TRAFFIC SAFETY ANALYSIS AND MANAGEMENT: A CASE STUDY

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Abstract: Road safety is an important aspect that creates ecological balance and social well-being. A road accident creates a situation that leaves behind distress, sorrow, and sufferings. Therefore identification of causes of road accidents becomes highly essential for adopting necessary preventive measures against a critical event. The damage created by road accidents to large extent is unrepairable and therefore needs attention to eradicate this continuously increasing trend of awful "epidemic". Road accident in India is among the highest in the world, with at least 1,42,485 killed each year on the road.

Kashmir region is an ecologically sensitive place but lacks necessary facilities and infrastructure regarding road transportation, ultimately resulting in the critical event-road accidents creating a major problem for common people in the region.

The objective of this project is to study the safety aspect of Khanabal to Pantha chowk stretch of National Highway 1A and also to suggest the possible remedies for lessening/eliminating the road accidents on the road stretch.

Index Terms- Traffic Safety, Analysis, Management, NH1A.

INTRODUCTION

1.1 GENERAL

Road accident is a serious problem in Khanabal to Pantha chowk road stretch of NH1A. In the year 2014 to 2016 there were 726 road accidents that lead to approximately 178 fatalities and left 1002 injured (as per data collected from Pantha chowk, Pampore, Awantipora, Bijbehera and Anantnag Police stations).

Many of the data elements currently collected are not of sufficient quality to meet the needs of data analysts. A primary source of highway safety data is crash data collected by police officers at the scene. Police are unique in their ability to collect on-scene crash data shortly after the crash occurs, as well as the transient data that may erode (i.e., tire marks) or be removed from the scene.

Although police are in a unique position to collect crash data, data collection is not their only responsibility. Their primary on-scene responsibilities include securing the crash site, caring for injured persons, and re-establishing traffic flow. Therefore, on-scene data collection systems must consider the officer's needs when implementing new technologies.

Once a series of data collected, accident sites have are selected for possible treatment and before a decision can be made on which sites will be treated and the type of improvement work necessary, further information is usually needed. This extra data, obtained through site visits, should relate to both the site accident data and to the other factors that might help to determine what the problem at the site are. On-site visit data should include details of the road, its environment, vehicle features and road user characteristics, signs and marking, lighting, width, poles, posts, number of lanes, rocks, trees, other cross fall comprehensibly obstruction hazards, gradient credibility, parked vehicles, safety barriers, fences, shoulder , lane centre, on-street parking, side slopes, verge and edge lines, culverts, median and other markings, off-street parking and bridge abutments, visibility, footpath, clearway hours, kerbs, delineators, drainage, loading facilities, bus stops, off traffic control devices, physical obstruction of parked vehicles, friction intensity, speed limit, super elevation, land uses, channelization, crossing facilities, turning radius etc.

Having identified dominant accident types at a location or area under study will, hopefully, give an indication of an appropriate remedial measure. This involves selecting a package of possible countermeasures for a site and prioritizing the potential treatments. This is done by deciding on appropriate objectives of the various safety strategies based on achieving satisfactory accident reductions. It is desirable to consider a number of alternative proposals for each site. For every proposal it should be checked that:

- The measures are likely to decrease the type of Potential Countermeasures accident at which they are aimed.
- No further increase in other types of accident is likely to occur as a result of the selected measure.
- No adverse effect on environment.
- Cost effective or economical.

1.2 LOCATION OF STUDY STRETCH

National Highway 1A (NH 1A) that has been renumbered as NH 44, is a National Highway in North India that connects the Kashmir valley to Jammu and the rest of India. The northern terminal is in Uri in Jammu & Kashmir and the southern terminal is in Jalandhar. Stretches of NH 1A run through some extremely treacherous terrain and shut-offs because of avalanches or landslides are common in winter months. The famous Jawahar Tunnel that connects Jammu with the Kashmir Valley across the Pir-Panchal Range falls en route. The total length of NH 1A is 663 km.

The case study is done on the Khanabal to Pantha chowk road stretch of NH-1A, which is around 44 kms of flexible pavement, bituminous course. The Khanabal to Pantha chowk stretch of national highway carries heavy traffic and lacks the necessary transportation facilities and infrastructure, ultimately making it prone to road traffic accidents and creating a major problem for the common people in this region.

Fig.1.1 Study stretch of National Highway 1A Khanabal to Panthachowk.

1.4 CAUSES OF ACCIDENTS

The causes of road accidents are several and can be divided broadly into following categories.

- Road Engineering
- Traffic Engineering
- Lack of Monitoring Agencies.
- Human negligence and error.

1.4.1 ROAD ENGINEERING

The blind curves, disturbing gradients, faulty alignments of roads are the possible reasons for road accidents. Another reason is the nature of our highways. Roads have not been engineered to accommodate sharp curves, hills and bumps.

1.4.2 TRAFFIC ENGINEERING

Though traffic engineering is a part and parcel of road engineering it has never received its due priority. The tendency of neglecting cautionary sign boards by the drivers is one of the main causes of accidents. The absence of direction signs at the intersecting roads, high traffic density on National Highways, high speed while passing through populated areas are also contributing to road accidents.

1.4.3 LACK OF MONITORING AGENCIES

The non-cooperation from road related authorities are contributing heavily in road accidents by their apathies and inaction to serious problems. The authorities are contributing very largely in increasing the road accidents by allowing movements of non-road worthy vehicles, as well as movement of extra lengthy ,abnormally loaded, over projected goods ,loaded vehicles without proper cautionary indication board and sometimes without compliance of required safety measures.

1.4.4 HUMAN NEGLIGENCE AND ERROR

The concept of driver fatigue seldom gets the importance it deserves. During accidents all possible causes of fatal accidents as drivers negligence, over- speeding de-boarding, victim’s fault of hit and run, but driver fatigue has never been listed . Driver fatigue is a complex problem and it is very much a road safety problem. It is better to be aware with the various issues connected with driver fatigue sooner than later.

1.5 OBJECTIVE

A comprehensive safety management of road infrastructure becomes more and more important in this road stretch, Khanabal to Pantha chowk NH 1A. This paper gives an insight into the road stretch's analytical road safety work based on the policies:

5E's-

- Engineering.
- Enforcement.
- Education.
- Encouragement.
- Emergency Preparedness.

Mapping of accidents (i.e. locations, types, circumstances, road users, etc.) is an essential prerequisite for drawing sound conclusions concerning accident countermeasures. This applies in particular to accident accumulation sites (black spots).

Road safety analysis procedures contribute significantly to a better understanding of creating safer standards for roads.

These accident countermeasures include technical aspects of vehicles as well as behavioural influencing measures and road infrastructure related measures.

It could be strongly expected that these procedures will comprise the kernel of any safety related work for roads in this region - some details will be given here as follows:

a) The aspects of road traffic safety have to be considered in the planning and design process on a strategic level. The evaluation requires the possibility to carry out cost-benefit-analyses on the basis of reliable and comprehensive accident data.

b) Further on there is the road safety audit defined as on independent and systematic screening procedure for the existing road network. Road safety audit are in common use in a number of parts but are comparatively new in J & K.

c) To keep the standard for safety and operability of a road section there is a need of periodical official inspection to recognize defectives exactly and efficiently. The method is established to find defects on the road side or infrastructure.

On the other hand the local road authorities have to check their sections of the road network at regular intervals. This is a process of monitoring the road safety trend on the existing road sections. All items together present a consistent system of a road safety analysis. A successful application of these procedures for practical use depends strongly on the available data-basis, then identifying Black Spots with respect to severity and fatality of accidents and detailed investigation of these sites for recommending preventive measures.

1.6 OVERALL METHODOLOGY

The methodology of the project work is classified into three major steps. The first one is the accident data collection, the second one is the data analysis and last step is to recommend countermeasures. The overall methodology involves:

- Data collection of various accident records from Police stations that comes under the jurisdiction of this road stretch (reference FIR records).
- Data storage.
- Data collection from onsite visit.
- Analysis of data and prioritization of data statistics.
- Identification of black spots.
- Recommendations of countermeasures for various accident black spots.

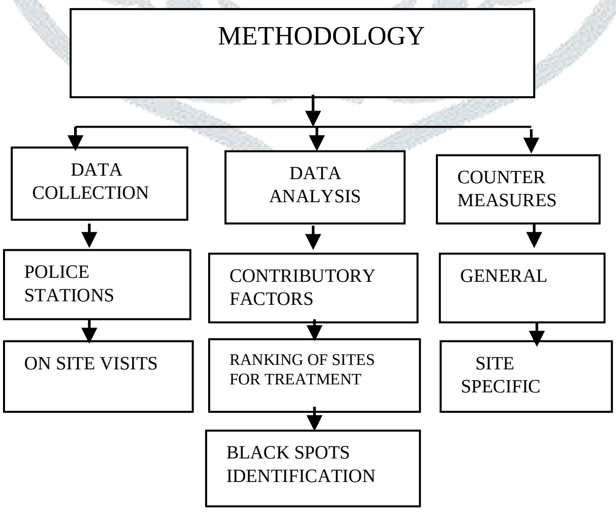

Fig 1.2 Illustration of the methodology of the Project.

DATA COLLECTION

2.1 INTRODUCTION

Highway safety data analysts desire better quality data to meet a wide variety of needs.

Many of the data elements currently collected are not of sufficient quality to meet the needs of data analysts. A secondary source of highway safety data is crash data collected from police stations and primary data are collected from site visit.

2.2 PRIMARY DATA COLLECTION

Primary data collection involves the following parameters which are collected after site visit.

1. Design Speed
2. Horizontal Curves,
3. Super-elevation,
4. Sight Distance
5. Vertical Grades.
6. Carriageway width.
7. Shoulder width.

2.2.1 DESIGN SPEED:

Excessive speed is one of the main causes of road crashes. Speeds are deemed to be excessive when drivers travel too fast for the prevailing conditions. Designers must recognize situations where high speeds can be expected as a result of normal driver behaviour and design these sections of road to a standard appropriate for their safe and efficient operation.

The design speed is the speed selected as the basis for establishing appropriate geometric elements for a section of road. These elements include horizontal and vertical alignment, super-elevation and sight distance. The design speed must be set before any design can be started, because design elements are related to the design speed in order to obtain a balanced design in terms of driving safety, comfort, and mobility.

The chosen design speed should be a logical one consistent with the road function as perceived by the driver and also one that takes into account the type of road, the anticipated operating speed, and the terrain that the road traverses. Changes in terrain and other physical controls may, however, dictate a change in design speed on certain sections. The justification for introducing a reduced design speed should be obvious to the driver. The design speed is calculated by moving a vehicle with highest moving traffic flow plying on the National Highway. Generally it was found that the speed was around 80-100 km/ph.

2.2.2 HORIZONTAL CURVES

The maximum comfortable speed on a horizontal curve depends on the radius of the curve. Although it is possible to design the curve with maximum super-elevation and coefficient of friction, it is not desirable because re-alignment would be required if the design speed is increased in future. Therefore, a ruling minimum radius R_{ruling} can be derived by assuming maximum super-elevation and coefficient of friction.

$R_{ruling} = v^2/g\ (e + f)$ (1)

Ideally, the radius of the curve should be higher than $R_{ruling.}$ However, very large curves are also not desirable.

2.2.2.1 ALGORITHM TO FIND RADIUS OF A CURVE OF AN EXISTING ROAD

A very common method used by accident investigators is to calculate roadway curve radii from chord-offset measurements taken in the field. The Chord-Offset Method usually uses a 100-foot tape held on either end at the precise edge of the roadway, while a carpenter's rule is used at the middle of the tape to measure the distance between the edge of the tape and the edge of the roadway. These two measurements, the 100-foot chord length and the measured middle offset, are then used in the following equation to compute the radius Fig 2.1)

$R = C^2 /8V + V/2$

Where R = the roadway curve radius, feet, C = the chord length, feet,

V = the measured middle offset, feet.

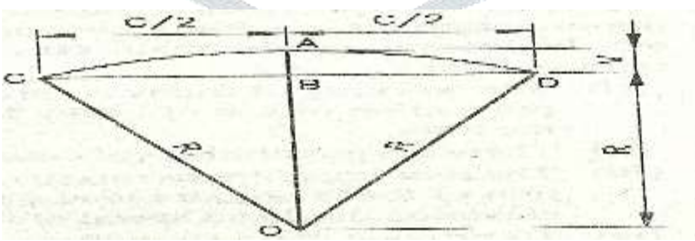

Fig 2.1 Calculation of radius by offset method.

Table 2.1: Absolute minimum Radius of curves for various terrain.

TYPE OF ROADS	PLAIN TERRAIN	ROLLING TERRAIN	MOUNTAINEOUS TERRAIN IN AREAS NOT AFFECTED BY SNOW	MOUNTAINOUS TERRAIN IN SNOW BOUND AREAS	STEEP TERRAIN IN AREAS NOT AFFECTED BY SNOW	STEEP TERRAIN IN SNOW BOUND AREAS
NATIONAL AND STATE HIGHWAYS	230	155	50	60	30	33
MAJOR DISTRICT	155	90	30	33	14	15

ROADS						
OTHER DISTRICT ROADS	90	60	20	23	14	15
VILLAGE ROADS	60	45	14	15	14	15

EXTRA WIDENING:

Extra widening refers to the additional width of carriageway that is required on a curved section of a road over and above that required on a straight alignment. This widening is done due to two reasons: the first and most important is the additional width required for a vehicle taking a horizontal curve and the second is due to the tendency of the drivers to ply away from the edge of the carriageway as they drive on a curve. The first is referred as the mechanical widening and the second is called the psychological widening.

MECHANICAL WIDENING

The reasons for the mechanical widening are: When a vehicle negotiates a horizontal curve, the rear wheels follow a path of shorter radius than the front wheels. This phenomenon is called off tracking, and has the effect of increasing the effective width of a road space required by the vehicle. Therefore, to provide the same clearance between vehicles traveling in opposite direction on curved roads as is provided on straight sections, there must be extra width of carriageway available. (Fig 2.2)

Therefore the widening needed for a single lane road is:

$W_m = nl^2/2R$

Where R is a radius of curve, n= number of lane, l= length of wheel base

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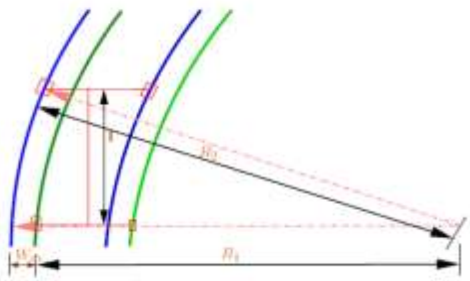

Fig 2.2 Extra widening in horizontal curve.

PSYCHOLOGICAL WIDENING

Widening of pavements has to be done for some psychological reasons also. There is a tendency for the drivers to drive close to the edges of the pavement on curves. Some extra space is to be provided for more clearance for the crossing and overtaking operations on curves. IRC proposed an empirical relation for the psychological widening at horizontal curves.

Therefore, the total widening needed at a horizontal curve, We is:

$W_e = W_m + W_{ps} = nl^2/2R + v/9.5\sqrt{R}$ (2)

Where v= design speed in kmph,

R is a radius of curve, n= number of lane,

1=length of wheel base.

2.2.3 SUPERELEVATION

When a vehicle goes around a curve, it experiences a lateral force known as centrifugal force. This lateral force pushes the vehicle and occupants outward from centre of the circle. The lateral force is caused by the directional change of the vehicle (i.e., directional change of the velocity vector) called centripetal acceleration. This is similar to the acceleration forces from increasing vehicle speed, with the exception that the acceleration is towards the centre of the circle. Super-elevation is the banking (rotation) of a highway to counter some of the lateral force. The banking causes a portion of the lateral acceleration to act normal (perpendicular) to the banked pavement. This is felt as a downward (with respect to the vehicle) force by the vehicle occupants. The remaining portion of the lateral force may act one of three ways depending on the banking and speed of the vehicle (Fig 2.3);

If the speed is balanced for the banking, the lateral force acting outward on the vehicle will be countered by the forces pushing the vehicle down the slope of the banking. The vehicle and occupants will experience a downward force (perpendicular to the roadway) and the vehicle will travel around the curve with little steering input. This is a neutral or equilibrium condition.

If the vehicle is traveling faster than the equilibrium speed, the resultant lateral force acts outward on the vehicle and occupants. At excessive speeds, the vehicle will skid or roll off the road.

If the speed is lower than the equilibrium speed, the vehicle and occupants are forced inward. Extreme banking can cause top heavy vehicles to rollover towards the inside of the curve. Additionally, icy conditions can cause the vehicle to slide down the banking, particularly when the tires are spinning to accelerate in stop and go traffic.

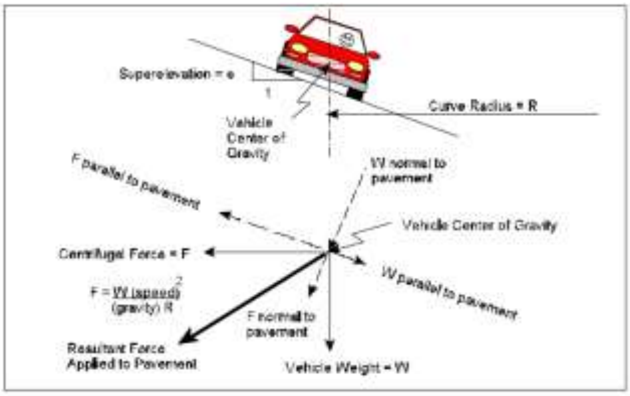

Fig 2.3 Concerning forces on banked roadways.

While designing the various elements of the road like super-elevation, we design it for a particular vehicle called design vehicle which has some standard weight and dimensions. But in the actual case, the road has to cater for mixed traffic. Different vehicles with different dimensions and varying speeds ply on the road. For example, in the case of a heavily loaded truck with high centre of gravity and low speed, super-elevation should be less, otherwise chances of toppling are more. Taking into practical considerations of all such situations, IRC has given some guidelines about the maximum and minimum super-elevation etc.

Design of super-elevation:

For fast moving vehicles, providing higher super-elevation without considering coefficient of friction is safe, i.e. centrifugal force is fully counteracted by the weight of the vehicle or super-elevation. For slow moving vehicles, providing lower super-elevation considering coefficient of friction is safe, i.e. centrifugal force is counteracted by super-elevation and coefficient of friction. IRC suggests following design procedure;

Step 1: Find e for 75 percent of design speed, neglecting f, i.e

$e1 = (0.75v)^2/gR$

Step 2: If $e1 \leq 0.07$, then $e = e1 = (0{:}75v)^2/gR$,

Else

if $e1 > 0{:}07$ go to step 3.

Step 3: Find f1 for the design speed and max e, i.e

$f_1 = v^2/gR - e = v^2/gR - .07$

if $f_1 < 0.15$, then the maximum e =.07 is safe for the design speed, else go to step 4

Step 4: Find the allowable speed v_a for the maximum e=.07 and f =.15, $v_a = \sqrt{22gR}$. If $v_a \geq v$ then the design is adequate, otherwise use speed adopt control measures.

2.2.3.1 MAXIMUM SUPERELEVATION RATES

High rates of super-elevation may cause slow moving vehicles to slide down the banking in snow and ice. High super-elevation rates can be difficult to attain in urban settings due to closely spaced intersections, numerous driveways, and limited right of way.

The maximum super-elevation rates which are commonly used:

Depends on (a) slow moving vehicle and (b) heavy loaded trucks with high CG. IRC specifies a maximum super-elevation of 7 percent for plain and rolling terrain, while that of hilly terrain is 10 percent. The minimum super elevation is 2-4 percent for drainage purpose, especially for large radius of the horizontal curve.

2.2.3.2 ROLLOVER

The typical passenger car will skid long before it rolls over on the pavement, particularly in wet weather. Trucks, vans, and sport utility vehicles have much higher centers of gravity and may roll over before skidding, particularly in dry weather and at lower speeds.

2.2.3.3 FRICTION

Friction allows cornering, braking, and acceleration forces to be transmitted from the tires to the pavement. Rather than using the “coefficient of friction” from dynamics, highway engineers use a ratio of the lateral forces that the pavement can resist. This lateral ratio is most commonly referred to as the “friction factor”.

The friction factor to counter centrifugal forces is reduced by vehicle braking (decelerating) and accelerating. The friction factor also depends on numerous variables, including the vehicle speed, weight, suspension, tire condition), tire design, pavement, and any substance between the tire and pavement. Since the friction factor decreases as speed increases, numerous studies have been performed to develop friction factors for various speeds.

Table 2.2 Coefficient of side friction for various design speeds and radius of curve

Design Speed (kmph)	Coefficient of side friction (f_s)	Minimum Radius (m)
30	0.17	30
40	0.17	55
50	0.16	90
60	0.15	135
70	0.14	195
80	0.14	250
90	0.14	340
100	0.13	450

2.2.4 SIGHT DISTANCE

The safe and efficient operation of vehicles on the road depends very much on the visibility of the road ahead of the driver. Thus the geometric design of the road should be done such that any obstruction on the road length could be visible to the driver from some distance ahead. This distance is said to be the sight distance. Sight distance available from a point is the actual distance along the road surface, over which a driver from a specified height above the carriage way has visibility of stationary or moving objects. Three sight distance situations are considered for design:

- Stopping sight distance (SSD) or the absolute minimum sight distance.
- Intermediate sight distance (ISD) is designed as twice SSD.
- Overtaking sight distance (OSD) for safe overtaking operation.
- Head light sight distance is the distance visible to a driver during night driving under the illumination of head lights.
- Safe sight distance to enter into an intersection.

The most important consideration in all these is that at all times the driver traveling at the design speed of the highway must have sufficient carriageway distance within his line of vision to allow him to stop his vehicle before colliding with a slowly moving or stationary object appearing suddenly in his own track lane.

The computation of sight distance depends on:

- Reaction time of the driver:

Reaction time of a driver is the time taken from the instant the object is visible to the driver to the instant when the brakes are applied. The total reaction time may be split up into four components based on PIEV theory. In practice, all these times are usually combined into a total perception-reaction time suitable for design purposes as well as for easy measurement. Many of the studies shows that drivers require about 1.5 to 2 secs under normal conditions. However, taking into consideration the variability of driver characteristics, a higher value is normally used in design. For example, IRC suggests a reaction time of 2.5 secs.

- Speed of the vehicle:

The speed of the vehicle very much affects the sight distance. Higher the speed, more time will be required to stop the vehicle. Hence it is evident that, as the speed increases, sight distance also increases.

- Efficiency of brakes:

The efficiency of the brakes depends upon the age of the vehicle, vehicle characteristics etc. If the brake efficiency is 100%, the vehicle will stop the moment the brakes are applied. But practically, it is not possible to achieve 100% brake efficiency. Therefore the sight distance required will be more when the efficiency of brakes are less. Also for safe geometric design, we assume that the vehicles have only 50% brake efficiency.

- Frictional resistance between the tyre and the road:

The frictional resistance between the tyre and road plays an important role to bring the vehicle to stop. When the frictional resistance is more, the vehicles stop immediately. Thus sight required will be less. No separate provision for brake efficiency is provided while computing the sight distance. This is taken into account along with the factor of longitudinal friction. IRC has specified the value of longitudinal friction in between 0.35 to 0.4.

- Gradient of the road:

Gradient of the road also affects the sight distance. While climbing up a gradient, the vehicle can stop immediately. Therefore sight distance required is less. While descending a gradient, gravity also comes into action and more time will be required to stop the vehicle. Sight distance required will be more in this case.

2.2.4.1 STOPPING SIGHT DISTANCE

Stopping sight distance (SSD) is the minimum sight distance available on a highway at any spot having sufficient length to enable the driver to stop a vehicle traveling at design speed, safely without collision with any other obstruction. There is a term called safe stopping distance and is one of the important measures in traffic engineering. It is the distance a vehicle travels from the point at which a situation is first perceived to the time the deceleration is complete. Drivers must have adequate time if they are to suddenly respond to a situation. Thus in highway design, sight distance at least equal to the safe stopping distance should be provided.

The stopping sight distance is the sum of lag distance and the braking distance. Lag distance is the distance the vehicle travelled during the reaction time t and is given by vt, where v is the velocity in m/sec^2.

Braking distance is the distance travelled by the vehicle during braking operation. For a level road this is obtained by equating the work done in stopping the vehicle and the kinetic energy of the vehicle.

If F is the maximum frictional force developed and the braking distance is l, then work done against friction in stopping the vehicle is

$$Fl = fWl$$

Where, W is the total weight of the vehicle.

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{Wv^2}{g}$$

$$fWl = \frac{Wv^2}{2g}$$

The kinetic energy at the design speed is

$$l = \frac{v^2}{2gf}$$

Therefore, SSD = lag distance + braking distance and given by:

$$SSD = vt + \frac{v^2}{2gf}$$

Where, v is the design speed in m/sec^{2,} t is the reaction time in sec, g is the acceleration due to gravity and f is the coefficient of friction.

When there is ascending gradient of +n%, the component of gravity adds to braking action and hence braking distance is decreased. The component of gravity acting parallel to the surface which adds to the braking force is equal to

$$W \sin\alpha \approx W \tan\alpha = Wn/100.$$

Equating kinetic energy and work done:

$$\left(fW + \frac{Wn}{100}\right)l = \frac{Wv^2}{2g}$$

$$l = \frac{v^2}{2g\left(f + \frac{n}{100}\right)}$$

The general equation is given

$$SSD = vt + \frac{v^2}{2g(f \pm 0.01n)}$$

2.2.4.2 OVERTAKING SIGHT DISTANCE

The overtaking sight distance is the minimum distance open to the vision of the driver of a vehicle intending to overtake the slow vehicle ahead safely against the traffic in the opposite direction. The overtaking sight distance or passing sight distance is measured along the center line of the road over which a driver with his eye level 1.2m above the road surface can see the top of an object 1.2 m above the road surface (Fig 2.5)

The factors that affect the OSD are:

- Velocities of the overtaking vehicle, overtaken vehicle and of the vehicle coming in the opposite direction.
- Spacing between vehicles, which in-turn depends on the speed.
- Skill and reaction time of the driver.
- Rate of acceleration of overtaking vehicle.
- Gradient of the road.

The overtaking sight distance is

OSD= d_1 + d_2+ $d_{3\,=}$.28v_bt+.28v_bT +2s+ .28VT

v_b= speed of overtaking vehicle, kmph

t=reaction time of driver

V= speed of overtaking vehicle or design speed

s=spacing of vehicles=.2v_b+6

Table 2.3 Minimum requirement of sight distance for various design speed

Design speed, kmph	Safe SSD, m	Safe OSD, m
40	45	165
50	60	235
60	80	300
65	90	340
80	120	470
100	180	640

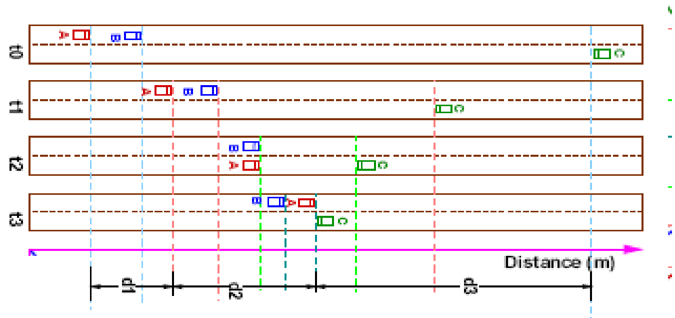

Fig 2.4 Overtaking Sight Distance

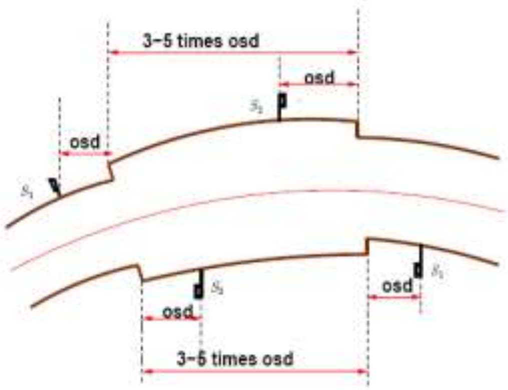

Fig 2.5 Safe Overtaking Zone

VERTICAL GRADES

The vertical alignment of a road consists of gradients (straight lines in a vertical plane) and vertical curves. The vertical alignment is usually drawn as a profile, which is a graph with elevation as vertical axis and the horizontal distance along the center line of the road as the horizontal axis. Just as a circular curve is used to connect horizontal straight stretches of road, vertical curves connect two gradients. When these two curves meet, they form either convex or concave. The former is called summit curve, while the latter is called a valley curve

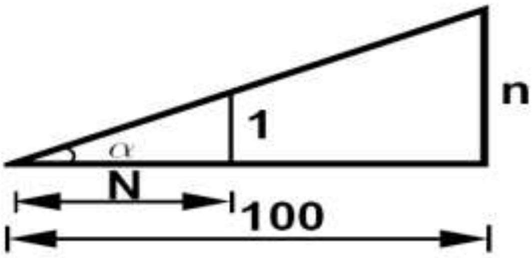

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Fig 2.6 Vertical Gradient Expression

2.2.5.1 GRADIENT

Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. While aligning a highway, the gradient is decided for designing the vertical curve. Usually steep gradients are avoided as far as possible because of the difficulty to climb and increase in the construction cost.

2.2.5.2 EFFECT OF GRADIENT

The effect of long steep gradient on the vehicular speed is considerable. This is particularly important in roads where the proportion of heavy vehicles is significant. Due to restrictive sight distance at uphill gradients the speed of track is often controlled by these heavy vehicles. As a result, not only the operating costs of the vehicles are increased, but also capacity of the roads will have to be reduced.

Representation of gradient:

The positive gradient or the ascending gradient is denoted as +n and the negative gradient as -n. The deviation angle N is: when two grades meet, the angle which measures the change of direction and is given by the algebraic (Fig 2.6)

Difference between the two grades (n1 -(-n2)) = n1 + n2 = n1 + n2.

TYPES OF GRADIENT

Many studies have shown that gradient up to seven percent can have considerable effect on the speeds of the passenger car. Ruling gradient, limiting gradient, exceptional gradient and minimum gradient are some types of gradients which are discussed below.

2.2.5.2.1 RULING GRADIENT

The ruling gradient or the design gradient is the maximum gradient with which the designer attempts to design the vertical profile of the road. This depends on the terrain, length of the grade, speed, pulling power of the vehicle and the presence of the horizontal curve.

2.2.5.2.2 LIMITING GRADIENT

This gradient is adopted when the ruling gradient results in enormous increase in cost of construction. On rolling terrain and hilly terrain it may be frequently necessary to adopt limiting gradient. They should be limited for short stretches not exceeding about 100 meters at a stretch. In mountainous and steep terrain, successive exceptional gradients must be separated by a minimum 100 m length gentler gradient

Critical length of the grade:

The maximum length of the ascending gradient which a loaded truck can operate without undue reduction in speed is called critical length of the grade. A speed of 25 kmph is a reasonable value.

Minimum gradient:

Therefore minimum gradient is provided for drainage purpose and it depends on the rain fall, type of soil and other site conditions. A minimum of 1 in 500 may be sufficient for concrete drain and 1 in 200 for open soil drains are found to give satisfactory performance.

Table 2.4 Gradients For Roads In Different Terrain In %:

Terrain	Ruling	Limiting	Exceptional
Plain/Rolling	3.3	5	6.7
Hilly	5	6	7
Steep	6	7	8

TABLE 2.5 DATA COLLECTED FROM VARIOUS ACCIDENT PRRONE SITES.

S. NO	PLACE	R.D (kms)	RADIUS (m)	SUPER ELEVATION (%)	SIGHT DISTANCE (m)	CARRIAGWAY WIDTH(m)
1	KHANABAL CHOWK	O	STRAIGHT	2.5	400	12
2	BATENGOO	1.4	STRAIGHT	2	250	9
3	URNHAL	3.4	STRAIGHT	1.125	350	9.1
4	PADSHAHI BAGH	5.6	STRAIGHT	2.5	200	11
5	BRIJBEHERA BAZAR	5.65	STRAIGHT	2.5	130	11
6	GREEN TUNNEL	6.9	STRAIGHT	2	220	10
7	SANGAM BRIDGE CURVE	8.1	37	7	20	7
8	AWANTIPORA	22.4	STRAIGHT	2	220	8.2
9	GALANDER	35.5	80	7	60	9
10	SEMPORA	42	STRAIGHT	2	350	10
11	DPS CROSSING PANTHA CHOWK	43	STRAGHT	2.5	180	18

2.2.6 WIDTH OF CARRIAGE WAY

Width of the carriage way or the width of the pavement depends on the width of the traffic lane and number of lanes. Width of a traffic lane depends on the width of the vehicle and the clearance. Side clearance improves operating speed and safety. The maximum permissible width of a vehicle is 2.44 and the desirable side clearance for single lane traffic is 0.68 m. This require minimum of lane width of 3.75 m for a single lane road .However, the side clearance required is about 0.53 m, on both side and 1.06m in the centre.

2.2.7 SHOULDER

Shoulders are the useable area or graded area between the edge of the travel lane and the curb line or edge of embankment. Shoulders direct surface drainage off the roadway and toward a subsurface drainage system. They serve as recovery areas allowing errant vehicles to correct their direction without leaving the roadway or risk hitting roadside obstructions. Shoulders may be paved or unpaved. Paved shoulders permit fast vehicles to overtake without forcing oncoming traffic off the sealed surface and should therefore contribute to a reduction in the accident rate. The IRC standard indicates a paved shoulder of minimum width of 2.5 m is recommended for 2-lane rural highways in India.

2.3 SECONDARY DATA COLLECTION

DATA COLLECTED FROM POLICE STATIONS

Data on traffic accidents in the study road stretch i.e, (Khanbal to Pantha chowk) were collected from First Information Report (FIR) of five police stations:

- Pantha chowk.
- Pampore.
- Awantipora.
- Bijbehara.
- Anantnag.

Although there is already a system exists to capture road accident data via FIR records available with the concerned Police station the aim to establish a comprehensive data system has not been fully realized. This is due to the current system structure where each police station in the road stretches under study maintaining individual database. The compilation for all the police station accident data are later done through the Court separately. However the compilation has introduced several issues especially data quality problem. Data integrity and checking probably has not been done at the state level thus making the compilation at the national level troublesome. Moreover for variables without predetermined values each police station will have their own reporting style. On the other hand road accident data were not fully utilized for decision making and performance monitoring due to the existing system unable to perform extensive and detailed analysis on road safety.

Therefore accident data are often kept just for record keeping purposes rather than using it as source of intelligence and further technical development. Therefore a new system is needed to address the issue of data compilation as well as for data analysis. The main objective of the study presented in this paper is to develop a model necessary to identify these hazardous locations on roads commonly termed as black spots. In general, the various factors that cause accidents can be broadly categorized into road related, vehicle related and driver related. In this paper, an attempt is made to implement the road related factors for predicting the accident prone points (black spots) on roads and thus help in identifying the required remedial measures.

ANALYSIS OF DATA

3.1 INTRODUCTION

It is well known by highway engineers and traffic police that road accidents tend to cluster together at certain locations, commonly termed "accident blackspots". At such sites, it is likely that some aspect of highway design, layout and state of road or traffic control is a contributory factor in the accident occurrence. As a consequence, it has been well established that considerable safety benefits may result from the application of appropriate road engineering or traffic management measures, which are accident countermeasures.

3.2 RESULTS AND DISCUSSIONS

After data collections, data were analysed statistically by graphs and pie charts. Figures 3.1-3.8

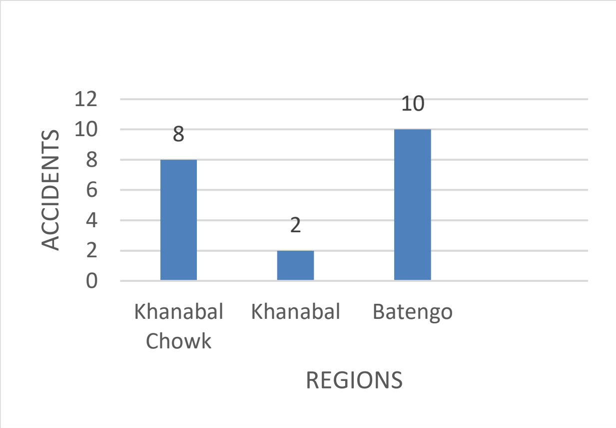


Fig.3.1 Accidents on NH 1A in Anantnag P/S area (2014-2016)

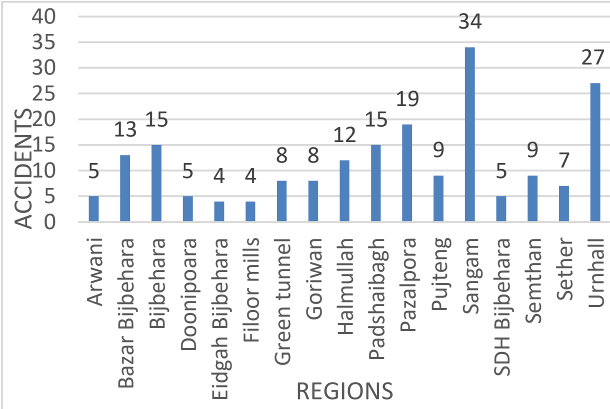


Fig.3.2 Accidents on NH 1A in Bijbehara P/S area (2014-2016)

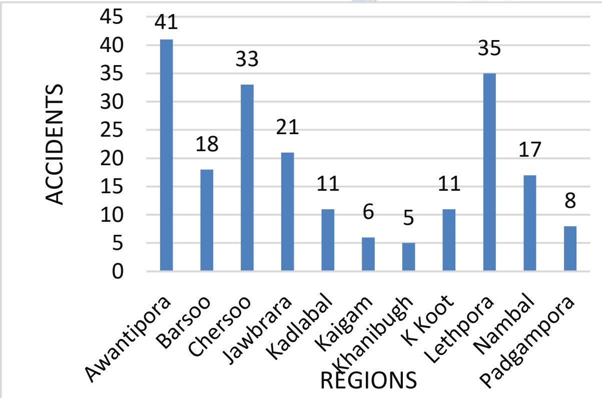


Fig.3.3 Accidents on NH 1A in Awantipora P/S area (2014-2016)

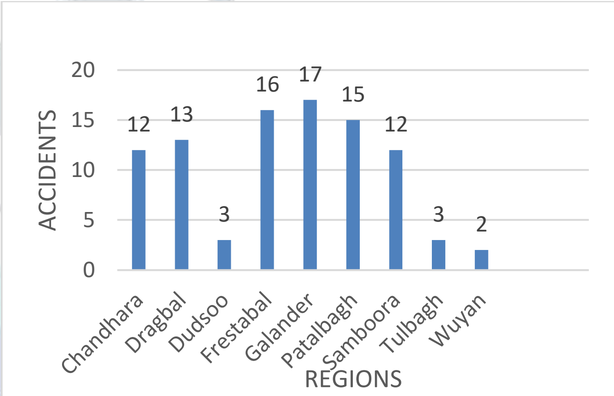


Fig.3.4 Accidents on NH 1A in Pampore P/S area (2014-2016)

NUMBER OF DEATHS/INJURIES

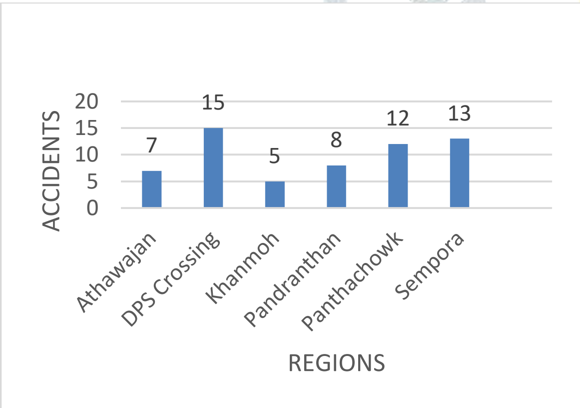


Fig.3.5 Accidents on NH 1A in Pantha chowk P/S area (2014-2016)

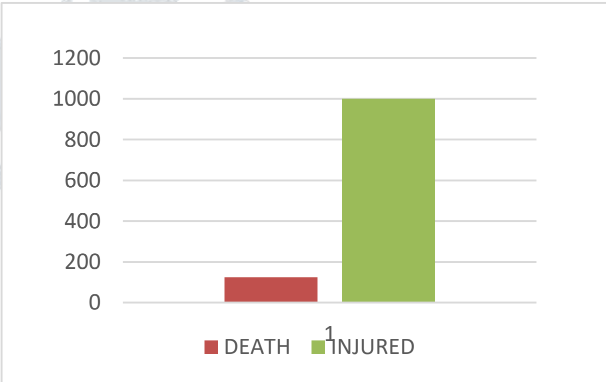


Fig. 3.7 Number of Deaths/Injuries Under Study Stretch from 2014-16

TYPES OF VEHICLES

HOURLY VARIATION OF ACCIDENTS

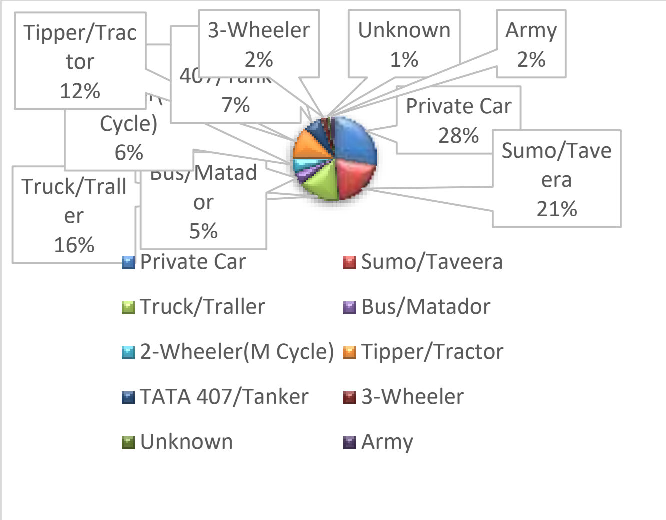


Fig 3.6 Vehicle Involvement In Accidents In Study Stretch (2014-2016)

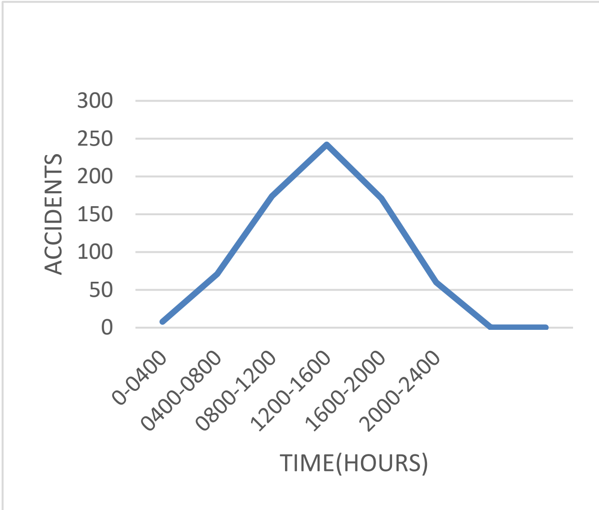
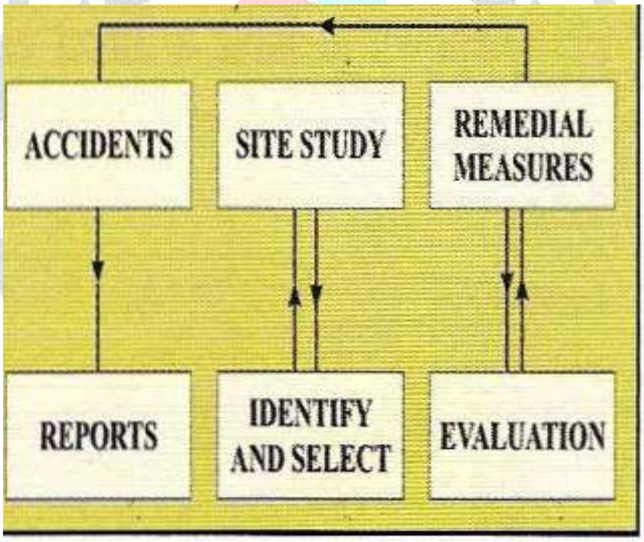


Fig.3.8 Hourly Variation of Accidents in the Study Stretch (2014-2016)

3.3 ACCIDENT TYPES AND CONTRIBUTING FACTORS

The analysis of the types of accident and the causal factors contributing to the accident is a vital step to reach an understanding of why accidents occur and how to treat the problem. Some of the most important aspects to be studied include casualty, severity, weather, road surface condition, road layout, junction type, vehicle manoeuvres, vehicle types, vehicle speeds, driver compliance with road sites/ regulations, driver age and gender, pedestrian involvement etc.

3.4 ACCIDENT BLACK-SPOT INVESTIGATION



BLACKSPOTS:

The treatment of specific types of accidents at a single location or on short-lengths of roads, (e.g. 300 m - 500 m stretches of road).This involves treating a specific site or short length of road. Look for clustering by accident-type, rather than identifying sites on the basis of total accident numbers only. Particular accident-types can be identified, for example, there may be cluster of right-angle accidents or run off road accidents.

ROUTE ACTION:

The application of remedies along a route with a high accident rate. This involves systematically investigating accidents along a section of road where the road character is relatively homogeneous. Study of such routes must include investigation of each site and section of road with repeated accident-type.

3.5 ACCIDENT INVESTIGATION AND IDENTIFICATION OF POTENTIAL SITES FOR TREATMENT

The main objective of accident investigation in the engineering context is to identify sites where common patterns of accidents can be prevented or at least their severity reduced by the introduction of improvements in the road environment.

3.5.1 PRELIMINARY ACCIDENT ANALYSIS

Before embarking on an in depth investigation at any site, it is advisable to check that the site has a statistically higher number of accidents than might be expected and the difference is statistically different. This is based on data's collected from Police stations.

3.5.2 PRELIMINARY SITE VISIT

The site visit is a very important element of accident investigation to familiarize the investigator with the site check that available to try to identify contributory features like sight lines, street furniture, road surface condition. It may be necessary to make visits at different times of day.

3.5.3 IDENTIFY AND PRIORITIZE SITES

Now, it is necessary to identify these hazardous locations on roads commonly termed as black spots. In general, the various factors that cause accidents can be broadly categorized into road related, vehicle related and driver related. In this stage, an attempt is made to implement the road related factors for predicting the accident prone points/stretches (black spots) on roads and thus help in identifying the required remedial measures.

A road network is distributed over a given area. Hence it always possess a 'spatial characteristic' i.e., it always has the geographic locations associated with it. Thus, in order to model a road network, an information system capable of processing spatial data is required. A map is used to analyse, manipulate and retrieve spatial data. Therefore identification of accident-prone location on roads can be easily done using a map.

3.6 METHODOLOGY

This methodology requires a map of the desired road network and certain specified road attributes to carry out prioritization. The analysis then identifies accident black spots on the given road network. While carrying out the analysis the method incorporates the road related factors such as road geometries and accident severity data's collected from P.S which lead to accidents.

The factors considered for evaluating accident prone locations on road are as follows:

- Road width.
- Number of lanes.
- Approximate number of vehicles per day.
- Type of road.
- Drainage facilities.
- Surface condition of the pavement.
- Frequent vehicle type.
- Presence of shoulders, edge obstructions, median barriers and ribbon development.
- Radius of horizontal curve

3.6.1 PRIORITIZATION OF ROADS FOR ACCIDENT OCCURRENCE

Prioritization involves assigning suitable weights to different factors so as to achieve a desired result. In this method, the various factors, which tend to influence the occurrence of accidents on roads are assigned weights on a scale of 0-10 in such a manner that the factors which tends to increase the probability of the accidents have *lower* weights. In order to prioritize roads for occurrence of accidents, the various factors considered and the weights assigned to them are given in following table. The final weight assigned to each road link is obtained by adding all the individual weights and normalizing the value using maximum weight (in this case 110) that can be assigned.

Table 3.1 Factors used in Prioritization with their weights

	Factors affecting occurrence of accidents	Possible variations	Weight Assigned
A	Relative severity rates =(No. of severity at specific site/ highest no of severity at a site in study stretch)×10	10-9 9-8 8-7 7-6 6-5 5-4 4-3 3-2 2-1 1-0	1 2 3 4 5 6 7 8 9 10
B	Approximate number of vehicles per day	Less than 1000 Less than 2500 Less than 5000 Greater than 5000	10 7 4 1

C	Width of the road	Single lane 3.75 m Two lanes without raised kerbs, 7.0 m Two lanes with raised kerbs,7.5m Intermediate carriageway Multi-lane pavements	2 4 6 8 10
D	Drainage facilities provided	Good Satisfactory Poor No Drainage	10 7 4 1
E	Surface condition of the pavement	Concrete WBM Surface Painted Other Bituminous Bad surface	10 8 4 6 2
F	Frequent vehicle type on the road	Bus / Truck Car/Sumo Two Wheelers All Types Carts	2 4 6 3 10
G	Presence of shoulders	Yes (good) Poor shoulder No	10 6 4
H	Presence of edge obstructions like advertising hoardings, trees etc very close to the road	Yes No	4 10
I	Provision of median barriers , signs or markings	Yes No	10 4
J	Presence of ribbon development near roads	Yes No	4 10
K	Road Geometric	Straight stretch no junction Straight stretch with junction Slight curve Steep curve no junction Steep curve with junction	10 5 7 3 1

Prioritization Scheme

Final Weight (%)	Accident Prone
80 - 100	Very Low
60 - 80	Low
40 - 60	Medium
0-40	High

Hence,
Total weight = (Σ Individual Weights) x 100/110.

Thus road links with high final weight are less prone to accidents than the road link with low final weight. The classification of roads for occurrence of accidents based on final weights is done using the following classification scheme (table 3.2).

Table 3.2

BLACK SPOT	A	B	C	D	E	F	G	H	I	J	K	APL
KHANABAL CHOWK	7	1	8	7	6	4	6	4	6	4	5	43.6

BATINGO (PETROL PUMP)	8	4	4	7	6	3	4	4	4	5	5	49.1
URNHAL (NEAR HP GAS SERVICE STATION)	8	4	4	4	2	3	6	5	4	7	10	51.8
PADSHAIBAGH	4	4	4	4	6	3	6	4	4	4	5	39.1
BIJBEHARA BAZAR	4	3	6	7	2	3	4	4	4	4	7	43.6
GREEN TUNNEL CROSSING	3	3	4	10	6	3	6	4	4	8	5	50.1
SANGAM BRIDGE	1	3	4	7	2	3	6	4	4	5	3	38.2
AWNTIPORA(NEAR MASJID)	2	3	7	4	2	3	6	4	4	4	5	40
GALANDER	3	4	4	7	6	3	6	4	4	4	1	41.9
SEMPORA JUNCTION	5	4	4	4	2	3	6	4	4	4	5	40.9
DPS CROSSING PANTHA CHOWK	4	1	8	7	6	3	6	4	8	4	5	50.9

3.6.2 RANKING OF SITES

On the basis of prioritization model ranking of site is done according to their APL values which are as follows:

1. Sangam Bridge.
2. Padshaibagh.
3. Awantipora.
4. Sempora.
5. Galander.
6. Khanabal Chowk.
7. Bijbehara Bazar.
8. Batengo.
9. Green Tunnel.
10. DPS Crossing.
11. Urnhall.

3.7 SAFETY ISSUES

3.7.1 HORIZONTAL ALIGNMENT

Unexpected tight horizontal curve can lead to accidents as drivers try to negotiate them at too high a speed. A similar situation may occur on horizontal curves or other hazardous situations such as on steep gradients or long straight where drivers are encouraged or misled by the approach geometry and lend to travel at excessive speeds.

The sight distances associated with larger radii curves .may also encourage drivers to overtake when it is unsafe.

3.7.2 VERTICAL ALIGNMENT

Stopping sight distances should be provided on all vertical curves, although sight distance requirements for safe overtaking are usually difficult to achieve on crest curves. It may be difficult for a driver to appreciate the sight distance available on a crest curve and he may overtake when it is insufficient for him to do so safely. Thus, in such conditions drivers should be given adequate warning through traffic signs and road markings. Successive short vertical curves on a straight section of road may produce misleading visibility.

3.7.3 SHOULDERS

Shoulders Inadequate or discontinuous shoulders tend to encourage drivers to keep away from the edge of the main carriageway and to straddle the center line of the road and reduce safety.

The lack of adequate shoulders also reduces capacity and forces drivers to park their vehicles on the main carriageway. These situations become especially dangerous during night-time.

Shoulders are not given adequate attention in their constructions and maintenance. This results in large edge drops, potholes and inadequate widths. The edge drop can lead to drivers' loss of control as well as erosion of the surfaced section.

3.7.4 ROADSIDE SAFETY

Crashes resulting from simply leaving the roadway represent a sub-stational portion of the road crash problem. When a vehicle leaves the traffic lane, the path of the vehicle and any object in or near that path become contributing factors to the degree of severity of the crash.

3.7.5 PLANATATION

Road plantations can reduce headlight glare, increase traffic guidance, control soil erosion and in-short, act as a safety cushion and noise barrier.

The trees and vegetation are planted on the basis of conventional practice, which is not suitable for present-day fast traffic. Shade trees are given preference, along roads and in medians irrespective of their functional requirements for safety.

Wrongly-located and ill-maintained trees drastically reduce the capacity of pedestrian paths forcing the pedestrians to move on to carriageway. During periods of maintenance, sometimes trees are left on the carriageway, thus, constituting a major hazard and congestion.

3.7.6 JUNCTION

It is found that road stretch is connected to many villages through link roads where junctions are not easily recognizable, drivers will drive more hesitantly and accident risk may increase. Two streams of traffic can interact in three basic ways, i.e. merge, diverge, or cross. There is also a more complex maneuver called the weave, which in effect is merge followed by a diverging action. In both the crossing and merging maneuvers it is necessary for drivers in one stream to find gaps of suitable size in the other stream for their vehicles to enter. Risk of accident becomes high where:

- Acute Crossing Angle,
- Multiple Manoeuvres,
- Lack of Spatial Guidance and
- High Approach Speeds persists.

Sight distance requirements are very important which is blocked by trees or road side constructions, parking of vehicles before approach roads. Main road drivers not able to see approaching side road vehicles as early as possible so as to be prepared and able to take evasive action when necessary.

3.7.7 DEVELOPMENT CONTROL AND ENCROACHMENT

Safety Issues:

- Effective land use planning is dependent upon strict rules to control development and enforcement. When those rules are broken unauthorized buildings and advertising hoardings encroach onto the road or cause obstructions which cab create additional dangers for road users and this need to be prevented.

- Problem occur due to lack of development control and inadequate enforcement with vendors, squatter areas and shanty areas developing around industrial areas and along busy major routes. These can often encroach right up to the carriageway edge, creating hazardous conditions for pedestrian and passing traffic.
- These encroachments cause increased pedestrian-vehicular conflict points, reduce visibility of traffic, cause hazardous distractions to the motorists, reduce the effectiveness of traffic control devices, cause glare problem to the traffic and affect roadside amenities.
- When roads are planned or constructed it is usually with the expectation that particular land uses will be serviced by the road. Land uses change over time and if these are incompatible they can have a dramatic effect on the efficiency of a road.
- When all activities cannot be contained within a particular site it inevitably spreads onto adjacent land and the transport corridor.
- Many residential or commercial units with unauthorized direct access onto major transport corridors cause danger to residents and to through traffic.

3.8 CONLUSION

The study shows that the main causes, effects and locations of accidents on National Highways are:

- The main recorded cause of accidents is driver error.
- Negligence and over speeding is as high as 90%.
- Mostly involved vehicles in the accident are private cars followed by passenger. vehicles such as sumo, taveera etc. and heavy load carrying vehicles such as trucks and tippers.
- Most of the accidents occur at junctions, curves due to to insufficient sight distance, lack of traffic guidance, and absence of markings and poor road geometries.
- Accidents are more prominent between 8 a.m in morning to 8 p.m in the evening.

COUNTERMEASURES

4.1 INTRODUCTION

Countermeasures are problem oriented and the choice of measure for a particular set of contributory factors must be aimed at resolving problems. Potential solution and the basis for countermeasures are of three types:

1.Remove the conflict:

- Prevent pedestrian crossing
- Prevent hazardous vehicle maneuverer

2. Improve visibility:

- Move the hill or obstruction
- Move the crossing

3. Reduce speeds:

- Reduce speed limits
- Provide speed breaker or other physical devices

4.2 FOLLOWING PARAMETERS ARE TO BE IMPROVED TO INCREASE THE SAFETY ON THE NATIONAL HIGHWAY.

1. Improving Driver Expectancy.
2. Improving Safety at Junction.
3. Provision of Overtaking Zones.
4. Use of Traffic Control Device.
5. Speed Control and Reduction.
6. Pedestrian Safety.
7. Countermeasures for Specific type of Collisions.

4.2.1 IMPROVING DRIVER EXPECTANCY

Safety issues:

- Driver should not face unusual or unique situations, which don't conform their expectations.
- The road and its environment constantly provide the driver with visual cues about the road ahead and the driving tasks, which they may need to perform.
- Misleading or no information leads to hazardous situations. An expectancy violation occurs when something unexpected suddenly intrudes.
- Factors contributing to accidents which are indicative of driver expectancy problems are: Unexpected or apparently wrong maneuver or actions by road user, Illegal behaviour, Unlawful exceeding of speed.

Safer Practice:

Improving the readability of the road and to react in a way that is consistent with potential hazards ahead. Introduction of signs, markings, channelization and at places enforcement of speed limits. This will provide road users consistent and coherent information.

4.2.2. IMPROVING SAFETY AT JUNCTIONS

Safety issues:

At junctions traffic stream, which cross or merge are more prone to accidents. Reduction of conflicts by separating traffic stream either by road markings or by small; islands to channelize traffic improve safety.

A junction may not be visible sufficiently far in advance because of topography or road alignment. The frequent absence of road markings and warning signs results in poor conspicuity of functions and hence danger to approaching drivers.

Safer Practice:

- Channelization, raised median strips and marking can reduce hazardous maneuver hence conflicts at junctions.
- Advance signing is necessary to ensure that drivers select the correct lane for the maneuvers.
- Other techniques can be adopted to make junction more conspicuous: Vegetation growth should be kept low so as not to block sight distance, Reflective paints used to highlight the presence of junction, minor realignment of junction to reinforce priorities and to create a deliberate break in the apparent continuity of road for driver on the minor route, when road crossing at right angles, offsetting channelizing islands on the minor road can be provided and when road crossing at an acute angle, the minor road can be realigned to make a staggered junction, better illumination where pedestrian movements are maximum can prevent night time accidents.

4.2.3 PROVISION OF OVERTAKING ZONE

Safety issues

Overtaking is an inherently maneuver especially on a single carriageway roads where it creates the potential for head on collisions. For example overtaking proved to be very harmful at curves and before bridges.

Overtaking zones offer a cheaper alternative approach and they can sometimes be achieved within the existing road structure. In this road overtaking behavior is generally poor with inadequate sight distance available. Due to a general lack of signs and markings, drivers may not be fully aware of facilities provided.

Safer practice

- Overtaking zones can be provided for improvement of a route as well as specific black spots.
- Clear definition of where overtaking is permitted and where not is essential. This should be done with traffic signs and with distinctive lane and centerline markings.

- By offering regular opportunities for overtaking, Drivers may be less inclined to overtake at hazardous locations and content to wait until they reach next zone.
- In rural roads where speeds are high, if the carriage way is sufficiently wide or if there is provision of widening overtaking zones can be provided.
- As per IRC 66-1976 Recommendation Gantry type overhead sign should be erected to ensure that important road signs like speed limits, no overtaking zones are not missed by drivers.

4.2.4 USE OF TRAFFIC CONTROL DEVICES

- Longitudinal markings can be applied in many circumstances where lack of lane discipline prevails. Both edge and centerline markings can be used to give clear information to drivers as to the correct position of road.
- Pictorial markings like urn arrows or symbols on the carriageway to warn about hazards ahead.
- Delineators can be used at specific blackspots and high embankment routes to guide the driver.

4.2.5 SPEED CONTROL AND REDUCTION

- Excessive speed and drier error are two most commonly occurring contributory factors in road accidents reducing speed therefore, is likely to offer substantial safety benefits.
- Self enforcing physical measures are necessary to encourage drivers to slow down. Self enforcing devices like speed breakers are used near residential areas where enforcement is limited. These require advance warnings so that motorist is given ample opportunity to slow down and don't get severe shocks.
- Rumble strips, jiggle bars and rumble areas provide a sound stimulus to drivers.
- Speed can also be reduced and pedestrian safety improved by making changes to the road alignment.

4.2.6 PEDESTRIAN SAFETY

FOOTPATH:

The footpaths are mainly occupied by the roadside vendors in the commercial areas. The national highway needs to be provided with wider footpaths considering dead widths. In the places where pedestrians congregate, it is essential to increase the width (near junctions etc).

GUARD RAILS:

The guard rails play an important role in segregating the pedestrians from the vehicles and prevent jaywalking thus enhancing the safety of the system. The issue of providing the guard rail opening at pedestrian desire crossing lines needs to be considered. The footpaths are often considered as emergency exit lanes during the grid locking by the motorized two wheelers which can be prevented by using such guard rails.

PEDESTRIAN CROSSINGS:

Pedestrians need to cross the roads at some locations during the course of travel. The crossing locations should provide for safe and comfortable movement. Two types of crossings i.e. at-grade and grade-separated, are provided exclusively based on traffic intensity.

4.2.7 COUNTERMEASURES FOR SPECIFIC TYPE OF COLISIONS

4.2.7.1 HEAD-ON COLLISIONS

Head on collisions results not only from unsafe overtaking maneuvers, but also from vehicles entering opposing lanes through loss of control, high speed or inattentiveness. So countermeasures taken are:

- The trimming of roadside obstructions or vegetation, or installation of barrier lines where sight distance may be restricted by road alignments.
- Pavement particular widening, either generally as shoulder sealing.
- The installation of road markings to aid physical separation of opposing flows.
- Providing overtaking zones.

4.2.7.2 SIDE-SWIPE COLLISIONS

Side-swipe collision between vehicles travelling in opposite stream is similar to head on collision. Where side swipe occur between vehicles travelling in same direction, warning signs and tapper markings are advised.

Table 4.1 Safety measures to compensate geometric deficiencies

Geometric Deficiency	Safety Measures
Narrow lanes and shoulders	Pavement edge marking Raised pavement markers Post delineators.
Steep side slopes/Roadside obstacles	Flatten side slopes up to 3:1 or steeper where runoff accidents occur e g. at sharp curves Remove obstacles like tree, poles or relocate ribbon development. Pavement markings and signage.

Narrow Bridge	Warning signs and markings Transition guardrails at bridge approach. Rehabilitated or new bridge rails.
Sharp horizontal curves	Widening carriageway and shoulders. Appropriate super-elevation. Flattening steep side slopes Pavement anti-skid treatment. Obstacle removal and use off- road side barriers like guardrails. Reflective guide markings and raised pavement marking.
Poor sight distance	Traffic control device and markings and signs. Fixed hazard obstacles removed. Shoulder widening.
Hazardous intersection	Traffic control devices. Traffic control signalization. Speed controls. Channelization and use of roundabouts.
Edge drop shoulders	Paving shoulders at critical points like sharp cures Tapering pavement edge shape.
Lack of skid resistance	Providing high skid resistance during maintenance programme. Apply a specific “anti-skid” treatment at potential junctions and pedestrian crossings Re-texturing and surface dressing. Use of porous asphalt on wearing course.

4.3 GENERAL SAFETY PRACTICE/ REMEDIES FOR THE ROAD STRETCH

4.3.1 HORIZONTAL ALIGNMENT

Where possible, the horizontal curvature of a road should be consistent with speed requirements. If a relaxation in standard is necessary for economic or environmental reasons, clear signs, markings and other warning devices should be introduced to make the driver aware of the potential problem ahead.

Potentially unsafe overtaking on curves with inadequate sight distances should be prevented by signs, road markings or physical barriers (additionally, positive signing or markings may be introduced to inform drivers of safe overtaking opportunities. Shorter, sharper curves with longer straight sections for overtaking may be better.

Available information suggests that accident rates on horizontal curves increases markedly if sight distance is less than 300 m. Therefore; large radius horizontal curves may be introduced on otherwise straight alignments to relieve driver monotony and to enable drivers to make better judgments of approaching vehicles speed.

4.3.2 SUPERELEVATION:

For safety purposes, Indian code recommends a maximum superelevation of 7% but it is recommended that lesser rates than 7% may be used in areas where snow and ice may appear on the roadway.

4.3.3 VERTICAL ALIGNMENT

The major control for safe operation on crest vertical curves is the provision of ample sight distances for the design speed. Stopping sight distances should be provided on all vertical curves, although sight distance requirements for safe overtaking are usually difficult to achieve on crest curves. It may be difficult for a driver to appreciate the sight distance available on a crest curve and he may overtake when it is insufficient for him to do so safely. Thus, in such conditions drivers should be given adequate warning through traffic signs and road markings.

Vertical grades passing through roadside petrol pumps or when connecting approach roads blocked by hill should be provided with sufficient warning signs and markings and safe speed limits are also advisable.

Drivers must be clearly warned of situations, which cannot be readily anticipated from the geometric profile seen ahead. In particular, sharp changes in horizontal alignment should not be introduced at or near the bottom of a sag curve or at or near the top of a crest curve. It is good practice to provide special descending lanes on downgrades.

4.3.4 SPECIAL LANES FOR ROAD SAFETY

Additional special or auxiliary lanes are sometimes provided which are located immediately adjacent to the basic lanes. These are generally short and are provided only to accommodate some or other special circumstances. Auxiliary lanes are often used at intersections. They can be turning lanes, either to the left or to the right, or through lanes. These are principally intended to remove slower vehicles, or stopped vehicles waiting for a suitable gap in opposing stream. Merging and diverging lanes are provided at interchanges to achieve lane balance and to facilitate deceleration or acceleration of the vehicles, according to the situation.

4.3.4.1 SLOW VEHICLE BAYS

Slow vehicle bays are the formalized use of very short lengths of widened, unobstructed sealed shoulder on two-lane two-way roads, to allow slow moving vehicles to pull out of a traffic lane and give following vehicles an opportunity to pass. Slow vehicle bays should usually be less than 300 m in length

4.3.4.2 PASSING LANES

Overtaking and passing of slow-moving vehicles on two lane rural roads can be restricted even on relatively flat sections of road because of restricted horizontal and vertical sight distance reduces passing opportunities, and/or high traffic volumes, particularly in the opposing direction, do not provide sufficient gaps for passing maneuvers to be performed safely. It is desirable to provide for overtaking or intermediate sight distance to allow faster vehicles to overtake and to delay the need for passing lanes. However, as traffic volumes increase on roads with adequate sight distances, safe passing opportunities decrease. Consequently, if passing lanes are not provided, queues build up, driver frustration increases and unsafe passing maneuvers often result. The provision of passing opportunities also improves the traffic operation and delays the need for widening the road to four lanes. Driver frustration can be reduced by signing which informs them of the next passing opportunity lane lengths of 1.5 km to 2.0 km will provide sufficient opportunity for most queues formed behind a slow vehicle to overtake it and disperse. The minimum length of a passing lane is 800 m.

4.3.4.3 EMERGENCY ESCAPE LANES

On steep down grade where there is a history of accident is high, escape lanes may be considered to bring these vehicles to a safe and controlled stop. Deceleration is provided by the retardation component of gravity on an upgrade and drag/friction of the vehicle tires running on the gravel or earth surface. The lanes are usually located adjacent to the road shoulder on the left hand side of the road. A gravel bed arrester system might be appropriate. The typical depth of the loose gravel bed is 450 mm and its width is 6.0 m.

4.3.5 SHOULDER

Edge line marking may also help to discourage traffic from using the shoulder as a carriageway and is an effective safety measure. Hard shoulders with bituminous surfacing using different coloured stone chippings or surfacing composed of less expensive surface dressing materials than used for the carriageway are an effective way of differentiating between the shoulder and the main carriageway. IRC recommends an extra 1 % slope for shoulders.

As per IRC-73: 1980, Geometric Design Standard for Rural Non-Urban Highways; shoulder widths can vary between 2.5 m width for National and State Highways.

Highways passing through rural communities are often used by high volumes of pedestrians, cyclists and other Vulnerable Road Users, who have little choice but to travel along road in close proximity to fast vehicles. As a consequence, many VRUs are put in a high risk situation, which inevitably leads to large numbers of pedestrian and vulnerable user accidents. The sealed shoulder is often adopted for road maintenance purposes but it also provides a very acceptable surface for walking and cycling. The shoulder pavement should ideally be 1.5 m wide to allow pedestrians to feel relaxed while using the footpath. A very effective safety measure, which has been applied recently by road authorities, is the installation of shoulder rumble strips (or audible edge lines), that are warning devices intended to alert drivers that they are leaving the travelled way and that a steering correction is required. This treatment has a positive effect on run-off-the-road accidents.

4.3.6 ROAD SIGNS

Road signs play a key role in influencing driver behaviour, orientation and information.

Careful provision of road signs can make a considerable contribution to the safe and efficient operation of road networks. Traffic signs should be designed to convey clear and unambiguous messages to road users so that they can be understood quickly and easily

Traffic signs may be divided into three broad categories.

- Warning signs
- Regulatory signs
- Information signs.

Road signs should be used in conjunction with markings, which communicate with the driver and guide him safely. Wherever feasible, reflective signs and markings should be used on major rural roads so that the carriageway is clearly delineated (especially at night time). The civic authorities responsible for road signs do not seem to be adequately trained in the provision of road signs. In many cases, wrong signs have often been installed. Training programs should be organized for engineers and other persons responsible for installing road signs.

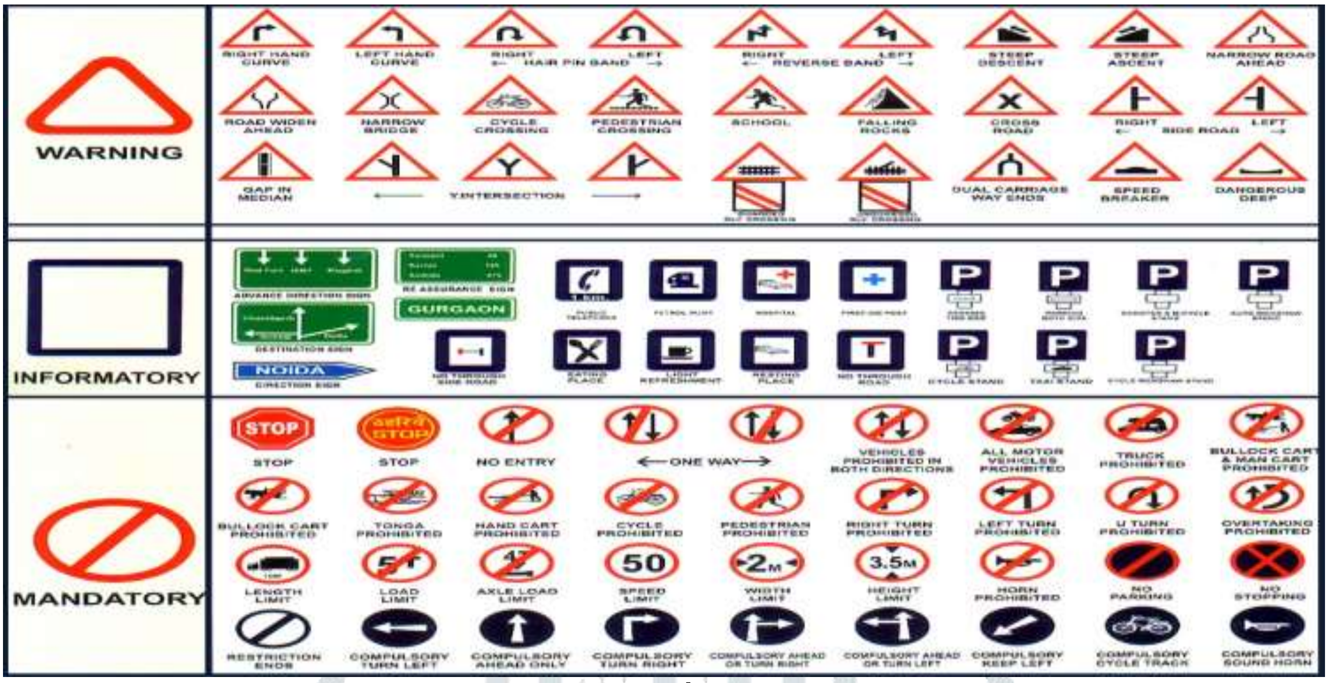


Fig 4.1 road signs.

4.3.7 PARKING FACILITIES

In small communities situated on National and State Highways, it is necessary control parking. This can be most successfully accomplished by creating p service roads to allow parking adjacent to the frontage activities. If this cannot done, speeds should be controlled to improve safety.

4.3.7.1 SERVICE ROADS

Service road, or frontage road as it is sometimes called, is a public or private street or minor local road, auxiliary to and normally located parallel and adjacent to a higher classified thoroughfare and controlled access facility, that maintains local road continuity and provides access to parcels adjacent to the controlled access facility.

They control access to abutting properties, thus increasing the safety and operation of the main facility while accommodating the needs of local traffic, pedestrians and bicyclists off the mainline.

In the absence of adequate truck parking facilities on these highways, truckers have a tendency to park their vehicles on service roads, thus negating the benefits of service roads to the vulnerable road users. In the absence of such service roads, the pedestrian-vehicular conflicts increase and road safety is threatened (For eg, FCI).

4.3.7.2 REST AREA & FUELING STATIONS FOR MOTORISTS

A rest area for motorists is an attractive, park-like area separated from, but within general sight of, the through pavement with parking suitable for cars, cars with caravans and trailers. Minimum facilities required in a rest area for motorists are shade, picnic tables, benches and rubbish bins. The provision of toilets, water, barbecue facilities with fuel, and lighting will depend on local conditions, the quality of maintenance able to be secured and the amount of use. However, every attempt should be made to ensure that the standard of facilities is consistent over a route. In isolated locations, which attract overnight use, showers may be provided in rest areas, where practical. Importantly, these facilities also reduce the incidence of crashes involving stationary vehicles parked on the road shoulder.

To encourage entry, access to rest areas should be seen to be safe and easy to access. The usual considerations of the standard safety elements of sight distance, stopping distance, auxiliary lanes, and provision for turning at intersections, must be applied to the design of the access to the rest area. To encourage the use of the roadside amenities, a uniform standard of access configuration may be appropriate for the entire set of amenities along a particular route, even though a lower standard might be indicated at some locations on the route.

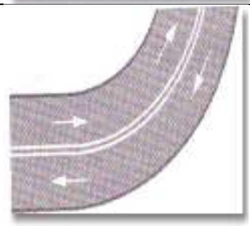
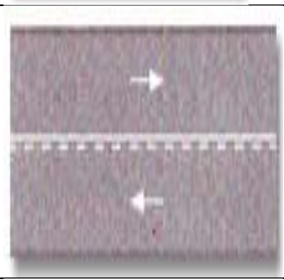
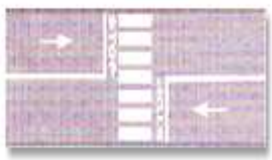
4.3.8 ROAD MARKINGS

Road paint or thermoplastic road markings are used on the road surface to convey warnings, to provide information and to indicate required manoeures. They can make a significant contribution to the safe and efficient operation of the network. Road markings play a very important role in guiding the driver and providing him / her with the information necessary to negotiate conflict points on the road network. It should be given a high priority for improving road safety. Stop and Give way lines on roads help position drivers at a point such that they can safe maneuver through the junction. Centerline and edge marking of rural roads can help to delineate the road ahead so that any horizontal or vertical curvature can be clearly seen by approaching road users. Centerline markings can be used to convey information about whether or not it is safe to overtake, while markings in the center of lanes should be used more to indicate particular hazards ahead. The hybrid markings consisting of both reflective road markings and reflective studs can be useful for night time driving.

Road Marking or Pavement Marking Signs:-

Centre and edge lining, especially if reflective, assists in the efficient and safe usage of the carriageway and is strongly recommended. They allow drivers more easily and accurately to judge their position on the road and are particularly helpful in conditions of poor visibility such as in rain, fog or darkness. A lack of edge definition can increase pavement deterioration due to vehicles driving onto the shoulder and may increase the risk of accidents. Reflective delineator posts are especially useful at night-time. These are typically one meter high and set one meter from the carriageway.

Table 4.2 Road markings

Centre Line Marking For A Two Lane Road	
Lane Line And Broken Centre Line	
Centre Barrier Line Marking For A Four Lane Road	
Double White/Yellow Lines: Used where visibility is restricted in both directions. Neither stream of traffic is allowed to cross the lines.	
Combination Of Solid And Broken Lines: If the line on your side is broken, you may cross Over Take - but only if it is safe to do so. If the line on your side is continuous you must not cross.	
Stop Line: A stop line is a single solid transverse line painted before the intersecting edge of the road junction/ intersection	
Border or Edge Lines: These are continuous lines at the edge of the carriageway and mark the limits of the main carriageway up to which a driver can safely venture.	

4.3.9 ROADSIDE SAFETY

Common existing roadside hazards include:

- Trees.
- Electric poles.
- Embankment side- slopes.
- Roadside furniture.

Safety Issues:

Properly laid rows of trees along the roadside and shrubs at the median delineate the alignment of the roadway and help the road user. However, sight distances and the visibility of signs by planting must not be comprised. For eg, at intersections unsatisfactory plantation affects visibility adversely. Satisfactory planting design at intersections must achieve adequate sight distances for approaching motorists in order to avoid abrupt and unexpected conflict situations

Roadside plantation can serve many engineering functions. Besides its aesthetic appeal, it provides vehicle drivers with the means of tracking the roadway, helps check excessive speed, lessens pollution, reduces dazzle from opposing vehicles and also supplies visual enjoyment helping to reduce fatigue and monotony. IRC recommends setback distance of not less than 4 to 6 m from the edge of carriageway, whereas most requires the first row of trees some 10-12 m from the centerline of the extreme traffic lane.

Adequate spacing of trees is necessary to show spatial continuity. A minimum spacing of 10 m 15 m has been recommended by IRC. On curves, near level crossings and intersections, trees with high crowns should be planted, or alternatively two or three should be omitted to provide a clear view of road ahead. The running of vehicles into trees growing on shoulders of roads result in serious consequences. In difficult conditions of horizontal and vertical alignment, with sharp turns of a road and vertical curves having a small radius, especially at night, in bad weather and during fogs, the trunks of trees painted white or having attached retro reflective sheets help drivers to orient themselves in the direction of the road playing the same role as specially installed roadside guide posts.

4.3.10 DEVELOPMENT CONTROL AND ENCROACHMENT

Safer practice

Any planning and design process must incorporate a degree of flexibility to allow for growth and the development of activities or uses that were unforeseen earlier. The planners must be aware of the scale of change that can take place

Strict control of roadside hoardings and advertisement boards is required for any type of illegal developments.

Land use and highway requirements change over time some additional capacity should be designed into road networks to enable such changes to be accommodated without detrimental effects upon road safety.

If development control standards permit the growth of activities to encroach onto the transport corridor, additional countermeasures may be required to maintain a safe level of service to the community as a whole. These include strong enforcement policies, alternative locations for activities, service roads and building regulations should be available to control a building line for roadside developments and suitable heights kerb to prevent encroachment by vehicles onto the footway.

Strong development control can only prevent encroachment onto roads if there are alternative locations for commercial activities to be undertaken.

SPECIFIC SITE ANALYSIS

4.4.1. KHANABAL CHOWK

Site conditions:

- Channelized TEE intersection.
- Good drainage
- Camber : 2.5%
- Sufficient sight distance.
- Leg 1 and leg 2 on NA 1A and leg 3 on NH1B

Leg 1 details

- Two lane road without seperat4ion
- Road width :12m
- Shoulder : 1.5m
- Camber : 2.5%

Leg 3 details

- Two lane road without seperation
- Road width : 11m
- Shoulder 1.5 m
- Camber :1.5m

Leg 2 detail

- Two lane road with median bisector
- Lane width : 7m
- Camber : 2.5%
- Median 1.2m

Road geometry data analysis:

Stopping distance available 48m

$S=v*t+v^2/2gf$

$48=v*25+v^2/2*9.8*0.37$

V = 60 kmph

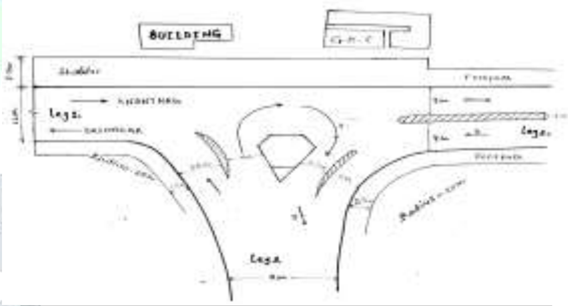


Figure 4.4 sketch of khanabal chowk

Causes of accident:

- High pedestrian traffic.
- High vehicular traffic.
- Lack of sign and markings.
- High vehicular speed.
- Inadequate sight distance.

Countermeasures:

- Provide pedestrian crossing near college area.
- Provide road markings and signs.
- Provide guard rails.
- Restrict speed up to 60 kmph.

4.4.2. BATENGOO (PETROL PUMP)

Site conditions:

- Straight two lane road without separation.
- Road width :9m
- Good drainage
- Gradient: 0.4% rise and 1.25% fall
- Camber : 2%
- No problem of sight distance.
- Road boundary line: 6.9m

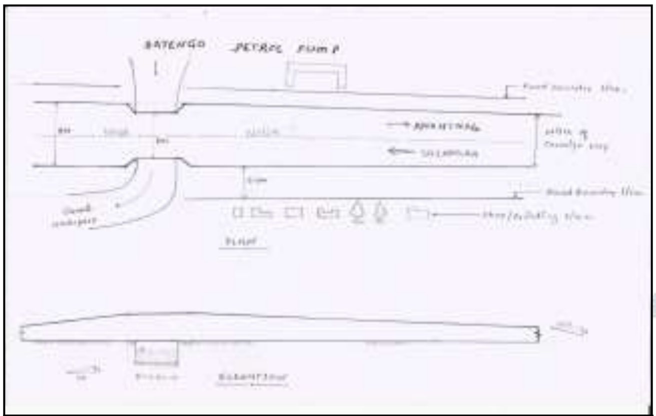


Figure 4.5 sketch of Batengo petrol pump

Causes of accidents:

- Narrowing of road width over the canal.
- No sign and for speed limit.
- No road marking
- High speed of vehicles.

Road geometry data analysis:

- Grade change = (0.4+1.2) % =1.6%
- Since vertical curve is not provide so design speed as per IRC is 35 kmph
- Safe stopping sight :

Initial velocity=80 kmph =22.22m/s

Final velocity=35 kmph = 9.72

Let braking efficiency= 70%

v*v = u*u – 2gfs

s = (22.2*22.2 – 9.72*9.72)/(2*9.81*.36*0.7)

s = 80.7m

Counter measures:

- Provide width restriction sign at distance of 81m
- Provide road markings.
- Transition guard rails on road over the canal.
- Restrict speed up to 35kmph.
- Widening of the road over canal.

4.4.3. URNHAL (HP GAS SERVICE STATION):

Site condition:

- Road Width: 9 m
- Road surface condition is poor
- Camber: 1.125%
- Two lane road without separation.
- Left Shoulder width 1.6m and right shoulder width is 2.5m
- Road margin 19.2m on right side.
- Very poor drainage.
- Sufficient sight distance.

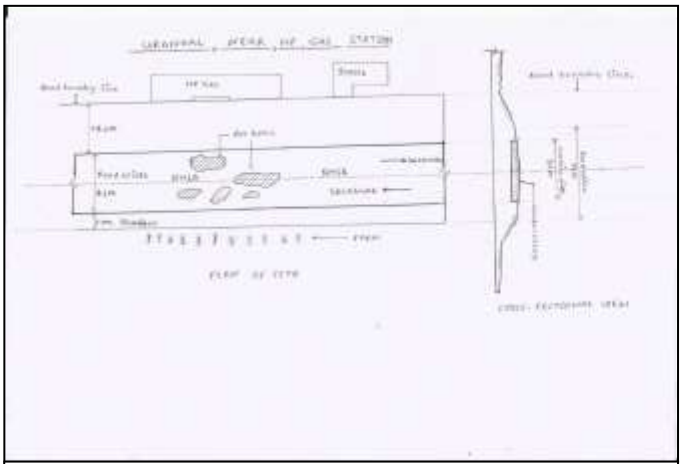


fig 4.6 Sketch of Uranhal near hp gas station

- Presence of potholes on road forcing vehicle to enter the other lane where the chances of head on collision with the vehicle from opposite direction increase.
- Toppling of vehicle due to pothole.
- No road markings.
- Poor drainage due to improper camber.
- Soft shoulders on the roadway.

Counter measures:

- Provide camber of 2%.
- Repair the potholes and improve road surface condition.
- Provide road markings.
- Stabilise the soft shoulders.

4.4.4. PADSHAHIBAGH INTERSECTION:

Site condition:

- TEE intersection at junction.
- Link road has gradient of 1 in 75(1.33%)
- Road width: 11 m.
- Shoulder 2.5 m.
- Camber 2.5%.
- Poor drainage and water logging.

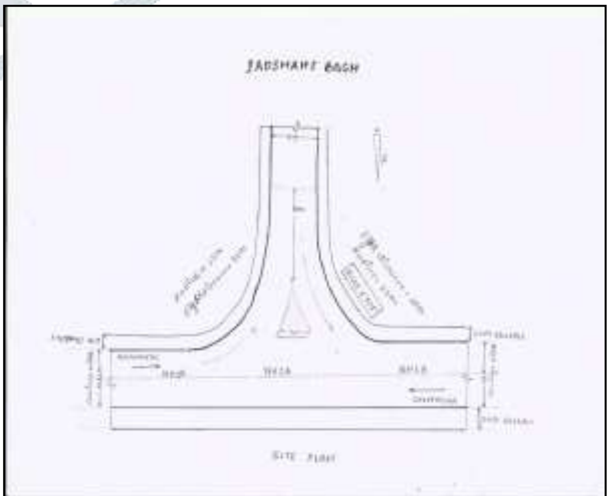


Figure 4.7 sketch of Padshahi bagh intersection

Causes of accident:

- Presence of bus stop facility on the road at curve.

- Gradient of link road at the junction.
- Lack of inadequate sight distance.
- Decrease in the effective friction due to water logging and gradient.
- High pedestrian traffic.
- High vehicular traffic.
- Lack of sign and road markings.
- Presence of electric poles on road side.

Road geometric data analysis:

Grade change = 1.33

Safe speed due to gradient = 35 + (40-35)*(1.2-1.33)/(1.2-1.5)

Safe speed = 37.5kmph =10.32m/sec

Safe sight distance required = 10.32*2.5 +10.32*10.32/(2*9.81)(.38+0133) = 40m

Stopping sight distance required (40m) is not available at sight.so speed must be reduced.

Design speed as per sight distance :

31.5 = v*2.5 + v*v/(2*9.81)(.38*.7 + .0133)

v = 35 kmph

Counter measures:

- Flatten the link road at junction.
- Provide road marking and sign.
- Provide pedestrian crossing.
- Shift bus stop facility away from the junction.
- Underground cabling of electric wire to remove electric poles.
- Improve the water drainage.
- Restrict speed up to 35 kmph.

4.4.5. BIJBEHERA MARKET

Site conditions:

- Two lane road with no lane separation.
- Road width: 11m
- Width of drain: 0.8m
- Road Condition: Very poor surface condition with lot of pot holes.
- Good drainage.
- High pedestrian traffic
- High vehicular traffic.
- camber: 1.7%
- heavy traffic congestion
- 1.5m footpath on both sides

Fig 4.8 sketch of Bijbehera market

Causes of accidents:

- High traffic volume.
- High Pedestrian Traffic.
- Poor surface condition with large pot holes.
- Lack of signs and marking.

Counter measures:

- Road markings and signage.
- Provide pedestrian crossing and guard rails
- Speed restriction up to 30 kmph.
- Improve road surface condition and repair pot holes.

4.4.6. GREEN TUNNEL

Site condition:

- Cross intersection with two link roads.
- Camber : 2%
- Tree plantation along the road.
- Sufficient sight distance.
- Two lane road with no lane separation.
- Shoulder width:1m
- Drainage: Good
- Road surface Condition: Good

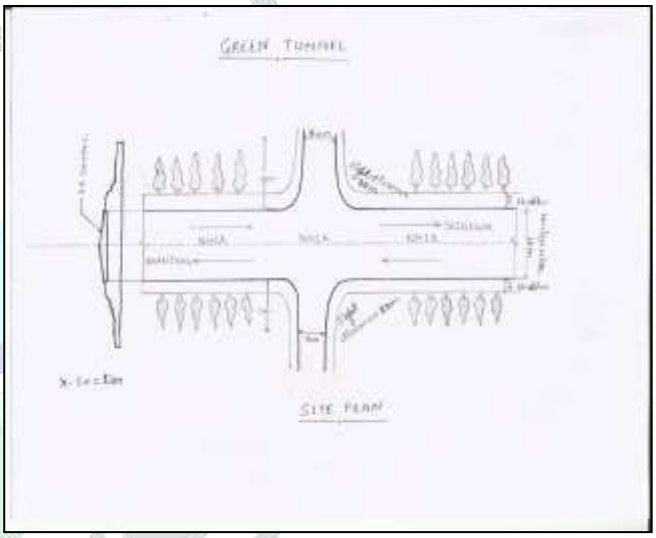


Fig 4.9 sketch of Green tunnel

Causes of accidents:

- Inadequate shoulder width.
- Sight distance reduction on junction reduction due to presence of trees.
- High speed of vehicles.
- Lack of sign and road markings.
- Provide guard rails.

Counter Measures:

- Removal of the trees obstructing sight distance.
- Providing road marking and proper signage.
- Increasing the shoulder width.

4.4.7. SANGAM BRIDGE

Site conditions:

- Sharp horizontal curve of radius 37 m.
- Two lane road with no lane separation.

- Shoulder of 1.6 m on each side.
- Super elevation: 7%
- Gradient :1 in 60=1.67%
- Sight Distance: 20 m(Blind curve)
- High traffic Volume.
- Poor road condition road surface.

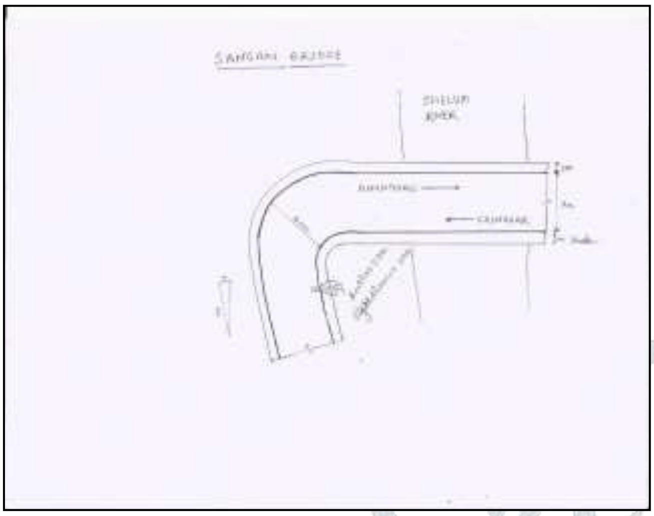


Fig 4.10 sketch of Sangam bridge

Road geometric data analysis:
e + f = v*v/(r*g)
0.07 + 0.15 = v*v/(37*9.81)
v = 33.5 kmph

Calculation of safe sight distance
20 = .278*2*v + v*v/254(.15 +.0167)
v = 20 kmph
safe speed at curve = 20 kmph

Calculation for extra widening
Extra widening required = 2*7*7/(2*40) + 20/9.5(√40)
Extra widening required = 1.5m

Causes of accidents:

- Poor road conditions of road surface.
- No road marking.
- High approach speed.
- In adequate sight distance
- Heavy vehicular traffic.
- Presence of tree branches on road.

Counter measures:

- Provision of road widening at curves.
- Removal of trees obstructing the sight of vehicle.
- Repairing of the pot holes.
- Restrict speed up to 20 kmph on curve.

4.4.8. AWANTIPORA (MASJID)

Site condition:

- Straight Road with road width: 8.2m
- Two lane road with no lane separation.
- Road Condition: Poor
- High vehicular traffic
- Poor drainage

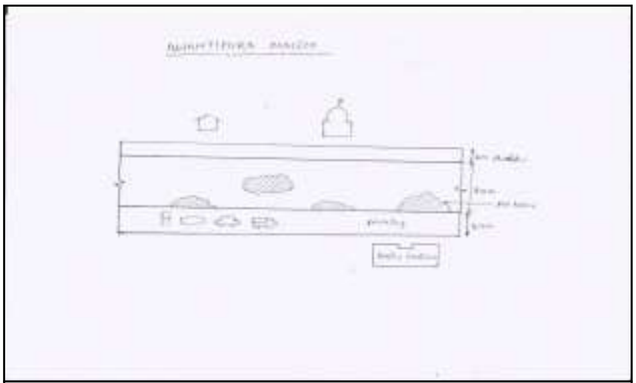


Fig. 4.11 Sketch Of Awantipora Site

Causes of accidents:

- Parking of vehicles on shoulder and road.
- Edge drop shoulders.
- Uneven and rough surface with small pot holes.
- High speed of vehicles.
- No sign and road marking.
- High pedestrian traffic.

Counter measures:

- Provide road markings and signage
- Develop parking facilities.
- Provide pedestrian crossing.
- Repairing the potholes and improving road surface.
- Levelling of shoulder.

4.4.9. GULANDER INTERSECTION

Site conditions

- Intersection of 3 legs
- Leg 1 and Leg 2 are legs of highway and leg 3 is link road.

Leg 1 details

- Road width : 9m
- Right shoulder 1.6m
- Radius :80m
- Super elevation : 3.3%
- Sight distance :60m
- Gradient : 1.176%

Leg 2 details

- Road width : 9m
- Shoulder available on left:3m and on right :1m
- Sufficient sight distance
- Leg 3 details
- Road width : 8m
- Shoulder 1.5m

Fig 4.12 sketch of Gulander intersection

Road geometric data analysis:
For leg 1:
Safe speed as per sight distance
$60=.278v*2+v*v/(.33+.01176)254$
$V=54$ kmph
Safe speed as per superelevation
$e+f=v*v\backslash Rg$
$.033+.15=v*v/80*8.81$
$V=44$ kmph
For leg 2:-
Safe speed up to 60 kmph.

Causes of accident

- High speed of vehicles.
- No sign and road marking.
- Inadequate sight distance
- Presence of gradient at intersection.
- Visibility reduction due to dust.
- Presence of deep open drain on curve of road.

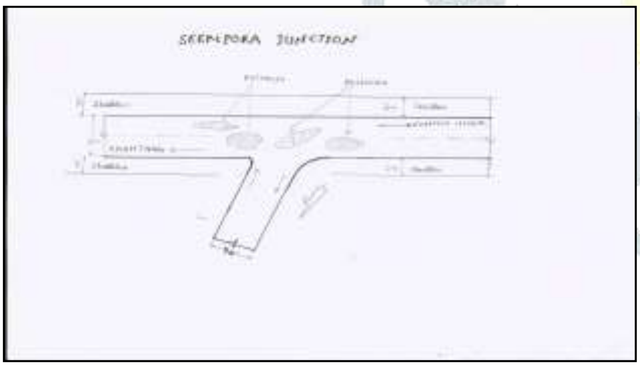
Counter measures:

- Widening of road and shoulder at curves.
- Provide sign and road markings.
- Improve traffic operation at intersection.
- Flatten the road curve.
- Provide guard rails on road over the drain.
- Cover the open drain.

4.4.10. SEEMPORA JUNCTION

Site condition:

- Two lane road without lane separation.
- Road width : 10m
- Un-channelized skewed junction.
- Link road has gradient of 1in 20(5%)



Causes of accidents:

Fig 4.13 Sempora junction.

Fig 4.13 Sempora junction

- No island on junction to channelize traffic.
- Presence of pot holes in the road
- No road markings and signs.
- High road traffic
- High speed of vehicles
- Soft shoulders
- Presence of gradient at junction.

Counter measures:

- Provide island or median at the junction.
- Provide sign and road markings.
- Repair the potholes and improve road surface condition.
- Flatten the link road at junction.
- Stablize the soft shoulder.

4.4.11. DPS CROSSING PANTHA CHOWK

Site condition:

- Channelized intersection
- Two lane road separated by median.
- Lane width:9m

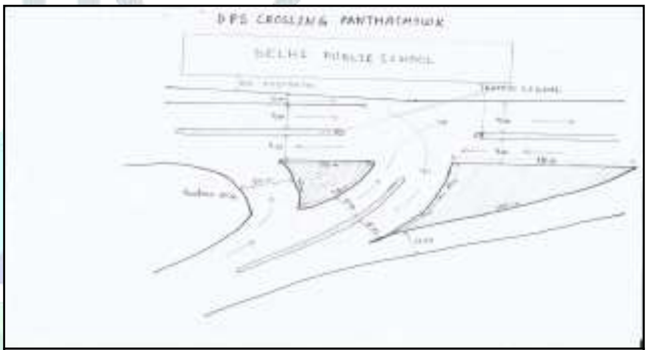


Fig 4.14 sketch of DPS crossing Panthachowk

Causes of accidents:

- High vehicular traffic.
- Multiple manoeuvres.
- High pedestrian traffic.
- Non functioning traffic signals.
- High traffic congestion.

Countermeasures:

- Provide road signs.
- Develop pedestrian facility.
- Enforce the traffic signal facility.

5.0 CONCLUSIONS and RECOMMENDATIONS

After conducting the case study on the road stretch Khanabal to Pantha chowk of NH1A while considering the following parameters:

- Road accident data from Police stations(FIR Records)
- Approximate number of vehicles per day
- Width of carriageway
- Road geometric and junctions

- Sight distance
- Presence of road side obstruction
- Drainage facility
- Surface condition of pavements
- Shoulder conditions
- Provision of signs and markings
- Running speed of vehicles.

We came to the following conclusions which are frequents contributory factors causing accidents:

- Unlawful exceeding of speed
- Bad overtaking practice near curves and market/residential area
- Lack of proper signs and markings
- Inadequate pedestrian facility
- Soft /poor shoulder condition or edge drop shoulder
- Insufficient sight distance
- Visibility /perception of curves and junction
- Poor design of road geometric to meet the requirement of running speed of vehicle
- Hazardous potholes and rutting

RECOMMENDATIONS

- Chevrons marking in T-junction and sharp bends.
- Pre-warning signs before junctions, curves, bridges and residential area.
- Give way signs and lane markings
- Cutting of foliage blocking sight distance
- Cabling of electric wires to remove road side poles
- Stabilization of soft shoulders and leveling of edge drop shoulder
- Enforcement of speed limits
- Continuous maintenance of roads and improvement of rutted surface as well filling of potholes
- Pedestrian refuge should be provided at junctions
- Pedestrian crossings should be provided at road stretch where pedestrian movement is more.

ACKNOWLEDGEMENT

I would like to express my profound sense of deepest gratitude to my guide and motivator, Dr.(Prof) M. S. Mir , Civil Engineering Department, National Institute of Technology, Srinagar for his valuable guidance, sympathy and co-operation for providing necessary facilities and sources during the entire period of this project.

I would also like to thank J&K Police Department especially concerned Police Stations of my Project for providing valuable data and a helping hand throughout the course of the project.

I wish to convey my sincere gratitude to all the faculties of Civil Engineering Department of Mewar University who have enlightened me during my studies. The facilities and co-operation received from the technical staff of Civil Engineering Department is thankfully acknowledged.

I express my thanks to all those who helped me one way or other. I would like to thank the authors of various research articles and books that I referred to.

I would like to thank my parents wholeheartedly for being there, for providing the necessary support and source of guidance and inspiration.

Finally, I would like to thank Almighty for blessing me with all that I possess.

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