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ROAD SAFETY AUDIT ON URBAN ROADS OF BENGALURU

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Abstract – *Road transportation is a major sector in the development of any Country. With its growth, there comes a problem of accidents. Road safety has become a matter of great concern. So the formal safety performance examination of an existing or future road or intersection such as Road Safety Audit (RSA) is necessary as it qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users.*

In this study various black spots of the Bengaluru city are selected and the accident analysis is done by studying the FIR copies of accidents occurred in those Black spots. FIR copies of 2017, 2018 & 2019 were obtained from concerned traffic police stations of Bengaluru city. After examining all the existing features and conditions of roads using IRC-SP:88-2010 checklist and carrying out questionnaire survey, safety measures are recommended for all kind of road users during day and night times as well in dry and wet conditions.

Key Words: **Blackspot, Checklist, IRC (Indian Road Congress), RSA (Road Safety Audit), FIR (First Information Report), MoRT&H (Ministry of Road Transport & Highways)**.

1. INTRODUCTION

People majorly depends on road for their movement from one place to another like home to school, college, health care centre, offices, etc., Road transportation contributes to the economic. Industrial, social and cultural development of any country. Other forms of transportation such as railways, airways, waterways are also dependent on roadways.

The major road networks that are providing links between economically important ports, cities, towns are National Highways (NH) and State Highways (SH). The places where maximum accidents are occurred with greater concentrations are NH and SH. This has become a huge problem in this century all over the world.

As per data released by the Police computer wing and state crime records bureau in 2019, Karnataka had 40,658 accidents with 10,958 fatalities. Bengaluru topped the list with 4,684 accidents and 768 fatalities. Out of which 58.56% of accidents happened on NH and SH compared to district and other roads.

With the increase in road accidents and related casualities in last few decades, there is an urgent need to give greater weight on road safety. Places where more number of accidents takes place repeatedly are called as blackspots. Present work is related on such blackspots that are present around the Bengaluru city to know the reasons for the accidents occurred and to suggest suitable measures in order to reduce them in future.

1.1 ROAD SAFETY AUDIT (RSA)

Road Safety Audit is the systematic procedure for the assessment of accident range and safety performance in the provisions made in new road schemes, road improvement or rehabilitation works, both before and after the implementation of the project.

1.2 ROAD SAFETY AUDIT (RSA) IN INDIA

In 2002, MoRT&H sponsored a project related to Development of RSA for existing sectors to CRRI in 2002 (April). NHAI entrusted CRRI about engineering design for RSA on NH-2 having a total length of about 900km. It was the longest road project in the world taken for RSA.

The first Road Safety Audit Project in India was taken by CRRI in 2000 at Indore bypass.

In India, there may not be any formal requirements for safety of all kinds of roads other than highways. But these are the alarming situations in this century that every road needs safety measures because of rapidly increasing vehicle users each year.

1.3 OBJECTIVES OF THE STUDY

- Collect accident data from FIR copies provided by traffic police stations in the city for past 3 years (2017-2019) that helps in statistical accident analysis.
- Identify the blackspots for which RSA has to be done using checklist as per IRC-SP:88-2010.
- Inventory of road geometrics and traffic condition.
- Conduct questionnaire survey on road users, Traffic Police that strengthens the analysis.
- Suggest required remedial measures based on the study to reduce accidents in future.

2. METHODOLOGY

2.1 PROJECT METHODOLOGY

- From the statistical analysis of collected data, blackspots that connects NH around the city are selected.
- Odometer survey is done to check length and confirm chainage of respective stretches of roads.
- Examine the existing features and conditions of roads in the selected blackspots at day and night using IRC-SP:88-2010 (Road Safety Audit manual) checklist.
- Carryout questionnaire survey - road users, traffic police officers opinion might be helpful for analysis.
- Suggest required measures that needs to be done at the respective blackspots to reduce the number of accidents.

Table -1: LIST OF BLACKSPOT LOCATION IN BENGALURU CITY SELECTED FOR THE STUDY

SL. NO.	TRAFFIC POLICE STATION (TPS) JURISDICTION OF BLACKSPOT	BLACKSPOT LOCATION
1	MADIWALA	Hosur Main Road - Madivala TPS to silk board fly over
2	ELECTRONIC CITY (E-CITY)	Hosuru Main Road- Hulimavu TPS to Singasandra Bus stop
3		Hosuru main road- E City TPS to Naganathapura junction
4		Hosuru main road- E City TPS to Konappana Agrahara
5		Hosuru main road- E City TPS to EC-1, to Veerasandra Junction
6	BANASAWADI	Outer ring road, Bheema Jewellers
7		Outer ring road, Near Forest office
8		Outer ring road, Near Chroma Showroom
9	HALASOOR	Koramangala inner ring road
10		Old Airport road
11	KENGERI	RVCE Mysore road - Dubasipalya to UCO Bank Junction
12		Madhu Petrol bunk Mysore road- Satellite Bus station to UCO Bank Junction
13		Shukkuru Junction Mysore road-UCO Bank Junction to NICE road Junction
14		Doddabele Junction Mysore road -UCO Bank Junction to NICE Road Junction
15	YESHAWANTAPUR	NH-4 RMC Yard to MEI junction
16	PEENYA	NEAR Navayuga toll- H Cross Junction to Navayuga
17		Chokkasandra junction- Chokkasandra junction to SM circle
18	V V PURAM	Minerva circle JC road- Minerva circle to Kamath Hotel
19		Annapoorna Junction, to Kalasipalya Main road
20	K S LAYOUT	Purvankara Apartment to Unitech Gate
21		Nagegowdanapalya- Nagegowdanapalya Bridge to Sompura Lake
22	HEBBALA	Yogeshwarangara cross
23	CHIKKAJALA	Sir MVIT junction
24	KEMPEGOWDA INTERNATIONAL AIRPORT (KIA)	Kannamangalapalya Gate

2.2 APPROACH TO ROAD SAFETY REVIEW

MoRT&H defines blackspots as the spot on road or stretch of a road up to 500m endorsing either 5 road accidents or 10 deaths during 3 years of period.

The observations are mainly focused on following critical elements of the roads.

- Road safety concerns due to the design standards adopted and executed.
- Road safety concerns at high risk stretches (Earlier Black Spots or Probable Black Spots).
  - Requirement of Retro-reflective pavement markings (RRPMs), road markings, road delineators, road side & median safety barriers and road signs and its road safety concerns.
  - Road safety concerns at Junctions/Intersections and gaps in medians.

- Requirement of speed calming measures & traffic channeling Measures and road safety concerns at these locations.
- Road safety concerns at 'S' curves or other sharp curves (Provision of Extra widening, Super elevation, road run-off & recovery space, Chevrons, Crash barriers, Guard stones)
- Road safety concerns at high embankment.
- Road Safety Concerns due to inadequate lighting facility near habitations and junctions.
- Requirement of Foot Paths, Raised Table top crossing, Zebra Crossing or Extra lanes for Non-motorized and motorized two wheelers in the vicinity of the Habitations.

2.3 FREQUENCY, SEVERITY & LEVEL OF RISK OF ACCIDENTS

The classification of frequency, severity, level of risk of the traffic accidents and suggestion of treatment approach are given in the tables 2,3,4,5 respectively.

Table -2: FREQUENCY DEPENDING UPON THE POSSIBLE CRASH IS TERMED

FREQUENCY	DEFINITION
FREQUENT	One or more than one accidents in one month
PROBABLE	One or more than one accidents per year but less than one in a month
OCCASIONAL	Accident occurs once in every five to ten years
IMPROBABLE	Accident occurs Less than one every ten years

Table -3: SEVERITY DEPENDING UPON THE TYPE OF CRASH IS TERMED

SEVERITY	DESCRIPTION	EXAMPLE
CATASTROPHIC	Occurrence of Multiple-deaths	A bus collision at high speed with a bridge abutment. High speed, multi-vehicle crashes on expressways or highways.
SERIOUS	Occurrence of a death with or without serious injuries	High or medium speed vehicle collisions. Vehicle collisions with fixed roadside objects. Pedestrian crashes on highways.
MINOR	Occurrence of Minor injuries only	Low speed collisions: such as a bicyclist sliding on a sandy road surface, a pedestrian hit in a car park or a rear end crash in a slip lane.
LIMITED	Occurrence of Trivial injuries or only property damage	Very low speed vehicle collisions. A car can collide with a median island in a car park. Pedestrian trips on uneven footpath.

Table -4: DEFINITION OF RISK

RISK	From Table 2-Frequency & Table-3 Severity			
	FREQUENT	**PROBABLE**	**OCCASIONAL**	**IMPROBABLE**
LIMITED	**High**	**Medium**	**Low**	**Low**
MINOR	**Intolerable**	**High**	**Medium**	**Low**
SERIOUS	**Intolerable**	**Intolerable**	**High**	**Medium**
CATASTROPHIC	**Intolerable**	**Intolerable**	**Intolerable**	**High**

Risk is defined in table 4 by observing the classification of frequency and severity in tables 2 & 3 respectively.

Table -5: COURSE OF ACTION OR TREATMENT TO BE SUGGESTED BASED ON RANK OF "RISK"

RISK	SUGGESTED TREATMENT APPROACH
Low	Safety concerns need to be corrected risk reduces, if a treatment cost is low.

Medium	Safety concern shall be correct hence the risk significantly reduced if the treatment cost is moderate but not high.
High	Safety concern shall be corrected or the risk significantly reduced even if the cost is high.
Intolerable	Safety concern must to be addressed at any cost.

3. ROAD SAFETY AUDITING

3.1 MANUAL ON ROAD SAFETY AUDIT

Road safety auditing is done using the Road safety Audit manual i.e., "Manual on Road Safety Audit" IRC:SP:88-2010. For the present study stage 6 is selected i.e. On exiting road during the stages of operation and maintenance.

Auditing is done under different parameters from the check list like General, General-Alignment, cross section, junction, signal controlled junction, Road sign, Informatory sign, Road marking, Lighting, Road side hazards and Road side facilities is done.

Table -6: CHECKLIST FOR ROAD SAFETY AUDITING

SL. NO.	PARTICULARS	YES/NO	REMARKS
GENERAL			
1	Are the vehicles are prevailing the speed levels within desired limits?		
2	Parking of vehicles stop in manner that may cause hazards?		
3	Is plantations obscure perceivability or Notice sign?		
4	Is the carriage and surface of road marking visibility?		
5	Is the islands and medians of required width provided?		
6	Does these are likely to be a needed for crossing facilities for side walkers?		
7	Does bus bays and bus-stops are safely placed with proper visible and clearance for the traffic?		
8	Is over taking opportunity for fast moving vehicles?		
ALIGNMENT			
1	Whether the design speed proposed is properly functioning for the road?		
2	Is cautionary sign placed or Not?		
3	Whether the proposed alignment gives proper visibility for design speed?		
CROSS SECTION			
1	The width of shoulder, carriageway, Median (if any), service roads are as per standards or Not? And are required of the volume and for proper function for the road with mix traffic?		
2	Note any suitable location where Cross sections standards altered for the route of inconsistency for the expectations of driver?		
3	Identify/specify any location of the Roadway is restricted for the capacity of roadway and Note down any location of regular traffic congestion?		
4	As per the standards safer side drains are provided or Not?		
5	For the pedestrians adequate width of footpath/width on median is provided or Not?		
JUNCTION			
1	Whether the actual designed Junction type is suitable for the deserved traffic volume & is good for more than two roads?		
2	Whether it is designed layout of junction is adequate for all the types of vehicles and vehicular movements?		
3	Whether there are any deficiencies For the night time lighting provision?		
4	Are intersections or junctions at that Spot having appropriate markings, signs to keep away from accidents?		

5	Whether the signal operation sequence do conform all the Requirements of standards?		
6	Do the signals clearly indicates which movements are allowed at one time?		
7	Whether the positioned signal heads can be seen easily by the drivers so that they react in time?(Go/Stop)		
8	Whether the positioned signal for pedestrians is clearly visible or Not?		
ROAD SIGNS			
1	For provisions or the arrangements made as road signs (Regulatory, Informatory Warning signs & Delineators) Satisfactory as per the standard?		
2	Check for use of Nonstandard signs (shape and color) and unauthorized traffic signs?		
3	Check for visibility of traffic signs by watching traffic signs during the night time and identify whether any lack of reflectivity?		
4	Are the signs are positioned Correctly to use the needed timely actions by the drivers?		
5	Are warning and regulatory signs are placed wherever needed?		
ROAD MARKING			
1	Road markings are adequate and visible clearly during various weathering condition and during night/day time?		
2	Whether the type of markings used is correct under various situations (Ex: edge line, lane line)?		
3	At the junction any zebra crossing Markings are provided or Not?		
4	Stop lines positioning is appropriate or Not?		
LIGHTING			
1	During night lighting is needed on the project roads like interchanges; truck lay bays, buses bays, toll plazas?		
2	Whether the light poles located cause any hazardous to traffic?		
3	Whether the provided street Lightings specify any route guidance?		
4	Are there any electrical poles or utility poles near the edge of the berms which may cause hazards to traffic?		
ROAD SIDE HAZARDS			
1	Whether the provided clear zone as per guidelines?		
2	Whether any hazard is associated with presence of boulders, large tress and whether they shall be treat properly to develop roadside safety?		
3	Check whether any vegetation or Trees and other obstacle the side walkers and driver?		
4	Whether any fixed road side objects occurs on the roadway?		
5	On the right of roadway any business activates or road side stall exits or Not?		
6	Whether the provided fencing is free of separate horizontal rails in clear zone?		
7	In the median whether the vegetation height is less than 60cm on curves?		
ROAD SIDE FACILITY			
1	Whether the alignment, cross Section and signage promotes drivers for adjusting the speed while entering the city and to maintain it at some significancy level?		
2	Whether for the pedestrians any safe provision is provided adequately and along the road side walkway facility is provided or Not?		
3	Adequate roadside parking is provided safely under control or Not?		

4	Whether any decision is being taken for improving the parking situation and traffic in the place where the road passes?		
5	Whether provided bus stop location is free from traffic line?		

3.2 STATISTICAL ANALYSIS OF ACCIDENTS

FIR data which is collected from different traffic police station about road accidents is used to rank black spots as first, second and third so on.

The ranking is given mainly as per the road accident severity that is fatal or death, major injury, minor injury and damage etc.

The black spot with more accidents and higher severity is given as first rank and less accidents with lower severity is given as last rank.

The ranking is mainly done on the basis of Accident Point Weightage (APW).The Weightage taken for different nature of accidents is

- Fatal -6
- Major injury -3
- Minor injury -0.8
- Vehicle damage – 0.2

The calculation of APW is shown below.

For Black spot 1, APW = 8*6+7*3+5*0.8+6*0.2 = 74.2

For Accuracy lan of APW is taken. ln (74.2) = 4.3067

Table -7: STATISTICAL ANALYSIS OF ACCIDENTS

BLACK SPOT	FATAL	MAJOR INJURY	MINOR INJURY	DAMAGE	APW	Ln (APW)	RANK
1	08	07	05	06	74.2	4.3067	13
2	03	13	08	10	65.4	4.1805	20
3	10	12	08	11	104.6	4.6501	5
4	15	08	06	10	120.8	4.7941	3
5	06	10	08	12	81.36	4.3988	12
6	06	10	05	06	72.2	4.2794	15
7	07	08	04	10	71.2	4.2654	16
8	10	09	11	10	97.8	4.5798	6
9	07	05	03	10	61.4	4.1174	21
10	07	05	03	10	61.4	4.1174	21
11	06	09	08	19	73.2	4.2931	14
12	05	10	05	10	68.4	4.2253	18
13	09	08	06	11	85	4.4426	9
14	05	10	08	12	68.8	4.2323	17
15	08	09	10	08	84.6	4.4379	10
16	06	13	02	11	58.5	4.0472	22
17	04	08	04	04	50	3.9120	23
18	08	12	08	15	93.4	4.5368	7
19	05	15	05	20	83	4.4188	11
20	12	08	12	15	108.6	4.6877	4
21	10	45	15	10	209	5.3421	1
22	03	14	06	08	66.4	4.1956	19
23	08	12	02	12	88	4.4773	8
24	12	20	14	23	147.8	4.9943	2

From the accidents analysis, Rank 1 is given to NAGEGOWDANAPALYA (Blackspot 21) and less severity black spot is CHOKKASANDRA JUCNCTION (Blackspot 17) with ranking 23. It is observed that Blackspots 9&10 has same ln (APW) of 4.1174. So both Blackspots are ranked at 21.

3.3 QUESTIONNAIRE SURVEY

As part of this study, a questionnaire survey is also conducted at the location of black spots. From the reviews of public, traffic police officers along with the study carried out at the blackspots, the accidents are mainly due to the driver negligence, irregular pedestrian moments, traffic violations from the road users, bad road condition. Some questions that were asked to the public in the survey are listed in table 7.

Table -8: QUESTIONNAIRE SURVEY CONDUCTED IN THE STUDY

Sl. No.	QUESTIONS	REMARKS		COMMENTS
		Yes	No	
01	Due sight distance	33	67	Geometric is fine at all black spots except few
02	Due to drink and drive	65	35	Most accidents occur due to drink & drive
03	Due to inadequate sign boards	55	45	Need more sign boards at all black spots
04	Insufficient provision of street lights	58	42	Need to install street lights at some locations
05	Random moment of pedestrian	75	25	Irregular pedestrian movements is more.
06	Due to over speed	78	22	Vehicle speed is more than design speed
07	Due to commercial activities besides the	63	37	The commercial activities are at all the black spots

	pavement			
08	Due to violating the traffic rules	66	34	Traffic violations are common at all blackspots
09	Due to less visibility of the road markings	72	28	Road markings are faded at most of the locations

Fig -1: IMPROPER MAINTENANCE OF ROAD SIDE DRAIN AT BLACKSPOT 1

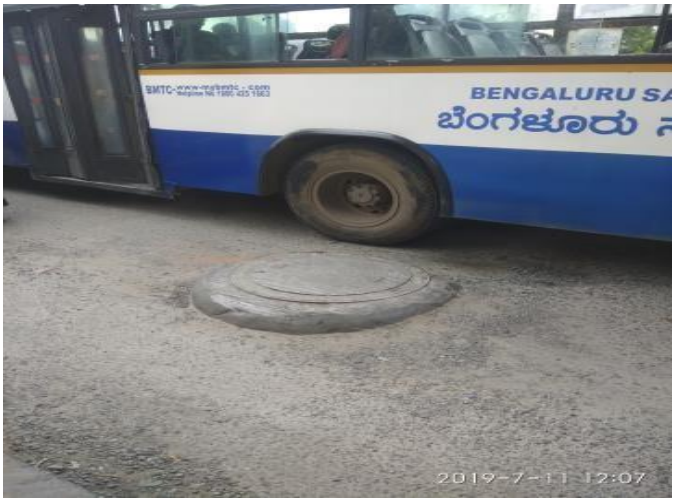

Fig -2: MANHOLE AT THE CENTER OF ROAD AT BLACKSPOT 6

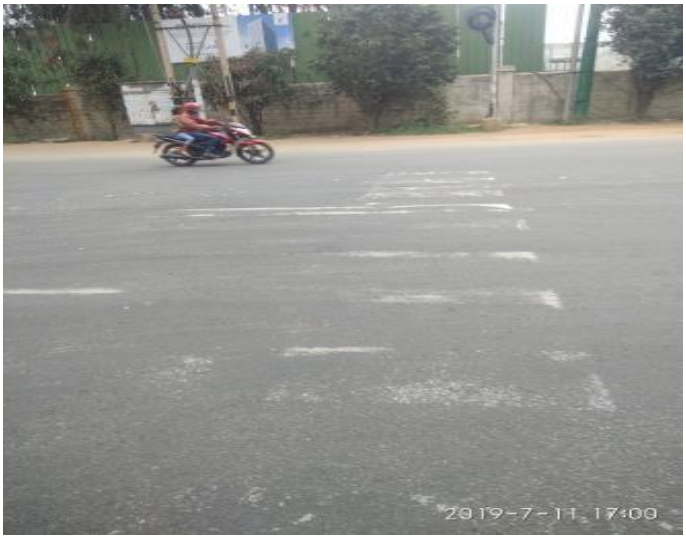

Fig -3: FADED ROAD MARKINGS AT BLACKSPOT 16

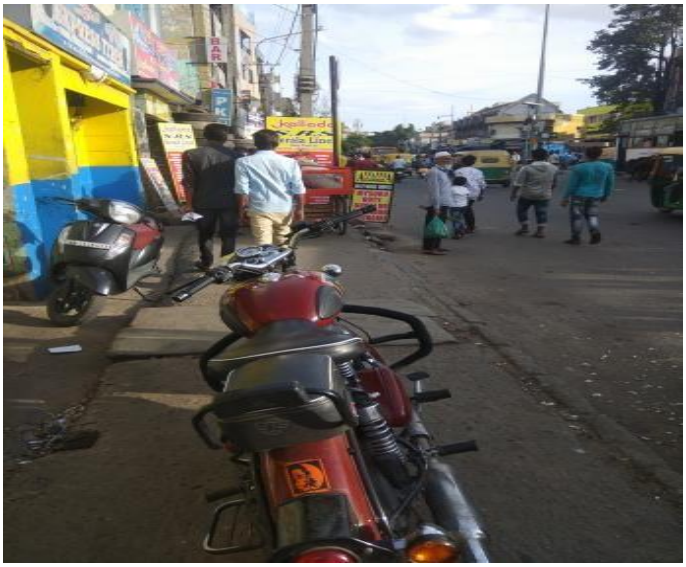

Fig -4: TWO WHEELER PARKING ON PEDESTRIAN PATH AT BLACKSPOT 20

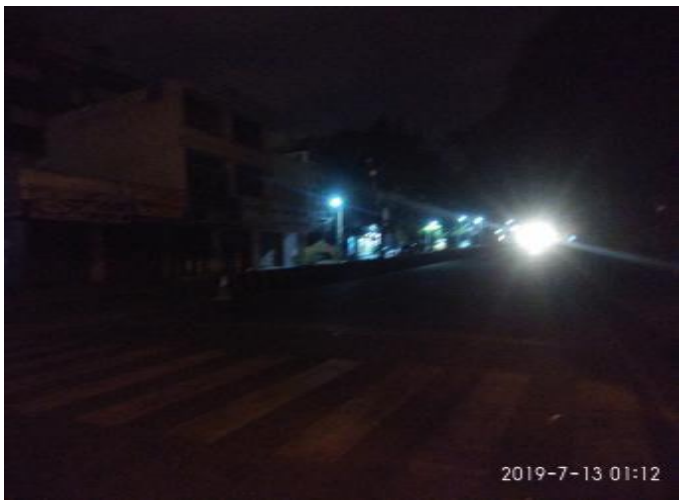

Fig -5: NIGHT GLARY EFFECT DUE TO NO STREET LIGHTS AT BLACKSPOT 21

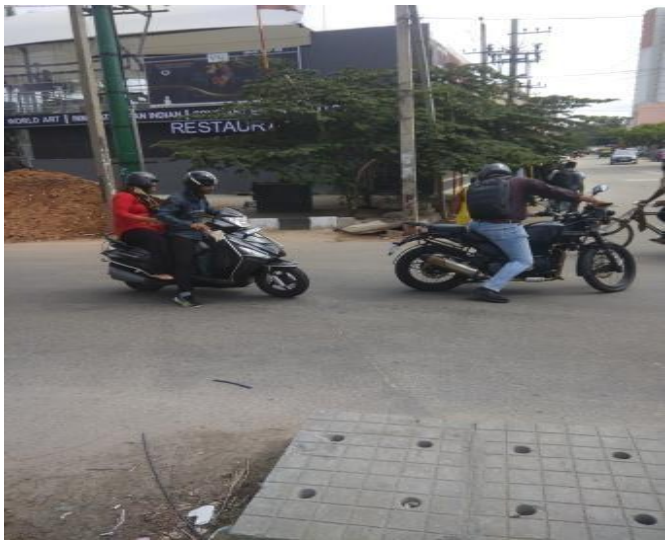

Fig -6: ACCIDENT TOOK PLACE DUE TO LACK OF SIGHT DISTANCE AT BLACKSPOT 23 DURING THE SURVEY

4. CONCLUSIONS

This study is carried out using IRC guidelines and MoRT&H specifications and IRC guidelines and can be concluded as follows.

- From statistical ranking analysis, it is found that Nagegowdanapalya Bridge to Sompura is high accident zone and Chokkasandra Junction is low accident zone.
- Most of these black spots are present near NAMMA METRO- Bengaluru construction sites, because of which road geometry is altered form its original features turning them as blackspots.
- These black spots connects to NH so the vehicle speed is more along with increasing vehicle density and median openings is the cause for most of the cases resulted in accidents.
- Intelligent Transport System has to be implemented in Bengaluru city for efficient management of traffic.
- Efficient and strict administration by the Government Agencies to install necessary lightings, road markings, traffic signs/ boards and maintain pavement condition from frequent potholes, drainage problems, sight visibility to reduce accidents at black spots in future.
- Awareness and accountability has to improve among the road users because most of the accidents were occurred due to negligence of driver, traffic violations by road users.

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