CCC 2025 **Proceedings of the Creative Construction Conference** (2025)
Edited by: Miroslaw J. Skibniewski & Miklós Hajdu & Žiga Turk
https://doi.org/10.22260/CCC2025/0087

MITIGATING COST AND SCHEDULE RISKS IN REMOTE CONSTRUCTION PROJECT SITES

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Abstract

Construction projects in remote locations face intensified risks that directly impact cost and schedule performance due to logistical complexities, limited accessibility, and absence of nearby infrastructure. Empirical reports suggest that these projects are significantly more prone to delays, budget overruns, and operational disruptions, often resulting from inadequate planning, seasonal constraints, and resource scarcity that are not prevalent in urban construction environments. This study investigates the unique challenges encountered in delivering construction projects "off the beaten path," with a specific focus on sites across the state of Alaska. Using a qualitative research approach, semi-structured interviews were conducted with eleven construction professionals including project engineers, site superintendents, and quality control managers who have extensive experience managing remote construction projects, particularly in the state of Alaska. Thematic analysis of the interview data identified six critical themes that influence project success: company mission and goals, site characteristics, schedule risk factors, logistics, material transportation, and human resources. Findings reveal that successful execution in these environments requires early logistical planning, localized knowledge, strategic pre-fabrication, and a core team of adaptable personnel. Moreover, contractors with a long-term strategic interest in remote work develop competencies that enable competitive advantages in bidding and execution. This research contributes to the understanding of how practitioners navigate remote construction jobsites and offers practical recommendations for mitigating cost and schedule impacts in remote projects. The insights presented aim to support both contractors and project owners in enhancing decision-making and planning for future construction endeavours in isolated locations.

Keywords: Cost mitigation, logistics, remote construction, risk management, scheduling

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2025.

1. Introduction

The management of construction projects from initiation to completion requires substantial resources, many of which are unknown or uncertain at the time of bidding. Among these, cost and schedule are the most critical determinants of project success [1]. Despite advancements in planning tools and software, the construction industry continues to struggle with project delivery efficiency. Compared to other industries, the construction industry is synonymous to experiencing poor improvements in its overall productivity [2], [3]. In the United States, this challenge is compounded by a persistent shortage of skilled labor, which has limited the industry's ability to meet growing infrastructure demands [4]. Poor productivity and labor shortages have led to frequent cost overruns and schedule delays in construction projects nationwide [5, 6]. These issues are especially pronounced in remote locations such as Alaska, where construction deviates significantly from urban project delivery models. In such environments, unique constraints—including limited supporting infrastructure, severe weather conditions, and restricted access to materials and labor—intensify operational complexity and risk exposure across project phases.

In the construction industry, the ability to complete a project within budget and on schedule is a fundamental measure of success, especially given the industry's tight margins and competitive environment. However, achieving this goal remains a persistent challenge. Even with the application of various cost-control techniques and digital tools, cost overruns continue to occur globally [7]. These

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overruns are rarely incidental; rather, they stem from a variety of causes including delays, estimation errors, unstable market drive, poor scope definition, and unforeseen site conditions. Numerous international studies have examined the causes of cost overruns, demonstrating that while the phenomenon is widespread, the contributing factors often vary based on regional and contextual differences. For example, studies conducted in Vietnam [8], Nigeria [9], Ghana [10], Kuwait [11], Turkey [12], Malaysia [13], Libya [14], Pakistan [15], and Indonesia [16] all point to the recurring and global nature of cost overrun challenges. These studies also suggest that political, economic, and cultural factors shape the specific nature and intensity of these risks.

In the case of Alaska, the challenges of construction are uniquely amplified. Unlike most other U.S. states, Alaska features vast, sparsely populated regions, limited transport networks, and extreme climatic conditions. These realities make conventional construction planning and resource mobilization approaches less effective. As Alaska continues to experience infrastructure growth, understanding the underlying causes of cost and schedule risks becomes relevant and urgent. Given these contextual distinctions, there is a need for an Alaska-specific study that examines how cost overruns and schedule delays can be better understood and mitigated. This paper seeks to address this gap by exploring the experiences of construction professionals who manage remote projects in Alaska. Through this lens, the study aims to investigate and identify strategies for mitigating cost and schedule risks in remote construction projects, using Alaska as a case study.

To achieve this aim, the study is guided by the following objectives:

- Examine logistical and operational challenges in delivering construction projects in remote areas
- Identify key risk factors that contribute to cost and schedule overruns in these environments
- Evaluate existing mitigation strategies used by construction professionals with experience in remote projects.

The remainder of this paper is organized as follows: Section 2 presents the literature review; Section 3 describes the research methodology; Section 4 outlines the findings, discussion and key recommendations; Section 5 provides the conclusion.

2. Literature review

Remote construction projects, particularly in geographies like Alaska, present distinct operational complexities that extend beyond traditional construction challenges. These difficulties are rooted in geographic isolation, limited accessibility, harsh environmental conditions, and constrained resource availability. This section critically reviews the most relevant literature on cost and schedule risks, workforce deployment, digital technology adoption, and risk management practices, highlighting key gaps that this study aims to address.

2.1. Cost and Schedule Overruns in Remote Construction Projects

Cost and schedule overruns remain among the most prevalent issues across construction sectors globally [6]. Cost overrun trends, as discussed by Sovacool et al. [17], have direct implications for investment decisions in large-scale infrastructure projects. Overruns not only affect project ROI but also distort electricity pricing models and public infrastructure funding. These macroeconomic consequences are notably critical in Alaska, where the economic viability of large public projects is closely tied to community access and sustainability outcomes. Projects in remote regions are vulnerable due to unpredictable logistics, limited seasonal work windows, and high costs of transporting labor and materials. Sovacool et al. further identify that large-scale projects such as hydroelectric dams and nuclear facilities are especially vulnerable to cost risks, with weather, currency fluctuation, and underdeveloped infrastructure being major contributors. These findings mirror the challenges faced in Alaskan construction, where remote locations worsen procurement delays and amplify financial risk. Moreover, financial underestimation at early project stages—due to incomplete feasibility analyses—is a recurring issue [18]. Aarthipriya et al. [19], complement this perspective by investigating how risk analysis models such as Monte Carlo simulations can quantify the influence of delays on project cost and duration. Their work, which focuses on residential development projects in India, concludes that

proactive risk analysis at the planning phase is critical. The adaptation of such tools in remote Alaskan projects could provide valuable foresight, especially in managing weather-related schedule variability and material delivery constraints.

Human capital is a pivotal component of construction delivery, and its strategic deployment becomes even more vital in remote projects. Lin [20], explores the decision-making process behind allocating regular (headquartered) staff versus hiring local labor for remote construction. Lin proposes a cost-risk trade-off model that considers psychological compensation, logistical expenses, and productivity variance. For Alaskan projects—where skilled local labor may be scarce—this model stresses the need to weigh financial costs against the operational stability provided by experienced staff. In a related study, which focus on decent work conditions and their impact on productivity, especially in isolated and demanding construction environments. The findings of Boyark and Khatkov [21], indicate that worker welfare, clarity in role definition, and consistent engagement can mitigate absenteeism and foster retention.

2.2. Planning, Scope Definition, and Governance in Remote Contexts

Metwally et al. [22] assert that effective scope delineation reduces stakeholder disputes, clarifies expectations, and prevents scope creep. In Alaska, where construction sites are often separated from administrative centres, robust upfront planning is essential to avoid miscommunication and mid-project course corrections. Their study further emphasizes that contract clarity, method statements, and risk-sharing provisions should be tailored for remote settings. For example, ambiguity in procurement timelines or shared responsibilities may lead to unanticipated disruptions in areas where re-supply or labor substitution is infeasible. Gurgun et al. [23] note that ineffective communication, late procurement, and unclear authority chains contribute significantly to timeline setbacks. Their research categorizes delay factors as procedural, operational, or contextual, with remote projects often suffering from a mix of all three. Aderbag et.al. [24] reinforce this conclusion by analysing cost and time risks in housing projects using Monte Carlo simulations. Their results highlight how even minor lapses in early planning can lead to exponential project delays when compounded by unexpected site challenges—an outcome that mirrors the high-risk nature of remote Alaskan sites.

Moreover, the resent global shift towards Industry 4.0 has introduced a suite of technologies that can improve construction efficiency, particularly in remote or constrained environments. However, as observe, many construction projects continue to face delays despite technological availability [20, 22]. Their systematic review identifies BIM, UAVs, cloud-based coordination platforms, and AI as underutilized resources. This observation is particularly relevant to remote Alaskan projects where physical oversight is often limited. Technologies such as drones for site surveillance, remote sensors for environmental monitoring, and AI-assisted planning tools could reduce reliance on physical inspections and allow for faster decision-making. Despite the clear benefits, their adoption remains low due to high initial costs, training requirements, and resistance to change. Parsamehr et al., similarly advocate for the use of BIM integrated with predictive analytics to support real-time updates on project scheduling, cost control, and material logistics [26]. BIM's data-rich interface offers stakeholders a transparent view of project status, enabling earlier identification of deviations from the baseline schedule. Tuljapurkar and Tiwari argue for the application of GIS-based spatial risk assessment models in construction risk planning [27]. Their model allows project managers to visualize physical and environmental threats such as flooding, permafrost instability, and weather unpredictability. In Alaskan contexts, these tools can support decisions on site layout, foundation systems, and seasonal work scheduling, offering a structured framework for managing environmental uncertainties. Additionally, they propose integrating GIS outputs with BIM models for enhanced pre-construction planning and simulation. This fusion allows for real-time risk visualization and is particularly suited to projects with high stakes in logistical precision and environmental sensitivity.

3. Methodology

This study adopts a qualitative research methodology to explore the cost and schedule risk factors associated with remote construction sites in Alaska. The choice of a qualitative approach is grounded in the nature of the research problem, which seeks to understand context-specific complexities, human

experiences, and strategic decision-making processes in construction environments that are highly variable and logistically constrained. Qualitative methods are particularly well-suited for exploratory research in under-examined contexts [28], as they allow for a nuanced understanding of phenomena that are difficult to quantify or generalize statistically.

3.1. Research design & participant selection

A qualitative exploratory research design was employed, supported by semi-structured interviews. Such designs are commonly used in construction management studies where prior research is limited or when the aim is to deeply examine complex, context-dependent issues [29]. In the context of remote construction in Alaska—where harsh environmental conditions, labor scarcity, and limited access converge—this design provides the flexibility to gather rich, practitioner-informed insights. Semi-structured interviews were chosen for their ability to balance structure with the freedom to pursue participant-driven insights. This method is well-established in built environment research as an effective tool for capturing professional perspectives, strategic reasoning, and risk response behaviours [30]. The open-ended format enabled participants to reflect meaningfully on their experiences managing construction in Alaska's remote regions.

Participants were identified using purposive sampling, a non-random, criterion-based approach that is widely used in qualitative research to select information-rich cases relevant to the central phenomenon under investigation [31]. Eleven participants were selected, including project managers, site superintendents, quality control officers, and logistics specialists—each with at least five years of experience managing remote construction projects in Alaska. The selection of Alaska as the study context reflects its unique combination of geographic, climatic, and logistical challenges that distinguish it from most contiguous U.S. states. These include dependence on marine and air transport, limited seasonal access windows, and the importation of labor. These characteristics provide a powerful lens through which to investigate broader themes in remote project delivery.

All questions were provided to the interviewees prior to the time of the interview, typically two days to the date of the interview. This was done to reduce the perception of this being a test of what the interviewee knows, and thus maximize the chances of eliciting a greater breadth and depth of the interviewee's knowledge and experiences by giving them ample opportunity to collect their thoughts and look over their professional history in construction. Confidentiality was assured, in each case, as some of the questions dealt with knowledge and decisions related to bidding, which is a topic that can touch on specific business practices or management philosophy of the interviewee's company. A rough timeframe of around forty-five minutes to an hour was specified when inviting candidates to interview, not to establish a hard stop after a certain amount of time, but to establish some left and right boundaries on the time commitment expected from each interviewee. As each one was currently employed full-time, and in some cases located on site at their construction field office trailers, care was given to demonstrate respect for their busy schedules by establishing a clear time requirement up front. This also had the result of ensuring that a sufficient amount of data would be generated over the course of the interview to allow for proper qualitative data collection and data analysis.

3.2. Data collection

Primary data were collected through semi-structured interviews, conducted both in person (within the state of Alaska) and virtually via Zoom. While all interviewees were construction managers actively overseeing remote Alaskan construction projects, they represented a range of roles—from quality control managers to senior project executives—and were affiliated with a variety of organizations. Each interview followed a guide consisting of ten open-ended questions, allowing for thematic consistency while supporting the emergence of individualized insights. Due to the logistical realities of remote construction, some participants were only available virtually, while others were interviewed in person during site visits or regional meetings. The participating companies also varied in structure and geographic presence. All were executing large-scale projects in Alaska (defined as over $10 million), yet only about half maintained a physical office in the Anchorage metropolitan area. One firm was headquartered in Anchorage, while others had regional branches there but were based elsewhere in the U.S. Notably, two firms had no Alaskan presence at all—one headquartered in Seattle and another

based in Germany. This variation added valuable diversity to the participant pool and strengthened the relevance of the study across different organizational contexts.

3.3. Data analysis & methodological fit

All interview data were transcribed and analysed using thematic analysis, following the six-phase framework developed by Braun and Clarke [32] This process includes familiarization with the data, generating initial codes, identifying and reviewing themes, defining and naming themes, and producing the final report. Thematic analysis is widely used in construction research to extract insights from qualitative data and is particularly effective for interpreting complex managerial experiences. The qualitative design and use of semi-structured interviews are methodologically well-aligned with the study's aim: to explore how cost and schedule risks are perceived and managed in the unique context of remote Alaskan construction. While previous studies have predominantly relied on survey-based or quantitative methodologies [17, 20, 24], this study contributes by offering deeper, first-hand insight into the human, logistical, and operational dynamics that shape risk in remote environments. As such, it helps bridge the gap between theoretical models of project risk and the lived realities of professionals managing construction in one of the most logistically challenging regions in the United States.

4. Result and Discussion

This section presents a detailed synthesis of the qualitative content analysis conducted from eleven in-depth interviews with construction professionals actively engaged in managing remote construction projects in Alaska. The analysis revealed six major themes that encapsulate the challenges, strategies, and decision-making processes involved in mitigating cost and schedule risks in remote environments as presented on Fig. 1. These themes—collectively provide the foundation for understanding risk factors and mitigation strategies within the context of this study's objectives.

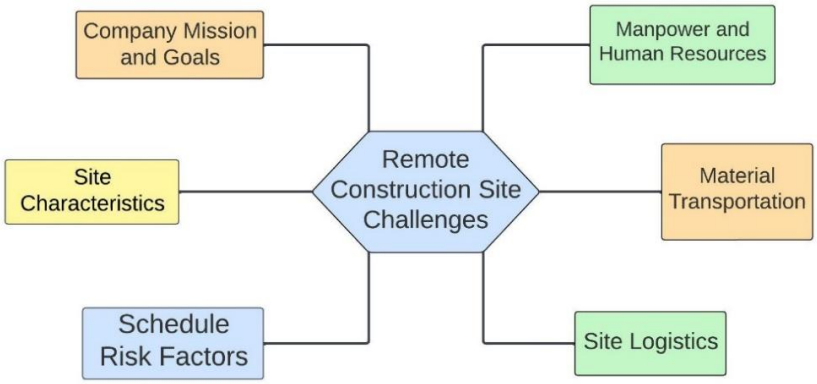

Fig. 1. Main Themes.

Figure 1: Main Themes

4.1. Company mission and goals

Participants emphasized that remote construction was not simply a necessity, but an intentional component of their organizational mission as detailed in Fig. 2. Many companies identified remote work as part of their strategic identity, actively seeking projects in challenging environments due to competitive advantages they had developed over time. Their organizational cultures fostered adaptability, rugged individualism, and pride in delivering high-quality infrastructure in isolated communities. Most companies specialized in niche skills required for remote construction, such as mobilizing teams by barge or plane, modular construction, and working under tight seasonal windows. Over time, these skills reinforced their competitive edge and improved their capacity to mitigate risks that would deter less experienced competitors.

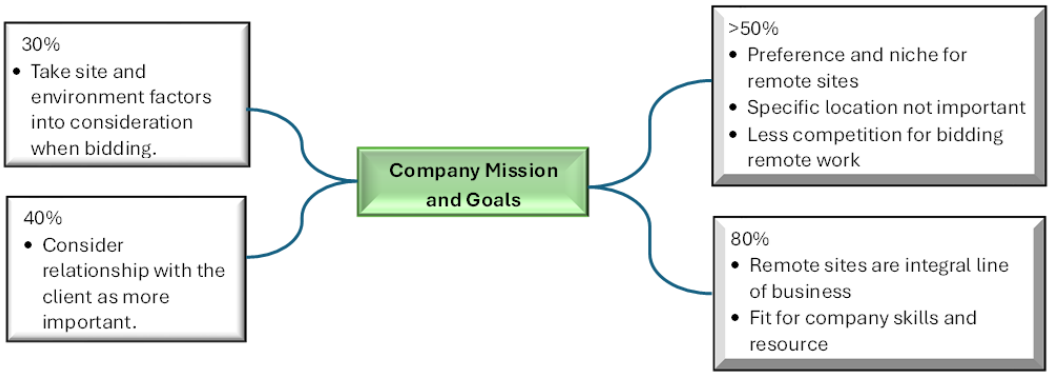

Fig. 2. Company mission and goals main theme.

Furthermore, participants stated that remote projects often provided more autonomy to field teams and were free from the bureaucratic oversight common in metropolitan projects. This operational freedom, combined with higher margins and fewer competitors, made remote projects desirable. Contractors made deliberate decisions during the bidding process based not just on location, but on how well the project matched their team's experience, capacity, and long-term goals. Additionally, company leaders reported that past successes in remote areas influenced future opportunities, creating a positive feedback loop. Winning remote projects-built trust with clients and positioned contractors for repeat work in underserved regions.

4.2. Site characteristics

The geographic, climatic, and logistical uniqueness of each remote site was a recurring topic. Participants noted that a subtle understanding of local site conditions—beyond the generalized idea of 'remoteness'—was essential to accurate planning and successful project execution.

Sub-themes under site characteristics included in Fig. 3:

- Material availability: Local quarries and suppliers were rarely usable due to quality, pricing, or reliability. Even common materials like water and aggregate had to be shipped in at times.
- Infrastructure variance: Power sources, road conditions, and internet access varied widely, impacting how equipment was selected and powered.
- Community engagement: Contractors emphasized the value of strong local relationships, especially where the project influenced the local economy. Collaborating with local suppliers, when feasible, enhanced both community support and operational resilience.

The difficulty in predicting site conditions was compounded by the lack of online or documented information. Participants described “boots-on-the-ground” assessments as essential. These early visits influenced everything from material orders to labor deployment, and from housing solutions to risk assessment protocols.

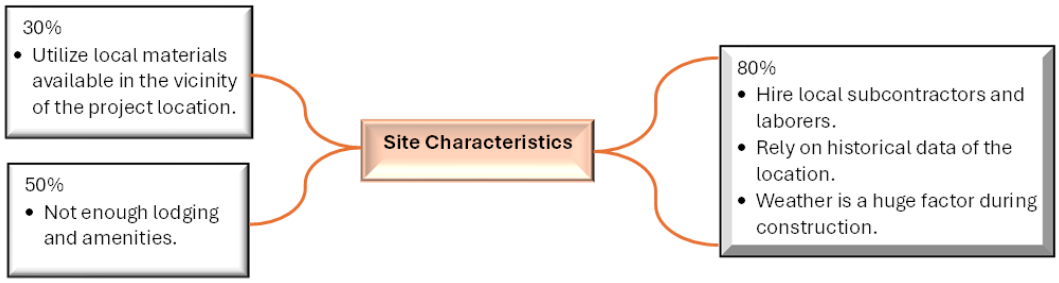

Fig. 3. Site characteristics main theme.

4.3. Schedule risk factors

Participants highlighted that construction schedules in remote Alaska face amplified risks due to external dependencies, regulatory constraints, and narrow weather windows. These risks were further categorized into Fig. 4:

- Environmental risks: Weather-induced delays were common, and full seasonal shutdowns were often necessary. Heavy snow and sea ice limited operations and constrained barge schedules.
- Barge dependency: Materials often arrived by sea, and scheduling depended on tides, weather, and port availability. One delay could impact weeks of work. Barge unloading, often dependent on calm seas and temporary land bridges, introduced additional uncertainty.
- Weather-linked resource availability: Seasonal business shutdowns of batch plants, rock quarries, and material suppliers meant that scheduling had to account for resource access, not just labor or equipment readiness.
- Logistical ripple effects: Late shipments led to storage costs, idle workers, and equipment downtime. In some cases, essential equipment had to be flown in, greatly increasing costs.

To mitigate these issues, most contractors used layered contingency buffers, early procurement, and real-time schedule tracking. Nevertheless, all interviewees agreed that risk could be minimized but never eliminated.

Fig. 4. Schedule risk factor main theme.

4.4. Site logistics

Among all the themes, logistics emerged as the most consistently complex and expensive aspect of remote construction. The transport of materials and personnel required precision planning and deep regional knowledge. Contractors had to make trade-offs between cost, speed, and reliability when selecting between barges, planes, and (in rare cases) rail transport.

Key logistics insights included Fig. 5:

- Mode of transport decisions: Barges were ideal for large shipments but were inflexible. Air transport was faster but costly and limited by weight/volume constraints.
- Cost layering: Some contractors preferred owning barges, citing scheduling flexibility and long-term savings. Others relied on rental or joint ventures with logistics companies to manage costs.
- Multi-modal coordination: In projects without road access, goods were moved through complex handoffs between ports, airfields, and local vehicles. Each stage introduced risks that had to be managed.

Interviewees agreed that early mistakes in logistics planning could ripple through the entire project. Having a single logistics lead per project and building long-term supplier relationships were identified as good practices.

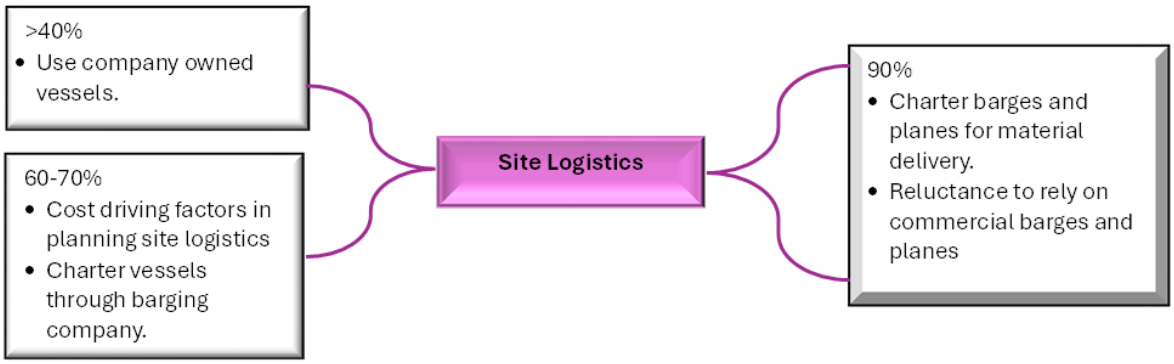

Fig. 5. Schedule risk factor main theme.

4.5. Material transportation

Transporting materials to remote sites presented unique challenges due to the sheer distances, lack of infrastructure, and limited staging areas. The discussion centred around three sub-themes:

- Supply chain integrity: Contractors emphasized the importance of secure packaging, on-site protection, and backup shipments for high-risk items. Theft and spoilage were real concerns.
- Redundancy planning: Stockpiling materials—especially aggregates—was preferred to just-in-time delivery, even if it increased initial haul costs. Equipment downtime due to missing parts was considered more expensive than over-preparing.
- Flexibility and timing: Contractors needed to balance cost and urgency. Planes were used for lightweight, time-sensitive shipments (e.g., electronics or tools), while barges carried bulk materials.

Interviewees also pointed to the lack of flexibility in changing transportation plans mid-project. Planning multiple contingencies before construction began was considered essential.

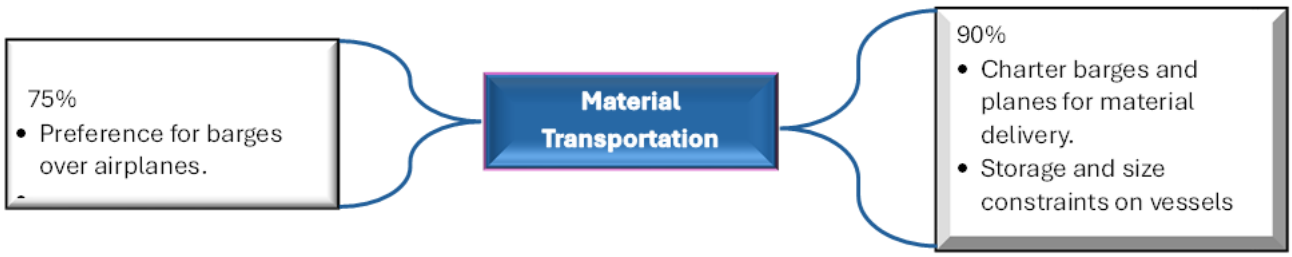

Fig. 6. Material transportation main theme.

4.6. Manpower and human resources

Worker management was viewed as both a major cost driver and a risk factor. Long shifts, physical hardship, and isolation led to high burnout risks.

Key insights included Fig. 7:

- Fatigue management: Most crews worked 7/12 schedules. Contractors used rotation cycles (4–8 weeks), mid-cycle breaks, and overlap planning to ensure team continuity.
- Local labor usage: Local hires helped reduce travel and accommodation costs and fostered goodwill in the community. However, skill limitations often meant locals were used for general labor, while critical tasks were handled by core crews.
- Self-performance: Many firms preferred to self-perform trades such as earthwork, carpentry, and concrete, citing greater control and reduced subcontractor risk. Specialty trades like mechanical and electrical were often subcontracted.

- Accommodations: Lodging constraints, especially during tourist seasons, increased project costs. Some firms invested in “man camps” to maintain control over housing logistics.

Morale strategies included bonuses, recreational facilities, and cultural respect for local communities. Participants stressed the importance of emotional resilience and team chemistry in high-stress environments.

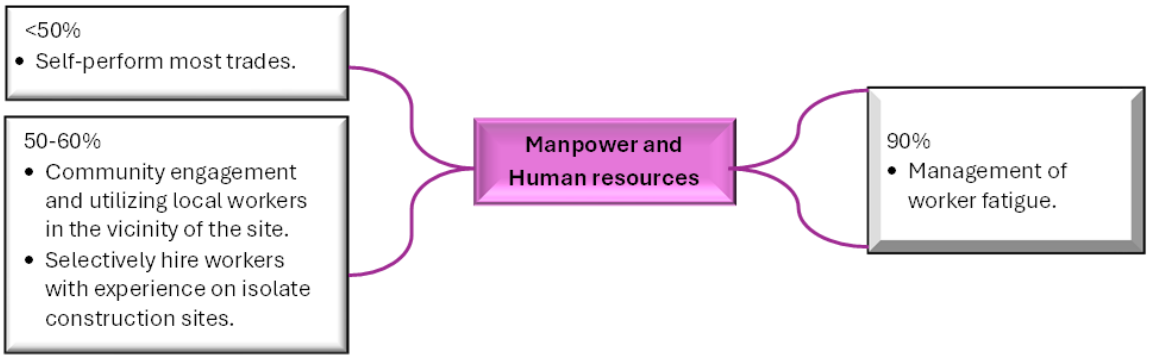

Fig. 7. Manpower and human resources main theme.

4.7. Synthesis and implications for remote construction risk mitigation

This thematic analysis reveals that remote construction in Alaska requires a multifaceted, proactive approach to managing risk. Each theme links directly to one or more study objectives:

- Objective 1 (Logistics and Operations): Themes 2 and 4 reveal that successful remote construction hinges on rigorous logistics and detailed site planning. Project-specific preconstruction assessments were critical to operational success.
- Objective 2 (Risk Identification): Themes 3 and 5 expose the breadth of risk—from weather to resource access to subcontractor reliability. These risks were best managed through layered contingencies, early material procurement, and hybrid transport models.
- Objective 3 (Mitigation Strategies): Strategies such as self-performing critical trades, developing rotational labor cycles, building stockpiles, and using company-owned barges were seen as effective and replicable.

From these findings, several actionable recommendations are proposed:

1. Invest in Front-End Logistics Planning:

Contractors should engage in early and extensive pre-construction planning that includes site visits, community consultations, and feasibility analyses of local material and labor availability. This step is critical for understanding and mitigating transportation constraints, access limitations, and seasonal variations.

2. Develop a Rotational Workforce Strategy:

Long work shifts and isolation lead to burnout. Contractors should implement planned rotational cycles with appropriate R&R scheduling. Local workforce integration should be encouraged to reduce costs and enhance community relations.

3. Prioritize Self-Performance of Core Trades:

Where possible, self-performing critical trades reduces dependency on unreliable third-party subcontractors. Firms should continue developing internal capabilities in site preparation, concrete work, and logistics-heavy activities such as barge operations.

4. Establish Redundancy in Supply Chains:

Material shortages and transport delays can derail projects. Contractors must plan for multiple transportation options, alternate suppliers, and adequate on-site stockpiling to buffer against uncertainty.

5. Enhance Decision-Making Autonomy for Site Teams:

Empowering on-site project managers with delegated authority accelerates response times, especially during crises such as weather delays or equipment failure. Decision-making structures should reflect the unique demands of remote sites.

6. Foster Knowledge Sharing and Institutional Learning:

Lessons learned from each remote project should be formally captured and used to inform future planning. Firms should build databases of regional knowledge, supplier reliability, and logistical timelines.

7. Collaborate with Regional Stakeholders:

Strong relationships with local communities, regional authorities, and transportation service providers are key to reducing regulatory and logistical friction. Early stakeholder engagement can also pre-empt social and environmental challenges.

5. Conclusion and recommendations

This study explored the complexities of managing cost and schedule risks in remote construction projects, with a specific focus on Alaska. Through qualitative interviews with eleven experienced construction professionals, six key themes emerged—Company Mission and Goals, Site Characteristics, Schedule Risk Factors, Site Logistics, Material Transportation, and Manpower and Human Resources. These themes collectively illustrate the multifaceted nature of remote construction and reveal both challenges and strategic responses that firms employ to ensure successful project delivery. The findings stress that remote construction projects differ significantly from their urban counterparts. They require a specialized mind set, adaptive organizational culture, and a high level of logistical, technical, and human resource planning. Contractors who consistently succeed in these environments share common traits: they invest in front-end planning, self-perform critical trades, maintain experienced rotational crews, stockpile materials well in advance, and integrate contingency buffers throughout all project phases. Furthermore, their strategic decisions are based not just on technical analysis but also on lived experience and local knowledge.

In conclusion, remote construction in Alaska demands more than technical competency—it requires a holistic, experience-driven approach that blends logistical foresight, strategic workforce management, and proactive stakeholder engagement. The insights from this study offer valuable guidance not only for construction professionals in Alaska but also for practitioners engaged in infrastructure delivery across similarly challenging environments worldwide. The proposed recommendations serve as a foundation for developing a practical framework for risk mitigation in remote construction, and they open avenues for further research into scalable tools, policy interventions, and technology adoption that can improve outcomes in this demanding yet vital sector.

References

[1] V. Kumar, A. Pandey, and R. Singh, “Project success and critical success factors of construction projects: project practitioners’ perspectives,” Organization, Technology and Management in Construction: an International Journal, vol. 15, no. 1, pp. 1–22, Jan. 2023, doi: 10.2478/otmcj-2023-0001.

[2] M. Abdul Nabi and I. H. El-adaway, “Understanding the Key Risks Affecting Cost and Schedule Performance of Modular Construction Projects,” J. Manage. Eng., vol. 37, no. 4, p. 04021023, Jul. 2021, doi: 10.1061/(ASCE)ME.1943-5479.0000917.

[3] J. Larsson, P. E. Eriksson, T. Olofsson, and P. Simonsson, “Industrialized construction in the Swedish infrastructure sector: core elements and barriers,” Construction Management and Economics, vol. 32, no. 1–2, pp. 83–96, Feb. 2014, doi: 10.1080/01446193.2013.833666.

[4] (Associated General Contractors of America) AGC, “Eighty percent of contractor’s report difficulty finding qualified craft workers to hire as association calls for measures to rebuild workforce,” The construction Association. [Online]. Available: https://www.agc.org/news/2018/08/29/eighty-percent-contractors-report-difficulty-finding-qualified-craft-workers-hire

[5] T. Duncheva and F. F. Bradley, “Multifaceted Productivity Comparison of Off-Site Timber Manufacturing Strategies in Mainland Europe and the United Kingdom,” J. Constr. Eng. Manage., vol. 145, no. 8, p. 04019043, Aug. 2019, doi: 10.1061/(ASCE)CO.1943-7862.0001641.

[6] F. H. Shah, O. S. Bhatti, and S. Ahmed, “A Review of the Effects of Project Management Practices on Cost Overrun in Construction Projects,” in CSCE 2023, MDPI, Aug. 2023, p. 1. doi: 10.3390/engproc2023044001.

[7] Y. A. Olawale and M. Sun, “Cost and time control of construction projects: inhibiting factors and mitigating measures in practice,” Construction Management and Economics, vol. 28, no. 5, pp. 509–526, May 2010, doi: 10.1080/01446191003674519.
[8] L. Le-Hoai, Y. D. Lee, and J. Y. Lee, “Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries,” KSCE Journal of Civil Engineering, vol. 12, no. 6, pp. 367–377, Nov. 2008, doi: 10.1007/s12205-008-0367-7.
[9] N. Mansfield, O. Ugwu, and T. Doran, “Causes of delay and cost overruns in Nigerian construction projects,” International Journal of Project Management, vol. 12, no. 4, pp. 254–260, Nov. 1994, doi: 10.1016/0263-7863(94)90050-7.
[10] Y. Frimpong, J. Oluwoye, and L. Crawford, “Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study,” International Journal of Project Management, vol. 21, no. 5, pp. 321–326, Jul. 2003, doi: 10.1016/S0263-7863(02)00055-8.
[11] P. A. Koushki, K. Al-Rashid, and N. Kartam, “Delays and cost increases in the construction of private residential projects in Kuwait,” Construction Management and Economics, vol. 23, no. 3, pp. 285–294, Mar. 2005, doi: 10.1080/0144619042000326710.
[12] D. Arditi, G. T. Akan, and S. Gurdamar, “Cost overruns in public projects,” International Journal of Project Management, vol. 3, no. 4, pp. 218–224, Nov. 1985, doi: 10.1016/0263-7863(85)90053-5.
[13] M. R. Abdul Kadir, W. P. Lee, M. S. Jaafar, S. M. Sapuan, and A. A. A. Ali, “Factors affecting construction labour productivity for Malaysian residential projects,” Structural Survey, vol. 23, no. 1, pp. 42–54, Feb. 2005, doi: 10.1108/02630800510586907.
[14] M. M. Al-Gathafi, “Riskness of time and cost overruns and the effectiveness of risk response measure strategies in the Libyan construction industry.” University of Liverpool, UK., 2005.
[15] N. Azhar, R. U. Farooqui, and S. M. Ahmed, “Cost Overrun Factors In Construction Industry of Pakistan,” in Advancing and Integrating Construction Education, Research & Practice, Karachi,, Pakistan, 2008.
[16] P. F. Kaming, P. O. Olomolaiye, G. D. Holt, and F. C. Harris, “Factors influencing construction time and cost overruns on high-rise projects in Indonesia,” Construction Management and Economics, vol. 15, no. 1, pp. 83–94, Jan. 1997, doi: 10.1080/014461997373132.
[17] B. K. Sovacool, D. Nugent, and A. Gilbert, “Construction Cost Overruns and Electricity Infrastructure: An Unavoidable Risk?,” The Electricity Journal, vol. 27, no. 4, pp. 112–120, May 2014, doi: 10.1016/j.tej.2014.03.015.
[18] M. Shan, B.-G. Hwang, and L. Zhu, “A Global Review of Sustainable Construction Project Financing: Policies, Practices, and Research Efforts,” Sustainability, vol. 9, no. 12, p. 2347, Dec. 2017, doi: 10.3390/su9122347.
[19] V. Aarthipriya, G. Chitra, and J. S. Poomozhi, “Risk and its impacts on time and cost in construction projects,” 10.5267/j.jpm, pp. 245–254, 2020, doi: 10.5267/j.jpm.2020.6.002.
[20] J. Y. Lin, “New Structural Economics: A Framework for Rethinking Development,” The World Bank Research Observer, vol. 26, no. 2, pp. 193–221, Aug. 2011, doi: 10.1093/wbro/lkr007.
[21] Y. G. Boyark and Y. V. Khatkov, “CRITICAL MANGANESE RAW MATERIAL COMMODITY FLOWS IN RUSSIA,” IZVESTIYA, vol. 331, no. 4, pp. 38–53, Apr. 2020, doi: 10.18799/24131830/2020/4/2592.
[22] Y. B. Metwally, A. M. Elsaid, S. M. Elhamaida, and M. A. E. Abd Elsamad, “Project Navigating: A Guide to Successful Construction Project Management,” Advanced Sciences and Technology Journal, vol. 2, no. 1, pp. 1–27, Jun. 2025, doi: 10.21608/astj.2025.345552.1030.
[23] A. P. Gurgun, K. Koc, and H. Kunkcu, “Exploring the adoption of technology against delays in construction projects,” ECAM, vol. 31, no. 3, pp. 1222–1253, Mar. 2024, doi: 10.1108/ECAM-06-2022-0566.
[24] M. A. Aderbag, S. Kh. Elmabrouk, and M. A. Sherif, “Risk Analysis Related to Costing and Scheduling of Construction Projects,” in Proceedings of the International Conference on Industrial Engineering and Operations Management, Bandung, Indonesia, 2018.
[25] J. O. Toyin, S. Azhar, A. Sattineni, and A. A. Fasoyinu, “Influence of Information and Communication Technology Application in Construction Jobsites: A Systematic Review and Bibliometric Analysis,” ITcon, vol. 29, pp. 444–479, May 2024, doi: 10.36680/j.itcon.2024.021.
[26] M. Parsamehr, U. S. Perera, T. C. Dodanwala, P. Perera, and R. Ruparathna, “A review of construction management challenges and BIM-based solutions: perspectives from the schedule, cost, quality, and safety management,” Asian J Civ Eng, vol. 24, no. 1, pp. 353–389, Jan. 2023, doi: 10.1007/s42107-022-00501-4.
[27] V. Tuljapurkar and K. C. Tiwari, “Spatial Risk Assessment and Geographic Information System based Approach for Construction Projects Risk Management,” Wireless Pers Commun, vol. 139, no. 1, pp. 209–245, Nov. 2024, doi: 10.1007/s11277-024-11606-1.
[28] J. W. Creswell and C. N. Poth, Qualitative Inquiry and Research Design: Choosing Among Five Approaches. Sage publication, 2016.
[29] R. F. Fellows and L. Anita, Research Methods for Construction. John Wiley & Sons, 2021.
[30] C. C. Ejidike, M. C. Mewomo, T. O. Olawumi, S. Wang, and M. K. Buniya, “Barriers to the Adoption of Smart Building Technology in Developing Countries: An Empirical Survey,” J. Constr. Eng. Manage., vol. 151, no. 6, p. 04025067, Jun. 2025, doi: 10.1061/JCEMD4.COENG-15466.
[31] M. Patton, “Qualitative Research and Evaluation Methods,” vol. 3, Sage publication, 2002.
[32] V. Braun and V. Clarke, “Using thematic analysis in psychology,” Qualitative Research in Psychology, vol. 3, no. 2, pp. 77–101, Jan. 2006, doi: 10.1191/1478088706qp063oa.