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Resilient health and safety performance on construction sites from a safety-II perspective

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Abstract
This study investigated how construction management practices influence resilient health and safety (H&S) performance on construction sites, using a Safety-II perspective. To achieve this objective, data were collected through a case study research method, involving a purposive sample of 32 construction personnel across multiple case studies in the Free State Province, South Africa. The findings reveal that while formal safety management systems and visible managerial engagement exist within the construction sites, resilience depends on dynamic practices that facilitate learning, anticipate risks, and support worker adaptation. Additionally, the findings highlight the critical role of experienced personnel (such as artisans) and structured reflective processes in translating tacit knowledge into organizational learning, bridging the gap between compliance-focused Safety-I approaches and adaptive Safety-II practices. However, this study's limitations include the focus on a single province for data collection, which restricts the generalizability of the findings to the broader South African construction industry. In addition, the practical application of this study recommends continuous H&S risk conversation, structured reflection, and mentorship programs, supported by a diagnostic framework to evaluate and enhance construction management practices for improved H&S outcomes within the South African construction industry.

Keywords Construction management, Safety management system, Safety-II paradigm, South Africa

1 Introduction

The South African construction industry operates within a stringent regulatory framework established by the Occupational Health and Safety Act (1993) [1] and the Construction Regulations (2014) [2]. This framework aligns with a Safety-I paradigm, which conceptualizes safety as the absence of adverse events, accidents, incidents, and near misses. Consequently, Safety-I focuses on the attention to identifying and eliminating the causes of failure through compliance, constraints, and procedural adherence [3]. This implies that construction safety in the context of South Africa is primarily managed through strict regulatory compliance, with emphasis on preventing accidents by

controlling failures rather than proactively enhancing resilience or learning from everyday work practices. The Construction Regulations (2014) aim to reduce accidents that frequently result in fatalities and injuries in the construction industry [4]. This approach has established a necessary baseline, but its limitations are becoming increasingly apparent given the inherent complexity of the construction industry, which is characterized by dynamic project conditions, construction risks, diverse skills, and intense production pressures [5].

H&S issues in the South African construction industry illustrate a compliance-driven, also known as Safety-I-oriented approach that prioritizes worker behavior, documentation, and rule enforcement over the management of systemic and contextual safety risk factors on construction sites [6]. This is evidenced by persistent problems at the construction site level, such as productivity pressure to meet deadlines, high employment of workers and subcontracting, inadequate supervision, lack of skills, fatigue from long workdays, and uneven enforcement of safety regulations, particularly on small and medium-sized construction projects [7]. These conditions reflect a Safety-I orientation, which conceptualizes safety primarily as the absence of accidents and incidents, emphasizing compliance with rules and procedures and individual worker behavior, rather than addressing the broader systemic, organizational, and contextual factors that influence safety outcomes.

Instead of implementing proactive interventions that address planning deficiencies, poor coordination, and organizational decision-making under dynamic project conditions, contractors typically resort to reactive measures, such as disciplinary action, toolbox talks, and procedural revisions, to address safety issues after incidents have occurred [8]. This reactive mindset hinders the effectiveness of continuous safety initiatives in an industry characterized by complexity, unpredictability, and severe time and cost constraints, as safety is managed as the absence of failure rather than the development of resilient work practices [4]. A compliance-centric mindset may inadvertently promote a complex, reactive culture that is ill-prepared to understand and support the everyday adjustments employees and supervisors must make to achieve effective outcomes in unexpected real-world settings [9].

This context necessitates an exploration of complementary safety philosophies. The Safety-II paradigm offers a fundamental reconceptualization, defining safety as the capacity to succeed under varying conditions [10]. In addition, the Safety-II paradigm is focused on the principle that humans and their adjustments, as they work, are vital to maintaining safety [11]. It shifts the analytical focus from "what goes wrong" to "what goes right," recognizing that safe outcomes are dynamically created through people's ability to adjust their performance to match actual demands, a concept termed "work-as-done" [3]. From this perspective, the role of management transforms from primarily enforcing pre-defined controls to enabling success by establishing the system's and workforce's capacity for resilient performance. This involves providing resources, fostering a climate of trust and open dialogue, facilitating learning from daily work, and empowering workers' expertise. In the unique socio-economic and operational pressures of the South African construction industry, where formal procedures often intersect with informal practices and adaptive workarounds, the Safety-II lens is particularly relevant for understanding how safety is genuinely achieved.

The Safety-II perspective highlights the importance of resilience and the ability of systems to succeed under various conditions [11]. However, research in the construction industry has largely neglected the structural and regulatory contexts that influence safety practices. This gap is particularly pronounced in compliance-driven environments such as the South African construction industry, where safety management is significantly shaped by statutory requirements, including the Construction Regulations (2014) [9]. As a result, existing applications of Safety-II often fail to account for industry realities such as subcontracting arrangements, production pressures, skills shortages, and inconsistent regulatory enforcement, all which impact safety management on construction sites. A greater focus on these contextual and organizational factors would facilitate a more practical integration of the Safety-II perspective into construction safety management [11], allowing its principles to move beyond theoretical discussions and contribute more effectively to enhancing safety performance in the industry.

While Safety-II principles have gained increasing recognition in high-reliability industries globally [3], countries such as the United Kingdom, Norway, and Australia have applied these approaches in sectors including rail, aviation, and healthcare by focusing on learning from everyday successful work practices and worker adaptations to strengthen organizational resilience and safety performance [3]. However, in developing countries such as South Africa, limited empirical research has examined how construction management practices support the adoption of this perspective. Therefore, this study addresses this gap by posing the following research question: "How do construction management practices contribute to resilient health and safety (H&S) performance on construction sites through a Safety-II perspective?" The objective is to evaluate construction managers' practices not as barriers to failure but as potential enablers of everyday success, thereby offering a novel and actionable perspective for advancing safety performance in the construction industry.

2 Literature review

Safety-I remains the dominant paradigm underpinning contemporary safety management practices within the construction industry [3]. This approach is inherently reactive toward safety management, as it focuses on analyzing incidents after they occur to identify specific causes and implement corrective measures [10]. Such reasoning is grounded in a linear cause-and-effect model of accident causation, where safety failures are typically attributed to identifiable breakdowns such as human error or component malfunction. Within the construction industry, this perspective has reinforced a compliance-oriented view of safety management, in which accidents are largely interpreted as the result of workers' failure to adhere to established procedures and regulations [4]. Consequently, on construction sites, managerial attention is directed toward controlling worker behavior rather than examining the broader organizational and operational conditions that shape safety performance.

From this perspective, human error is frequently framed as the primary explanation for safety incidents, encompassing actions such as deviations from planned procedures, incorrect decision-making, or lapses in attention during task execution [4]. In the construction industry, this interpretation often manifests in the attribution of accidents to behaviours such as the failure to wear personal protective equipment (PPE), poor housekeeping practices that lead to slips, trips, and falls, or breakdowns in communication

during construction activities [12]. However, such explanations tend to simplify the complex nature of construction work by isolating individual actions from the wider socio-technical environment in which they occur. As a result, the Safety-I approach may overlook deeper systemic contributors to accidents, including design deficiencies, organizational pressures, and coordination challenges inherent in construction projects.

Within the Safety-I paradigm, managerial responses are typically oriented toward the implementation of obstacles, strict procedural compliance, and extensive documentation intended to constrain variability and prevent deviations from prescribed work-as-imagined practices [13]. However, this approach assumes that work activities can be fully anticipated and controlled through predefined procedures, overlooking the adaptive adjustments that individuals and organizations routinely make to cope with dynamic and uncertain site conditions [14]. In the South African construction industry, this orientation is institutionalized through compliance-focused safety risk assessment and the strong regulatory emphasis placed on the construction safety management systems as required by the Construction Regulations (2014) [2]. While these mechanisms are designed to ensure regulatory accountability, they may inadvertently shift managerial attention toward procedural conformity rather than the underlying operational conditions that shape safety. Consequently, several studies argue that excessive reliance on this compliance-driven model can foster a "checklist culture," where safety activities become procedural obligations rather than meaningful engagements with the realities of construction site work, thereby creating a potential disconnection between formal safety management systems and everyday operational practice [15].

In contrast, the Safety-II paradigm offers a systems-oriented perspective that conceptualizes safety as the capacity of an organization to function effectively under both expected and unexpected conditions. Rather than concentrating solely on the prevention of failure, Safety-II emphasizes understanding how everyday work succeeds despite operational variability and constraints [16]. This perspective recognizes that workers and managers continually adapt their actions to changing circumstances, enabling systems to perform reliably even in complex and uncertain environments. From this viewpoint, safety emerges from the resilience of the socio-technical system, reflected in its ability to anticipate potential disruptions, monitor evolving conditions, respond effectively to pressures, and learn from operational experience [3]. By shifting analytical attention from procedural compliance to adaptive capacity, the Safety-II perspective provides a framework for examining how managerial practices and organizational conditions can actively support safe performance in complex construction environments.

Safety-II reframes safety management by shifting the analytical focus from limiting performance variability to understanding how adaptive adjustments allow work to be successfully completed under changing conditions [17]. Instead of viewing variability solely as a source of failure, Safety-II recognizes it as an inherent characteristic of complex work systems. This perspective is particularly relevant in the construction industry, where uncertainty, dynamic site conditions, and organizational fragmentation stem from subcontracting and reliance on general workers to create situations that rigid procedural control cannot fully address [18]. In such environments, workers' ability to interpret evolving risks and adjust their practices becomes crucial for maintaining safe operations. As a result, Safety-II challenges the traditional view of workers as hazards to control,

instead of seeing them as vital sources of operational knowledge and adaptive capacity that support system performance in everyday work situations [15].

This perspective also redefines the managerial role in safety management within the construction industry. Rather than acting primarily as compliance enforcers, managers become facilitators of resilient performance within complex operational systems [19]. This shift involves fostering adaptive work conditions by promoting open communication, allowing workers to voice concerns or suggest adjustments without fear of repercussions [20]. Managers must also ensure that teams have access to essential resources such as time, information, authority, and protective equipment. Additionally, developing structured learning processes to analyze both successful and problematic outcomes in routine operations is vital for bridging the gap between "work-as-imagined" in formal procedures and "work-as-done" in practice [21]. Through these mechanisms, managerial leadership transitions from enforcing procedural compliance to enabling organizational learning and adaptive capacity.

The analytical relevance of the Safety-I perspective is particularly clear in the South African construction industry, where systemic constraints often create a gap between prescribed safety procedures and actual operational realities. Factors such as structural fragmentation, extensive subcontracting, and ongoing skills inequalities lead to environments marked by production pressures, fluctuating availability of general workers, and limited resources [22]. In these conditions, safety at construction sites often relies on informal coordination, experience-based judgment, and adaptive decision-making by supervisors and managers. However, the prevailing Safety-I framework, which focuses on compliance, tends to overlook these adaptive practices by prioritizing documentation, behavioral control, and rule enforcement as the main indicators of safety performance [18]. Consequently, the mechanisms through which safety is effectively achieved during daily operations are not well understood. Adopting a Safety-II perspective provides a more robust analytical approach by acknowledging and supporting the adaptive strategies that construction teams use to manage safety in complex and uncertain environments.

3 Research methodology

This study used an interpretivist approach to investigate how construction management practices contribute to resilient health and safety (H&S) performance on construction sites from a Safety-II perspective. A qualitative methodology was suitable for data collection due to the exploration nature of the research question and the need to capture contextual experiences and organizational practices within real construction projects. Qualitative inquiry examines complex social and organizational processes, with understanding constructed through participants' perspectives rather than numerical measurement [23]. The guiding research question was: "How do construction management practices contribute to resilient health and safety (H&S) performance on construction sites through a Safety-II perspective?"

A multiple case study design was used to investigate four construction sites in the Free State province of South Africa. The Free State province of South Africa is the study area, and four active construction sites were specifically selected as case studies to investigate the phenomenon within the cases [24]. The inclusion of the case studies presented in Table 1 represents different types of construction activities, including

Table 1 Case study sites and participant sampling

Case study site	Code	Project type	Participant positions	Number of participants
Site A	CSA	Building construction works	Site manager	1
			Safety manager	1
			Foreman	1
			General workers	4
Site B	CSB	Civil engineering works	Site manager	1
			Safety manager	1
			Residential engineer	1
			Artisans	2
			General workers	3
Site C	CSC	Mixed-use construction works	Site manager	1
			Safety manager	1
			Resident engineer	1
			Artisans	2
			General workers	4
Site D	CSD	Building construction works	Site manager	1
			Safety manager	1
			Foreman	1
			Artisans	2
			General workers	3
Total participants				32

building projects (CSA and CSD), civil engineering works (CSB), and mixed-use construction projects (CSC), thereby enabling the study to examine safety practices across a range of construction contexts. The term mixed-use construction projects (CSC) refer to multi-story buildings that integrate different functions within a single development, typically combining commercial spaces, residential units, and office facilities. The four active construction site projects were chosen as case studies because they provided real-world contexts for a thorough investigation of safety management practices and the factors influencing them in ongoing construction activities in the Free State province [24]. In addition, the selection of four case studies facilitated analytical replication, enhancing the robustness of findings through comparisons across diverse project contexts. In alignment with Eisenhardt, using multiple cases supported theory development by uncovering recurring patterns and contrasts in construction management practices and H&S performance across the sites [25].

A purposive sampling strategy was employed to select both the construction projects and the participants. The four case studies were chosen based on their active status, accessibility, and relevance to construction management and H&S implementation. Participants were deliberately selected based on their roles and direct involvement in management, supervision, and health and safety activities. A total of 32 participants were interviewed across the four sites, including site managers, safety managers, residential engineers, foremen, artisans, and general workers. This purposive sampling ensured the inclusion of information-rich participants with relevant experiential knowledge, crucial for qualitative case study research [23]. Table 1 summarizes the case study sites and participant distribution.

This study is cross-sectional in nature because qualitative data were collected through semi-structured interviews conducted between August and October 2025, capturing participants' practices and experiences at a single point in time. Semi-structured interviews were chosen to ensure consistency across cases while allowing flexibility to explore emerging issues and site-specific dynamics [23]. An interview guide was created based on existing literature on construction management, resilience, and health and safety

(H&S), enabling participants to reflect on both formal procedures and informal practices that influence safety performance. All interviews were audio-recorded with informed consent and transcribed verbatim to ensure data accuracy.

The data were analyzed using thematic analysis, following a systematic and iterative process of coding and theme development. For instance, initial open coding identified recurring concepts within each case, followed by axial coding to link themes to broader categories related to managerial practices, enabling conditions, and constraints impacting resilient H&S performance. A cross-case analysis was then conducted to compare patterns across the four sites, in line with Eisenhardt's approach to building explanations from multiple cases [25]. To enhance trustworthiness, the study employed data triangulation across cases, maintained a detailed audit trail, and ensured transparency in analytical decisions [24].

4 Results

This section presents qualitative findings from four case studies conducted at construction sites in the Free State Province, South Africa. The research posed the question, "How do construction management practices contribute to resilient health and safety (H&S) performance on construction sites through a Safety-II perspective?" The results are analyzed thematically, highlighting patterns that emerged during data coding and theme development.

4.1 Formal managerial structures for coordinating H&S practices

Participants were asked to explain how established managerial systems, procedures, and communication mechanisms facilitate the coordination and implementation of health and safety (H&S) practices on construction sites. In all four case studies, managers reported the use of formalized H&S systems designed to coordinate work and ensure safe operations. Their responses revealed the presence of structured safety communication mechanisms, such as daily toolbox talks, safety inductions, safety files, and method statements. Together, these elements illustrate the formalized processes employed to communicate and reinforce safety practices on construction sites.

The participants' focus on structured safety communication mechanisms reflects a reliance on the Safety-I perspective, which emphasizes compliance, rule-following, and accident prevention. For instance, the case studies demonstrated that daily toolbox talks, safety inductions, safety files, and method statements serve as formal procedures intended to control worker behavior and ensure adherence to established safety protocols. This approach fosters a reactive safety culture centered on avoiding incidents rather than proactively enhancing system resilience or addressing broader contextual factors that influence safety performance. One site manager in CSB stated,

> *"We ensure that every worker goes through induction and that toolbox talks are conducted daily, so safety is always communicated."*

Additionally, participants reported that adequate resources were provided to support safety compliance, particularly regarding personal protective equipment (PPE) and access to safety documentation. A safety manager in CSA explained,

> *"All PPE is issued, and the safety file is available on site for reference whenever needed."*

Participants viewed the availability of these protocols and tools as evidence of established safety support systems. These protocols illustrate how managers rely on readily available safety files and PPE as tangible indicators of formal safety guidance and compliance frameworks on construction sites.

From the workers' perspective, there was widespread acknowledgment of managerial involvement in safety activities. Most general workers in CSA and CSB indicated that managers actively participated in H&S matters daily, while some in CSC noted that managerial involvement was frequent, though not constant. Across the four case studies, general workers observed that managerial engagement was most noticeable during formal safety activities such as toolbox talks, inspections, and audits. Some participants remarked:

> *"Managers are present every morning during toolbox talks and sometimes during the day when they conduct safety checks" (General worker, CSA).*
> *"Managers are active during safety meetings and site inspections" (Foreman, CSC).*

Moreover, several general workers in CSC noted that managerial engagement was not consistently integrated into all aspects of daily work. While managers were accessible, their involvement often occurred in specific events rather than continuously. One artisan in CSD observed,

> *"Managers are mostly around during safety meetings or when there is an inspection."*

These observations highlight that formal managerial structures were primarily enacted through organized and observable safety activities. They also illustrate a compliance-driven safety approach, in which managerial involvement is largely limited to formal safety events such as meetings and inspections, thereby reinforcing traditional Safety-I practices. To enhance safety performance in the South African construction industry, it is crucial to promote more consistent and proactive managerial engagement in daily site operations, thereby improving continuous safety oversight and learning.

4.2 Managerial awareness of workers' operational context and decision-making in supporting resilient safety performance

When construction managers were asked to identify factors influencing workers' decision-making and work adaptations related to safety performance, all respondents emphasized the significant roles of leadership and organizational culture. They noted that their leadership practices set expectations and shape safety behavior on-site. A site manager from CSC noted, *"the behavior of management sets the tone for how workers approach safety on construction sites."* This observation underscores that leadership practices and organizational culture play a crucial role in shaping workers' safety-related decision-making and work adaptations. It emphasizes the importance of managerial behavior in influencing safety performance and promoting proactive safety practices in the construction industry.

Additionally, most construction managers acknowledged that production demands and financial pressures affected how work was performed on construction sites. A site manager from CSB reported that time constraints, program pressures, and cost considerations were major factors influencing workers' decision-making. A safety manager at CSB said, *"there is always pressured to complete work on time and within budget, which*

affects how tasks are carried out." This statement highlights that construction schedules and financial constraints significantly impact workers' decision-making on construction sites. It underscores the necessity for construction management practices that balance productivity demands with strong safety performance in the industry.

This acknowledgment highlights that work execution is influenced by competing demands beyond formal safety procedures. The managers in the case studies recognized that formal safety protocols alone cannot address the conflicting pressures of time, cost, and productivity in construction. This finding illustrates the complexities of construction work and suggests that recognizing these competing demands can lead to more adaptive safety management approaches. As a result, this recognition can enhance the effectiveness and resilience of H&S practices in the South African construction industry.

Similarly, general workers described how contextual factors impacted their daily tasks. Foremen and artisans in CSD shared that site conditions, task sequencing, and coordination with subcontractors often necessitated adjustments to planned methods. One foreman in CSD explained, "sometimes the site conditions are different from what was planned, so we have to make changes on the ground." A general worker in CSB added, *"you follow the plan, but when something changes, you must find a safe way to continue the work."*

These accounts show that managers and workers recognize the dynamic nature of construction work, where tasks are influenced by changing conditions. This understanding enhances safety performance through more responsive decision-making on construction sites.

4.3 Experiential knowledge as a resource for understanding and improving safety outcomes

Participants were asked to explain how the professional experience of managers and workers contributes to interpreting site conditions, managing risks, and enhancing safety performance in complex construction environments. The analysis highlighted that participants' perceptions of the causes of unsafe conditions varied with their work experience. Those with high experience attributed safety outcomes to organizational systems, management practices, and individual actions. An experienced artisan in CSB remarked, *"With experience, you understand that safety depends on planning, communication, and support from management, not just on what workers do."* This suggests that experienced participants acknowledged that inadequate planning, poor communication, and limited managerial support contribute to work environments where artisans, including bricklayers, face greater exposure to hazards, thereby increasing the likelihood of accidents.

In contrast, less experienced workers tended to define safety primarily in terms of following rules and procedures. For instance, a general worker at CSC stated, *"If everyone follows the rules, then accidents can be avoided."* These differing perspectives illustrate variations in how safety is conceptualized across construction projects. This variation affects safety outcomes in the industry, as it emphasizes rule compliance as a key method for preventing accidents. Moreover, the differing viewpoints based on worker experience reveal how safety is understood and practiced, impacting the overall effectiveness of safety management practices. Adopting a Safety-II perspective could help address these issues by encouraging both managers and workers to focus on understanding everyday

work practices and making adaptive decisions. This shift promotes resilience and proactive safety improvements that extend beyond mere adherence to rules.

Several seasoned participants emphasized that their understanding of safety evolved over time with exposure to diverse construction projects. A foreman from CSA stated:

> *"After working on many sites, you learn that small decisions and communication gaps can make a big difference."*

These insights underscore the importance of experience in shaping workers' interpretations of risk and their approaches to managing safety.

4.4 Managerial practices enabling learning, monitoring, and anticipation of safety risks

During the interviews, the researcher assessed the safety management systems of each of the four case studies. All sites had well-defined safety management protocols for construction activities. However, one case study, referred to as CSC, exhibited significant deficiencies in several key areas. For instance, in CSC, there was a lack of documented evidence of management training in H&S, records of formal reviews of safety meetings, and consistent documentation of daily risk assessments. A resident engineer from CSC remarked,

"We do talk about safety issues, but there isn't always proper documentation or follow-up after meetings."

This observation highlights a Safety-I perspective, which focuses on formal procedures and documentation to ensure compliance, rather than understanding the on-site work processes. The shortcomings in training, meeting reviews, and risk assessment documentation suggest that CSC's safety management prioritizes enforcing rules and preventing failures rather than fostering adaptive practices or resilience in construction activities.

In contrast, the other case studies revealed consistent practices for monitoring and reflection. Managers involved workers in discussions about past tasks and potential future risks with the construction activities. For example, a foreman in CSA remarked, *"After completing a task, management sometimes asks what challenges we faced so that the next activity can be planned better."* General workers in CSA noted that these conversations improved coordination and preparedness regarding H&S practices. These responses suggest that when managers engage workers in discussions about previous and upcoming tasks, it fosters reflection and learning. However, the practices remain centered on formal oversight, reflecting a compliance-driven approach to safety. While these interactions enhance coordination and preparedness, they primarily reinforce adherence to procedures rather than promoting proactive, system-wide resilience.

The qualitative data show variability in how managerial practices promote systematic learning and anticipation across the case studies. While basic safety compliance is generally upheld, the consistency and depth of reflective and anticipatory practices vary among construction site projects. Inconsistent implementation of these practices hinders the development of proactive safety behaviors. Addressing this variability is essential to strengthen systematic learning and improve safety performance, ensuring compliance is supported by adaptive and resilient practices.

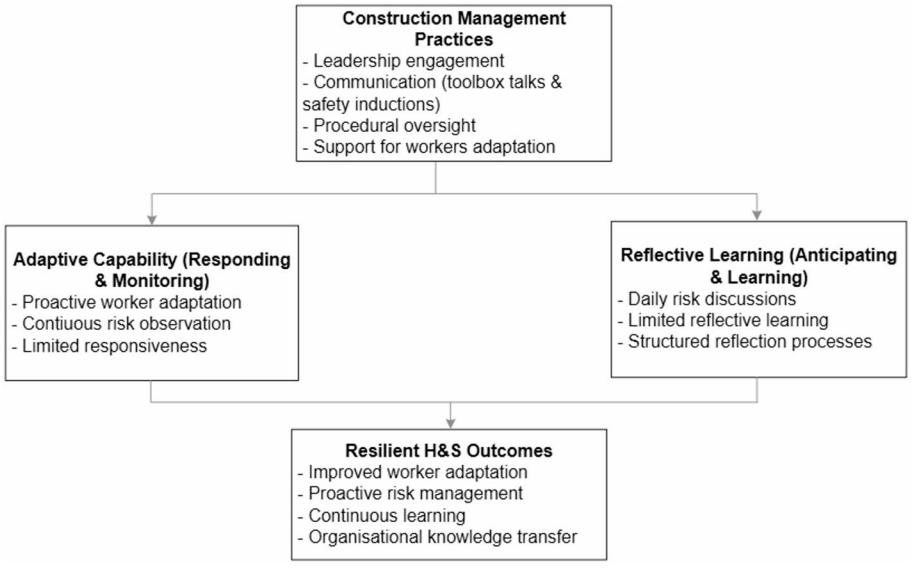

Fig. 1 Diagnostic framework linking safety-II perspective, managerial practices, and resilient H&S outcomes in construction

5 Discussion

This study, using a Safety-II perspective, clarifies current construction management practices and identifies opportunities to improve resilient health and safety (H&S). Across the four case studies, participants reported well-established formal safety management systems at their construction sites, including structured communication tools like daily toolbox talks, safety inductions, and method statements. These practices align with a Safety-I approach focused on visible leadership and procedural compliance [3]. However, evidence from CSC, and to a lesser extent CSD, revealed gaps in critical Safety-II enabling activities, such as missing managerial training records, inconsistent documentation of reflective meetings, and a lack of daily risk assessments. These findings support existing literature, which emphasizes that resilience stems from dynamic, iterative practices that foster adaptive capacity [18].

Furthermore, the absence of structured, reflective, and anticipatory practices at some sites impedes the institutionalization of learning and limits the organization's ability to translate worker adaptations into collective knowledge. Workers at CSA, CSB, and CSD reported proactive adaptations to manage site pressures; however, these adaptations were often undocumented, reflecting a compliance-driven Safety-I mindset rather than systematic learning and anticipation [3]. Considering the South African construction industry's high employment of general workers, widespread subcontracting, and productivity pressures [7], it is crucial for managers to actively facilitate engagement, co-develop strategies with workers, and recognize successful adaptations as learning opportunities.

The diagnostic framework developed in this study (Fig. 1) provides a method for assessing how construction managers promote resilience in H&S performance. It evaluates construction management practices across four interconnected dimensions: responding, monitoring, anticipating, and learning. These dimensions are linked to leadership engagement, communication strategies, procedural oversight, and the capture of tacit knowledge, which helps managers identify both strengths and areas for

improvement. The framework facilitates proactive worker adaptations and responsive engagement, promotes continuous monitoring and daily risk discussions, and supports structured reflective sessions, while also identifying instances of limited responsiveness and absent learning mechanisms. Utilising this framework enables proactive interventions, institutionalises lessons learned, supports adaptive worker behaviours, and enhances risk anticipation in complex environments. In South African construction projects, where organisational memory is often limited, the framework promotes continuous learning, improves adaptive decision-making, and ensures safety practices evolve beyond mere compliance, fostering true resilience.

Across all sites, experienced personnel proved crucial for resilience. Their systems thinking and practical knowledge allowed managers to anticipate risks, mentor less experienced staff, and refine procedures to address real-world complexities. This expertise bridged the gap between compliance measures and the dynamic realities of construction sites, fostering collaborative problem-solving and adaptive responses to production pressures and subcontracting challenges. Recognizing and institutionalizing these successful adaptations transformed operational practices into shared organizational knowledge, enhancing overall resilience and safety performance.

Construction sites with limited Safety-II practices, especially CSC, demonstrated the risks of over-relying on compliance-focused approaches. While these sites met basic Safety-I standards through documentation and system development, the absence of reflective meetings, daily risk assessments, and learning mechanisms undermined a resilient system's essential capabilities: responding, monitoring, anticipating, and learning [3]. These findings highlight the urgent need for safety protocols that explicitly assess Safety-II enabling capacities, emphasizing managerial support for adaptation, learning, and empowerment over mere procedural compliance. This study offers valuable insights by demonstrating the application of Safety-II principles in South African construction management, providing practical guidance through a diagnostic framework and outlining a pathway for managers to transition from reactive, compliance-driven Safety-I practices to proactive, resilient safety measures.

6 Conclusion

This study explored how construction management practices influence H&S performance on construction sites, using a Safety-II perspective. The findings indicate that genuine resilience depends on dynamic practices that foster continuous learning, proactive H&S risk anticipation, and workforce adaptability, even when robust formal safety systems and visible engagement are already in place. Experienced personnel and thoughtful reflection are essential for converting tacit knowledge into organizational learning, thereby connecting compliance-driven Safety-I approaches with adaptive Safety-II practices. The study recommends that construction managers cultivate continuous risk dialogue, structured reflection, and mentorship programs to embed learning within the organization and strengthen its adaptive capacity. Furthermore, the diagnostic framework developed provides a practical means of evaluating and refining construction management practices to improve resilience. However, this research is limited by its qualitative design and single-province setting, which may limit the generalizability of the findings across South Africa. Future research should focus on validating and expanding these insights in other provinces and across diverse project types.

Author contributions
LG Mollo conceptualized the study and contributed to the draft preparation including the data collection and analysis and writing of the manuscript.

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Data availability
The original contributions presented in this study are included in the article. Further inquiries can be directed at the corresponding author.

Declarations

Ethics approval
This study received ethical approval from the Faculty of Engineering, Built Environment and Information Technology Research Committee at the Central University of Technology, and all research methods were conducted in accordance with relevant institutional, national, and international ethical guidelines and regulations under ethical clearance number FRIC 2025-07(01).

Consent to participate
Informed consent to participate in the study was obtained from all participants prior to data collection.

Consent to publish
Informed consent to publish anonymized data and findings was obtained from all participants prior to their participation in the study.

Competing interests
The authors declare no competing interests.

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