STM JOURNALS

Journal of
Industrial Safety Engineering

ISSN: 2395-6674
Volume 12, Issue 2, 2025
May–August
DOI (Journal): 10.37591/JoISE

https://journals.stmjournals.com/joise

Research JoISE

Identification of Hazards and Evaluation of Risks in Flyover Construction Site

Sourabh Jain[1,*], Hitesh Garg[2], Nitesh Parmar[2], Nitin Kumar Mogia[2], Pankaj Baghel[2], Rohit Singh[2], Ashwani Kumar[2]

Abstract

Indore, a rapidly growing city in Madhya Pradesh, India, faces significant traffic congestion challenges. Constructing flyovers has been suggested as an effective measure to resolve this problem. This project of Reti mandi flyover which is 1199.65 long and 37 km wide having six lanes. This review aims to evaluate the feasibility and sustainability of flyover construction in Indore, considering urban infrastructure development, traffic management, environmental impact, and socio-economic factors. The construction of flyovers, while essential for improving traffic flow and reducing congestion, presents numerous hazards and risks, particularly in rapidly urbanizing cities like Indore. As a key infrastructure project, flyover construction involves complex processes that span multiple phases, including excavation, piling, superstructure development, and finishing work. Every phase of construction presents distinct risks to workers, nearby communities, and existing infrastructure. In Indore, one of the fastest-growing cities in India, the increasing demand for improved transportation infrastructure has led to the proliferation of flyover construction projects. These large-scale undertakings, however, are often accompanied by safety challenges due to dense urban environments, fluctuating weather conditions, high traffic volumes, and a variety of stakeholders involved. The objective is to identify the risks associated with the installation of steel box girders, assess their severity, and determine appropriate control measures to manage these risks effectively. Starting from identifying ha9zards at each stage of the work activity, a risk assessment is carried out, the results of which can be used as a reference for risk control, to reduce the risk of work accidents.

Keywords: Flyover, construction risk, risk matrix, superstructure development, worker safety construction management, job safety analysis

***Author for Correspondence**
Sourabh Jain
E-mail: sourabhjainft@ipsacademy.org

[1]Assistant Professor, Fire Technology and Safety Engineering Department, Indore Professional Studies Academy, Institute of Engineering & Science (Affiliated to Rajiv Gandhi Proudyogiki Vishwavidyalaya), Indore, Madhya Pradesh, India
[2]Student, Fire Technology & Safety Engineering Department, Indore Professional Studies Academy, Institute of Engineering & Science (Affiliated to Rajiv Gandhi Proudyogiki Vishwavidyalaya), Indore, Madhya Pradesh, India

Received Date: March 24, 2025
Accepted Date: April 30, 2025
Published Date: May 05, 2025

Citation: Sourabh Jain, Hitesh Garg, Nitesh Parmar, Nitin Kumar Mogia, Pankaj Baghel, Rohit Singh, Ashwani Kumar. Identification of Hazards and Evaluation of Risks in Flyover Construction Site. Journal of Industrial Safety Engineering. 2025; 12(2): 17–26p.

INTRODUCTION

Flyovers play a crucial role in easing traffic congestion, shortening commute times, and improving overall road safety. However, their construction demands thorough planning, taking into account factors such as terrain, soil characteristics, and environmental impact. This presentation focuses on a case study from Indore City, showcasing the approaches used, key outcomes, and their relevance to future infrastructure projects. A significant part of the study involves identifying potential hazards during the installation of steel box girders, evaluating the severity of these risks, and outlining effective strategies for mitigating them during construction. The construction of flyovers, while essential for improving traffic flow and reducing congestion, presents numerous hazards and risks, particularly in rapidly urbanizing cities like Indore. As a key infrastructure project, flyover construction involves complex processes that span multiple phases, including excavation, piling, superstructure development, and finishing work. Each stage introduces a unique set of risks to workers, the public, and surrounding structures. In Indore, one of the fastest-growing cities in India, the increasing demand for improved transportation infrastructure has led to the proliferation of flyover construction projects. These large-scale undertakings, however, are often accompanied by safety challenges due to dense urban environments, fluctuating weather conditions, high traffic volumes, and a variety of stakeholders involved [1–4].

Flyovers, also known as overpasses or elevated road bridges, are structures designed to span across roads or railways, primarily to ease traffic congestion in busy urban areas or intersections. While both bridges and flyovers serve the purpose of providing a route over obstacles without interrupting the flow below, they differ in terms of their function and placement. A bridge typically connects two distinct points separated by natural features such as rivers, valleys, or seas. In contrast, a flyover is constructed to improve traffic movement within densely populated or high-traffic zones [5–9].

The construction of flyovers must be approached with consideration for sustainable development practices to minimize environmental and social consequences. Key environmental aspects that should be assessed include air, water, and soil quality, as well as noise pollution. From a socio-economic perspective, potential negative impacts may include a decline in commercial land value due to business disruptions, increased noise and disturbances during construction, and an elevated risk of accidents for residents in nearby areas [10–15].

To minimize these impacts, it is crucial for construction workers to comply rigorously with health and safety protocols. Comprehensive training on safety practices related to equipment handling, material use, and working hours is crucial to ensure that workers are not subjected to excessive labor and remain safe on the job. Additionally, ensuring the well-being and fair treatment of workers should be a core part of the project planning process.

AREA OF STUDY

Industry Overview

The flyover construction industry is a specialized branch of the broader civil construction sector, primarily dedicated to the design, planning, and development of elevated roadways, overpasses, and bridges. These structures, often referred to as flyovers or viaducts, are built to allow roadways to cross over physical barriers such as highways, railway tracks, rivers, or uneven terrain. This sector is crucial in developing efficient urban transportation systems, alleviating congestion, and improving travel safety. Given the rising need for advanced and eco-friendly transport systems, the flyover construction industry continues to evolve, driven by engineering innovations and modern construction technologies [16–18].

Historical Background

The origins of elevated road structures can be traced back to ancient times, with historical evidence of bridge and overpass-like systems in civilizations such as those in Greece, Rome, and China. However, the concept of the modern flyover began to emerge in the mid-1900s, coinciding with the introduction of innovative building materials and engineering methods. One of the earliest contemporary flyovers was constructed in the United States during the 1940s. Since then, the adoption of flyovers has expanded globally, becoming a staple in urban infrastructure to manage growing traffic demands [18].

TYPES OF FLYOVER BRIDGES

Road Crossing Flyover

This type of flyover is engineered to streamline the flow of high-volume traffic by elevating it above intersecting roads. Lower-traffic routes are routed beneath the structure, improving overall efficiency. Access to the elevated section is typically facilitated by ramps on either side, enabling vehicles to merge onto the flyover safely and seamlessly.

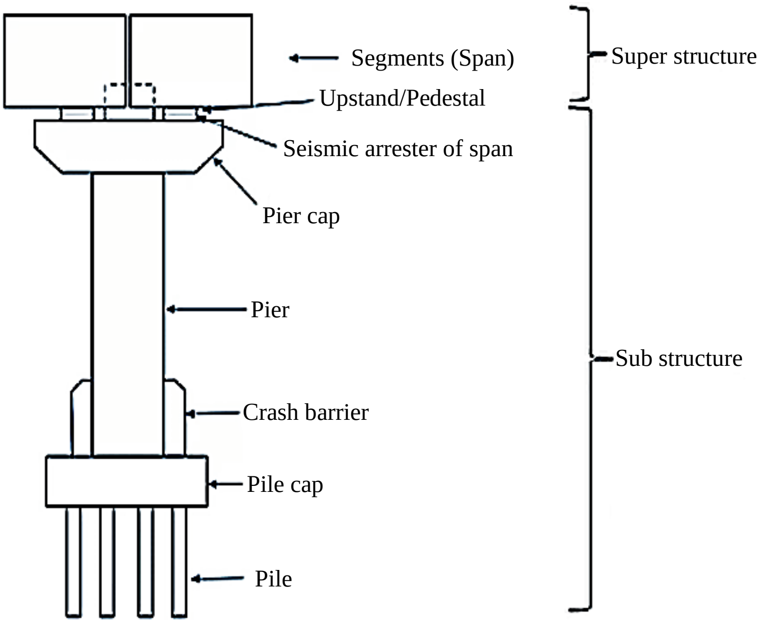

Figure 1. Structure of flyover.

Railway Crossing Flyover

In cases where railway crossings experience high volumes of both train and road traffic, the construction of a flyover becomes essential to keep the traffic moving efficiently and safely. By building the flyover alongside the road, it allows the main traffic to continue moving uninterrupted while trains pass by (Figure 1).

FLYOVER CONSTRUCTION

The transportation challenges are faced by cities globally. It then explores the Singapore model, where effective land transport policies have facilitated the development of an efficient and extensive transport network. Following this, the study discusses urbanization in India and the country's urban transport policy. Construction sites generally fall into two categories: underground and elevated flyovers. In underground metro systems, work is carried out below ground level, whereas elevated metro systems are constructed above ground level. Underground metro is preferred when there is a high population density and heavy traffic congestion. However, the cost of constructing underground flyovers is significantly higher compared to elevated ones. Elevated projects present a higher risk for personal injuries and hazardous occurrences, making health and safety management a top priority on construction sites. Hazard Identification and Risk Assessment are crucial steps in construction safety management, as unaddressed risks often lead to the most difficult and dangerous situations.

How Flyover is Constructed and What Procedure is Followed

A flyover is constructed by first conducting thorough site surveys and designing the structure, followed by building the substructure (piers and foundations) and then the superstructure (the deck and girders) on top, typically using precast concrete segments that are lifted into place and connected together; the entire process involves site preparation, excavation, foundation construction, pier erection, deck placement, and finishing touches like road surfacing and barrier installation.

Key Steps in Flyover Construction

Soil Investigation

Before the commencement of any type of construction, the soil investigation is a crucial pre-construction process. It is necessary to know the soil and rock properties at the place of construction to avoid any construction failure. The soil investigation is primarily done to determine the water levels, soil's bearing capacity, composition, and stability.

These are determined through various methods which involve drilling boreholes, taking soil samples, and performing tests. This data assists the engineers in determining the suitable foundation design that can support the bridge's weight and withstand environmental forces.

Design and Environmental Assessment

When the soil report is ready, the immediate initial step is Detailed Design. In this process, engineers and other professionals involved in the project focus on detailed plans and specifications for the bridge. This includes structural calculations, materials selection, and construction methods. The functioning of the bridge under various conditions is frequently simulated through the use of various advanced software and modelling tools to make sure the design is safe and secure.

Environmental Assessment

Construction of big infrastructures like bridges just does not impact the area of construction but it also impacts the surroundings. The environmental assessment is conducted to study the potential impact of construction on flora, fauna, and the overall ecosystem in the area of construction.

Site Investigation and Planning

- Topographic survey to understand the terrain.
- Geotechnical analysis to assess soil conditions and determine suitable foundation types.
- Traffic studies to identify traffic patterns and design the flyover accordingly.
- *Design phase:* Creating detailed plans for the flyover structure, including the substructure (piers and abutments) and superstructure (deck and girders).

Site Preparation

- Clearing the construction area.
- Utility relocation if necessary.
- Excavation for foundations.

Substructure Construction

- *Foundation construction:* Depending on soil conditions, this could involve pile foundations, caissons, or raft foundations.
- *Pier construction:* Erecting vertical piers to support the superstructure, often using precast concrete segments lifted into place (Figure 2).

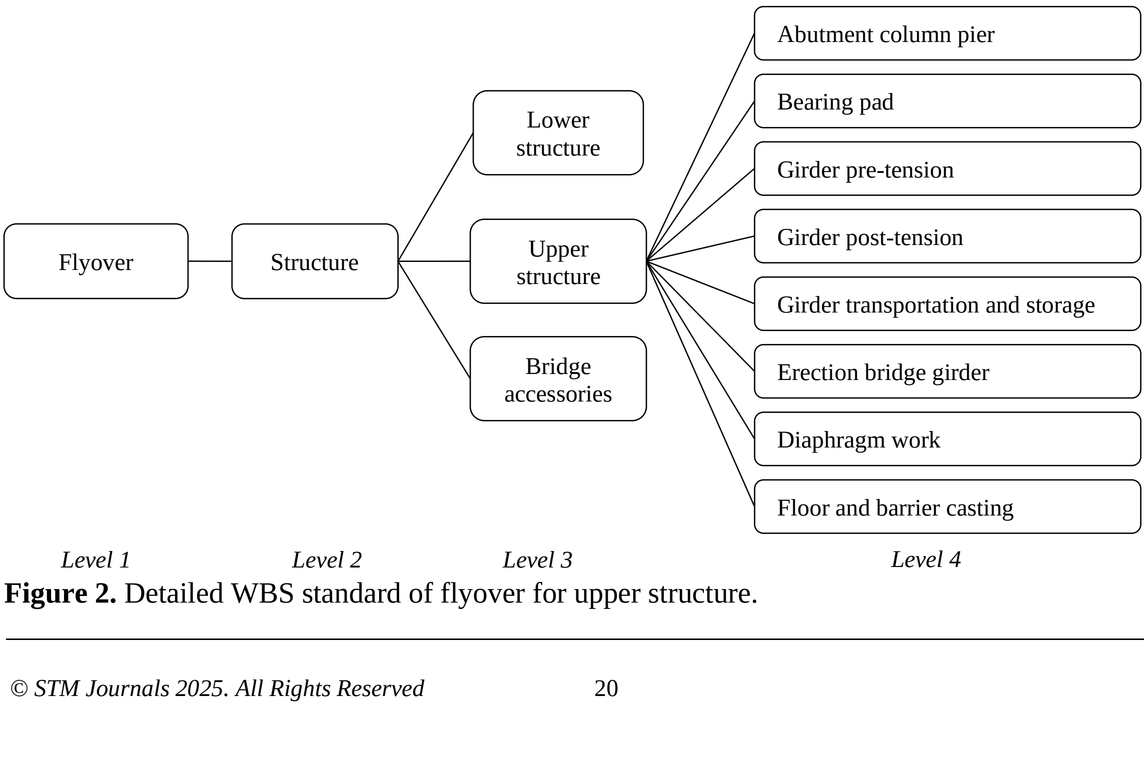

Figure 2. Detailed WBS standard of flyover for upper structure.

Divisions of Industry

- *Division 1:* General,
- *Division 2:* Drainage,
- *Division 3:* Earth works,
- *Division 4:* Pavement widening and shoulders,
- *Division 5:* Concrete powder and concrete cement,
- *Division 6:* Asphalt pavement,
- *Division 7:* Structure,
- *Division 8:* Toll facility services, and
- *Division 9:* Restoration.

RETI MANDI FLYOVER

The Reti Mandi railway overbridge in Indore, India is being built by the Public Works Department (PWD). The bridge is being constructed at the Reti Mandi railway crossing on the Indore-Mhau rail line (Figures 3 and 4).

Figure 3. Reti Mandi Flyover overbridge construction.

Figure 4. Installing steel box girder.

Details of the Reti Mandi railway overbridge:

- The overbridge will be built at the railway crossing near Rajendra Nagar, Indore.
- The overbridge will be an RCC-T beam bridge.
- The overbridge will have an open foundation ramp portion with an RE wall.
- The overbridge will be 1199.65 m long and 37 m wide.

PROBLEM FORMULATION

Legal Parameters

The recurring collapse of bridges and flyovers in India highlights the need for a comprehensive framework to address the underlying causes and mitigate future risks. The problem can be formulated as follows.

Primary Objective

Develop an integrated approach to enhance the resilience of Indian bridges and flyovers, ensuring public safety, minimizing economic losses, and promoting sustainable urban infrastructure development.

- *Incident 1:* Kolkata Flyover Collapse (2016)
- *Location:* Vivekananda Road Flyover, Kolkata, India
- *Date:* September 4, 2016

Overview of the Flyover Project

The Vivekanand Flyover, a 2.5-km-long elevated roadway, was initiated under the Jawaharlal Nehru National Urban Renewal Mission with the intention of alleviating heavy traffic congestion in the Burra Bazar area, one of Asia's largest wholesale market zones, extending toward Howrah Station, a major city transit hub. Designed with two composite carriageways, the flyover comprises reinforced concrete slabs supported by steel plate girders, which in turn rest on steel piers spaced along the structure's length.

Although the foundation stone for the project was laid in 2008, actual construction began on February 24, 2009, with an estimated budget of ₹164 crore. Initially planned for completion by 2012, the project faced significant delays due to challenges in acquiring land and financial constraints encountered by the executing agency.

Structural Failure Investigation

Due to the unavailability of detailed engineering drawings, including dimensions and structural connection specifications, the investigation into the flyover's collapse had to rely heavily on photographic evidence shared through platforms such as the SEFI (Structural Engineers Forum of India). A close examination of these images reveals that the structural failure likely originated from an unusual joint configuration at Pier 40(C), where cantilevered beams were installed. The images display torsional deformation in the steel plate girders positioned above the cantilevered beams, suggesting that the collapse might have resulted from lateral torsional buckling, possibly due to insufficient bracing of the girder's top flanges.

Current Research Focus

The current study adopts a descriptive research approach and is primarily based on secondary data sourced from institutional records, government reports, websites, news articles, books, and magazines. The core objective of this research is to identify, understand, and mitigate potential hazards associated with flyover construction, thereby contributing to safer infrastructure development practices.

Research Gape between existing work and proposed work

Our proposed idea is to work on a tool for managing the hazards that took place when installing steel box so as to provide effective and efficient response against the hazards happening in flyover construction. This will reduce the impact of hazards on infrastructure or roads and also will help to reduce accidents due to overloading of goods and most importantly will save human lives by preventing accidents that are happening these days due to rush on roads traffic and alleviate the traffic congestion.

MATERIALS AND METHODOLOGY

Materials Used in Flyover Construction

Concrete

Concrete is a widely utilized composite material in construction, composed of cement, aggregates (such as sand or gravel), and water. It provides excellent compressive strength, making it essential for various structural components of flyovers.

- *Precast concrete:* Manufactured off-site in controlled environments, precast components guarantee consistent quality and speed up the on-site assembly process.
- *Reinforced concrete:* Steel reinforcement bars (rebar) are embedded in concrete to enhance its tensile strength and durability, preventing cracks and improving its overall resistance.

Steel

Steel is integral to the superstructure of flyovers, particularly in load-bearing parts like girders and beams. It is highly valued for its strength, flexibility, and performance under different stress conditions.

- *Steel girders and beams:* These elements are responsible for supporting the weight of the structure and vehicular loads, making them crucial for the flyover's integrity.
- *Anti-corrosion treatments:* Steel components are treated with protective coatings to prevent rust, particularly in humid or coastal environments, ensuring a longer lifespan.

Reinforcement Bars (Rebar)

Rebars are used to counteract the weakness of concrete in tension. Placed strategically within the concrete, they allow the structure to handle both compression and tension forces effectively.

- *Types of rebar:* The most common type is standard carbon steel; however, for more aggressive environments, such as coastal regions, epoxy-coated or stainless-steel rebars are preferred.
- *Role in structures:* Rebars enhance the structural capacity of concrete, enabling it to withstand dynamic and static loads over time.

Bitumen and Asphalt

These materials are used to create the top surface layer on flyover decks, providing a smooth and durable driving surface.

- *Performance benefits:* Asphalt helps reduce surface vibrations and cracking, offering a smoother and more comfortable driving experience.
- *Maintenance:* While periodic resurfacing may be necessary, asphalt remains a cost-effective and low-maintenance option.

Composite Materials

Fiber-reinforced polymers (FRP) and other composites are gaining popularity due to their excellent strength-to-weight ratio and corrosion resistance.

- *Advantages:* These materials are lightweight yet durable, making them ideal for environments exposed to corrosion, such as coastal or industrial areas.
- *Applications:* Composites are used in bridge decking and as additional reinforcement elements, enhancing structural performance without adding significant weight.

Pre-Stressed Concrete

This method involves pre-tensioning steel tendons within the concrete to counteract stresses that occur during use.

- *Structural advantages:* Pre-stressed concrete controls cracking and increases load-bearing capacity, making it ideal for long spans.

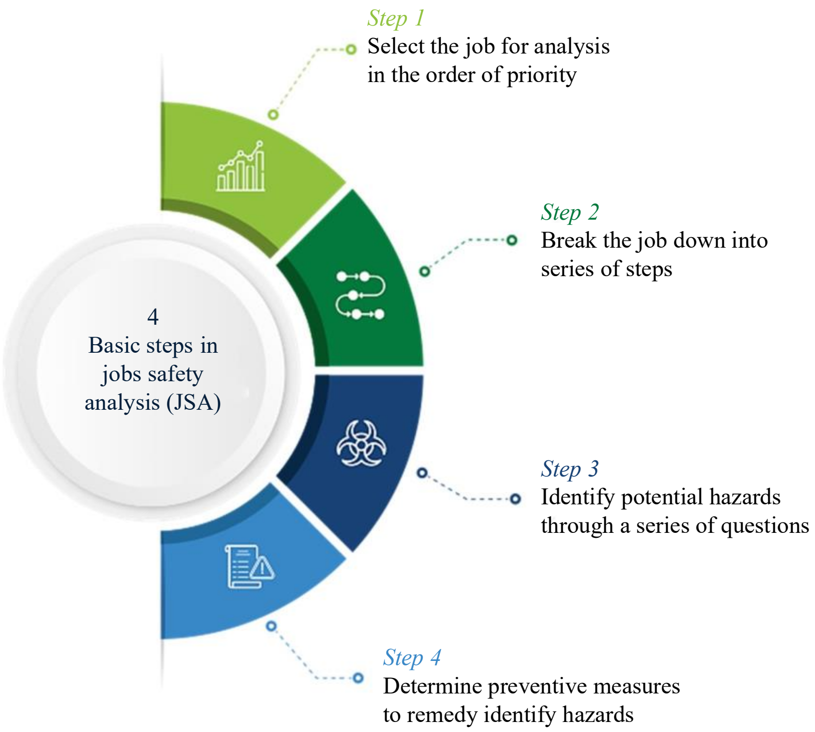

Figure 5. Steps of job safety analysis.

- *Applications:* Pre-stressed concrete is commonly used in flyover beams, girders, and deck slabs, where strength and durability are paramount.

Methodology

Job Safety Analysis (JSA)

Job Safety Analysis (JSA) is a systematic approach used to identify and manage workplace hazards associated with specific tasks. It improves safety by breaking down each job into individual steps, evaluating potential risks, and implementing preventive measures to ensure worker safety (Figure 5).

Key Steps in JSA

1. *Select the job task:* Identify high-risk jobs or tasks that require analysis.
2. *Break down the job into steps:* Divide the task into smaller sequential steps.
3. *Identify hazards:* Determine potential risks at each step (e.g., falls, burns, chemical exposure).
4. *Implement control measures:* Develop safety procedures, use PPE, and eliminate hazards.
5. *Review and update:* Continuously improve and update the JSA as needed.

Benefits of JSA

- Enhances workplace safety and reduces accidents.
- Helps in compliance with safety regulations.
- Improves worker awareness and training.
- Increases efficiency by streamlining tasks.

JSA is widely used in industries such as construction, manufacturing, and oil and gas to ensure a safer working environment.

OBSERVATION AND RESULT SUMMARY

Risk in a project is a measure of the opportunities and consequences of not achieving predetermined project targets. In analyzing the risk factors that occur, is based on the result of observations and includes stakeholders and experts. Risk analysis is based on three impact parameters including economic, environmental, and social. Meanwhile, other research related to risk analysis in construction activities is more dominant in risk analysis researches on worker safety. As the results of measurements, various risks are identified as a result of flyovers construction during the construction phase. Risks are categorized into three parts, namely risks to the physical environment which include groundwater and air, economic risks which include the household economy and the economy of the affected area, social risks which include comfort, safety, and aesthetics. Risk assessment of construction activities can help decision-makers identify major impact factors and make friendly construction plans for environmental, social, and economic factors in the early stages of construction. The impact of construction activities on road infrastructure development activities varies greatly. This depends on the construction technique and the material used for construction. Analysis of the impact's distribution and the level of impact will help to determine the steps to be taken as well as the utilization of existing resources and energy. During the study conducted at the flyover construction site in Indore, several observations were made regarding workplace safety, hazard occurrence, and risk levels. The key observations include:

Common hazards Identified:

- Falling from height due to inadequate safety measures.
- Electrocution hazards from exposed or improperly managed electrical equipment.
- Heavy machinery movement posing collision risks.
- Slips, trips, and falls caused by uneven surfaces and construction debris.
- Material handling risks due to improper lifting techniques and lack of PPE.

CONCLUSION

The foundation of ensuring workplace safety and preparing for emergencies begins with identifying and analyzing potential hazards. While ideally all hazards should be addressed, limitations in resources often prevent this from happening simultaneously. Therefore, hazard identification and risk assessment play a critical role in setting priorities: focusing first on high-risk scenarios, while less urgent or unlikely threats can be managed over time.

The research highlights that systematic approaches are commonly applied in assessing risk, utilizing methods such as brainstorming sessions, safety checklists, and adherence to occupational health and safety regulations. In the context of Indian construction sites, two of the most significant hazards identified are working at heights and manual material handling.

Various communication tools are used to convey risk information on construction sites. These include toolbox talks, site meetings, visual aids like posters, and informal conversations. Key personnel such as safety committees and gang supervisors are central to ensuring that safety messages are delivered effectively. However, the study also found that conflicts can arise, particularly when there is a disconnection between health and safety efforts and the goals related to quality and productivity, often due to hierarchical power dynamics.

Personal Protective Equipment (PPE) is a primary method of risk control on most construction sites. The study noted that PPE was generally available, although its effective use depends on proper implementation and oversight. Legal frameworks were also found to play a crucial role in how risks are assessed, communicated, and managed. These regulations often mandate controls for common hazards like falls from height, and require clear communication of risks to workers, along with the provision of necessary PPE.

Additionally, external enforcement mechanisms, such as routine inspections, penalty systems, and compliance certification, were observed to significantly influence how construction companies manage risk. A company's internal safety culture is another key factor; firms that prioritize safety tend to consider health and safety expertise during recruitment of site managers and safety officers, and they are more likely to invest in resources like training and protective equipment for their workers.

The experience and educational background of site workers also impact how risks are evaluated and managed. Seasoned workers and those with safety training are often more effective in recognizing and addressing hazards. Furthermore, the layout and size of the construction site, its geographic location, work procedures, and the composition of the workforce all contribute to how safety is handled on-site. Finally, several barriers to effective safety risk management were identified. These include limited public knowledge about safety regulations, insufficient funding and personnel, gaps in regulation coverage, complex project designs, challenges in procurement processes, and overall low levels of education among site workers. Site layout and physical location also add complexity to managing safety effectively.

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