https://doi.org/10.34074/rere.00610

Research Article

Weather-Related Delays in New Zealand Metal Roofing Projects: Challenges, Impacts, and Mitigation Strategies

Suraj Kharel, Firas Majthoub Almughrabi

AIC OTAGO POLYTECHNIC

ABSTRACT

Metal roofing is widely used in residential and light commercial construction in New Zealand, yet weather conditions can disrupt installation activities, affecting project schedules, costs, worker safety, and roofing performance. This study investigates weather-related disruptions affecting metal roofing projects in New Zealand, with particular attention to the weather conditions associated with delays, their perceived impacts, and mitigation strategies adopted by industry practitioners.

Data was collected through a structured online survey of 45 construction professionals involved in roofing projects, including roofing contractors, project managers, quantity surveyors, site supervisors, builders, and other practitioners. Likert-scale questions examined the frequency of weather-related disruptions and their perceived effects on project schedules, costs, equipment utilisation, subcontractor coordination, and roofing performance. Open-ended questions provided supporting qualitative evidence regarding industry experiences and mitigation practices.

Heavy rainfall and strong winds were identified as the most frequently reported weather-related disruptions, with 95.6% and 88.9% of respondents, respectively, indicating that these conditions affected roofing projects at least sometimes. 62.2% of respondents agreed or strongly agreed that weather-related disruptions extend project schedules, while 73.3% agreed or strongly agreed that adverse weather increases project costs. In relation to roofing performance, 62.2% of respondents agreed or strongly agreed that damp installation conditions increase corrosion risk, while respondents also identified potential effects on sealant performance, detailing quality, and protective coatings. Qualitative responses highlighted weather monitoring, flexible scheduling, material protection, rescheduling, and communication as commonly reported mitigation practices.

The findings indicate that weather is perceived by the surveyed New Zealand roofing practitioners as an important risk to project delivery and roofing performance. Practical measures identified by respondents include improved weather monitoring, flexible scheduling, material protection, and clearly defined weather-related safety procedures. Future research could combine practitioner perceptions with project records, meteorological data, and long-term maintenance information to provide more objective evidence of weather-related impacts.

Keywords: Weather-related delays; Metal roofing; New Zealand construction; Project scheduling; Mitigation strategies.

INTRODUCTION

Construction projects are affected by a range of internal and external factors, with weather representing an important external risk because it can influence productivity, project schedules, worker safety, construction quality, and project costs (Schuldt et al., 2021). Metal roofing is particularly weather-sensitive because installation is undertaken in exposed environments and involves working at height, handling roofing materials, and coordinating installation activities. Rainfall, strong winds, frost, and humidity can therefore disrupt roofing operations and affect project performance (MBIE, 2012; Schuldt et al., 2021).

New Zealand's diverse climatic conditions present particular challenges for weather-sensitive construction, with substantial regional variation in rainfall, humidity, wind, and temperature (McLeod & Renwick, 2024), and recent extreme weather events have highlighted the sector's vulnerability to severe weather (MBIE, 2024; New Zealand Infrastructure Commission and Te Waihanga, 2023).

Previous research has examined weather-related construction delays, productivity, safety, material performance, and mitigation strategies (Schuldt et al., 2021). However, much of this research considers construction activities broadly, with limited empirical evidence on how practitioners involved in metal roofing projects in New Zealand experience and manage weather-related disruption.

This study addresses this gap through a questionnaire survey of construction professionals involved in residential and light commercial roofing projects in New Zealand. The study aims to identify the weather conditions most frequently associated with roofing delays, examine their perceived effects on project costs and scheduling, and identify mitigation strategies reported by industry practitioners.

LITERATURE REVIEW

Weather as a Construction Risk

In New Zealand, both routine weather conditions and severe weather events can affect construction operations. Regional climatic variation means that rainfall, wind, temperature, and humidity can influence construction activities differently across the country (McLeod & Renwick, 2024). Severe weather events can further disrupt construction programmes and increase pressure on project resources (MBIE, 2024), while adverse weather conditions such as precipitation, wind, extreme temperatures, and high humidity can reduce construction productivity (Sopic et al., 2025). Studies based on construction practitioners have found that precipitation, wind, and temperature can have substantial effects on construction productivity, with the magnitude of the effect depending on the type and intensity of the weather and the work activity involved (Larsson & Rudberg, 2023).

Weather Effects on Metal Roofing

Metal roofing is particularly exposed to weather because installation is undertaken outdoors and often involves work at height, handling large sheets, and lifting materials. Rainfall can make roof surfaces wet and increase slip risks, while also affecting activities that require dry conditions, including the application of some sealants and coatings. Strong winds can make handling and positioning roofing sheets difficult, increase risks associated with work at height, and expose metal roof cladding to wind uplift forces that can affect its stability and performance (MBIE, 2012; New Zealand Metal Roofing Manufacturers Inc, 2026; Tiwari et al., 2025).

Temperature, moisture, dew, frost, and humidity can also influence roofing installation and material performance. Environmental conditions may affect the curing or application of products and contribute to moisture-related prob-

lems where materials are not appropriately protected or installed. These factors demonstrate the importance of considering environmental conditions when planning roofing activities (New Zealand Metal Roofing Manufacturers Inc, 2026).

Effects on Schedule and Project Costs

Weather-related disruption can reduce productivity and require activities to be postponed, resequenced, or repeated. Delays to roofing can also affect following trades because roofing is an important part of achieving a weather-tight building envelope. This can create knock-on effects across the construction programme and increase resource requirements (Schuldt et al., 2021).

Financial impacts can result from lost labour productivity, extended equipment and site costs, rescheduling, and additional supervision, while weather-related disruption can also reduce productivity and extend project duration (Ballesteros-Perez et al., 2017). Weather disruptions may also affect subcontractor coordination where planned activities cannot proceed as scheduled. Effective communication and programme adjustments are therefore important when weather-sensitive work is disrupted.

Safety and Material Performance

Weather conditions can create significant safety challenges for roofing workers, while safety conditions during roofing activities can also influence worker risk-taking behaviour and productivity (Hasanzadeh & de la Garza, 2020). Wet surfaces, strong winds, reduced stability, and difficult material handling can increase the risks associated with working at height and lifting operations. Appropriate risk assessment and compliance with workplace safety requirements are therefore important when weather conditions deteriorate (MBIE, 2012).

Weather exposure can also influence perceptions of roofing material performance and durability. Moisture and environmental exposure may contribute to corrosion or other material-related concerns where protective measures are inadequate, as water ingress, humidity, and environmental exposure can influence the corrosion of steel elements in building envelope systems (Soufeiani et al., 2020). However, practitioner perceptions of long-term performance should be distinguished from objective evidence of actual roofing defects or deterioration.

Mitigation Strategies

Previous research identifies several approaches for managing weather-related construction risks. Weather forecasting and monitoring can support short-term planning and allow contractors to adjust activities before adverse conditions occur. Incorporating weather information into construction planning can also help anticipate weather-related variations in project duration and support more effective scheduling decisions (Ballesteros-Perez et al., 2017). Flexible scheduling and activity resequencing can reduce the effects of unavoidable interruptions (Schuldt et al., 2021).

Material protection is also important, particularly where roofing products or installation processes require specific environmental conditions. Appropriate storage, handling, and protection can reduce moisture exposure and support construction quality. Communication between contractors, subcontractors, consultants, and clients is similarly important for coordinating changes to work sequences and managing weather-related disruption.

Research Gap

Existing literature demonstrates that weather can affect construction productivity, scheduling, safety, costs, and material performance. However, much of the available research considers construction activities generally rather than

focusing specifically on metal roofing in New Zealand. There is limited empirical evidence on the weather conditions most frequently associated with roofing delays, their perceived effects on project delivery, and the mitigation strategies used by roofing practitioners. This study addresses this gap by examining these issues through a questionnaire survey of construction professionals involved in residential and light commercial metal roofing projects in New Zealand.

RESEARCH METHODOLOGY

Research Design

This study adopted a primarily quantitative research approach using a structured questionnaire survey to investigate weather-related delays affecting metal roofing projects in New Zealand. A quantitative approach was appropriate because the research sought to identify the frequency of different weather conditions and examine respondents' perceptions of their effects on project performance. The questionnaire also included open-ended questions to provide supporting qualitative information about participants' practical experiences, mitigation strategies, and weather-related roofing challenges. Combining structured survey data with participants' comments supported interpretation of the quantitative findings by providing additional context on how weather-related disruptions are experienced and managed in practice.

The research was designed to address three research questions:

1. What weather conditions contribute to delays in New Zealand metal roofing projects?
2. How do weather-related delays affect project schedules and costs?
3. How do weather-related delays affect roofing performance, and what strategies do practitioners use to manage these disruptions?

The research design addressed these questions through data collected from construction professionals involved in residential and light commercial roofing projects in New Zealand. The survey captured information on weather conditions associated with roofing disruptions, their reported effects on project delivery and roofing performance, and the mitigation practices used by industry practitioners.

Target Population and Sampling

The target population comprised construction professionals involved in planning, supervising, or delivering metal roofing projects in New Zealand. Participants included roofing contractors, project managers, quantity surveyors, site supervisors, builders, consultants, and other professionals involved in roofing-related activities.

Purposive, non-probability sampling was employed because the study required participants with relevant practical experience of weather-related challenges during roofing projects. The survey was distributed through professional networks, roofing associations, LinkedIn, Facebook, Instagram, and direct industry contacts to reach practitioners involved in the New Zealand construction industry.

A total of 45 valid responses were obtained and included in the analysis. Respondents primarily represented residential and light commercial roofing projects and included professionals from a range of technical and management roles.

Data Collection

The questionnaire consisted of five sections. Section A collected demographic information, including participants' professional role, years of experience, project type, and location. Section B examined the frequency of different weather conditions that delayed roofing activities. Section C focused on the perceived effects of weather-related delays on project schedules, costs, equipment utilisation, and subcontractor coordination. Section D examined perceived long-term effects on roofing durability and performance. Section E included three open-ended questions addressing participants' practical experiences, mitigation approaches, and observations regarding weather-related delays. Most closed-ended items used five-point Likert scales, while the open-ended questions provided supporting qualitative evidence and contextual information.

The questionnaire was developed based on the study research questions and the weather-related issues discussed in the literature review. The questionnaire items were designed to capture three main areas: the weather conditions associated with roofing delays, the perceived effects of weather-related disruptions on project performance, and the strategies used by practitioners to manage these disruptions. The questionnaire items were also informed by relevant industry guidance relating to metal roofing installation and weather-related safety considerations. The questionnaire was targeted at construction professionals with practical involvement in metal roofing projects in New Zealand, including roofing contractors, project managers, quantity surveyors, site supervisors, builders, consultants, and other professionals involved in roofing-related activities. Eligibility was confirmed based on participants' self-reported relevant experience or involvement in metal roofing projects in New Zealand.

Before the main survey was distributed, the questionnaire was pilot tested with seven participants with relevant construction experience. Feedback from the pilot test was used to assess the clarity and relevance of the questionnaire items and to make revisions before the final questionnaire was administered.

Data Analysis

Quantitative data were analysed using descriptive statistics. Response frequencies and percentages were calculated to identify patterns in reported weather conditions, project delays, safety, cost impacts, and roofing performance. The analysis focused on identifying the weather conditions most frequently associated with construction delays and examining respondents' perceptions of their effects on project performance.

Open-ended responses were reviewed and grouped into recurring themes relating to weather-related causes of delays, mitigation strategies, scheduling practices, safety considerations, and long-term roofing performance, consistent with approaches for analysing open-ended survey responses through thematic coding (Popping, 2015).These responses were used as supporting qualitative evidence to provide contextual information for interpreting the quantitative findings and identifying practical industry practices.

Questionnaire consistency and validity considerations

Several measures were used to support the consistency and relevance of the questionnaire. A structured questionnaire with standardised questions and predefined response categories was administered consistently to all participants. The questionnaire was developed around the study research questions and the weather-related issues discussed in the literature review, covering weather conditions, project impacts, roofing performance, and mitigation strategies.

The questionnaire was pilot tested with seven participants before the main survey, and revisions were made based

on feedback received during the pilot process. This process helped identify areas where questions could be clarified or improved before the questionnaire was distributed to the main sample.

The questionnaire included both frequency-based and agreement-based Likert-scale questions, allowing respondents to report the frequency of weather-related disruptions and their perceptions of project impacts. The use of standardised response categories supported consistency in data collection across participants.

However, formal statistical reliability testing and construct validity testing were not undertaken. Therefore, the study does not claim that the questionnaire demonstrated formal statistical reliability or construct validity. The findings should instead be interpreted within the exploratory scope of the study and in consideration of the self-reported nature of the responses.

The use of purposive sampling and a sample of 45 respondents also limits the generalisability of the findings. These limitations are considered when interpreting the results.

Ethical Considerations

Ethical approval was obtained under Otago Polytechnic's low-risk ethics procedures (AIC-RE-2025-71). Participation in the study was entirely voluntary, and informed consent was obtained before respondents completed the questionnaire. No personally identifiable information was collected, and responses were treated confidentially. Survey responses were securely collected through Google Forms and stored in password-protected electronic files accessible only to the research team. Findings were reported in aggregated form to prevent the identification of individual participants or organisations.

RESULTS

Respondent Characteristics

A total of 45 valid responses were obtained from professionals involved in metal roofing projects in New Zealand. Respondents represented a range of professional roles, including roofing contractors, project managers, quantity surveyors, site supervisors, and other construction practitioners. Most respondents (75.6%) had fewer than five years of experience working on metal roofing, while 13.3% had between six and ten years of experience. No respondents reported between 11 and 20 years of experience, while 2.2% had between 21 and 25 years and 8.9% had more than 25 years of experience. Most respondents (68.9%) were based in Auckland, while 31.1% were based in other regions. Residential projects were the primary project type for 75.6% of respondents, compared with 24.4% who primarily worked on commercial projects. Table 1 summarises the respondent and demographic characteristics of the respondents.

Weather Conditions Affecting Roofing Projects

Among the surveyed practitioners, weather-related disruption was reported as an important challenge affecting metal roofing projects. Respondents reported varying levels of disruption associated with heavy rainfall, strong winds, morning dew/frost, and high humidity. Among the weather conditions examined, heavy rainfall was reported as the most frequent source of project delays, followed by strong winds.

As shown in Table 2, 60.0% of respondents indicated that heavy rainfall caused delays either "often" (42.2%) or "very often" (17.8%). Strong winds were the second most frequently reported condition, with 46.7% of respondents reporting delays either "often" (28.9%) or "very often" (17.8%). Morning dew/frost also contributed to disruption, with

Table 1: Respondent Demographic Characteristics.

Variable	Category	n	%
Experience	Less than 5 years	34	75.6
	6–10 years	6	13.3
	11–15 years	0	0.0
	16–20 years	0	0.0
	21–25 years	1	2.2
	Over 25 years	4	8.9
Professional role	Roofing Contractor	15	33.3
	Project Manager	9	20.0
	Quantity Surveyor	8	17.8
	Site Supervisor	6	13.3
	Others	7	15.6
Primary project type	Residential	34	75.6
	Commercial	11	24.4
Region	Auckland	31	68.9
	Other regions	14	31.1

37.8% of respondents selecting ”often” (31.1%) or ”very often” (6.7%). High humidity was reported less frequently, with 24.5% indicating that it affected roofing activities either ”often” (17.8%) or ”very often” (6.7%).
These findings indicate that weather-related interruptions are associated with both severe weather conditions and less extreme conditions such as morning dew/frost and high humidity. The results indicate that respondents associated different weather conditions with interruptions to the continuity of roofing activities and reported project delays.

Table 2: Frequency of Weather Conditions Causing Project Delays.

Weather condition	Very Often (%)	Often (%)	Sometimes (%)	Rarely (%)	Never (%)	Not Applicable (%)
Heavy rainfall	17.8	42.2	35.6	4.4	0.0	0.0
Strong winds	17.8	28.9	42.2	8.9	2.2	0.0
Morning dew or frost	6.7	31.1	35.6	20.0	4.4	2.2
High humidity	6.7	17.8	57.8	11.1	2.2	4.4

These findings indicate that respondents reported disruption to roofing installation from both extreme weather events and routine conditions such as morning dew/frost and high humidity.

Effects of Weather on Project Performance

Respondents reported that adverse weather had perceived effects on several aspects of project performance. 62.2% of respondents agreed or strongly agreed that weather-related disruptions extended project schedules, while 73.3% agreed or strongly agreed that adverse weather increased overall project costs.

Weather was also perceived to affect resource utilisation. Approximately 73.3% of respondents agreed or strongly agreed that weather interruptions increased equipment and crane costs. Furthermore, 55.6% agreed or strongly agreed that weather-related disruptions negatively affected subcontractor coordination.

Overall, the results presented in Table 3 indicate that respondents perceived weather-related disruption to have implications for project schedules, costs, equipment utilisation, and subcontractor coordination.

Table 3: Perceived Impacts of Weather-Related Delays.

Impact	Agree/Strongly Agree (%)
Extends project schedules	62.2
Increases project costs	73.3
Increases equipment and crane costs	73.3
Disrupts subcontractor coordination	55.6

Effects on Roofing Quality and Long-Term Performance

Respondents perceived that weather conditions during installation may have implications not only for project schedules but also for the quality and long-term performance of roofing systems. Approximately 62.2% agreed or strongly agreed that installing roofing over damp substrates increases the likelihood of corrosion and moisture-related defects, while 57.8% agreed or strongly agreed that adverse weather can reduce the effectiveness of sealants and adhesives.

Similarly, 62.2% of respondents agreed or strongly agreed that repeated work interruptions increase the likelihood of detailing errors, particularly around flashings, and roof penetrations. Over half (55.5%) also agreed or strongly agreed that prolonged exposure of roofing materials before installation can negatively affect protective coatings and long-term durability."

Table 4: Perceived Impacts on Roofing Performance.

Statement	Agree/Strongly Agree (%)
Damp substrates increase corrosion risk	62.2
Sealants perform poorly in adverse weather	57.8
Stop-start work increases detailing errors	62.2
Material exposure reduces coating performance	55.5

These findings indicate that respondents perceived weather-related installation conditions as having implications beyond construction scheduling, particularly for roofing quality and long-term performance.

Qualitative Findings

The open-ended responses provided supporting contextual information on participants' experiences of weather-related disruption and the approaches used to manage these challenges. The responses were reviewed and grouped according to recurring ideas relating to weather-related causes of delays, mitigation strategies, and potential roofing performance issues. As the open-ended questions were included primarily to support interpretation of the quantitative findings, the responses are presented as supporting open-ended comments rather than as a standalone qualitative analysis. Response frequencies and participant quotations are therefore not reported as part of a formal thematic analysis.

The open-ended comments mainly related to **weather-related disruption**. Respondents commonly identified heavy rainfall and strong winds as disruptive weather conditions. These comments indicated that such conditions could create unsafe working environments, interrupt crane operations, and prevent or delay the installation of roofing materials.

A second area identified in the open-ended comments was **mitigation strategies**. Respondents commented on ap-

proaches used to manage weather-related disruption, including monitoring weather forecasts, flexible work scheduling, temporary protection of materials, rescheduling of high-risk activities, and communication with subcontractors.

The third area concerned **potential roofing quality and long-term performance issues.** Some respondents commented on potential effects associated with adverse installation conditions, including moisture ingress, premature corrosion, coating deterioration, and sealant failure. These comments provide additional practitioner perspectives that support the interpretation of the quantitative findings. However, they represent respondents' observations and perceptions and do not provide independent evidence of long-term roofing defects or establish causal relationships.

Overall, the open-ended comments complement the quantitative results by providing additional context on the types of weather-related challenges experienced by practitioners and the practical approaches they reported using to manage these challenges.

DISCUSSION

The findings indicate that weather is a significant consideration for metal roofing projects in New Zealand, particularly because roofing activities are undertaken outdoors and are sensitive to rainfall and wind. The survey results identified heavy rainfall and strong winds as the most frequently reported weather conditions associated with delays. These findings are consistent with previous research showing that adverse weather can reduce construction productivity and disrupt planned work sequences, and that better planning, scheduling, and communication can improve roofing productivity (Choi, 2007; Schuldt et al., 2021).

Rainfall was identified as a major source of disruption. Respondents reported that wet conditions can interrupt roofing activities, particularly where roof surfaces become unsafe or where installation processes require dry conditions. Rain-related interruptions can also affect project sequencing because delayed roofing work may prevent subsequent activities from proceeding as planned. Strong winds were another important source of disruption. Wind can make roofing sheets more difficult to handle and position and can increase risks associated with working at height. These findings align with the New Zealand Metal Roofing Manufacturers Inc (2026) Code of Practice, which identifies environmental conditions as an important consideration during metal roofing installation. Research on metal roof cladding has also shown that wind uplift can influence the structural performance of roofing systems, particularly under high wind loading (Tiwari et al., 2025).

The survey also identified financial and resource consequences associated with weather disruption, consistent with recent research showing that adverse weather can intensify challenges relating to construction time, cost, and quality (Dong et al., 2025). Delays can result in additional labour and equipment costs, particularly where workers, cranes, or other resources remain committed while planned roofing activities cannot proceed. These findings are consistent with research identifying extended project duration, productivity losses, and increased costs as consequences of adverse weather and construction delays (Ballesteros-Perez et al., 2017; Schuldt et al., 2021).

Safety was another important concern identified by respondents. Wet roof surfaces and strong winds can increase the difficulty of working at height and handling roofing materials. This finding is consistent with MBIE (2012), which emphasises the need to consider weather conditions when undertaking work on roofs. Research on roofing tasks has also demonstrated the relationship between roofing work, worker safety, and productivity, highlighting the importance of managing safety risks during roofing activities (Hasanzadeh & de la Garza, 2020).

Respondents also identified potential effects of weather exposure on roofing quality and long-term performance. However, these findings represent practitioner perceptions rather than measured evidence of actual long-term deterioration. This distinction is important because the survey did not include physical inspections, defect records, or

long-term monitoring of completed roofing systems. Technical guidance for New Zealand buildings also indicates that corrosion risk across the building envelope varies with local weather and climate conditions and the level of environmental exposure (BRANZ Limited, 2021).

Participants reported several mitigation approaches, including weather monitoring, flexible scheduling, material protection, and communication among project participants. These strategies are consistent with previous research emphasising weather forecasting, planning, and proactive management as ways of reducing weather-related disruption (Khanh, 2026; Schuldt et al., 2021).

Overall, the findings support an integrated approach in which weather risk is considered throughout project planning, daily site decisions, safety management, and coordination between project participants.

PRACTICAL IMPLICATIONS

The findings provide practical guidance for contractors, project managers, consultants, and clients involved in metal roofing projects in New Zealand. Weather risk should be incorporated into project planning and daily site management, particularly for weather-sensitive roofing activities.

Planning and scheduling. Contractors should incorporate weather forecasts into programme planning and allow flexibility for weather-sensitive activities. Where adverse conditions are anticipated, activities can be resequenced or alternative tasks undertaken to reduce disruption to the overall programme.

Safety management. Clear weather-related stop-work criteria and pre-start checks should be used for roofing activities involving work at height, lifting, and material handling. Site teams should assess rainfall and wind conditions before and during roofing operations and postpone work where conditions cannot be managed safely.

Material protection and quality. Roofing materials should be stored and protected appropriately from moisture and environmental exposure. Installation should follow relevant manufacturer requirements for environmental conditions, particularly where products such as sealants or coatings require suitable surface or weather conditions.

Communication and contract administration. Early communication between contractors, subcontractors, consultants, and clients can support timely programme adjustments when weather disruption occurs. Project teams should also maintain records of significant weather events and associated delays to support transparent programme management and, where applicable, extensions-of-time processes.

LIMITATIONS OF THE STUDY

This study has several limitations. First, the study was based on a relatively small sample of 45 construction professionals, which limits the extent to which the findings can be generalised to the wider New Zealand construction industry. Although respondents represented a range of professional roles and geographical regions, the sample had a concentration in Auckland, which accounted for 68.9% of respondents, and residential projects, which were the primary project type for 75.6% of respondents. In addition, 75.6% of respondents had fewer than five years of experience working on metal roofing. Consequently, the findings should be interpreted as exploratory evidence of practitioner-reported experiences rather than as nationally representative estimates of weather-related impacts across the New Zealand roofing industry.

Second, the research relied primarily on self-reported perceptions and experiences rather than direct measurements of project performance. Consequently, responses may have been influenced by individual experience, professional judgement, and recall bias. While practitioners provide valuable practical insights, future research incorporating project records, meteorological data, and productivity measurements could provide more objective evidence of the relationship between specific weather conditions and roofing project performance.

Third, the study focused specifically on metal roofing projects, particularly residential and light commercial construction. Therefore, the findings may not be directly applicable to other roofing materials, construction methods, or large-scale commercial and industrial projects. In addition, the study was conducted within the New Zealand context, where climatic conditions, construction practices, and regulatory requirements may differ from those in other countries. These contextual differences should therefore be considered when applying the findings beyond the New Zealand roofing sector.

RECOMMENDATIONS FOR FUTURE RESEARCH

This study provides several opportunities for future research. First, future studies could involve larger national surveys to improve the representativeness of the findings and enable comparisons between different regions of New Zealand. Such research could provide a more comprehensive understanding of regional differences in weather-related challenges affecting roofing projects.

Second, longitudinal research examining completed roofing projects over several years could provide stronger evidence regarding the relationship between installation weather conditions and long-term roofing performance. Combining construction records with maintenance and repair data could improve understanding of how adverse weather conditions may influence durability, maintenance requirements, and lifecycle costs.

Third, future research could investigate the application of Building Information Modelling (BIM), artificial intelligence (AI), and predictive weather analytics to construction scheduling and weather-risk management. Integrating real-time weather forecasting with digital project management tools could support more informed decision-making and improve activity sequencing in response to anticipated weather conditions.

Finally, comparative international research involving countries with relevant climatic and construction contexts, such as Australia, the United Kingdom, and Canada, could provide further insight into approaches for managing weather-related roofing risks. Such comparisons could help identify transferable practices and inform the development of more adaptable weather risk-management strategies for weather-sensitive construction activities.

CONCLUSION

This study examined weather-related delays in New Zealand metal roofing projects using questionnaire responses from 45 construction professionals. The findings indicate that heavy rainfall and strong winds were the most frequently reported weather conditions associated with roofing delays. Respondents also identified effects on project scheduling, costs, resource utilisation, worker safety, and roofing quality.

The study contributes practitioner-reported evidence on weather-related challenges specific to metal roofing in New Zealand. Respondents reported using weather monitoring, flexible scheduling, material protection, and communication to manage weather-related disruption. These findings support the integration of weather considerations into project scheduling, safety management, and quality assurance. However, the findings reflect practitioner perceptions and do not provide objective evidence of long-term roofing deterioration. Future research could combine practitioner responses with project records, meteorological data, and long-term performance monitoring to further

examine these relationships.

REFERENCES

Ballesteros-Perez, P., Rojas-Cespedes, Y. A., Hughes, W., Kabiri, S., Pellicer, E., Mora-Melia, D., & del Campo-Hitschfeld, M. L. (2017). Weather-wise: A weather-aware planning tool for improving construction productivity and dealing with claims. *Automation in Construction*, *84*, 81–95. https://doi.org/10.1016/j.autcon.2017.08.022

BRANZ Limited. (2021). *Metal corrosion in NZ buildings-Fact sheet 3 (FS3): Corrosion over the building envelope (Version 2)*. https://codehub.building.govt.nz/resources/metal-corrosion-in-nz-buildings-fact-sheet-3-fs3

Choi, S. D. (2007). Opportunities for improving productivity in roofing construction. *International Journal of Construction Education and Research*, *3*(1), 67–77. https://doi.org/10.1080/15578770701238980

Dong, R., Muhammad, A., & Nauman, U. (2025). The influence of weather conditions on time, cost, and quality in successful construction project delivery. *Buildings*, *15*(3), 474. https://doi.org/10.3390/buildings15030474

Hasanzadeh, S., & de la Garza, J. M. (2020). Productivity-safety model: Debunking the myth of the productivity-safety divide through a mixed-reality residential roofing task. *Journal of Construction Engineering and Management*, *146*(11), 04020118. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001916

Khanh, H. D. (2026). Weather-related delays in Vietnamese building projects: A quantitative and comparative analysis [Article 14]. *Discover Civil Engineering*, *3*. https://doi.org/10.1007/s44290-026-00411-3

Larsson, R., & Rudberg, M. (2023). Effects of weather conditions on concrete work task productivity: A questionnaire survey. *Construction Innovation*, *23*(2), 306–321. https://doi.org/10.1108/CI-02-2021-0012

McLeod, H., & Renwick, J. (2024). Linking people and climate: The Extreme Events Climate Index for Aotearoa for Stats NZ geographies and iwi rohe. *New Zealand Population Review*, *50*, 269–324. https://population.org.nz/wp-content/uploads/2024/10/NZPR-VOL-50_McLeod-and-Renwick.pdf

Ministry of Business, Innovation and Employment. (2012). *Best practice guidelines for working on roofs*. https://www.worksafe.govt.nz/topic-and-industry/working-at-height/roofs/working-on-roofs-gpg/

Ministry of Business, Innovation and Employment. (2024). *Building and construction sector trends: Annual report 2023*. https://www.mbie.govt.nz/building-and-energy/building/building-system-insights-programme/sector-trends-reporting/building-and-construction-sector-trends-annual-report/2023

New Zealand Infrastructure Commission and Te Waihanga. (2023). *The 2023 Auckland Anniversary weekend storm: An initial assessment and implications for the infrastructure system*. https://tewaihanga.govt.nz/our-work/research-insights/the-2023-auckland-anniversary-weekend-storm

New Zealand Metal Roofing Manufacturers Inc. (2026). *NZ metal roof and wall cladding code of practice (v26.09)*. https://www.metalroofing.org.nz/cop/

Popping, R. (2015). Analyzing open-ended questions by means of text analysis procedures. *Bulletin de Methodologie Sociologique*, *128*(1), 23–39. https://doi.org/10.1177/0759106315597389

Schuldt, S. J., Nicholson, M. R., Adams, Y. A. I. I., & Delorit, J. D. (2021). Weather-related construction delays in a changing climate: A systematic state-of-the-art review. *Sustainability*, *13*(5), 2861. https://doi.org/10.3390/su13052861

Sopic, M., Vrankovic, A., & Marovic, I. (2025). Understanding and quantifying the impact of adverse weather on construction productivity. *Applied Sciences*, *15*(19), 10759. https://doi.org/10.3390/app151910759

Soufeiani, L., Foliente, G., Nguyen, K. T. Q., & San Nicolas, R. (2020). Corrosion protection of steel elements in facade systems - A review. *Journal of Building Engineering*, *32*, 101759. https://doi.org/10.1016/j.jobe.2020.101759

Tiwari, S., Roy, K., Fang, Z., & Lim, J. B. P. (2025). Metal roof cladding system under wind loading: State-of-the-art. *Journal of Wind Engineering and Industrial Aerodynamics*, *257*, 105939. https://doi.org/10.1016/j.jweia.2024.105939