

Analysis Of Safety Implementation Constraints And Risk Mitigation Strategies In Budget-Limited Small Construction Sites

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ABSTRACT

The construction industry is globally recognised as one of the highest-risk industrial sectors, and this risk is amplified on small, budget-limited sites that dominate India's urban and semi-urban building activity. Such sites, typically valued below ₹5 crores, commonly lack dedicated safety engineers, structured monitoring systems, adequate safety budgets and formal training programmes, leading to unsafe behaviour, frequent accidents and avoidable economic losses. This study analyses the safety implementation constraints faced by budget-limited small construction sites and proposes practical, low-cost risk-mitigation strategies suited to such environments. A mixed-method research design was adopted, comprising site-level hazard identification, field observation checklists, structured questionnaire surveys administered separately to workers, supervisors and contractors, and semi-structured interviews. Personal protective equipment (PPE) compliance analysis revealed a marked gap between equipment provided and equipment actually used on site, with helmet usage recorded at 65% against 80% provision and safety-belt usage as low as 12% against 20% provision. Only 25% of surveyed workers had attended a toolbox talk and merely 18% had received any formal safety training, while 60% could not interpret common hazard signage. Fall from height, electrocution and struck-by-falling-object hazards emerged as the most critical risks. The findings indicate that weak safety culture, insufficient supervision and financial constraints, rather than the unavailability of statutory guidelines, are the principal barriers to compliance with the Building and Other Construction Workers (BOCW) Act, 1996. A five-step safety management model — identify, provide, train, monitor and improve — together with low-cost interventions such as mandatory toolbox talks, basic PPE kits and weekly safety audits, is recommended to enhance safety performance on small sites without requiring major capital investment.

Keywords: Construction safety; Small construction sites; PPE compliance; Risk mitigation; BOCW Act; Budget constraints.

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1. INTRODUCTION

The construction industry is one of the largest contributors to national infrastructure development worldwide, yet it continues to be classified among the highest-risk industrial sectors owing to frequent accidents, unsafe work environments and workforce vulnerability. The transient nature of construction work — temporary workplaces, heavy machinery operation, working at height, confined spaces and constantly changing site conditions — creates an environment that is inherently prone to hazards.

In India, small construction sites, generally defined as projects costing less than ₹5 crores, dominate the sector, particularly in urban and semi-urban areas. These include residential buildings (G+1, G+2), small commercial complexes, renovation and extension works, interior fit-out works, and repair and maintenance projects. Unlike large infrastructure projects, small sites typically operate without dedicated safety engineers, structured monitoring systems, adequate budget allocation for safety, documented Safety Management Plans, or formal training programmes. This deficiency contributes directly to

unsafe behaviour, a higher incidence of accidents, and consequent economic losses.

Several factors underscore the need for this study: a disproportionately high accident rate among small contractors, general negligence of safety documentation, poor availability and usage of personal protective equipment (PPE), limited awareness of statutory provisions such as the Building and Other Construction Workers (BOCW) Act, and a workforce that is frequently migratory and untrained. Identifying the root causes of these deficiencies and proposing cost-effective, feasible solutions is therefore of considerable practical value.

2. LITERATURE REVIEW

A review of recent and established literature indicates that safety implementation on small and medium construction enterprises (SMEs) is largely informal. Soyingbel observed that few SMEs maintain structured risk-identification or documented risk-management procedures and recommended integrating formal risk assessment into routine SME operations. Mandowa et al.² and Rantsatsi et al.³ identified inadequate resources, weak leadership, insufficient worker involvement, and a lack of qualified occupational safety and health (OSH) practitioners as major obstacles, calling for leadership training, resource allocation and sustained culture change. Bachar et al.⁴ highlighted that SMEs cannot fund every available safety measure and must instead optimise resource allocation toward high-impact controls such as PPE, fall protection and training. Similarly, Khoshakhlagh et al.⁵ reported that low PPE usage is linked more to poor safety knowledge and a weak safety climate than to cost alone, suggesting that awareness campaigns and routine supervision are as important as procurement.

Turgay⁶ noted that SMEs have limited capacity for structured risk management and often accept rather than treat risk owing to resource constraints, recommending a prioritised framework of risk avoidance, reduction, transfer and acceptance. Al-Bayati⁷ attributed PPE non-compliance to inadequate supervision, poor risk perception and lack of climate-appropriate PPE selection. Buniya et al.⁸ grouped twelve barriers into four dimensions — non-conducive work climate, poor governance, poor safety awareness and unsupportive management — while the ILO WISCON Guide⁹ observed that small enterprises largely belong to the informal economy with negligible access to labour inspection or OSH services, and instead promoted simple, low-cost work improvements such as better housekeeping and local-level training modules. Yusof et al.¹⁰ identified financial limitation, lack of training and lack of knowledge as the critical restriction factors for small contractors, while Gillen et al.¹¹ found that small firms typically lack formal OSH management systems and

demonstrate weak management commitment and minimal documentation.

Collectively, the literature suggests that small construction sites face safety challenges arising from the absence of formal safety systems, poor safety culture, insufficient training, low PPE compliance, weak regulatory enforcement, unsafe working conditions and human behavioural issues. It also indicates a need to evaluate these issues empirically through field surveys, onsite observation and interviews, and to propose cost-effective improvements specifically tailored to small construction environments.

2.1 Legal and Regulatory Framework

The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act) mandates safety training, PPE provision, medical facilities and welfare amenities for construction workers in India. Relevant Indian Standard (IS) codes include IS 3696 for ladders and scaffolds, IS 3764 for excavation safety, and IS 13367 for PPE standards. Despite this statutory framework, enforcement on small, budget-constrained sites remains inconsistent.

2.2 Research Gap

From the reviewed literature, four gaps are apparent: (i) limited studies focus specifically on small residential construction sites, which constitute the majority of construction activity in India; (ii) there is a gap in evaluating safety awareness specifically among workers on small sites; (iii) few studies assess the Standard Operating Procedures (SOPs), checklists and documentation followed by small contractors; and (iv) there is a scarcity of research on low-cost safety solutions applicable to small projects. This study addresses these gaps through a field-based, multi-stakeholder investigation.

2.3 Aim and Objectives

This study aims to identify the root causes of safety deficiencies on small construction sites and to propose cost-effective, feasible solutions for enhancing safety performance. The specific objectives are to: (1) examine hazards typically present on small construction sites; (2) evaluate existing safety management practices and their effectiveness; (3) assess safety awareness levels among workers and supervisors; (4) investigate the barriers hindering implementation of safety measures; and (5) recommend feasible, cost-effective strategies for improving site safety performance.

3. MATERIALS AND METHODS

3.1 Research Framework

A structured, mixed-method research framework was followed, comprising six stages: identification of hazards, field observations, questionnaire survey, interviews, data analysis, and formulation of recommendations. The study

focused on small-scale construction projects in urban and semi-urban areas, covering trades such as masons, helpers, carpenters, bar-benders, plumbers and electricians, with particular emphasis on working at height, scaffolding, electrical safety and material handling.

3.2 Data Collection Tools

Two principal instruments were used. **(a) Questionnaire survey:** three separate questionnaire sets were administered — a worker questionnaire covering general information, safety awareness (five-point Likert scale), PPE usage and availability, training and communication, and site conditions; a supervisor/site-engineer questionnaire covering safety management practices, safety resources and training, and site safety practices; and a contractor/site-owner questionnaire covering safety

policy, legal compliance (including BOCW Act awareness) and safety-issue prioritisation. **(b) Observation checklist:** a structured on-site checklist was used to record PPE compliance, site housekeeping, electrical safety, material storage and working-at-height practices, supplemented by dedicated checklists for scaffolding, excavation, electrical systems, material handling and machinery, fire and emergency preparedness, and worker training documentation.

3.3 Sample Size

Data were collected from 60–100 construction workers, 10–15 supervisors, and 5–10 contractors across the surveyed small construction sites, providing a representative cross-section of the workforce hierarchy typically found on such projects.

4. RESULTS AND DISCUSSION

4.1 PPE Compliance Analysis

Table 1 summarises the percentage of workers to whom each PPE item was provided against the percentage who were actually observed using it on site.

PPE Type	Provided (%)	Used (%)
Helmets	80	65
Safety Shoes	60	50
Reflective Jackets	40	30
Gloves	55	35
Safety Belts	20	12

Table 1: PPE Compliance — Provided vs. Used (%)

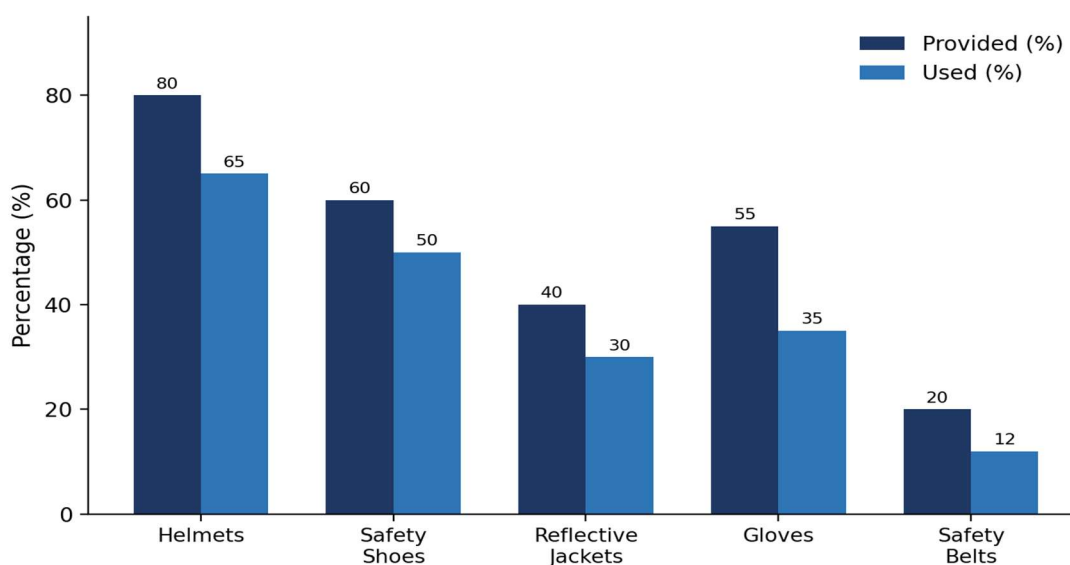


Fig. 1: PPE Provided vs. Used Across Sampled Sites

A consistent gap is observed between PPE provided and PPE used across all categories (Table 1, Fig. 1). Helmet usage, at 65%, was the highest of all categories but still 15 percentage points below provision, while safety-belt usage was critically low at 12%, against an already limited provision rate of 20%. This gap indicates that procurement of PPE alone is insufficient; workers frequently avoid wearing issued equipment due to discomfort, lack of enforcement, or the absence of a supervisory safety culture, corroborating the findings of Khoshakhlagh et al.⁵ that low PPE usage stems primarily from behavioural and supervisory deficits rather than cost alone.

4.2 Training Awareness

Training-related indicators were similarly weak: only 25% of surveyed workers had attended a toolbox talk, merely 18% had received any form of formal safety training, and 60% were unable to correctly interpret common hazard signage. These figures indicate that safety communication on small sites is largely informal or absent, limiting workers' ability to recognise and respond to hazards independently.

4.3 Supervisor-Rated Site Condition Assessment

Supervisors and site engineers were asked to rate five key site-safety parameters on a five-point scale (Very Poor to Excellent). For comparability, responses were consolidated into two bands — "Poor/Very Poor" and "Good/Excellent" — as summarised in Table 2.

Parameter	Rated Poor / Very Poor (%)	Rated Good / Excellent (%)
Housekeeping	35	30
Scaffolding Safety	45	23
Electrical Safety	40	27
PPE Enforcement	50	22
Documentation	60	15

Table 2: Supervisor-Rated Site Condition Assessment

Documentation emerged as the weakest parameter, with 60% of supervisors rating it Poor or Very Poor and only 15% rating it Good or Excellent, followed closely by PPE enforcement (50% Poor/Very Poor). Scaffolding and electrical safety were rated Poor or Very Poor by 45% and 40% of supervisors respectively, while housekeeping — although still weak — was the relatively better-managed parameter of the five. This pattern suggests that record-keeping and active enforcement, rather than physical site conditions alone, are the most neglected aspects of site safety management.

4.4 Contractor Safety Policy and Legal Compliance

Table 3 summarises contractor-level responses on safety policy, budgeting and statutory compliance. Only 35% of contractors reported having a written safety policy, and just 28% allocated a dedicated safety budget for their projects. A dedicated safety officer was employed only 'Always' by 10% of contractors, while 50% reported 'Never' employing one on small projects. Awareness of BOCW Act, 1996 requirements stood at 45%, and only 30% of contractors provided mandatory safety training to their workforce; formal documentation of any kind (risk assessments, toolbox-talk records, incident logs or PPE issue registers) was maintained by only 38% of contractors.

Compliance Indicator	Response (%)
Written safety policy in place	35% Yes
Dedicated safety budget allocated per project	28% Yes
Dedicated safety officer employed (small projects)	10% Always / 40% Sometimes / 50% Never
Awareness of BOCW Act, 1996 requirements	45% Yes
Mandatory safety training provided to workers	30% Yes
Formal safety documentation maintained (any type)	38% Yes

Table 3: Contractor-Level Safety Policy and Legal Compliance Indicators

These results indicate that statutory awareness alone does not translate into practice: although nearly half of contractors were aware of BOCW Act provisions, considerably fewer had operationalised this awareness into a written policy, dedicated budget, or documented safety system.

4.5 Barriers to Safety Implementation

Contractors were asked to identify the principal barrier to implementing safety measures on their sites. As shown in Table 4 and Fig. 2, cost of implementation was cited by 45% of contractors as the leading barrier, followed by worker behaviour (25%), time constraints (20%) and lack of skilled labour (10%).

Barrier	Contractors Citing as Principal Barrier (%)
Cost of implementation	45
Worker behaviour	25
Time constraints	20
Lack of skilled labour	10

Table 4: Ranked Barriers to Safety Implementation (Contractor Perspective)

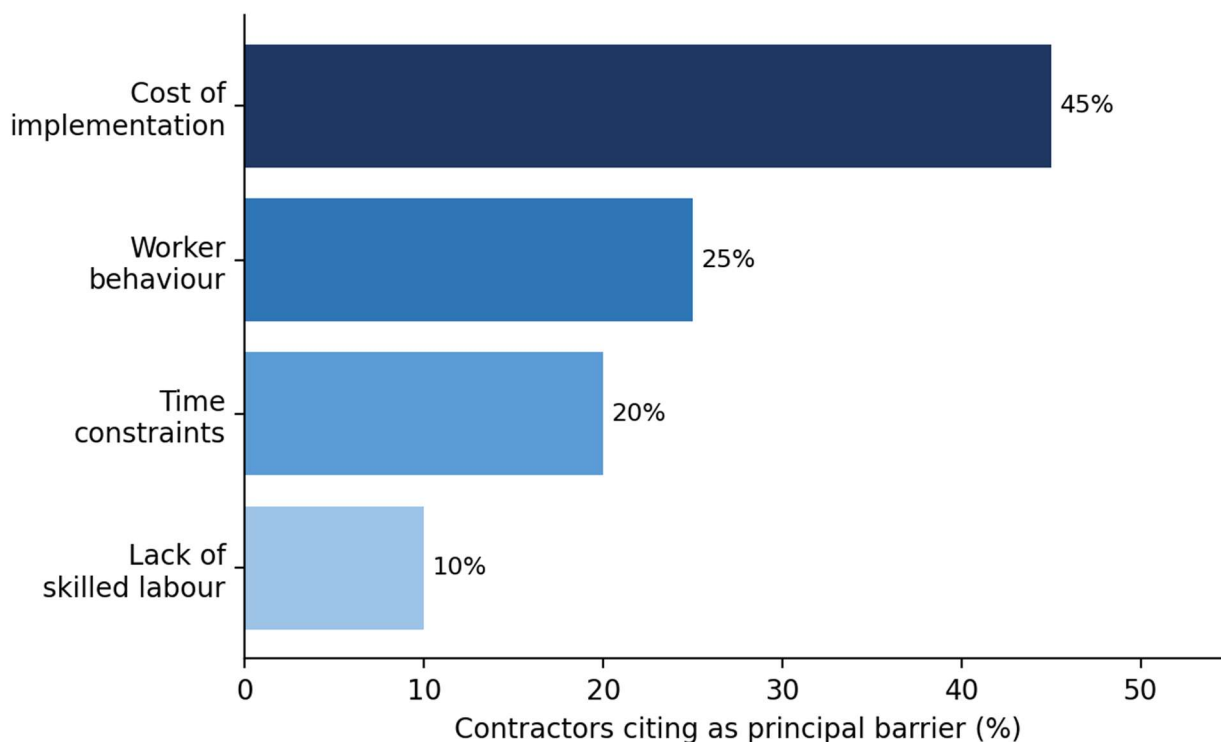


Fig. 2: Ranked Barriers to Safety Implementation — Contractor Perspective

The dominance of cost as a perceived barrier, despite relatively modest actual expenditure required for interventions such as toolbox talks, signage and basic PPE, reinforces the interview finding (Section 3.8) that safety is frequently perceived as an added expense rather than a risk-reducing investment.

4.6 Identified Hazards

Field observation and interviews consistently identified the following hazards across sampled sites: working at height without a safety belt, absence of edge protection, unsafe or improperly erected scaffolding, electrical wires lying exposed on the ground, and the absence of fire extinguishers at accessible locations.

4.7 Risk Assessment

Table 2 presents a representative qualitative risk assessment of the hazards identified during the study.

Hazard	Likelihood	Severity	Risk Rating
Fall from height	High	High	Critical
Electrocution	Medium	High	High
Falling objects	High	Medium	High
Slip / Trip	High	Low	Medium

Table 2: Representative Risk Assessment of Identified Hazards

4.8 Interview Findings

Semi-structured interviews with contractors, supervisors and workers revealed a broadly shared perception that safety measures increase project cost, an acknowledgement among supervisors of insufficient training, and a general lack of awareness among workers regarding emergency procedures. These qualitative findings are consistent with the quantitative results and reinforce that cost perception, rather than actual affordability, is a central psychological barrier to safety investment on small sites.

4.9 Discussion

The results align closely with the broader SME safety literature. Consistent with Arewa and Farrell¹², who reported disproportionately higher accident and fatality rates among SMEs relative to larger enterprises, the sampled sites exhibited weak documentation, minimal supervision and low training penetration. The finding that PPE usage lags well behind provision supports Hasle and Limborg¹³, who identified the absence of in-house OHS expertise as a key SME challenge, and Vinberg¹⁴, who highlighted limited financial resources and insufficient safety inspection as recurring barriers. However, the interview data suggest that perception of cost, more than actual budget constraint, drives much of the observed non-compliance — a nuance consistent with Akinosho et al.¹⁵, who emphasised that effective risk management depends as much on stakeholder involvement in decision-making as on financial allocation. Overall, the evidence supports the conclusion that low-cost, behaviourally-oriented interventions — rather than large capital investment — are likely to yield the greatest improvement in safety performance on budget-limited small construction sites.

5. CONCLUSION

5.1 Key Findings

The study confirms that budget-limited small construction sites are characterised by a weak safety culture, absence of formal safety training, insufficient PPE usage relative to provision, inadequate supervision, non-compliance with BOCW Act provisions, and generally hazardous working environments. Supervisor ratings identify

documentation and PPE enforcement as the weakest site-safety parameters, while contractor-level data show that fewer than one in three sites operate under a written safety policy or a dedicated safety budget. Cost of implementation, cited by 45% of contractors, is the leading perceived barrier to safety compliance — ahead of worker behaviour, time constraints and skilled-labour shortages — indicating that behavioural and administrative change, rather than large capital outlay, offers the most feasible route to improvement.

5.2 Recommendations

Based on the findings, the following low-cost, practical interventions are recommended for adoption on small construction sites:

- Mandatory daily toolbox talks to reinforce hazard awareness.
- Provision of a basic PPE kit to every worker, coupled with enforced usage.
- Weekly safety audits conducted by a designated site representative.
- Installation of clear safety signboards at hazardous locations.
- Proper scaffolding erection and mandatory edge protection at height-work areas.
- Basic first-aid training for at least one worker per crew.
- Monthly fire drills and accessible fire-extinguisher placement.

5.3 Proposed Safety Management Model

A simplified, five-step safety management model is proposed for adoption on small, budget-constrained sites: (1) identify hazards, (2) provide appropriate PPE, (3) train workers, (4) monitor compliance, and (5) improve continuously. This cyclical model requires minimal financial outlay while embedding safety into routine site operations.

5.4 Future Scope

Future research may extend this work through the application of structured safety training modules, comparative studies on medium-scale projects, and the use of digital safety tools such as mobile-based checklists and 4D Building Information Modelling (BIM) for real-time hazard visualisation and monitoring.

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