ROAD SAFETY AUDIT FOR FOUR LANE NATIONAL HIGHWAYS

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ABSTRACT

Road Safety Audit (RSA) is a formal procedure for assessing accident potential and safety performance of new and existing roads. RSA is an efficient, cost effective and proactive approach to improve road safety. It is proved that RSA has the potential to save lives. The RSA was originated in Great Britain and is well developed in countries like UK, USA,Australia, New Zealand, Denmark, Canada, Malaysia and Singapore. It is at varying stages of implementation in developing nations like India, South Africa, Thailand and Bangladesh. RSA appears to be an ideal tool for improving road safety in India, as basic and accurate data on accidents have yet to be collected.

The study aims to evaluate Road Safety Audit of a section of four-lane National Highway (NH)-58 and will focus on evaluating the benefits of the proposed actions that have emanated from deficiencies identified through the audit process. After conducting RSA, it is found that trucks are parked on highway which reduces the effective width of carriageway and creating traffic hazards to high speed moving traffics. Unauthorized median openings were found which should be immediately closed. Missing road and median markings to be done and speed signs should match with speed. Access and service lanes are also deficient which requires immediate improvement. The most Vulnerable Road User (VRU) i.e. pedestrians and cyclists facilities near habitation are lacking and needs to be facilitated on priority.

Keywords: Road Safety Audit, Safety Analysis, Four-Lane National Highways.

1. Introduction

The road accidents deaths and injuries are global phenomena but more sever situation in mixed traffic condition as prevailing on Indian multilane highways. Concept of quality management and sustainable safety have gained ground in the past two decades and may have been among the factors that led policymakers and project managers to realize the need for purely safety-oriented tools. Road Safety Audit (RSA) is one of the best tools for improvement of road safety; in which experts attempt to identify potentially dangerous features on the highway environment and suggest remedial measures.
Road Safety Audit can be defined as a systematic approach for evaluation of existing or new roads by an independent audit team at the stages of planning, design, construction, operation & maintenance to achieve accident free roads and to enhance overall safety performance.

Road Safety Audit (RSA) was originated in Great Britain (1980) is now spread in several countries around the world. The RSA system established in UK spread to USA, New Zealand, Australia, Denmark, Canada, Malaysia, China, Japan and Singapore and now it is used as a model in many countries for the formulation of guidelines and planning of their trunk roads. It is at varying stages of implementation in developing countries like India, South Africa, Thailand, Egypt, Pakistan and Bangladesh.

2. Road Safety Concern in India

Road fatality rates in India are probably among the highest and out of 1.25 million deaths worldwide every year, 10 per cent (about 125,000) of all road deaths are in India.

Table 1: Number of Accidents and Number of Persons Involved: 2001 to 2009

Years	No. of accidents		No. of persons		Accident severity*
	Total	Fatal	Killed	Injured	
2001	405637	71219 (17.6)	80888	405216	19.9
2002	407497	73650 (18.1)	84674	408711	20.8
2003	406726	73589 (18.1)	85998	435122	21.1
2004	429910	79357 (18.5)	92618	465521	21.5
2005	439255	83481 (19.0)	94968	465282	21.6
2006	460920	93917 (20.4)	105749	496481	22.9
2007	479216	101161 (21.1)	114444	513340	23.9
2008	484704	106591 (22.0)	119860	523193	24.7
2009(P)	486384	110993 (22.8)	125660	515458	25.8

(P): Provisional.
*Figures within parentheses indicate share of fatal accidents (i.e. involving death) to total accidents. * Accident Severity : No. of Persons Killed per 100 Accidents*

Source: *Road Accident of India 2009*

In an effort to minimize the growth of accidents on Indian roads, Road Safety Audit (RSA) is being pursued in a very big way on the existing as well as on proposed new highways. As a part of this effort National Highways Authority of India(NHAI) has commenced road safety audit for various projects of National Highways Development Projects (NHDP). Various states of the country are also started RSA for their road projects.

In this paper it is aimed to evaluate Road Safety Audit of a newly constructed section of four-lane National Highway (NH)-58 of India and will focus on evaluating the benefits of the proposed actions that have emanated from deficiencies identified through the audit process

3. Objectives of study

i. To develop a methodology for Road Safety Audit for four lane National Highways.
ii. To develop a model for identification of safety influencing parameters in minimizing likelihood accident rate on selected section of four lane National Highways network.
iii. To examine safety features adopted in the selected section of four lane National Highway-58 and find out deficiencies in the road network which led to accident and safety hazards to road users.
iv. To identify the speed limits matching with the vehicles speed on existing road profile of the highway section.

4. Site Selection for Study Area

The stretch from Km 75.00 to Km 130.00 of National Highway 58 had been selected for candidate analysis. The selected highway stretch has been newly reconstructed and upgraded to four lane. The two important obligatory points on the study area are Meerut and Muzaffarnagar of the highway in the state of Uttar-Pradesh, India. The road stretch traverses through a flat and rolling terrain of mostly agricultural and urban settlement land. The location map terrain map and route map are shown in Figure 1, Figure 2 and Figure 3 respectively. This National Highway is maintained and operated by National Highway Authority of India (NHAI) under the Ministry of Road Transport and Highways (MOR&TH).

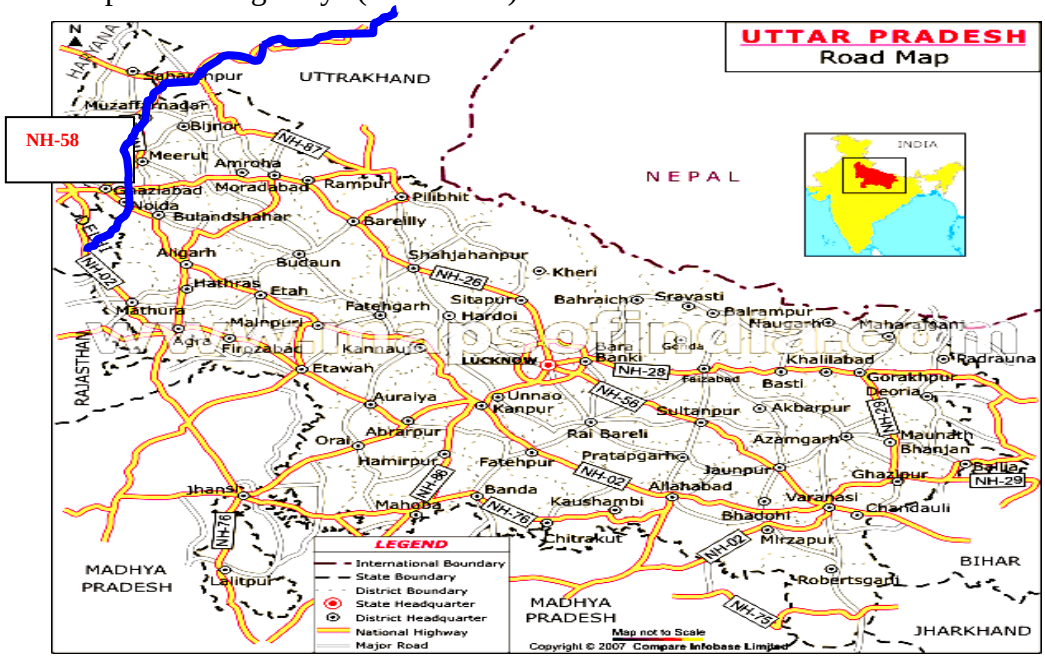

Figure 1: Location Map of Study Area

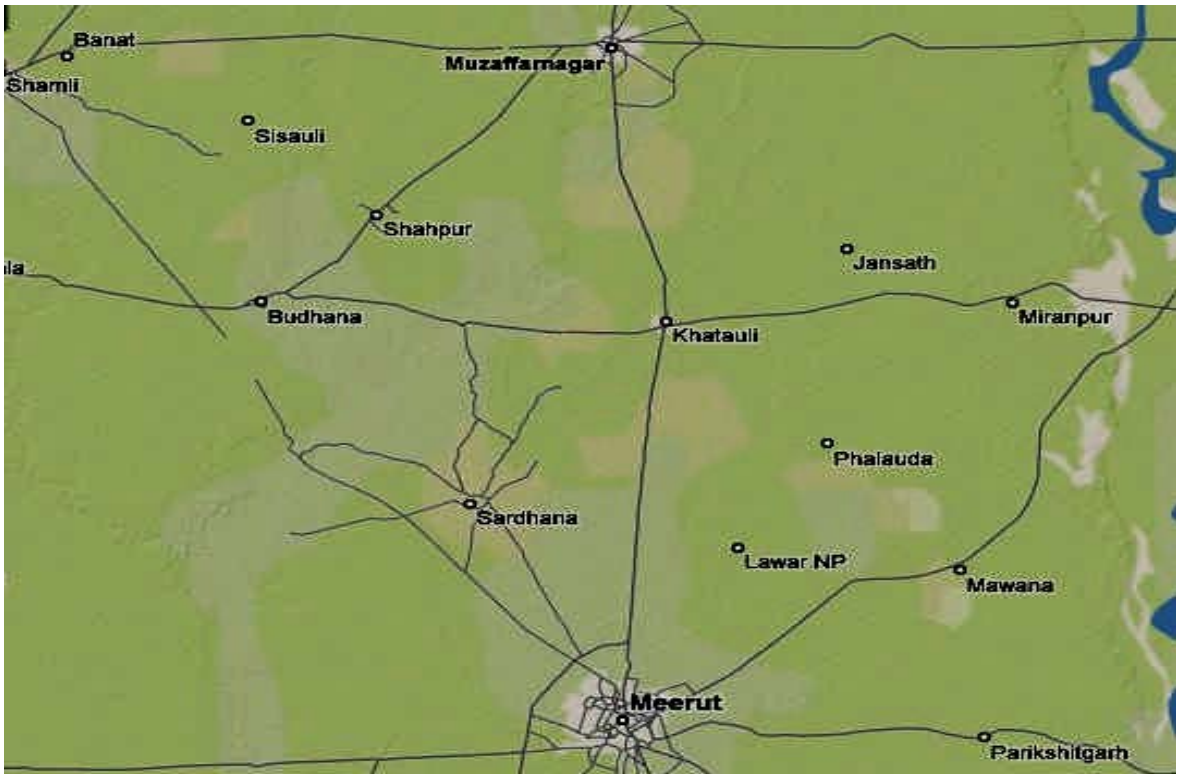

Figure 2: Terrain Map of Study Area

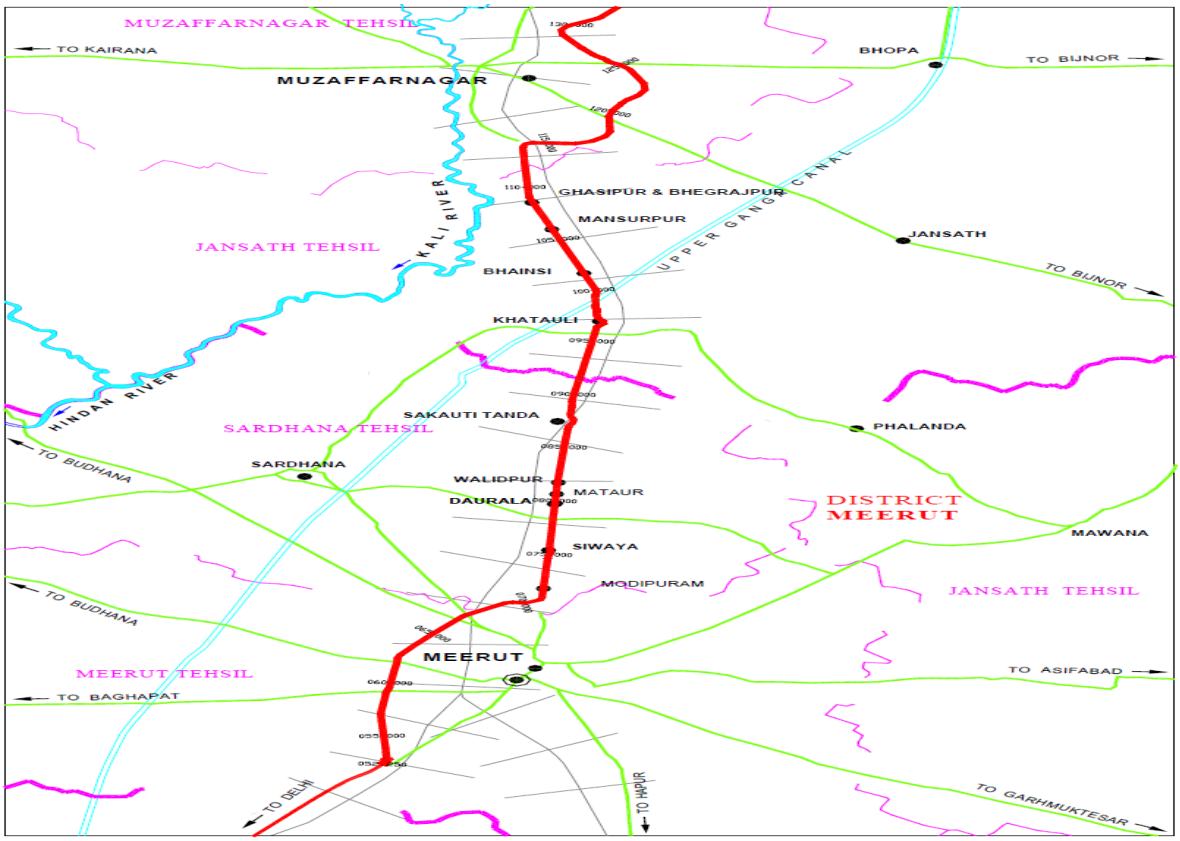

Figure 3: Route Map of Study Area

5. Salient Features of the Study Segment

Main Carriageway is 7.00m wide with 1.50m paved and 2.00m earthen shoulder on either side of the roadway. The median width is 4.5m and raised type in general. A length 12.000 Km road has median width 8.5m of depressed type. Cross section of four lane divided National Highway in Rural Area is shown in Figure 4.9. Service road of total length 7.680 Km is having 5.50m wide on the study section of NH. Road infrastructures details are as under,
Major Junctions: 7 numbers

Major Bridges: 02 numbers (Over Major Ganga Canal & Khatauli Escape Canal)

Minor Bridges: 03 numbers at Km. 109.260, 115.250 & 117.700.

R O B: 02 numbers at Km. 87.583 & 114.289.

Underpass: 05 numbers at Km 78.815, 87.400, 102.896, 118.550 & 122.175.

Culverts: 186 no.

Truck lay byes: 02 numbers

Bus lay bays: 07 numbers

Toll Plaza: 1 number at Km.75.990

Figure 4: Divided Four Lane atKm 130.00 (Muzaffarnagar By-pass) on NH-58 in Opposite Direction

Figure 5: A View of a Section of Four Lane National Highway-58

6. Classified Traffic Volume Study

Classified traffic volume count can be done at a time interval of 15 minutes, 30 minutes or one hour. Data may be classified depending upon need of the study. In the study, traffic volume data collected from NHAI of a mid-block location at Km 75.400 of NH-58. Classified traffic volume count survey was carried out near toll plaza. The main objective of classified traffic volume count was to assess the traffic characteristics on project road sections in terms of hourly traffic variation, peak hour traffic, average daily traffic, traffic composition and directional distribution. Traffic composition were Car, Mini Bus (M. Bus), Bus, Light Commercial Vehicle (LCV), Multi Axel Vehicle (MAV), Private Bus (PVT Bus), Trucks-2Axel,

Trucks-3Axel, Tractors, Two-Wheelers(TW), Auto-Rikshaw and Animal Drawn Vehicles(ADV). The survey was carried out by manual vehicle counting and classified the vehicles passing through survey station. The counts were made separately for motorized and non-motorized vehicles. Based upon vehicle survey count, AADT (Average Annul Daily Traffic) was found 20293 PCUs(Passenger Car Units). Details of traffic surveys are shown in Table 2, Table 3, Figure 6 and Figure 7.

Table 2: AADT in PCUs as on 14 December 2010

PCUs	1	1.5	3	1.5	3	4.5			
YEAR	CAR	M. BUS	BUS	LCV MAV	TRUCKS-2 AXLE	TRUCKS-3 AXLE VEHICLES	TOTAL	TOTAL	PCUs
2010	6979	64	1025	1330	1058	1440	145	12042	20293

Peak volume and hourly variation of traffic at survey locations has shown below in the Table 3 at location Km 75.400 on NH-58.

Table 3 : Peak Hourly Traffic as on 14 December 2010

Km	Section	Peak Hour Traffic		Peak Hour
		Vehicles	PCUs	
Km75.400	Meerut - Muzzafarnagar NH-58	1272	1516	1516 14:00-15:00

Fleet composition of vehicles on NH-58 of study segment is shown in Figure 6 below.

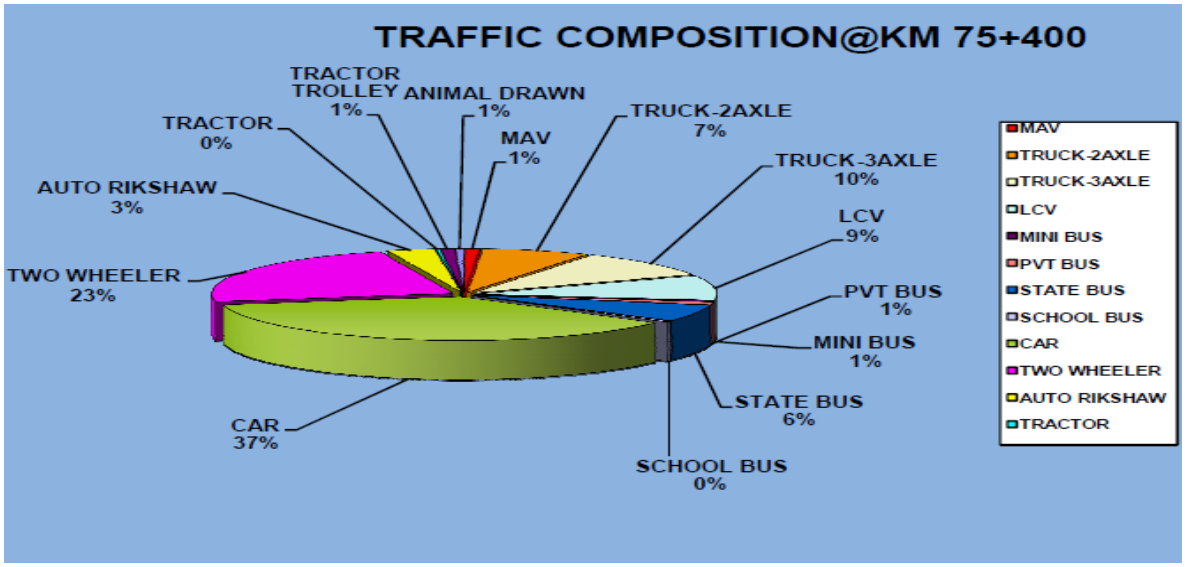

Figure 6: Fleet Composition of Vehicles on NH-58 at Km 75.400

Daily variation of traffic is shown in Figure 7 of location Km 75.400 on NH-58.

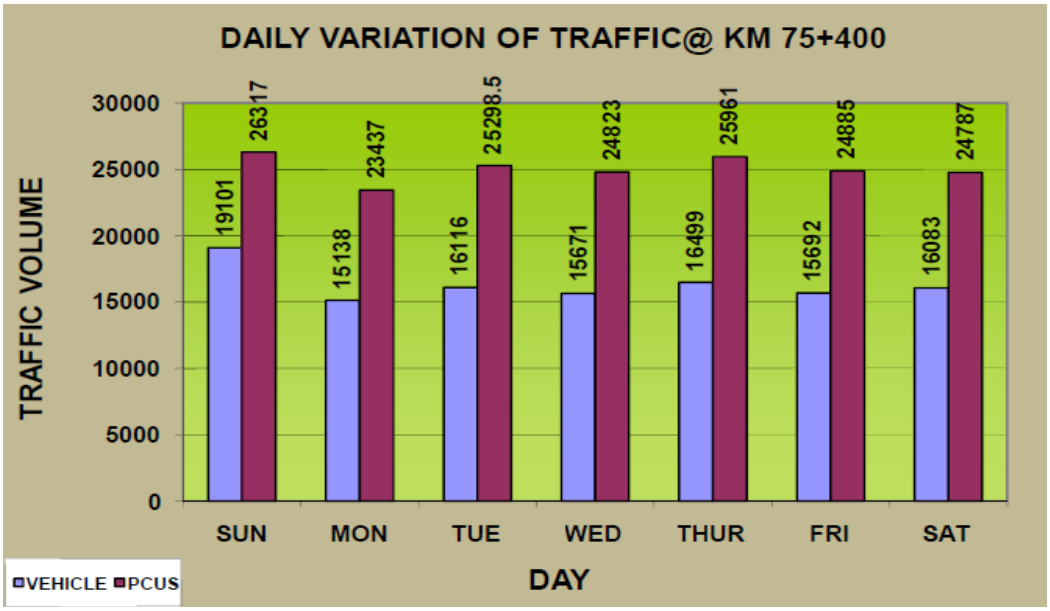

Figure 7: DVT at Km 75.400 on NH-58

6.1 Recommended Growth Rate (%) of Motor Vehicles

The growth rate of commercial vehicles is considered directly proportional to the growth rates estimated for different sectors such as agriculture, industry, trade and mining, etc. of the influence zones. The National State Domestic Product (NSDP) for the various sectors is considered.

In order to arrive at the growth rate of commercial vehicles, the influence of each zone in terms of commercial traffic has been considered. The relative impact of each sector was gauged on the basis of commodities being carried by goods vehicles. The growth rate in passenger traffic, especially cars/van/jeeps largely depends on the growth in per capita income and population in the project influence area and GDP (Gross Domestic Product) of the state. The recommended growth rates of vehicles on the project corridor are given in Table 4.

Table 4: Recommended Growth Rates in %

Year	Truck-2axle	Truck-3axle	MAV	LCV	BUSES	MINI BUS	CAR/JEEP
2008-2012	4.64	4.64	4.25	4.64	3.87	3.57	4.47
2013-2017	4.25	4.25	3.87	4.25	3.57	3.2	4.17
2018-2022	3.87	3.87	3.48	3.87	3.2	2.98	3.87
2023-2027	3.48	3.48	3.09	3.48	2.98	2.98	3.57

Source: NHAI Meerut Division, U.P., India

7. Spot Speed Survey

Spot speed survey had been done on the highway on 09 March 2011 by using radar gun. The ROMDAS(Road Measurement Data Acquisition System) survey vehicle was also used to check speed matched with specified speed limit or not. Three times ROMDAS vehicle was run to check speed of vehicle match geometric profile or not and found speed match with road profile.All installed speed sign posts were matched with speed of driving vehicle. However, few vehicles were found over speeding. The details of average spot speed are shown in Table 5.

Table 5 : Spot Speed (SS) (Haridwar - Delhi)

Location	Type of Vehicle	Min. (KMPH)	Max. (KMPH)	Average SS in Km/Hrs.
Km129.000	Heavy Vehicles	25	78	60.86
	Light Vehicles	45	95	
	2- Wheeler	33	72	
Km113.8000	Heavy Vehicles	33	86	59.24
	Light Vehicles	35	102	
	2- Wheeler	28	56	
Km 105.500	Heavy Vehicles	30	75	58.72
	Light Vehicles	42	81	
	2- Wheeler	33	80	
Km 91.800	Heavy Vehicles	48	89	66.53
	Light Vehicles	51	110	
	2- Wheeler	31	89	
Km 84.00	Heavy Vehicles	30	68	52.67
	Light Vehicles	40	87	
	2- Wheeler	26	75	
Km 75.500	Heavy Vehicles	38	76	58.23
	Light Vehicles	44	98	
	2- Wheeler	29	86	

8. Collection of Accident Data

The accident data of the selected highway stretch were collected from respective police stations. The accident data were collected for a period of five years from 2005 to 2010. The accident data available from police records consisted of the location of accident and the details of severity of accidents, namely, fatal, major injury and property damage.

Table 6: Summary of Accidents Detail of NH-58 of Study Area

Year	Total no. of Accidents	Total no. of Deaths	Total no. of Injuries
2006	196	103	196
2007	183	85	220
2008	137	78	168
2009	115	44	135
2010	113	59	102

Main observation from accident data collected was that it gave an impression of under-reporting of accidents. Actual numbers might be much more. It was also observed that minor accidents were ignored in many cases where as severe accidents involving loss of life or serious injuries were most often reported. Summary of accidents detail of study stretch of National Highway 58 has been shown in Figure 8.

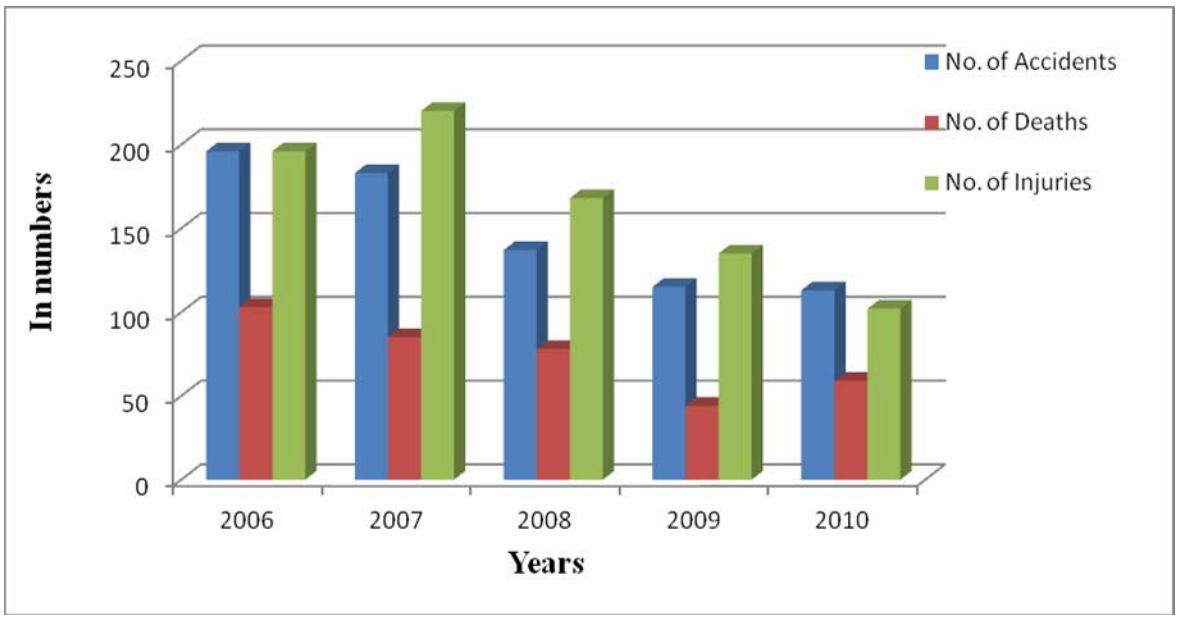

Figure 8: Graph of Accidents on NH-58 of Study Area

9. Cost of Accidents:

A Working Group set up by the Planning Commission in the year 2000 to look into road accidents, injury prevention and control had gone into the issue of social cost of accidents in India and had estimated the cost at Rs.55,0000 million in the years 1999-2000. It constituted 3% of the GDP of the country for year 1999-2000.

10. Costs of Conducting Road Safety Audits

In the safety audit manual published by TNZ (1993), the cost of audits was divided into three categories: consultant fees, the client's time to manage the audit, and costs associated with implementing recommendations that are adopted. The client's time on a project averaged about 1

day per audit. It is important to note that additional costs may result from changes to a project's scope and schedule. RTA indicated that a safety audit of a new facility cost approximately the same as a geotechnical survey (FHWA Study Tour, 1997). Recent experience places the average cost of a conventional audit for small to mid-sized projects between $1,000 and $5,000 (Sabey, 1993, Jordan, 1994, Pieples, 1999). TNZ found that fees range from NZ$1000 to $8000 (US$700 to $6000) with most falling in the NZ$3000 to $5000 (US$2000 to $3600) range (1993). The actual cost depends greatly on the size and complexity of the project and composition of the required audit team. Hamilton Associates estimate that audits add approximately 5 to 10 percent to design costs, or less than one-half of 1 percent to construction expenses (1998). These estimates are slightly higher than costs experienced to date for the MRDC project. AUSTROADS approximates that audits will add 4 to 10 percent to the road design costs (1994). As design costs are roughly 5 to 6 percent of the project sum, the increase in total cost is usually quite small. On smaller projects (traffic calming or retrofits), the costs may be a higher percentage of the overall capital cost. Costs of redesign/rectification should be considered which will vary on a project-to-project basis. The cost of rectifying deficiencies depends on how early in the design process the problem is identified as well as the amount of time required to redesign the area.

11. Benefits of RSA

AUSTROADS and the United Kingdom identified the **following benefits** of conducting a road safety audit; (AUSTROADS, 1994 and IT, 1996). An RSA can:

- Reduce the risk (including probability and severity)of accidents on new projects and at interfaces with existing roads;
- Increase the prominence of road safety in the minds of all involved in the planning, design, construction, and maintenance of the project;
- Reduce the whole life cost of the project by reducing the number of post opening modifications; and
- Ensure inclusion of all road users rather than the traditional focus on the four wheelers.

Belcher and Proctor (1990) suggest that road safety audits can provide increased safety in two ways:

- By removing preventable accident-producing elements, such as inappropriate intersection layouts, at the planning and design stages; or
- By mitigating the effects of remaining or existing problems by the inclusion of suitable crash-reducing features, such as anti-skid surfacing, guard fencing, traffic control devices, and delineation. It should be stressed that audits are most effective when conducted during the earlier stages of planning and design. Economics are greatly diminished at the final design, construction, and post-opening stages of project development since mitigation is typically much more expensive.

12. Road Safety Audit for Four Lane National Highway

A safety audit team was formed to carry out audit of safety features in highway environment of newly upgraded divided four lane highway section between Km 75.00 (Meerut By-pass) and Km 130.00 (Muzaffarnagar By-pass) on National Highway-58. The team consisted of a social activist, local people, road user and highway engineers. Both social and engineering aspects had been discussed during sites visit.

Safety assessment of various parmeters had been noted on survey perfoma which was developed as per IRC: SP: 88-2009 check list of existing road. The safety parameters included for safety audit were Width of Right of Way (ROW), Carriageway Width and Condition (CWC), Median Width, Condition and its Openings (MWCO), Condition of Shoulder in Paved / Earthen (CSPE), Condition of Vegetation Control (CVC), Side Drain Condition (SDC), Guard Rail (GR), Road Markings (RM), Marker Post(MP), Horizontal Alignment(HA), Curve Warnings and Chevron Markings (CWCh), Other Warning and Advisory signs (OWA), Cross Drainage works (CD), Fly Over/Road over bridge/ Under Pass (FO/UP), Access Roads/Side Roads (ARSR), Junction (J), Overhead Structures/Hoardings (OSH) and Land Use (LU). The selected road segment was divided into 200m each to carry out extensive safety assessment of highway environment. All identified safety parameters and their conditions had been noted in the survey Proforma. Road safety audit had been conducted for both direction of the divided four-lane National Highway 58 in between Km 75.00 and Km 130.00.

13. Correlation between Dependent and Independent Variables

Correlation analysis of collected influential safety parameters had been done. Here, dependent variable is taken as accident rate and independent variables are taken as J, CWC, MWCO, CSPE, RM, CWCh, OWA, CD, ARSR, LU, TV and SS. Derived correlation between dependent and independent variables are found good correlation with TV, CWC, SS, RM, MWCO and OWA.

14. Development of Accident Prediction Models for identifying safety influencing parameters

14.1. Multiple Linear Regression (MLR) Analysis

Table 7: MLR Model Parameters with T-Values and P-Values

	NH-58 (Sample Size 249)		
Model parameter	**Value**	**T-Statistics**	**P-Value**
Intercept	0.076	0.513	0.608
J	0.034	0.912	0.363
CWC	0.022	0.629	0.530
MWCO	0.000	-1.882	0.061
CSPE	-0.026	-6.037	0.000
RM	0.159	7.335	0.000
CWCh	0.015	0.405	0.686
OWA	0.115	3.305	0.001
CD	0.129	4.176	0.000
ARSR	0.003	1.407	0.161
LU	0.019	1.234	0.219
TV	0.480	12.833	0.000
SS	-0.158	-5.302	0.000

From Table 7, it was found that traffic volume, road markings, average spot speed, condition of shoulder (paved/earthen), cross drainage and other warning or advisory signs are the most significant safety variables which having T-value more than 2 and P-value less than 0.05 on model development.

Linear Equation developed from MLR model for prediction of accident rate is as under:

$$AR = c + a_1*TV + a_2*RM + a_3*SS + a_4*CSPE + a_5*CD + a_6*OWA + a_7*MWCO + a_8*ARSR + a_9*LU + a_{10}*J + a_{11}*CWC + a_{12}*CWCh \quad \text{..... .....} \quad (1)$$

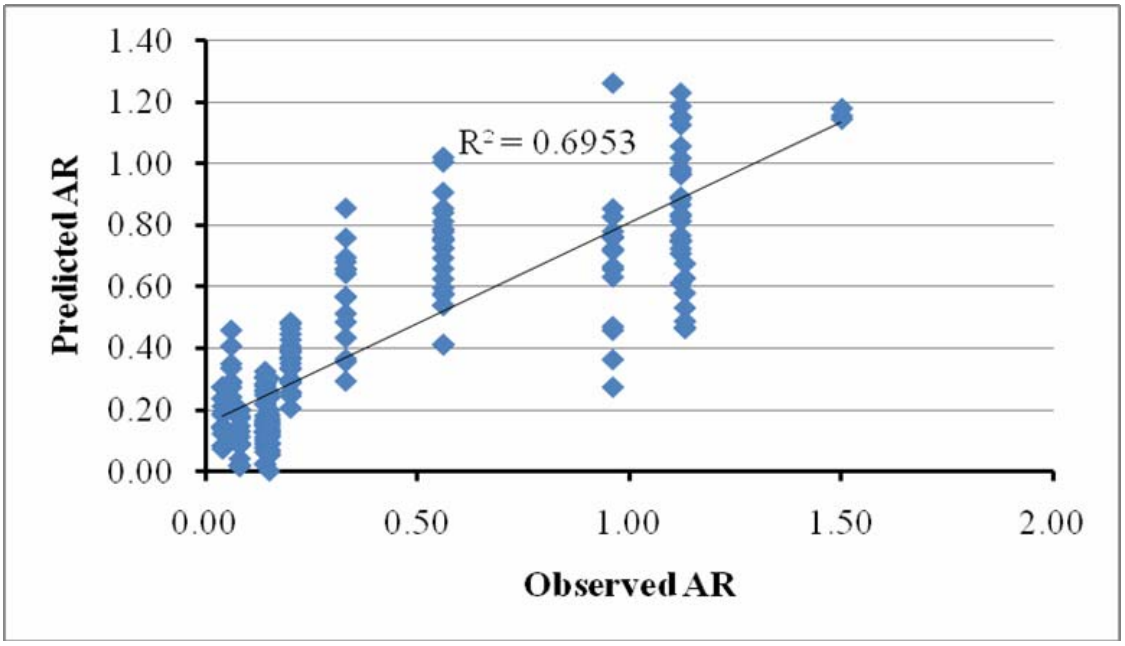

Figure 9: Observed and Predicted Accident Rates (MLR Model)

14.2. Non-Linear Regression Analysis

General equation of non- linear equation is developed for prediction of accident rate of the highway which is written as follows:

$$AR=c+a_1(TV)^{b}_{1}+a_2(RM)^{b}_{2}+a_3(SS)^{b}_{3}+ a_4(CSPE)^{b}_{4} + a_5(CD)^{b}_{5} + a_6(OWA)^{b}_{6} + a_7(MWCO)^{b}_{7} + a_8(ARSR)^{b}_{8} + a_9(LU)^{b}_{9}+ a_{10}(J)^{b}_{10} + a_{11}(CWC)^{b}_{11} + a_{12}(CWCh)^{b}_{12} \quad \text{---------- ..... (2)}$$

R^2 for non-linear regression model was found 67.65% and corresponding R^2 value for Linear regression model was 69.53%, this shows less correlation in non-linear than linear regression model. Figure 10 shows relation between observed and predicted accident rate.

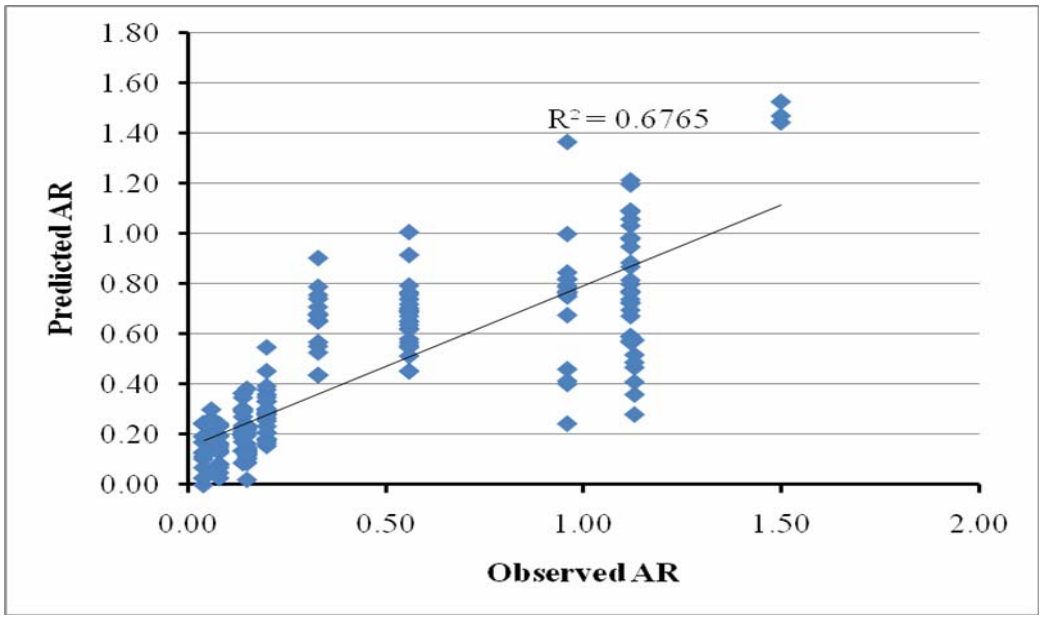

Figure 10: Relation between Observed and Predicted Accident Rate (Non-Linear Model)

14.3. Development of ANN Model

To train the multilayer feed forward back propagation network, MATLAB R2009b neural network tool box has been considered. Graph obtained through data simulation is shown in Figure 11.

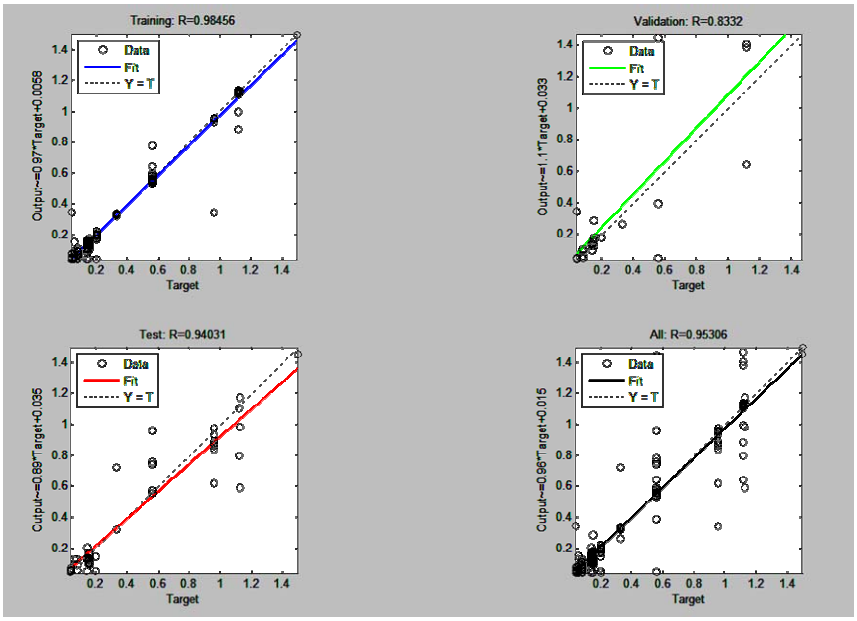

Figure 11: Correlation between Obseved and Predicted AR (ANN Model)

14.4. Validation of ANN Model

For model validation, 111 number sample points were taken from opposite direction (Km 130.00 Muzaffarnagar bye pass to Km 75.00 Meerut bye pass) data of NH 58. The data were used in proportion of 70 %, 20%, and 10% for model training, testing and validation respectively.

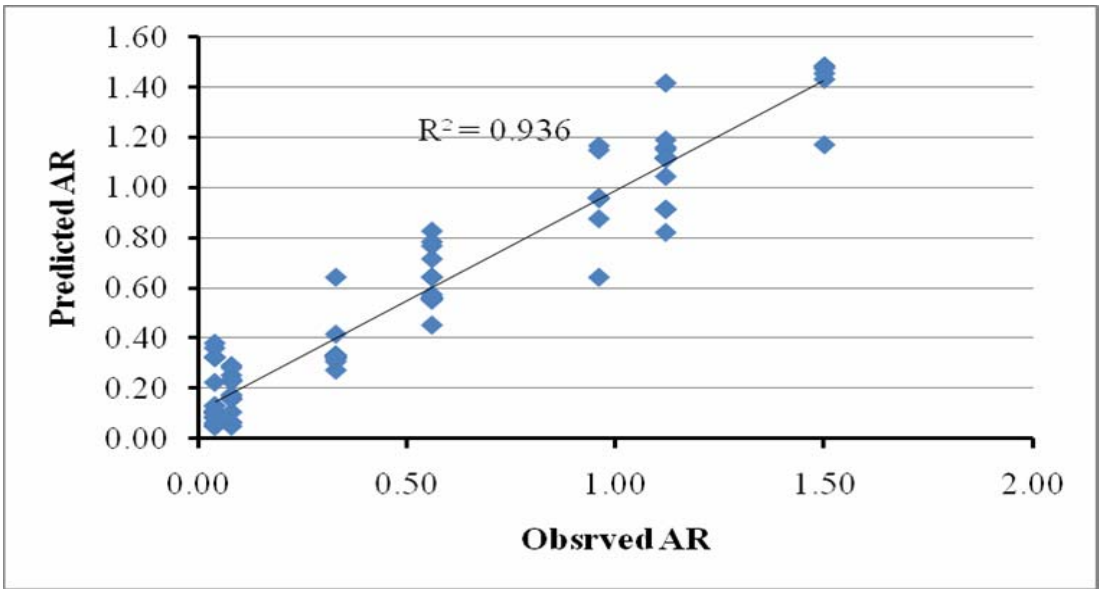

Figure 12: ANN Model Validation Graph in between Observed and Predicted Accident Rate

After result compression, it was found that ANN model shows very good correlation between observed accident rate and predicted accident rate with R^2 value 98.50% in model development and 93.60% in cross validation. On the basis of developed model; any other road safety data through RSA study can be used for prediction of accident rate of four lane National Highways of the country.

15. General Observations and Study Application

Horizontal and Vertical Curve details: Design of horizontal curves were checked to ensure whether adequate super elevation, transition lengths have been provided for chosen radius of curve and for particular design speed. Vertical curves were checked for minimum curve length to be adopted for specific change in grade to have adequate sight distances. The horizontal and vertical curves are designed as per IRC requirements and no major deficiency has been observed in the design.

Crash Barrier locations: The crash barriers have been provided on embankments whose height is more than 3.0m, at major and minor bridge approaches and sharp curves. Crash barrier is not properly connected with bridge concrete crash barrier at many locations. There should be no gap between Metallic crash barrier and rigid concrete crash barrier. In the approaches of structures, it should be extended up to the end of approach.

Major Junction Locations: Geometrical improvements at many of the major junctions are not started due to hindrances and some are in progress. Grading and linking of minor arms to project road are pending in most of the junctions and are held-up due to one or the other reason. Lane Marking and installation of high mast lighting on the project road at all junctions is yet to be completed. Installation of road studs has to be done in all junctions. Object / hazard markers are to be provided within the channelizing and divisional island facing traffic to warn the drivers in advance.

Minor Junction Locations: Lane marking, 'STOP' line marking, directional arrows, pedestrian markings etc, have to be done in all the junctions. As per IRC, it is necessary to provide road hump on minor arms at a distance of 10m from edge of project road to regulate the speed of vehicles entering the project road. 'STOP' signs are to be properly installed on minor arms and shall be located at a distance of 3m from 'STOP' line and aligned perpendicular to face the on-coming traffic

Grade separator and Vehicular underpass Locations: Adequate vertical clearances have been provided under all the flyovers and vehicular underpasses. Geometrical improvement of at-grade road needs to be taken-up with proper channelizing islands for uninterrupted traffic movements.
Sign posts, Hazard markers and Road Studs: Speed limit sign boards and informatory sign boards have to be installed at merging and diverging lanes of service roads, major junctions, petrol pumps and hospitals. Delineators shall be provided along the edge of longitudinal curve. It is desirable to provide road studs have to be provided along centre and edge line of all horizontal curves. Hazard markers shall be provided for channelizing and divisional islands at all major junctions, median openings, before parapet of CD structures/bridges, before crash barrier, before vertical posts/columns of over head gantry sign boards resting on shoulders. All signs are reflectorised type with high intensity retro-reflective sheeting of encapsulated type has been provided.

Lighting arrangement: Adequate lighting arrangement is in progress on flyovers and on at-grade roads in town limits. High mast lighting has to be provided at some locations. Lighting arrangement is also required below slab in vehicular underpasses. All major and minor junctions of the highway should be facilitated with high mast lighting arrangement for safe movement of vehicular traffic and pedestrians.

Pavement Marking: Lane marking was completed in majority of road sections. Pedestrian cross marking at school, hospital, town/village limits, bus bays, VUP and PUP locations shall have to be carried out for safe movement of pedestrians.

Pedestrian facilities locations: Raised foot path needs to be provided in town and village area for safety of pedestrians. Raised foot path is in progress at bus bay locations. Pedestrian guardrail shall be provided at the places where pedestrian activity is high and on raised foot path on the side of carriageway at bus stops and bus bays for adequate length but not less than 20 m on either side for pedestrian safety.

Bus bay & Truck lay bye locations: Informatory sign boards shall be installed ahead of the bus bay and truck lay byes. Pavement marking needs to be carried out. Raised pedestrian footpath needs to be constructed for safety of passengers. Proper transition in carriageway shall be provided.

Speed regulatory measures at junctions: As per Indian Road Congress specification, it is necessary to provide road hump with necessary sign boards on minor arms at a distance of 10m from the edge of main carriageway to regulate the speed of vehicles entering the project road.

Locations of vehicular skidding and surface pounding: There were no locations with excessive bleeding and corrugations in pavement surface. Median opening/median drains for efficient drainage of surface water is under construction in super elevated sections. On high embankments, rain cuts have been observed on the earthen slopes. This needs to be rectified. Excessive filling in medians have resulted in spilling over of earth on carriageway in some of the stretches. This needs to be removed by dressing the filled earth to kerb height or even less.

Toll Plaza: Toll plaza with various facilities is still under construction and to be completed. Proper lanes marking with adequate channelization have to be provided at toll plaza. Lighting to meet required lux level along with high mast lighting shall be provided as per the requirements of the project. Proper flaring in carriageway shall be provided.
Highway patrolling: The pavement maintenance agency should provide route patrols round the clock to assist motorists. The patrol personnel should be adequately trained in traffic management, road safety and in primary First Aid. The road agency should also provide ambulances having all facilities of emergency assistance required like stretcher to carry the patient, Emergency Medicines, oxygen etc. The Concessionaire should have cranes of sufficient capacity having all requisite arrangements of pulling and lifting of accidental/break down vehicles.

Service Roads: Service Roads are to be constructed in habitant areas which are still to be completed in the some stretches. Proper flaring at start and end of Service Roads should be provided before merging or diverging. Road signs should also be installed at all flaring locations. Proper chevron marking should be provided at start of separator between Main Highway and Service Road. Hazard Marker shall also be installed at start of divider.

Drainage: Pucca Drain is provided in Urban Areas / Service Roads which is in progress. It is noted that Gratings are to be provided for outfall of water in the drain. These drain should be covered to ensure safety of pedestrian.

Median openings: Most of the Median openings have been provided with storage lane for 'U-turn' vehicles. 'STOP' line and 'U-turn' marking has to be taken-up to guide the drivers properly. No vegetations have to be planted in median (up to 100.0m) to maintain clear sight distance at median opening locations. Median opening sign boards have been installed in most of the locations. Arrow marking is still to be done in storage lanes. It is observed that at some locations of the project stretch, the local people were damaging the median kerbs and using as unauthorized median openings. These should be restricted and all such openings should be closed.

Specific Location Observations

Our observations specific to location are presented with photographs which had been taken during Safety Audit. Location & problem encountered are described along with photographs below.

Figure 13: Minor Junction at Km74.060

- Junction not developed.

Figure14: Drain on Left Side at Km 74.840

Drain cover should be provided so that Pedestrian can walk safely. Gap between Drain Edge and Road should be filled.

Figure 15: Unauthorized Median Opening at Km 75.160

Temporarily proper sign board should be installed.

Figur16: Minor Junction at KM 76.950

Minor Junction not developed

Figure 17: Median Opening at Km 77.835

• Object Marker not provided.
• Pavement Marking missing.

Figure 18: Underpass at Km78.350

Soil should be removed from the carriageway

Figure19: Underpass at Km 78.350

• Drain should be covered.

Figure 20: Underpass at Km 78.350

• Gap between wall and drain should be filled.

Figure 21: Underpass at Km 78.350

Footpath should be provided on service road at underpass location.

Figure 22: Minor Junction at Km 86.750

Storage lane not provided

Figure 23:Embankment of ROB Approach at Km 87.600: Rain cuts were seen on slopes as the slopes were not protected.

Figure 24: Unauthorized Median Cut at Km 113.210: Unauthorized Median cut should be closed wherever possible. Temporarily proper sign board should be installed.

Figure 25: Service Road & Start of Underpass at Km 121.800: Hazard Marking and Chevron Marking are missing.

Figure 26:Confusing information board of Truck lay bay at Km 122.400

Summary of unauthorized median openings of selected section of NH-58 four lane are listed below in Table.4. These medians should be immediately closed for ensuring road safety.

Table.4. List of Unauthorized Median Openings

Sl. No.	Chainage (Kms)	Remarks
1	75.160	Recommended to be closed.
2	76.700	Recommended to be closed.
3	87.050	Recommended to be closed.
4	88.800	Recommended to be closed.
5	102.200	Recommended to be closed.
6	105.240	Recommended to be closed.
7	111.380	Recommended to be closed.
8	113.210	Recommended to be closed.

CONCLUSIONS

Based on the present study of road safety audit for 4 lane national highways the following conclusions have been drawn**:**

Due to newly upgraded four lane National Highway-58 between Km 75.000 to Km 130.00, the road standards have been raised suddenly. But other related factors are not brought to this level such as road user behavior, surrounding prevailing conditions etc. The road standards are permitting high speeds, but prevailing traffic conditions are not conducive to such speeds. Earlier the average speed of vehicles was 30-40 Kmph and now 60-70 Kmph where as design speed is 100 Kmph which is very high. From data simulation, it found that Road Markings, Condition of Shoulder, Traffic Volume, Spot Speed, Median Opening and Carriageway condition were main parameters for causing accidents. It was also seen that slow moving traffics were creating traffic hazards for fast moving traffic as it always occupied the innermost lane of highway. Therefore service roads should be provided for the entire length of four lane roads in order to separate slow moving traffic from fast moving traffic. All unauthorized median openings should closed and adequate provisions for crossing local people be made on priority. All undeveloped major and minor intersections must be developed with adequate lighting provisions as quickly as possible since maximum accidents were observed on these locations. Pedestrian guardrail should be provided all along the footpath of service road and at bus stops.

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