A Case Study on Pre-Opening Stage Road Safety Audit

Ashish\(^1\), Sachin Dass\(^2\), Saurabh Jaglan\(^3\), Aman Ahlawat\(^4\) and Manju Suthar\(^5\)

\(^1\)PG Student, M.Tech. in Highway Safety and Engineering, \(^2\)\(^3\)\(^4\)Assistant Professor.  
\(^1\)\(^2\)\(^3\)\(^4\)Department of Civil Engineering, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonipat, Haryana, India.  
\(^5\)Department of Civil Engineering, Chandigarh University, Chandigarh, India  
\(^1\)faujithebraveheart@gmail.com, \(^2\)sachindass@gmail.com, \(^3\)saurabhjaglan86@gmail.com, \(^4\)ahlawataman39@gmail.com, \(^5\)Manju.e10702@cumail.in

Abstract. Transportation has been instrumental in the growth of cultures since the dawn of time, allowing individuals to migrate and goods to be transported. A poorly aligned road not only creates a possible traffic threat but also increases commuting costs and puts a burden on drivers and travellers. As a result, careful decisions are critical in highway construction, both in terms of current needs and the potential growth of the region. A Road Safety Audit is a critical technique for paying detailed attention to road safety during the planning, construction, and maintenance phases of a road. The two key techniques in road safety work are accident reduction and accident prevention. This study focuses on both aspects. The road chosen in this study is another District Road in Bareilly District, Uttar Pradesh. It originates from Fatehganj Paschmi near NH-530 and merges with SH-37 at Baheri. Road Safety Audit is conducted on the road section before opening it to the traffic. This is a two-lane road without a paved shoulder in which Bareilly-Shahi Road also merges from side at Chainage km 3+400. It has a Major Junction at Chainage km 10+000 which is densely populated Shahi Village. This study is about the road safety measures adopted on the newly built Bhitoura-Shahi-Shergarh-Baheri road and identifies any flaws that could result in an accident or pose a safety risk to road users. It is constructed to liberate people from traffic congestion. During the day, there is a lot of traffic on the road. On the basis of primary and secondary data collection, a systematic analysis of the road section is carried out. The methodology used entails gathering primary data performing a physical survey (inventory) and analyzing the observations, and secondary data from the appropriate authorities. Various recommendations to improve the deficiencies in order to ensure safe and efficient mobility are suggested as per IRC. The plants and tree along the road sides although control pollution of vehicles yet sometimes their branches have to be cut to reduce accidents.

Keywords: Transportation, accident reduction, accident prevention, Road Safety Audit.

1. INTRODUCTION

The present study has been carried out on Bhitoura-Shahi-Shergarh-Baheri Road in the district Bareilly Uttar Pradesh, India. This road was selected for the present study as it is the major link between NH-530 and SH-37. It is an Other District Road of 41.80 km in the district Bareilly which originates from Fatehganj Paschmi, near Bareilly-Rampur Highway and merges with Bareilly-Nainital Highway at Baheri [1–3]. This is a two-lane road without paved shoulder in which Bareilly-Shahi Road also merges from side at Chainage km 3+400. It has a Major Junction at Chainage km 10+000 which is densely populated Shahi Village. The road was found with frequent changes in land
use patterns, differences in driving habits, traffic patterns, etc. An RSA is carried out after its construction in order to recommend proper safety provisions as per IRC guidelines. This ODR is of high importance being sandwiched between a major NH and SH and caters high mixed traffic volume [4–6]. The entire project under Road Safet Audit is helpful to reduce the accident in the study area and in term of cost also. The present study is used to find out black spot as well as the basic causes of road accidents. The identified causes can be removed for selected stretch /area to rectify as well as some one future traffic movement. This pre opening stages is considered to be site inspection as well as improvement measurement against road safety. The audit steps of present study can be utilize on the other stretch by road safety auditor, where more accidents are happening yearly. The vegetations can play an important role on highways safety, but excess cutting/filling of plants can be a cause increase in environmental pollution. As the road side trees and plants on median are very much useful to control pollution of moving vehicles, but sometimes the branches obstruct various types of sign board and markings. These obstruction leads to lack of information to the drive and cause accidents. So present study can be use for reduction in environmental pollution and increase in road safety of selected streach. A good suggested travel pattern of traffic may lead to provide proper level of service for vehicles using the road [4–9].

2. Purpose of a pre-opening RSA

Identify and resolve any safety concerns prior to the post-construction stage [10–12]. Consider the road safety features that are not shown on the comprehensive design drawings. Check to see that the road users' demands have been addressed properly and safely. Inspect the recently built road for any temporary traffic signs, temporary road markings, construction equipment’s, barriers, fences, debris, etc. Examine first hand how the different design and construction components interact with one another and with the local road network. Identify any items that were overlooked during a previous audit. Follow-up on any issues that were discovered during a previous audit, see figure 1 and table 1.

![Figure 1. Alignment Plan of Bhitoura-Shahi-Shergarh-Baheri Road](image)

**Table 1. Salient Features of Bhitoura-Shahi-Shergarh-Baheri Road**

| S. No. | Description                  | Details                              |
|--------|------------------------------|--------------------------------------|
| 1.     | Length of Road               | 41.80 km                             |
| 2.     | Width of Carriageway         | 7m                                   |
| 3.     | Type of Road                 | Two Lane Without Paved Shoulder      |
| 4.     | Number of Major Bridge       | 1                                    |
| 5.     | Number of Minor Bridges      | 16                                   |
| 6.     | Number of Culverts           | 61                                   |
7. Number of Major Junctions 1
8. Number of Left-Side Roads 14
9. Number of Right-Side Roads 14
10. Number of Crossroads 6
11. Number of Staggered Intersections 2
12. Number of Curves 15
13. Number of Habitation Areas 16
14. Number of Police Station 1
15. Number of Mosques/Majaaar/ Dargah/Temples acting as potential hazards 4
16. Number of Educational Institutions/Schools 14
17. Number of Bus Stops 7
18. Number of Filling Stations 6

3. LITERATURE REVIEW

Studies the safety scenario on NH-5 passing through Visakhapatnam Metropolitan region. It is a case study which describes various recommendations to improve an existing road. represents RSA of SH-2 for “Lawan-Dudu” stretch. Various types of surveys have been carried out, presents an RSA on a 22 km stretch on Rajkot-Ahmedabad NH-27 from CH. 185+200 to CH. 207+200 for black spot from police station [13–16]. Survey data is obtained for Classified Traffic Volume and Spot Speed. Road inventories are carried out to gather information about the conditions on road, road geometry, road markings, traffic signs, road side furniture, etc. discusses the design defects and other safety features on a 10 km MDR having terrain and mixed traffic cause the accidents. The road stretch of 10 km from Vikarabad to Kerelli towns is chosen for RSA. Road markings such as centre line markings, edge markings, etc. are missing throughout the road. The paper followed the practical guidelines of PIARC for Road Safety Auditors and Inspectors and proposed some easy-to-do and even low-cost recommendations [17–21]. Another RSA of an existing interchange on NH-2 at Modi Mill flyover conducted. The researcher argues in the conclusion that even if the road user fails to obey the rules, the road designers must take necessary steps to prevent people from being killed or seriously injured. presents an RSA of NH-52 from Manur to Khalghat. To reduce the accidents, the primary step is the conduction of an RSA to study the basic causes leading to the accidents. Furthermore, these causes must be rectified following the recommendations made according to IRC guidelines. Sawan presents an RSA of NH-16 from Hanuman Junction CH. 1058.00 km to Vijayawada Vaaradh CH. 1100.50 km with 354 mitigation points for questionnaire survey. Accident data is collected to identify the potential hazardous locations from the questionnaires. aims to perform an RSA with Spot Speed studies and traffic volume count. From simulation data, it is observed that road markings, poor maintenance of shoulder and carriageway, unauthorised median openings, traffic signals, shoulder, carriageway, unauthorised median openings etc are the major causes of accidents. explores the design defects and other road safety features on NH-2 Delhi-Mathura Road is a part of CRRI RSA training program of 15 days. data is collected by a public questionnaire survey and Spot Speed studies and Traffic Volume studied. Audits in the mid-block sections with different safety-related steps, such as roadside hazards, inadequate road markings, etc. can be better conducted in one segment in an RSA, aims to assess the RSA of a 4-lane NH-58 road stretch and focus is to evaluate the implications of the recommendations proposed against the deficiencies.

4. NEED OF STUDY

Though several research findings are available for some developed countries of the world but their applicability to Indian conditions is limited. It is also observed that very few researchers have carried out RSA in night and adverse weather conditions. It is found that there is inconsistency and improper coordination among various stakeholders responsible for road safety. The roads chosen by majority of the researchers are either NH or SH. Almost no one has focused on ODRs.
5. Site visit and data collection
The audit team visited the road stretch several times and performed the safety audit for all the parameters mentioned in check lists in different conditions. Photographs are taken of potential safety hazards and verified using softwares such as GeoSetter and Google Earth Pro. It helps in getting the accurate alignment plan of the road. Complete videography of the entire road stretch is also done which is analysed later to assess the condition of vegetation control, roadside amenities, etc. Total Station Survey along the road stretch is carried out extensively covering the important geometrical safety parameters, see figure 2.

![Figure 2: Step Followed in Audit](image)

6. FINDINGS
The Major Issues endangering the safety of commuters on road are tabulated in table 2.

Table 2. Different issues endangering the safety of road and the recommendations to overcome them.

| S.N.o. | Chainage | Hazardous Issues | Recommendations | Photographs of the Issues |
|--------|----------|------------------|-----------------|--------------------------|
| 1      | 0+000    | Project Starts   | Provide advance warning sign of Built-up area for the traffic coming from Shahi and Give way sign as per. | ![Photograph of Issue](image) |
|        |          | (not a hazardous issue) |                 |                          |
| S.N. | Chainage | Hazardous Issues                                                                 | Recommendations                                                                                           | Photographs of the Issues |
|------|----------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------|
| 2    | 0+680    | Approach Road leading towards Railway Station (RHS)                             | Provide Flag sign for Railway Station and Side Road sign with Rumble strips on the approach road to the railway station as per . | ![Image](image1)          |
| 3    | 1+080    | Improper orientation of LHS Curve Sign                                           | Erect the LHS curve sign properly as per.                                                                | ![Image](image2)          |
| 4    | 1+100 and 1+150 | Unstandardized Guarded Railway Crossing Sign                                    | The configuration of existing Guarded Railway Crossing signs on both sides of railway crossing are not conforming to . Replace the existing sign boards with proper sign boards as per fig. no. - 15.71 in . | ![Image](image3)          |
| 5    | 1+290    | Damaged Parapet Wall of the Pipe Type Culvert                                   | Repair the parapet wall. Provide delineators with cats’ eyes on all sides of the Culvert with Hazard Marking as per . | ![Image](image4)          |
| 6    | 1+780; 7+540; 14+320 and 32+570 | Temple/ Majaar near the shoulder.                                                | Shift the hazardous building away from the RoW. If not possible, provide Hazard Marker with Compulsory Keep Left/ Right Signs as per . | ![Image](image5)          |
| S.N.o. | Chainage | Hazardous Issues | Recommendations | Photographs of the Issues |
|-------|----------|-----------------|----------------|--------------------------|
| 7     | 3+400    | Skewed Junction: Side Road (RHS) with Baraat Ghar and Bus Stop. | Provide No Standing sign to prevent vehicles from standing unnecessarily waiting for buses/ Baraat. Also, provide advance informatory and warning signs. Provide Stop Sign, Rumble strips and T-Intersection Major Road Ahead sign on side road as per. | ![Image of Skewed Junction: Side Road (RHS) with Baraat Ghar and Bus Stop.](image) |
| 8     | 3+690 and 33+600 | MNB (Damaged Parapet Wall) | Repair the parapet wall. Provide delineators with cats’ eyes on all sides of the Culvert with Hazard Marking as per. | ![Image of MNB (Damaged Parapet Wall)](image) |
| 9     | 5+370    | Pond on RHS     | Provide W-beam metal Crash Barrier along the length of the water body. | ![Image of Pond on RHS](image) |
| 10    | 9+680; 19+700 and 23+100 | Unstandardized Sign Board | The configuration of existing sign is not conforming to. Replace the existing sign board with Built-up area sign boards as per fig.no. - 15.35 in. | ![Image of Unstandardized Sign Board](image) |
| 11    | 10+000   | Major Junction  | Provide pedestrian crossing, advance warning signs and Informatory sign boards as per. | ![Image of Major Junction](image) |
| S.N. | Chainage | Hazardous Issues | Recommendations | Photographs of the Issues |
|------|----------|------------------|----------------|--------------------------|
| 12   | 11+320; 22+840 and 25+110 | Undesired Overhead Gantry in Hindi Language | The existing Overhead Gantry is of no use. Instead of investing money in these kind of gantries, it is highly recommended to provide reassurance sign boards which are quite worth as per fig.no. - 16.05 in | |
| 13   | 20+600 | Y-Junction | It is recommended to improve this junction to T-intersection. Provide advance warning signs of Side Road and informatory signs of bus stop with bar marking. Provide rumble strips, Stop Sign and Major Road Ahead sign on the | |
| 14   | 20+800 to 21+000 | Major Bridge | Provide delineators on parapet wall with cats’ eyes on the edge lines and crash barriers on all four sides of the Major Bridge with Hazard Marking as per | |
| 15   | 21+400 | High Embankment on RHS and poorly oriented shoulder mounted Chevron sign. | Provide W-beam metal Crash Barrier along the length of the high embankment and erect properly the Chevron signpost. | |
| 16   | 24+000 | Poles on main carriage way in densely populated market area. | Remove them from the carriageway else provide retro-reflective tapes on them. | |
| S.N.o. | Chainage | Hazardous Issues | Recommendations | Photographs of the Issues |
|-------|----------|-----------------|----------------|--------------------------|
| 17    | 25+220; 31+420 | High Embankment with pond on RHS | Provide W-beam metal Crash Barrier along the length of the high embankment and water body. | ![High Embankment with pond](image1.png) |
| 18    | 26+750 | RHS Curve Sign (Poor Sight Distance due to Vegetation) | Trim the Vegetation so as to improve the sight distance of the sign board. | ![RHS Curve Sign](image2.png) |
| 19    | 31+650 | Pond on LHS just after crossroad | Provide W-beam metal Crash Barrier along the length of the water body. | ![Pond on LHS](image3.png) |
| 20    | 35+450 | Inter College on LHS | Although pedestrian crossing exists but necessary sign boards of School Ahead as per are not provided. Provide School Ahead sign boards with bar markings on main carriageway as per. | ![Inter College](image4.png) |
| 21    | 35+550 | Irrelevant Sign Board | The existing signs of Side Roads before and after crossroad are indicating only about single sided roads. Replace the existing sign boards with Cross Road sign boards as per fig.no. - 15.14 in. | ![Irrelevant Sign Board](image5.png) |
Staggered Intersection with Masjid on RHS

Provide Hazard Marker on hazardous building on RoW with Compulsory Keep Left/Right Signs as per [6, 8]. Provide rumble strips on side roads to reduce the speed of approaching vehicles. Provide bar markings with pedestrian crossings on our stretch to alert the drivers as per [7].

MNB with High Embankment on both sides with water body on RHS

Repair the parapet wall. Provide delineators with cats’ eyes on all sides of the Culvert with Hazard Marking as per . Provide W-beam metal crash barriers along the length of high embankment and water.

Speed Breaker

Replace the Speed Breaker with Rumble strips to reduce the jerk on the vehicles.

Major Junction

Because of the virtue of existing geometry of the junction, the traffic coming from Shergarh and entering NH will not get proper turning radius. The alignment shall be improved to accommodate

7. CONCLUSIONS

From above table, it is clear that all existing unstandardized traffic signs shall be replaced with standard sign boards as per IRC:67-2012. Road markings at mentioned locations shall be marked as per IRC:35-2015. The pedestrian crossings shall be provided for all approaches of a junction as per IRC:103-2012. All curves shall be delineated with chevrons. All the culverts, MNBs or major bridges shall be made visible with OHM and delineators as per IRC:79-2019. High embankments shall be protected with W-beam metal crash barriers. School zone traffic calming measures including road markings and raised pedestrian crossings shall be in place as per IRC:103-2012. Improve all Y-junctions as per site conditions. The walls of all religious structures in the vicinity of carriageway shall be delineated properly, if not removed. The abrupt speed breakers shall be replaced with rumble strips at junctions. The cat’s’ eyes are recommended to be provided in specific zones for better visibility at night. The vegetation and branches of the trees throughout the road shall be periodically trimmed to cut off the glare and to improve the night visibility of edge lines by using IRC:SP:21-2009.
8. LIMITATION

The road safety audit is very much important in term of increase in safety of road user, but it’s a complicated process to conduct. A person/auditor must be having certified course completion certificate for identify safety issues. Sometimes the clearance of issues from various other departments can delay or revised the final finding of audit. The work/steps required improving the traffic condition and junction condition can divert the route, which can increase the travel time and cost of travellers. The audit finding may leads to increase overall budget of selected stretch in terms of changing some designs. The spacing available on actual site condition may be a hazard to change/improve the junction having more accidents.

9. SCOPE OF FURTHER STUDY

The road safety audit is an important part of good travel pattern of vehicles using that stretch. This RSA can be conducted on every junction which have more monthly/yearly accidents and spotted as black spots. The black spots can be identified and the steps used in present study to be implemented on them for improvement of the road behaviour. The RSA can be implementing on other complete road of N.H. and S.H. for reduction in accidents time by time. The modification and improvement provided by RSA can be used to reduce accidents on similar types of other roads with some changes. The steps involved in RSA for different stages can be used for different road stages in terms of newly constructed road to improvement on existing road. The stages of RSA can be implemented on during construction stage and after construction, before opening of traffic and after opening of traffic wherever the condition allows.

10. ACKNOWLEDGEMENTS

The authors sincerely thank The Superintending Engineer and The Executive Engineer, Provincial Division, Public Works Department, Bareilly, Uttar Pradesh for their cooperation.

REFERENCES

[1] Jun Y, Park J and Yeom C 2021 The evaluation of experimental variables for sustainable virtual road safety audits Sustain. 13
[2] Dorokhin S, Zelikov V A and Starkov E V 2021 Road Safety Audit Based on the Results of 2019 IOP Conference Series: Earth and Environmental Science vol 666, ed S D.B. (IOP Publishing Ltd)
[3] Tomczuk P, Chrzanowicz M, Mackun T and Budzyński M 2021 Analysis of the results of the audit of lighting parameters at pedestrian crossings in warsaw Arch. Transp. 59 21–39
[4] Dhankute A and Parida M 2020 Risk Analysis for a Four-Lane Rural Highway Based on Safety Audit ed V A Arkatkar S.S. Velmurugan S. Lect. Notes Civ. Eng. 69 599–618
[5] Chatterjee S and Mitra S 2019 Safety Assessment of Two-Lane Highway using a Combined Proactive and Reactive Approach: Case Study from Indian National Highways Transp. Res. Rec. 2673 709–21
[6] Kustra W, Ukowska J, Budzyński M and Jamroz K 2019 Injury Prediction Models for Onshore Road Network Development Polish Marit. Res. 26 93–103
[7] Arranz Cuenca A and Canovas Masero J 2019 Road safety audits in the federal road network
Shinta N L P, Linggasari M I D, Limawan H and Antonius A 2019 Cipularang toll road safety audit of traffic signs and road markings *IOP Conference Series: Materials Science and Engineering* vol 508 (Institute of Physics Publishing)

Abu Mansor S N, Ahmad Saman M S, Tengku Razman T M S and Masnel H 2019 Road safety audit - What we have learnt? *IOP Conference Series: Materials Science and Engineering* vol 512, ed W Y C Jakami F.M. Hamidun R. (Institute of Physics Publishing)

Sai Pavan N N G, Raja K H, Rahul B G and Asadi S S 2018 A statistical evaluation on road safety audit: A model study from hanuman junction to kanaka durga vaaradhi Vijayawada *Int. J. Mech. Eng. Technol.* 9:721–33

King J A, King M J, Edwards N, Hair S A, Cheang S, Pearson A and Coelho S 2018 Addressing transport safety and accessibility for people with a disability in developing countries: a formative evaluation of the Journey Access Tool in Cambodia *Glob. Health Action* 11

Budzynski M, Jamroz K, Kustra W, Michalski L and Gaca S 2017 Road Infrastructure Safety Management in Poland *IOP Conference Series: Materials Science and Engineering* vol 245, ed Y I D M M M R J Segalini A. Coisson E. (Institute of Physics Publishing)

Xu G, Crowe R, Rousseau G and Bedsole L K 2017 Slamming on the brakes on a mounting problem *Public Roads* 80 10–7

Aydin C and Balla N 2017 Road safety audit: A case study *ISEC 2017 - 9th International Structural Engineering and Construction Conference: Resilient Structures and Sustainable Construction* ed Y V S A Y S Pellicer E. Adam J.M. (ISEC Press)

Tumavičė A, Vitkienė J, Kaniušėnienė S, Kravcovas I and Lingytė I 2017 The key issues of road design found from road safety inspections and road safety audits *10th International Conference on Environmental Engineering, ICEE 2017* ed C D Vaiskunaite R. (Vilnius Gediminas Technical University Publishing House “Technika”)

Garzón M, Escobar D and Galindo J 2017 Road safety audits. Example of methodological application [Auditorias de seguridad vial. Ejemplo de aplicación metodológica] *Espacios* 38

Aggarwal S, Jindal D, Chaudhary R, Dua A, Aujla G S and Kumar N 2018 EnergyChain: Enabling energy trading for smart homes using blockchains in smart grid ecosystem *Proceedings of the 1st ACM Mobihoc Workshop on Networking and Cybersecurity for Smart Cities, SmartCitiesSecurity 2018*

Gairola P, Gairola S P, Kumar V, Singh K and Dhawan S K 2016 Barium ferrite and graphite integrated with polyaniline as effective shield against electromagnetic interference *Synth. Met.* 221 326–31

Kaur M and Wasson V 2015 ROI Based Medical Image Compression for Telemedicine Application *Procedia Computer Science* vol 70 pp 579–85

Chaudhary R, Jindal A, Aujla G S, Kumar N, Das A K and Saxena N 2018 LSCSH: Lattice-Based Secure Cryptosystem for Smart Healthcare in Smart Cities Environment *IEEE Commun. Mag.* 56 24–32

in Ecuador [Auditores de seguridad vial en las carreteras nacionales de Ecuador] *Carreteras* 4 38–46
[21] Singh U and Rattan M 2014 Design of linear and circular antenna arrays using cuckoo optimization algorithm *Prog. Electromagn. Res. C* **46** 1–11