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A Road Safety Audit on "LAWAN-DUDU" Stretch along SH-02

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Abstract – *An ongoing challenge to transportation engineer is to plan and operate the transportation system in such a way that it meets various societal objectives such as reducing travel time and enhancing safety. Over the years, there has been an unprecedented increase in road transportation and vehicular traffic in India due to an exponential growth in the economy and consumption habits, which has led to unsafe conditions on our highways.*

In an era of continuous growth in mobility and demand for transportation, safety is an issue of major social concern and an area of extensive research and work. The rate of accident in developing countries like India increases year by year. To reduce this adverse effect of transportation, the work toward road safety is become necessary now a day. Study of the road network and geometric feature are essentially to tackle problem of accident in a city. The occurrence of accident not only causes immediate loss in term of property and life but may also cause a long term pain or grief. This study presents accident scenario and lack of road safety provisions for State Highway. For that purpose, various types of surveys related to work has been carried out. These data are associated with some standard like IRC for the analysis. The results of this analysis give the scenario of accident and road safety provided. By the study of the accident scenario, this study gives the road safety measures to prevent the accidents.

Key Words: *Road Safety Audit, State Highway, IRC, Identification of Safety Influencing Parameter.*

1. INTRODUCTION

Road is one of mode of transportation's need and its Safety is an important issue. It includes number of events like framework, arrangement of more secure vehicles, enactment and law authorization, portability arranging, , kid and old matured individual's security, urban land use arranging and etc.

With rising mechanization and extending street organize, travel dangers and traffic introduction develop at an a lot quicker rate, as the development of enrolled vehicles consistently dwarfs populace development and new streets are built. Today street traffic wounds are one of the main sources of passing's, inabilities, and hospitalization with serious financial expenses over the world.

During the year 2016, there were around 4.9 lakhs street mishaps which murdered 1,50,785 individuals and harmed more than 4.9 lakhs people in India. These numbers convert into one street mishap consistently and one street mishap passing at regular intervals for India. Street traffic wounds and fatalities force a colossal monetary weight on creating financial matters specifically. In India, the greater part of the street mishap casualties are in the age gathering (15-49 years), the key blue collar and kid rising age gathering. The loss of the principle bread worker and head of family because of death or incapacity can be calamitous, prompting settle for the easiest option and destitution, notwithstanding the human expense of loss. Street auto collisions are manageable to therapeutic activity. Many created nations have seen drop in street mishaps and loss numbers by receiving multi- delayed way to deal with street wellbeing that incorporate traffic the executives, street structure, more secure vehicle, law implementation, arrangement of mishap care and so forth. The test for us is to embrace and assess these ways to deal with suits our necessities.

With fast increment of multilane interstates and vehicles in India; the losses because of mishaps on the streets are expanding a seemingly endless amount of time after year. The street mishaps passing and wounds are worldwide marvels however more extreme circumstance in blended rush hour gridlock condition as swaying Indian multilane roadways. Presently Road security has become a developing worry for the general population when all is said in done and thruways proficient specifically as street mishaps are a significant wellspring of life. Moreover; the monetary misfortunes brought about by harmed or loss of working days coming about because of wounds casualty have been assessed at billions of rupees every year.

To improve street security; chief, approach creator, originator, and organizer are utilizing numerous instruments and strategies. Street wellbeing Audit (RSA) is probably the best instrument for development of street security; in which specialists endeavor to distinguish conceivably perilous highlights on the expressway condition and propose medicinal measures. RSA guarantees the innocuous

versatility of traffic and diminishes in mishap rates on street. A lot of assets can be conveyed to decrease mishaps by improving the street calculations and operational states of the streets. Street security experts can accomplish this through playing out an autonomous check of the wellbeing components. These experts can remark on the security parts of the street in the wake of performing deliberate assessment. In India, fundamental and precise information of mishap presently can't seem to be gathered in which RSA can help in diminishing mishap events at defective street mathematical and configuration by embracing suitable preventive measures.

Defining the Main Features of RSA (Road Safety Audit)

Road safety audit can be explain as "a formal examination of an existing of future road or traffic project, or any project that interacts with road users, in which an independent, qualified examiner reports on the projects' accident potential and safety performances" .This explanation was changed in year 2001 as "a formal examination of an existing or future road or traffic project, in which an independent, qualified team reports on the project's accidents potential and safety performance".

UK, (1996), guidelines for the Safety Audit of Highways define road safety audit as "advertising formal procedure for assessing accident potential and safety performance in the provision of new road schemes for improvement and maintenance of existing roads".

Indian Road has Safety Manual published in 2010 elaborates Road Safety Audit in terms "a formal procedure for assessing accident potential and safety performance in the provision of new road schemes, the improvement, and rehabilitation of existing roads and the maintenance of existing road".

From the above explanation, Road Safety Audit is characterized an efficient methodology for assessment of existing or new streets by an autonomous review group at the phase of arranging, structure, development, activity and support to accomplish mishap free streets and to upgrade generally speaking wellbeing execution.

The primary point of street wellbeing review is to guarantee that all new street plans work as securely as practicable. This implies Safety ought to be considered all through the whole pattern of structure, development and pre-opening of any task office and furthermore during activity and upkeep of the expressway.

1.1 RSA in India

This audit is an ideal instrument for improving street security in India. As fundamental and exact information on mishaps presently can't seem to be gathered, preventive measures through solution of RSA can help in a huge manner by lessening mishap events because of defective street geometrics and structure. A lot of assets can be sent to diminish mishaps by improving the calculations and operational states of streets. This can be accomplished by a street wellbeing pro playing out an autonomous mind security components. This authority, after efficient assessment, can remark on the wellbeing parts of street. The RSA can be applied to all sort of street ventures new street development just as restoration of existing streets.

With an end goal to limit the development of mishaps on Indian streets, Road Safety Audit (RSA) is being sought after in a major path on the current just as proposed new streets. As a piece of this exertion, National Highways Authority of India has initiated street security review venture of National Highways Development Projects (NHDP) covering a length of about 3300Km.

Each street venture has an assignment of 2 percent of the task cost for security. Actually, this financial plan has been utilized as possibility for various purposes in the task. Other hand, the Commission for Global Rod Safety (CGRS) has made a real to life suggestions for a distribution of 10 percent of the undertaking reserve for street wellbeing highlights (CGRS, 2009) which merits cautious thought.

1.2 Requirement of This Research

As the situation of accidents occurring on roads around the world are worse. It is well understood that the elimination of the accidents altogether from the roads is not possible, but they can be minimized. This would require a clear understanding of characteristics and causes of traffic accidents based on an efficient database. To assess the situation and to know the cause of accidents, one has to conduct a comprehensive study on road safety features. On many occasions, a completely new highway project has been designated as the most vulnerable just after a few years of construction. A Road Safety Audit can be expected to identify those deficiencies which are responsible for accidents on highway environment and suggest remedial proposal to reduce accidents from a highway segment.

1.3 Aim of the Research

The objectives if this thesis as follows:

1. To develop a methodology for Road Safety Audit for State Highway.
2. To examine safety features adopted in the selected section of a stretch on State Highway and find out deficiencies in the road network which led to accident and safety hazards to road users.
3. To identify the need of alternate measures of traffic management to access the existing section with

respect to the standards of Indian Road Congress (IRC).

1.4 Scope of the Study

The extent of this report is to feature the worldwide and public on street wellbeing review, which is generally new and exceptionally savvy apparatus for mishap counteraction. The current examination has been completed on a section of State Highway-02 in the State of Rajasthan. The thruway conveys traffic of various powers and at various speeds. Blended traffic in with various conduct lead to plant down the speed and reason for mishaps.

The expressway stretch from Lawan to Dudu area (Km 12/0 to Km 130/0) was picked for concentrate due the variety in interstate condition. The expressway was found habitually changing in land utilizes, contrasts in driving propensities, law authorization, traffic examples and interstate structure theory. The interstate mirrors the nation street client conduct which needs exceptional consideration and further investigation.

It is material both for new activities and existing streets. A Safety Audit is done at discrete phases of street improvement ventures. It is an iterative cycle of surveying street plan components and by and large include agenda which are crucial to the methodology, and where wellbeing aptitudes and decisions are central.

2. REVIEW OF LITERATURE

2.1 Scientific Studies Conducted in India

Pariekh V.et al. (2014) have done street security review "An Identification of Black Spot" on occupied passageway between Narnuol-Narooda, National interstate of Ahemedabad city. There were 2 primary goal in this paper, first was to complete of street wellbeing review of existing condition on chosen passageway and second was to recognize dark spot based on mishaps happened on chosen hallway. To accomplish both of points ordered volume tally study. Mishap Data, Spot speed overview, and Road Inventory review has been completed and temedial measures were given for the chose hall. In the wake of performing Road security review they have inferred that dominant part of mishaps were found at Narol Circle, Isanpur, Ghodasar, C.T.M. also, Expressway go across street. They found that there was no arrangement of traffic lights at any of five crossing points on chosen hallway and no arrangement of administration path and stopping path from Ghodsar to Jasodanagar street. There was less street space accessible for the through traffic since overwhelming volume of cars were left along the street which caused gridlock and mishaps at different basic areas.

Nataraju Jakkula et al. (2013) have completed a street security review of National Highway in India at development stage to discover lacks in the street system and wellbeing danger boundaries for street clients and laborers in work zone which prompted mishaps. This investigation was completed on the stretch of National Highway-202 from Km.18.600 (Hyderbad, AP) to Km 130.00 (Yadagiri, AP), Main focus of this study was to find out safety parameters of work Zone as well as worker and to recommend the improvement for the safety of work zone as well as workers. After conducting the study, they have concluded that most of the places on existing road the hazard marker on fixed object and CD works parapet walls were missing, and barricades with retro-reflection tapes to segregate the construction activities and zone from the main carriageway. On the basis of the study, they recommended that hazard markers should be fixed, appropriate barricades be provided, and training to the workers should be given on safety issue such as operating fire extinguishers etc. regularly by the contractors.

Agarwal P. K. et al. (2013) have introduced "A Methodology for Ranking Road Safety Hazardous Locations utilizing Analytical Hierarchy Process". In this examination, for positioning street wellbeing risky areas, a four phase approach was introduced which didn't need mishap information. To complete the investigation, different stage distinguished were stage I: ID of security factor, stage II: Determination of relative significance (loads) of wellbeing factor, stage III: Determination of rating of security factor condition, and stage IV: Ranking of street wellbeing dangerous areas. Street wellbeing risky condition were decayed in to unsafe areas at straight segments. Security dangerous condition at bend segments, and wellbeing unsafe condition at convergence. To decide the relative significance (loads) of the distinctive distinguished wellbeing factors, Analytical Hierarchy measure (AHP) was utilized. Another significant result of this examination was wellbeing Hazardous Index which was created utilizing weight of security factors and condition rating of security components and this wellbeing Hazardous Index was utilized for positioning security unsafe areas in a street arrange.

Jain S.S. et al. (2011) have completed a Road Safety Audit for Four-Lane National Highways. This investigation was completed on the stretch of National Highway-58 from Km, 75.00 to Km 130.00. Principle targets of this investigation were to build up a Road Safety Audit strategy for four-path National Highways, to look at security highlights present on chosen stretch and discover inadequacies which prompted mishaps and wellbeing dangers to street clients, to build up a model for ID of security affecting boundaries to limit mishap rate on chosen expressway segment. To complete the examination, characterized Traffic Volume Survey, Spot Speed Survey, and assortment of Accident Data were finished. From the investigation; they have inferred that principle boundaries for causing mishaps were the state of shoulder, Traffic Volume, Spot Speed, Median Opening, and carriageway condition. They recommended that there ought to be arrangement for Administration Street for the whole

length of four-path streets so as to isolate sluggish and quick moving traffic.

2.2 Scientific Studies Conducted in Abroad

Lech Michalski and Stanislaw Gaca (2014) have introduced "Instruments for street framework wellbeing the executives Polish encounters". Principle target of street security framework the board is to guarantee that when streets are structured, assembled, arranged, and utilized street dangers can be methodicallly distinguished, surveyed, eliminated, and alleviated. To help street specialists with dynamic on issues including street framework wellbeing, street, security, and lessening the expense of utilizing street structure in their specific life cycle, security the board strategies were created. On poland's public streets, the technique of street security assessment recognize three kinds of investigation: generally (IO), Detailed (ID), and exceptional (IS) examination. Based on study they inferred that underlying investigation demonstrated that the specific devices for street foundation wellbeing the executives could decrease the quantity of setbacks: The streets which didn't experience street wellbeing the executives cycle stage (street security sway appraisal, street security review, and street wellbeing the board), viability was higher on that streets.

Chamber and Stewart (1999) created measurable models for rustic four-path unified and separated roadways. The models were created as a major aspect of a cross-sectional examination for contrasting the wellbeing execution provincial two-path and four-path parkways. Committee and Stewart utilized information gathered in California, Minnesota, North Carolina, and Washington. The models were created utilizing traffic stream and shoulder width as info factors. Bigger shoulder widths were related with less crashes for isolated four-path roadways.

Fitzpatrick et al. (1995) analyzed the security execution of Two Way Left Turn (TWLT) paths on four-path provincial parkways in Texas. This kind of Design is frequently utilized on provincial parkways found neighboring urban territories, where the nearby land is as a rule completely urbanized for business action. In light of a cross-sectional investigation, their outcomes show no factual contrasts in the quantity of accidents between with TWLT paths and interstates with Flush medians with low garage densities.

Halcrow Fox (1981) analyzed the relationship between open street math and injury crash rates in the UK, so as to get to the street security ramifications of more adaptable plan guidelines. Specifically, level span, slope, and sight separation were talked about. In light of study, it was seen that there was a less huge increment in crash rates with diminishing sight separation, mostly on the grounds that sight separation was likewise related to flat range.

3. METHODOLOGY FOR ROAD SAFETY AUDIT

The security investigation system introduced in this part gauges the wellbeing exhibitions for a current four-path expressway working under traffic request. The wellbeing execution of four-path parkway is the normal yearly mishap recurrence, which can be determined for a specific street portion, convergence, or whole venture. An approach has been created for street wellbeing review for four-path National Highway which is appeared with stream diagram in following figure 3.1

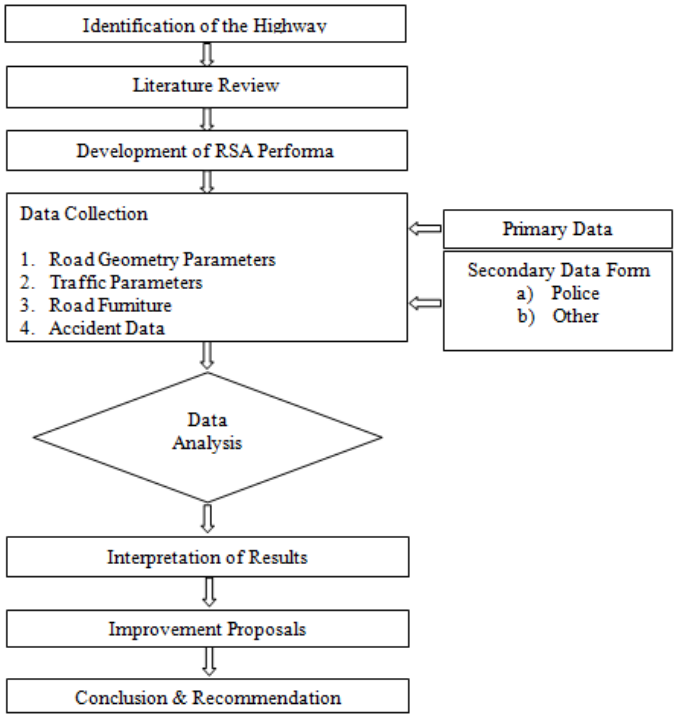

Fig. 3.1 Flow Chart for Road Safety Audit Study Methodology

3.1 Road Safety Audit Stages

Well being Audit can be applied on another streets and (b) existing streets. On new streets, wellbeing review will prompt abstaining from building clumsy circumstances and on existing streets, review will prompt improved streets from the security perspective. Stages for Road Safety Audit are given as-

- During Feasibility (Planning) Stage-1 Audit
- During Preliminary Design Stage-2 Audit
- Completion of Detailed Design Stage-3 Audit
- During Construction Stage Stage-4 Audit
- Completion of Construction Stage-5 Audit
- On Existing Roads (Monitoring) Stage-6 Audit

The multifaceted nature and level of exertion of the review cycle changes with each stage.

4. AREA OF RESERACH AND ANALYSING DATA

Street Safety Audit of the Stretch "lawan-tunga-chaksu-phagi-dudu on State Highway-02" (From Km 12+000 to Km 130+000) absolute length of 118 Kms was done with the mean to decide the wellbeing needs of all street clients. Traffic on the interstates are blended in nature and contain weighty and light vehicles. Lawan to dudu street stretch is the most appropriate to direct during development stage street wellbeing review for Two-path State Highway..

The investigation area of State Highway-02 (12/0-35/0) is Single path (3.00 m) and (35/0-67/0 and 70/0-130/0) is Two Lane (7.00 m) and 3 Km (67+000 to 70+000) is underneath Single path (3.00 m). Work for two lanning was in progress in Km 110/0 to 130/0.The State Highway 02 originates from Dausa in the district of Dausa and goes upto Kuchaman in the district of Rajasthan. The Highway passes through Lawan District of Dausa, Tunga, Kotkhawda, Chaksu, Gopalpura, Mashorajpura, Phagi & Dudu of Jaipur & Sambhar, Loharana, Govindi, Nava, Mandwara and Kuchaman of Nagaur.

The route map of the selected SH-02 stretch is shown in figure 4.1.

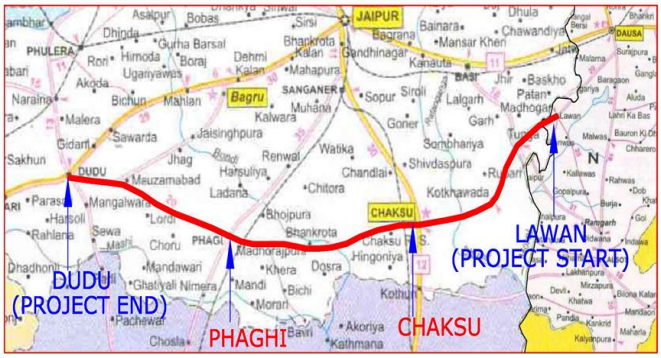

Fig. 4.1: Location Map of Study Area on SH-02

5. ROAD SAFETY AUDIT-OBSERVATION & PROPOSALS

5.1 Observation and Proposals

From data analysis, it was observed that safety influencing parameters were identified which were responsible for road accidents. Road agencies could enhance safety aspects by effective monitoring of these identified parameters. the most influencing safety parameters were identified as median opening, safety barriers, visibility along curves, condition of Vegetation Control, and Curve Warnings etc. which could be directly controlled by road maintaining agencies. some site-specific observations and proposals were discussed in following section.

5.1.1 Major/Minor Junctions

The intersections/junction should be designed having regard to flow, speed, composition, distribution and future growth of traffic. Design should be specific to each site with due regard to physical conditions of the site available. The design of different elements of intersection should be done as per IRC: SP: 41 "Guidelines on Design of At-Grade Intersections in Rural and Urban Areas" including other criteria as given in IRC SP 84:2014.

Observations

Lane marking, 'Stop' line marking, directional arrows, pedestrian marking etc, were found missing on all minor junctions. There were also found significant level difference in between minor and major road. Some of the Deficiencies in minor junctions which were observed during RSA are as follows-

- There no identification of the access roads meeting the Project Stretch
- No provision for calming of vehicles before approaching the intersection.
- Improper visibility of approaching minor junction for Project Stretch Highway traffic and vice due to obstructions.

Base on current topographical situation and site observations following junctions were found for improvement along study area –

Table 5.1: Identified Junctions for Improvements along SH-02

S. No.	Chainage (Km)
1	16+350
2	17+000 (T-junction)
3	18+500 (Y-Junction)
4	22+000
5	22+400
6	26+900
7	44+900
8	54+000 (T-Junction)
9	58+300
10	73+200
11	86+000
12	94+000 (Major Junction)
13	107+600

Remedial Proposals

As per IRC, it is necessary to provide road hump on minor arms at a distance of 10m from edge of main road to regulate the speed of vehicles entering the main roads. All damaged approaches should be repaired. Undeveloped and level difference of minor roads should be developed and should be levelled on priority as vehicle will try to enter on main

highway with high speed which will severe accidents. Apart from these following proposals are to be made

- Guidelines for the Design of Interchanges in Urban Areas, as per IRC: 92-1985.
- Guidelines for the Design of At-Grade Intersection in Rural & Urban Areas, as per IRC:SP: 41.
- Stop and Give Way Signs, as per IRC 67: 2012.
- Information sign boards for the identification of access roads, as per IRC 67: 2012.
- Speed Breakers on side roads as per IRC 84: 2014.
- Proper Road Markings for turning Traffic, as per IRC 35: 1997.

5.1.2 Visibility along curves

For proper visibility, the effect of horizontal and vertical curves and the cross-section generally examined during road design. As per IRC SP: 21-2009, growth of vegetation close on the road curves may lead to serious reduction of clear sight distance and may cause accidents.

Observation

At the time of Road Safety Audit, Sign boards at curves were found removed/damaged or missing. It was also observed that delineators have not been provided on horizontal curve.

Remedial Proposals

From the observation, it is suggested that there should not be dense plantation along the curves so that clear sight distance or visibility along curves be ensured for fast moving traffic and safety of road users. Chevron sign boards should be provides as per IRC 67-2012 & IRC: 35-2015 where sign boards at curves were missing or removed/damaged and Chevron sign boards should be visible for a sufficient distance to provide the road user with adequate time to react to the change in alignment. On horizontal curves, the sign boards should not be fixed normal to the carriageway but the angle of placement should be determined with regard to the type/category of the approaching traffic. It is also recommended that delineators should be provided in accordance with IRC: 79-1981.

Fig 5.2 Curve sign boards and Chevron sign boards

5.1.3 High Tension Lines and Vertical Clearance

Vertical clearance is the clear vertical distance between carriageway crown and the lowest point of any overhead conductor installation which includes the conductor wire, bearer wire, guard wire, stay wire, guard cradle , or screen. The lowest point should be determined after accounting for the maximum possible sag in the lowest member of the conductor installation. During the road safety audit two high tension cables were found lower than the permissible limit on the stretch. It is recommended to provide proper clearance of 6.50m in accordance to IRC:32. To provide proper clearance the road surface should be lowered sufficiently with gentle slope and proper cross drainage works. If not possible to lower the road surface, it was suggested to provide a bypass for the vulnerable traffic on both sides separately. It is also suggested to provide proper informatory sign for maximum height allowable, and direction board for the bypasses. It was also suggested to install height barrier on both side of the High Tension Line.

5.1.4 Pavement Marking

Lane and edge marking were found missing on some road sections. However, at few locations, edge and lane marking were got faded which require immediate painting. Centre and edge marking should be further highlighted through studs fitting in certain interval. This will help drivers to become more alert and warn them from lane departure of their vehicles. This extra facility on lane marking will make driver safer. Pavement marking and Road Studs should be provided as per IRC: 35-2015.

5.1.5 Warning Sign Boards, Hazard Markers

Warning drivers of the upcoming hazards is very important. To warn the drivers warning sign boards, hazard makers are to be used. It should be ensured that no trees, advertisement boards, encroachment should be within the Right of Way.

Observations

During the road safety audit most places of hazard were found vulnerable. Proper warning sign boards breaker, schools. upcoming village, driver slow, Drive slow densely Populated Area, Cattle Crossing were not found.

Remedial Proposals

Warning Sign Boards should be installed at every start of village, major junctions, schools, hospitals etc. in accordance with IRC: 67-2012. Hazard markers should be provided on channelizing and divisional islands of all major junctions, before parapet of cross drainage structure/bridges, before crash barrier, before vertical posts/columns of overhead gantry sign boards resting on shoulders as per IRC: 79-1981. Figure 5.3 below show the Warning Sign Boards which should be provided at vulnerable places.

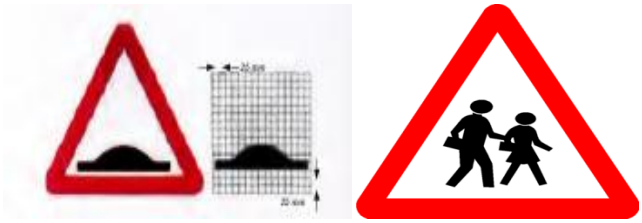

Fig. 5.3 Warning Sign Boards

5.1.6 Traffic Control Zones

Since the SH-02 stretch in which road safety audit was conducted was in construction stage, it is necessary to cover the traffic control ones in the area of work under progress.

Observations

At the time of road safety audit it was found that no workplace was well versed with traffic control management and well furnished with the appropriate safety tools and devices.

Remedial Proposals

It is necessary to help the drivers to be more attentive by using signage, rumble strips and anything that brings alertness and gets them to realize that there is something different about this stretch of road and there would be lower speed limits in the work zones. Work zone safety measures should be aggressive and comprehensive. It should include public service announcements, safety training for workers in work zones, lower speed limits in work zones, rumble strips and other speed reducing measures, proper signages, flagman to control and guide traffic, stepped-up enforcement as per IRC SP:55-2014. Some of the most necessary sign boards to be provided are shown in figure 5.4 below

Fig 5.4 Sign Boards at Traffic Control Zone

6. CONCLUSIONS

Design fundamentals of a highway play a vital role in deciding the safety performance. For accidents, the human factor may be identified as a major cause which is practically impracticable to control driver's frame of mind and their physical condition. The highway engineer cannot control alcohol abuse or seat belt usage and has little potential to improve driver's decision at intersections. However, good geometric design will help to control traffic operating speeds on guided path and will reduce accidents. The thought behind a good design is to force road users, not to commit any mistakes and nullify driver's carelessness. However, it is found that very less importance is to given to safety issue in India as compared to developed countries. Based on above suggestion and from present detailed Road Safety Audit on SH-02, the following conclusions are drawn:

1. Road geometries were provided as per guidelines of MORTH Manual of Specifications and Design Specifications.
2. Minor junctions had sight distance problem due to vegetation when approaching to main highway. Informatory sign boards showing name of the access road to the main highway was also missing. Accidents were observed to be more at those locations.
3. Safety barriers were missing at high embankment area, along the curve. Safety barriers were not connected properly with the rigid concrete safety barriers at same locations.
4. Due to vegetation, visibility along the curves was not proper. At curves, missing/removed curve sign boards were also found.
5. It was also found that local people were damaging median kerbs of some location of the study stretch which were using as unauthorized median found with missing solar blinkers and informatory sign boards.
6. Lacking of Informatory sign boards was also found on highway segment at some locations. Sign posts were installed but still cautionary/mandatory sign boards were found missing from the post.
7. lack of Workplace Traffic Management was found missing. Along with it, the necessary cautionary sign boards were also found missing.
8. Two High Tension Lines were found hanging without proper vertical clearance which poses high safety risk to all vehicles and trucks.

Recommendations

Based on present study of Road Safety Audit of State Highway following recommendations have been drawn for further studies:

Identified safety influencing parameters should be constantly monitored to enhance overall safety of the State Highway. For the safety of road users, provision for most influencing safety parameters should be made so that number of accidents can be reduced.

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