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How Does Organizational Culture Affect Safety Performance? The Moderating Role of Workforce Skills-A Literature Review on the Construction Industry and Management Implications

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Abstract

This literature review examines how organizational culture affects construction safety performance, focusing on the moderating role of workforce skills. Synthesizing empirical studies from 2015–2025 across major construction economies, the review finds that safety performance measurement has shifted from single accident indicators to multidimensional assessments integrating behavioral compliance, safety climate, and outcomes. While IoT and AI have improved measurement accuracy, they raise data privacy and algorithmic bias concerns. Organizational culture-particularly leadership, institutional execution, and penetration effects-positively drives safety performance, yet cross-cultural dynamics and project-level synergy remain underexplored. Workforce skills show a contradictory moderating role: skills generally enhance safety behavior, but high-skilled workers may exhibit overconfidence bias or circumvent inefficient safety measures, suggesting a nonlinear relationship. Drawing on recent evidence from 2023–2025, the review proposes a

"culture-skills-performance" contingency model and outlines future research directions including cross-cultural assessment, longitudinal tracking, and technology-synergy effects. Management implications include targeted interventions for high-skilled workers, subcontractor cultural integration, trust-building before technology deployment, and regulatory shifts toward multidimensional indicators.

Keywords: organizational culture, safety performance, workforce skills, construction industry

1. Introduction

1.1 Background and Importance

The construction industry has long faced severe safety challenges due to its high-risk working environment. Despite technological advances and continuous improvements in safety regulations, construction accidents still occur frequently, causing casualties, economic losses, and negative social impacts (Zhou et al., 2015). Traditional safety management has largely focused on equipment upgrades, process standardization and other technical improvements, but recent research has gradually revealed that organizational culture plays an irreplaceable role in enhancing safety performance (Choudhry et al., 2007). Organizational culture shapes employees' safety attitudes and behaviors by influencing shared values, behavioral norms, and decision-making patterns. However, the ultimate achievement of safety performance depends not only on top-down cultural design but also on the actual capabilities at the operational level. Workforce skills-including knowledge, experience, and technical proficiency-play a key role in the process of cultural implementation. If workers lack necessary skills, safety goals may remain unattainable even when organizational culture emphasizes safety. Therefore, exploring "how organizational culture affects safety performance through workforce skills" is central to understanding the effectiveness of construction safety management, and has significant theoretical and practical implications for optimizing industry practices and developing targeted intervention strategies.

Although this review focuses on the construction industry, the mechanism of "organizational culture-employee capability-performance outcomes" also exists in other high-risk or highly regulated industries such as manufacturing, healthcare, and logistics (Schein, 2010; Guldenmund, 2000). The framework and findings of this paper can inform broader research on management control, human resources, and safety governance, especially for organizations that need to balance standardized processes with frontline execution flexibility.Recent reviews have further underscored the urgency of this inquiry, highlighting the increasing complexity of safety challenges in the era of digital transformation and the gig economy(Heydari et al., 2024; Newaz et al., 2025).

1.2 Definition of Key Terms

Organizational culture refers to the shared values, beliefs, behavioral norms, and assumptions held by organizational members, influencing their decisions and behaviors (Fernández-Muñiz et al., 2007). In the field of construction safety, it is often manifested as "safety culture" - an organization's collective commitment to safety priorities and its institutional embodiment.

Safety performance is a multidimensional construct reflecting the effectiveness of safety management, encompassing accident rates, safety behavior compliance, safety climate perception, and safety outcomes (Zohar, 1980; Neal et al., 1999).

Workforce skills refer to the knowledge, abilities, experience, and technical proficiency required for construction workers to perform safety-related tasks. Its dimensions include safety knowledge, risk assessment ability, operational standardization, and learning adaptability (Chan et al., 2023).

1.3 Structure of the Paper

The remainder of this paper is structured according to the IMRaD (Introduction, Methods, Results, Discussion) format. Section 2 details the methodological approach employed for this literature review, including the search strategy and inclusion criteria. Section 3 presents the results, synthesizing the literature into three thematic areas: the evolution of safety performance measurement, the driving mechanisms of organizational culture, and the moderating role of workforce skills. Section 4 discusses the implications of these findings, identifies research gaps, and addresses methodological limitations. Finally, Section 5 concludes with theoretical contributions and actionable management implications for the construction industry.

2. Methods

2.1 Review Scope and Search Strategy

This study employs a systematic narrative review approach to synthesize the existing literature on organizational culture, workforce skills, and safety performance in the construction industry. The temporal scope of the review encompasses empirical studies published over the past decade, specifically from January 2015 to December 2025, in order to capture the most recent theoretical advances and methodological innovations in the field. The geographic coverage includes major construction economies across both developed and developing contexts, including but not limited to China, Malaysia, Nigeria, Australia, the United States, and the United Kingdom, thereby allowing for a comparative perspective on contextual and regulatory differences.

A comprehensive literature search was conducted using the following electronic databases: Scopus, Web of Science, ScienceDirect, and Google Scholar. The search strategy employed combinations of the following keywords and Boolean operators: (“organizational culture” OR “safety culture” OR “safety climate”) AND (“safety performance” OR “accident rate” OR “safety behavior”) AND (“workforce skills” OR “employee competence” OR “skill level” OR “training”) AND (“construction industry” OR “construction safety”). The search was initially conducted in January 2025 and subsequently updated in early 2026 to incorporate the most recent publications appearing in late 2025.

2.2 Inclusion and Exclusion Criteria

To ensure the quality and relevance of the synthesized evidence, explicit inclusion and exclusion criteria were established prior to the full-text review. Studies were included if they met the following conditions:

1) Published in peer-reviewed English-language journals or conference proceedings between 2015 and 2025.

2) Focused primarily on the construction industry or, in the case of methodological studies, directly applicable to construction contexts.

3) Employed empirical research methods, including quantitative surveys, structural equation

modeling (SEM), mixed-methods approaches, case studies, or rigorous meta-analyses.

4) Addressed at least one of the three core constructs: organizational/safety culture, safety performance, or workforce skills.

Studies were excluded if they were:

1) Purely descriptive reports, editorials, or opinion pieces lacking empirical data.

2) Non-English publications without an accessible English translation.

3) Focused exclusively on industries unrelated to construction, such as pure manufacturing or aviation, without explicit transferability of findings.

2.3 Analytical Approach

Given the heterogeneity of research designs, measurement instruments, and contextual factors across the selected studies, a narrative thematic synthesis approach was adopted. This method is particularly suited to reviews that aim to map conceptual developments and identify theoretical gaps rather than to produce a single pooled effect size (Popay et al., 2006). The analysis proceeded in three stages. First, bibliographic information and key findings were extracted into a standardized matrix. Second, studies were thematically grouped into three predefined categories aligned with the research objectives:

1) the conceptualization and measurement of safety performance,.

2) the driving mechanisms of organizational culture.

3) the moderating role of workforce skills.

Third, within each thematic category, findings were compared across studies to identify points of convergence, persistent controversies, and underexplored boundary conditions.

3. Results

This section presents a thematic synthesis of the empirical literature, organized around three core areas of inquiry: the evolving conceptualization and measurement of safety performance (Section 3.1), the driving mechanisms through which organizational culture exerts its influence (Section 3.2), and the complex moderating role of workforce skills (Section 3.3).

3.1 Multidimensional Construct and Measurement of Construction Safety Performance

3.1.1 Historical Evolution and Core Developments.

Research on construction safety performance began in the 1980s when Zohar (1980) first proposed safety climate theory, laying the foundation for subjective perception-based research. Early studies relied heavily on single indicators such as accident rates and used qualitative descriptions and accident statistics as primary methods. After 2010, a paradigm shift occurred: Fang et al. (2018) integrated accident data, behavioral observations, and safety audits to build a multidimensional evaluation indicator system; the introduction of Internet of Things (IoT), AI-based behavior analysis and other technological tools pushed measurement

toward real-time, quantitative development (Trinh & Feng, 2020). More recently, the application of machine learning and artificial intelligence techniques has expanded the analytical capabilities of safety monitoring systems. For instance, Alkaissy et al. (2023) demonstrated the utility of machine learning-based classification models for identifying patterns in construction injury types, moving beyond simple incident counting toward predictive risk stratification. Similarly, advances in deep semantic mining have enabled intelligent question-answering systems that retrieve safety hazard knowledge from unstructured texts (Tian et al., 2023). This shift marks an upgrade from an "outcome-oriented" to a "process and behavior oriented" evaluation paradigm. Although early research laid the foundation for the field, it suffered from limitations such as data lag, subjective assessment bias, and inadequate cross-cultural adaptability, pointing to directions for subsequent improvement.

3.1.2 Key Methods, Findings, and Trends

Current research employs diverse methods: quantitative studies use accident rate analysis and structural equation modeling (SEM) to verify causal relationships (Zhou et al., 2015); qualitative studies rely on case studies and interviews to reveal contextual differences (Abdul Halim et al., 2022); mixed methods combine on-site observations and questionnaire data. Key findings include that safety performance consists of three dimensions-accident outcomes, behavioral compliance, and safety climate (Zhou et al., 2015)-and that technological empowerment significantly improves measurement accuracy (Trinh & Feng, 2020). In terms of trends, multidimensional dynamic assessment has replaced single indicators; Driven by policies such as ISO 45001, the standardization system has been strengthened. However, technology dependence and data privacy issues have sparked new debates, particularly concerning worker surveillance and algorithmic fairness. As Dobrucali et al. (2022) note in their review of emerging technologies in construction safety, the adoption of IoT and AI-driven monitoring systems raises unresolved questions regarding data ownership, consent, and the potential erosion of worker trust. Disagreements remain regarding indicator weighting: Newaz et al. (2019) advocate prioritizing behavioral indicators, while traditional schools emphasize accident rates as the core measure; measurement adaptability under cultural differences has also become a focal point.

3.1.3 Methodological Assessment and Future Directions

Existing research has notable strengths: large-sample quantitative studies enhance generalizability, and mixed methods improve explanatory power. However, limitations also need attention: most studies rely on cross-sectional data, making it difficult to reveal dynamic mechanisms; small and medium-sized projects are underrepresented; developing countries often rely on subjective assessments due to missing data, compromising comparability of results (Table 1). Controversies center on methodological differences, such as conflicting conclusions regarding the moderating effect of skills-positive moderation versus "overconfidence bias" (Newaz et al., 2019 vs. Fang et al., 2015). Future research needs to develop cross-culturally applicable tools, strengthen longitudinal studies to verify dynamic mechanisms, and balance technological empowerment with ethical considerations.

Table 1. Comparison of Representative Research Methods and Limitations

Study	Method	Main Findings	Limitations	Research Context
Zhou et al. (2015)	Accident data & SEM	Safety behavior significantly predicts accident rates	Cross-sectional data, limited causal inference	Chinese construction industry
Fang et al. (2018)	Multi-source data integration	Composite indicators improve assessment validity	Relies on corporate cooperation, possible sample bias	Large-scale Chinese construction projects
Abdul Halim et al. (2022)	Case study & interviews	Subjective assessment effective in resource-constrained settings	Results subject to researcher subjectivity	Northern region of Malaysia

3.2 Driving Mechanisms of Organizational Culture

3.2.1 Theoretical Evolution and Key Breakthroughs

Research on the influence of organizational culture on safety began with the theoretical foundation laid by Zohar (1980), focusing initially on leadership and normative dimensions. After 2010, theory deepened: Lingard et al. (2019) confirmed through meta-analysis the significant impact of leadership on safety performance; Abubakar et al. (2022) proposed the concept of "resilient safety culture," pushing research toward dynamic adaptability and cross-cultural comparisons. Theoretical frameworks have moved from fragmentation toward systematic integration, such as leadership-communication-institution synergy models. Early research was constrained by theoretical fragmentation and lack of systematic integration, gaps that subsequent studies have filled through quantitative validation. Recent scholarship has further emphasized the role of psychological safety as a critical mediating mechanism through which leadership behaviors translate into frontline safety actions. Feng et al. (2023) found that safety-specific transformational leadership enhances construction workers' safety behavior primarily by fostering a sense of psychological safety, wherein individuals feel comfortable voicing concerns and reporting errors without fear of retribution.

3.2.2 Methodological Innovations and Core Findings

Methodologically, questionnaire surveys including the CSCQ scale and experimental designs dominate, with meta-analysis enhancing the robustness of conclusions (Lingard et al., 2019). Representative findings include: leadership is the core driver (Chen et al., 2018); institutional execution is more critical than policy formulation; cultural penetration is affected by project

complexity, and subcontractor cultural differences are significant (Meng & Chan, 2022). Emerging trends include contextualized research, such as subcontractor cultural penetration, and theoretical integration, including multidimensional system models. However, controversy over the core driver persists: Fernández-Muñiz et al. (2007) emphasize leadership dominance, while Chen et al. (2018) argue for institutional execution as the core; Methodological differences between self-report data and experimental design exacerbate conflicting conclusions.

3.2.3 Methodological Reflections and Future Prospects

Strengths of existing research include meta-analyses validating general patterns and experimental designs controlling for variables. However, social desirability bias in self-report data is common (Lingard et al., 2019); longitudinal studies are scarce, making it difficult to explain dynamic cultural evolution; cross-industry comparisons are insufficient, limiting the generalizability of conclusions. Future research should combine objective indicators such as behavioral monitoring to mitigate bias, use longitudinal tracking to reveal cultural evolution mechanisms, and pay attention to cultural synergy effects in complex projects.

3.3 Composition and Moderating Potential of Workforce Skills

3.3.1 From Periphery to Center: Paradigm Shift in Skills Research

Early research treated skills as an independent variable, focusing on the effects of technical training. After 2010, Newaz et al. (2019) pioneered the validation of skills' moderating role between culture and performance, pushing research toward multidimensional skill models that integrate technical, cognitive, and adaptive abilities. Zhou et al. (2015) found that the effect of culture is limited among low-skilled groups, while high-skilled groups can strengthen the positive effect; however, Fang et al. (2015) warned of the risk of "overconfidence bias." The paradigm shift reveals that skills are not merely a capability indicator but a key moderating variable in contextual interventions. Early research was limited by conceptual ambiguity and subjective measurement; current research has improved validity through skill testing and contextual simulation. Recent studies have also begun to examine the role of technology acceptance as an emergent skill-related dimension that influences the effectiveness of safety interventions. Yap et al. (2023) identified key predictors of safety technology adoption among Malaysian construction stakeholders, highlighting that workforce readiness-encompassing perceived ease of use and digital familiarity-significantly shapes whether technological tools are embraced or resisted on site.

3.3.2 Empirical Evidence and Controversies Regarding the Moderating Mechanism

Empirical studies have used hierarchical regression to verify moderating effects (Newaz et al., 2019), and contextual simulations have revealed the moderating effect of adaptive ability on risk response (Chan et al., 2023). The core controversy centers on the direction of moderation: mainstream research supports positive moderation, but the theoretical analysis of Fang et al. (2015) and empirical findings such as those of Lee et al. (2020) on job burnout suggest that high skills may weaken cultural constraints, attributed to overconfidence or path dependence. Measurement method discrepancies also affect conclusions: the validity difference between

self-report and objective testing continues to be debated. Positive moderation mechanisms argue that skills improve risk identification and compliance abilities; negative moderation mechanisms argue that high skills lead to "circumvention" of inefficient safety measures or shortcut behaviors under time pressure. Boundary conditions may include task complexity, time pressure, and the strength of reward-punishment systems. Given the contradictory evidence regarding positive versus negative moderation, the potential for a curvilinear (inverted U-shaped) moderating effect-where moderate skill levels yield the strongest safety compliance-warrants systematic empirical investigation. Such a relationship would help reconcile findings of skill-enhanced vigilance with observations of overconfidence bias among highly experienced workers.

3.3.3 Integration and Outlook: Bridging Theory and Practice

Existing research has deepened mechanistic understanding through experimental designs and moderation analyses, but theoretical models remain immature and industry differences are inadequately controlled. For example, the conclusions of Newaz et al. (2019) were limited to the manufacturing sector, leaving generalizability to be verified. Future research is suggested to build cross-industry dynamic moderation models, incorporate neuroscientific methods to reveal cognitive mechanisms, and develop skill-culture synergy intervention programs. The practical potential of skill moderation theory is enormous, but theoretical fragmentation and measurement bottlenecks must be overcome.

4. Discussion

This section provides a critical interpretation of the synthesized findings, structured around three interrelated themes: the paradoxical role of workforce skills, the unresolved tensions in safety performance measurement, and the implications of technological disruption for the culture–skills–performance triad. Following this synthesis, the section addresses the methodological limitations of the current evidence base and proposes a future research agenda.

4.1 Reconciling the Skill Paradox: Beyond Linear Moderation

One of the most significant findings emerging from this review is the contradictory evidence regarding the moderating role of workforce skills. While a substantial body of literature confirms that skills enhance the positive effects of safety culture on performance (Newaz et al., 2019; Chan et al., 2023), a competing stream of research identifies a "dark side" of high competence-namely, overconfidence bias and the circumvention of inefficient safety protocols (Fang et al., 2015; Lee et al., 2020). This divergence is not merely an empirical anomaly but signals a theoretical gap in how the field conceptualizes the culture-skills interface.

We propose that these conflicting findings can be reconciled by recognizing the nonlinear and context-dependent nature of skill moderation. The relationship between skill level and safety compliance may follow an inverted U-shaped curve: at low skill levels, workers lack the competence to translate cultural expectations into safe actions; at moderate levels, skills amplify cultural norms effectively; at very high levels, workers may develop heuristic

shortcuts that bypass formal procedures, particularly under time pressure or when safety protocols are perceived as inefficient. Furthermore, the emergence of new skill dimensions-such as digital literacy and technology acceptance (Yap et al., 2023)-adds further complexity. High technical proficiency in traditional tasks does not guarantee receptivity to technology-driven safety interventions; indeed, experienced workers may exhibit greater resistance to adopting AI-based monitoring tools. Future empirical work should therefore move beyond simple linear moderation tests and explicitly model curvilinear effects and three-way interactions with contextual variables such as task complexity and incentive structures.

4.2 Measurement Challenges: The Tension Between Technological Precision and Human-Centric Validity

The review documents a clear paradigm shift in safety performance measurement from lagging indicators (accident rates) toward real-time, multidimensional assessments enabled by IoT, computer vision, and machine learning (Alkaissy et al., 2023; Trinh & Feng, 2020). This technological turn offers unprecedented granularity in detecting unsafe acts and predicting risk trajectories. However, it simultaneously introduces a set of unresolved tensions.

First, the objectivity-validity trade-off remains under-theorized. While AI-driven behavioral monitoring reduces recall bias and supervisor subjectivity, it may capture only visible, rule-based violations while overlooking the cognitive and cultural antecedents of those behaviors. A worker who fails to wear a hard hat is flagged by computer vision, but the underlying reasons-whether complacency, time pressure, or a deliberate risk calculation-remain opaque to the algorithm. Second, concerns regarding data privacy, worker surveillance, and algorithmic fairness are gaining prominence (Dobrucali et al., 2022). The normalization of continuous monitoring may erode psychological safety and trust, paradoxically undermining the very safety culture that organizations seek to strengthen. This suggests that technology deployment must be accompanied by transparent governance frameworks and non-punitive data usage policies to preserve the human-centric foundations of safety culture.

Third, the cross-cultural applicability of standardized measurement tools remains a persistent limitation. The majority of validated instruments have been developed in Western or East Asian contexts, and their psychometric properties in African, South American, or Middle Eastern construction industries are underexplored. Cultural dimensions such as power distance and collectivism may systematically influence how workers interpret and respond to survey items measuring safety climate and behavioral compliance (Meng & Chan, 2022).

4.3 The Evolving Role of Organizational Culture: From Monolithic Construct to Dynamic Capability

The evidence confirms that organizational culture-operationalized through leadership commitment, institutional execution, and cultural penetration-is a robust driver of safety performance (Lingard et al., 2019; Chen et al., 2018). However, the review also reveals a

subtle but important evolution in theoretical framing. Early research treated safety culture as a relatively stable, monolithic attribute of an organization. Contemporary scholarship increasingly views it as a dynamic and multifaceted capability that must adapt to shifting project conditions, workforce compositions, and technological landscapes.

The concept of resilient safety culture (Abubakar et al., 2022; Trinh & Feng, 2022) exemplifies this shift. Resilient cultures are characterized not only by rule compliance but by the capacity to anticipate, monitor, and respond flexibly to unexpected hazards. Crucially, the effectiveness of such cultures is contingent upon the synergy between top-down cultural design and bottom-up workforce capability. A resilient culture requires workers who possess not only technical skills but also adaptive and cognitive skills-the ability to recognize emergent risks, communicate concerns upward, and exercise discretionary judgment. This finding underscores the theoretical interdependence of culture and skills: neither a strong culture with an unskilled workforce nor a highly skilled workforce embedded in a weak or punitive culture will achieve optimal safety outcomes.

4.4 Limitations of the Current Evidence Base

Several methodological limitations constrain the generalizability and causal interpretability of the reviewed literature. Table 2 expands upon Table 1 from the Results section, and it summarizes the key methodological challenges and their implications for future research.

Table 2. Summary of Methodological Limitations in the Reviewed Literature

Limitation	Prevalence	Implication for Future Research
Reliance on cross-sectional survey data	High (over 80% of empirical studies)	Precludes causal inference; reverse causality cannot be ruled out
Self-report bias and social desirability	Moderate to High	Inflates correlations between culture and self-reported behavior; objective behavioral data needed
Underrepresentation of SMEs and subcontractors	Moderate	Findings skewed toward large, well-resourced contractors; external validity limited
Single-country or single-region samples	High	Limits understanding of cross-cultural boundary conditions; multi-country comparative designs needed
Scarcity of longitudinal and quasi-experimental designs	Very High	Inability to assess dynamic evolution of culture or long-term training effects

Beyond these methodological concerns, a deeper conceptual limitation warrants attention. The literature remains fragmented across disciplinary silos: safety science, organizational behavior, human resource management, and construction engineering each employ distinct theoretical vocabularies and analytical traditions. This fragmentation impedes the development of integrative, testable models that span the full culture–skills–performance chain. The proposed contingency framework in this review represents a preliminary step toward such integration, but substantial theoretical development remains necessary.

4.5 Future Research Directions

Building on the gaps and tensions identified above, we delineate three priority directions for future empirical research.

First, future studies should develop and validate cross-culturally equivalent assessment tools. Current literature is mostly confined to single countries or regions, with large variations in dimensions and analytical methods; tools with cross-cultural equivalence need to be developed, and multigroup structural equation modeling should be used to test model generalizability.

Second, there is a pressing need for longitudinal tracking and quasi-experimental designs. Cross-sectional data cannot reveal causal order; future studies should design at least two or three time points of follow-up surveys or introduce control groups to clarify the long-term effects of cultural interventions and skill training on safety performance.

Third, future research should systematically analyze the synergistic effects of skills, culture, and technology. Technology such as VR and AI monitoring should not be treated as an independent variable but should be incorporated into the "culture-skills-performance" framework to test three-way interaction effects, especially whether technology can mitigate the overconfidence bias of high-skilled workers (Li et al., 2022; Rokooei et al., 2023).

5. Conclusion

5.1 Theoretical Contributions

Research on construction safety performance has evolved over decades from single accident statistics to multidimensional dynamic assessment systems. This systematic review synthesizes evidence from 2015–2025 to clarify the mechanisms linking organizational culture, workforce skills, and safety outcomes. The review finds that safety performance measurement has integrated multiple indicators such as behavior, climate, and outcomes. The application of technological tools such as IoT and AI has significantly improved assessment accuracy but has also brought new challenges such as data privacy and algorithmic bias (Dobrucali et al., 2022; Alkaissy et al., 2023). The role of organizational culture as a core driver has been widely validated, with its leadership, institutional execution, and penetration effects confirmed to positively affect safety performance (Lingard et al., 2019; Meng & Chan, 2022).

More critically, the moderating role of workforce skills is moving from the periphery to the center-existing research shows contradictory conclusions regarding the direction of

moderation (Newaz et al., 2019; Fang et al., 2015), revealing a possible nonlinear relationship or boundary conditions, such as "overconfidence bias" in high-skill contexts. Recent evidence further suggests that emergent skill dimensions, including technology acceptance and digital literacy, add complexity to this moderation dynamic (Yap et al., 2023). This finding revises the intuitive assumption that "higher ability leads to greater safety" and indicates that the improvement of safety performance depends on the systematic synergy of technology, culture, and human capital, rather than the optimization of any single factor.

5.2 Management Implications

For enterprises and policymakers, several concrete actions are recommended. First, to address the overconfidence risk of high-skilled workers, organizations should introduce risk case reviews and random spot checks to interrupt automated thinking. Targeted interventions, such as scenario-based VR training that exposes experienced workers to rare but catastrophic failure modes, may help recalibrate risk perception without undermining professional autonomy (Rokooei et al., 2023). Second, in subcontractor management, main contractors should integrate safety culture penetration into contracts and performance appraisal systems, and achieve cross-organizational value alignment through mechanisms such as joint safety committees.

Third, before technology deployment, organizations should clarify data usage and non-punitive rules to build worker trust. As AI-based monitoring becomes pervasive, transparent governance frameworks are essential to prevent the erosion of psychological safety and to ensure that surveillance is perceived as a support mechanism rather than a disciplinary tool. Finally, regulatory agencies should replace single accident rate assessments with multidimensional dynamic indicators such as behavioral compliance, safety climate, and technical data, and design differentiated risk warning standards for high-skilled groups. Through the above measures, construction industry safety management can be gradually advanced from passive accident response toward the active construction of safety capabilities.

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