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Identification and Mitigation of Blackspots and Implementation of An Advanced Traffic Management System on NH-216A (A Spur of National Highway-16)

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Abstract: ***As the population is increasing day by day the number of vehicles is also increasing. As the number of vehicles is increasing, the number of accidents also increases. Analysis of previous data indicates that 66% of the accidents occur due to human error and 33% due to road parameters such as road and vehicle interaction, other road users, and environmental factors. Road safety has recently become a major concern in most modern societies. The identification of sites (black spots) that are more dangerous from an accident point of view can help in better scheduling road safety policies. The study includes the collection of accident data and prioritizing the accident-prone locations by using the Weighted Severity Index (WSI) method. This study includes the identification of Accidental Black Spots and improving these Accidental Black Spots by using ATMS. This project emphasizes accident studies on the National Highway-216A (Diwancheruvu to Siddantham) in East Godavari District, State of Andhra Pradesh, India. So the main aim of this study is, therefore, to identify the major accident black spots on National Highway -16 and mitigation of Accidental Black Spots by using Advanced Traffic Management System.***

Keywords: Accident, National Highway, Black Spots, Advanced Traffic Management System (ATMS), Weighted Severity Index (WSI).

I. INTRODUCTION

A. Accidents

The increase in the number of motor vehicles is due to the growth of population and unconventional growth of technology and economics. As mobility increases, the probability of accidents also increases. The basic elements in traffic accidents are road users, vehicles, road and its condition, road geometry, and environmental factors, etc. The fatality rate is more in developing countries as compared to developed countries.

The main cause of road accidents is drunken driving, careless and rash driving, over speeding, sudden braking, skidding, traffic rule violation, sudden twists, and turns while driving, etc. Moreover, road accidents can affect 1% of the annual gross product resources of developing countries.

Road accidents cannot prevent/stop, but by using suitable traffic engineering, safety plan, and management measures, the accident rate can be decreased. One of the most important factors to reduce traffic is the identification of hazard locations. In recent years, road safety and the rapid growth of traffic have become a major concern throughout the world. A road traffic accident is a major problem.

As per the Road Accident Report for 2019, a total number of 4,49,002 accidents took place in the country during the calendar year 2019 leading to 1,51,113 deaths and 4,51,361 injuries. Road accidents in India kill almost 1.5 lakhs of people annually. Accordingly, India accounts for almost 11% of the accident-related deaths in the World. It is estimated that the economic losses due to road accidents in India are over Rs 100 billion per year. The identification of accident location, analysis, and treatment of road accident black spots are widely regarded as one of the most effective approaches to road accident prevention.

B. Road Accident

Road Accident is an accident (collision, overturning, or slipping) that occurred or originated on a road open to public traffic resulting in either injury or loss of life, or property damage, in which at least one moving vehicle is involved.

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C. *Accident Type*

1) Fatal: An accident in which one or more persons are killed.
2) *Major (Hospitalised):* An accident in which none of the victims are killed however at least one person has sustained one or more serious injuries such as fractures, internal body injury, severe general shock, unconsciousness and needs hospitalization for medical treatment.
3) *Minor (Not Hospitalised):* An accident in which none of the victims were killed nor was any victim hospitalized. However, at least one of the victims has a slight injury and requires first aid.
4) *No Injury:* An accident in which were harmed in any way and does not even require first aid. However, public or private property may have been damaged and requires restoration.

D. *Black Spot*

A black spot is a place on a road that is considered to be dangerous because several accidents have happened there. Accidents happened there because of a variety of reasons, such as sharp curves in a straight road, so oncoming traffic is concealed, the design of junctions is not proper on a fast road, poor or concealed warning signs at a crossroads. Accident black spots can be improved by improving the signage, speed restrictions, improving sightlines, straightening bends, etc. In Andhra Pradesh, in the last ten years, 33,922 accidents occur in which 10,727 people died and approximately 54,702 people were injured. It shows that every year in Andhra Pradesh more than 1000 people died in road accidents. The major causes of road accidents in Andhra Pradesh are the condition of roads are not good and also the rough driving is responsible for this.

1) *Definition of Road Accident Black Spot as per MoRT&H:* Road Accident Black spot is a stretch of National Highway of about 500m in Length in which either 5 road accidents (in all three years put together involving fatalities/grievous injuries) took place during the last 3 calendar years or 10 fatalities (in all three years put together) took place during the last 3 calendar years.
2) *Advanced Traffic Management System (ATMS):* A system of vehicle detectors, cameras, and communication systems is used to monitor traffic, optimize signal timing, and improve the flow of traffic. The difficulties arising in controlling traffic congestion have attracted the attention of many researchers to work in the areas of Advanced Traffic Management System (ATMS). Intersections integrated with intelligent technologies have the potential to control traffic congestion and its outcomes. Advanced Traffic Management System (ATMS) is an efficient and cost-effective solution to manage highway traffic by collecting real-time information, processing, analysing, and finally providing the proper solution according to the situation to the users. Various applications of the Advanced Traffic Management System (ATMS) are suggested which will help to manage the traffic efficiently, reduce the traffic congestion on the study route and improve the road safety of the road users. The study provides possible solutions for reducing traffic congestion through the application of the Advanced Traffic Management System (ATMS). Broadly, the ATMS implementation shall cover the design, supply, installation, commissioning, and operation and maintenance of Advanced Traffic Management Systems (which is one of the components of Intelligent Transport System – ITS). The system would include outdoor equipment including emergency call boxes, variable message sign systems, vehicle actuated speed system, meteorological data system, close circuit TV camera (CCTV) system, traffic counting and classification system, mobile radio communication system, and transmission system. The indoor equipment would comprise a large display board, central computer (with Network Management System – NMS), CCTV monitor system, call center system, or management of emergency call boxes housed in a control center with uninterrupted power supply.

The systems shall meet the following objectives:

a) Smooth and uninterrupted traffic flow
b) Enhance road safety
c) Real-time information and guidance to users
d) Emergency assistance round the clock
e) Alerts for abnormal road and weather conditions
f) Reduced journey time and inconvenience

II. METHODOLOGY

The methodology of the project is shown in the flowchart given below.

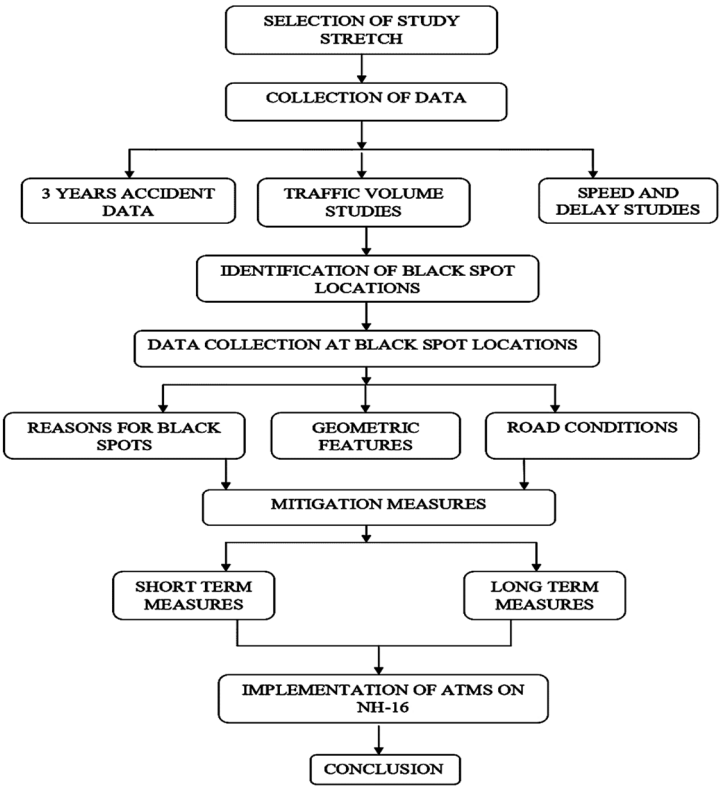


Fig.1 Methodology

A. Selection of Study Stretch

The area which is selected for accident studies is 49 km long National Highway-216A (a spur road of National Highway-16) section between Diwancheruvu to Siddantham from Km. 901+500 to Km. 950+542, Andhra Pradesh.

National Highway 216A is a spur road of National Highway-16 which is a major National Highway in India, that runs along the east coast of West Bengal, Odisha, Andhra Pradesh, and Tamil Nadu. It was previously known as National Highway 5.

Many cities and towns in various districts in the States of West Bengal, Odisha, Andhra Pradesh, and Tamil Nadu are connected by National Highway 16. NH 16 has a total length of 1,764 km (1,096 mi) and passes through the states of West Bengal, Odisha, Andhra Pradesh, and Tamil Nadu.



Fig. 2 Map of Study Stretch (Diwancheruvu to Siddantham)

B. Collection of Data

The data collected are 1

1) *Accident Data Collection:* The past 3 years (2018 To 2020) accident data is collected from the National Highways Authority of India for the section of Diwancheruvu to Siddantham section (from Km. 901+500 to Km. 950+542). The analysed accident data is represented in table 1:

Table 1

Road Accidents on NH-16 for the Section of Diwancheruvu to Siddantham

Year	Total Accidents	Fatalities	Major Injured	Minor Injured
2018	438	36	215	254
2019	371	35	171	325
2020	348	27	101	295

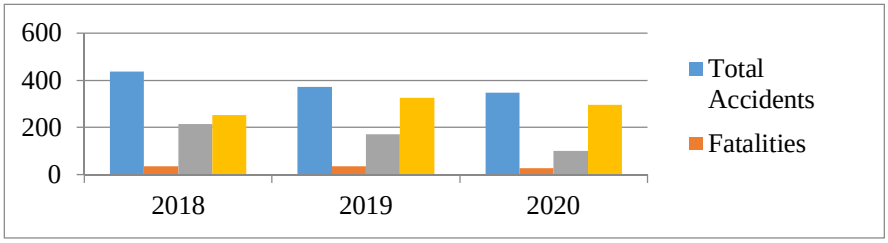


Fig. 3 Road Accidents on NH-16 for the section of Diwancheruvu to Siddantham

2) *Traffic Volume Studies:* The Traffic volume studies are carried out manually for one week by taking vehicle data for the section of Diwancheruvu to Siddantham at Ethakota Toll Plaza. Daily vehicle details are noted in the datasheet shown in table 2. The data is collected for different vehicles based on axle loads and are grouped for PCU.

Table 2:

Datasheet used for Conducting Traffic Volume Studies

Date	Two Wheeler	Three Wheeler	Car/Jeep	Mini Bus	Bus	Tempo / LCV	2 Axle	3 Axle	M Axle	Tractor with Trailer	Tractor	Cycle	Cycle Rickshaw

The traffic volume studies are conducted at Ethakota Toll Plaza on both sides of the carriageway from 10.05.2021 to 16.05.2021 timing 24X7. The vehicle data is collected and presented in table 3.

Table 3

Traffic Volume at Ethakota toll Plaza (10.05.2021 TO 16.05.2021)

Date	Section	Passenger Traffic						Goods Traffic							Non Motorised	
		2W	3W	Car	Jeep /Van	Mini Bus	Bus	LCV Passenger	LCV Freight	2 Axle	3 Axle	Multi Axle	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw
10 May 2021	Diwancheruvu-Siddantham	9866	1249	3669	64	94	503	48	1199	650	994	1603	12	113	0	0
11 May 2021	Diwancheruvu-Siddantham	10997	1532	4625	62	91	625	78	1422	674	1041	1601	10	123	0	0
12 May 2021	Diwancheruvu-Siddantham	10801	1450	4614	74	94	582	52	1610	646	991	1564	11	125	0	0
13 May 2021	Diwancheruvu-Siddantham	11653	1456	4321	58	88	586	95	1467	579	986	1541	5	124	0	0
14 May 2021	Diwancheruvu-Siddantham	10584	1334	4668	70	92	661	80	1456	565	964	1475	6	142	0	0
15 May 2021	Diwancheruvu-Siddantham	10365	1204	4203	45	86	601	62	1209	434	745	1274	8	128	0	0
16 May 2021	Diwancheruvu-Siddantham	9896	1226	2900	60	57	565	55	1359	595	865	1259	10	135	0	0
10 May 2021	Siddantham-Diwancheruvu	10023	1185	3650	73	93	577	44	1323	470	968	1521	10	173	0	0
11 May 2021	Siddantham-Diwancheruvu	11108	1421	4879	117	101	631	71	1428	471	1056	1550	4	166	0	0
12 May 2021	Siddantham-Diwancheruvu	10975	1426	4436	93	109	601	54	1330	600	1017	1532	9	170	0	0
13 May 2021	Siddantham-Diwancheruvu	12265	1517	4760	90	105	583	72	1189	641	957	1468	11	152	0	0
14 May 2021	Siddantham-Diwancheruvu	10715	1287	4725	57	99	684	64	1166	641	921	1574	9	177	0	0
15 May 2021	Siddantham-Diwancheruvu	10339	1219	3901	26	83	590	56	1019	706	932	1464	8	168	0	0
16 May 2021	Siddantham-Diwancheruvu	9863	1241	2921	40	80	590	45	1075	537	882	1422	12	169	0	0
Total Weekly Traffic		149450	18747	58272	929	1272	8379	876	18252	8209	13319	20848	125	2065	0	0
PCU Factor		0.5	0.5	1	1	1.5	3	1.5	1.5	3	3	4.5	1.5	4.5	0.5	2
Total PCU		74725	9374	58272	929	1908	25137	1314	27378	24627	39957	93816	188	9293	0	0
Average Daily Traffic		21350	2678	8325	133	182	1197	125	2607	1173	1903	2978	18	295	0	0
PCU ADT		10675	1339	8325	133	273	3591	188	3911	3518	5708	13402	27	1328	0	0
Tollable PCU		-	1339	8325	133	273	3591	188	3911	3518	5708	13402	-	-	-	-

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3) *Speed and Delay Study:* The speed and delay study was carried out by using the moving observer method from Diwancheruvu to Siddantham (49.042 Kms) and Siddantham to Diwancheruvu (49.042 Kms) to find out the average journey speed presented in table 3.4 and delay of the traffic stream is presented in table 3.5.

a) *Speed Studies*

Table 4
Speed Studies

Stretch	Average Speed
Diwancheruvu to Siddantham	67.35 kmph (00:43:40)
Siddantham to Diwancheruvu	63.25 kmph (00:46:30)

b) *Delay Studies*

TABLE 5
Delay Studies

Stretch	Average Delay Time	Reason for Delay
Diwancheruvu to Siddantham	192 Seconds	Traffic Signals at 1. Lalacheruvu Junction(62 Sec) 2. Morampudi Junction(130 Sec)
Siddantham to Diwancheuvu	188 Seconds	Traffic Signals at 1. Lalacheruvu Junction(62 Sec) 2. Morampudi Junction(126 Sec)



Fig. 4 Traffic Signal at Lalacheruvu Junction



Fig. 5 Traffic Signal at Morampudi Junction





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C. Identification of Black Spots

The accident data of the Diwancheruvu to Siddantham section for the duration of 2018 to 2020 is collected from the National Highways Authority of India and the data is analysed as per the MoR&H circular RW/NH-15017/109'2015-P&M(RSCE), dated 28.10.2015. as per the MoRT&H circular Road, Accident Black Spot is a stretch of National Highway of about 500m in Length in which either 5 road accidents (in all three years put together involving fatalities/grievous injuries) took place during the last 3 calendar years or 10 fatalities (in all three years put together) took place during the last 3 calendar years. The data is analysed and the Black Spot locations are presented in table 6.

Table 6
Black Spot Locations

Sl. No	Location	Chainage		Total accidents in past 3 years	Total Fatalities in past 3 years	Total Major injuries in past 3 years	Total Minor injuries in past 3 years
		From Km.	To Km.				
1	Lalacheruvu Junction	907.750	908.250	14	0	3	5
2	Morampudi Junction	910.550	911.050	25	2	9	9
3	Vemagiri Junction	918.200	918.700	16	1	13	9
4	Kadiyapu lanka Center	923.250	923.750	19	3	6	8
5	Madiki centre	928.180	928.680	34	2	15	24
6	Chemudulanka centre	929.780	930.330	48	6	35	26
7	Choppella	931.120	931.620	20	3	14	13
8	Choppella Lakula centre	931.650	932.150	31	1	19	26
9	Mulastanam	932.850	933.350	52	1	33	30
10	Jonnada Ramp Centre	936.400	936.900	46	5	38	15
11	Govt J.R.Collage center,RTC Ingate	940.770	941.270	46	2	21	30
12	Ethakota center	945.050	945.550	41	2	14	34
13	Gopalapuam center	947.200	947.560	42	3	28	30

1) *Weighted Severity Index (WSI):* In this method, the weighted severity index is calculated based on the classification of accidents as fatal, grievous injuries and minor injuries. Location having the highest severity index value is ranked first followed by the rest. The concept of this method is that the fatality or injury crashes are given greater weightage than property damage-only crashes. The data is analysed and the Black Spot locations as per the Weighted Severity Index (WSI) are presented in table 7.

Table 7
Black Spot Locations As Per The Weighted Severity Index (WSI)

Sl. No	Location	Chainage		Total accidents in past 3 years	Total Fatalities in past 3 years	Total Major injuries in past 3 years	Total Minor injuries in past 3 years
		From Km.	To Km.				
1	Chemudulanka centre	929.780	930.330	48	6	35	26
2	Jonnada Ramp Centre	936.400	936.900	46	5	38	15
3	Gopalapuam center	947.200	947.560	42	3	28	30
4	Kadiyapu lanka Center	923.250	923.750	19	3	6	8
5	Govt J.R.Collage center,RTC Ingate	940.770	941.270	46	2	21	30
6	Madiki centre	928.180	928.680	34	2	15	24
7	Mulastanam	932.850	933.350	52	1	33	30

8	Choppella Lakula centre	931.650	932.150	31	1	19	26
9	Vemagiri Junction	918.200	918.700	16	1	13	9
10	Ethakota center	945.050	945.550	41	0	14	34
11	Morampudi Junction	910.550	911.050	25	0	9	9
12	Choppella	931.120	931.620	20	0	14	13
13	Lalacheruvu Junction	907.750	908.250	14	0	3	5

III. DATA COLLECTION AT BLACK SPOT LOCATION

The data collection at the black spot located in the present study is detailed in the below figure.

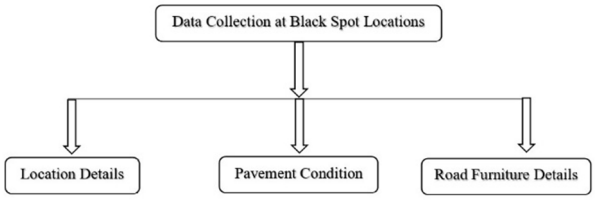


Fig. 6 Flowchart of Data Collection at Black Spot Location

1) The data collection involves Location details Road Features, Median opening details, Approach Road conditions, Intersection details, and Pavement cross-sections.

2) Pavement condition involves Alligator cracking, Bleeding, Block cracking, Bumps and sags, Corrugations, Depressions, Edge cracking, Joint reflections, Lane/shoulder drop-off, Longitudinal, and transverse cracking, Potholes, Rutting, Shoving, Slippage cracking, Swelling, Ravelling.

3) Road Furniture condition involves the condition of Road Markings, Road Signs, Road Studs, Safety Barriers, Guard Posts, Traffic Delineators, and Highway Lighting.

IV. REASONS AND MITIGATION MEASURES AT BLACK SPOT LOCATIONS

Location	Reasons for Black Spot	Short Term Measures	Long Term Measures
❖ Mulastanam ❖ Km. 932.850 to Km. 933.350	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 933+165. ❖ There is a T-Junction at Km. 933+165. ❖ Highway lighting is not provided. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided.
❖ Chemudulanka center ❖ Km. 929.780 to Km. 930.330	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 930+330. ❖ There is a T-Junction at Km. 929+770. ❖ Illegal parking's at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded.	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired. ❖ Un-Authorized Median	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided.

Location	Reasons for Black Spot	Short Term Measures	Long Term Measures
	❖ Road studs are not provided ❖ Un-Authorized Median Opening at Km. 929+800	Opening at Km. 929+800 to be closed.	
❖ Jonnada Ramp Centre ❖ Km. 936.400 to Km. 936.900	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 933+165. ❖ There is a T-Junction at Km. 936+450. ❖ Illegal parking's at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Govt J.R.Collage center, RTC Ingate ❖ Km. 940.770 to Km. 941.270	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 936+450. ❖ There is an X-Junction at Km. 940+880. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Gopalapuam center ❖ Km. 947.200 to Km. 947.560	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 947+560. ❖ There is an X-Junction at Km. 947+560. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Ethakota center ❖ Km. 945.050 to Km. 945.550	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 945+150. ❖ There is an X-Junction at Km. 945+150. ❖ Illegal parking's at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided.

Location	Reasons for Black Spot	Short Term Measures	Long Term Measures
❖ Madiki center ❖ Km. 928.180 to Km. 928.680	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 928+420. ❖ There is a T-Junction at Km. 928+515. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Sign Boards not provided. ❖ Highway lighting is not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Pedestrian Guard Rails to be provided.
❖ Choppella Lakula centre ❖ Km. 931.650 to Km. 932.150	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 931+900. ❖ There is a T-Junction at Km. 931+900. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided ❖ Un-Authorized Median Opening at Km. 931+400.	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired. ❖ Un-Authorized Median Opening at Km. 931+400 to be closed.	❖ Junction improvement to be done as per IRC:SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided.
❖ Morampudi Junction Km. 910.550 to Km. 911.050	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 910+800. ❖ There is a T-Junction at Km. 910+774. ❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Choppella Km. 931.120 9to Km. 31.620	❖ Illegal parking at the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ There is a T-Junction at Km. 931+370. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC:SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC:SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided.
❖ Kadiyapu Lanka Center Km. 923.250 to Km. 923.750	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 923+510. ❖ There is a T-Junction at Km. 923+510.	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be

Location	Reasons for Black Spot	Short Term Measures	Long Term Measures
	❖ Illegal parking on the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Traffic flow against the laneway. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Vemagiri Junction Km. 918.200 to Km. 918.700	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 918+507. ❖ There is an X-Junction at Km. 918+500. ❖ Illegal parking on the shoulder side of the Highway. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Highway lighting is not provided. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.
❖ Lalacheruvu Junction Km. 907.750 to Km. 908.250	❖ There is a Built-up area with ribbon development (Densely Populated). ❖ The Shelter lane is not provided for median opening at Km. 907+830. ❖ There is an X-Junction at Km. 907+825. ❖ Illegal parking at the shoulder side of the Highway. ❖ Highway lighting is not provided. ❖ Encroachments lying within ROW and bushes along the earthen shoulder. ❖ Sign Boards not provided. ❖ Road Marking faded. ❖ Road studs are not provided	❖ Sign Boards to be provided as per IRC:67-2012. ❖ Road Markings to be provided as per IRC:35-2015. ❖ Road Studs to be provided as per IRC: SP:84-2014. ❖ Encroachments to be removed. ❖ Earthen Shoulder should be repaired.	❖ Junction improvement to be done as per IRC: SP:84-2014 and as per IRC-SP-41-1994. ❖ Highway lighting to be provided. ❖ Vehicular Under Pass (VUP) should be provided with a Service road of 7.5m on Both Sides of the Carriageway.

V. IMPLEMENTATION OF ADVANCED TRAFFIC MANAGEMENT SYSTEMS

Applications of the Advanced Traffic Management System (ATMS) are suggested which will help to manage the traffic efficiently, reduce the traffic congestion on the study route and improve the road safety of the road users. The study provides possible solutions for reducing traffic congestion by the application of the Advanced Traffic Management System (ATMS).

A typical ATMS implementation shall comprise of at least the systems/sub-systems depicted as below:

1) Video Surveillance System (CCTV)
2) Video Incident Detection System(VIDS)
3) Vehicle Actuated Speed Display
4) Emergency Road Side Telephone System
5) Variable Message Signs (VMS) [Fixed and Portable]
6) Meteorological Data System (MET)
7) Weigh-in-Motion system
8) Automatic Traffic Counter cum Classifier (ATCC)
9) Network / Communication Infrastructure system
10) Mobile Radio Communication System
11) Travel time Estimation system
12) ATMS Control Centre

Guidelines/Rationale for Locating - ATMS Device / System

ATMS Equipment	Application / Requirement
Emergency Call Box (ECB)	Emergency Road Side Telephone (ERT) / ECB shall be provided at every 2 km along the Project Highway. In addition to this, zones experiencing telecom black spots along the Project Highway shall be provided with ERT.
Variable Message Signs (VMS)	VMS shall be provided at (i) major entries to Project Highway, (ii) before major junctions on the main carriageway that can lead to alternate routes to the highway, (iii) before each large village or town on Project Highway with potential for traffic congestion. The minimum visible distance of VMS shall be 250 m. Message languages: Hindi, English, and Local language
Vehicle Actuated Speed Display	The system shall be located suitably depending on the chosen detection location (e.g. at the entry of every village)
Meteorological Data Systems (MET)	A single MET system shall be installed at the ATMS Control Centre for Project Highway where the entire highway is located on similar terrain and with similar weather conditions. More systems are to be installed depending on the changing terrain and varying weather conditions.
PTZ CCTV Camera	To monitor traffic conditions (Day & Night) on the highway including junctions with considerable traffic, populated village town sections/road junctions, and vulnerable sections of the highway. Range of 1 km on the highway (i.e. 1 km on either side).
Video Incident Detection System (VIDS)	Detection range from the Camera location: 200 m (Day and night) Provision of warning with flashing lights: a) 100 m before the area of detection b) 200 m before the area of detection to warn arriving vehicles To be located such that detection range is 200 m or less
Automatic Traffic Counter and Classifier (ATCC)	ATCC shall be installed (ii) before the traffic diversion points where the traffic diverting from Project Highway to other linked road and (ii) 1 km ahead of the toll plaza
Travel Time Estimation System	RFID Transceivers located 500 m before and after the toll plaza, in either direction.
Radio Mobile System (RMS) / Mobile Communication System	Tower & base station shall be installed for communication on the whole Project Highway. Portable handheld wireless sets shall be provided to relevant members of the O&M team for communication. Vehicle-mounted communication units shall be fitted on ambulances, RPV, and other relevant O&M vehicles. Provision shall be there for all handheld and vehicle-mounted units to communicate with the base station at ATMS Control Centre as well as amongst themselves.
Portable Weigh In Motion	Typically to be located at entries to the highway and at chosen locations close to where heavy loads are likely to be carried (i.e. near manufacturing industries) to implement periodic / surprise checks.
ATMS Control Centre	One ATMS Control Centre including the equipment (hardware, software, and local networking) shall be developed on Project Highway
Communication System	Communications System utilizing Optic fiber, point-to-point wireless links, GSM/GPRS, and Wi-Fi Communications linked to ATMS Control Centre shall be provided depending on equipment communication criteria.
Power supplies for field equipment	Working on Mains power supported with back-up (largely on renewable energy) to facilitate 24 X 7 operation and for the ATMS Control Centre working on Mains power supported by UPS and Diesel generator set of adequate capacities, to facilitate 24 x 7 operation.

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VI. CONCLUSIONS

A. The identification and analysis of accident black spots help in identifying the stretches where accidents are more and these spots reduce road safety in general.

B. The spot-on road where traffic accidents frequently occur is termed as black spots. The current study was an attempt to find out the most vulnerable accident locations or black spots on NH-16 in East Godavari District, Andhra Pradesh. The Weighted Severity Index (WSI) method was used to rank the accident locations. We have suggested some possible alternative measures to improve the safety and effective transportation system.

C. The safety hazards are observed along project highways such as Un-Authorized Median openings, deficiencies in illumination (Highway lighting), and Road furniture items. It is suggested that priority be given to improving the safety at Median opening and Junction locations. The suggested priority action plan is to improve the road markings, develop the Junctions, improve the visibility of signage and maintain them in good condition.

D. The implementation of the Advanced Traffic Management system is started on NH-16 from Anakapalli to Gundugolanu. We are meeting the officials of the NHAI and the Concessionaire of the study stretch in that meeting they said that the implementation will be completed by the end of 2021 and the Advanced Traffic Management System is available from 2022 in the project stretch.

VII. ACKNOWLEDGEMENT

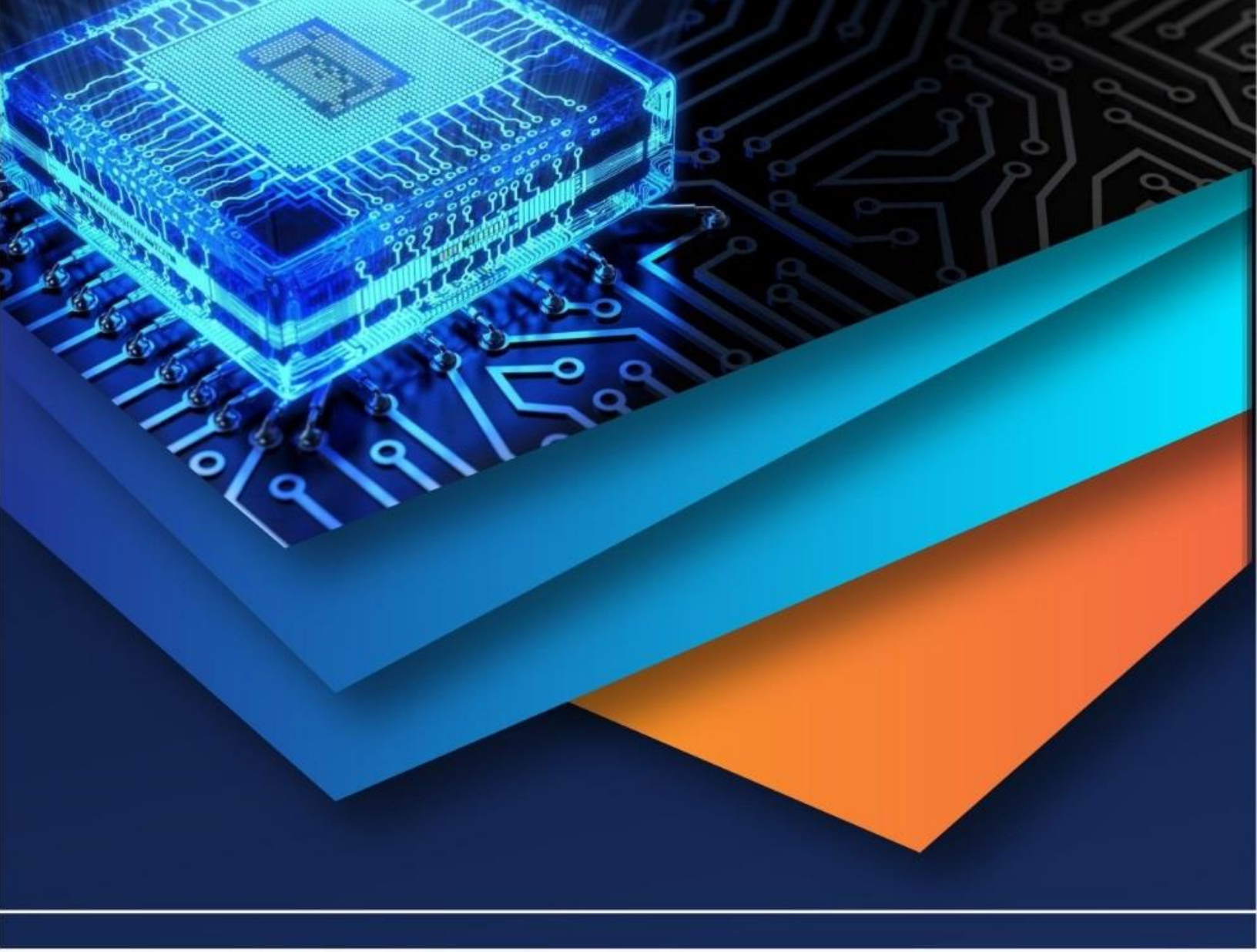
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