MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Te Kāwanatanga o Aotearoa
New Zealand Government

Building and Construction Sector Trends

ANNUAL REPORT 2023

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Ministry of Business, Innovation and Employment (MBIE) Hīkina Whakatutuki – Lifting to make successful

MBIE develops and delivers policy, services, advice and regulation to support economic growth and the prosperity and wellbeing of New Zealanders.

MORE INFORMATION

Information, examples and answers to your questions about the topics covered here can be found on our website: **www.mbie.govt.nz.**

DISCLAIMER

This document is a guide only. It should not be used as a substitute for legislation or legal advice. The Ministry of Business, Innovation and Employment is not responsible for the results of any actions taken on the basis of information in this document, or for any errors or omissions.

The results in this report are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), which is managed by Statistics New Zealand (Stats NZ). The insights presented in this report are the work of author(s), not Stats NZ. The anonymised data used in this report was provided by Stats NZ under conditions that protect the security and confidentiality of the data, as required by the Data and Statistics Act 2022. For more information about the IDI, please visit **www.stats.govt.nz/integrated-data**.

ONLINE: ISSN 2744-6743

FEBRUARY 2024

Please cite this report as: Ministry of Business, Innovation and Employment (2024). *Building and Construction Sector Trends – Annual Report 2023.*

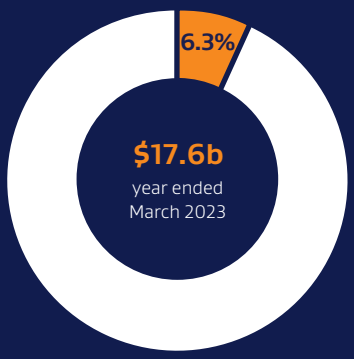
Contents

Executive Summary

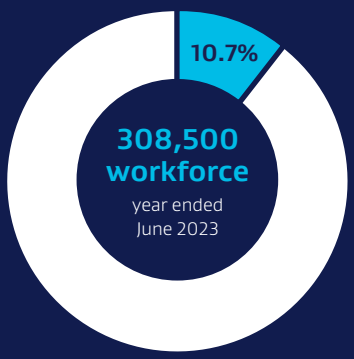
The New Zealand building and construction sector continues to evolve amidst changing conditions and global trends. This report highlights key insights into the sector's performance and emerging trends between July 2022 and June 2023.

THE BUILDING AND CONSTRUCTION SECTOR IS A MAJOR CONTRIBUTOR TO NEW ZEALAND'S ECONOMY:

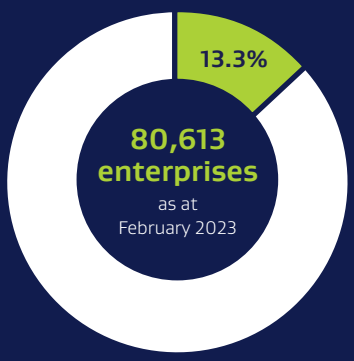
Real GDP



Employment



Businesses



Sector Performance

FOLLOWING A PERIOD OF STRONG POST-PANDEMIC GROWTH, THE CONSTRUCTION SECTOR IS EXPERIENCING A SLOWDOWN DUE TO RISING ECONOMIC UNCERTAINTIES AND SOFTENING DEMAND.

New dwelling consents have returned to more sustainable levels after a period of record-high residential consents in early 2022.

Investment in infrastructure is expected to drive construction activity, particularly in Cyclone Gabrielle recovery efforts.

The construction workforce continues to grow but labour shortages persist.

Economic uncertainty and high construction costs impacted business confidence and growth in 2022. However, business confidence has improved in 2023 as inflationary pressures ease and disruptions diminish.

Global Innovation Trends

THE GLOBAL CONSTRUCTION INDUSTRY IS UNDERGOING A RAPID TRANSFORMATION DRIVEN BY INNOVATIVE BUILDING DESIGN, TECHNOLOGIES AND MATERIALS.

New Zealand's commitment to climate change mitigation aligns with the global movement towards sustainable construction practices, with a shared goal of achieving net zero carbon emissions by 2050.

Global building design trends increasingly embrace low-carbon, sustainable principles, giving rise to net-zero (operational) carbon, regenerative, passive and biophilic structures.

Emerging building technologies offer integrated solutions that enhance efficiency, productivity and safety in the construction process.

A global call to embrace circular economy through *reuse, renew* and *reduce* practices is driving a shift towards earth-based, bio-based and low-carbon materials.

Introduction

The building and construction sector is a vital pillar of New Zealand's economy. For the year ended March 2023, it contributed 6.3 per cent of the country's real Gross Domestic Product (GDP) – amounting to over NZ$17.6 billion[1,2]. It also employed nearly 308,500 people (or 10.7 per cent of the country's total workforce) in the year ended June 2023.

The sector's contribution to GDP has grown modestly since the early 2000s. However, this upward trend has slowed since the latter part of 2022. The sector faced several challenges over this period, including mounting inflation, rising interest rates, and severe weather events. Despite these setbacks, non-residential construction building activity increased by 28.3 per cent over the year to June 2023.

Events over the past year, particularly the Auckland Anniversary floods and Cyclone Gabrielle, highlighted New Zealand's vulnerabilities to climate threats and the urgent need for robust disaster response, recovery, and adaptation strategies. In response to these, the government allocated an initial NZ$6 billion for the National Resilience Plan (The Treasury, n.d.) to 'build back better' from recent weather events, and future-proof and strengthen critical infrastructure networks.

Strategic investment and sustainable practices are essential for fostering a resilient construction sector in the future. New Zealand's innovation goals are aligned with global sustainable construction efforts, as demonstrated by various initiatives undertaken by the government and the industry. The Building for Climate Change Programme envisions near zero building-related emissions by 2050 (MBIE, n.d.). In line with this vision, new policies such as the *Building (Modular Component Manufacturer Scheme) Regulations 2022* (Parliamentary Counsel Office, 2022) and the upcoming Building Act Amendments (MBIE, 2022a), aim to enhance modular building standards and climate resilience. Alongside these regulatory initiatives, voluntary metrics emphasise New Zealand's transition towards a more sustainable construction industry. These metrics include the New Zealand Green Building Council Green Star rating (New Zealand Green Building Council, n.d.), the Homestar rating system (New Zealand Green Building Council, n.d.), and the Passive House certification (Passive House Institute New Zealand, n.d.). Moreover, through the Construction Sector Accord (the Accord), the industry and government have collaborated to implement a range of initiatives to tackle the sector's challenges and foster resilience within the building industry.

Local and global ripples in construction

New Zealand experienced several severe weather events in 2023, including the Auckland Anniversary flooding and Cyclone Gabrielle. The Auckland Anniversary flooding in January caused extensive damage to infrastructure, homes, and businesses in the Auckland region. Cyclone Gabrielle which followed in February dealt widespread damage to the upper and central parts of the North

[1] Annual GDP figures for the year ended March 2023 has been revised in the September release - Gross domestic product: September 2023 quarter | Stats NZ

[2] as expressed in 2009/10 prices

Island. The Treasury estimates the total damage of these events to range between $9 billion to $14.5 billion (The Treasury, 2023a).

This widespread damage requires a significant amount of rebuilding and repair work and is expected to stimulate demand for building and construction services in the foreseeable future (The Treasury, 2023b). To address this need, the New Zealand Government allocated a billion-dollar flood and cyclone recovery package as part of Budget 2023 (National Emergency Management Agency, 2023). The package prioritises essential repairs to roads, railways, and schools, while also investing in proactive measures to prepare for future events and enhance flood protection.

The war in Ukraine was one of the most significant geopolitical events impacting the global economy, including New Zealand, in 2023. Shortly after the war started in February 2022, the New Zealand's Foreign Affairs and Trade assessed that the most significant impacts of the war would be indirect primarily through higher fuel and commodity prices, financial market volatility and the potential drag on global economic activity (New Zealand Foreign Affairs and Trade, 2022). In August 2023, the New Zealand Security Intelligence Service reported that the ongoing impacts of Russia's invasion of Ukraine are being felt internationally through disruptions to supply chains (New Zealand Security Intelligence Service, 2023).

The conflict had some impacts on the construction industry, both directly and indirectly. Global oil prices rose sharply in response to the conflict, increasing the cost of fuel for transport and machinery used in construction projects. It also affected the supply and demand of other commodities used in construction, such as aluminium (Reserve Bank of New Zealand, 2022). However, the global chain disruptions from the war have since eased and the prices of commodities, particularly oil, have now stayed lower than their peaks in early 2022.

Purpose of the report

This report provides an overview of the significant trends in New Zealand's building and construction sector - offering insights into its current state, challenges, and opportunities. It also sheds light on global innovations in building design, technologies, and materials.

The report contributes to fulfilling the requirement of Section 169 of the Building Act (2004) (Parliamentary Counsel Office, 2023), which mandates the Chief Executive to monitor current and emerging trends in building design, technologies, and related matters, and to provide an annual report to New Zealand's Minister for Building and Construction.

Research approach and limitations

This report draws upon extensive desktop research conducted between May and September 2023. Construction sector data is primarily sourced from Statistics New Zealand (Stats NZ), with additional insights derived from the Building System Insights Programme (BSIP) products, such as the State of the Building and Construction Sector 2022. Other industry reports, research papers, and surveys from various sources also contributed to the analysis. A comprehensive list of all data sources used can be found in the References section on page 40.

The data presented in this report covers the period from 1 July 2022 to 30 June 2023. While this timeframe served as the primary focus, certain annual comparisons required adjustments to specific reporting months to align with data availability. These adjustments were clearly indicated throughout the report.

This report acknowledges the following caveats:

- The data presented, particularly in figures and tables, is valid for the dates specified.
- Certain data, such as GDP and workforce, are subject to ongoing reviews. Figures included were accurate at the time the desktop review was undertaken but may not be the most recent at time of publication. We advise caution when using these figures.
- Identified trends are based on the information available at the time of research and are subject to change due to various factors, including market conditions, regulatory changes, or unforeseen events (such as natural disasters and pandemics).

Workforce Dynamics and Demographics

Construction is one of the largest employment sectors

The construction industry is the third largest employing industry in New Zealand, accounting for 10.7 per cent of the country's total workforce for the year ending June 2023. In that period, there were approximately 308,500 workers employed in construction, an increase of 13,700 workers compared to 2022. Over the last decade, strong growth in building activity has been reflected in employment gains. There was an increase of 140,800 workers from 167,200 in 2013, representing an annualised growth rate of 6.3 per cent. This is more than double the 2.8 per cent annualised growth rate of all industries. These figures demonstrate the steady and sustained growth of the construction sector over the past decade.

Figure 1: Annual employment in construction sector (year ended June 2013-2023)

Over the year to June 2023, the construction sector played a prominent role in driving the overall increase in filled jobs, according to Stats NZ's *Quarterly Employment Survey* (2023a). There were 17,100 more filled jobs in construction in the June 2023 quarter compared to the June 2022 quarter. This growth has been driven by a combination of factors, including ongoing population growth, a strong pipeline of housing and infrastructure projects, and increasing demand for construction services. As a result of these factors, construction has become one of the sectors with the highest percentage growth in filled jobs in recent years.

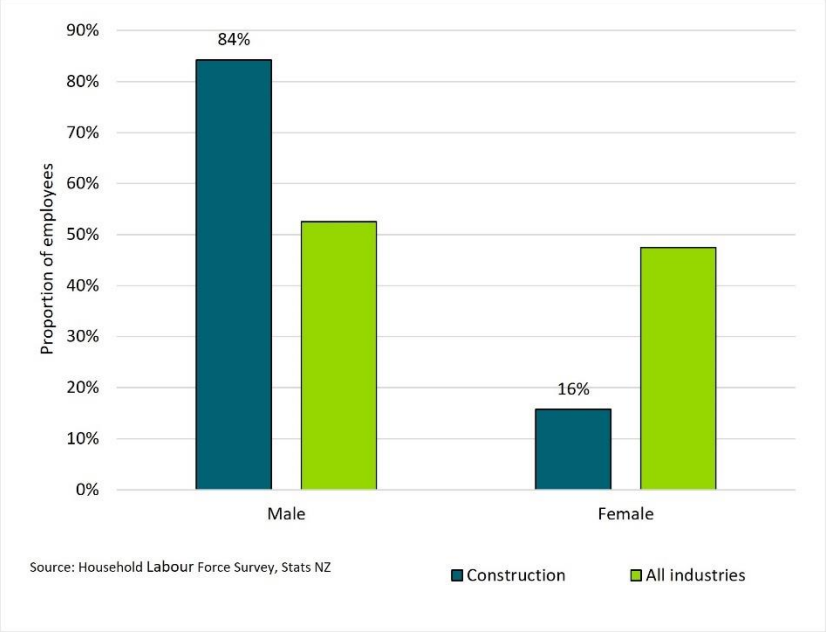
The number of construction jobs being added (as measured in filled jobs) in New Zealand continues to grow, increasing 9.7 per cent in the year to June 2023, including a 3.1 per cent increase over the June 2023 quarter. This marks the highest annual growth rate since the year ended March 2022, when it reached 10.6 per cent. Within this overall growth, the construction sector ranked sixth among all sectors in terms of filled jobs growth during the June 2023 quarter. It trailed sectors such as transport,

accommodation and food services, financial and insurance services, information and telecommunication and arts and recreation.

Construction makes strides in diversity but remains behind other sectors

Women are underrepresented in the construction sector. Based on data from the Household Labour Force Survey (HLFS) for year ended June 2023 (Stats NZ, 2023b), women make up 47.4 per cent of the overall New Zealand workforce. The construction sector ranks second to last (the last being mining industry) in terms of women representation, with only 15.8 per cent of those employed in the industry being women. Figure 1 shows that of the growth in the construction sector workforce in the year to June 2023, 10,100 workers were male and 3,600 were female.

Figure 2: Construction sector workforce by sex (as at December 2022)



Despite construction remaining a highly male-dominated industry, HLFS data shows that the proportion of women in the construction workforce has been increasing over the past decade. From 11.3 per cent in 2013, the share of women working in the construction sector rose to 15.8 per cent in 2023. This trend translates to an increase in the number of women workers from 18,900 in 2013 to 48,600 in 2023, representing a 157.1 per cent growth or an additional 29,700 women workers in the sector. This growth rate outpaced the 75.3 per cent increase in the number of male workers during the same period.

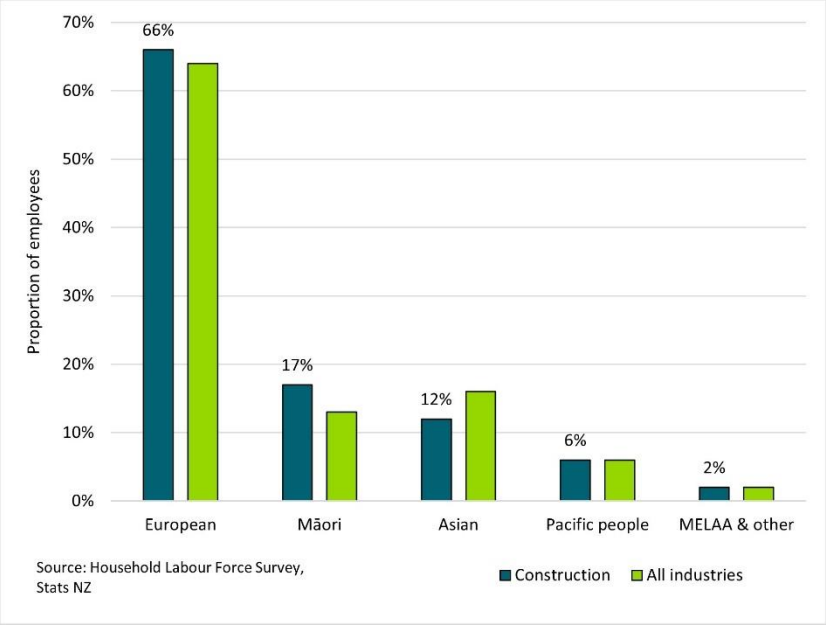
According to Stats NZ's quarterly Linked Employer-Employee Dataset (LEED) (Stats NZ, 2023c) for the construction sector, the average worker turnover rate for women was 13.3 per cent between June quarter 2018 and June quarter 2023. This is almost similar to the turnover rate for male workers at 13.0 per cent.

In terms of occupational distribution, almost one-third of women in construction are employed in office and administrative positions, compared to just one per cent of male workers. In recent years,

industry efforts focused on promoting gender diversity have attracted more women into construction trades and professional services sectors. As of December 2022, there were 1,926 female apprenticeships in the construction sector, a 10 per cent increase compared to the same period in 2021 (Ministry of Education, 2023a). Enhancing gender diversity and developing a pipeline of skilled female construction workers needs a comprehensive approach. This may involve exploring strategies to provide clear pathways into construction careers, such as apprenticeships and traineeships, and examining ways to address barriers that may discourage women from pursuing careers in the construction industry.

The ethnic makeup of the construction workforce is changing. The proportion of workers in the sector who identify as European decreased by 11 per cent between 2018 and 2022. Over the same period, the proportion who identify as Māori increased from 12 to 17 per cent, and Asian workers increased from 9 to 12 per cent. The proportion of Pacific peoples also increased from four per cent in 2018 to six per cent in 2022.

Figure 3: Construction sector workforce by ethnicity (as at December 2022)



Workers who identify as Māori are overrepresented as labourers in the construction sector but training data indicates more Māori are also pursuing higher-skilled careers in construction. More than one in five Māori workers in the sector are labourers, compared to one in ten among non-Māori workers. However, over the past five years, the proportion of Māori learners who enrolled in construction-related tertiary programmes has been growing. This growth suggests that more Māori are pursuing qualifications and training that can lead to higher-skilled and more rewarding careers in the construction industry. For example, three quarters of Māori learners studying construction-relevant qualifications are enrolled at Te Pūkenga subsidiaries (Ministry of Education, 2023b).

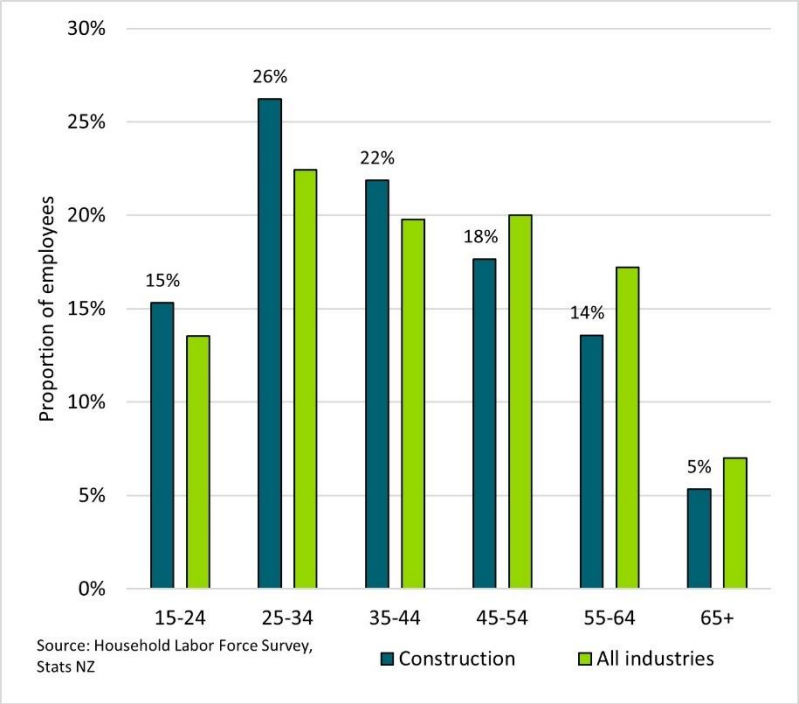
While the ethnic distribution of learners enrolled in New Zealand Qualifications Authority Level 4 qualifications mirrors the national population percentages, Māori and Pacific learners are overrepresented in qualifications below level 4 and underrepresented in qualifications above level 4 (Ministry of Education, 2023a). This suggests that Māori and Pacific learners are more likely to gain

qualifications below level 4, such as certificates and diplomas, than they are to gain qualifications above level 4, such as degrees. This disparity highlights the need for targeted support to Māori and Pacific learners to encourage them to pursue higher levels of education and gain qualifications that lead to more skilled and better paying jobs in the construction industry.

More construction workers are reaching retirement age. In the year ended December 2022, construction workers aged 55 and above make up 18.8 per cent of the construction workforce. Over the last decade, the number of construction workers from this age group increased from 6,000 in 2013 to 15,500 (an increase of 158.3 per cent), while the number of workers aged 15 to 24 years increased from 24,500 to 44,500 (an increase of 81.6 per cent). This means that within 10 years, nearly 20 per cent of construction workers will be reaching retirement age, while fewer young people are entering the construction sector.

To address the ageing profile of the construction workforce, the industry has taken steps to attract younger workers. Apprenticeships are helping attract and train younger workers to meet the future demand for skilled tradespeople. Initiatives such as the government's Apprenticeship Boost Programme (Te Pūkenga – New Zealand Institute of Skills and Technology, 2023) supports businesses to keep existing apprentices and hire new ones as part of New Zealand's recovery from the economic impacts of COVID-19. As of June 2023, 26,855 architecture and building-related apprentices have been supported through the programme. The three most common occupational training areas for these apprentices were carpentry and joinery (59.1 per cent); plumbing, gas fitting and drain laying (14.0 per cent); and painting, decoration, sign writing and other finishes (6.0 per cent).

Figure 4: Construction sector workforce by age band (as at December 2022)



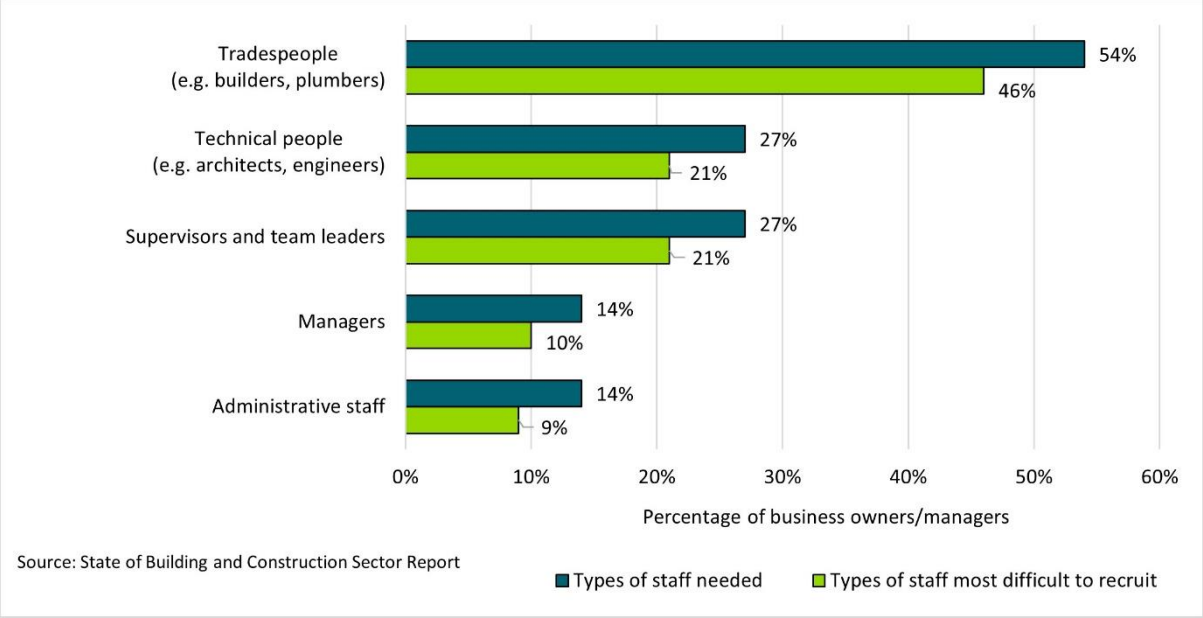
Labour constraints and skills shortages persist in the construction sector

The New Zealand construction sector has struggled to attract skilled labour for the past decade. Research from the Infrastructure Commission estimated that the infrastructure workforce would need to grow from around 40,000 to 97,000 over the next 30 years to fully address New Zealand's infrastructure needs (Infrastructure Commission, 2021). A construction workforce model from Waihanga Ara Rau forecasts that on average, about 600 full-time equivalent (FTE) employees are required each quarter for the residential recovery work damaged by Cyclone Gabrielle over the next two years (New Zealand Infrastructure Commision, 2022; Waihanga Ara Rau, n.d.).

BDO New Zealand's 2021 Construction Sector Report also found that the current labour shortages are due to the cyclical nature of construction activity and the high levels of building activity. It found that around 53 per cent of respondents were actively looking for on-site staff, up from around 45 per cent in 2020. (BDO New Zealand, 2021).

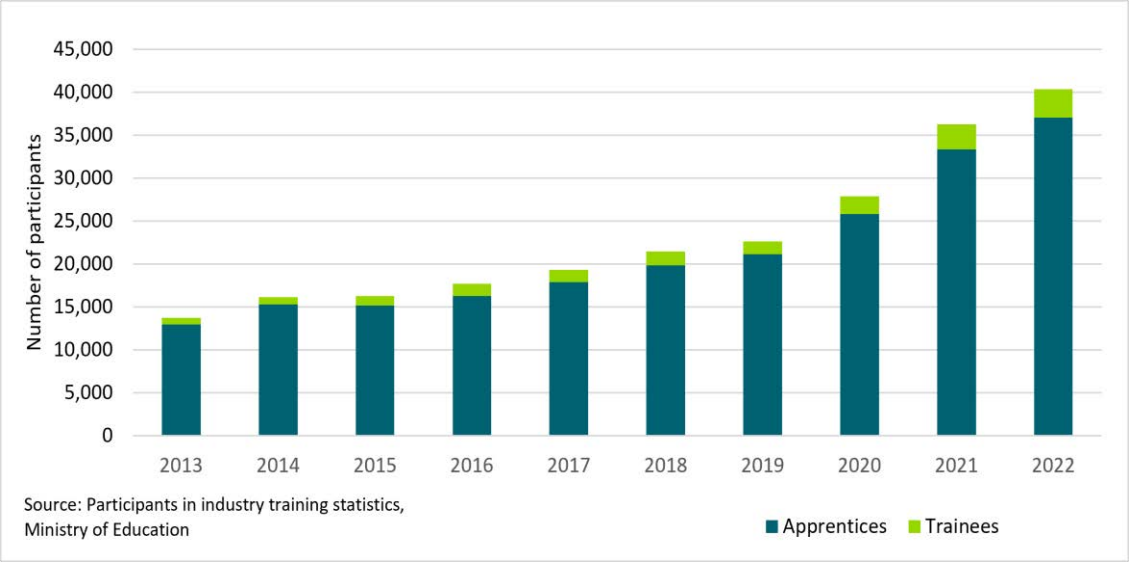
Skilled construction workers were not only in high demand but also posed significant recruitment challenges. Findings from MBIE's *State of the Building and Construction Sector Report 2022* (Figure 2) found that 46 per cent of business owners or managers surveyed were having difficulty recruiting tradespeople. This was also the case for supervisors and team leaders (21 per cent reported difficulty) and technicians (22 per cent reported difficulty) (Research New Zealand, 2022).

Figure 5: Construction sector roles in high demand and/or difficult to fill



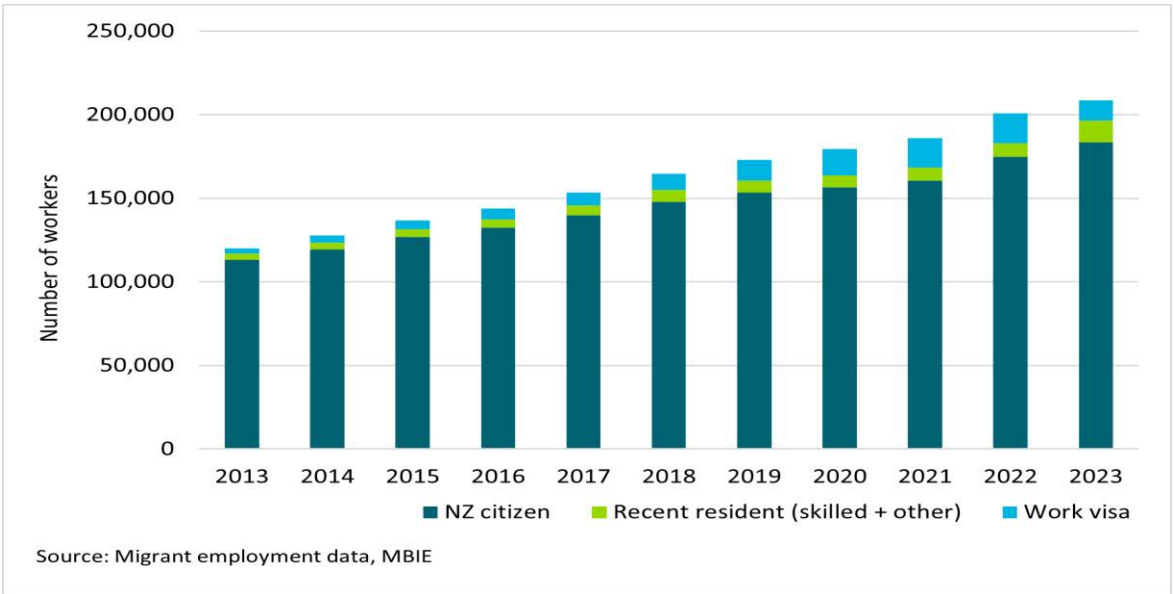
There is a strong pipeline of new entrants to the industry, but skilled and experienced staff continue to be most highly sought. Apprenticeships in architecture and building are currently at a record high with 37,015 apprentices in the year ended December 2022 (Figure 6). Including trainees, there were a total of 40,320 new entrants in architecture and building in 2022, an increase of 26,630 people since 2013.

Figure 6: Participants in architecture and building-related training (year ended December 2013-2022)



Immigration also plays a role in the construction workforce. Analysis of the size of construction workforce by their entitlement to work in New Zealand suggests that the proportion of construction workers with work visas grew from 2.5 per cent in the year ended March 2013 to 10 per cent in the year ended March 2023. Moreover, the number of construction workers who have migrated to New Zealand has also risen to 10.8 per cent in 2023 (Figure 7).

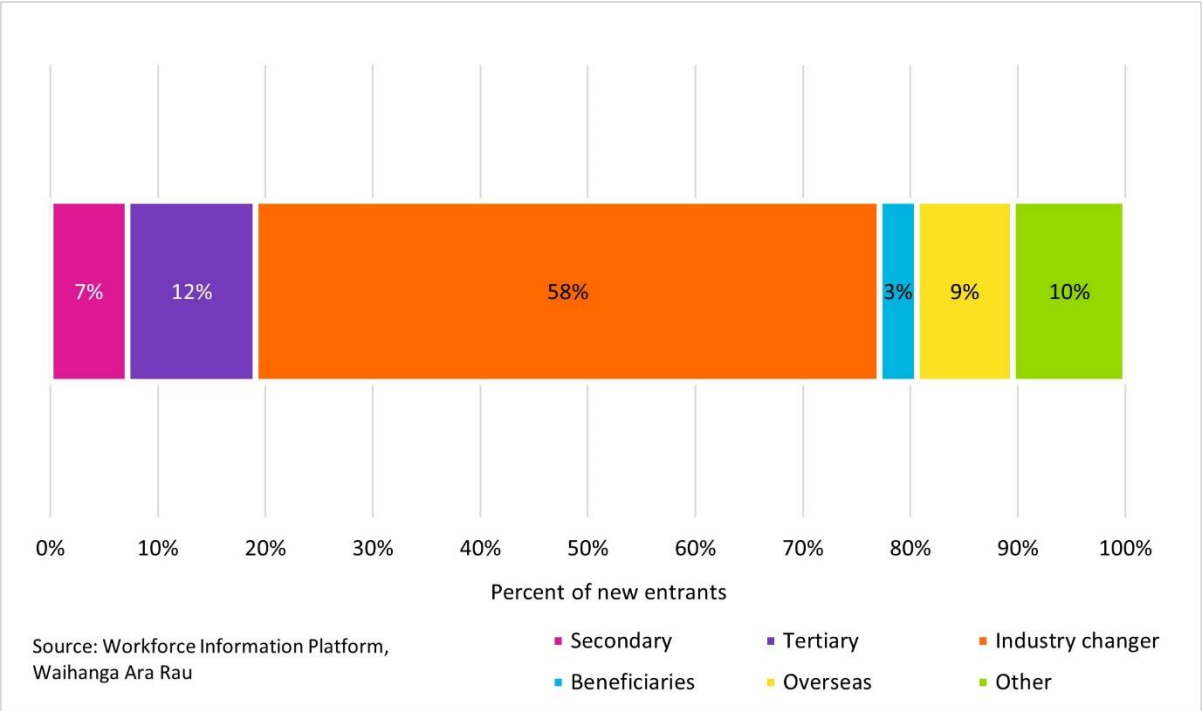
Figure 7: Construction workers by residency status (year ended March 2013-2023)



Analysis from Waihanga Ara Rau Workforce Development Council showed that in 2021, approximately 58 per cent of people who entered the construction sector were new entrants, while secondary and

tertiary graduates accounted for 19 per cent, and 9 per cent came from overseas (Waihanga Ara Rau, 2023). Furthermore, people who are industry changers (transitioned into the construction and infrastructure workforce) were previously employed in the administrative and support services, manufacturing, and retail trade sectors.

Figure 8: Sources of construction new entrants (2021)



Key New Zealand Economic and Industry Trends

New Zealand's construction industry is a significant contributor to the country's economy. It is the fifth largest industry, producing 6.3 per cent of the real Gross Domestic Product (GDP). As of February 2023, the sector comprised around 80,613 businesses nationwide (Stats NZ, 2023d), directly employing 308,500 people (about 10.7 per cent of the total workforce) for the year ended June 2023 (Stats NZ, 2023b). It also accounted for eight per cent of all imports to year ended 2023.

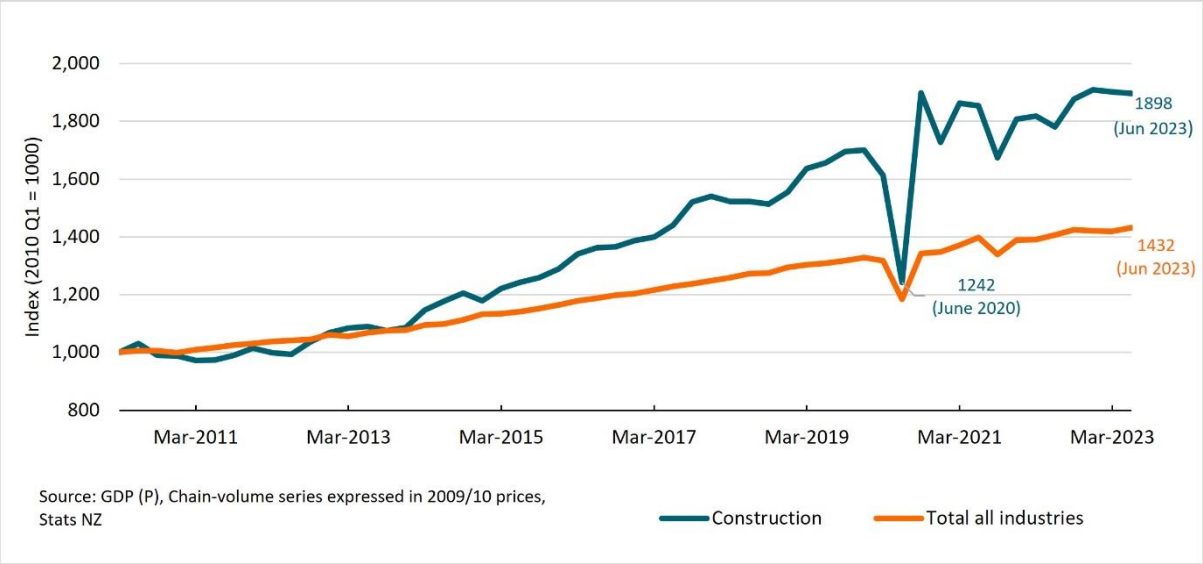
The proportion of Māori-owned construction businesses is increasing. The share of Māori-owned construction businesses in New Zealand increased from 12.6 per cent in 2011 to 14 per cent in the 2021 financial year (Ministry of Maori Development, 2023). These Māori-owned businesses cover a range of construction activities, including construction services (64.6 per cent), residential and non-residential building construction (32.3 per cent) and heavy and civil engineering construction (3.1 per cent) in the 2021 financial year. Māori construction businesses seem to have a slightly higher representation in the construction service sub-sector, compared to non-Māori construction businesses (64.5 per cent cf. 62.9 per cent).

Sector growth has slowed since mid-2022 amid increasing challenges

Construction growth in New Zealand has slowed since mid-2022 due to cost pressures and economic constraints. While construction activity grew from approximately 5 per cent of New Zealand's real GDP in the early 2000's to about 6.3 per cent in 2022, it showed more volatility than the overall economic activity with pronounced cycles of 'boom and bust'. Despite a relatively strong performance during 2021-2022, its growth has slowed down since mid-2022 (Stats NZ, 2023e).

The construction sector experienced a period of strong growth between 2019 and 2022. The 'building' sub-sector's contribution to real GDP increased from $5.8 billion in the March 2019 year to $6.1 billion in the Mar 2022 year. Over the same period the 'infrastructure' sub-sector's contribution to GDP increased from $4.7 billion to $5.2 billion.

Figure 9: Quarterly GDP growth (March 2011 quarter to June 2023 quarter)



In the year ended March 2023, total construction output (as measured in GDP) rose 4.4 per cent, a drop from the 6.3 per cent growth rate recorded in the previous year. This decline was largely due to challenges faced by the residential and commercial segments, such as hotel and retail spaces.

Residential construction suffered from inflationary pressures and economic challenges. Rising expenses for construction materials and wages weighed down on building costs. Additionally, persistent labour shortages and supply chain issues for some materials caused construction delays. The lower number of residential building consents also suggested a reduced investment in the residential market (ANZ, 2023).

On the other hand, infrastructure construction saw strong growth over the past year supported by strong public investment in water and transport infrastructure projects, as well as cyclone Gabrielle recovery and rebuild efforts. The Infrastructure Commission's Pipeline snapshot in January-March 2023 (Infrastructure Commission, 2023a) reported a 17 per cent increase in the total value of infrastructure projects, compared to December 2022.

Fall in new dwelling consents, strong growth in infrastructure segment

Investment in the residential sector has been strong in recent years, with an annual investment growth of 3.2 per cent for year ended March 2023. However, this growth slowed in the later part of the year, with a decrease of 2.2 per cent in the December 2022 quarter and a further 0.4 per cent drop in the March 2023 quarter (Stats NZ, 2023e). This moderation in investment was likely due to high inflation, rising interest rates and escalation of construction costs which dampened property demand.

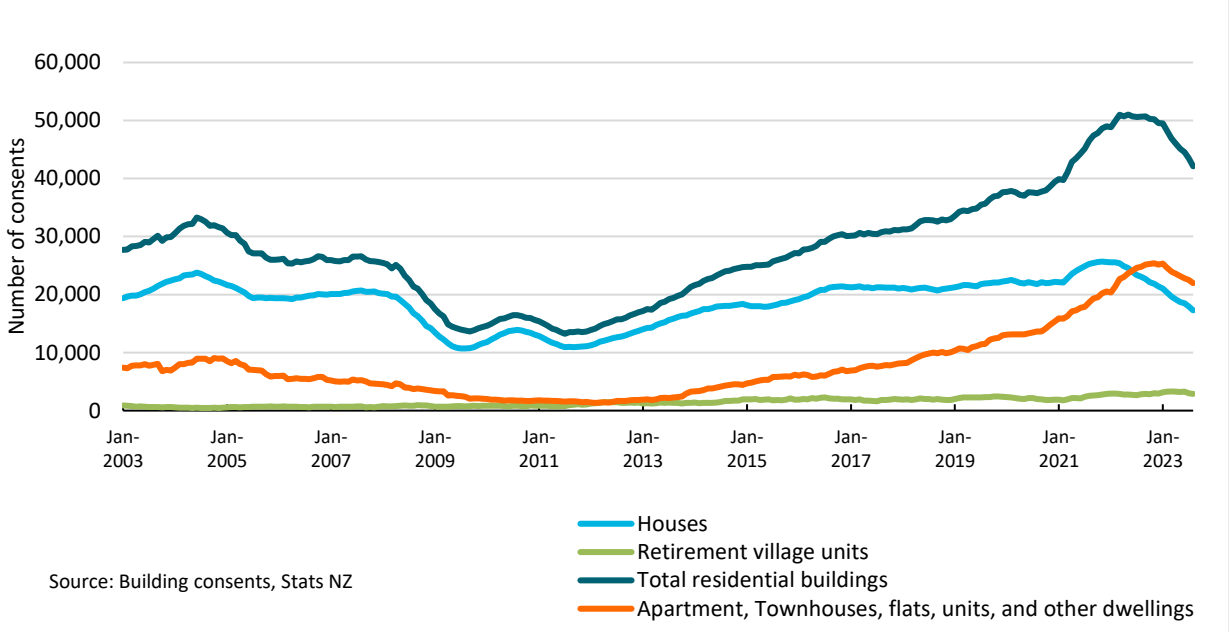
The number of new home consents peaked in early 2022 and has since returned to a more sustainable level. This is illustrated in Figure 10, which shows a decline in annual new home consents since the record high of 51,015 consents recorded in the year to May 2022. The number of new home

consents has now returned to a similar level observed in 2021, where a total of 44,331 new homes were consented.

Stats NZ data on Code Compliance Certificates estimated the number of completions issued for the year ended March 2022 at approximately 36,000 dwellings (Stats NZ, 2022). This is below the current level of 44,429 new dwellings consented. This suggests a healthy pipeline of work for the construction sector in the short and medium term.

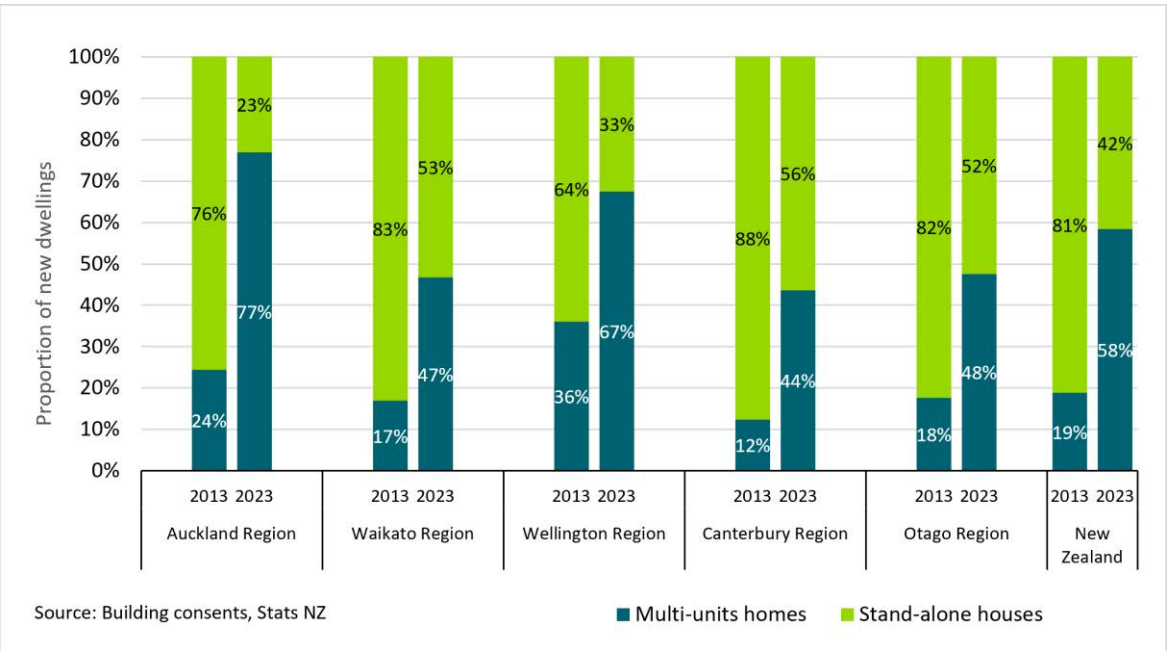
For the year ended June 2023, 44,529 new homes were consented nationwide, representing a year-on-year decline of 12.2 per cent from the 50,736 consents issued in the year to June 2022. This downward trend persisted in the September 2023 quarter, marking the fourth consecutive quarter with a decrease in both the number of stand-alone houses and the number of multi-unit homes consented (Stats NZ, 2023f).

Figure 10: New residential dwellings consented



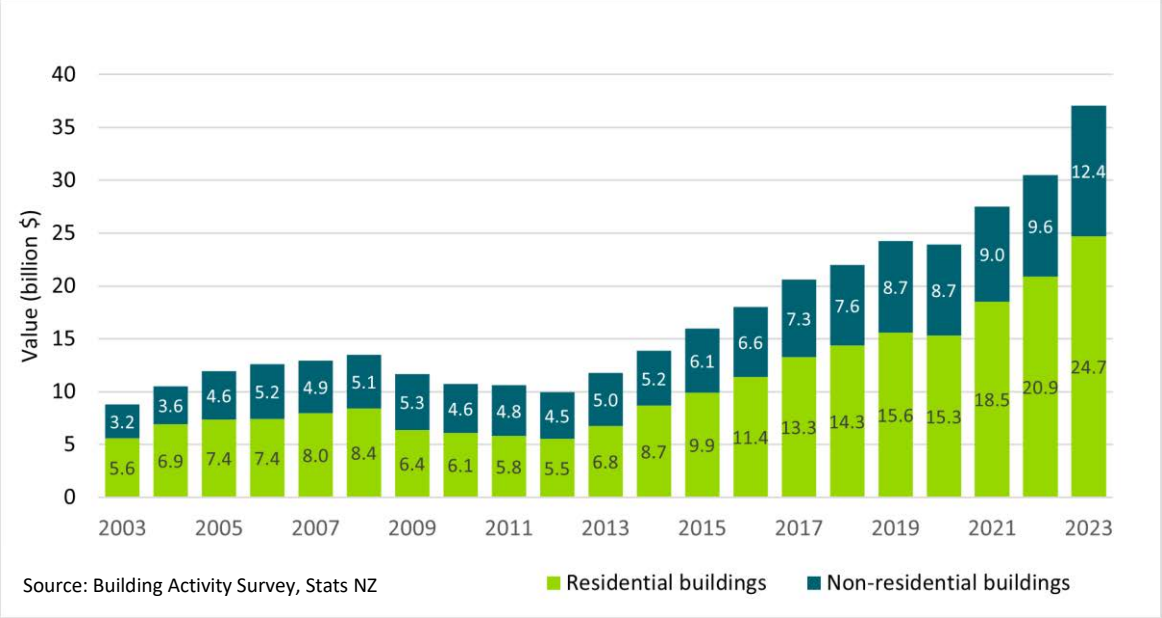
The ongoing nationwide shift towards multi-unit dwellings remains evident. From 2013 to 2023, there has been a significant shift towards multi-unit homes in New Zealand. Figure 11 illustrates how the proportion of stand-alone houses decreased from 81 per cent to 42 per cent of new dwellings consented, while the proportion of multi-unit homes increased from 19 per cent to 58 per cent. The annual number of multi-unit homes consented surpassed stand-alone houses in the March 2022 quarter since the series began. Over the past decade, the number of townhouses, flats and units consented has more than tripled, growing from 3,550 in the year ended June 2013 to 26,031 in the year ended June 2023.

Figure 11: New dwellings consented by building type (year ended June 2013-2023)



Growth in the value of non-residential building activity has outpaced that of residential building activity. The value of residential building work put in place increased 12.5 per cent in the year to June 2022, and 18.5 per cent in the year to June 2023. However, the value of non-residential building work put in place shows stronger growth, increasing by 7.3 per cent in the year to June 2022, compared to 28.3 per cent in the year to June 2023 (Stats NZ, 2023g).

Figure 12: Annual value of residential and non-residential building work put in place (year ended June 2003-2023)



Non-residential building consent values also remain high, up 14.7 per cent over the 12 months to June 2023. Hotel and hostel consent values have declined by more than half in the year to June 2023, indicating a reduced investment in tourism-focused assets. This decline has been offset by increases in other building types including hospitals (up 67 per cent), warehouses (up 46 per cent), and office and transport buildings (up 29 per cent over the same period). These trends highlight the government's emphasis on social infrastructure and the private sector's efforts to strengthen local supply chains in the past few years.

Expectations for continued high infrastructure investment remain strong. Te Waihanga / New Zealand Infrastructure Commission's *Rautaki Hanganga o Aotearoa – New Zealand Infrastructure Strategy 2022–2052* (New Zealand Infrastructure Commision, 2022) committed an additional $61.9 billion investment over the next five years. Despite these expectations, completed infrastructure projects have been limited, declining by 3.6 per cent in the June quarter following a previous drop of 4.2 per cent in the March 2022 quarter.

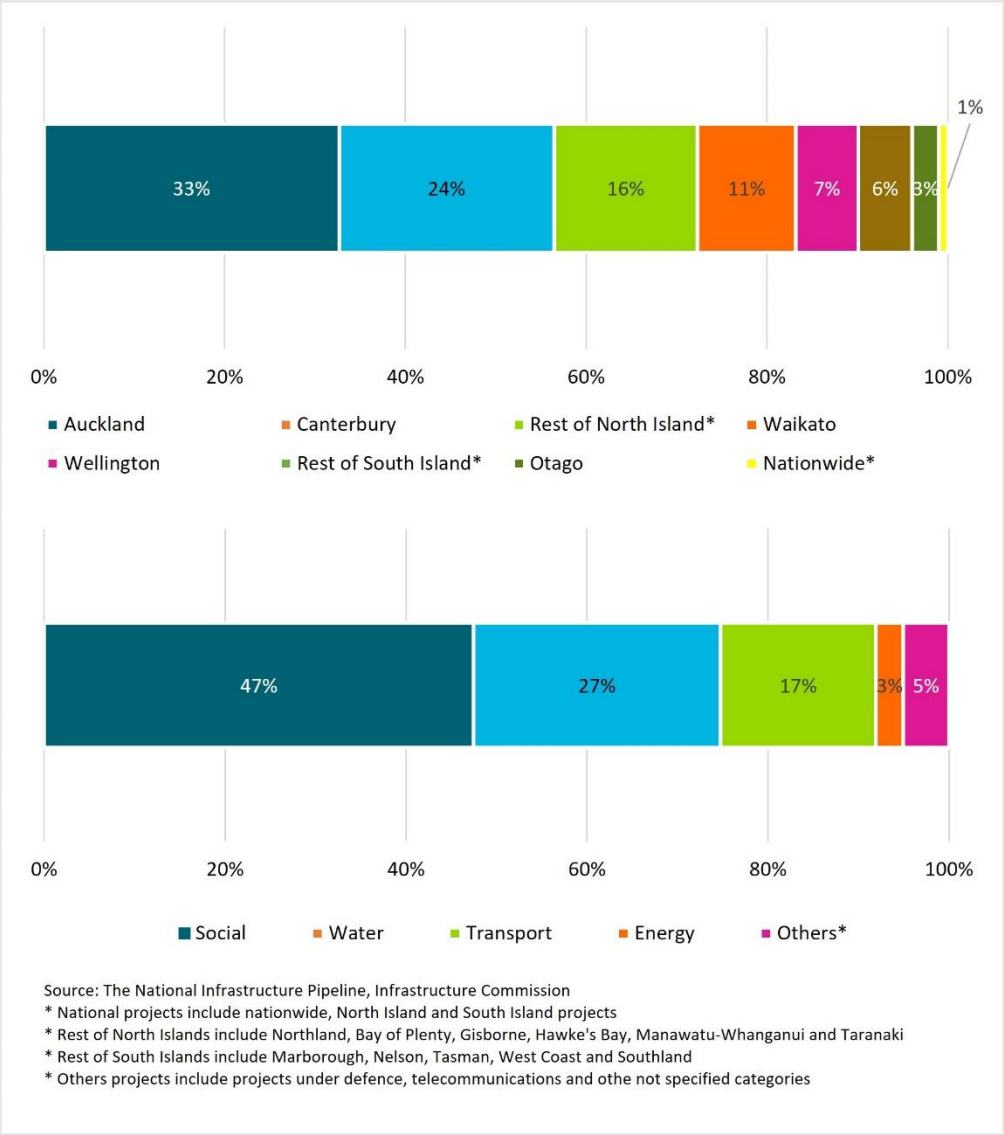
The infrastructure pipeline shows strong growth, which may offset the slowing demand in the residential sector. In the May 2023 Budget, the New Zealand government allocated approximately $71 billion for public infrastructure spending over the next five years, including for schools, hospitals, public housing, and rail networks (New Zealand Government, 2023).

Annual total government Gross Fixed Capital Formation on infrastructure reached $17.3 billion in 2022, marking the highest level in real terms in 20 years. Between 2015 and 2022, public sector investment in non-building construction and land improvements more than doubled in real terms, reaching $11.1 billion (Stats NZ, 2023e).

The New Zealand Infrastructure Commission estimates the current infrastructure pipeline to be $65 billion encompassing 2,588 ongoing and planned projects. Figure 13 shows that approximately 33 per cent of this investment will be directed towards Auckland, while Canterbury is projected to receive 24 per cent of the funds. At the regional level, 16 per cent of the investment will be allocated to Hawke's Bay, Gisborne, and Northland, reflecting the infrastructure needs arising from Cyclone Gabrielle recovery efforts. Nearly 50 per cent of the pipeline focus on social infrastructure projects such as social housing, education, and healthcare facilities.

The Infrastructure Pipeline also shows significant spend in the social sector, accounting for 47 per cent of total projects. These social infrastructure projects include 42 per cent on housing, 20 per cent on health infrastructure, 20 per cent on education facilities, and 14 per cent on community facilities. (Infrastructure Commission, 2023b)

Figure 13: Infrastructure projects by region and sector (June 2023 quarter)



The North Island weather events in January/February 2023 caused extensive damage, with the Treasury estimating the total cost of repairs to range between $9 billion and S14.5 billion. Over half of this damage have affected public infrastructure, particularly water, electricity, and transportation systems. Damage to residential property (insured and uninsured) is estimated to be between $2 billion and $3.5 billion (The Treasury, 2023c).

Extreme weather events resulted in insurance claims exceeding those of the Kaikoura earthquake. As of June 2023, the Insurance Council reported that $1.08 billion had been paid out in claims, representing an estimated 34 per cent of the total $3.18 billion worth across 107,569 claims. This surpassed the total claims incurred for the Kaikoura earthquake in 2016, which amounted to around $2.27 billion (Insurance Council of New Zealand, 2023).

In the aftermath of the North Island weather events of January 2023, Rapid Impact Assessment data (as of 1 June 2023) revealed 8,675 placards were issued, indicating the extent of damage sustained by affected properties. Of these properties, 5.7 per cent were red-stickered, deemed high-risk due to extensive damage and prohibiting entry, while 38.5 per cent were yellow-stickered, posing moderate risk and restricting access (MBIE, 2023a).

Impact from economic uncertainty and financial stress continues but shows signs of easing

Higher costs alongside supply chain issues, labour challenges, and cashflow concerns have intensified pressures within the construction industry. A survey by the New Zealand Institute of Economic Research (NZIER, 2022) revealed that 38 per cent more builders reported an increase in overdue debtors (customers who have not paid their invoices by the due date) in the three months to June 2022, compared to those who reported a decrease. This represents the highest level recorded since 2009, indicating growing financial stress within the industry.

Furthermore, the NZIER survey reported a net 55 per cent of firms anticipate further increases in overdue debtors over the next three months, exceeding the peak observed during the Global Financial Crisis. This indicates a deepening concern among construction businesses regarding their financial stability.

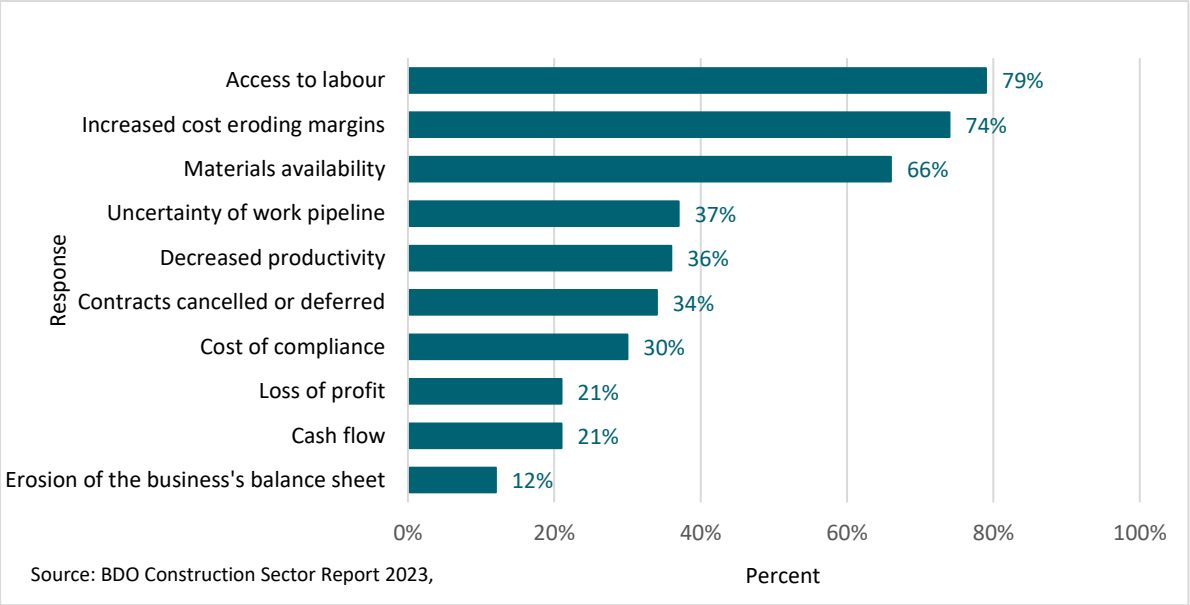
However, amidst these challenges, the latest Quarterly Survey of Business Opinion June 2023 by NZIER suggested a slight improvement in business confidence within the building sector. The survey found a decrease in the number of businesses anticipating a weaker outlook for the coming months, 59 per cent compared to 76 per cent in the previous quarter (New Zealand Institute of Economic Research, 2023). This suggests a modest decrease in pessimism within the sector.

While business confidence in the sector has improved slightly, concerns persist over rising insolvencies due to finanical stress. The number of construction businesses declared insolvent jumped to 418 in the year ended June 2023, from 210 over the previous 12 months, according to insolvencies data from the Company Office. In the year to June 2023 construction insolvencies comprised 23.5 per cent of all insolvencies, the highest proportion since 2020.

High material and labour costs, supply chain disruptions and skills shortages remain as nagging challenges for the sector. These challenges are causing construction costs to rise faster than expected. In the June 2022 quarter, the value of building work put in place increased by 19 per cent compared to the previous year. However, once cost increases are removed, the underlying growth in construction volume was only 3.4 per cent over that period. In the June 2022 quarter, non-residential construction costs rose 3.6 per cent, residential construction costs increased 4.2 per cent, and civil construction costs jumped 5.4 per cent from the previous quarter.

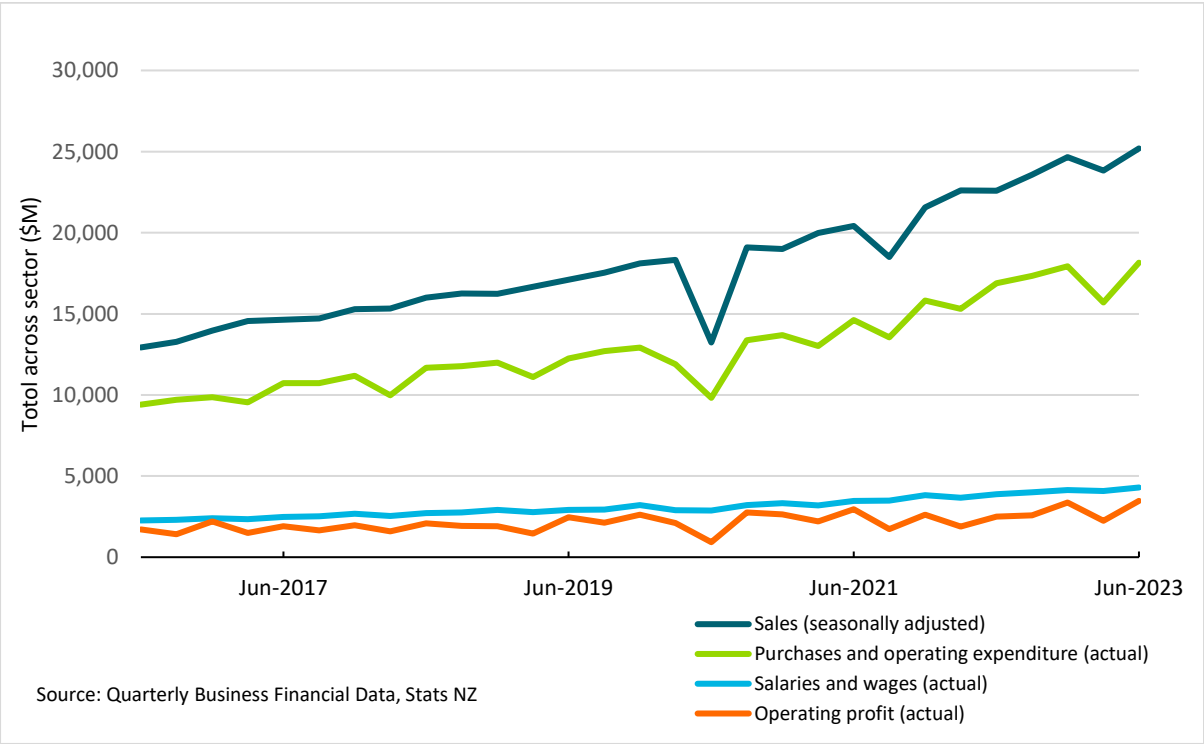
The BDO Construction Sector Report 2023 found that cost escalation, supply chain disruptions, and skills shortages are the three most pressing challenges facing the sector (see Figure 14). Finding skilled labour is particularly an ongoing challenge.

Figure 14: What have been the biggest adverse impacts on your business this year?



Rising costs for building materials and labour are eroding the profit margins of construction companies. As illustrated in Figure 15, total sales in the construction sector reached $25 billion in June 2023 quarter, representing a 11.7 per cent increase from the June 2023 quarter. However, actual purchases and operating expenditure also surged by 7.6 per cent and salaries and wage rose 11 per cent in the June 2023 quarter, compared to the June 2022 quarter.

Figure 15: Quarterly business financials for construction sector



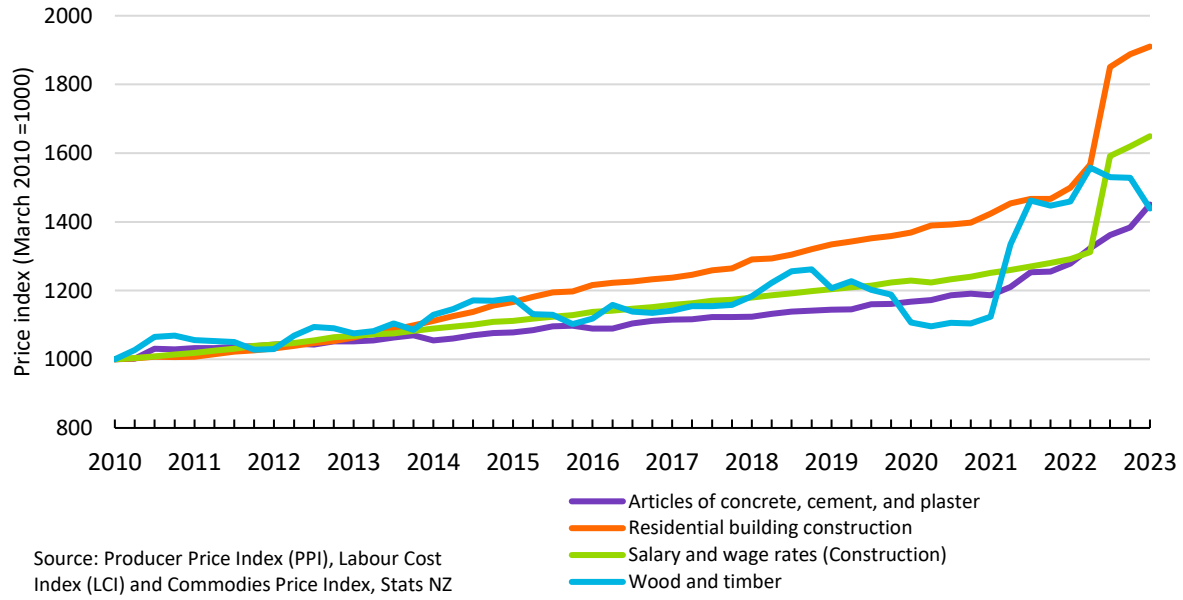
Smaller construction businesses are being impacted by higher operating expenditure more severely than larger businesses. The operating profit growth for small construction businesses, with one to 19 employees, dropped by 23.7 per cent between 2021 and 2022. Medium-sized businesses, with 20 to 99 employees, also experienced a decline in growth, although less severe, at 12 per cent. Meanwhile, large businesses, with over 100 employees, managed to achieve a moderate growth rate of 3.6 per cent (Stats NZ, 2023h).

However, there are signs that inflationary pressures may be easing, particularly in the construction sector. A recent ANZ Business Outlook survey (ANZ, 2023) found that only a net 36 per cent of construction companies anticipated rising prices in the following three months, down from a net 47 per cent in the previous month and over a net 90 per cent a year ago (ANZ, 2023).

The cost of construction materials continues to rise, but at a slower pace. Figure 16 shows that between March 2013 and March 2023, construction input prices increased 22 per cent, while output prices increased by 33 per cent respectively, both grew faster than the overall Consumer Price Index (CPI) of 6 per cent over the same time period (Stats NZ, 2023i).

The annual price of building a new house went up 7.8 per cent in the year to June 2023, slowing from 11.5 per cent in the year to March 2023 (Stats NZ, 2023j). The rate of growth is markedly lower than the 18.3 per cent rise seen in mid-2022, as supply disruptions continue to ease and demand on the sector slows down.

Figure 16: Residential construction cost price indices



Source: Producer Price Index (PPI), Labour Cost Index (LCI) and Commodities Price Index, Stats NZ

For the year ended June 2023, the costs of wood and timber decreased by nine per cent due to easing pandemic-related supply shortages and a slowdown in the building boom. The latest Cordell Construction Cost Index shows overall construction costs increased by 0.6 per cent in the June 2023

quarter, a significant slowdown from the average quarterly increases of 2.0 per cent experienced in 2021 and 2022 (CoreLogic, 2023).

This moderation in cost growth is reflected in the annual growth rate of construction costs, which has dipped from a record high of 10.5 per cent to 8.8 per cent in the three months to March 2023. The rising interest rates, which have contributed to a drop in the number of new home consents, have also played a part in easing the demand pressures in the construction sector.

Construction labour costs rose faster than all industry's average. The Labour Cost Index (LCI) for construction industry wage and salary workers increased by 4.2 per cent for the year ended June 2023 compared with 3.4 per cent growth for all industries (Stats NZ, 2023b).

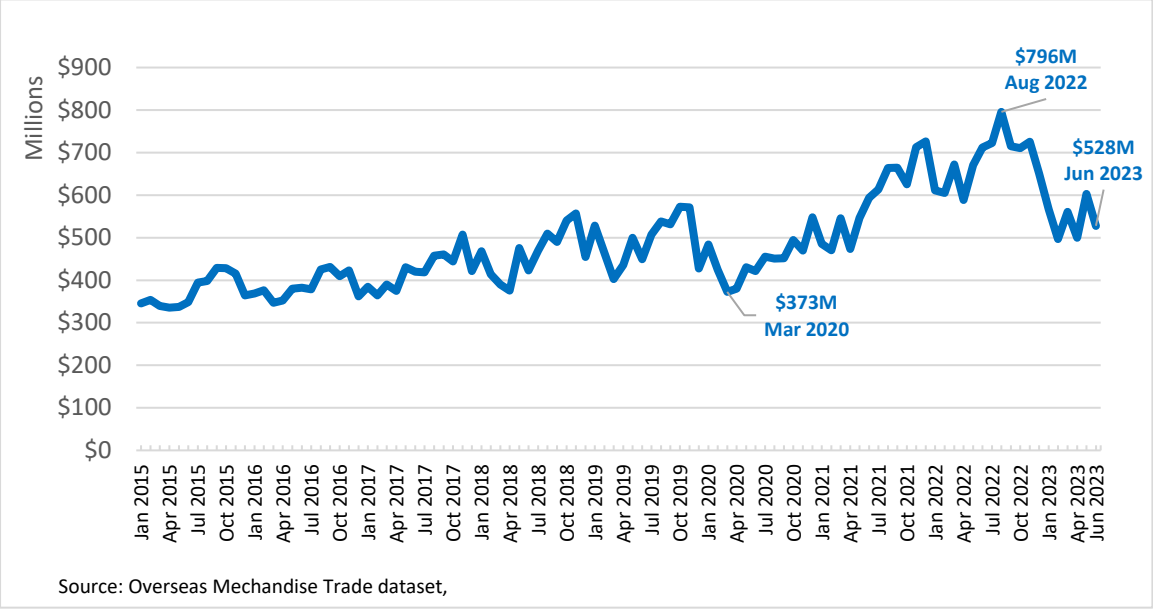
The average hourly rate (including overtime) for construction industry workers was $36.88 in the June 2023 quarter, an increase of $2.89 (or 8.5 per cent) from the hourly rate of $33.99 in the June 2022 quarter. This growth outpaces the national hourly rate increase of 6.9 per cent over the same period (Stats NZ, 2023b).

Supply constraints on construction materials seem to be easing but material costs are still rising. The availability of crucial materials like plasterboard has improved, as evidenced by the 1.1 million square metres of plasterboard and related products imported into New Zealand in the year ended June 2023, up 76.9 per cent compared with the year ended June 2022. The monthly volume of plasterboard and related products imported has continued to decrease from its peak of 997,222 square metres in September 2022, indicating a return to normalcy in plasterboard supplies. Timber prices have also stabilised to some extent, and metal components are showing a similar trend of price stabilisation.

Despite the easing of supply constraints, cement and concrete prices have continued to climb since 2021, leading to higher production costs. Cement production costs rose six per cent year-on-year in the June quarter, following a 6.5 per cent increase in 2022, according to Statistics New Zealand's Production Price (input) Index (Stats NZ, 2023k). The recent surge in demand for cement and concrete in infrastructure projects may have contributed to the price increase.

Figure 17 illustrates that the estimated value of building and construction products imported into New Zealand has fallen from a record high last year. In August 2023, building and construction goods accounted for a total import value of nearly $800 million (Stats NZ, 2023l). On average, the estimated value of imports for building and construction goods accounted for approximately seven to eight per cent of total imports for each month.

Figure 17: Estimated value of imports of building and construction products (January 2015 – June 2023)



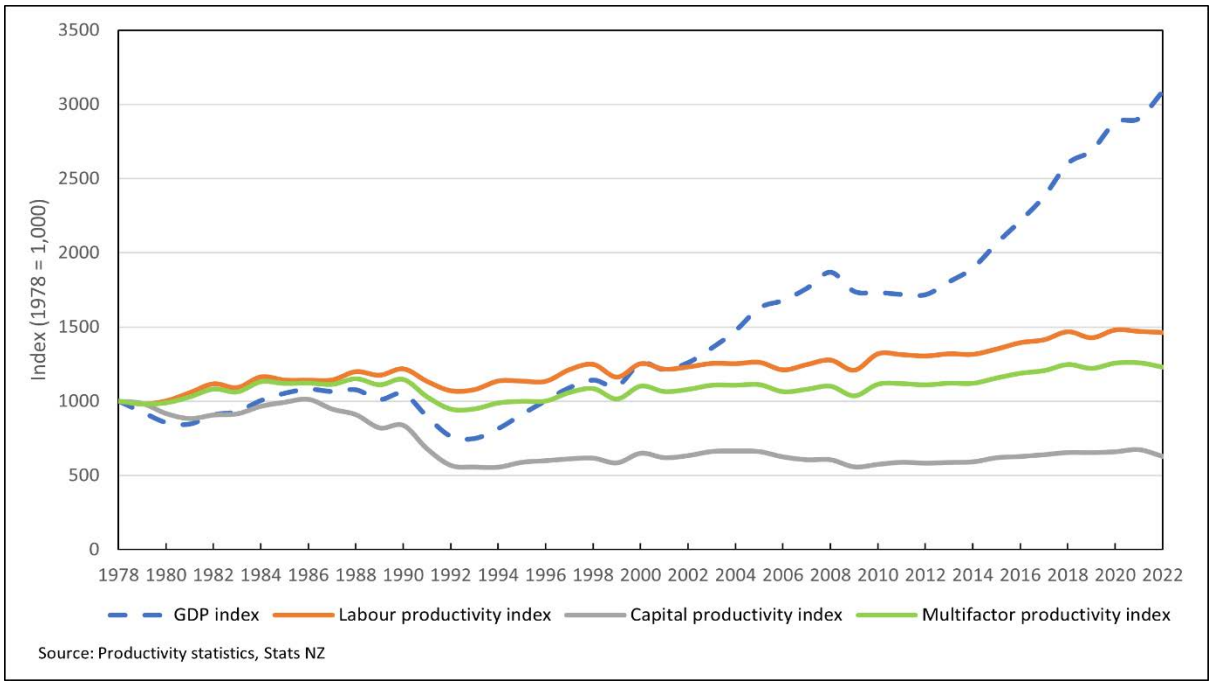
Source: Overseas Mechandise Trade dataset,

Shipping costs to Australia and New Zealand are showing signs of easing. Approximately 90 per cent of all construction products sold in New Zealand are imported from overseas (EBOSS, 2021b). China is the top country from which building and construction products are imported. An analysis conducted by Infometrics suggested that shipping costs from China to Australia and New Zealand have barely fallen from their record highs in January 2022, with the index down by just 8.9 per cent in September 2022 (Glynn, 2022).

The construction sector continues to face challenges related to productivity. The construction industry lags behind other sectors in achieving sustainable, strong productivity growth over time. Industry-level productivity data (Figure 18) shows that construction sector productivity increased relatively slowly between 2020 and 2023 (Stats NZ, 2023m). Labour productivity grew at a rate of 0.5 per cent per annum during this period, placing construction among the lowest-performing sectors. Similarly, multifactor productivity[3] in construction increased at an annual rate of 0.4 per cent, which is higher than many other industries but substantially lower than the other goods-producing industries.

[3] Multifactor productivity (MFP) reflects the overall efficiency with which labour and capital inputs are used together in the production process. Changes in MFP reflect the effects of changes in management practices, brand names, organisational change, general knowledge, network effects. (OECD,2023)

Figure 18: Productivity Index for construction sector (1978-2022)



The New Zealand Institute of Building conducted a study to investigate the underlying reasons for the construction sector's relatively poor productivity compared to other industries. Their findings revealed that the sector's low productivity stems from a complex set of entrenched behaviours and practices related to business and regulatory processes, rather than on-site construction practices. Moreover, the study identified relatively low rates of innovation and high injury rates as contributing factors to the sector's productivity challenges (New Zealand Institute of Building, 2021).

The construction sector is one of the largest employers in New Zealand, but it also has a significant proportion of workplace-related illness and accidents. The construction industry consistently ranks among the highest for work-related injuries and illnesses. For the 12 months to May 2023, WorkSafe New Zealand reported that there were 6,252 work-related injury claims resulting in more than a week away from work, up seven per cent from the previous 12 months. The injury incidence rate for the construction industry reported by Stat NZ's injury statistics 2022, has remained relatively stable since 2017, with 135 claims per 1,000 FTE employees in 2022. This places the construction sector behind agriculture, forestry, and fishing (149 claims per 1,000 FTEs) and manufacturing (152 claims per 1,000 FTEs), but still significantly higher than the industries' average of 72 claims per 1,000 FTEs. This is despite the construction industry having the highest number of claims since 2022, reflecting its steady employment growth since 2018 (Stats NZ, 2023n).

The physical demands of the job such as heavy lifting, repetitive motions, and working at heights can create hazards for construction workers. WorkSafe New Zealand's work-related injury data has identified muscular stress while lifting and carrying or putting down objects as the construction industry's most common injury, accounting for 25 per cent of all work-related injuries in the sector. From June 2022 to May 2023 there were 1,590 muscular stress injury claims in the sector for lifting and carrying or putting down objects, an average of 132.5 claims per month. Compared to the previous 12 months, the number of muscular stress claims increased by 6.8 per cent.

Between June 2022 and May 2023, data from WorkSafe's Fatalities Register found that construction sector had the country's third most work-related deaths, behind the transport, postal and warehousing, and the agriculture sectors. During this period, there were a total of 11 work-related deaths in the construction industry, an increase of one compared to the previous 12 months. Of those 11 fatalities, five incidents involved falling from heights, five involved vehicle incidents, and one involved being struck by a falling object. Eight cases involved people over 55 years old.

Mental health and wellbeing are also critical concerns in the construction sector. In addition to physical risks, the demanding conditions of construction work can also contribute to higher levels of mental fatigue and stress. Research by MATES in Construction (MATES in Construction NZ, 2022) has revealed that construction workers are six times more likely to die from suicide than in a work accident. This translates to the construction industry losing nearly one person every week to suicide. Moreover, young men in the industry are twice as likely to die by suicide compared to young men working outside the construction sector.

Increased innovation is crucial to reducing greenhouse gas emissions from construction

The building and construction sector is a significant contributor to greenhouse gas emissions. Emissions are released during the production of building materials, the construction of buildings, and the energy consumed in buildings throughout their operation. In 2021, the sector was responsible for 11,555 kilotonnes (kt) of COe_{-2} emissions, based on a consumption-based approach including international trade – an increase of 5.3 per cent from 2020.

Increased renewable energy use in electricity generation saw a decrease of 3.3 per cent in operational emissions from 6,906 kt in 2020 to 6,677 in 2021. Emissions from the use of fossil fuels for heating and cooking also decreased slightly from 3,143 kt in 2020 to 3,101 in 2021.
However, strong residential and non-residential building activities in recent years have contributed to higher embodied emissions. There was a 20 per cent increase in embodied emissions from the manufacture and transport of materials in the construction sector, from 4,067 kt in 2020 to 4,878 kt in 2021. This growth includes a 68 per cent increase in net imported emissions and a 5.7 per cent increase from transportation emissions.

Embracing technology's potential offers a promising pathway to minimising the construction industry's carbon footprint. This pathway lies in the development and implementation of environmentally sustainable products, methods, practices, and systems, effectively replacing traditional, carbon-intensive approaches.

Investment in construction research and development (R&D) is increasing, but still lags behind other industries in innovation expenditure. This low level of investment hinders the development of a more productive and innovative sector. While the R&D expenditure for the sector has increased from $106 million in 2016 to $185 million in 2022, it still only accounts for a 4.4 per cent of total business R&D expenditure in New Zealand, placing construction among the sectors with the lowest R&D investments (Stats NZ, 2023o)**.**
According to Callaghan Innovation, significant efforts are necessary to achieve New Zealand's vision of becoming a leading innovator in the construction industry within the Small Advanced Economies group and the Organisation for Economic Co-operation and Development (Callaghan Innovation, n.d.).

To facilitate the adoption of innovation for business transformation, the country must address several critical challenges including slow productivity gains, a fragmented supply chain with minimal collaboration, and a general lack of awareness of emerging issues and opportunities among companies. Callaghan Innovation is collaborating with the industry to build a more collaborative, productive, innovative, and sustainable construction sector. Between 2021 and 2022, the number of construction businesses it supported has more than doubled, from 186 to 374.

Emerging trends in building design, technologies, and materials

The global construction industry is undergoing rapid changes due to the adoption of innovative design approaches, technologies, and materials. These trends present an opportunity for New Zealand's construction sector to improve its performance, regulations, and quality standards by learning from the best practices of other countries. This section provides an overview of key innovation trends currently reshaping the global construction landscape. It also features local examples applying and adapting these trends.

Building Design: A shift towards low-carbon, sustainable principles

To prevent the worst consequences of climate change, humanity needs to limit global temperature increase to 1.5°C. New Zealand has committed to this goal under the Paris Agreement, aiming for net-zero carbon emissions by 2050 (Climate Commission, 2023).

However, the 2022 Global Status Report for Buildings and Construction revealed that the sector has fallen behind on its decarbonisation target for 2050 (United Nations Environment Programme, 2022). In 2021, the sector accounted for more than 34 per cent of global energy demand and 37 per cent of energy and process-related CO2 emissions. The sector's operational energy-related CO2 emissions continued to climb, rising 5 per cent since 2020 and 2 per cent above pre-pandemic levels. In New Zealand, the Building Research Association of New Zealand (BRANZ) estimates that buildings contribute directly and indirectly to up to 20 per cent of the country's total greenhouse gas emissions (BRANZ, n.d.).

The UNEP report calls for a fundamental shift within the sector, aligning with the Paris Agreement's objectives. Achieving this goal requires prioritising innovative building design principles such as net zero (operational) carbon, regenerative, passive and biophilic design.

Net-zero (operational) carbon buildings offset their emissions throughout their lifespan. These buildings achieve this by combining energy-efficiency with reliance on renewable energy sources, either on-site or off-site (World Green Building Council, 2018). In essence, they operate without producing any net greenhouse gas emissions.

The number of net-zero carbon buildings is expanding. In 2019, the New Building Institute identified 580 certified, verified, and emerging projects (Hobart, 2019). By 2023, this figure has climbed to roughly 856 certified net-zero buildings worldwide, as documented in the World Green Building Council's Advancing Net Zero Status Report (World Green Building Council, 2023).

In New Zealand, the Building for Climate Change (BfCC) programme aims to achieve "near zero carbon" buildings by 2050 (MBIE, n.d.), which is a way to enable "net zero carbon" buildings. Near zero (or net-zero ready) buildings have minimal embodied carbon and are highly energy efficient, with the remaining emissions easily offset. The government aims to reduce building-related emissions by 0.9Mt – 1.65Mt CO2-e (million tonnes of carbon dioxide equivalent) in the 2022-2025 period (MBIE, 2023).

Measuring carbon emissions of buildings is a crucial tool for informing sustainable design choices and aligning with decarbonisation goals. By comprehending a building's environmental impact throughout its entire lifecycle, from materials to operations, designers and owners can make informed decisions that minimise its carbon footprint and contribute to a sustainable future.

The Life Cycle Assessment (LCA) approach provides a standard framework for this analysis. It takes into account both embodied carbon (generated by the production and transportation of building materials) and operational carbon (arising from the building's energy use during its lifetime). To aid architects, engineers, and designers in this task, numerous carbon measurement tools have been developed in recent years, offering insights into assessing and reducing building emissions.

In New Zealand, BRANZ created tools like LCAQuick: Life cycle assessment tool and LCAPlay: Options assessment tool, to help with low-carbon design (BRANZ, n.d.), while the New Zealand Green Building Council (NZGBC) released embodied carbon resources and the Green Star NZ certifications (New Zealand Green Building Council, n.d.). Green Star NZ is a nationally recognised rating tool that assesses buildings across categories like energy, water and embodied carbon.

Table 1 shows the growing number of buildings with environmental certifications from the NZGBC since 2020. These include Green Star NZ, National Australian Built Environment Rating System (NABERS) NZ, and Homestar- all evaluating the sustainability performance of buildings. Since 2020, all four certifications showed growth – 34 per cent increase in 2021 and 50 per cent increase in 2022. Green Star NZ recorded the highest increase, from 21 in 2021 to 88 in 2022. This can be attributed to the government's preference for Green Star NZ as a sustainable building rating tool due to its specific adaptations to the New Zealand context and its market maturity (MBIE, 2022b). The NZGBC also recently introduced the Net Zero Buildings certification, a voluntary certification that tracks major sources of carbon emissions in building operations, including energy, water, waste, and refrigerants (New Zealand Green Building Council, 2023).

Table 1: Number of Buildings with NZGBC Certifications (2020 to 2022)

Year	Green Star NZ registrations	NABERSNZ certifications	Homestar registrations	Homestar Built Ratings	Overall growth
2020	21	53	4754	960	Baseline
2021	54	72	5960	1689	↑ 34%
2022	88	116	6315	2150	↑ 50%

Source: NZGBC 2023

Chapter 12 of the *New Zealand Emissions Reduction Plan* outlines key government initiatives to promote sustainable construction and net-zero carbon buildings, spearheaded by the BfCC programme (Ministry for the Environment, 2022). BfCC focuses on (MBIE, n.d.):

- **Regulatory changes** which aim to enhance operational efficiency and reduce the whole-of-life embodied carbon of buildings. This might involve mandatory reporting requirements, carbon

caps for new projects and a review of the role of sustainable building rating systems (New Zealand Government, 2021).

- **Legislative reforms**, specifically the proposed amendments to the Building Act 2004, which seeks to embed carbon reduction and operational efficiency in new buildings. They also introduce national waste minimisation requirements, mandatory energy performance ratings and waste minimisation plans for specific construction and demolition activities. (MBIE, 2023b). These changes will be implemented gradually after public consultation.
- **Non-regulatory incentives** which encourage voluntary emissions reduction in both new and existing buildings.

Complementary initiatives include:

- The Accord's **Carbon Waste Measurement Tools Initiative** which supports the development of carbon and waste measurement tools and resources, empowering businesses to assess and address their environmental footprint (Construction Sector Accord, 2023c).
- The **Carbon Neutral Government Programme** which requires minimum Green Star ratings for new non-residential government buildings: five stars from April 2022 for projects over $25 million and five stars from April 2023 for projects over $9 million (New Zealand Government, 2021).

Regenerative design builds structures that actively boost the health and well-being of both people and the environment. Architects and designers are embracing this philosophy to reverse the impacts of construction on the environment (Bauhaus Earth, 2023). Key strategies used in regenerative design include: harnessing renewable energy sources (such as solar and wind power); capturing and reusing water (through rainwater harvesting, greywater recycling, etc.); waste reduction and resource recovery (by incorporating composting systems, recycling facilities, etc.); and using non-toxic, low-impact materials to enhance indoor air quality and protect building users from harmful substances (National Institute of Building Sciences, 2023).

The International Living Future Institute is a leading organisation that promotes regenerative buildings. Its *Living Building Challenge* certifies structures that meet exceptional standards of sustainability, health, and equity (International Living Future Institute, n.d.). In New Zealand, regenerative design has been combined with indigenous creativity and Te Ao Māori to create living buildings like:

- Te Kura Whare, which showcases the Tūhoe culture and features a café, library, sacred archives and grand Tribal Chamber and amphitheatre for community events (International Living Future Institute, 2022).
- Te Wānanga o Raukawa (Ōtaki campus), which operates entirely on solar power, captures and uses rainwater, and treats wastewater on-site, while supporting native plant life around the structure. (Te Wānanga o Raukawa, 2022).
- The Living Pā, which is expected to be completed in 2025 and will be waste-free, net-zero energy and water, and made of non-toxic materials (Victoria University of Wellington, 2023).

Passive buildings are gaining traction worldwide, including in New Zealand. These buildings minimise energy consumption by using techniques such as insulation, airtightness, ventilation, and passive solar to reduce the need for additional heating and cooling (Anand, Kadiri, & Putcha, 2023).

The Passive House standard is one of the most widely used standards for passive building design. There are over 70,000 Passive House buildings worldwide that meet rigorous standards not only for energy efficiency but also for comfort and quality (Frew, n.d.).

In New Zealand, Kāinga Ora has built several passive houses, including the *Bader Ventura Development* in Auckland, the first government-funded Passive public housing project in Australasia. It comprises 18 passive house apartments designed to slash energy use and heating and cooling costs to just $1 a day (Kāinga Ora, 2023). Another example is the Toiora High Street Cohousing in Dunedin, New Zealand's largest Passive House project to date and the first multi-unit Passive House residential dwelling that features a mini village of 21 homes (Sustainable Engineering Ltd, 2023).

Biophilic design is another growing architectural trend that connects humans and nature within buildings. It involves incorporating natural elements into buildings to improve occupant well-being and promote sustainability. Biophilic design has gained global attention as more evidence has shown its benefits in reducing stress and anxiety, boosting mood, and improving cognitive function and creativity. (Zhong, Schröder, & Bekkering, 2022).

Biophilic design can resemble nature, traditional architecture, or cultural heritage, using symbols, shapes, colours and materials. It can also incorporate natural elements like plants, water, light, ventilation and views into the structure (Grazuleviciute-Vileniske, Daugelaite, & Viliunas, 2022).

Building Technologies: Integrated solutions for efficiency, productivity, and safety

Emerging technologies such as Building Information Modelling (BIM), artificial intelligence (AI), virtual reality (VR), augmented reality (AR), construction robots, and modern methods of construction – have the potential to greatly improve the way buildings are designed, built, and managed. While these technologies have been used independently in the past, a recent trend is their increasing integration, to create an even more profound impact on the industry.

Building Information Modelling (BIM) is combined with other emerging technologies to amplify its capabilities. BIM in New Zealand defines BIM as "a coordinated set of processes, supported by technology that add value through the sharing of structured information for buildings and infrastructure assets" (BIMinNZ, 2016). It has been used in the global construction industry for more than a decade, and its adoption has grown rapidly. In New Zealand, for example, the use of BIM on construction projects has expanded from 34 per cent in 2014 (when the BIM Acceleration Committee was established), to 70 per cent in 2021. Within that period, BIM's use has extended across all stages of the project lifecycle, from planning and designing to construction and operation. According to the BIM Benchmark Survey in 2021, the key benefits derived by industry and subcontractor groups from its implementation include enhanced coordination, improved clash detection, and optimised cost and resource efficiency (EBOSS, 2021a).

Several companies around the globe are integrating BIM with artificial intelligence and machine learning to achieve enhanced design, quality, and efficiency (Pan & Zhang, 2022; Wang, Zhou, & Li, 2020)**;** improved productivity and safety on site (Chen, Zhang, & & Hu, 2022; Zhang, Liu, Hu, & Zhang, 2022); and better project coordination and collaboration (BIM and Beam, 2023; Owen, 2023). Others are integrating BIM with VR and AR to visualise building appearances before construction and allow early identification and rectification of design issues (Potseluyko, Rahimian, Dawood, Elghaish, & Hajirasouli, 2022) and train workers using simulated tasks in a safe environment (Site Safe NZ, 2023).

In New Zealand, the Accord, BIMinNZ and NZIOB are working together to create the Construction Digital and Data Roadmap, to foster widespread digital tool adoption. The five-year roadmap features initiatives like BIM / digital engineering resources for clients and designers, aiming to propel the industry towards optimised efficiency, data-driven decision-making, and sustainable practices.

Construction robots are gaining traction due to their potential to significantly improve productivity and enhance safety within the industry. Over the past decade, leading nations in this field, like the United States, China, India, Singapore, and Canada have developed robots capable of automating repetitive and labour-intensive tasks**,** including laying bricks (FBR, 2023)**;** tying reinforcing steel (Advanced Construction Robotics, 2023)**;** and cutting, drilling, sanding, and transporting materials (Baubot, 2023). There are also robots that can build 3D maps and monitor potential hazards in construction sites (Naska.AI, 2023) and those that can be worn (like an exoskeleton), capable of supporting and protecting workers while they perform physical and demanding tasks, such as carrying heavy objects (Ekso Bionics, 2023).

Modern Methods of Construction (MMC) boost quality, efficiency, and sustainability in construction projects. These innovative techniques, including prefabrication, modular construction, and 3D printing, deliver high-quality, cost-effective and sustainable buildings.

Prefabrication and modular construction, collectively known as offsite manufacturing (OSM), involve manufacturing prefabricated elements offsite and assembling them on-site. This approach is gaining momentum, with the global market for prefabricated construction projected to reach $157 billion by 2023 (Utilities One, 2023). Countries like Japan and Sweden are leading the way and New Zealand is rapidly embracing this innovative approach.

XFrame, developed by a doctoral student at Victoria University of Wellington, addresses key challenges in construction: efficiency, sustainability, and adaptability. This modular building system features easy installation and removal of panels, enabling rapid reconfiguration of buildings. Lightweight and flexible framing allows for customised designs and layouts, while circular economy design promotes component reuse and recycling (Intellectual Property Office of New Zealand, n.d.).

The New Zealand government is actively promoting the adoption of MMC to address the country's growing infrastructure demands. Key initiatives driving increased MMC uptake in the construction industry include:

- Streamlined consenting: Building Act 2004 amendments pave the way for offsite manufacturing and prefabrication by simplifying approvals for innovative and efficient building methods (MBIE, 2022c).

- Collaborative innovation: The Infrastructure Action Plan 2023 unites industry experts, research, and academia to develop a market strategy and boost MMC innovation (The Treasury, 2023d).
- Quality assurance: The Building (Modular Component Manufacturer Scheme) Regulations established a voluntary certification scheme for manufacturers, building trust in MMC products and streamlining approvals (MBIE, 2022d).
- Government-industry collaboration: Accord-led MMC forums address the Commerce Commission's recommendation for a coordinated approach (Commerce Commission, 2022). The government forum focuses on Crown projects, while the industry forum (co-led with OffsiteNZ), develops tools and resources to enhance MMC adoption across the sector (Construction Sector Accord, 2023a).

3D Printing is another MMC technique that is growing rapidly due to benefits of time and cost savings, as well as reduced waste. It uses materials like concrete, metal, and resin to build entire structures or components for houses, bridges, etc. The global market for 3D-printed construction is expected to rise from USD3.42 billion in 2022 to USD519.49 billion by 2032 (Precedence Research, 2023). This growth is fuelled by factors such as affordability and sustainability and technological advancements. Research shows that 3D printing can slash construction waste by 60 per cent, production time by 70 per cent of production time, and labour costs by 80 per cent (Ranjha, Kulkarni, & Sanjayan, 2018).

New Zealand's Qorox became the first in Australasia to implement building code-compliant concrete 3D printing solutions. It also constructed NZ's first fully 3D-printed home (Property & Build, 2023).

Building materials: Embracing circular economy through reuse, renew and reduce practices

The construction industry is a significant contributor to global greenhouse gas emissions, with building materials accounting for a substantial portion of this impact. To achieve net-zero emissions from the built environment sector by 2050, a shift in how we procure and use building materials is essential.

A recent report entitled *Building Materials and the Climate: Constructing a New Future*, jointly developed by the United Nations Environment Programme (UNEP) and Yale Centre for Ecosystems and Architecture, highlights the urgency of decarbonising building materials. The report proposes a transition to regenerative material practices that prioritise the use of earth- and bio-based materials (United Nations Environment Programme, 2023). These naturally derived materials have low environmental impact, have the potential to store carbon, and contribute to biodiversity preservation.

The growing awareness of waste as a valuable resource resonates with New Zealand's construction sector. Industry leaders are increasingly aware of the reputational risks associated with wasteful practices and are embracing concepts such as the circular economy, which promotes resource conservation and waste reduction (Construction Sector Accord, 2023b).

In a collaborative effort, the Accord and the Sustainable Business Network hosted a cross-industry workshop, under the Sustainable Construction Cross Sector Forums initiative, to identify the root causes of construction waste using circular economy principles. Workshop participants identified five priority areas for addressing construction waste. Three of these priorities - integrated design, reverse logistics and product stewardship - have led to the formation of industry action groups. The remaining two priorities - information and knowledge sharing - were identified as enabling projects that will be spearheaded by the Accord (Construction Sector Accord, 2023c).

Earth-based materials are made from soil, such as clay, sand, gravel, or silt. They can be used to create various building materials such as rammed earth, compressed earth blocks and clay plasters. Earth-based building materials have enormous potential as solutions for low-energy dwellings, energy efficiency, thermal comfort, eco-architecture, climate responsiveness, affordability, and recyclability (ScienceDirect, 2022).

Despite the benefits of earth-based materials, they are not widely used in many countries, including New Zealand. A 2022 study by Massey University and Otago Polytechnic found that only 1 per cent of houses in the country are earth buildings (Samarasinghe & Falk, 2021). The study identified several barriers to the growth of the earth building industry in New Zealand, such as: lack of awareness about the advantages of earth building; high cost and time of construction compared to conventional methods; limited availability of skilled labour and quality materials; regulatory hurdles and compliance issues; and negative perceptions and stereotypes associated with earth building.

Bio-based materials are made from living organisms, such as plants, animals and fungi. They can be used to create various building products such as insulation, structural elements, or packaging (Hookham, 2022). Bio-based materials have low environmental impact and high biodegradability. They can also reduce the dependence on fossil fuels and synthetic materials. Some examples of bio-based materials are straw, mass timber and hempcrete.

Straw is a bio-based material that has been extensively used throughout human history and has seen a revival in recent years. It is readily available and easily sourced, offering a cost-effective alternative to traditional building materials such as concrete, steel and brick (Yin, Yu, Ma, Liu, & Yin, 2023). Insulation materials made from straw are increasingly recognised due to their superior hygrothermal properties, low life-cycle costs, and low carbon footprint (Zhuo, Trabelsi, & El Mankibi, 2022). When used appropriately in construction, straw bales provide high levels of insulation and can help keep a home quiet and warm in winter and cool in summer. Straw bales have low embodied energy and are a renewable or sustainable building product (BRANZ, 2010).

Research on straw materials has advanced significantly over the past few years, leading to the development of new straw-based materials with enhanced properties. These materials offer promising solutions for sustainable construction due to their lower environmental impact, higher economic viability, and greater social acceptability compared to other conventional alternatives, such as cement, steel and wood (Yin, Yu, Ma, Liu, & Yin, 2023). Innovative straw-based materials that have been developed include straw fibre concrete, straw biomass ash and straw building panels.

New Zealand has an abundance of underutilised straw, capable of constructing the walls of approximately 2000 stand-alone houses annually (Hall, 2019). Strawlines, an innovative modular housing system, proposes to use straw and timber prefabricated panels to deliver affordable, low carbon homes to communities in Te Tau Ihu (Fineline Architecture, 2022). Hiberna Modular, another New Zealand company, has improved straw bale construction with its new Structural Insulated Panels (Hiberna Modular, 2023). These panels capitalise on straw's inherent advantages, including strength, fire resistance, moisture control, insulation and a low environmental impact.

Mass Timber are wood products used in medium and high-rise buildings and construction projects. These products include cross-laminated timber (CLT), glulam and laminated veneer lumber (LVL), derived from trees such as oak, bamboo, cherry, cedar, mahogany and birch. They are a sustainable and renewable alternative to traditional building materials such as concrete and steel. In 2021, the global mass timber construction market was valued at $857.1 million but is project to reach $1.5billion by 2031 (Allied Market Research, 2023).

Although New Zealand has an abundant forest resource, wood is rarely used in commercial and institutional scale construction (Ministry for Primary Industries, 2022). The use of wood in the country has only been growing at an estimated 1 per cent per year, and New Zealand lags behind countries like Australia, Austria, Canada, Germany, and the United States, in the use of mass timber. To accelerate the construction industry's use of wood and mass timber, the government has partnered with Red Stag Investments Limited to implement the Mid-Rise Wood Construction programme. The programme is expected to deliver economic benefits, with net value of $155 million by 2023 and $330 million by 2036.

Notable mass timber projects include the Clearwater Quays, New Zealand's first mass timber mid-rise apartment building (WoodWorks, 2023) and the Tauranga City Council building, set to become New Zealand's largest mass timber office building (Tauranga City Council, 2023).

Hempcrete, a mixture of hemp hurds (the inner part of the hemp stalk) and a lime-based binder, is emerging as a promising bio-based material for insulation and moisture regulation in buildings. Despite its growing popularity globally, hempcrete construction in New Zealand has been limited due to obstacles such as the lack of a local hemp fibre processing facilities and the absence of an NZ-certified hempcrete binder (Hemp Building Association New Zealand, 2021). However, recent developments such as the opening of a decortication plant in Christchurch and the invention of *Geobind* hemp-binder by a local builder are seen as a game-changer by the emerging hemp construction industry (Jensen, 2022). These new developments will enable builders to source hempcrete locally, instead of importing it from overseas.

Low carbon concrete has the potential to make a significant contribution to reducing greenhouse gas emissions. According to the United Nations Environmental Programme (UNEP), 30 billion tonnes of concrete are used each year, and the demand is expected to further increase due to population growth, urbanisation and infrastructure development. To achieve net-zero emissions by 2050, there is an urgent need to reduce emissions associated with concrete production and use.

In August 2023, Concrete New Zealand released a Roadmap to Net-Zero Carbon Concrete, mirroring a similar publication by the Global Cement and Concrete Association in 2022 (Concrete New Zealand, 2023). Both roadmaps focus on strategies such as reducing emissions from cement and clinker production, recarbonation and more efficient concrete design. They also require that over 30 per cent of the emissions savings to achieve net-zero concrete must come from carbon capture and storage (CCS) technology, which is not yet commercially viable anywhere in the world.

Green concrete is a type of low-carbon concrete that has minimal environmental impact compared to traditional concrete (A. Sivakrishna, 2020). This reduced environmental footprint comes from minimising energy consumption, carbon dioxide emissions and natural resource

depletion, associated with concrete production and use. Cement, the component of concrete with the largest carbon footprint, can be partially replaced with alternative, lower-carbon materials to effectively reduce concrete's emissions.

Supplementary Cementitious Materials (SCMs) have been used for decades worldwide as viable alternatives to cement. Examples of SCMs are pulverised fly ash (waste from coal-burning power stations) and ground granulated blast furnace slag (waste from steel manufacturing plants) (Concrete New Zealand, n.d.). While not widely used in New Zealand, these materials are becoming more common in concrete mixes offered by mainstream concrete providers like Firth and Allied Concrete. In 2023, Holcim, one of New Zealand's cement suppliers, established a facility in Auckland to import their ECOPlanet cement mixes, which incorporate SCMs, increasing their availability in the country (Holcim NZ, 2023).

However, the global supply of SCMs is projected to decline over time as the industries from which they arise become less prevalent. Recent studies indicate that global supply is already constrained to such an extent that importing SCMs for use in New Zealand may not result in a significant reduction in global emissions (Institution of Structural Engineers, 2023). Alternative SCMs available in New Zealand include calcined clay, silica fume, and natural pozzolans which offer domestic supplies of potential SCMs. Despite research into their performance by Concrete New Zealand, these materials are not yet available at a commercial scale.

In addition to using SCMs, other ways to green concrete include using recyclable and reusable materials. Concrete is often made with aggregates, which are the coarse and fine particles that make up the bulk of the material. Traditionally, aggregates have been quarried from natural sources, but there is a growing movement to use recycled and reusable materials instead. This can include paper or fibre, plastic waste, post-consumer glass and concrete debris. Using recycled materials reduces the need to extract virgin materials from the environment, saving energy and reducing emissions. Another way is using **bio-concrete** which is a type of concrete the uses bacteria to heal cracks in the material. The bacteria are added to the concrete mix, and when they come into contact with water and oxygen, produce a substance that fills the cracks. This can help to extend the lifespan of concrete structures and reduce the need for repairs.

Neocrete, a New Zealand company, has developed products that can help to green concrete (Neocrete, 2022). D5 Green reduces the water permeability of concrete, allowing for a reduction in cement content without loss of strength. It reduces carbon emissions and improves the performance of the concrete. Neocrete Activator increases the strength and durability of concrete and can also help reduce the amount of water needed to make concrete.

New Zealand pours four million cubic metres of concrete each year, producing 1.4 million tonnes of greenhouse emissions. The widespread use of products such as D5 Green and Neocrete Activator has the potential to help reduce New Zealand's carbon emissions from concrete. These products' have strong export potential to the world's largest concrete users such as China, India, the US and the European Union (Callaghan Innovation, 2021).

References

A. Sivakrishna, A. A. (2020). Green concrete: A review of recent developments. *Materials Today: Proceedings*, 54-58.

Advanced Construction Robotics. (2023). *TyBot*. Retrieved from https://www.constructionrobots.com/tybot

Allied Market Research. (2023, April). *Mass Timber Construction Market: Opportunities and Forecast, 2022-2031.* Retrieved from https://www.alliedmarketresearch.com/mass-timber-construction-market-

Anand, V., Kadiri, V. L., & Putcha, C. (2023, January). Passive buildings: a state-of-the-art review. *Journal of Infrastructure Preservation and Resilience, 4*, 3. doi:https://doi.org/10.1186/s43065-022-00068-z

ANZ. (2023, May). *Business Outlook: May 2023*. Retrieved from https://www.anz.co.nz/content/dam/anzconz/documents/economics-and-market-research/2023/ANZ-BusinessOutlook-20230531.pdf

Bassir, D., Lodge, H., Chang, H., Majak, J., & Chen, G. (2023, June). Application of artificial intelligence and machine learning for BIM: review. *International Journal for Simulation and Multidisciplinary Design Optimization, 14*, 8. doi:https://doi.org/10.1051/smdo/2023005

Baubot. (2023). *The Future of Construction is Here*. Retrieved from https://www.baubot.com/

Bauhaus Earth. (2023). *ReBuilt: Transformation pathways toward a regenerative built environment*. Retrieved from https://www.bauhauserde.org/initiatives/rebuilt-transformation-pathways-toward-a-regenerative-built-environment

BDO New Zealand. (2021). *Rethinking Construction: 2021 BDO New Zealand Construction Sector Report.* Retrieved from https://www.bdo.nz/en-nz/insights/construction/rethinking-construction-2021-bdo-new-zealand-construction-sector-report

BIM and Beam. (2023, May 10). *BIM and AI: How Artificial Intelligence is Transforming BIM Workflows and Job Roles after 2023?* Retrieved from https://bimandbeam.com/2023/05/bim-and-ai-artificial-intelligence-impact/

BIMinNZ. (2016). *A game-changer*. Retrieved from BIM in New Zealand: https://www.biminnz.co.nz/

BRANZ. (2010). *BU530 Straw bale construction.* Retrieved from https://www.branz.co.nz/pubs/bulletins/bu530/

BRANZ. (n.d.). *Low-carbon tools*. Retrieved November 2023, from https://www.branz.co.nz/low-carbon-resources/low-carbon-tools/

BRANZ. (n.d.). *Reducing greenhouse gas emissions int he construction industry*. Retrieved November 2023, from https://www.branz.co.nz/sustainable-building/climate-change/reducing-greenhouse-gas-emissions-construction-industry/

Callaghan Innovation. (2021, May). *Neocrete: Redefining concrete and cementing an eco-friendly future for construction.* Retrieved from https://www.callaghaninnovation.govt.nz/stories/cementing-eco-friendly-building/

Callaghan Innovation. (n.d.). *Construction Innovation Whare*. Retrieved November 2023, from https://content.callaghaninnovation.govt.nz/construction-innovation

Chen, Q., Zhang, C., & & Hu, Y. (2022). A review of AI-based hazard detection and prevention in construction. *Engineering, Construction and Architectural Management*, 1-27.

Climate Commission. (2023, November). *Final report: 2023 Advice on the direction of policy for the Government's second emissions reduction plan*. Retrieved December 2023, from https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/advice-for-preparation-of-emissions-reduction-plans/2023-draft-advice-to-inform-the-strategic-direction-of-the-governments-second-emissions-reduction-plan-april-2023/2023-advice-on-

Commerce Commission. (2022, December). *Market study into residential building supplies.* Retrieved from https://comcom.govt.nz/about-us/our-role/competition-studies/market-study-into-residential-building-supplies

Concrete New Zealand. (2023, August). *A Net-zero Carbon Concrete Industry for Aotearoa New Zealand Roadmap to 2050.* Retrieved from https://cdn.ymaws.com/concretenz.org.nz/resource/resmgr/docs/cnz/c_roadmap_concrete.pdf

Concrete New Zealand. (n.d.). *Supplementary Cementitious Material (SCM) Research*. Retrieved November 2023, from https://concretenz.org.nz/page/s_scm_research

Construction Sector Accord. (2023a, October). *Progress Report 2022/2023*. Retrieved from Innovation: https://www.constructionaccord.nz/progress/progress-report-2022-2023/innovation/

Construction Sector Accord. (2023b, October). *Environment*. Retrieved from Progress Report 2022/2023: https://www.constructionaccord.nz/progress/progress-report-2022-2023/environment/

Construction Sector Accord. (2023c, October). *Environment*. Retrieved from Progress Report 2022/2023: https://www.constructionaccord.nz/progress/progress-report-2022-2023/environment/

CoreLogic. (2023, October). *Cordell Construction Cost Index (CCCI).* Retrieved from https://www.corelogic.co.nz/news-research/reports/cordell-construction-cost-index

EBOSS. (2021a). *BIM Benchmark Survey 2021.* Retrieved from BIM in NZ: An industry-wide view: https://www.eboss.co.nz/bim-in-nz/bim-benchmark-survey-2021

EBOSS. (2021b). *Construction Supply Chain Q4 Update.* Retrieved from https://www.eboss.co.nz/assets/marketing/supply-chain-survey/EBOSS-Construction-Supply-Chain-Q4-Update.pdf

Ekso Bionics. (2023). *Introducing Ekso EVO: The next evolution of EksoVest*. Retrieved from eksoBIONICS: https://eksobionics.com/eksoworks/

FBR. (2023). *Hadrian X*. Retrieved from https://www.fbr.com.au/view/hadrian-x

Fineline Architecture. (2022, November). *Strawlines*. Retrieved from https://www.finelinearchitecture.co.nz/projects/blog-post-title-four-zt9xm-4pws7-nyt7p-j9w94-7y5f5-jspse-j3w6a-p9h5k-74ecl-7st49-tjyw5-l9ehe

Frew, S. (n.d.). Pioneering Passivhaus: 3 Decades of Setting Standards for Building Efficiency. *Architizer Journal*. Retrieved November 2023, from https://architizer.com/blog/inspiration/stories/pioneering-passivhaus/

Glynn, J. (2022, October). *Shipping costs decline more slowly in NZ.* Retrieved from Infometrics: https://www.infometrics.co.nz/article/2022-10-shipping-costs-decline-more-slowly-in-nz

Graham, J. (2023, August). *The benefits of cloud-based BIM management for project collaboration*. Retrieved from PlanRadar: https://www.planradar.com/au/benefits-cloud-based-bim-management-project-collaboration/

Grazuleviciute-Vileniske, I., Daugelaite, A., & Viliunas, G. (2022). Classification of Biophilic Buildings as Sustainable Environments. Buildings. 12(10):1542. Available from: . *buildings, 12*(10), 1542. doi:https://doi.org/10.3390/buildings12101542

Hall, M. (2019, December). *Counting straw : the capacity of New Zealand's grain growing sector to supply straw for construction.* Retrieved from Research Bank: https://www.researchbank.ac.nz/handle/10652/4926

Hemp Building Association New Zealand. (2021). Retrieved from https://hba.nz/

Hiberna Modular. (2023). *High performance panels for Consciously crafted buildings*. Retrieved from https://hibernamodular.co.nz/

Hobart, S. (2019, May). *2019 Zero Energy Buildings Count Nears 600.* Retrieved from New Buildings Institute: https://newbuildings.org/nbi-releases-zero-energy-building-count-and-trends-for-2019/

Holcim NZ. (2023). *ECOPlanet: A range of low-carbon cement and cementitious binders for Aotearoa's homes, buildings and infrastructure.* Retrieved from https://www.holcim.co.nz/ecoplanet

Hookham, B. (2022, July). *Nature as inspiration: Bio-based materials for sustainable construction*. Retrieved from ArchitectureAU.

Infrastructure Commission. (2021, October). *New Zealand's infrastructure challenge: Quantifying the gap and path to close it*. Retrieved from https://tewaihanga.govt.nz/our-work/research-insights/new-zealand-s-infrastructure-challenge-quantifying-the-gap-and-path-to-close-it

Infrastructure Commission. (2023a, May). *Pipeline snapshot: January-March 2023*. Retrieved from https://media.umbraco.io/te-waihanga-30-year-strategy/ga2pafrd/infrastructure-qr-march23.pdf

Infrastructure Commission. (2023b, June). *Pipeline snapshop: April - June 2023*. Retrieved from https://tewaihanga.govt.nz/the-pipeline/pipeline-snapshot

Institution of Structural Engineers. (2023). *The efficient use of GGBS in reducing global emissions.* Retrieved from https://www.istructe.org/resources/guidance/efficient-use-of-ggbs-in-reducing-global-emissions/#:~:text=This%20paper%20concludes%20that%20whilst,be%20used%20where%20required%20technically.

Insurance Council of New Zealand. (2023, June). *2023 Climate Disaster Payouts Top $1 Billion*. Retrieved from https://www.icnz.org.nz/industry/media-releases/2023-climate-disaster-payouts-top-1-billion/

Intellectual Property Office of New Zealand. (n.d.). *XFrame.* Retrieved November 2023, from https://www.iponz.govt.nz/case-studies/xframe

International Living Future Institute. (2022, October). *Te Kura Whare*. Retrieved from https://living-future.org/case-studies/te-kura-whare-2/

International Living Future Institute. (n.d.). *Living Building Challenge*. Retrieved November 2023, from https://living-future.org/lbc/

Jensen, M. (2022, December). *Kerikeri's Geobind hemp binder has potential to change NZ housing market forever*. Retrieved from New Zealand Herald: https://www.nzherald.co.nz/northland-age/news/kerikeris-geobind-hemp-binder-has-potential-to-change-nz-housing-market-forever/KECGPQTDVNHFRDHTNDJBE6N4BE/

Kāinga Ora. (2023, September). *Bader Drive and Ventura Street*. Retrieved from https://Kāingaora.govt.nz/urban-development-and-public-housing/public-housing/public-housing-developments/auckland-region/bader-drive-and-ventura-street/

Luna, D. (2023, February). *The future of BIM: Emerging trends and technologies*. Retrieved from BIMobject: https://business.bimobject.com/blog/the-future-of-bim-emerging-trends-and-technologies/

MATES in Construction NZ. (2022, September). Retrieved from https://mates.net.nz/wp-content/uploads/2022/09/MATES-Wellbeing-data-analysis-final-6.pdf

MBIE. (2022a, December). *Proposed Building for Climate Change amendments released*. Retrieved November 2023, from Building Performance: https://www.building.govt.nz/about-building-performance/all-news-and-updates/proposed-building-for-climate-change-amendments-released/

MBIE. (2022b, January). *Carbon-neutral government programme: Report back on the use of sustainable building rating systems [Proactive release] (Report No. 18636).* Retrieved from https://www.mbie.govt.nz/dmsdocument/18636

MBIE. (2022c, June). *New laws will support housing supply and improve building product information*. Retrieved from https://www.mbie.govt.nz/about/news/new-laws-will-support-housing-supply-and-improve-building-product-information/

MBIE. (2022d, September). *Building Performance*. Retrieved from BuiltReady modular component manufacturing scheme launched: https://www.building.govt.nz/about-building-performance/all-news-and-updates/builtready-offsite-manufacturing-scheme-launched/

MBIE. (2023, December). *Building for Climate Change*. Retrieved from Building Performance: https://www.building.govt.nz/getting-started/building-for-climate-change/background/

MBIE. (2023a). Placards data.

MBIE. (2023b, March). *Proposed Building for Climate Change amendments*. Retrieved from Building Performance: https://www.building.govt.nz/getting-started/building-for-climate-change/proposed-amendments/

MBIE. (n.d.). *Building for Climate Change*. Retrieved November 2023, from Building Performance: https://www.building.govt.nz/getting-started/building-for-climate-change/

MBIE. (n.d.). *Building Performance*. Retrieved November 2023, from Building for Climate Change: https://www.building.govt.nz/getting-started/building-for-climate-change/background/

Ministry for Primary Industries. (2022, October). *Mid-Rise Wood Construction.* Retrieved from https://www.mpi.govt.nz/funding-rural-support/primary-growth-partnerships-pgps/current-pgp-programmes/mid-rise-wood-construction/

Ministry for the Environment. (2022, May). *Aotearoa New Zealand's first emissions reduction plan: Building and construction.* Retrieved from https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/building-and-construction/

Ministry for the Environment. (2023, October). *Carbon Neutral Government Programme*. Retrieved from https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/carbon-neutral-government-programme/

Ministry of Education. (2023a, June). *New Zealand's workforce-based learners.* Retrieved from https://www.educationcounts.govt.nz/statistics/new-zealands-workplace-based-learners

Ministry of Education. (2023b, September). *Apprenticeship boost initiative: Monthly demographic statistics.* Retrieved from https://www.educationcounts.govt.nz/statistics/apprenticeship-boost-initiative-monthly-demographic-statistics

Ministry of Maori Development. (2023). Data on Maori Business.

Monarch Innovation. (2023, August). *5 Innovative BIM trends in 2023*. Retrieved from https://www.monarch-innovation.com/bim-trends-in-2023

Naska.AI. (2023). *Noether*. Retrieved from https://naska.ai/noether/

National Emergency Management Agency. (2023, May). *Weekly Update from the Cyclone Recovery Unit – 29 May 2023.* Retrieved from https://www.civildefence.govt.nz/resources/news-and-events/news-and-events/weekly-update-from-the-cyclone-recovery-unit-29-may-2023

National Institute of Building Sciences. (2023). *Living, Regenerative, And Adaptive Buildings*. Retrieved from Whole Building Design Guide: https://www.wbdg.org/resources/living-regenerative-and-adaptive-buildings#:~:text=Regenerative%20and%20restorative%20buildings%20not,environment%2C%20including%20repairing%20surrounding%20ecosystems.

Neocrete. (2022, November). *Neocrete scoop in Inside Resources.* Retrieved from https://www.neocrete.co.nz/post/neocrete-scoop-in-inside-resources

New Zealand Foreign Affairs and Trade. (2022, February). *Potential Impacts of the Russian Invasion of Ukraine on the New Zealand economy*. Retrieved November 2023, from https://www.mfat.govt.nz/en/trade/mfat-market-reports/potential-impacts-of-the-russian-invasion-of-ukraine-on-the-new-zealand-economy/#:~:text=The%20most%20significant%20impacts%20on,drag%20on%20global%20economic%20activity.

New Zealand Government. (2021, November). *Climate standards for new government buildings*. Retrieved from https://www.beehive.govt.nz/release/climate-standards-new-govt-buildings

New Zealand Government. (2023, May). *Wellbeing Budget 2023: Support for today, Building for tomorrow.* Retrieved from https://budget.govt.nz/budget/pdfs/wellbeing-budget/b23-wellbeing-budget.pdf

New Zealand Green Building Council. (2023). *Net Zero Buildings.* Retrieved from https://www.nzgbc.org.nz/net-zero-buildings

New Zealand Green Building Council. (n.d.). *Homestar*. Retrieved November 2023, from https://nzgbc.org.nz/introduction-to-homestar

New Zealand Green Building Council. (n.d.). *Introduction to Green Star*. Retrieved November 2023, from https://nzgbc.org.nz/introduction-to-green-star

New Zealand Infrastructure Commision. (2022). *Rautaki Hanganga o Aotearoa 2022 - 2052 New Zealand Infrastructure*. Retrieved from Rautaki Hanganga o Aotearoa - New Zealand Infrastructure Strategy: https://tewaihanga.govt.nz/the-strategy

New Zealand Institute of Building. (2021, November). *Improving New Zealand Construction Industry Productivity: An Overview.* Retrieved from https://nziob.org.nz/assets/CPG-Abridged-version-Final-30-Nov.pdf

New Zealand Institute of Economic Research. (2023, July). *NZIER's QSBO shows a modest increase in business confidence and continued easing in capacity pressures, July 2023*. Retrieved from https://www.nzier.org.nz/publications/qsbo-shows-a-modest-increase-in-business-confidence-and-continued-easing-in-capacity-pressures

New Zealand Security Intelligence Service. (2023). *New Zealand's Security Threat Environment 2023.* New Zealand Security Intelligence Service.

NZIER. (2022, July). *NZIER's QSBO shows businesses feeling more downbeat as demand stagnates - Quarterly Survey of Business Opinion, July 2022*. Retrieved from NZIER: https://www.nzier.org.nz/news/nziers-qsbo-shows-businesses-feeling-more-downbeat-as-demand-stagnates-july-2022

Owen, M. (2023, March 08). *Why BIM, PIM and AI are driving transformation in the Construction Industry*. Retrieved from World Construction Today: https://www.worldconstructiontoday.com/articles/why-bim-pim-and-ai-are-driving-transformation-in-the-construction-indust

Pan, Y., & Zhang, L. (2022, November 03). Integrating BIM and AI for Smart Construction Management: Current Status and Future Directions. *Archives of Computational Methods in Engineering, 30*, 1081–1110.

Parliamentary Counsel Office. (2022, June 7). *Building (Modular Component Manufacturer Scheme) Regulations 2022*. Retrieved November 2023, from New Zealand Legislation: https://www.legislation.govt.nz/regulation/public/2022/0171/latest/LMS697926.html

Parliamentary Counsel Office. (2023, August 24). *Building Act 2004*. Retrieved November 2023, from New Zealand Legislation: https://www.legislation.govt.nz/act/public/2004/0072/latest/DLM307366.html?search=sw_096be8ed81dbaa71_section+169_25_se&p=1: https://www.legislation.govt.nz/act/public/2004/0072/latest/DLM307366.html?search=sw_096be8ed81dbaa71_section+169_25_se&p=1

Passive House Institute New Zealand. (n.d.). *Passive House Institute New Zealand*. Retrieved November 2023, from https://passivehouse.nz/

Potseluyko, L., Rahimian, F. P., Dawood, N., Elghaish, F., & Hajirasouli, A. (2022, August). Game-like interactive environment using BIM-based virtual reality for the timber frame self-build housing sector. *Automation in Construction, 142*, 104496. doi:https://doi.org/10.1016/j.autcon.2022.104496

Precedence Research. (2023, February). *3D Printing Construction Market Size, Share, Trends, and Forecast by Material Type, Construction Method, End-User, and Region, 2023-2032.* Retrieved from https://www.precedenceresearch.com/3d-printing-construction-market

Property & Build. (2023, November). *NZ's first fully 3D-printed home is largest in Southern Hemisphere*. Retrieved from https://www.propertyandbuild.com/nzs-first-fully-3d-printed-home-largest-southern-hemisphere/?utm_source=InfraNew

Ranjha, S. A., Kulkarni, A., & Sanjayan, J. (2018, November). 3D Construction Printing – A Review with Contemporary Method of Decarbonisation and Cost Benefit Analysis. *1st International Conference on 3D Construction Printing (3DcP)*.

Research New Zealand. (2022, November 23). *State of the Building and Construction Sector: Annual Monitor 2021-2022. Technical Report.* Wellington: MBIE. Retrieved November 2023, from https://www.mbie.govt.nz/building-and-energy/building/building-system-insights-programme/state-of-the-building-and-construction-sector/

Reserve Bank of New Zealand. (2022, May). *Financial and economic impacts of Russia's invasion of Ukraine on New Zealand.* Retrieved November 2023, from https://www.rbnz.govt.nz/hub/publications/financial-stability-report/financial-stability-report-for-may-2022/financial-and-economic-impacts-of-russia-invasion-of-ukraine-on-new-zealand

Samarasinghe, D. A., & Falk, S. (2021). Promoting Earth Buildings for Residential Construction in New Zealand. *12*(9), 1403. doi:https://doi.org/10.3390/buildings12091403

ScienceDirect. (2022, September). *Construction and Building Materials*. Retrieved from Modern earth building materials and technologies.

Site Safe NZ. (2023, August 18). *Site Safe launch virtual reality training course for New Zealand's construction industry*. Retrieved from https://www.sitesafe.org.nz/news--events/news/foundation-passport-VR/

Stats NZ. (2022, May). Retrieved from Experimental Indicators About Building Timeframes: https://www.stats.govt.nz/news/stats-nz-releases-experimental-indicators-about-building-timeframes/

Stats NZ. (2023a, July). *Quarterly Employment Survey: June 2023 quarter.* Retrieved from https://www.stats.govt.nz/information-releases/labour-market-statistics-june-2023-quarter/

Stats NZ. (2023b, August). *Labour Market Statistics: June 2023 quarter*. Retrieved from https://www.stats.govt.nz/information-releases/labour-market-statistics-june-2023-quarter/

Stats NZ. (2023c, November). *Linked Employer-employee Data: September 2022 quarter*. Retrieved from https://www.stats.govt.nz/information-releases/linked-employer-employee-data-september-2022-quarter-nz-stat-tables/

Stats NZ. (2023d, October). *New Zealand Business Demography Statistics: At February 2023*. Retrieved from https://www.stats.govt.nz/information-releases/new-zealand-business-demography-statistics-at-february-2023/

Stats NZ. (2023e, September). *Gross Domestic Product: June 2023 quarter*. Retrieved from https://www.stats.govt.nz/information-releases/gross-domestic-product-june-2023-quarter/

Stats NZ. (2023f, August 01). *Building Consents Issued: June 2023*. Retrieved from https://www.stats.govt.nz/information-releases/building-consents-issued-june-2023/

Stats NZ. (2023g, September). *Value of Building Work Put in Place: June 2023 quarter*. Retrieved from https://www.stats.govt.nz/information-releases/value-of-building-work-put-in-place-june-2023-quarter/

Stats NZ. (2023h, September). *Business Financial Data: June 2023 quarter*. Retrieved from https://www.stats.govt.nz/information-releases/business-financial-data-june-2023-quarter/

Stats NZ. (2023i, July). *Consumers Price Index: June 2023 quarter.* Retrieved from https://www.stats.govt.nz/information-releases/consumers-price-index-june-2023-quarter/

Stats NZ. (2023j, August). *Business Price Indexes: June 2023 quarter.* Retrieved from https://www.stats.govt.nz/information-releases/business-price-indexes-june-2023-quarter/

Stats NZ. (2023k, March). *Productivity Statistics: 1978-2022*. Retrieved from https://www.stats.govt.nz/information-releases/productivity-statistics-1978-2022/

Stats NZ. (2023l, June). Overseas Merchandise Trade on Plasterboard and Plaster-related Product.

Stats NZ. (2023m, March). *Productivity statistics: 1978–2022.* Retrieved from https://www.stats.govt.nz/information-releases/productivity-statistics-1978-2022/

Stats NZ. (2023n, September). *Injury Statistics - Work-related Claims: 2022*. Retrieved from https://www.stats.govt.nz/information-releases/injury-statistics-work-related-claims-2022/

Stats NZ. (2023o, April). *Research and Development Survey: 2022*. Retrieved from https://www.stats.govt.nz/information-releases/research-and-development-survey-2022/

Sustainable Engineering Ltd. (2023). *Toiora High Street Cohousing*. Retrieved from https://architecturenow.co.nz/articles/green-commons-toiora-high-street-cohousing/

Tauranga City Council. (2023, March). *New Zealand's largest mass timber office building coming to town*. Retrieved from https://www.tauranga.govt.nz/council/council-news-and-updates/latest-news/artmid/456/articleid/8672

Te Pūkenga – New Zealand Institute of Skills and Technology. (2023). *Apprenticeship boost.* Retrieved from https://bcito.org.nz/employers/boost/

Te Wānanga o Raukawa. (2022, March). *Te Wānanga o Raukawa joins 'The Living Building Challenge*'. Retrieved from https://www.wananga.com/te-wananga-o-raukawa-joins-the-living-building-challenge

The Treasury. (2023a, April). *Impacts from the North Island weather events.* Treasury. Retrieved from https://www.treasury.govt.nz/sites/default/files/2023-04/impacts-from-the-north-island-weather-events.pdf

The Treasury. (2023b, September). *Pre-election Economic and Fiscal Update 2023.* Retrieved from https://www.treasury.govt.nz/sites/default/files/2023-09/prefu23.pdf

The Treasury. (2023c, April). *Impact from the North Island weather events*. Retrieved from https://www.treasury.govt.nz/sites/default/files/2023-04/impacts-from-the-north-island-weather-events.pdf

The Treasury. (2023d, May). *Infrastructure Action Plan 2023.* Retrieved from https://www.treasury.govt.nz/sites/default/files/2023-05/infrastructure-action-plan-2023.pdf

The Treasury. (n.d.). *Support for today, Building for tomorrow*. Retrieved November 2023, from Budget 2023: https://budget.govt.nz/budget/2023/wellbeing/investments/recovery-resilience.htm

United Nations Environment Programme. (2022, November). *2022 Global Status Report for Buildings and Construction: Towards a zero-emissions, efficient and resilient buildings and construction sector.* Retrieved November 2023, from https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

United Nations Environment Programme. (2023, September). *Building Materials And The Climate: Constructing A New Future.* Retrieved from https://www.unep.org/resources/report/building-materials-and-climate-constructing-new-future

Utilities One. (2023, October). *Energy-Efficient Prefab and Modular Construction A Key Driver in Green Job Creation.* Retrieved from https://utilitiesone.com/energy-efficient-prefab-and-modular-construction-a-key-driver-in-green-job-creation

Victoria University of Wellington. (2023, October). *The Living Pā*. Retrieved from https://www.wgtn.ac.nz/living-pa

Waihanga Ara Rau. (2023). *New Entrant Origins*. Retrieved from Workforce Information Platform: https://wip.org.nz/entrant-origins?year=2021&workforce_definition=Core

Waihanga Ara Rau. (n.d.). *Emergency Response Workforce Calculator.* Retrieved November 2023, from https://wip.org.nz/emergency-calculator?types=Residential&scenario=unadjusted

Wang, Y., Zhou, Y., & Li, H. (2020). BIM and AI for sustainable construction: A review. *Journal of Cleaner Production, 262*.

WoodWorks. (2023, June). *Clearwater: Showcase for sequestration*. Retrieved from https://woodworks.events/clearwater-showcase-for-sequestration/

World Green Building Council. (2018). *19 Global Cities Commit to Making New Buildings Net Zero Carbon by 2030*. Retrieved from https://worldgbc.org/article/19-global-cities-commit-to-making-new-buildings-net-zero-carbon-by-2030/

World Green Building Council. (2023, July). *Advancing Net Zero Status Report.* Retrieved from Publications: https://worldgbc.org/article/2023-advancing-net-zero-status-report/

Yin, Q., Yu, M., Ma, X., Liu, Y., & Yin, X. (2023). The Role of Straw Materials in Energy-Efficient Buildings: Current Perspectives and Future Trends. *Energies, 16*(8), 3480. Retrieved November 2023, from doi:https://doi.org/10.3390/en16083480

Zhang, Y., Liu, R., Hu, Y., & Zhang, Z. (2022). A review of AI-based 3D reconstruction for as-built BIM. *Automation in Construction, 139*, 104272.

Zhong, W., Schröder, T., & Bekkering, J. (2022). Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review. *Frontiers of Architectural Research, 13*(8), 114-141. Retrieved from https://doi.org/10.3390/su13084323

Zhuo, Y., Trabelsi, A., & El Mankibi, M. (2022). A review on the properties of straw insulation for buildings. *Construction and Building Materials* .

Appendix: Selected Data Tables

		Year ended March		
		2022		2023
Gross Domestic Product (GDP)				
Real GDP (in 2009/2010 prices)	NZD millions	16,898		18,106
	annual % change	-2.40%		2.1%
Real residential investment (in 2009/2010 prices)	NZD millions	16,799		16,726
	annual % change	3.1%		-0.4%
Real non-residential investment (in 2009/2010 prices)	NZD millions	6,693		7,491
	annual % change	3.1%		11.9%
Building consents and activity				
Residential dwelling consents	consents issued	50,736		44,529
	annual % change	14.40%		-12.20%
stand-alone houses	consents issued	23,913		18,498
	annual % change	-2.50%		-22.60%
multi-unit homes	consents issued	26,823		26,031
	annual % change	35.50%		-3.0%
Value of total building work put in place	NZD$ millions	30,490		37,073
	annual % change	21.60%		10.80%
Residential building work put in place	NZD$ millions	20,862		24,718
	annual % change	12.50%		18.50%
Non-residential building work put in place	NZD$ millions	12,355		9,628
	annual % change	7.30%		28.3%
Prices				
Consumers price index (CPI) – home ownership index	% change from the same quarter of the previous year	18.30%		7.80%
Producers price index (PPI) – construction input index		13.10%		5.70%
Producers price index (PPI) – construction output index		12.70%		6.80%
Wood and timber price index		17.10%		-9.0%
Ready-mixed concrete index		6.00%		15.50%

		Year ended June		
		2022		2023
Labour market				
Employment (HLFS)	no. of employees	294,800		308,500
	annual % change	7.1%		4.6%
LCI salary and wage rates				
construction sector	% change from the same quarter of the previous year	3.00%		4.20%
all industries		2.10%		3.40%
QES average hourly earnings				
construction sector	NZD	33.99		36.88
	% change from the same quarter of the previous year	5.90%		8.50%
all industries	NZD	37.04		39.60
	% change from the same quarter of the previous year	6.40%		6.90%

		Year ended March		
		2021		2022
Labour productivity index				
construction sector	annual % change	-0.5%		-0.7%
all industries	annual % change	0.00%		0.20%

		Year ended December		
		2021		2022
Health and safety				
Injury incidence rates				
construction sector	claims per 1,000 FTEs	144		135
all industries	claims per 1,000 FTEs	91		87

Te Kāwanatanga o Aotearoa
New Zealand Government

DDI 10576