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# **Implementation of Road Safety Audit to Highlight the Deformities in the Design and Environmental Safety Features: A Case Study on National Highway-326**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/IJECC/2022/v12i1131089

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/90513>

**Original Research Article**

**Received 01 June 2022  
Accepted 03 August 2022  
Published 04 August 2022**

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## **ABSTRACT**

Road Safety Audit is an advanced strategy for detecting the highly affected areas which are more prone to accidents and security Increase of existing and new streets. RSA is a well-organized, economical and making a move to improve road security. It is demonstrated that RSA has the capacities to rescue lives as it provides and formulates all possible safety measures and techniques which are extremely essential to have a secured journey. The RSA was first implemented in Britain and later followed by other nations like Australia, Denmark, Malaysia, Singapore, New Zealand, Canada and United Kingdom & United States of America. It is at different phases of execution in flourishing countries like India, South Africa, and Thailand. RSA plays a significant role for enhancing road security in India, as fundamental and exact information on accidents still can't seem to be gathered. The fundamental part of this study is to assess Road Safety Audit of a segment of two-path National Highway (NH) - 326 and the job of an auditor is to give autonomous suggestions in the form of written recommendation. The fundamental goal of the investigation is to recognize highly affected zones which are more prone to accidents and dark spot regions on the road from FIR, to think about the impact of geometric design of roads and influence of traffic characteristics on various parameters of roads and experimentation and establishment of statistical relationship between accidents rates and different variables causing accidents. This paper investigates the deformities in the design and other safety features.

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**Keywords:** Road safety audit; NHAI; improve design standards; environmental safety.

## 1. INTRODUCTION

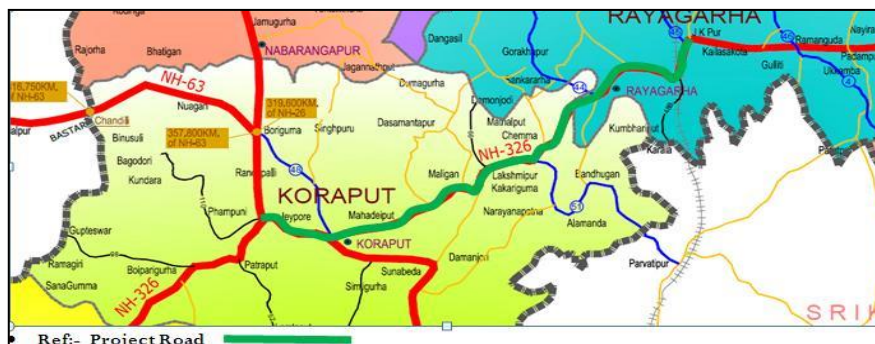
The street accidents, deaths and injuries are worldwide phenomena and the main factor responsible for these fatal accidents is the mixed traffic that is presently existing on Indian multilane highways. Idea and principles of quality management and sustainable safety have made progress in the last 20 years and it could be the reason that drove policymakers and project managers to understand the requirement for simply road security tools. Road Safety Audit (RSA) is probably the best tool for development of road security; where specialists endeavor to recognize possibly the prone areas where more possibilities of accidents exist on the highway and propose the safety methods [1,2]. Road Safety Audit can be characterized as a well-organized and consistent approach for assessment of existing or new streets by an autonomous audit teaming various parameters such as planning, design, construction, operation & maintenance aiming to attain secured roads and to implement measures to improve and enhance overall safety [3,4]. In the last three decades, the incidence of traffic crash fatalities and injuries has been reduced significantly in the high-income countries but not in the low- and middle-income countries [5,6]. The traffic patterns in the former are not only different but are also less complex than those in the latter. Traffic in low-income countries comprises a much higher share of vulnerable road users and so vehicles, roads and the environment have to be designed for their safety [7].

The RSA was begun in Great Britain (1980) is currently being followed in few nations around the globe. The RSA framework set up in United Kingdom and later adopted in USA, New Zealand, Australia, Denmark, Canada, Malaysia,

China, Japan and Singapore and now it is utilized as models for various nations. It is used for the detailing of rules and arranging of their trunk streets [8-10]. It is at different phases of execution in developing nations like India, South Africa, Thailand, Egypt, Pakistan and Bangladesh. Estimating the effect of interest is complicated by the various ways in which the number of accidents and the concentration of air pollutants may co-vary with structural, seasonal, and weather-related phenomena. As road traffic itself is a major source of air pollution, endogeneity bias is a concern [11-13]. In order to credibly identify the effect of interest, we rely on atmospheric temperature inversions as an instrument inducing plausibly exogenous variation in pollution levels [14,15]. A main concern are unobserved weather conditions that may be correlated with inversion episodes and influence road safety [16,17].

## 2. SITE SELECTED

National Highway 326 (NH 326) is one of the recognized highways in India that connects states like Andhra Pradesh and Odisha. It was later improved and developed as a new highway after the evolution of existing state highways of two States. The starting point of this highway is from Aska and covers the areas like Rayagada, Koraput, Jeypore, Malkangiri, Motu in Odisha and finishes at Chinturu road in Andhra Pradesh. The road selected for this examination is the existing street from Koraput bus stand to Rayagada by means of Laxmipur, which is the part of National Highway 326 (Fig. 1). Considering the deplorable condition between Jeypore (Koraput) to JK-Pur (Rayagada) the road safety audit of the stretch of road is conducted (Fig. 1).



**Fig. 1. The road map of the NH-326 plying from Jeypore to JK Pur within Odisha (Source Google)**

### 3. SALIENT FEATURE OF THE HIGHWAY

The width of the primary carriageway is 7 meters having shoulders each of width 2 meters on either side of the carriageway. The highway start from NH-59 Junction near Aska in Ganjam district, negotiating Rayagada, Jeypore, Motu in the State of Odisha (513.7 km in Odisha) and terminating on NH-30 at Chinturu in Andhra Pradesh (13.6 km), the details of the road are listed in Table 1.

#### 3.1 Review of Literature

Decadal progress of NH in Odisha has been either developed and upgraded was 2010 to 2014 was 1040 km and from 2014 to 2018 was 2329 km. Proposal for augmenting the total length of NH in Odisha 6968 km by 2018 and there was proposal to increase the NH length to 9493 km which has been futile due to the pandemic COVID-19 (NHA report Odisha – 2018).

Disobedience of traffic guidelines, over speed, and incapacitate design of roads are causing road crashes and mortalities in NH 326. So, it is upsetting and the need of the hour to prepare the road safety audit (RSA) of the road under research and investigation, and implementing the safety measures for road [18,19].

Researches have been conducted about roads types, accessibility, and road safety for road upgrading, enhancement and improvement. Many researchers have worked on studied the urban road safety on vehicle speed reduction, and others have probed to severity on accident injury and recommended suggestive measures, Vardaki et al., [20], Luca Persia [21], Singh, [22], Goel et al., [23].

The areas through which NH 326 is running where in huge numbers of Busses, trucks and tippers are running. The plying of heavy volume over the NH 326 has deteriorated the NH. There are continuous road accidents; numbers of serpentine bends and over turnings causes many road accidents causing disruption in traffic flow, delay in travel time and human losses. The numbers of drainages and accident of forest animals particularly the elephant has drawn the attention to have a road safety audit (RSA) and recommend for adequate road safety standards

for the NH passing area as a case study, Panda et al. [24], Mishra et al. [25], Bagh et al. [26].

#### 3.2 Methodology

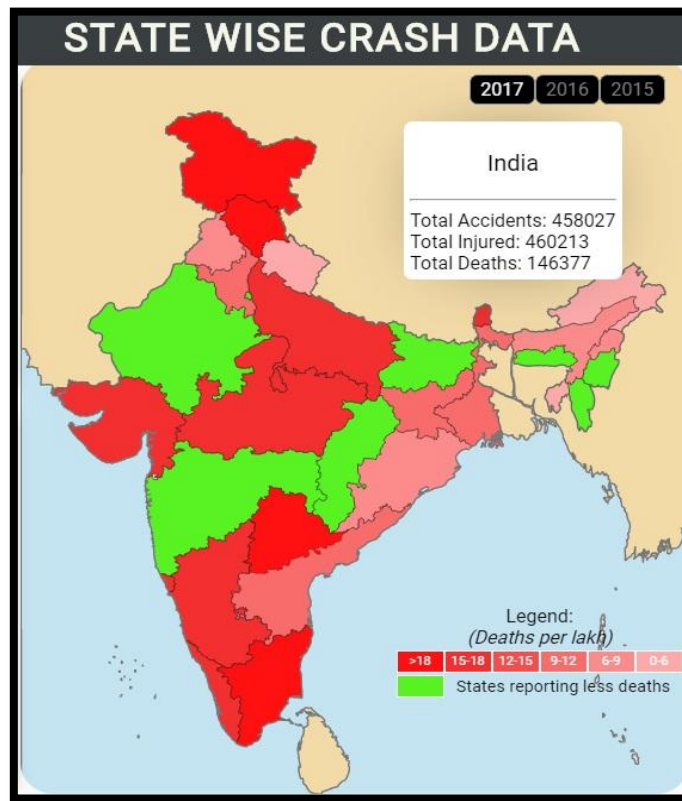
The coherent course for scrutinizing the safety on the road that warrants the keep fit the particular highways being improved or constructing new roads. The focused objectives of the run-through is to optimize the upcoming road mishaps that may manifest the structure or pavement has been constructed and roads under use [27], the benefits of RSA is cost effective, and addresses Throwaway, and reconstruction costs to reduce safety deficiencies, lifecycle cost (if designed properly), societal costs (for collisions not severe) and hence liability claims (reduced numbers of crashes and their severity).

1. The methodology involves various steps of Road safety audit by collection of past statistical accident data from various sources, identifying the black spots.
2. The 30km distance of NH-326 (part) from Km 212.700 to Km 253.700 and Km 281.700 to Km 311.700 is under construction.
3. The research activities include visit to the site and identify the fault zones, and finally find out solutions to the observation and prioritize the curative actions.
4. For the old works, realignment of the roads and designing an alternate pavement has been considered widening and strengthening proposal is recommended.
5. At the high traffic zones; provision of intersections, access roads are recommended for ameliorating the traffic odds.
6. The causes of defects in road formation towards causing crashes, black spots are identified and necessary zebra crossings, pedestrian tracks, road marking and sign boards near the accident zones are also reported.
7. For the chainage of high embankments provision of safety barriers, guard walls, guard posts and crash barriers where necessary is conveyed
8. At river/drainage road crossings, in the side slopes rough stone dry packing and safety barriers and concrete crash barriers are proposed.
9. Rail over bridges are proposed where it is found necessary has been proposed.

**Table 1. Details of features in Road Safety Audit of National Highways (326)**

SL. No.	Road Features	Numbers	SL. No.	Road Features	Numbers
1	Major Junctions	04	2	Major Bridges	05
3	Minor Bridges	04	4	Culverts	80
5	Truck lay Bays	01	6	Bus bays	34
7	Industries/Institutions	53	8	T- Junctions	16
9	Intersections	02	10	Y-Junctions	22
11	Gap in median	22	12	Road curve	222
13	Petrol Bunks	10	14	Pilgrimage	17

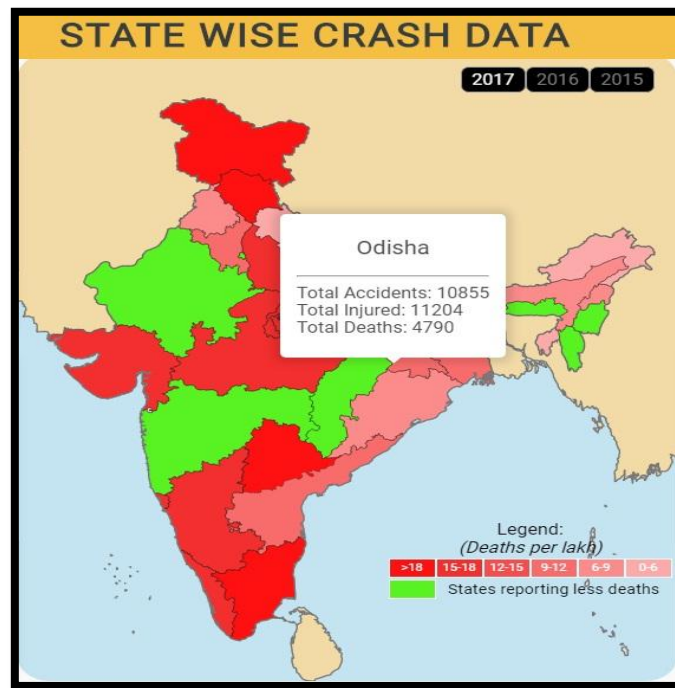
**4. ACCIDENT DATA**



**Fig. 2. Accident statistics o of the total numbers of different states of India (2017)  
(Source: State wise crash data, India 2017 from Google)**

As per the reports obtained on Road Accidents in India 2016, distributed by Transport Research wing under Ministry of Road Transport and Highways, Government of India, has uncovered that most of the people met with fatal road accidents in India last year, when compared to the number of fatal accidents in 2017. The information has additionally uncovered the fact that the states of Uttar Pradesh and Tamil Nadu are on the top accounting for number of deaths this year. According to the information referred to in the report, the country recorded minimum of 4, 80,649 accidents in 2016, leading to 1, and

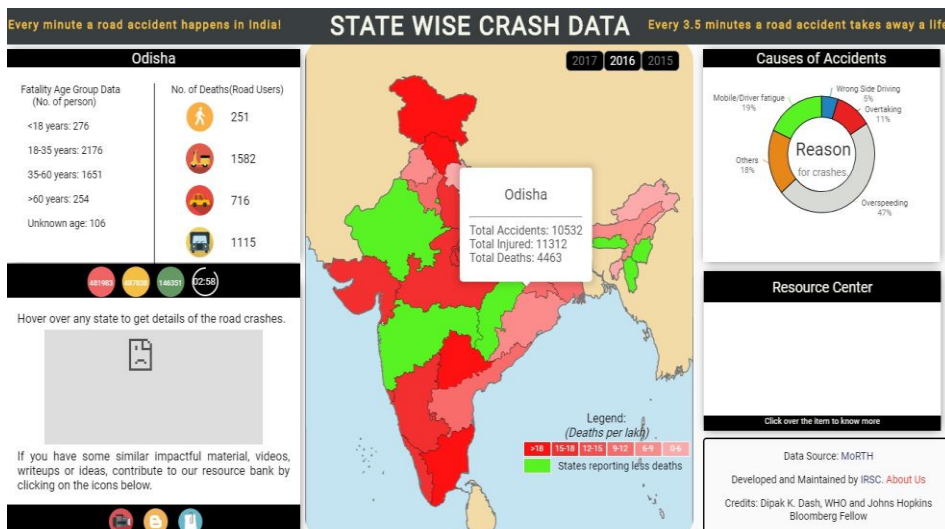
50,783 deaths. In the year 2017 road accidents decreased to 4.3% when compared with earlier year 2016. We should formulate the designing measures to decrease the road accidents. About 120806 lethal accidents occurred in 2020, which was 12.23% less than that of 2019 which was 137689 in number. About 366138 accidents on roads of India during 2020, out of which 116496 (31.8%) over NH and EH (National and Express Highways), 90755 numbers (24.8%) over SH (State Highways), and rest 158887 numbers (43.4%) over rest other roads (Fig. 2).



**Fig. 3. Accident statistics of the total numbers of different places in Odisha (2016)**  
 (Source: State wise crash data, Odisha 2016 from Google)

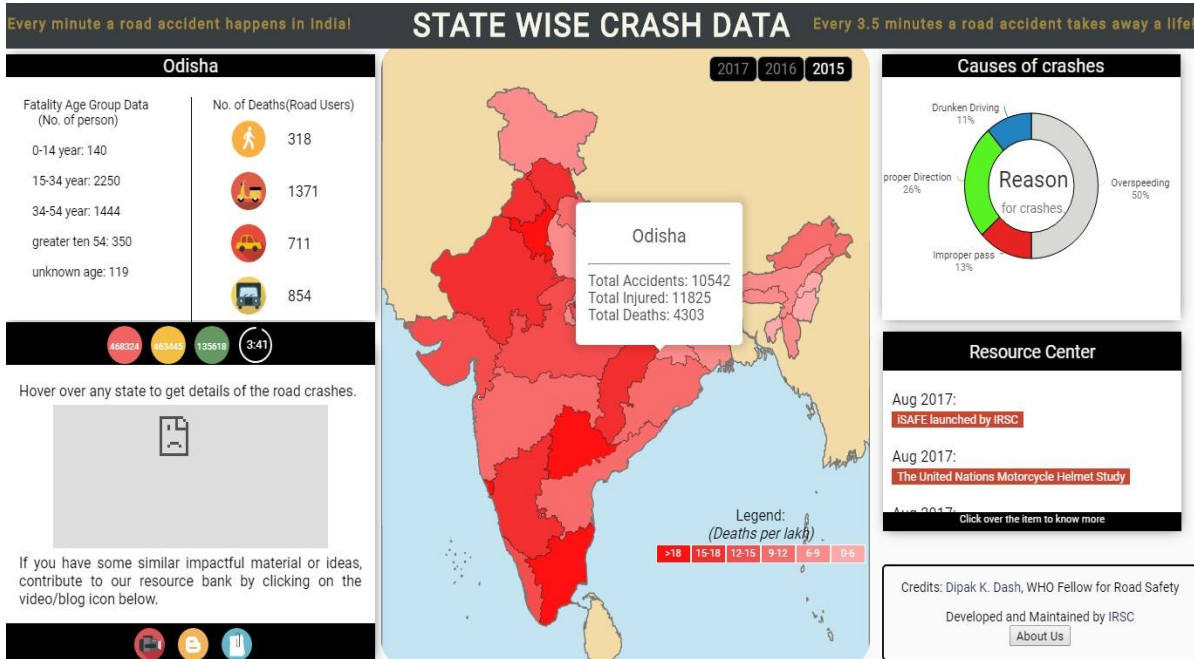
According to the report of Road Accidents in Odisha 2017, distributed by Transport Research wing under Ministry of Road Transport and Highways, Government of India has uncovered that most of the people met with fatal accidents in Odisha this year as per Government of Odisha (GoO), when compared to the number of deaths

in 2016. The information have revealed that most extreme number of deaths occurred this year. According to the information referred to in the report, Odisha state recorded an accident rate of 10,532 in 2016, in which 4463 are fatal accidents. Fig. 1 gives the statistics of road accident India 2017, (Fig. 3).

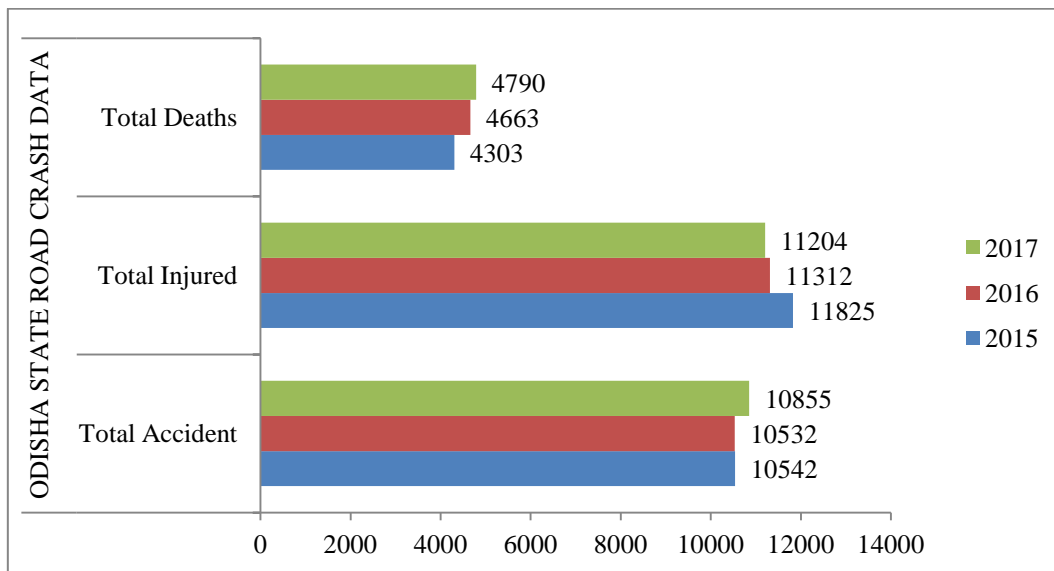


**Fig. 4. Crash statistics of the total numbers of different states of India, (2016)**  
 (Source: State wise crash data, Odisha, India 2016 from Google)





**Fig. 5. Crash statistics o of the total numbers of different states of India, (2015) (Source: State wise crash data, Odisha, India 2015 from Google)**





**Fig. 6. Road accidents on NH-326 between Koraput to Rayagda in last 2 years**



In the year 2017 road accident inclined to 3.0% as compared to previous year 2016. It is a very serious matter; we should emphases the engineering measures for reducing road accidents and should have action plan immediately (Fig. 4, Fig. 5 and Fig. 6).

### 5. DESIGN ASPECTS AND GENERAL OBSERVATIONS

*“NH-326 from Km 212.700 to Km 253.700 Km and Km 281.700 to Km 311.700 (Old chainage 0/000 to Km 30/000 and from Km 58/0 to Km 99/0)”*

**Table 2. Design aspects and general observations**



<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
<b>1</b>	<b>Under-construction stage</b>		
<b>Case - I</b>	At chainage: 11/500Km, The road alignment is not safe for moving vehicles on design speed, because there is an “S” curve. As the culvert to be retained and the alignment is finalized. Both the entry and exit point of culvert should properly match with the transition of S curve.	➤ All the relevant sign boards, road marking, lighting, both side <b>(entry and exit of curves must provide ramblers)</b> , delineator, Hazard marker at CD and etc. should be provided as per guide line.	<b>Very much Essential</b>
			
<b>Case-2</b>	At chainage: 14/100km -14/200km, Bridge approach embankment slope is not the standard 2:1, embankment is not safe, soil erosion take places.	➤ There need protection wall at both side, the nallah bed sours present, so need ‘D’ wall for floor protection and nallah water way protection.	<b>Very much Essential</b>
			
	(Left Side View) (Right Side View)		



<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
<b>Case - 3</b>	<p>At chainage km(21/800 -21/850), the road is constructed by cutting the road ways, the cutting is not maintaining slope 1:1, both side slope are vertical, so the embankment may falls at any time, both side edge bears trees it may fell down at any time.</p>  <p><i>(Right Side View)</i></p>  <p><i>(Right Side View)</i></p>	<p>➤ The slope should be maintained proper and check the stability of embankment, trees should be cut immediately. Breast wall on LHS around 50m length and RHS around 100m length need to be provided.</p>	<p><b>Very much Essential</b></p>
<b>4</b>	<p>At chainage 29/530km, Left side cutting slope is not maintained, it is almost vertical, Right side village road crossing, which is connects with a steeper gradient, and site distance is very poor.</p>	<p>➤ The junction need to develop properly and the cutting slope should be rectified</p>	<p><b>Very much Essential</b></p>
<b>5</b>	<p>At chainage: 58/0km Laxmipur junction &amp; At chainage: 78/0km Rukuna junction There needs to install overhead signboards and all other road furniture for junction improvement.</p>	<p>➤ Laxmipur junction should be developed immediately</p>	<p><b>Very much Essential</b></p>





<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
<b>6</b>	At chainage: 58/500 km 7x1200 mm dia Hume pipe, both side approach needs safety barrier.	➤ Both side approach needs to provide safety barrier by using guard post or metal beam crash barrier	<b>Very much Essential</b>
<b>7</b>	At chainage: 60/300 km, Habitation area Durja and School precaution and safety information mandatory sign boards etc. are to be provided.	➤ All the relevant sign boards, road marking, lighting and rumbles as per guide line should be provided	<b>Very much Essential</b>
<b>8</b>	At chainage: 61/440 km, MB 1x8x8m, High embankment both side approaches need to provide safety barrier and protection to the embankment.	➤ Both side approach needs to provide safety barrier by using guard post or metal beam crash barrier, the high embankment should be protected with PCC/RCC concrete wall.	<b>Very much Essential</b>
<b>9</b>	At chainage: 62/262 – 62/400 km High embankment need to provide safety barrier	➤ Both side of road edge need safety barrier by using guard post or metal beam crash barrier.	<b>Very much Essential</b>
<b>10</b>	At chainage: 68/496 km, Habitation area and School LHS precaution and safety information mandatory sign boards etc. are to be provided.	➤ All the relevant sign boards, road marking, lighting and rumbles as per guide line should be provided	<b>Very much Essential</b>
<b>11</b>	At chainage: 75/600 km, Habitation area Potali and School precaution and safety information mandatory sign boards etc. are to be provided. Here also horizontal curve site distance is obstructed.	➤ All the relevant sign boards, road marking, lighting, rumbles, reflector should be provided as per guide line.	<b>Very much Essential</b>





<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
12	At chainage: km (88/5-88/800) 2 hair pin bends and from km(90/0-91/0) 3hair pin bends and steeper gradient, informatory signboards, safety barrier and guard wall, beast wall need to provide	➤ All the relevant sign boards for hair pin bend, steeper gradient incline/decline, curve sign, wild animal crossing, road marking, lighting, rumbles, reflector should be provided as per guide line.	<b>Very much Essential</b>
			
13	At chainage: 93/985 km, Habitation area, R.I office, Hospital, 5 big trees at curve location, horizontal site distance site distance is obstructed.	➤ All the relevant sign boards, road marking, lighting, rumbles, reflector less ribbons should be provided. Tree should be marked properly for alerting drivers.	<b>Very much Essential</b>
			

<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
14	At chainage: 94/273 km, Habitation Guma School (RHS) precaution and safety information mandatory sign boards etc. are to be provided.	➤ All the relevant sign boards, road marking, lighting, rumbles should be provided as per guide line.	<b>Very much Essential</b>
			
15	At Chainage: km (95/435 -95/487), No overtaking zones	➤ No overtaking zone sign and road marking, lighting etc. to be provided	<b>Very much Essential</b>
16	At chainage: km (95/990), 'S' CURVE	➤ Curve sign, no overtaking zone sign and road marking, lighting etc. to be provided, super elevation, extra widening , safety barrier at LHS to be provided	<b>Very much Essential</b>
			

<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
17	<p>At chainage: 96/790, Bridge 3x34.5, High embankment both side approaches need to provide safety barrier.</p> 	<ul style="list-style-type: none"> <li>➤ Few guard post exists, which are quite insufficient for hazards, So both side approach needs to provide safety barrier by using guard post or metal beam crash barrier.</li> </ul>	<b>Very much Essential</b>
18	<p>At chainage: 97/000km, MB 7x9x4.2m, High embankment both side approaches need to provide safety barrier and protection to the embankment. Right side Hill, Horizontal curve affected with site distance.</p> 	<ul style="list-style-type: none"> <li>➤ Both side approach needs to provide safety barrier by using guard post or metal beam crash barrier, the high embankment should be protected with PCC/RCC concrete wall. Hill side may be protected with breast wall. Clearing the hip and ground for clear site distance needed.</li> </ul>	<b>Very much Essential</b>

**LHS View**



Sl. No	Observation	Measures	Priority
			
	<b>RHS View</b>		
19	At chainage: km (97/968), Sharpe CURVE, site distance obstructed, LHS Temple, RHS Reserve forest.	➤ Curve sign, no overtaking zone sign, Loose gravel falling symbol and road marking, lighting etc. to be provided, super elevation, extra widening , safety barrier at LHS to be provided	<b>Very much Essential</b>
20	At chainage: km 98/468 horizontal curve, vegetation affected the site distance.	➤ Curve sign, road marking, lighting etc. to be provided, site distance affected by the vegetation need to be clear.	<b>Very much Essential</b>
			



<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
<b>In general</b>			
<b>2.</b>	<b>Alignment and Cross section</b>		
<b>2.1</b>	<b>Old chainage (0/000 to Km 30/000 and from Km 58/0 to Km 99/0)</b>		
	The road formation is around 3.66m. The width of carriage way is single lane. The shoulder is earthen. The road passes through ghats (In stretches) inside reserve forest. In the most of the stretches of ghats the either side of the road is hilly.	➤ The entire stretch will be widened and strengthened to 7.0m carriage way providing GSB, WMM, DBM & BC	<b>Desirable</b>
<b>3.</b>	<b>Intersections and Access Roads</b>		
<b>3.1</b>	➤ There are two major intersections one is at Koraput (0/0km) and One is at Rupkona market (to Kasipur) and 64Nos minor access village/urban roads on either side of the main carriageway from Koraput to Rayagda connecting to the various localities of the two district. At all the major/minor intersections, appropriate Warning and Informatory signs are missing. Though there are several minor access roads but due to full carriageway width with bituminous pavement having without earthen shoulder necessary warning signs have not provided.	➤ Provision of sign boards and alarming information signage are provided in the DPR. ➤ Pedestrian crossing and side walk facilities at the intersection need to be created. Also consider painting the Road markings on all minor roads indicating the pedestrian crossings and road openings with dotted line coupled with the provision of STOP line marking on the intersecting road.	<b>Essential</b>
<b>4.</b>	<b>Road Crash Black Spot Analysis</b>		
<b>4.1</b>	<b>*Built up area</b> School/Aganawadi / Hospital/ Bank Km. 1/0-1/2 , 2/080, 2/830 , 58/0 -58/300, 58/550 – 58/880, 60/500 – 60/700, 60/800-61/000, 62/600-62/880, 69/200 – 69/500, 75/600 – 75/800, 82/700 – 82/800, 83/100-83/300, 93/900 -94/300	➤ Pedestrian crossing and side walk facilities at the intersection need to be created. Also consider painting the Road markings on all minor roads indicating the pedestrian crossings and road openings with dotted line coupled with the provision of STOP line marking on the intersecting road. ➤ Proper signage is to be erected at least 100 mtr ahead of the these area ➤ road marking, Zebra crossing ➤ Rambler strip and delineator to be provided	<b>Essential</b>



<b>Sl. No</b>	<b>Observation</b>	<b>Measures</b>	<b>Priority</b>
	<p><b>*High Embankment</b>                      4/620 – 4/800 (RHS), 5/740 – 5/900 (BHS), 8/350 – 8/400 (LHS),                      8/550-8/700 (LHS), 14/050 14/100 (RHS), 30/0 – 30/1, 60/130 -60/200,                      61/500-61/600, 64/080-65/000, 68/740 – 68/760 (pond), 70/300-70/400,                      70/900-71/100, 72/500 – 72/630 (LHS), 84/200 – 84/300, 89/300 – 89/                      700 (LHS Valley), 90/400 -90/700(RHS valley), 97/500 – 97/850 (RHS)</p>	<ul style="list-style-type: none"> <li>➤ Safety barrier, road marking, guard wall/ metal beam crash barrier / guard post need to be provided.</li> </ul>	<b>Essential</b>
	<p><b>*High Embankment Bridge Approach</b>                      4/420 – 4/800, 17/800, 21/750, 80/0 -80/100, 85/00- 85/200, 96/700 -                      96/850, 97/400, 98/550</p>	<ul style="list-style-type: none"> <li>➤ Safety barrier, road marking, Concrete crash barrier / guard post need to be provided.</li> </ul>	<b>Essential</b>
	<p><b>*Reverse Curve/Sharpe Curve</b>                      1/0 – 1/4 , 3/555, 11/410, 12/100 -12/250, 17/150-17/250, 24/300 -                      24/500, 25/200 -25/600, 27/664, 70/700-70/900, 78/200 – 78/400,                      79/00 -79/200, 80/400 – 80/600, 83/100 – 83/300 , 85/0 – 85/200,                      87/300 – 87/400, 87/900 -88/100, 91/500 – 91/700, 91/800 -92/000,                      92/200 -92/400, 95/400 -95/650,</p> <p><b>*Hair Pin Bend</b>                      88/700 -89/00, 90/100 -90/400</p>	<ul style="list-style-type: none"> <li>➤ Proper signage is to be erected at least 100 mtr ahead of the curve area</li> <li>➤ road marking, Rambler strip and delineator to be provided on the both edges of the curve.</li> </ul>	<b>Essential</b>
	<p><b>*Rail Over Bridge</b>                      At chainage: 1/890km</p>	<ul style="list-style-type: none"> <li>➤ Informatory sign board to be provided.</li> </ul>	<b>Essential</b>
	<p><b>*Major Junctions</b>                      0/0km, 0/330, 77/800</p>	<ul style="list-style-type: none"> <li>➤ Pedestrian crossing and side walk facilities at the intersection need to be created. Also consider painting the Road markings on all minor/major roads indicating the pedestrian crossings and road openings with dotted line coupled with the provision of STOP line marking on the intersecting road.</li> <li>➤ Junction need to develop properly and the grades of the junctions and merging point should be as per code provision.</li> <li>➤ Proper signage is to be erected at least 100mtr ahead of the these area</li> <li>➤ road marking, Rambler strip and delineator to be provided</li> </ul>	



## 5.1 Results and Discussion

It is well-known that Road Safety Audit (RSA) scrutinizes the prescribed safety recital, and investigation of a current, or upcoming road network or intersection, by the internal managers or a third party independent team that finds faults and suggest recommendations. They submit reports on budding road safety concerns and ascertain prospects for perfections for the stakeholders, (U.S. Dept. of Transportation/Federal Highway Administration) <https://safety.fhwa.dot.gov/rsa>. The benefits achieved from RSA reduces the severity, number and claims for crashes, precautionary safety measures saves safety issues, awareness, human factors and costs.

Installation of road safety automated road divider, reduce traffic volume, increases travel time and the environment. During safety auditing, defects are identified that helps in reducing running maintenance of the road. That also reduces accidents and improves the road safety criterion. At times traffic volume management is done through constructing VUP, AUP, PUP or flyover which is at times costly. The RSA projects regulate the traffic in a congested road. It prioritizes to allow more volume of vehicles that reduces the traffic density [28,29].

The different defects either from design prospect, alignment, and environmental view are identified prioritised and the ameliorative measures are recommended as:

- a. Where road alignment and designed speed is not safe, their rambles are suggested and given highest priority (Case 1).
- b. The zone of high level hydraulic structures or embankment need with priority to construct protection walls, safety barriers, riprap walls at slopes or guide walls with retaining structures, drain provision to avoid accidents (Case 2, 6, 8, 9, 10 and 17).
- c. For extension where side cuttings are needed, retaining structures with provision of drains are prioritized with necessary road marking and signboards (Case 3, 4, and Case 5).
- d. In populous areas, schools, hair pin bends, Ghats area hospitals, crowded hats and settlements the safety barriers, sign boards, light signals, speed breakers, even traffic arrangement are very much essential to avoid accidents (Case 7, 11, 12, 14 and 19)

- e. A large numbers of trees needs to be cut for expansion, improving horizontal sight distance, extensions and conversion of 2-lane to four lane. The cutting of trees shall kill the silent greenery of the ghats area between Jeypore to JK pur. The new road shall deteriorate the environmental vegetation's. The loss of the old plants must be rehabilitated through afforestation and new plantations (case 13, 15, 16 18, and 20).

The improvement and upgrading of roads always invites plying more and more number of vehicles, mobility that brings advancement socially, economically and politically of the area. It is always obtained at the cost of vegetation, deterioration of the geo-bio system of the area. Finally the increase of GHG gases and balding of the mountainous region and ghats area shall invite the climate change of the area.

## 6. CONCLUSIONS

The present study has exhibited a Road Safety Audit that featured problems in safety management in demonstrating the factors like observation, explanation behind concern, proposal and need of the issue. It proposed the different proposals that can be easily implemented and at lower cost. The review is applied to the dangers outside the system of standards and codes. Based on this case study on the four-lane national highway-65 [previously NH-9] the following conclusions have been drawn From the four lane National Highway-65 i.e., from 247.650 km to 270.340 km, by analyzing the information it is found that road markings, condition of shoulder, condition of carriageway and median opening are the factors for causing accidents on the NH-65.

It also observed that the moderately moving vehicular traffic is generating traffic problems for the fast moving vehicular traffic as it generally occupies innermost lane of national highway. Along this four lane national highway, service roads need to be provided so as to isolate slow moving vehicular traffic from fast moving vehicular traffic. All the unauthorized gap-in-median should be closed and necessary provisions like foot-over bridges to be provided for the local neighborhood to cross the national highway on the priority basis. All undeveloped minor and major crossings should be developed with necessary lighting provisions such that the

accident rate can be decreased along the surveyed areas.

Footpath for the pedestrians needs to be developed near the habitat areas, industries, and educational institutions. The roads are to be properly maintained wherever it is deteriorated immediately. The guard rail needs to be provided along the entire length of the footpath. Facilities for the disabled people at bus stops need to be developed on the NH-65.

## ACKNOWLEDGEMENTS

We are extremely thankful for the immense support of the Organizations/Institutions like CUTM UNIVERSITY & CADD CONSULTING ENGINEERS PVT LTD for their contributions and suggestions for performing this Road Safety Audit.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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