

REVIEW OF ROAD SAFETY AUDIT ON MUNICIPAL CORPORATION SAGAR

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Abstract: - This review paper presents a comprehensive road safety audit conducted in Sagar, an urban center facing challenges in ensuring the safety of road users. The audit focuses on evaluating the existing road infrastructure, identifying potential hazards, and proposing effective safety measures. It employs a systematic and multidisciplinary approach, involving a thorough review of traffic data, accident records, and local regulations, as well as field surveys and active engagement with stakeholders. The audit identifies various safety risks and shortcomings, including inadequate signage, poor lighting, insufficient pedestrian facilities, traffic congestion, and hazardous intersections. Driver behavior, traffic regulation enforcement, and public awareness campaigns related to road safety are also examined. Based on the findings, a series of recommendations are proposed to mitigate the identified risks and enhance road safety in Sagar. These suggestions encompass short-term and long-term measures, considering economic feasibility, effectiveness, and compatibility with existing infrastructure. Proposed interventions include improving pedestrian infrastructure, implementing traffic calming measures, enhancing road visibility through better lighting, optimizing signal timings, and promoting awareness campaigns to educate road users on safe practices. The outcomes of this road safety audit provide valuable insights for local authorities, policymakers, and stakeholders involved in traffic management and infrastructure development in Sagar. The implementation of the recommended measures is expected to lead to significant reductions in road accidents, injuries, and fatalities. Furthermore, the findings and methodologies of this audit can serve as a reference for other cities facing similar road safety challenges, aiding in the formulation of evidence-based strategies to ensure safer transportation systems.

1. Introduction: -

The significant global issue lies in the remarkable surge in the number of drivers, leading to an alarming rise in traffic accidents worldwide. These accidents impose a heavy burden on the socio-economic structure, despite the implementation of several laws and regulations aimed at improving traffic safety. Negligence and nonchalant handling of traffic safety and rules by drivers account for about 90% or more of most traffic accidents.

According to the World Health Organization's 2009 Global Status Report, India records the highest number of traffic accident-related deaths globally. The country experiences an annual increase of 8% in traffic fatalities due to the growing number of vehicles, which contributes to road width changes and a subsequent rise in accidents. A significant portion of these traffic fatalities occurs in road construction areas, where numerous workers are injured or killed annually. In 2012, about 50 million people were injured, and approximately 1.2 million lost their lives in various road accidents worldwide, with developing countries, particularly low- or middle-income nations, bearing the brunt of these fatalities. Pedestrians, cyclists, and two-wheeled vehicle riders were among the most affected victims. The World Health Organization's report predicts that traffic accidents will be the fifth leading cause of death globally by 2030.

Recognizing the increasing road traffic accidents, the World Health Organization declared 2004 as the Year of Road Safety and designated April 7th as World Health Day to draw attention to this critical issue. The impact of road safety has become a matter of utmost importance in recent decades, with the socio-economic cost of road accidents estimated to be 3% of India's GDP. Given the heavy reliance on roads for daily commuting to schools, workplaces, institutions, and business centers, ensuring road safety is paramount. Safety auditing places a primary emphasis on ensuring that the road network aligns with safe design principles to safeguard all road users.

1.1 Road Safety Audit: - A road safety audit is a systematic evaluation of an existing or proposed road or highway project to identify potential safety risks and propose appropriate measures to mitigate those risks. It is conducted by a team of professionals with expertise in road design, traffic engineering, and safety. The goal of a road safety audit is to enhance the safety performance of the road infrastructure by identifying and addressing potential hazards that may contribute to accidents or injuries. During a road safety audit, the team examines various elements of the road design, including geometric features, signage, markings, traffic control devices, pedestrian and cyclist facilities, and other relevant factors. They assess the road's potential impact on road users, considering factors such as visibility, driver behavior, speed management, and pedestrian safety. The audit team typically follows

a structured process that involves reviewing project plans, conducting site visits, and assessing the road's compliance with relevant safety standards and guidelines. They identify potential safety issues or deficiencies and provide recommendations for improvements. These recommendations may include modifications to the road design, installation of additional safety features, or changes in traffic management strategies. Road safety audits are typically conducted at different stages of a road project, such as during the initial planning phase, before construction begins, and after completion. By conducting these audits, transportation agencies and road authorities can proactively address safety concerns, reduce the likelihood of accidents, and create road infrastructure that prioritizes the well-being of all road users.

1.2 Elements of Road Safety Audit

A road safety audit typically assesses various elements of the road design and traffic environment to identify potential safety risks. Here are some key elements that are commonly considered during a road safety audit:

- **Road Geometry:** The audit evaluates the geometric features of the road, such as horizontal and vertical alignments, lane widths, curves, intersections, and roundabouts. It assesses if the road layout provides adequate sight lines, minimizes driver confusion, and accommodates safe maneuvering.
- **Traffic Control Devices:** This element examines the presence, visibility, and effectiveness of traffic signs, signals, markings, and other control devices. It ensures that these devices are appropriately placed, easily understood by road users, and provide clear guidance for safe driving.
- **Pedestrian and Cyclist Facilities:** The audit reviews the provision of sidewalks, crosswalks, pedestrian signals, cycling lanes, and other facilities for non-motorized road users. It assesses the safety and accessibility of these facilities, including adequate separation from vehicular traffic and appropriate signage.
- **Roadside Features:** This element considers the presence of roadside barriers, guardrails, crash cushions, and other protective features. It evaluates their effectiveness in reducing the severity of accidents and minimizing hazards associated with roadside obstacles or hazards.
- **Lighting and Visibility:** The audit assesses the adequacy of lighting conditions, particularly in areas such as intersections, pedestrian crossings, and road segments with low visibility. It ensures that appropriate lighting levels are maintained to enhance visibility and promote safety.
- **Traffic Flow and Management:** This element examines the overall traffic flow, including factors like speed management, lane configurations, signal timings, and the effectiveness of traffic calming measures. It aims to identify potential congestion or operational issues that could impact safety.
- **Road User Behavior:** The audit considers the behavior and interactions of different road users, including drivers, pedestrians, cyclists, and other vulnerable road users. It assesses factors such as driver expectancy, compliance with traffic rules, and the provision of clear guidance for all road users.
- **Accident Data Analysis:** The audit may analyze historical accident data to identify patterns, high-risk locations, and recurring safety issues on the road. This analysis helps in targeting specific areas or elements that require improvement.
- **Emergency Services Access:** The audit evaluates the accessibility of the road for emergency vehicles and the provision of appropriate infrastructure to support their response in case of incidents or accidents.

These are some of the key elements considered during a road safety audit. The specific elements and their depth of evaluation may vary depending on the scope and objectives of the audit, as well as the relevant guidelines or standards followed by the auditing agency.

1.3 Benefit of road safety Audit

Road safety audits offer several benefits in improving the safety of road infrastructure and reducing the risk of accidents. Some of the key benefits include:

- **Accident Prevention:** Road safety audits help identify potential safety hazards and risks in the road design and traffic environment. By addressing these issues proactively, road safety audits can prevent accidents and reduce the severity of collisions.
- **Improved Road Design:** The findings and recommendations from road safety audits contribute to the development of safer road designs. This includes optimizing geometric features, enhancing signage and markings, improving visibility, and integrating safer infrastructure for pedestrians and cyclists.

- **Cost-Effectiveness:** Conducting road safety audits during the planning and design stages of road projects can result in cost savings over the long term. Identifying and rectifying safety issues early on helps avoid costly modifications and retrofitting in the future.
- **Enhancing Road User Experience:** Road safety audits aim to create road environments that are user-friendly and promote safe and efficient travel for all road users. By improving road design, signage, and traffic management, road safety audits contribute to a more pleasant and comfortable experience for drivers, pedestrians, and cyclists.
- **Compliance with Standards and Guidelines:** Road safety audits ensure that road infrastructure meets the required safety standards and guidelines set by regulatory bodies and transportation authorities. This helps maintain consistency and uniformity in road design practices, promoting safer road networks.
- **Reduced Legal and Liability Risks:** Implementing the recommendations from road safety audits demonstrates a commitment to road safety. This can reduce legal and liability risks for road authorities and project stakeholders, as they have taken proactive steps to identify and mitigate potential safety hazards.
- **Stakeholder Engagement:** Road safety audits involve engaging with various stakeholders, including engineers, planners, designers, and local communities. This collaborative approach allows for a comprehensive evaluation of safety concerns and incorporates different perspectives, leading to better-informed decisions and improved road safety outcomes.
- **Continuous Improvement:** Road safety audits are not limited to new road projects; they can also be conducted on existing roads to assess their safety performance. Regular audits help identify areas for improvement and support the ongoing monitoring and enhancement of road safety.

Overall, road safety audits provide a structured and systematic approach to enhance road safety, reduce accidents, and create road environments that prioritize the well-being of all road users. By addressing potential safety risks early on, road safety audits contribute to safer and more sustainable transportation networks.

2. Objective of Research Work

Main specific objectives of the thesis are

- Collection and Evaluation of data in aspect of road safety audit of Municipal Corporation Sagar.
- Performance of Road Safety Audit of Municipal Corporation Sagar, on major intersections, where the probability of accidents is more.
- Calculation of Score on the basis of collected data to categories intersections on the basis of Road Safety of Municipal Corporation Sagar.
- Speed Analysis on the on major intersections and roads of Municipal Corporation Sagar.

3. Literature Review

- **"Road Safety Audit of Highways in India: A Review" by Madan, A., et al. (2014):** This study provides an overview of road safety audits conducted on highways in India. It examines the existing practices, challenges, and benefits of road safety audits in the Indian context. The research emphasizes the need for a standardized approach, capacity building, and institutionalization of road safety audits to improve road safety outcomes.
- **"Road Safety Audit in India: A Review" by Pandey, A., et al. (2016):** This review paper discusses the status of road safety audit implementation in India. It examines the challenges and potential solutions for effective implementation of road safety audits. The study highlights the importance of integrating road safety audits into the road planning and design process and the need for institutional support and capacity building in India.
- **"Evaluation of Road Safety Audit Practice in India: An Assessment of Current Status and Challenges" by Chakrabarti, D., et al. (2019):** This research evaluates the current status of road safety audits in India and identifies the challenges faced in their implementation. It examines the effectiveness and limitations of road safety audits in improving road safety in the Indian context. The study emphasizes the importance of addressing institutional and capacity-related challenges to enhance the effectiveness of road safety audits in India.
- **"Road Safety Audit of Urban Roads: A Review of Current Practices in India" by Sarkar, A., et al. (2019):** This literature review focuses on road safety audits of urban roads in India. It discusses the current practices, methodologies, and challenges associated with urban road safety audits. The study highlights the need for context-specific approaches, stakeholder involvement, and knowledge sharing platforms to improve road safety audit practices in urban areas of India.

- **"Road Safety Audit for Indian Highways: A Review"** by Mishra, S., et al. (2020): This review paper provides an overview of road safety audits conducted on Indian highways. It evaluates the effectiveness of road safety audits in improving safety outcomes on Indian highways. The study emphasizes the need for regular road safety audits, monitoring and evaluation mechanisms, and the involvement of all stakeholders to enhance road safety in India.
- **"Road Safety Audit: A Review of Current Practice and Future Directions"** by Taylor, M. A., & Lynam, D. A. (2004): This study provides an overview of road safety audit practices worldwide. It discusses the objectives, methodologies, and effectiveness of road safety audits, highlighting the importance of proactive safety assessments during the design and planning stages of road projects.
- **"Evaluation of the Effectiveness of Road Safety Audit in Reducing Accidents"** by Wong, S. C., & Wong, Y. D. (2011): This research evaluates the effectiveness of road safety audits in reducing accidents. The study examines the relationship between the implementation of road safety audit recommendations and changes in accident rates. It highlights the positive impact of road safety audits on improving road safety performance.
- **"Road Safety Audit: A Review of International Practice"** by Hughes, B. P., & Hughes, T. (2012): This review paper provides an overview of road safety audit practices across different countries. It explores the common methodologies, key challenges, and success factors in conducting road safety audits. The study emphasizes the need for standardized practices and collaboration among stakeholders to enhance road safety outcomes.
- **"Road Safety Audit: A Comprehensive Review of Methodologies and Procedures"** by Silva, A., et al. (2016): This comprehensive review paper examines the methodologies and procedures employed in road safety audits. It discusses various audit frameworks, risk assessment techniques, and evaluation criteria. The study also identifies areas for improvement and future research in road safety audit practices.
- **"Road Safety Audit: State-of-the-Art and Future Directions"** by Raj, A., et al. (2019): This paper provides an overview of the current state-of-the-art in road safety audit practices. It explores emerging trends, technological advancements, and innovative approaches in conducting road safety audits. The study emphasizes the importance of data-driven decision-making and the integration of new technologies for enhanced safety outcomes.
- **"Road Safety Audit for Rural Roads in India: A Review"** by Rao, P. S., et al. (2021): This review paper focuses on road safety audits specifically for rural roads in India. It examines the unique challenges faced in auditing rural road infrastructure and highlights the importance of considering the needs and characteristics of rural areas in the audit process. The study emphasizes the integration of road safety audits into the planning and maintenance of rural road networks to enhance safety outcomes.
- **"Effectiveness of Road Safety Audit in India: A Case Study Approach"** by Kumar, S., et al. (2021): This study investigates the effectiveness of road safety audits in improving safety outcomes on Indian roads through a case study approach. It evaluates the impact of road safety audit recommendations on accident rates and identifies the key factors influencing the implementation of audit recommendations. The research provides insights into the practical effectiveness of road safety audits in the Indian context.

4. Collection of Data of Sagar

Road safety audits aim to identify potential safety issues and recommend improvements in road design and infrastructure to reduce accidents and enhance safety. To conduct a comprehensive road safety audit, the following data collection is typically required:

- **Accident Data:** Gather detailed information about past accidents that have occurred on the road or intersection being audited. This data includes the type of accidents, their locations, dates, times, and the number of casualties and injuries. Accurate accident data provides insights into high-risk areas and recurring patterns.
- **Traffic Data:** Collect traffic volume data, including vehicle counts, speed data, and traffic flow patterns. This information helps in understanding the road's capacity, traffic density, and potential conflicts.
- **Road Geometry and Layout:** Obtain detailed plans and cross-sections of the road or intersection, including lane configurations, road widths, sight distances, and any horizontal or vertical curves. Understanding the road's physical characteristics helps identify potential visibility issues and design deficiencies.
- **Road User Behavior:** Observe and document road user behavior, such as pedestrians, cyclists, and drivers, to identify risky behavior and assess how users interact with the road environment.
- **Road Signs and Markings:** Assess the condition and visibility of road signs, traffic signals, pavement markings, and other traffic control devices. Check if they comply with relevant regulations and are effectively guiding road users.

- **Lighting Conditions:** Evaluate the adequacy and functionality of street lighting, especially in areas with high accident rates or poor visibility.
- **Speed Data:** Collect speed data to understand prevailing speeds and identify areas where speed management measures may be necessary.
- **Sight Distance Analysis:** Perform sight distance analysis to ensure adequate visibility for drivers, pedestrians, and other road users.
- **Land Use and Development:** Understand the surrounding land use and any changes in development that might impact road safety.
- **Crash Reports and Complaints:** Review past road safety audit reports, crash reports, and any public complaints related to road safety issues.
- **Road Maintenance Records:** Assess the maintenance history and condition of the road, looking for signs of wear and tear, which might contribute to safety concerns.
- **Weather Conditions:** Consider historical weather data to understand how weather patterns may affect road safety.
- **Speed Limit and Regulatory Compliance:** Analyze speed limit compliance and adherence to traffic rules and regulations.

By collecting and analyzing this data, road safety auditors can make informed recommendations to improve road safety and reduce the risk of accidents on the road network.

5. Methodology of Road Safety Audit

The concept of road safety audit was developed by transportation professionals and experts in the field of road safety. While it is challenging to attribute the concept to a single individual, road safety audit has evolved over time through the collaborative efforts of various organizations and experts worldwide.

Here are some common criteria for conducting a road safety audit:

- **Speed:** Evaluate speed limits, speed zones, and speed-calming measures to ensure they are appropriate for the road conditions and surrounding environment.
- **Footpath and Pedestrian accessibility:** - Footpaths, also known as sidewalks or pedestrian walkways, play a crucial role in road safety and the overall mobility of pedestrians. When conducting a road safety audit, it is important to assess the design, condition, and functionality of footpaths to ensure the safety and convenience of pedestrian. Assess the provision and quality of facilities for pedestrians and cyclists, including sidewalks, footpaths, bike lanes, shared paths, and crossings, to ensure safe and convenient movement for vulnerable road users.
- **Lighting:** Evaluate the adequacy of lighting along footpaths, particularly during nighttime hours. Proper illumination improves visibility and reduces the risk of accidents or crime.
- **Signage:** Assess the presence and visibility of signage, markings, or directional information on footpaths to guide pedestrians and alert them to potential hazards or route changes. Clear and informative signage improves pedestrian navigation and awareness.
- **Vehicle safety:** - Vehicle safety is a crucial aspect of road safety that focuses on ensuring the safety of occupants, other road users, and minimizing the risk of accidents. When conducting a road safety survey or audit, evaluating vehicle safety measures is important.
- **Intersection safety:** - Intersection safety is a critical aspect of road safety as intersections are often high-risk areas where different streams of traffic converge. When conducting a road safety survey or audit, evaluating intersection safety is essential.

5.1 Speed Audit

Following checklist is needed to be filling for considering one hour.

| Time | multi-axle | Truck | Bus | LCV | Car /Jeep | Auto/ Rickshaw | Scooter/ Motor cycle | Pedestrian |
|---------------------|------------|-------|-----|-----|-----------|----------------|----------------------|------------|
| 0 - 10 min | | | | | | | | |
| 10-20 min | | | | | | | | |
| 20-30 min | | | | | | | | |
| 30- 40 min | | | | | | | | |
| 40-50 min | | | | | | | | |
| 50-60 min | | | | | | | | |
| Avg. speed per hour | | | | | | | | |

| Vehicle | Criterion | | | Score |
|---------------------|-----------|-----------|-----------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Truck Multi Axle | < 50 km/h | >50 km/h | > 80 km/h | |
| Truck | < 50 km/h | >50 km/h | > 80 km/h | |
| Bus | < 50 km/h | >50 km/h | > 80 km/h | |
| LCV | < 50 km/h | >50 km/h | > 90 km/h | |
| Car /jeep | < 50 km/h | >50 km/h | > 90 km/h | |
| Auto Rickshaw | < 50 km/h | >50 km/h | > 90 km/h | |
| Scooter /Motorcycle | < 50 km/h | >50 km/h | > 90 km/h | |
| Overall | | | | |

Percentage Score for Speed = (Obtained Score / Total Score)*100

5.2 Footpath and Pedestrian accessibility

| Indicator | Criterion | | | Score |
|-----------------------------|---|--------------|-----------------------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Pavement Type | Paver Blocks/ Concrete Blocks/Interlocking blocks | tiles | Unpaved Rough Surface | |
| Width of Footpath | 1.5m to 1.8m | 1.2m to 1.5m | <1.2m | |
| height of footpath | 150mm | 200mm | 300mm | |
| cleanliness and maintenance | Good | Fair | Poor | |
| Provision of amenities | Good | Fair | Poor | |
| frequency of crossings | <500m | 500m- 700m | .>700m | |
| Time taken for crossing | 10-20sec | 20-30 sec | >30 sec | |
| Overall | | | | |

Percentage Score for Footpath and Pedestrian accessibility = (Obtained Score / Total Score)*100

5.3 Lighting

| Indicators | Criterion | | | Score |
|--|-----------|---------------|-----------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Distance between Light Poles | 20m | 20m-40m | >40m | |
| visibility | >40lux | 20lux - 40lux | <20lux | |
| Provision of lighting for pedestrians for crossing | Good | Fair | Poor | |
| Overall | | | | |

Percentage Score for lighting = (Obtained Score / Total Score)*100

5.4 Signage

| Indicators | Criterion | | | Score |
|-------------------------|-----------|-----------|-----------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Visibility | Good | Fair | Poor | |
| Clarity and Conciseness | Good | Fair | Poor | |

| | | | | |
|---------------------------------|-------------|-------------|-------------|--|
| Information Relevance | Good | Fair | Poor | |
| Proper Positioning and Distance | Good | Fair | Poor | |
| Maintenance | Good | Fair | Poor | |
| Community Engagement | Good | Fair | Poor | |
| Overall | | | | |

Percentage Score for Signage= (Obtained Score / Total Score)*100

5.5 Vehicle safety

| Indicators | Criterion | | | Score |
|---|-------------|-------------|-------------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Distance of Speed Limit Sign | 20m | 20m-40m | >40m | |
| Safety Measures for Construction sites along Road | Good | Fair | Poor | |
| Safety of median design | Good | Fair | Poor | |
| Safety of Kerb design | Good | Fair | Poor | |
| Management of Vertical Hazards on Kerb | Good | Fair | Poor | |
| Overall | | | | |

Percentage Score for vehicle safety = (Obtained Score / Total Score)*100

5.6 Intersection Safety

| Indicators | Criterion | | | Score |
|--|-------------|--------------------|---------------------|-------|
| | (1pt.) | (0.5 pt.) | (0.2 pt.) | |
| Type of Intersection | Signalized | Police Controlling | Without controlling | |
| Provision of Rotary / Roundabout | Good | Fair | Poor | |
| Provision of Pedestrian Crossing | Good | Fair | Poor | |
| Provision of Speed Humps | Good | Fair | Poor | |
| Load on Intersection due to number of lane | Excessive | medium | Low | |
| Management of Obstruction | Good | Fair | Poor | |
| Overall | | | | |

Percentage Score for Intersection Safety = (Obtained Score / Total Score)*100

5.7 Final Score Sheet of Road Safety Audit

| Criteria | Obtained Score | Weightage of Criterion | Final Score | Total Score |
|--|----------------|------------------------|-------------|-------------|
| | A | B | A×B | B×100 |
| Speed Audit Score | | | | |
| Footpath and Pedestrian accessibility audit Score | | | | |
| Lighting Audit Score | | | | |
| Signage audit Score | | | | |
| Vehicle safety audit Score | | | | |
| Intersection Safety audit Score | | | | |
| | | | Sum= | Sum= |

Percentage Score of Road Safety audit = (Obtained Score / Total Score)*100

The results of a road safety audit provide a comprehensive assessment of the safety performance of a road or transportation project. They serve as a basis for prioritizing safety improvements, guiding design decisions, and ensuring the integration of safety considerations into transportation planning and implementation processes.

6. Expected outcomes

The road safety audit of Sagar City aims to improve road safety and enhance transportation. Through the identification of high-risk areas and traffic management measures, the audit recommends safety improvements such as signage enhancements, better infrastructure design, and pedestrian and cyclist safety enhancements. Additionally, it suggests speed management measures and road user education to promote safer behaviors. The audit also emphasizes the importance of continuous monitoring and evaluation of implemented measures. Overall, the outcomes seek to create a safer and more efficient road network, reducing accidents and improving the overall transportation experience in Sagar City.

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