BC Non-Profit Housing Association

3-Over-3 Study Feasibility: Summary Report of Case Studies

Prepared by BC Non-Profit Housing Association

Based on studies prepared by:

Fast+Epp

RDH

WSP

GHL Consultants Ltd

Altus Group

Funded by:

British Columbia Office of Mass Timber Implementation

Forestry Innovation Investment

BC Housing

Contents

Executive Summary

BC is in a housing crisis and innovative solutions to increase the stock of affordable housing in the province need to be considered. BC Non-Profit Housing Association (BCNPHA), supported by a team of expert consultants, led this study to explore a unique option for creating more affordable housing units in BC. The objective of the 3-over-3 Mass Timber Residential Infill Construction Feasibility Study, funded by the Province of BC's Office of Mass Timber Implementation, Forestry Innovation Investment Limited, and BC Housing, is to assess whether building design can be used to add three additional storeys to existing three-storey residential buildings, without displacing the tenants or removing the existing structures. The study also examined the feasibility of incorporating mass timber into the building design.

This study involved preparing preliminary feasibility studies using three affordable housing case study sites in the City of Vancouver. These properties were chosen because the City of Vancouver would allow the current zoning to change from three storeys to six storeys. The feasibility studies explore the possible structures, the code implications, and estimated costs. These feasibility studies will be used to determine if any of the proposed structures should be considered for further investigations. The three case study sites are listed below:

Site	Operator	Funding	Year Built	Tenant Group
Building 5	BC Indigenous Housing Society	BC Housing Operating Agreement	1987	Families
Chelsea Manor	New Chelsea Society	Self-funded (expired BC Housing Operating Agreement)	1968	Seniors
Chimo Terrace	BC Housing	Directly Managed by BC Housing	1970	Singles, Couples, and Families

Led by BC Non-Profit Housing Association and guided by an advisory group, a team of consultants developed proposed 3-over-3 concepts and prepared preliminary feasibility studies for each of the case study sites exploring the:

- Architectural feasibility of the proposed concept
- Structural feasibility of the proposed concept
- Code implications of the proposed concept
- Cost estimates compared to redevelopment
- Embodied carbon compared to redevelopment (Chimo Terrace only)

BCNPHA reviewed the three feasibility studies and prepared this summary report, highlighting the key findings across the 3-over-3 feasibility studies. Key findings included:

1. A transfer deck is the best option to support the new structure, compared to building immediately on top of the existing building. Using the transfer deck approach, there are many design variations to consider depending on the site and building specific details of the existing site, such as crawl spaces, whether to connect the two structures or not, types of foundations, etc.
2. Mass timber can facilitate the 3-over-3 concept because of its long span and strength-to-weight ratio. The prefabrication of mass timber also reduces the on-site construction times, thereby reducing disruption for tenants, if they stay on-site during construction, and creating more affordable housing faster.
3. There are various site- and building-specific features that facilitate or hinder the addition of the 3-over-3 concept. Examples include peaked versus flat rooves, window alignment, shape of the existing building, space surrounding the existing building, presence of underground garages/basements, etc.
4. The new building would be considered an addition to the existing building, rather than a separate building. This will trigger life-safety and seismic upgrades to the existing building, which will add significant cost to the project and disruption for tenants. While the supports for the new structure could provide seismic upgrades to the existing building as well, the estimated costs of fire safety upgrades to the existing building are approximately $5.20 per square foot. There may be room for negotiation on the level of upgrades required for the existing building, but it will be important to upgrade the lower building to ensure fairness for the existing tenants.

5. While the design team believes the new structures can be added and upgrades to the existing building completed with tenants remaining on-site for the most part, the code consultant does not recommend existing tenants remain on-site during the construction of the new structure. If tenants do stay on-site, the code consultant recommends construction considerations to ensure the construction process is safe for tenants remaining on-site.
6. Adding three storeys over an existing three-storey building using mass timber construction might be more expensive compared to redevelopment, but it is potentially within a range of +9%-23%.

Estimated Case Study Site Costs Compared with Average Redevelopment Costs

	Building 5	Chelsea Manor	Chimo Terrace	Case Study Average	Average Redevelopment
Total Construction	$525/sqft	$572/sqft	$590/sqft	$562/sqft	$480-535/sqft[1]

Building 5

Chelsea Manor

Chimo Terrace

1. 4-6 storey building, in Vancouver, with 1 level of below grade parking, and includes $50/square foot for demolition costs, but not temporary tenant relocation costs nor hazmat removal or abatement.

7. The 3-over-3 concepts presents non-tangible benefits for tenants and operators compared to a redevelopment of the sites. For example, the 3-over-3 concept may allow tenants to stay in place rather than having to temporarily relocate (or potentially relocate for a shorter amount of time) which reduces disruptions for tenants and facilitates operations.[2]

8. The 3-over-3 concept offers environmental benefits compared to redevelopment. A comparison of the two scenarios showed the 3-over-3 concept reduced embodied carbon compared to a redevelopment (comparison building is a six-storey building using stick frame and mass timber construction).

9. The 3-over-3 concept creates benefits for the whole community. This concept, particularly with its use of mass timber construction, offers a quicker way to add affordable housing to the community and helps create local jobs by supporting BC's mass timber industry, including jobs for Indigenous people.

10. The design team and advisory group generated and discussed ideas for how the 3-over-3 concept could potentially be applied to create more affordable housing in BC communities, such as affordable housing over heritage buildings, transforming the lower floors into a hotel to generate income for the housing provider, building over acquired private rental buildings, or including additional storeys. It is important to note that the feasibility of these ideas was not assessed in this phase of the study.

Despite the limitations associated with this being a preliminary analysis of the 3-over-3 concept, the report concludes:

1. The 3-over-3 concept is structurally feasible, with a range of options. Some building and site features enable or inhibit the 3-over-3 concept, but the structural concepts could be applied to other buildings or sites even if not fully feasible for one of the case study sites.

2. Mass timber facilitates the 3-over-3 concept due to its long span and strength-to-weight ratio. With mass timber being prefabricated, this material facilitates the concept by reducing disruption for tenants because of less on-site construction. Prefabricated materials also reduce construction time, so tenants can access affordable housing sooner.

2. The next phase of this study will include more detailed safety plans to confirm it is feasible for residents to remain on-site during construction.

3. The 3-over-3 concept is estimated to potentially eliminate or reduce the amount of time the tenants need to be temporarily relocated during the construction period. Temporary tenant relocation for redevelopment projects is three-to-five years while temporary tenant relocation for 3-over-3 is anticipated to range from a few hours to a few days. Further analysis will be conducted in the next phase of this research to determine safety plans should tenants remain in place during construction.

4. The 3-over-3 concept could have safety concerns and high levels of disruption for tenants if they stay on site during construction.

5. The requirement to incorporate seismic, accessibility, and life-safety upgrades to the existing building adds significant cost and complexity to the feasibility of this concept, but some of these costs will be accounted for in the costs of the new structure, as the new structure would provide seismic support and improved accessibility features for the existing building.

6. It is worth taking this research to the next phase by doing more in-depth analysis that is site specific and to better determine if the benefits of the 3-over-3 concept compared to redevelopment outweigh the challenges.

   - Alternative construction options such as the addition of the three storeys to a building and alternative materials such as mass timber have potential to unlock more safe and affordable housing faster. With BC's deep housing crisis and many people in immediate need of safe and affordable housing, options to create housing faster need to be explored.

   - Another option to consider is applying the overbuild concept using mass timber to a building that is not used as affordable housing, such as a non-negotiable heritage building. This could mitigate costly tenant relocation or concerns about tenant safety.

Project Purpose

This study explores the possibility of adding three additional storeys to an existing three-storey affordable housing site instead of redeveloping the site to add density and increase the stock of affordable housing.

BC is in a housing crisis and innovative solutions to increase the stock of affordable housing in the province need to be considered. BC Non-Profit Housing Association (BCNPHA), supported by a team of expert consultants, has led this study to explore a unique option for creating more affordable housing units in BC.

Given the abundance of low-rise rental stock across the province, the shortage of affordable housing, and the high price of land, the concept of building a part three building in the pre-zoned air space parcel holds great potential. This study explores the possibility of adding three additional storeys to an existing three-storey affordable housing site instead of redeveloping the site to add density and increase the stock of affordable housing. This study also explores whether the use of mass timber, with its advantageous strength-to-weight ratio, could enable this innovative construction technique, resulting in a gentle densification approach that is less disruptive than conventional redevelopment.

The objective of the 3-over-3 Mass Timber Residential Infill Construction Feasibility Study, funded by the Province of BC's Office of Mass Timber Implementation, Forestry Innovation Investment Limited, and BC Housing, is to assess whether a mass timber building design can be used to add three additional storeys to existing three-storey residential buildings, without displacing tenants or removing structures. The study considers innovative construction techniques, such as the creation of an exo-skeleton or columns around the exterior of the buildings or other means and methods.

The study assessed the following key themes to determine whether the concept is feasible and should be further explored:

- What are the possible structures that can be used to add three storeys to existing three-storey buildings, including the materials, constructability, architectural considerations, and enclosures?
- What are the site and structural constraints for the proposed structures for adding three storeys to existing three-storey buildings?
- What are the code and policy barriers and implications to implement the concept and how can barriers be addressed?
- How do the costs of adding three storeys to existing three-storey buildings compare to the average costs of redeveloping the sites?

To respond to these questions, this study involved preparing preliminary feasibility studies using three non-market housing case study sites in the City of Vancouver. The feasibility studies explore the possible structures, the code implications, and estimated costs. These feasibility studies will be used to determine if any of the proposed structures should be considered for further investigations. The three case study sites are listed below:

Site	Operator	Funding	Year built	Tenant group
Building 5	BC Indigenous Housing Society	BC Housing Operating Agreement	1987	Families
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Chelsea Manor

Intended Impact of Proposal on Community and Tenants

With the goal of meeting growing need for affordable housing in BC, opportunities to increase the number of units on sites might be appealing to operators compared to a multi-year redevelopment during which tenants would likely need to be temporarily relocated. The impacts of adding three storeys to these sites could be both positive and negative for tenants and the surrounding community.

	Potential Positive Impacts	Potential Negative Impacts
Existing tenants	• Improved accessibility of the building (e.g. access to elevators) • Not having to temporarily relocate during redevelopment • The building will be more aesthetically pleasing • Tenants might be able to move into a new unit on the same site while the existing building is renovated or redeveloped • Improved/more on-site amenities • Adding three storeys would likely require upgrades to the existing building, according to the findings of the three case studies	• Reduced parking spaces • Increased demand for parking • Fairness for tenants in existing building compared to new building (e.g. heating/cooling, life-safety, accessibility, condition of housing, rental costs, etc.) • Construction impacts • Some tenants may need to temporarily relocate during the construction of the new structures • Potential permanent loss of outdoor gathering spaces, but if tenants can remain on site during construction, the loss of outdoor space would need to be balanced against the impact of temporary relocations during a redevelopment process (mitigation could also potentially be creating a rooftop gathering place)
Community/ Neighbours	• Increased affordable housing to better meet the needs of the community • Less disruption due to construction compared to redevelopment • The building will be more aesthetically pleasing	• Construction noise • Loss of views • More demand for street parking

Methodology

BCNPHA coordinated the administration of the study and the various consulting teams, as well as prepared the summary report providing an overview of the key findings across the three feasibility studies.

The consulting teams included:

Consultant	Role	Deliverable
Fast + Epp	• Member of the design team • Prepared 3-over-3 concept for Building 5 • Assessed structural feasibility of 3-over-3 concept for Building 5	• Structural Feasibility Study for Building 5
RDH Architecture	• Member of the design team • Prepared 3-over-3 concept for Chelsea Manor • Assessed architectural feasibility of 3-over-3 concept for Building 5, Chelsea Manor, and Chimo Terrace	• Architectural Feasibility Studies for Building 5, Chelsea Manor, and Chimo Terrace
WSP Canada Inc.	• Member of the design team • Prepared 3-over-3 concept for Chimo Terrace • Assessed structural feasibility of 3-over-3 concept for Chelsea Manor and Chimo Terrace • Conducted embodied carbon analysis for Chimo Terrace	• Structural Feasibility Study for Chelsea Manor and Chimo Terrace • Embodied Carbon Analysis for Chimo Terrace
GHL Consultants Ltd	• Did code analysis for the proposed 3-over-3 structures for Building 5, Chelsea Manor, and Chimo Terrace	• Feasibility Studies from a Code Perspective for Building 5, Chelsea Manor, and Chimo Terrace
Altus Group	• Calculated cost estimates for the proposed 3-over-3 structures for Building 5, Chelsea Manor, and Chimo Terrace • Provided comparisons to the average costs for redevelopment of affordable housing sites	• Feasibility Studies from a Cost Perspective for Building 5, Chelsea Manor, and Chimo Terrace

The consulting teams were provided with guidance from an advisory committee. The advisory committee provided input on the common table contents for the feasibility studies and the common assumptions. The advisory members also provided information about the case study buildings and sites, provided feedback on the preliminary concepts for the structures for each case study site, and reviewed the feasibility studies. The advisory committee consisted of representatives from:

- Organizations operating the case study sites (BC Indigenous Housing Society, New Chelsea, and BC Housing)
- The Province of BC's Office of Mass Timber Implementation
- Forestry Innovation Investment Ltd.
- BC Housing
- Canada Mortgage and Housing Corporation
- City of Vancouver
- National Research Council

Report Contents

The three feasibility studies are available in the appendix of this report. Each feasibility study includes various reports prepared by the relevant consultants:

- An architectural analysis report
- A structural analysis report
- A code analysis report
- Cost estimates report
- Embodied carbon report (Chimo Terrace only)

This report provides a summary of the key findings across the three feasibility studies, looking at:

- The commonalities and differences across the proposed 3-over-3 structures, as well as the benefits and challenges of the various components of the proposed concepts
    - The code implications of the 3-over-3 concept based on the findings across the three case study sites
    - The cost estimates of each of the three proposed 3-over-3 structures compared to the average costs of redeveloping an affordable housing site
- Potential impacts of the 3-over-3 case studies

- Potential barriers of the 3-over-3 concept
- Potential opportunities for the 3-over-3 concept
- Limitations of the feasibility studies
- Future research questions
  - Conclusions based on the findings of the three feasibility studies

Building Selection Process

Three case study sites were selected for this first phase of the Mass Timber Residential Infill Construction Study. The building selection process involved identifying suitable buildings located in areas within the City of Vancouver with zoning that would allow for this project. The City of Vancouver provided a zoning map that identified the areas that would allow buildings of six stories or greater. To identify the suitable buildings, BCNPHA used BC Housing's AssetPlanner™ building condition assessment database. The list of potential buildings was screened to exclude buildings with a significantly high facility condition index (FCI). A high FCI indicates the building is near the end of its life or will require significant investment to rehabilitate. The list of buildings was further refined by visually confirming if the building form was suitable for the project. Buildings with complex architectural features were excluded. Buildings with insufficient space between the building and the lot line were also excluded. From the 13 suitable buildings, the design team consultants reviewed and picked the three buildings being used in this study. See Appendix 1 on page 41 for further information on each selected building.

What is Mass Timber?

Mass timber is a category of engineered structural load-bearing columns, beams and panels manufactured from joining multiple layers of wood. Typically, the layers of wood are joined together with glues, nails and dowels. Examples of mass timber include cross-laminated timber (CLT), glue-laminated timber, dowel-laminated timber, nail-laminated timber, laminated strand lumber, laminated veneer lumber, and parallel strand lumber. See page 37 on how mass timber can facilitate the 3-over-3 concept.

Comparison to Steel

While timber is not as strong as steel in terms of its strength, it offers several advantages that make it a strong and viable option for building construction. One of the key strengths of mass timber is its high strength-to-weight ratio, which allows for long spans and flexible design options. Additionally, mass timber has a higher burning temperature and can char on the outside, which helps to protect its structural integrity during a fire. This makes it a safe and reliable choice for many building applications.

Description of Proposed 3-Over-3 Structures

The design team proposed three different structures for applying the 3-over-3 concept at each of the case study sites. All three proposed structures involve the use of mass timber, steel and concrete, but with different support systems for the three additional storeys. All three proposed structures also incorporate an interstitial space between the existing and new structures, as well as additional stairwells and elevator shafts.

The following table provides an overview of the proposed 3-over-3 structures for each of the case study sites. Figure 1, Figure 2 and Figure 3 show the proposed design concepts. More information about the proposed structures and drawings are available in the Appendices of this report.

	Building 5	Chelsea Manor	Chimo Terrace
Supports	• Steel diagrid, tied into new foundations. • Foundations will be a grade beam surrounding the existing building, aligning with the new diagrid structure. • Does not touch the existing building, but could add seismic support to the existing building if required by code.	• Vertical structure using full height steel frames on columns to span over the existing building with separation walls. • Foundations are piled foundations. • Connects to existing building to provide seismic support.	• Steel rectangular transfer table surrounding the existing building. • New steel columns along the existing building's envelope. • Foundations are piled foundations. • Connects to existing building to provide seismic support.
Enclosures	• Modular panels, prefabricated off-site, installed by crane. • Six inches of insulation.		

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	Building 5	Chelsea Manor	Chimo Terrace
Interstitial Spaces	• Interstitial space will be accessed by way of the existing rooftop hatches. • Will provide mechanical crossover space. • Sanitary lines from the building above will be collected and conducted to shafts that run vertically outside the existing building. • Existing plumbing stack vents and suite exhaust ducts will also be collected and run up through the new building within two hour shafts to the roof level. • Central HRV systems and cooling systems could be hung from the ceiling of this space, attached directly to the new structure to avoid imparting loads on the existing building. • Will be sprinklered throughout. • Existing roof drains maintained to avoid flooding events for the building below.		
Materials	**Steel:** diagrid support system for new structure **Mass timber:** cross-laminated timber new walls, roof, new floors, stairwell and elevator shaft **Concrete:** new grade beam foundations	**Steel:** vertical structure **Mass timber:** cross-laminated timber floor, roof, exterior walls, interior load bearing walls, stairwell and elevator shaft **Concrete:** pile footings	**Steel:** transfer frame columns, elevator shaft and stairwell **Mass timber:** shear walls for new structure **Composite steel decking:** transfer table **Cross-laminated timber:** panels for floors of new structure **Concrete:** pile footings
Elevator Access	• Existing elevator serving lower three floors. • New single elevator shaft including an exit will be incorporated to the exo-skeleton to access the upper three storeys, but also accessible to the lower three floors, increasing the accessibility of the existing building.	• No elevator in existing building. • Two elevator shafts outside the existing building footprint will be added. • The two elevator shafts will serve all floors. • Elevators will provide access to underground parking.	• No elevator in existing building. • Two elevator shafts will be added to the exterior of the building footprint and serve all floors

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	Building 5	Chelsea Manor	Chimo Terrace
Stairwells	• Added outside the existing building footprint provides construction fire safety and does not increase the exiting capacity for the existing building's exiting system.		
Energy Efficiency Measures	• Targeting at least Step 4 of BC Energy Step Code. • Enclosure first design paradigm. • Highly insulated wall assemblies, floor, and roof. • Lower window to wall ratio. • Triple pane windows.		
New Structure Design Features	• No balconies. • Could include common rooftop space. • A diagrid is a very expressive and unique structure that will attract attention.	• No balconies in the design but the depth of the structure would allow the future installation of thermally broken balconies. • Could include common rooftop space.	• No balconies in the design but the depth of the structure would allow the future installation of thermally broken balconies. • Could include common rooftop space. • Large bank of windows to provide a point of interest on the street facing façade. • Exterior colours, cladding, and façade articulation will be required to break up the massing of the building.
Exterior Alterations to Existing Building	• Balconies will be removed and replaced with Juliette balconies. • Some underground parking will be lost to accommodate the foundations.	• Some underground parking will be lost to accommodate the foundation. • New building that connects all floors in both buildings. • Will gain elevator access to underground parking.	• Balconies will be removed during construction, but could be reincorporated to the design. • Solar shading panels could be incorporated into the design by attaching the panels to the exo-skeleton.

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Figure 1: Building 5 diagrid structure

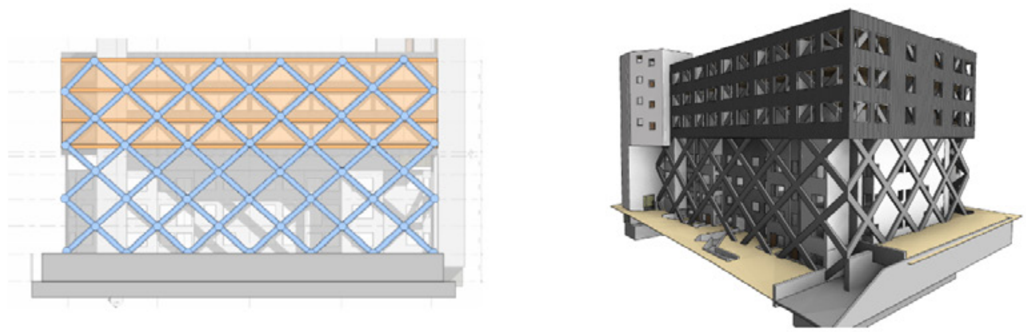


Figure 2: Chelsea Manor vertical structure and transfer structure

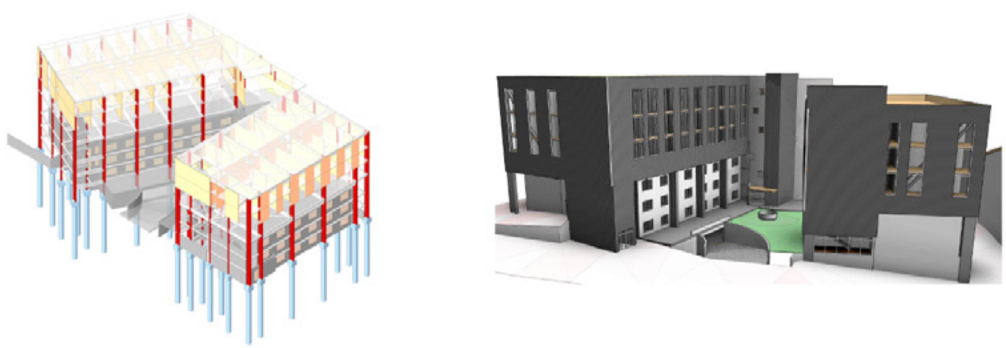
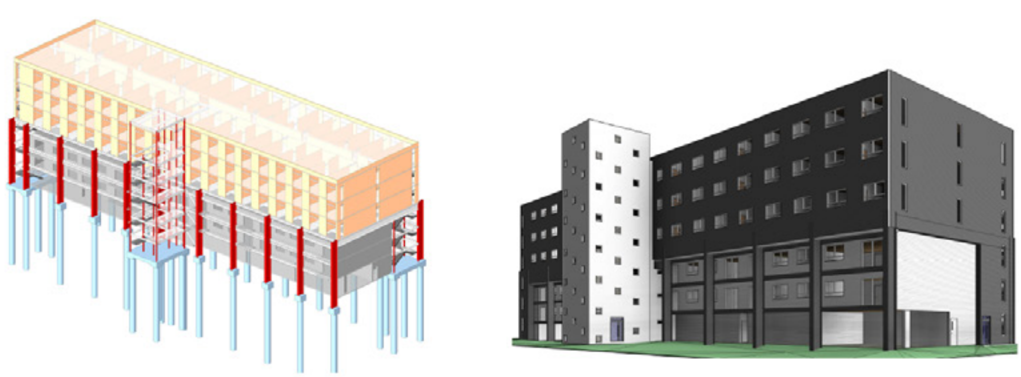


Figure 3: Chimo Terrace transfer deck structure



Structure and Design of Existing and New Structures

Key Finding: A transfer deck is the best option to support the new structure, compared to building immediately on top of the existing building. Using the transfer deck approach, there are many design variations to consider depending on the site and building-specific details of the existing site, such as crawl spaces, whether to connect the two structures or not, types of foundations, etc.

The design committee proposed using transfer decks to support the new structures for all three case study sites, rather than building directly on top of the existing buildings. The proposed structures for each case study site have features unique to that site in response to site specific factors or ideas about design.

Design Features	Benefits	Challenges/Considerations
Transfer Deck (Chimo Terrace)	• This structure type can be easily applied to other existing buildings with minor customizations. • Offers a blank space that could be built using a variety of unit mixes that best meet operator and community housing needs. • Can support different construction types for the units, including mass timber, modular or other prefabricated units, or traditional stick build. • Once the transfer deck is erected, construction of the additional three stories can progress without disruption to tenants. • Can be connected to the existing building or not. Seismic code met for existing building if connected.	• If upgrades or redevelopment are needed for the building below, it can be difficult to bring in materials through cranes for the construction process once the transfer deck is in place. • Not suitable for zero lot line buildings that have been built to the property line. No space to add new foundation and transfer structure. • Requires the removal of balconies.

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Design Features	Benefits	Challenges/Considerations
Three-Storey Walls Supported by Steel Diagrid (Building 5)	• Can be connected to the existing building or not. • Diagrid structures are efficient at supporting building loads and resisting lateral loads. • Diagrid design is appealing, adding interest to the building.	• Diagrid would block windows of existing building according to the proposed design, affecting the comfort for tenants in those units. • Requires the removal of balconies.
Vertical frame with CLT Panels Slotted In (Chelsea Manor)	• Can be connected to the existing building or not. Seismic code met for existing building if connected. • Once the main transfer deck above the existing building is erected, construction of the additional three stories can progress without disruption to tenants. • Can support different construction types for the units, including mass timber, modular or other prefabricated units, or traditional stick build.	• If upgrades or redevelopment are needed for the building below, it can be difficult to bring in materials through cranes for the construction process once the transfer deck is in place. • Not suitable for zero lot line buildings that have been built to the property line. No space to add new foundation and transfer structure. • Requires the removal of balconies. • Spacing of the support structure limits the design of the over build, i.e. limits the width modular components and placement of windows.
Interstitial Crawl Space	• Provides space for mechanical and plumbing and electrical systems between the two buildings, as well as venting. • Will be sprinklered and have fire walls for added fire protection between the two buildings.	• Adds to the height of the building. • This space needs to be less than the height of a storey so not to be considered a storey. If the height of this space is less than a storey, it will be considered a service space. • It is ideal if the service space is enclosed to protect the services within them.
Vertical Shafts for Mechanical and Plumbing	• Does not require penetration of existing building for plumbing and electrical. • Construction does not disrupt tenants.	• Might impact the exterior aesthetics. • Requires sufficient insulation to prevent plumbing from freezing.

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Design Features	Benefits	Challenges/Considerations
New Elevator Shaft	• For buildings without an elevator, the new elevator will improve accessibility for the building.	• To seismically isolate it, the new elevator will be constructed externally from the building. The overall building footprint will increase which might be a problem for properties with limited space. • Setback variances might be required to accommodate the elevator on the exterior of the building.
New Stairwell	• The new stairwell will not increase ingress/ egress load for the existing building.	• To seismically isolate it, the new stairwell will be constructed externally from the existing building. The overall building footprint will increase which may be a problem for properties with limited space. • Setback variances may be required to accommodate the stairwells on the exterior of the building.
Connected to Building Below	• Offers seismic supports to the existing building, which will address the City of Vancouver bylaws requiring seismic upgrades to the existing building. • Costs for seismic upgrades to the existing building will be embedded in the structural costs for the new structure, rather than being an additional cost.	• Potentially, there will be additional costs when lower building is redeveloped.
Separate from Building Below	• Allows the housing provider to upgrade the existing building at a later time or potentially even redevelop the lower building without affecting the new structure.	• According to City of Vancouver bylaws, the new structure will still be considered an addition even if it not touching the existing building, thereby triggering life-safety and seismic upgrades to the lower building. • The existing building does not benefit from any seismic supports from the support system for the new structure because the buildings are not connected.

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Design Features	Benefits	Challenges/Considerations
Vertical Structural Support System (Pile Footings)	• High-capacity foundation can be located close to the existing structure with minimal effects on the existing structure. • Vertical supports can brace existing building.	• The overall building footprint will increase to accommodate the pile footings which may be a problem for properties with limited space. • Pile footing placement may impact subgrade parking and services.
Concrete Grade Beams Structural Support System	• Helpful when there is an underground garage/basement limiting the ability to add vertical supports to the site.	• The overall building footprint will increase to accommodate the pile footings which may be a problem for properties with limited space.
Upper Building Extending Past Lower Building Footprint	• Increase overall floor area further by having the overbuild extend past the existing building. • Shade created by the new building would help reduce solar heat gain in lower units, according to the proposed designs.	• Shade created by the new build would reduce daylight to lower units, according to the proposed designs.
Adding Bumpers between the New Supports and Existing Building	• Offers additional seismic stability for both the existing and new structures.	

Key Finding: Mass timber can facilitate the 3-over-3 concept.

Mass timber is a group of engineered wood products that combine smaller wood elements using adhesives, nails, screws, or dowels to create strong and sustainable structural components. These materials are used for beams, columns, floor and wall panels, and other building elements, offering strength, versatility, and durability for various structural applications.

The proposed new structures all include cross-laminate timber (CLT), a type of mass timber. CLT is incorporated into the walls and floors for the new structures. The design team proposed using 5 ply CLT. However, other materials are also incorporated to the proposed structures, such as concrete grade beams and steel bracing systems.

Use of mass timber construction can facilitate the 3-over-3 concept in several ways:

1. While steel is a strong material for building the new structure, it is a heavy material and most assembly is done on-site. Mass timber, however, is both lightweight and strong, minimizing the need for extensive foundations, which facilitates the 3-over-3 concept where there would be limitations on the locations and types of foundations that could be added to the site.

2. Mass timber is also partially prefabricated off-site, which would be ideal for the 3-over-3 concept where there will be limited space for construction on-site with the existing building still in place and it would mean less disruption for existing tenants. This would mean fewer workers on-site and improved safety for tenants remaining on site during construction. The opportunity for accelerated timelines with the use of mass timber might result in improved return on investment (ROI) due to quicker occupancy and cash flow.

3. For seismic design, the greatest advantage mass timber construction offers over concrete construction is the substantial reduction in building weight, which leads to reduced lateral forces.

4. Mass timber would allow for more efficient implementation of a cohesive building exterior that applies to both the existing and new structures. The mass timber panels can span six storeys, meaning they can be used as the exterior of both structures, creating a unified design.

5. Mass timber has long spans, creating opportunities for more affordable multi-storey buildings.

6. The 3-over-3 concept raises concerns related to fire protection between the existing and new structures, with the new structure being on top of the existing structure. Mass timber can again facilitate this concept because this material has demonstrated strong fire resistance, with large timber elements forming a protective char layer during exposure to flames, allowing them to maintain strength and endure hours of burning, more so if encapsulated.

7. Steel is being used for the primary support structure which includes the vertical supports and the transfer deck. Steel is also needed because steel columns have a smaller footprint compared to wood columns for a given strength. Wood columns could be used; however, the overall building footprint would be larger.

Please see Appendix 5 for resources explaining what mass timber is, its benefits, and its challenges.

Key Finding: There are various site and building specific features that facilitate or hinder the addition of the 3-over-3 concept. Examples include peaked versus flat rooves, window alignment, shape of the existing building, space surrounding the existing building, presences of underground garages/basements, etc.

The design features of the existing buildings and sites can help or hinder the potential for adding three storeys over the existing structure.

Existing Building Design Feature	Benefits for 3-over-3 Concept	Challenges for 3-over-3 Concept
Peaked Roof	NA	Additional costs may be incurred to modify existing roofing structure to accept the overbuild. Due to the peaked roof, the overbuild would sit higher. The additional height may pose problems with potential height restrictions.
Flat Roof	Flat rooves are desirable because they require minimal modifications compared to peaked roovess to accept the overbuild. Flat roovess will have the least impact on overall height of the overbuild.	NA
Balconies	NA	Balconies may conflict with the position of the overbuild support structure which results in added costs to remove or accommodate the balconies. The loss of balconies may impact the wellbeing of the tenant. The removal of some balconies will create inequalities between tenants.
Aligned Windows	Aligned windows can better accommodate the placement of the overbuild support structure to minimize the blocking of windows.	The spacing of the aligned windows may conflict with the overbuild support structure. For example, the placement of a support column could block a row of windows across multiple floors.
Non-Aligned Windows	N/A	Non-aligned windows may result in windows being blocked by the overbuild support structure. This will impact the wellbeing of the tenants.

Existing Building Design Feature	Benefits for 3-over-3 Concept	Challenges for 3-over-3 Concept
Elevator in Existing Building	The existing elevator ensures the building meets the BC Building Code for a six-storey building.	Increases the operating cost with two elevators needing maintenance and eventual replacement.
Rectangular Building Shape	Rectangular buildings provide a uniform base for the overbuild. This should result in the least costs while maximizing space efficiency and constructability.	N/A
Dynamic Building Shape	N/A	Articulated building shapes might increase the complexity in the placement of the overbuild support structure and the transfer deck. This will result in higher construction cost.
Underground Parking/Basement	The existing support structure may be able to support the overbuild support structure. This will result in reduced construction costs.	The existing support structure may not be able to support the overbuild support structure. The overbuild support structure may need to penetrate the underground parking/basement. This will result in lost parking and basement space.
Surface Parking	• The surface parking provides space to accommodate the overbuild support structure. The footprint of the overbuild section can also expand by overhanging the surface parking. This can increase unit count or size. • Surface parking can be used for construction sequencing/staging. • Surface parking can also be used to expand laneway access to meet building code requirements.	N/A
Laneway Adjacent	Adjacent laneways can be used for construction staging and cranes.	The laneway needs to be wide enough to accommodate emergency vehicles that meet code once the building becomes Part 3.

Table continues on next page

Existing Building Design Feature	Benefits for 3-over-3 Concept	Challenges for 3-over-3 Concept
Small Lots	Can add density without increasing the footprint of the existing building.	• The site may not have enough space surrounding the existing building to accommodate support structures for the new structure. • Site around surrounding area may not be sufficient for construction sequencing, cranes, and staging. • Surface parking would be lost to accommodate the new structure and foundations, according to the designs proposed, and compounded by increasing density on the site.
Seismic Risk for Site	Supports for the new structure can provide seismic supports for the existing building, especially for those that do not meet current code.	A location with less seismic activity may be better suited for this concept, as ensuring seismic stability of the support structure is a significant driver of the cost in the case study sites.

Key Finding: The structural concepts have not been designed to meet a particular pro forma. The proposed structures leave designers with options for unit mix.

The design team designed their proposed structures in a way that many different unit mixes could be considered based on what best meets the needs of the operators and housing need in the community. The proposed structures assumed that all units would be designed to meet BC Housing's 2019 Design Guidelines and Construction Standards to inform minimum requirements for square footage of units in the new building for each type of unit. By ensuring the designs and unit mix meet BC Housing's design guidelines, the new units can be eligible for consideration for BC Housing funding to help subsidize the units.

Key Finding: The new structure and the existing structure can be completely disconnected if needed.

While the proposed structures do involve some integration between the new structure and the existing building, it is possible to have the new structure be a completely separate building structurally through incorporating:

- A horizontal fire wall (though horizontal fire walls are not currently recognized by the City of Vancouver bylaws)
- Supports that do not connect to the existing building or foundations
- Mechanical, electrical, and plumbing running either inside the crawl space between the two buildings or through vertical shafts outside the existing building
- Having stairwell and elevator structures attached the exterior of the new structure so they do not touch the existing structure (this is more feasible if the existing building already has an elevator)
- Design where the gravity loads are completely separate from the existing building

Some considerations for having structurally separated buildings are:

- How far would the new structure's supports need to be from the existing building to be considered separate
- Would there be adequate space on the site to accommodate the new structure's supports if not integrated with the existing building
- A collapse of the existing building could impact the supports for the new structure even if the buildings are not connected, though there are provisions for a progressive collapse to prevent this scenario
- There would still need to be an integrated fire alarm system and fire protection system. A fire in one of the two structures should trigger an evacuation of the other building to be safe.

Code Implications

Key Finding: The new building would be considered an addition to the existing building, rather than a separate building.

An important question impacting the feasibility of the 3-over-3 concept is whether the new structure can be considered a separate building or would the new structure be considered an addition to the existing building. If the existing structure and new structure are considered one building, the existing building would need to be upgraded to meet current life-safety standards. While this would be an ideal outcome of adding a new structure for the existing building, the cost of the upgrades could mean redevelopment of the site would make more sense.

BCNPHA engaged a code consultant to review the plans for the new structures and provide advice on the code implications of the proposed new structures. The feasibility studies explored two options where the new structure has some connections to the existing building and one option where the new structure has no connections to the existing building.

The code consultant concluded the new structure will be considered a Part 3 addition to the existing buildings, regardless of whether the new structures are connected or not to the existing buildings. There are no provisions in the BC Building Code and City of Vancouver bylaws to allow the new structure to be considered a separate building.

The code consultant does not believe a horizontal fire wall is suitable or effective to reduce the need for fire safety upgrades to the existing building. The consultant believes adding a sprinkler system to the existing building is important to limit the size of a fire in that building. If the existing building is not sprinklered, it must be assumed fire can spread rapidly to all 3 levels of the existing building. Firefighters would not have adequate water and resources to protect both structures in this scenario. Even with a 3 hour non-combustible or mass timber slab, flames would wrap around the slab and engulf the new structure. The flames would make it difficult or impossible for firefighters to save the new building. The slab would have to be extended six metres or more beyond the new structure on all faces to provide protection from flames from the existing building. This is not to say that the concept is not feasible, rather that a horizontal fire wall would not eliminate the need to fire safety upgrades to the existing building.

Key Finding: The new structure being considered an addition will trigger life-safety and seismic upgrades to the existing building, which will add significant cost to the project and disruption for existing tenants.

Despite having firewalls between the new structure and existing building and the two structures being structurally independent, according to current policy and building code, the new structure will be considered an addition rather than a new structure. Based on the building code, the existing building will require improvements to seismic and life-safety systems.

The upgrades that would be required to the existing buildings include:

- Seismic upgrades
- Alarms and detectors
- Emergency exits and paths
- Fire panel access
- Water access for firefighters
- Access for emergency vehicles
- Sprinklers
- Energy retrofits
- Accessibility features
- Water efficiency
- Ventilation
- Building envelope
- Lighting level
- Noise transmission

The upgrades will add significant cost to the project. Another consideration is that some required upgrades may not be possible due to building or site constraints (e.g. adding sprinkler systems, inadequate fire route access for the size of the new combined building). The upgrades would involve major construction projects for the existing building, which may mean some or all existing tenants would temporarily need to relocate. Safety plans to keep tenants on site during construction will be explored in the next phase of this study.

Bringing the existing building up to current codes will mean the tenants have a safer home and reduced risk for operators.

The code consultant advised that the existing building might not have to fully meet current standards and there could potentially be room for negotiation with the City of Vancouver to help achieve life-safety standards while controlling costs. The City of Vancouver may consider partial upgrades if hardship can be demonstrated and minor relaxations are proposed.

Despite the additional costs and construction impacts, the required upgrades benefit the existing tenants and operations of that building. Bringing the existing building up to current codes will mean the tenants have a safer home and reduced risk for operators. Bringing the existing building up to current code would create more fairness for the tenants in the existing and new buildings. Upgrading the existing building would also reduce risks of damage to the new structure in that the new structure would be more protected from a structural failure of the existing building hitting the supports for the upper structure or from the impacts of a fire in the building below.

The code consultant also recommended ensuring the building height is limited to 18 metres, measured up to Level 6, so as not to trigger additional requirements applied to buildings that are considered to have high building status. See appendices on pages 49, 146 and 271 for code report.

Key Finding: There are potentially ways to mitigate the cost and tenant impacts of upgrading the existing building to allow the three-storey addition.

There are ways to potentially mitigate the cost and tenant impacts of the required upgrades. Some of the costs of upgrades could be embedded into the costs of the new structure. For example, the costs for the seismic upgrades could be mitigated if the new structure connected with the existing building in a way that would provide support to the existing building. The Chimo Terrace and Chelsea Manor designs involve transfer decks which connect to the lower building, thereby offering seismic support to the existing building. The concept also involves achieving a cohesive look for the two structures, so the costs of new cladding for the existing building would be part of the costs of adding the new structure. The new cladding would address some of the upgrades required, such as making the building envelope more energy efficient and replacing existing cladding with non-combustible materials.

There are also methods of adding sprinkler systems that do not require opening walls. For example, sprinkler pipes can be surface mounted to walls and covered up with crown moulding.

There may also be other funding programs that could be accessed to fund the upgrades to the existing building. There are several initiatives to fund renewals and energy retrofits of buildings to extend their useful life. Example of funders at the time of writing this report includes the following:

- BC Housing: Capital Renewal Fund
- BC Hydro/FortisBC: Social Housing Retrofit Support Program
- CleanBC: Social Housing Incentive Program
- Canada Mortgage and Housing Corporation: Canada Greener Affordable Housing Fund
- Federation of Canadian Municipalities: Sustainable Affordable Housing Fund

The code consultant also advised that the upgrades to the existing building will be a negotiation with the City of Vancouver. The City of Vancouver will be motivated to add affordable housing units in the community, so they may be willing to compromise on some of the upgrades required to ensure the upgrades do not make the overall project cost prohibitive. This, however, needs to be balanced to ensure the safety of the existing tenants.

Key Finding: There may be requirements in the BC Building Code and City of Vancouver bylaws triggered by the change from a Part 9 building to a Part 3 building that cannot be accommodated with the existing site.

Larger buildings have additional regulations. Whether the new structure is considered an addition or a separate building, there will be more people living on the site. Part 3 buildings have different requirements including access routing, fire department connections and fire hydrants. Depending on the site, some of these requirements might not be possible to accommodate. For example, the width of the laneway beside the existing building would be virtually impossible to widen to accommodate emergency vehicles. There also needs to be a certain turning radius on access routes to allow for emergency vehicles when shifting to Part 3 building requirements. The fire connection and fire hydrant must be within a specified distance from the principal entrance. In addition, the fire panel access also needs to be within a certain distance of the access route. It may not be possible to relocate the fire panel, fire department connection, fire hydrant or alley to accommodate the requirements.

However, just because the concept may not work for some sites, does not mean the concept could not be applied to other sites that can accommodate the additional bylaw requirements.

Key Finding: The code consultant does not recommend existing tenants remain on-site during the construction of the new structure. If tenants do stay on-site, the code consultant recommends a number of construction considerations to ensure the construction process meets applicable code and bylaws and ensures the safety of tenants remaining on site during the construction process.

The code consultant recommended a number of safety measures to ensure the construction process complies with applicable code and bylaws. While there are no specific safety provisions for the construction of 3 new storeys on top of an existing building, the code consultant did recommend:

- A review of construction exposure hazard for a six-storey combustible building will be requested by the Vancouver Fire and Rescue Services
- A detailed approach to construction hazards and fire hazards will be needed since the existing building will remain occupied during construction of the new structure
- Adding a sprinkler system to the existing building should be prioritized with temporary water supplies if the building is to remain occupied during construction of the new structure

The design team firms feel it is feasible to have existing tenants remain on-site during the construction of the new structure and upgrades to the existing building. They have experience doing deep energy retrofits with existing tenants staying on-site. The design team believe only short relocations may be needed for some tenants, but that most tenants will be able to remain on site. The tenants can remain when the foundation and vertical supports are being constructed. The tenants need to leave the building when the transfer deck is being erected and made secure. The design team believes the tenants can return once the transfer table has been erected which can take a few hours to a few days. The transfer table creates a barrier between the existing building and the construction above. In comparison, traditional redevelopment can displace tenants for three to five years.

Cost Implications

Key Finding: Adding three storeys over an existing three-storey building using mass timber construction may be more expensive compared to redevelopment, but potentially within a range of +9%-23%.

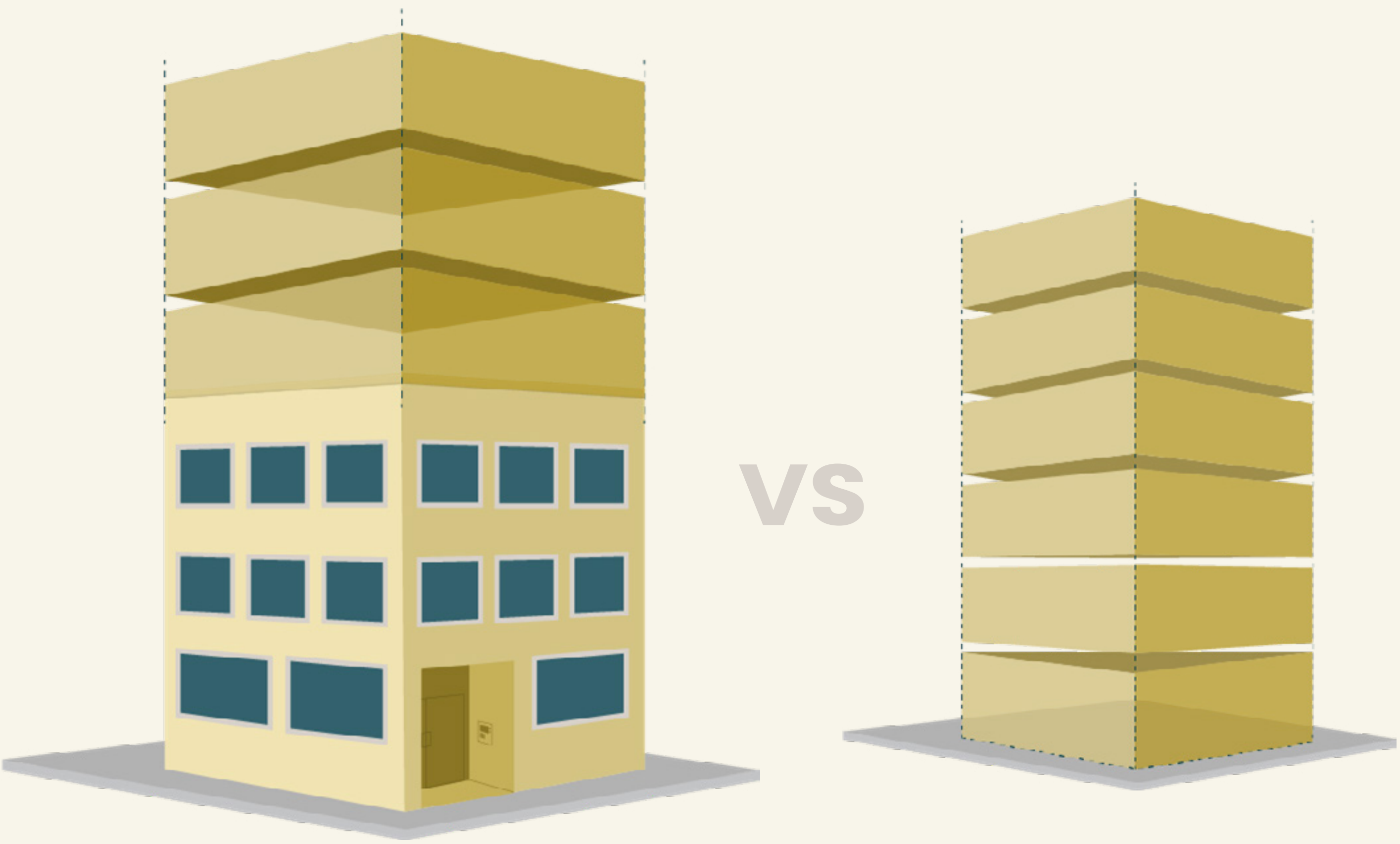
The average cost for adding three storeys to the case study sites, including some upgrade costs for the existing buildings, was $562 per square foot, ranging from $525-$590 per square foot. By comparison, average redevelopment costs for a four-to-six-storey building could range from $480-$535[3] per square foot. This redevelopment cost estimate excludes tenant relocation costs and hazmat removal and abatement costs. The costs are based on construction costs at the time of writing this report and does not include cost escalation.

This means the cost of the 3-over-3 concept can range from 9% to 23% higher compared an average redevelopment. The average 3-over-3 cost per square foot across the three case study sites is within 5% of the upper estimate for the average redevelopment, and with the average redevelopment estimate excluding tenant relocation and hazmat abatement/removal costs, the difference indicates the 3-over-3 concept as a potential alternative to redevelopment.

The 3-over-3 costs are based on proposed concepts, while the average redevelopment costs are based on actual costs for the development of 25 affordable housing sites in Vancouver over the last four years, so the 3-over-3 concept could end up costing more per square foot than the estimated costs if implemented. However, even if the cost per square foot is higher for the 3-over-3 concept compared to a redevelopment, the calculation would still need to factor in the financial costs and social costs of a potentially longer tenant relocation, as well as the environmental impact of a redevelopment.

Estimated Case Study Site Costs Compared with Average Redevelopment Costs

Cost of the 3-over-3 concept can range from 9% to 23% higher compared to redevelopment but has other potential benefits



3-over-3 Approach

$525-590/SF

Estimated cost of adding three storeys + some upgrade costs for the existing building

Redevelopment

$480-535/SF

Average redevelopment costs for a four-to-six storey non-market building (excluding cost estimates for tenant relocation and hazmat removal/abatement)

Costs are based on construction costs at the time of writing this report and does not include cost escalation

Table 2: Estimated Cost Comparisons Across the Case Study Sites to Average Redevelopment Costs

	Building 5	Chelsea Manor	Chimo Terrace	Case Study Average	Average Redevelopment
Total Construction	**$525/sqft**	**$572/sqft**	**$590/sqft**	**$562/sqft**	**$480-535/sqft**[4]
Transfer Table/ Diagrid[5]	$123/sqft	$139/sqft	$167/sqft	$143/sqft	n/a
Estimated Upgrades to Existing Building[6]	$5.20/sqft	$5.20/sqft	$5.20/sqft	$5.20/sqft	n/a
Estimated Demolition Costs	n/a	n/a	n/a	n/a	$50/sqft[7]

Source: *Altus Group, 2024*

Some of the drivers of the cost differences between the case study sites were:

- Foundation type: the pile foundation is more costly to construct compared to the grade beam foundation.
- Steel usage: based on the construction cost, the transfer deck concept uses more steel compared to the vertical support and diagrid concepts.

While mass timber will facilitate the 3-over-3 concept, mass timber construction often also involves additional costs to ensure fire safety during the construction process. Designs need to factor in fire safety exits for construction teams working on the site. Costs will also be incurred for fire protection for the mass timber panels during the construction process. Housing societies that have used mass timber in recent developments have also reported higher insurance premiums and recommend having a strong construction team who can answer questions from the insurance company to secure rates as low as possible. At this time, BC-based mass timber costs are high, but European examples show that as demand for mass timber increases, the factories can become more efficient, and costs will decrease. As demand increases and safety is demonstrated, insurance companies may also become more comfortable with the material, resulting in lower premiums.

4. This estimate is based on the development of 25 affordable housing buildings in the last 4 years. Altus advised that 24-27% of the total construction costs for the redevelopment would need to account for non-profit premiums such as durability, accessibility, sustainability, and bylaw requirements.
5. Excludes upgrades to existing building, walls, interiors. This cost just refers to the supports and floor for the new structure. This cost is a component of the total construction cost estimates for the case study sites, not in addition to those costs.
6. This cost includes upgrades to the fire safety system (e.g. adding sprinkler system and other fire protection). This cost estimate may not capture the full cost of the life-safety upgrades that will be required by the City. Costs for seismic upgrades are included in the transfer table/diagrid supports for the new structures, as these new structures would provide seismic supports for the existing buildings.
7. This cost excludes hazmat removal and abatement.

Key Finding: There may be ways to reduce the financial costs of the proposed concepts for adding three storeys to existing three-storey buildings.

Costs for adding three storeys to existing three-storey buildings could be reduced by taking specific site characteristics into consideration. For example, applying this concept to a site that already has fire lanes that meet the code for six-storey buildings would help reduce any additional costs to address this limitation. With upgrades likely required to the existing building, selecting an existing building that has some of the life-safety requirements already in place could help reduce costs, such as a building that already has sprinklers. The Building 5 case study has lower costs compared to the other case studies in part because the building already has an elevator serving the first three floors of the existing building.

There might also be opportunities to find other funding sources related to the upgrades required for the lower buildings. For example, the Rental Protection Fund (RPF) provides funding to cover upgrades to buildings acquired through the program. With many of the buildings converted to non-profit housing through the RPF, it is possible that the 3-over-3 concept could be applied to buildings acquired through the RFP rather than existing non-profit housing, to help access funding for the upgrades to the existing building.

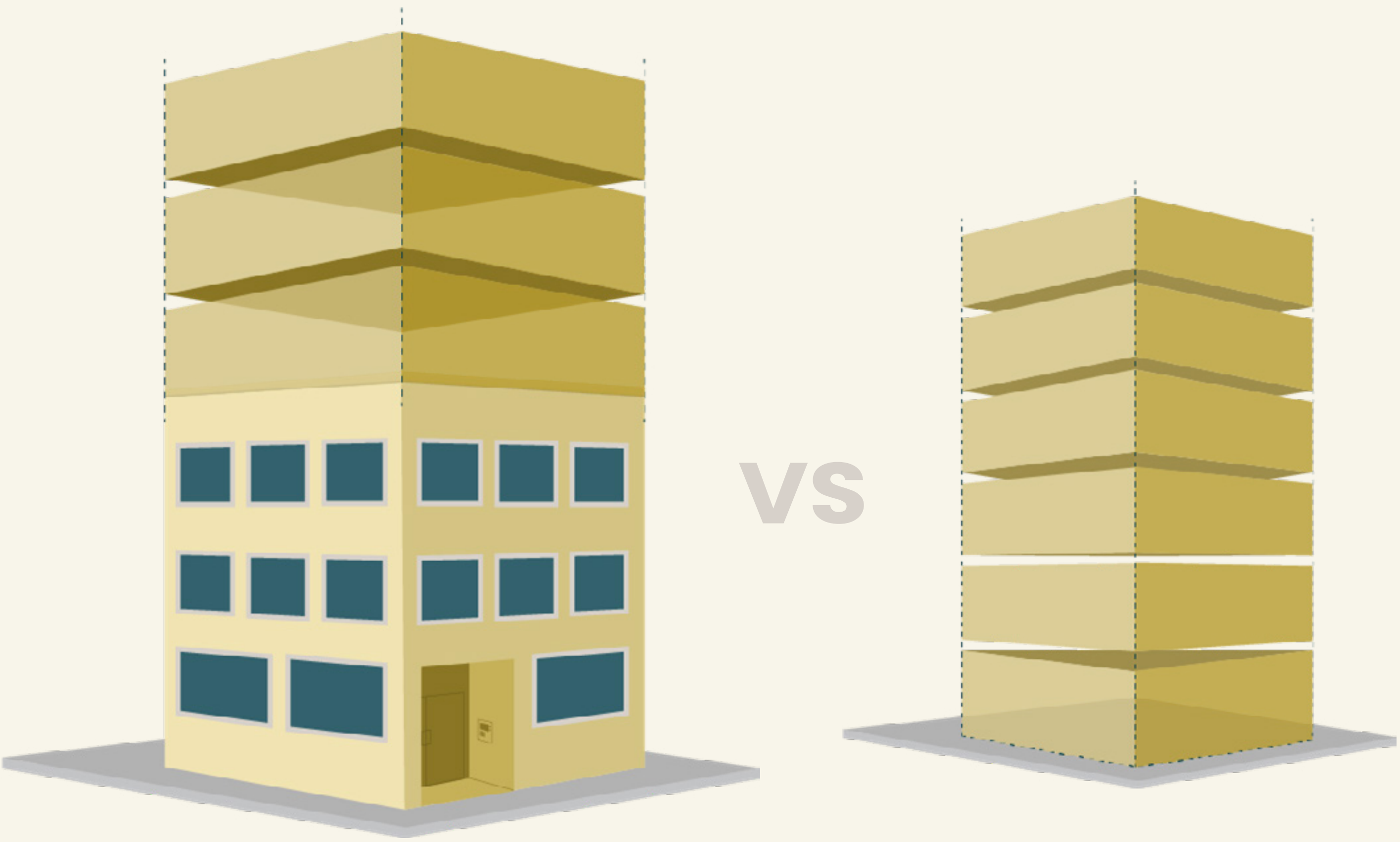
Material selection is another way costs could be reduced for the 3-over-3 concept. BC's mass timber industry is rapidly growing, and as demand increases, costs are expected to become more competitive with international markets like Europe, where the supply chain is already well established. Mass timber offers long-term benefits such as sustainability, reduced carbon emissions, and faster construction. As other materials may become more expensive due to the impacts of potential tariffs, locally produced mass timber in BC may become less costly relative to other materials.

Different structure types for the three-storey addition to the site can also impact costs. For example, the cost of the diagrid structure was found to be less compared to the cost of the transfer table approach among the proposed designs. The diagrid estimated costs were $123 per square foot, whereas the transfer table could cost $167 per square foot. The primary cost difference comes from the different foundation types (pile foundation versus grade beams) and the amount of steel required for the transfer table versus the diagrid.

Embodied Carbon Impact of 3-Over-3

Embodied Carbon for 3-over-3 Compared to Redevelopment

The 3-over-3 concept has 10% less embodied carbon and 3% less embodied carbon intensity compared to a six-storey redevelopment using mass timber construction



3-over-3 Approach Embodied Carbon (kg CO2 e)

1,446,002

↓ 10% kgCO2e

- Reuses existing building
- Less new materials compared to redevelopment
- Less transportation carbon compared to redevelopment

Redevelopment Embodied Carbon (kg CO2 e)

1,602,882

Key Finding: The 3-over-3 concept has 10% less embodied carbon and 3% less embodied carbon intensity compared to the six-storey redevelopment scenario (six storey - stick frame and mass timber).

The 3-over-3 concept is believed to have lower embodied carbon because it reuses the existing building and uses less new materials compared to redevelopment. A study was conducted by WSP to quantify the embodied carbon between the 3-over-3 concept and a six-storey redevelopment using stick frame and mass timber construction. Due to budgetary constraints, one site was chosen for this study. Chimo Terrace was chosen for this study.

The study examined the embodied carbon throughout the building's lifecycle. This includes embodied carbon from the new materials, construction phase, operational phase (occupied by residents) and end of life. The study found the embodied carbon and embodied carbon intensity of the six-storey redevelopment higher than the 3-over-3-concept.

Table 1: Embodied carbon emissions results

	3-over-3 Concept	Six-storey redevelopment	Difference (%)
Embodied carbon (kg CO2 eq)	1,446,002	1,602,882	Redevelopment = 10% higher
Embodied carbon intensity (kg CO_2 eq/m^2)	204	211	Redevelopment = 3% higher

The study found the following causes for the higher carbon emissions from the six-storey redevelopment:

- While the 3-over-3 concept requires a significant amount of structural steel, the six-storey redevelopment requires a greater quantity of concrete, steel, CLT and dimensional lumber.
- Six-storey redevelopment includes carbon emissions from demolishing the existing building.
- New construction material transportation is higher for the six-storey redevelopment.

Potential Impacts of 3-Over-3 Concept for Existing Buildings, Tenants and Operators

The design team and advisory group discussed a range of potential impacts of the 3-Over-3 concept on existing buildings, tenants, and housing operators. While not all of these impacts were examined in the first phase of the study, they were identified by subject matter experts as important areas for further investigation. These considerations could be explored more deeply in the next phase through targeted research, literature reviews, case studies from other jurisdictions, or by evaluating the outcomes of a 3-Over-3 pilot project.

Key Finding: The 3-over-3 concepts presents non-tangible benefits for tenants and operators compared to a redevelopment of the sites. For example, the 3-over-3 concept may allow existing tenants to stay in place rather than having to temporarily relocate (or potentially relocate for a shorter amount of time) which reduces disruptions for tenants and facilitates operations.[8]

The goal of the adding three storeys to the existing building rather than redeveloping the property is to minimize the impact for the existing tenants. Adding a new structure over the existing building would involve some challenges for the tenants, but this concept could also lead to improvements for them and the existing building.

Creates new affordable housing faster because:

- Anticipated shorter timelines compared to redevelopment
- Uses prefabricated mass timber

Reduces need for temporary tenant relocation, avoiding:

- Disruption to social connections, access to health care, schools, and services
- Pressure on already strained housing market

Improved tenant safety, comfort and, pride because:

- Adding new structure will require upgrades to existing building
- New structure will enhance seismic stability, accessibility, and fire safety features of existing building
- Updates to building envelope to match new structure will improve energy efficiency and provide a refreshed look

8. The next phase of this study will include more detailed safety plans to confirm it is feasible for residents to remain on-site during construction.

Benefits	Description
Tenants would potentially not have to temporarily relocate or tenant relocation could be for a shorter time	• Temporary relocation is a difficult process for tenants, so being able to stay on-site rather than having to temporarily relocate for a longer redevelopment process (e.g. tenants may need to temporarily leave their neighbourhoods, which disrupts social connections, access to health care providers, schools, work, and other community-based services. • Temporary tenant relocation is a costly and time-consuming process for operators of affordable housing. • With a shortage of affordable housing, temporarily relocating tenants who already have homes to other existing affordable housing further exacerbates waitlists for housing. • This potential benefit would require further investigations in future phases of this study to confirm.
Improved life-safety for existing tenants	• Requirements to upgrade the existing building due to the addition of the new structure will mean tenants are living in a safer building (e.g. seismic improvements, fire safety improvements, etc.).
Improved accessibility for existing tenants	• Older three-storey buildings tend to be walk-ups – with elevators added to serve the new and existing structure, existing tenants will be able to get up to higher floors more easily and more easily access laundry facilities, especially for those with mobility challenges or with children in strollers.
Exterior of existing building will be upgraded to match the new structure	• The new exterior will offer more energy efficiency for the existing building, thereby enhancing tenant comfort. • The look of the existing building will get a refresh, creating renewed pride for existing tenants with their homes.
Expands the housing society's portfolio of affordable housing	• With additional housing units, housing providers have more opportunity to address their waitlists. • A larger portfolio offers more opportunities to cross-subsidize across buildings, increasing the financial viability of the housing society.
Increases the choice of housing for people in need of affordable housing	• The shortage of affordable housing means those on waitlists often need to take housing that does not meet their needs – this additional housing provides more choice for those waiting for housing, especially since the unit mix of the new structure can be flexible to meet community needs.

Key Finding: The 3-over-3 concept offers environmental benefits compared to redevelopment. A comparison of the two scenarios showed the 3-over-3 concept reduced embodied carbon compared to a redevelopment.

Benefits	Description
Embodied carbon costs of adding three storeys to an existing building are lower compared to redevelopment	• Mass timber not only stores carbon throughout its lifecycle but also offsets substantial greenhouse gas emissions. For example, an 18-story timber structure can remove the equivalent of over 2,300 cars' annual carbon emissions from the atmosphere.[9]
Mass timber is a renewable resource	• Mass timber uses fast-growing trees, so the resources can be quickly replenished.[10] • Mass-timber production involves sustainable forestry practices to ensure the resources used are replaced (e.g. using smaller logs from wildfire prevention thinning and damaged timber).[11]
Mass timber reduces waste in the construction process	• Mass timber prefabricated off-site in a more factory setting which is more controlled, so calculations are more precise resulting in less waste. • Mass timber is built in the factory to meet the specifications required for each project, which means less waste compared to shipping standard products that need to be adjusted to meet the specifications once on-site. • Software is used to maximize the use of each piece of timber to reduce waste. • Any leftover pieces of wood are repurposed for other uses, such as materials for other construction, bioenergy, or woodchips. • Mass timber can be used for multiple purposes within a construction process, including insulation, structure, and exterior finishes, thereby reducing the need for additional products.

9. Are Mass Timber Buildings the Solution to the Affordable Housing Crisis?, https://mercermasstimber.com/2024/04/25/mass-timber-buildings-affordable-living-spaces/
10. The potential use of mass timber in mid-to high-rise construction and the associated carbon benefits in the United States, https://journals.plos.org/plosone/
11. Mass-timber production involves sustainable forestry practices to ensure the resources used are replaced (e.g. using smaller logs from wildfire prevention thinning and damaged timber) article?id=10.1371/journal.pone.0298379

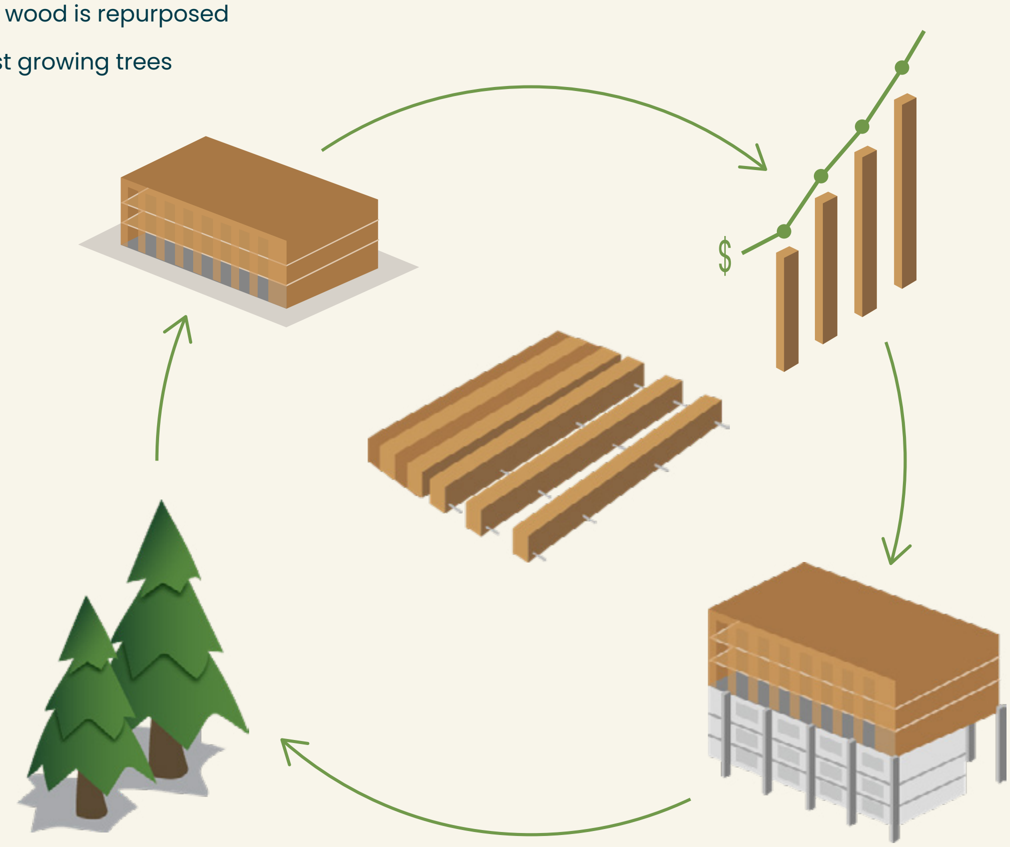
Potential Benefits of Using Mass Timber Construction in 3-over-3 Concept

Sustainability:

- Prefabricated in factory using software to meet project specifications, resulting in less waste
- Leftover wood is repurposed
- Uses fast growing trees

Benefits the local economy:

- Local material
- Boosts BC's economy



Opportunities for Indigenous-led forestry stewardship:

- Uses sustainable forestry practices that are aligned with traditional Indigenous stewardship practices

Facilitates 3-over-3 concept:

- Long span and strength-to-weight ratio
- Prefabricated off-site, resulting in quicker timelines and less disruption for tenants
- Offers additional features (e.g. insulation, seismic stability, visually appealing)

Key Finding: The 3-over-3 concept creates benefits for the community. This concept, particularly with its use of mass timber construction, may offer a quicker way to add affordable housing to the community and help create local jobs by supporting BC's mass timber industry, including jobs for Indigenous people.

Benefits	Description
Increases affordable housing when no land is available	• Land can be difficult to access to build affordable housing (e.g. zoning issues, cost of land, neighbourhood opposition). • The concept creates additional density on lands already zoned for affordable housing and higher density. • The concept allows for the creation of new affordable units on city-owned buildings. • Affordable residential units could be created above existing commercial buildings with this concept.
May offer faster option to increase availability of affordable housing in the community	• Adding affordable housing to an existing site saves time on finding suitable land and potentially working through a rezoning process. • Adding affordable housing on top of an existing building means density can be added to the site without having to take the time to redevelop, which would include time for decanting the building, rezoning processes, demolition, and construction. • This study focused on case study sites that have already been zoned for six storeys, so rezoning would not be required. • Timelines for the proposed structures will be explored in the next phase of this study, and will be compared to average redevelopment timelines.
Reduces pressure on existing housing in the community	• Too many people are experiencing homelessness and core housing need, and waitlists for affordable housing are long – this concept offers a way to add affordable housing to a community more quickly compared to new builds or redevelopment of existing sites. • Redevelopment of a site to add density would require existing tenants to be temporarily housed elsewhere, adding pressure to the already low vacancy and high-priced housing market until the redeveloped site is ready.

Table continues on next page

Benefits	Description
Use of BC mass timber creates local jobs	• Locally produced mass timber boosts B.C.'s economy by generating employment in harvesting, transportation, manufacturing, and installation sectors.[12 13]
Use of BC mass timber supports this new local industry	• BC has a growing mass timber industry, so products would not need to be brought in from other jurisdictions.
Use of mass timber supports Indigenous communities	• Mass timber creates manufacturing and construction jobs and skills. • Sustainable forestry practices can include profit sharing with Indigenous communities. • Use of sustainable forestry practices are aligned with traditional Indigenous stewardship practices and provides opportunity for Indigenous-led control over natural resources and land stewardship. • Indigenous architects can incorporate cultural expression in the design of mass timber structures. • Mass timber construction may provide faster construction options to increase the stock of Indigenous-led affordable housing. • Mass timber construction for affordable housing advances reconciliation.

12. Understanding mass timber, https://www.naturallywood.com/design-and-construction/mass-timber/
13. Are Mass Timber Buildings the Solution to the Affordable Housing Crisis?, https://mercermasstimber.com/2024/04/25/mass-timber-buildings-affordable-living-spaces/

Barriers and Challenges with the 3-Over-3 Concept

Key Finding: The 3-over-3 concept could also create some challenges or raise concerns about the impact on tenants and operations of the existing buildings. These challenges and concerns include safety, fairness, and disruption and cost of upgrade requirements to the existing buildings.

Potential Barriers and Challenges At A Glance

Safety: Safety concerns if tenants stay on-site during construction

Parking: Loss of on-site parking to accommodate new structure

Comfort: Reduced air/light through to existing buildings

Disruption: Construction of new structure and upgrades to existing building may be disruptive for tenants

Rent: Even with subsidies, homes in new structure will have higher breakeven rent compared to existing units

Fairness: The new structure will include newer units, which could create fairness issues for tenants in existing units

Mass timber: Fire safety concerns and higher insurance costs associated with newer construction material

Barrier/Challenge	Impacts	Mitigation
Reduced air/light through to existing buildings	• Some support structure designs would block the windows on the existing building, according to the designs proposed.	• Considering building features, such as window alignment and less dynamic building shapes when selecting buildings might reduce impacts of support structures on existing building. • Though cheaper and architecturally interesting, the diagrid will be more likely to block the existing windows compared to the transfer table supports.
Concerns about safety	• A collapse of the existing building (e.g. due to earthquake or fire) could damage the supports for the new structure. • A collapse of the new structure could damage or destroy the building below. • Fire travels up and with the lower buildings being more at risk of fire because they do not meet current code, a fire in the existing building could affect the building above even with a firewall (e.g. smoke damage, damage to the upper structures supports). • Fire chiefs in BC have raised concerns about the fire safety of using mass timber.	• Seismic, sprinklers, and other fire safety upgrades will be required according to municipal bylaws for the existing building if the structure is added above. • The support system for the upper structure can be tied to the existing building to provide seismic support to the lower structure. • The upper structure will be built to meet current seismic building code and bylaw regulations. • The crawl space between the upper and lower structures will be sprinklered. • The alarm system will trigger evacuations of both structures in event of a fire. • Mass timber chars from the outside in and have one-hour fire ratings and can achieve higher ratings when encapsulated.

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Barrier/Challenge	Impacts	Mitigation
Affordability for tenants in new structure	• Even with subsidies, the new housing offered through the new structure would have a higher breakeven rent compared to the units in the existing building. • The construction costs will be higher, so rents will need to be higher to cover the costs.	• Please see section about cost mitigation opportunities. • The new units could be rented out at market and below market rents, so the market units could cross-subsidize the below market units, allowing for deeper subsidy. • With the units designed to BC Housing's guidelines, it may be possible to access BC Housing operating subsidies if there are appropriate funding programs available. • It may be possible to access CMHC or BC Housing construction financing to access financing at a lower rate to reduce the breakeven rents. • There may be opportunities for property tax exemptions from the city to lower operating costs and thereby lower rents.
Blending the new and existing buildings	• The lower building's exterior would need to be upgraded to allow for a consistent aesthetic between the two buildings, according to the designs proposed.	N/A
Fairness for tenants in existing building versus new building	• The new structure will include newer units that meet current BC Building Code, local government by-laws, and design standards. • Existing tenants may wish to transfer to the new units, which could be a costly relocation project for operators. • The breakeven rent for the newer units would likely be higher than the existing units, meaning the new units would have higher rents.	• The existing building would need to be upgraded through negotiations with the local government to improve life-safety features for existing tenants. • Another way to look at this issue is to think about the new structure as a new neighbour or partial redevelopment of the site rather than as an extension of the existing building (Chelsea Manor has previously engaged in this kind of scenario when part of the site was redeveloped in 2007). • Housing providers often face this fairness issue when they add new developments to their portfolios and have practices in place to address fairness and tenant requests to be relocated to the new buildings.

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Barrier/Challenge	Impacts	Mitigation
Disruption for existing tenants due to the construction	• Construction of the new structure and upgrades to the existing site while tenants are on-site could be noisy and produce fumes that are disruptive and uncomfortable to residents on site. • There could be safety risks to building over a tenanted site (e.g. if building materials were to fall).	• Safety plans would need to be in place to ensure the construction will not lead to safety issues for people in the existing building. • Some or all residents may need to move temporarily but, if so, it would be for shorter amounts of time, thereby reducing the disruption and cost associated with temporary tenant relocation compared to redevelopment.
Loss of parking to accommodate the new structure supports	• Tenants and staff will lose access to some surface or underground parking spaces.	• Building operators advised the design team that the parking is not fully used, so loss of parking spaces is okay. • Applying the 3-over-3 concept to buildings that are close to public transit would mitigate the impact of any loss of parking. • Local governments including the City of Vancouver are relaxing parking space requirements for affordable housing.

Opportunities for the 3-Over-3 Concept

Key Finding: The design team and advisory group generated and discussed many ideas for how the 3-over-3 concept could potentially be applied to create more affordable housing in BC communities.

It is important to note that the feasibility of these ideas were not assessed in this phase of the study.

Possible Applications At A Glance

> 3 Storeys: Taller over-build construction where re-zoning is possible to increase affordability and # of new homes on site

Combined modular construction: Stacking modular units on a transfer deck instead of stick build construction for new structure to shorten timelines and reduce disruption

On-site tenant relocation: Housing in new structure could be used as temporary housing while existing structure is redeveloped

Repurposing existing structure: Existing tenants could move to housing in new structure while existing building is repurposed (e.g. hotel to generate income for housing provider)

Housing over other structures: New structure could be added to other types of buildings (e.g. heritage, low-rise commercial)

Mixed income housing: Since housing in new structure will be more costly to operate, it could offer mixed income housing to cross-subsidize existing units

Re-Use of Modular Units from Province's Rapid Respond to Homelessness

The Government of British Columbia introduced the Rapid Response to Homelessness program in 2017. The Province invested $291 million into building over 2,000 supportive housing units across BC using modular construction. The program involved a mix of both permanent and temporary units to respond to increasing in homelessness in communities throughout BC. The modular units were self-contained 320-square-foot studio apartments. Buildings typically included about 50 modular units and 2,000 square feet of amenity space.

Since some of these modular buildings were intended to be temporary, they may be available to be reused now. The transfer deck approach to the 3-over-3 concept presents an opportunity to re-use these modular units. The units could be stacked onto the transfer deck to be used as either temporary or permanent housing. For example, the modular units could potentially be used as temporary housing for tenants already living on the site to allow for redevelopment or upgrades of the lower building without having to temporarily relocate tenants to a new site. After the redevelopment or upgrades of the lower building, the modular units could remain to be used as permanent housing for new tenants or be replaced with other forms of housing (e.g. larger modular units, stick build construction, etc.).

Ideas for Consideration: Uses of Existing Building or New Structure

While these ideas would require further investigation, the design team and advisory group discussed potential alternative uses for the existing or new structures. The new structures could offer an opportunity to create mixed-income housing on the site. For example, if the housing in the new structure was used for low end of market housing or middle-income housing rather than deeply subsidized housing, the new units could be used to ensure the financial viability of the building, especially for buildings preparing for the expiry of operating agreements or that already have agreements that have expired.

The new structure could also be used to house existing tenants, so they could move into new units that meet current BC Building Code requirements and local bylaws. Meanwhile, depending on zoning, the lower building could be repurposed to become, for example, a commercial space to help offset operating costs for the site.

Hotels are also looking for space, particularly in areas outside of the downtown core. An option to cover the costs of the upgrades to the lower building is to add the three storeys using the 3-over-3 concept. Existing tenants could move into the new units, so they are not displaced. A hotel company could then retrofit the existing building below to create a new hotel. The land for the hotel could be leased from the housing society, thereby generating income.

The 3-over-3 concept also presents an opportunity for the BC Builds program where new affordable housing could be built over many types of existing buildings. This can include heritage buildings and other low-rise buildings. Heritage building sites can be densified without affecting the existing building. With rezoning, residential units could be place above low-rise commercial buildings.

Beyond 3-over-3

The concept could be applied to include more than three additional storeys. Mass timber construction can accommodate structures of up to 18 storeys. Adding more than three storeys would maximize the land available to create more affordable housing in communities. Adding more than three storeys was not considered in the feasibility studies completed in this phase of the study.

Alternative Materials

The mass timber product included in the design team proposals is cross-laminate timber (CLT). There are other types of mass timber that could be used such as nail laminated timber or dowl laminated timber. Using a wider range of timber products could increase the options for manufacturers thereby reducing the price and time to get products.

Limitations of the 3-Over-3 Residential Infill Construction Study

The 3-over-3 Residential Infill Construction Study is meant to be a preliminary assessment of the 3-over-3 concept. This phase of analysis is meant to assess the feasibility of adding three storeys to existing three-storey non-market housing buildings, including potential structures, whether these structures are feasible from a structural and architectural perspective, and what these potential structures might cost compared to the average redevelopment of affordable housing sites. If this preliminary analysis finds that the concept is potentially feasible for any of the three case studies, more detailed site-specific analysis will be conducted. Appendix 2 shows the assumptions that were made to allow for a high-level feasibility study at this stage of the research. The preliminary analysis has several limitations, including:

- The study relied on Cost D pricing.
- The study assumed a particular soil type.
- The proposed designs did not incorporate specific unit mixes, which limits the cost estimates and ability to compare various scenarios between this concept and potential redevelopment options.
- Only average redevelopment costs were considered, though there are various redevelopment scenarios are possible, each with trade offs compared to the 3-over-3 concept.
- The study did not consider acoustic rating.
- The study did not include a safety plan for tenants remaining on-site to truly assess the feasibility of tenants staying on-site during the construction of the new structure and upgrades to the existing building.
- A full analysis of material options and costs would need to be conducted to ensure the best quality for the lowest cost.
    - With all three case study sites located in the City of Vancouver, local bylaws were considered in the code analysis. The BC Building Code or bylaws in other municipalities may lead to different conclusions related to the code analysis.
- The study's team did not involve any general contractors. It would be helpful to have a general contractor review the proposed concepts for constructability, impact on occupants, potential phasing of construction, etc.

Future Research Questions

- Is there a possibility to increase the height thresholds for specific design applications such as the proposed infill design? What are the fire safety impacts of marginally taller buildings?
- What are the construction timelines? Because of the prefabricated materials used, would the construction timelines be faster compared to stick-build?
- What safety plans are needed if tenants are to stay on-site during construction? If there is some tenant displacement, how would the timelines compare to redevelopment?

Conclusions

- The 3-over-3 concept is structurally feasible, with a range of options. Some building and site features enable or inhibit the 3-over-3 concept, but the structural concepts could be applied to other buildings or sites even if not fully feasible for one of the case study sites. The structural designs proposed offer flexibility in terms of the unit mix and construction types for the new units.
- Mass timber facilitates the 3-over-3 concept due to its long span and strength-to-weight ratio. With mass timber being prefabricated, this material could facilitate the concept by reducing disruption for tenants if they were to stay on-site as a result of less on-site construction. Prefabricated materials also reduce construction time, so affordable housing can be ready for occupancy sooner.
  - While one of the benefits of the 3-over-3 concept is that temporary tenant relocation can potentially be avoided, there was not agreement among the consultants about whether tenants should stay on-site during the addition of the three storeys and upgrades to the existing building. There could be safety concerns and high levels of disruption for tenants if they remain on-site during construction. If temporary tenant relocation is necessary, do the non-tangible benefits still outweigh the higher costs and limits to the structures compared to a redevelopment? With mass timber involving prefabricated materials, the on-site construction time could potentially be faster compared to a redevelopment, which would still make the concept beneficial in that temporary tenant relocations would be for shorter periods of time.
- The requirement to upgrade the existing building adds significant cost and complexity to the feasibility of this concept. While there may be way to offset these costs, the upgrades could make it difficult for tenants to remain on-site during the construction process, perhaps diminishing the potential benefit of being less disruptive for tenants. However, the requirement for upgrades does address concerns around fairness of the 3-over-3 concept, ensuring that everyone on the site is living in a safer home. Some of the costs for upgrades will be accounted for in the costs of the new structure, as the new structure would provide seismic support and improved accessibility features for the existing structure.
- With the potential to add housing more quickly and potentially not requiring temporary tenant relocation, it is worth taking this research to the next phase

by doing more in-depth analysis that is site specific and to better determine if the benefits of the 3-over-3 concept compared to redevelopment outweigh the challenges. It would be important to investigate construction timelines and safety plans for tenants remaining on-site during the construction to properly measure the potential benefits of the 3-over-3 concept. It may also be beneficial to explore if there would be different results if this concept was applied in other jurisdictions where there are different policies and bylaws.

  - Alternative construction options such as the addition of the three storeys to an existing building and alternative materials such as mass timber, have potential to unlock more safe and affordable housing faster. With BC's deep housing crisis and many people in immediate need of safe and affordable housing, options to create housing faster need to be explored.

  - Another option to consider is applying the overbuild concept using mass timber to a building that is not currently used as affordable housing, such as a non-negotiable heritage building. This could potentially mitigate costly tenant relocation or concerns about tenant safety.

- With the impacts of climate change affecting BC and having a particularly strong impact on the operations of non-profit housing, options to reduce embodied carbon and upgrade existing buildings to be more energy efficient are benefits of the 3-over-3 approach that could help offset the cost considerations.

Appendix 1: About the Existing Case Study Buildings

Chelsea Manor

Chelsea Manor at 3640 Victoria Drive, Vancouver is owned and managed by the New Chelsea Society. Chelsea Manor consists of two 3-storey wood-framed apartment buildings connected by a corridor built in 1968 and opened in 1972. The two buildings have a total floor area of 26,000 SQFT. An interconnected phase 2 building was opened in 1973; however, phase 2 was redeveloped in 2007 as a separate building. The remaining two buildings have a mix of 36 bachelor units, 12 one-bedroom units and 1 two-bedroom unit for independent singles and couples. There is also a below-grade parking lot.

The exterior walls are clad with a brick veneer on the first floor and vinyl siding on the remaining floors. The windows are original metal-framed single-glazed units. A 2-ply SBS roofing membrane protects the flat roof, and the mansard roof is protected by asphalt shingles. The roofing was replaced in 1993.

The common area is heated by a standard efficiency hydronic natural gas boiler with hydronic radiators in the hallways. The boiler was replaced in 2015 and the hydronic piping is from the original construction. Most of the units are heated by natural gas wall-mount unit heaters. Two units are heated and cooled by a heat pump. Domestic hot water is provided by two standard-efficiency direct-fired natural gas water heaters. The water heaters were installed in 2017 and 2022. The domestic water distribution piping and sanitary waste piping and hydronic piping are original. Being an older 3-storey walk-up apartment, the building lacks an elevator and sprinkler system.

Building 5

Building 5 at 1856 East Georgia Street, Vancouver is owned and operated by the BC Indigenous Housing Society. The building is a 26,400 SQFT, 3-storey, 27-unit, wood-framed apartment building built in 1987. The building has a mix of 3 one-bedroom, 12 two-bedroom, 6 3 bedroom and 4 four-bedroom units. There is also a below-grade parking lot. The building provides independent indigenous family housing.

The exterior walls are clad with original vinyl siding. The windows are original aluminum framed double-glazed units. The flat roof is protected by a 2-ply SBS, and the sloped mansard roofing is protected by asphalt shingles.

Electric baseboards provide space heating to all areas. Domestic hot water is provided by standard-efficiency natural gas boilers that were replaced in 2006. The below-grade parking lot, mechanical room and electrical room are sprinklered. The building has one elevator.

Chimo Terrace

The building at 2140 Wall Street is a 30,000 SQFT, 3-storey, 34-unit, wood-framed apartment building. The building at 2080 Wall Street is a 34,000 SQFT, 3-storey, 44-unit, wood-framed apartment building. Both buildings were built in 1971. The buildings have a mix of 41 one-bedroom and 37 two-bedroom units for independent-living singles and families. Half of the first floor of both buildings provides covered parking.

Both buildings received a full building envelope renewal in 2019. The exterior walls are clad with a rain-screened stucco system. Each of the first and second-floor units has a cantilever balcony. The windows are vinyl-framed triple-glazed units. A 2-ply SBS roofing membrane and sheet metal fascia protect the roof.

Electric baseboards provide space heating to all areas. Domestic hot water is provided by mid-efficiency natural gas boilers that were replaced in 2006. The domestic water distribution piping was also replaced in 2006 and the sanitary waste piping is original. Both buildings lack an elevator and sprinkler system.

Appendix 2: Common Assumptions for Feasibility Studies

BCNPHA and the 3-over-3 design team developed a set of assumptions to inform the level of analysis for the 3-over-3 feasibility studies. For this phase of analysis, the design team will assume certain common factors are true across the three case study sites.

The assumptions will limit the scope of this first level of analyzing the feasibility of the concept, allowing the design team to focus the initial feasibility studies on code/policy implications, structural considerations, and cost considerations, without having to do a detailed site-specific analysis. The assumptions will also help apply the findings of the feasibility studies across a range of similar buildings, not just the three case study buildings.

Application	Common Assumptions
Fire safety	1. Cross-laminated timber will be sufficient to protect the new building from the potential fires in the existing building 2. Passive fire protection technology will be used in the new building
Geotechnical	1. All sites will be assumed to have Site Class C soil rather than referencing site-specific soil conditions 2. The design team will comment on implications for structure and design of the new building if the soil is softer than Site Class C
Unit type/size	1. BC Housing's Design Guidelines and Construction Standards (2019) will inform the minimum requirements for square footage of units in the new building for each type of unit (Construction Standards & Guidelines | BC Housing) 2. Units in the new building will be designed to ensure they can be funded by BC Housing 3. Can adjust widths and depths of units within the BC Housing guidelines for minimum size to suggest what types of units can be incorporated into the new building 4. Feasibility studies should not prescribe the layouts to meet a pro forma – the new building's layout will allow for many different pro forma to choose from

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Application	Common Assumptions
Energy targets	1. Energy targets for the new building should meet Step 4 of the BC Energy Step Code to be compliant with BC Housing's requirements for funding 2. Energy targets will only be applied to the new building, not the existing building
Upgrades to existing building	1. Assume existing building will not need to be upgraded 2. If changes are necessary, use BC Housing's estimates for building upgrade costs per square foot to inform cost assumptions for updating existing building to meet current code requirements (e.g. life and safety, energy standards)
Parking	1. Parking stalls do not need to be added for the new building 2. Parking spaces can be lost for the existing building to accommodate the new structure
Form	1. The new building's footprint should not extend too far past the existing building's footprint 2. Can consider using air space of adjacent properties
Enclosure costs and design	1. The new building will use a Step 4 building enclosure 2. The enclosure will include four inches of insulation
Other spaces	1. Design of new building should assume at least one amenity room will be included (e.g. common room, laundry facility, common kitchen)
Interior finishes	1. Assume interior finishes for new building will follow BC Housing's Design Guidelines and Construction Standards (2019) (Construction Standards & Guidelines | BC Housing) 2. Cost consultant will have experience reviewing BC Housing buildings
Accessibility	1. Elevator(s) is needed for new building 2. New elevator(s) will serve existing building to improve accessibility 3. Code consultant will provide advice on how new elevator(s) can be incorporated to serve the existing building without triggering requirements to upgrade the existing building
Tenants	1. No or shorter temporary tenant relocation 2. If some temporary tenant relocation is needed to accommodate the construction of the new building, the housing operator will manage this process (how tenants would be accommodated is outside scope of feasibility study)

Appendix 3: Housing Operator Needs

It is hoped that adding three storeys to a building will have benefits for the tenants and the operations of the buildings and sites. The three operators of the case study sites shared some of the challenges at the existing buildings that could potentially be addressed through the addition of three storeys.

The shared principles are needed to balance the goals of architectural appeal, energy efficiency, and economic efficiency in order to achieve the operator's needs.

Needs	Details
Increased stock of affordable housing	• The operators of the cases study sites all have long waitlists for housing. • The rent for the new units will be more expensive than for the existing units, so need to ensure the new units are still affordable to help the operators address their waitlists. • Some operators are open to other forms of affordable housing in the new spaces, such as BC Builds and affordable market housing. • Could the existing building be converted to commercial or other types of spaces?
Fairness	• There is concern about how the disparity in the condition of the existing units versus the new units would be addressed for tenants. • What can be done to improve the condition of the existing units as part of this concept.
Improved accessibility for existing tenants	• Only one of the three case study sites has an elevator. • The existing buildings are home to seniors, people with mobility challenges, and families with young children requiring strollers. • Adding three storeys, including an elevator to access the new floors, could improve the accessibility of the existing building for tenants if the elevators are also accessible to existing storeys.

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Needs	Details
Improved access to laundry	• Without elevators, accessing laundry can be difficult for some of the tenant households, particularly those with strollers or mobility challenges. • Adding common laundry space to the new floors and improving access through added elevators could help ease challenges with accessing on-site common laundry spaces.
Operations	• Operators need to confirm they have the staffing required to operate additional spaces. • What kinds of operating funding would be available to operate the units in the new structure (some of the existing buildings have already had their operating agreements expire). • Operators reported operational challenges associated with balconies and would prefer the new units not have balconies (e.g. transfer of cigarette smoke between units, use of balconies as storage, risk of fires from e-bikes being stored on balconies). • Some buildings lack indoor amenity spaces. • Operators would like to see more space for common kitchens, a daycare or space for programming for children, more storage, etc. • Improved common bathrooms and bike storage were identified as additional needs for tenants and site staff. • Renovations could create opportunities for improved life/safety features in some of the buildings.
Improved heating and cooling for existing tenants	• Units can get too hot in the summer, especially with more extreme weather events. • Some of the outdoor spaces are currently used as misting stations during extreme heat. • Some of the buildings have single pane windows.
Opportunities to add space to the site	• Some operators wondered about acquiring additional space for the sites – e.g. using air space over adjacent sites with the new structure or acquiring the adjacent sites.

Appendix 4: Existing Zoning and Expansion Opportunities for Case Study Sites

The existing zoning and zoning parameters for the three sites are shown in Table 2. The three sites are zoned for three-storey multi-unit residential buildings. Changes to the zoning bylaw will be necessary to accommodate the additional floor above the existing structure. This was accounted for during the initial site selection process. The City of Vancouver identified RM-3A and RM-4 zoned regions that can be rezoned to accommodate 6-storey multi-unit residential buildings in Figure 4. The selected buildings fall within the regions.

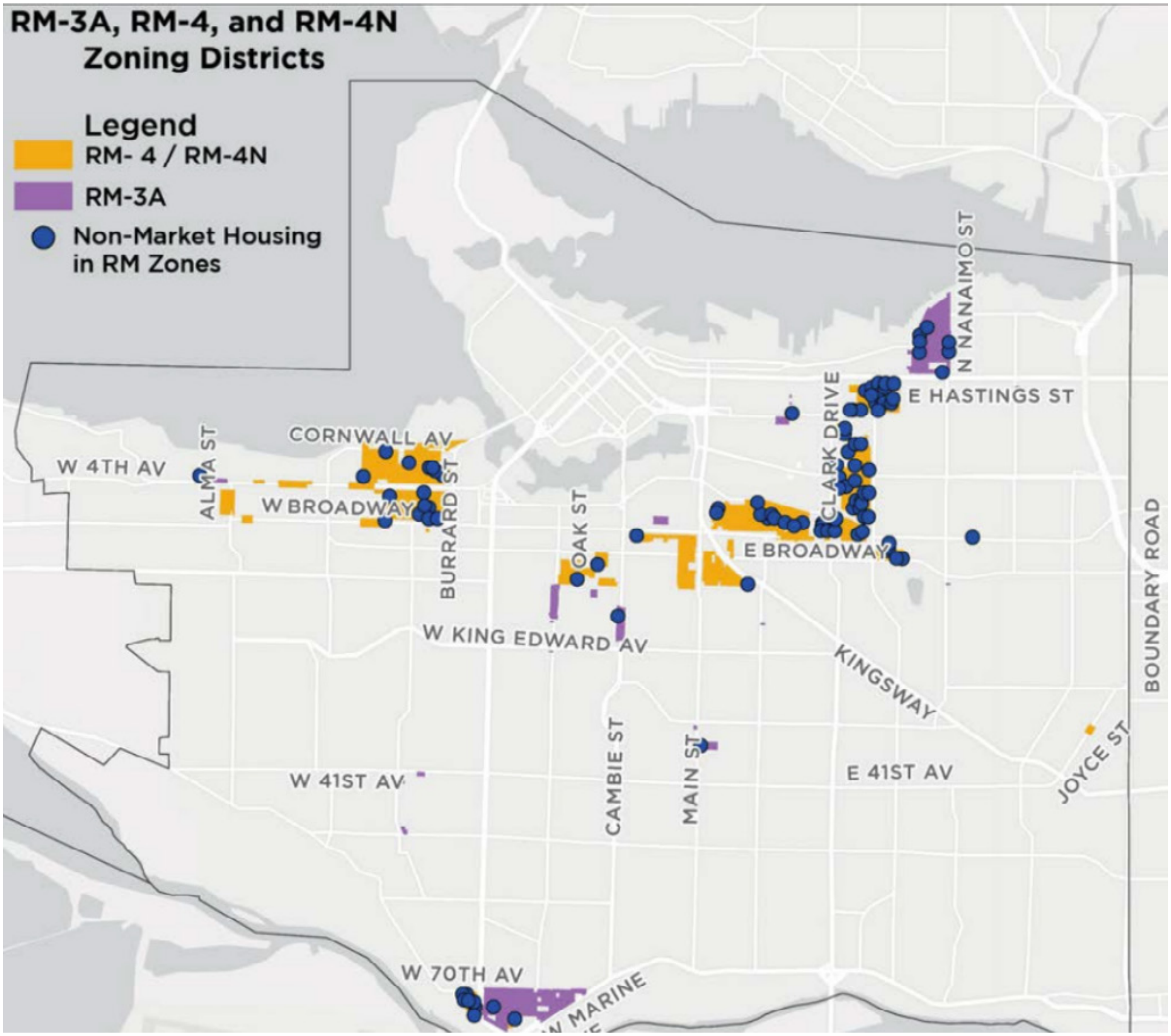
The sites allow a maximum floor space ratio (FSR) of 3.00 for social housing projects; therefore, density can be increased two to three times. The additional 3 storeys will increase the FSR at each building by two times which falls within the allowable FSR.

The sites have similar minimum setbacks for the front, side and rear yards. Based on a preliminary evaluation, some of the elevations are already built up to the minimum setback. Changes to the zoning bylaw may be necessary to accommodate the new foundations needed to support the additional three storeys.

Table 2 Existing zoning and zoning parameters

	Chimo Terrace	Chelsea Manor	Building 5
Zoning Type	RM-3A	RM-4/CD-1 (207)	RM-4
Site size (SQFT)	2140 Wall St.: 27625 ft^2 2080 Wall St.: 33964 ft^2	54256.23 ft^2	17812 ft^2
Max height	10.7 m	11.9 m	10.7 m
Max FSR	3.00 for social housing	1.00 (Need to check if social housing exception)	3.00 for social housing
Current FSR	2140 Wall St.: 1.09 2080 Wall St.: 1.00	1.27	1.48
Potential FSR increase	2140 Wall St.: 275% 2080 Wall St.: 300%	236%	203%
Min. front yard	6.1 m		6.1 m
Min. side yard	2.1 m		2.1 m
Min. rear yard	10.7		10.7

Figure 4 City of Vancouver Opportunity Zoning Map



Appendix 5: Mass Timber Resources – what is it, benefits and challenges

BC Housing. A Comparative Feasibility Study for Encapsulated Mass Timber Construction: BC Energy Step Code Compliant 7 to 12 Storey Buildings. 2024. A Comparative Feasibility Study for Encapsulated Mass Timber Construction: BC Energy Step Code Compliant 7 to 12 Storey Buildings - Research Centre - BC Housing

BC Housing. Building Insight – Vienna Housing No. 3 – Use of Wood, Prefabrication, and Mass Timber. 2024. Builder Insight - Vienna House No. 3 - Use of Wood, Prefabrication and Mass Timber

Natural Resources Canada. The State of Mass Timber in Canada in 2021. 40364. pdfAppendix 6: Building 5: Structural, Architectural, Code and Cost Reports, and Drawings

Appendix 6: Building 5: Structural, Architectural, Code and Cost Reports, and Drawings

https://bcnpha.ca/wp-content/uploads/2025/10/5._Building_5_-_Architectural_Drawings1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/4._Building_5_-_Code_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/3._Building_5_-_Class_D_Cost_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/2._Building_5_Structural_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/1._Building_5_-_Architectural_Report1.pdf

Appendix 7: Chelsea Manor: Structural, Architectural, Code and Cost Reports, and Drawings

https://bcnpha.ca/wp-content/uploads/2025/10/5._Chelsea_Manor_-Architectural_Drawings1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/4._Chelsea_Manor_Code_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/3._Chelsea_Manor_-_Class_D_Cost_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/2._Chelsea_Manor_-_Structural_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/1._Chelsea_Manor_-_Architectural_Report1.pdf

Appendix 8: Chimo Terrace: Structural, Architectural, Code, Cost and Embodied Carbon Reports, and Drawings

https://bcnpha.ca/wp-content/uploads/2025/10/5._Chimo_Terrace_-_Architectural_Drawings1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/4._Chimo_Terrace_-_Code_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/3._Chimo_Terrace_-_Class_D_Cost_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/2._Chimo_Terrace_Structural_Report1.pdf

https://bcnpha.ca/wp-content/uploads/2025/10/1._Chimo_Terrace_-_Architectural_Report2.pdf

Appendix 9: Embodied Carbon Study

https://bcnpha.ca/wp-content/uploads/2025/10/33-Chimo-Terrace-Housing-Embodied-Carbon-Study.pdf