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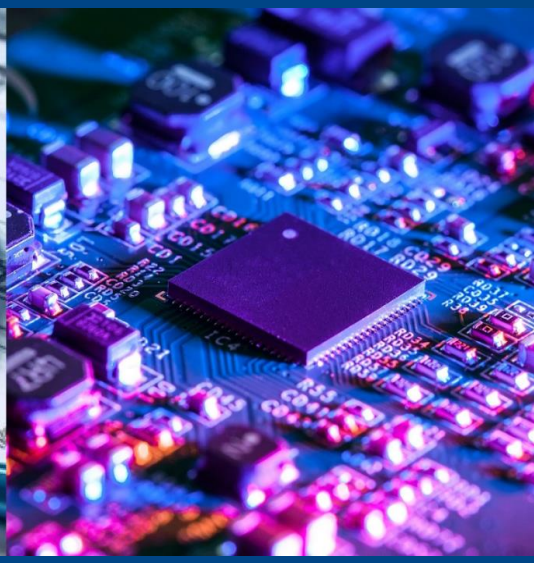

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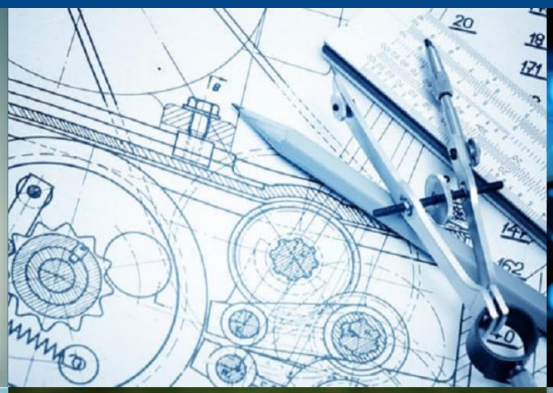

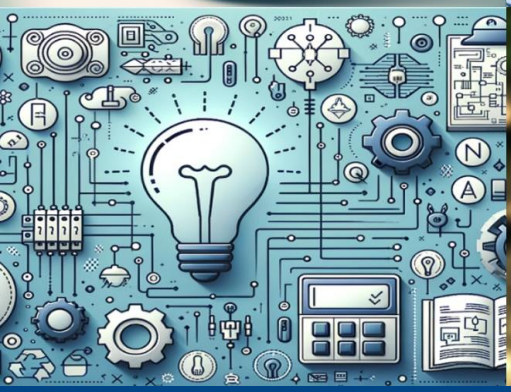

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Implementation of Emergency Switch, Pull Cord Switches, and Under-Run Protection for Hazard Elimination in Moving and Rotating Parts of Girder Transporter-1100 MT

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ABSTRACT: The purpose of this study is to enhance the effectiveness of industrial safety measures by implementing emergency switches, pull cord switches and under run protection in the moving and rotating parts of the Girder Transporter-1100 MT. This work focuses on minimizing occupational hazards by integrating engineering controls into mechanical systems used in large-scale infrastructure projects. To develop effective safety management strategies, a mathematical model of the labour protection system was designed, considering legal, socio-economic, and organizational factors. The research is based on actual statistical data on occupational injuries in mechanical engineering over the past 12 years, providing a foundation for evaluating the impact of safety interventions.

The feasibility of utilizing mathematical modelling for injury prevention is justified, as it links proactive safety measures with risk assessment outcomes, thereby reducing subjectivity in decision-making. The proposed model optimizes hazard mitigation by accounting for the actions or inaction of both employees and employers, ensuring compliance with occupational safety standards. Additionally, it introduces an optimized penalty system for violations, promoting accountability. The study substantiates the necessity of a robust legal framework to regulate employer and employee responsibilities in labour safety.The proposed hazard elimination measures are universal and can be adapted to various mechanical engineering applications. The study also presents hierarchy control and risk assessment which helps systematically assess and implement safety improvements. Unlike conventional safety management models, this approach incorporates real-time statistical data on hazardous occurrences and compliance levels, fostering a proactive safety culture. By establishing the correlation between industrial risks and labor protection policies, the study provides a structured methodology to reduce workplace hazards in girder transportation and similar engineering environment.

I. INTRODUCTION

A Girder Transporter is a specialized heavy-duty vehicle designed to transport massive precast concrete girders and launching girders in large-scale infrastructure projects. It plays a critical role in high-speed rail construction by efficiently shifting 1050 MT box girders from the casting yard to the erection location and relocating the launching girder (LG) back to the casting yard.

High-speed rail projects require the precise handling of heavy components to ensure structural integrity and timely project execution. The Girder Transporter enables safe and controlled movement of these components over long distances, reducing manual handling risks and improving efficiency. However, given the weight and complexity of the operations, safety concerns arise due to potential mechanical failures, operator errors, and unforeseen obstacles.
To mitigate these risks, strict safety protocols and engineering controls are necessary. This study focuses on implementing emergency switches and pull cord mechanisms in the moving and rotating parts of the Girder Transporter to enhance operational safety. These measures aim to eliminate hazards, prevent accidents, and ensure compliance with industrial safety standards in large-scale construction projects like the Bullet Train.

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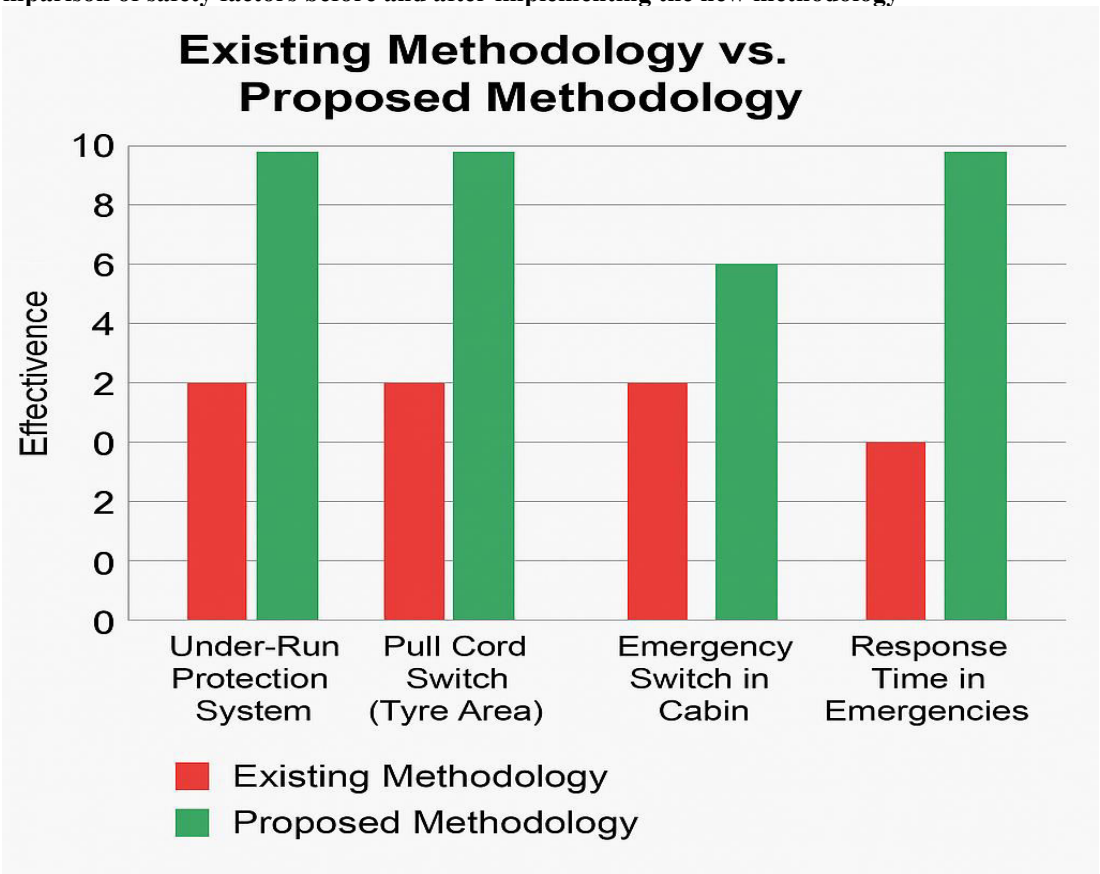
II. PROPOSED METHODOLOGY

To enhance safety in the Girder Transporter (1100 MT) used in the Mumbai-Ahmedabad High-Speed Rail (MAHSR) Project, an advanced safety enhancement plan is proposed. The plan involves implementing two key engineering controls: 1. Under-Run Protection System: Prevents workers and objects from being caught underneath the transporter. 2. Pull Cord Mechanism & Emergency Switch: Enables emergency stopping for the entire tyre area to prevent accidents.

Identify Key Safety Factors for Comparison:

Safety Factor	Existing Methodology	Proposed Methodology
Under-Run Protection	❌ Not Available – Risk of entrapment	✅ Installed – Prevents access under the transporter
Pull Cord Switch (Tyre Area)	❌ No Emergency Stop	✅ Installed – Immediate hazard response
Emergency Switch (Signalman)	⚠️ No direct stop control	✅ Signalman can instantly stop transporter
Overall Hazard Risk	🔴 High	🟢 Low
Emergency Response Time	⏳ Delayed	⚡ Immediate

Comparison of safety factors before and after implementing the new methodology



Existing Methodology Vs Proposed Methodology

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III. RESULT AND DISCUSSION

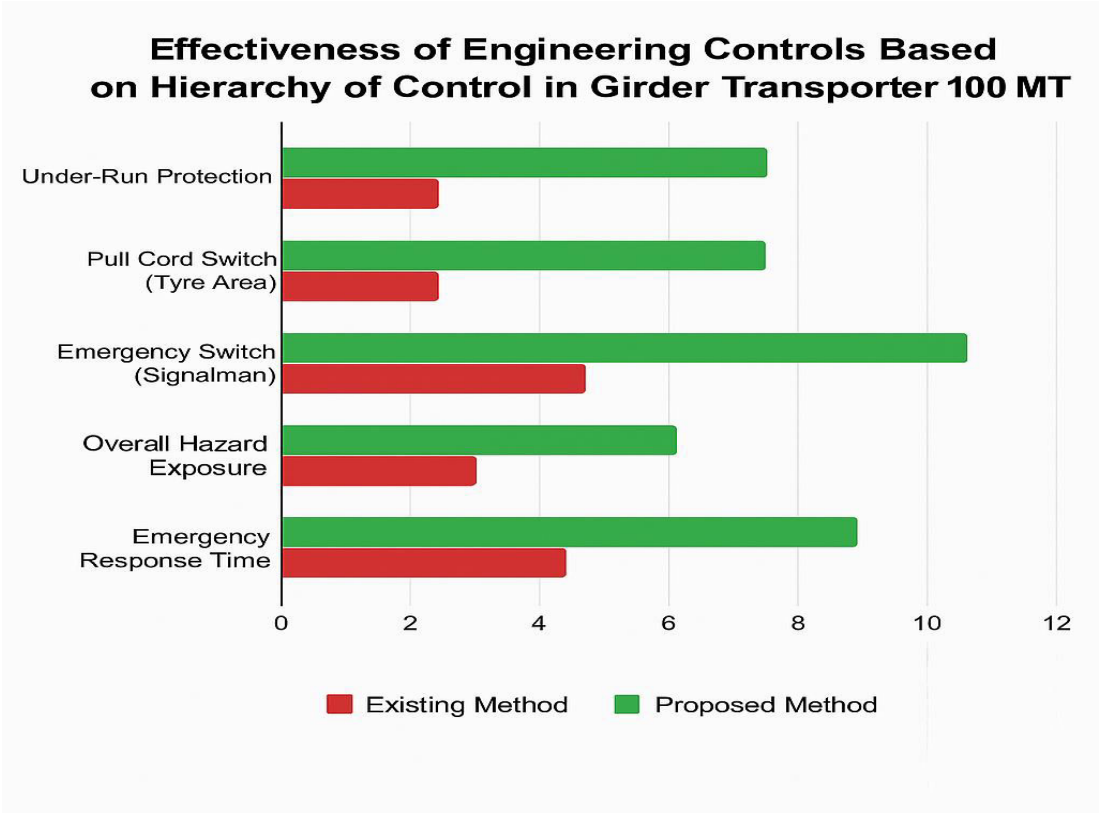
Graphical Analysis:

Below is a bar graph comparing the effectiveness of control (based on risk reduction score from 0 to 10) before and after implementation:

Safety Measure	Existing Method (Before)	Proposed Method (After)
Under-Run Protection	2	9
Pull Cord Switch (Tyre Area)	1	9
Emergency Switch (Signalman)	2	10
Overall Hazard Exposure	2	8
Emergency Response Time	5	10

- Green bars represent the proposed methodology, showing substantial improvement.
- Red bars represent the existing system, highlighting safety gaps.

Comparing the effectiveness of control



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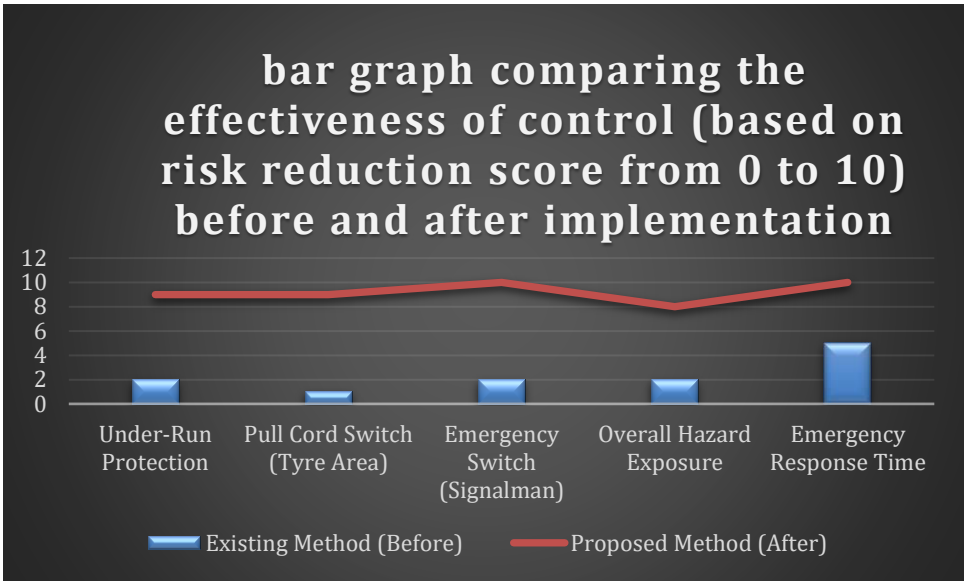

Bar graph comparing the effectiveness of control

Risk Assessment Implementation:

Risk Assessment is a core component of a proactive safety management system. It involves identifying hazards, evaluating associated risks, and implementing controls to reduce these risks to acceptable levels. For the Girder Transporter 1100 MT, a structured risk assessment was conducted, leading to the implementation of engineering controls, as prioritized by the Hierarchy of Control.

The following three engineering solutions were identified and implemented:

1. Under-Run Protection System
2. Pull Cord Switch in Tyre Entire Area
3. Emergency Switch in Signalman Cabin

Risk Rating Comparison Before & After Implementation

Hazard Scenario	Likelihood (Before)	Severity (Before)	Risk Level (Before)	Risk Level (After)
Personnel trapped under vehicle	4 (Likely)	4(Catastrophic)	16(High Risk)	4 (Low Risk)
No quick stop in tyre area	4 (Almost Certain)	3(Major)	12 (High Risk)	3 (Low Risk)
Delay in emergency response by signalman	4 (Likely)	4 (Major)	16 (High Risk)	4 (Low Risk)

Risk Rating Comparison Before & After Implementation

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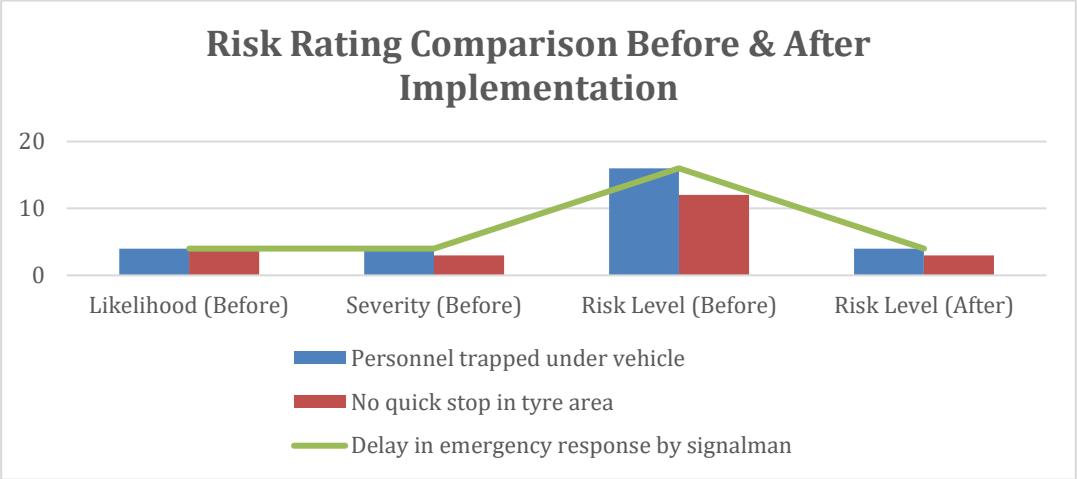

Risk Rating Comparison Before & After Implementation

- Risk Matrix uses a 4x4 scale (Likelihood × Severity)
- Controls implemented fall under Engineering Controls, third tier in the Hierarchy of Control, offering permanent, equipment-based solutions that do not depend on human behaviour.

Discussion

The implementation of these engineering controls resulted in a significant risk level reduction, transforming high-risk hazards into low-risk situations. By eliminating or minimizing exposure through physical systems (e.g., guards, emergency switches), dependency on operator behaviour is reduced.

- Under-Run Protection physically blocks access under the transporter, drastically reducing fatality risk.
- Pull Cord System ensures immediate manual intervention without delay.
- Emergency Switch in Cabin empowers centralized emergency control and reduces human error or communication lag. This approach aligns with international safety best practices and demonstrates how applying the Hierarchy of Control through engineering measures is a highly effective strategy in industrial safety management.

IV. CONCLUSION

The implementation of engineering controls in the Girder Transporter 1100 MT follows the Hierarchy of Controls to effectively eliminate hazards and ensure a safer working environment. By integrating Under-Run Protection Systems, the risk of workers and objects being trapped underneath is significantly reduced, providing a physical barrier against potential accidents. Additionally, the Pull Cord Mechanism and Emergency Switch in the Signal Man Cabin enable immediate emergency stopping, ensuring quick response to unforeseen situations and preventing accidents in the transporter's tyre area.

By prioritizing engineering controls which are more effective than administrative measures or PPE this system proactively mitigates risks at the source. This approach not only enhances worker safety but also improves operational efficiency and compliance with industry safety standards, reinforcing the commitment to hazard elimination and risk reduction in heavy equipment operations.

By implementing engineering controls and following the Hierarchy of Control, we ensure a safe and efficient working environment for the Girder Transporter 1100 MT.
These new systems will:

- Eliminate hazards by restricting unsafe access.
- Enhance response time with emergency stop mechanisms.

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- Improve compliance with safety regulations.
- Create a safer worksite with minimal risk of accidents.

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