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Elrasheid Elkhidir Dr
Massey University, New Zealand, e.elkhidir@massey.ac.nz

Suzanne Wilkinson
Auckland University of Technology, suzanne.wilkinson@aut.ac.nz

Regan Potangaroa
Massey University, r.potangaroa@massey.ac.nz

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Impacts of Natural Disasters on the Construction Industry: Contractors' Perspectives

Elrasheid Elkhidir, e.elkhidir@massey.ac.nz
Massey University, New Zealand

Suzanne Wilkinson, suzanne.wilkinson@aut.ac.nz
Auckland University of Technology, New Zealand

Regan Potangaroa, r.potangaroa@massey.ac.nz
Massey University, New Zealand

Abstract
Contractors are at the core of the construction industry and the forefront of disaster response and reconstruction programs. The resilience capacity and the wellbeing of the contracting industry are crucial. This study investigates the impacts of natural hazard disasters on construction contractors. Semi-structured interviews with twelve senior executives from leading construction firms were conducted, and the data was thematically analysed. The research revealed four prominent themes: opportunities arising from disaster events, workforce and materials challenges, incurred damages and losses, and weather-related disruptions. The increased project demands resulting from damages by disasters constitute growth opportunities for the contractors, and the urgent nature of the response and reconstruction works usually entail lower levels of pre-construction bureaucracies. However, the sudden hike in demand introduces significant challenges for the sector. Workforce shortages due to labour migration to affected areas, material shortages, and financial losses from uncompensated overheads and damages were experienced. One study finding was that contractors employ various strategies to manage these impacts, including workforce redistribution, multi-skilling training initiatives, and technological solutions such as GPS tracking systems for resource management. Additional impacts revealed included weather-related disruptions in project delivery and performance due to climate change and the changing weather pattern in New Zealand. While the construction sector demonstrates adaptability in disaster response, there is a critical need for more robust disaster preparedness strategies, including formal resource-sharing agreements, regional resource pools, and climate-adjusted planning and scheduling models.

Keywords
contractor adaptability, contractor resilience, post-disaster reconstruction

1. Introduction

The construction sector's involvement in disaster events is multifaceted. Firstly, the construction sector, particularly contractors, who are responsible for executing projects on the ground, hold legal responsibility for delivering a safe and disaster-resilient built environment capable of withstanding the impacts of disasters and that could efficiently accommodate the needs and requirements of

communities and reduce their vulnerability. Furthermore, contractors are also the first point of questioning regarding structural and infrastructure failures due to disasters, and this often causes friction in the relationships with the sector clients and may result in a loss of reputation (Abu Talib et al., 2016). Moreover, contractors are often at the forefront of disaster-related construction activities such as the initial response efforts and post-disaster recovery construction. The swiftness of the industry's response to the impacts of disaster on the urban environment is crucial (Pamidimukkala et al., 2020). For example, a prompt contractor's response could save lives, facilitate evacuation efforts, reduce road accidents, stabilise supply chains, and aid in reaching isolated areas due to disaster events (Pribadi et al., 2018).

Despite its criticality and importance in the disaster response and reconstruction phases, contractors are not regularly involved in disaster management planning efforts and calls for more sector involvement in disaster planning were initiated (Stringfellow, 2014). Moreover, the sector should ensure its own resilience and business continuity during disaster events. Natural disasters impacting the wellbeing and performance of construction contractors include high winds, floods, precipitation, extreme temperatures, earthquakes, and landslides (Wedawatta et al., 2011; Wedawatta and Ingirige, 2012; Schuldt et al., 2021).

Disaster response and rebuilding programs create opportunities and offer projects that aid the construction sector's growth. The destruction left in the aftermath of disaster events inflates the demand for maintenance and creates new projects necessary for restoring life-as-usual (Wedawatta et al., 2010). For example, a significant rebuilding program resulted from the destruction left in the aftermath of the Canterbury 2011 earthquake that devasted Christchurch City in New Zealand (Chang et al., 2010; Wilkinson et al., 2016). Similarly, the 2004 tsunami in Sri Lanka created substantial construction demands in response to the widespread destruction of buildings and infrastructure (Ingirige et al., 2008).

Alternative construction procurement and delivery methods may be required to cater for the urgency and increased construction demands. For example, Chester et al. (2021) suggested reverting to design-build procurement methods instead of the traditional design-bid-build procurement methodology during disaster response and reconstruction efforts. Similarly, Tang et al. (2022) highlighted how integrating innovative tools like the Design Structure Matrix (DSM) and alternative delivery methods such as design-build could enhance processes, shorten schedules, and enhance coordination in disaster reconstruction projects. The adoption of technology and Construction 4.0 applications was suggested by several researchers to facilitate operations and respond effectively to the heightened demands. For example, Oktavianus et al. (2022) suggested the use of AI and BIM in early damage detection, which reflects on the overall construction process. Schuldt et al. (2021) recommended adopting project scheduling models incorporating weather data, allowing for efficient schedule adjustments. Furthermore, flexible contract terms, with clear clauses regarding weather disruption events, were recommended to reduce litigation arising during such events (Apipattanavis et al., 2010).

Despite the growth opportunities, disaster events introduce several shocks and stresses for the construction sector. Shocks are defined as a 'sudden event that impacts on the vulnerability of a system and its components', while a stress refers to a 'long-term trend that undermines the potential of a given system and increases the vulnerability of actor within it' (DFID, 2011). One persistent issue is insufficient skilled labour for the response and reconstruction stages. For example, difficulties in recruiting and resourcing skilled labour were experienced in post-disaster reconstruction programs during the Canterbury 2011 earthquake (Wilkinson et al., 2016; Chang-Richards et al., 2017). Inflation and price increases due to excessive construction demands could also occur, as experienced in the aftermath of the 2004 tsunami in Sri Lanka (Ingirige et al., 2008). Analogously, the influence of

disaster events on increasing labour and material costs and interrupting the construction market was indicated in the 2010 Chile earthquake (Forcael et al., 2017).

Furthermore, Sadiqi et al. (2012) highlighted how the rush and urgency for post-disaster reconstruction prioritises speed over planning, leading to inadequate consideration of community needs and vulnerabilities. Similarly, Celentano et al. (2018) concluded that expediting post-disaster reconstruction processes may result in quality defects, inappropriate designs, and the choice of substandard materials. Further impacts included loss of business reputation, supply chain disruption, information and communication challenges, site and facility disruptions, finance challenges, stakeholders and end users conflicts, technology and the environment (Abu Talib et al., 2016). Furthermore, the industry faces the imperative to work under adverse conditions, including hazardous construction sites, limited access and dependence on skilled operators to deploy heavy equipment (Pribadi et al., 2018).

Logistical and operational disruptions frequently undermine project performance during disaster events. Pamidimukkala et al. (2020) identified eleven key challenges, including increased overhead costs and labour costs, disrupted logistics, equipment/plant and materials damage, damage to structural components, delays, environmental and psychological factors, and loss of lives. Disaster events could impact supply chain businesses in several ways, including business failures, profit losses, project delays and failures, project cost escalations, project quality challenges, loss of lives, injuries, and property damage (Sandanayake et al., 2018). This would directly impact construction projects regarding costs, schedule delays, performance and quality issues, material and equipment shortages, and financial losses (Metcalf et al., 2010; Sandanayake et al., 2018; Ayat and Kang, 2021). The construction sector should reduce its vulnerability and enhance its coping capacity and coping strategies to withstand the impacts of extreme weather events on the sector (Wedawatta et al., 2010).

This paper aims to identify the impacts of natural hazard disasters on construction contractors in New Zealand, highlighting the construction contractors' vulnerabilities and resilience strategies. Adopting a qualitative approach, twelve semi-structured interviews were conducted with top-tier contractors operating in civil and building construction domains. The interviews were audio-recorded, transcribed, and thematically analysed, as described in the following section. The paper then presents and discusses the main identified impacts on the industry, followed by a conclusions and recommendations section.

2. Research Methodology

Semi-structured interviews were conducted to provide the flexibility needed for an in-depth examination of specific topics with a purposive sample (Ritchie and Lewis, 2003). The purposive sampling allowed for a deliberate and strategic selection of participants who shared relevant characteristics or attributes linked to the study's focus (Ritchie and Lewis, 2003). Twelve semistructured interviews were conducted with senior executives from twelve of New Zealand's most prominent firms. Given the small size of New Zealand, and the concentration of major construction projects within top-performing construction firms, this purposive sample was considered adequate for gaining in-depth insights and capture a range of experiences from key decision-makers in the industry. This ensured that the data reflects diverse perspectives on disaster impacts. Additionally, saturation was reached as no new themes emerged during the data analysis, confirming the sufficiency of the sample size . The building contracting firms were selected from the list of top firms in New Zealand, as reported in the annual BCI Construction League report (BCI, 2024). The majority of the horizontal construction in New Zealand are public projects, such as transportation, roading, and water. The civil and horizontal construction firms were selected from the major contracting companies undertaking government projects.

The study explored the impacts of natural hazards and disasters on the construction sector. Interviewees were asked to share their experiences and insights about various disaster events, encouraging them to reflect on their professional expertise. The questions deeply examined how natural hazards and disasters affected their construction operations and businesses. Open-ended responses were encouraged to capture a wide range of perspectives. Braun and Clarke's (2006) thematic analysis framework was employed to analyse the data, identifying patterns and similarities across responses. These were grouped into meaningful categories, ultimately leading to the development of key themes that formed the basis of the study's findings. NVivo software was employed to assist with the thematic analysis.

Data collection saturation was achieved, with no new themes, categories or insights emerging during the data analysis. After analysing and coding the collected interviews, it was evident to the research team that additional data did not contribute novel or new codes to the identified themes. This approach enhanced the study's rigour by ensuring the data's depth, credibility, and representativeness. Details about the participants and their assigned designations or codes are presented in Table 1.

Table 1 Research participants, roles, and designations used in this research

Organisation Type	Role	Designation
General Contractor	Chief Executive Officer	P1
General Contractor	Chief Executive Officer	P2
General Contractor	Chief Executive Officer	P3
General Contractor	Contracts Manager	P4
General Contractor	Chief Executive Officer	P5
General Contractor	Contracts Manager	P6
General Contractor	Construction Manager	P12
Civil Contractor	General Manager	P7
Civil Contractor	General Manager	P8
Civil Contractor	Chief Executive Officer	P9
Civil Contractor	Chief Executive Officer	P10
Civil Contractor	Contracts Manager	P11
Civil Contractor	General Manager	P12

3. Findings and Discussion

This section presents the findings and themes identified after analysing the semi-structured interviews. Four main themes were identified: opportunities arising from disaster reconstruction demands, workforce and material shortages, financial and physical damages caused by disaster events, and weather-related disruptions to construction operations.

3.1. Opportunities

Construction contractors viewed natural disasters as an opportunity for the sector in many ways. Firstly, disaster events usually lead to the creation of projects, increasing the demand for more supply (P1, P5, P9). Interviewee P1 reflected on the project pipeline created due to the Canterbury 2011 earthquake, stating:

"The Canterbury earthquake has had a big impact on us because it created a lot of opportunity; that was a positive for us."

Secondly, the nature of "urgency" accompanying response and rebuilding projects in the aftermath of natural disasters comes with merits. For example, Interviewee P9 explained that the pre-construction activities are often facilitated and expedited by governing and consenting bodies, stating:

"Less bureaucracy and front-end preparation and admin work because the work needs to be done. They go to people who can do it."

Disasters often leave destruction in the aftermath and catalyse economic growth and job creation within the construction sector. As Wedawatta et al. (2010) argued, these events generate significant demand for adaptation, maintenance, and reconstruction, driving opportunities for construction firms. The Canterbury earthquake exemplifies how major disaster events can boost the industry through large-scale residential and commercial rebuilding programs (Chang et al., 2010; Wilkinson et al., 2016). While these opportunities bear growth and economic benefits to the sector, they also require careful planning and coordination to ensure the capacity and capability of the sector to respond to the increased demands, as will be discussed in this section. Furthermore, the increased demand for construction services during post-disaster reconstruction presents opportunities for innovation and technological advancement in the sector. Alternative procurement methods, construction methods, and technologies could be utilised to overcome some of the impacts of sudden increased demands due to disaster events (Chester et al., 2021; Oktavianus et al., 2022; Tang et al., 2022).

The acceleration of pre-construction processes during emergencies aligns with the observations of Pribadi et al. (2018), who highlighted the criticality of swift construction responses to stabilise supply chains and restore access to isolated areas. However, while reduced bureaucracy benefits short-term recovery, it may bypass standard compliance and building permit procedures, leading to potential quality, materials, and planning issues (Sadiqi et al., 2012; Celentano et al., 2018). Developing agreements and memorandums of understanding between the local authorities and the construction sector detailing the expectations, the level of compliance and delivery, and the ethical expectations in cases of expedited post-disaster reconstruction projects may aid in streamlining the administrative requirements without compromising the quality or structural integrity.

3.2. Workforce, & Materials Challenges

Providing more rebuilding projects in disaster-affected areas could also negatively affect the construction sector, as interviewees P2, P8, and P12 stated. Skills and talent usually shift their focus or relocate their services to disaster-affected regions in pursuit of opportunities, as stated by interviewee P2.

"What happens is that natural disasters take labour away from the other markets. Anybody in groundworks, drainage, or any construction practice will go to the infrastructure."

Interviewee P12 further added the materials supply disruptions, reflecting on their experience after Cyclone Gabriele struck Auckland in early 2023, stating:

"The challenge was on the call on the industry to respond. It was hard securing services such as finishing trades. Everything was also completely consumed, for example, carpet supply. That's a practical challenge."

Contractors usually adopt several mitigation measures, such as re-assigning and re-distributing their available workforce (P8, P11). For example, interviewee P8 stated that they evaluate the workload of their workforce and redirect those with lower workloads to high-demand areas, stating:

"When the East Coast storms hit, we started sending people from all around New Zealand, particularly parts of the South Island that have got quite quiet now regarding infrastructure."

However, the re-deployment and redistribution of the workforce may not always be feasible and may cause disruptions in operations, especially with limited resources and already high working loads. In this regard, interviewee P11 stated:

> *"We've had years of rainfall in just five months, accompanied by multiple landslides. We had to bring contractors in for some of these, and our design teams had to work on the urgent new response projects. But then, when the design teams are busy with that, they'll have to stop other major designs. So, there's a knock-on effect."*

To avoid delaying ongoing projects, some construction contractors offered alternative mitigation measures. For example, creating multi-skill staff members and transferring skills across teams could be effective in responding to the growing demand for disaster response reconstruction activities, as reflected by interviewee P8:

> *"Crews that would normally just lay asphalt could be asked to go in and help the teams that are supposed to be clearing the drains, for example. So, it's not their main skill set, but we have the ability and versatility to redirect them on those emergencies."*

Interviewee P8 further reflected that the demand for response activities is becoming more frequent, mandating attention to the staff residence locations for planning, stating:

> *"We have got five depots strategically located around the city. We try to ensure we're not getting people to commute longer than necessary. When we do have these natural disasters, we can better understand where our people are and how we can utilise them. We also use technology. We've got about 500 light vehicles equipped with GPS tracking systems. We know where our staff and vehicles are in cases of disasters."*

Similar to the findings of Wilkinson et al. (2016) and Chang-Richards et al. (2017), this study reveals that skill shortages are one of the main challenges experienced during disaster events as a result of urgent demands. New Zealand is already experiencing construction skill shortages under normal conditions, and the onset of disasters significantly exacerbates these shortages (Chang-Richards et al., 2017). The impact of skill shortages further propagates to the unaffected regions due to labour migration in pursuit of the provided opportunities and less pre-construction bureaucracy. This leads to inflated labour costs and may cause disruptions to ongoing projects in the unaffected regions, as iterated by interviewees P2 and P12.

The interviewees indicated that they commonly revert to redistributing their available workforce in order to meet the required surges in demand. However, careful planning is required in such situations to avoid jeopardising the progress of ongoing projects and prevent delays and cost overruns. Contractors should also develop and train their teams, focusing on multi-skilling workers to handle diverse tasks, enabling more efficient workforce redistribution when needed, as explained by interviewee P8, and in harmony with the findings of Pamidimukkala et al. (2020). The approach of interviewee P8 in strategically locating their depots and collecting their workforce residential information may enhance the capacity of contractors to respond promptly when required. Developing robust business continuity plans enables contractors to respond effectively and efficiently to disaster events and their aftermath. Technology, such as GPS-based monitoring systems, could optimise vehicle and workforce allocation during emergencies and expand into a resource management system to track the availability of equipment and vehicles across regions.

Similar to the findings of Abu Talib et al. (2016), supply chain disruptions and material shortages were experienced by the New Zealand contractors during disaster events. Contractors undergoing projects in disaster-prone regions should strive to develop pre-disaster agreements and regional alliances with suppliers to ensure supply flow during disaster events. Establishing stockpiles of critical materials and securing long-lead items and materials could enhance the resilience and operations of contracting firms during disaster events.

3.3. Damages & Losses

In addition to the resource disruptions accompanying natural disaster events, the construction sector may also undergo significant losses and damages. Firstly, financial damages due to uncompensated overheads and other costs are often experienced (P5, P7). Interviewee P7 reflected on this issue, stating:

> *"If we're doing construction and a disaster happens, there are delays to the contract, which we can claim under the contract. We would get time but not the overhead, preliminaries, and general costs."*

Natural hazards also affected the construction sector by causing damage to project sites, equipment, and machinery. Interviewee P7 highlighted that while construction contracts may include some mitigation measures, they often fail to address delays caused by extended lead times for replacing damaged equipment or materials sourced from international suppliers, stating:

> *"During the 2023 floods in Auckland, the whole site, including the storage and survey equipment, was flooded. Some materials were contaminated because of wastewater. Who is going to pay for that? Yes, there is insurance, but then you have physical and lead time delays leading to actual delays on site."*

Financial impacts on the construction sector, such as damage to materials and equipment, uncompensated delays and increased costs, align with the findings of Pamidimukkala et al. (2020), who identified cost overruns as a significant challenge in disaster recovery projects. Addressing these challenges requires revisiting contractual frameworks to include clauses that account for disaster-induced delays and provide fair compensation for overheads. This would ensure financial stability for contractors while facilitating timely project completion.

3.4. Weather Disruptions

Disaster events were also perceived to cause considerable disruptions to the work operations of contractors on site. The changing weather patterns due to climate change constituted a significant threat and disruption to project delivery, as delivery on site could be highly dependent on the weather conditions, as expressed by interviewee P8, who stated:

> *"We depend heavily on having fine days to deliver much of our work. But we can't do concreting or shorter when it's raining. If we can work an extra 10% of the days and through summer, it's huge."*

The frequent changes in the weather patterns, mainly due to climate change impacts, are currently jeopardising the execution of construction projects. In this regard, interviewee P7 stated:

> *"In New Zealand, the earthwork season is usually between the November and February months of the calendar year. In 2023, we had heavy rain early in the year, and the ground was saturated, so it just kept flooding again. We were in the drought three years ago at this time of the year. There is now the potential for us to*

have another rain event like last year during the earthworks season. But we'll never win a tender if we allow those changes."

The unpredictability of weather patterns, exacerbated by climate change, presents significant risks for the construction sector. As Wedawatta et al. (2010) and Wedawatta and Ingirige (2012) highlighted, the sector must enhance its coping capacity to withstand the impacts of extreme weather events. This involves integrating predictive weather models and adaptive scheduling into project management to mitigate delays and optimise resource utilisation (Schuldt et al., 2021). Building temporary weather shelters on construction sites and storing equipment in protected environments during adverse weather can reduce damages and operational disruptions, reducing financial damages and losses, as discussed in section 3.3. Furthermore, adaptive contracts that include provisions for weather-related delays can ensure fair compensation and protect contractors from financial losses (Apipattanavis et al., 2010). The sector's vulnerability to weather-related disruptions highlights the need for technological innovation in construction methods. For example, using prefabrication and modular construction techniques could allow more work to be completed in controlled environments and thus reduce the sector's vulnerability to weather-related disruptions (Schuldt et al., 2021).

The findings of this study are beneficial to construction contracting firms as well as policy makers. Construction contractors should try to adopt robust resource sharing strategies, use climate-adapted scheduling practices, invest in workforce training the creation of multi-skilled teams to enhance their resilience and reduce the possible disruptions caused by natural hazard disasters. Furthermore, advocating for clearer and more comprehensive contractual terms addressing delays, damages, and overheads compensation. Policy makers should encourage the participation and input of the industry in disaster management planning initiatives. Table 2 provides an overall summary and overview of the shocks and stresses impacting construction contractors due to disaster events and the suggested mitigation measures

Table 2 Summary of main shocks impacting construction contractors and mitigation measures

Main Themes	**Subthemes**	**Mitigation Strategies**	**Examples/Case Studies**
Opportunities	Increased project demands	Promote integration of AI, BIM, and modular construction; develop business continuity plans.	Canterbury Earthquake (2011): Accelerated pre-construction activities.
	Expedited processes	Enhance coordination with governing bodies; develop formal agreements for ethical compliance.	Sri Lanka Tsunami (2004): Rapid reconstruction with reduced administrative barriers.
Workforce & Material Challenges	Skilled labour shortages	Multi-skilling initiatives, disaster-specific training programs, workforce redistribution.	Response during Cyclone Gabrielle (2023): Redeployment of South Island workforce to affected areas.
	Workforce migration	Establish resource-sharing pools and workforce retention strategies.	NA.
	Supply chain disruptions	Pre-disaster stockpiles, fixed-price contracts, and regional alliances with suppliers.	Auckland Floods (2023): Stockpile utilisation for rapid response.
	Inflation & price surges	Ensure inflation coverage in contracts; establish pre-disaster agreements.	NA.
Financial Damages	Uncompensated overheads	Revise contracts for disaster-induced delay compensations.	NA.

	Equipment damages	Secure storage facilities, risk-sharing insurance models, and temporary weather shelters.	Auckland Floods (2023): Flooding of survey equipment and contaminated materials.
Operational Disruptions	Weather unpredictability	Predictive weather models; adaptive scheduling; modular construction; temporary weather shelters.	2023 Flooding Season: Saturated grounds delay earthworks during critical summer months.

4. Conclusions and Further Research

This study underscores the profound impacts of natural disasters on the construction sector in New Zealand, revealing a dual narrative of opportunity and challenge. While post-disaster reconstruction offers avenues for growth and innovation, it simultaneously introduces significant workforce, material, financial, and operational disruptions. The industry's response demonstrates resilience and adaptability, despite being constrained by skill shortages, supply chain vulnerabilities, and weather unpredictability. Robust disaster preparedness measures and policy support are required to enhance the ability of construction contractors to respond to effectively to disaster events. By adopting advanced technologies, strategic resource management, and robust contractual frameworks, contractors can enhance their resilience against future disasters. Policy makers should engage with contractors and consider their input in disaster management and planning initiatives. Broad engagement and collaboration between policymakers, decision makers, and construction contractors is essential during disaster management planning initiatives. Enhanced business continuity planning and resource allocation and sharing agreements can improve contractors' resilience towards natural hazard disasters' impacts. Ensuring the adequacy of construction contracts to address compensation for disaster related delays and damages will help sustain financial stability of the construction contractors.

Further research should focus on quantifying these impacts across different geographic and economic contexts, exploring interdisciplinary approaches to disaster preparedness, and developing predictive models for risk mitigation. Future studies also should consider perspectives beyond contractors to provide a comprehensive understanding of disaster resilience in the construction industry.

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