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Road Safety and Audit: An Accident Studies of Selected Stretch Road

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Abstract:
Road safety Audit is important component in transportation planning process. Because of by 2020, road accident will be the 6th largest cause of death worldwide. Road safety is one of the main driving sources of the development of vehicular communication (VC) systems, relies on high-rate safety messaging. Safety measures should be included into transportation planning now a day the way the planning process is performed, including design, construction, operation, maintenance and analysis, is significantly affects traffic safety. This paper presents the Road safety Audit on the basis of vehicular communication, design, construction, operation, maintenance and analysis of various accidents occur in the road. In the future development providing safety to road user is very essential.

Key words: *Road safety Audit (RSA), vehicular communication (VC)*

1. Introduction

Every year a large number of people are died and injured on roads. Every year, states, counties, regions and municipalities spend amount of resources on trying to reduce accident by reconstructing and improving the roads. Road safety audit is simple procedure for assessment the accident potential and likely safety performance of a specific design of roads. Road safety assessment is a simple procedure for assessment of the likely effects of proposed road or traffic schemes. That has substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes. This paper aims to describe and illustrate the use of safety audits and safety assessment in helping to design and build safe road to users and reducing accident. Generally, roads are designed with a large number of criteria such a travel time, user comfort and convenience, fuel consumption, construction costs, environmental impact and objectives of urban or regional planning. Safety is one of judging something, but is often implicitly assumed to be achieved by adhering to prescribed standards of alignment and layout for each element of the design. Safety audit procedures ensure that independent expertise is used to make explicit the safety implications of an entire design and, doing so, lead to safer design of both new and modified roads. The scope of RSA is usually confined to an separate road scheme, which may be a new road or modification to an existing road. The foundation for safety audit is the application of safety principles to the design of a new or a modified road to prevent future accidents occurring or to reduce their severity. As vehicular traffic began to increase, the congestion on the streets began to hamper the safe and efficient movement of traffic. It is therefore necessary to give increasing attention to the operational characteristics of highway transportation and study the need for better geometric design, capacity, intersections, traffic regulations, signals, traffic signs, roadway markings, parking facilities and design of street lighting. Due to the rapid urbanization, the tremendous rise in number of vehicles is variably accompanied by ever increasing volume of traffic and intense traffic congestion on roads. In road traffic especially, the peaking phenomenon is very pronounced, giving rise to congestion. Because of the seriousness of the problem of congestion an understanding of the economic effects of congestion and the methods available for its mitigation are relevance to a traffic engineer. The existing street system which was evolved over the centuries was never designed to cope up with the future development. It has become quite difficult to stop the vehicle and get down at one's own will. Parking at a safe place is almost impossible in some areas. Congestion results in delays and time losses. An inevitable result of growth of traffic has been the increase in road accidents, which take a great toll of human life every year. In many of the accidents, the pedestrians are the sufferers. Children and the aged are another group that receives severe punishment. The methodology and techniques of these studies have been developed to a high degree and one can expect to evolve reasonably worked out answers to the problems of traffic. The work under study plans for better utilization and efficient reorganization of the existing street system, new bye-passes and expressways which can help to give relief to the traffic congestion.

The main objective is to provide safe traffic movements. Road accident cannot be totally prevented, but by suitable traffic engineering and management measures, the accident rates can be decreased considerably.

1.1. Accident Studies

The problem of accident is very acute in highway transportation due to complex flow patterns of vehicular traffic, presence of mixed traffic and pedestrians. Traffic accidents may involve property damages, personal injuries or even casualties. One of the main objectives of traffic engineering is to provide safe traffic movements. Road accident cannot be totally prevented, but by suitable traffic engineering and management measures, the accident rate can be decreased considerably. Therefore the traffic engineer has to carry out systematic accident studies to investigate the causes of accidents and to take preventive measures in terms of design and control. It is essential to analyse every individual accident and to maintain zone-wise accident records. The statistical analysis of accidents carried out periodically at critical locations or road stretches or zones will help to arrive at suitable measures to effectively decrease the accident rates.

The various objectives of the accident studies may be listed as:

- To study the causes of accidents and to suggest corrective treatment at potential location.
- To evaluate existing design
- To support proposed designs
- To carry out before and after studies and to demonstrate the improvement in the problem
- To make computations of financial loss
- To give economic justification for the improvements suggested by the traffic engineer

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2. Causes of Accidents

There are four basic elements in a traffic accident:-

- The Road user
- The vehicles
- The road and its condition, and
- Environmental factors- traffic, weather etc.

The road user responsible for the accident may be the driver of one or more vehicles involved, pedestrians or the passengers. Vehicles involved in the accident may also be defective. The condition of the road surface or other existing geometric features or any of the environmental conditions of the road may not be up to the expectation causing an accident. To sum up, an accident may be caused due to combination of several reasons and seldom due to one particular reason. Hence it is often not possible to pin point a particular single cause of an accident.

2.1. Various Causes of Accidents May Hence Be Listed as Given Below

- **Drivers** : excessive speed and rash driving, carelessness violation of rules and regulations, failure to see or understand the traffic situation, sign or signal, temporary effects due to fatigue, sleep or alcohol.
- **Pedestrians**: violating regulations, carelessness in using the carriageway meant for vehicular traffic.
- **Passengers**: lighting from or getting into moving vehicle.
- **Vehicle defects**: failure of brakes, steering system or lighting system tyre burst and other defects in the vehicles.
- **Road condition**: slippery or skidding road surface, pot holes, ruts and other damaged conditions of the road surface.
- **Road design**: defective geometric design like adequate sight distance, inadequate width of shoulder, improper curve design, improper lighting, and improper traffic control devices.
- **Weather**: unfavorable weather conditions like heavy rain fall which restrict normal visibility and render driving unsafe.
- **Animals**: stray animal on the road.
- **Other causes of accident**: incorrect signs or signals, gate of level crossing not closed when required, ribbon development, badly located advertisement boards or service station etc.

3. Accident Studies Records and Various Investigations

The various steps involved in traffic accident studies are collection of accident data, preparation of reports, location file and diagrams, and application of the above records for suggesting preventive measures.

3.1. Collection of Accident Data

The collection of accident data is the first step in the accident study. Standard forms for collecting the data are prepared, as suggested by IRC. The details to be collected are briefly mentioned here;-

- **General**: Date, time, persons involved in the accident and their particulars, classification of accident like fatal, serious, minor etc.
- **Location**: Description and details of the location of accident.
- **Details of vehicles involved**: Registration number make and description of the vehicle, loading details, vehicular defects.

- **Nature of accident**: Condition of vehicles involved, details of collision, and pedestrians or objects involved, damages, injuries casualties etc.
- **Road and traffic conditions**: Details of road geometrics, whether the road is straight or curved, surface characteristics such as dry, wet or slippery etc. Traffic condition- type of traffic, traffic density etc.
- **Accident cost**: The total cost of the accident computed in terms of rupees, of the various involvements like property damages, personal injuries and casualties.

3.2. Accident Report

The accident should be reported to police authorities who would take legal actions especially in more serious accidents involving injuries, casualties or severe damage to property. Accident report of the individuals involved may be separately taken. The accident data should be collected as given above and the accident report is prepared with all facts which might br useful in subsequent analysis, claims for compensation, etc.

3.3. Accident Records

The accident records are maintained giving all particulars of the accidents, location other details. The records may be maintained by means of location files, spot maps, collision diagrams and condition diagrams.

3.3.1. Location Files

These are useful to keep a check on the location of accident and to identify points of high accident incidence. Location fields should be maintained by each police station for the respective jurisdiction.

3.3.2. Spot maps

Accident location spot maps show accidents by spots, pins or symbols on the map. A map of suitable scale say, 1cm= 40 to60 m, may be used for spotting urban accidents.

3.3.3. Condition diagram

A condition diagram is a drawing to scale showing all important physical conditions of an accident location to be studied. The important features generally to be shown in this diagram with suitable dimensions marked there in an roadway limits , curves , kerb lines, bridges, culverts trees and all details of roadway conditions, obstruction to vision , property lines, signs, signals etc. There are standard symbols used in showing various details. The condition and collision diagrams may be combined together in a single sketch.

3.4. Accident Investigation

The scientific approach for accident investigations suggested by the authors is summarized below. It is suggested that mobile laboratory may be kept ready in every city. A bus equipped with essential instruments to measure the alcohol content in the breath, reaction time and other driver characteristics, skid resistance of pavement surface, etc, and a traffic engineer and his assistants may form the proposed mobile laboratory which should reach the accident spot as soon as possible after an accident. The following investigations may be carried out to enable analysis of the accident on a scientific basis.

3.4.1. Recording general observations for Accident investigations

- Measurement of length of skid marks due to partial and full skidding.
- Recording the relative positions of vehicles and objects involved in the accident and collision diagram supplemented with photographs.
- Details of accidents injuries and damages.
- Condition of pavement surface, shoulders and other surface through which the vehicles involved in the accident have moved; environmental conditions.
- Condition diagram of accident location with relevant measurements and dimensions.

3.4.2. Driver tests for Accident investigations

Analysis of breath of drivers involved in the accident for alcohol content (using a suitable breathalyzer; if alcohol consumption is indicated above a prescribed limit, collection of blood sample for further analysis in a forensic laboratory) In case the driver is dead , tests may be conducted on the spinal fluid for estimating the alcohol content , if any. Tests on driver characteristics such as reaction time, distance judgment, angle of clear vision etc. If the accident has occurred during night, glare vision, and glare recovery tests are to be conducted on the driver in addition to the above tests.

3.4.3. Vehicle tests for Accident investigations:

- Tests on the condition of brakes and steering of the vehicles involved.
- Tests on essential accessories and general condition of the vehicles involved in the accident.
- Characteristics and details of dents on the vehicles and other objects involved and the cross section details of the collapsed member.

3.4.4. Probable causes of the accident

Assessment of the probable causes ,(primary, secondary and contributing causes) of the accident, its type, site conditions, position of the vehicles and other objects involved and other existing conditions.

3.4.5. Cost analysis for Accident investigations

Estimation of the cost of accident by working out the cost involved for following items:

- Injuries and fatalities of persons involved
- Damages to the vehicles
- Property damages
- Other consequences including traffic delay
- Investigation and legal proceeding

4. Traffic Capacity Studies

Traffic volume is the number of vehicles moving in a specified direction on a given lane or roadway that pass a given point or cross section during specified unit of time. Traffic volume is expressed as vehicles per hour or vehicles per day. Traffic density is the number of vehicles occupying a unit length of lane of roadway at a given instant, usually expressed as vehicles per kilometer. Traffic volume is the product of the traffic density and traffic speed. The highest traffic density occurs when the vehicles are practically at a standstill on a given route, and in this case traffic volume will approach 0. Traffic capacity is the ability of a roadway to accommodate traffic volume. It is expressed as the maximum number of vehicles in a lane or a road that can pass a given point in unit time, usually an hour, i.e. vehicles per hour per lane or roadway. Capacity and volume are measures of traffic flow and have the same units. Volume represents an actual rate of flow and responds to variation in traffic demand, while capacity indicates a capability or maximum rate of flow with a certain level of service characteristics that can be carried by the roadway. The capacity of a roadway depends on a number of prevailing roadway and traffic conditions.

Basic capacity is the maximum number of passenger cars that can pass a given point on a lane or roadway during the hour under the most nearly ideal roadway and traffic conditions which can be possibly be attained. Two roads having the same physical features will have the same basic capacity irrespective of traffic conditions, as they are assumed to be ideal. Thus basic capacity is the theoretical capacity. Possible capacity is the maximum number of vehicles that can pass a given point on a lane or roadway during 1 hour under prevailing roadway and traffic conditions. The possible capacity of a road is generally much lower than the basic capacity as the prevailing roadway and traffic conditions are seldom ideal. In a worst case when the prevailing traffic condition is so bad that due to traffic congestion, the traffic may come to a standstill, the possible capacity of the road may approach zero.

When the prevailing roadway and traffic conditions approach the ideal conditions, the possible capacity would also approach the basic capacity. Thus the value of possible capacity varies from zero to basic capacity. For the purpose of design, neither basic capacity nor possible capacity can be adopted as they represent two extreme cases of roadway and traffic conditions. Practical capacity is the maximum number of vehicle that can pass a given point on a lane on roadway during one hour, without traffic density been so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to manoeuvre under the prevailing roadway and traffic conditions. It is the practical capacity which is of primary interest to the designers who strive to provide adequate highway facilities and hence this is also called design capacity.

4.1. Factors affecting practical capacity

Some of the important factors that affect the practical capacity of a traffic lane are listed below:-

- **Lane Width**: - As the lane width decreases, the capacity also decreases. The practical capacity of 3.0 m wide lane in a two lane road may decrease to 76% of the capacity of a 3.5 m lane.
- **Lateral Clearance**: -Vertical obstructions such as retaining walls or parked vehicles near the traffic lane reduced the effective width of a lane and thus result in reduction in the capacity of lane. Further,restricted lateral clearance affects driving comfort and increases accident rates .A minimum clearance of 1.85m from the pavement edge to the obstruction is considered desirable so that capacity is not affected at adversely. When the distance from pavement edge to an obstruction decreases to 0.75m on one side only, the capacity decreases to 96%and when this obstruction is on both sides, the percentage further decreases to 80% of the standard design capacity.
- **Width of shoulders**:-Narrow shoulders reduce the effective width of traffic lanes as the vehicles travel towards the centre of the pavement. When vehicles in emergency (like that of a tyre puncture or other breakdown) have to park on the shoulder of insufficient width, there is diction in effective lane width resulting in a great reduction in the capacity of the lane.
- **Commercial vehicles**: -Large commercial vehicles like truck and buses occupy greater space and influence the other traffic in the same lane as well as the vehicles along the adjoining lanes. Also these heavy commercial vehicles may travel at lower speed especially on grades.
- **Alignment**: -If the alignment and geometrics are not up to the desired standards, the capacity will decrease. Particularly, restrictions to side distance requirements cause reduction incapacity. Steep and long grades affect the capacity. When 60% of the road length has substandard OSD, the capacity decreases to 65% of the standard design capacity
- **Presence of intersection at grade**: Intersections restrict free flow of traffic and thus adversely affect the capacity. The capacity of an intersection of two roads crossing at grade will be slightly less than the road with lower capacity of the two. At

signalized intersection as the vehicles have to stop alternately to allow crossing traffic, the capacity of the intersection will be further decreased .In order to provide consistent traffic flow and maximum capacity on important highways, is necessary to plan them as controlled access highways with grade separated intersections

- **Other factors**: Other factors which affect the capacity are the stream speed, one or two way traffic movement, number of traffic lanes, vehicular and driver characteristics, composition of traffic and the traffic volume

5. Objectives of Study

- Minimizing the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes;
- Reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes;
- Reducing the long-term costs associated with a planning decision or a road scheme;
- Enhancing the awareness of road safety needs among policy-makers and scheme designers.
- To minimize the number and severity of accidents that will occur on the new or modified road;
- To avoid the possibility of the scheme giving rise to accidents elsewhere in the road network; and
- To enable all kinds of users of the new or modified road to perceive clearly how to use it safely.

6. SITE Selection for Study Area

The stretch selected in Nagpur city from Sitabuldi to Butibori for analysis. The selected highway stretch has been newly reconstructed and upgraded. The location map shown in Figure 1 This National Highway is maintained and operated by National Highway Authority of India (NHAI) under the Ministry of Road Transport and Highways (MOR&TH).

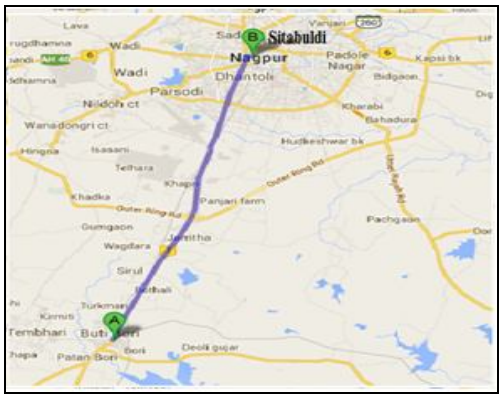


Figure 1: Location map of proposed area under study

7. Collection of Accident Data

The accident data collected of the selected highway from respective police stations. The accident data collected for a period of four years from 1/1/2010 to 31/12/2013.The accident should be reported to police authorities who would take legal actions especially in more serious accidents involving injuries, casualties or severe damage to property. Accident report of the individuals involved may be separately taken. The accident data should be collected as given above and the accident report is prepared with all facts which might be useful in subsequent analysis, claims for compensation, etc. It is given in table 1.

Year	Fatal	Serious injured	Major injured	Minor injured	No of accident
2010	41	58	59	15	173
2011	29	82	105	32	248
2012	55	82	114	56	307
2013	81	83	77	103	344

Table 1: Summary of Accidents Detail of Study Area

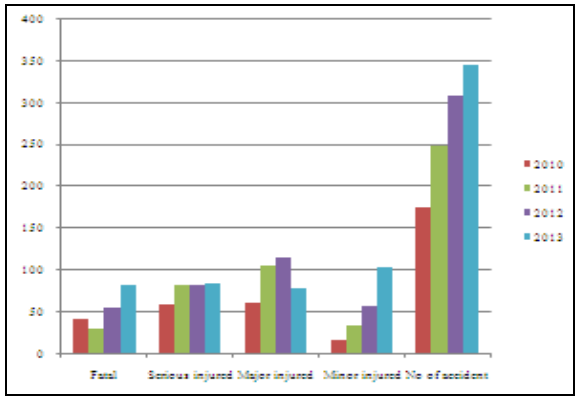
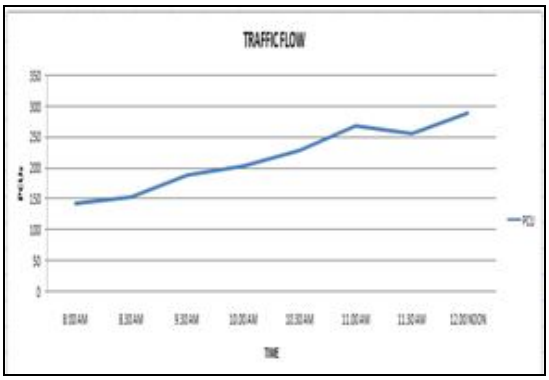


Figure 2: Graphically accidents details in each years

8. Traffic Condition

According to data collection the traffic condition on National Highway from Sitabuldi to Butibori at day time and evening with passenger car unit is given as:



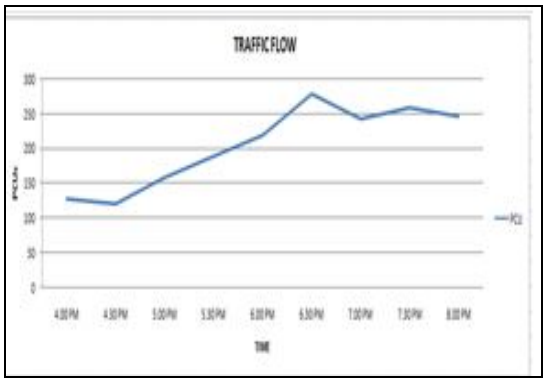


Figure 3: Graph to present traffic flow variations Day time

Figure 4: Graph to present traffic flow variations Evening time

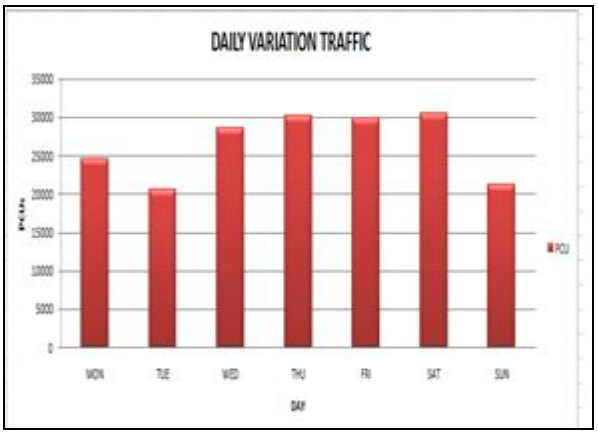


Figure 5: Traffic variations on different days

9. Recommended Growth Rate (%) of Motor Vehicles

The growth rate of commercial vehicles is considered directly proportional to the growth rates estimated for different sectors such as agriculture, industry, trade and mining, etc. of the influence zones. The National State Domestic Product (NSDP) for the various sectors is considered. In order to arrive at the growth rate of commercial vehicles, the influence of each zone in terms of commercial traffic has been considered. The relative impact of each sector was gauge on the basis of commodities being carried by goods vehicles. The growth rate in passenger traffic, especially cars/van/jeeps largely depends on the growth in per capita income and population in the project influence area and GDP (Gross Domestic Product) of the state. The recommended growth rates of vehicles on the project corridor are given in table 2 as per National Highways Authority of India

Year	BUS		2-Axle		3-Axle		MAV	
	Growth Rate	AADT	Growth Rate	AADT	Growth Rate	AADT	Growth Rate	AADT
2004		299		2077		772		148
2005	5.0%	314	8.0%	2243	8.0%	834	8.0%	160
2006	5.0%	330	8.0%	2423	8.0%	900	8.0%	173
2007	5.0%	346	8.0%	2616	8.0%	972	8.0%	186
2008	5.0%	363	8.0%	2826	8.0%	1050	8.0%	201
2009	5.5%	383	8.5%	3066	8.5%	1140	8.5%	218
2010	5.5%	405	8.5%	3327	8.5%	1236	8.5%	237
2011	5.5%	427	8.5%	3609	8.5%	1342	8.5%	257
2012	5.5%	450	8.5%	3916	8.5%	1456	8.5%	279
2013	5.5%	475	8.5%	4249	8.5%	1579	8.5%	303
2014	5.5%	501	8.5%	4610	8.5%	1714	8.5%	328
2015	5.5%	529	8.5%	5002	8.5%	1859	8.5%	356
2016	5.5%	558	8.5%	5427	8.5%	2017	8.5%	387
2017	5.5%	588	8.5%	5888	8.5%	2189	8.5%	420

Table 2: Recommended Growth Rates in %

10. Spot Speed Study

As the traffic increases due increasing number of vehicles. Therefore number of accidents is also increased, according to data collection. As the numbers of increasing vehicles cannot be control, so speed is only the factor that after controlling it on national highway reduces the accidents. So to decide speed limit on highway spot speed study should be done in this study. Spot speed study survey had been done on the highway on 12 October 2013 by using Video graphic method for determining spot speed.

Sec.	Mph 176ft	Passenger vehicle	Bus	Truck	Total
1	120				
1.2	100				
1.4	86				
1.6	75	31			31
1.8	67	42			42
2	60	58			58
2.2	55	61	21	3	85
2.4	50	49	35	6	90
2.6	47	41	21	9	71
2.8	43	45	22	21	88
3	40	30	20	36	86
3.2	37	12	11	38	61
3.4	36	6	5	15	26
3.6	34	2	2	6	10
3.8	32			3	3
4	30			1	1
4.2	29				
				Total	652

Table 3: Spot Speed data form

Speed (mph)	Frequency of Vehicles	Cumulative Frequency	Cumulative Percent	Speed Percentile
30	1	1	0.15	
32	3	4	0.61	
34	10	14	2.14	
36	26	40	6.13	
37	61	101	15.49	
40	86	187	28.68	
43	88	275	42.17	50th
47	71	346	53.06	
50	90	436	66.87	
55	85	521	79.9	85th
60	58	579	88.8	
67	42	621	95.24	
75	31	652	100	

Table 4: Spot Speed Study Distribution Table

11. Conclusion

Based on the present study of RSA for highways the following conclusions have been concluded**:**

- The road standards have been suddenly raised. But other related factors are not brought to this level such as road user prevailing surrounding conditions, etc. The road standards are permitting high speeds, but prevailing traffic conditions are not conducive to such speeds. Earlier the average speed of vehicles was 30-40 Kmph and now 60-70 Kmph where as design speed is 100 Kmph which is very high. From simulation data, it found that Road Markings, Condition of Shoulder, Spot Speed, Traffic Volume , Median Opening and Carriageway condition were main parameters for causing accidents. It was seen that slow moving traffics were creating hazards for fast moving traffic as it always occupied the innermost lane of highway.
- I have concluded that to reduce congestion all the heavy traffic from MIDC area(Buti Bori) should be diverted Nagpur to Wardha road, there should be a provision of fly over , Road widths should be increase to avoid congestion, Signals should be provided, Parking must be provided in market area, Speed of vehicles must be reduced, condition of street lightning should be improved and for minimizing accidents. Conducting traffic safety program, Travel time studies need to be repeated periodically, Traffic management and traffic operation schemes should be adopted**.**

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