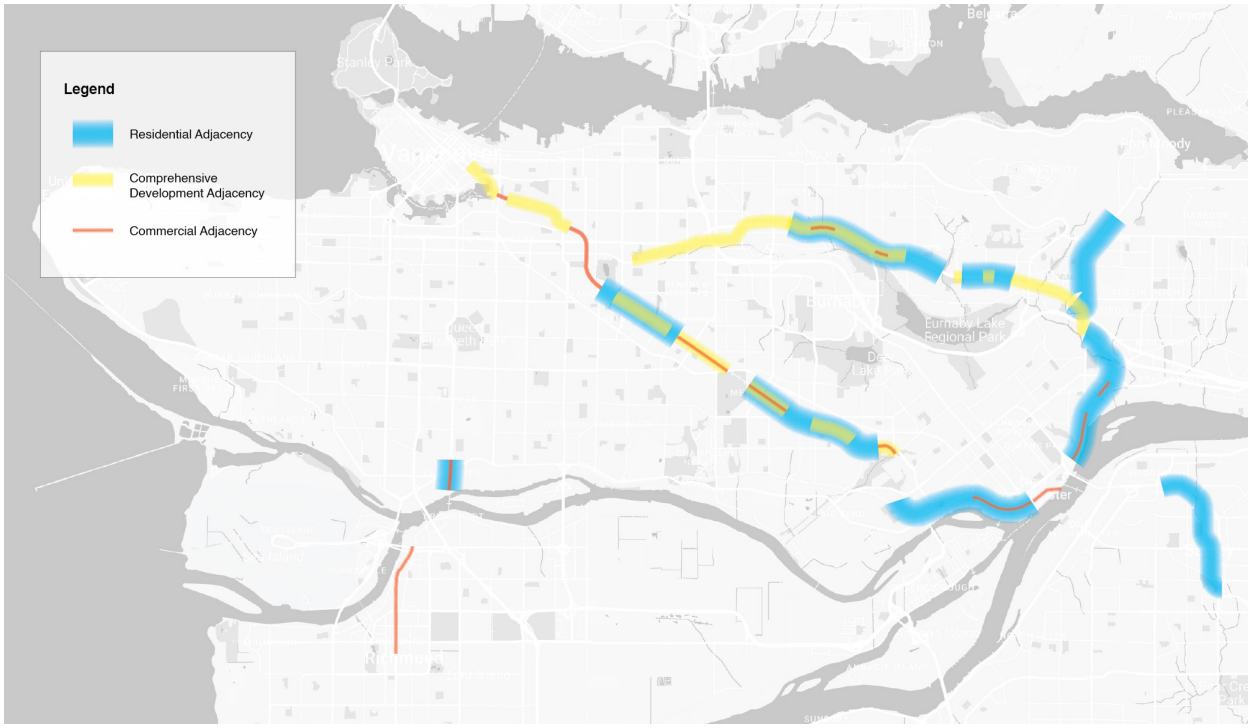



**[Fig. 91]** Elevated SkyTrain overlooking the streets

The SkyTrain spans 79.6 kilometres [40] long, with most of its line being elevated, leaving vast spaces beneath the line that can be repurposed. However, not all segments are viable for development. Foliage, steep grade changes and varying clearances make certain areas pose occasional  constraints Through creative design and engineering solutions, there will be workarounds that will fit housing in many of these sites.




**[Fig. 92]** This diagram illustrates the segments of the SkyTrain that are underground and those that are elevated.




**[Fig. 93]** This diagram illustrates the surrounding land use adjacent to the site that are designated as residential or mixed-use areas or comprehensive development that are located beneath the tracks. Note that the diagram is disjointed because the SkyTrain sometimes go at grade or below-ground

Adjacent land use such as residential or comprehensive development zones suggest areas where new housing could be integrated into the existing urban fabric. Additionally, a substantial part of these segments are on publicly owned land, largely owned by BC Hydro (publicly-owned) with the space being tied to both the government and TransLink. The “Parkway Alive” initiative that activated certain areas of the Parkway to be more communal through painting, live performances and other community events that had 7000 attendees across 26 events. At one point, part of the event involved collecting community’s feedback and implemented to the BC Parkway Enhancement Plan, which envisioned six character zones that run from Boundary Rd to Royal Oak station. The plan includes permanent upgrades such as lighting along pathways, playgrounds, seating and gathering spaces, wayfinding and signage, public art, stormwater gardens and planned community events. This shows that a permanent community infrastructure beneath the SkyTrain is already being planned, and the thesis proposal could be an extension of this momentum where housing can be integrating with these shared public amenities. [47]



**[Fig. 94]** Local events near the Skytrain rails, brings together community but also feedback to further inform the future of the space beneath the SkyTrain area`

47 City of Burnaby. (2025, April). BC Parkway: Boundary to Royal Oak framework plan. https://burnaby.widen.net/s/2j7kvjc6wk/bc-parkway-framework-plan-final

Keep in mind that Vancouver's demographic is diverse, so the housing should reflect the city's varied spatial and cultural landscape. With neighborhoods that differ drastically from place to place due to different demographics, density, and environmental conditions, the design should not be one rigid design but a flexible framework that stakeholders from the area and designers adapt to the site's vernacular identity.




**[Fig. 95]** Printmaking event display during a Parkway Alive event near Patterson station

### 3.2.1 Beyond Transit-Oriented Development

"*There's an affordability crisis going on in the city of Vancouver," he said. "And we have a supply-and-demand imbalance in the city of Vancouver, and how we address that over the longer term is we build more housing."* [48]

- *Ken Sim, Mayor of Vancouver*

Vancouver's current push for urban intensification has generally been focused on Transit-Oriented Development (TOD) that encourages density around transit nodes. Specifically, areas within 200 metres of a SkyTrain station must meet a minimum density requirement of up to 20 metres in building height and areas within 400 metres require a minimum of up to 12 metres.[49] In short, this is a strategy that focuses on encouraging higher residential density, mixed uses and more reliance on transit rather than cars. [50] Vancouver followed suit, and a major component of Vancouver's plan for Transit-Oriented Communities is through the "6 D's model" : Density, Diversity, Design, Destination Accessibility, Distance to Transit, and Demand Management[51]

While TOD strategies have worked around station nodes, the corridors between stations which are directly beneath the tracks have remained unconsidered. These

---

48 The Canadian Press. (2023, October 11). Vancouver mayor pushes for Burnaby-style development around several SkyTrain stations in the city. CBC News. https://www.cbc.ca/news/canada/british-columbia/vancouver-housing-SkyTrain-stations-sim-1.6993366

49 British Columbia Government. (2024, May 29). Provincial policy manual: Transit-oriented areas (Version 3.0). https://www2.gov.bc.ca/assets/gov/housing-and-tenancy/tools-for-government/local-governments-and-housing/toa_provincial_policy_manual.pdf

50 TransLink. (n.d.). Transit-oriented communities. https://www.TransLink.ca/plans-and-projects/strategies-plans-and-guidelines/transit-oriented-communities

51 TransLink. (2012, July). Transit-oriented communities design guidelines: Creating more livable places around transit in Metro Vancouver (Version 1.0). https://www.TransLink.ca/-/media/TransLink/documents/plans-and-projects/managing-the-transit-network/transit-oriented-communities/transit_oriented_communities_design_guidelines.pdf

zones are close to transit, and present an opportunity to intensify housing without further vertical growth, as it builds out horizontally. Developing housing and community here would align with the core TOC “6 D’s” model in the following ways:

1. **Distance (to Transit):**

   The Under-Skytrain housing is often generally close and accessible to transit, so it allows residents to efficiently reach their destinations throughout the city.

2. **Density:**

   Note that Vancouver has many urban centres in which many are located by SkyTrain stations. As a result, there are are a number of spaces under the SkyTrain line that are fairly dense or have potential to include more residential commercial, so injecting more housing and community in these spaces can create more density and decrease urban sprawl.

3. **Destination:**

   It adds more density without adding height onto to existing residential spaces. The Under-SkyTrain housing is often generally close and accessible to transit, so it allows residents to efficiently reach their destinations throughout the city rather than in cars, units will not have parking included.

4. **Diversity:**

   The housing typology and mix of building uses will be adapted to the wide range of social, economic and cultural aspects throughout the city.

5. **Design:**

   The design will be modular and adaptable to be sensitive to its contexts. Chapter 4 explores the design.

6. **Demand Management:**

   The proximity to transit encourages transportation use and eliminates parking minimums, which aligns with the TOC principle of Demand Management. This reduces traffic congestion and encourages walking and cycling.

In addition to improving efficiency of land use, this model creates housing opportunities in areas that are often disconnected from surrounding communities (away from amenities and communal spaces). It repositions leftover zones as a way to make neighborhoods more continuous through running it throughout the line and accessible through its transit-proximity.

## 3.3 Land Economics

A key advantage of developing housing beneath the SkyTrain is that while the SkyTrain hovers above a range of land uses, a good portion of the land is publicly owned - with the Metrotown, Royal Oak corridor site that is studied later in the thesis as a design study is owned by BC Hydro[52] (a crown corporation that is the main electricity distributor in the province, hence government), meaning the city would not need to purchase new property. With many sections of the space under the SkyTrain underutilised, the opportunity cost to change the zoning to allow for development would remain quite low. However, the development of these affordable under-SkyTrain housing can help with economic value in many ways.

52 City of Burnaby. (n.d.). BC Parkway Enhancement Project. https://burnaby.ca/our-city/projects/bc-parkway-enhancement-project

Housing close to transit infrastructure means less demand for car ownership and parking, reducing traffic congestion, allowing for more traffic flow, and using the city's existing SkyTrain system and the increased flow of people which results in more economic growth. Additionally, the introduction of residential housing in previously under used areas would increase foot traffic and create new opportunities for local businesses that give potential for mixed-use spaces to be incorporated into the development. As a result, these areas become sought after, increasing its economic value - and giving potential to these neglected spaces a type of urban design and an architecture that can uplift the social and aesthetic value of the neighbourhood.

## 3.4 Prefabrication in Practice

Given that the space under Vancouver's elevated SkyTrain system being quite vast and linear, it is an opportunity to think how affordable housing and adjoining structures to be implemented in a scalable way. However, according to a 2024 "Seizing the Modular Construction Opportunity" report by the CSA, Canada's construction industry faces limitation to keep pace with its rising demands due to reasons such as shortage of laborers, and the increased deficit of housing supply. In fact, in July 2023, there were 80,000 vacancies that need people to work in construction and speculations in the CSA document that Canada will have a deficit of 7.8 million houses by 2025. One of the most promising strategies would be modular housing. It has even been implemented in British Columbia, such as the Trethewey Supportive Housing in Chilliwack where 46 units are assembled in 299 days, and Vancouver's Olympic village in which 320 modular units were implemented after the Olympic games that became permanent affordable housing. [53] Prefabrication aligns well with the demands of building beneath infrastructure, where it is important to be minimizing disruption and working within tight constraints. Real-world examples, like the Bella Bella Staff Housing Facility,

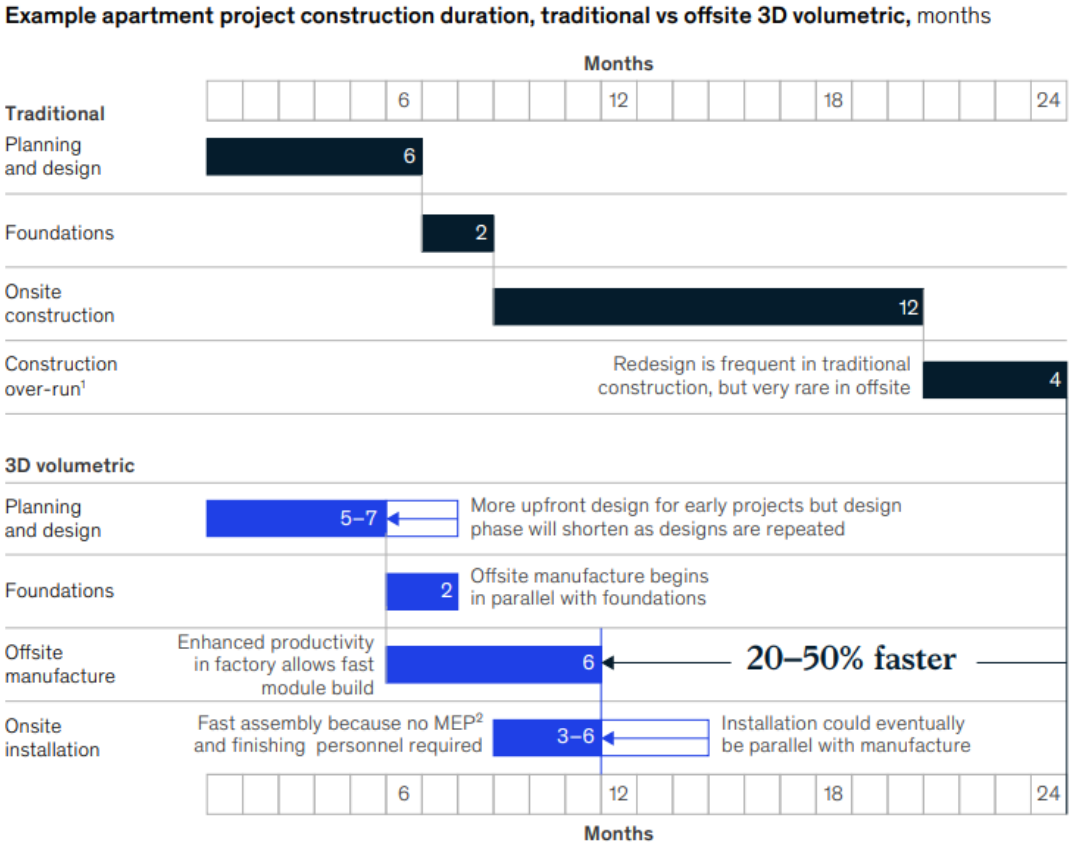
53 Dragicevic, N., Riaz, K. (2024) Seizing the Modular Construction Opportunity. Canadian Standards Association, Toronto, ON.

show how modular construction can significantly reduce timelines making it a practical solution for underutilized urban sites.

In dense cities like Vancouver, prefabricated construction is an alternative to traditional building methods. It allows for tighter timelines, less site disruptions which makes it particularly suited for sites underneath elevated rail infrastructures such as SkyTrain and especially in the denser areas. Unlike traditional site built structures that rely on onsite construction that rely on the unpredictability of the site - prefabricated buildings are manufactured in a as full units or components in factory controlled environments before they are transported and assembled on-site for the full building. Of course, prefabricated housing isn't the end-all-be-all of construction and this section looks at the benefits and challenges of modular housing and whether or not it makes sense that it would make sense to be implemented in our site.

## Benefits and Challenges of Prefabricated Construction

### Benefits




**[Fig. 96]** Comparing traditional and 3d volumetric fabrication, timelines are generally 20-50% faster

1. Faster Construction Timelines:

   Modular units are typically built in an indoor factory setting offsite, which means both the construction and site work can be happening concurrently.[54] For example, the Bella Bella Staff Housing Facility on the central coast of BC was estimated to take two years to complete using traditional construction, but was completed in only seven months with modular construction. [55]

54 BC Housing, Manufactured Housing Association of BC, & Real Estate Institute of BC. (2014). Modular and prefabricated housing: Literature scan of ideas, innovations, and considerations to improve affordability, efficiency, and quality. BC Housing.

55 Henderson, E. (2020, February). Modular construction for energy efficient, affordable housing in Canada (Technical Bulletin No. 013). RDH. https://www.rdh.com/wp-content/uploads/2020/03/TB-13-Modular-Construction-for-Energy-Efficient-Affordable-Housing-2020-03-05.pdf

2. Lower Costs:

   With the modules being built in a factory, modular construction can lead to cost savings. There is less need for on-site labor and The Iqaluit Hotel is an example, where it came under budget and completed a year ahead of schedule due to the modular construction technique.[18]

3. Quality Control:

   Being built indoors in a controlled environment means there's a more consistent and higher standard of quality. Better quality control also means better airtightness, reduces flanking - critical in nosy under-SkyTrain spaces.[18]

4. Sustainability:
   a. Less Waste – Factory optimization leads to more efficient material use, reducing waste compared to traditional construction. [56]
   b. Energy Efficient – Precise manufacturing of building envelope components results in better airtightness and thermal performance, lowering operational energy costs.[18]
   c. Smaller Construction Footprint – With less on-site labor, storage, and traffic, modular construction minimizes site disruption and impact on surrounding communities.[18]
   d. Reusability – Modular buildings can be disassembled and relocated, making it easier to reuse components rather than relying on resource-intensive demolition and reconstruction. [18]

56 Wilson, J. (2019, March). Design for modular construction: An introduction for architects. The American Institute of Architects & National Institute of Building Sciences.

**Challenges**

1. Transportation

   Modules must be transported to the construction site, which can be costly and can risk damage during transit. However, this can be mitigated by using durable materials, proper wrapping, and protective measures to ensure modules arrive intact. [18]

2. Limited Supply

   Since the modular construction industry is still developing, there are fewer manufacturers specializing in modular systems which leads to higher costs and longer lead times due to supply chain limitations.

3. Regulations

   Modular projects must comply with building codes just like traditional construction, but the application and inspection processes can differ. Lack of familiarity with modular systems among regulatory bodies can lead to delays and additional hurdles in permitting and approvals. [20]

4. Higher Initial Costs

   While modular construction can be more cost-effective in the long run, initial costs may be higher due to technical approvals, engineering requirements, and safety compliance measures, which are not yet standardized across the industry.

5. Design Constraints

   Modular construction can impose limitations on building form, making complex geometries or irregular layouts more difficult and costly. Thicker walls and deeper floor assemblies thar are necessary for the structural integrity of self-contained

modules meaning reduced usable interior space. Additionally, clear spans and high ceilings (such as in warehouses or large retail spaces) are constrained by maximum transportable module dimensions

There are constraints that come with installing modular units beneath the SkyTrain. These areas fall within TransLink's Limit 2 zones: anything within 3 m of the dripline or 1 m from columns requires TransLink trained member to oversee the construction process. [57] Standard cranes can be a hazard for this type of operation because of overhead interference and swing risks. Ground-based equipment is more practical. Forklifts, reach stackers, and side-loading handlers can place modules at grade. For second-storey units, a long-reach forklift or scissor lift can raise modules within clearance limits. Final alignment is handled with cable winches or guides. These low-clearance methods reduce risk while keeping within safety thresholds. In terms of foundation, it depends on the context and where it is along the line. For public zones like plazas or markets, cast-in-place foundations work best. For housing, pier foundations with a perimeter beam usually wood or LVL are faster and less invasive, as long as the site isn't too sloped. Modules can be secured using embedded plates and anchors.

**Utilities**

Power can be routed through BC Hydro or coordinated with nearby transit infrastructure given that it has TransLink approval. Overhead conduit mounting is often the cleanest option since it avoids underground conflicts w[58]here there may be other systems at play. Water and gas services are highly site-dependent. Because of existing infrastructure and transit footings and for the purposes of this thesis leaves them to

57 TransLink. (2022, December). SkyTrain limits of approach: Safety requirements for work near automated trains and infrastructure. https://www.translink.ca/-/media/translink/documents/business-with-translink/real-estate/skytrain_limits_of_approach.pdf

58 Shroff, D. N., & Joshi, A. T. (2022). Pre-fabricated architecture for urban adaptability: Factory built constructions – sustainable & flexible urban solutions (Master's thesis, Politecnico di Torino).

further case-by-case study. Overgeneralizing here could risk proposing unworkable solutions.




**[Fig. 97]** Loaded Container Handler aka. Reach Stacker - used to lift and transport Shipping Containers.

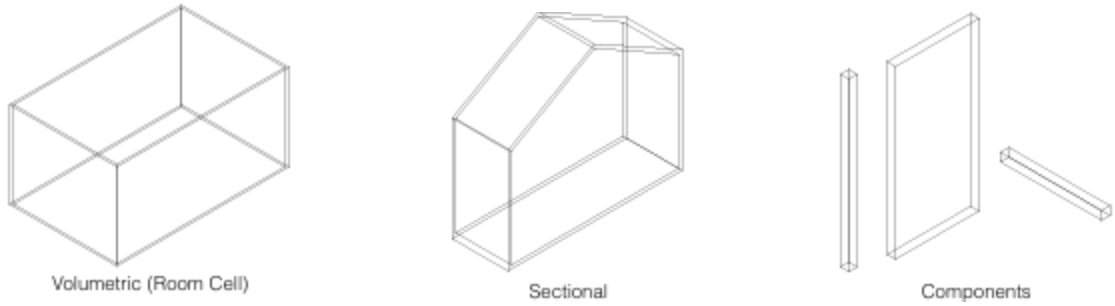
Note that while the previous section focused on the pros and cons of modular/volumetric housing, there are other prefabrication strategies worth considering such as panelized and sectional systems. For the purposes of this thesis, three types will be modeled: modular/volumetric, panelized, and sectional. These methods are often used in combination, depending on site constraints, logistics, and design intent. Categorization helps compare tradeoffs across prefabrication strategies.

Modular/volumetric systems refer to fully enclosed 3D units are essentially rooms or pods that are built off-site and transported as complete components. While this

approach offers high control over finishes and construction quality, transporting “boxes” can be inefficient due to the empty interior space and the need to fit truck-size limits. This makes them less ideal when transport cost or tight access is a concern. In contrast, panelized systems consist of flat elements like walls, floors, or roofs, which can be packed more densely and allow more material to be moved per load.

However, not all volumetric systems are bulky or rigid. Some are designed as flat-pack kits or foldable structures, which can be assembled on-site and transported more efficiently. These hybrid models blur the lines between categories and demonstrate how modular strategies can be adapted for better transport and space efficiency.

The chart below offers a simplified model of prefabrication as a spectrum, from volumetric (high control, lower flexibility) to panelized (high flexibility, lower off-site control). These are generalizations; in reality, prefabricated systems exist in many forms, each with tradeoffs shaped by context, and design goals. This helps frame prefabrication not as a fixed type, but as a set of adaptable strategies.




**[Fig. 98]** Visual Representation of the 3 types of prefabricated units: Volumetric (modular), Sectional (sliced version of modular) and Components (which includes panelized)

| Type | Description | Pros | Cons |
|---|---|---|---|
| **1. Volumetric (Modular)** | *Full 3d room-sized components (ie. bedrooms) built off-site and assembled into place.* | - Quick and minimal on-site construction<br>- High quality due to high control in factory<br>- Ideal for repetitive units, allowing for efficient mass production | - Great for smaller units, larger units may not be transportable due to truck-size limits<br>- Standardized geometry, less design flexibility |
| **2. Sectional** | *Prebuilt sections/ segments, still need on-site integration* | -If volumetric units are too large, another option for transport<br>- Mid-range flexibility | -Less efficient to transport than panelized systems<br>- Needs more on-site work than volumetric |
| **3. Panelized** | *Flat components/ panels for assembly (generally on face of facade)* | -Allows for flexible building shapes and forms<br>-Flat components means efficient stacking for transport | - More onsite work compared to Volumetric and Sectional |

**`Construction**

Light-frame wood construction would be a suitable choice for affordable prefabricated housing in BC. Dimensional lumber is a vernacular material in BC, with it being an abundant resource due to the local forestry resources. It is widely used in low and mid-rise residential buildings in British Columbia, which means many established systems in place that make it both a more accessible and economical resource and is compatible with prefabricated assemblies.

Steel is another common material, though it has high precision and strength, it might be excessive and too costly for a low-rise project. CLT (cross-laminated timber), although robust, visually attractive and having the benefits of being wood also suffers from the same problem of higher material cost and not as suitable for a cost-sensitive project such as this one.

For wood-based modular construction, which typically distributes loads along wall lines similar to conventional bearing wall systems, slab-on grade foundation is not recommended. Instead, pier and perimeter foundation systems are most appropriate.[59] These systems support the distributed linear loads effectively while allowing for installation even among uneven terrain. In order to address the exposed underside between the elevated modules and the ground, a skirt / cladding system is typically installed around the base. By doing so it:

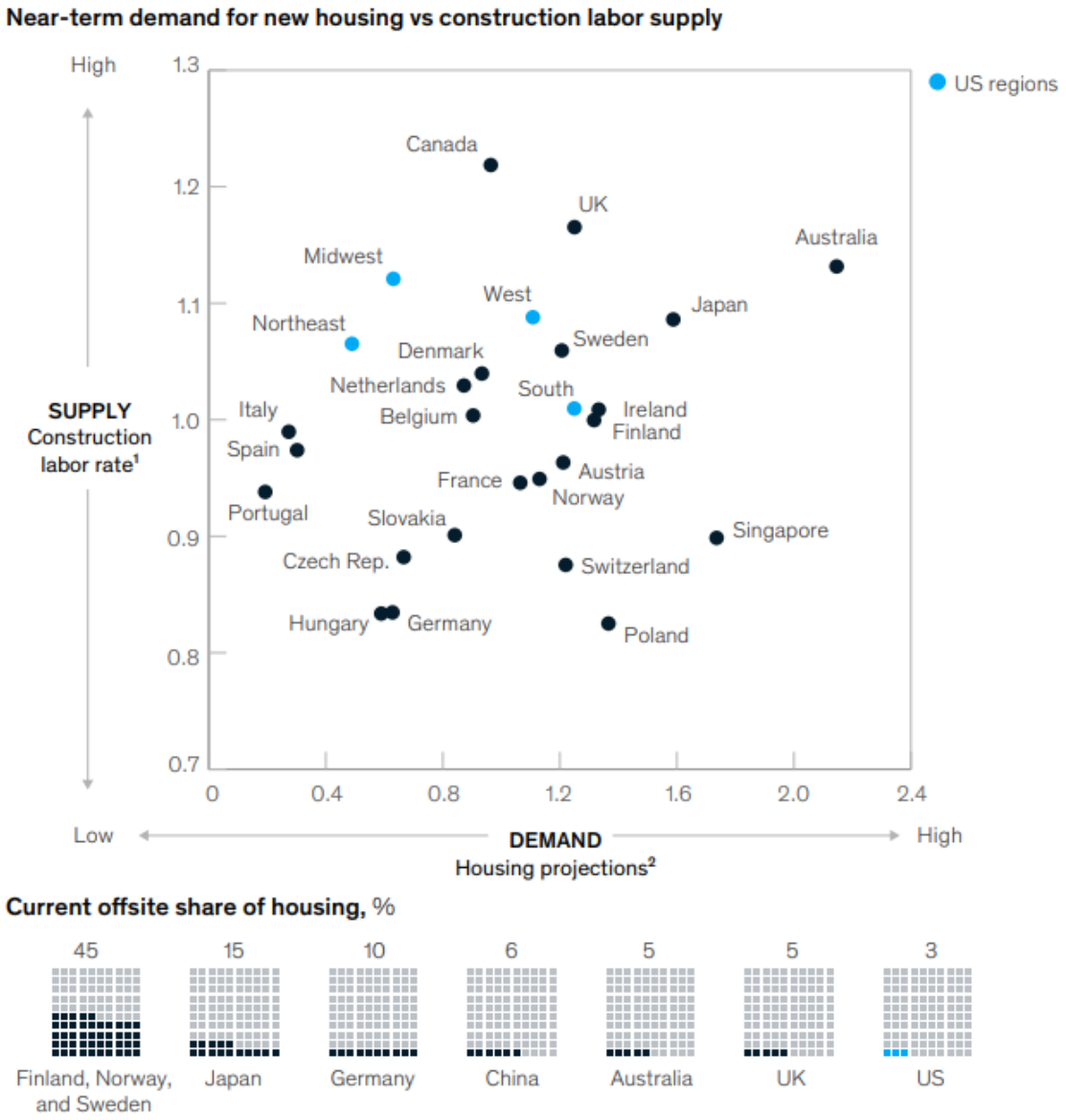
- Conceal underside for a more finished look
- Prevents trash/debris from accumulating beneath the units
- Reduces thermal loss
- Prevents pests, rodents and small animals from entering below

59 Smith, R. E. (2010). Prefab architecture: A guide to modular design and construction. John Wiley & Sons.

The skirt or cladding system should have an access panel that can be added for services and maintenance.

**Cost**

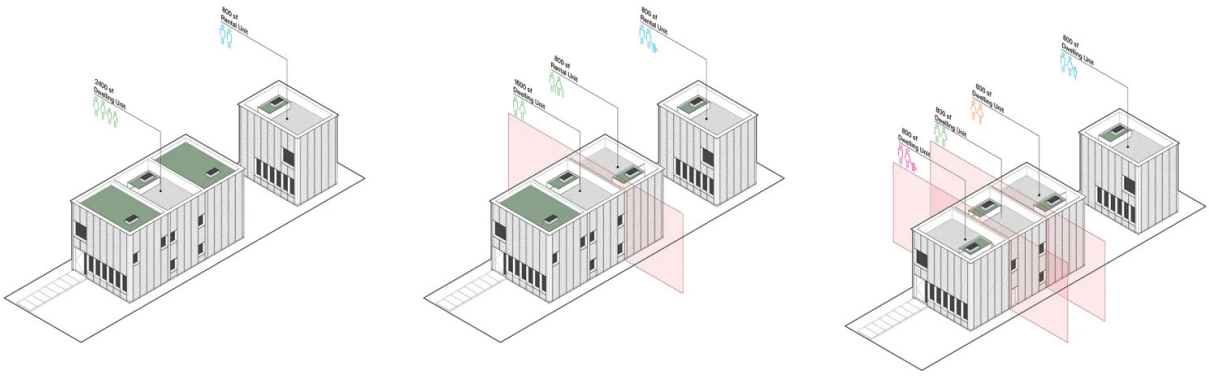
As of 2025, Canada exhibits strong potential for the growth of offsite construction . It current is positioned to be an ideal candidate for scaling prefabricated housing with its high construction labour rates and average housing demands (see figure 99).




**[Fig. 99]** Comparison of new housing vs construction labor supply, Canada scoring high on construction labour rate.

The construction cost estimate for my design proposals is modelled on Leckie Studio's TripTych home, as it shares similarities as the thesis proposed design, as they are both prefabricated component based structures, light-frame wood in material and both two-storey residential. The unit is with the reported construction cost on its

website is around $400 per square foot.[60] In TripTych, the building components (walls, floors and roof) are pre-manufactured, shipped flat-packed before being assembled on site. Interior fit-outs are designed as plug-in modules. This makes it mostly a panelized prefabricated system. The thesis design proposals in later chapters differ geometrically and use a hybrid prefabrication approach that mixes both volumetric and panelized systems.



**[Fig. 100]** The TripTych concept is a component based system in which it can configure to a number of programmatic layouts and lot conditions. The configuration on the far left consists of one standard 2400 sq ft house and an 800 sq m single unit. The middle configuration consists of a 1600 sq ft unit and two 800 sq ft units. The configuration on the far right consists of four smaller units that consists of 800 sq ft.

60 Leckie Studio Architecture + Design. (n.d.). Addapt Home / TripTych [Residential project]. https://leckiestudio.com/portfolio/triptych



**[Fig. 101]** Leckie Studio's TripTych concept of a prefabricated panelized duplex concept is shown in relation beside Vancouver Special housing

For comparison, Leckie Studio's "Duplex 01" design was also referenced here. This design was part of a broader template book developed for the BC Ministry of Housing's Standardized Design Guidelines.[61] These guidelines were commissioned to incentivize more design and construction of smaller scale and multi-unit housing on lots were previously zoned for single-family zone. Note that "Duplex 01" is a two unit design that is two storeys with two bedrooms per unit. According to the SHP Class D Estimate

61 British Columbia Ministry of Housing. (2024, September). Standardized housing designs catalogue. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/bc_std_des_catalogue_v1.pdf

Report, the construction cost if estimated $462 per sq ft. While still a preliminary estimate, its scale and form are more directly aligned with the design proposals in the thesis.



**[Fig. 102]** Leckie Studio's on-site constructed duplex that is part of their proposal for their "Standardized Housing Designs Catalogue"

There's a common misconception that prefabrication is always cheaper. In practice, there is a series of trade-offs that can make it more or less economical depending on varying factors. Up-front capital are often higher: since to build off-site,

one would need production space (rented or owned), factory build-out, specialized equipment, QA systems, and trained labor. Off-site fabricators also needs to make a profit which adds to the unit pricing. Design fees may see a rise due to it being a more customed component rather than a conventional one. On the installation side, there will still be on-site work to be done including moving and even lifting the units to place and making sure it is properly stacked and the site is properly prepared. Transport also has many factors at play. How it is charged vary by the unit (modules or panels) size, weight, distance transported, required escorts/permits (oversized), loading method, and how the units will be placed on site. Generally, volumetric modules ship a lot of air, so the dollar per square meter of floor area is less efficient compared to flat-packed and panelized elements. [62]

Replacement parts and repairs can also be slower or costlier if the components are proprietary or made only by a specialized company since these custom components less recognized by conventional sellers.

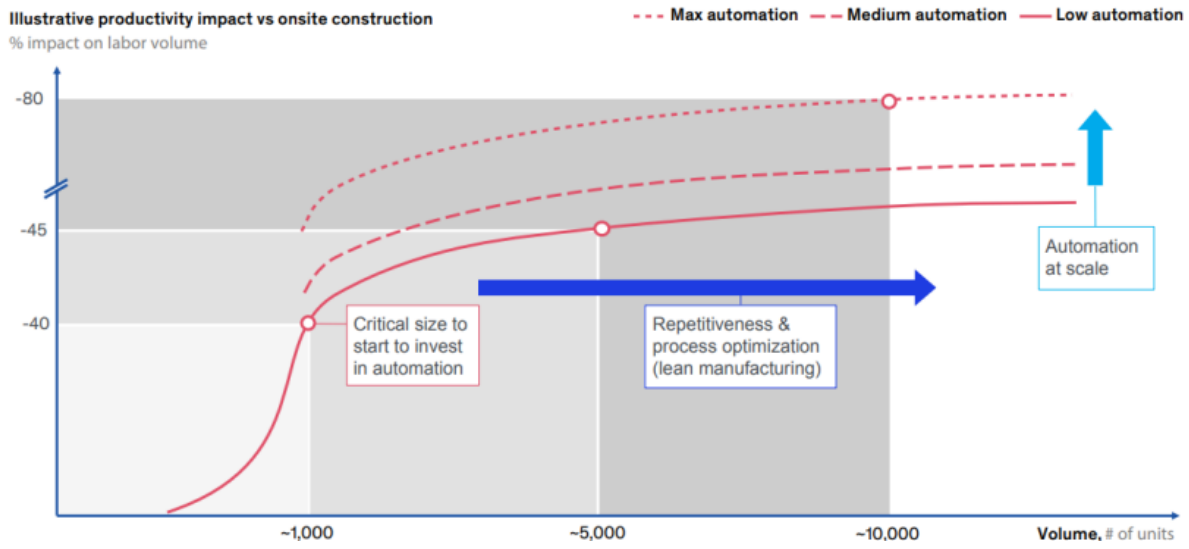
It is important to note that because many of these costs are front-loaded, real savings usually show when the factory's output is high enough to distribute these fixed costs to more units (economies of scale). Analysis by McKinsey suggests that there is significant productive improvement once the output reaches roughly 1000+ standardized units. [63]

62 Chiu, S. T.-L. (2012, April 9). An analysis on : the potential of prefabricated construction industry [G]. doi:http://dx.doi.org/10.14288/1.0103132

63 McKinsey & Company. (2019, September). Voices on infrastructure: Scaling modular construction. https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/voices%20on%20infrastructure%20scaling%20modular%20construction/voices-on-infrastructure_scaling-modular-construction.pdf

**Figure 5: How to achieve economies of scale in unit production**

The first critical productivity step is achieved at approximately 1,000 units a year, beyond which productivity gains slow down.




**[Fig. 103]** Productivity in offsite construction see its first major gain at 1000 units per year, further improvements rely on automation scale and process optimization

## 3.5 Noise and Vibration

A significant issue with designing housing under the SkyTrain is its proximity to noise from the vehicle above. The proximity to this infrastructure requires strategies to approach noise control that tackles both airborne noise and structure-borne vibrations. The sources of noise can penetrate typical building materials, making it essential to develop strategies that limit the transmission of sound into residential spaces. This chapter outlines mitigation strategies tailored to the unique challenges of building beneath elevated railways.

### 3.5.1 Sources of Noise Pollution

Much of the noise emission from the passenger trains is caused by rolling contact between the steel rails and wheels due to the roughness of the contact surfaces. This results in vibration that creates structure-borne noises. [64]

According to the SkyTrain Noise study done in 2018 by SLR Consulting, decibels around the track range from roughly 70 dBA to 92 dBA depending on factors such as train speed, track maintenance quality, environmental factors like weather and surrounding infrastructure.

Different sound frequencies require different mitigation strategies. For high-frequency noise, the train produces a variety of mechanical sounds, including the squeaking of the wheels that transmit by air.[65] These are protected by the monolithic concrete structure, although some can spill through the edges and air gaps. For facades, even laminate glass with thin interlayers is sufficient.[34] However, low-frequency noises, which are structure-borne vibrations or “roaring”, can travel through the SkyTrain monolithic concrete structure and spread through the roof of the residential units. Such rumbling could resonate down to the ground, reaching residential spaces.

It is also important to note that the SkyTrain does not run 24/7 - operations stop at night from roughly around 1 am to 5 am (varies depending on the station and day of week), which minimizes the impact of noise and disturbance to its surrounding

64 SLR Consulting. (2018, November 28). SkyTrain noise study: Noise report and maps. South Coast British Columbia Transportation Authority (TransLink). https://www.TransLink.ca/-/media/TransLink/documents/plans-and-projects/SkyTrain-noise-study/SkyTrain-noise-report-20181128.pdf

65 Allen, E. (2005). How Buildings Work: The Natural Order of Architecture (3rd ed., pp. 138-148). Oxford University Press USA - OSO.

environments.[66]

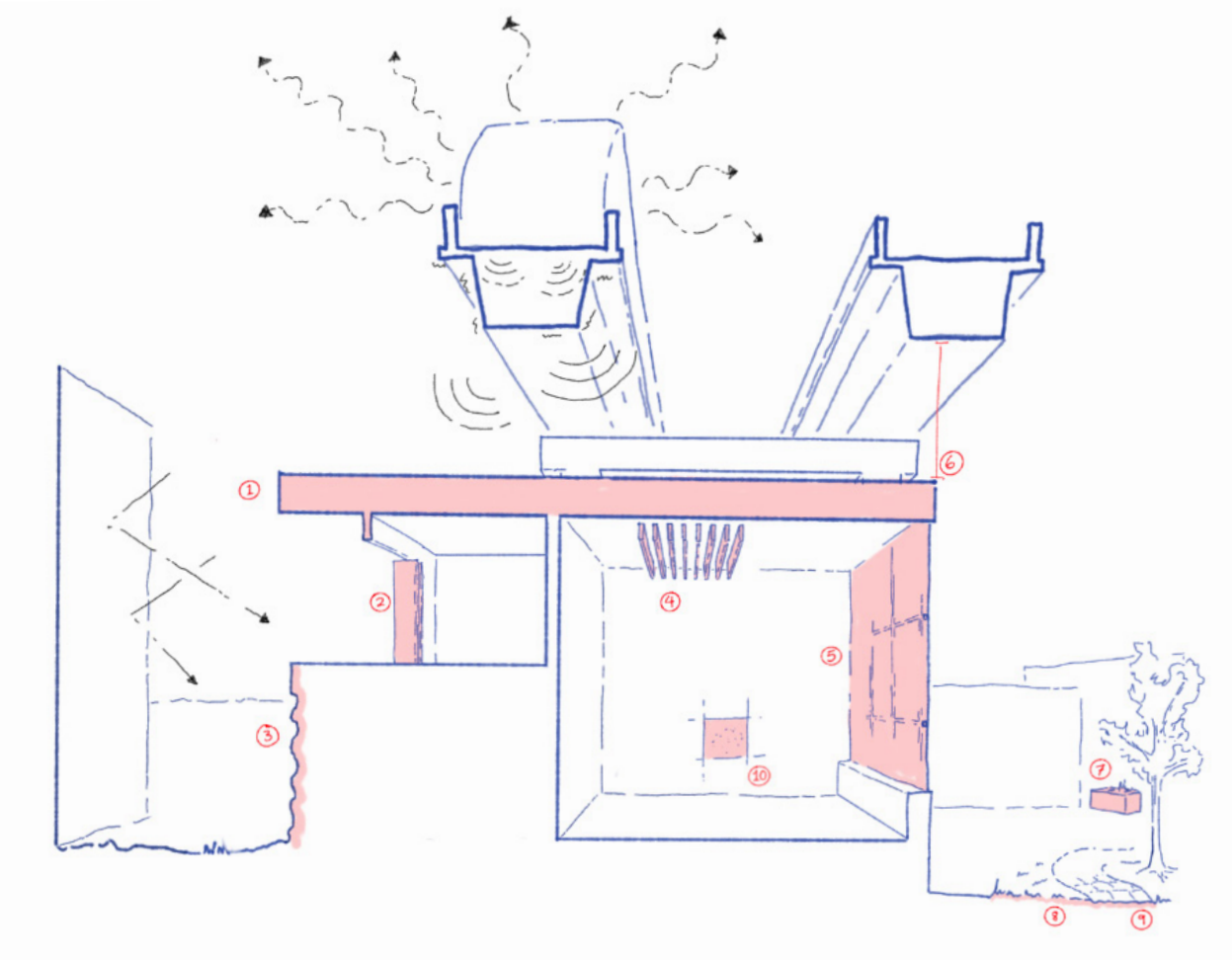
While noise and vibration are valid concerns when building under the SkyTrain, similar challenges have already been tackled in other elevated rail developments. For example, the Chūō Line in Tokyo has successfully integrated housing and mixed-use spaces beneath its tracks, showing that these issues can be managed with the right design strategies. This precedent demonstrates that living under transit infrastructure is not only feasible but already in practice in high-density cities. Instead of viewing noise as a dealbreaker, the focus should be on how to control and mitigate it effectively. The presence of case studies like the Chūō Line suggests that with proper planning and technology, housing under the SkyTrain can be both comfortable and sustainable, reinforcing that the issue of noise is a design problem.

66 TransLink. (n.d.). SkyTrain schedules. Retrieved September 9, 2024, from https://www.TransLink.ca/schedules-and-maps/SkyTrain

## 3.5.2 Passive Noise Mitigation Strategies

### Structural Thickness and Density for Low-Frequency Noise

Low-frequency noise and vibrations, primarily from the SkyTrain's movement, present the most significant challenges. These low-frequency sounds can travel through lightweight materials, making thickness and density critical to effective noise control. [67] Here are some design recommendations for sound mitigation (diagram with numbering above)[36]:




**[Fig. 104]** Noise Mitigation Strategies, highlighted in red are methods of mitigating sound and vibration

67 Fernández Solla, I. (2012, June 30). Acoustic properties of glass: Not so simple. Façades Confidential. https://facadesconfidential.blogspot.com/2012/06/acoustic-properties-of-glass-not-so.html

1. Thick, heavy roofing and wall materials are necessary to block low-frequency sounds. A thick concrete roof slab has the mass and density that can absorb low-frequency vibrations, dampening the noise and minimizing its transmission into the housing units below. For example, gravel placed on top of the roof adds mass that can mitigate the low-frequency sounds that resonate through the structure.

2. The exterior facades should be constructed using thick, reflective materials like concrete or dense masonry. These materials bounce sound waves away from the building, limiting the transmission of external noise into the interior spaces. If there are glazed openings, there can be an additional option to add another door of denser material to block out the sound further.

3. Textured or uneven facades can disperse noise rather than flat, clean surfaces

4. Ceiling sound-absorbing baffles can further absorb noise coming from the roof.

5. Glazing should have more thickness and mass to it to block out noise, especially at lower frequencies, due to sound attenuation increasing with mass. Additionally, the use of laminated glass instead of monolithic glass is better for sound insulation due to the damping effects of polyvinyl butyral (PVB) in between laminated glass. [11]

6. The structure of the residential should be detached from the structure of the SkyTrain to prevent vibration.

7. Planters can hold deep volumes of soil that can further absorb surrounding sound.

8. Landscaping features such as grass, and trees can absorb sound itself.

9. Paved paths can be made of sound-absorbent material so that noise does not reflect off the ground. Avoid conventional paving materials such as asphalt which has hard surfaces that can reflect sound.

10. Interior Partitions with acoustic insulating properties further diminish sound.

For parallel elevated tracks running side by side with a gap in the middle, it is recommended to install sound barriers between the SkyTrain tracks and the housing units to help to deflect and block the noise from reaching residential areas. These barriers are designed to reflect sound waves toward the source or upwards into the air, preventing noise from penetrating living spaces below.

## 3.6 Shared and Public Spaces

It is note that even for spaces that aren't occupied by housing, or exists between housing - that are more open rather than fully programmed - these spaces can be thoughtfully planned as well. A patch of open ground might become a small market one weekend, a quiet yoga spot the next, or simply a place for picnics and informal gatherings. Seating and steps can double as mini amphitheatres or spillover spaces for performances. Play areas can reclaim forgotten corners, giving children room to explore while encouraging neighbors to linger. Alongside small shops or co-working spaces, café tables and shared furniture can animate the periphery of the infrastructure. The goal isn't just to fill space and optimize it's to create a sequence of small invitations that bring meaning and motion from point to point, whether you live here or are simply passing through.

For co-living communities, these shared outdoor and transitional spaces become an extension of the home and are open areas where residents cross paths and gather naturally. Interior shared programs should support this same ethos, offering programs such as communal kitchens, laundry rooms, multipurpose rooms, and small gyms that make up a self-contained micro-neighborhood. Rather than just isolating individuals into overly private units, co-living models can create shared ownership of the environment. organic interactions and Residents might cook together in a shared kitchen, host potlucks, or casually meet over tea at a shared terrace. These shared amenities offer a richer quality of life than what could be packed into a conventional micro-unit, allowing people to live smaller but better.

The ground level, meanwhile, should remain porous and alive. For more high-traffic and public areas (such as many areas near the station), the space could be activated by small retail, cafés, local vendors, and civic programs that root the housing in the surrounding community. These become the “corner-stores” of the surrounding area that serve both the residents and visitors of the station. It should support small-scale entrepreneurship and pop-ups over chains that reinforcing a neighborhood-scale economy. Generally, there should be a gradient from public: shops should be located closer to the station where spaces are loud and open, residential should be set deeper in to allow for privacy. By considering the spaces beyond just the living units - it creates an environment where the residents and visitors wish to grow and contribute to.

# 4

# [Design Implementation]

Given the various site conditions throughout the SkyTrain, the focus is on creating a scalable prototype that can incorporate flexibility, communal needs and site constraints affects design, and managing noise and vibration that is emitted from the SkyTrain.

The current chapter will look at three systems applied to two sites that explore high-density and medium-density sites. It will be applied to real world locations near Metrotown station and Royal Oak station in order to give a sense of how it may look and function in real world contexts.

# [Design Implementation Overview]

**Sizing of 3 systems**

**3 systems in 2 sites:**

System 1 [Box-Link-Box]
System 2 [Core-Spine-Pod]
System 3 [Base-Extend-Face]

**Site 1: Metrotown Station**

[Box-Link-Box] + [Core-Spine-Pod]

**Site 2: Royal Oak Station**

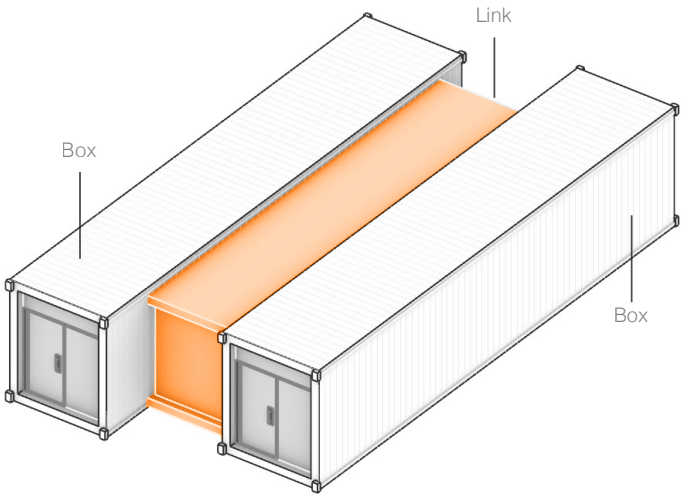
[Base-Panel-Face]

## 4.1 System 1:

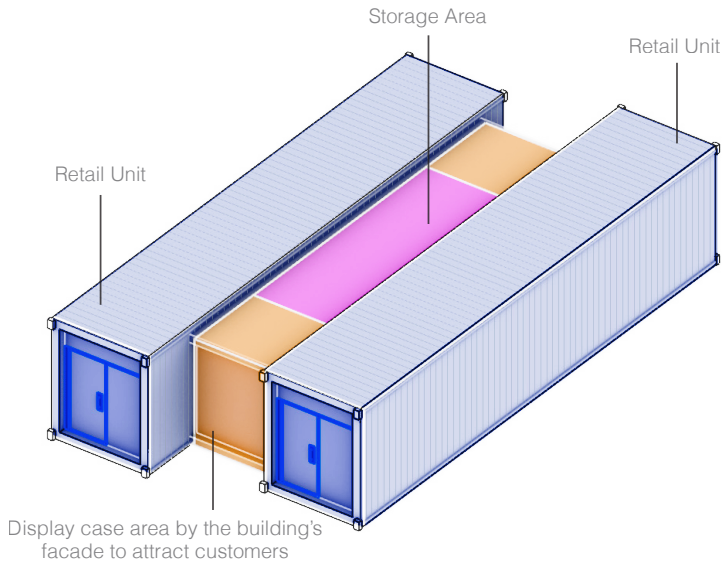
Box-Link-Box
(Retail Prototype)

*In the Case Study section, Boxpark and Hatch were able to keep the steel container structure with minimal to no modifications. This makes sense partly to save costs, and partly because the structure already has enough space to fit its retail programming. However, as a design thesis, the project treats the shipping container as a modular unit open to formal experimentation. A rectangular aperture is introduced to allow spatial linkage between adjacent containers, forming a "Box-Link-Box" typology.*

*The "Box-Link-Box" model acts as a retail buffer along high-density corridors to activate the space, make it more communal while absorbing the foot traffic and noise before transitioning into residential zones. The shipping containers draws from precedents like the Boxpark projects in London and Stackt in Toronto. Note that these containers have thermal, plumbing and layout constraints which make them more appropriate for lower-intervention commercial spaces rather than longer-term housing.*



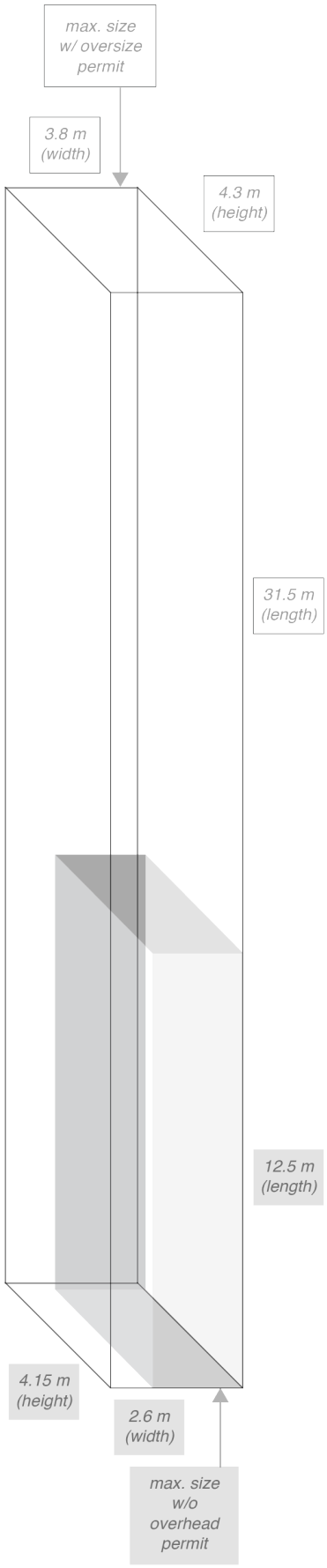

**[Fig. 105]** Two shipping containers “Boxes” are linked together with an intermediate unit with glazed ends, connected by the “Link”



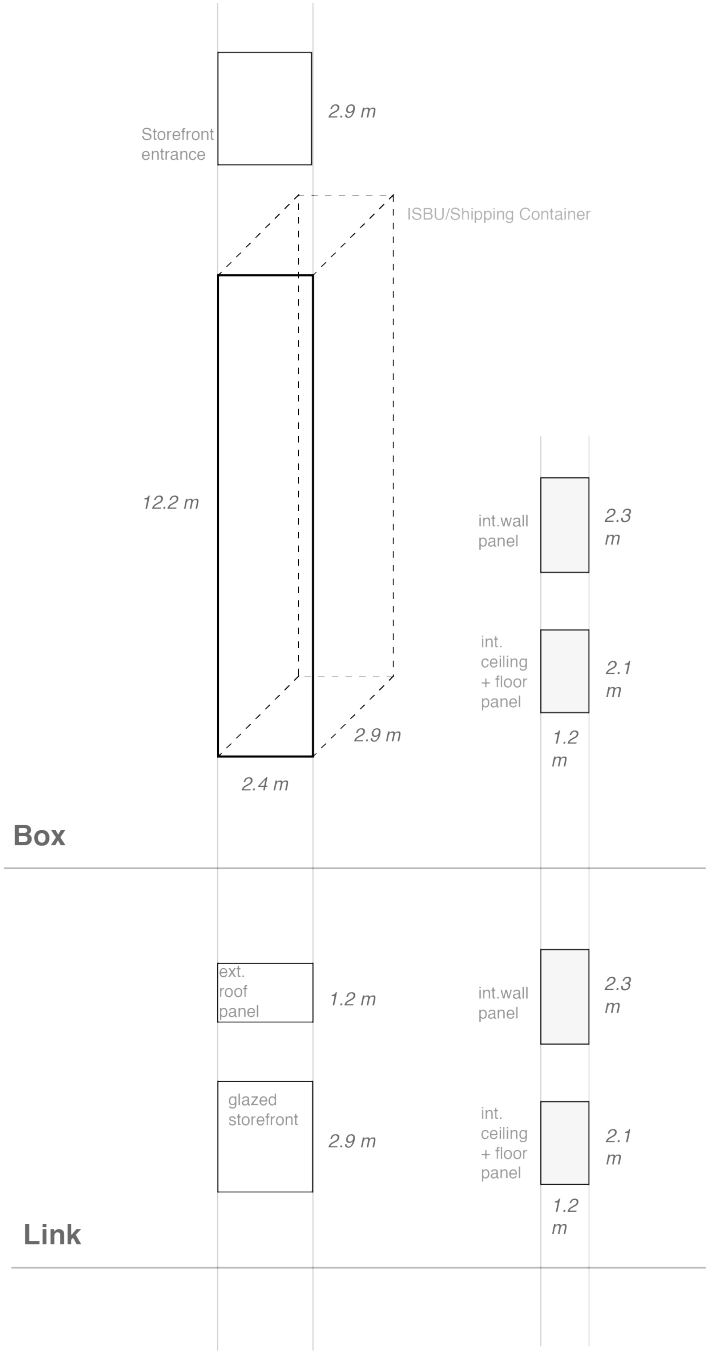

**[Fig. 106]** Programmatic Diagram of the Box-Link-Box Unit, with 2 retail units joined by a linking glazed component that acts as a display case to attract customers

**Fig. [107]** *Left* This diagram shows the maximum volume a truck can transport in British Columbia with and without an oversize permit. Oversize permit adds to the cost.

**Fig. [108]** *Right* This diagram shows the different panels and volume/area of the Box-Link-Box and how they relate to one another that determine their sizing.




## Truckbed Size



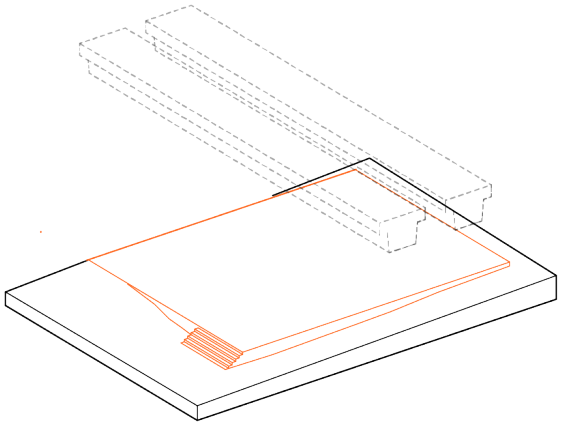

For interior and exterior panels, 1.2 m panels are used, as they are typical panel dimensions. 2 panels also conveniently fit the exterior roof width dimensions of 2.4 m for the “Link” Component.

**Legend**

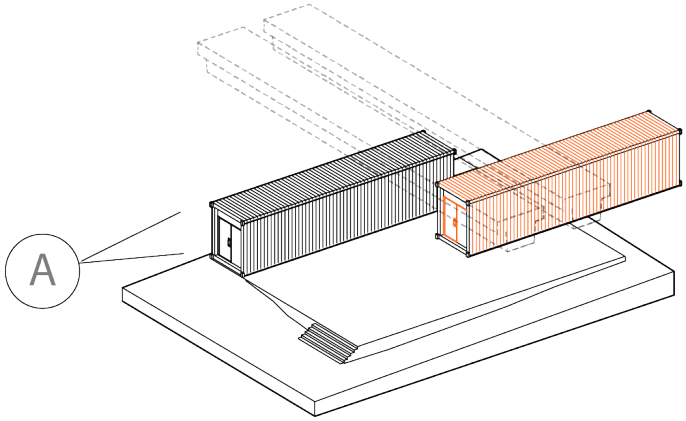
- *Transported*
- *Not Transported (Embedded off-site)*

0 2 4 10 m

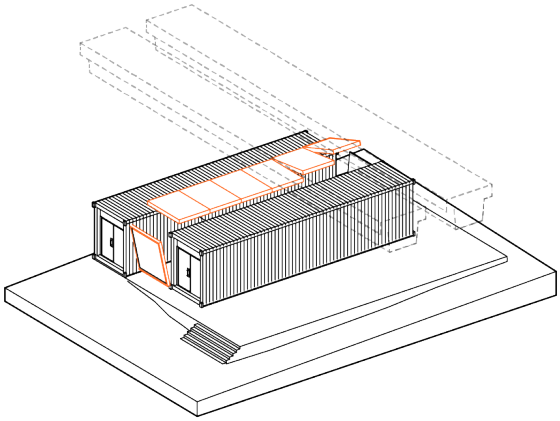
**Scale**



Cast-in-place Concrete to create hardscape plaza area for the public



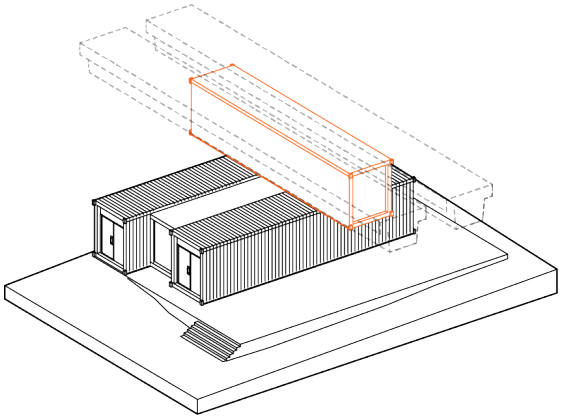

Containers are placed in with Forklifts

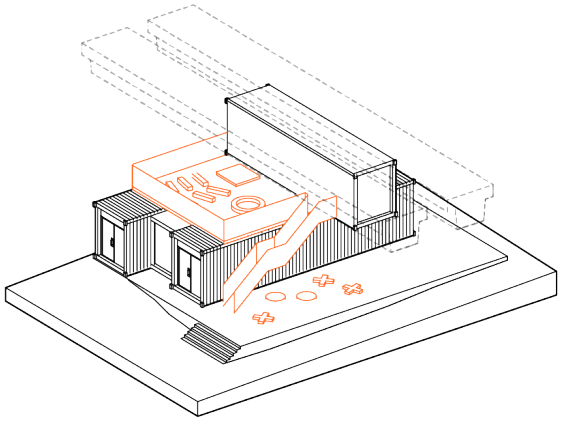


Panels are installed between the containers to link the two containers together.

**Fig. [109]** The following series of diagrams explain the on-site procedures to build the Box-Link-Box system

A loaded container handler then lifts a container to the second storey, it is then pulled to place beneath the concrete structure with an electric winch.





Railings and public furniture are installed in place.

A

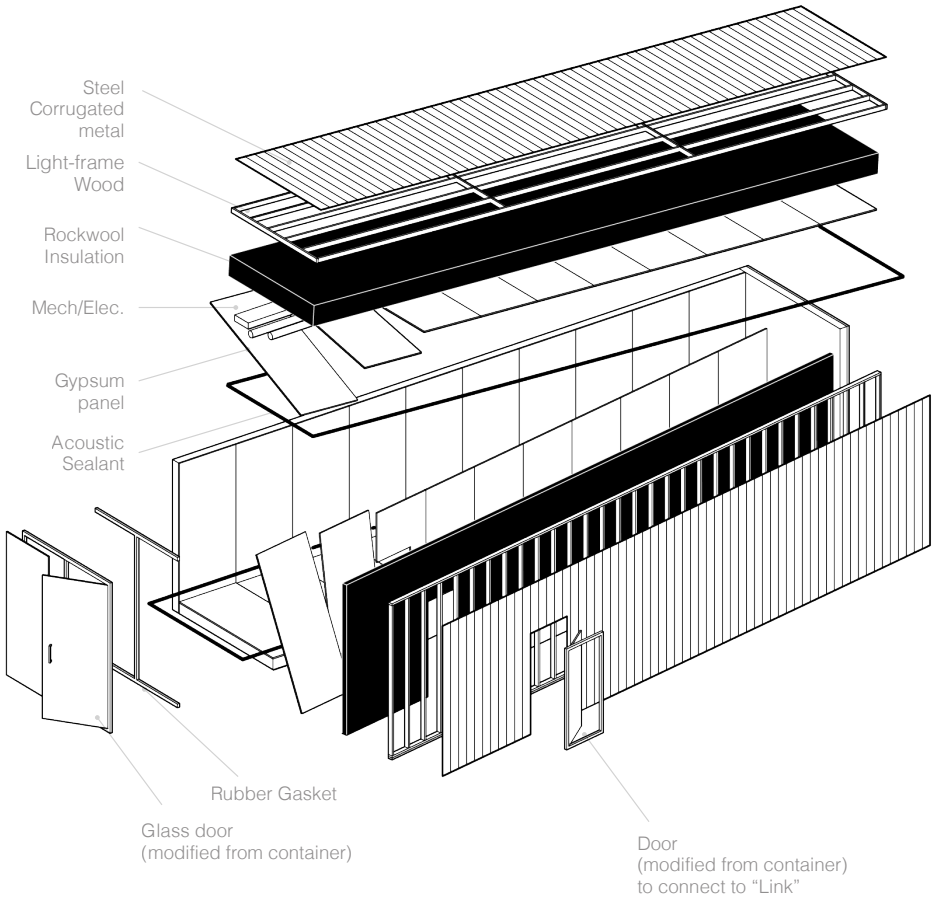


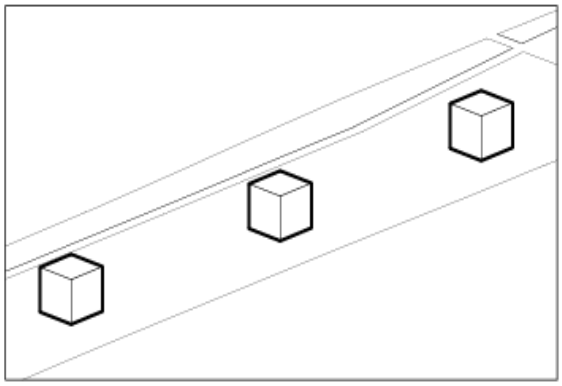

**Fig. [110]** The following diagrams explain the off-site components to build the Box-Link-Box system, these are assembled before transported to site This diagram omits standard envelope layers (e.g.air/vapor barriers) to focus on interior assemblies related to acoustic performance (shaded in black) in transit-adjacent conditions.

## 4.2 System 2:

[Core-Spine-Pod]
(Co-Living Prototype)

*Vancouver's housing crisis and high rent prices make traditional apartments unattainable, especially near transit stations. This is especially an issue for young adults and students, and a demand for more high-density housing. The co-living unit design for this project reduces costs by having spatially efficient bedrooms and sharing common amenities that can reduce individual rental expenses. Having many shared amenities also create a sense of community among its residents who can connect with one another more naturally than in isolated apartments. The density and access to transit provides easy access for students to get to jobs, schools and entertainments. With people frequently moving in and out, co-living is a low-commitment, that can accommodate a more dynamic lifestyle.*

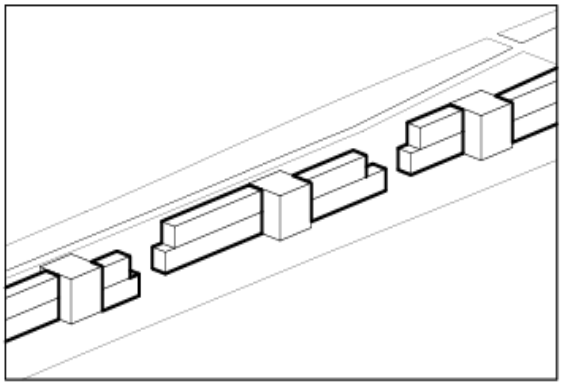
# Core-Spine-Pod I Program



## CORE

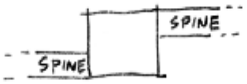
*Located within each modular housing cluster is the “Core”, the nucleus that contains communal essential amenities including kitchen, living room and dining areas and lounge areas. This is where residents can publicly gather. There are several decentralized cores than one large core to not become a megastructure*

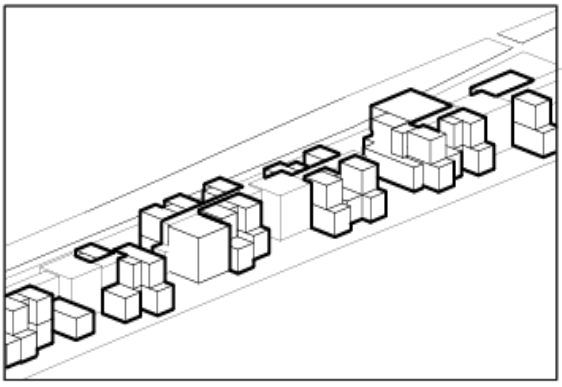


## SPINE

*Extending outwards from the core is the “spine”, these are corridors that connect the public Core areas to the Pods. These corridors contain activities such as bookshelves and whiteboards to engage residents in the co-living units.*



## POD

*The Spine feeds into “Pods”, which are mainly compact prefabricated bedroom modules that contain flexible furniture, or other essential programs such as laundry rooms, bike rooms, electrical rooms.*

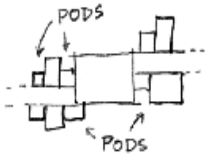
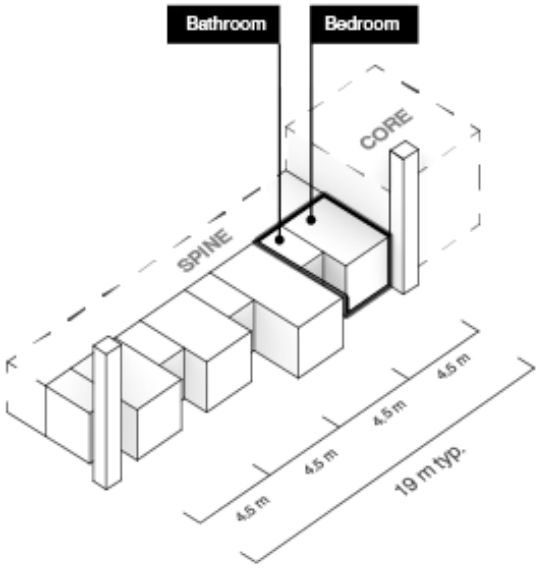
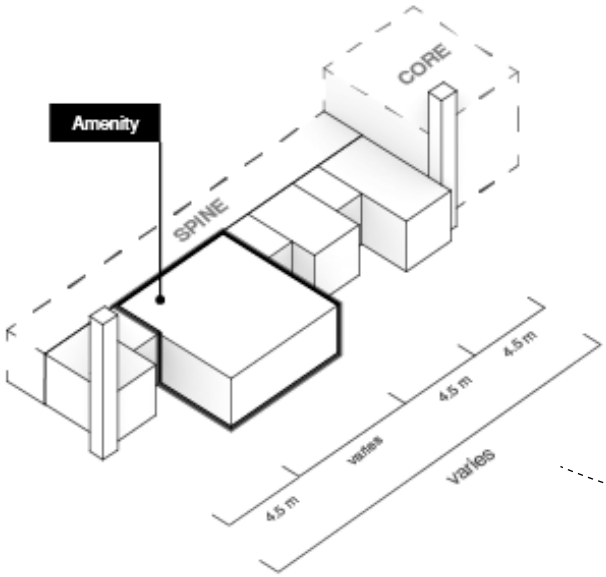



**Fig. [111]** The prototype for the co-housing units under the SkyTrain follows an organizational structure that consists of Core, Spine and the Pods, it is an adaptable framework that is designed to cater for the everchanging site conditions and flexibility

# Pods I Bedroom, Bathroom and Amenity




*The dimension of the SkyTrain rails column to column span by the Metrotown station is roughly **19 metres face to face**. The bedroom and bathroom dimensions span **4.5 metres,** which means bay to bay accommodates 4 units with 1.5 meters to spare.*




*The SkyTrain rail columns near Metrotown Station have spans that v**ary from location to location**. Amenity and Storage programming can have **varying dimensions** that fit between the units.*

**Fig. [112]** Pods extending out of the spine have its own rhythmic framework to accommodate the spacing between the columns. While the Metrotown SkyTrain rail columns may be more consistent in spacing, they can vary from location to location in other parts of the city.

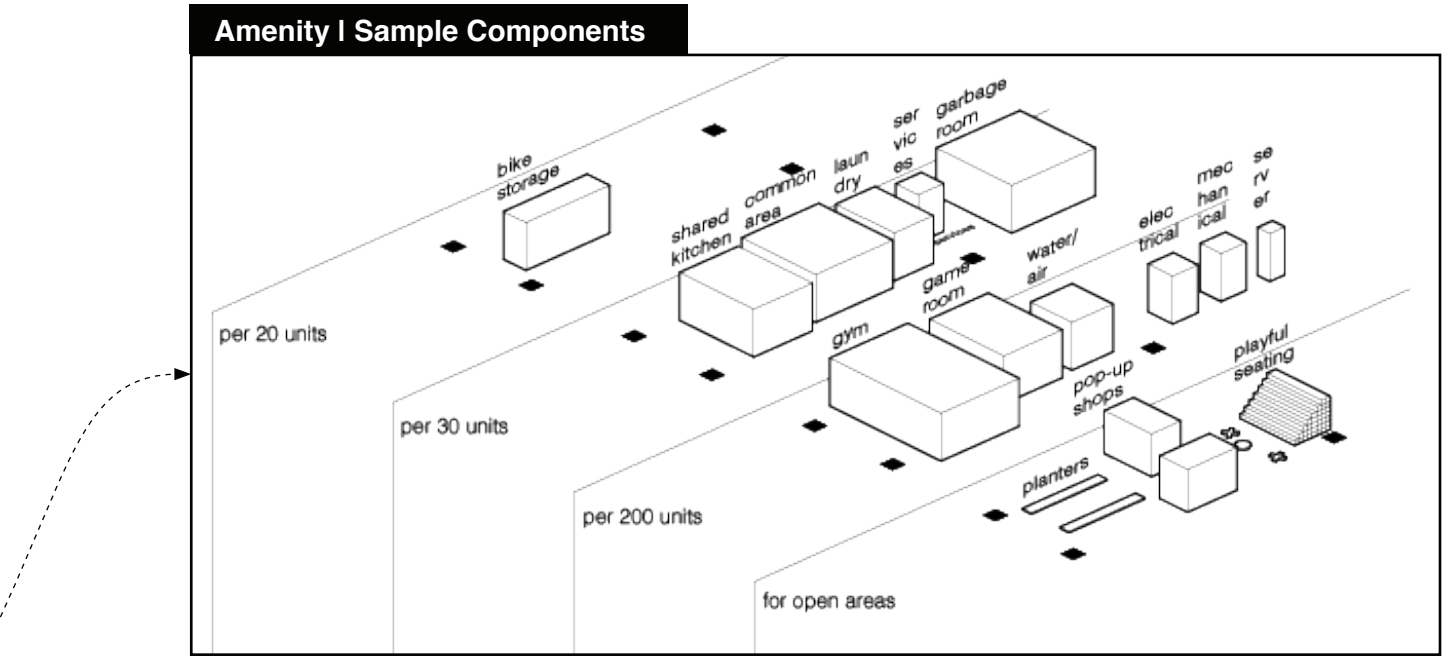



**Fig. [113]** This diagram shows the different programs that can inserted between the bedroom/ bathroom units. It also shows the approximate frequency it appears per unit of pod

# Pods I Option 1

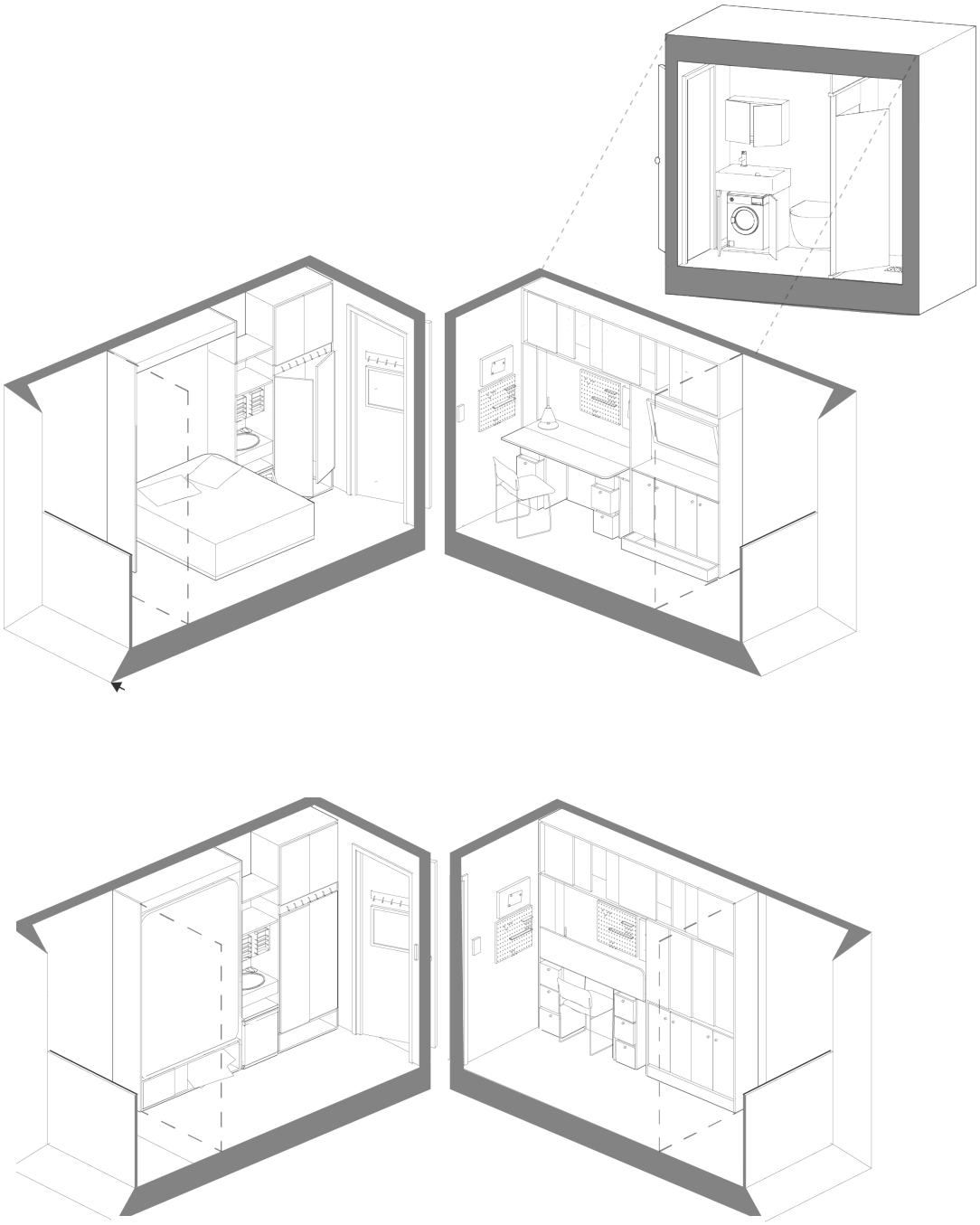


**Fig. [114]** Each pod includes essential living elements such as A foldable bed, a desk, multiple storage units, and a kitchenette. Washrooms are shared either between 1 or 2 units. The furniture in the units **is** flexible and can be folded up, and by doing so so that the unit leaves a rectangular footprint that allows for more versatile space, giving occupants the freedom to use it in ways that best suit their diverse requirements.

# Pods I Option 2

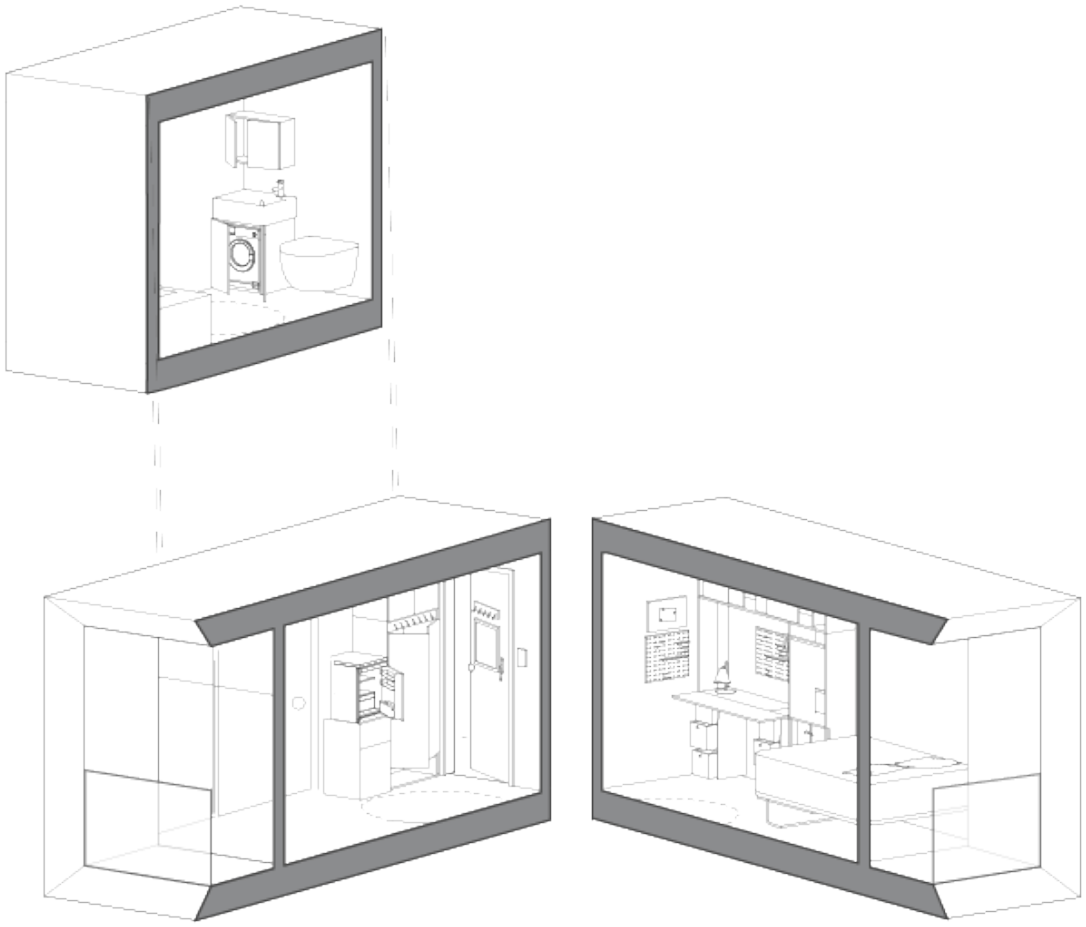


**Fig. [115]** Another option of a bedroom/bathroom pod with more square footage and static furnishing

# Core I Pivot Point System

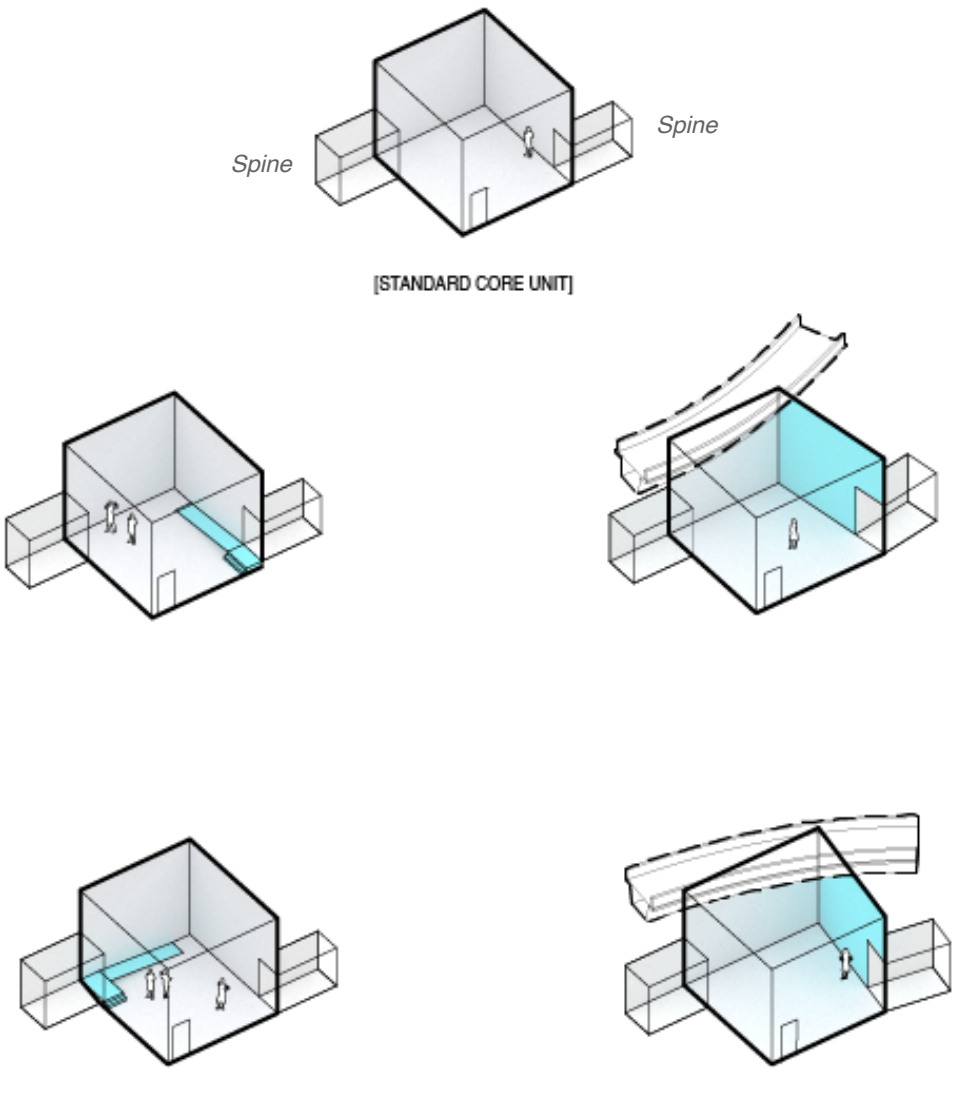



**Fig. [116]** The Cores act as a pivot point for the rest of the structure to adapt to different site conditions.

# Core I A Communal Centre

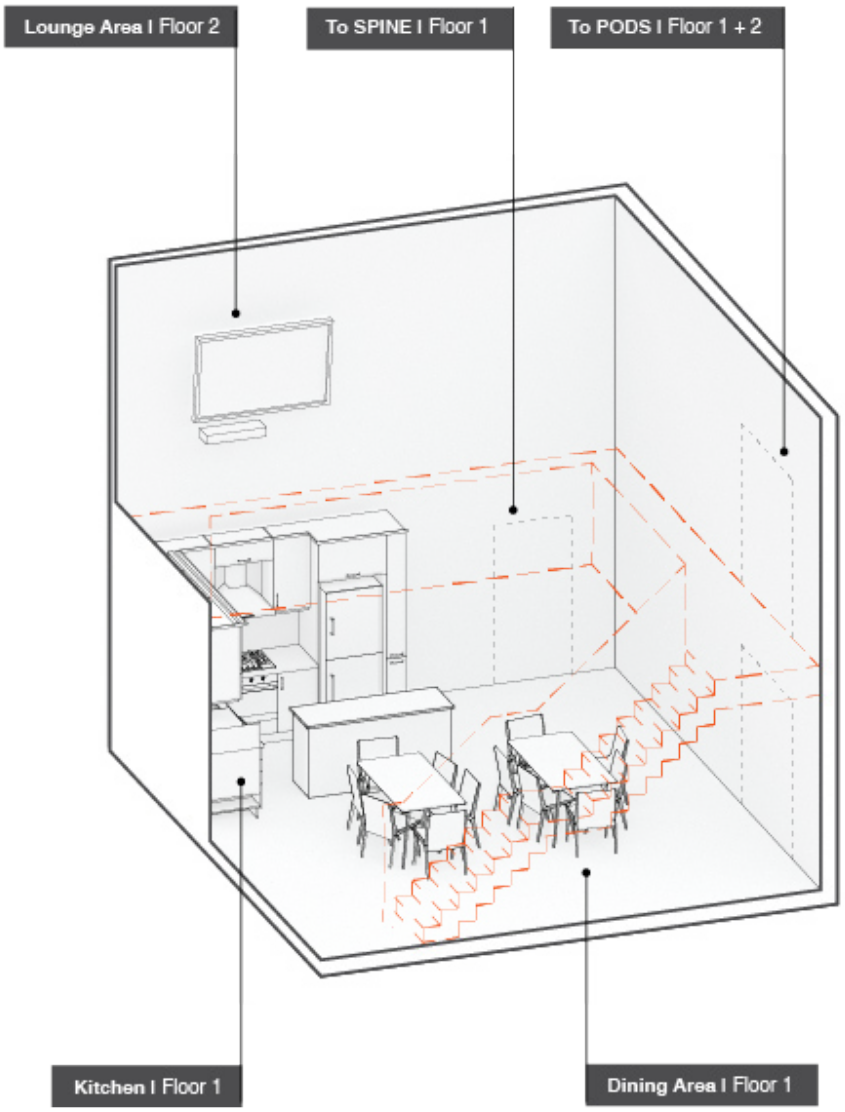
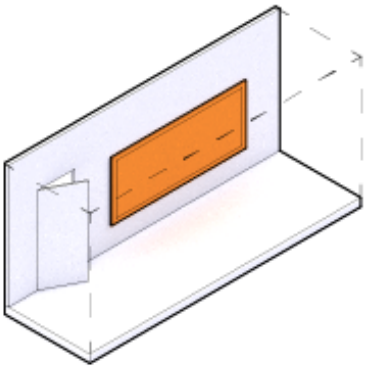
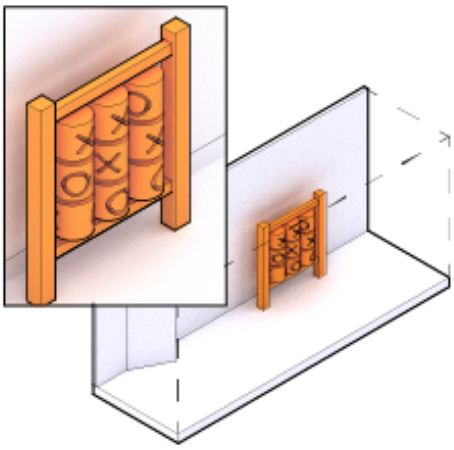



**Fig. [117]** The Core itself often contains essential communal amenities including a kitchen, dining, lounge areas for its occupants to gather.

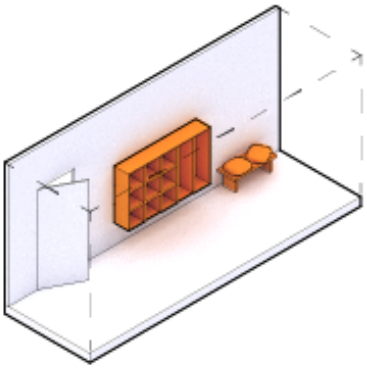
# Spine I A Social Threshold



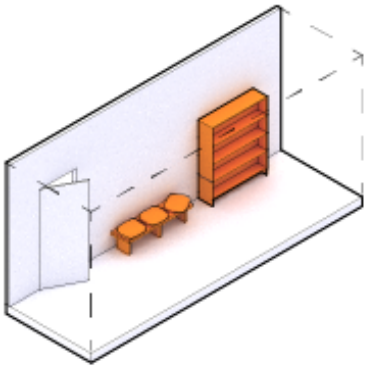
***PRODUCTIVE***
*DRAWINGS, POSTERS,*
*BULLETINBOARD, IDEAS, NOTES*



***PLAY***
*ARCADE, INTERACTIVE DISPLAYS,*
*PLAYFUL OBJECTS*



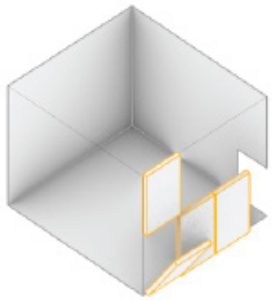
***PRODUCTIVE***
*COMMUNAL SHELVING, SHARED*
*BOARD GAMES*



***LEARN***
*TINY LIBRARY, SHARED MAGAZINES,*
*MAPS, DISCUSSION AREA*

**Fig. [118]** The Spine corridors have various communal programming that gives potential for social interaction with those that live among the pods.

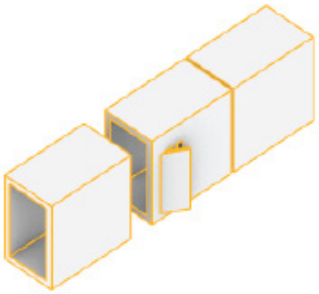
# Core-Spine-Pod I Prefab Components



**Core I Panelized (with Onsite structure)**

Panel dimensions:
3.0 m x 1.5 m x 0.2 m

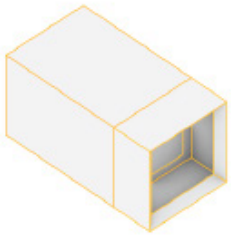
Panelized because:
- Given the large volume of the Core, it cannot be transported volumetrically
- Each has custom geometry (angled facades), panels give it the flexibility



**Spine I Sectional**

Module dimensions:
3.0 m x 3.0 m x 1.8 m (2.6 m wide spine options available too)

Sectional because:
- Repetitive linear corridor for modularity
- Variable door or window placement at set intervals demands customizability/ For the design, there can be 3 types of sectional components (regular, embedded door and embedded window)



**Pod I Volumetric/Modular**

Module dimensions:
3.0 m x 5.4 m x 3.0 m (Bedroom Op. 1 - shown in this diagram)
3.0 m x 6.0 m x 3.0 m (Bedroom Op. 1)
1.5 m x 2.6 m x 3.0 m (Bathroom)

Volumetric because:
- Standardized/Reptitive modules that are within the transport size restrictions
- Can be furnished offsite, more precise tolerance for private bedroom and bathroom spaces

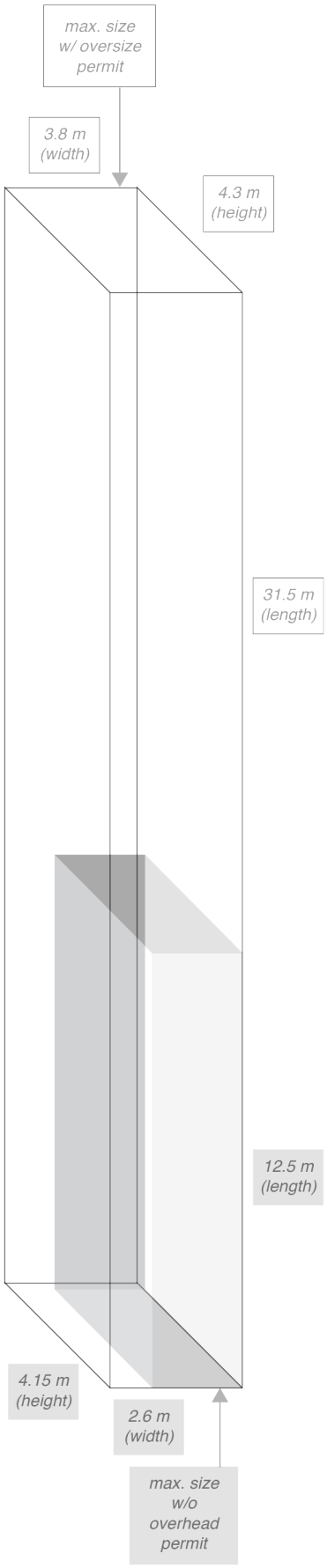
**Fig. [119]** The Core-Spine-Pod is a hybrid prefabricated system that combines panelized, sectional and volumetric components

## Component Sizing

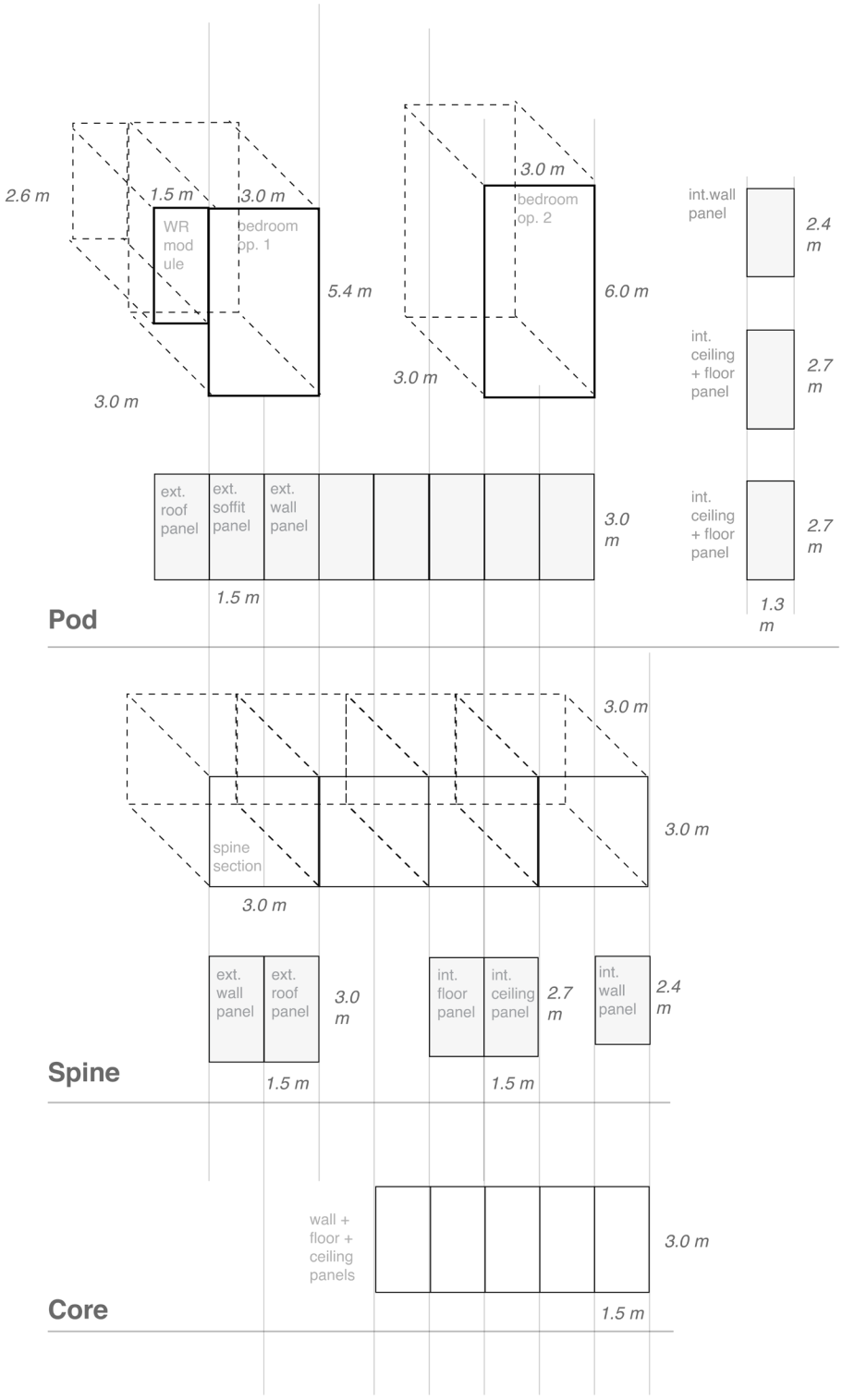
**Fig. [120]** *Left*
This diagram shows the maximum volume a truck can transport in British Columbia with and without an oversize permit. Oversize permit adds to the cost.

**Fig. [121]** *Right*
The Core-Spine-Pod is a hybrid prefabricated system that combines panelized, sectional and volumetric components

This diagram shows the different panels/modules and volume/area and how they relate to one another that determine their sizing.




## Truckbed Size

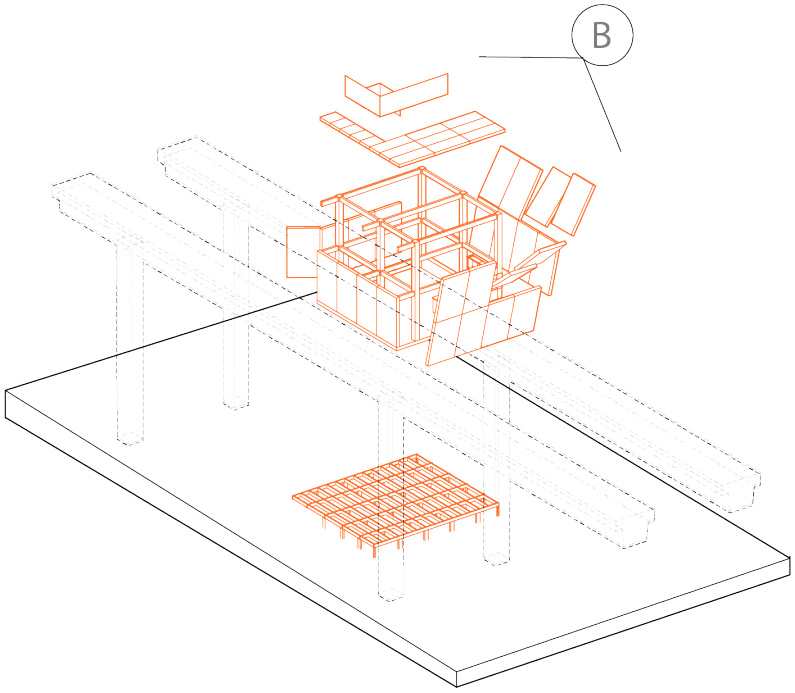



The pods are based upon prefabricated unit sizing for micro-living/student living determined by case-studies, so they are efficient without being generous.

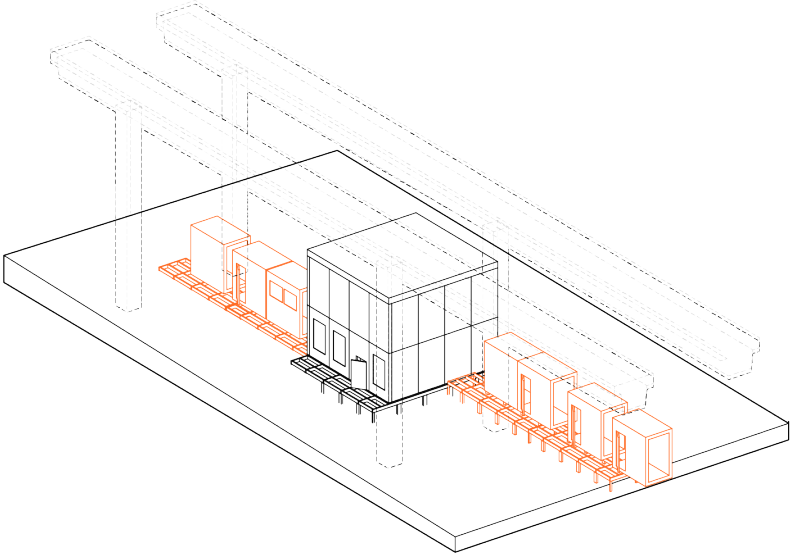
Given the 3.0m width of the units, the interior width are roughly 2.6 m wide, fitting 2 1.3 m panels.

To take advantage of economy of scale, this module is used in System 3 as well.

The 1.5m interior and exterior panel sizing is driven by the spine structure. Since the spine components are connected sectionally, the ends are left open except for the first and last part of the section, not having to accomodate for interior walls.



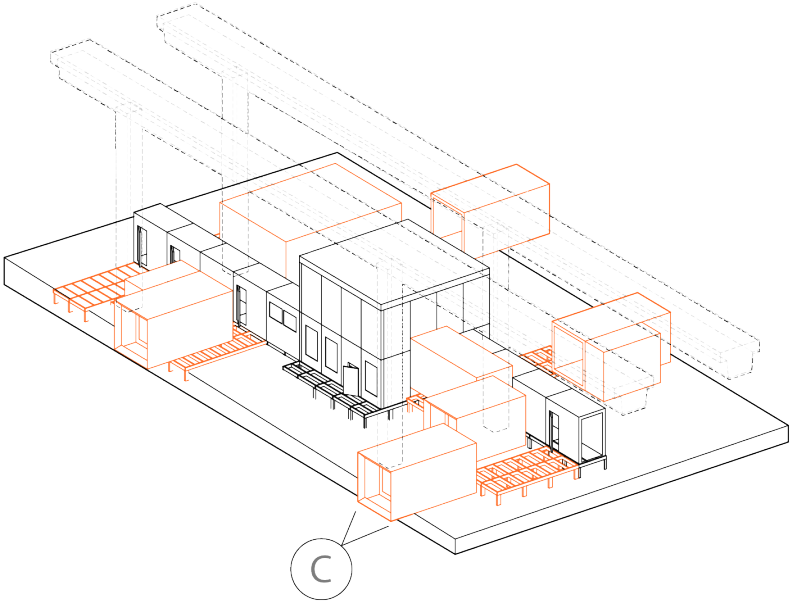

A pier foundation is installed, then a wood perimeter is added in which the Core is installed



Pier foundations for spine are installed

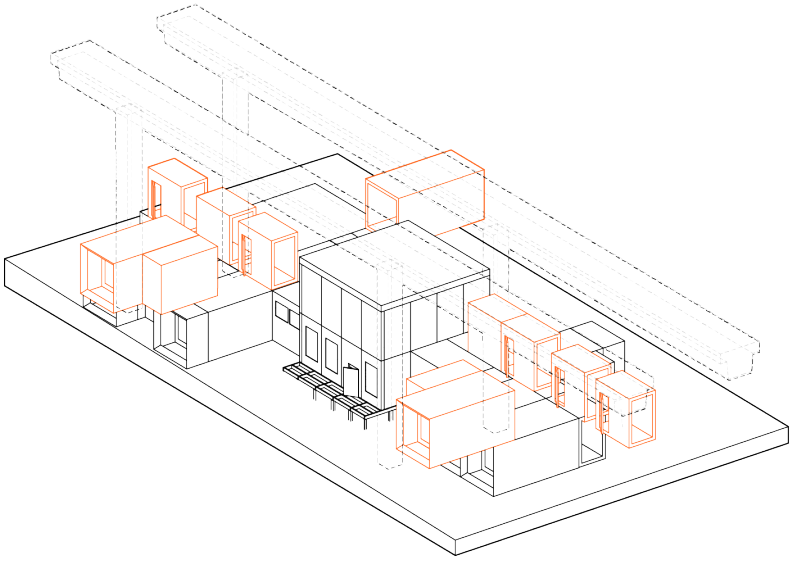
Spine sections are lifted on with forklifts

**Fig. [122]** The following series of diagrams explain the on-site procedures to build the Core-Spine-Pod system

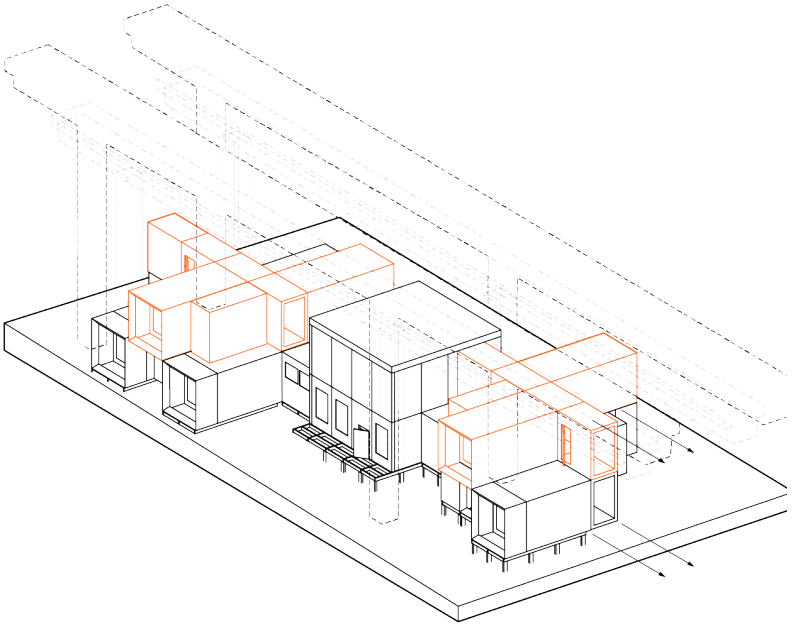



Pier foundations for pods are installed

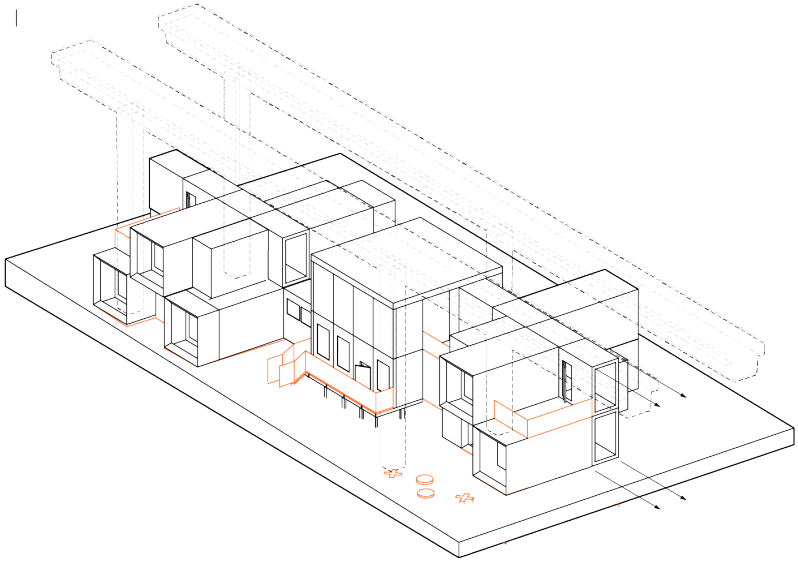
Pod modules are then lifted on with forklifts.



Second floor components are then lifted by forklifts



The second floor components are then pulled into place with electric winch



Railings and public furniture is installed on site

# Core I Off-site Components

B

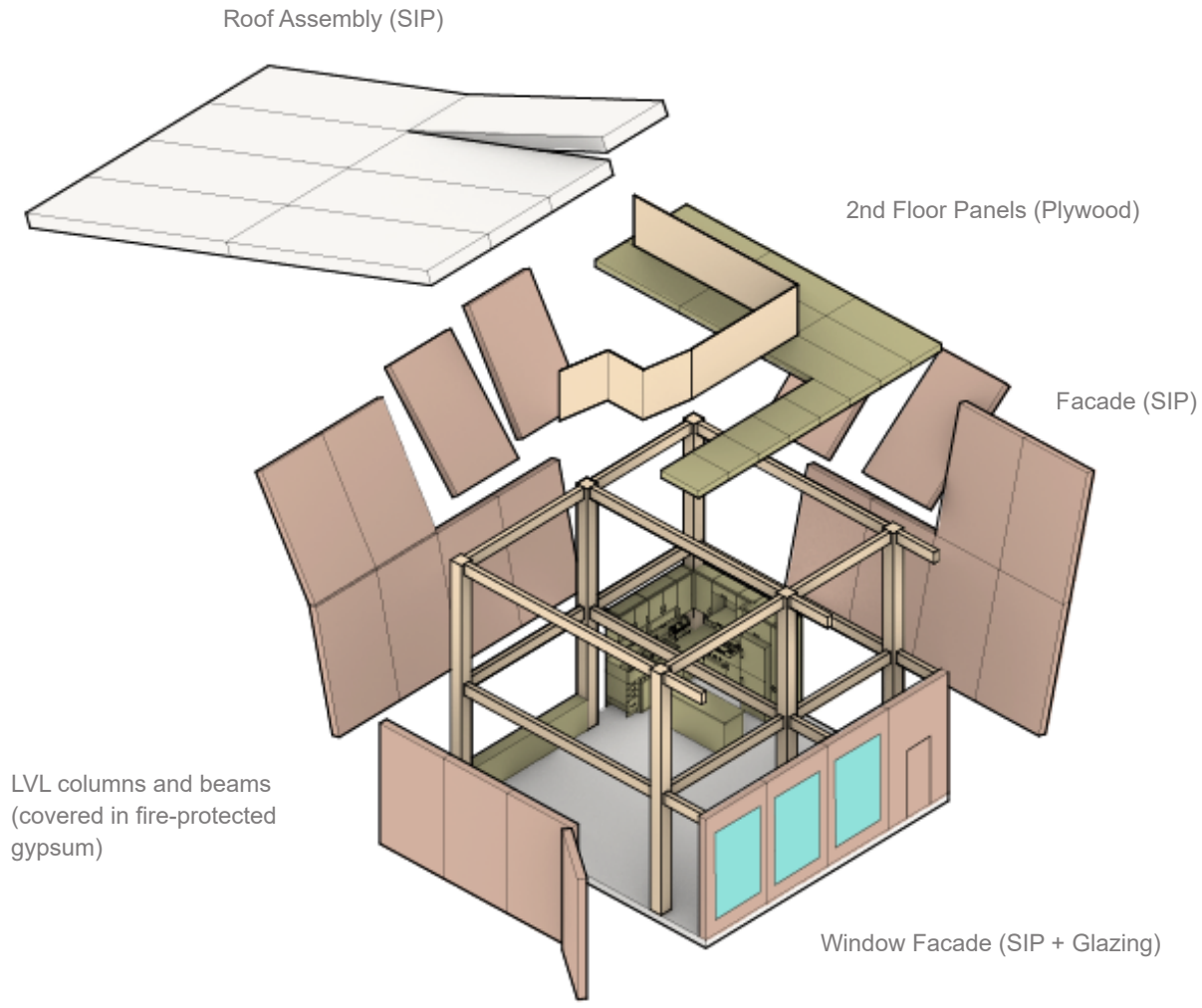



**Fig. [123]** Building Components of the Core. An LVL structure is built that supports the stairs, floors, roof. SIP panels are built around the structure as an envelope.

# Pod I Off-site components

C

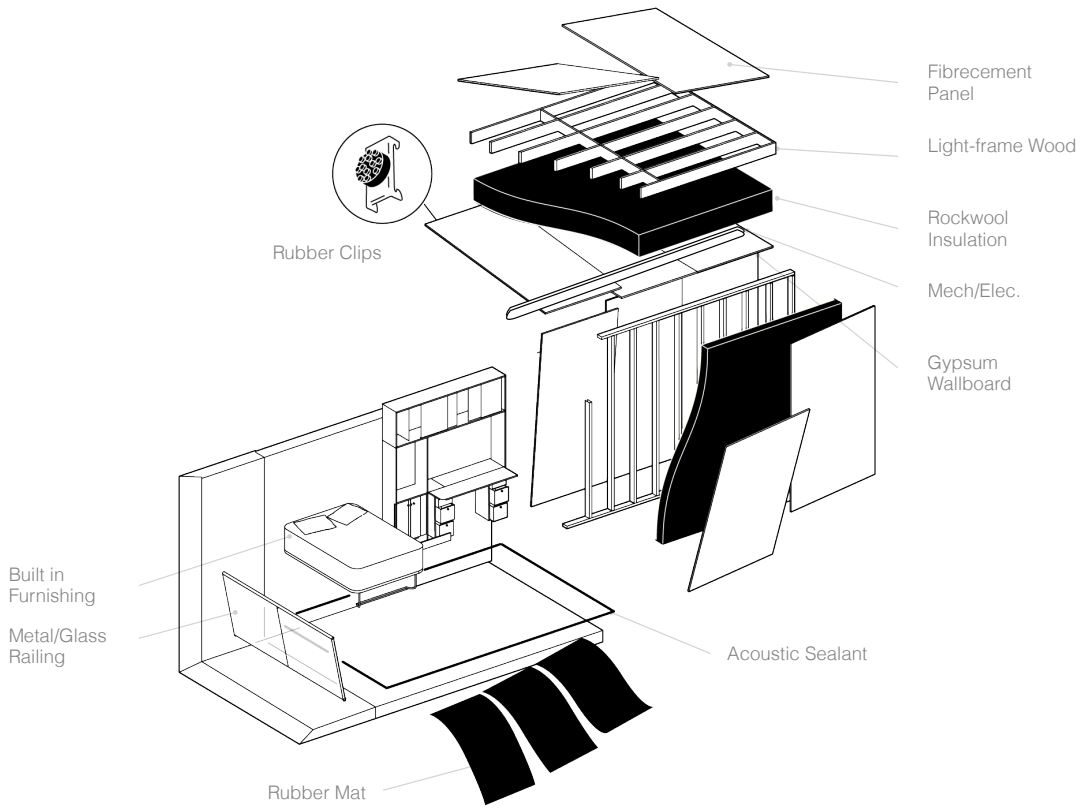



**Fig. [124]** Building Components of Option 1 Bedroom Pod. This diagram omits standard envelope layers (e.g., sheathing, air/vapor barriers) to focus on interior assemblies related to acoustic performance (shaded in black) in transit-adjacent conditions.

## 4.3 Sample Site: Metrotown Station

**System 1 [Box-Link-Box] +**

**System 2 [Core-Pod-Spine]**

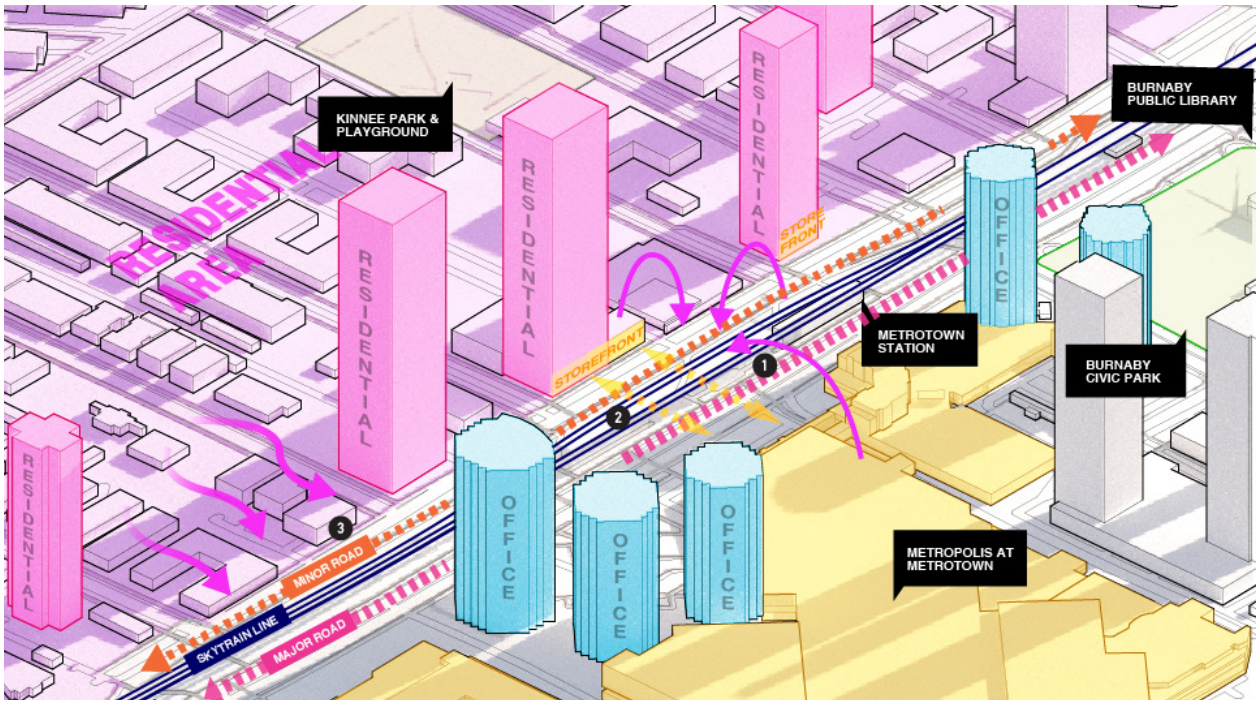
Given Metrotown Station's role as a major transit hub with connections to both SFU and UBC - the largest universities in BC by population, there is high demand for student and young professional housing. Traditional housing has its place, but in accessible areas it can be quite unaffordable.

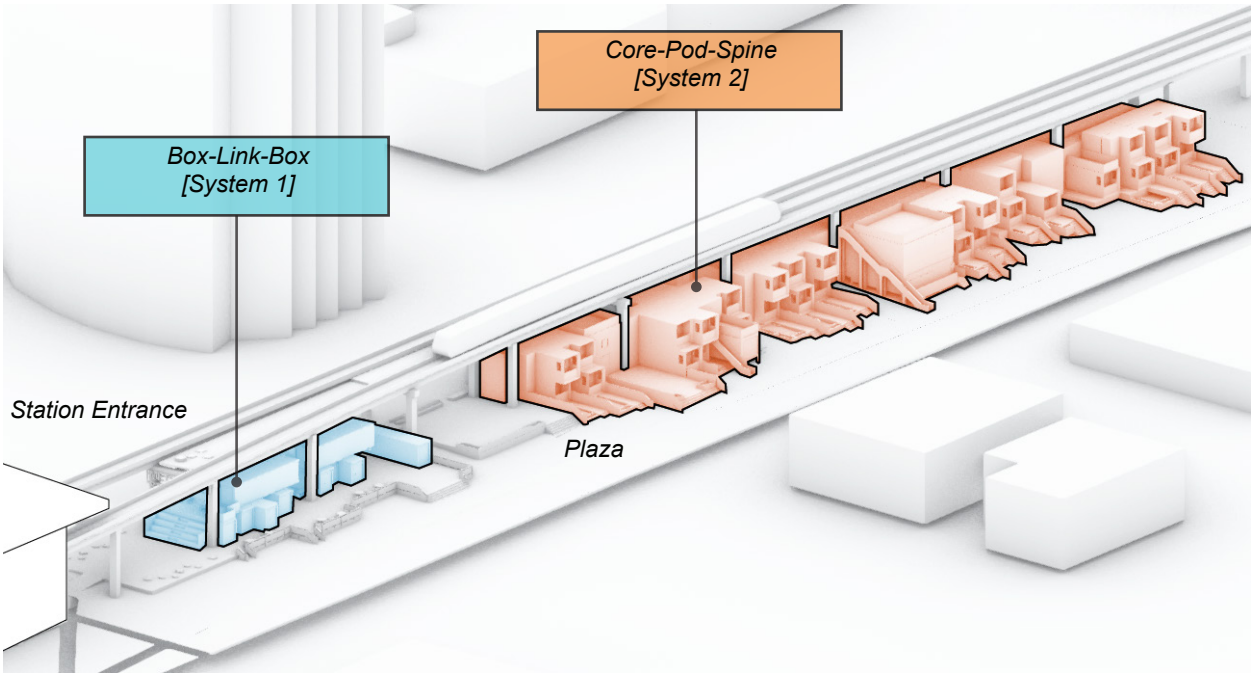



**Fig. [125]** The site is located in Burnaby, BC that is located along the Expo Line rails near Metrotown station.



**Fig. [126]** The site is a high-density area that is surrounded by many high-rise and mid-rise towers around the site. The rails are along an underutilized part of a strip of landscape that has potential to be be readapted to become something more.


KINNEE PARK & PLAYGROUND
RESIDENTIAL
RESIDENTIAL
RESIDENTIAL
RESIDENTIAL
STOREFRONT
STOREFRONT
BURNABY PUBLIC LIBRARY
OFFICE
METROTOWN STATION
BURNABY CIVIC PARK
OFFICE
OFFICE
OFFICE
METROPOLIS AT METROTOWN
1
2
3
MINOR ROAD
SKYTRAIN LINE
MAJOR ROAD


Core-Pod-Spine
[System 2]
Box-Link-Box
[System 1]
Station Entrance
Plaza

# Urban Study

**[Fig. 127] Site Analysis** *Above*

Metrotown Station is the second-busiest in Greater Metro Vancouver, after Waterfront Station (which is located underground). It is a high-activity area and offers unique opportunities for development beneath the SkyTrain. It is located at the intersection of numerous pedestrian f lows and forms part of the Expo Line SkyTrain system, connecting to the bus loop that serves 14 bus routes and has 14 loading bays. The space is surrounded by buildings, shops, metrotown station, Square, Crystal Mall, As a result, the site is a prime space for housing due to its accessibility. Traditional housing can be expensive and inaccessible, with co-living that can lower rent due to shared spaces in an otherwise expensive location.

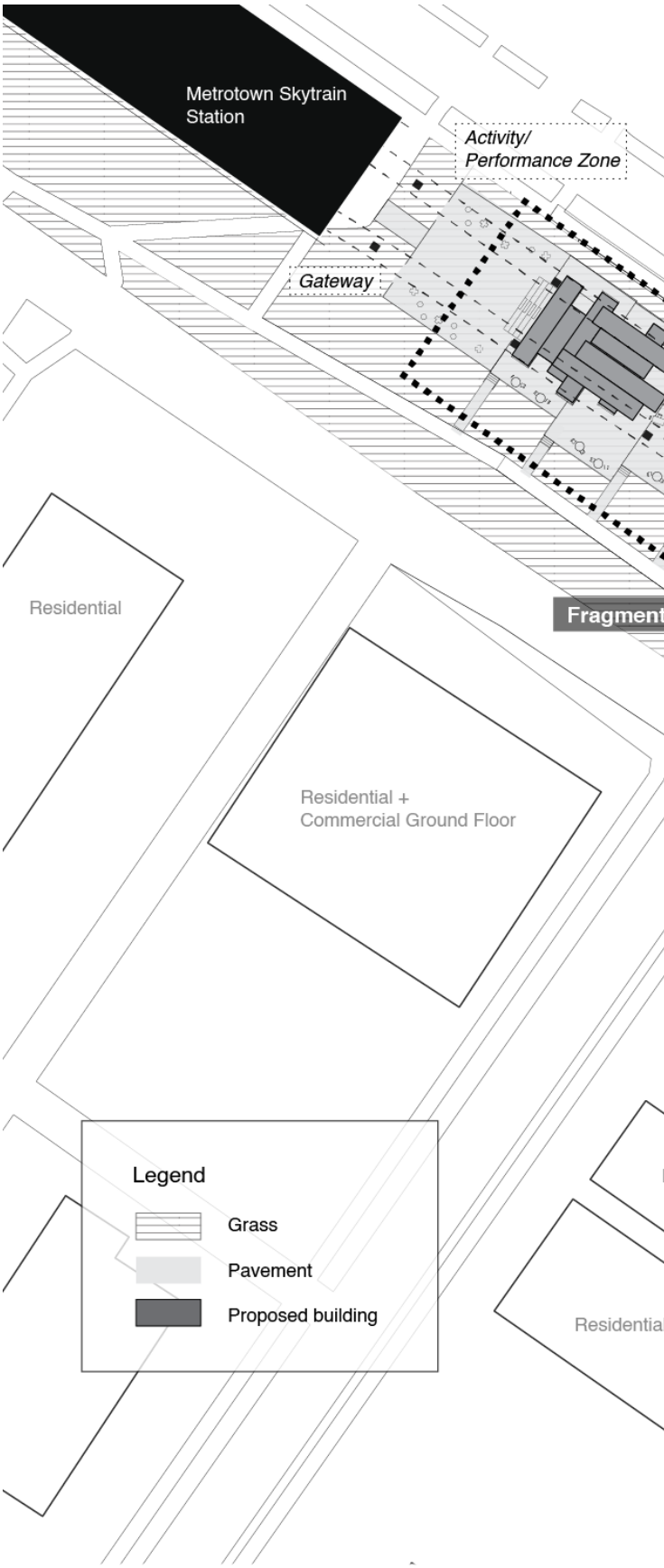
**[Fig. 128] Massing** *Below*

As commuters exit the SkyTrain station - a gateway - they transition to a buffer zone, a public transition space that is designed to accommodate seating, open plazas and communal activities. The space acts as a threshold and allows for gathering and informal performances before leading to a commercial area that contains shipping containers that holds shops and cafes along a pedestrian path. Further along, the environment shifts to a quieter residential area, with housing pods. This sequencing allows a gradual transition between public to commercial to a more private domain.

# Site Plan

**[Fig. 129]**

The site plan illustrates Metrotown Station as a key gateway to the area. Given the high foot traffic, the space in front of it is designed as an Activity/Performance Zone that as an active buffer zone that leads to t shops to activate the street and engage passersby. Moving further down the road, away from the station, the layout transitions into residential co-living units, creating a more community-oriented and livable environment.

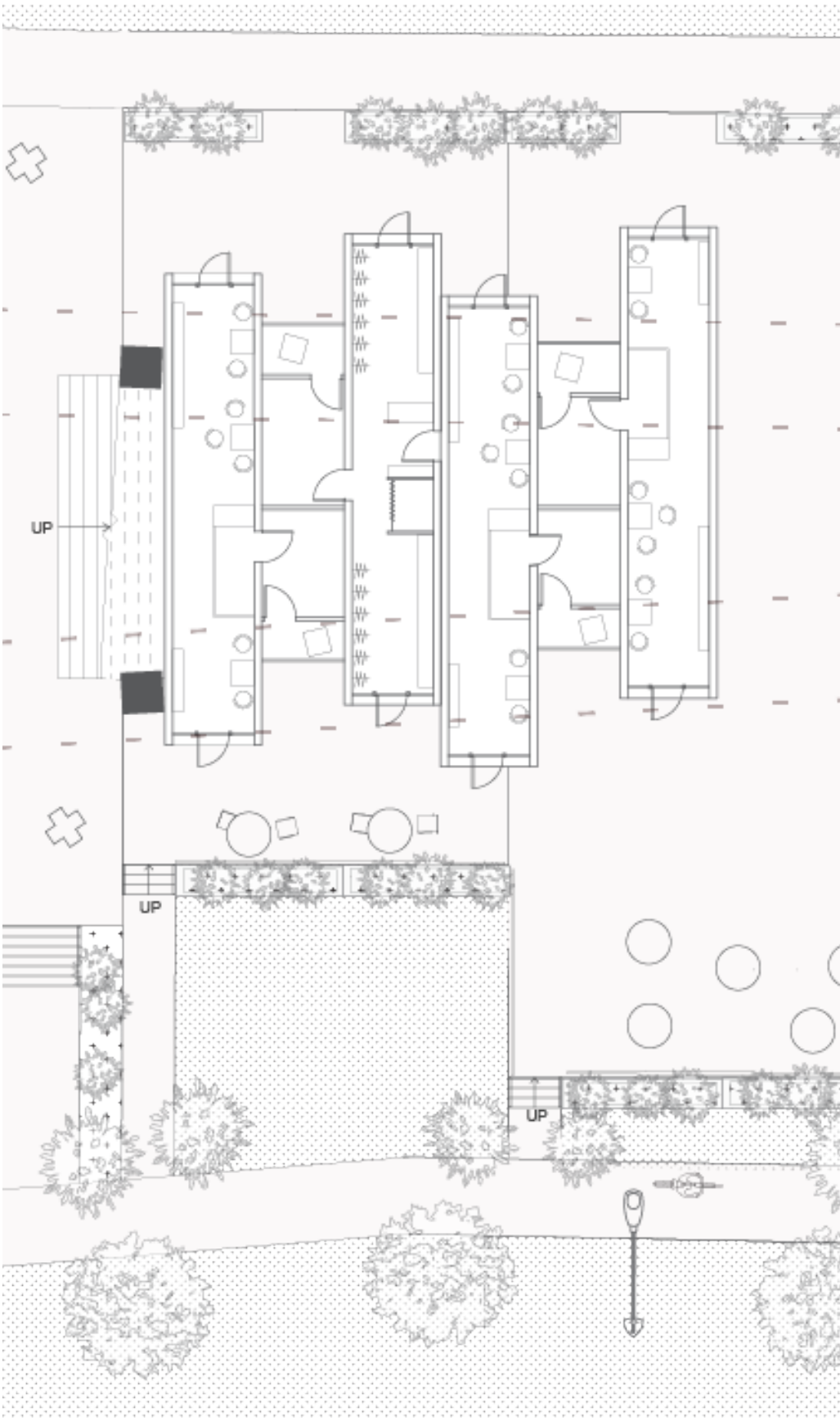



Metrotown
(Mall)
Office Tower
Shops
Blacktop
Residential
Metrotown
(Mall)
Residential +
Commercial
Ground Floor
Residential
Residential
Fragment B
N
0
10
30 m

# Fragment A (Box-Link-Box)

**[Fig. 130]**

Shipping container shops are surrounded by large open public spaces and landscaped areas that allow for community gatherings such as picnics, yoga, small concerts, and other outdoor activities.



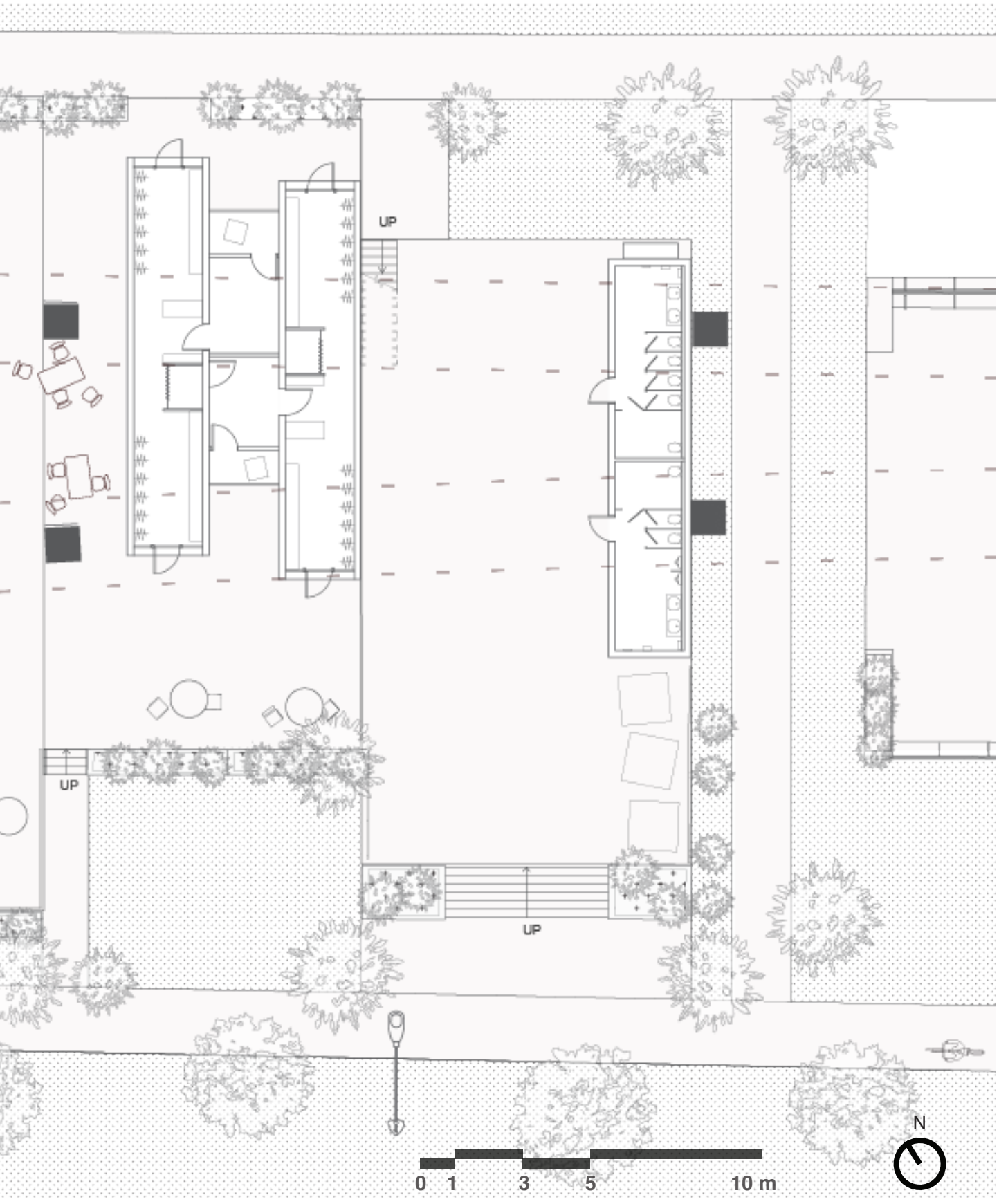

UP
UP
UP
0 1 3 5 10 m
N

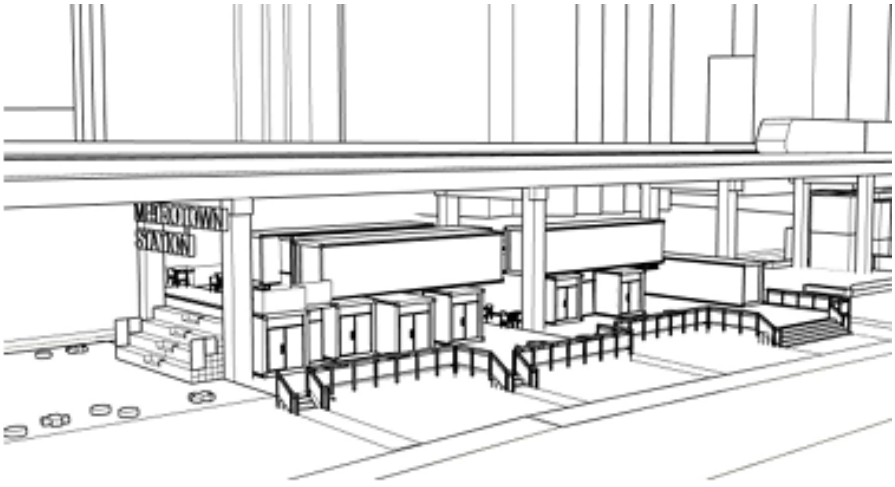


**Fig. [131]** The repurposing of shipping containers as storefronts attract visitors that are coming out of the station. The shops are compact and narrow that house businesses that don't need much square footage.




**Fig. [132]** Upper floor offers seating and communal gathering areas. Ample open space in and around the area for public activities to take place. The lively colours are to bring life below the grey monolithic SkyTrain structure above and the former underutilized park space below. Surrounding paved areas and grass allow for outdoor public activities (sports, performances) to take place.



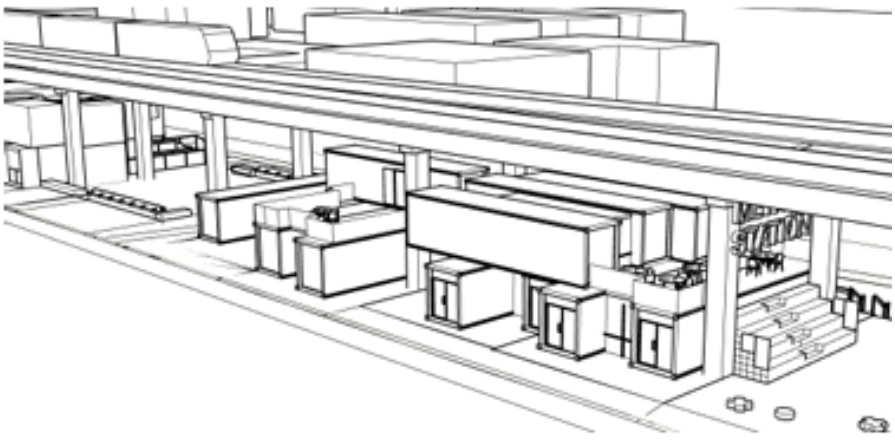
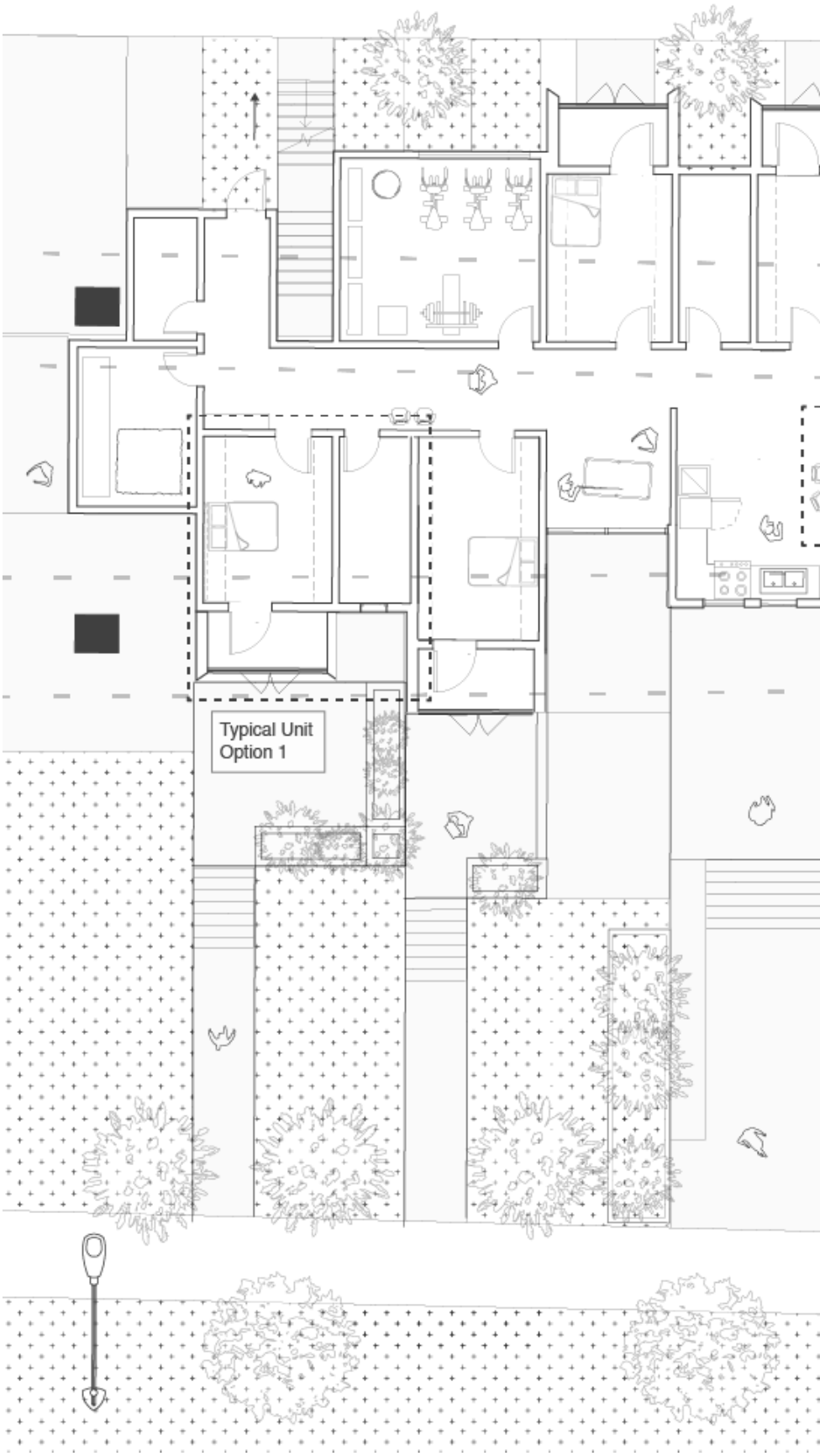



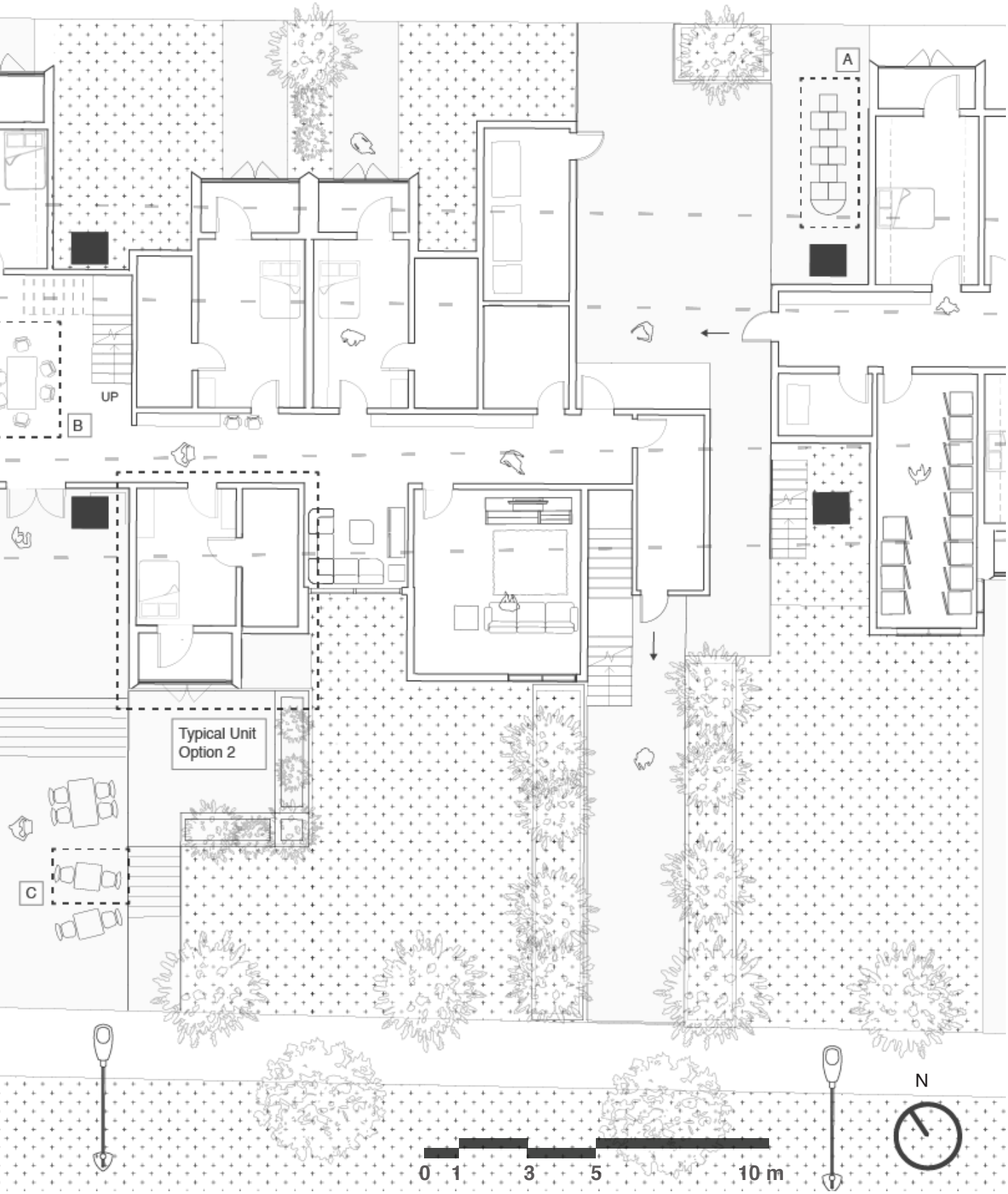
**Fig. [133,134,135]**
Once visitors exit out of metrotown station, they encounter a large "Metrotown Station" signage and an informal performance/ blacktop area that is in front of it.The two vignettes at the bottom show the aerial view of the shipping container shopping area

# Fragment B (Core-Spine-Pod)

**[Fig. 136]**

These Residential co-living units have pockets of outdoor spaces that are framed by the trees and bushes around it, that soften the landscape while providing privacy and comfort for the residents.




A
UP
B
Typical Unit
Option 2
C
N
0 1 3 5 10 m

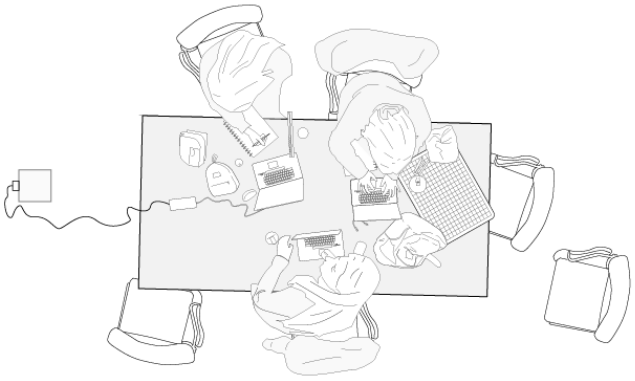




# Residential Pods

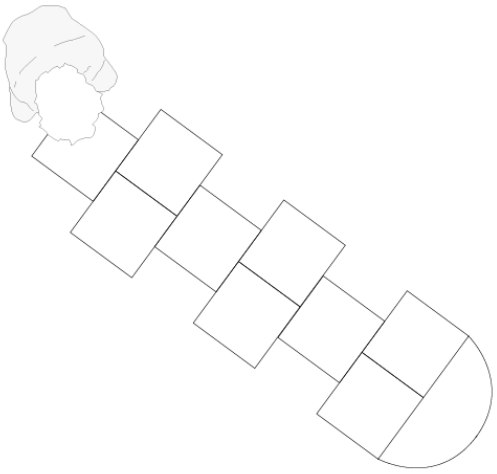
**[Fig. 137, 138]**

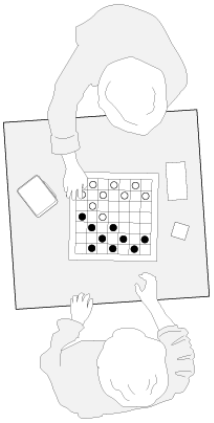
The residential co-living space is designed to be a two-storey modular building that houses young adults and students. It contains amenities and has plenty of green areas that contrast and softens the grey infrastructural rails above to create a more inviting environment. The units are slightly raised to create semi-private patios for residents. While the material shown in the renders are aluminum panels, facade material can be varied with stucco, etc. to match the surrounding context.



A
Communal spaces allow for different residents to connect and collaborate with one another.

B
Open paved spaces can be adapted to contain playful elements that engages the community.





C
Outdoor furniture allow for a variety of planned and unplanned events for the community.

**Fig. [139]** Various spontaneous program can happen within the communal spaces indoors and outdoors.

# Co-living Section

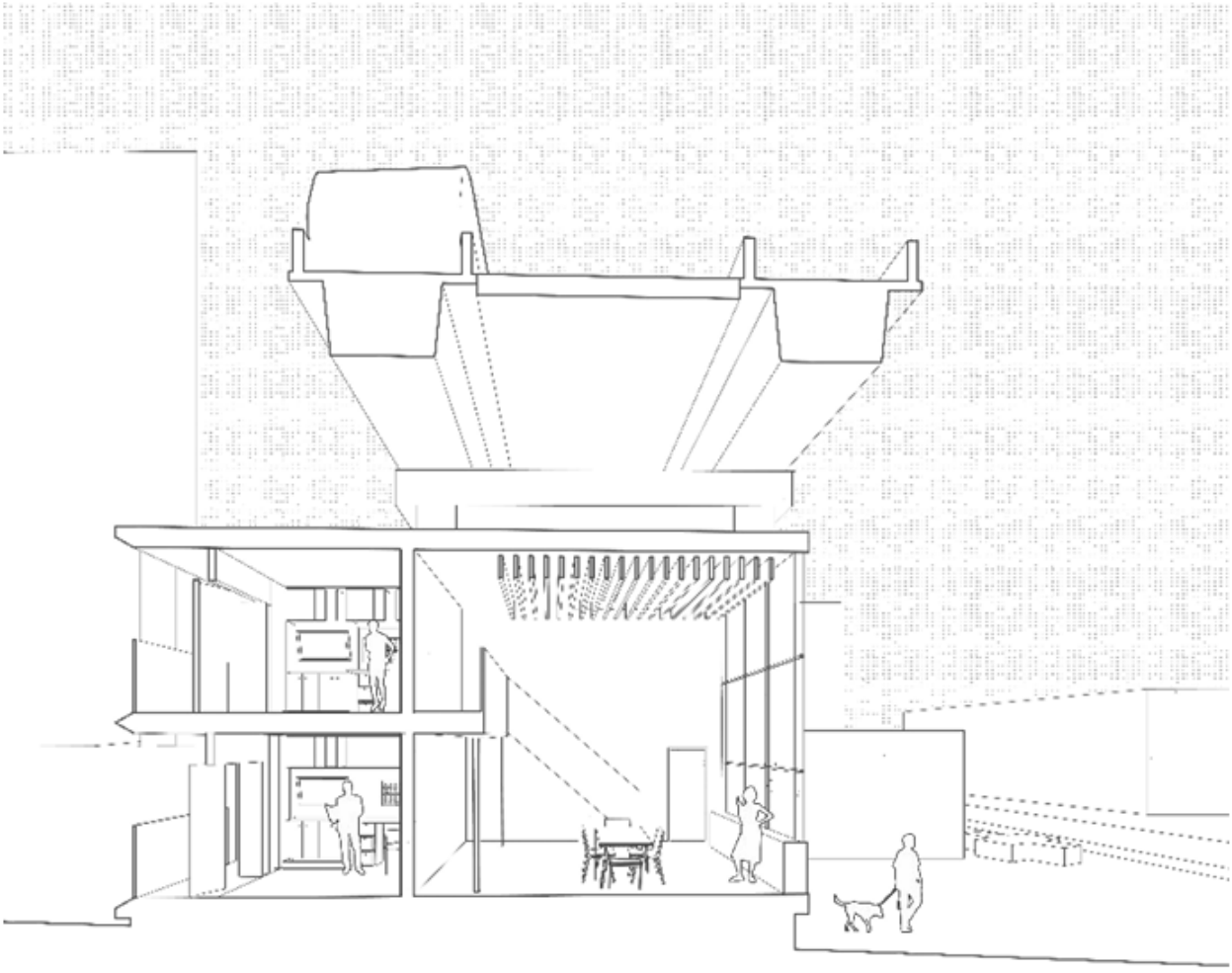


**Fig. [140]** Section drawing through the Core (communal dining area) and the pods (individual units) . While a flat roof is not ideal for housing, it allows more clearance on the second floor for units and potential roof access.

# 4.4 System 3

[Base-Extender-Face]
Prototypical System for
Medium-Density Live-Work

*Medium-density areas beneath the SkyTrain are well-suited for live-work housing as it balances accessibility and affordability. The areas are situated between urban cores and quieter residential zones that make it ideal for freelancers and budding small businesses. Having workspaces that are in proximity to transit allow professionals to meet clients, access resources and operate more efficiently without having long commutes or costly .*

# Base-Extend-Face I Concept

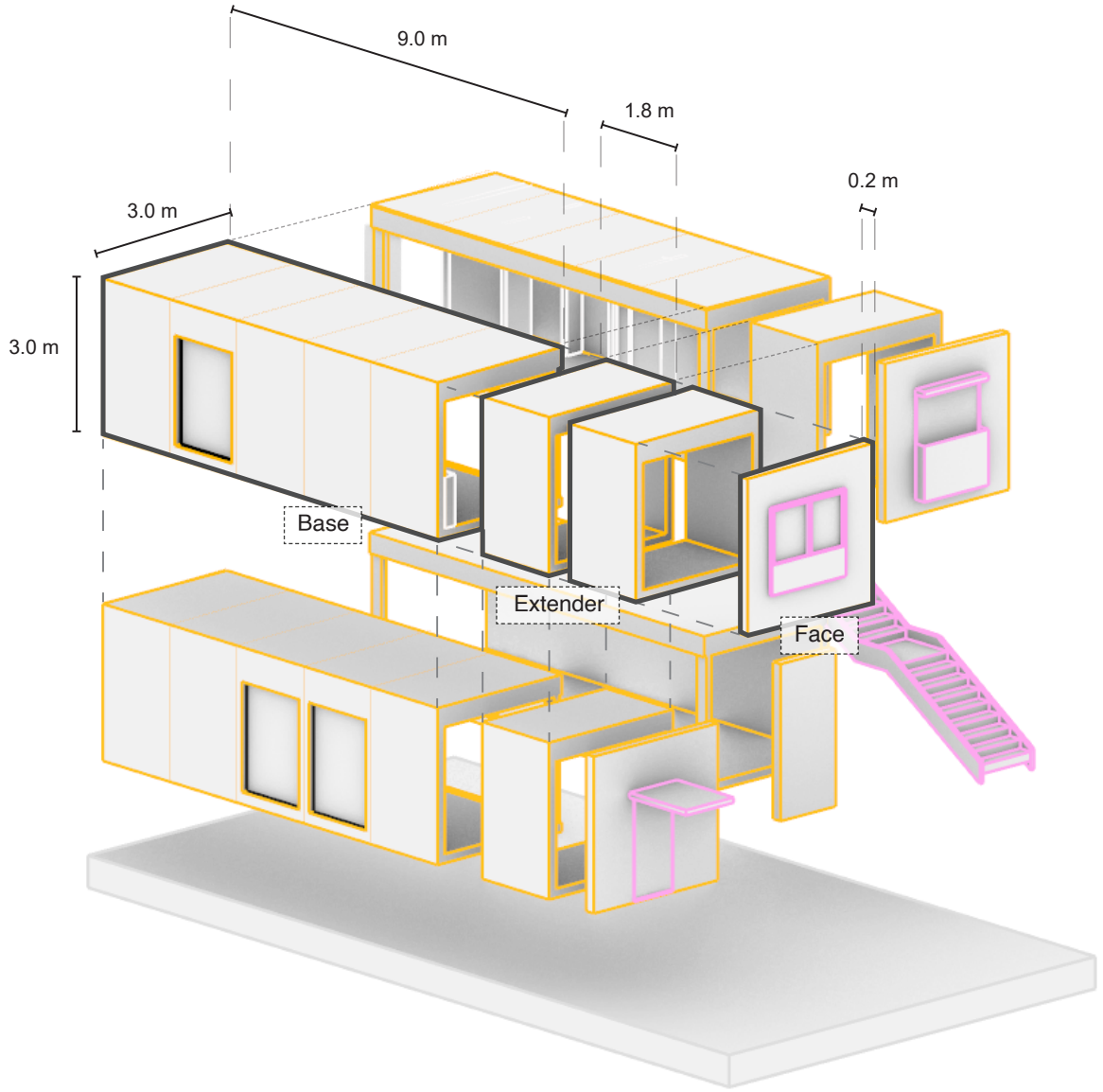
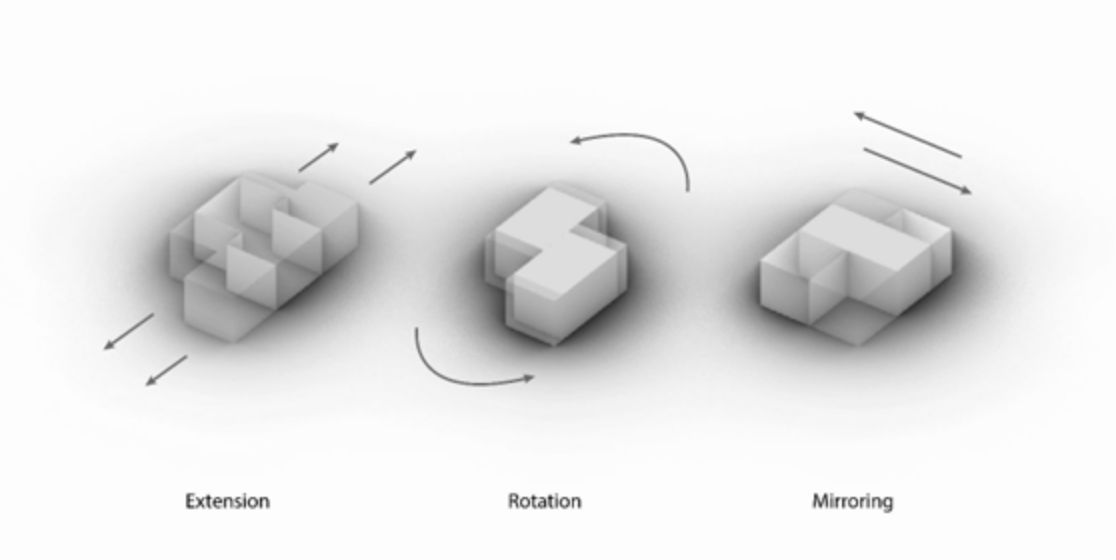



**Fig. [141]** Diagram showing the relationship between the 3 components: The Base (volumetric) is where most of the core programming happens. The Extender (sectional) is added to connect with the base as a custom module to accommodate larger floor areas. The Face (panelized) is customizable that creates variety along the facade.

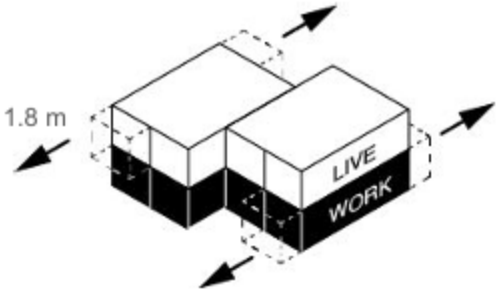
# Base I Orientation




[**Fig. 142]**

Note that while they are prototypical floorplans, the overall floor plans and plans can be adjusted and morphed to accommodate the needs of the site and program. There are three major ways these forms can be manipulated, as shown in the diagram below. **"Extension"** is useful when certain programs require more area. **"Rotation"** responds to the orientation needed and fits the site context. **"Mirror"** By combining extension, rotation and mirroring, it creates numerous combinations of structures that are both flexible and adaptable within itself and to its environment.

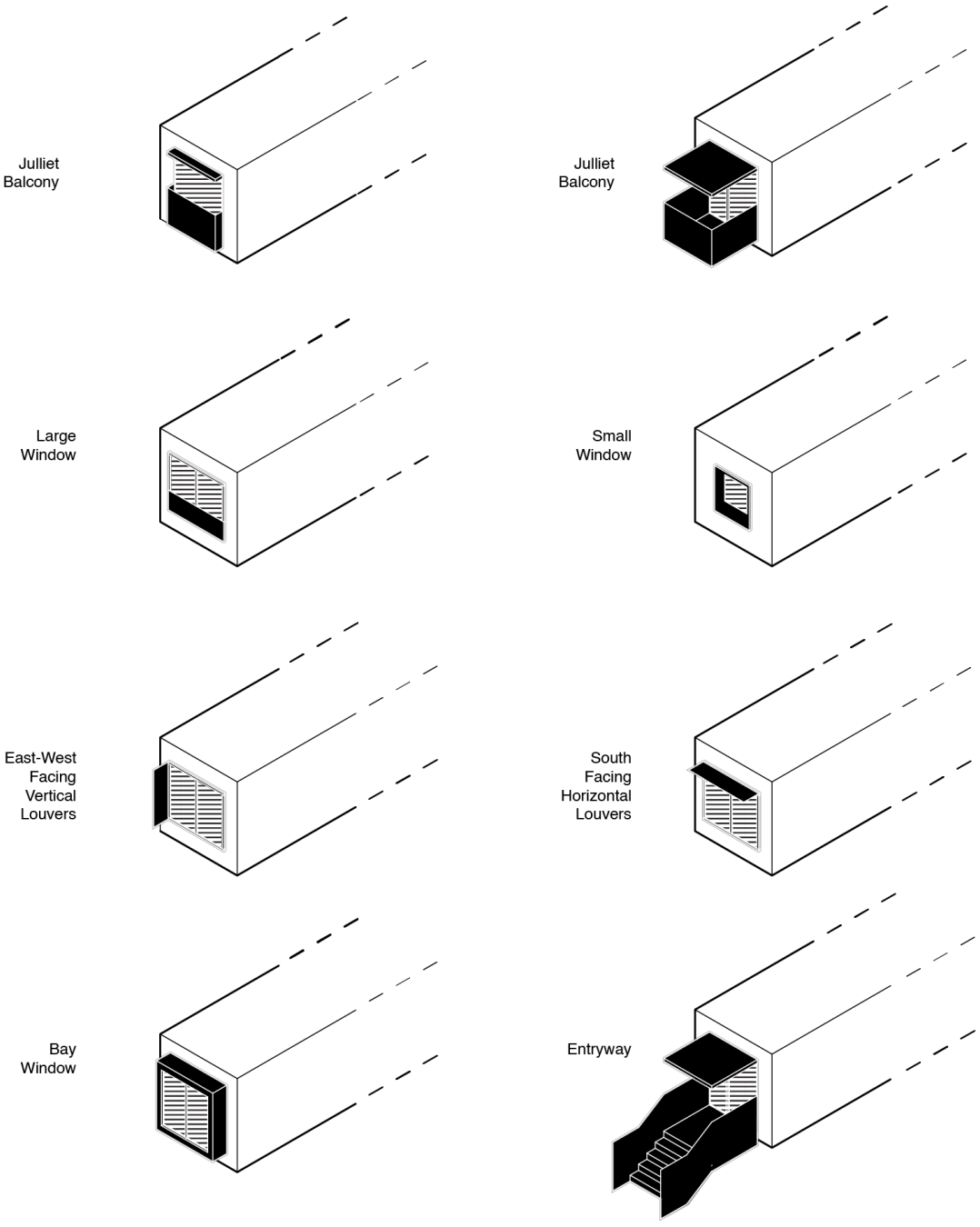
# Extender I Arcticulation




[**Fig. 143]**

Live units are located on the second storey, while the work and shop units are located on the ground floor to connect with the public ground plane. Each unit can be extended in 1.8m increments for further customizability and creating articulation on facade.

# Face I Customizability



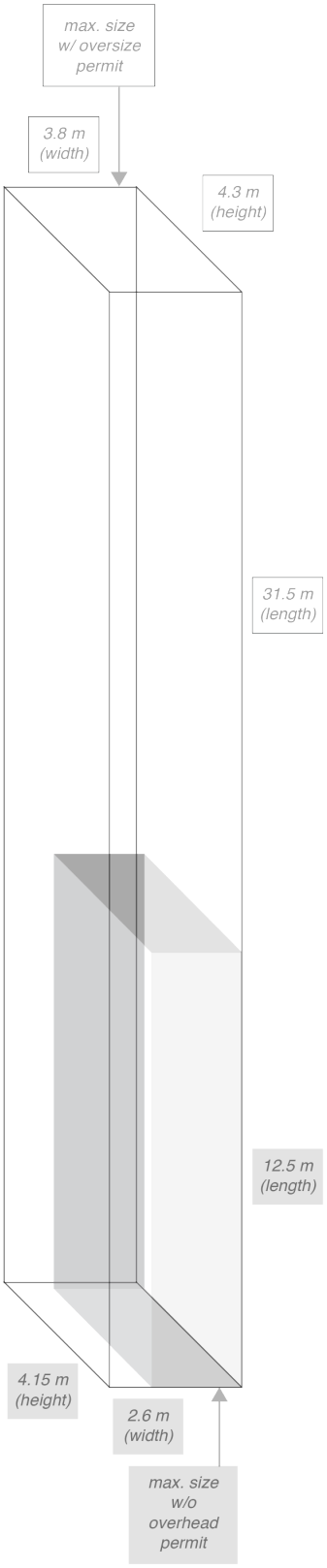

[**Fig. 144**]

To create more customizability and variety for the facade, the diagram shows the different facade articulation one may use when designing the live-work units that can accomodate various programs and site conditions.

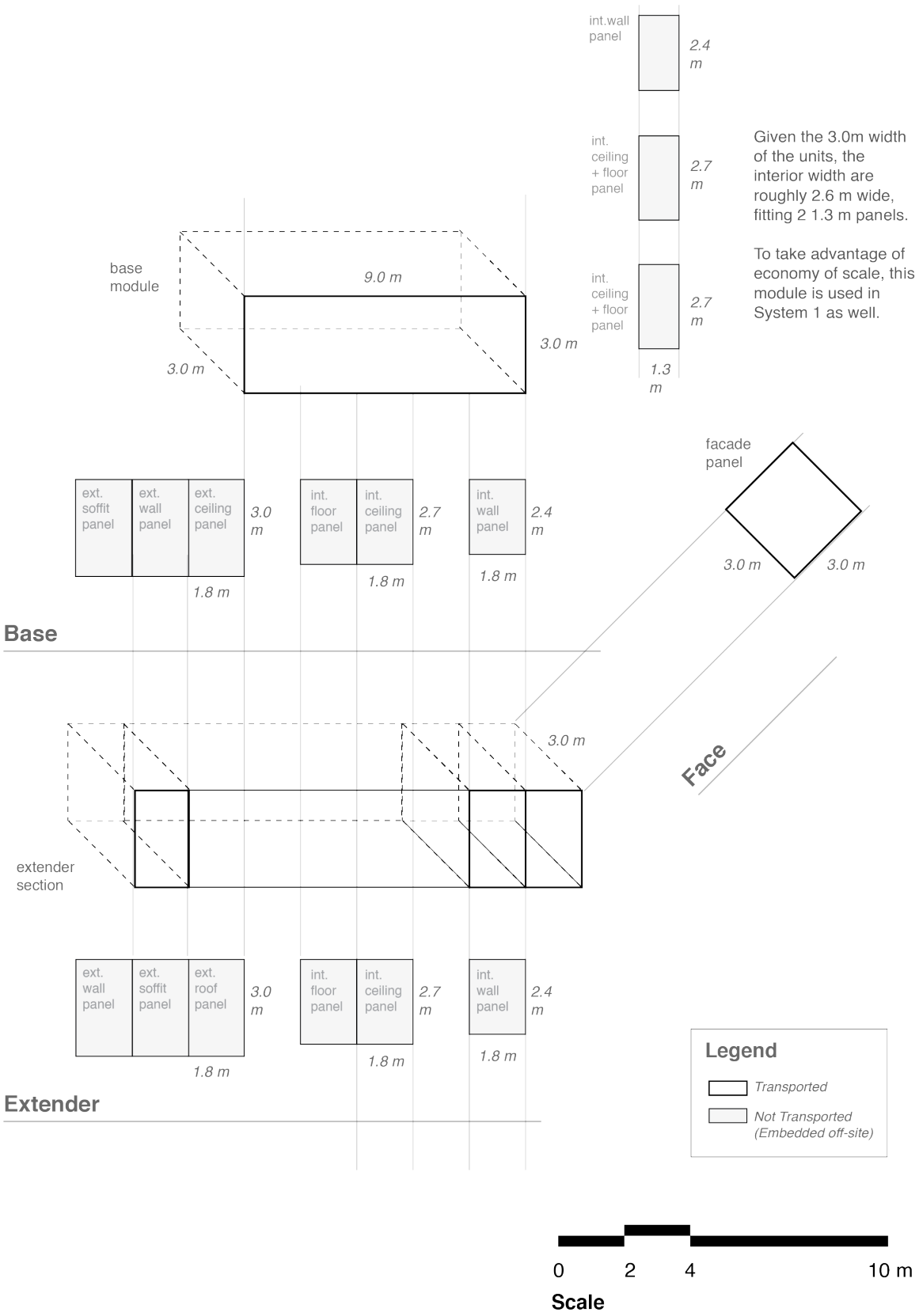
**Fig. [145]** *Left*
This diagram shows the maximum volume a truck can transport in British Columbia with and without an oversize permit. Oversize permit adds to the cost.

**Fig. [146]** *Right*

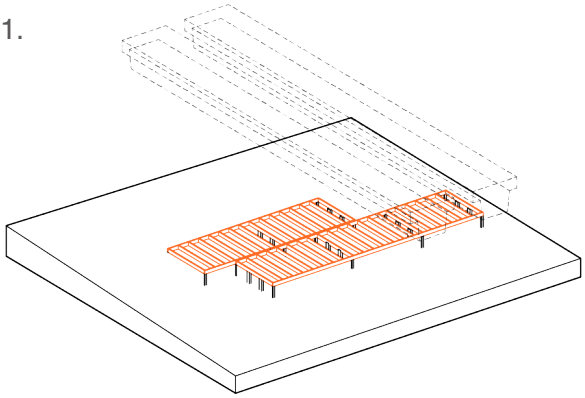
This diagram shows the different panels and volume/area of the Base-Extender-Face components and how they relate to one another that determine their sizing.




## Truckbed Size

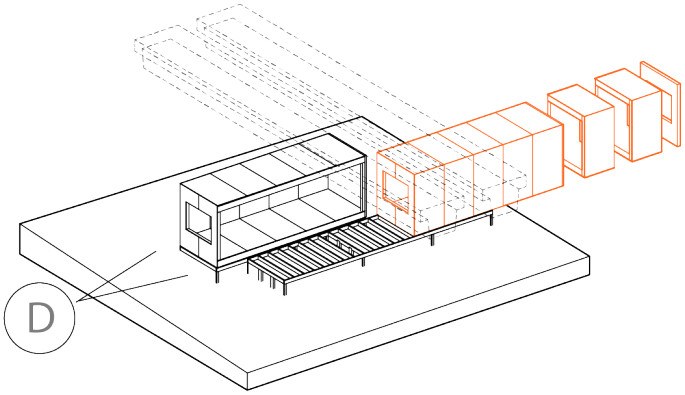

int.wall panel
2.4 m
int. ceiling + floor panel
2.7 m
int. ceiling + floor panel
2.7 m
1.3 m
Given the 3.0m width of the units, the interior width are roughly 2.6 m wide, fitting 2 1.3 m panels.
To take advantage of economy of scale, this module is used in System 1 as well.
base module
9.0 m
3.0 m
3.0 m
facade panel
3.0 m
3.0 m
ext. soffit panel
ext. wall panel
ext. ceiling panel
3.0 m
1.8 m
int. floor panel
int. ceiling panel
2.7 m
1.8 m
int. wall panel
2.4 m
1.8 m
Base
3.0 m
Face
extender section
ext. wall panel
ext. soffit panel
ext. roof panel
3.0 m
1.8 m
int. floor panel
int. ceiling panel
2.7 m
1.8 m
int. wall panel
2.4 m
1.8 m
Extender
Legend
Transported
Not Transported (Embedded off-site)
0
2
4
10 m
Scale

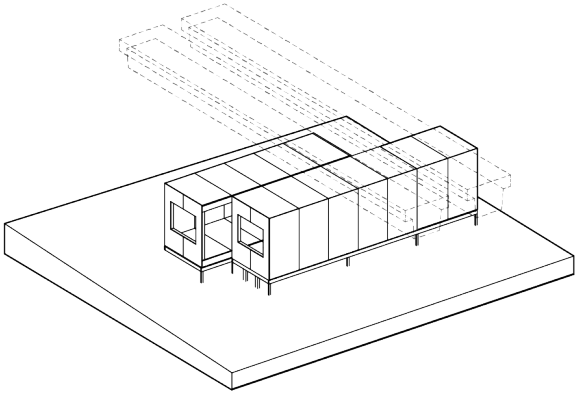
1.



1. Pier foundation are installed with wood frame perimeter

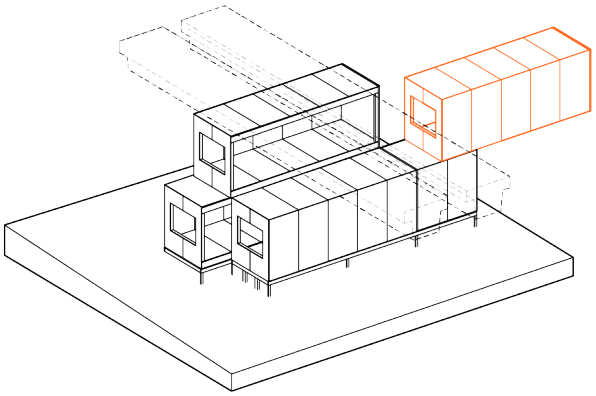
2. Sections are forklifted into place along with their extended section pieces and facade face.



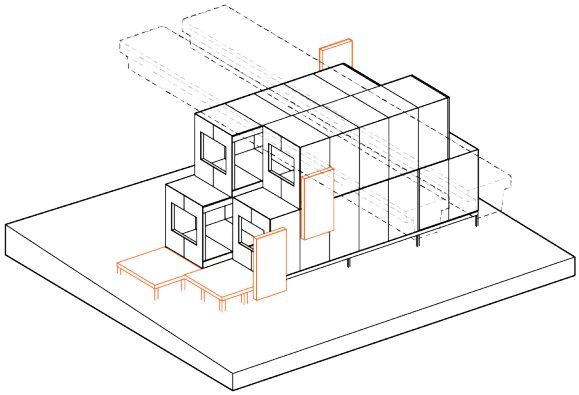
Pier foundation are installed with wood frame perimeter

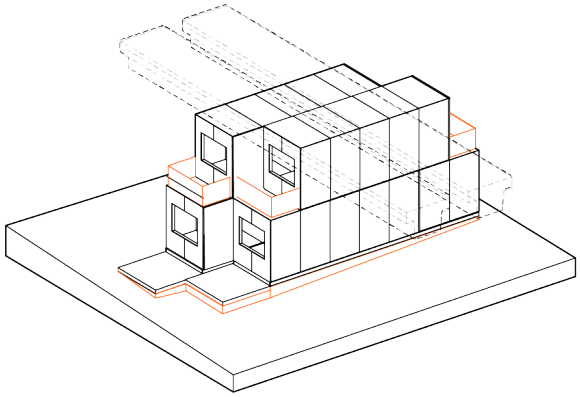
**Fig. [147]** The following series of diagrams explain the on-site procedures to build the Base-Extender-Face system



Pier foundation are installed with wood frame perimeter

Panels are installed to fill in the gaps between the units.





Fibrecement panel skirt wraps around the perimeter

Railings are installed for balcony and patio areas

D

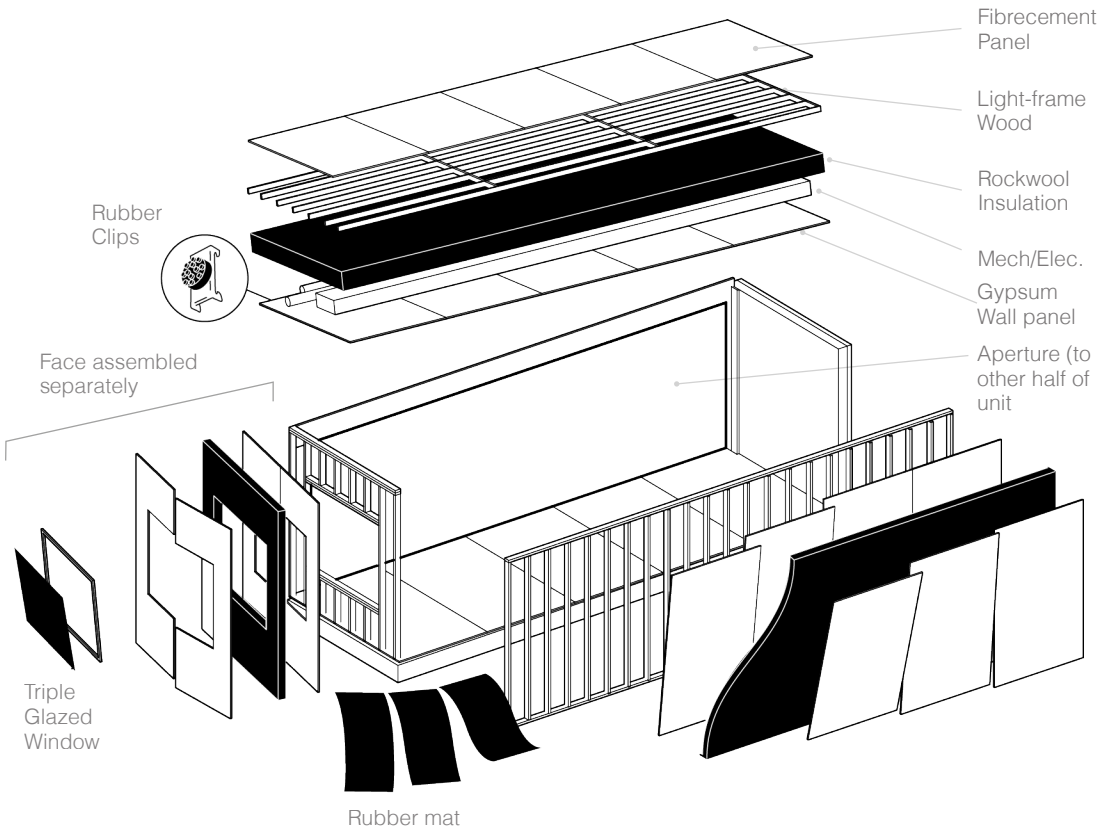


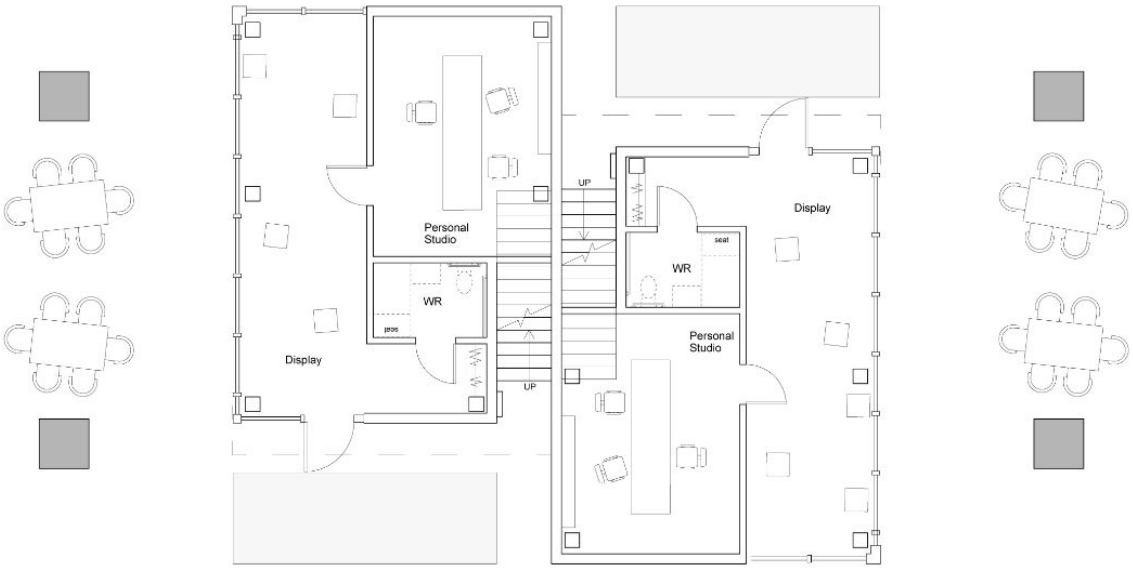

**Fig. [148]** The following diagram explain the on-site procedures to build the Base and Face components. The Face has the option to be attached on or off-site. This diagram omits standard envelope layers (e.g., sheathing, air/vapor barriers) to focus on interior assemblies related to acoustic performance (shaded in black) in transit-adjacent conditions.

# Base I Example Bases (Floor 1 - Work)




0 2 5 m

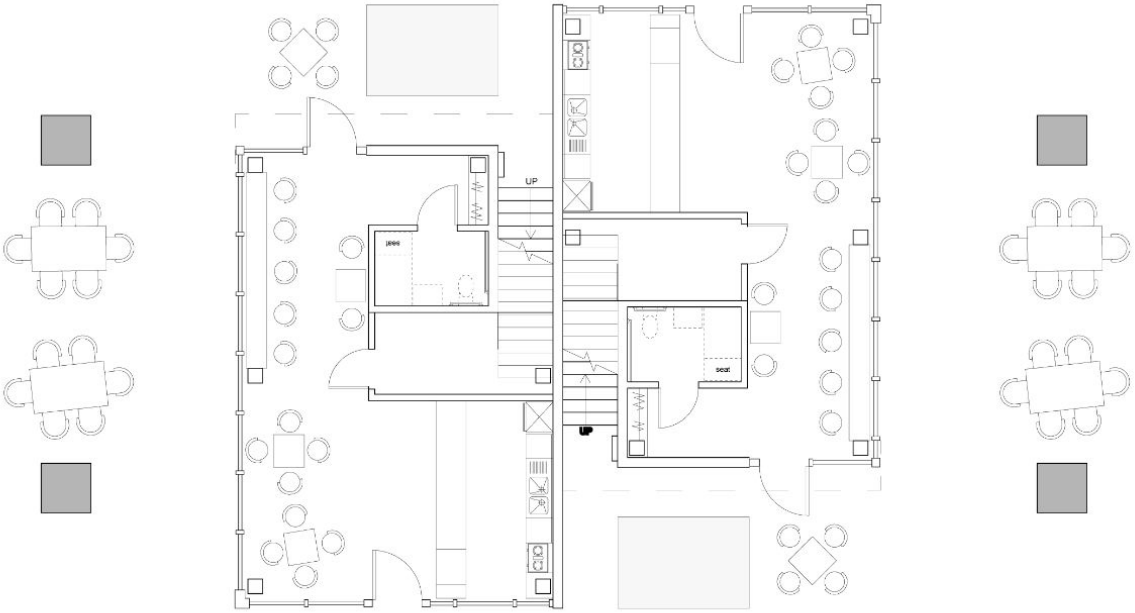
Art Studio




0 2 5 m

Office

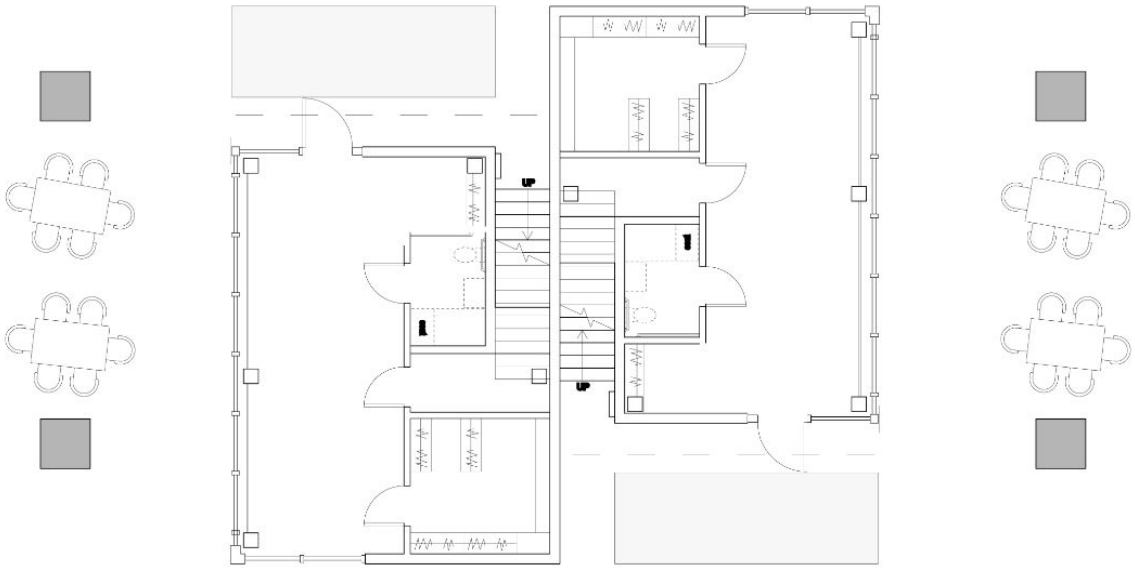
# Base I Example Bases (Floor 1 - Work)







Cafe

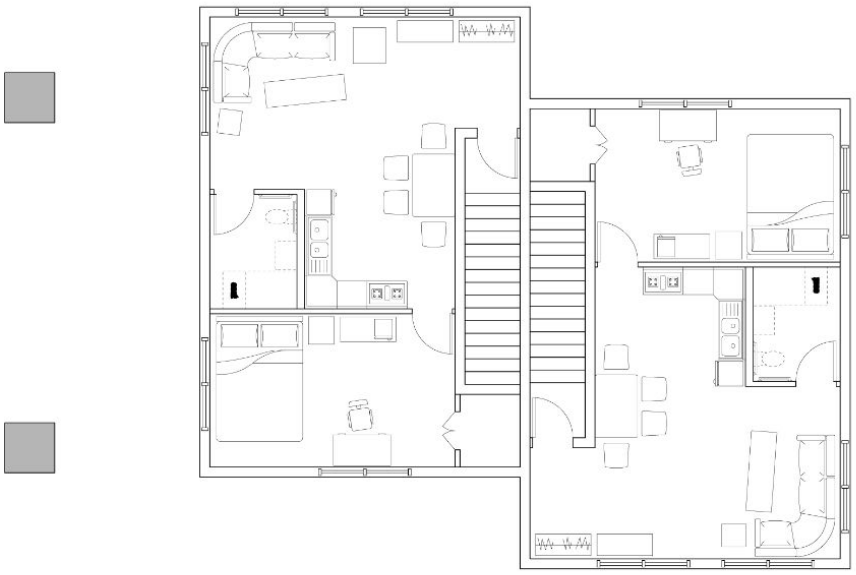






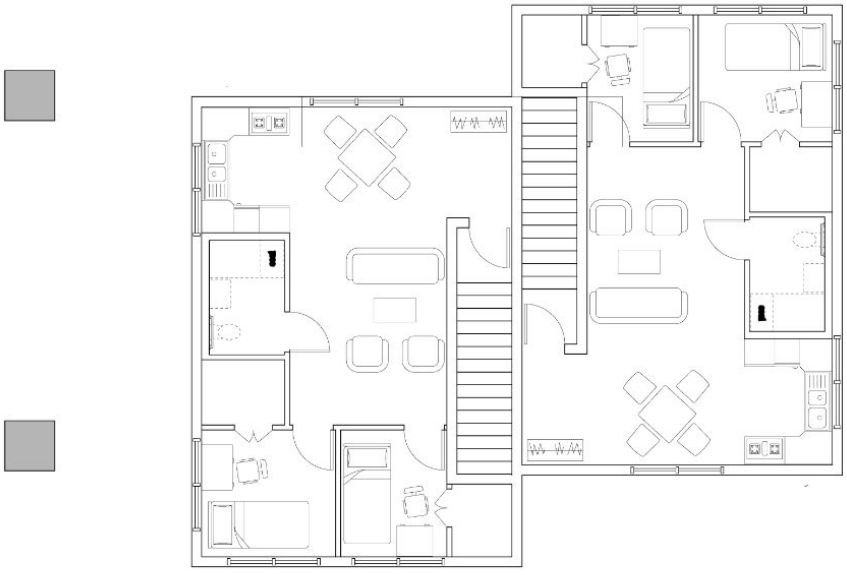
Dance Studio

# Base I Example Bases (Floor 2 - Live)



Couple Unit

0 2 5 m



Two Bedroom Unit

0 2 5 m

**[Fig. 149,150,151]** *Previous Three Pages*

The live-work template allows for “work” program on the first floor while having “live” program on the second floor. The first four floor plans show four sample options of work programming including an art studio, office, cafe and dance studio options. The grey boxes represent the SkyTrain columns that are spaced apart 20 metres in this example. Adjacent to the units are tables and hairs that allow for communal activity to happen in between these spaces. The last two floor plans show two samples of live programming, one for couples and another for two bedroom units.

These are meant as “Base” floorplans, meaning that the floorplans themselves can extend telescopically for more floor area given the site conditions allow for it.

## 4.5 Sample Site: Royal Oak Station

### System 3 [Base-Extender-Face]

The following section looks at applying the Live-Work system to an area near Royal Oak Station as a sample site. It aligns with the Royal Oak Community Plan's[39] goals of supporting local economy and providing diverse housing options. By introducing Live-Work units, the project encourages small businesses while offering affordable housing within a transit-accessible location that can reduce long commutes.

Strategically positioned along BC Parkway and near Royal Oak Avenue, the Live-Work system also supports the area's goal of enhancing pedestrian activity through introducing ground floor businesses and making efficient use of land near transit corridors. The activation of ground-level uses help reinforce the street as a prominent character street. Adding Live-Work units around the station to create a communal area.

39 City of Burnaby. (n.d.). Royal Oak Community Plan. [Draft]. Retrieved February 28, 2025, from https://burnaby.widen.net/s/wq67mhsps7/edmonds-royal-oak-and-cascade-heights-draft-community-plans-and-phase-3-engagement---attachment-2-2024-10-17

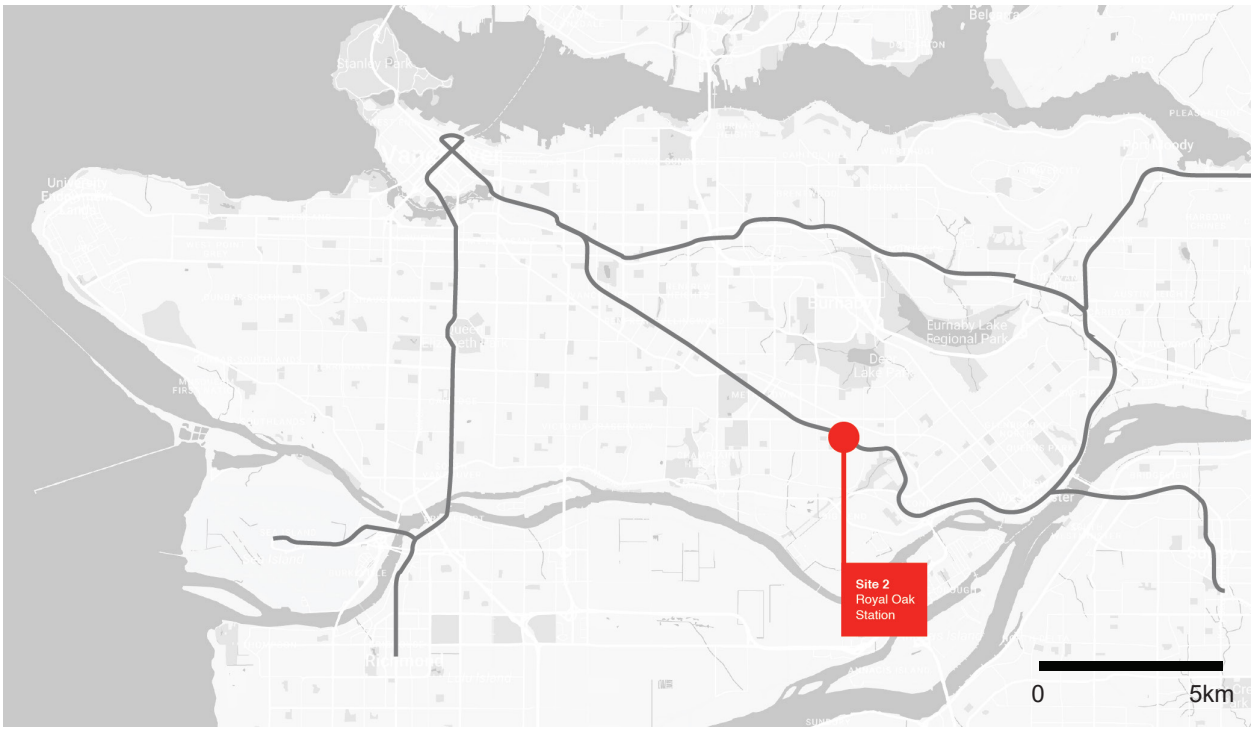



**Fig. [152]** Location of Site 2 in context of Greater Vancouver

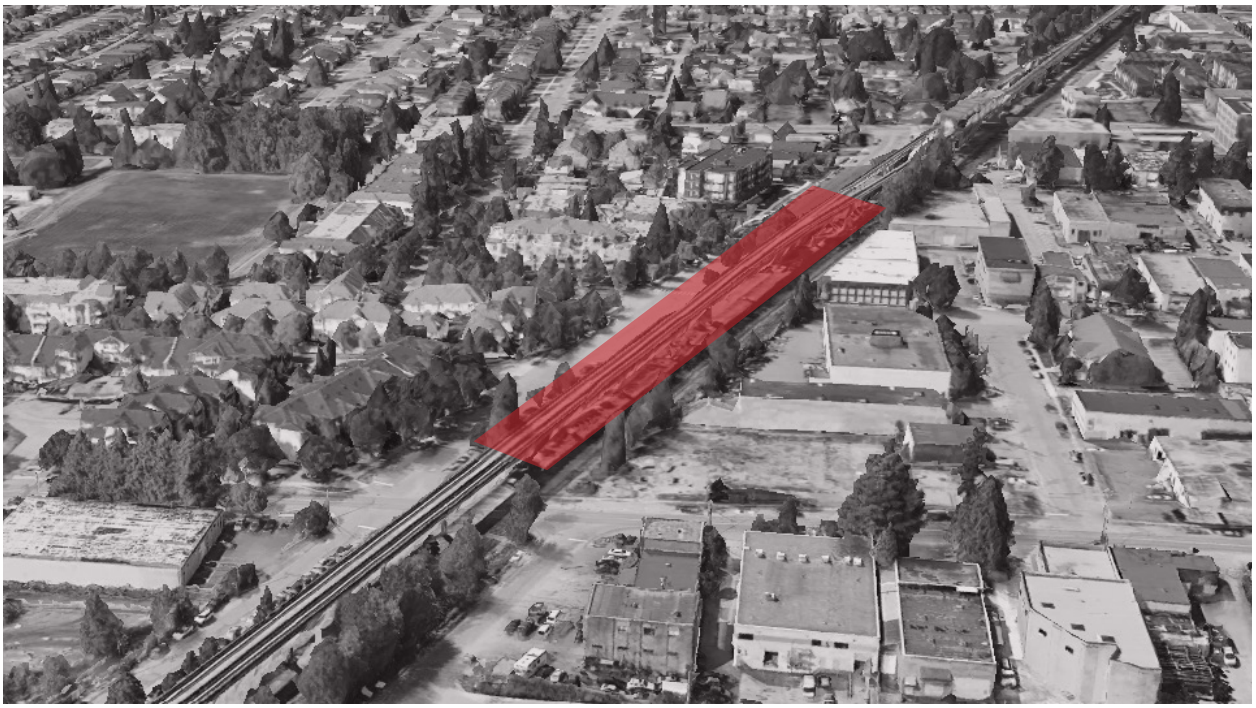
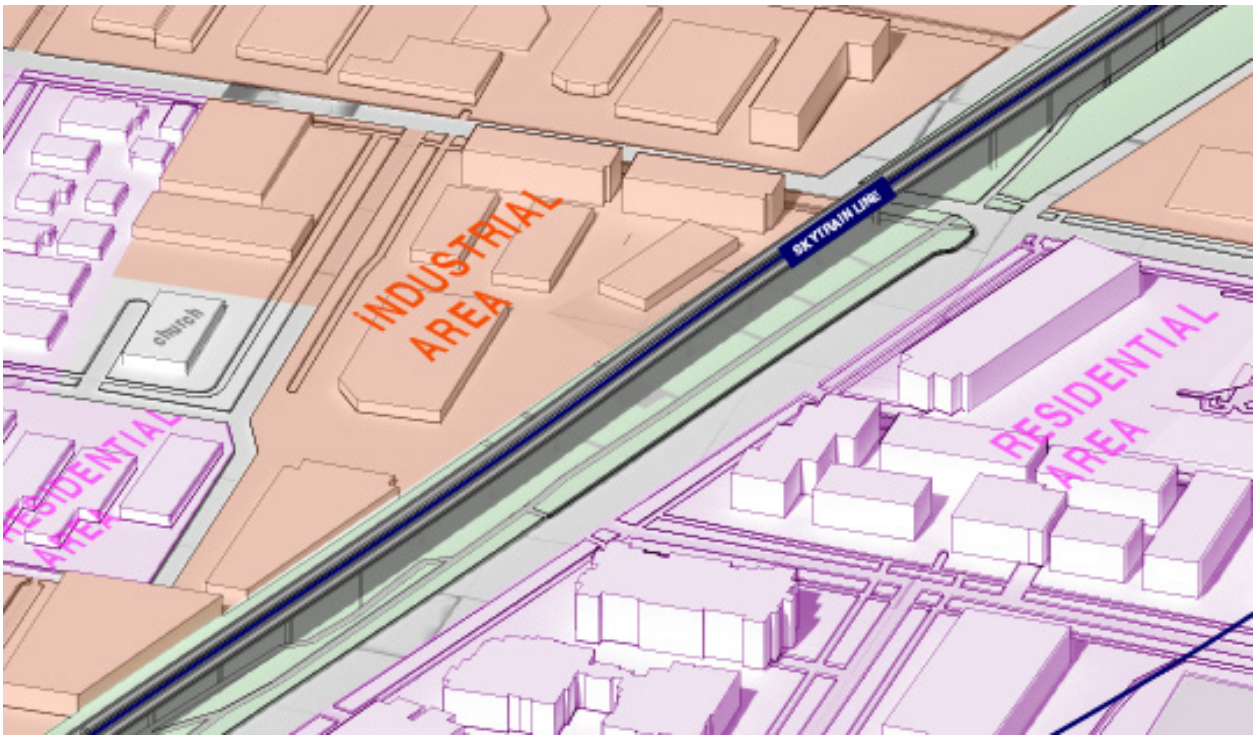
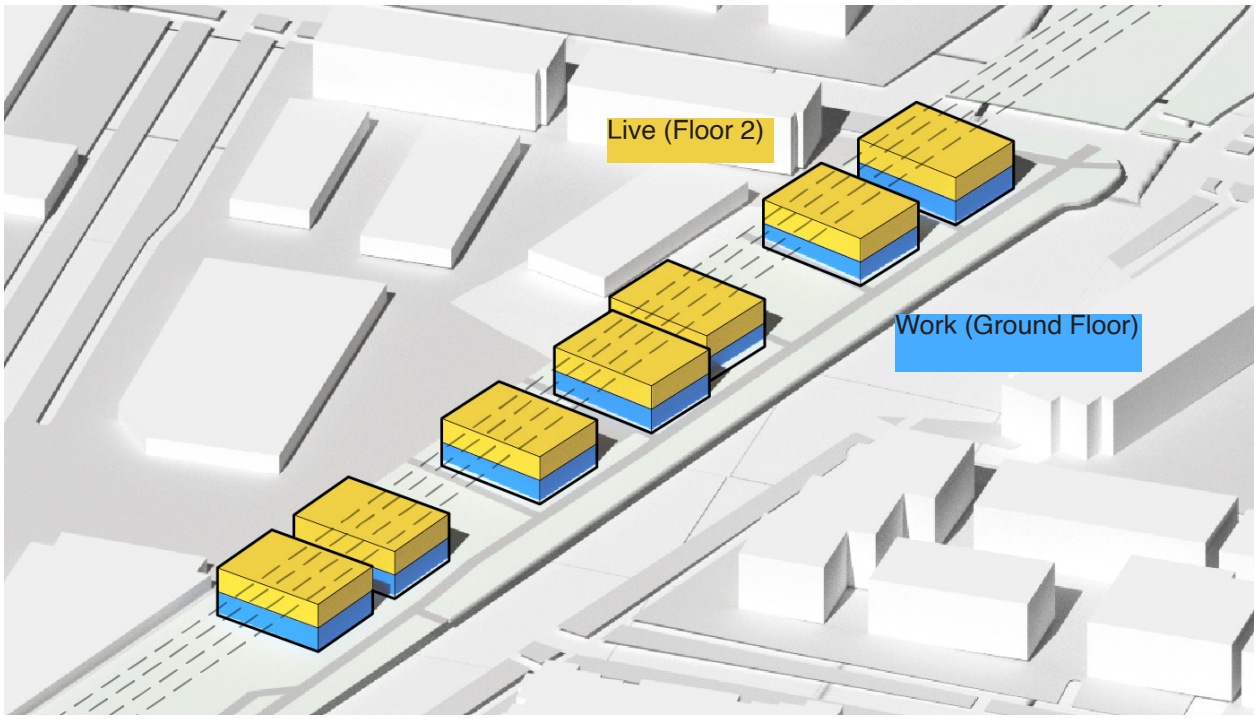


**Fig. [153]** Site 2 Extents in Axometric View


INDUSTRIAL AREA
SKYTRAIN LINE
RESIDENTIAL AREA


Live (Floor 2)
Work (Ground Floor)

# Urban Study

**[Fig. 154] Site Analysis** *Above*

The site for this implementation is a block away, roughly half a kilometer from Royal Oak station, it's a noticeably quieter area than Metrotown station and is surrounded by low-rise residential and industrial buildings.

**[Fig. 155] Massing** *Below*

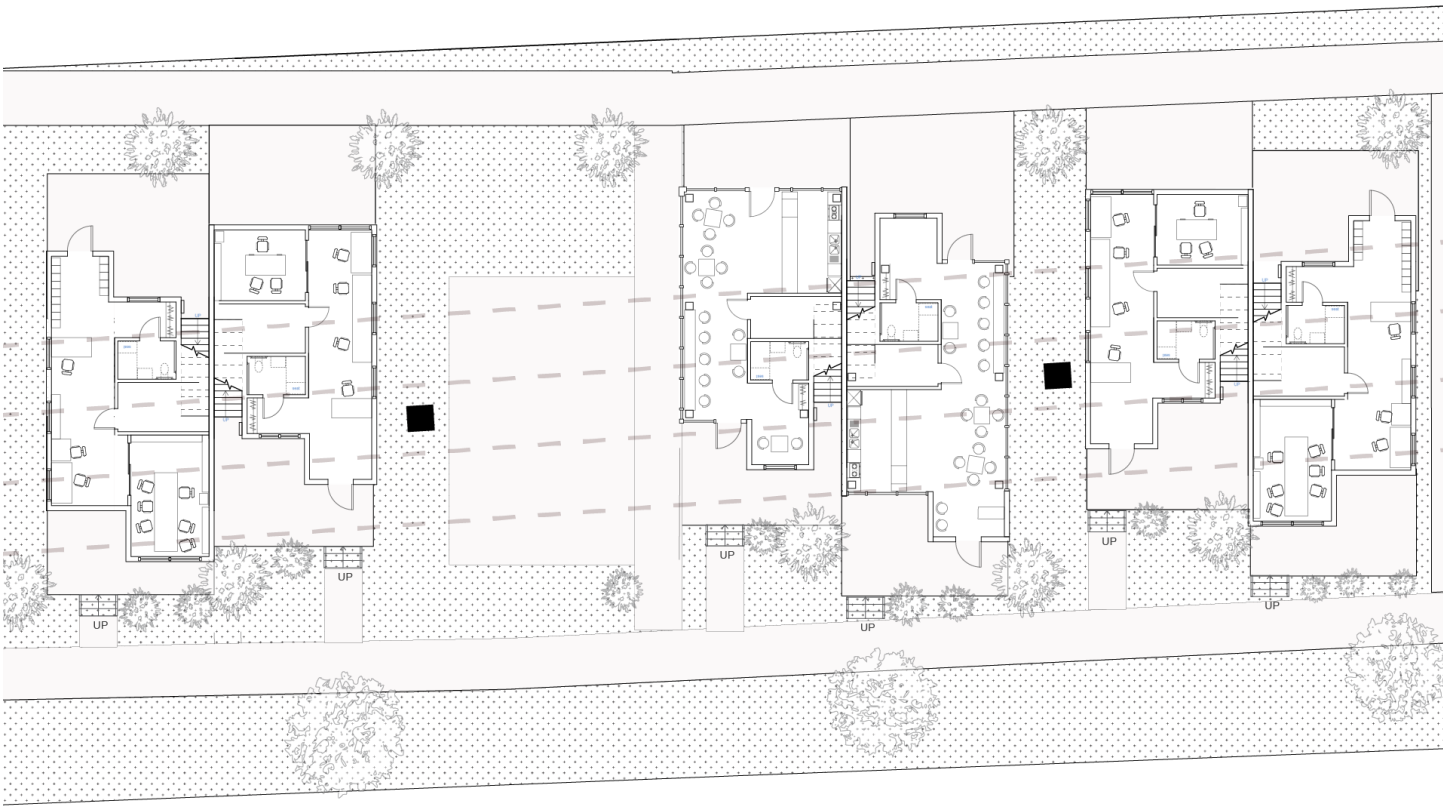
Given the huge residential area and lack of shops or community spaces within the surrounding block - it would make sense to incorporate more stores and shops as a place to gather or a place of interest that would activate the ground floor, giving a sense of community and bringing back the concept of a neighbourhood or village to this area. These will be serviced by the residents that live on the second floor of their respective buildings. Between the units would be opened areas or other communal programs that is a safe space for residents to gather.

# Site Plan

**[Fig. 156]**
The site plan shows how typical live-work units fit within the Royal Oak site. Located north and south of the site are residential areas. The proposed small shops (some work spaces in the live-work configuration is dedicated to shops) will serve the residential zones



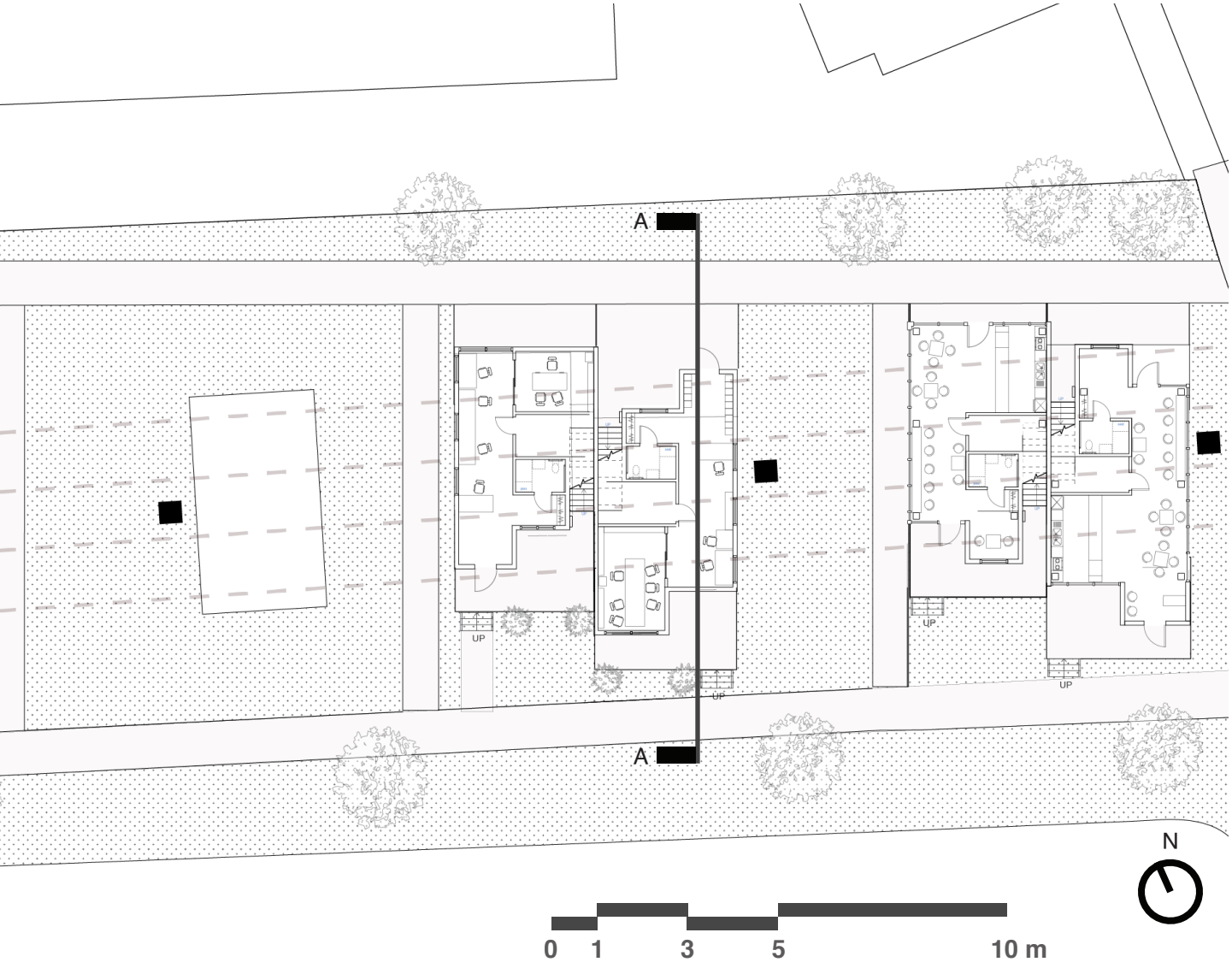

Residential
FRAGMENT C
0
5
15 m
N

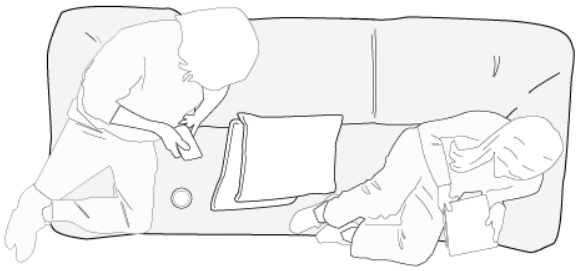



# Fragment C

**Fig. [157]**

The Live-work units have a ground floor that is more commercial; can be small shops, cafes or workshops. There are large green spaces and paved areas for a variety of community events


A
A
UP
UP
UP
N
0 1 3 5 10 m



**[9:47 pm]**

**Fig. [159]**
While there are less communal areas, the larger spaces allow for gather in the units

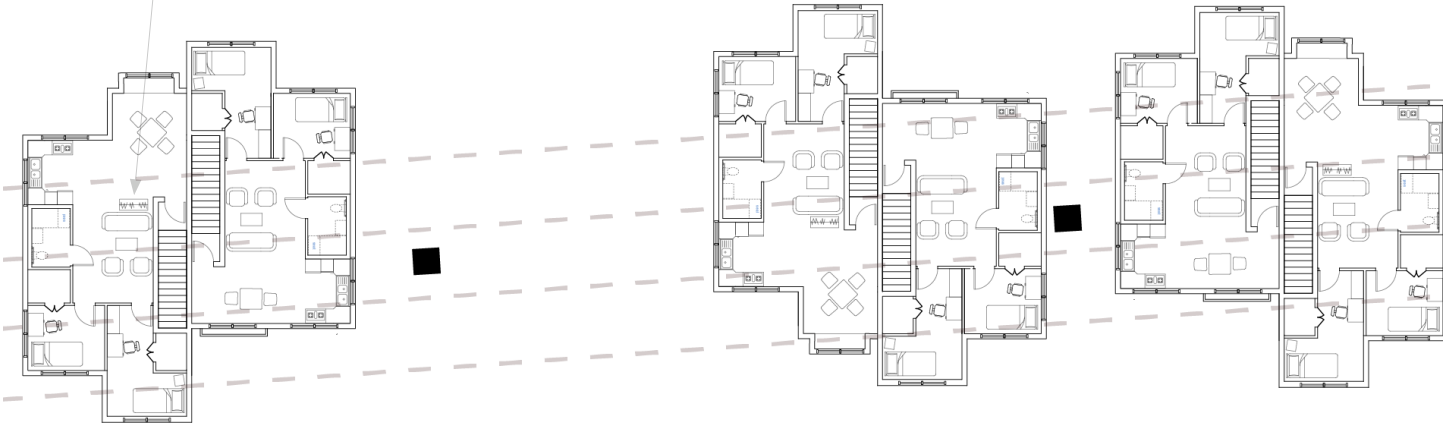
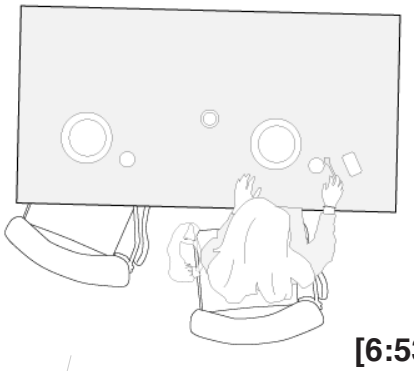
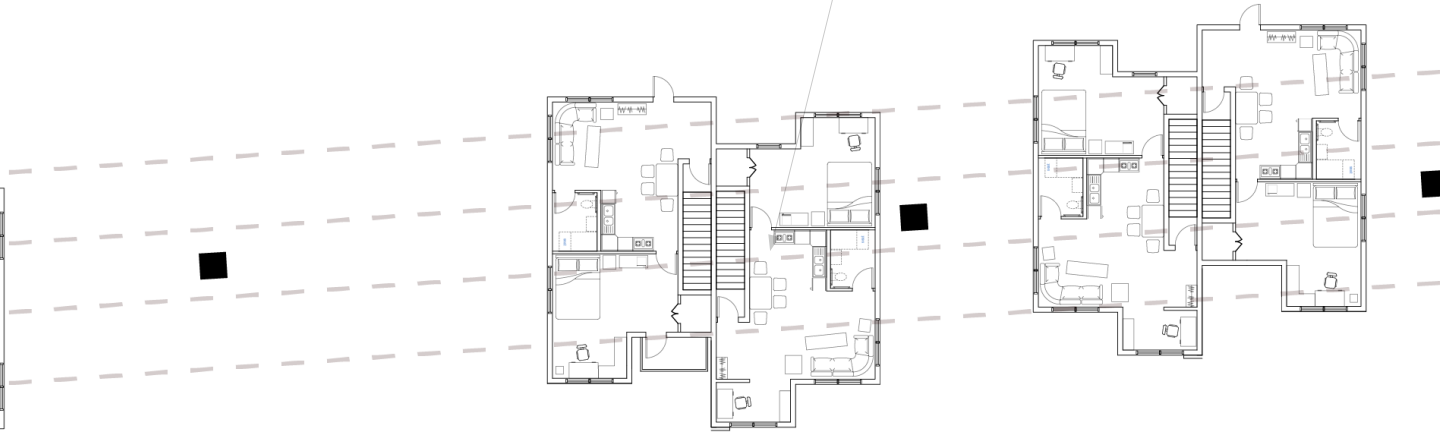


**Fig. [158]**
Second Floor has plans for residential housing, that include 2 bedroom and 1 bedroom (couples) options.

**Fig. [160]**
The live-work units are comparatively larger than the pods and allow for more individual spaces, having their own kitchen/dining areas, etc.



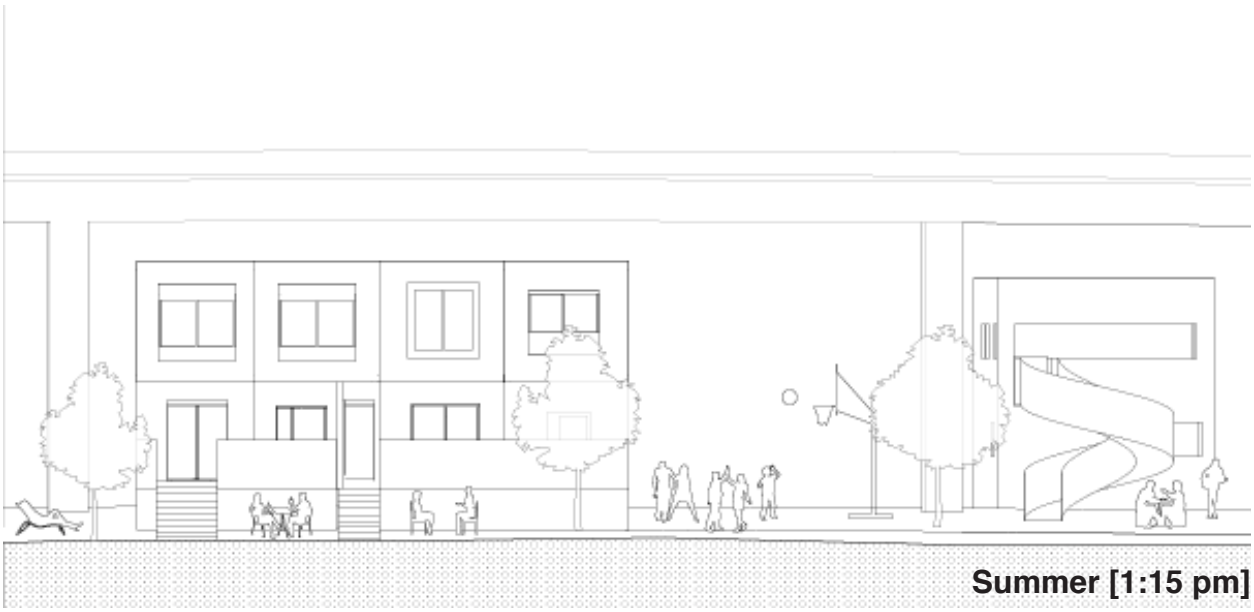
**[6:53 pm]**








# Flexible In-Between Spaces



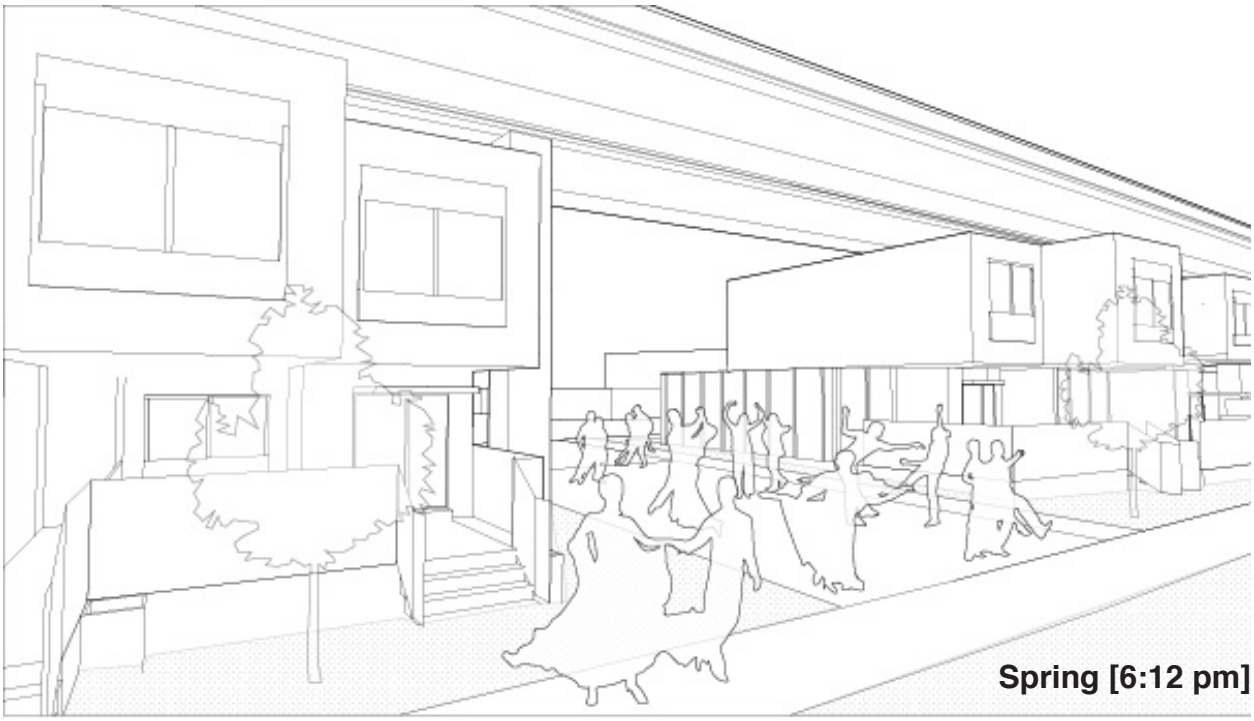




**Fig. [161]** *Above* Afternoon actiities happen including chess in the frontyard, basketball and outdoor dining

**Fig. [162]** *Below* Evening activities such as dance event that occurs once a month takes place in the open areas.

# Live-Work Section A-A

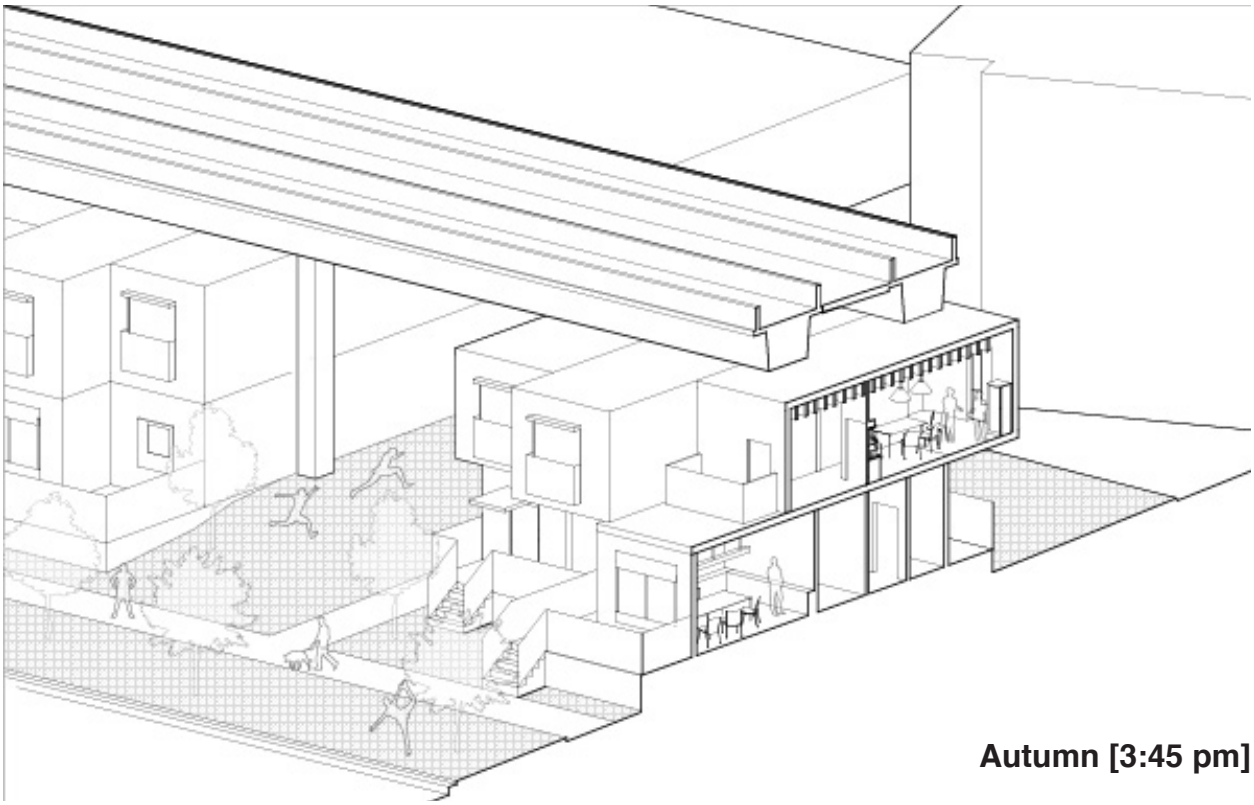



**Fig. [163]**
The section shows the ground floor work area and the upper floor live area. The baffles located in the live area to help with sound mitigation from the transit sound above. Each level has their own balcony/patio space.







# Live-Work

**[Fig. 164, 165, 166]** *Top, Middle, Bottom*
The Live-Work Units at Royal Oak break down their form to avoid feeling overly monolithic, especially under the heavy presence of the SkyTrain above. The box volumes create variation in scale, that keep the units visually distinct while maintaining a modular system. The variety in window and door frames give each unit its own identity that prevents repetition from feeling rigid. The white fiber-cement panel facade option keeps the design clean and durable, with colored accents around openings and stairways that adds vibrance and highlights entry points.



Lansdowne Station



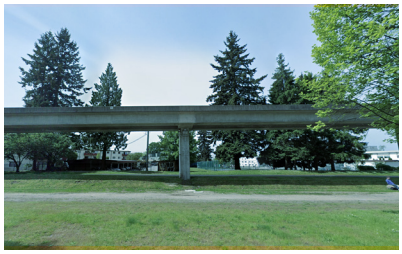
Production Way Station



Joyce Station



Metrotown Station



Metrotown-Royal Oak Station



Joyce-Patterson Station



Nanaimo Station



Gateway Station



Lansdowne Station

**Fig. [167]**
The various underserved spaces beneath the Vancouver Skytrain elevated rails.




**Fig. [168]**
Systems that are suitable for for the various site conditions beneath the Skytrain.

# [5 Conclusion]

This thesis looks at the underutilized spaces beneath Vancouver's SkyTrain and how they can be repurposed into affordable modular housing. With the city's ongoing housing crisis and limited land, these overlooked spaces provide an opportunity to add much-needed housing. By studying built precedents, existing modular projects and underbridge developments, each project gives us lessons to build spaces that are livable, adaptable, and practical.

Through modular construction, housing can be built faster and with minimal site disruption, which is essential for high-traffic urban areas. The flexibility of these units means they can be customized to different site conditions, allowing for varied layouts rather than a rigid, one-size-fits-all approach. At the same time, integrating public and communal spaces ensures that these developments do not become isolated, but instead contribute to the surrounding neighborhoods. Key concerns such as noise, accessibility, and structural limitations have been considered, with strategies outlined to mitigate these challenges.

It is important to note that while this specific project focuses on Vancouver's elevated SkyTrain rails - it's an approach that questions how cities may use their spaces that may be overlooked. This project shows that even within the constraints of existing infrastructure, it is possible to build - rather than viewing them as barriers. Whether these ideas are realized depends on policy, investment, and public support - but it is clear that under-SkyTrain housing could be a real, scalable way to introduce new housing - making better use of the spaces the city already has.

# Bibliography


百瀬伸夫. (2018, February 7). 高架下の新たな商空間からはじまる「沿線まちづくり」!!〜JR中央線「中央ラインモール構想」〜 [New commercial spaces under elevated tracks spark transit-oriented development: JR Chūō Line “Chūō Line Mall Concept”]. 日経メッセ JAPAN SHOP. https://messe.nikkei.co.jp/js/column/cat454/137268.html

アーバンライフ東京編集部. (2019, November 29). 中央線「ラインモール構想」現地レポート ベンチャー魂とローカル人情の融合を見よ [Chūō Line “Line Mall Vision” field report: A fusion of venture spirit and local warmth]. Urban Life Tokyo. https://urbanlife.tokyo/post/24494/

淵脇祐樹. (n.d.). 高架下が街づくりをリードする「中央ラインモール構想」。若者のビジネスチャンス創出や地域交流拠点にも. LIFULL HOME’S PRESS. https://www.homes.co.jp/cont/press/rent/rent_00944

山下PMC. (2017). 中央ラインモールプロジェクト [Chuo Line Mall Project]. CMAJ Digest, 1. https://cmaj.org/templates/cmaj_new/member/pdf/2017/digest/01_digest.pdf

Allen, E. (2005). How Buildings Work: The Natural Order of Architecture (3rd ed., pp. 138-148). Oxford University Press USA - OSO.

ArchDaily. (2014, April 18). LT Josai Shared House / Naruse Inokuma Architects. https://www.archdaily.com/497357/lt-josai-naruse-inokuma-architects

ArchDaily. (2023, January 19). POWWOWWOW Commercial Centre / all(zone). https://www.archdaily.com/995133/powwowwow-commercial-centre-all-zone

ArchEyes. (2025, March 8). Habitat 67 by Safdie Architects: A visionary experiment in modular housing. https://archeyes.com/habitat-67-by-safdie-architects-a-visionary-experiment-in-modular-housing/

Architizer. (n.d.). 17.6-square-meter apartment.  Retrieved August 27, 2024 https://architizer.com/projects/176-square-meter-apartment/

ASPECT Studios. (n.d.). Caulfield to Dandenong Railway & Linear Park. https://www.aspect-studios.com/projects/caulfield-to-dandenong-railway-linear-park

BC Housing, Manufactured Housing Association of BC, & Real Estate Institute of BC. (2014). Modular and prefabricated housing: Literature scan of ideas, innovations, and considerations to improve affordability, efficiency, and quality. BC Housing.

Block, I. (2021, July 16). Nakagin Capsule Tower to be dismantled and turned into rental accommodation and exhibits. Dezeen. Retrieved February 27, 2025, from https://www.dezeen.com/2021/07/16/nakagin-capsule-tower-dismantled-news/

British Columbia Government. (2024, May 29). Provincial policy manual: Transit-oriented areas (Version 3.0). https://www2.gov.bc.ca/assets/gov/housing-and-tenancy/tools-for-government/local-governments-and-housing/toa_provincial_policy_manual.pdf

British Columbia Ministry of Housing. (2024, September). Standardized housing designs catalogue. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/bc_std_des_catalogue_v1.pdf

Buildner. (n.d.). Under Bridge architecture competition: Affordable housing series 17th edition. https://architecturecompetitions.com/underbridge/brief

Canadian Architect. (2021, November 29). Durham Modular Supportive Housing. https://www.canadianarchitect.com/durham-modular-supportive-housing/

CCA (Canadian Centre for Architecture). (2016, February). 1964: Fun Palace. https://www.cca.qc.ca/en/articles/issues/2/what-the-future-looked-like/32737/1964-fun-palace

Chiu, S. T.-L. (2012, April 9). An analysis on : the potential of prefabricated construction industry [G]. doi:http://dx.doi.org/10.14288/1.0103132

Cilento, K. (2009, June 9). The New York High Line officially open. ArchDaily. https://www.archdaily.com/24362/the-new-york-high-line-officially-open

City of Burnaby. (n.d.). BC Parkway Enhancement Project. https://burnaby.ca/our-city/projects/bc-parkway-enhancement-project

City of Burnaby. (n.d.). Royal Oak Community Plan. [Draft]. Retrieved February 28, 2025, from https://burnaby.widen.net/s/wq67mhsps7/edmonds-royal-oak-and-cascade-heights-draft-community-plans-and-phase-3-engagement---attachment-2-2024-10-17

City of Vancouver. (2025, April 1). Micro dwelling policies and guidelines. https://guidelines.vancouver.ca/guidelines-micro-dwelling.pdf

CityNews. (2016, December 2). Evergreen extension opening today. https://vancouver.citynews.ca/2016/12/02/evergreen-extension-opening-today/

Consolidated Regulations of British Columbia. (2025). Commercial Transport Regulations, B.C. Reg. 30/78. Consolidated Regulations of British Columbia. https://www.bclaws.gov.bc.ca/civix/document/id/crbc/crbc/30_78

Diller Scofidio + Renfro. (n.d.). The High Line. https://dsrny.com/project/the-high-line

Dragicevic, N., Riaz, K. (2024) Seizing the Modular Construction Opportunity. Canadian Standards Association, Toronto, ON.

Equipment Management Services. (2019, May 7). The pros and cons of building a shipping container house. EMS. https://ems-llc.com/the-pros-and-cons-of-building-a-shipping-container-house/

EDGE Design Institute Ltd. (2016). Seven Victory Avenue Special Unit. https://www.edgedesign.com.hk/2017-seven-victory-avenue

Fernández Solla, I. (2012, June 30). Acoustic properties of glass: Not so simple. Façades Confidential. https://facadesconfidential.blogspot.com/2012/06/acoustic-properties-of-glass-not-so.html

Flanigan, T. (n.d.). The Ponte Vecchio ("Old Bridge") in Florence. Khan Academy. https://www.khanacademy.org/humanities/renaissance-reformation/late-gothic-italy/florence-late-gothic/a/the-ponte-vecchio-old-bridge-in-florence

Gardner, W. O. (2020). The metabolist imagination: Visions of the city in postwar Japanese architecture and science fiction. University of Minnesota Press.

Good Design Australia. (2019). Caulfield to Dandenong Level Crossing Removal Project. https://good-design.org/projects/caulfield-to-dandenong-level-crossing-removal-project/

Ghida, D. B. (2024). Revitalizing urban spaces: Ten key lessons from the "Viaduc des arts" adaptive reuse and placemaking. Frontiers of Architectural Research, 13(5), 1095-1112.

Henderson, E. (2020, February). Modular construction for energy efficient, affordable housing in Canada (Technical Bulletin No. 013). RDH. https://www.rdh.com/wp-content/uploads/2020/03/TB-13-Modular-Construction-for-Energy-Efficient-Affordable-Housing-2020-03-05.pdf

Homelessness Services Association of BC. (2023, October). 2023 homeless count in Greater Vancouver: Final data report. Reaching Home's Community Entity for Greater Vancouver. https://hsa-bc.ca/_Library/2023_HC/2023_Homeless_Count_for_Greater_Vancouver.pdf

JR Chuo Line Community Design Co., Ltd. (n.d.). Plan. Chuo Line House. https://chuolinehouse.com/plan/

Leckie Studio Architecture + Design. (n.d.). Addapt Home / TripTych [Residential project]. https:/leckiestudio.com/portfolio/triptych

Mauboules, Celine, and Dustin Lupick. "2023 Homeless Count, Vancouver." 2023 Homeless Count: Vancouver, October 31, 2023. https://council.vancouver.ca/20231031/documents/regu20231031p1_2023_Homeless_Count.pdf.

Maki, F. (1964). Investigations in Collective Form. Washington University in St. Louis. https://doi.org/10.7936/3R0Q-4715

McKinsey & Company. (2019, September). Voices on infrastructure: Scaling modular construction. https://www.mckinsey.com/~/media/mckinsey/business%20functions/operations/our%20insights/voices%20on%20infrastructure%20scaling%20modular%20construction/voices-on-infrastructure_scaling-modular-construction.pdf

Merin, G. (n.d.). Architecture Classics: Habitat 67 / Safdie Architects. ArchDaily. Retrieved February 27, 2025, from https://www.archdaily.com/404803/ad-classics-habitat-67-moshe-safdie

Metro Vancouver. (2022, December). Metro Vancouver housing data book. Metro Vancouver. https://metrovancouver.org/services/regional-planning/Documents/metro-vancouver-housing-data-book-2022.pdf

Montgomery Sisam Architects. (2024). Durham Modular Transitional Housing. Retrieved February 27, 2025, from https://www.montgomerysisam.com/project/durham-modular-supportive-housing/

Naturally:Wood. (2024). MONAD. https://www.naturallywood.com/projects/monad/

Naturally:Wood. (n.d.). Brock Commons Tallwood House. Retrieved February 27, 2025, from https://www.naturallywood.com/projects/brock-commons-tallwood-house/

Pauly, B., Cross, G., & Weiss, D. (2016). No Vacancy : Affordability & Homelessness in Vancouver [R]. doi:http://dx.doi.org/10.14288/1.0416187

Russwurm, L. (2016, March 10). SkyTrain. In The Canadian Encyclopedia. Updated by N. Baker, December 16, 2019. https://www.thecanadianencyclopedia.ca/en/article/SkyTrain

Recollective Consulting Inc. (2023). MONAD. https://recollective.ca/project/monad/

Shinada, K. & Tky-Kgy-Daigaku (Eds.). (2002). Pet architecture guide book. World Photo Pr.

Shroff, D. N., & Joshi, A. T. (2022). Pre-fabricated architecture for urban adaptability: Factory built constructions – sustainable & flexible urban solutions (Master's thesis, Politecnico di Torino).

Shulman, L., & Honey-Rosés, J. (2024) How small is too small? Assessing the well-being impacts of nano suites on university students. People, Place and Policy, 18(1), pp. 26-47. https://doi.org/10.3351/ppp.2024.4785923692

Singer, C. R. (2025, June 19). Canada's cities rank highly in Global Liveability Index despite Calgary drop. Immigration.ca. https://immigration.ca/canadas-cities-rank-highly-in-global-liveability-index-despite-calgary-drop/

Smith, R. E. (2010). Prefab architecture: A guide to modular design and construction. John Wiley & Sons

SLR Consulting. (2018, November 28). SkyTrain noise study: Noise report and maps. South Coast British Columbia Transportation Authority (TransLink). https://www.TransLink.ca/-/media/TransLink/documents/plans-and-projects/SkyTrain-noise-study/SkyTrain-noise-report-20181128.pdf

The Canadian Press. (2023, October 11). Vancouver mayor pushes for Burnaby-style development around several SkyTrain stations in the city. CBC News. https://www.cbc.ca/news/canada/british-columbia/vancouver-housing-SkyTrain-stations-sim-1.6993366

TransLink. (n.d.). Transit-oriented communities. https://www.TransLink.ca/plans-and-projects/strategies-plans-and-guidelines/transit-oriented-communities

TransLink. (n.d.). Ridership. https://www.TransLink.ca/plans-and-projects/data-and-information/accountability-centre/ ridership

TransLink. (n.d.). SkyTrain schedules. Retrieved September 9, 2024, from https://www.TransLink.ca/schedules-and-maps/SkyTrain

TransLink. (2012, July). Transit-oriented communities design guidelines: Creating more livable places around transit in Metro Vancouver (Version 1.0). https://www.TransLink.ca/-/media/TransLink/documents/plans-and-projects/managing-the-transit-network/transit-oriented-communities/transit_oriented_communities_design_guidelines.pdf

TransLink. (2022, December). SkyTrain limits of approach: Safety requirements for work near automated trains and infrastructure. https://www.translink.ca/-/media/translink/documents/business-with-translink/real-estate/skytrain_limits_of_approach.pdf

Whelan, D. (2023, September 1). Bruntwood sells Hatch to STACK. Place North West. https://www.placenorthwest.co.uk/bruntwood-sells-hatch-to-stack/

Wilson, J. (2019, March). Design for modular construction: An introduction for architects. The American Institute of Architects & National Institute of Building Sciences.