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IOT-BASED REAL-TIME MONITORING SYSTEMS TO ENHANCE WORKERS' SAFETY IN HIGH-RISE CONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

High-rise construction projects are high-risk ventures and key drivers of economic growth, yet they face severe safety challenges in rapidly urbanizing regions. Despite advancements in IoT-based monitoring systems enabling real-time hazard detection and proactive safety measures, their adoption in developing countries remains limited due to economic, technical, and socio-cultural barriers. This study investigates how IoT technologies can enhance worker safety in Sri Lankan high-rise construction through a qualitative approach, including semi-structured interviews with 17 industry experts (safety officers, project managers, and IoT engineers). Findings reveal pervasive hazards, including falls, scaffold collapses, and electrical risks, which are exacerbated by gaps between formal safety protocols and their on-the-ground implementation. IoT solutions, including wearable sensors, building information modelling (BIM) integration, and drones, show transformative potential, with estimates suggesting a 30% reduction in accidents upon global adoption. However, worker resistance, high costs, and inadequate policy frameworks hinder Sri Lanka's adoption. Experts rated the nation's IoT readiness at a low 2–3 out of 10, indicating considerable scope for advancement. Key challenges identified include public concerns over surveillance, poor durability of devices in harsh monsoon conditions and language barriers. The study advocates for multi-stakeholder collaboration, policy incentives, and phased IoT integration to bridge the gap between international best practices and local realities. By addressing these barriers, IoT can shift Sri Lanka's construction safety paradigm from a reactive approach (post-accident responses) to a proactive one (preventive risk mitigation).

Keywords: *Construction Safety; High-rise Buildings; IoT Technologies; Real-time Monitoring; Sri Lanka.*

1. INTRODUCTION

The construction industry (CI) contributes approximately 6% to the world's gross domestic product (GDP) and supports other industries by offering built infrastructure (Ghosh et al., 2020). CI is also the largest consumer of raw materials and a significant emitter of greenhouse gases (Ghosh et al., 2020). Rapid urbanization is accelerating with over 200,000 individuals entering the cities daily, raising demands for residential houses,

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which is subjecting construction activities to be pressurized (Kamble & Sabanna, 2023). High-rise constructions have emerged to address the shortage of land and population growth while symbolizing the economic advancement (Fakhari & Ünver, 2023). However, high-rise constructions require keen technical and quality controls to mitigate faults and improve safety (Mangaraj et al., 2023). Moreover, construction of high-rise buildings, despite their benefits, poses severe threats to construction safety, including falls from heights, which results from personal, non-personal, and environmental circumstances (Arifuddin et al., 2020).

Statistics of the safety challenges of the CI are supported by global sources. For instance, falls from heights account for approximately 52 deaths a month and 745 deaths a year, 1,000 severe injuries, and 5,000 productivity loss hours per incident (Khan et al., 2023). As well as this, it indicates the significance of human and economic cost, with fatalities representing 20% of workplace deaths (Arifuddin et al., 2020). However, the substantial losses that are preventable with the regulations and construction practices that meet the sustainable development goals are thoroughly investigated (Awolusi et al., 2018). Construction safety precautions play a significant role in helping to save lives and continue the growth of CI within the world via urbanization.

Proper control of safety relies on organisational routines, behaviour of the workers, and environmental controls (Li et al., 2018). However, typical hazards due to scaffolding, lifting, and equipment use still persistently appear (Wang et al., 2024). On the other hand, technical advancements such as Internet of Things (IoT) sensors, wearables, and AI-driven monitoring systems enable real-time hazard detection and data-driven interventions (Wang et al., 2024). These methods offer greater reliability compared to traditional approaches, which heavily depend on variable human compliance (Melagoda & Rowlinson, 2022). As developed countries such as Singapore and the UAE have reduced the fall incidents using digital tools such as building information modelling (BIM) and drones in scaffolding inspections by 40% (Khan et al., 2023). Mobile-based safety platforms help in overcoming resource constraints and increase compliance in risky zones in Sri Lanka (Sandagomika et al., 2020). Such innovations standardize safety protocols, eliminate some persistent hazards, and increase productivity in the same way as the global smart construction practices.

In addition, virtual and augmented reality (VR/AR) enable risk-free safety training, and IoT systems enable the usage of real-time data to avoid risks (Rahman et al., 2023). Issues such as the cost of investments, resistance to change, and limited technical knowledge need to be addressed while implementing modernized technologies in the CI (Tabatabaee et al., 2022). Construction safety in Sri Lanka falls behind as there is a lack of regulations and integration of technology within the industry (Melagoda & Rowlinson, 2022). Moreover, IoT-based models have been proven to yield cost and efficiency benefits globally, even though there are challenges such as economic constraints and unawareness in Sri Lanka (Sandagomika et al., 2020).

This study evaluates the current safety issues encountered in high-rise construction projects in Sri Lanka, examines global best practices in IoT-based safety management systems, and investigates the extent to which such technologies have been implemented locally. By focusing on these areas, the study aims to understand how IoT-driven safety practices can be leveraged to enhance occupational safety performance in Sri Lanka's high-rise construction sector, considering the country's unique technological, economic, and regulatory conditions.

2. LITERATURE REVIEW

2.1 SPECIFIC RISKS IN HIGH-RISE CONSTRUCTION

High-rise construction offers a unique set of safety issues that involve immense risk to workers. The issues include typical risk factors, such as prevalent dangers such as falls from heights, exposure to environmental hazards, risks associated with heavy equipment operation, and the potential for fire.

2.1.1 Falls from Heights

Falls are a crucial concern in the construction industry, particularly in high-rise areas. Such accidents are responsible for a high percentage of fatal incidents, involving about 33% of all fatal accidents related to construction work. Falls in 2020 claimed 351 lives in a total of 1008 construction-related deaths in the United States, which emphasizes the need for increased safety measures (Nugroho et al., 2023; Manzoor et al., 2022).

2.1.2 Environmental Hazards

Working environments involving high-rise buildings often expose labour to various environmental hardships, such as extreme weather and harmful air quality (Karthick et al., 2022). The problem of poor air quality is extremely critical, as it is accompanied by the development of severe respiratory diseases and reduced mental functions, which negatively impact both attention and memory in workers (Chen et al., 2022). As estimated by the World Health Organization (WHO), air pollution is the cause of around 7 million deaths annually, and construction workers are most susceptible because they are constantly in contact with harmful chemicals and environments (Chen et al., 2022).

2.1.3 Equipment Safety and Proximity Alerts

The use of heavy machinery and equipment is a distinguishing trait in high-rise building construction, posing significant threats to the safety of labourers (Dhakal & Giri, 2024). Constructions involving contact impacts from objects, which include cases involving touch with movable machinery or falling materials, are a leading cause of deaths, accounting for about 10% of construction worker deaths, as OSHA estimates. The very nature of such operations requires the establishment and execution of stringent safety practices to control such incidents (Nugroho et al., 2023).

2.1.4 Fire Hazards

The fire risk potential is an important concern in high-rise buildings. The use of combustible materials, such as asbestos, in addition to the intricacies surrounding the evacuation corridors in such buildings, escalates the threat of unprecedented fire disasters (Qin et al., 2022). Information supplied by the National Fire Protection Association (NFPA) shows that building construction scenarios are 3.5 times riskier in terms of fire outbreak incidence in comparison to other building types, thus putting in perspective the increased risk present in such environments (National Fire Protection Association).

2.2 MODERN TECHNOLOGIES AND THEIR BENEFITS TO THE CONSTRUCTION INDUSTRY: THE ROLE OF IOT

The construction industry (CI) significantly contributes to global economic growth, accounting for 6% of global GDP and employing over 7% of the workforce (Ghosh et al., 2020; Fei et al., 2021). High-rise construction helps address land scarcity and population growth but introduces complex safety risks due to elevated material handling and multi-trade coordination (Navaratnam, 2022; Nugroho et al., 2023). IoT technologies are increasingly used to manage these risks by enabling real-time monitoring, reducing human error, and supporting early hazard detection (Awolusi et al., 2018; Fang et al., 2024). IoT can predict unsafe scaffolds or equipment failures through automated data collection (Cheng & Cao, 2022; Khan et al., 2023). However, existing studies often overlook the challenges of integrating IoT into current workflows and safety cultures, particularly in developing regions.

In addition to safety, IoT boosts operational efficiency by streamlining processes. Integration with BIM helps project managers anticipate hazards, reducing delays and rework (Wang et al., 2024), while wireless protocols ensure smooth data communication for real-time decision-making (Zidek et al., 2018). Successful implementations in Singapore and the UAE have reduced accidents by up to 30%, improved efficiency, and lowered costs (Khan et al., 2023; Sidani et al., 2023). Nonetheless, these successes largely occur in resource-rich settings, and there is limited analysis of how contextual factors affect IoT adoption across regions. In contrast, countries like Sri Lanka face adoption barriers due to infrastructural, economic, and cultural limitations (Melagoda & Rowlinson, 2022), exposing a gap in the literature that often generalizes IoT's benefits without fully addressing these localized challenges.

2.3 IOT-ENABLED SYSTEMS TO ENHANCE WORKERS' SAFETY

Three technologies from the IoT are improving occupational safety as wearable devices, systems that monitor the environment, and safety platforms located centrally.

2.3.1 Wearable Technologies

Through IoT, smart helmets and Radio Frequency Identification (RFID) tags keep an eye on workers' vital signs (heart rate, body temperature, and fatigue) and their locations (Huang et al., 2020; Okonkwo et al., 2022). When workers get too close to unstable scaffolds or crane operating areas, these devices alert safety managers and immediately send out an emergency notice (Danilenka et al., 2023). In high-rise projects, RFID-enabled vests have helped cut the number of fatalities from falls by 25% by making sure workers are within safe zones (Khan et al., 2023). Despite these benefits, limited research explores worker perception, wearability issues, or resistance to tracking technologies, which could significantly affect practical adoption.

2.3.2 Environmental Monitoring Systems

Scaffolding, cranes, and enclosed spaces now have IoT sensors that report any danger to workers, such as possible damage, bad air, or poor weather. Thanks to strain gauges and vibration sensors, collapses can be detected early, and gas detectors stop suffocation in closed-off areas (Cheng & Cao, 2022; Danilenka et al., 2023). Acoustic sensors in Singaporean high-rises decreased accidents related to equipment by 40% by spotting noises that pointed to possible mechanical problems (Khan et al., 2023). However, comparative studies evaluating the effectiveness, reliability, and cost-efficiency of these sensor systems in different climates or project scales remain scarce.

2.3.3 Centralized Safety Platforms

All data from drones, AI cameras, and pressure pads can be collected by centralised IoT hubs to find hazards, plan proper resources, and keep safety rules in check (Gambo & Musonda, 2022). As an illustration, using IoT in Dubai cut safety inspection times by half by automating the study of risk trends (Sidani et al., 2023). These systems assume stable power and high connectivity, yet such assumptions may not hold in lower-income regions—an issue often underexamined in case-based literature. Moreover, implementing such systems is challenging for developing countries because they are expensive, have unreliable electricity, and their workforce often objects to being watched (Melagoda & Rowlinson, 2022; Tabatabaee et al., 2022).

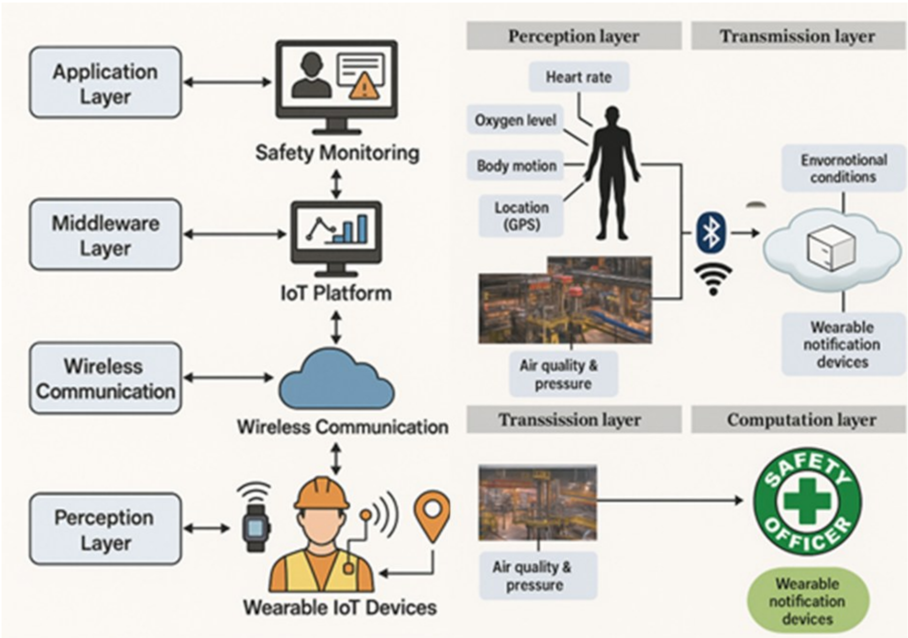

Figure 1: Layered architecture of IoT-enabled safety monitoring system for construction workers

Figure 1 outlines a hierarchical IoT safety system comprising application-level monitoring, middleware platforms, communication protocols, and wearable sensors working together for rapid hazard detection and response. While the architecture is technically robust, real-world deployment demands adaptation to specific local conditions, a factor often overlooked in mainstream models.

Most existing literature fails to account for challenges in countries like Sri Lanka, where IoT devices must be durable and interfaces localized. This study addresses that gap by exploring how IoT systems can be tailored to Sri Lanka's economic and environmental realities, aligning with Sustainable Development Goals 8 (decent work) and 9 (industry, innovation, and infrastructure).

2.4 INTEGRATION OF IOT APPLICATIONS IN CONSTRUCTION IN THE GLOBAL AND LOCAL CONTEXT

Globally, IoT adoption in construction has shown transformative impacts. In Dubai, integrating IoT with BIM during the Burj Khalifa project reduced structural inspection time by 60%. In comparison, Singapore's use of RFID-tagged helmets led to a 25% drop in fall-related incidents. Qatar's use of AI-powered drones during FIFA World Cup stadium construction enhanced site surveillance. These examples showcase IoT's potential but often overlook failed or challenged implementations, limiting understanding of associated risks.

In Sri Lanka, IoT use is still emerging but has shown promise. Pilot projects in Colombo prevented scaffolding collapses using vibration sensors and reduced respiratory issues by 15% with air quality monitors. However, broader adoption is hindered by high costs, staff resistance, and unreliable infrastructure. This contrast underscores the need for adaptive, locally grounded frameworks that go beyond isolated successes to support sustainable, long-term integration.

3. METHODOLOGY

This study adopted a qualitative approach to explore the challenges and enablers of IoT adoption in Sri Lanka's high-rise construction sector. Qualitative methods allow for the exploration of context-specific industry insights (Rampin & Rampin, 2021; Bingham, 2023). A purposive sample of 17 professionals, including project managers, safety officers, quantity surveyors, IoT engineers, and site supervisors, was selected based on experience and relevance to the study (refer to Table 1).

Semi-structured interviews (30–45 minutes) were conducted in person and online. All interviews were transcribed and analysed using manual content analysis. Both predefined categories (e.g., technical, cultural) and emerging themes (e.g., policy, cost) were coded manually. The process involved repeated reading of transcripts, identifying meaningful units of text, assigning codes, and grouping them into themes. Thematic saturation was confirmed after 15 interviews, with two additional interviews validating no new insights.

Table 1: Profile of the experts

Expert Code	Designation	Years of Experience
E1	Quantity Surveyor	11
E2	Project Manager	20
E3	Engineer (IoT specialist)	18
E4	Site Supervisor	13
E5	Quantity Surveyor	12
E6	Quantity Surveyor	19
E7	Safety Officer	10
E8	Quantity Surveyor	12
E9	Safety Officer	16
E10	Engineer	11
E11	Safety Officer	10
E12	Site Supervisor	14
E13	Project Manager	17
E14	Project Manager	10
E15	Safety Officer	15

Expert Code	Designation	Years of Experience
E16	Project Manager	17
E17	Quantity surveyor	18

4. FINDINGS AND DATA ANALYSIS

4.1 SAFETY RISKS IN HIGH-RISE CONSTRUCTION

Interviews with seventeen industry professionals reveal that high-rise construction in Sri Lanka carries extensive risks, with falls from height emerging as the most critical concern. E4 and E8 described hazardous practices such as working atop unstable ledges and treating open lift shafts as routine obstacles. Scaffolding failures during monsoon seasons, cited by E5–E7, account for 68% of preventable accidents. Material handling risks include airborne plywood panels (E5), falling steel beams (E9), and unsafe hoisting rigs made from frayed ropes (E4, E11). Electrical dangers were also widespread, with makeshift waterproofing using plastic bags (E4, E10) and exposed wiring in drainage systems (E11), reflecting a casual attitude toward life-threatening risks.

Other reported hazards included structural collapse during renovations (E1), worker exhaustion (E3), and high-risk explosive activities. E8 observed neglected safety harnesses as symbols of the broader gap between safety rules and real-world practice, while E12 linked this to a cultural perception that safety protocols are too time-consuming. Collectively, the insights show that meaningful safety improvements require more than equipment they demand deep-rooted cultural change and a shift in how risk is perceived and managed on construction sites.

4.2 DAMAGES RESULTING FROM SAFETY FAILURES

Safety failures lead to a cascade of devastating consequences, impacting individuals, projects, and companies. Experts detailed these damages, which range from physical and psychological harm to severe economic and reputational losses. The following Table 2 presents these impacts.

Table 2: Consequences of safety failures

Impact category	Description of damages	Supporting data and expert observations
Physical and Psychological Harm	• Physical Injuries: Fractures, spinal cord injuries, permanent blindness from flying rebar, and fatalities from falls due to worn-out harnesses. • Psychological Trauma: Development of disabling phobias (e.g., fear of heights), suicidal tendencies, and ongoing mental distress among workers forced to continue in unsafe conditions.	E1, E3, E4, E8, E10, E11
Direct Economic Costs	• Incident Costs: Medical and related expenses ranging from Rs 1.8 million to Rs 4.3 million per incident.	E4, E5, E6, E7

Impact category	Description of damages	Supporting data and expert observations
Project and Business Impacts	• Catastrophic Event Costs: A single curtain wall failure resulted in damages estimated at Rs 22 million. • Project Delays: An average delay of 78 days per accident, with some incidents causing delays of up to five months. • Cost Escalation: Delays led to project cost increases of Rs 2.4 million to Rs 3.1 million per day. • Reputational Damage: 63 of clients reportedly blacklisted companies after major accidents, and 72 of subsequent bids from such companies were ignored. This "brand damage" has lasting commercial implications.	E2, E4, E6, E7, E10

4.3 EXISTING SAFETY METHODS AND IMPLEMENTATION CHALLENGES

4.3.1 Current Safety Protocols and Implementation Gaps in High-Rise Construction

Expert insights present a strong theoretical framework for high-rise construction safety, with measures aligned to international standards. E1 emphasized the use of PPE, SWMS, and site assessments, while E2 and E3 advocated for compliance with ISO and ILO standards. Progressive companies, as noted by E4–E7 and E9–E11, are adopting advanced practices like allocating 3.5%–4.5% of project costs to safety funds, enforcing subcontractor safety bonds (5%–7%), and using multi-language presentations to overcome communication barriers. These strategies provide a structured and globally informed approach to safety management.

Despite this, experts pointed to a significant disconnect between policy and on-ground practice. E4 warned of safety being treated as "paperwork does not practice," with support from E5, E7, E9, and E11, who described “safety theatre” as perfect documentation concealing unsafe realities. E5 and E6 reported dangerous behaviours such as workers sharing a single harness, while E7 and E11 observed gear being discarded during unsupervised shifts. This reveals a troubling culture of compliance driven by audits rather than genuine safety commitment.

4.3.2 Systemic and Behavioural Barriers to Effective Safety Implementation

Experts highlighted routine implementation challenges in the construction sector, often rooted in procedural compliance over proactive safety. E8 noted that safety officers prioritize bureaucracy, while incentive schemes mentioned by E2 and E4 may encourage near-miss cover-ups. Though frameworks like the "3E" and "SEE" approaches exist, their impact is limited by poor staff attitudes and tight budgets. E9 illustrated the cost of short-termism through a case where skipping safety measures to save Rs. 200,000 resulted in Rs. 1.5 million in accident-related expenses.

Cultural and behavioural factors further hinder safety compliance. E12 emphasized mandatory safety gear and regular briefings yet found evidence of issue concealment to avoid workflow delays. Language barriers (E4, E10, E11), resistance to safety protocols

(E7, E11), and a prevailing "convenience culture" (E7, E11, E12) all reflect an industry prioritizing ease over compliance. Experts agree that real change requires moving beyond checklists to build a genuine safety culture rooted in behavioural insights, tailored incentives, and strong, context-aware leadership.

4.4 SUCCESSFUL SAFETY MONITORING INTERVENTIONS

4.4.1 Effectiveness of Safety Monitoring Interventions

Both high-tech and low-tech monitoring solutions have proven effective in Sri Lanka. The following Table 3 highlights key success stories.

Table 3: Examples of successful safety monitoring interventions

Project location	Intervention	Cost of intervention	Outcome / averted loss	Expert citation
Marina Square	Strain gauges are installed on structural elements.	Rs.1.2 million	Detected critical stress, enabling evacuation before a collapse. Averted an estimated Rs 150 million in damages and multiple fatalities.	E4
Liberty Plaza/Port City	Tilt sensors and laser alignment systems on cranes and structures.	Rs.450,000–Rs.1.8 million	Prevented potential structural failures and crane collapses, averting losses estimated at ten times the investment cost.	E5, E10
Various High-Risk Sites	Dual-person supervision for critical tasks.	(Operational Cost)	A watchful supervisor averted a fatal accident from a failing beam.	E3, E12
General Application	Smartphone-based app using simple laser levels.	(Low Cost)	Demonstrates that low-tech, accessible solutions can significantly improve safety monitoring.	E8

4.4.2 Drivers and Barriers to Adoption

Experts in high-rise construction in Sri Lanka have highlighted the importance of IoT safety systems in preventing disasters. They highlighted the need for industrial-grade solutions with waterproof enclosures rated IP68 to withstand monsoon conditions, equipment that can endure falls from a height of three feet onto concrete, and user-friendliness. They also advocated for incorporating Sinhala/Tamil voice alerts to assist workers with low literacy levels or limited English proficiency. Alarms must be intuitive, recommending intense audio and visual alerts instead of app alerts.

The life-saving potential of IoT systems is highlighted through example of a monitoring system saving multiple deaths and damages, and a crane collapse in Colombo. Customizing IoT systems to the unique challenges of Sri Lanka is crucial, with proposals for solar-powered capability and strict cost caps. The experts also stressed the need to align with existing accounting principles to deliver verifiable return on investment to contractors.

4.5 PRIORITY OF REAL-TIME DATA TYPES FOR CONSTRUCTION SAFETY MONITORING

Experts identified the most critical data types for real-time monitoring to prevent accidents. The emphasis was consistently on simple, actionable alerts rather than complex analytics. The following Table 4 prioritises these data types.

Table 4: Priority data types for real-time safety monitoring

Monitoring category	Priority data type	Rationale and purpose	Supporting experts
Personnel Monitoring	• Worker location in hazardous zones • Worker fatigue levels	• Enable targeted emergency response. • Predict and prevent human-error accidents.	E4, E5, E6, E7, E8, E10, E11, E12
Environmental Monitoring	• Wind speed• General weather conditions • Air quality in enclosed spaces	• Ensure safe crane operation. • Proactive site shutdowns. • Prevent respiratory hazards.	E1, E3, E4, E5, E10, E11, E12
Equipment and Structural Monitoring	• Vibration patterns in structures • Crane load measurements • Equipment maintenance status	• Indicate imminent structural stress or failure. • Prevent overloading and collapse. • Link maintenance neglect leads to accident risk.	E4, E5, E6, E7, E8, E10

4.6 INTERNATIONAL PRACTICES ADAPTABLE TO SRI LANKA

Experts identified several international best practices that could be successfully adapted to the Sri Lankan context by focusing on simplicity, visual cues, and cultural integration, and these data are summarised under Table 5.

Table 5: International practices on safety

Practice or technology	Origin	Adaptation required	Suggested and supported by
Simplified Digital Systems	Singapore/Dubai	Replace apps with lights/buzzers	E4, E5, E6, E7, E10
Color-Coded Tagging	Dubai	Visual systems without digital dependency	E5, E10, E11
QR Code Inspections	Australia	Paperless but simple interface	E6, E7, E9
Safety Moments	New Zealand	Adapted to tea-break culture	E8, E13

Practice or technology	Origin	Adaptation required	Suggested and supported by
Physical Safety Nets	International	Low-cost visible protection	E12, E15
Automated Compliance	Dubai	Link to payments with simple deductions	E5, E9, E16
Drone Monitoring	Multiple	Focus on hazard mapping, not just progress	E14, E17

4.7 SRI LANKA'S READINESS FOR IOT SAFETY

Experts expressed serious concern about Sri Lanka's preparedness for adopting IoT in construction safety, rating it as low as 2–3 out of 10. Key challenges include resistance from workers who see IoT devices as surveillance tools, sometimes leading to sabotage, and persistent issues with basic safety practices. Managerial reluctance to invest without clear ROI or client demand further stalls progress, creating a paradoxical "catch-22" where adoption is needed to prove value, but value cannot be proven without adoption.

To overcome these barriers, experts recommend a phased, context-specific approach that integrates IoT into existing systems without overwhelming the current framework. Emphasis is placed on training, technological adaptation, economic incentives, and supportive policies. Importantly, solutions must suit Sri Lanka's unique socio-economic context rather than mimic models from more technologically advanced nations.

5. DISCUSSION

The combined literature and expert evidence highlight a clear and significant gap between theoretical safety frameworks and actual practices in high-rise construction. Literature confirms the high-risk nature of such projects, particularly regarding falls, hazardous scaffolding, and material handling (Abbood et al., 2021; Bhilwade et al., 2022), a concern echoed by E4, E8, and E10, who noted the normalization of risky behaviours. Electrical hazards and equipment failures are also well-documented; studies point to unsafe temporary wiring as a major risk (Cai et al., 2020), supported by experts E4, E10, and E11, who observed poor waterproofing and exposed cabling in practice.

Although IoT-based safety solutions like wearable sensors and real-time monitoring show strong potential for incident prevention (Musarat et al., 2022; Wang et al., 2024), their implementation remains inconsistent. Experts E4, E5, and E10 reported failed deployments due to environmental conditions, user resistance, and unclear return on investment (ROI), discouraging management from adopting these systems. While technologies such as BIM and IoT can theoretically reduce incidents by up to 30% (Rodrigues et al., 2022), experts E6, E9, and E12 noted their minimal usage in Sri Lanka, citing high costs, inadequate infrastructure, and a lack of supportive policies.

Cultural compatibility also emerged as a barrier to adoption. E8 emphasized the need for localized adaptations, such as using colour-coded symbols or reinforcing safety during tea breaks, to better align with local practices. Overall, while integrated safety technologies have transformative potential, the findings underscore the need for context-sensitive deployment strategies, cultural alignment, and supportive economic and policy measures to ensure sustainable adoption.

6. CONCLUSION

The research found that even though high-tech safety solutions from IoT (like real-time monitoring and BIM integration) have great potential, they are rarely used in Sri Lanka's high-rise building sector. It is difficult to implement on a large scale because of workforce resistance, inadequate policies, and the lack of a match between global technologies and local economic situations. It is essential to use a phased approach, adapting to culture by using inexpensive IoT devices and providing localised training and interfaces, to shift from being reactive about safety to being proactive. This strategy may prevent many accidents and still suit Sri Lanka's economic and environmental limits.

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