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EVALUATION OF WORKER'S SAFETY IN BRIDGE CONSTRUCTION

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Abstract - *Bridges play a crucial role in transportation infrastructure by enabling the efficient movement of both people and goods. The construction of bridges presents significant safety and health hazards for the workers involved. The research aims to conduct a comprehensive examination and evaluation of the safety of construction workers who are specifically engaged in bridge construction projects. The goals include researching safety issues, legal provisions, assessing safety measures, analyzing technologies, and determining the most effective safety technology. The study draws on primary data from surveys, interviews, and on-site observations, as well as secondary data from accident histories and safety records. Recommendations will be adapted with an emphasis on on-going evaluation and adaption of safety practices to maintain a safer work environment.*

Key Words: **Bridge construction, Worker's safety, Hazards, Fatalities, Safety measures, Employee satisfaction.**

1.INTRODUCTION

Bridge construction is a demanding industry that involves heavy gear, dangerous terrain, and heights. Employees are at risk of falls and structural collapses. To safeguard employee safety and guarantee project success, an effective safety culture must be established. Considering building bridges involves high-risk tasks and intricate challenges, worker safety is crucial. Effective safety regulations, ongoing training, supervision, and appropriate safety equipment, such as fall protection systems and personal protective equipment, are necessary to create a safe work environment in the building of bridges. Risks such as operating machinery near roadways or in small areas require to be addressed to employees. Placing a high priority on worker safety lowers costs and increases productivity by reducing accidents, injuries, and fatalities. It promotes a positive atmosphere at work, raising employee satisfaction and retention.

2. AIM AND OBJECTIVE

The objective of this study focuses on understanding and addressing the safety concerns of workers involved in building bridges. It involves looking into the laws and regulations concerning worker safety and assessing how well safety measures are being implemented during different stages of construction. Additionally, the study examines various technologies that could enhance safety for workers throughout the bridge-building process.

3. METHODOLOGY

The methodology for assessing and improving safety practices in bridge construction involves three main steps: data collection, case study analysis, and training recommendations.

Firstly, data collection involves gathering primary and secondary data sources. Primary data sources include surveys, interviews with workers and supervisors, and on-site observations to understand current safety practices and challenges.

Secondly, conducting a case study involves assessing the construction site's current safety policies and practices. This includes evaluating compliance with safety regulations, guidelines, and industry standards.

Finally, training recommendations are developed based on the findings from the data collection and case study analysis. These recommendations are tailored to the specific circumstances of the construction project, considering factors such as location, design, materials, and other relevant variables affecting safety.

4. LITERATURE REVIEW

4.1 SAFETY & HEALTH FOR CONSTRUCTION WORKERS IN BRIDGE CONSTRUCTION

Ensuring safety and health for construction workers in bridge construction in India involves adherence to regulations, comprehensive training, and provision of personal protective equipment (PPE). Measures such as fall protection, scaffolding safety, and regular equipment maintenance are crucial. Emergency response plans, weather considerations, and promoting health and hygiene further contribute to worker well-being. Safety inspections, noise control, and establishing safety committees are vital for identifying and addressing hazards. Additionally, prioritizing worker welfare by providing fair wages, insurance, and healthcare access fosters a safe and supportive work environment.

4.2 LAWS AND REGULATIONS TO GOVERN SAFETY IN THE CONSTRUCTION SECTOR

`	LAWS `	DESCRIPTION	PUNISHMENT
1	Factories Act (1948)	*Measures related to working hours, overtime, breaks, annual leave, and the employment*	Two years in imprisonment and a fine of up to Rs. 2 lakhs
2	Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act (1996)	To provide necessary *protective equipment and training*	Punished by a fine of up to two thousand rupees or a sentence of jail that can last up to three months
3	The Contract Labour (Regulation and Abolition) Act (1970)	*Ensure certain rights for contract laborers*	Imprisonment for a term which may extend to three months, or with fine which may extend to one thousand rupees
4	The Indian Electricity Rules (1956)	*Measures related to working hours, overtime, breaks, annual leave, and the employment*	The penalty for most offenses is a fine which may extend to three hundred rupees.
5	Building and Other Construction Workers' Welfare Cess Act (1996)	*Fund initiatives such as health care, education, housing, and social security.*	

Table -1: Laws and regulation

5. NET CASE STUDIES

5.1 Natham flyover collapse

On August 2021, tragedy struck during the construction of a flyover as part of the Madurai-Natham National Highways project in India. A section of the flyover between Pandiyan Hotel junction and Chettikulam collapsed, claiming the life of one worker and injuring another. The incident occurred due to a fault in the hydraulic cables while workers were fixing bearings between precast concrete segments. Despite efforts to warn, one worker, Aakash Singh from UP, suffered serious injuries and was hospitalized. Poor maintenance of construction equipment played a significant role in the accident. Various factors such as construction defects, substandard materials, lack of maintenance, inadequate oversight, human error, and insufficient risk assessment contributed to the tragic event. This incident underscores the critical importance of adhering to safety standards and implementing rigorous maintenance practices in construction projects to prevent such disasters.

Fig 1: Natham flyover collapse

5.2 Koilldam bridge collapse

On January 2022, a section of a new bridge being constructed over the Kollidam River near Anaikkarai in Thanjavur district collapsed. The bridge, intended to span 950 meters from Anaikkarai to connect northern districts through Ariyalur, collapsed while more than fifteen workers were present. The cause of the collapse was attributed to a mechanical breakdown. The incident occurred as a large crane was being utilized to install a block between spans 16 and 17. The block fell as a result of a hydraulic hose failure, causing no damage to nearby pillars or structures.

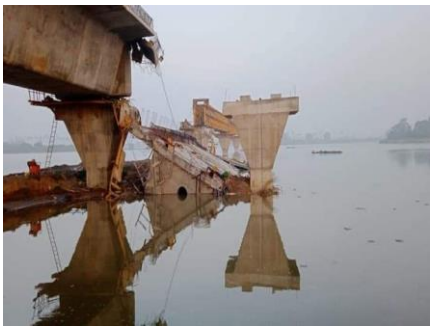

Fig 2: Kollidam bridge collapse

5.3 Thana crane accident

On August 2023, tragedy struck during the construction of the Samruddhi Mahamarg, a 701-kilometer expressway linking Mumbai and Nagpur. Managed by the Maharashtra State Road Development Corporation, the project spans 10 districts, including Nagpur, Washim, Wardha, and others. The first phase, from Nagpur to Shirdi, was inaugurated by Prime Minister Narendra Modi in December 2022, covering

520 kilometers. Chief Minister Eknath Shinde announced plans to complete the third and final phase by December of the same year. Unfortunately, a crane collapse claimed at least 20 lives during construction. The crane, reportedly collapsing from a height of 200 feet, was engaged in lifting girders for an under-construction bridge. This incident highlights the risks associated with large-scale infrastructure projects and underscores the importance of stringent safety measures to prevent such tragedies.

Fig 3: Thane crane accident

5.4 Morbi bridge collapse

The Jhulto Pul, a 230-meter-long pedestrian suspension bridge soaring 15 meters above the Machchhu River, connects the Mahaprabhuji and Samakantha districts. After undergoing six months of repairs, it officially reopened on October 26, 2022. On October 30, 2022, the bridge collapsed under the weight of over five hundred people, exceeding its official capacity of 125.

Fig 4: Morbi bridge collapse

The premature reopening, without the necessary fitness certificate, and structural deficiencies like rusted cables, broken anchors, and loose bolts were identified as the primary causes of the disaster, according to a forensic report presented in court.

5.5 COMPARATIVE ANALYSIS

These case studies highlight the direct consequences of infrastructure failures during construction, revealing common issues such as inadequate maintenance, oversight, and adherence to safety protocols. The incidents, including the Madurai-Natham flyover collapse, Thane crane accident, Kollidam River concrete span collapse, and Morbi bridge collapse, all resulted from mechanical failures and insufficient maintenance practices. They underscore the critical importance of rigorous safety measures, regular equipment inspections, and structural assessments to prevent such tragedies. These incidents serve as poignant reminders of the need for strict adherence to regulatory standards and thorough maintenance procedures to safeguard the well-being of workers and the public during construction projects.

6. LIVE CASE STUDIES

6.1 Perungalathur bridge

Stretch name: LC-32 IN BETWEEN TAMBARAM AND VANDALUR RAILWAY STATION
Area: Perungalathur
Length of the bridge: Total of 6 arm

- Chennai to Chengalpattu arm=812.897m
- Eastern bypass arm= 324.098m
- Chengalpattu to Chennai arm=743.172m
- Srinivasa nagar road arm = 452.159m
- Quadrant = 100.060m

Start date: 01.12.2020
Completion date: 23.10.2023 eot – 30.12.2023
Project cost: 243 crores
Bridge construction cost: 155 crores
Land acquisition: 79 crores
Current status: 73%
Total. no. of. workers: 40-50
Structural consultants: Highway department
Main contractor: Renaatus consultants
First aid room: yes
Fall protection: Double liner life harness

Fig 5: Perungalathur bridge under construction

PPE

- Helmet
- Reflective jacket

- Goggles – white ,black
- Gloves
- Harness
- Safety shoes
- Safety jacket
- Mask
- Face shield
- Ear plug
- Apron
- Safety persons: 2 (day & night)
- Security: 10
- Supervision: PM, DPM, senior engineer - 6
- Workers training: yes

ELECTRICAL SAFETY
Possible occurrence: Electric cable may get puncture due to binding.
Electrical over run leads to shortage of high voltage
Measures taken: Using advanced Electrical Leakage Circuit Breaker (ELCB) / immediate dis-connectivity, socket used at possible location.

ELCB
In order to prevent shock in electrical installations with high earth impedance, earth-leakage circuit breakers, or ELCBs, are utilized as safety devices. When the voltage level over the danger threshold, it senses tiny stray voltages on the metal casings of electrical equipment and breaks the circuit.

PURPOSE
The primary functions of an earth leak detection circuit (ELCB) are to identify Earth leaks, guard against electrical shock injuries to humans, and stop short circuit-related electrical fires.


Fig 6: Perungalathur bridge

TRAFFIC MANAGEMENT
The Highway Department, with the assistance of local police, managed traffic in Perungalathur by creating two access points: one for government buses and bus stop drop-offs, and another for two-wheeled vehicles, Cars.

TRAFFIC DIVERSION
STRIP LIGHT - Strip lighting has been installed along the entire bridge to aid in identifying nighttime construction activities, in addition to the barricade.

SOLAR BLINKER - A solar indicator has been positioned at the diversion entrance, aiding traffic diversion for four-wheelers and making it easier to avoid the construction area.

REFLECTIVE STICKER - For the purpose of indicating the work, reflective stickers are placed on the barricade's surface.

FIRE SAFETY
Electrical overruns, due to high voltage, result in wire shortages and can lead to fires in the construction area.

FIRE EXTINGUISHER – In total of 3 extinguisher in the site
- Near office
- DB room
- Near panel board

SIGNAGE
- Take diversion
- Speed limit
- Vertical limit
- Deep excavation
- Work in progress

SAFETY PRECAUTIONS
- Safety catch net
- Material fall arrest
- Man fall arrest
- Safety dust net
- Barrication
- Strip light

The Perungalathur bridge project, LC-32, spans between Tambaram and Vandalur railway stations with six arms, including the longest from Chennai to Chengalpattu at 812.897m. Started on December 1, 2020, and slated for completion by December 30, 2023, the project costs 243 crores, with 155 crores for construction and 79 crores for land acquisition. Currently 73% complete, it employs 40-50 workers under Renaatus consultants with oversight from the Highway department. Safety measures include PPE, ELCBs for electrical safety, and multiple fire extinguishers. Traffic management involves strip lighting, solar blinkers, and reflective stickers, ensuring smooth flow and safety.

6.2 MINOR BRIDGE CONSTRUCTION IN VEMBAKKAM, MAHABALIPURAM.

Stretch name: Chainage 13.5
Area: Vembakkam
Length of the bridge: 47.6M

- Total of 3 spans
- Each span – 15m
- 2 outside wall of 0.8m
- Middle wall of 0.5m

Bridge type: Minor bridge
Start date: 01.12.2020
Completion date: 10.06.2023
Project cost: 6 CR
Current status: 65%
To. no. of. workers: 40

- WORKING HOURS: 7am – 8pm
- Workers from Bengal, Bihar, Andhra Pradesh
- Structural consultants: LN Malvia

Main contractor: JSR ECR
Labor insurance: yes
Safety engineer: 2
Safety meeting: conducted every month
Security: 2
Signage: yes

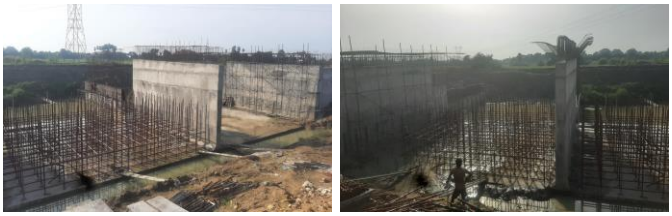

Fig 7: Minor bridge at Vembakkam

The Vembakkam bridge project at Chainage 13.5 spans 47.6 meters with three 15-meter spans and walls of 0.8m and 0.5m. As a minor bridge, it began on December 1, 2020, and is set to complete by June 10, 2023, with a project cost of 6 crores. Currently 65% complete, it employs 40 workers from Bengal, Bihar, and Andhra Pradesh, working from 7am to 8pm under JSR ECR and structural consultants LN Malvia. Safety is prioritized with labor insurance, two safety engineers, monthly safety meetings, and proper signage, all overseen by two security personnel.

7. FINDINGS FROM THE STUDY

Two construction sites performed a thorough safety assessment to evaluate worker safety, site security, and protocol adherence. While first aid kits, safety programs, and safety representatives are present at both locations, emergency phone numbers are not displayed. First aid supplies are kept at Site 1, but not at Site 2. There are no eye wash stations at either location.

While Site 2 lacks sufficient fire extinguishers and other hot work precautions, key safety measures include the use of PPE appropriately and comprehensive fire protection plans. Scaffolding procedures and fall safety devices are in place, several flaws including exposed holes and missing guardrails have been identified. Site 2 exhibits additional gaps in the electrical safety precautions, which are only partially addressed.

Site 2 has deficiencies in seat belt use and ROPS, heavy equipment operations typically comply with safety guidelines. Both sites have certified operators and the most recent inspections for their cranes and hoists.

Excavation and trenching procedures are largely in compliance at Site 2, more regular inspection is required. Site 1 has stronger management of its cutting and welding operations, but Site 2 does not have a sufficient fire watch or PPE compliance. There are protocols in place for demolition that guarantee the management of hazardous materials and utility disconnections.

Managing hazardous materials entails abatement strategies and qualified staff, but Site 2 need better containment and disposal methods. While both locations demonstrate a high level of overall commitment to safety procedures, several details still need to be addressed to guarantee complete compliance and worker safety.

8. RESULTS AND DISCUSSION

Safety and worker welfare are given top priority in both projects but Perungalathur bridge project's greater scale and complexity, it has more comprehensive and detailed safety measures in place. Using cautions safety equipment like ELCBs, thorough traffic management plans, and strong fire safety protocols demonstrate a proactive attitude to controlling the hazards that come with such a big infrastructure project. The proposed Vembakkam Bridge complies with all applicable safety requirements. It would be preferable to incorporate some of the more advanced safety features found in the Perungalathur project, especially in the areas of fire safety and cautious traffic control. Regular inspections and updates to safety protocols could ensure that both projects maintain high safety standards, ultimately safeguarding the well-being of all workers and ensuring timely project completion.

By addressing these safety and management gaps, both projects can enhance their compliance with safety regulations, reduce the risk of accidents, and ensure the health and safety of their workforce, thereby setting a benchmark for future infrastructure projects.

9. CONCLUSION

Considering the high-risk nature of the construction sector, worker safety is most importance in bridge construction projects. This research clarifies the vital significance of worker safety first, identifying the main safety challenges, and assessing current safety measures through an analysis.

Operating heavy gear and working at heights, workers at serious danger of accidents and injuries when building

bridges. A safer workplace can be created with the implementation of strong safety laws, continual training programs, and the supply of suitable safety gear, such as fall prevention systems and personal protective equipment.

In addition to lowering the number of injuries and fatalities worker safety also creates a happy work environment that increases employee retention and satisfaction. Human lives shouldn't be lost in the process of building bridges. Prioritizing safety may ensure the well-being of construction workers and progress the building of crucial transportation infrastructure.

10. RECOMMENDATIONS

In order to prevent the risks in bridge construction, wireless technologies play a vital role in ensuring worker safety by providing real-time communication, monitoring, and data collection capabilities.

RFID tags attached to worker's helmets or equipment enable real-time tracking, while GPS integration allows for precise location monitoring, particularly beneficial in emergencies or on expansive construction sites.

Bluetooth technology is utilized for proximity sensors, issuing alerts when workers approach hazardous areas. Wearable sensors monitor vital signs, triggering alerts if distress is detected. Drones equipped with cameras and sensors surveillance, identifying safety hazards, and ensuring protocol adherence.

Video surveillance, mesh networks, and IoT devices further enhance safety by collecting data on environmental conditions and structural integrity. These wireless technologies collectively create a safer working environment, facilitating better communication, real-time incident response, and data-driven safety improvements, ultimately safeguarding the well-being of construction workers in bridge construction projects.

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