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Safety Audit (RSA) on NH-56- Khamera – Padoli

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ABSTRACT

The road infrastructure of a growing country plays a critical role in the economics and development of the country. Users' basic needs are met by transportation provided by road systems. Mistakes result in the loss of many lives and a significant amount of property damage. This paper is an attempt to break down the activity wellbeing situation on National Highway 56, India, and to recognise countermeasures for extents where the aggregate damage caused by accidents can be significantly and quickly reduced.After completing a Safety Audit (RSA), it was discovered that trucks are parked on freeways, reducing the effective width of the carriageway and posing a threat to fast-moving traffic. Unapproved median openings have been detected and should be closed as soon as possible. Missing road markings must be completed, and speed signs must be organised in a timely manner. Service streets are insufficient, necessitating rapid change. The Vulnerable Road User (VRU), i.e. those walking and cycling to work, is underrepresented and should be promoted where necessary. The required advice was offered for quality improvements to be done in the future, taking into account coordinates of the full study region.

Keywords: Traffic safety, Safety Audit (RSA), Road accidents, Spot Speed, Tailgating behaviour

INTRODUCTION

According to the Global Status Report on Road Safety 2018, road traffic has been a significant developmental problem, a global health threat, and the major cause of mortality and injury worldwide, killing nearly 1.36 million people in 2016. Perhaps it reported that nearly 90% of these fatalities occurred in developing nations.
India records 0.39 million road fatalities per year (as of 2012), accounting for about 35% of all road mishaps worldwide.
Accidents are one of the leading causes of involuntary deaths in India, according to data issued by the Ministry of Road Transport and Highways. From 2001 to 2012, Table 1.1 shows the number of road mishaps in India every year.

Table 1.1: Year- Wise Statistical Distribution of Road mishaps in India

Year	Number of Accidents		Number ofpersons		Number of persons killed per 100 accidents
	Total	**Fatal**	**Killed**	**Injured**	
2017	4,79,216	1,01,161 (21.1%)	114,444	513,340	23.9
2018	4,84,704	1,06,591 (22.0%)	119,860	523,193	24.7
2019	4,86,384	1,10,993 (22.8%)	125,660	515,458	25.8
2020	4,99,628	1,19,558 (23.9%)	134,513	527,512	26.9

Figure 1.1 indicates that pedestrians and cyclists account for 17% of fatalities, while two-wheeler users account for 26%.

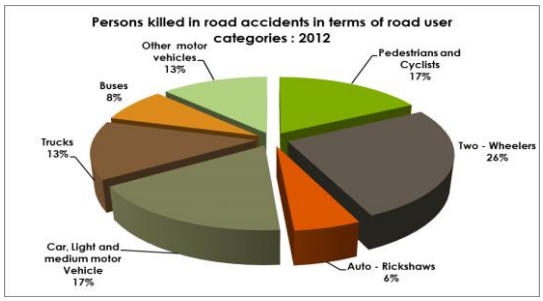


Figure 1.2 depicts the number of lives lost per 100 incidents in India's different states in 2012. Nagaland had one of the worst scenario, with 133.3 people killed per 100 incidents, according to the study. Goa has fewer deaths than other regions, with 6.8 people killed per 100 incidents.

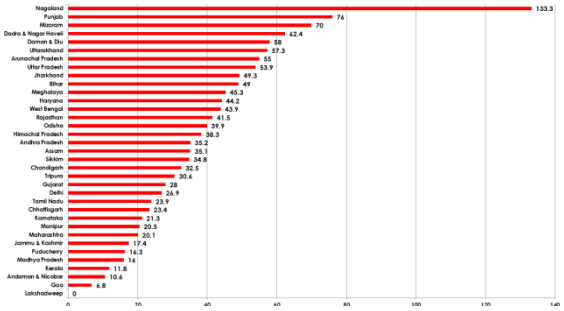


Figure 1.2: No. of persons killed per 100 accidents in the year 2012 (State wise)
Source: Road Accident in India 2012 report, Ministry of Road Transport and Highways

1.2: Road Safety Condition in Rajasthan

Since 2015, the rate of road mishapsin Rajasthan has been increasing (Chart 1.3). Rajasthan placed 4th in the world in terms of total number of traffic incidents (51,810) in 2018, accounting for 10.6% of all road accidents. The overall number of fatal accidents per lakh population, on the other hand, decreased slightly from 69.1 in 2012 to 68.2 in 2018..

Rajasthan had the 7th highest number of traffic accident deaths in the country in 2018. While there was a reduction in the number of casualties in 2015 as compared to 2010, the number has continued to rise in 2012 and 2018.Over the same time, the share of road accident deaths increased from 6.4 % in 2015 to 6.2 % in 2018, while the overall number of people killed per lakh population increased from around 10 percent. The severity of road mishaps rose from 15.8 in 2015 to 16.5 in 2018. The four cities with populations of one million or more accounted for 14.5 % of all traffic deaths.

Rajasthan had the 4thhighest number of fatal accidents casualties among the States/UTs. From 2010 to 2015, the number of people involved in automobile accidents decreased, then rose marginally in 2012 and then decreased again in 2018. Rajasthan's share has risen steadily year after year, from 10.8% in 2010 to 11.3 % in 2018. The four million-plus cities are responsible for up to 20 % of all casualties.

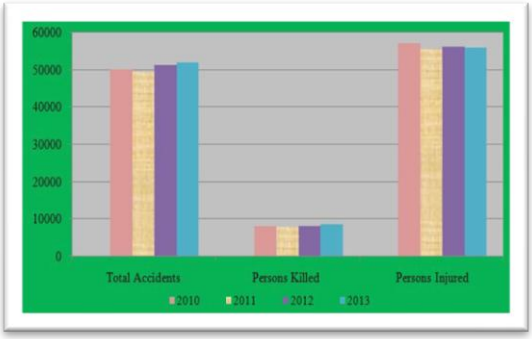


Figure 1.3:Road Accidents in Rajasthan: 2010-2018
Source: *Rajasthan year wise distribution, Ministry of Road Transport and Highways*

1.2.1: Road Safety Conditions in Khamera Post Office

In Rajasthan, Khamera Post Office had the highest number of road accidents, while Jabalpur had the highest number of road crash severity and fatalities:

Table 2: *Accident Data in 2019 of Khamera Post Office, Rajasthan.*

	Udaipur	**Jodhpur**	**Jaipur**	**Jaisalmer**
Fatal Crashes	242	273	368	372
Injury Crashes	2,465	1,572	3,341	2,611
Total Crashes	3,393	2,156	4,513	3,303
Total Persons Injured	2,720	1,800	3,676	3,113
Total Persons Killed	252	317	391	409
Crash Severity	**7.4**	**14.7**	**8.7**	**12.4**

1.3 Safety Audit (RSA)

The Safety Audit (RSA) (RSA) is a project analysis that assesses and identifies road user safety issues. The focus in this RSA phase is on ensuring the safety of road users including pedestrians and cyclists. RSA can be used in the following situations:

I. Assessing the protection of a current road or infrastructure.
II. Identifying a planned infrastructure's safety issues at the planning, design, and implementation phases.

When planning transportation programmes, safety issues are often overlooked, resulting in higher socio-economic impacts. For example, the death of a household's earning member will have a wide range of consequences for his or her family. Injuries may decrease an individual's efficiency or cause the family's livelihood to be lost.

Safety Audit (RSA)s can be used on a broad spectrum of highway projects and all forms of roads in both urban areas and semi- urban areas. Safety Audit (RSA)s should be carried out on all road plans, including the following:
a. Projects involving signalised and non-signalized intersection design,
b. Routes for pedestrians and cyclists,
c. In metropolitan areas, local traffic control schemes,
d. Neighbourhood traffic calming steps
e. Bridge approaches,
f. Grade separators and interchanges,
g. Use of a Mass Rapid Transit System, and so on.

A Safety Audit (RSA)'s aim is to improve safety by recognising and addressing risks associated with road safety flaws. Auditing at various stages of a project, beginning with the planning stage, will help to identify issues early on and reduce the time and expense of retrofitting roads and infra to improve safety later on.

Benefits of performing a RSA:-
a. Determining potentially dangerous areas along a route,
b. Minimizing the magnitude and frequency of road accidents,
c. Minimizing the overall cost of a project to the community by avoiding incidents, damage, and trauma.

1.3.1 Safety Audit (RSA) Requirements:

The RSA process begins with a proposal to construct a new route, contribute in the rebuilding, widening, or significant improvement of an existing road, or simply assess the safety aspects of the concept infrastructure. Safety Audit (RSA)s (RSA) should be conducted on a regular basis, beginning with the planning stage of a roadway project, to ensure that all users' safety concerns are addressed at all times. RSA should be carried out during the corresponding crucial stages/processes throughout life cycle of a project.

a. Feasibility (if any new proposal is made on existing infrastructure)
b. Design process
c. Construction process
d. Maintenance process

Following the completion of the feasibility stage audit, the feedback and suggestions are used to help develop the new transportation infrastructure.
The design audit's shortcomings, if any, must be resolved by making appropriate improvements to the planned infrastructure/facility's design.
After the approval of design drawings/documents and the completion of the procurement process, the construction stage audit is performedThe monitoring stage is the final stage of the RSA process. A monitoring stage audit should be performed on a project's service monitoring and ensuring that the infrastructure continues to support road users in a secure environment.

1.3.2 Required tools for conducting RSA

In the annexure, you'll find a set of checklists that can be used to execute RSA at different times.
a. Standard Checklist- During the feasibility, monitoring, and maintenance stages, the standard checklist should be completed. Any repair or retrofitting of the current facilities must be audited using the standard check list. A standard checklist should also be completed shortly after the project's completion and on a regular basis thereafter
b. Design Checklist- The design checklist must be completed after the planned design has been completed, with the condition that a standard checklist has already been completed in the case of a brown field project.
c. Design Checklist- During the project's construction process, the construction checklist must be completed.
On longer-term projects, it is recommended that construction stage audits be performed every 3 months.

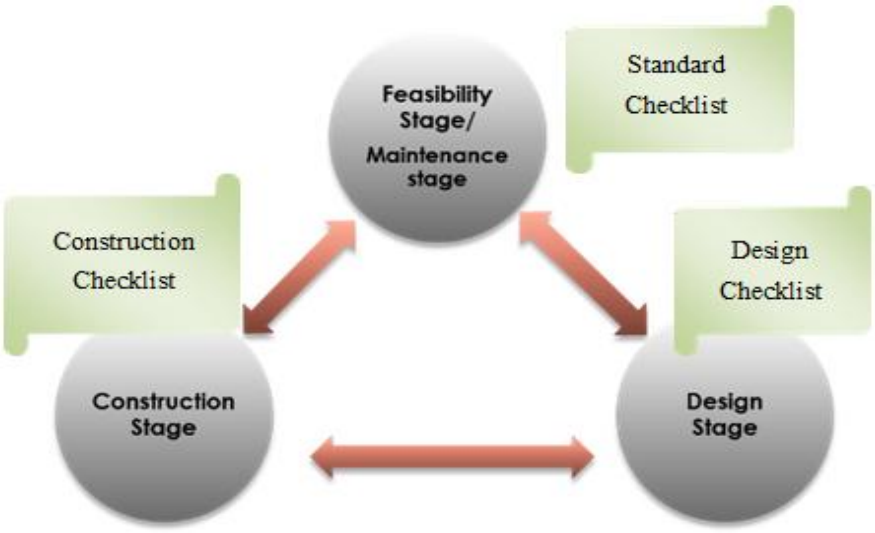


Figure 1.4: Different Checklist for conducting RSA.

1.4 Processes for conduction of RSA

Stepwise processes are being implemented for different Stages of Audit. Even if no infrastructure improvements or new infrastructure is being added, RSA can be performed on any established road infrastructure.

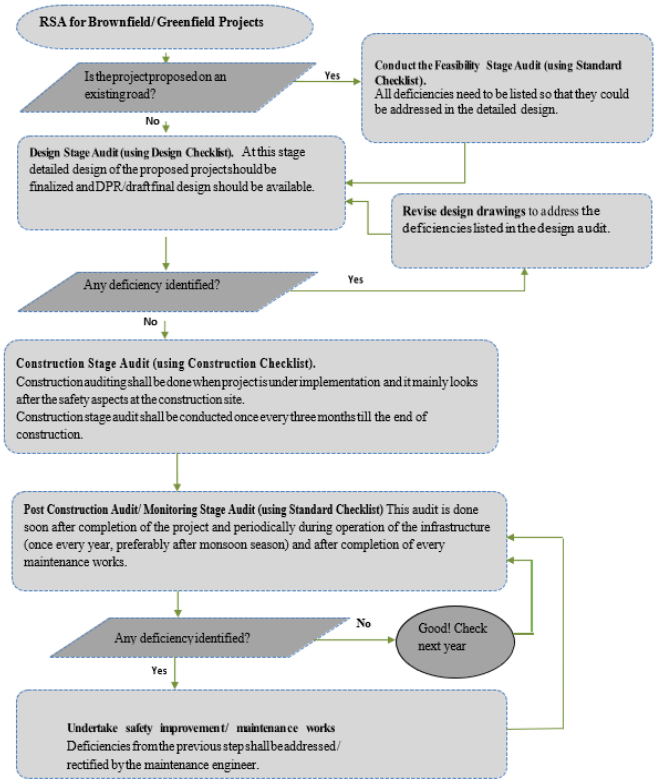


Figure 1.5: Different processes for conducting RSA.

1.5 Problem Location

The location included in the study is of NH-56 of India, connecting three of the state i.e., Rajasthan, Rajasthan and Maharashtra. This highway stretches out of 386 Kilometres from Jhalawar, Rajasthan (North end) to Malkapur, Maharashtra (South End). Problem and Study location was identified between Shri Vaishnav Vishwavidyalaya, Khamera Post Office, Rajasthan to Chitaurgarh Bus Stand, Chitaurgarh, Rajasthan stretching 18.1 Kilometres.

Since Chitaurgarh is considered as Industrial Hub of Rajasthan region hence this location is also among the prime black spots throughout this stretch when connecting Khamera Post Office to Chitaurgarh. This paper will help in suggesting the changes in the road mishaps scenario and will also help in suggesting the key changes.
This project is a Brownfield project and already been constructed so changes in the alignment of the road would not be possible. Hence the Monitoring Stage/Post Construction Stage using Standard Checklist (as attached in Annexure – I) will be inculcated.

1.6 Objectives of the Study:
Objectives for this Audit Report are as follows:

- Review of IRC 88 "Guidelines for Road Safety"
- Using updated safety audit checklists, collect data on highway geometric architecture and operating conditions, dangerous areas, and other roadside features.
- Collection of traffic data and road inventories of Khamera Post Office and Chitaurgarh sections
- Using Safety Audit (RSA)ing, examine potential safety risks and, if appropriate, prescribe remedial treatment options.

1.7 Scope of the Study:

- Reduction in road road mishaps and minimalizing the remedial work by maintenance and corrections.
- To research the methodology of RSA as a method in regards to preparing for the safer roads;
- To investigate the current road mishaps situation in selected stretch;
- To assess a framework for an RSA technique that can be carried out at the local government level;
- To conduct a stage-by-stage RSA of selected road stretch.

II. LITERATURE REVIEW

2.1 'Right awareness and correct judgments are the two primary measures for preventing pre-crash road accidents, and each individual road user must learn and understand this...' (Mehta et. al., 1996)

2.2 Road Accidents
Automobiles have exploded in popularity as a outcome of rapid urbanisation and increased economic activity. In several Indian metropolises, its among the main causes of traffic crashes. The rising number of road mishaps places significant social and economic pressures on survivors, as well as a variety of overhead expenses.
Causes of Accidents on the road are ;

- As an outcome of unbefitting vehicular contacts, and
- Among vehicles as well as other drivers and pedestrians, as well as elements on the road.

(Pandey K., 2020) included traffic accident analysis and gave review for designing an accident prediction model in which they concluded that rapid growth in the novice drivers are among the causes for higher accident growth. Also, Mixed traffic conditions and Road Elements like improper lighting conditions along the stretch of roads, non-designed traffic signal among bends and construction among road side are primary causes of fatal accidents too.
In the year 2000, 80,119 people were killed and 3,42,100 people have been injured in road mishaps in India, according to official figures. However, since not among all of the accidents are being reported to Police, this figure is an underestimation. The real figures were possibly in the range of 13,00,000 people who required hospital care and 55,00,000 people who suffered minor injuries. In India, the situation is deteriorating, and road traffic injuries have risen steadily over the last three decades (Table 2.1). This is because of the owing to the combination of factors, including a spike in the amount of drivers on the road and the lack of a concerted official strategy to address the problem.

Table 2.1 Road Accidents in India 1970-2001 (Figures in Thousands)

Year	Road Accidents	Persons Killed	Persons injured
1975	114.2	14.6	70.2
1980	116.7	16.8	77.1
1985	153.1	24.7	109.2
1990	207.1	39.1	163.5
1995	282.8	54.2	244.2
2000	348.7	70.7	323.1
2005	391.5	78.8	399.5
2010	394.9	85.3	382.6

(Source : Road Safety Cell, M/O Road Transport & Highways.)

Athanasios Galanis et. al., 2017: This research backs up the idea that walking behaviour varies dependant on the types of lane. Primary arterials

(91.8% of pedestrians) had the highest amount of legal activity, while local streets had the lowest rate (53.7 percent). Low motorised traffic flow, combined with repair and accessibility issues in pedestrian facilities, encourages pedestrians to walk down a street, neglecting their safety concerns. Development of pedestrian movement with a focus on safety issues will shift the modal split in favour of vulnerable groups, enhance an urban area's resilience index, with improved pedestrians quality of life.

Pandey K., 2020: This study suggests at intersections as well as on the lane, proper lighting should be installed. By widening the road and signalling the flow of traffic, a higher volume of traffic should be maintained in the direction of the area. Drunk drivers should be checked and not allowed to drive, and appropriate enforcement measures should be implemented. Thus, an audit report could strengthen the study and proper implications was been suggested.

2.3 Safety Audit (RSA):

Prof. H. S.Goliya, et.al., CEAMD SGSITS Khamera Post Office, India(2018): The aim for this study was to identify actual and potential safety hazards for road users on the NH-3 Section from Rau Circle to Manpur. The study assisted in thinking critically about the layout of safety devices and methods by which the probability of a collision can be minimized, as well as identifying conflict points and providing action to reduce the magnitude of such an accident at these conflict points. According to the report's evaluation, non-designed medians gap and limited visuality on curves, road embankments, and also the intersections were among the major hazard factors.

This study indicated that a significant amount of total median gaps at 11 locations caused accidents, and that high concentration of foliage and animal danger was impacting traffic flow. In addition, several turns were not demarcated with chevrons, and traffic at the Rau-Circle intersection was frequently stopped at the rotary section due to incursion across the detection zone.

Abdul Rahoof et. al., (2017): India's conditions getting worse, and Road Traffic Injuries (RTI) have been growing in past years. A RSA is a systematic method for an independent inspection committee to evaluate the safety of an actual or prospective road or convergence point. Safety Audit (RSA)s may be used at any stage of a project's progress, from planning to preliminary construction, installation, and construction.

RSA's can also be used on any projected project, ranging from minor roads to interstate highways.

RSA's can be viewed as a constructive, low-effort way to improve healthy being.

Arun S Bagi et. al., (2012): A RSA is a process for evaluation of the potential for accidents and also the safety efficiency while developing of newer road schemes, the renovation and repairing of local roads, and road repairs. The auditor's job is to provide objective advice in the form of written recommendations. After considering the recommendations, the designer or client makes a formal decision about whether or not to implement each of the suggested safety changes.

Hamilton Ben, et. al., (2005): Slower, more cautious traffic, improved protection for cyclists and pedestrians, and a more appealing urban climate overall—in which local design and culture take precedence over traditional traffic infrastructure—are the results, according to this article.

Chatterjee S., et. al., (2019): The risk matrix was proven to be effective in selecting countermeasure design in a more scientific manner, focusing on the most common crash types and severity levels predicted at high crash locations. Eventually, it was discovered that combining reactive research results with proactive construction safety is more advantageous because they are systematically proven with past accident reports and provide awareness of possible safety risks at sites with similar characteristics.

Huvarinen Y., et. al., (2017): This paper demonstrated that adhering to vehicle road design and construction requirements does not ensure traffic safety. In the sense of growing motorization, psychological pressures, and increased accident risks, the emphasis is on the weakest component of the traffic system – "a individual." The hypothesis about the need for additional resources capable of reducing the risks of incidents posed by the human factor is supported by evidence. We looked at the outcomes of three decades of global road industry experience and continuous methodical development. The Safety Audit (RSA) is the primary method.

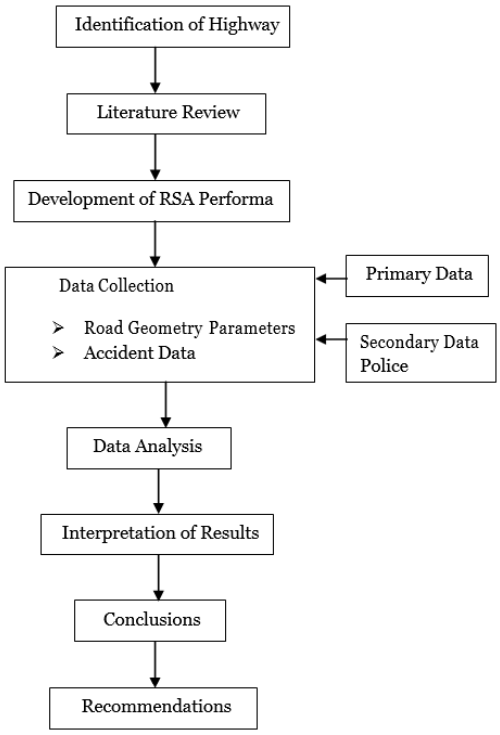
Vardaki, S., et. al., (2014): This study concluded as the fact that the RSA guidelines were adopted soon after the RSA was conducted was a significant factor in assessing the success of the RSA. Initial findings from a before-and-after data evaluation on skid resistance characteristics, speeds, and accidents at locations where RSA guidelines were implemented revealed improved skid resistance characteristics as well as a decline in the amount of accidents.

Kanellaidis. G., et. al., (2015): It is widely acknowledged that the results of the RSA can be used to provide input to teams working on similar projects. Because the identical equipments/design recommendations are used for roadway network, the results of the RSA study can provide infrastructure operators and designers with input that aids them in recognising potential safety issues at an early stage.

III. METHODOLOGY

Every project has a methodology that must be followed. New highways, existing roads, and newly built roads may all be subjected to undergo safety assessment. The following technique is used to conduct a RSA of the specified section of the road is shown in Figure 3.1.

The unit should look at the planning, cross-sections, orientation, accessible roadside furniture and services, interchanges, road user amenities, signage, marking, and lighting, as well as road side threats.



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A Safety Audit (RSA) should take into account the following factors:

a) Inconsistency in alignment - there shouldn't be any unexpected sharp curves or steep gradients. If this section is inevitable, proper street signs and speed control measures should be in place.

b) There must not be any narrow sections in the cross-sections. If they can't be avoided, they must be accompanied by warning signs.

c) Shoulders should be broad enough.

d) Adequate super elevations and extending (on curves).

e) Slopes as well as drains to be provided on the sides.

f) Bends and other difficult parts should be with traffic signs.

g) Dangerous place should be installed with signs and safety barriers.

h) Walking paths, parking lots, and service roads

I Crossings, intersections, and grade separators layout and design should be properly designed.

j) The availability of lay-bys for bus stops.

k) Installation of Street markers, road signs other TCDs, roadside furnitures, and crash barriers.

l) On multilane roads, installation of guard rails and collision barriers on bridge and in between medians.

m) Overtaking section marking and evaluation of sections with poor sight distance and poor horizontal curves.

IV. DATA COLLECTION

4.1 Collection of accident data

Accident data was initially obtained from several police stations in the research region length from Shri Vaishnav Vishwavidyalya (Khamera Post Office) CH 00.00 km (NH-56) to Chitaurgarh junction CH 18.10 km (NH-56). Between 2016 and 2020, there were 27 fatal accidents out of a total of 139 accidents reported. The data for the study stretch was gathered from one distinct police stations within the research stretch's jurisdiction. The data from the road inventory study is used to provide details on the existing road infrastructure on the designated length of NH-56.

From SVVV (CH: 00.00Km) to Chitaurgarh (CH: 18.10Km), the NH-56 has housing and agriculture land uses on both sides of the route. Various parameters of road geometry were considered in the road inventory study, including traffic sign, exiting roadway width, traffic signal, markings, and shoulder widths, as well as bridges.

Table 4.1 Accidents on SVVV-Sanwer Road

Year \ Type	Fatal	Grievous	Minor Injury	Total
2019	8 (20.5%)	22 (56.4%)	9 (23.1%)	39
2020*	7 (23.34%)	15 (50%)	8 (26.66%)	30

* indicates accident numbers up to December 2020 only

(**Source**: Compiled from records of Banganga Police Station, Chitaurgarh Industrial Area, RAJASTHAN)

The Ghatol-Chitaurgarh Industrial Road accounts for nearly one-sixth of all road accidents that occur within the Banganga, Chitaurgarh police station's jurisdiction. The data for the time of the accident is shown in Table 4.2.

Table 4.2 Accident Occurrence Time

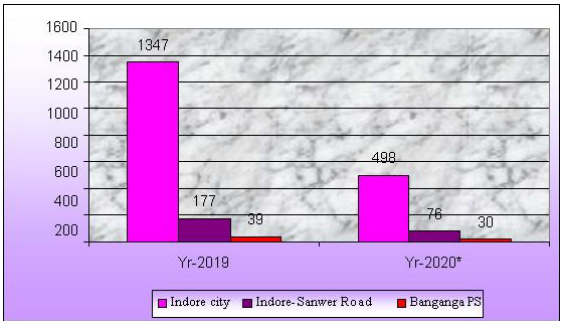
Year \ Type	During Day	During Night	Total
2019	26 (66.7%)	13 (33.3%)	39
2020*	19 (63.4%)	11 (36.6%)	30

* indicates accident numbers up to December 2020 only

(**Source**: Compiled from records of Banganga Police Station, Chitaurgarh Industrial Area, RAJASTHAN)

4.2 Count of Traffic Volume

A categorised volume count of NH-56's selected corridor was been completed. Manual procedures/methods were used to control the flow of various types of vehicles on an hourly basis. On the study stretch, categorized volume counts were conducted out every week using a photographic approach. Dharampuri Township, located



Graph 4.1 Shares of Road Accidents

* indicates value till December 2020 only

(**Source**: Compiled from Records of Banganga Police Station, Chitaurgarh Industrial Area)

7.600 km, was one of the locations where CVC was completed. Because of the higher annual income through agriculture for the people living in the surrounding area, the number of 2-wheelers and agri-vehicles on the study stretch was higher. People that live near the sampling sites corridor frequently ride their motorcycles or cars to work in nearby cities such as Chitaurgarh Industrial Area, Ghatol, Padoli Gordhan, Dharampuri, Rajoda and Barodiya.

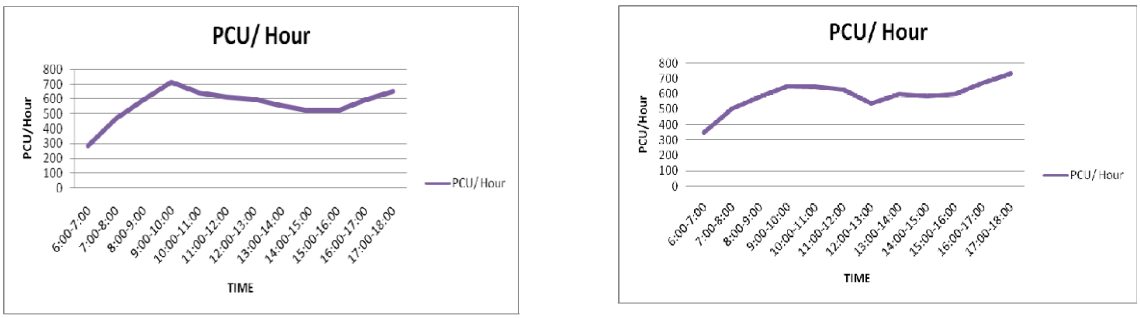


Figure 4.1: PCU/HOUR vs TIME at CH: 07.600Km towards Ghatol

Figure 4.1: PCU/HOUR vs TIME at CH: 07.600Km toward Chitaurgarh

4.3 Study of Spot Speed

On the study length around PadoliGordhan, Senawasa, Jetpura, Rajoda, LakhmanKhedi, and Chitaurgarh S.O. Post Office, spot speed studies were conducted. The survey was conducted out using a manual count method for 30 metres near the area. The speed of the vehicle was measured by maintaining the distance constant at 30 metres and taking into account the time it took for the vehicle to travel that distance. The survey's goal was to see if the vehicle's speed matched the geometric profile of the road, and it was discovered that it did. The speed of all erected speed sign posts was matched to that of the driving vehicle. However, only a few automobiles were discovered to be speeding.

Table 4.3. Spot speed study data

Chainage	98th % speed	85th % speed	50th % speed	15th spe
1.18 km	61	48	39	31
2.40 km	66	54	43	34
5.60 km	64	46	34	26
9.60 km	88	79	57	44
12.90 km	53	44	35	26
17.10 km	51	43	37	29

Figure 4.2: Spot Speed Survey Data Collection

4.4 Study on speed and delay

In the east-west direction, the average journey speed in the survey stretch was 50.6 kmph and the average delay for the entire study length was

Figure 4.3(a): Speed and Delay Study

2.26 minutes, whereas in the west-east direction, the average journey speed in the study stretch was 51.25 kmph and the average delay for the entire study stretch was about 2.0 minutes. Parking on the roadway has caused traffic congestion at the Padoli Gordhan, Jetpura, SenawasaandChitaurgarh S.O. Post Office

4.5 Tailgating behaviour Observation

Vehicles must follow the vehicles in the front of them for about 4 seconds (some places require a longer gap). Only, 96 tailgating cases were seen in Rajoda over the time frame, with 23 percent of car drivers and 43 percent of 2-wheeler drivers tailgating throughout that time period. Drivers of relatively sluggish three-wheelers (10 percent) and heavy motor vehicles (24 percent) were witnessed tailgating other vehicles while maintaining the smallest possible distance from the front car. Also the increasing majority of tailgating cases were noticed during the evenings peak periods between 5:00 p.m.-6:00 p.m. while smallest amounts of incidents were seen between 1:00 P.M – 2:00 P.M.

Table 4.4: Field Observation of Risk Taking Behaviour (Tailgating)

Time	Car/Jeep	%	2-wheeler	%	3-wheeler	%	H.M.V.
10:00 -11:00 am	3	3	8	9	3	3	2
11:00 -12:00 am	5	5	10	11	1	1	5
1:00-2:00 pm	2	2	5	5	1	1	3
4:00 - 5:00 pm	4	4	10	11	1	1	4
5:00 - 6:00 pm	9	9	7	7	4	4	8
Total	23	23	40	43	10	10	23

4.6 Observation of honking horn behaviour

Overall, 182 vehicles were recorded manually on the Dharampuri intersection, forcefully honking the horns, with 2-wheelers drivers accounting for 35 percent of the overall vehicle numbers, trailed by H.M.V's, cars, and 3-wheeler drivers accounting for 30 percent, 22 percent, and 13 percent, respectively.The highest number of incidents of loud honking horns were recorded between 5:00 and 6:00 p.m., while the lowest number of incidents were reported between 1:00 and 2:00 p.m.

4.7 Incorrect overtaking behaviour observation

When comparing to other automobiles, 3- wheeler were determined to have the least amount of overtake (15%) from the incorrect side. The highest number of incidents were recorded between 1:00-2:00 p.m. and 5:00-6:00 p.m., and the lowest amounts were observed between 11:00 a.m. and 12:00 a.m.

4.8 Identification of Road Accident prone locations

The majority of the route is open to high-speed vehicle movement (60 km/h). On the other side, there are very few spots along the entire length of the road where a pedestrian zebra crossing is available. In this context, it is reasonable to conclude that the total route poses a significant risk of

Recommendations:

The further recommendations based on the problems identified are as under:

a.) According to IRC:5, the type design for crash barriers may be used:

b.) According with IRC, Collision barriers must be established away from the edge of the roadway at least 150 mm;

c.) As per the IRC, Traffic Sign board shall be installed from a distance of 1.5 to 3 m;

d.) As per IRC: 5, Collision barriers shall include smooth face on the parapets of the bridges and shall be suitably extended up to the edges of the bridge to improve driver safety.

e.) Extended Animal barriers should be established alongside road stretch as per IRC:5 for reduction of cattle or animals left wild on road.

accidents involving road users and motorists travelling at high speeds. With the help of data from the Banganga Police Station's accessible criminal convictions, a few collision areas were discovered, as shown in Table 4.7.

Table 4.6: Field Observation of Wrong side overtaking

Time	Car	%	2-wheeler	%	3-wheeler	%	H.M.V.	%
10:00 - 11:00 am	12	6	13	7	3	2	8	4
11:00 - 12:00 am	9	5	7	4	6	3	7	4
1:00- 2:00 pm	13	7	17	9	12	6	12	6
4:00 - 5:00 pm	11	5	10	5	6	3	8	4
5:00 - 6:00 pm	14	7	17	9	4	2	9	5
Total	59	30	64	33	31	15	44	22

Baroli Intersection

Type / Year	Fatal	Grievous	Minor	Total
2019	2	3	-	5
2020*	1	-	-	1

Ringnodiya Chowk (Rotary Intersection)

Type / Year	Fatal	Grievous	Minor	Total
2019	-	4	1	5
2020*	-	7	2	9

Tarana

Type / Year	Fatal	Grievous	Minor	Total
2019	2	2	5	9
2020*	-	2	-	2

* indicates accident number up to December 2020 only (**Source**: Compiled from records of Banganga Police Station, Chitaurgarh Industrial Area, Chitaurgarh)

The Chitaurgarh-Khamera Post Office Road was opened to the public in March 2008, and since then, there have been numerous incidents on the road. In the following section of the chapter, many problems are recognised, and recommendations and ideas are made.

V. PROBLEM IDENTIFICATION AND RECOMMENDATIONS

5.1 Physical verifications based on data collection:

Based on the data received and evaluated further recommendations will be discussed as per Indian standards if any shortcoming exist in the road geometry or due to traffic conditions.

5.1.1 Problems Identification at CH 2.8, Ghatol

Problems identified at the selected stretch throughout were as follows:-

a.) Absence of Animal Barriers throughout the selected road stretch.

b.) No crash barriers throughout the selected road stretch.

c.) Unrestricted T-section crossing with no signage

d.) Movement of cattle on road.

Figure 5.1: Problem Identification at chainage CH 2.8 (Ghatol)

5.1.2 Absence of Speed Breaker and Signal facilities at CH 4.3 (Padoli Gordhantowards Chitaurgarh)

Figure 5.2: Problem Identification at CH 4.3 (Padoli Gordhan to Chitaurgarh)

Problems identified during this section of stretch were as follows:

a.) Absence of speed humps on the main road as well as intersection road.

b.) Unrestricted traffic without signal at both sides of intersecting roads.

c.) Presence of shops(gumti) alongside road restricting shoulder width of intersection.

d.) No precautionary sign when approached to the intersection.

e.) Lightened traffic markings.

f.) No crash barriers throughout stretch.

Recommendations:

Suggestions for the problems identified at the selected chainage:

a.) A speed hump shall be provided in accordance with IRC 99-1988 recommendations, with a width of 3.7 metres, a height of 0.1 metres, and a radius of 17 metres for a preferred advisory crossing speed of 25 kilometres per hour. It must be in white paint markings to make it more visible at night.

b.) A signage must be installed to raise awareness of the bump and to inform cars 180 metres ahead of time that there is a hump ahead.

c.) Retro-reflective marking on the road must be installed to increase night vision for a safety standpoint.

d.) Guard barriers should be placed right 0.5 m from the kerb to allow enough room for passing cars and to safeguard traffic users, as it becomes a safety hazard.

e.) A signage must be installed to raise awareness of the intersection and to inform cars 180 metres before approaching to the intersection either in night or day.

f.) Traffic markings should be painted white in accordance with the road inventory.

5.1.3 Problem Identification at CH 5.4 and CH 5.7 (Padoli Gordhan towards Chitaurgarh)

Further additions in Padoli Gordhan region at CH 5.4 and CH 5.7 along the study

Figure 5.3(a): Unsignalized intersection at CH 5.4 (Padoli Gordhan)

Figure 5.3(b): Reduction in Road width by Roadside Dhaba at CH 5.7 (Padoli Gordhan)

a.) Unsignalized Intersection without proper traffic sign.

b.) Unsignalized Y-Intersection with improper marking of medians.

c.) Visual obstruction by a hand cart alongside road of the Y-Intersection with traffic separators.

d.) Decrement in road width by illegal hoarding board installation.

e.) No visible traffic marking throughout road.

f.) Parking in the restricted parking area.

Recommendations:

a.) Marking of road shall be prepared in accordance with IRC: 35-1997 rules;

b.) All Y-junction and T-junction must have give-way markings;

c.) At the shoulders, dust must be eliminated;

d.) Because road markings exhibit wear and tear in some areas, they must be kept in good shape and their visibility at night must be examined on a regular basis.

e.) Old marks must be appropriately erased to prevent cars from misinterpreting the message.

f.) At every turn, bus stop, and school, there must be road information markings;

g.) To ensure nighttime safety, retro-reflective road markings must be installed.

VI. CONCLUSIONS

6.1 Conclusions made from accident studies:

After the study of the collected accident data this study concludes that Safety Audit (RSA)'s performed after every quarterly or half yearly would significantly put up the necessary recommendations and will help in reduction of accidents if and only if caused because of the road geometrical detail, absence of traffic markings and signage, absence of guard rails, etc.,

Since the road accident data received from the local Police station and Police officials of Banganga Police Station, Chitaurgarh seemingly elaborates that much of the accidents were due to driver negligence but few of the accidents involved road geometrics. Many other accidents weren't even reported maybe due to fear of unfollowed traffic rules, illegal activities etc.,

6.2 Conclusions made from traffic volume studies:

Since the traffic volume of the selected stretch primarily consisted of motorcycles, trucks, agri-vehicles like tractor trolleys and cars respectively, hence the usage of the Khamera Post Office-Chitaurgarh or Khamera Post Office-Ujjain road is of utmost importance and since the traffic volume gets incremented hence the maintenance of the road also plays a vital role to keep up the unrestricted traffic flow.

6.3 Conclusion on spot speed data of selectedstretch:

As observed at the various sections selected throughout stretch namely, Padoli Gordhan, Senawasa, Jetpura, Rajoda Bus stop, LakhmanKhedi, and Chitaurgarh S.O. Post Office, the 98th percentile speed at Rajoda (88) was among the highest of all at 98th percentile, meaning speed which is greater than the speed of 98% of road users was observed higher at Rajoda section followed by Barodiya

Ema (66), Dharampuri, Jetpura (64), Padoli Gordhan (61), LakhmanKhedi (53) and Chitaurgarh PO (51) respectively at 98th percentile. For 85th percentile while spot speed study, Rajoda had the highest number 79, meaning most of the vehicles were travelling at 85% of the designed speed. The study was carried forward and was followed by Senawasa(54), Padoli Gordhan (48), Dharampuri (46), LakhmanKhedi (44) and Chitaurgarh PO (43). It can be concluded that the road alignment are far set as per the IS codes. Although in some regions it can be seen that many of the road side inventory kept missing which are in the needful state as many of the accidents then can be averted if installed.

6.4 Conclusion as per speed and delay studies:

The study showed that from east-west direction, the average journey speed in the survey stretch was 50.6 kmph and the average delay for the entire study length was 2.26 minutes, whereas in the west-east direction, the average journey speed in the study stretch was 51.25 kmph and the average delay for the entire study stretch was about 2.0 minutes. Parking on the roadway has caused traffic congestion at the Padoli Gordhan, Jetpura, Senawasaand Chitaurgarh S.O. Post Office respectively.

6.5 Conclusion as per the observation of tailgating behaviour

Certain conclusions were made when the tailgating behaviour was observed, only, 96 tailgating cases were seen in Rajoda over the time frame, with 23 percent of car drivers and 43 percent of 2-wheeler drivers tailgating throughout that time period. Drivers of relatively sluggish three-wheelers (10 percent) and heavy motor vehicles (24 percent) were witnessed tailgating other vehicles while maintaining the smallest possible distance from the front car. Also the increasing majority of tailgating cases were noticed during the evenings peak periods between 5:00 p.m.-6:00 p.m. while smallest amounts of incidents were seen between 1:00 P.M – 2:00 P.M. This concludes that Rajoda has good number of tailgating by the drivers. Although the reasons are unknown for this tailgating behaviour because the road inventories found at the selected points were up to the mark. Further places were also observed but the study couldn't be performed as due to COVID-19 pandemic, a total lockdown was observed throughout state restricting the movement. Further studies could be carried out in the other sections of the road stretch for proper information.

6.6 Conclusion made through observing honking horn behaviour:

Overall, 182 vehicles were recorded manually on the Dharampuri intersection, forcefully honking the horns, with 2-wheelers drivers accounting for 35 percent of the overall vehicle numbers, trailed by H.M.V's, cars, and 3-wheeler drivers accounting for 30 percent, 22 percent, and 13 percent, respectively. The highest numbers of incidents of loud honking horns were recorded between 5:00 and 6:00 p.m., while the lowest number of incidents was reported between 1:00 and 2:00 p.m. This concludes the fact that honking horns by the drivers will create impact on nearby residents as the selected point is a residential area around highway. This will result in the noise pollution increment which deficits the hearing sounds and promotes in heart-attack cases and non-sleepiness behaviour in human.

6.7 Conclusion made from incorrect overtaking behaviour observation

When comparing to other automobiles, 3- wheeler were determined to have the least amount of overtake (15%) from the incorrect side. Most of the 2-Wheelers overtaken through incorrect side accounting for 33% during the study time. The highest numbers of incidents were recorded between 1:00-2:00 p.m. and 5:00-6:00 p.m., and the lowest amounts were observed between 11:00 a.m. and 12:00 a.m. This concludes that the road side inventories are not successfully implemented which is resulting in the overtaking behaviour. Also, some of the slow-moving vehicles were observed at the lanes where high speed vehicles should move so this anyhow also resulted in the overtaking behaviour.

6.8 Conclusions made from identification of Road Accident prone locations

The majority of the route is open to high-speed vehicle movement (60 km/h). On the other side, there are very few spots along the entire length of the road where a pedestrian zebra crossing is available. In this context, it is reasonable to conclude that the total route poses a significant risk of accidents involving road users and motorists travelling at high speeds. Padoli Gordhan intersection as per the data provided by Banganga, Chitaurgarh Police Station counted for highest number of accidents as the laning doesn't contains proper traffic signs, signals and speed humps at the intersecting roads.

6.9 Conclusion made through the physical verifications through photographic method:

While visiting and studying the verifications physically, many of the problems accounted that could result in the problems persisting on road or would help in increasing amount of accidents either fatal, grievous or minor.

Throughout the selected stretch, intersections weren't properly elaborated through proper signage and mostly all the intersection were missing the traffic signals resulting in inappropriate crossing of vehicles. Even if signage is provided they are either in a bad shape or the vision is obstructed due to overgrowing shrubs and bushes alongside road. IRC: 67-2012 hereinafter referred to as the code of professional conduct for road signs, and therefore should be installed not less than 60 cmsfrom the kerb edge in kerbed roads and 2-3 m as from carriageway edge in unkerbed roads.

Second most observed thing throughout road stretch, was no installation of collision barriers. If barriers would be installed then the vehicles after collision would not result in body roll instead the vehicles would remain on road. Also barriers will help the drivers by reducing the movement of animals (street dogs, cattle etc.) as it was noticeable at many places throughout road stretch. As per IRC: 5, Collision barriers shall include smooth face on the parapets of the roads and bridges and shall be suitably extended up to the edges of road or bridge parapet to improve driver safety.

Guard barriers should be placed right 0.5 m from the kerb to allow enough room for passing cars and to safeguard traffic users, as it becomes a safety hazard.

Marking of road shall be prepared in accordance with IRC: 35-1997 rules as the marking throughout road stretch due to wear and tear of road surface was either chipped off or not maintained. The retro reflective marking on the road must be installed to increase night vision for a safety standpoint. Also, many of the places didn't defined the road shoulders across the road stretch. So, the conclusion can be made by maintenance of the road marking and proper road markings need to be painted with retro reflective paints helping the road users to drive safely even in the night.

Road information markers shall be installed at all turns, bus stops, and schools. The bus and truck bays shall be marked with "BUS STOP" or "TRUCK LAY-BYE"

This problem of open and broken Truck Lay-bye separator without signage persisted after Padoli Gordhan where many of Layovers were not mentioned through proper signage. Even interrupted bus stops were existing when observed, due to no or improper bus stands leaving the bus users to board buses anywhere throughout the road stretch.

Overloaded slow-moving vehicles were observed throughout stretch which somehow resulted in the interruption of the traffic flow. A service-lane

construction or a by-pass lane to heavy loaded slow-moving vehicles if implemented would result in gaining the design speed by other fast-moving vehicle.

6.10 RECOMMENDATIONS:

a.) To begin, a strategy plan should be developed to establish collaboration across various institutions at the state and city levels.

b.) At the administrative level, a body will be established to provide accurate accident data for rigorous examination, assisting in the identification of various concerns and accident-prone sites.

c.) All significant road developments in metropolitan areas will be required to undergo a Safety Audit (RSA), and grants will only be granted once the audit is completed.

d.) While any urban road design scheme is being developed, a Safety Audit (RSA) should be included as an obligatory obligation. Upgrading existing roads, upgrading junctions / crossroads, and re-designing a road segment are examples of such schemes.

e.) Suggestions for different issues found in a Safety Audit (RSA) Report must be implemented in order to improve road user safety. Instead of reactive activities, a traffic safety audit is a proactive effort. It should be remembered that a Safety Audit (RSA) identifies specific problems with unique solutions for each situation.

f.) Recommendations released by the Indian Road Congress should be implemented into the design of various road features and should be an inherent part of any road design. Major designers feel that design guidelines are deterministic, but with the help of the Safety Audit (RSA), a remedy for a specific area can be identified and handled using the best possible option offered in the report.

VII. FUTURE SCOPE AND LIMITATIONS

a.) A number of roadways can be exercised to discover safety problems using the Safety Audit (RSA) approach reviewed in this study. Solutions to the identified problem are briefly explained to provide a clear direction for action.

b.) It is possible to perform safe road planning using the different stages of Safety Audit (RSA) approach. It is far more cost-effective to conduct a Safety Audit (RSA) at the conceptual design phase, and the proposals may be quickly implemented while the scope of work is being completed.

c.) For the sake of safety, all existing roads may be subjected to Audit stages. Accidents are common on major roadways in residential areas.

If it is not practicable to undertake a Traffic Safety Audit for all existing roads, it must be done at least on all significant road junctions and intersections. By implementing the suggestions of a Safety Audit (RSA) Report, at least urban road junctions can be protected.

Limitations:-

a.) There is no procedure for conducting a Safety Audit (RSA) in a city in India.

b.) While wide publications, it was discovered the most effective strategy for reducing road crash rates to date was Safety Audit (RSA), and as a result, comparisons of RSA to other approaches are not carried out in great depth.

c.) Because of lesser accident locations, black-spot analysis was not conducted for the selected stretch.

d.) Because accident data for the years 2019 and 2020 was only obtainable for the roadways under examination, none particular road accident patterns could be studied due to the lack of previous records.

e.) The accident study is limited to the year 2020 because previous data in several heads, which were required for the analysis, were unavailable.

f.) For each of the roads under consideration, the most recent traffic volume data was lacking, which could have an impact on junction/intersection capacity.

g.) Apart from congestion visibly observed at several areas during formal visits to the site, precise pedestrian flow data was lacking.

h.) There was no current and updated traffic volume data on the intersections of the roadways under study.

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