Review of Medium Density Housing (MDH) Construction Trends

I. Apriani, C. Toma & R. Henry
The University of Auckland, Auckland, New Zealand.

ABSTRACT

Aotearoa New Zealand is facing a housing crisis driven by low supply and affordability, prompting a shift towards urban densification. In response, the central and local government has introduced intensification policies, leading to the rapid emergence of Medium Density Housing (MDH) nationwide that exhibit design variations. These policies aim to increase housing supply while providing more affordable options close to workplaces and amenities. However, the rapid change in construction form has introduced diverse architectural requirements, structural systems, and material choices, resulting in a potential variation in building performance. This study examined 72 mid-rise apartment buildings, one of the most complex forms of MDH, across New Zealand to understand recent construction trends and design drivers. Key findings include the emergence of walk-up apartments as cost-effective designs, the rise of mixed-use developments in apartment buildings, and the adoption of the mid-rise apartment within retirement village complexes. These trends contribute to the variations in building form. From the structural perspective, precast concrete construction remains prevalent in this style of building. However, there is an emerging adoption of light timber frame (LTF) in lower mid-rise apartment construction and hybrid systems to address architectural complexity. This study serves as a baseline for further studies assessing multi-criteria performance, including seismic resilience, environmental impact, cost-effectiveness, and societal needs of construction trends as the result of intensification. By addressing these criteria, the study will contribute to the development of sustainable and resilient communities in New Zealand, aligning with New Zealand's long-term housing needs and priorities.

1 INTRODUCTION

New Zealand has been experiencing a second peak in population growth since 1900. However, housing supply is responding almost one-third slower than the previous peak in 1950s (New Zealand Infrastructure Commission, 2022). This shortfall has driven a 180% rise in house prices in the past two decades, resulting in New Zealand having the highest cost-to-disposable-income ratio among OECD nations in 2020 (The Economist, 2021; The Treasury, 2022).

With the projected population to reach 6.8 million by 2048 (Stats NZ, 2022), the country requires between 23,763 and 33,305 new dwellings annually to avoid the prolonged crisis (Hong, 2021). Local and central governments have adopted strategic urban planning rules to boost housing supply. At the local level, Auckland Unitary Plan 2016 has upzoned much of the city, allowing for increased housing supply within the suburban area (Greenaway-McGrevy et al., 2021a). Similarly, Wellington City Council has initiated efforts to boost housing supply by designating special housing areas (SHAs) to support residential growth, while Christchurch City Council has encouraged private investment and improving the regulatory environment to facilitate an increase in affordable housing (Christchurch City Council, 2014; Wellington City Council, 2014). At the Central Government level, the Resource Management (Enabling Housing Supply) Amendment Act 2021 supports the National Policy Statement on Urban Development (NPS-UD) and Medium-Density Residential Standards (MDRS), enabling Medium-Density Housing (MDH) with streamlined approvals (Ministry for the Environment, 2022).

With these intensification initiatives, the country's housing stock, which standalone single-family homes had previously dominated, is shifting toward Medium-Density Housing (MDH). The transition to higher-density housing has introduced design variations that pose significant challenges and opportunities for the construction industry. While there is no standard definition of MDH in New Zealand, BRANZ has classified MDH based on type of house and number of storeys (Bryson & Allen, 2017): (a) Category 1: 1-2 storey attached houses; (b) Category 2: 2-4 storey attached dwellings; and (c) Category 3: 3-6 storey mid-rise apartment buildings.

Despite the rapid growth of MDH, there is limited research on the structural systems and design trends employed in mid-rise apartments in New Zealand. This study addresses this gap by examining structural trends and systems, highlighting strategies to meet architectural and structural demands while tackling challenges such as seismic resilience, sustainability, and cost-effectiveness. The findings aim to provide insights that contribute to the development of sustainable and resilient housing solutions aligned with New Zealand's long-term priorities.

2 SURVEY OF RECENT MID-RISE APARTMENT BUILDINGS IN NEW ZEALAND

This study broadened the scope of mid-rise apartments beyond the BRANZ definition of 3-6 storeys to include buildings ranging from 2-9 storeys while still maintaining key characteristics of mid-rise apartments, such as horizontally separated residential units, multiple units per floor, and integrated communal access features (Bryson & Allen, 2017). By extending these criteria, the study captured a wider variety of configurations, such as two-storey loft-style walk-up apartments, whose total height resembles three or four-storey buildings, and seven to nine-storey apartments, which introduced further variation in design forms. This broader definition allows for a more comprehensive understanding of the diversity and potential growth of MDH forms, providing deeper insights into New Zealand's evolving housing stock and the impact of intensification policies on residential development.

The data collection was designed to capture recent construction trends and regional variation influenced by recent intensification policies in New Zealand. Therefore, the selected locations focused on Tier 1 cities in New Zealand (Auckland, Wellington, Christchurch, Tauranga, and Hamilton). The buildings were identified through a combination of sidewalk review, desktop review, and Google Earth's Street view. After creating a list of selected buildings that meet the criteria, design documents were collected from council property files. Additionally, web searches were conducted to gather supplementary information and gain a deeper understanding of specific buildings.

Overall, 72 mid-rise apartment building design documents were collected. These buildings were developed by 34 firms, involving 32 structural engineers and 37 architects, reflecting diverse designs. Auckland, Wellington, and Christchurch, as major urban hubs, demonstrated the highest concentration of mid-rise apartments, influenced by policies encouraging sustainable growth near transport hubs and amenities. In contrast, Hamilton and Tauranga had fewer mid-rise developments, reflecting historical housing preferences and smaller populations. However, recent intensification efforts, such as Hamilton's Plan Change 12 and Tauranga's Plan Change 33, aim to increase density and boost housing supply. Despite the limited number of buildings identified in these cities at the time of data collection, their inclusion in this study provides valuable insights into regional dynamics and future trends in mid-rise apartment construction across New Zealand.

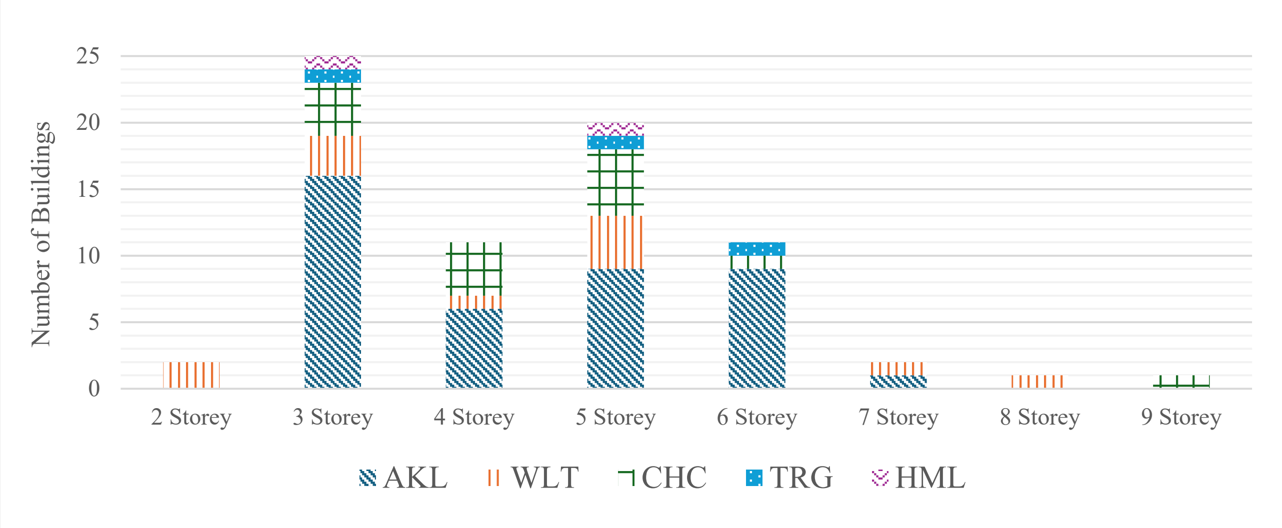


Figure 1 Number of Storeys by City

3 BUILDING CLASSIFICATION

Vertical accessibility is a key feature of mid-rise apartment buildings, with lifts serving as essential components to ensure inclusivity for building users. According to NZS 4121:2001 Design for Access and Mobility, lifts are mandatory in buildings with four storeys or more, whereas buildings up to three storeys are allowed to exclude them and rely only on stair access. The flexibility in vertical accessibility has facilitated the emergence of walk-up apartments, which have been widely adopted in other countries as an affordable housing solution in response to rapid urban population growth (Dennis, 1998; Lin & Chen, 2015; Oorschot et al., 2018). Walk-up apartments eliminate the need for elevators to simplify construction while maximizing functionality within the height limit. This study classified walk-up apartments into two distinct forms: regular and lofted-style walk-up apartments, which optimize space and functionality. These developments highlight the innovative approaches to balancing accessibility, affordability, and efficient land use in medium-density housing.

Mixed-use developments are becoming increasingly important in New Zealand's urban landscape, aligning with the National Policy Statement on Urban Development (NPS-UD) to address housing shortages and manage urban sprawl. Mixed-use apartments enhance the housing supply by integrating residential, commercial, and other functions within a single development. These buildings often require larger column-free spaces on lower levels for retail or commercial units, necessitating longer-span beams and advanced structural systems to address irregularities and seismic demands, introducing engineering complexities and higher costs. Similarly, mid-rise retirement villages are emerging to meet the growing needs of an ageing population. These developments offer compact, multi-unit living spaces with integrated shared amenities such as lounges, healthcare facilities, and recreational areas, enhancing accessibility and social engagement while increasing structural complexity.

The building distribution, as illustrated in Figure 9, shows that walk-up apartments and mixed-use developments were identified in all cities except for Tauranga, where no walk-up apartments were found. While this study only included two retirement village buildings, the emergence of mid-rise apartment types for this building form was observed across these five cities.

Table 1 presents a proposed mid-rise apartment classification based on building accessibility and functionality. These classifications underscore emerging variations of building forms, illustrating how functional requirements engineering complexities and construction challenges.

Table 1 Mid-rise apartment building forms classification

Label	Classification	Characteristics
A	Walk-up	Up to three storeys, featuring relatively simple and symmetrical building configurations, with minimal structural complexity.
B	Lofted-style Walk-up	Two-storey walk-up apartments with high ceilings designed to accommodate mezzanine levels in each unit, resulting in a vertical extension of the unit space.
C	Lifted Residential	Typically, 3 or more storeys, with uniform storey heights and more complex structural requirements due to vertical access systems like lifts.
D	Lifted Mixed-use	Exhibits height variations and additional openings, particularly on levels accommodating non-residential functions such as retail or commercial spaces.
E	Retirement Village	Features intricate designs to include communal spaces, healthcare facilities, and accessibility features tailored to the needs of elderly residents.

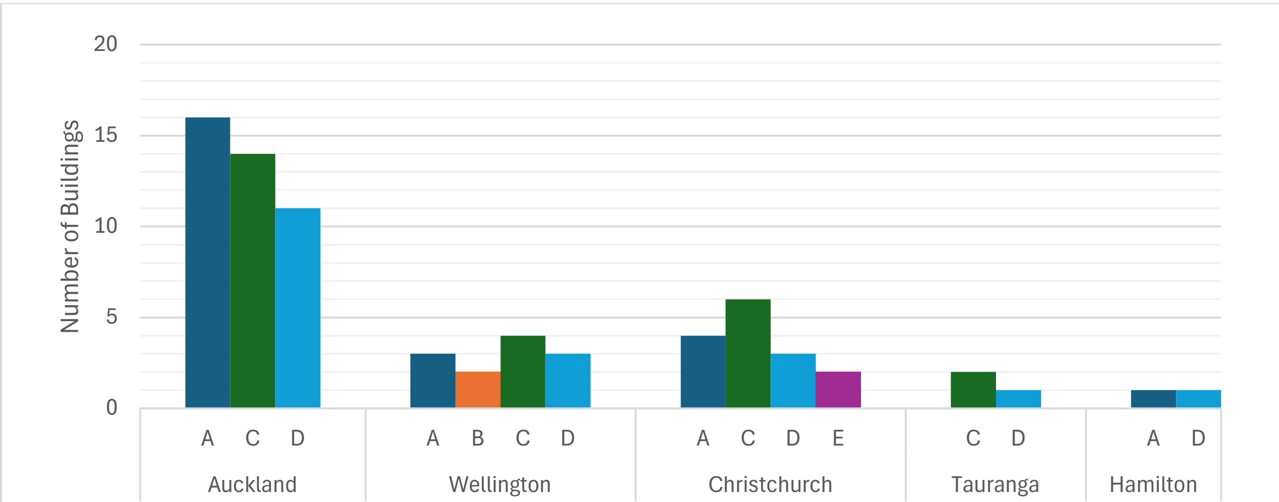


Figure 2 Mid-rise Apartment Building Forms Classification by City

4 STRUCTURAL CLASSIFICATION

4.1 Sub-structure

Traditional lower-rise residential buildings in New Zealand typically use timber piles or concrete slab foundations, which effectively distribute loads and provide stability under low structural demands. However, as housing density increases and mid-rise apartments emerge, foundation design needs to adapt to more complex structural requirements and varying site conditions.

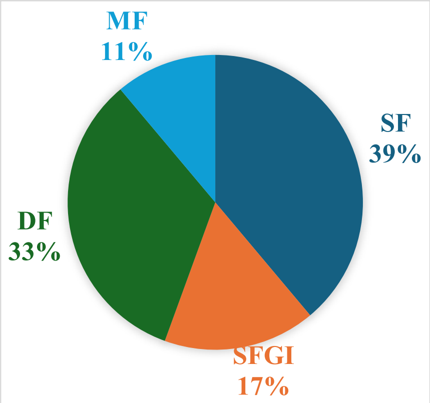
This study classified foundations based on their depth into four categories: shallow foundations (SF), deep foundations (DF), shallow foundations with ground improvement (SFGI), and mixed foundations (MF), which combines shallow foundations with deep foundations in specific sections (see Table 2). Almost 40% of the buildings utilized SF, followed by deep DF at 33%. The remaining 30% of buildings were split between SFGI and MF. Regarding building form distributions, walk-up apartments relied predominantly on shallow foundations (50%), whereas most non-walk-up apartments utilized deep foundations (43%).

Regionally, Auckland exhibited a relatively balanced distribution of shallow and deep foundations, whereas deep or mixed foundation systems dominated buildings in Wellington. In Christchurch, more than half of the buildings were designed with shallow foundations combined with ground improvement, while 25% utilized deep foundations. In Tauranga, the three identified buildings featured a mix of shallow foundations (SF), shallow foundations with ground improvement (SFGI), and deep foundations (DF). Finally, both buildings in Hamilton's city centre were designed with shallow foundations.

Overall, concrete bored piles were the predominant foundation type among deep foundations, whereas, in shallow foundations, a combination of strip and pad footings was the most common.

Table 2 Foundation in Mid-rise apartment buildings classification

Label	Classification	Description	Type of Foundation/Ground Improvement
SF	Shallow foundation	Used where the load-bearing capacity of the soil near the surface is sufficient to support the structure	Pad footing Strip footing Rib raft foundation
SFGI	Shallow foundation with ground improvement	These systems involve SF enhanced with mechanical ground improvement techniques to increase soil stability and load-bearing capacity.	Rammed Aggregate Piers (RAP) Stone column ground improvement Full Displacement Concrete Pile
DF	Deep foundation	Deep foundations are employed when shallow soils cannot provide adequate support.	Concrete bored pile Timber driven pile Micro piles Steel screw pile
MF	Mixed foundation	Mixed foundations combine SF and DF to address variable soil conditions across a site	Combination of SF&DF



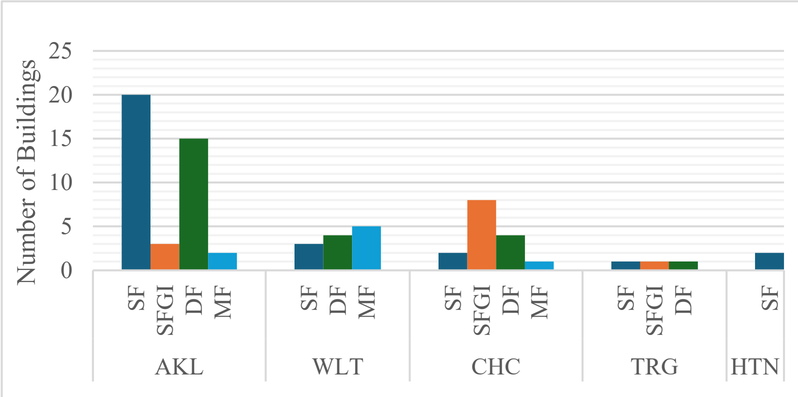


Figure 3 Proportion of Foundation System

Figure 4 Foundation Distribution by City

4.2 Superstructure

Overall, this study classified the superstructure based on lateral-load resisting system, considering structural systems and materials. Table 3 and Figure 4 present the classification and distribution of these systems within the building database.

Reinforced concrete walls (RCW) were the predominant lateral-resisting system, used in 45% of buildings as a single lateral system across Auckland, Wellington, and Christchurch. In mid-rise apartment buildings, RCW configured multiple functions, including intertenancy walls, external perimeter walls, and core walls for lifts and stair shafts. To accommodate larger openings, RCW was combined with Steel Frames (SF) in 8% of buildings (RCW&SF) across Auckland, Christchurch, and Tauranga, while RCW with Reinforced Concrete Frames (RCF) was observed in only one building. Another wall system identified in mid-rise apartments was Reinforced Masonry Walls (RMW), which utilized concrete block walls. Similar to RCW, RMW functioned as intertenancy walls, external perimeter walls, lift core-walls, and stair shafts. However, RMW was significantly less common, with only 5% of buildings incorporating this system distributed across Auckland and Christchurch.

Framing systems were also identified in mid-rise apartments, including Reinforced Concrete Frames (RCF) and Steel Frames (SMRF), Concentric Braced Frames (CBF), Buckling-Restrained Braced Frames (BRBF), or combinations of these systems. In this study, combinations of steel frame systems were classified as SF. While only one building utilized RCF, exclusively in Auckland, 11% of the buildings in the database featured SF systems, distributed across all other cities except for Auckland.

In low-rise residential buildings, Light Timber Frame (LTF) construction has been a dominant structural system for low-rise residential buildings in New Zealand due to the abundance of timber, a robust timber industry, and familiarity among builders (Isaacs, 2010). These buildings utilized plywood or plasterboard shear walls as lateral bracing elements. This study observed that LTF construction emerged, especially in walk-up apartments that share similar configurations with terraced houses, accounting for 14% of building database and distributed across Auckland, Wellington, and Christchurch. The use of mass timber structures in mid-rise apartment buildings was also observed. Mass timber systems, such as Laminated Veneer Lumber (LVL) and Cross-Laminated Timber (CLT), were identified in two Christchurch buildings, demonstrating the growing adoption of engineered timber solutions for multi-storey residential construction.

Some buildings featured more complex lateral load-resisting systems, incorporating multiple lateral resisting structural systems in one building. This combination included RCW&RMW, LTF&RCW, SF&RMW, and RCW&RCF. These buildings were categorized under the Mixed Structural System (MS) classification.

A notable finding was a building incorporating base isolation in Christchurch to achieve Low Damage Design (LDD), which was classified as BI in this study. The building featured RCWs designed to remain fully elastic under seismic events. This example highlights diversity within New Zealand residential building stocks, where LDD strategies are increasingly adopted in high-seismic regions to improve building performance and resilience.

Table 3 Structural system in Mid-rise apartment buildings classification

Label	Classification	Description
RCW	Reinforced Concrete Walls	RCW serves as single lateral load-resisting elements, intertenancy walls, exterior walls, stair shaft, and lift core walls.
RMW	Reinforced Masonry Walls	RMW serves as single lateral load-resisting element, intertenancy walls, exterior walls, stair shaft, and lift core walls.
RCF	Reinforced Concrete Frames	RCF serves as a moment-resisting system, providing both lateral and gravity load resisting elements
SF	Steel Frames	SF serves as a moment-resisting system, providing both lateral and gravity load resisting elements, designed as MRF, CBF, BRBF, or their combinations.
LTF	Light Timber Frame	LTF with lateral bracing elements typically plywood or plasterboard sheathed walls.
TS	Timber Structure	Mass timber structure, sometimes combined with LTF, serves as lateral resisting structure and gravity element
RCW&SF	Reinforced Concrete Walls and Steel Frame	Combination of RCW and SF act as dual lateral system or lateral resisting system in orthogonal directions.
MS	Mixed-Structural System	Complex combinations between lateral load resisting system other than RCW&SF.
BI	Base Isolation	Building with isolation system between superstructure and foundation to achieve low damage design (LDD) objective.

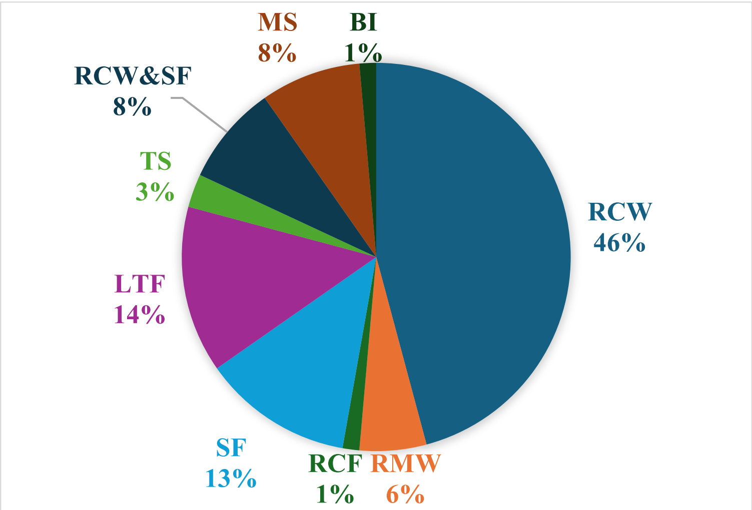


Figure 5 Proportion of Structural System

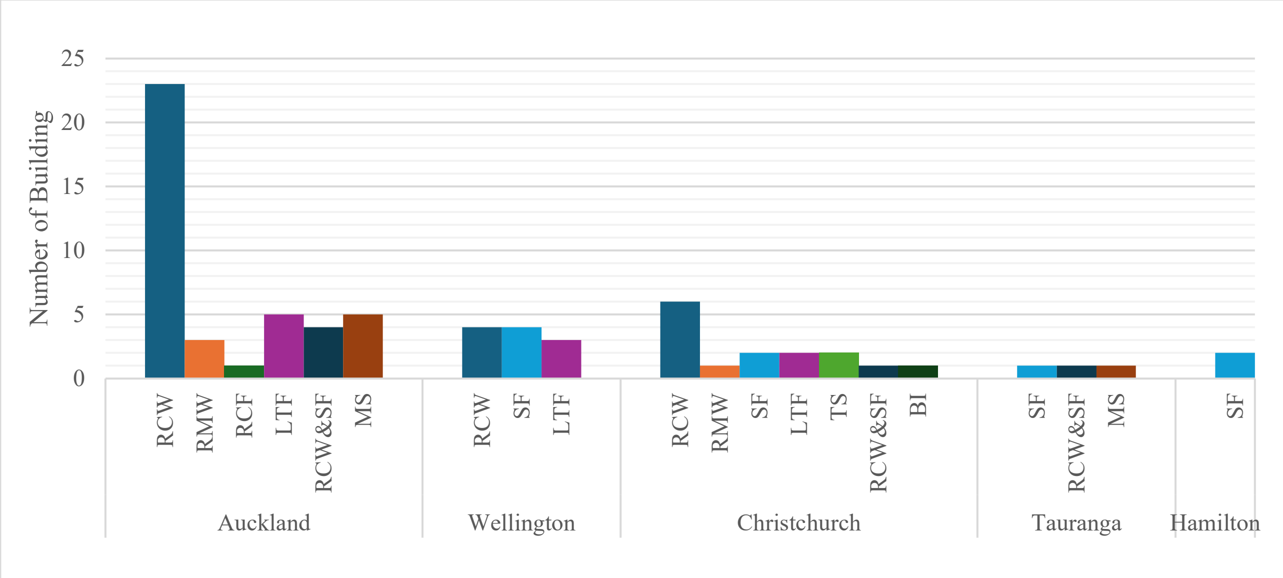
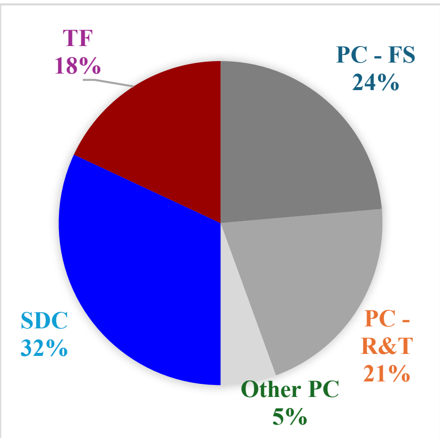


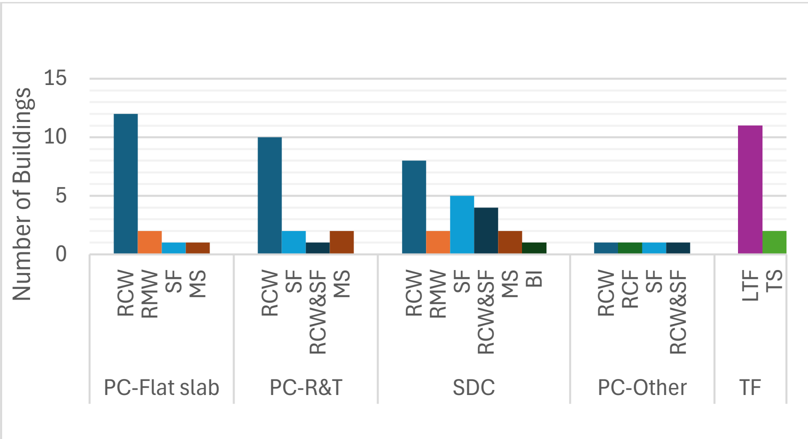
Figure 6 Distribution of Structural Systems by City

4.2.1 Suspended floor

Suspended floors in mid-rise apartment buildings, as identified in the building database, are presented in Figure 7 and Figure 8. Precast Concrete (PC) floors were the most prevalent flooring system, accounting for 50% of the database, with nearly equal proportions of precast flat slabs (PC-FS) and precast ribbed slabs with timber infill (PC-R&T). However, when considered individually, steel deck composite (SDC) floors were the most widely used (32%) and applied across a broader range of structural systems. These flooring systems follow a similar construction approach, where the first layer serves as both the structural floor and permanent formwork, improving construction efficiency by reducing temporary formwork, waste, and labour costs. The top layer, incorporating cast in-situ concrete topping, ensures a monolithic connection to structural elements and functions as a diaphragm for lateral load distribution.

While concrete and steel-based buildings utilized varied suspended floor systems, all timber structures exclusively relied on timber flooring. Timber floors were solely used in timber structures, with no other structural system incorporating them. Timber flooring in the building database is classified into joist floors and CLT panel floors.





PC-FS: Precast flat slab; PC – R&T: Precast rib&timber infill; Other PC: Other type of precast floor; SDC: Steel deck composite; TF: Timber floor

Figure 7 Proportion of Suspended floor *Figure 8 Suspended floor distribution by structural system*

4.2.2 Ductility

The distribution of design ductility in this study shows that 60% of buildings were designed for a nominally ductile response ($\mu = 1.25$), 31% were limited ductile ($\mu < 3$), and 10% were classified as ductile structures ($3 < \mu < 6$). RCW buildings were predominantly nominally ductile (85%), with all RCW buildings in Auckland falling into this category (NZS 1170.05, 2004). In contrast, limited ductile RCW budlings were identified only in Wellington and Christchurch, where the area required higher seismic demands. Steel Frame (SF) buildings exhibited a broader ductility range, with nearly 70% classified as ductile in one or both lateral load directions, while the remaining buildings were classified as elastic to nominally ductile. Mid-rise apartment buildings with Light Timber Frame (LTF) structures were designed with ductility levels ranging between 2 and 3.5.

All mixed systems combining RCW and SF in Auckland were nominally ductile, while two similar buildings in Christchurch and Tauranga were designed as ductile structures. Other mixed structural systems demonstrated varied ductility classifications depending on the combination of lateral load-resisting elements and regional seismic demands.

5 DISCUSION AND FUTURE WORK

This study explored the structural systems and design trends in mid-rise apartment buildings as one of emergence trend in Medium-Density Housing (MDH) intensification across New Zealand. The variations in building forms were influenced by affordability, mixed-use development, and the needs to boost housing supply for across New Zealand community. This trend is evident in emergence of walk-up apartment buildings and mixed-used development across New Zealand's major cities. While in Auckland mid-rise apartment buildings were distributed across suburbs, in other metropolitan cities like Christchurch and Wellington remained concentrated around city centre, with only few found in Christchurch suburbs. In Hamilton and Tauranga, mid-rise apartments were less prevalent, but ongoing intensification efforts suggest the potential for future growth of this building typology.

Reinforced concrete walls found as the predominant structural solution for mid-rise apartments. However, Light Timber Frames (LTF) with plywood or plasterboard bracing elements, traditionally used in low-rise structures, have been adopted in mid-rise construction due to material availability and cost efficiency. Mixed structural systems have also emerged to accommodate complex architectural needs, yet their robustness and construction detailing require further assessment. In terms of regional structural system distribution, Auckland and Christchurch exhibited greater variation in structural systems, while Wellington, despite having a considerable number of buildings, predominantly adopted a single structural system. In Tauranga, no identical building typologies were observed, whereas in Hamilton, both identified buildings exclusively utilized Steel Frame (SF) systems.

This study also highlighted variations in ductility levels influenced by variation in structural system and seismic demands. While RCW buildings in Auckland were nominally ductile ($\mu = 1–1.25$), Wellington and Christchurch featured limited ductile ($\mu < 3$) and ductile structures ($3 < \mu < 6$), reflecting higher seismic requirements.

Future work will involve engaging directly with stakeholders, including architects, structural engineers, and developers, to gain deeper insights into the factors influencing design decisions. By understanding these considerations, future research can better address the interplay of cost-effectiveness, sustainability, and structural resilience in mid-rise apartment construction. These discussions will also help identify areas for improvement in current practices and foster innovation in the design of MDH.

REFERENCES

Bryson, K., & Allen, N. (2017). *Study Report SR376: Defining medium-density housing*. BRANZ. https://www.branz.co.nz/pubs/research-reports/sr376/

Christchurch City Council. (2014). *Christchurch Housing Accord*. Christchurch City Council. https://www.ccc.govt.nz/assets/Documents/Services/Social-Housing/Christchurch-Housing-Accord-2017-Final.pdf

Dennis, R. (1998). *Apartment Housing in Canadian Cities, 1900–1940*. Urban History Review, *26*(2), 17–31. https://doi.org/10.7202/1016656ar

Greenaway-McGrevy, R., Pacheco, G., & Sorensen, K. (2021a). *The effect of upzoning on house prices and redevelopment premiums in Auckland, New Zealand*. Urban Studies, 58(5), 959–976. https://doi.org/10.1177/0042098020940602

Hong, L. (2021). *The Need to Build: The demographic drivers of housing demand*. The New Zealand Initiative. https://www.nzinitiative.org.nz/reports-and-media/reports/the-need-to-build/?0=

Isaacs, N. (2010). *Timber framing – rapid and reliable*. Building History

Lin, J.-A., & Chen, L.-C. (2015). *The Modern Vernacular Reassessed: The Socioarchitectural Origin of the Taipei Walkup Apartments*. Journal of Urban History, *41*(5), 908–926. https://doi.org/10.1177/0096144214566963

Ministry for the Environment. (2022, May). *Understanding the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021*. Ministry for the Environment – Manatū Mō Te Taiao. https://environment.govt.nz/assets/publications/understanding-the-RMA-EHS-general-overview.pdf

New Zealand Infrastructure Commission. (2022). *The decline of housing supply in New Zealand: Why it happened and how to reverse it*. New Zealand Infrastructure Commission / Te Waihanga, Te Waihanga Research Insights series.

Oorschot, L., Spoormans, L., El Messlaki, S., Konstantinou, T., De Jonge, T., Van Oel, C., Asselbergs, T., Gruis, V., & De Jonge, W. (2018). *Flagships of the Dutch Welfare State in Transformation: A Transformation Framework for Balancing Sustainability and Cultural Values in Energy-Efficient Renovation of Postwar Walk-Up Apartment Buildings*. Sustainability, 10(7), Article 7. https://doi.org/10.3390/su10072562

Standard New Zealand. 2004. NZS1170.5: *Structural design actions Part 5: Earthquake actions – New Zealand*. Standards New Zealand

Stats NZ. (2022). *National population projections: 2022(base)–2073*. https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/

The Economist. (2021, April 16). *Global house-price index: Our interactive guide to housing data across the world*. The Economist. https://www.economist.com/graphic-detail/global-house-prices

The Treasury. (2022). *Housing affordability in Aotearoa New Zealand: The importance of urban land supply, interest rates, and tax*. https://www.treasury.govt.nz/sites/default/files/2022-09/sp-housing-affordability-aotearoa-new-zealand-9sep22.pdf

Wellington City Council. (2014). *Wellington City Housing Accord*. Wellington City Council. https://wellington.govt.nz/your-council/plans-policies-and-bylaws/policies/housing-accord