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SAFETY MANAGEMENT PRACTICES, ACCIDENT CAUSES, AND PREVENTION STRATEGIES IN BUILDING CONSTRUCTION PROJECTS: A COMPREHENSIVE REVIEW

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ABSTRACT

The construction industry plays a pivotal role in economic and infrastructural development but is a hazardous industry owing to occupational dangers. This review adopts a narrative literature approach to analyze the issues of safety management, causes of accidents, prevention measures, safety culture, and innovative technologies used in construction buildings. Management commitment, risk assessment, safety training, supervision, safety auditing, and employee participation in safety management are identified as critical elements of safety management. Human, management, workplace, equipment, environmental, organizational, and design aspects are found as major causes of accidents in the construction industry. Prevention through design, engineering control, personal protective equipment, emergency planning, root-cause analysis, and advanced technologies including BIM, artificial intelligence, computer vision, wearables, drone, and virtual reality are covered in the review. Overall, the review emphasizes that an integrated and proactive safety management approach is essential for reducing construction accidents and improving safety performance.

Keywords: *Construction Safety, Safety Management, Accident Prevention, Safety Culture, Risk Assessment, Emerging Technologies.*

1. INTRODUCTION

The construction sector plays an important role in the process of economic development, infrastructural development, creation of jobs and urbanization. On the other hand, it is a risky business as the construction site is dynamic in nature, is temporary in nature, involves labour-intensive work, many people including contractors, sub-contractors, material and machinery are involved [1]. Workers on construction sites face different types of hazards including falling from height, falling objects, electrical hazards, machinery hazards, excavation hazards, structural collapses, fires, noise, dust, vibrations, and ergonomics. ILO (2022) stressed that safety and health management is critical in all stages of construction projects.

The accidents in construction could lead to death, injuries, illnesses, delay of projects, economic losses, damage to equipment, legal issues, and loss of productivity. Past studies have proven that accidents in construction were never the result of one hazardous act or situation; instead, accidents were often due to the interactions of several factors such as management practices, worker behavior, site conditions, equipment, etc.

Figure 1: Construction Accidents [2]

Construction safety management has been moving away from a reactive approach that simply reacts to incidents to a proactive approach using techniques like hazard identification, risk evaluation, safety education, management commitment, workforce involvement, engineering control, monitoring, and continual improvement over the past years. In addition, new technologies including BIM technology, artificial intelligence, wearable technology, drones, computer vision, sensors, and virtual reality can be used to identify hazards, monitor safety, predict risks, and train workers. On this note, this review focuses on safety management practices, accident causes, safety culture and human factors, accident prevention strategies, new technologies, and future directions [3].

1.1 Research Objectives

- To look at the key safety management practices employed in construction projects of buildings, such as management commitment, risk assessment, safety training and safety monitoring.
- To determine the key causes and factors of accidents in construction projects of buildings, including human factors, management factors, worksite factors, equipment factors and organizational factors.
- To review the key accident prevention techniques and the latest technology.

2. REVIEW METHODOLOGY

This study utilized a narrative literature review method to investigate the issues of safety management, causes of accidents, safety culture, preventive techniques and new technologies in construction projects [4]. Thematic analysis of research articles, review papers and occupational safety literature was performed to highlight the safety hazards, preventive techniques, and new approaches for improving safety performance in construction projects.

3. SAFETY MANAGEMENT PRACTICES IN BUILDING CONSTRUCTION PROJECTS

Safety management in building construction is an organized approach to identifying hazards, risk assessment, hazard control, monitoring of safety performance and improvements. As building construction sites are dynamic and situations keep on changing with the phases of construction, safety management should continue until completion of the job [5]. For effective safety management, involvement of all the parties involved is needed like management, project managers, engineers, supervisors, workers, contractors, and sub-contractors.

3.1 Management Commitment and Safety Leadership

The level of management commitment is one of the key elements that affect safety at construction sites. Safety policies are set by the top level of management, which gives resources and assigns competent safety people, thus ensuring that safety is an important project goal. Good safety leadership motivates employees to adhere to safety measures and report hazards without any undue threats [6].

Management commitment is evident through the adoption of a safety policy, availability of safety resources, routine site inspections, participation in safety meetings, accident investigations and near-misses' investigations, and taking prompt measures to rectify problems. Proper management commitment will assist in cultivating a positive safety culture in construction projects.

3.2 Hazard Identification and Risk Assessment

Identification of hazards and risk assessment are core elements of construction safety management [7]. There needs to be a systematic analysis of the construction works to identify the hazards that might arise from the construction process and establish the means of controlling the hazards. The common techniques used include job safety analysis (JSA), job hazard analysis (JHA), among others.

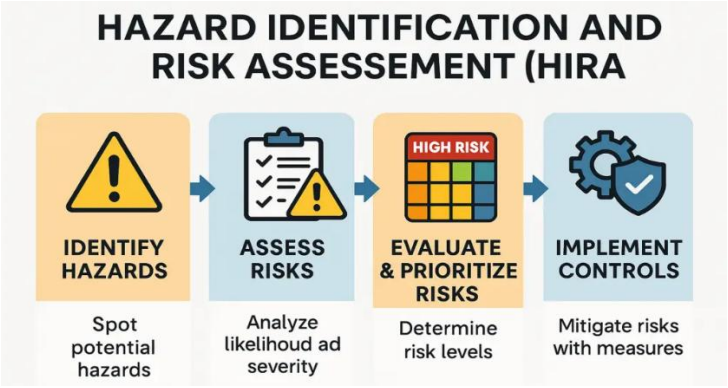

Figure 2: Hazard Identification and Risk Assessment (HIRA) [8]

Because the construction environment is dynamic in nature, risk assessment must always be updated in the case of any changes made in the method of construction, tools used, materials used, site environment, and labor. Risk assessment helps prevent accidents before they happen.

3.3 Safety Training and Competency

Adequate safety training makes sure that the workers understand the potential dangers on the job and learn how to do their jobs safely. This starts with site induction and is maintained throughout the project through refreshers and toolbox talks. Some of the important topics that must be covered are: Working at Heights Scaffolding Electrical Safety Machinery Operations Lifting Excavations PPE Hazard Reporting [9]

Training should be conducted under proper supervision, since employees should use their skills effectively under real-world conditions on the site. The combination of frequent training and supervision may increase awareness of safety concerns, eliminate unsafe actions, and enhance employee skills.

3.4 Safety Inspection and Monitoring

Conducting regular safety inspections is vital in detecting hazards prior to their causing accidents. These inspections must address scaffolding, ladders, machinery, electrical installations, lifting devices, excavation operations, housekeeping, accesses, temporary constructions, fire safety, and personal protective equipment [10].

The safety performance must be assessed by considering leading and lagging indicators. Examples of leading indicators are safety inspections, training programs, near-misses, and the closure of corrective actions. On the other hand, fatalities, injuries, lost-time accidents, and occupational diseases are examples of lagging indicators.

4. MAJOR CAUSES AND TYPES OF ACCIDENTS IN BUILDING CONSTRUCTION

Construction accidents happen due to a variety of factors that contribute both immediately and fundamentally to accidents [11]. Immediate causes of accidents can be unsafe acts and unsafe conditions, whereas fundamental causes of accidents can be inadequate management, poor planning, lack of training, production pressure, and poor communication.

Table 1: Major Causes of Accidents in Building Construction [12]

Cause category	Major factors	Common accident outcomes
Management factors	Poor safety commitment, inadequate resources, weak policies	Unsafe practices and delayed corrective actions
Worker factors	Lack of training, fatigue, unsafe behaviour, poor awareness	Falls, machinery injuries and struck-by accidents
Worksite factors	Poor housekeeping, unsafe access, inadequate lighting	Slips, trips, falls and collisions
Equipment factors	Defective equipment, poor maintenance, missing	Machinery-related injuries

	guards	
Environmental factors	Heat, dust, noise, vibration, poor visibility	Injuries and occupational illnesses
Communication factors	Poor coordination, unclear instructions, language barriers	Task conflicts and unsafe operations
Organizational factors	Weak safety culture, subcontracting, production pressure	Systemic safety failures
Design factors	Unsafe design and inadequate construction-stage planning	Hazardous work conditions

Falls from Height

Falls from roofs, scaffolds, ladders, platforms, formwork, uncompleted floors, and unprotected openings are some of the most serious construction risks [13]. These may be attributed to a lack of guardrails, unstable scaffolds, edge protection, openings and unsuitable fall protection.

Struck-by and Falling-object Accidents

Employees may get injured from construction materials, tools, vehicles, cranes, loads in suspension, and moving machinery. Such accidents can be minimized by implementing exclusion zones, safe storage of materials, traffic control, lifting procedures, and adequate supervision [14].

Caught-in and Caught-between Accidents

Employees can get themselves stuck between the machinery and other equipment, structures, excavations, or collapsing loads. Proper machine guarding, equipment isolation, working distances, and supervision can prevent such injuries.

Electrical Accidents

Electrical hazards may result from faulty wiring, damaged electrical wires, lack of grounding, overloading of circuits, moisture, and exposure to overhead power lines. Proper installation, checking, grounding, isolation, and training of workers is therefore very necessary.

Machinery and Equipment Accidents

Injuries due to heavy equipment include those caused by overturns, collisions, entanglement, malfunctions, and inappropriate usage of the equipment. It is essential to practice routine maintenance, operator proficiency, equipment examination, use of alarms, visibility controls, and segregation of pedestrians [15].

5. SAFETY CULTURE, HUMAN FACTORS, AND WORKER PARTICIPATION

A safety culture represents the collective attitudes, values, beliefs, and behavior related to safety in an organization [16]. A good safety culture can be said to exist if the safety of people is viewed as an intrinsic value and not merely a legal mandate of the organization. For a construction project, a good safety culture would involve people being able to identify dangers, adhere to procedures, report on any safety issues, and avoid accidents. The management plays a critical role in building this kind of safety culture.

The human factor is another source of construction safety. Being tired, lack of training, distraction, bad communication, inexperience, taking risks, and ignoring procedures can all be contributing to unsafe behavior. Nonetheless, these elements should not be regarded solely as an indication of failure on the part of individual employees. They are usually affected by the organizational environment characterized by overworking, production pressure, lack of supervision, poor job planning, and lack of rest. Thus, safety management should take into account both individual behavior and the environment in which it operates [17].

Worker participation can enhance safety management in that the workers have firsthand experience regarding the hazards in the workplace, problems experienced, and the unsafe situations. The workers should thus be encouraged to take part in tool box talks, risk assessments, safety inspections, reporting of hazards, reporting of near misses, and

accident investigations. Their involvement can improve communication, increase hazard awareness, and encourage greater ownership of safety practices.

The key features that contribute to a positive safety culture in construction sites are:

- High commitment to worker safety by management.
- Safety communication among management, supervisors and employees.
- Worker involvement in safety actions.
- Provision of training and skill development.
- Enforcement of safety measures.
- Hazard and near-miss reporting without penalty.

Another factor that is critical for construction site safety is the involvement of different subcontractors [18]. Various subcontractors might be having different safety procedures, varying in terms of their training, experience, and organizational culture. Inconsistency among subcontractors might give rise to conflicting work practices and more risks. Hence, principal contractors must ensure that there is a common safety procedure for all subcontractors and proper coordination exists.

6. ACCIDENT PREVENTION AND SAFETY IMPROVEMENT STRATEGIES

Prevention of accidents is an integral part of construction site safety management, which should address the identification of risks and control of risks prior to causing any harm or damage [19]. The hierarchy of controls can be used as a systematic way of choosing preventive methods, with more attention being paid to the elimination or reduction of hazards at the source rather than to individual behavior and use of personal protective equipment (PPE).

Table 2: Construction Accident Prevention Strategies [20]

Prevention level	Main strategy	Examples in construction
Elimination	Remove the hazard completely	Prefabrication and off-site assembly
Substitution	Replace hazardous methods/materials	Use safer materials or equipment
Engineering control	Physically isolate workers from hazards	Guardrails, barriers, machine guards
Administrative control	Modify work procedures	Training, permits, scheduling, supervision
PPE	Protect workers from residual hazards	Helmets, gloves, safety shoes, harnesses

6.1 Prevention Through Design

Safety must be taken into account right at the start of designing and planning the construction project and not just when the construction work commences. Safety is possible if one takes into account safe access, structural stability, prefabrication, temporary works, material handling, construction sequence, and maintenance requirements [21].

The concept of prevention through design is especially relevant since prevention of a hazard or risk at the design stage proves to be much more efficient than controlling a hazard at a later stage when construction work has already commenced. Safety considerations early on in the process can minimize the complexity of controls and increase construction efficiency.

6.2 Engineering Controls

Engineering controls offer physical barriers between the worker and the hazard and are usually more effective compared to relying on worker behavior alone. Engineering controls are especially necessary in risky construction activities such as working at heights, operating machinery, handling materials, and being exposed to dust or harmful substances.

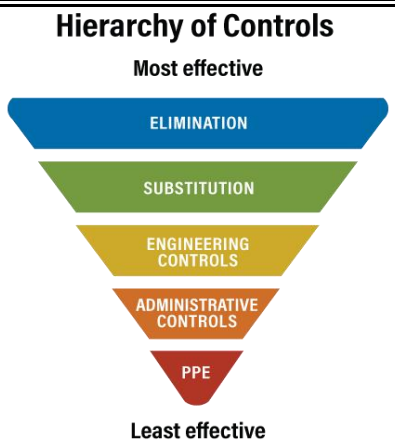

Figure 3: Hazard and Risk - Hierarchy of Controls [22]

Engineering controls such as guard rails, safety nets, toe boards, machine guards, barriers, edge protection, mechanical lifting devices, dust collection systems, and ventilation are common. If engineering controls are properly designed, they can help protect workers from any hazard by reducing their exposure.

6.3 Personal Protective Equipment

Personal protective equipment offers protection from hazards which cannot be entirely removed by other means. Personal protective equipment used on construction sites includes safety helmets, safety footwear, gloves, eye and face protection, hearing protection, respiratory protection, high visibility clothing, and fall arrest systems [23].

Nonetheless, PPE is to be seen as the last resort in safety measures rather than the main means of dealing with hazards. The efficiency of PPE largely depends on its proper choice, fitting, checking, maintaining, replacing, and training of the employees. Moreover, supervisors should also make sure that employees wear PPE properly.

6.4 Emergency Preparedness

Even with proper preventative measures in place, construction projects must always be ready to deal with any emergency situations that may arise. This is known as emergency planning, and it entails setting up procedures that would be followed in case of any emergencies. These include fires, collapses, electric shocks, injuries, chemicals, extreme weather conditions, and evacuations.

There should be appropriate first-aid provisions, emergency provisions, communication facilities, trained staff, emergency contact numbers, and designated assembly points in construction sites. Conducting emergency drills may assist employees to know their roles and increase efficiency of emergency actions.

6.5 Accident Investigation and Root-Cause Analysis

Investigation of any accident needs to take into consideration not only the immediate causes of the accident but also the underlying causes that may have led to the occurrence of the accident. This investigation needs to analyze the situation surrounding the accident, the danger involved, whether adequate training and supervision were provided, how effective the safety measures were and the measures that need to be taken to ensure that similar accidents do not occur in the future.

7. EMERGING TECHNOLOGIES IN CONSTRUCTION SAFETY MANAGEMENT

Safety management in building construction through digital technology is becoming popular in the sense that it can enhance hazard detection, monitoring, training, communications and risk prediction [24]. The Building Information Modelling (BIM) approach can be used in ensuring that safety issues are considered during project planning and sequencing, thus facilitating the identification of hazards, spatial conflicts, access difficulties and temporary work issues even before construction starts. Likewise, use of artificial intelligence (AI) and computer vision can be effective in identifying hazardous working environments such as absence of personal protective equipment, proximity hazards, entry into forbidden zones and many more.

Additional possibilities for real-time monitoring include wearables, drones, sensors, and IoT solutions. Wearables can track the worker's location and proximity to dangerous zones, whereas drones can inspect roofs, building façades, structures, and hard-to-reach places without putting workers into unnecessary danger. Sensory and IoT devices can monitor conditions of the environment and equipment. Moreover, virtual and augmented reality can be utilized for providing realistic simulations for working at heights, equipment use, emergencies, and other types of activities.

Table 3: Summary of Literature on Digital Technologies and Safety in Construction [25]

Reference	Focus of Study	Key Findings
Alizadehsalehi et al. (2020) [26]	BIM–UAV integration for construction safety	BIM and UAV integration improves safety monitoring, hazard identification, and decision-making.
Aljibori et al. (2023) [27]	Corrosion protection coatings	Advanced coatings improve material durability and reduce structural deterioration.
Li et al. (2018) [28]	VR/AR applications in construction safety	VR and AR support safety training, hazard visualization, and risk awareness.
Ghobakhloo et al. (2025) [29]	Industry 4.0 digital transformation	Digital technologies improve information sharing, monitoring, coordination, and decision-making.

Though promising, new technology must be a tool to assist management commitment, skilled supervision, engineering controls, employee education, and employee participation [30]. It requires proper application, accurate data, employee acceptance, cost-effectiveness, privacy protection, and integration with current construction site safety management systems.

8. CONCLUSION

This review indicates that construction safety is determined by many interconnected factors relating to management, human factors, worksite, machinery, environment, organizational, and design aspects. In order to achieve safety management successfully, a construction site should be managed through strong commitment on the side of management, hazard and risk assessment, training, supervision, inspection, participation of workers, and monitoring activities. Construction accident prevention will be enhanced through design for safety, engineering and administrative measures, right PPE, emergency planning, and root cause analysis. New technologies like BIM, artificial intelligence, computer vision, wearable technology, drones, virtual reality, and IoT can also help with pro-active hazard detection, monitoring, training, and risk prediction. In general, the combination of organizational commitment, worker engagement, risk management, continuous improvement, and technological support is vital for successful construction safety management.

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