ACCIDENT STUDIES AND ROAD SAFETY AUDIT ON NATIONAL HIGHWAYS

A Dissertation submitted
In partial fulfilment of the requirements for
the award of the degree of

MASTERS OF ENGINEERING
IN
CIVIL INFRASTRUCTURE ENGINEERING

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DECLARATION

I, Kapil Bhagat, hereby declare that this thesis entitled **"Accident studies and Road Safety Audit on National Highways"** is an authentic record of my study carried out as requirements for the award of degree of **Master of Engineering** in **Civil Infrastructure Engineering** in the Civil Engineering Department, Thapar University, Patiala under the supervision of **Dr. Naveen Kwatra, Head & Associate Professor and Mr. Tanuj Chopra, Assistant Professor,** Department of Civil Engineering, Thapar University, Patiala during July 2012 to July 2014 . The matter embedded in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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CERTIFICATE

This is to certify that above statement made by the student concerned is correct and true to the best of my knowledge and belief.

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CHAPTER-1

INTRODUCTION

1.1 General

According to the official statistics (National Crime Records Bureau), In India in 2008, 118,239 people were killed in road accidents. The death rate in India is about 10 to 20 time higher then high income countries like Japan, Australia, UK, and USA. In India the share of national highways and state highways is about 6 to 7 % of the total road networks but it cater to about 70 to 75% of total traffic. However in India only national highways comprises of only 2% of total road network, which account for 20% of total road accidents and 25% of total traffic fatalities.

World Health Organization in their global status report on road safety presented in 2009 revealed that more people die in road accidents in India than anywhere else in the world, including the most populous China. This also been seen that traffic fatalities increased by about 5% per year from 1980 to 2000 but for now the rate of traffic fatalities has jump up to 8% per year in recent years. The reasons in the increase in percent of fatalities are may be due to increase in number of vehicles in recent years and secondly due to absence of coordinated official policy to control the problem. The fatality rate has increased from36 fatalities per million persons in 1980 to 103 fatalities per million persons in 2008. Many of these traffic injuries and deaths take place in constructions zones on all roads and highways. In addition, a many number of workers working in construction and maintenance of roads also get injured and killed every year. This increasing trend in injuries and fatalities has been recognized as a public health problem of significance by the authorities and public at large. In economic terms, the cost of the road crash injuries is estimated at roughly one percent of gross national product in low income countries, 1.5 percent in middle income countries and 2 percent in high income countries.

The management of accident risk is both a short-term and a long-term strategy, which requires support of central and state authorities. The most effective way of managing accident risk is through the development of a 'safety culture'. A safety culture is the beliefs and ideas shared by all members of an organisation about accidents and their risk of happening and proper measure which are to be taken to decrease in the number of accidents. The year wise road accidents in India are shown in the table given below Accident is an event, occurring suddenly, unexpectedly and inadvertently under unforeseen circumstances. An accident may be defined as a collision occurred on a way or street open to public traffic (The collisions may be between vehicles; between vehicles and pedestrians; between vehicles and animals; or between vehicles and geographical or architectural obstacles) resulting in killing or injuring of one or more persons and involvement of at least one moving vehicle. ‘Accidents are not natural but they are caused’ is a common cliché in the area of traffic safety. Thus if accidents are caused by some, surely the ones responsible for could be identified and appropriate remedial measures developed and implemented to the extent feasible. Accidents are not often caused due to ignorance, but due to carelessness thoughtlessness and over confident. Road accidents are associated with number of problems from person to the environment and vehicle the road, for proper study of the accidents each problem has to study separately. Due to growth in urbanization in many developing countries there is increase in the number of vehicles to a large extend which led to increase in traffic congestion in many urban centres which ultimately increase the number of accidents on road network which were never designed for these number of traffic and traffic type. Therefore the number of accidents is more in developing countries like India, Ghana as compared with developed countries like USA & Japan. The deaths per 1000 vehicles registered in some developing countries are shown in fig 1.1

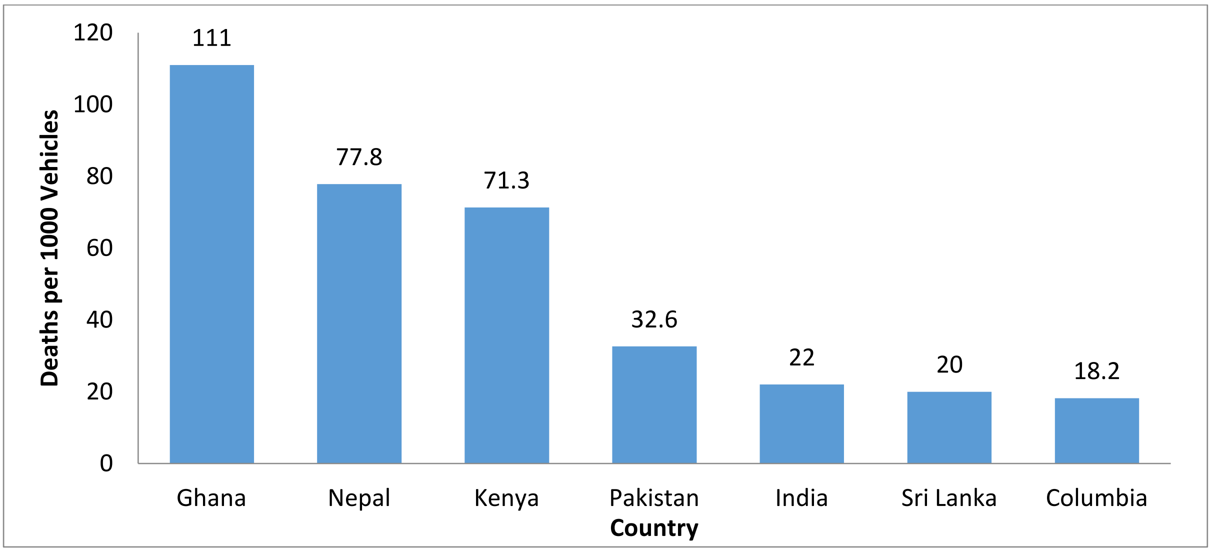


***Fig1.1* Comparison of death/1000 vehicles among various developing countries (source-Accidental Deaths & Suicides in India Published by National Crime Records Bureau)**

1.2 Accident scenario in India

The fast growth in the Road Transportation Sector in India has been a key element in the economic development of the country. But on the other hand this fast growth in Transportation Sector led in to increase in traffic accidents too. During 2008 India ranked fourth in the world among leading deaths due to accidents. In 2008 more than 1 lakh people die in road accidents and around 5 lakh people injured due to accidents in India. India's motor population is just 1% of the worlds but her share of the world traffic accident is 6%. Though the accident rate is decreased during the last 25 years due to awareness among people education and safety programmes but still the accident rate is very high as compared to the developed nations.

***Table 1.1* Year wise road accidents statistics in India (source- Accidental Deaths & Suicides in India Published by National Crime Records Bureau)**

Year	**Number of Accidents**		**Number of Persons**		**No of persons killed per 100 accident**
	Total	**Fatal**	**Killed**	**Injured**	
2001	405,637	71,219	80,888	405,216	19.9
2002	407,497	736,50	84,674	408,711	20.8
2003	406,729	73,589	85,674	435,122	21.1
2004	429,910	79,357	92,618	464,521	21.5
2005	439,255	83,491	94,968	465,282	21.6
2006	460,920	93,917	105,749	496,481	22.9
2007	495,145	106,221	118,374	522,883	23.4
2008	539,112	129,395	131.497	589,294	24.1

***Table 1.2* Various elements contributed in road accident in India(source Accidental Deaths & Suicides India Published by National Crime Records Bureau)**

ELEMENT	**PERCENTAGE**
Road User	65.0
Road & Surroundings	2.5
Vehicle	2.5
Road User and Road & Surroundings	24.0
Road User and Vehicle	4.5
Road User, Road & Surroundings & Vehicles	1.5

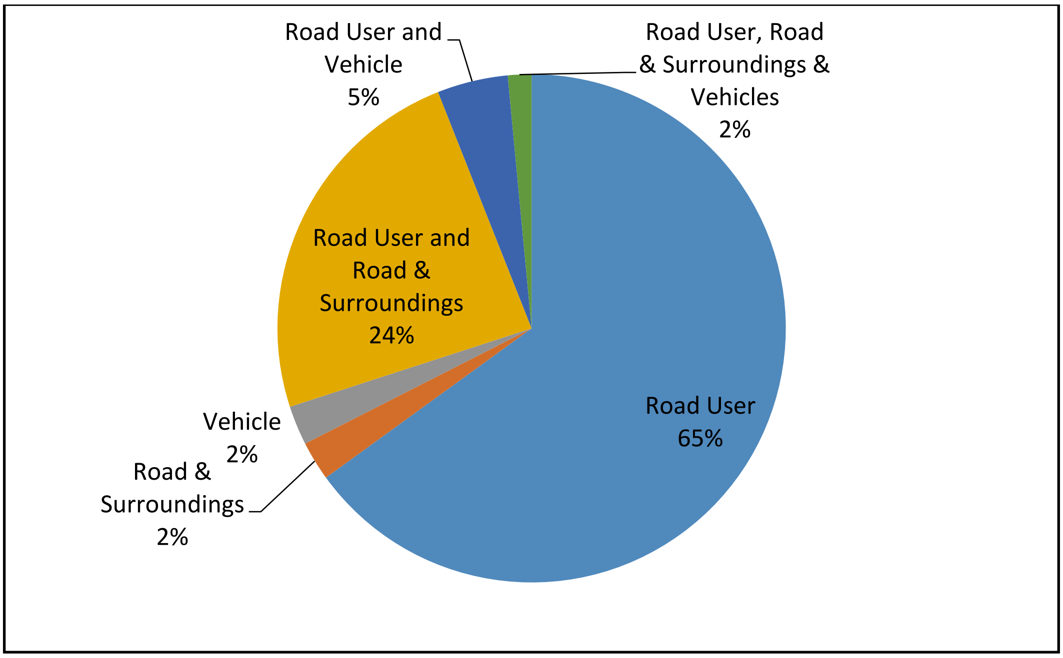


Fig 1.2 **showing that most of accidents take place because of the fault of road user only (source-Accidental Deaths & Suicides in India Published by National Crime Records Bureau)**

1.3 Road Safety Audit

A road safety audit may be defined as an independent inspection of a future road project to identify anything that may affect the road's safety. A road safety audit is also a formal examination of proposed or existing roads and roads related areas from the perspective of all road users with the intension of identifying road safety deficiencies and areas of risk that could lead to road crashes. It does not consider crash history. The mostly commonly used definition of road safety audit as developed by transportation association of Canada is " a road safety audit is a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users. It is conducted by an independent qualified team of professionals. The primary objective of a road safety audit is to help in project for successfully achieving Safer Journeys and safe system approach- that is minimization of death and serious injury on the roads. The road safety audit brings in picture all the areas of the project that is not feasible with a safe system and brings those drawbacks to the attention of the client.

1.3.1 Elements of Road Safety Audit

- It should always focuses on the safety aspects of the project.
- It should be carried out by those professionals who are independent of the client, Designer or Contractor.
- The people carrying safety audit must have appropriate experience and training and who understand the safe system approach well.
- It should be a formal documented process.
- All potential road users should consider in the audit.

Road safety audit is not intended to be

- A replacement for a design review, a peer review or a quality control review.
- A judgement of the quality of a project (as the project will likely have other components).
- A means of ranking or comparing one project or option over another (although it may form part of the decision process).
- A redesign of a project.
- A check with standards, guidelines or drawings and specifications.
- An informal check, inspection or consultation.

1.3.2 Benefits of Road Safety Audit

- Road safety audits helps in achieving the objectives of a safe system by proper inspection and vision and hence provides a safer road with explaining roads.
- Road safety audit helps in the proper and accurate design. Deficiencies of which can cause major crashes n thus helps in minimise the risk of high-severity crashes.
- Road safety audit should help in minimising the need for rework and physical remedial works caused by road safety deficiencies at the various stages of project development, including construction.
- Road safety audit help in reduce the whole of life costs of the project.
- It helps in improve the awareness of, and contribute to, improvements in safe design practices.

1.4 Approach & Methodology of Road Safety Audit

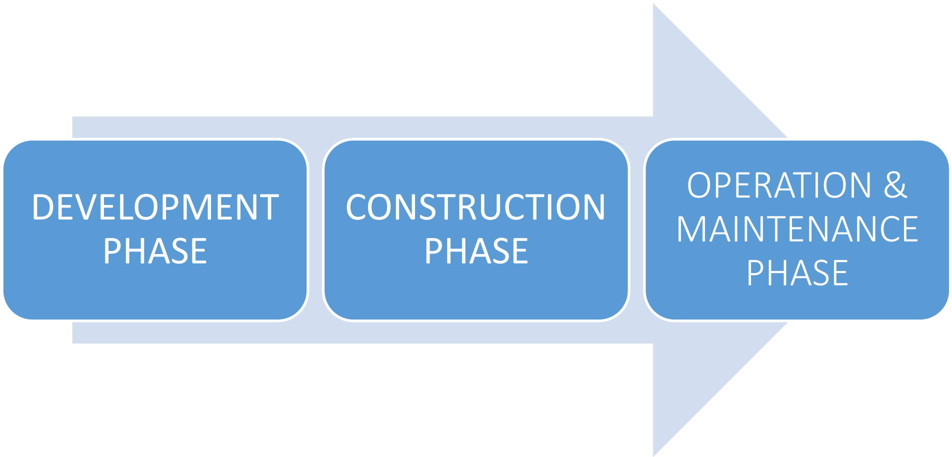
The road safety audit is generally taken at the completion of preliminary design and where possible,

Project of road safety audit is divided in to three stages

Stage 1:- Audit during development Phase. (Design and Planning)

Stage 2:- Audit during Construction phase.

Stage 3:- Audit after completion of the project. (O&M Planning)



During Development Phase:

This is the 1st stage of road safety audit and will be undertaken at the completion of preliminary design (order publication report stage) before the draft orders has published and for development-led highway improvement schemes before planning consent where possible. This is the last occasion where the requirement of land used for the construction may be increased so therefore it is essential to consider fully road safety issues. The main aspects which must be consider in this stage are as follows

- At this stage all the members of the audit team shall visit together the sites of highway improvement schemes that involve permanent change to the existing highway layout or features and the sites where new offline highway improvement schemes tie-in to the existing highway.

- In this the road safety audit team organize meeting and various options for the proposed project has been discussed and the most feasible option is preferred to choose. Therefore this stage is
- Collection of data for all the accidents in the project highway for preceding two years from Police Stations (Primary Source) and other secondary sources.
- To perform the analysis of fatal and grievously injured accidents "to identify the black spots" and relate to Accidents records with Traffic Volume to show trend as per Traffic Volume Count.
- Carrying out a design stage Road Safety audit as per the applicable manual, guidelines, standards and good industry practices; and prepare a draft Safety Report. This audit shall also take into consideration the changes being proposed to the cross section (geometrics) due to 4 or 6-laning of existing roads and its likelihood effect on fatal and serious accidents based on the accident data collected above and suggest countermeasures to mitigate the accident potential.
- To review the comments from Concessionaire, Independent Engineer and NHAI on the draft Safety Report and furnish the Final Safety Report that inter-alia shall include costing of all the safety recommendations.

During Construction Period:

In this stage the audit is undertaken when highway improvement scheme is going on the ongoing work on the road to check the ongoing construction on the road. This to minimize potential risk to road users and the difficulty that would be experienced by audit teams in traversing the site when open to traffic. Auditors are required to examine the highway improvement schemes from all the users' viewpoints and may decide to walk through the scheme to assist their evaluation and ensure they have comprehensive understanding. The issues which are raised in the previous stage of the audit should also be reviewed at this stage of the audit. The main aspects of the audit are as follows

- To study the Safety Report of the development period and provide a gap report vis-à-vis what was given in Final Safety Report and Safety Report which was finally implemented.

- To inspect the Project Highway Keeping into consideration the construction planning for the project as prepared by the Concessionaire and then identified the safety implications of the construction planning.
- Carry out the Safety Audit once in a calendar quarter, till COD, to assess the adequacy of safety measures adopted and provided in construction zone(s).
- Collect accident data (monthly) from the Concessionaire/PD office/other secondary source and examine causes of fatal accidents including suggesting countermeasures.
- Submit a Quarterly Safety Report on additional Road Safety measures, if any and Summary of audit carried out in every quarter.
- Receive comments from Concessionaire, Independent Engineer and NHAI and furnish revised recommendations of safety measures duly examining the above comments and submit Safety Reports.
- Provide Monthly Reports on all activities which were planned, actually executed and planned next month. It is essential and part of financial quote of bidder.
- Conduct work Zone Safety Audit for civil works, Casting yards and stores as per Contract Agreement and submit quarterly safety report.

During Operation and Maintenance Phase

This audit is undertaken during the first year of highway improvement scheme is open to traffic, a check should be kept on the number of accidents that occur, so that any serious problem can be identified and remedial work arranged quickly.

- To review and analyze the annual report and accident data of the proceeding year, and will undertake an inspection of the Project Highway.
- To complete the safety audit with in a period of one month and will submit a safety report recommending specific improvements if any required to be made on the road, bridges, culverts, marking signs, road furniture and project facilities including cattle crossings and pedestrian crossings. Such recommendations will be processed and acted upon in the manner as given in schedule L of the contract.

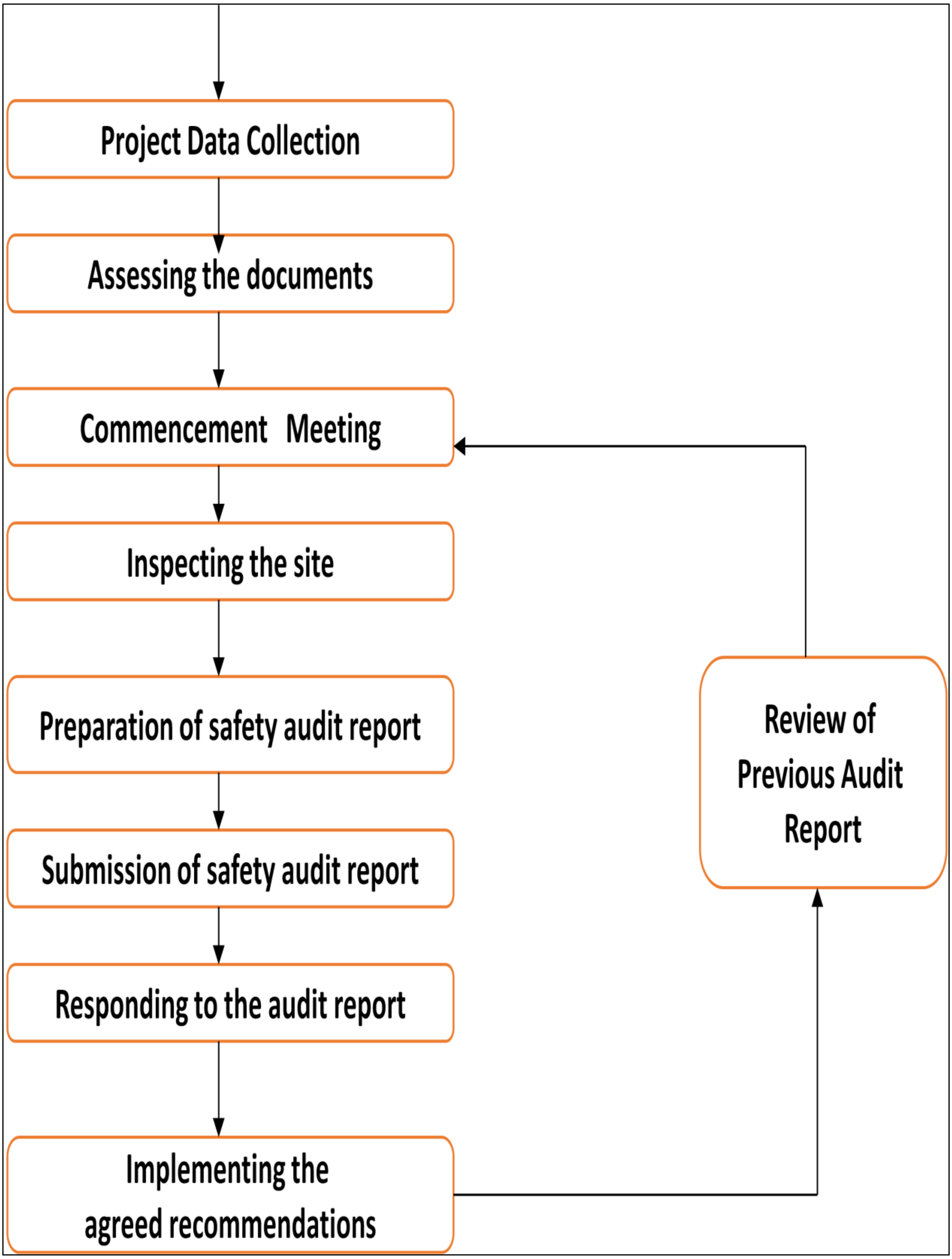


Fig 1.3 **Safety Audit procedure flow diagram**

1.5 Members of Road Safety Audit Team & their Duties & Responsibilities

Project sponsor	The project manager or officer (employed or contracted by the road jurisdiction) responsible for delivering or overseeing the road infrastructure related works.
Lead auditor	A road safety auditor with qualifications, experience and skills required to lead manage the conducting phase of the road safety audit process and participate in the entire undertaking of the road safety audit.
Audit team member	A road safety auditor with qualifications, experience and skills required to participate in the entire undertaking of the road safety audit.
Active observer	A person with an interest in undertaking the road safety audit who participates in the road safety audit as directed by the lead auditor. The person may be gaining experience to become a road safety auditor, offering the local perspective on the words or overseeing the auditing practices
Road safety advisor	A practicing professional with specific skill sets, experience or knowledge in road safety matters required to provide road safety advice to the project sponsor on critical aspects of the road safety audit process. A road safety advisor may participate/assist in the entire road safety audit process. The advisor does not need to be independent of the works
Specialist advisor	A practicing professional with specific skill sets, experience or knowledge in road safety matters required to provide independent specialist advice to the project sponsor or the audit team on critical aspect of the project. A specialist advisor does not participate in the entire road safety audit.
Project stakeholder	A person with an interest in the road infrastructure related works. May be a planner, designer, construction manager, asset manager, operations manager or alliance manager
Approval manager	The manager employed by the road jurisdiction who is accountable for delivering or overseeing the road works.

Library administration	The manager or officer (employed or contracted by the road jurisdiction) responsible for administering the road safety audit reports library.
Service provider	The person, contractor, organization or party required to deliver services.

1.6 Documents required for Road Safety Audit

- Manual for Safety in Road Design (1998)
- Road Safety Audit Manual (2010)
- India Accident Investigation & Prevention Manual. MOST, ADB and TRL.
- IRC: SP: 91-2010, Guidelines for Road Tunnels.
- Danish Road Directorate (1993) Safety audit handbook.
- IHT (1996) Guidelines for road safety audit. London: Institution of Highways and Transportation.
- Motor Vehicle Act - 1 (1988)
- Towards Safer Roads in Developing Countries - A Guide for Planners & Engineers,
- TRL, Ross Silcock (1994)
- International Approaches to Road Safety Audit, M.J. Goodge, Austoroads, Australia, 1992.
- IRC-53 (1992) Road Accident Forms A-1 & 4.
- All relevant IRC Standards and Guidelines relevant for conducting Road Safety Audit.
- IRC-73-(1980) Geometric design standards for Rural (non urban) Highways
- IRC-SP-23(1993) Vertical curves for Highways

CHAPTER 2

LITERATURE REVIEW

Rao et al., (2005) carried out accident study between Anakapalli & Visakhapatnam of NH-5 India has a road network of 3.3 million km consisting of National Highway (NH), State Highway (SH), Major District Roads (MDR) and Other District roads (ODR). National Highways constitute 2% of the total road length and carries more than 40% of passenger traffic and 85% of goods traffic has registered more accidents accounting for 20%, as compared to other roads. ‘Accidents are not natural but they are caused’ is a common cliché in the area of traffic safety. According to a study it is indicated that 66% of the accidents occur due to human error and 33% due to road parameters such as road and vehicle interaction, other road user and environmental factors. India’s motor vehicle population is just 1% of the world’s, but her share of world road traffic accidents is 6% though the accident rate has been steadily decreasing over the past 25 years, though the accident rate is still very high compared to the developed nations.

This study lays emphasis on accident on the 40 km long National Highway - 5 section between Anakapalli and Visakhapatnam, in the State of Andhra Pradesh, India. The spectacular growth in the Road Transportation Sector in India has been a key element in the economic development. Growth in urbanization and in the number of vehicles in many developing countries has led to increased traffic congestion in urban centres and increase in traffic accidents on road networks, which were never designed for the volumes and types of traffic, which they are now required to carry. In addition, unplanned urban growth has led to incompatible land uses, with high levels of pedestrian-vehicle conflicts. The drift from rural areas to urban centres often results in large number of new urban residents unused to such high traffic levels. It has been estimated that in India, more than 70,000 people die and nearly 4 lakhs persons are injured in about 3 lakhs and more road accidents every year.

The five year accident data was collected from the concerned police station and analyzed thereafter. This study stretch of National Highway-5 starts from Koppaka Village (near ROB), Anakapalli to New NHAI office, Visakhapatnam (i.e. from Km 359.2 to Km 395.875 and from Km 0.0 to Km 2.837), with a total length of 39.512kms. It is a four lane divided highway with shoulder and side drains. The open side drains exist for some part of the study stretch. The service road exists for short length and is discontinuous.

The effect of road conditions in road safety to date is still underestimated. On the basis of widespread scientific research involving analysis of road accidents and a study of how vehicles are driven under different road conditions, it will be probable for the highway engineer to establish the effect of road conditions on accidents

The collected data revealed that there were 64 deaths and 373 injuries recorded between January to December, 2002 and 20 deaths, 82 injuries were recorded between January to June, 2003. The entire section of NH-5 between Anakapalli to Visakhapatnam is unsafe from safety point of view. The main reason is local traffic has direct access to the National Highway, which results in congestion and accidents. Analysis of accident data within the study area showed that about 376 accidents occurred on the study stretch of NH-5 in the year 2002. A further analysis of this data also revealed that about 66 persons were killed and about 389 persons were injured on the study stretch in the same year. A close look on the total accidents on all types of the roads in the Visakhapatnam city has revealed that the accidents on NH-5 (study stretch) alone are around 34%, which is a significant part and a major reason for authorities concern. Maximum accidents were occurred at km 370.4 (near Toll Booth), km 373.4 (near Ravi Filling Station), km 1.178(near Temple) and km 1.651(near Hill top road). The identified black spots were investigated in detail to assess the cause of accidents and suggest the remedial measures to minimize the accidents.

There is another black spot at km 374.4 near Ravi filling station. Two median openings were provided for the convenience of filling fuel at an interval of 20 m. Hence, the road user moves in wrong direction to fill the fuel and has resulted in increased accident rate and as remedial measures it was suggested to the National Highway Authority of India (NHAI) to close both the median openings to minimize the accident, as the fuel filling facility is available on both sides.

The analysis of the data from safety point of view indicated that the vehicle drivers are the single major factor responsible for the accidents as they fail to perceive the situation ahead because of poor reflexes, fatigue, inexperience or being under the influence of intoxicants. The accident data for the section indicated that two wheelers are the ones who mainly suffer the fatalities and major injuries, which is around 35% followed by trucks 23% involved in accidents. According to the Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 1973 - 1988, 2005 the reasons for the accidents can be attributed lack of signage, raised median cover with trees/bushes, making pedestrians not visible to driver, improper design of pedestrian crossing, frequent median openings, and lack of enforcement to control wrong side movements. There are however, other factors, which contribute directly or indirectly to the accidents include road, vehicle, road user and environmental factors.

From the results of the analysis, it can be concluded that this National Highway section needs improvement from safety point of view. A large number of accidents have been occurring over such a small section of 40 km length. Proper traffic guidance and control system to guide road users ensuring safe movement of vehicles has been recommended and some of the facilities such as pedestrian crossings and median openings, acceleration and deceleration lanes were re-designed in order to improve the safety of the road and minimize the accidents.

Singh and Mishra (2006) carried out road accident analysis in patna city and studied about the various reasons for accidents. Urban transport facilities in most of the Indian cities are inadequate and deteriorating over the years. The development of public transport system has not kept pace with the traffic demand both in terms of quality and quantity. As a result, the use of the undesirable modes such as personalized transport, mainly two-wheelers, and intermediate public transport, mainly three-wheelers, is growing at a rapid speed. Roads and footpaths today are heavily encroached by parked vehicles, hawkers, and roadside business forcing pedestrians to walk on the road. This results not only in restricting the traffic flow, but also putting the pedestrians‘ life at a great risk. Bihar is one of India‘s poorest and densely populated states, its capital city Patna, is noisy, crowded, polluted, and typically chaotic. The roads in the city are congested and encroached by other activities. Bus services in particular have deteriorated, and their efficiency and quality of service have been declining thus inducing passengers to turn to personalized modes and IPTs. This results not only in restricting the traffic flow, but also putting the road users‘ life at a great risk. The total number of fatal accidents as well as related fatality in the city is increasing over the years.

The vehicular population growth is tremendous in Patna, with just 4,384 registered motor vehicles in 1981 to 294,164 in 2001, an increase of 67 fold in a span of just two-decades. If we calculate it from 1981 to 2001, annual growth rate figure goes up to around 23%. It is observed that growth of personalized vehicles such as two-wheelers and cars is very steep due to non-availability of mass transport system. Public transport system in Patna, in general, is inadequate, inefficient, and unplanned and therefore, it is not able to serve the travel demand of the public in the best possible way.

Patna is also suffering from the problem of deaths and injuries on its roads. The total number of fatal accidents as well as related fatality in the city is increasing over the years. The primary data is collected from the office of Superintendent of Police (Traffic), Patna. This study is based on the data collected from the 14 police stations in Patna city. Persons killed per 100 accidents are alarmingly high, as high as 45 during the year 2000. Although fatality rate is relatively low in Patna, fatality risk is higher than the Indian average. Pedestrian deaths as a percentage of all road fatalities are extremely high in the city. During the recent years, they constitute more than 90% of all road fatalities. Since both adults working age group and pedestrians constitute a large proportion of road accident fatalities, it is believed that the vast majority of pedestrian casualties occur to the economically active cohort. As far as vehicle-wise accident rates are concerned, buses are the most risky. On an average, they are causing around sixteen accidents per thousand buses per annum. In general, trucks and three-wheelers are the second and third most risky vehicles, respectively. Furthermore, the city traffic police have identified few accidents prone locations on the basis of severity and frequency of accidents. From the year 2000 onwards, new bypass road on national highway (NH - 38) is considered to be the most accidents prone location in the city where around 15% of all the accidents occur during recent years. The problem of deaths and injuries as a result of road accidents in Indian cities is serious enough to demand attention of respective administrative authorities. Apart from the humanitarian aspects of reducing road deaths and injuries, a strong case can be made of reducing road crash deaths on economic grounds alone. It is estimated that the total economic loss due to road accidents is of the order of Rs. 60 billion each year in India.

Kowtanapanish studied about the black spot identification in Thailand and also describes traffic accident problems as well proposed measured for the country. Of all the systems with which people have to deal every day, road traffic systems are the most complex and the most dangerous. In Thailand, the Thais are killed on the roads with an average of around 12,000 persons per year or about 2 persons per hour. In other words, every day, approximately 50 Thai people who leave homes to work, school, shop, temple/ church/mosque, social gathering never return homes because of road accidents. Road accidents have not caused only lives and disability to the Thai citizens but also substantial damages to the country’s economy. It was estimated that the economic losses due to road accidents in Thailand are over 100,000 million Baht per year, which means over 12 million Baht per hour or about 3.4% of the country GNP.
The paper, describes traffic accident problems as well as the proposed countermeasures in the country. The black spot improvement programs especially the current practiced and researches to identify black spot locations are highlighted. Both conventional method and public participation method are used to identify the black spot locations.

To improve road safety problems in Thailand, Tanaboriboon proposed the safety countermeasures matrix, followed Dr. Haddonûs framework, presented. It can be seen that the proposed countermeasures involving all components of accident (road user, vehicles, road and environment) in the three-related phases of time (pre-crash, during crash, and post-crash). Countermeasures are composed of enforcement, education and campaign and engineering and emergency medical service approaches in dealing with the three contributing components of accidents: road users, vehicles, and road and environment.

Black spot is a term used to refer to a section of road that is regarded as a high-risk location for car crashes. Black spot programs are designed to reduce the crash risk in the areas by improving the physical conditions or management. To improve the physical conditions of the roadway, the accident mitigation process was divided into several steps. Identification of locations for safety improvement is the starting point of all the processes. The process is sometimes known as Black spot identification or hazardous location identification.

To make the road safer, it is important to identify the right site for safety improvement, if not, resources can be wasted on sites that are incorrectly identified as potentially unsafe but sites that are truly unsafe can go untreated and remain unsafe. Therefore, black spot identification is an essential step for black spot improvement program.

Accident Density Method**:** The accident density is calculated from the number of accidents per unit length for a section of highway. Sections with more than a predetermined number of accidents are classified as high accident locations.

Accident rate Method**:** This method uses accident numbers divided by vehicle exposure to provide rates such as accidents per million entering vehicles per spot location and accidents per million vehicle-miles for sections of highways. Locations with higher than a predetermined rate are classified as high accident locations.

Accident Rate Method**:** The concept of this method is that the number of fatal and/or injury accidents at a location or section of highway are given a greater weight than property damage- only accidents. Cautions should be exercised to select the proper weights when using this method. The weights should ideally be based on socio-economic values. In reviewing the literature, several weights values were proposed for Thailand.

Determining whether a site has a safety problem is frequently based on the accident history for the road. However, implementation of such program requires relevant accident data, which are normally unavailable or limited in developing countries. Nevertheless, there are other inputs such as public input that proved to be useful in the identification processes. In

Thailand, the success of utilizing public input in the black spot identification process was also revealed. Kowtanapanich et al. proposes the framework of an Accident Public Participation Program (APPP) to assist the road user to report/inform the site with poor safety performance. The real world applications of such a program are presented through a selected case study in Khon Kaen City. The findings indicate statistically significant agreements between the two datasets-the user inform locations and the black spot location identified by using historical accident data. Besides the indirect benefits to creating public awareness, the proposed methodology is potentially useful as a means for both speeding up and economizing the black spot locations identification process.

Fukuda et al., (2009), introduce Hiyari- Hatto method to identify and collect data on existing and potential black spot locations. The Hiyari-Hatto, initiated in Japan, is a traffic psychological method to encourage road users to participate/involve in the traffic safety program in order to elicit information through their expression of potential accident experiences that almost occurred/caused them dead or injured. The empirical study was conducted in Soi Chokchai 4 and Soi Ladprao 39 in Bangkok. The findings from this study indicated that Hiyari-Hatto method is a significant alternative method for public participatory enhancement to develop black spot database nationwide.

GIS Applications Since accident is spatially distributed in nature, use of Geographic Information System (GIS) and database software will provide the capability to store data, update data, retrieve data, compare data and spatially display the data. These modern computer technologies allow black spot map to be electronically generated from a well-designed accident database. Computer record systems can also produce rankings of high-accident locations based on either total accidents occurring or accident rates.

Despite the Government’s best efforts in recent years, unfortunately, there are still over 12,000 deaths and more than one million injuries each year as the result of road accidents, with several hundred thousand people disabled. To overcome the situation, one of the government’s safety programs to help curb road accidents in the country is to implement the black spot improvement program. To implement such program, the first and most important step is to identify the site for safety improvement. This article discusses two main approaches to identify black spot location currently practiced in Thailand. The first one is a classical approach which relies on the historical accident occurrence. Several methods such as accident number, accident rate, quality control approach, and severity index are addressed. The second approach is proposed as an alternative approach to identify black spot when accident data are limited or not available at the site. For this method, the public participation tactics is utilized to gather public input locations to identify the potential black spot locations. Besides the identification method, the modern technologies to facilitate the black spot improvement program are also discussed in this article.

Mungnimit et al., studied about the sequential data analysis for black spot analysis. Thailand has been facing the major economic and social losses due to road accidents. Studies show that the total annual traffic accident cost reaches 3 percent of the country's GPD or about 120 billion baht. The major causes of road accidents are road user, vehicle condition, and road environment.

Even though road accidents are unpredictable in most cases, road safety devices and geometry improvements of hazardous locations on highways can either minimize the chance of accident occurrence or reduce accident severity. Road environment contributes to 27.60 percent in overall accidents. Therefore, an accurate tool to identify black spots and hazardous locations on highways based on historical accident data is an important step that would help locate problematic locations on highways for safety engineers to analyze causes, propose solutions, estimate budgets and set prioritizations.

Highway black spots are highway locations where the potential for accidents is unacceptably high. The most common assumption for a black spot location is that there should be any road environmental or geometric issues resulting in the repetition of accidents.

The conventional method used to identify highway black spots relies on fixed lengths of road sections, where the total length is divided into 300, 500, and 1,000-meter road sections. Next, the number of accidents happened within each road section is calculated and compared to the black spot criteria. However, the method is inaccurate because the section length is fixed where accidents within each section may not be related to each other. Moreover, the method tends to overlook hazardous locations in which the section lengths should be long enough to cover all continuous accidents that seem to be related to each other. The sequential pacing data analysis technique simulates a manual method where road inspectors travel along a highway and inspect all accident records. As illustrated in Figure 2, nearby accidents within 100- meter of distance will be grouped together as a black spot location, where any accidentlocated farther than 100-meter away from the current location will be assigned another black spot location ID.

The total number of accidents within each black spot location will be summarized and compared to the black spot criteria. The process continues from the first to the last kilometer of each highway route and covers all highways under supervision of the department of highways.

Since Thailand Department of Highway (DOH) has currently implemented on the criteria for black spot, the numbers of highway black spots identified from the process are 748 and 698 locations based on 2006 and 2008 accident data respectively. In 2007, the list of 748 black spot locations based on 2006 accident data was distributed to 15 regional offices around the country for local engineers to investigate causes and propose solutions and budgets to the central office. The bureau of highway safety considered the data from all locations and prioritized black spot sites based on accident frequency, severity, total accident cost, and the proposed budget information. In 2009, which is the first year of highway black spot improvement program, DOH has received 400 million baht from the central government to improve 93 black spot sites, while the remaining sites are scheduled for the upcoming fiscal years. Since Thailand Department of Highway (DOH) has currently implemented on the criteria for black spot, the numbers of highway black spots identified from the process are 748 and 698 locations based on 2006 and 2008 accident data respectively. In 2007, the list of 748 black spot locations based on 2006 accident data was distributed to 15 regional offices around the country for local engineers to investigate causes and propose solutions and budgets to the central office. The bureau of highway safety considered the data from all locations and prioritized black spot sites based on accident frequency, severity, total accident cost, and the proposed budget information. In 2009, which is the first year of highway black spot improvement program, DOH has received 400 million baht from the central government to improve 93 black spot sites, while the remaining sites are scheduled for the upcoming fiscal years.

The conventional method for highway black spot identification relies on fixed lengths of road sections. However, the major disadvantage of the method is that the hazardous section length must be fixed, which is contrary to the real-world situation where the section length varies depending on the characteristics of accident clusters. Moreover, the method tends to overlook a hazardous location because the fixed section length can split continuous accidents into two different BS sections. In fact, the section length should be flexibly long enough to cover all continuous accidents of a BS section, as long as those accidents are still within 100-meter of distance from each other. The sequential pacing data analysis technique simulates a manual method based on a condition that nearby accidents within 100-meter of distance will be grouped together as a black spot location. Compared with the conventional method, the sequential pacing data analysis technique is more accurate in identifying black spots regardless of the BS section length. An accurate tool to identify black spots and hazardous locations on highways would help safety engineers to locate high-risk road sections. The list of black spot locations can be quickly distributed to 15 regional offices around the country for local engineers to investigate causes and propose solutions to the central office, where budgets and prioritizations can be strategically finalized.

Karim et al., (2009) studied issue and challenges about safety of the roads. A fairly recent measure which aims to identify possible deficiencies related to road safety in various stages of implementation of any road project has been instituted in early 1997. The road safety audit covers new road infrastructure projects as well as road improvement schemes. The road safety audit procedures have been developed to include all stages of project implementation, i.e. from planning stage to preliminary design, detailed design, construction (or pre-opening) and operational stage.

The problem of road accidents in Malaysia is increasingly becoming the main concern of the general public, particularly those in relevant government agencies such as the Ministry of Transport, Ministry of Works and the Traffic Police. The huge economic loss due to road accidents is a waste and various strategies have been embarked upon to reduce the number of accidents, especially the fatal ones. Reducing the high rate of crashes and road fatalities definitely requires a multi-faceted approach focusing on measures related to education, engineering, road environment, enforcement of traffic regulations and emergency services.

This paper discusses the road safety audit procedures with reference to the Malaysian experience. The pro-active approach adopted in the road safety audit is generally becoming more important as compared to the re-active approach of accident black spot investigation. The unique experiences and challenges faced in all stages of the implementation of the road safety audit process in Malaysia may be very relevant to other countries that are in the process of implementing them.

Rapid growth in Malaysia in terms of the level of motorization can be seen and road infrastructure development over the past twenty-five years. The country's population doubled from just over 10.4 million in 1975 to over 23 million in 2000 with an average growth rate of about 5% per year. Within the same period the length of roads increased five folds from just above 12,000 km to almost 65,000 km. There is also a marked increase in registered vehicles during the same period from just over 1.2 million in 1975 to over 10.5 million in year 2000. This is rather alarming and the grave situation has led to various measures including aggressive campaigns and continuous enforcement being undertaken by the relevant parties. The motorcyclists have always been made a target group in safety campaigns and enforcement.

In terms of the types of vehicles involved in accidents the yearly statistics indicate that an alarmingly high percentage of buses are actually involve in accidents as compared to other vehicle types. The taxis come in next except that in the period 1989 to 1991 the percentage of taxis involved in accidents is highest amongst all vehicle types.

A series of intervention programs that relate to strategic safety problems and issues was implemented in the effort to deal effectively with the situation. The basic 3Es approaches were intensified as the main thrust in the accident prevention and reduction strategies while simultaneously the injury reduction and post-crash injury reduction strategies were implemented to further reduce the level of injuries.

In the Malaysian context, Road Safety Audit (RSA) may be defined as the formal examination of the planning, design and construction of a road project, and of the characteristics and operations of an existing road, by independent and qualified examiners, to identify any potentially unsafe feature or operational arrangement that may adversely affect the safety of any road user (Public Works Department Malaysia, 1997). The RSA process is to ensure that all road projects are capable of providing the highest practicable standard of traffic safety for all road users. The main objectives is to identify potential safety hazards on new roads, at the appropriate stage, so that they can be eliminated or treated to mitigate the adverse effects at minimum cost, and to identify hazardous features of an existing road.

The RSA process is composed in five stages that can be conducted on any road project. The stages are as follows: Feasibility and Planning stage, Draft (Preliminary) Design stage, Detailed Design stage, Construction and Pre-Opening stage, Operational stage or RSA of Existing Road.

The RSA process starts with identifying problems related to the overall concept for a project; road network safety implications, route options, intersection and interchanges types and locations will be identified. Many of the traffic engineering features are usually established during the preliminary design stage. The detailed design stage usually involves the selection and application of standards and guides to meet the specific site conditions. The next stage of audit is normally done prior to the practical completion of a project just before the opening to traffic. It involves site inspections during the day and at night to observe details on actual placement of items such as guardrails, street lighting, traffic signing, landscaping and to check that the needs of respective road users meet the desired safety standards. This is practically the final stage to correct any deficiencies before the road is opened to traffic. At final stage, audit can be performed on either a newly completed road opened to traffic or on an existing road which is earmarked for upgrading.

As RSA is a specialized task that requires specific knowledge and experience related to traffic engineering, traffic management, road user behavior and road safety principles and practices. In Malaysia, the Public Works Department (PWD) through the Road Safety Section of the Road Design Unit undertakes the role of accrediting the road safety auditors before one is appointed to perform the RSA. The road safety auditor is appointed by the client (consultant/contractor) after receiving prior consent from the road authority. The services of the road safety auditor will also be paid by the client instead of by the road authority and the payment will have to come from the total fees received by the client.

In the effort to accelerate infrastructure development in the country some of the important and large road projects are awarded on a 'design and build' basis and this is usually done on a fast track mode. For such projects many activities are running simultaneously and there is seldom a clear cut distinction between the different stages of planning, preliminary design and detailed design. Decisions have always to be made quickly and issues raised by the auditor may not be easily resolved and any delay would be costly to the client. Although RSA is still at its infant stage in Malaysia, the local road authority (PWD) has taken positive steps to enforce its implementation in almost all federal road projects because of the strong commitment of the government and road authority to improve the level of safety on the nation's roads. RSA may be regarded as an important part of the quality assurance process that would bring the best possible return on the investment of public and private funds, more so for the interest of the road users at large.

Jain et al., (2009) worked on safety audit on four lane national highways. 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 road accidents deaths and injuries are global phenomena but more sever situation in mixed traffic condition as prevailing on Indian multilane highways. 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. 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).

In this paper it is aimed to evaluate Road Safety Audit of a newly constructed section of four lanes 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. The stretch from Km 75.00 to Km 130.00 of National Highway 58 has been analyzed. The selected highway stretch has been newly reconstructed and upgraded to four lanes. The two important obligatory points on the study area are Meerut and Muzaffarnagar of the highway in the state of Uttar-Pradesh, India.

In the study, traffic volume data collected from NHAI of a mid-block location at Km 75.400 of NH-58. The survey was carried out by manual vehicle counting and classified the vehicles passing through survey station. 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. Main observation from accident data collected was that it gave an impression of underreporting 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.

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. From the data collected 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 are not rightly placed on highway.

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.

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. 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.

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 adequate ambulance facility and in primary First Aid.

Service Roads: Service Roads are to be constructed in habitant areas which are still to be completed in the some stretches. Road signs should also be installed at all flaring locations.

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.

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.

Based on the study of road safety audit for 4 lane national highways it can be concluded that due to newly improvised four lanes National Highway-58 between Km 75.000 to Km 130.00, the road standards have been upgraded though other related factors are not brought to this level such as road user behaviour, surrounding prevailing conditions etc. The road standards are high speed friendly, but prevailing traffic conditions are not favourable to such speeds. The roads have been designed to match the speed of 100kmph while only 60-70kmph could be matched instead of earlier the average speed of vehicles of 30-40 kmph. Major and minor undeveloped intersections need to 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.

Vardaki et al., (2010) worked on safety aspects on freeways. Road Safety Audit is a formal, systematic, independent assessment of the potential road safety problems associated with a new road scheme or road improvement scheme. The assessment should involve the placing of equal emphasis on all road users. RSA meets the “Safe System” requirements which are: designing, constructing and maintaining a road system so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury; improving roads and roadsides to reduce the risks of crashes and minimize harm; measures for higher speed roads including dividing traffic, designing forgiving roadsides and providing clear driver guidance; managing speeds.

Attica Freeway (also known as “Attiki Odos”) is a newly designed and constructed urban freeway. In 2009, in order to address the need to improve safety levels, the Attica Freeway Operations Authority decided that an RSA should be carried out by a team of experienced road safety engineers. Attica Freeway is a 70 km freeway and there are 39 Entrances to the Freeway through toll plazas with 195 toll lanes. Mainly it is a 3 lane freeway with a small section (less than 20 km) with 2 lanes, Attica.

The Road Safety Audit team conducted the RSA with the goal to identify potentially dangerous roadway or traffic features of the freeway operating environment, as well as potentially misleading or missing information by the application of safety principles of positive guidance and self-explaining roads while recognizing the potential influence of human factors such as road users’ limitations in capabilities or unfamiliarity. The RSA audit lasted approximately one month. The RSA team developed checklists for the specific project, as was requested by the operator. The freeway was inspected in daylight and at night-time in wet and dry conditions and included all movements at each interchange. The inspection was undertaken from the point of view of all road users.

During the road inspection emphasis was placed on how drivers might perceive or adjust their behaviour to the features of the roadway, allowing the identification of any aspects of the roadway where drivers' expectations about the road and traffic might be violated or where the layout fails to give the right message. The road was reviewed on the basis of the adequacy of time available to drivers in order to decide and perform manoeuvres, the conformity of road layout to driver expectancies, checking potential violations of expectancies related to roadway design. Inspections were scheduled during typical or representative traffic conditions, allowing the RSA team to understand how usual traffic conditions and road user behaviour may affect safety during the daytime and at night.

The RSA findings were recorded in the RSA report together with recommendations for implementation. The road marking was faded at certain locations, while old markings controlling temporary traffic had not been removed effectively. Improvement of road markings was recommended since ineffective markings could cause course deviation and driver behaviour problems especially in a high speed environment as a result of inadequate warning and guidance.

The RSA team identified locations where the roadside barrier was interrupted for a short distance. This would cause an errant vehicle entering the unprotected zone to be "trapped", with no possibility to retain control and crash into roadside obstacles behind the barriers. In addition, there were sometimes no safety barriers in front of roadside obstacles such as lighting columns, pipes in tunnels and electrical and mechanical installations.

During the inspection, the RSA team identified horizontal curves with limited sight distance. A comparison between the available sight distances and the required stopping sight distances (calculations based on the speed limit) on curves identifies where there were visibility restrictions in the left lane due to the height of vegetation or the height of the guardrail as well as in the right lane mainly due to the tunnel wall. The RSA team suggested that decreasing the speed limit, placement of appropriate warning signs, and elimination of plantation on horizontal curves, improvement of road surface skid resistance and speed limit enforcement.

Accident data revealed a significant proportion of accidents involving motorcyclists. In particular, motorcycles represent 3 % of traffic while their share in road deaths is 60 %. The improvements might be related to the shot blasting as well as to the reduction in average speeds at locations where speed radars were installed. As improvement measure, by the summer of 2010, the installation of automatic speed cameras was completed at 14 sites. About half of them were installed along the Imittos Ring Road. The first results show a reduction in the average speed of 4%. Given the potential temporary character of these changes, continuous monitoring of operating speeds is considered necessary, particularly at locations with visibility restrictions, to ensure that the issues will be addressed promptly.

The RSA of Attica Freeway issues raised, as well as the recommendations for improvement which were considered for pilot implementation, were selected on the basis of their potential effectiveness on a wider scale without major implications for freeway operation. They cover horizontal curves with visibility restriction; freeway split locations; delineated areas where traffic is prohibited; road safety barriers installation; the special configuration of the restraint system in close proximity to bridge abutments and columns; and the installation of a skirting to restraint systems for the guidance, warning and protection of motorcyclists. On the basis of the RSA findings, the freeway operator decided on the prompt implementation of several countermeasures, and in cooperation with the RSA team submitted to the Ministry of Infrastructure a proposal for pilot implementation of selected safety improvements already included in the RSA report.

A local enforcement officer and a team from the operator staff with experience in maintenance practices and conditions participated in the meetings providing firsthand knowledge for the project. The RSA team discussed the preliminary RSA results in a preliminary findings meeting before the conclusion of the RSA report. An important factor determining the effectiveness was that the RSA recommendations were implemented shortly after the RSA was completed. Preliminary results from a before-and-after analysis of data regarding skid resistance characteristics, speeds and crashes at locations where RSA recommendations had been implemented showed improvements in skid resistance characteristics and a reduction in the number of crashes and incidents.

CHAPTER-3
PROJECT DESCRIPTION

3.1 General

During the last fifty years rapid development has taken place with increase in volume of traffic. The existing roads are not able to cope with the increased traffic and there is a need to widen/upgrade this road. Present chapter gives an outlook of the present condition of the project corridor along with the proposed development. Improved road connectivity can reduce travel times and lower the costs of vehicle use. The ultimate aim of the proposed project is to promote societal welfare of the State. The developments of above project will play a significant role in changing the socio-economic condition of people living in this region through dynamic externalities that such development often generates. The National Highways Authority of India (NHAI) under Govt. of India (GOI) through Ministry of Road Transport & Highways (MORTH) is contemplating to enhance the traffic capacity and safety for efficient transhipment of goods as well as passenger traffic on the heavily trafficked National Highway sections. GOI has entrusted National Highways Authority of India (NHAI) with the responsibility of improving the quality of highways of national importance. The site of the Project Highway comprises the section of National Highway-21 commencing from Km 73.200 to Km 186.500 i.e. the Kiratpur-Nerchowk in the state of Himachal Pradesh and Punjab. The project highway involves widening of existing alignment from km 73.200 to km 86.000, km 159.070 to km 167.473 and km 179.582 to 184.323. The remaining alignment is proposed as new four lane divided highway configurations. The entire road portion will be four lane including the bridges and other structures except the Tunnel portion which is of two lane configurations. level of service offered by road under the prevailing roadway and traffic condition Given the prevailing traffic levels, bottlenecks (terrain/R & R) on the existing road alignment and also the strategic importance of the project road, it is expected to take off with the opening of the **Rohtang Pass Tunnel**, hence, recommended to build a 4 lane road on new alignment. Moreover, Kulu-Manali is an important tourist destination in India. This road construction will provide better transportation facility for tourists visiting Manali-Rohtang Pass from different parts of India and abroad.

3.2 Project Details

***Table 3.1* Chainage-wise link between existing chainage and design chainage**

S.No	Existing Chainage	Design Chainage	Remarks
	KIRATPUR BILASPUR SECTION		
1	73.200	0	Old alignment
2	74.000	0.8	Old alignment
3	75.000	1.808	Old alignment
4	76.000	2.785	Old alignment
5	77.000	3.805	Old alignment
6	78.000	4.82	Old alignment
7	79.000	5.805	Old alignment
8	80.000	6.788	Old alignment
9	81.000	7.779	Old alignment
10	82.000	8.773	Old alignment
11	83.000	9.515	Old alignment
12	84.000	10.609	Old alignment
13	85.000	11.714	Old alignment
14	86.000	12.673	Old alignment
15		13.673	New Alignment
16		14.673	New Alignment
17		15.673	New Alignment
18		16.673	New Alignment
19		17.673	New Alignment
20		18.673	New Alignment
21		19.673	New Alignment
22		20.673	New Alignment
23		21.673	New Alignment
24		22.673	New Alignment
25		23.673	New Alignment
26		24.673	New Alignment
S.No	Existing Chainage	Design Chainage	Remarks

27		25.673	New Alignment
28		26.472	New Alignment
	BILASPUR NER CHOWK SECTION		
1	126.5	126.5	Start of New Alignment
2		127	New Alignment
3		128	New Alignment
4		129	New Alignment
5		129.5	
6		130	New Alignment
7		131	New Alignment
8		132	New Alignment
9		133	New Alignment
10		134	New Alignment
11		135	New Alignment
12		136	New Alignment
13		137	New Alignment
14		138	New Alignment
15		139	New Alignment
16		140	New Alignment
17		141	New Alignment
18		142	New Alignment
19		143	New Alignment
20		144	New Alignment
21		145	New Alignment
22		146	New Alignment
23		147	New Alignment
24		148	New Alignment
25		149	New Alignment
S.No	Existing Chainage	Design Chainage	Remarks
26		150	New Alignment
27		151	New Alignment

28		152	New Alignment
29		153	New Alignment
30		154	New Alignment
31		155	New Alignment
32		156	New Alignment
33		157	New Alignment
34		158	New Alignment
35		159	New Alignment
36	165.425	159.07	Old Alignment
37	166	159.595	Old Alignment

Table 3.2 **Details of the widening and new alignment to be developed.**

S.No	Location(Design Chainage)		Length
	From Km	To Km	
Kiratpur-Bilaspur Section			
1	0	12.732	12.732(4-lane along existing road)
2	12.732	26.462(as per Kiratpur- Bilaspur section) & 129.500 (as per Bilaspur Ner-chowk section)	13.73(4-lane New Alignment)
3	126.5	129.5	3.00 Km(4-lane New Alignment)
4	129.5	159.07	29.57 Km(4-lane New Alignment)
5	159.07	167.473	8.403 Km(4-lane New Alignment)
Proposed Sundernagar Bypass			
6	167.473	179.582	5.678Km(2-lane New Alignment to be constructed
Widening of Existing Road			
7	179.582	184.323	4.741Km(4-lane along existing road)
Ner Chowk Bypass			
8	184.323	188.874	4.550 Km(4-lane New Alignment)
Connection of Barmana Cement Factory to New Alignment			
9	0	1.971	1.971 (2-lane New Alignment)

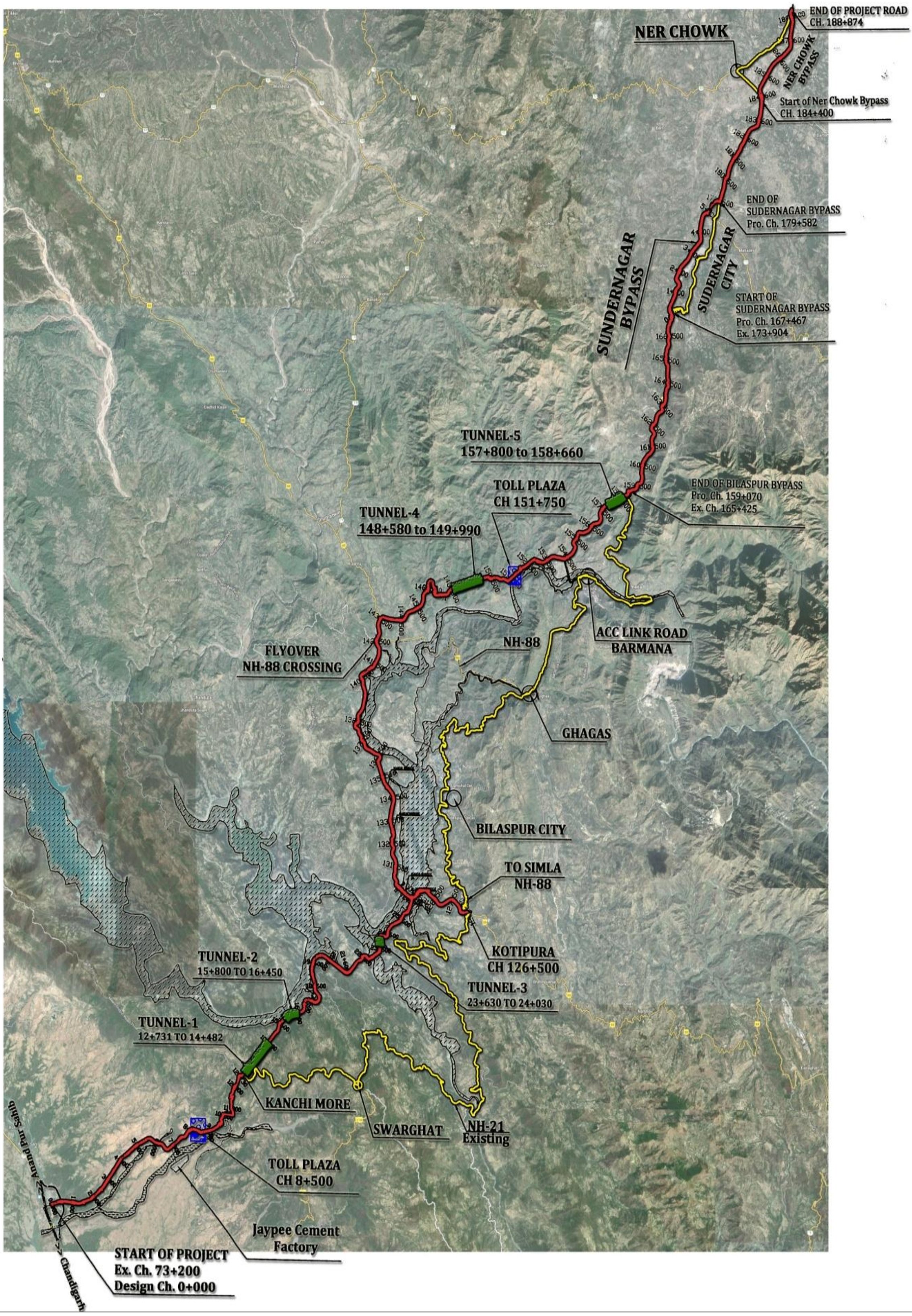


Fig 3.1 **Project Alignment (Red Line: New Alignment, Yellow Line: Existing Alignment)**

The salient Features of Project Road is as below

Table 3.3 Salient Features of the Project

Features	Existing	Proposed
Km	73.000 to 187.000	73.200 to 186.500
Length km	114	84.38
New Length (4 laning)	Nil	79.31 (only the tunnels are of two lane)
Major Bridges	05	15
Minor Bridge	14	29 new and rehabilitation / widening of one existing minor bridge
Culverts	Pipe Culverts: -211 Slab Culverts: - 449	New: 98 (Box / Slab) Rehabilitation / widening of all existing culverts
Railway Over Bridge	Nil	Nil
Pavement	Two-lane with earthen shoulder on both sides.	Paved Carriageway will be 17.50 meters wide in plain/rolling terrain & 14.00 meters in hilly/mountainous terrain excluding median with shoulders.
Bypasses	Nil	02 (Sunder Nagar bypass and Ner-Chowk bypass)
Length of Service Roads	Nil	Nil
Bus Lay byes	Nil	50
Toll Plaza	Nil	02 (at km 81.620 and km 151.735)
Truck Lay byes	Nil	03
Rest Area	Not properly provided	Will be provided as per IRC-SP:84-2009
Major at Grade junctions	Nil	12

Table 3.3 **Salient Features of the Project**

Grade separated Interchange	Nil	One of 41.375 km length and having intersection with NH-88 at km 142.680
Flyovers	Nil	One
Underpass	Nil	Nil
Non-vehicular /Pedestrian /Cattle Crossings	Nil	04
Tunnels	Nil	05

3.3 Condition of the existing pavement

During my thesis I have been visited site for quite a number of times. The exiting road is in very bad condition. There are very few sign boards on the road and are in very bad condition. All the bridges are having inadequate width. The riding quality on the whole stretch is very bad. There are number of trees, transformers and clusters along the road. There are loosen earthen shoulders and improper toll barrier on the stretch. The parapets are in bad conditions. There are many curves with lot of sight obstruction. Many intersections are not properly designed. The median are with improper dimensions. There are no safety barriers along the existing road of the major portion of the highway. There are no road signs and markings being done on the road. Drains are also improper along the existing highway. Heavy development along both sides of the road. Some are the following pictures which I took during my visits on the site can give the outlook of the highway.

Fig 3.2 **Start of the Project Site at km 73+200**

Fig 3.3 **A four lane highway just before the start of project road**

Fig 3.4 **Minor Bridge with Poor riding quality & inadequate width**

Fig 3.5 **Loose Earthen Shoulders all along the existing project highway NH-21**

Fig 3.6 **Curve with lot of sight obstruction and without any road signs and markings.**

Fig 3.7 **Improper Toll Barrier**

Fig 3.8 **Improperly designed intersection without proper markings and sign**

Fig 3.9 **Very Poor Road Safety Aspects on the existing two lane highway**

Fig3.10 **Median with improper dimensions**.

Fig3.11 **Transmission tower on the road side without hazard sign and inadequate width**

Fig 3.12 **Very bad condition of km stone along the old alignment**

Fig 3.13 **Bad Condition of the sign & informatory boards through out the existing highway**.

Fig 3.14 **Very Poor Road Safety Aspects on the existing two lane highway**

Fig 3.15 **Improper Drains along the Project Highway**

Fig 3.16 **Heavy Built up areas with in the proposed widening of the existing highway**

Fig 3.17 **Built up areas including temples with in the proposed widening of the existing highway**

Fig 3.18 **Damagaed parapets along the existing Highway**.

Fig 3.19 **Improper Intersections without any safety aspects on the exiting highway.**

Fig 3.20 **Road side parking on the shoulder**.

Fig 3.21 **Single sign board of speed limit through out the project highway**

Fig 3.22 **Accident on the horizontal curve**

3.6 Project Objective

The project aims to enhance road safety of a stretch during development, construction and operation phase of 4 laning of Kiratpur - Ner Chowk section of NH-21 from km, 73.200 to km. 186.500 in the state of Himachal Pradesh.

CHAPTER 4

ACCIDENT DATA COLLECTION & ANALYSIS

4.1 Study Area

The corridor comprises the section of National Highway-21 commencing from Km 73.200 Km (Kiratpur Sahib in the state of Punjab) to km. 186.500 (Nerchowk in the state of Himachal Pradesh). The traffic volume on this particular section is very high as this road connects with various important cities of the state. Many tourists travel on this road because of the popularity and well known tourism of the state. This consists of all types of traffic i.e. buses, trucks, cars two-wheelers etc.

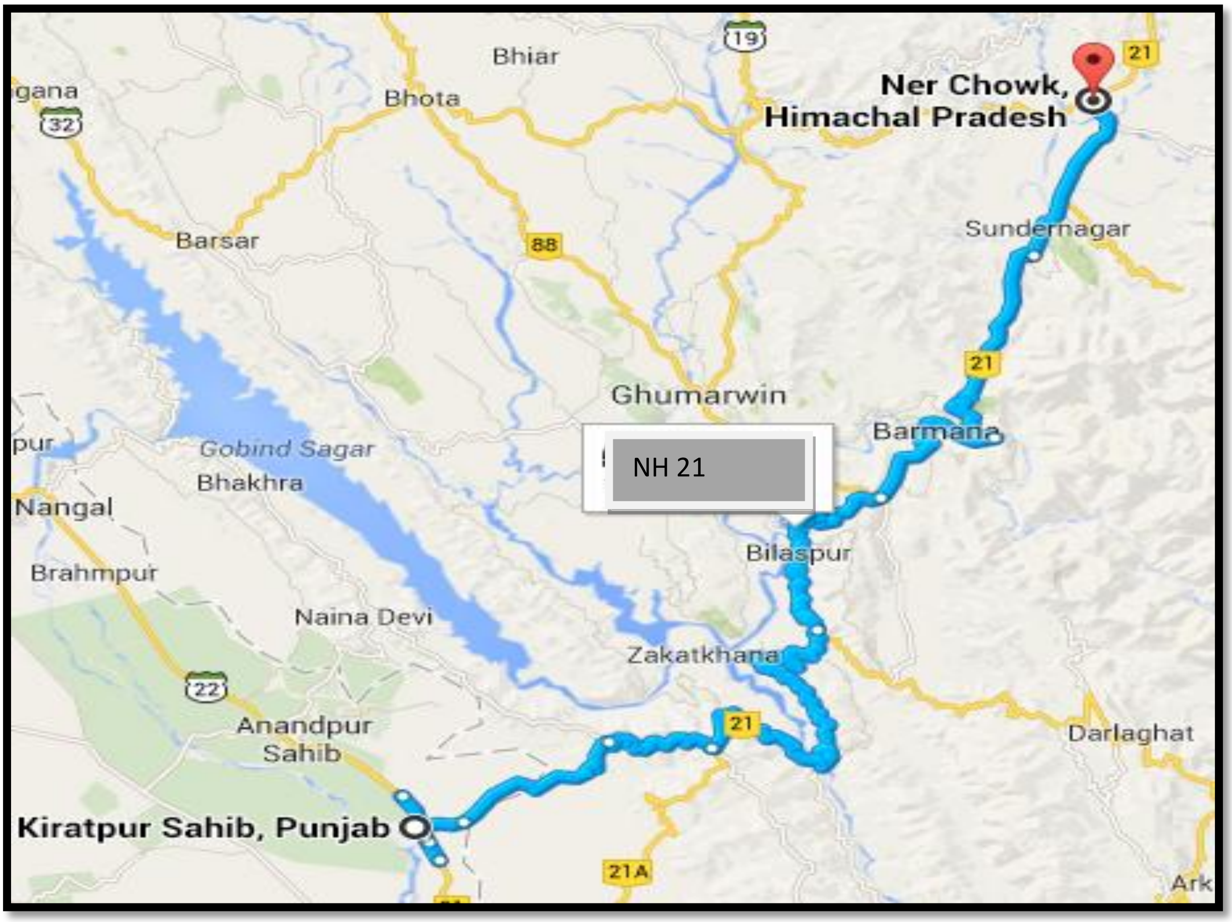


Fig 4.1 **Location of collected accident data (NH-21)**

4.2 Nature of data

The present study is based on secondary source of data i.e. from the case diaries and police records of the accident case in all the district police stations which fall on this particular stretch. Simple random sampling technique was applied for the collection of accident data. Complete enumeration of data for six months (i.e. from October 2013 to march 2014) was done. Besides other relevant information were collected from the concerned officials through personal discussions and interviews. The

4.3 Format for the collection of accident data

The collected data for six months is attached in the sheets

Table 4.1 **Format for accident Data collection**

Road Accident Report																		
			A	B	C	D	E	F	G	H		No. of Affected Person						
S No.	Date	Time of Accident (am/pm)	Accident Location	Nature of Accident	Classification of Accident	Causes	Road Feature	Road Condition	Intersection Type & Control	Weather Condition	Vehicle Responsible	Fatal	Grievous	Minor	Non Injured	No. of animals killed if any	Help provided by Ambulance/Patrol	Remarks
1																		
2																		
3																		
4																		

Where,

A: urban/Rural and details of Surrounding Land use

B: 1-overturnig, 2- head on collision, 3-Rear End Collision, 4-collision Brush/Side Wipe, 5-Right Turn Collision, 6-Skidding, 7-Right turn Collision, 8-others

C: 1-Fatal, 2-Grevious injury, 3-Minor injured, 4-Non injury

D: 1-Drunken, 2-Overspeeding, 3-vehicle out of control, 4-Fault of driver of motor vehicle/driver of other vehicle/cyclist/pedestrian/Passanger,5-Defect in mechanical condition of vehicle/Road condition

E: 1-Single Lane, 2-Two lanes, 3-Three lanes or more without central divider, 4-Four lanes or more with central divider

F: 1-Straight Road, 2-Slight Curve, 3-Sharp Curve, 4- Flat Road, 5-Gentle incline, 6-Steep Incline, 7-Hump, 8-Dip

G: 1-T Junction, 2-Y Junction, 3-Four Arm Junction, 4-Staggered Junction, 5-Junction with more than 4 arms, 6-Roundabout Junction, 7-Manned rail crossing, 8-Unmanned Rail crossing

H: 1-Fine, 2-Mist/Fog, 3-Cloud, 4-Light Rain, 5-Heavy Rain, 6-Hail/sleet, 7-Snow, 8-Strong Wind, 9-Dust Storm, 10-Very Hot, 11-Very Cold, 12-Other weather condition

4.4 Location of Fatal, Grievous and Minor Accidents

Table4.2 **Month wise location of accidents (where F – Fatal, G – Grievous & M – Minor)**

Location/Chainage	Oct	Nov	Dec	Jan	Feb	Mar
Baner					1G	
Nouni						1G
Lakhanpur		1F				
Ghagas						1G
Beri			1G	1G		
Barmana		1M	1M		1F	3G,1M
Salapar				1G		
Harabagh	2G	1G				
Bhojpur					1G	
Sunder nagar	2G				1G	2G
Hamsafar				1G		
Control Gate						1G
Nowlakha		2G	1G		1G	
Nerchowk	1G	3G,1M	1G	3G,1M	2M	1F,1G
Naresh Chowk	1G		1F			
Lagat			1F			
Dintol	1G					
Jamili	1F					
Lalit Chowk		1G				
Dhanutu	1G			2G		
Punk			1G			
Salar			1G			
Near Santosh Mata Temple					1G	
Gutkar						1G
Caular						1G

4.5 Estimation of Accident Severity Index (ASI)

For estimation of ASI, the weight age to fatal accidents is assigned as 7 and to grievous injury accident as 3

Based on Fatal & Grievous Accidents

$$ASI = (N_f X W_f) + (N_f X G_g)$$

Where,

N_f = No of fatal accidents at the location

W_f = Weight age assigned to fatal accident

N_g = No of fatal accidents at the location

W_g = Weight age assigned to fatal accident

Table 4.3 **Calculation of ASI for various locations**

Name of the location	No of fatal accidents (N_f)	Weight age to fatal accidents (W_f)	No of fatal accidents (N_g)	Weight age to fatal accidents (W_g)	ASI= (N_f X W_f) + (N_f X G_g)
Baner	0	7	1	3	3
Nouni	0	7	1	3	3
Lakhanpur	1	7	0	3	7
Ghagas	0	7	1	3	3
Beri	0	7	2	3	6
Barmana	1	7	3	3	16
Salapar	0	7	1	3	3
Harabagh	0	7	3	3	3
Bhojpur	0	7	1	3	3
Sunder nagar	0	7	5	3	15
Hamsafar	0	7	1	3	3
Control Gate	0	7	1	3	3
Nowlakha	0	7	4	3	12
Nerchowk	1	7	9	3	34

Naresh Chowk	1	7	0	3	7
Lagat	1	7	0	3	7
Dintol	0	7	1	3	3
Jamili	1	7	0	3	7
Lalit Chowk	0	7	1	3	3
Dhanutu	0	7	3	3	9
Punk	0	7	1	3	3
Salar	0	7	1	3	3
Near Santosh Mata Temple	0	7	1	3	3
Gutkar	0	7	1	3	3
Caular	0	7	1	3	3

4.6 Black spots

Hazardous spots with accident severity index (ASI) more than threshold value (average severity + 1.2 (standard deviation) are treated as black spot

Average Severity = 165/25 = 6.6

Standard Deviation = 6.89

Threshold value = 14.81

There are three Spots having ASI more than threshold value which are treated as Black Spots. These black spots are marked in the figure 4.4

Table 4.4 **Spots marked as black spots and their ASI values**

SPOTS	ASI	Reasons for accident	Mitigation Measures
Nerchowk	34	Over speeding	Speed sign has to be required
Sunder nagar	16	Over speeding	Service roads need to b provided
Barmana	15	Bad condition of road, Over speeding	Speed signs have to be provided; Service road for Barmana cement should be provided.

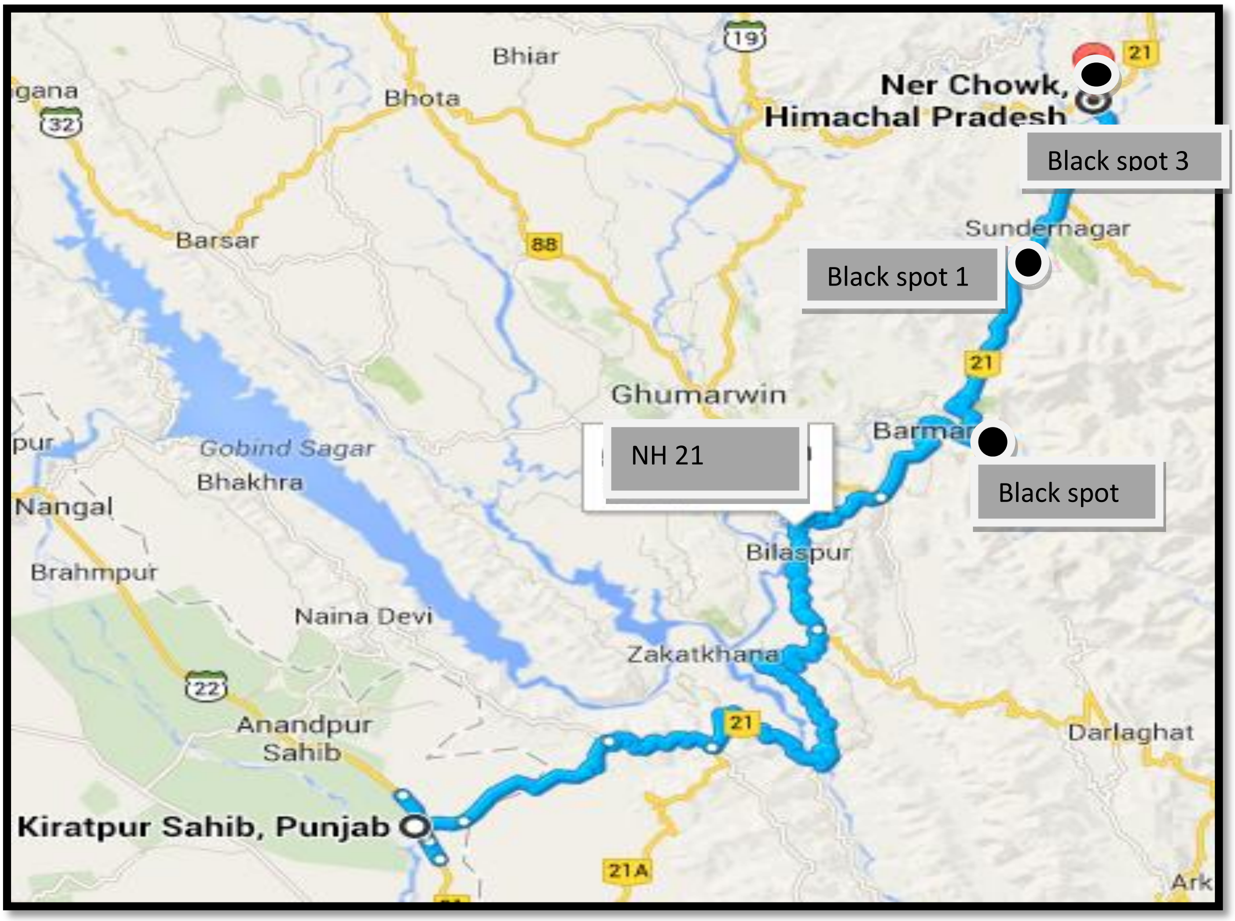


Fig 4.2 **Location of black spots**

4.7 Calculation of RMEV

The RMEV (rate per million of entering vehicles) is defined as the number of crashes per million vehicles entering the study location during the study period

It is expressed as

$$RMEV = (A \times 1{,}000{,}000)/V$$

Where

RMEV = crash rate per million entering vehicles

A = number of crashes, or by type occurring at the location

V= average daily traffic (ADT) X 183 (for six months)

Table 4.5 **Calculation of RMEV**

Location	**No of crashes**	**Average Daily Traffic**	**V = ADT X 183**	**RMEV =(A X 1000000)/V**
Baner	1	18293	3347619	0.30
Nouni	1	18293	3347619	0.30
Lakhanpur	1	18293	3347619	0.30
Ghagas	1	18293	3347619	0.30
Beri	2	18293	3347619	0.60
Barmana	7	18293	3347619	2.09
Salapar	1	18293	3347619	0.30
Harabagh	3	18293	3347619	0.90
Bhojpur	1	18293	3347619	0.30
Sunder nagar	5	18293	3347619	1.49
Hamsafar	1	18293	3347619	0.30
Control Gate	1	18293	3347619	0.30
Nowlakha	4	18293	3347619	1.19
Nerchowk	14	18293	3347619	4.18
Naresh Chowk	2	18293	3347619	0.60
Lagat	2	18293	3347619	0.60
Dintol	1	18293	3347619	0.30
Jamili	1	18293	3347619	0.30
Lalit Chowk	1	18293	3347619	0.30
Dhanutu	3	18293	3347619	0.90
Punk	1	18293	3347619	0.30
Salar	1	18293	3347619	0.30
Near Santosh Mata Temple	1	18293	3347619	0.30
Gutkar	1	18293	3347619	0.30

4.8 Analysis of accident data

***Table 4.6* Month wise number of Fatal, Grievous & Minor Accidents**

Month	**No of accidents**		
	Fatal	Grievous	Minor
October	1	15	8
November	1	15	2
December	2	1	6
January	1	17	1
February	2	8	5
March	10	10	8
Total	17	66	30

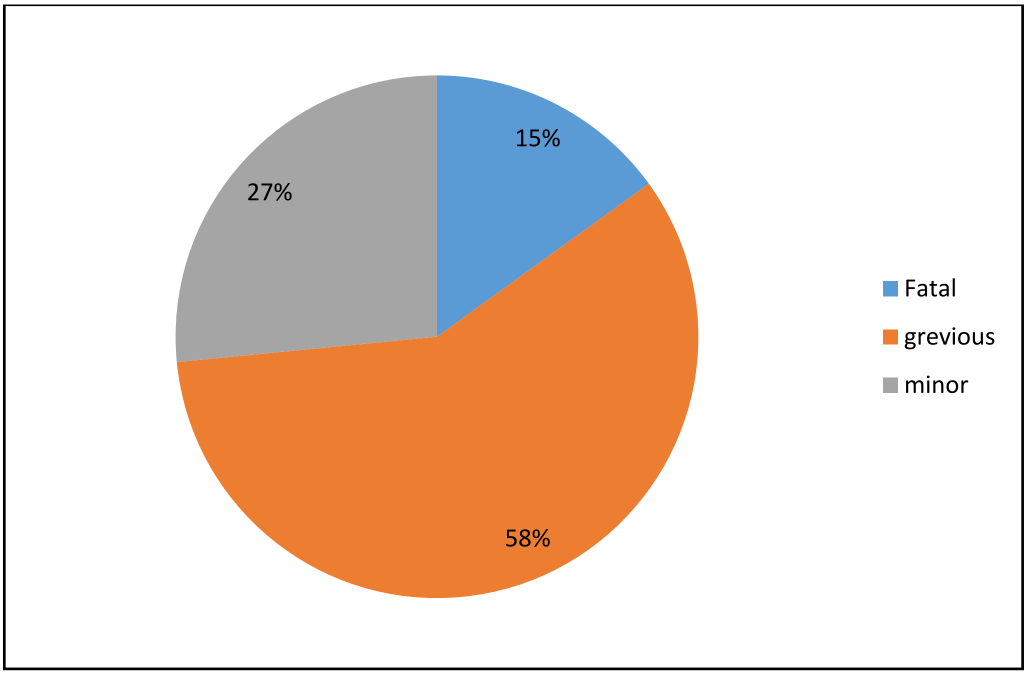


***Fig 4.3* Percentage wise Nature of accident**

It is clearly observed from the fig 4.5 data that most of the accidents which took place are grievous accidents. Because of the hilly terrain and bad condition of the road it is difficult for people to control vehicles which result into serious accidents.

Table 4.7 **Vehicle type & number of accidents**

Vehicle	**No of accidents**
Motorcycle	22
Truck	27
Car	33
Pickup/Van	8
Bus	5
M/C	3
Tractor	1
Trailor	1
Auto rickshaw	1
Unknown	3
Tanker	5
Scooter	3

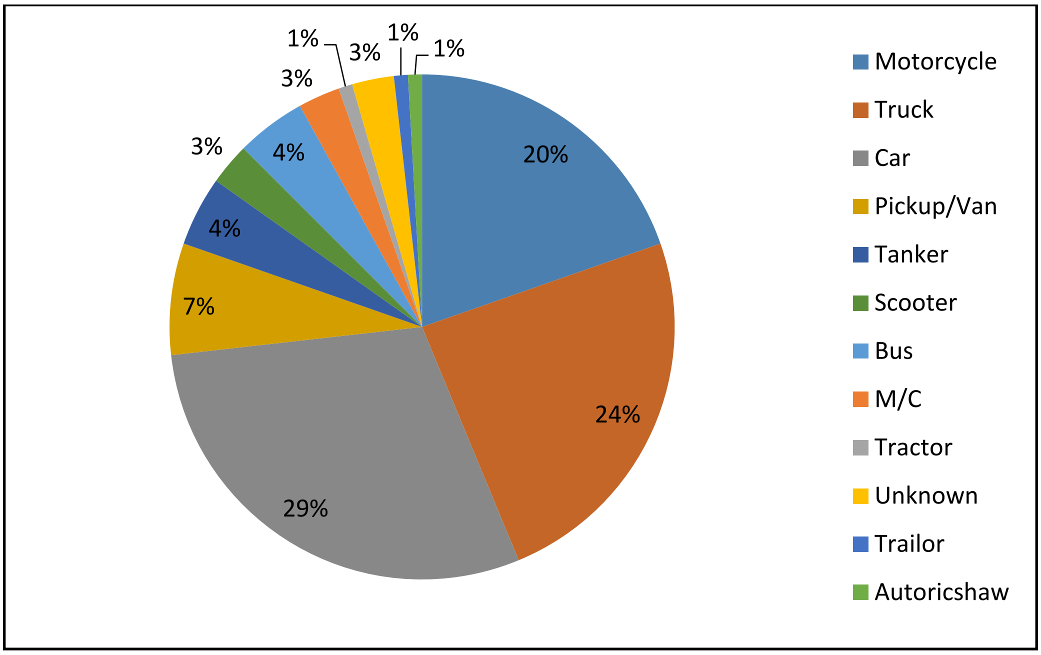


Fig 4.4 **Percentage wise different type of vehicles responsible for accidents**

This can be concluded from the fig 4.4 the percentage of vehicles like car, truck and motor cycle is quite high. The cause of this can be the road is not fit for any kind of vehicle because all the types of vehicle i.e. two wheelers, four wheelers and heavy vehicles are equally participating in accident

***Table 4.8* Number of accidents and their causes**

Causes	No of accidents
Drunken	0
Over speeding	11
Vehicle out of control	22
Fault of driver	24
Defect in mechanical condition/Road condition	0

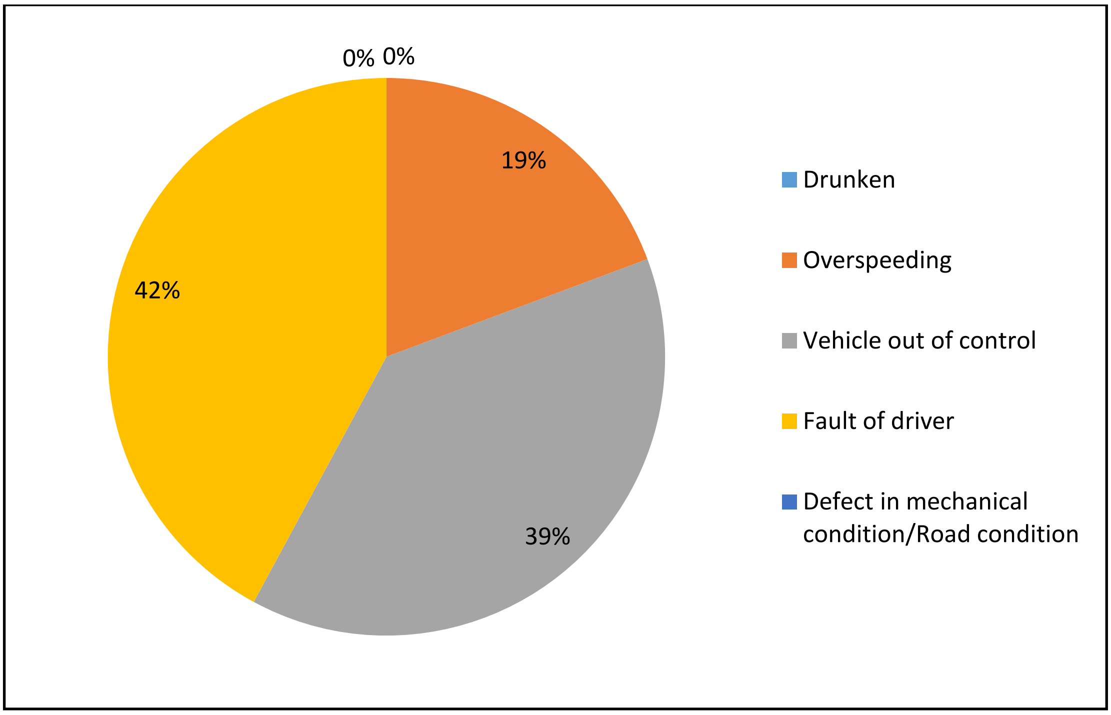


***Fig 4.5* Percentage wise causes of road accident**

It can be concluded from here that the main cause of the accidents is the fault of the driver since most of the accidents took place because of driver's fault. Vehicle out of control is also causing accidents there can be two reasons for this (a) the fault of driver itself and (b) bad condition of the road.

***Table 4.9* Nature of Accidents**

Nature	No. of Accidents
Overturning	2
Head on collision	32
Rear end collision	3
Collision brush/Side wipe	9
Right turn collision	2
Skidding	20
Left turn collision	3
Others	2

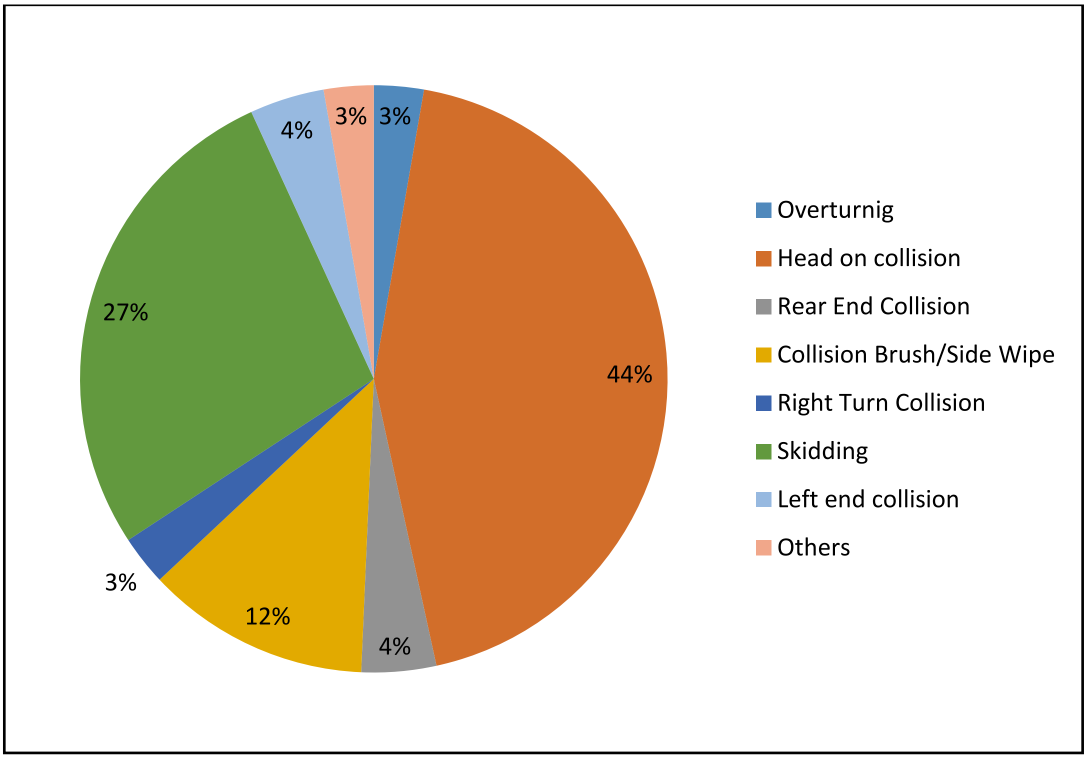


***Fig4.6* Nature of accidents**

The nature of the accidents is more towards head on collision and skidding. Since the study location is a hilly terrain over speeding is the cause of skidding and due to hilly terrain on curves, head on collision is possible.

***Table 4.10* Accidents on different condition of road**

Nature of Road	No of accidents
Straight road	11
Slight curve	36
Sharp curve	2
Flat road	1
Gentle incline	4
Steep incline	0
Hump	0
Dip	0
Straight road & Gentle incline	5
Slight curve & Gentle incline	1
Sharp curve & Gentle incline	1

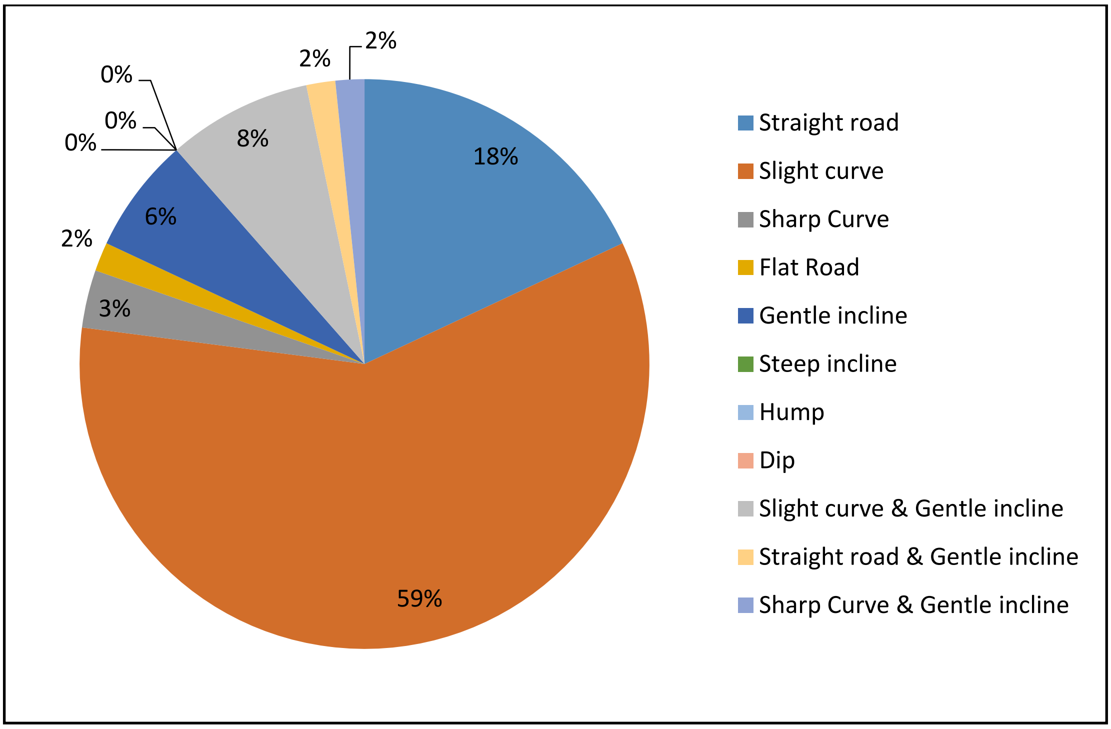


***Fig 4.7* Percentage wise accidents on different condition of road**

The percentage of accidents on the curves is very high, it is about 60% of the total accidents. The reasons of accidents on the curves may be inadequate curve length, absence of sign board

Table 4.11 **Number of accidents in different weather conditions**

Weather	No of accidents
Fine	49
Mist/Fog	4
Cloud	6
Light rain	7
Heavy rain	6
Hail/Sleet	0
Snow	0
Strong wind	0
Dust storm	0
Very Hot	0
Very Cold	0
Other conditions	0

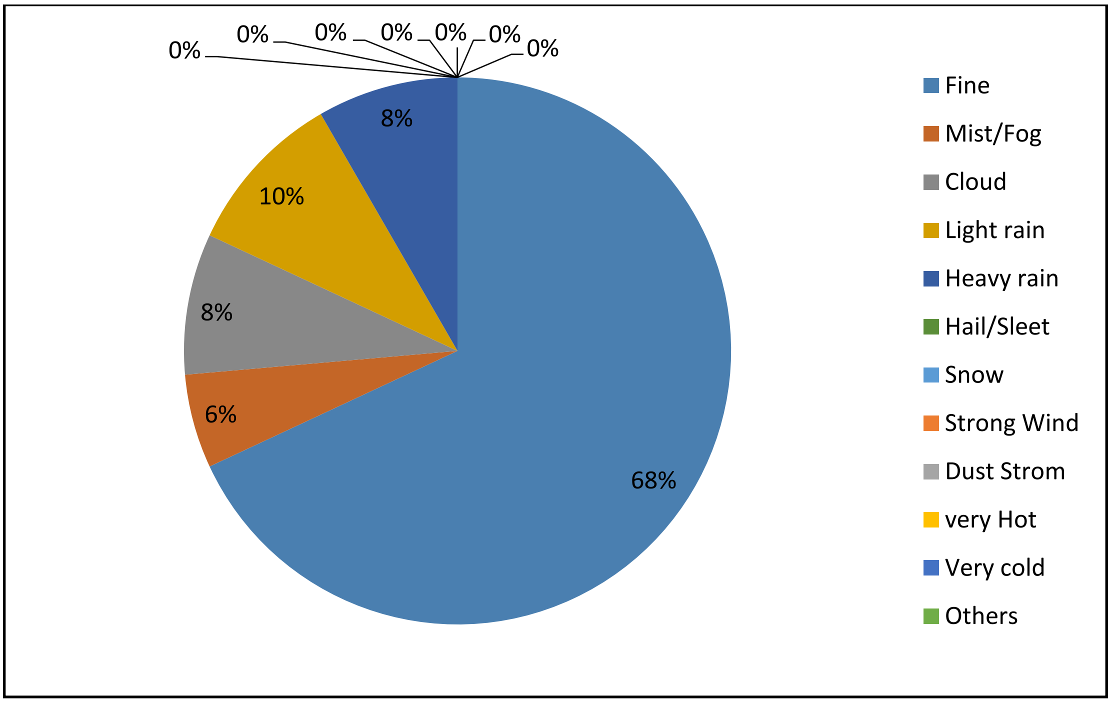


Fig 4.8 **Accidents in different weather condition**

CHAPTER 5
DEVELOPMENT PHASE AUDIT

5.1 Development phase audit

This is the 2nd stage of road safety audit and is undertaken at the completion of preliminary design (order publication report stage) before the draft orders has published and for development-led highway improvement schemes before planning consent where possible. This is the last occasion where the requirement of land used for the construction may be increased so therefore it is essential to consider fully road safety issues. The main aspects which must be considered in this stage are as follows.

- Collection of data for all the accidents in the project highway for preceding two years from Police Stations (Primary Source) and other secondary sources.
- To perform the analysis of fatal and grievously injured accidents "to identify the black spots" and relate to Accidents records with Traffic Volume to show trend as per Traffic Volume Count
- The various audits on the design of horizontal and vertical alignment is also done in this phase.
- Audits on intersection layout, lane and shoulder width is also done in this phase

5.2 Vertical Curves

Due to changes in grade in the vertical alignment of highway, it is necessary to introduce vertical curve at the intersections of different grades to smoothen out the vertical profile and thus ease off the changes in gradients for the fast moving vehicles

The vertical curves used in highway may be classified into two categories

- Summit Curves
- Valley Curves

5.2.1 Summit Curves

These are also known as crest curves with convexity upwards. When a fast moving vehicle travels along a summit curve, the centrifugal force will act upwards, against gravity and hence a part of the pressure on the tyres and spring of the vehicle suspension is relieved. So there is no problem of discomfort to the passengers. The only problem in designing summit curves is to provide adequate sight distance.

Length of summit curve for stopping sight distance (SSD)

$$L=NS^2/4.4 \qquad [5.1]$$

Where

L = length of the summit curve

S = Stopping sight distance (for design speed =100km/hr S = 182.29mtrs)

N = Deviation angle (grade difference)

5.2.2 Valley curve

These curves are also called sag curves with concavity upwards. There is no problem of restriction to sight distance in valley curves during day light. However, during night driving under head lights of vehicles, the sights distance available at valley curve is decreased. The most important factors considered in valley curve design is availability of topping light distance under head light of vehicles for night driving. The length of the valley curve for head light sight distance may be determined as

$$L= NS^2/ (1.5 + 0.035S) \qquad [5.2]$$

Where

L = length of the Valley curve

S = Stopping sight distance (for design speed =100km/hr S = 182.29mtrs)

N = Deviation angle (grade difference)

5.2.3 Calculation of required length for Summit and Valley curve

The data presented in the table 5.1 is taken as per drawing for the design of valley curves and summit curves. The value of gradients in and gradient out is calculated from the drawing by subtracting the RL of 1st station from the corresponding station's RL. The difference between gradient in and gradient out will give the difference in grade calculated in the column 4 of table 5.1. The curve length given in the column 5 is as per the drawing. If gradient out is greater than gradient in that will be considered as valley curve and if gradient in is greater than gradient out that will be considered as summit curve. The length required as per IRC for summit curve and valley curve is calculated by equation 5.1 and 5.2 respectively.

Table 5.1 **Difference in Curve length and required Curve length for valley and summit curves**

Vertical Curve NO	Gradient (in)	Gradient (OUT)	Difference in Grade	Curve length	Type of Curve	Length Required (SSD)	Difference in length
1	-0.079	0.244	-0.323	70	v	13.585	56.415
2	0.244	-0.258	0.502	80	s	37.746	42.254
3	-0.258	0.045	-0.303	60	v	12.744	47.256
4	0.045	-0.179	0.224	60	s	16.843	43.157
5	-0.179	2.5	-2.679	116	v	112.675	3.325
6	2.5	-2.6	5.1	383	s	383.473	-0.473
7	-2.6	0.008	-2.608	115	v	109.689	5.311
8	0.008	0.554	-0.546	60	v	22.964	37.036
9	0.554	-0.145	0.699	60	s	52.558	7.442
10	-0.145	3.1	-3.245	136	v	136.480	-0.480
11	3.1	-3.15	6.25	460	s	469.943	-9.943
12	-3.15	0.204	-3.354	140	v	141.065	-1.065
13	0.204	-0.131	0.335	80	s	25.189	54.811
14	-0.131	0.115	-0.246	80	v	10.346	69.654
15	0.115	2.6	-2.485	105	v	104.516	0.484
16	2.6	-2.65	5.25	387	s	394.752	-7.752
17	-2.65	-0.002	-2.648	112	v	111.371	0.629
18	-0.002	3	-3.002	145	v	126.260	18.740
19	3	-3	6	442	s	451.145	-9.145
20	-3	0.002	-3.002	130	v	126.260	3.740
21	0.002	0.033	-0.031	60	v	1.304	58.696
22	0.033	-0.002	0.035	60	s	2.632	57.368
23	-0.002	1.98	-1.982	110	v	83.360	26.640
24	1.98	-2.13	4.11	303	s	309.034	-6.034
25	-2.13	0.02	-2.15	100	v	90.426	9.574
26	0.008	2.1	-2.092	90	v	87.987	2.013
27	2.1	-2.1	4.2	310	s	315.802	-5.802
28	-2.1	0.025	-2.125	90	v	89.375	0.625
29	0.025	0.173	-0.148	120	v	6.225	113.775
30	0.173	0.074	0.099	60	s	7.444	52.556
31	0.074	3.1	-3.026	130	v	127.270	2.730
32	3.1	-3.1	6.2	457	s	466.183	-9.183
33	-3.1	-0.036	-3.064	130	v	128.868	1.132
34	-0.036	2.8	-2.836	120	v	119.278	0.722

Vertical Curve NO	Gradient (in)	Gradient (OUT)	Difference in Grade	Curve length	Type of Curve	Length Required (SSD)	Difference in length
35	0	-2.645	2.645	195	s	198.880	-3.880
36	-2.645	0.6	-3.245	140	v	136.480	3.520
37	0.6	-2.25	2.85	210	s	214.294	-4.294
38	-2.25	-0.016	-2.234	100	v	93.959	6.041
39	-0.016	0.074	-0.09	60	v	3.785	56.215
40	0.074	2.8	-2.726	120	v	114.652	5.348
41	2.8	-2.2	5	368	s	375.954	-7.954
42	-2.2	2.2	-4.4	190	v	185.058	4.942
43	2.2	-2.6	4.8	354	s	360.916	-6.916
44	-2.6	0.002	-2.602	110	v	109.437	0.563
45	0.002	3.3	-3.298	140	v	138.709	1.291
46	3.3	-3.3	6.6	486	s	496.260	-10.260
47	-3.3	-0.143	-3.157	135	v	132.779	2.221
48	-0.143	0.062	-0.205	70	v	8.622	61.378
49	0.062	-0.044	0.106	70	s	7.970	62.030
50	-0.044	0.124	-0.168	60	v	7.066	52.934
51	0.0124	-0.204	0.2164	60	s	16.271	43.729
52	-0.204	-0.023	-0.181	60	v	7.613	52.387
53	-0.023	0.186	-0.209	60	v	8.790	51.210
54	0.186	2	-1.814	80	v	76.294	3.706
55	2	0	2	148	s	150.382	-2.382
56	0	1.732	-1.732	75	v	72.846	2.154
57	1.732	-1.98	3.712	275	s	279.108	-4.108
58	-1.98	2.2	-4.18	190	v	175.805	14.195
59	2.2	-2.4	4.6	340	s	345.878	-5.878
60	-2.4	0.149	-2.549	120	v	107.208	12.792
61	0.149	0.177	-0.028	100	v	1.178	98.822
62	0.177	0.003	0.174	100	s	13.083	86.917
63	0.003	2.2	-2.197	95	v	92.403	2.597
64	2.2	-2.2	4.4	324	s	330.840	-6.840
65	-2.2	-0.012	-2.188	95	v	92.024	2.976
66	-0.012	0.282	-0.294	60	v	12.365	47.635
67	0.282	0.014	0.268	60	s	20.151	39.849
68	0.014	0.081	-0.067	60	v	2.818	57.182
69	0.081	-0.25	0.331	150	s	24.888	125.112
70	-0.25	2	-2.25	95	v	94.632	0.368
71	2	-1.9	3.9	292	s	293.244	-1.244
72	-1.9	-0.076	-1.824	85	v	76.715	8.285
73	-0.076	2.25	-2.326	100	v	97.828	2.172
74	2.25	-2.4	4.65	343	s	349.637	-6.637
75	-2.4	-0.251	-2.149	90	v	90.384	-0.384
76	-0.251	0.069	-0.32	180	v	13.459	166.541

Vertical Curve NO	Gradient (in)	Gradient (OUT)	Difference in Grade	Curve length	Type of Curve	Length Required (SSD)	Difference in length
77	0.069	-0.176	0.245	100	s	18.422	81.578
78	-0.176	-0.16	-0.016	60	v	0.673	59.327
79	-2.85	-0.024	-2.826	120	v	118.858	1.142
80	-0.024	2.75	-2.774	118	v	116.671	1.329
81	2.75	-2.6	5.35	395	s	402.271	-7.271
82	-2.6	0.107	-2.707	115	v	113.853	1.147
83	0.107	-0.057	0.164	150	s	12.331	137.669
84	-0.057	2.5	-2.557	110	v	107.544	2.456
85	2.5	-2.5	5	368	s	375.954	-7.954
86	-2.5	1.345	-3.845	195	v	161.716	33.284
87	1.345	0	1.345	120	s	101.132	18.868
88	0	-1.881	1.881	140	s	141.434	-1.434
89	-1.881	-0.044	-1.837	100	v	77.262	22.738
90	-0.044	2.2	-2.244	95	v	94.380	0.620
91	2.2	-2.2	4.4	324	s	330.840	-6.840
92	-2.2	-0.049	-2.151	95	v	90.468	4.532
93	-0.005	3.1	-3.105	130	v	130.592	-0.592
94	3.1	-3	6.1	450	s	458.664	-8.664
95	-3	0.158	-3.158	132	v	132.821	-0.821
96	0.158	-0.072	0.23	150	s	17.294	132.706
97	-0.072	2.2	-2.272	95	v	95.557	-0.557
98	2.2	-2.2	4.4	324	s	330.840	-6.840
99	-2.2	-0.013	-2.187	95	v	91.982	3.018
100	-0.013	3.3	-3.313	140	v	139.340	0.660
101	3.3	-3.3	6.6	486	s	496.260	-10.260
102	-3.3	-0.159	-3.141	135	v	132.106	2.894
103	-0.159	0.242	-0.401	150	v	16.866	133.134
104	0.242	-0.36	0.602	160	s	45.265	114.735
105	-0.36	0.282	-0.642	200	v	27.002	172.998
106	0.282	0.027	0.255	120	s	19.174	100.826
107	0.027	2.2	-2.173	95	v	91.393	3.607
108	2.2	-2.2	4.4	324	s	330.840	-6.840
109	-2.2	0.037	-2.237	100	v	94.085	5.915
110	0.037	-0.052	0.089	200	s	6.692	193.308
111	-0.052	-0.179	0.127	100	s	9.549	90.451
112	-0.179	3.3	-3.479	145	v	146.322	-1.322
113	3.3	-3.3	6.6	486	s	496.260	-10.260
114	-3.3	-0.141	-3.159	140	v	132.863	7.137
115	-0.141	0.755	-0.896	60	v	37.685	22.315

5.3 Horizontal Curves

A horizontal curve is a curve in plan to provide change in direction to the central line of a road. When a vehicle traverses a horizontal curve, the centrifugal force acts horizontally towards through the centre gravity of the vehicle

5.3.1 Calculation of length for horizontal curve

The data given in the table 5.2 is as per the drawings. The radius of the horizontal curve is curve is calculated with the help of the given length in the drawing. The deflection angle is calculated from the code with the help of length and radius of the curve. The required length for the horizontal curve is calculated by the relation

$$L = 150\ (5-N)\ X30 \qquad [5.3]$$

Where

L = required length of the horizontal curve

N = deflection angle

Table 2 **Difference in Curve length and required curve length of Horizontal Curve**

Horizontal curve no	**Radius (m)**	**Deflection angle**	**Length of curve (m)**	**Transition length(m)**	**Length of curve required(m)**	**Total curve length provided (m)**	**Difference in curve length(m)**
1	4000.0	6.03	420.93		119.12	420.93	301.82
2	2700.0	2.77	130.30		217.05	130.30	-86.75
3	3000.0	3.60	188.49		192.01	188.49	-3.52
4	10000.0	1.62	282.18		251.50	282.18	30.69
5	550.0	8.80	84.43	80.00	36.14	244.43	208.29
6	700.0	7.08	86.48	70.00	87.64	226.48	138.84
7	8000.0	4.33	604.44		170.13	604.44	434.31
8	7800.0	3.06	416.61		208.19	416.61	208.42
9	850.0	9.37	139.08	60.00	18.76	259.08	240.32
10	25000.0	0.15	64.71		295.55	64.71	-230.85
11	2000.0	13.72	478.97		-111.65	478.97	590.62
12	25000.0	0.31	133.29		290.84	133.29	-157.55
13	1050.0	4.30	78.83	50.00	170.96	178.83	7.87
14	10000.0	0.76	132.85		277.17	132.85	-144.32
15	1850.0	3.55	114.46		193.65	114.46	-79.18
16	1850.0	3.61	116.69		191.58	116.69	-74.90
17	1850.0	4.83	155.89		155.16	155.89	0.72
18	2000.0	5.02	175.32		149.32	175.32	26.00
19	5000.0	0.58	50.43		282.66	50.43	-232.24

20	750.0	10.21	133.68	65.00	-6.37	263.68	270.04
21	800.0	16.47	229.91	60.00	-193.97	349.91	543.88
22	25000.0	0.23	101.30		293.04	101.30	-191.74
23	10000.0	0.63	110.18		281.06	110.18	-170.88

5.4 Preparation of check list

It has been found that the use of checklists is a valuable tool while conducting audit. The detailed check list for the audit of Road Alignment design which is the part of the development audit has been prepared accordingly

S. NO.	DESCRIPTION	YES/NO	REMARKS
1	Is the proposed design speed appropriate to the function of the road, the mix of traffic likely to use it, and the road environment? (Check whether different sections need different design speeds?).	Yes	
2	If the speed is not up to the mark of design speed, whether proper cautionary sign have been provided?		Signage's details not available
3	Visibility, Sight Distance (SD)		
	(a) Review whether the standards adopted for provision of visibility in the design are appropriate for the ruling design speed and for any unusual traffic mix. **(b)** Review if sight lines are obstructed by: - Safety fences - Boundary fences - Street furniture - Parking facilities - Signs - Landscaping - Bridge abutments **(c)** Review the railway crossings, bridges and other hazards are conspicuous. **(d)** Will sight lines to be obstructed by temporary features such as parked vehicles in lay-byes or parked or queued traffic has been taken care of? **(e)** Does the alignment (horizontal and vertical)	Not shown in plan profile	Details parameters not provided Details has not been provided At most of the locations

S. NO.	DESCRIPTION	YES/NO	REMARKS
	give sufficient forward visibility for the selected design speed? (Check for inadequate stopping sight distances)		Vertical & horizontal curves are inadequate
4	Check for consistency throughout the route; note any location where alignment standard changes abruptly and is not as would be expected by drivers.		
5	Do the horizontal and vertical alignments fit together comfortably? (Check for bad combinations, such as a sharp bend immediately after a summit curve, and sag curve within a bend).		At most of the locations combination of horizontal and vertical curves are not provided.
6	Does the alignment provide safe overtaking opportunities? Does it avoid creating situations where the forward visibility is marginal for overtaking (neither clearly adequate nor inadequate)?	NO	
7	Does the vertical alignment pose excessive demands on the power of heavy vehicles? Has it been designed so those maximum grades are interspersed with recovery grades? Are there passing places to enable faster vehicles to overtake slow-moving heavy vehicles?	YES	

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 General

The study was undertaken to know about the various causes of accidents and frequency of accidents to locate the black spots and to study the various aspects of Road Safety Audit. The accident data is collected for the six months of the National Highway 21 (Kiratpur to Nerchowk section) from the district police head quarter falling in this particular stretch of the section. There are three districts police head quarters which come in this stretch (Kiratpur, Bilaspur & Mandi). The data was collected at the end of the every month for six months (from October 2013 to march 2014). For the Road safety audit during development phase of the road, drawing is collected to audit the design of vertical and horizontal curves.

6.2 Conclusions

From the study following conclusion can be drawn

- Road Safety Audit is very important for controlling accidents and for the proper design and maintenance of the Highways
- There are three locations which are located as the black spots since the value of ASI of these locations is more than average ASI (black spots and ASI explained in 4.7 & 4.8 of Chapter 4)
- Total horizontal curve length provided generally less than required w.r.to degree of curvature.
- vertical curves length are inadequate for safe sight distance for 100kmph at many locations
- Checklist for layout, location and access to Fuel Stations and Properties along national highway has been prepared with the latest notifications of MORTH.

6.3 Reasons for concern

- Visibility is affected, if horizontal curve is provided before/after a summit curve will give kink effect in Vertical alignment. Proper co-ordination of horizontal and vertical curve will ensure safety, improve utility of the highway and contribute to overall aesthetics.
- Inadequate or inconsistent provision of vertical curve length results in poor geometrics, inadequate sight distance and unsafe for the design speed of the road.

- If the deflection angle is small and inadequate length of horizontal curve, driver feels that the curve length is shorter and the radius of curve is smaller than actual values, causing the driver to reduce speed. If the driver tries to run his vehicle without decreasing speed, the vehicle will run along a larger radius and may enter other lanes and cause collision.

6.4 Recommendations

- Proper speed limit signs should be provided at the black spots
- Service roads need to be provided at some of the locations.
- Good quality materials should be used so as increase the life of the roads
- Proper shoulder width, median width should be provided.
- Proper co-ordination of horizontal and vertical curve should be done.
- Vertical curve length should be provided as per IRC standards.
- Adequate horizontal curve length should be provided as per IRC 73,(page no. 19 clause no.9.1.5) guide lines curve length should be at least 150m for a deflection angle of 5 degree, and this should be increased by 30m for each one degree decrease in deflection angle.
- All the auditors should follow the checklists for access checklist for layout, location and access to Fuel Stations and Properties along national highway.

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ANNEXURE

Stage-1: Development Stage Check list for Safety Audit

CHECK LIST 1 – AUDIT OF COMPREHENSIVENESS OF PLANNING

SL. NO.	DESCRIPTION	Compliance /Non Compliance	REMARKS
1	Is the proposed design appropriate in relation to the forecast traffic volumes, traffic characteristics and the adjoining land use?		
2	Does the route fit in with the physical constraints imposed by the topography?		
3	Does the route serve major generators of traffic in a safe and adequate manner?		
4	Is the frequency of junctions and their type appropriate for the function of the road and its design speed?		
5	Does the project road fit in well with the existing road network? (Check for potential problems at the connections – will changes in traffic volumes cause problems)		
6	Does the project road relieve routes or sites with bad accident records? Does it have any harmful effects on safety on the surrounding road network?		

CHECK LIST 2 – AUDIT OF ROAD ALIGNMENT DESIGN

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Is the proposed design speed appropriate to the function of the road, the mix of traffic likely to use it, and the road environment? (Check whether different sections need different design speeds?).		
2	If the speed is not up to the mark of design speed, whether proper cautionary sign have been provided?		
3	Visibility, Sight Distance (SD)		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	(a) Review whether the standards adopted for provision of visibility in the design are appropriate for the ruling design speed and for any unusual traffic mix. **(b)** Review if sight lines are obstructed by: - Safety fences - Boundary fences - Street furniture - Parking facilities - Signs - Landscaping - Bridge abutments **(c)** Review the railway crossings, bridges and other hazards are conspicuous. **(d)** Will sight lines to be obstructed by temporary features such as parked vehicles in lay-byes or parked or queued traffic has been taken care of? **(e)** Does the alignment (horizontal and vertical) give sufficient forward visibility for the selected design speed? (Check for inadequate stopping sight distances)		
4	Check for consistency throughout the route; note any location where alignment standard changes abruptly and is not as would be expected by drivers.		
5	Do the horizontal and vertical alignments fit together comfortably? (Check for bad combinations, such as a sharp bend immediately after a summit curve, and sag curve within a bend).		
6	Does the alignment provide safe overtaking opportunities? Does it avoid creating situations where the forward visibility is marginal for overtaking (neither clearly adequate nor inadequate)?		
7	Does the treatment at curves, proposed if any, make appropriate, adequate and safe provision for transition curves, super elevation and carriageway and formation widening?		
8	Does the vertical alignment pose excessive demands on the power of heavy vehicles? Has it been designed so those maximum grades are interspersed with recovery grades? Are there passing places to enable faster vehicles to overtake slow-moving heavy vehicles?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
9	Is the transition between project road and the existing road (s) i.e., access roads handled safely?		

CHECKLIST 3 – AUDIT OF PROPOSED CROSS-SECTION

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Are the widths of the carriageway, shoulders, medians (if any), service roads in accordance with standards and adequate for the function of the road and volume and the mix of traffic likely to use it?		
2	Check whether bridges have footpaths and they have proper gradients/crash barriers. a) Existing Bridges b) New proposed Bridges c) Approaches of proposed VUP/PUPs		
3	Note any location where the cross-section standard changes abruptly along the route or is otherwise inconsistent with driver expectations.		
4	Identify any locations where the capacity of the roadway is restricted and note locations of regular traffic congestion.		
5	Have the shoulders and side slopes been designed to a safe standard and note any locations with inadequate shoulder width?		
6	Have the side drains been designed to a safe standard? Are the batter slopes and drains safe for run-off vehicles to traverse?		
7	Is the transition between the project road and the existing road(s) handled safely? (Check for major changes in standards).		
8	Check whether the cross-section has adequate provision for the Vulnerable Road Users including persons with disabilities:		
A	Pedestrians: Have paved footpath, adequate refuge width on median and proper ramps, up and down kerbs, where there is regular pedestrian traffic?		
B	Bicyclists: Segregated areas (e.g. paved shoulders) where numbers are significant.		
9	If cross sections have been provided with proper cross slope/ super elevation as per design speed		

CHECKLIST 4 – AUDIT OF INTERSECTION/INTERCHANGE DESIGNS

SL. NO.	DESCRIPTION	YES/NO	REMARKS
A	**General**		
1	Is the general layout of junction caters safely for all road users including disabled road users? (Check whether there are other junctions too close to it. Check whether approaching drivers will get a clear view of it. Check with respect to pedestrians, cyclists and two wheelers etc.)		
2	The type of junction (T-type, staggered, signal controlled, roundabout) suitable for the function of the two or more roads, the traffic volume, the traffic movements (pedestrians and vehicular) and the site constraints? Is it safest alternative?		
3	Is the layout of the junction adequate for all permitted vehicular movements and for all types of vehicles?		
4	Will the general type of junction, its layout and the priority rules be recognized by approaching drivers well in time? Is the route through junction as simple and clear as possible? (Check for unusual or over-complicated layout? Check that signage's and marking are correct and clear?)		
5	Does the layout encourage slow controlled speed at and on the approach to stop/give way lines and other critical decision points? (Check for Y and skew junctions, which can be a problem. Also roundabout with inadequate deflection?)		
6	Are the sight lines at and on the approach to stop/give way lines and other critical decision points adequate and unobstructed? (Check for Y and skew junction, which can be problem. Check signs, lighting columns, pedestrian guardrails etc.?		
7	Is there adequate provision for channelizing the different streams of traffic? (Check the provision for right turn lanes, deceleration lanes and acceleration lanes?)		
8	Is adequate provision made for pedestrians and non-motorised vehicles?		
9	Is the provision of nighttimes lighting adequate, if not what are the deficiencies?		
10	Are junctions (s) at that stretch having proper markings such as a) Stop Lines b) Give way lines c) Pedestrian crossing d) Cyclist crossing e)Marking on approaches to		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	intersections(chevron/Diagonal marking) f) Marking on speed change lanes. g)Direction arrows h) Protected right turn lane i) Marking on rotaries j) Continuity lines Are junctions (s) at that stretch having proper sin ages such as **1)Cautionary Sign** a)Major road ahead crossing b)Major road ahead c)Right/Left Y intersection d)Right/Left T intersection e)staggered intersection f)Merging/Diverging of traffic ahead g)Rumble strips h)Roundabout **2)Mandatory Sign** a)Stop b)U-turn prohibited c)U-turn ahead d)Speed limit **3)Route Marker Sign** a)NH route marker b)NH route marker with definition plate with straight arrow on it c)NH route marker with definition plate with slanted arrow to right on it d)NH route marker with definition plate with slanted arrow to left on it **4)Informatory sign** a)Place identification sign b)Advance direction sign		
B	**Roundabouts**		
11	Is the geometry simple and easily understood? (Pay attention to roundabouts which are not circular, or which have awkward entry paths).		
12	Are there too many entries for safe efficient operation? Are they sufficiently separated from each other to avoid confusion?		
13	Does the design deflect entering traffic sufficiently to ensure entry speeds are safer? (Check entry path curvature, centre island size and positioning).		
14	Is there visibility for entering traffic adequate? (Check if		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	visibility is too good, if encourage entry speeds which are too high)		
15	Is the visibility for circulating traffic adequate?		
16	Has the Central Island been designed to be forgiving to errant vehicles?		
17	Has adequate provision been made for pedestrians to cross the arms of the junction?		
18	Have the needs of cyclists and other non-motorized vehicles been considered?		
19	Does the signing make the priorities clear? (Entering traffic must give way to circulating traffic).		
C	**Signal-Controlled Junction**		
20	Does the signal sequence conform to the requirements of the regulations and standards?		
21	Do the signals clearly indicate which movements are allowed at any one time? /Are the timings of various phases of signal cycle adequate?		
22	Are the signal heads positioned so that drivers can see them easily, and in time to react (stop or go)?		
23	Are the signals for competing phases located in such a way that they are visible only to the traffic for which they are intended?		
24	Are all right turning movements protected as far as possible?		
25	Do the signing; marking and channelization make it clear to drivers what path they should take through the junction?		
26	Are pedestrian crossing places marked, and are pedestrians channelled to these crossings?		
27	Are the pedestrian signals positioned so those pedestrians can see them?		
28	Whether the pedestrian crossing signal controls are provided where appropriate? If so, there is a need for the crossing movements to be fully protected from conflicting traffic movements for example where there will be serious conflicts with turning traffic.		
D	**Vegetation and Plantation**		
29	Is the top of vegetation in the traffic island as well as chandeliers, dividers less than 600 mm above the road top level for a length of 15 m from the end of the dividers?		
30	Is the vegetation/plantation at the corners of the junction retracted for enough back from the edge of the shoulders to afford clear view of approaching traffic to the driver?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
31	Are there no branches of trees projecting over the road berms/pavement at a height less than 7 m?		
32	Is the soil fill in Median/Island is overflowing on the carriageway?		
33	Is the vegetation proposed in median is cattle friendly?		

CHECKLIST 5 – AUDIT OF ROAD SIGNS PROPOSAL

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Is the provision for road signs (regulatory, warning and informatory signs and delineators) adequate and in accordance with standards? (Check with respect to size, shape and placement etc.) **1)Cautionary Sign** a)Right/Left hand curve b)Right/left reverse bend c)Cattle crossing d)School ahead e)Pedestrian crossing f)Right/Left side Road g)Gap in median h)Built up area i)Start/End of dual carriageway j)Rumble strips **2)Mandatory Sign** a)Stop b)Give Way c)Compulsory Keep left d)U-turn prohibited e)U-turn ahead f)No stopping or standing g)Speed limit **3)Route Marker Sign** a)NH route marker b)NH route marker with definition plate with straight arrow on it c)NH route marker with definition plate with slanted arrow to right on it d)NH route marker with definition plate with slanted arrow to left on it **4)Informatory sign** a)Ahead or turn right		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	b)Sound horn c)Petrol pump d)Hospital e)Public telephone f)Resting place g)Bus stop h)Truck lay bye ahead i)Toll plaza ahead j)Police station ahead k)Weigh bridge ahead l)Place identification sign m)Advance direction sign		
2	Safety Audit of VMS i)Horizontal clearance of vertical post of sign from carriageway edge ii)Vertical clearance of VMS signs at highest point on carriageway iii) Readability of VMS signs during Day/Night.		
3	Check for any unauthorized traffic signs and use of non-standard signs (color and shape).		
4	Location and spacing of signs		
A	Note locations where there are too many signs placed		
B	Note the signs placed too close to each other		
5	Note if all traffic signs are clearly visible and are prominently displayed for the intended road users.		
6	Find any instances where the legibility of the information on traffic signs is inadequate, bearing in mind the speed of vehicles and the amount of information displayed.		
7	Determine effectiveness of traffic signs by observing them at night and identify any lack of reflectivity.		
8	Examine type of sign posts used and record situations where sign posts constitute a fixed roadside hazard or where the use of frangible sign posts should be considered.		
9	Are there any situations where traffic signs themselves are obstructing essential 'Line of /Sight' for drivers and pedestrians?		
10	Regulatory signs a)Location 1 ....Type.......................... b)Location 2 ....Type.......................... Warning signs a)Location 1 ....Type.......................... b)Location 2 ....Type..........................		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
A	Are appropriate regulatory signs provided where necessary?		
B	Are warning signs provided only where they are warranted?		
11	Informatory signs		
A	Has signing been done on a systematic route or regional strategy that it is logical and meets needs of unfamiliar driver?		
B	Are all important junctions provided with advance direction sign, distance information sign and intersection sign etc.?		
C	Are these signs correctly positioned to enable the required timely action to be taken by the intended drivers?		
D	Find instances of poor legibility and poor arrangement of information on signs.		
E	Overhead signs –size, message information adequate, languages as per IRC standards.		

CHECKLIST 6 – AUDIT OF PAVEMENT MARKINGS PROPOSAL

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	General adequacy and visibility of road markings, during day/night time and in wet/ dry weather conditions		
2	Has correct type of markings been used in various situations (e.g. lane line, edge line etc.)?		
3	Are correct colours used for laying road markings?		
4	Is there any deficiency in the delineation of merge and diverge areas, including situations where ‘through’ traffic may inadvertently lead into auxiliary and turn lanes?		
5	Are zebra crossing markings provided at junctions and mid-blocks of the sections (depending upon the movement of pedestrian)?		

6	Is positioning of stop lines appropriate?		
7	Are the directional arrows marked on the pavement guiding the driver or creating confusion to the driver?		
8	Are there locations where there is a lack of "Hazard markings' at approach end of island, medians and culverts/bridges etc.?		
9	Have retro-reflective markers been installed? Where coloured markers are used, have they been installed correctly?		
10	If chevron alignment markers are installed, have the correct types of markers been used?		

CHECKLIST 7 – AUDIT OF LIGHTING SCHEME

SL. NO.	**DESCRIPTION**	**YES/NO**	**REMARKS**
1	Is there any need of lighting on the project roads, or parts of it, to be lighted at night (particularly where there are pedestrians and parking along the road) important interchanges, bus bays, truck lay byes, toll plazas?		
2	Are the proposed lighting scheme and illumination levels of an appropriate standard, consistent with the needs of the location, pedestrian and other factors?		
3	Identify the locations where street lighting columns constitute a hazard to traffic (on the outside of sharp curves, on small islands, noses of medians) or which may conflict visually with traffic signals or signs?		
4	Does the existing street lighting enhance as 'route guidance', rather than confuse the driver's ability to 'see the direction of the route ahead'?		

5	Are the appropriate types of poses used for all locations and correctly installed (e.g. slip-base at correct height, rigid poles protects if within clear zone)?		
6	Has lighting for signs, particularly overhead signs, been provided where necessary?		
7	Are there any lighting or telephone poles close to the edge of the berms so as to pose hazard to traffic?		
8	Are there any lighting poles in the median(less than 2m wide) unprotected by crash barriers?		

CHECKLIST 8 – AUDIT OF ROADSIDE HAZARDS

SL. NO.	**DESCRIPTION**	**YES/NO**	**REMARKS**
1	Is a clear zone provided in accordance with the guidelines? Is the appropriate treatment or projection provided for any objects within the clear zone?		
2	Are bridge and culvert parapets and other obstructions close to moving traffic? If so, can they be relocated? If not, are they adequately provided with signs and, where necessary, protected by safety barrier?		
3	Are bridge parapets designed to contain errant vehicles, where the speed and volume of traffic warrants them?		
4	Are the ends of bridge parapets, bridge railing and pedestrian guardrail/crash barriers of a safe design?		
5	Are there any poles or columns along the road and comment on whether some or any of them can be removed, relocated to less hazardous positions etc.		
6	Is there a degree of hazard associated with large trees, boulders, etc. and whether these can be treated to improve roadside safety?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
7	Do the trees and other vegetations obstruct driver and pedestrian sight lines, which are essential for safe traffic operation?		
8	Are there any ‘fixed roadside objects’, which occur within the roadway? Comment on the need to treat them in terms of road safety?		
9	Is there an existence of roadside stalls and other roadside business activities within the right of way of the road?		
10	Are the provide crash barriers suitable for the purpose?		
11	Is the length of crash barrier at each installation adequate? Are the crash barrier installed correctly?		
12	Is the provided barrier/fencing in the clear zone free of separate horizontal rails?		
13	Is there adequate delineation/visibility of barriers and fences during nighttimes?		
14	Are there any thorny bushes by the roadside, whose branches are likely to hurt the passengers occupying the window seat of a vehicle, especially a non-AC bus?		
15	Is any thick growth of vegetation by the roadside enough far back from the edge of the pavement to enable a driver to take protective steps in time if any human or animal should run across the road from behind or within the vegetation?		
16	Are there any sharp edged or pointed fixtures or tops of supporting verticals on the median crash barriers or on dividers which can hurt a motor cyclist in case of a collision or crash or loss of balance?		
17	Are there any village name boards or direction boards by the roadside with pointed ends to hurt a passenger in a bus on window seat?		
18	Bridges/Canal crossings: Are the open spaces by the side of ends of Parapets covered by protective crash barriers or walls to prevent vehicles going into the river or canal?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
19	Have the roadside trees close to edge of berms, which cannot be removed for want of permission of tree authority, been made visible at night and day by white washing/pasting reflective tape on them?		
20	Is the height of vegetation in the median at breaks in median at junctions or for U Turns or for pedestrian crossings reduced to less than 60 cm for a length of 20 m to afford complete visibility to drivers?		
21	Is the height of vegetation in the median less than 60 cm on curves?		
22	Is the median clear of any trees with trunks with girth greater than 30 cm? If not, are such locations enveloped by protective crash barriers?		
23	Are fixing details of pipe railing such that the entire length of pipe is smooth and continuous without any projection on road ward side?		
24	Are entrances to abandoned roads properly fenced off?		

CHECK LIST 9 – AUDIT OF ROADSIDE FACILITIES PLANNED

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Do the cross-section, alignment and signage’s encourage drivers to adjust their speed on entering the town or village and maintain it at an appropriate level? (Check that it will be quite clear to drivers that the road environment is changing and that they slow down).		
2	Is there adequate and safe provision for pedestrians and non-motorised traffic to walks alongside the road and to cross it? (Check for provision of footpaths, shoulders and safe crossing places and whether pedestrian movements are controlled and channelled by guardrail in busy places?)		
3	Are the design and provision of roadside parking and access to properties adequate, controlled and safe?		

4	Has the opportunity been taken to improve the traffic and parking situation in the town and villages through which the road passes? (Check for junction improvements, access control, provision of service lanes, parking areas and bus stops).		
5	Are bus stop locations safe and proper and whether the provision for buses to stand clear of traffic lanes has been made? Also is there need for lighting at these locations for the security and safety of passengers?		
6	Is there any need for overtaking opportunities along the route at regular intervals on divided roads, particularly where traffic flows are high or in hilly terrain?		
7	Consider the need for rest areas and other roadside stopping places e.g., truck stops, scenic view points, wayside picnic areas etc, and note any current ‘unofficial’ places where vehicles stop and the degree of hazard that this involves.		

CHECKLIST 10 – SAFETY AUDIT FOR VULNERABLE ROAD USERS

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Has there been a survey of non-motorised vehicle and pedestrian flows? a)Location 1 ....Type.......................... b)Location 2 ....Type..........................		
2	Will there be any major conflicts between motorized traffic and pedestrians and other disabled / handicapped road users? a)Location 1 ....Type.......................... b)Location 2 ....Type..........................		
3	Have pedestrians need for crossing the road and walking safely alongside it been adequately provided for? (Check particularly in towns and villages and at all junctions – check shoulder width – check whether it is desirable and feasible to provide a segregated footway – check whether steps are provided where pedestrians will have to climb high embankments).		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	a)Location 1 ....Type........................... b)Location 2 ....Type...........................		
4	Is the provision for pedestrians and non-motorised vehicles at bridges and narrow sections adequate in relation to pedestrian and vehicular traffic volumes and traffic speeds? a)Location 1 ....Type........................... b)Location 2 ....Type...........................		
5	Have measures been taken to reduce the accident risk for children going to and from roadside schools (Pedestrian guardrail may be needed to prevent children from running out into the road)? a)Location 1 ....Type........................... b)Location 2 ....Type...........................		
6	Have the need of cyclists and other non-motorised vehicles been provided for (Check shoulder width – check the needs and feasibility of segregated cycle/cycle rickshaw lanes, especially in towns)?		
7	Are bicycle safe grates provided at drainage pits where necessary?		
8	Does the volume of motorcycle traffic justify the provision of separate lanes? (Check in towns).		
9	Are bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility? a)Location 1 ....Type........................... b)Location 2 ....Type...........................		
10	Where necessary, is fencing installed to guide pedestrians and cyclists at crossings or overpasses? a)Location 1 ....Type........................... b)Location 2 ....Type...........................		

CHECKLIST 11 –AUDIT OF DETAILED DESIGN (ON COMPLETION)

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Have all recommendations from the previous stage been followed? If not, reasons thereof?		
2	Visibility, sight distance a) Are horizontal and vertical alignments consistent with the required visibility requirements? b) Confirm whether the standard adopted for provision of visibility in the design is appropriate for the ruling design speed and for any unusual traffic mix. c) Check whether sight lines are obstructed by: - Safety fences - Boundary fences - Street furniture - Parking facilities - Signs - Landscaping - Bridge abutments d) Check whether railway crossings, bridges and other hazards are conspicuous. e) Will sight lines to be obstructed by temporary features such as parked vehicles in lay-byes or parked or queued traffic has been taken care of?		
3	Check whether the design standards are appropriate for all the new requirements of the proposed project and check for consistency of general standards and guidelines such as lane widths, camber and cross-fall.		
4	Cross-sections: a) Are cross-falls appropriate? b) Is there a suitable gutter gradient or is the carriageway laid at a suitable height above the shoulder?		
5	Lighting columns, traffic signals, sign standards, etc: a) Have requirements on safe distances to carriageway and cycle path been observed? b) Have breakaway safety devices or such like been proposed?		
6	Signs and markings: a) Are markings consistent along the entire road section? b) Is the information clear? c) Are there enough signs? d) Are there too many signs? e) Will signs mask each other or traffic signals (be sure to include all plans for signs and markings in your assessment)? f) Are the signs correctly positioned, without obstructing		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	sight distances/visibility in any way?		
7	Are the proposed types of kerb stone/edge marking appropriate?		
8	Lighting: a) Is there any risk that the lighting can be optically misleading and will it have any detrimental effects on traffic signals and signs? b) Are there any unlit areas that could conceal hazards? c) Will an illuminated side road mislead road users on the planned, unlit road? d) Are all pedestrian crossings illuminated (not merely the formally marked crossings, but also unmarked places where pedestrians could be expected to cross)? e) Will powerful illumination of adjoining areas or strongly illuminated advertisements cause problems?		
9	Junctions, interchanges and their design: a) Will road users coming from all directions (including side roads) be able to see that they are approaching a conflict area? Are give-way lines, stop lines, turning lanes and ramps clearly visible? b) Are existing conjoining and intersecting roads appropriately adjusted and matched to the new road (without sharp bends and gradients)? c) Do the routes of road users through the junction seem clear for all directions and manoeuvres? d) Is there sufficient space for all types of vehicles to undertake all manoeuvres? e) Are the crossing facilities for pedestrians and non-motorised traffic adequate and safe? f) Can parking cause problems? g) Have roundabouts been considered? In urban areas, ghost markings and left- turning lanes with islands are safest; they prevent overtaking and assist pedestrians and cyclists who are crossing the road.		
10	Decide whether or not old, unremoved section of road can give undesired optical directions.		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
11	Special points at roundabouts: a) Are all entrance lanes curved and is speed adequately reduced? b) Will the central island be visible? c) Are the measures taken for the benefit of pedestrians from safe stopping distance and cycle traffic adequate?		
12	At the junction/transition to existing roads (especially from multi-lane to two-lane, dual to single carriageway): a) Are there sudden changes of alignment? b) Does the road standard change too rapidly, or can road users clearly see and recognise the transition in good time? c) Would a roundabout be able to mitigate any sudden changes in standards and alignment?		
13	Are existing junctions and intersections adjusted and matched to the new road appropriately (without sharp bends and gradients)?		
14	Guardrails, hedges and railings: a) Are all vulnerable areas protected? b) Are bridge pillars, steel posts, trees etc., protected by guardrails where necessary? c) Are there places where hedges are necessary to prevent pedestrians from crossing? d) Are the chosen hedges/guardrails "light" enough? e) Do guardrails/road side furniture have any hazardous sharp protruding edges?		
15	Road surface: a) Has a porous type of surface been chosen? b) Will an exceptionally high-friction surface be necessary in especially exposed places? c) Would a change of surface as a purely visual signal to road users be of benefit? Used in this way, could a change of surface be misunderstood by road users?		
16	At junction/transition to existing road network (especially from multi-lane to two-lane, end of central reserve) a) Is there sufficient advance warning? b) Are reflector posts correctly positioned? c) Are ghost markings appropriate in connection with the merging of two lanes? d) Is there continuity of edge markings?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
17	For two-lane sections prepared for expansion to four lanes with central reserve (e.g. expressways built as "semi-motorways" a) Will road users be clear everywhere that they are not on a one-way, two-lane carriageway? b) Should night illumination of signs be of extra high standard? c) Is overtaking prevented at all points where prevention is necessary? d) Should special measures be adopted at bridges built with a view to future expansion?		
18	Examine adjoining areas for potential safety problems (airfield, signals for maritime traffic and railways, flying golf balls etc.)		
19	Additional temporary signs will be necessary for most new constructions. In this context consider: a) Is the text, etc. comprehensible and correct? b) Have all signs etc., been positioned safely? c) When will they be removed? Be sure also to use the separate checklists for specific facilities and measures.		
20	Landscaping: a) Is there advertising conflict between landscaping and visibility requirements? Has ultimate growth height been considered and potential obstructions to pedestrian visibility and potential for trees to become collision objects? b) Will maintenance of soft landscaping be safe?		
21	Plantations: a) Will plantations obscure visibility and has a maximum height been specified? b) Are plantations likely to encroach on markings or lighting? c) Will fully-grown trees constitute a hazard (have the requirements on distances to rigid obstacles be observed?)? d) Can maintenance be carried out safely?		
22	Lay byes: a) Are there any lay-byes available in the section? b) Is the bye properly located and it is not inconvenient to the drivers to stop the vehicles? c) Is there any need to modify the lay-bye design (if yes, suggest the parameters that need modification)? d) Are advance warning signs and markings properly guiding the driver about the lay-bye? e) Is there any need of any additional signs and markings?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
23	Check provision for pedestrians to cross safely at intersections, signalised and pedestrian crossings, refuges, kerb extensions and at other locations.		
24	Are median barriers necessary and have they been properly detailed? Are there any design features such as end conditions which require special attention?		
25	Are there any poles located adjacent to moving traffic which could be sited elsewhere?		
26	Have frangible or breakaway poles been detailed?		
27	Is the unprotected median width adequate to accommodate lighting poles?		
28	Are there any obstructions, which are likely to create a safety hazard and can they be mitigated or relocated?		
29	Is a crash barrier provided wherever necessary and is it properly detailed?		
30	Check whether access to structures and road furniture is safe. Check that the road or utilities in the road reserve can be maintained safely. Both road users and maintenance personnel should be considered.		
31	Check that the requirements for the traffic management of the construction site and safety measures needed for workers and road users have been adequately spelled out from the safety point of view including the transition from the existing arrangements to the construction site and from the construction site to the final layout can be effected safely.		
32	Check for the arrangement for temporary and permanent traffic control devices, including possible signals, temporary diversion etc.		
33	Check that the design duly considers the needs of persons with disabilities.		
34	Other checks made at discretion of auditor or client.		

Stage-2: Construction Stage check list for Safety Audit

CHECKLIST 12 – General Aspects

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Has the Construction Safety Manual Prepared?		
2	Is there any Safety Committee constituted? (a) Members in the Committee (b) Nos. of meeting conducted		
3	Is there any Safety Inspection Team on site? (a) Numbers of Team members (b) Responsibility		
4	Is the Safety Training is Imparted? (a) Training Schedule (b) Course Title. (c) Course Duration. (d) Course Content. (e) Target Audience (f) Actual Audience with record of attendance		
5	Is there any scheme to promote safety? (a) Safety award and safety incentive (b) Display of Safety Banners/Boards		
6	Is Reporting of Accidents and Dangerous Occurrences register maintained? (a) To whom to report (b) Nos of Occurrence month wise (c) Severity of Accident i) Fatal Accident ii) Major Injury iii) Accident Dangerous Occurrence **iv)** Any Incident Involving a Member Of The Public		
7	a) Is Accident Investigation procedure is defined? b) If accident case investigated c) If recommendation of the investigation is implemented?		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
8	Is Emergency Preparedness Plan for each site is placed? Such as (a) The name, location and phone number of the Emergency Co-ordinator; (b) Designated Personnel with locations and phone numbers; (c) Details of the Emergency Response Team with locations and phone numbers; (d) Functions of the Emergency response Team; (e) The means of Escape; (f) Communication with the Emergency Services; • Police • Fire Services • Ambulance and Hospital Services (g) First-Aid Facilities; (h) Site plans; (i) Suppliers of emergency equipment such as sump pumps, lighting, carnage, etc.		
9	Is safety signs are placed as follows: (a) Wear Safety Helmets. (b) Permit to Work areas (c) Wear Safety Footwear. (d) Wear Hearing Protection. (e) Wear Eye Protection. (f) Danger Electricity. (g) Danger Crane Overhead. (h) Stop Look and Listen (i) No Smoking. (j) First Aid. (k) No Entry signs (l) Fire precautions		
10	Is safety signs are comply with the Internationally recognised Safety Colours as indicated below: • Blue Mandatory. • Yellow Danger. • Red Prohibition. • Green Safe Condition		

<table>
<tr><th>SL. NO.</th><th>DESCRIPTION</th><th>YES/NO</th><th>REMARKS</th></tr>
<tr><td>11</td><td>Is measures have been placed to reduce health hazard due to

(a) Toxic fumes
(b) Noise
(c) Dust
(d) Vibration
(e) Ventilation in enclosed areas
(f) Biological factors such as snake/insect bites, etc.</td><td></td><td></td></tr>
<tr><td>12</td><td>Is Personnel Protective Equipment are provided such as

a) Whether requirement of personnel protective equipment(PPE) is identified for each construction operation such as
• Safety Helmets.

i) Green for Safety Experts
ii) White for Engineers
iii) Blue for Supervisor
iv) Red for Electrician/Mechanic
V) Yellow for Labour.
• Hearing Protection.
• Respiratory Protection.
• Eye Protection.
• Protective Gloves.
• Safety Footwear.
• High Visibility Clothing
b) Are PPE equipments readily available at the time of need
c) Are PPE equipments worn by site management, engineers and supervisors
d) Whether workers engaged are using PPE
e) Does PPE are used as per the colour codes</td><td></td><td></td></tr>
<tr><td>13</td><td>Audit of Wearing of PPE during various construction activities
<table>
<tr><th>Sl. No.</th><th>Activity</th><th>Wearing of PPE</th></tr>
<tr><td></td><td>Surveying</td><td>Safety Helmet, Gumboot and Rubber Hand gloves of electrical grade while working near overhead powerlines</td></tr>
<tr><td>2.</td><td>Clearing & Grading</td><td>Safety Helmet, Gumboot and Cotton Hand gloves</td></tr>
<tr><td>3.</td><td>Excavation</td><td>Safety Helmet, Protective</td></tr>
</table></td><td></td><td></td></tr>
</table>

<table>
<tr><th>SL. NO.</th><th>DESCRIPTION</th><th>YES/NO</th><th>REMARKS</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>& filling</td><td>Footwear and Cotton Hand gloves</td></tr>
<tr><td>4.</td><td>Hot works like Bituminous works</td><td>Safety Helmet, Miners safety shoes with rubber sole Gumboot, Cotton Hand gloves and reflective jacket</td></tr>
<tr><td>5.</td><td>Height Works in Bridge, CD Works & Plant Area</td><td>Safety Helmet, Safety Belt, Protective Footwear and Fall Arrester as required</td></tr>
<tr><td>6.</td><td>Welding & Gas Cutting</td><td>Safety Helmet, Face Shield/with suitable filter, Leather Hand gloves and safety shoes</td></tr>
<tr><td>7.</td><td>Concreting Works</td><td>Safety Helmet, Gumboot & Rubber Hand gloves</td></tr>
<tr><td>8.</td><td>Grinding & Chipping Works</td><td>Safety Helmet, Face Shield/Goggles, Safety Footwear and Cotton/Leather Hand gloves</td></tr>
<tr><td>9</td><td>Flagmen</td><td>Safety Helmet, Reflective jacket, Protective Footwear, He should be provided with Red Flags, Slow & Stop Paddles & Batten</td></tr>
<tr><td>10</td><td>Work over water</td><td>Safety Helmet, Safety Belt & lifeline for preventing fall, Life Jacket, Protective Footwear</td></tr>
<tr><td>11.</td><td>Work at Night</td><td>Safety Helmet, Reflective Jacket, Protective Footwear, Sufficient Lighting, Blinkers/Flash lights on both ends</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>14</td><td>Audit of First Aid Measures

a) Weather first aid base is established at each Principal Work Area
b) Is the first aid base is equipped with emergency equipments, medicine, bandage, etc
c) Is any medical staff such as doctor, nursing staff available at base
d) Is Ambulance services are available
e) Is first aid boxes fully equipped at each location where 20 or more persons are working</td><td></td><td></td></tr>
</table>

CHECKLIST 13 –SAFETY AUDIT OF TRAFFIC MANAGEMENT

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Have all recommendations from the previous stage been followed? If not, why not?		
2	Whether information regarding the construction zone approaching has been provided well in advance or not?		
3	Whether standard procedure and contract conditions provide for proper management of the construction site and road users are properly and safely accommodated?		
4	Whether the transitions from the existing road to the site of works safe and clearly laid out?		
5	Whether the width of the lanes is satisfactory for the traffic passing through the works area?		
6	Whether sight and stopping distances adequate at site of works and at intersections?		
7	Whether bus stops appropriately located with adequate clearance from the traffic lane for safety and visibility.		
8	Whether appropriate street lighting or other delineation provided at the road works to ensure that the site is safe at night? Check the night time visibility of traffic control devices.		
10	For clear and sufficient information to the road user, advance warning signs installed or not?		
11	Is there any provision of marked lanes for safe and clearly guiding road users?		
12	Whether suitable measures provided through construction zones to control driver behaviour?		
13	Check for the adequacy of traffic control devices required for each zone i.e., at advance warning zone, at approach transition zone, at work zone and at Terminal Transition Zone. Check for placement and visibility of control devices, such as a) Signs		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	b) Pavement Markings c) Cones/Delineators/Drums/Barricading d) Flashing Lights e) Any other		
14	Has permission been taken while changing the standard layouts from safety point of view		
15	Whether police and other emergency services been consulted?		
16	Check for proper care and attention for pedestrian and non-motorised traffic at construction sites.		
17	Check for adequate safety provisions for the elderly and persons with disabilities.		
18	Whether flagmen are available on duty at the appropriate places? Check for proper traffic management practice to avoid inhibiting traffic to pass clear of work site and necessary attention to roadside safety.		
19	Whether the temporary diversion is provided at work zones in compliance with the contract and traffic management plan approved by the Engineer.		
20	Whether the Traffic Management Plan at work site prepared and submitted by the Contractor to the Engineer for approval.		
21	Is the Supervision Engineer ensuring the required quality of traffic management plan?		
22	Whether suitable speed reducing measures are provided at work zone.		
23	Other checks made at discretion of auditor or client.		

CHECKLIST 14 – SAFETY AUDIT OF CIVIL WORKS

SL. NO.	**DESCRIPTION**	**YES/NO**	**REMARKS**
1	Is Hazard Identification and Risk Assessment detailed method statements for various construction activities are made? Such as (a) Excavations (b) Blasting (c) Embankment Construction (d) Erection/ Removal of formwork (e) Demolition (f) Tunnelling operations (g) Tree Cutting (h) GSB (i) WMM (j) Bituminous Works (k) Concrete Pavement (l) Pile Foundation (m) Well foundation (n) Open foundation (o) Masonry Works (p) Form Works (q) Steel Reinforcement (r) Structural Concrete (s) Pre stressing (t) Sub Structure (u) Super structure (v) River training works (w) Culverts		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	(x) Wearing coat & Approaches		
2	Audit for excavations (a) Support for prevention of collapse of the sides (b) Preventing materials falling onto people working in the excavation (c) Preventing people and vehicles falling into the excavation (d) Preventing workers/ people being struck by plant (e) Preventing undermining nearby structures (f) Preventing contact with services. (g) Proper access to the excavated underground (h) area (i) Prevention from fumes		
3	Audit for Blasting (a) Type of explosives to be used (b) Anticipated effects of vibration on nearby structures (c) Blasting patterns (d) Delivery of the explosives (e) Transportation and storage of explosives on site (f) Drilling and charging of holes (g) Warning sirens (h) Provision of sentries		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	(i) Use of blast screens (j) ALL CLEAR (k) Ventilation following blasting (l) Atmosphere monitoring (m) Procedure for miss-fires		
4	Audit for Demolition (a) Services disconnection has been done (b) Signage of the area (c) Protection measures placed for Demolition area		
5	Audit for False Work/ Form Work (a) If the design and the supports for shuttering and false work / formwork been approved (b) Adequate provision made on the working platforms for the concrete placement operations, vibrators and the unobstructed movement of personnel controlling the rubber hose during the concrete pumping operations or the concrete skip during any skipping operations (c) Is it being erected safely from steps or proper platforms? (d) Are the props plumb and properly set out? (e) Are the bases and ground conditions adequate for the loads? (f) Are the correct pins used in the props? (g) Are the timbers in good condition? (h) Is it inspected by a competent person against the agreed design before permission is given to pour concrete?		
6	Audit for working at height (a) Ladder Placement		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	(b) Scaffolding (c) Working Platform (d) Railings (e) Provision of Safety Harness/ Fall Arresters (f) Wearing Helmets & safety belts by workers.		

CHECKLIST 15 – Safety Audit for Electrical and Mechanical works at construction work site

SL. NO.	DESCRIPTION	YES/NO	REMARKS
1	Audit for safety alert signs are mounted on machine (a) Whether triangular type sign colour coded yellow with black boarder and lettering for warning. (b) Whether triangular type sign colour coded red with white boarder and lettering for danger. (c) Whether operator and concerning staff are able to understand safety signs and their sensitivity.		
2	Audit for machine well equipped with required safety accessories when moving slower than normal highway speed such as (d) Is there proper lighting and markings to ensure they are visible to other road users. (e) Is there additional light – slow moving vehicle (SMV) emblems etc. are visible to other road users. (f) Is there all safety devices, signs and emblems are clean also in working condition.		
3	Audit for lifting (g) Certification of Lifting Appliances (h) Automatic Safe Load Indicators are installed (i) Audible warning devices are working		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	(j) Wire rope slings in proper condition with no broken wire or tint (k) Daily Inspection of Appliances is carried (l) Operation by Trained Personnel		
4	Audit for working in confined places (a) Flammable Substances and Oxygen Enrichment (b) Toxic Gas, Fume or Vapour (c) Oxygen deficiency (d) The Ingress or Presence of Liquids (e) Presence of Excessive Heat (f) Excessive Humidity		
5	Audit for electrical safety practices at Plant sites, camp sites and work sites (a) If protection provided for all main and sub-circuits against excess current, residual current and earth faults (b) If temporary power sources are of grounding type with ground connected (c) Are extension cords used are wire type and are in good condition (d) If all circuits are identified at panel boards (e) Are safety tags are used to indicate “danger- Do not operate” situation (f) Are Lock out/ Tag out procedure followed (g) Whether electrical appliances are provided with proper insulations, ELCB’s, ground fault circuit interrupters (h) Whether emergency lighting provided (i) Whether lighting provided at working locations is adequate & free from glare		
6	Audit for fire prevention measures placed at Plant sites, camp sites and work sites (a) Are fire extinguishers, fire plugs, etc, in good condition (b) Are fire extinguishers, fire buckets, hydrants and fire water periodically		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	inspected and tagged (c) Are fire escapes and exists clearly marked (d) Are trash and combustible material removed from work area (e) Whether fire fighting arrangement is done in storage area, genset area		
7	Audit for welding & cutting operations (a) Are welding & burning area well ventilated (b) Are compressed fuel & oxygen cylinders well separated and stored in well ventilated areas (c) Is frames of all arc welding machines grounded (d) Are all welding lead terminals protected from accidental contact by personnel or by metal object		
8	Audit for Safety measures for Machinery Tools & Heavy Equipments a) All woodworking machines shall be fitted with the following guards and devices • Top Guard • Riving Knife • Guards to protect all drive belts etc. • An emergency stop switch easily accessible by the operator • A push stick b) All Abrasive wheel machines shall be fitted with appropriate guards which shall be kept in place at all times the machine is in use		
9	Audit for operation of Machinery Tools & Heavy Equipments are provided a) Whether dangerous operations are supervised regularly by competent personnel b) Whether work permit system exists and enforced c) Whether physical condition monitoring is done regularly		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	d) Is certification of machinery & equipment is done regularly e) Are signals are understood and observed by operators & workers working on the equipments and plants f) Whether operator/personnel having statutory minimum age. g) Whether operator/personnel is trained in general training course organized by manufacturer or other authentic agency h) Whether operator/personnel is well acquainted about all kind of circuits used in machine and hazards situation if they mishandled i) Never store oily rags or inflammable material inside machine compartment j) Never bring spark, lighted matches, and open flame near battery top k) Never left leaked hydraulic pipe and auto electric wiring that can fire the machine and may be serious hazards to the public in vicinity l) Disposal of waste such as fuel, oil coolant, filters and old batteries must be done properly and special care to be taken not to contaminated with any water source m) Hand rails and steps of high altitude machines must be in good condition and clean n) Whether operator`s manual is studied by o) Whether try and tested all controls and machine functions with machine in open area before starting to work. p) Whether operator is well familiarize with work site including over head obstacles.		
10	Audit for Stores a) Weather storage of material is done properly b) Weather House-keeping of the storage is taken care off c) Whether containers of flammable gases and liquids are identified d) Whether gas cylinders are stored at a specific location e) Are these cylinders chained upright		

SL. NO.	DESCRIPTION	YES/NO	REMARKS
	f) Whether toxic material are stored at specific locations g) Is storage of toxic material done as per HSEM guidelines h) Is proper illumination provided in storage area i) Are the Do's and Don'ts list displayed for handling of toxic material		
11	Audit for House-keeping a) Weather slippery floors/defective floors storage of material is done properly b) Weather House-keeping of area is good/up to the mark c) Whether sanitary facilities, passage ways and walkways are provided nicely d) Whether chemicals and other waste disposal as per Government norms and regulations e) Is engine oil, canteen waste, office waste and sanitation waste disposed properly		
12	Audit for movement of vehicles at Plant sites, camp sites and work sites a) Whether helper is provided at the time of movement of vehicles in back gear b) Whether flagman is available at all the junctions within the camp/work area. c) Condition of roads within the plant/camp area. d) Weather helper is provided at the time of loading & unloading of materials into goods vehicles. e) Weather any spill of construction material from the truck during transportation.		

Stage-3: Completion of Construction/Pre-Opening checklist for safety Audit:

SL. NO.	DESCRIPTION	YES/NO	REMARKS

1	Have all recommendations from the previous stages been followed? If not, why not?		
2	Involve the site engineer		
3	Test the installations of traffic control devices as a road user: by car, by truck, by bus, by cycle and on foot-from disabled road user angle. Also in the dark/ night hours.		
4	Examine the carriageway for defects, especially at junctions to existing roads.		
5	Has the opening of the road facility been adequately publicized?		
6	How will the transition phase proceed?		
7	Check that provision for emergency vehicle access and stopping is safe?		
8	Check that all delineators and pavement markings are correctly in place.		
9	Check that all signs and other traffic control devices are correctly in place. Check that they are likely to remain visible at all times.		
10	Check that the road markings as installed have sufficient contrast with the surfacing and are clear of debris.		
11	Check that all lighting operating is effective from safety point of view.		
12	Check that no roadside hazard has been installed or overlooked.		
13	Check that the form and function of the road and its traffic management are easily recognized under likely operating conditions.		
14	Check that all temporary arrangements, signing, etc, have been removed and replaces by permanent arrangements.		
15	Other checks made at discretion of auditor or client.		

Stage 4: - Checklist during Operation and Maintenance Phase

SL.	DESCRIPTION	YES/NO	REMARKS

NO.			
1	Does the actual function of the road correspond to its intended function?		
2	Are the prevailing speed levels within desirable limits?		
3	Do the standard of the road correspond to its function, speed level and classification?		
4	Are the surface and carriageway markings in good conditions		
5	Are the surface and carriageway markings in good conditions?		
6	Are the specified distances to rigid obstacles maintained for all groups of road users?		
7	Are medians and islands of adequate width for the likely users?		
8	Are there signs of the pedestrian traffic in places that seem hazardous to pedestrians?		
9	Does there appear to be a need for more or better crossing facilities for pedestrians & non-motorised traffic?		
10	Has due considerations been given to children, the elderly, persons with disabilities?		
11	Are bus stops and bus bays safely located with adequate visibility and clearance to the traffic lane?		
12	Is provision for parking satisfactory in relation to traffic operations and safety?		
13	Are all locations free of construction or maintenance equipment, and any signing or temporary traffic control devices that are no longer required?		
14	Is the location of rest areas and truck parking areas along the route appropriate and adequate?		

CHECKLIST FOR LAYOUT, LOCATION AND ACCESS TO FUEL STATION ALONG NATIONAL HIGHWAYS

S.No	Item	Measurement at Site	MORTH Norms	Whether complying with MORTH Norm
1	**Distance from intersection**			
	1.1 Non-Urban(Rural) Stretch			
	1.1.1 Plain & Rolling Terrain			
	(i)Intersection with NHs/SHs/MDRs		1000m	YES/NO
	(ii)Intersection with Rural Roads/approach roads to private & public properties		300m	YES/NO
	1.1.2 Hilly/Mountainous Terrain			
	(i)Intersection with NHs/SHs/MDRs		300m	YES/NO
	(ii)Intersection with all other roads & tracks		100m	YES/NO
				YES/NO
	1.2 Urban Stretches			
	1.2.1 Plain and Rolling terrain			
	(A) Urban Area with population more than 20000 n less than one lakh			
	(i) Intersection with any category of Roads of Carriageway width of 3.5m and above		300m	YES/NO
	(ii) Intersection with any category of Roads of Carriageway width less than 3.5m		100m	YES/NO
	(B) Urban Area with population one lakh and above			
	(i) Intersection with any category of Roads(irrespective of carriageway width		100m	YES/NO
	1.2.2 Hilly/Mountainous Terrain			
	(i) Intersection with any category of Roads(irrespective of carriageway width		100m	YES/NO

2	Gap in the central median from fuel station(for divided carraige way only)		300m	YES/NO
3	Is it a part of Rest Area Complex?			YES/NO
4	**Distance from the nearest Fuel Station**			
	(A) Plain & Rolling terrain in Rural Areas			
	(i) Undivided Carriageway		min 300m	YES/NO
	(ii) Divided Carriageway		min 1000m	YES/NO
	(B) Hilly terrain & Urban stretches			
	(i) Undivided Carriageway		min 300m	YES/NO
	(ii) Divided Carriageway		min 300m	YES/NO
5	**(A)**Distance from Barrier e.g. Toll Plaza /Railway level crossings		1000m	YES/NO
	Mention wether the barrier located on the main carriageway or on Service Road seperated from the main Carriageway			YES/NO
	(B)(i) Distance from the start of approach road of Road Over Bridge		min 200m	YES/NO
	(ii) Distance from the start of Grade Seprator/Ramp		min 500m	YES/NO
6	Provision of 5.5m/7.0m wide service/connecting Road		neccesary at clustering of fuel station	YES/NO
	(i) Length of service road including deceleration and acceleration lanes for regulating ebtry to/exit from proposed fuel station		mention length (m)	
	(II) Whether the addition Land acquisition is required beyond the available ROW			YES/NO
	(iii) if yes, mention the additional L.A required to be done by the owner of fuel station		Mention Area(sq.m)	
7	Gradient of Highway Section		max 5%	YES/NO
8	Slope of Fuel station premises/Services Area for Drainage purpose		min 2%	YES/NO

9	(A) Width of Frontage of Plot		min 35m/20m	YES/NO
	(B) Depth of Plot		min 35m/20m	YES/NO
10	Length of Buffer Strip		min 12m (min 5m in hilly/urban area keeping min width of opening at entry and exit as 7.5m)	YES/NO
11	Width of Buffer Strip extending inside ROW		Min 3mm	YES/NO
12	Is there only one structure of approved identification sign on pole with existing on buffer strip		No structure or hoarding or parking space are allowed in the space in front of buffer strip	YES/NO
13	Hieght of Kerb for Buffer strip		min 275mm	YES/NO
14	Is the space from the outer of the buffer strip to the edge of the road turfed and raised with the provision of 275mm kerbs, with no other structure		No structure or hoarding or parking space are allowed in the space in front of buffer strip	YES/NO
15	Radius of turning curve		Min 13m	YES/NO
16	Radius of non- turning curve		Min 1.5m Max 3.0m	YES/NO
	(i) Whether addition Land acquisition is required by the side of ROW			YES/NO
	(ii) if yes, mention the additional L.A required to be done by the owner of fuel station		Mention Area(sq.m)	
17	Minimum downward slope of access towards the fuel station		Min 2%	YES/NO
18	Difference in level between highway and fuel station and acsess area measured at the edge of the shoulder on the Highway		Minimum 300mm	YES/NO
19	Provision of the culvert designed for Drainage		Slab culvert with iron grating of adequate strength	YES/NO
20	Provision of drinking water and toilet and display board at the entry of fuel station		Drawings showing these arrangement as per Highway Authority	YES/NO

21	Provision of adequate signs and markings		Min requirement as per drawings	YES/NO
22	whether the Oil company has certified that the fuel station is neither in operation nor energized and the construction of fuel station has not been commenced			YES/NO
23	Are the fuel stations are well distributed on both the sides of corridor			YES/NO
24	Proposed stations should not interfere with the future improvement of the highway			YES/NO

CHECKLIST FOR LAYOUT, LOCATION AND ACCESS TO PROPERTIES ALONG NATIONAL HIGHWAYS

S.No	**Item**	**Urban/Built of reaches**	**Rural reaches**	**Remarks**
1	Min distance between merging point of a service road including acceleration and deceleration lanes of 100m and 70m resp.	Length of plot+170m	Length of plot+170m	
	Min distance between merging point of two access on same side of the carriageway	100m	300m	If the distance is less than the distance specified, service road is provided/extended to cover the both access
2	Min distance from intersection/median opening and take off points of an access	100m	300m	If less than the distance specified, service road is provided/extended(which can left with the dead end also)

3	Min distance between merging point of two access on opposite side of the carriageway	In case of undivided carriageway it is preferred to have access connection to the properties on the opposite sides of the carriageway, which are exactly opposite to each other, to have minimum distraction to NH traffic. For divided carriageway no such restrictions applied.		
4	Min distance from crash barrier	1000m	1000m	If the distance is less than the distance specified, service road is provided/extended which can be left with the dead end also
5	Min distance from railway crossing	300m	300m	If the distance is less than the distance specified, service road is provided/extended which can be left with the dead end also
6	Width of entrance/exit	minimum 9m maximum12m		For other properties only
7	Radius of Turning curve	minimum 13m ruling20m		
8	Radius of non-Turning curve	minimum 1.5m maximum3m		
9	Length of acceleration Lane	100 m		
10	Length of deceleration Lane	70m		
11	Width of acceleration Lane	5.5m minimum		
12	Width of deceleration Lane	5.5m minimum		
13	Width of Sercice Road	5.5m-7.0m		

14	Crust composition of Service Road, Acceleration & Deceleration lane	Minimum 150mm thick Granular sub-base(GSB) overlaid by three layers of WBM, each of 75mm thickness overlaid by bituminous surfacing of min thickness of 20mm		
15	Crust composition of Access connection/Extended service road for residential properties	At least Gravel Road		For residential properties only
16	Width of Access connection/Extended service road for residential properties	Min 3.5m		
17	Radius of Turning curve	minimum 13m ruling 30m		
	ROAD SIGNS (ACCORDING TO IRC:67)			
18	Side road sign on NH before Deceleration lane			For other properties only
19	Appropriate facility information sign(i.e hospital school etc)			
20	One way Sign on left side of acceleration & deceleration lane			
21	No Parking Sign on left side of acceleration & deceleration lane			
22	No Entry sign on right side of deceleration at its connection with the Service road			
23	Appropriate no of Right turn prohibited signs on the Right side of the Service road in front of property plot			
24	Give way sign on the left side of the acceleration lane at 30m before its connection with NH			

25	No left turn sign on NH before its connection with Acceleration lane			
26	No Right turn sign on Right side of NH in case of undivided carriageway			
	ROAD MARKING (ACCORDING TO IRC:35)			
27	Marking for parallel acceleration lane			For other properties only
28	Marking for Tapered deceleration lane			
	DRAINAGE REQUIREMENTS			
29	Provision of culvert for Drainage in accordance with IRC SP-13	Min 1m span(Slab Culvert) with Grating perforations		For both residential properties and other properties
30	Provision for intercepting Drain with vertical drain system for rain water harvesting at the downstream end of the intercepting drain			
31	Downward slope of the access roads towards the intercepting drain	Min 2%		