PROACTIVE APPROACH TO ACCESS SAFETY ON COLLECTOR ROADS

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***Abstract*: It is important to ensure the safety on collector roads, as most of the safety audits are done mainly on highways and expressways, but as a result of the increasing number of vehicles in this scenario, and to avoid the queuing and congestion and to reach the destination in least time through easy route, most of the drivers nowadays choose these collector roads. But the implement of improvement programs on these roads are difficult due to the limitations on funding, expertise, time, and less availability of land. So, the better option for supporting the local transportation agencies about the safety issues is by conducting RSA. Through proactive approach, this project give rise to simple and cost-effective way of conducting the local RSA program. The study area was examined to analyse the existing condition of the road with reference to IRC manuals then based on observation certain ratings were provided and then given to experts to receive their judgements and it is analyzed by Analytical Hierarchy Process (AHP) based pair wise comparison in identifying the parameters which causes more road safety risk. The five parameters considered here are sight distance, drainage, signs and markings, cross sections, lighting and night time issues. During the road safety inspection, the road safety inspection the road experiences early stages of pavement distress, no lanes provided, signs and markings are not provided wherever necessary and it is also noted that especially most of the youngsters drive in a high-speed manner. As a result, this study prioritizes the parameters which need to give more importance at the time of design which is expected to be useful to various decision makers.**

***Keywords*: Analytical Hierarchy Process, Road Safety, Pavement distress**

1.INTRODUCTION

1.1 GENERAL

We know that transportation plays important role in the development of economic activities of the country by promoting goods and services. Assignment of socioeconomic development of the country is one of the key indicators. As the number of vehicles are increasing day by day but not providing any Improvement for the infrastructure of road. Providing the safety to roads is necessary. It is also necessary that the roads constructed or which are to be constructed in future are according to proper design, Accident prevention measures should be taken, provision of safety signs and symbols, proper road markings etc. So, it is necessary to improve the transportation safety, which is needed worldwide. Among the vehicle related crashes, the increased number of serious injuries related to the motor vehicle crashes which leads to even death. Most of the collector roads or low-volume roads crash data are not reported in crash statistics. So for identifying and thus to reduce the crash potential on roadways, Road Safety Audit (RSA) concept has been considered as an effective tool worldwide, by doing this we are able to analyse the safety aspects of the road at present and we can suggest the safety remedial measures and can be designed accordingly on the future construction or during maintenance

From this study, Section of road from TKM college road to Ayathil road has been undertaken. This road taken have considerable traffic during day time and some Black spots on the road. The main aim of the study is to develop a proactive approach to ensure the safety of the collector roads. Most of the collector roads are single lane roads with low design speed and low traffic volume. As these roads nowadays experiencing an increasing growth in traffic, there is a need to improve the infrastructure of these collector roads, so as to reduce the traffic accidents. By doing RSA, these roads are proactively approaching and noting out the safety issues before construction, at time of designing and also after construction.

1.2 OBJECTIVES OF STUDY

- To examine the current safety conditions on the road of the study area
- To conduct a proactive approach study for the road safety audit using Analytical Hierarchy Process
- To suggest preventive measures, need to consider in future design

1.3 SCOPE OF STUDY

- The study focuses on the importance of using proactive approach for conducting a road safety audit
- The scope of work is limited to collector road

2. LITERATURE REVIEW

2.1 GENERAL

Improving road safety on collector road is a tremendous challenge. One way of improving the road safety is conducting road safety audit. Proactive approach is one of the key tool for conducting road safety audit.

2.2 ROAD SAFETY AUDIT

Most studies are conducted by methods of assessment of road accidents. Most of the road safety Audit requires accident data to improve understanding about the safety functionality of roads. Road traffic accidents increases because of number of potholes on the road which cause the spinal injuries, bone injurie etc. (Omkar Gholap, Nikita Shinde- 2018). As a result of the expeditious modernization, the number of vehicles for transportation are rapidly increasing day by day without improving the infrastructure of the road and finally results in the increasing rate of accidents worldwide even for developing countries. The main reason for the increasing rate of accidents is the poor and inadequate services of public transport in cities, which urge most of the resides to use private modes of transport instead of using public transportation. As a result, the number of vehicles on road increases which increase the rate of accidents. (Devang P. Majithiya, Krishnan P. Savaliya-2016). The RSA is a method to improve the safety issues on roads. In this a selected road stretch is examined either individually or with experts and identify the safety issues, prioritizes the findings and reports on safety issues. There is no need to redesign the project as a result of RSA, but by conducting these audits it provides the recommendations, findings, suggestions and remedial measures which need to be considered once the project is renewed (Hesham Mahgoub, Ken Skorseth-2010). Typically, with short resources and focusing mainly on maintenance and operation of the existing roads, Road Safety Audit Review is one of the practical safety tool for the local agencies. The two-track which is taken towards this safety tool are training and prioritizing practical and providing low-cost solutions (Eugene M. Wilson and Martin E. Lipinski-2005). Normally, safer roads be the properly planned and constructed roads than older ones, but due to the differences occurred in traffic volume and mix in the road environment several problems arise out of the blue. Generally, for older roads, some of the popular remedial measures are used to improve site related accident factors suitably. The main objective of RSA process is to improve the safety through a proactive approach (Bhatt B. V, Shah N. C). Local roads have a greater impact on wildlife with respect to habitat destructions, noise load and traffic mortalities (Frank van Langevelde, Coby van Dooremalen-2009).

2.3 AHP MODEL

In the AHP model, superior alternatives can be identified. AHP has been applied to almost all fields involving decision-making, since its invention. Rather than pursuing complex mathematical methods, AHP employs pairwise matrices and their associated right-eigenvectors to generate appropriate priority sequences of alternatives . AHP is tolerant of different math tools, like linear programming, fuzzy logic, etc., whose merits can thus be extracted to achieve a desired outcome. Further, AHP organically combines qualitative and quantitative methods and decomposes a decision into a multi-level hierarchical structure. In this way, decision makers' thinking processes are systematized and simplified. Both cartographic experience and the relations between indicator values can be incorporated into the evaluation system. This is the first application of AHP in road selection. As a line-based method, our method is suitable for small-scale generalization. In addition, the surrounding habitations and facilities of a road can influence the importance of roads. In this regard, apart from summarizing structural characteristic indicators, an indicator reflecting the contextual characteristics of roads is built by scoring different categories of POIs. The importance values of strokes can be calculated in the AHP model, and the result of AHP serves as the fundamental basis for road selection. This method fully captures the attribute information of roads and conducts the road evaluation process in a structured and organized manner, which can be easily accepted. AHP delves deeper into the nature of road evaluation, multiple indicators, and the internal relations of roads.

3. METHODOLOGY

3.1 GENERAL

The auditing a road project are conducted in five stages:

STAGE 1: Feasibility stage/ Preliminary design stage

In this stage study about the attributes of the selected stretch such as design parameters such as the design standard values, sight distances, cross section etc. Careful inspection during these periods help to minimises the costs and avoid the loss of time.

STAGE 2: Detailed design stage

In this stage present out the final DPR that is occurs only on finalization of fussy design of road. But it will do before the provision of legal documents. Those typic considerations includes geometric features, about the lighting provided on the stretch, the road ideograph, the leeway on roads, delineators, etc.

STAGE 3: Systematization stage

During construction of the roadwork this audit stage will be conducted.At this stage the safety of the traffic mainframe plans will be examined at each stage of the construction. Typical issues examined at this stage include the provisions for pedestrian protection, worker protection, efficient number of reflectors, valid speed limits, available light and diversions at intersections.

STAGE 4: Before road opening stage

During this stage, in advance to the new road opening on the stretch of road a detailed inspection will be carried out. At the audit time the audit team will be operate, hazed, patrol to fulfil the needs of the road users. Mainly the inspection is important during night time, to check the visibility of signs, markings, etc.

STAGE 5: Safety audit of at present roads

The audit of existing roads was done so as to ensure the safety parameters of the selected stretch of the road compared with the design standards. This audit was also aims to identify any parameters that need to develop in future which improves safety. The safety problems identified during this stage should be solved with low cost in simple manner. (IRC: SP: 88-2019)

3.2 CHECKLISTS

Departure from standards, transversion, transversional variations, cant, shrubbery, lay-bays, access to roads, future widening, adjacent development, visibility and sight distances, new and existing road interface, provision for pedestrians, cyclists signs, lighting, pavement marking, on-street parking facilities (IRC: SP:88-2019, Bhatt B. V)

3.3 SOURCES OF DATA AND METHOD DATA ANALYSIS

During field observation based on, the current road condition a set of observations are done and based on that examine the required points and details were recorded. After those questionaries were developed in favour of the IRC: SP:88-2019 RSA manual with respect to the four decision criteria and distributed for three experts to receive their judgement. Depending on these experts judgement pair wise comparison matrices were developed and further analysis are done using Analytical Hierarchy Process (AHP) to identify significant factors which contribute the road safety risk and to prioritise the road section.

AHP analysis was developed using MS-excel tempelate by using following steps;

STEP-1: Collect and organize the experts judgements into square matrix(M) form and all columns of the square matrix are summed.

Eg:

Level	A	B	C
A	1	a	b
B	1/a	1	c
C	1/b	1/c	1
sum	1+1/a+1/b	a+1+1/c	b+c+1

STEP-2: Divide individual cell of the column with corresponding summation of its own column

Eg:

LEVEL	A	B	C
A	1/(1+1/a+1/b)	a/(a+1+1/c)	b/(b+c+1)
B	(1/a)/(1+1/a+1/b)	1/(a+1+1/c)	c/(b+c+1)
C	(1/b)/(1+1/a+1/b)	(1/c)/(a+1+1/c)	1/(b+c+1)

Step 3: Depending on the value obtained from step 2 each cell in the row were averaged.

Then take the sum of those columns to get PV(Priority vector)

Step 4: The priority vectors were computed

$$PV = Sum/n$$

Where 'n' will be the order of the matrix

STEP 5: Computation of the maximum eigen value of the judgement matrix(λmax)

$$\lambda max = Sum \times PV$$

STEP 6: For the judgement matrix order 'n' consistency index (CI) is determined.

$$CI = (\lambda max - n) / (n-1)$$

STEP 7: The value of consistency index is subjective to and failed to compare the judgement matrix. So random consistency ratio (RI) and the consistency ratio (CR) was developed. The threshold value of the consistency ratio should not be greater than 0.1 and the value of random consistency ration (RI) is taken from the table.

$$CR = CI/RI$$

Table-1: Random consistency index

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table-2: Sati's Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak/slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong / Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
8	Very very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

4. RESULTS AND DISCUSSION

4.1 GENERAL

This chapter discusses the result obtained from AHP. For the study the required section was divided into three stretches of 1km each, and the according to the judgement received from the experts pair wise matrix was developed and the factors resulting for this stretches were identified.

4.2 PRESENT CONDITION OF THE STUDY AREA

The total length of the road section is around 3km. The road is divided into 3 stretches. Each stretch of 1km.The overall condition of the road in the study area are identified during survey. The case of road safety problem needs to be examines based on the checklists. i.e, sight distances, signs and markings, cross sections. Lighting and night time issues of the road section in the road segment.

Stretch-1:Ayathil to puthanchandha route

This segment is the first part of the section which commences from the coordinates (76.63169,8.89355) and ends with the coordinates (76.63116,8.9005). Some problems were observed among these are,

- Sight distance obstructions
- Soil slide problem
- Pavement distress
- Insufficient drainage

Figure1: Route map of stretch-1

Table 3. Road safety audit of stretch-1

GPS Name	GPS Coordinates		Description	Figure illustrations
	Easting	Northing		
S11	76.630411	8.898801	Inadequate sight distance	

Stretch-2: Puthanchanda to kuttichira route

This road section commences from (76.63116,8.9006), ends (76.63213,8.90678) and has problems like

- Sight distances
- Impact of wild lifes on roads which causes

S12	76.631725	8.8939246	Soil slide problem	
S13	76.63145	8.895471	The pavement surface undulated and distressed	
S14	76.630417	8.899779	Inadequate sight distance	
S15	76.630401	8.8982705	Inadequate Drainge ,so that water clogged and side of the road	

sudden distractions to the drivers

- Pavement distruss
- Drainage problem

Figure.2: Route map of stretch-2

Table 4. Road safety audit of stretch-2

GPS Name	GPS Coordinates		Description	Figure illustrations
	Easting	Northing		
S21	76.631196	8.901704	Inadequate Sight distance	
S22	76.631728	8.904116	Inadequate sight distance .No marking provided since it is an intersection.pavement distress also observed	
S23	76.631038	8.9021949	Impact of wildlife on roads	
S24	76.632393	8.905378	Undulated and distressed road surface	
S25	76.631357	8.903265	Drainage problem	

Stretch-3: Kuttichira to TKM college route

Table 5. Road safety audit of stretch-3

S26	76.63114	8.901030	Drainage problem and potholes	

This road segment commences from coordinates (76.63205,8.90689) and ends to (76.63195,8.91512). Generally, this section of road experiences more of road to meet with a major highway intersection and this road approaches to schools and colleges so that these sections need some more prioritastion.The problems related to these section are drainage, pavement distruss, no lane marking provided even for major road, sight distances obstructions, no guard rails oru protection barriers provided for sloppy areas.

Figure 3: Route map on stretch-3

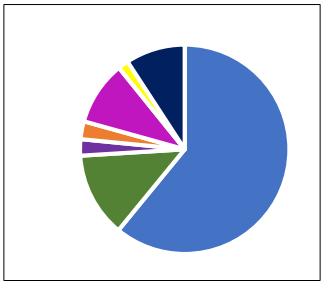
GPS Name	GPS Coordinates		Description	Figure illustrations
	Easting	Northing		
S31	76.631950	8.915123	Edge cracking	
S32	76.63129	8.91020	Inadequate sight distance	

S33	76.63198	8.909426	No lanes or signs provided since it is a major road	
S34	76.632025	8.907980	Pavement distress and the superelevation provided is not proper	
S35	76.63132	8.9128594	Sight distance problem ,pavement distress, Longitudinal ditch covered by vegetation, no guard rails or preventive measures provided since a large slop is there.	

S36	76.63120	8.910320	Transverse cracking	
S37	76.63103	8.910982	Transverse cracking	
S38	76.63206	8.90742	Pavement distresses	

FIGURE 4. FLOW DURING 4:00PM-5:00PM

4.3 VEHICLE COMPOSITION AND PEDESTRIAN COUNT



Bike-265(61%)

Car-57(13%)

LCV-11(3%)

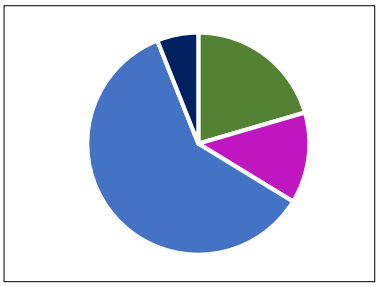
Cycle-12(3%)

Auto-43(10%)

Bus-7(2%)

Pedestrian-40(9%)

FIGURE 5. FLOW DURING 7:30PM-8:30PM



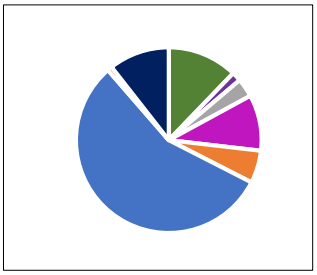
Bike-105(60%)

Car-29(20%)

Auto-22(13%)

Pedestrian-10(6%)

FIGURE:6. FLOW DURING 8:30AM-9:30AM



Bike-138(56%)

HCV-2(1%)

Pedestrian-27(11%)

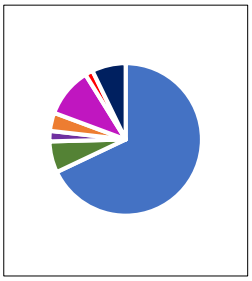
Car-29(12%)

LCV-4(2%)

Auto-24(10%)

Cycle-8(3%)

FIGURE 7. FLOW DURING 12:00PM-1:00PM



Bike-123(68%)

Car-12(7%)

LCV-4(2%)

Cycle-7(4%)

Auto-19(10%)

HCV-3(2%)

Pedestrian-13(7%)

4.4 AHP ANALYSIS AND JUDGEMENT VALUES

AHP give a proven, effective means to assign with complex decision making and was first introduced by Thomas Saaty in 1970's. The concept of AHP hierarchy is to handling problems related to a number of norms and alternatives. In the AHP model the structure composed of four different norms i.e goal, criteria, sub-criteria and alternatives. The case of road safety problem needs to be evaluated in terms of 5 decision norms, i.e sight distance, drainage, signs and markings, cross sections, Lighting and night time issues in the road segment using AHP. The significant factors which contribute the occurrences of road safety risk presented pairwise comparisons were done depending on the judgment values given by the experts. For the factors which its grounds high safety risk assigned as lowest one and vice versa.

Table 6. AHP Process for stretch-1

	Sight distance	drainage	Signs and markings	Cross sections	Lighting and night time issues	Sum	PV	CI	CR
Sight distance	1	2	4	6	5	2.12	0.424	0.07	0.062
drainage	0.5	1	3	7	5	1.55	0.31		
Signs and markings	0.25	0.33	1	4	3	0.74	0.148		
Cross sections	0.17	0.14	0.25	1	0.5	0.23	0.046		
Lighting and night time issues	0.2	0.2	0.33	2	1	0.35	0.07		

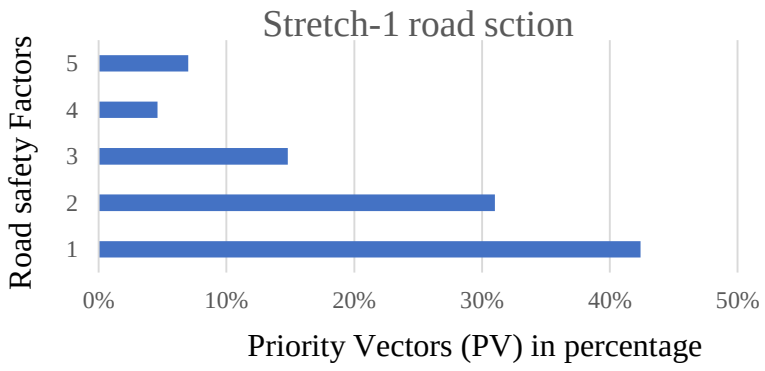


Figure 8. Road safety factors in percentage of priority vectors for stretch-1 road section

Table 7. AHP Process for stretch-2

	Sight distance	drainage	Signs and markings	Cross sections	Lighting and night time issues	Sum	PV	CI	CR
Sight distance	1	2	0.5	4	5	1.39	0.278	0.09	0.0803
drainage	0.5	1	2	4	6	1.46	0.292		
Signs and markings	2	0.5	1	6	7	1.62	0.324		
Cross sections	0.25	0.25	0.17	1	2	0.32	0.064		
Lighting and night time issues	0.2	0.17	0.14	0.5	1	0.21	0.042		

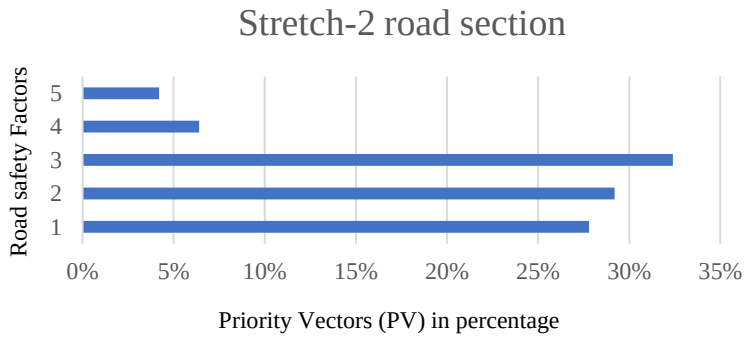


Figure 9. Road safety factors in percentage of priority vectors for stretch-2 road section

Table 8. AHP Process for stretch-3

	Sight distance	drainage	Signs and markings	Cross sections	Lighting and night time issues	Sum	PV	CI	CR
Sight distance	1	3	2	5	9	2.23	0.446	0.005	0.0044
drainage	0.33	1	0.5	3	6	0.94	0.188		
Signs and markings	0.5	2	1	3	4	1.21	0.242		
Cross sections	0.2	0.33	0.33	1	2	0.39	0.078		
Lighting and night time issues	0.11	0.17	0.25	0.5	1	0.23	0.046		

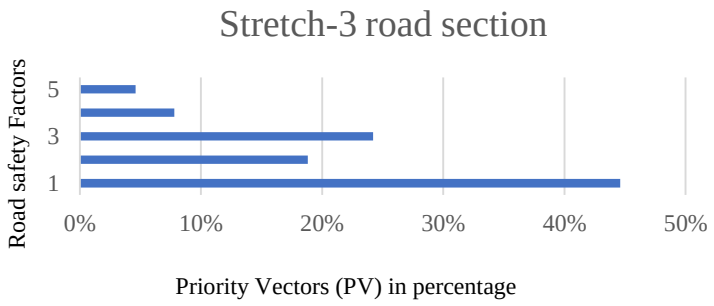


Figure 10. Road safety factors in percentage of priority vectors for stretch-3 road section

4.4.1 RESULTS FROM TABLES AND GRAPHS

The consistency values, CR=0.0044<0.0625<0.0803 which are less than the threshold value of CR=0.1.Therefore, the judgment is consistent and acceptable. From the result shown in the above table and figure on stretch-1, sight distance problem is around 42% with that of the other factors it is the most significant factor which contributes high speed safety risk along stretch-1 road section in present as well as future; drainage (31%), signs and markings (15%), cross sections (5%), lighting and night time issues (7%) followed respectively.

Similarly from the priority vector value shown in figure signs and markings along this stretch accounts around 32% for the road risk when compared to the other factors, hence it is the most significant factor which contributes high road safety risk at stretch-2 road section; sight distance (28%), drainage (29%), cross sections (6%), lighting and night time issues (4%) followed respectively.

In stretch-3 sight distance accounts around (45%) for the road risk when compared to other factors; drainage (19%), signs and markings(24%), cross sections(8%), lighting and night time issues(5%) followed respectively.

From the pie chart showing vehicle composition and pedestrian count it is clear that more traffic is at morning hours and the road users using bike is more predominant.During evening time HCV also take part through these sections.

4.5 REMEDIAL AND PREVENTIVE MEASURES

Some of the remedial and preventive measures that are provided based on the study are;

1.Carry out regular maintenance and provide markings where ever required to ensure the safety of the road users.

2.If possible arrange feasible area for the stray dogs as they wander on the road which create fearness to the pedestrains

3.Road and junctions should be wide and well lighted so that visibility is good

4.Parking on the road should be done as per the traffic rules.

5.Carry out regular repairs and maintenance of the road

6. Driving tests should be carry out transparently while giving license to people. So as to avoid accidents, destructions, etc.

7. The vegetation along the side of the roadway has grown to the point where moving is needed in the very near future to prevent animal-vehicle collisions and increase sight distance at approaches.

8.Proper drainage should be provided where ever needed. To avoid accidents especially during rainy season

9.Pavement distress should be taken into account and proper maintenance want to provided.

10.Proper signs and markings should be provided where ever needed, especially at intersections, lanes should be provided at the major roads, any yield sign or mirror should be placed to curves if sight distance obstruction is there.

5. CONCLUSION

In roads where increasing number of vehicles and due to this heavy traffic, so as to rehabilitate the roads, Road Safety Audit (RSA) is used as one of the guiding tool, by conducting this RSA we can reduce the risk of accidents as well as we can save the cost spend as for maintenance work and the loss of our valuable time. As a result of conducting this audit continuously on collector roads like conducting in highways, it helps the agencies to identify the spot on which it help the agencies to identify the spot on which safety improvements want to provide, accordingly they can prioritize. By this, they can develop a plan for the safety improvement. By providing proper connectivity to these roads throughout the network, help to expand the traffic volumes and capacity in an effective way. The proactive approach is one of the key tool for conducting RSA. For this Analytical Hierarchy Process(AHP) was done using MS.Exel. From this study of the road safety audit that the road segment from Ayathil to TKM College road section has experiences early stages of the pavement distress, not have proper sight distances, lanes are not marked, signs and markings are also not provided even for critical points. Since these section approaches to the schools and colleges especially youth drive at a high speed through these section. So it is essential to take necessary actions and precautions. For this study the 3km road section was divided into three stretches of 1km each and identified the problems in each section contribute a major safety risk due to sight distances and improper signs and markings. From the traffic flow it is evident that buses, LCV and HCV move through these sections, but proper maintenance and repair was not carry out here. AHP method based analysis mechanism of proactive road safety inspection helps to identify which road section is better, which section is worse and what are the parameters and problems need to be considered during the design period and the probability of occurrences of future road traffic accidents.

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