WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Road Safety Enhancement through Infrastructure Upgrades and Comprehensive Risk Audits

Satyaranjan Mallik[1], Jyoti Prakash Giri[2]

[1]PG Student, Department of Civil Engineering, Centurion University of Technology and Management, Bhubaneswar, Khurda, Odisha, India – 752050. Email:230303230006@centurionuniv.edu.in

[2]Assistant Professor, Department of Civil Engineering, Centurion University of Technology and Management, Bhubaneswar, Khurda, Odisha, India – 752050. Email: jyotprakash.giri@cutm.ac.in

ABSTRACT

India, with a population of 1.35 billion, is steadily progressing toward becoming a developed nation, with infrastructure development—particularly road network enhancement—playing a crucial role. Despite these efforts, the increasing number of vehicles has overwhelmed existing roads, raising serious safety concerns. a total of 4,61,312 accidents were recorded in the country, of which, 1,51,997 (32.9%) took place on the National Highways (NH) including Expressways, 1,06,682 (23.1%) on State Highways (SH) and the remaining 2,02,633 (43.9%) on Other Roads. Out of the total of 1,68,491 fatalities reported in 2022, 61,038 (36.2%) were on National Highways, 41,012 (24.3%) were on State Highways and 66,441 (39.4%) were on Other Roads. Out of the total, 1,55,781 fatal accidents reported in 2022, 55,571 (35.7%) were on National Highways, 37,861 (24.3%) were on State Highways and 62,349 (40%) were on Other Roads (ROAD ACCIDENTS IN INDIA 2022 MINISTRY OF ROAD TRANSPORT AND HIGHWAYS). National and state highways remain the most accident-prone, revealing the urgent need for stronger safety measures. Road safety is now a major public health issue, exacerbated by traffic congestion, disregard for rules, and weak enforcement, with human error being a leading cause. India's 11% share in global accident-related deaths underlines the gravity of the issue and the importance of integrating road safety education into the national curriculum. In rural areas, poor road conditions heighten the risks, especially on key routes like the Old Cuttack-Sambalpur Road (Old NH-655), which links several districts and supports both developed and developing regions. Upgrading this stretch and conducting thorough Road Safety Audits (RSA) are essential to curbing accidents. The proposed project for modernizing this road, currently maintained as an Other District Road (ODR), aims to improve regional connectivity while ensuring the safety of all road users.

Key Words: Safety at risk, Injuries, Health concern, Heavy traffic, Safety measures

1. INTRODUCTION

Road safety refers to the strategies and measures aimed at preventing road accidents and protecting all road users—drivers, passengers, pedestrians, bicyclists, and motorcyclists—from injuries or fatalities. It involves collective efforts from governments, organizations, and individuals through the enforcement of traffic laws, public awareness, infrastructure development, and the use of safety equipment like helmets and seatbelts. India faces a serious road safety crisis, with accidents, fatalities, and injuries increasing by around 5% annually over the past two decades, largely due to the rapid increase in the number of vehicles. The country's death rate per vehicle is 10 to 20 times higher than that of developed nations like Sweden, Norway, Japan, Australia, the UK, and the USA, and significantly higher even when compared to developing countries such as Brazil, Mexico, and Malaysia. In 2018, the Ministry of Road Transport & Highways reported 467,044 road accidents resulting in 151,417 deaths, with the majority of fatalities being vulnerable road users such as pedestrians, bicyclists, and motorbike riders, who form a large portion of daily commuters and often lack adequate protection. Addressing these issues requires a multi-pronged approach involving strict enforcement of traffic laws, timely infrastructure maintenance, comprehensive driver education, widespread use of safety gear, public awareness campaigns, and efficient emergency response systems. Effective road safety measures not only reduce accidents and fatalities but also foster disciplined driving habits, enhance overall safety, and contribute to economic growth by reducing traffic delays, healthcare costs, and productivity losses. Significant improvements can be achieved in India through better planning, technological integration such as intelligent traffic systems and speed cameras, and active citizen participation, with collaboration between government bodies, NGOs, and communities being essential. A vital tool in this process is the Road Safety Audit (RSA), an independent and formal assessment of a road's or intersection's safety performance, conducted at any stage of a project to proactively identify risks and suggest cost-effective improvements, as per Indian Roads Congress guidelines (IRC: SP: 88:2019). The primary goal of an RSA is to minimize the frequency and severity of accidents from the planning to maintenance stages, with objectives including reducing risks on both main and adjacent roads, addressing diverse user needs, avoiding design flaws, ensuring cost-effective and sustainable outcomes, and promoting a culture of safety among all stakeholders involved in road development and maintenance.

1.1 STUDY DESCRIPTIONS

Fig.1 Location of Project Stretch

The project road is the Intermediate Lane (IL) of the old NH 655. However, it has been handed over to the State Government and is now classified as an ODR Standard Road, with maintenance responsibilities falling under the State Government. The road begins at Chainage 0.000 km in Sankarpur, Dhenkanal District, and ends at Chainage 50.262 km in Maidharpur **(Fig.1),** Angul District. The total proposed length of the project section is 50.262 km. Geographically, the entire project stretch is located within the State of Odisha.

1.2 OBJECTIVE

The primary goal of a Road Safety Audit (RSA) is to proactively identify and address potential safety hazards throughout all stages of a road project—planning, design, construction, and operation—to reduce crash risks and enhance road user safety. RSAs aim to prevent accidents, minimize their severity, and ensure inclusive design for all users. By catching design issues early, they help avoid costly changes later and promote safer, more sustainable infrastructure.

RSA Objectives Include:

- Minimizing the risk and severity of accidents.
- Reducing crash risks on adjacent roads.
- Prioritizing safety for all road users.
- Lowering long-term costs by preventing unsafe designs.

2. LITERATURE REVIEW

A case study by Ramírez et al(2023): Road safety is a global concern, with over 1.25 million deaths and millions of injuries occurring yearly due to traffic accidents. Road Safety Audits (RSA) are used worldwide to evaluate road conditions and ensure safety standards. This research, using the PRISMA-ScR method, identifies the ten most common RSA guidelines—four focused on human factors and six on road factors, especially geometric design, signage, and safety devices. The study concludes that although road safety is a shared global issue, there is no standardized RSA methodology, and each country follows its own approach.

A case study by Faan Chen et al (2024): This study proposes a robust auditing framework for road safety, recognizing its critical link to economic stability and social development. It introduces a novel decision model—MEREC–ARAS–QBKM—that combines criteria analysis, performance assessment, and advanced clustering to evaluate road safety and guide policymaking. By improving traditional k-means clustering with quantile-based initialization, the model enhances reliability and reduces uncertainty. A case study on APEC economies confirms the model's effectiveness in identifying regional disparities and supporting targeted policy actions, ultimately promoting safer roads and socio-economic progress

A case study by Novati et al (2024):Improving urban road safety is challenging due to frequent accidents and high social costs. This study introduces a data-driven methodology combining historical accident analysis and proactive risk assessment using iRAP and GIS to identify high-risk areas and evaluate safety interventions. A key feature is cost–benefit analysis to prioritize actions and optimize resources. Tested in a medium-sized Italian city, the approach showed strong potential to reduce accidents and costs, offering a scalable model to support Vision Zero goals through targeted, effective planning.

A case study by Geetam Tiwari et al (2024):Road Traffic Injuries (RTIs) cause 1.35 million deaths annually, with 93% occurring in low- and middle-income countries (LMICs). While high-income countries have reduced RTIs through public health strategies and evidence-based measures, many LMICs still face rising injury rates. As these countries develop road infrastructure, adopting a scientific, context-specific approach is vital. Creating an evidence gap map is a crucial first step to identify available data, its sources, and existing knowledge gaps.

A case study by Geetam Tiwari et al (2019):Road accidents and their severe consequences are a major global issue. Preventing them requires coordinated efforts from governments, organizations, and communities. In Poland, the National Road Safety Programme 2013–2020 aimed to improve safety and reduce casualties. As the programme nears its end, this article reviews the results from 2010–2018, focusing on driver-related accident causes.

In conclusion, Road Safety Audit stands as a vital approach in the global effort to reduce road traffic injuries and fatalities. Its proactive, interdisciplinary nature makes it a powerful tool for enhancing road safety and public trust in transport infrastructure. While certain limitations persist, expanding RSA practices and addressing existing barriers will significantly improve road safety outcomes and help safeguard lives.

3. METHODOLOGY

Road Safety Audit (RSA) is a structured and proactive approach used to evaluate the safety performance of roads and identify potential risks to prevent future accidents. It ensures that the safety needs of all road users — including motorists, pedestrians, cyclists, and public transport users — are considered throughout the life cycle of a road project.

In India, RSAs are conducted at five key stages of a road project:

- Feasibility Stage
- Detailed Design Stage
- Construction Stage
- Pre-opening Stage
- Existing/Maintenance Stage

This study focuses on conducting a Road Safety Audit on an existing road that is already constructed and operational. The audit followed a systematic process involving field inspections, risk identification, and safety recommendations, as outlined in the following sections.

4. RSA FINDING

This study conducts a Road Safety Audit (RSA) of a rural road passing through a built-up area with high accident risk due to poor safety measures. It aims to assess current conditions, identify safety issues, and recommend improvements. Key concerns include inadequate pedestrian facilities, poor signage, road geometry, and lack of speed control. The goal is to enhance safety and reduce accidents.

4.1 Safety Observations Intersection Portion

Fig.2 Safety Observation in Intersection

The intersection lacks essential signage, posing a high risk to all road users in **(Fig.2).** There's no intersection, junction ahead, rumble strip, or stop sign, making it hard for drivers to anticipate crossings and increasing the chance of accidents.

Risk Factor: High

4.2 Safety Observations Curve Portion

Fig.3 Safety Observation in Curve Portion

This curve lacks crucial safety signs like curve and chevron markers in **(Fig.3),** posing a high risk to road users. The absence of proper signage increases accident potential.

Risk Factor: High

4.3 Safety Observations Built-up Portion

Fig.4 Safety Observation Built up area Portion

4.4 Safety Observations Structure Portion

Fig.5 Safety Observation Structure Portion Portion

Several structural safety issues were found during the audit. Most CD structure parapets lacked Object Hazard Markers (OHM) in (**Fig.5**), as did electric poles and trees within the Clear Zone. Narrow bridges without OHM signage further increase the risk.

Risk Factor: High

4.5 Safety Observations High Embankment Portion

Fig.6 Safety Observation High Embankment portion Portion

The lack of a metal beam crash barrier on the high embankment poses a serious safety risk in **(Fig.6).** Without it, vehicles are at high risk of overturning or falling, increasing the chance of fatal accidents. Immediate installation is crucial to protect lives.

Risk Factor: High

5. AUDIT RECOMMENDATION

To address the safety issues identified (Clause 4.0) of the Road Safety Audit (RSA) for the rural road, key recommendations include enhancing pedestrian facilities, installing clear signage, improving road geometry, implementing speed control measures, and ensuring regular maintenance and audits. These actions aim to reduce accident risks and improve overall road safety for all users.

5.1 Safety Recommendation Intersection Portion

Fig.7 Recommendation Intersection Portion

As seen in Fig. 2 All intersections must have side roads (left/right) on the main road with clear sight distance by removing bushes at the bell mouth. As per IRC-99-2018 Clause 2.3.3.4, transverse bar markings should be installed to reduce speed near hazardous locations. Speed breakers on arterial roads must comply with Clause 2.3.3. and the required recommendation provision is provided in Fig. 7.

5.2 Safety Recommendation Curve Portion

Fig.8 Recommendation Curve portion

As seen in Fig. 3 To ensure an accident-free curve, install a curve warning sign before the bend as per Clause 15.4 of IRC:67-2022. Place chevron signs at the curve to indicate sharpness per Clause 15.65. Use red and yellow road studs for night guidance as per Table 5.1 of IRC:35-2015. For curves near side or cross roads, refer to Figures 15.01a–d and 15.02a–d. Install speed limit signs as per IRC:67-2022. Where overtaking is unsafe, place a 'No Overtaking' sign as per Clause 14.6.21 of IRC:67-2022. The required recommendation provision is provided in Fig. 8.

5.3 Safety Recommendation Built-up & Market Portion.

Fig.9 Recommendation built-up Portion

As seen in Fig.4 Provide rumble strips with signs in built-up areas. Install built-up area and speed limit signs per IRC:67-2022 to warn of conflict zones. Use road studs for night guidance as per Table 5.1 of IRC:35-2015. The required recommendation provision is provided in Fig. 9.

5.4 Safety Recommendation Structure Portion.

Fig.10 Recommendation Structure Portion

As seen in Fig. 5.0 , roadside hazards like bridges, trees, and CD structures should be marked with retro-reflective Object Hazard Markers (OHM) as per Clause 15.66 of IRC:67-2022. The required recommendation provision is provided in Fig. 10.

5.5 Safety Recommendation High Embankment portion

Fig.11 Recommendation Structure Portion

As seen in Fig. 6.0 Install Metal Beam Crash Barriers (MBCB) as per IRC:119-2015 when water depth exceeds 2 m or embankment height is over 3 m. Use W-beam galvanized steel barriers with 2 m post spacing, 1.2 m embedment, terminal sections, reflectors, and necessary fittings for impact performance. The required recommendation provision is provided in Fig. 11.

6. CONCLUSION

The study focused on identifying high-risk areas on intermediate-lane highways through a Road Safety Audit (RSA) and recommending suitable safety measures. The RSA highlighted built-up zones with dense roadside development, leading to high commercial traffic and safety issues like pedestrian conflicts and limited visibility. Key recommendations include:

- Installation of signage as per IRC:67-2022
- Speed breakers at crossings
- Reflective road studs (IRC:79-2019)

Most road segments have straight alignments due to urban constraints. While sharp curves with existing safety features need no changes, some lack provisions. Additional recommendations include:

- Curve warning signs
- Chevron alignment boards
- Speed limit signs per IRC standards

IMPLEMENTATIONS

Fig.12 Implementations in Curve Portion

REFERENCE

1. Calderón Ramírez, J. A., Núñez López, I., García Gómez, L. G., & Montoya Alcaraz, M. A. (2023). Main guidelines in road safety audits: a literature review. Frontiers in Built Environment, 9, 1282251.
2. Development of Safety Audit Methodology for existing road sections, 2009. Environment and Road Traffic Safety Division, CRRI, New Delhi.
3. Gądek-Hawlena, T. (2019). The efficiency of actions to improve road safety–assessing the implementation of the programme objectives. Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Ekonomika i Organizacja Logistyki, 4(3), 55-64.
4. Goel, R., Tiwari, G., Varghese, M., Bhalla, K., Agrawal, G., Saini, G., ... & Mohan, D. (2024). Effectiveness of road safety interventions: An evidence and gap map. Campbell systematic reviews, 20(1), e1367.
5. IRC 67-2022-Code of Practice for Road Signs
6. IRC-SP-88-2019 Road Safety Audit
7. IRC-79-2019 Recommended Practices for Road Delineators
8. IRC -35 Road marking
9. IRC: Road Development Plan “VISION: 2021”, Ministry of Road Transport and Highways, Government of India,
10. NHAI Safety Manual.
11. Road Accidents in India, Ministry of Road. Transport and Highways, Transport Research Wing, Government of India, New Delhi, 2018.
12. Road Safety Audit Report on Six Laning of NH-8A (Ext.) from Gandhidham to Mundra Port in Gujarat State August 2014 National Highways Authority of India.
13. Toraldo, E., Novati, N., Rossi, D., & Ketabdari, M. (2025). A Novel Methodology for Planning Urban Road Safety Interventions. Applied Sciences, 15(4), 1993.
14. Xie, Z., & Chen, F. (2024). Auditing road safety achievement using MEREC–ARAS–QBKM model: an empirical study for APEC member economies. Scientific Reports, 14(1), 23049.