Perceived Contributing Factors and Consequences of Construction Machinery Accidents: A Survey of Construction Personnel

Muhammad Zulhilmi Mashud[1], Juzailah Nur Junus[1], Mohamad Zain Hashim[1*], Idris Othman[2], Murshamshul Kamariah Musa[3], Siti Haslina Hussin[4]

[1]Civil Engineering Studies, College of Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Pulau Pinang, Malaysia

[2]Department of Civil & Environmental Engineering, Universiti Teknologi, PETRONAS, 32610 Seri Iskandar, Perak, Malaysia

[3]Faculty of Law & International Relations, Universiti Sultan Zainal Abidin, Kampus Gong Badak, 21300 Kuala Terengganu, Terengganu

[4]Fakulti Pendidikan, Bahasa Dan Komunikasi, Universiti Malaysia Sarawak, Kota Samarahan 94300, Sarawak, Malaysia

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.101100206

Received: 08 November 2026; Accepted: 13 November 2026; Published: 24 November 2026

ABSTRACT

Construction machinery improves site productivity but presents hazards that can affect worker safety and project delivery. This study examined construction personnel's perceptions of selected factors associated with machinery accidents and their potential consequences for workers and contractors. An existing questionnaire dataset containing 51 responses was analysed descriptively. Five statements addressed potential contributing factors, machinery overloading, inadequate inspection and maintenance, non-implementation of safety procedures, poor communication, and inadequate lifting-work planning while five addressed potential consequences. Frequencies, percentages, combined agreement (Agree + Strongly Agree), and supplementary weighted item means were calculated from aggregated response counts. Machinery overloading (96.1%) and non-implementation of safety procedures (94.1%) attracted the greatest agreement among the potential factors, followed by poor inspection and maintenance (84.3%), inadequate lifting-work planning (82.4%), and poor communication (76.5%). Risk of death (92.2%) and serious injury or permanent disability (90.2%) led the perceived consequences, followed by project delay and loss of profit (both 88.2%) and reputational damage (86.3%). The study offers a compact, paired description of operational concerns and anticipated human and organisational outcomes in one survey. The results represent perceptions, not observed accident causes or causal effects.

Keywords: construction machinery; occupational safety; accident risk perception; machinery overloading; safety procedures; contractor performance

INTRODUCTION

Mechanised construction relies on excavators, cranes, loaders, bulldozers, trucks and other plant to move materials, execute earthworks and complete technically demanding tasks. Equipment reduces reliance on manual labour and supports productivity, but it also brings workers into contact with moving parts, suspended loads, reversing vehicles and high-energy operations. The interaction of machinery, personnel and evolving site conditions makes construction safety a continuing concern. Zuraidi et al. (2025), in a Malaysian survey of machinery-related worker safety, describe the simultaneous productivity benefits and injury risks associated with heavy equipment. Recent equipment-specific research similarly demonstrates that risks vary according to

operational and project characteristics rather than being uniform across machinery types (Song et al., 2026). In Malaysia, the construction sector recorded 5,379 occupational injury cases and 88 fatal occupational injuries in 2023, according to the Department of Statistics Malaysia (DOSM, 2024). These are sector-wide figures, not counts attributable solely to machinery. They nevertheless establish the importance of managing hazards in an industry that experienced the highest number of fatal occupational injuries among the sectors reported for that year. The Occupational Safety and Health (Construction Work) (Design and Management) Regulations 2024, effective from 1 June 2024, further emphasise the allocation and coordination of safety responsibilities across project participants (Government of Malaysia, 2024). For lifting work specifically, the Department of Occupational Safety and Health (DOSH, n.d.) highlights planning, load charts, inspection, competent personnel and signalling as elements of a safe system of work. Construction accidents are not adequately understood as isolated instances of worker carelessness or equipment malfunction. In Malaysia, Oni et al. (2024) identified eleven clusters of construction accident causation factors, spanning management problems, inadequate supervision and training, material and equipment handling, poor safety practices and the work environment. A systematic review of caught-in and caught-between events identified interacting equipment, procedural and organisational hazards (Darda'u Rafindadi et al., 2025). Such evidence suggests that equipment capacity, mechanical condition, procedural compliance and work coordination are useful categories for analysing perceived machinery safety concerns. The consequences of serious incidents extend beyond the moment of contact between a worker and a machine. Fatalities and permanent injuries can have lasting consequences for workers and families. Contractors may encounter work stoppages, investigation and recovery costs, schedule disruption, legal exposure and reputational damage. Hinsberg et al. (2025) examined the organisational risks associated with construction worksite fatalities, while Chowdhury et al. (2025) demonstrated that indirect construction accident costs can be substantial and difficult to estimate. Weeks et al. (2026) further investigated relationships among human factors, safety and operational efficiency. These studies support examining perceived human and organisational consequences together, although they do not imply that every machinery incident produces all such outcomes. Existing studies have developed accident-causation classifications, evaluated machinery safety practices or analysed observed equipment risks. The present dataset provides a narrower but useful opportunity: it records how one mixed group of construction-related respondents rated five possible contributing factors and five possible consequences in the same questionnaire. It does not contain recorded accidents, verified operational deficiencies, or measurements of project losses. The study therefore uses the term *perceived* consistently and treats endorsement of an item as recognition of a potential concern rather than proof of accident causation. Three objectives guide the analysis: (1) identify the perceived contributing factors associated with construction machinery accidents; (2) assess perceived consequences for workers and contractors; and (3) establish which factors and consequences received the highest respondent agreement. The contribution is an exploratory, practice-oriented comparison of ten clearly defined statements. It can inform discussion of preventive priorities, while recognising that actual safety intervention priorities must be established by competent risk assessment and site-specific evidence.

LITERATURE REVIEW

2.1 Machinery accidents as technical, operational and organisational events

Construction equipment incidents may involve being struck by a vehicle or moving machine, being caught between objects, equipment overturning, or contact with falling loads. These physical mechanisms differ, but the conditions that precede them can overlap. Darda'u Rafindadi et al. (2025) reviewed caught-in and caught-between accidents and reported risks involving equipment, vehicles, loading mistakes and structural or material movements. Their synthesis highlighted training deficiencies and non-adherence to safety protocols. Kudlinski and Ryu (2026) reviewed 87 studies concerning struck-by fatalities and emphasised the need to integrate frontline roles and responsibilities with preventive systems. These reviews show why machinery safety requires attention to both equipment conditions and coordination among people. Technical risk assessments often distinguish initiating conditions from hazardous events and possible consequences. Ancione and Milazzo (2025) analysed accident and near-miss reports for load-handling and lifting equipment, identifying overturning, collapses and falling loads as prominent hazards. Their analysis concerned several industrial settings and therefore should not be treated as a construction-only estimate of accident occurrence. Nonetheless, it offers a useful way to interpret the sequence from equipment or operational deficiencies to an

incident and then to a possible injury or operational impact. In contrast, the present survey measures respondents' agreement with statements about those conditions and consequences; it cannot reconstruct an incident sequence.

2.2 Machinery overloading

Machinery operating limits are central to safe use. An excessive load can exceed structural, lifting or stability capacity, especially when lifting radius, boom configuration, support conditions or load attachment differ from those assumed for the equipment. For cranes, rated capacity is conditional, rather than a single unrestricted number. DOSH (n.d.) instructs lifting planners to consider the maximum load, lifting methods, site risks and load charts relating to boom angle, load radius and capacity. Ancione and Milazzo (2025) provide relevant accident-sequence evidence concerning overturning, structural failure and falling loads. Their findings support the general hazard mechanism, but do not establish that overloading is the dominant cause in the respondents' work settings.

Equipment-specific risk analysis has also expanded beyond simple checklists. Song et al. (2026) used utilisation, subcontractor and cost variables to develop regression models for different equipment categories, finding that risk profiles varied across machinery types. Although their work did not directly validate a perception item on overloading, it illustrates why safe operational boundaries should be assessed with attention to the characteristics and use of the particular equipment. In this study, endorsement of the overloading statement is understood as recognition of the possible risk created when equipment is used beyond safe limits.

2.3 Inspection and maintenance

Inspection detects defects before equipment is put into service; maintenance preserves the operational condition of components that may otherwise deteriorate. Deficiencies in either process can undermine braking, lifting, hydraulic, structural or control functions. Preventive maintenance also requires documentation, ownership of corrective actions and decisions about removing unsafe equipment from use. DOSH (n.d.) identifies crane inspection and maintenance, related records and thorough examination as elements of lifting-work safety. Zuraidi et al. (2025) situate machinery management and preventive site practices within Malaysian construction worker protection. Mechanical condition must nonetheless be considered alongside operational context. A maintained machine can still be involved in an incident if used outside its limits, operated without suitable exclusion arrangements or controlled through unclear instructions. Conversely, a worker's perception that poor maintenance contributes to accidents is not evidence that any particular machine was poorly maintained. The survey measures acceptance of maintenance deficiency as a potential hazard, not maintenance compliance or equipment condition on actual sites.

2.4 Safety procedures and supervisory implementation

Work procedures translate hazard identification into practical instructions on equipment selection, operator authorisation, exclusion zones, pre-operation checks, loading and emergency response. The distinction between possessing a procedure and implementing it is important. Plans may be ineffective when workers do not understand them, supervisory responsibilities are unclear or deviations are tolerated under schedule pressure. Oni et al. (2024) found inadequate supervision, management problems and poor safety practices among their accident-causation clusters. Darda'u Rafindadi et al. (2025) similarly identify procedural non-adherence as a recurring concern in construction incident literature. More recent Malaysian evidence connects safety implementation with organisational participation. Krishnasamy et al. (2026) investigated ISO 45001:2018 implementation in Selangor using survey responses from 124 employees and interviews, reporting the relevance of management commitment, training and worker involvement to compliance and participation. Their study concerned a broader safety-management system, rather than the precise machinery incidents in the current dataset. Its relevance lies in emphasising that procedural safety depends on organisational action. Accordingly, non-implementation of procedures is treated here as an operational and managerial concern rather than an assumed measure of individual worker misconduct.

2.5 Communication and lifting-work planning

Machinery work often involves teams whose tasks must be coordinated across limited space. Operators, supervisors, banksmen or signalmen, riggers, drivers and nearby workers may hold different information about a moving load or equipment route. Where visibility is restricted, communication can be an essential safety control. Kudlinski and Ryu (2026) emphasise that assigned frontline roles warrant attention in preventing struck-by incidents. Their review points to the importance of responsibilities being understood and enacted, rather than relying solely on technical warning systems. Lifting plans provide a structured way to coordinate hazards, people and machinery before movement begins. DOSH (n.d.) recommends risk assessment, a written safe work system or method statement, suitable equipment, safe signalling, competent personnel, appropriate supervision, maintenance records and load-limit checks. Some of these controls are closely connected: a well-designed lift plan is of limited value unless it is communicated to operators and workers; clear communication is also inadequate if the selected machinery is technically unsuitable. Ancione and Milazzo (2025) show why the consequences of lifting failures can be severe. The two questionnaire items on communication and lifting planning therefore capture related but distinct aspects of operational coordination.

2.6 Human consequences: death and lasting injury

Machinery incidents can result in crushing injury, amputation, multiple trauma, disability or death, depending on contact mechanism and incident severity. Kudlinski and Ryu (2026) document the continuing significance of struck-by fatalities involving heavy equipment and vehicles. Darda'u Rafindadi et al. (2025) report injury outcomes ranging from minor to fatal in caught-in and caught-between events and identify long-term health impacts as an area requiring more research. These reviews establish the seriousness of possible outcomes, but they should not be interpreted as estimating the risk of death for every machinery operation. Zuraidi et al. (2025), using a survey of 28 respondents from G7 contractors in Shah Alam, examined injuries and machinery safety practices; cuts and lacerations were the most frequently reported injury type in that particular study. It would be inappropriate to generalise their injury distribution to all machinery operations. Nevertheless, the study demonstrates the value of worker-centred consideration of machinery safety in a Malaysian setting. The current questionnaire distinguishes the perceived risk of death from serious injury and permanent disability, allowing respondents to recognise both immediate fatal outcomes and potentially lifelong health consequences.

2.7 Organisational consequences: reputation, programme and profitability

Following serious incidents, contractors may face operational interruptions while emergency procedures, regulatory investigations or repairs are undertaken. Disruption can propagate through project sequencing where machinery is required for critical activities. Weeks et al. (2026) examined human factors, safety compliance and operational efficiency, demonstrating that safety management can be linked with productivity and schedule-related outcomes in their sample. Their results are not direct evidence of the duration of delay following a machinery accident in the present dataset, but they establish the relevance of safety to project performance. Financial consequences may include damaged equipment, replacement resources, interrupted production, administrative activity, legal costs and potentially uninsured expenditure. Chowdhury et al. (2025) developed a two-tiered machine-learning approach to estimate indirect accident costs using construction accident records, noting that the size and nature of these costs vary by case. Park et al. (2026) proposed a scenario-based approach for evaluating the economic case for construction safety technologies. Together, these studies show why accident prevention may have economic relevance even when direct costs alone are readily visible. However, profit loss cannot be assumed following every incident: contractual terms, insurance, recovery arrangements and actual disruptions matter. Reputational consequences arise through stakeholder perceptions of a contractor's safety management and response to major incidents. Hinsberg et al. (2025) examined financial, legal and reputational exposure following construction worksite fatalities and the role of crisis communication. The presence or magnitude of reputational damage depends on incident circumstances, organisational response and stakeholder expectations. The questionnaire accordingly measures whether participants regard reputational damage as a possible outcome, without claiming to quantify it.

METHODOLOGY

This study employed a quantitative cross-sectional survey design to examine perceptions of factors potentially contributing to construction machinery accidents and their consequences for workers and contractors in Malaysia. The present analysis used an existing questionnaire dataset comprising 51 responses. Respondents represented a range of construction-related roles, including site engineers, project managers, site supervisors, safety personnel, and a small number of participants in other categories, including students. Consequently, the sample is described as construction-related respondents rather than exclusively as experienced site practitioners.

The analysis covered Sections A, B, and C of the questionnaire. Section A recorded respondents' age, educational qualifications, professional designation, number of construction projects in which they had been involved, and years of work experience. Section B contained five statements (B1–B5) on potential contributing factors: machinery overloading (B1), inadequate machinery inspection and maintenance (B2), non-implementation of on-site safety procedures (B3), poor communication among construction workers (B4), and inadequate lifting-work planning, particularly for crane operations (B5). Section C contained five statements (C1–C5) addressing possible consequences: risk of death (C1), serious injury or permanent disability (C2), damage to company reputation (C3), project delay (C4), and loss of profit (C5). These labels reflect perceptions of potential factors and consequences, not observations of actual incidents or measured losses. Items were rated on a five-point Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Descriptive analysis was undertaken using the available aggregated item-response frequencies. For each item, frequencies and percentages were reported, and combined agreement was calculated as the number of Agree and Strongly Agree responses divided by the total number of responses (n = 51), multiplied by 100. Weighted means were calculated by multiplying each category frequency by its score (1–5), summing the products, and dividing by 51. Items were ranked by combined agreement; means were reported as supplementary descriptive summaries of ordinal responses, rather than as the basis for the rankings (Boone & Boone, 2012; Sullivan & Artino, 2013). No inferential tests or associations between items were computed because respondent-level data were unavailable.

RESULTS

4.1 Respondent characteristics

Table 1 summarises the five demographic variables. The largest age group was 21–30 years (45.1%), followed by 41–50 years (27.5%). Most respondents held a bachelor's degree (68.6%). Site engineers and project managers accounted for 25.5% each, while site supervisors accounted for 19.6%. Together, those three positions comprised 36 of the 51 respondents (70.6%), giving the sample a substantial engineering, project-management and supervisory component. Nevertheless, two students and several single-respondent categories were also included, so the sample should not be described as exclusively comprising experienced practitioners.

Table 1. Respondent profile.

Characteristic	Category	n	%
Age	21–30 years	23	45.1
	31–40 years	9	17.6
	41–50 years	14	27.5
	51–60 years	5	9.8
Education	Diploma	7	13.7
	Bachelor's degree	35	68.6
	Master's degree	8	15.7
	PhD studies	1	2
Designation	Site supervisor	10	19.6

	Site engineer	13	25.5
	Project manager	13	25.5
	Safety officer	6	11.8
	Safety manager	2	3.9
	Other roles, including two students	7	13.7
Projects involved	1–3	22	43.1
	4–6	14	27.5
	7–9	7	13.7
	More than 10	8	15.7
Working experience	Below 2 years	18	35.3
	2–5 years	7	13.7
	5–10 years	14	27.5
	More than 10 years	12	23.5

Approximately 43.1% reported involvement in one to three construction projects, while 29.4% reported involvement in seven or more. Regarding working experience, 35.3% reported less than two years, whereas 51.0% reported five years or more. These different profile measures should not be assumed to reflect equivalent types of experience: project involvement does not identify project scale, and years of employment do not identify direct exposure to machinery operations. The summary provides no basis to test whether respondents in more senior roles or with greater experience answered differently.

4.2 Perceived contributing factors

Table 2 presents the original response frequencies and the derived agreement statistics. All five statements attracted agreement from at least 39 of 51 respondents. B1, machinery overloading, ranked first with 49 respondents agreeing or strongly agreeing (96.1%). Two respondents were neutral and none disagreed. The weighted mean was 4.51, the highest among the five factors. B3, non-implementation of safety procedures, ranked second with 48 agreements (94.1%). Only one respondent disagreed and two were neutral. This item had 29 Agree and 19 Strongly Agree responses, indicating widespread endorsement even though its mean (4.29) was below that of the maintenance item.

Table 2. Perceived accident-contributing factors: response frequencies and rankings .

Rank	Code and factor	SD	D	N	A	SA	A+SA, n (%)	Mean
1	B1. Machinery overloading	0	0	2	21	28	49 (96.1)	4.51
2	B3. Non-implementation of safety procedures	0	1	2	29	19	48 (94.1)	4.29
3	B2. Poor inspection and maintenance	0	0	8	15	28	43 (84.3)	4.39
4	B5. Inadequate lifting-work planning	0	0	9	21	21	42 (82.4)	4.24
5	B4. Poor communication among workers	0	0	12	14	25	39 (76.5)	4.25

Note. SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree. Ranking is based on combined A+SA percentage, not mean. Means are descriptive summaries of ordinal item scores.

B2, poor inspection and maintenance, received 43 agreements (84.3%) and ranked third. Although 28 respondents strongly agreed equal to the number for overloading eight were neutral, lowering the combined agreement percentage. Its weighted mean of 4.39 was higher than B3's 4.29. This illustrates how mean score and combined endorsement can imply different orderings. B5, inadequate lifting-work planning, attracted 42 agreements (82.4%), divided equally between Agree and Strongly Agree. Nine respondents (17.6%) were neutral. B4, poor communication among workers, ranked fifth with 39 agreements (76.5%), but still had 25 Strongly Agree responses. Its 12 neutral responses (23.5%) were the largest neutral count among factor items. The differences are descriptive. In particular, the gap between the two highest-ranked factors represents only one respondent (49 versus 48). Since no respondent-level information is available, no claim of statistical

separation or causal ranking can be made. The main observation is that respondents widely endorsed all five safety concerns, with the strongest overall agreement for exceeding load limits and failing to implement procedures.

4.3 Perceived consequences

Table 3 presents the equivalent analysis for Section C. Risk of death (C1) received 47 agreements (92.2%) and had the highest mean (4.59); 35 respondents (68.6%) selected Strongly Agree. Serious injury and permanent disability (C2) followed with 46 agreements (90.2%) and a mean of 4.49. These were the two most highly endorsed consequences and had the largest counts of Strongly Agree responses.

Table 3. Perceived machinery accident consequences: response frequencies and rankings.

Rank	Code and consequence	SD	D	N	A	SA	A+SA, n (%)	Mean
1	C1. Risk of death	0	1	3	12	35	47 (92.2)	4.59
2	C2. Serious injury and permanent disability	0	1	4	15	31	46 (90.2)	4.49
3	C4. Delay in project progress	1	0	5	18	27	45 (88.2)	4.37
3	C5. Loss of profit	0	2	4	22	23	45 (88.2)	4.29
5	C3. Damage to company reputation	1	0	6	15	29	44 (86.3)	4.39

Note. C4 and C5 share third place on the prespecified combined-agreement measure. The ordering of means differs, because strongly agreeing is weighted more heavily than agreeing.

Project delay (C4) and loss of profit (C5) were tied on the principal measure at 45 of 51 respondents (88.2%). Although C4 attracted more Strongly Agree responses (27 versus 23), this distinction did not alter their tied ranking. Damage to company reputation (C3) received 44 agreements (86.3%), the lowest among the five consequence items but still more than four-fifths of the sample. Its mean (4.39) exceeded that of C4 despite its lower combined agreement, again showing that these summary measures describe different aspects of the response distribution. The high endorsement across consequences indicates that respondents recognised possible harm to people and construction organisations. It does not establish that the respondents had experienced these outcomes, that losses were measured, or that machinery accidents are more likely to cause one consequence than another. For example, 92.2% agreement that death is a possible consequence must not be interpreted as a 92.2% fatality probability.

DISCUSSION

5.1 Operational safety recognition and machinery load control

The strongest descriptive finding is the near-unanimous endorsement of overloading as a potential contributing factor. Machinery overloading also had the highest mean among factor statements, indicating that agreement was both widespread and frequently strong. This result is practically coherent because the physical performance of lifting and other equipment depends on loading limits. DOSH (n.d.) specifies consideration of maximum load, rated capacity and crane configuration during lifting-work planning. Ancione and Milazzo (2025) identify overturning and falling loads among important accident scenarios in load-handling operations, providing a technical rationale for attention to load control. Nevertheless, this survey does not identify whether overloading is common on the relevant sites, nor does it compare its actual contribution to incident occurrence with those of other conditions. The distinction matters: a widely understood catastrophic hazard can attract high agreement even if it is infrequent in everyday operation. Accordingly, the finding is better interpreted as evidence of safety awareness or perceived concern than as evidence that load exceedance is the leading mechanism of machinery accidents. Applying the result responsibly would involve checking whether load charts are available, equipment is selected appropriately, and lifting arrangements are verified by competent personnel not assuming that an unmeasured overload problem has already been demonstrated.

5.2 The gap between written procedure and implementation

Non-implementation of safety procedures followed closely behind overloading, attracting agreement from 48

respondents. This finding aligns with the organisational perspective developed by Oni et al. (2024), who identified inadequate supervision and poor safety practices within their Malaysian construction accident causation framework. It is also consistent with Darda'u Rafindadi et al. (2025), who found that inadequate training and procedural non-adherence recur in research on caught-in and caught-between accidents. The evidence therefore supports the importance of implementation, although it does not establish that procedural failures occurred within the sample's projects. Krishnasamy et al. (2026) provide a useful contemporary Malaysian comparison. Their investigation of ISO 45001 implementation connected safety participation and compliance with management commitment and worker involvement. In practical terms, this implies that instructions need to be understood, resourced, monitored and reinforced through routine work. The current item, however, is broadly worded. Respondents might think of different procedures, from pre-start checks and traffic management to lifting permits and emergency arrangements. Future questionnaires should distinguish the specific procedures, levels of implementation and accountability arrangements instead of treating non-implementation as a single undifferentiated issue.

5.3 Maintenance, lifting plans and communication as complementary controls

The remaining three factor statements attracted agreement between 76.5% and 84.3%, indicating substantial concern even where endorsements were less uniform. The high Strongly Agree count for inspection and maintenance suggests that many respondents regarded defective equipment management as especially relevant. Yet the relatively large neutral group implies variation in certainty. Without knowing each person's work role or machinery exposure, it is not possible to explain that variation reliably. It may reflect differences in familiarity with equipment maintenance, but this remains a hypothesis for later research rather than a finding of the present analysis. Lifting planning and communication are tightly connected in operation. DOSH (n.d.) advises that lifting plans cover risks, equipment selection, competent personnel, signalling, supervision, maintenance and the maximum load. An effective lifting plan thus integrates technical decisions with the arrangements needed to communicate those decisions. Kudlinski and Ryu (2026) also underscore the importance of defined human roles in equipment safety. The current pattern does not mean that communication is the least important practical control simply because F4 ranks fifth. An item with less endorsement may still concern a serious hazard under particular site conditions, and its importance should be assessed by hazard severity, exposure and control effectiveness rather than survey popularity alone. The item-level differences also indicate a methodological point. Inspection and maintenance ranked third on agreement but second on mean, while communication ranked fifth on agreement but above lifting planning on mean. Combining Agree and Strongly Agree produces a transparent, easily understood measure, yet it loses information about response intensity. Reporting full frequencies beside agreement percentages and means therefore avoids presenting a falsely precise hierarchy.

5.4 Human harm remains central to perceived consequences

Risk of death and serious injury or permanent disability were the most highly endorsed possible consequences. This ranking is unsurprising given the energy and mechanical forces involved in strikes, entrapment, overturning and falling-load incidents. Kudlinski and Ryu (2026) demonstrate that heavy-equipment and vehicle-related struck-by events continue to result in fatalities, while Darda'u Rafindadi et al. (2025) review severe outcomes associated with caught-in and caught-between mechanisms. These studies support the plausibility and seriousness of the questionnaire's human-harm statements. The results should not be interpreted as measuring the respondents' personal experience of injury. A respondent can strongly agree that a machinery incident may cause death without knowing of any local fatal event. Nonetheless, recognising potential severity is relevant to prevention because a low-frequency hazard may merit strong controls when its credible consequences are catastrophic. The finding supports maintaining worker protection at the centre of machinery-management decisions, including traffic segregation, exclusion zones, suitable lifting equipment, competent operation and emergency readiness.

5.5 Contractor impacts are also widely recognised

A second important observation is that organisational consequences were endorsed almost as strongly as worker harm. Project delay and loss of profit were tied at 88.2%, and reputational damage received 86.3%.

This suggests that many respondents associated machinery accidents with repercussions for project delivery and business continuity. Hinsberg et al. (2025) demonstrate that major construction safety incidents can create financial, legal and reputational exposure; Chowdhury et al. (2025) further show that indirect costs, including productivity disruption and material damage, are challenging to estimate. Weeks et al. (2026) provide complementary evidence linking human factors and safety performance to operational efficiency within their study context. These perceptions may be useful when communicating the broader importance of prevention to project managers and contractors. However, the questionnaire contains no data on cost magnitude, critical-path delay, company reputation before or after an event, or whether an incident actually occurred. Thus, the results do not support estimates of money lost or days delayed. Project delay and profit loss may also co-occur, but the present aggregated responses cannot establish an empirical association between them. In addition, not every accident will interrupt a critical activity or reduce contractor profit; outcomes depend on event severity, contractual arrangements and recovery capacity. The literature on safety investment should similarly be used cautiously. Park et al. (2026) evaluate safety technology using scenario-based economic modelling, but the current survey cannot justify a particular technology or calculate its return on investment. A defensible implication is that construction organisations should include potential disruption, repair and recovery needs in risk planning while evaluating any proposed intervention using site-specific data. The high agreement regarding reputation likewise indicates perceived exposure rather than measured changes in stakeholder confidence.

5.6 Implications for construction practice

The combined picture is one of broad awareness of five potential failure points and five potentially serious outcomes. A practical response would begin by reviewing machinery operating limits and confirming that appropriate equipment is selected for the task. For lifting operations, this includes verifying load weights, suitable rigging, configuration-specific load charts, ground or support conditions, and the presence of compe-

tent personnel. These measures follow the substance of DOSH (n.d.) guidance rather than being derived as tested interventions from the survey. A second response concerns the implementation of safe operating procedures. Contractors can examine whether task-specific methods are current, communicated and followed; whether workers have the necessary competence; and whether supervisors can stop unsafe activities. Inspection and preventive maintenance programmes should include defect reporting, records of completed checks and clear decisions about removing unsafe equipment from service. Plans for high-risk lifting and material movement should specify exclusion arrangements, signalling responsibilities and changes when conditions depart from the planned operation. Finally, machinery safety should be integrated into wider project planning. Site logistics, traffic routes, work sequencing, emergency response and contingency for equipment downtime affect the environment in which machinery is used. Recognising possible schedule and cost consequences may support management commitment to prevention. Yet the survey cannot rank preventive investments by expected harm reduction. Organisations should therefore combine the perceptual findings with machinery inspection results, near-miss records, incident investigations, task-based hazard assessments and the applicable regulatory framework.

5.7 Study contribution and limitations

The principal contribution is a transparent description of how 51 respondents rated a defined set of operational concerns and possible human and organisational consequences. It complements Malaysian research on accident causation (Oni et al., 2024) and machinery safety practices (Zuraidi et al., 2025), while connecting the discussion to recent literature on equipment-specific hazards and organisational effects. The fact that every item drew agreement from more than three-quarters of respondents is noteworthy, but it also limits the instrument's discriminating power: broad or obvious hazard statements may attract high agreement regardless of actual local exposure. The limitations are substantial. The sample is small and its selection method, geographic location and data collection date have not been documented. Some respondents were students or held roles outside daily site operations. Responses are perceptions rather than incident data, and positive agreement may be influenced by statement wording, social desirability or different interpretations of machinery safety. There is no independent evidence of questionnaire validation. The aggregated tables prevent

subgroup comparison, correlations, internal-consistency analysis and estimates of uncertainty that depend on the joint respondent-level distribution. The rankings are not causal or predictive, and differences of one or two respondents should not be overstated. Future studies should preserve respondent-level records, define recruitment criteria and sample across known project and machinery types. A stronger design would distinguish exposure, safety behaviours, hazard observations, near misses and verified accidents; examine equipment-specific circumstances; and link operational events with observed worker and project outcomes where ethically and practically feasible. Larger, appropriately sampled studies could test whether perceived risks differ by role or experience, while incident investigations and longitudinal designs could establish more direct evidence about preventive controls. Qualitative interviews may also clarify why some respondents remained neutral on communication, lifting planning or maintenance.

CONCLUSION

This study examined 51 respondents' agreement with five potential construction machinery accident factors and five possible consequences. Machinery overloading (96.1%) and non-implementation of safety procedures (94.1%) received the highest agreement among factors. Perceived risk of death (92.2%) and serious injury or permanent disability (90.2%) led the consequences, while project delay and loss of profit were tied at 88.2%. Reputational damage was also widely recognised (86.3%). These findings indicate that the surveyed group recognised machinery safety as both a worker-protection issue and a concern for contractor operations. The results should be understood as a descriptive snapshot, not proof that particular practices caused accidents or that specific outcomes occurred. For practitioners, the findings reinforce the relevance of load management, clear and implemented procedures, preventive maintenance, lifting plans and communication, supported by competent supervision and site-specific risk assessment. For researchers, they underscore the need to move from general awareness statements toward validated measures, clearly described samples and verified accident or project records. Within these boundaries, the analysis provides an accessible evidence base for discussing machinery-related safety priorities and designing more rigorous subsequent studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Ancione, G., & Milazzo, M. F. (2025). Identifying risk factors in handing and lifting loads by the analysis of near-miss and accident reports. *Safety Science, 181*, Article 106701. https://doi.org/10.1016/j.ssci.2024.106701
2. Boone, H. N., Jr., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension, 50*(2), Article 48. https://doi.org/10.34068/joe.50.02.48
3. Chowdhury, A. M., Yee, J.-J., Park, S. I., Ha, E.-J., & Choi, J.-H. (2025). Estimating indirect accident cost using a two-tiered machine learning algorithm for the construction industry. *Buildings, 15*(21), Article 3947. https://doi.org/10.3390/buildings15213947
4. Darda'u Rafindadi, A., Kado, B., Gora, A. M., Dalha, I. B., Haruna, S. I., Ibrahim, Y. E., & Ahmed Shabbir, O. (2025). Caught-in/between accidents in the construction industry: A systematic review. *Safety, 11*(1), Article 12. https://doi.org/10.3390/safety11010012
5. Department of Occupational Safety and Health. (n.d.). *Lifting work*. https://dosh.gov.my/en/keselamatan-tapak-bina/kerja-kerja-mengangkat/
6. Department of Statistics Malaysia. (2024). *Big data analytics: National occupational injury and disease statistics 2023*. https://www.dosm.gov.my/portal-main/release-content/big-data-analytics-national-occupational-injury-and-disease-statistics-
7. Government of Malaysia. (2024). *Occupational Safety and Health (Construction Work) (Design and Management) Regulations 2024* [P.U. (A) 147]. https://intranet.dosh.gov.my/factory-machinery/regulation-2-1/regulations/regulations-under-occupational-safety-and-health-act-1994-act-514/4732-occupational-safety-and-health-construction-work-design-and-management-regulations-2024/file

8. Hinsberg, K., Nadesan, M., Parrish, K., & Lamanna, A. (2025). Organizational impacts of construction worksite fatalities. *Systems, 13*(4), Article 223. https://doi.org/10.3390/systems13040223
9. Krishnasamy, V., Abdul Rahman, I., & Kunchi Mohamed, F. K. P. (2026). ISO45001:2018 implementation: An overview of its effectiveness in the construction industry at the state of Selangor, Malaysia. *International Journal of Built Environment and Sustainability, 13*(2), 135–151. https://doi.org/10.11113/ijbes.v13.n2.1662
10. Kudlinski, D., & Ryu, J. (2026). Struck-by fatalities in construction: A systematic review of regulatory roles, responsibilities, and research gaps. *Journal of Safety Research, 96*, 11–18. https://doi.org/10.1016/j.jsr.2025.11.010
11. Oni, O. Z., Olanrewaju, A., & Cheen, K. S. (2024). Identifying key accident causation factors in the Malaysian construction industry. *International Journal of Occupational Safety and Ergonomics, 30*(2), 366–377. https://doi.org/10.1080/10803548.2024.2308376
12. Park, J., Baek, S., Kim, T., Kim, N., & Kim, H. (2026). Scenario-based framework for economic evaluation of safety technology adoption in construction. *Journal of Management in Engineering, 42*(6), Article 04026049. https://doi.org/10.1061/JMENEA.MEENG-7613
13. Song, M., Jeong, J., Lee, J., Kumi, L., Lee, M., & Mun, H. (2026). Evaluating construction equipment accident risk by analyzing utilization and costs using regression models. *Risk Analysis, 46*(1), Article e70167. https://doi.org/10.1111/risa.70167
14. Sullivan, G. M., & Artino, A. R., Jr. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education, 5*(4), 541–542. https://doi.org/10.4300/JGME-5-4-18
15. Weeks, K., Safa, M., & Zamiran, S. (2026). The productivity–safety nexus: The impact of human factors on operational efficiency in construction projects. *Buildings, 16*(1), Article 87. https://doi.org/10.3390/buildings16010087
16. Zuraidi, N., Ab Rani, N. I., Abdul Hadi, A. A., & Ghafourian, K. (2025). Safety of workers when dealing with machinery in construction project. *Jurnal Kejuruteraan, 37*(2), 869–881. https://doi.org/10.17576/jkukm-2025-37(2)-25