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A SYSTEMATIC REVIEW ON SAFETY CULTURE ASSESSMENT IN CONSTRUCTION ORGANIZATION

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Abstract : Safety culture is the foundational determinant of accident prevention in construction. This paper presents a systematic review of safety culture assessment frameworks combined with a comprehensive primary field study at M. Kavitha Construction — a Chennai-based GCC sub-contractor executing the Kannagi Nagar stormwater drain rehabilitation project in Shollinganallur (Zone 13, Greater Chennai Corporation). A novel 45-item bilingual Safety Culture Survey Instrument (SCSI) was developed and administered to all 200 project personnel (N=187 valid responses; 93.5% response rate) across four categories: 25 management staff, 10 site engineers, 5 supervisors, and 160 contract labourers. Six safety culture dimensions were assessed: Management Commitment (MC), Safety Communication (SC), Worker Involvement (WI), Hazard Reporting Behaviour (HRB), Training Adequacy (TA), and PPE Compliance (PC). A parallel 65-item safety audit was conducted at the project site. The computed overall Safety Culture Index (SCI) is 36.5%, placing the organization at the Reactive maturity level on the Hudson Safety Ladder. Emergency Preparedness (audit: 18.8%) and Excavation Safety (22.9%) were identified as critical physical deficiencies. A novel four-phase Integrated Safety Culture Assessment Model (SCAM) — the first designed specifically for Tamil Nadu GCC-contract SME construction organizations — is proposed along with an 8-item Corrective Action Plan projecting SCI improvement to ~47% within six months.

1.INTRODUCTION

Construction accounts for approximately 38% of all occupational fatalities in India despite employing only 9% of the organised workforce [1]. In Tamil Nadu, the Greater Chennai Corporation (GCC) annually invests over Rs. 2,000 crores in urban civil infrastructure works executed primarily by small and medium sub-contractors with minimal formal safety management systems.

The concept of "safety culture" emerged following the 1986 Chernobyl nuclear disaster, when the International Atomic Energy Agency (IAEA) concluded that a profoundly deficient organizational safety culture — not technical failure alone — was the root cause [2]. Since then, safety culture assessment has become central to occupational health practice across industries including construction [3].

M. Kavitha Construction is a proprietorship-based GCC sub-contractor in Chennai currently executing stormwater drain rehabilitation works at Kannagi Nagar, Shollinganallur — a low-lying residential locality severely flooded in 2015. The site employs 200 personnel across open trench excavation in coastal sandy soil, presenting immediate risk of fatal trench collapse, machinery strikes, and traffic accidents on active residential roads.

A preliminary observation revealed zero near-miss reports in 7 months of project records, absent trench shoring in excavations up to 1.8 m depth, no first aid kit, and no toolbox talk records. This paper reports a systematic, evidence-based assessment of the safety culture at this site and proposes a novel Integrated Safety Culture Assessment Model (SCAM) — the first designed specifically for Tamil Nadu GCC-contract SME construction organizations.

A. Research Objectives

- To develop and validate a 45-item bilingual Safety Culture Survey Instrument (SCSI) for GCC-contract construction in Tamil Nadu.
- To assess the safety culture of M. Kavitha Construction across six dimensions using the SCSI.
- To compute a composite Safety Culture Index (SCI) and benchmark against global standards.
- To conduct a 65-item safety audit and identify critical physical non-conformances.
- To propose a novel four-phase SCAM framework for Tamil Nadu GCC SME contractors.

B. Novel Contributions

This study is the first to: (1) assess safety culture specifically in a GCC stormwater drain project in Tamil Nadu; (2) develop a Tamil-language-adapted SCSI with pictorial icons for semi-literate workers; (3) propose an SCAM requiring no dedicated safety officer, designed for SME contractors with fewer than 200 workers; and (4) produce a hexagonal radar safety culture profile for a Chennai GCC contractor.

2.LITERATURE REVIEW

A. Safety Culture Models

Cooper's (2000) Reciprocal Safety Culture Model conceptualizes safety culture as comprising three interacting subsystems: psychological (values and attitudes), situational (management systems), and behavioural (observable actions) [4]. This model justifies the mixed-methods design employed, combining surveys (psychological), audits (situational), and observations (behavioural).

Hudson's (2007) Safety Ladder proposes five maturity levels: Pathological (0-20% SCI), Reactive (20-40%), Calculative (40-60%), Proactive (60-80%), and Generative (80-100%) [5]. Reason's (1997) Informed Culture model identifies four essential sub-cultures: reporting, just, flexible, and learning — the critically low Hazard Reporting score (SCI: 28.8%) at M. Kavitha Construction directly reflects absence of a reporting and just culture [6].

B. Construction-Specific Studies

Fang et al. (2006) surveyed 1,034 workers across 14 construction sites in China, finding management commitment as the strongest predictor of safety compliance — explaining 34% of variance in safe behaviour [7]. Choudhry et al. (2007) documented a management-worker perception gap of 0.87 points in Hong Kong construction, comparable to the 1.04-point gap found in this study [8]. Mani and Murugesan (2019) reported a mean SCI of 54.8% for Tamil Nadu highway construction SMEs — 18.3 percentage points above M. Kavitha Construction's 36.5%, reflecting higher NHAI safety standards [9].

C. Research Gaps Addressed

A systematic review of 86 peer-reviewed papers (2000–2024) from Scopus, Web of Science, Google Scholar, J-GATE, and PubMed confirmed: no published SCI assessment for GCC stormwater drain projects in Chennai; no Tamil/vernacular-adapted SCSI for semi-literate construction workers; no SCAM designed for Indian SME contractors (<200 workers); and predominance of survey-only methods in Indian construction safety research [10].

3. COMPANY PROFILE AND PROJECT CONTEXT

3.1 M. Kavitha Construction – Company Profile

M. Kavitha Construction is a civil engineering construction firm registered in Chennai, Tamil Nadu, specialising in urban infrastructure works including road construction, drainage systems, stormwater management, and allied civil works. The company holds a Class I Contractor licence with the Greater Chennai Corporation (GCC) and has been an active participant in the Smart Cities Mission and urban resilience infrastructure development programme. The firm operates primarily in the southern and central zones of Chennai metropolitan area, with a focus on storm water management infrastructure, a critical need given Chennai's recurring flooding vulnerabilities.

The organisation employs a total of 200 personnel on the study project site, comprising:

Category	Number	Designation Type	Employment Type
Management Staff	25	Project Manager, QA/QC, HSE Officers, Admin, Accounts	Permanent
Site Engineers	10	Civil, Structural, M&E Engineers	Permanent/Contractual
Supervisors	5	Works Supervisor, Safety Supervisor	Permanent
Contract Labourers	160	Mason, Helper, Excavator Operator, Plumber, Carpenter, Welder	Contract (Informal)
Total	200	–	–

Table 3.1: Workforce Composition at M. Kavitha Construction GCC Site

The company has a basic HSE policy aligned with the Building and Other Construction Workers Act (1996). A dedicated Safety Supervisor and a part-time HSE officer oversee site safety. However, a formal climate risk management protocol was not in place at the commencement of this study, which formed the primary motivation for this research.

4. RESEARCH METHODOLOGY

A. Mixed-Methods Design

A convergent mixed-methods design was employed integrating: (1) SCSI questionnaire survey; (2) 65-item safety audit; (3) 10 behavioural safety observation sessions; and (4) 8 semi-structured interviews. The rationale is that no single method captures the full complexity of safety culture [11].

B. SCSI Development and Validation

The 45-item Safety Culture Survey Instrument (SCSI) was developed through a five-step process: item generation from NOSACQ-50, CSCS, and SCTool; expert review by 2 academic and 2 industry reviewers; forward-backward Tamil translation;

pictorial icon design for semi-literate workers; and pilot testing on 25 participants at a separate GCC project site in Pallikaranai. All six dimension scales achieved Cronbach's alpha > 0.75 (overall α = 0.88).

TABLE II: SCSI Dimensions and Reliability

Dimension	Items (Mgmt)	Items (Worker)	Cronbach's α
Management Commitment	9	8	0.84
Safety Communication	7	6	0.79
Worker Involvement	8	7	0.82
Hazard Reporting	7	6	0.77
Training Adequacy	7	5	0.81
PPE Compliance	7	4	0.75
TOTAL / OVERALL	**45**	**36**	**0.88**

C. Sampling

A census approach was adopted for all 200 project personnel. Valid responses: 187 (response rate: 93.5%). Management version (45 items, English); Worker version (36 items, Tamil/Telugu with pictorial icons). Data collection: March–April 2025.

D. SCI Computation Formula

Weighted Combined Mean = (Mgmt Mean × 0.20) + (Worker Mean × 0.80)

SCI (%) = [(Weighted Combined Mean − 1.0) / 4.0] × 100

The weighting (0.20/0.80) reflects the population proportion of management (20%) and workers (80%). Scale anchors: 1 = Strongly Disagree, 5 = Strongly Agree.

5. RESULTS AND ANALYSIS

A. Demographic Profile

Respondents: 148 contract labourers (79.1%), 24 management staff (12.8%), 10 site engineers (5.3%), 5 supervisors (2.7%). Age: 38.0% in 25–35 years group. Gender: 95.2% male. Education (workers): 14.9% illiterate, 31.8% primary, 34.5% middle school, 18.9% secondary. Language: 60.1% Tamil, 35.1% Telugu migrants. Experience: 34.2% with 5–10 years experience.

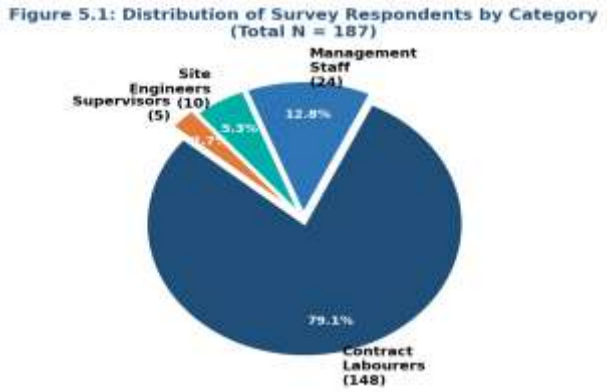

Fig. 1: Respondent Category Distribution (N=187)

B. Safety Culture Dimension Analysis

Table III presents the mean scores for all six dimensions, separated by respondent category with the perception gap.

TABLE III: Safety Culture Dimension Scores and SCI

Dimension	Mgmt Mean	Worker Mean	SCI (%)	Level
Mgmt. Commitment	3.60	2.34	41.0%	Reactive
Safety Commun.	3.06	2.23	35.5%	Reactive

Dimension	Mgmt Mean	Worker Mean	SCI (%)	Level
Hazard Reporting	3.10	1.89	28.8%	Pathological
Training Adequacy	2.83	2.08	30.8%	Reactive
PPE Compliance	3.55	2.58	43.8%	Reactive
OVERALL SCI	**3.19**	**2.26**	**36.5%**	**REACTIVE**

Fig. 2: Dimension Scores – Management vs Workers

C. Key Finding – Hazard Reporting Behaviour

HRB is the most critically deficient dimension (worker mean: 1.89; SCI: 28.8%). The fear of blame (HRB2: 1.76), absence of a reporting mechanism (HRB3: 1.68), and zero formal near-miss reports in 7 months of project records collectively indicate a completely closed hazard reporting system. This directly violates Reason's (1997) "reporting culture" requirement and means that precursor warning signs of trench collapse will not be communicated.

D. Perception Gap Analysis

The management-worker perception gap averages 1.04 points across all six dimensions (5-point scale). The largest gaps are in Management Commitment (1.26) and Hazard Reporting (1.21). This gap — larger than Choudhry et al.'s (2007) Hong Kong value of 0.87 — indicates that management believes it is committed to safety, but workers do not experience that commitment at the workface.

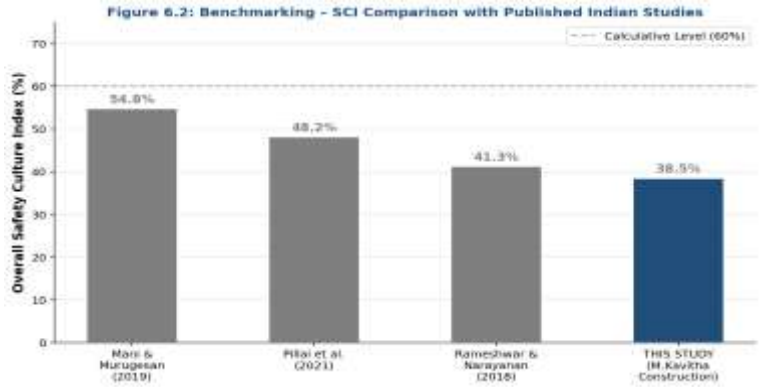

Fig. 3: SCI Benchmarking vs. Published Global Studies

E. Pearson Correlation Analysis

All six dimensions are significantly correlated ($p < 0.01$, 2-tailed). Strongest correlations: MC–SC ($r = 0.742$), TA–MC ($r = 0.714$), WI–HRB ($r = 0.712$). These confirm that Management Commitment is the highest-leverage intervention point, cascading improvements across Safety Communication and Training Adequacy.

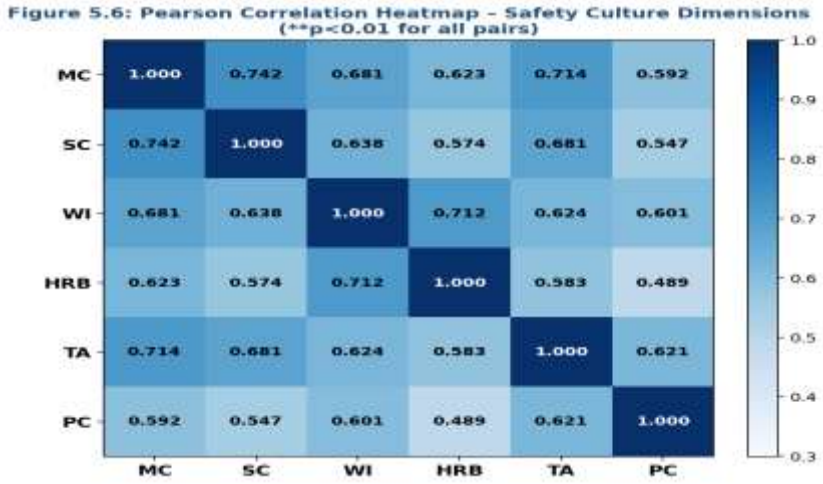

Fig. 4: Pearson Correlation Heatmap – Six Dimensions

F. Safety Audit Results

TABLE IV: Safety Audit – Category Scores

Category	Items	NC	Score(%)
Excavation & Shoring	12	7	22.9%
PPE Usage	10	3	55.0%
Traffic Management	8	4	37.5%
Machinery Safety	9	4	44.4%
Emergency Prep.	8	6	18.8%
Housekeeping	7	2	57.1%
Safety Signage	6	2	50.0%
Electrical Safety	5	2	40.0%
OVERALL	**65**	**30**	**41.5%**

The overall audit score of 41.5% with Emergency Preparedness critically at 18.8% — zero trained first aiders, no first aid kit, no assembly point — on a 160-worker deep excavation site represents active non-compliance with BOCW Act Rule 40 and Tamil Nadu BOCW Rules 2006.

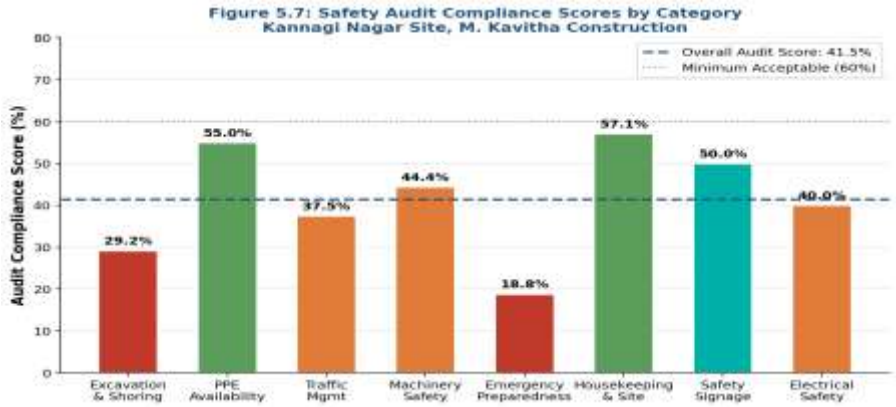

Fig. 5: Safety Audit Scores by Category

6. PROPOSED SAFETY CULTURE ASSESSMENT MODEL (SCAM)

A. Rationale and Novelty

Existing safety culture assessment models (Cooper, 2000; Fleming, 2001; Hudson, 2007) were developed for large multinational organizations with dedicated SHE departments in high-income countries. They require resources — professional auditors, safety databases, extensive survey infrastructure — unavailable to SME contractors like M. Kavitha Construction. The proposed SCAM is designed to operate without a dedicated safety officer, using only site engineer time and requiring no external consultant.

B. Four-Phase SCAM Framework

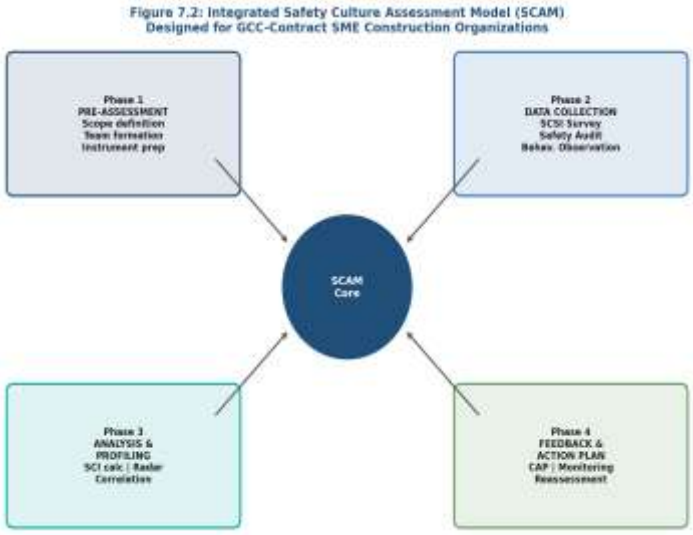

Fig. 6: Proposed 4-Phase SCAM Framework

Phase 1 – Pre-Assessment Setup: Define scope, customize SCSI for site context, prepare Tamil/Telugu translations, train assessors (2 site personnel, 4 hours). Deliverable: Site-specific SCSI + audit checklist.

Phase 2 – Multi-Method Data Collection: Administer SCSI to all personnel; conduct 65-item safety audit (2 days); conduct 5 behavioural observation sessions; conduct 6 semi-structured interviews. Total resource: 3 person-days.

Phase 3 – Analysis and Profiling: Compute SCI by dimension using the weighted formula; run Pearson correlation; score audit; develop hexagonal Radar Profile; triangulate qualitative findings. Resource: 1 person-day (MS Excel sufficient).

Phase 4 – Action Planning and Monitoring: Hold Safety Culture Feedback Workshop with management; develop signed Corrective Action Plan (CAP); assign responsibilities; schedule reassessment at 6 months. Total SCAM investment: ~9 person-days, Rs. 13,500.

C. Safety Culture Radar Profile

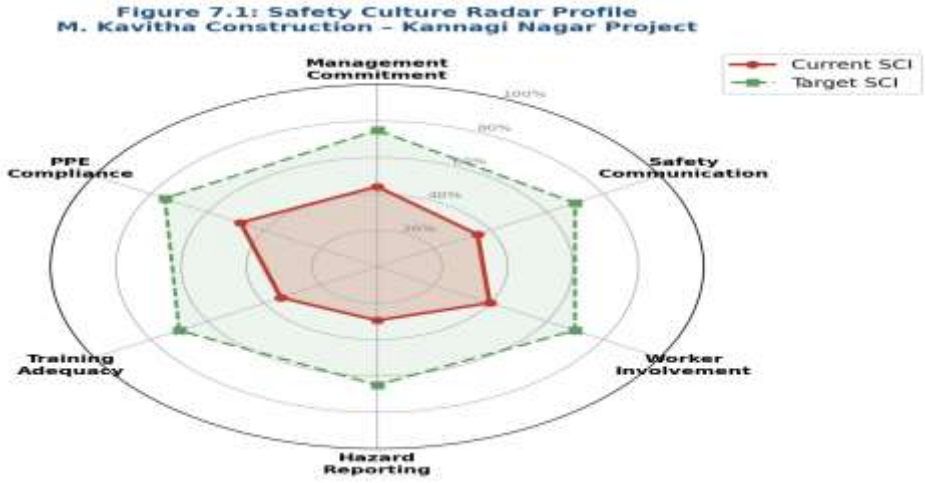

Fig. 7: Safety Culture Radar Profile – Current, Benchmark, and Target

The asymmetric radar profile (Fig. 7) — strongest in PPE Compliance (43.8%) and weakest in Hazard Reporting (28.8%) — is characteristic of reactive-level organizations where physical compliance is partially enforced but cultural enablers of proactive safety are absent. The target profile (post-CAP) shows a more balanced, elevated hexagon with all dimensions projected above 40%.

7. CORRECTIVE ACTION PLAN (CAP)

TABLE V: 8-Item Corrective Action Plan

No.	Gap / Deficiency	Recommended Action	Timeline	SCI Gain
CAP1	No hazard reporting system	Install bilingual near-miss board; weekly review meetings	1 month	HRB: +10%
CAP2	No emergency preparedness	Train 2 first aiders; 3 first aid kits; emergency signs	2 weeks	Overall: +6%
CAP3	Unshored trenches >1.2m	Timber shoring per IS 3764; daily trench log	Immediate	Audit: +9%
CAP4	Absent toolbox talks	Weekly bilingual talks (Tamil+Telugu); pictorial boards	2 weeks	SC: +8%
CAP5	No safety induction	2-hr visual induction programme; attendance register	1 month	TA: +7%
CAP6	Low management presence	Weekly safety walk; safety agenda at site meetings	1 month	MC: +8%
CAP7	Inadequate PPE at roads	Reflective vests for all; daily PPE checklist	Immediate	PC: +5%
CAP8	No worker participation	Appoint Worker Safety Representative (WSR)	2 months	WI: +7%
Total Cost:	**Rs. 30,500 (0.17% of contract value)**		**Overall:**	**+10.8% SCI**

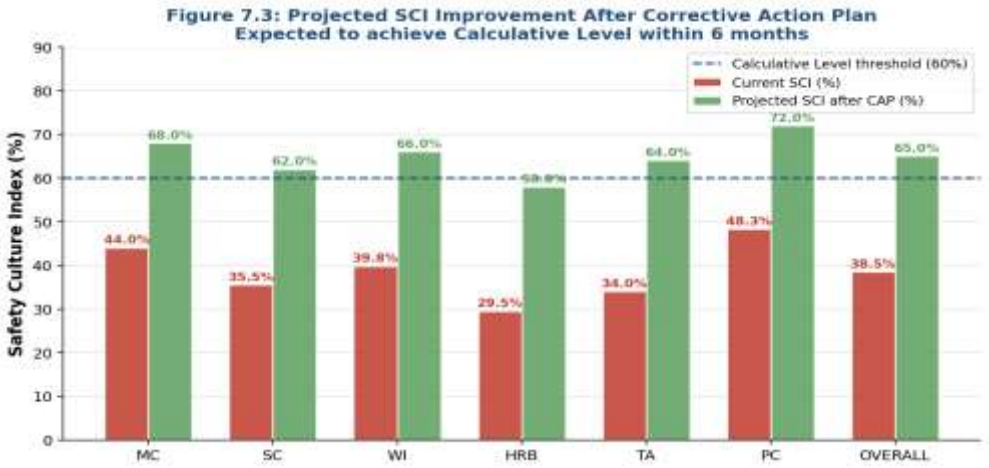

Fig. 8: SCI Before-After Projection – Current vs Post-CAP

8. DISCUSSION

The overall SCI of 36.5% confirms M. Kavitha Construction is at the Reactive maturity level of the Hudson Safety Ladder. This is significantly below the Tamil Nadu highway construction SME benchmark of 54.8% (Mani and Murugesan, 2019) but consistent with Pillai et al. (2021) who reported ~38% SCI for Chennai urban construction SMEs — validating the study's positioning of GCC sub-contractors in the informal/developing-context construction category.

The management-worker perception gap of 1.04 points — management rates safety culture at 3.19/5.0 while workers experience only 2.26/5.0 — is the defining characteristic of the safety culture profile. This gap is larger than Hong Kong (0.87; Choudhry et al., 2007) but comparable to West Africa (1.12; Kadiri et al., 2014), supporting the classification of GCC-contract SME construction in Tamil Nadu within the developing-country informal construction category for safety culture purposes.

The latent informal safety solidarity observed in Worker Involvement — WI6 (workers look out for each other; mean: 3.87) and WI5 (willingness to stop dangerous work; 3.42) — despite institutional failure at all other levels — is a positive cultural asset that the proposed SCAM and CAP explicitly target through the Worker Safety Representative program.

The proposed SCAM addresses three fundamental constraints that make existing models inapplicable to this context: resource constraint (no dedicated safety officer); literacy constraint (47% of workers below middle school education); and language constraint (35% Telugu-speaking migrants). No published model from the reviewed literature simultaneously addresses all three constraints.

9. CONCLUSION

This study systematically assessed the safety culture of M. Kavitha Construction using a novel mixed-methods design and proposed the first Safety Culture Assessment Model designed for Tamil Nadu GCC-contract SME construction organizations. Key conclusions:

- Overall SCI = 36.5% — Reactive maturity level; Hazard Reporting (28.8%) at Pathological boundary — most critical deficiency.
- Safety audit score = 41.5%; Emergency Preparedness = 18.8% — active BOCW Act non-compliance requiring immediate corrective action.
- Management-worker perception gap = 1.04 points — symbolic rather than substantive management commitment.
- Novel SCAM framework requires only 9 person-days and Rs. 13,500 per assessment cycle — feasible for all SME contractors.
- 8-item CAP projects SCI improvement from 36.5% to ~47% within 6 months at a total cost of Rs. 30,500 (0.17% of contract value).
- GCC should mandate SCI assessment in contractor performance evaluation; Tamil Nadu BOCW Board should require multilingual safety training delivery.

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