

Road Safety Audit on Karamana Kaliyikkavila Road (NH 66)

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Abstract— Originated in Great Britain, the procedure of road safety audit is now being spread in several countries around the world. It can be incorporated in the framework of designing, constructing, and operating road infrastructure as a means for preventing accidents. Karamana to Kaliyikkavila is one of the busiest road stretches of NH 66 in Thiruvananthapuram district of Kerala. The unsatisfactory condition of the road and increased rates of accidents demanded widening of the stretch. The construction activities being carried out there resulted in significant road safety issues. A Road Safety Audit was conducted for 12 km in the Karamana - Kaliyikkavila road stretch and four black spots were identified. The major problems that challenge the safety aspect of the road were identified by a negative response survey and an expert opinion survey. It was found that lack of information regarding construction zone approaching, lack of warning signs, lack of adequate parking facilities, insufficient road width and pollution seemed to be major problems in the road stretch under construction. For road stretch in pre-construction stage, edge drop, lack of proper drainage facilities, speed reduction measurements, road surface condition and insufficient road width are seemed to be the most important problems. On the basis of the results of Road Safety Audit, suitable rectification measures were also suggested, which are needed to be implemented in other parts of the stretch where construction is yet to commence

Keywords— Accident analysis; accident data; blackspot; safety audit

I. INTRODUCTION

Road Safety Audit (RSA) is an evaluation of a highway improvement scheme during design, at the end of construction and post-construction, to identify road safety problems and to suggest measures to eliminate or mitigate any concerns. Road Safety Audits are undertaken by terms of specialists trained in the skills of collision investigation and/or Road Safety engineering. RSA is an important tool for road safety engineering, which has the potential to make a significant contribution to highway safety.

The RSA is the formal examination which starts in the planning stage of the road projects itself. The RSA can be performed in different conditions such as preconstruction, during construction and post construction. In this thesis the RSA preconstruction and during the construction stage is performed. Several safety problems were identified by the accident analysis. The remedies were also suggested based on that.

Kannelaidis [1] has conducted the study on the aspects of Road Safety Audits and the role of an auditor in design and implementation of highway projects in Road Safety. A study was conducted about the human factors related to RSA through a practical example and also the involvements in RSAs like communication. Daksheshkumar [2] attempted to analyze the traffic safety situation Kapurai-Dboi section of SH-11, Gujarat, India and to identify countermeasures for stretches in which the total harm caused by crashes can be substantially and readily reduced. Guerrieri [3] has done study on cost benefit analysis of road safety measures and studied more about the road safety audit and conducted some case studies on safety measures on an urban and a suburban road .

Katiyari conducted Road Safety Audit on Wardha road from Morris College square to Airport intersection in Nagpur city and developed a model for identification of safety influencing parameters in minimizing accident rate on selected squares of roads [4]. Patel et. al studied the Road safety audit of selected stretch from Umreth junction to Vasad junction i.e., SH-83 and SH-188 which are one of the major state highways in the state of Gujarat and identified the blackspots and suggested remedial measures [5]. Ashokbhai and Jain have done a study on development of an accidental model for urban area [6]. Vigneshkumar and Vijay have done a study on road safety improvement in India and have analyzed the road design, vehicle design like speed of the vehicle, technical factors, vehicle size and capacity and also the Driver's behavior [7].

RAS was conducted for 12 km stretch in four lane road from Karamana to Kaliyikkavila in NH 66 and the findings are reported in this paper.

II. DATA COLLECTION AND ANALYSIS

Karamana to Balaramapuram is the study section of the road stretch where the widening of existing two lane to four lane in NH 47 is progressing. It is a 29 km stretch and the construction work includes construction of a major bridge at Amaravila, minor bridges, cut and covers and cross drainage structures. Fig.1 shows the study stretch of NH 66.

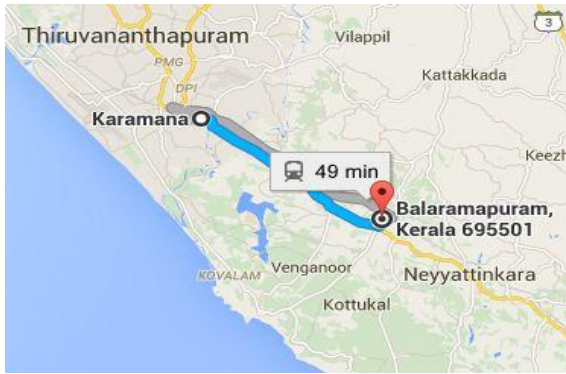


Fig 1. Study Stretch

A. Accident Data Collection

The accident data for the 2010, 2011, 2012, 2013, 2014 and 2015 were collected. The accident data during and before the road construction are compared in the analysis. Thus, the efficiency of providing safety in the construction site can be evaluated. The analysis comprises of accident analysis, traffic volume analysis and Road Safety Audit.

B. Variation of Accidents

The accident analysis was done based on annual variation, hourly variation, and vehicles involved in accidents. The number of accidents in each spots was identified. From that, four black spots were selected for the road safety audit.

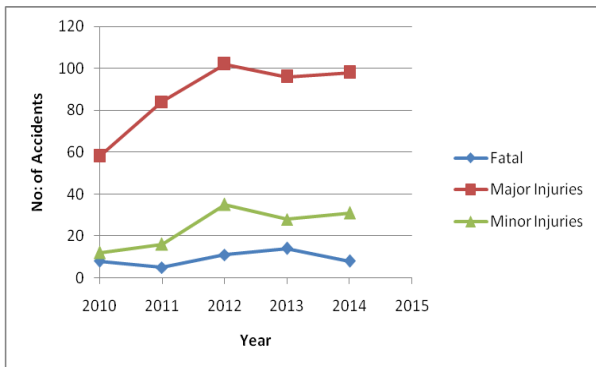


Fig 2. Number of Accidents Vs. Year

Fig 2 shows the yearly variation of accidents in the study stretch. In 2010, the major and minor injuries were very less, but next year the rate of injuries was increased and reached at the peak and then it declined continuously. Reasons for the fluctuation of the variation is identified as if traffic volume is increased rigorously, speed of the vehicles will decrease and hence number of accidents occurred will decrease. But widening of the existing two lane to four lane may increase the speed and there may be a considerable increase in the accidents. This situation should be prevented and various precautions should be taken for this.

The hourly variation of the accidents in the concerned highway stretch is shown in Fig. 3. It is found that during 10.00 pm to 08.00 am the number of accidents occurred is very less. Peak time periods of accident occurring are during 10.00 am to 12.00 am and 04.00 pm to 10.00 pm. It is found that total 240 accidents occurred at the selected black spots

during the past five years. Out of these 163 accidents *i.e.*, 69.77% accidents occurred during the day time.

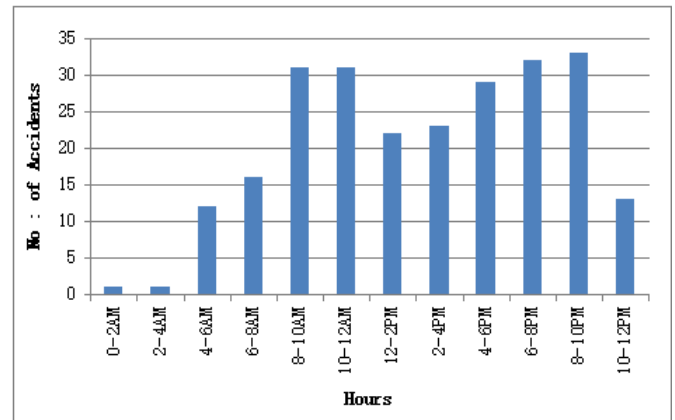


Fig 3. Number of Accident Vs. Time Period

C. Vehicles Involved in Accidents

Two wheelers and pedestrians were involved in most of the accidents. The average number of two wheelers involved in the accidents for last 5 years is 53.66%. For last two years it was increased by 10%. The average pedestrians involved accidents in last 5 years is 18.42%. For last 2 years the value decreased by 12%.

D. Black Spots

By the accident analysis the number of accidents occurred at each black spots were identified. Table 1 shows the number of accidents occurred at the different black spots in different years and the average of the five year accidents.

TABLE I: NO OF ACCIDENTS IN DIFFERENT BLACK SPOTS

Black spots	Total number of accidents					Average of 5 year accidents
	2010	2011	2012	2013	2014	
Kaimanam	9	5	16	16	9	11
Pappanamcode	11	14	8	14	27	14.8
Nemom	8	13	19	21	13	14.8
Pravachambalam	9	14	23	15	25	17.2

III. ROAD SAFETY AUDIT

The road safety audit can be done during different stages of road construction such as planning, design and construction etc. [8]. IRC SP 88:2010 specified different checklist which should be followed at different stages of construction [9]. The checklists are the questions related to road condition. The road safety audit on these black spot is executed with the help of these checklists of IRC SP 88:2010.

A. Severity Prediction

There are lots of safety issues detected in each black spot while conducting the road safety audit. The severity prediction for the each safety issue was a difficult task. For predicting the severity, 15 questions were prepared related to road conditions. The severity of a safety issue is measured by answering the checklists.. These questions are answered in

such a way that the positive response is expressed as ‘A’ and negative response as ‘B’. If the negative responses (B) are more than 10 out of 15, it is termed as severity HIGH. If B lies between 5 and 9, it is termed as severity MEDIUM. If B is less than 5, it is termed as severity LOW. Table II and Table III show the 15 checklists which are used for predicting the severity during construction and pre-construction respectively.

TABLE II: CHECKLISTS FOR SEVERITY INDEX DURING CONSTRUCTION

SI No	Questions during construction	Severity Response	
		Yes	No
1	Is there sufficient road width?	A	B
2	Whether information regarding construction zone approaching has been provided will in advance?	A	B
3	Is proper care and attention given for pedestrian and non-motorized traffic at construction site?	A	B
4	Construction workers provided with protective clothing, reflective jackets, hard hats, gloves etc.	A	B
5	Whether appropriate street lights are provided?	A	B
6	Is there any advance warning signs are installed for giving sufficient information to the road users?	A	B
7	Is the location of rest areas and truck parking areas along routs approximate and adequate?	A	B
8	Whether police and other emergency services have been considered?	A	B
9	Whether adequate safety provisions for the elders, children and per person with disabilities?	A	B
10	Whether bus stops appropriately located with adequate clearance from traffic lane for safety and visibility?	A	B
11	Whether construction workers provided with protection?	A	B
12	Whether flagman available in duty at the appropriate places?	A	B
13	Is there suitable measures adopted against pollution due to construction?	A	B
14	Whether suitable speed reducing measures provided?	A	B
15	Whether construction materials safely stocked without obstructing the traffic movement?	A	B

IV. RESULTS AND DISCUSSION

Several interpretations were generated from the result of RSA of four black spots. Interpretation from the severity response and interpretation from expert opinion survey are used for the present study.

A. Interpretation from the Severity Response

The interpretation of safety issues were generated from the severity response. It is based on the number of negative response generated with the safety issue.

The severity of each issue in black spots has been explained by the help of severity response checklists. All the safety issue in the black spot was correlated with the below mentioned 15 checklist questions for preconstruction and during construction. The 15 questions were answered as A or B for expressing the severity of that safety issue. The positive response of question is noted as A and negative response as B.

If the negative response of 15 questions of a severity issue is greater than ten, it is denoted as severity HIGH. If the response is in 5 – 9, and less than 5 is denoted as severity MEDIUM and LOW respectively which is listed in Table IV.

TABLE III: CHECKLISTS FOR SEVERITY OF PRE-CONSTRUCTION

SI No	Questions pre-construction	Severity Response	
		Yes	No
1	Is there sufficient road width?	A	B
2	Whether appropriate street lights are provided?	A	B
3	Is there any advance warning signs installed for giving sufficient information to the road users?	A	B
4	Whether care and attention being provided for pedestrian and non motorized traffic?	A	B
5	Whether adequate safety provisions for the elder, children and person with disabilities?	A	B
6	Whether bus stops approximately located with adequate clearance from traffic lane for safety and visibility?	A	B
7	Whether sufficient shoulder width provided?	A	B
8	Is the parking facilities is satisfactory?	A	B
9	Is road stretch free from traffic congestion?	A	B
10	Whether the road surface condition is satisfactory?	A	B
11	Is the road stretch free from objects which distract the driver behavior?	A	B
12	Is there any speed reduction measure near the spot?	A	B
13	Is the area around the spot free from sudden turning movement?	A	B
14	Is the level between road surface and unpaved shoulder negligible?	A	B
15	Is there adequate drainage facilities provided?	A	B

TABLE IV: SEVERITY RESPONSE PREDICTION

	Severity response	Severity
1	If the negative response (B) is greater than or equal to 10 out of 15	HIGH
2	If the negative response (B) is between 5 and 9	MEDIUM
3	If the negative response (B) is below 5	LOW

1) Interpretation from the RSA at Kaimanam During Construction Stage

Major deficiencies in Kaimanam are noted as:

- Negligence of the safety of workers
- Improper placing of barricades, sign boards and absence of reflectors
- Inadequate drainage facilities
- Construction materials are improperly placed.

Remedial Suggestions made are:

- Safety of workers is found to be a major challenge at Kaimanom. Workers were not equipped with safety jackets and other such features.
- Sign boards and barricades should be given in necessary locations.

- c) Drainage facilities should be properly given and construction materials should be stacked without hindering the traffic movement.

2) Interpretations from RSA of Pappanamcode

Major deficiencies in Pappanamcode are:

- a) Improper placing of barricades, sign boards, and absence of reflectors
- b) Inadequate drainage facilities
- c) Inadequate lighting
- d) Construction materials are improperly placed

Remedial Suggestions made are:

- a) Workers should be provided with adequate safety equipment (like reflecting jackets, helmets etc ;)
- b) Sign boards and barricades should be properly placed and reflectors should be given to obstructing objects
- c) Proper lighting should be given for night time visibility
- d) Construction materials should be stocked away from carriage way

3) Interpretations from RSA at Nemom

Major deficiencies in Nemom are:

- a) No speed reduction measures
- b) Inadequate drainage facilities
- c) No adequate pedestrian crossings
- d) Poor surface condition
- e) High edge drop
- f) High traffic congestion

Remedial Suggestions

- a) Speed reduction measures like humps, bumps, should be installed
- b) Proper drainage facilities should be provided and maintained
- c) Pedestrian crossing should be provided at proper place (near schools, bus stops etc.)
- d) Proper surface maintenance should be provided.

4) Interpretations from RSA of Pravachambalam

Major deficiencies in Pravachambalam noted are:

- a) High edge drop
- b) High traffic congestion
- c) Insufficient parking facilities
- d) Less carriage way and shoulder width
- e) Inadequate signs and signals

Remedial Suggestions are:

- a) Adequate shoulder width should be provided and paved
- b) Proper signs and signal should be installed and maintained at proper places
- c) Edge drop should be minimized.
- d) Adequate carriage way width and shoulder width should be provided.
- e) Adequate parking facility should be provided.

B. Interpretation from Expert Opinion Survey

The major safety issues of the road stretch were identified also with the help of an expert opinion survey conducted among ten experts. Table V and Table VI show the questionnaire for the expert survey for road stretches under construction and for pre-construction respectively. The experts ranked the different safety issues from 1 - 15 responsible for accidents according to their perspective with 1 being the major significant factor and 15 being the least significant factor. The questionnaire was considered for both before and during construction stage. From the results of the expert opinion survey, factors with ranks from 1 to 3 were given a weightage of 5, 4 to 6 were given a weightage of 4, 7 to 9 were given a weightage of 3, 10 to 12 were given a weightage of 2 and 13 to 15 were given a weightage of 1.

TABLE V. SAMPLE EXPERT OPINION SURVEY QUESTIONNAIRE FOR ROAD STRETCH UNDER CONSTRUCTION

SL No	Causes	Priority Order (1 - 15)
1	Insufficient Road width	
2	Lack of information regarding construction zone approaching	
3	Lack of care and attention given for pedestrian and Non - Motorized traffic	
4	Lack of Proper drainage Facilities	
5	Lack of adequate Street Light	
6	Lack of Warning Signs	
7	Lack of adequate Parking Facilities	
8	Lack of police and emergency services	
9	Lack of safety provisions for elder persons and children	
10	Location of bus stops	
11	Safety measures given for construction workers	
12	Absence of flagman at appropriate positions	
13	Pollution	
14	Lack of speed reducing measures	
15	Stocking of construction materials along Carriage Width	

For each problem a weight was calculated at each location with the negative response obtained and the weightage assigned by the experts on each problem as indicated below:

Observed weight at locations = Calculated value of negative response x Weightage by Experts,

where:

Calculated value of negative response=

$$\frac{\text{Number of negative response in a location}}{\text{Total number of locations}}$$

TABLE VI. SAMPLE EXPERT OPINION SURVEY QUESTIONNAIRE FOR ROAD STRETCH FOR PRE-CONSTRUCTION

SL No	Causes	Priority Order (1 - 15)
1	Insufficient Road width	
2	Lack of adequate Street Light	
3	Lack of warning Signs	
4	Lack of care and attention given for pedestrian and Non – Motorized traffic	
5	Lack of safety provisions for elder persons and children	
6	Location of bus stops	
7	Lack of shoulder width	
8	Inadequate Parking Facilities	
9	Traffic Congestion	
10	Road Surface condition	
11	Objects which distracts Driver behavior	
12	Speed reduction measurements	
13	Sudden turning movement	
14	Edge Drop	
15	Lack of Proper drainage Facilities	

1) *Results of Expert Opinion Survey under Construction Stage*

Table VII shows the weightage of locations Kaimanam and Pappanamcode based on expert opinion survey. By analyzing the results it is clear that according to the experts, road width, parking facilities, location of bus stops, attention to pedestrians and non motorized traffics and warning signs are the major safety measures to be prioritized in under-construction stage. By the calculated weight response at the location lack of information regarding construction zone approaching, lack of care and attention given for pedestrian and Non – motorized traffic, lack of proper drainage facilities, pollution, lack of adequate parking facilities, lack of safety provisions for elder persons and children.

2) *Results of Expert Opinion Survey Preconstruction Stage*

Table VIII shows the weightage of locations Nemom and Pravachambalam based on expert opinion survey. By analyzing the results it is clear that according to the experts, Insufficient Road width, Lack of warning signs, Inadequate road surface condition, edge drop, lack of proper drainage Facilities are the major safety measures to be prioritized in pre-construction stage. By the calculated weight response at the location lack of proper drainage facilities, edge drop, speed reduction measurements, road surface condition, insufficient road width, lack of adequate street light. Table VII shows the weightage of locations Nemom and Pravachambalam based on expert opinion survey.

TABLE VII. OBSERVED WEIGHTAGE BASED ON EXPERT OPINION SURVEY FOR ROAD UNDER CONSTRUCTION

Q. No	Weightage by experts	Kaimanam		Pappanamcode	
		Negative response	Calculated weight	Negative response	Calculated weight
1	4.7	0.05	0.24	0.36	1.68
2	3.0	0.70	2.10	0.93	2.78
3	3.6	0.85	3.06	0.93	3.34
4	2.6	0.80	2.08	1.00	2.60
5	1.7	0.75	1.28	0.36	0.61
6	3.3	0.40	1.32	0.64	2.12
7	3.9	0.80	3.12	0.64	2.51
8	2.6	0.80	2.08	0.43	1.11
9	2.6	0.90	2.24	0.93	2.41
10	3.8	0.02	0.76	0.29	1.08
11	2.7	0.55	1.49	0.50	1.35
12	2.6	0.35	0.91	0.07	0.19
13	3.4	0.95	3.23	1.00	3.40
14	2.8	0.45	1.26	0.21	0.60
15	1.5	0.75	1.13	0.71	1.07

TABLE VIII. OBSERVED WEIGHTAGE BASED ON EXPERT OPINION SURVEY FOR PRE- CONSTRUCTION

Q. No	Weightage by experts	Nemom		Pravachambalam	
		Negative response	Calculated weight	Negative response	Calculated weight
1	4.5	0.54	2.40	0.85	3.82
2	2.9	0.70	2.01	0.70	2.03
3	2.8	0.61	1.72	0.60	1.68
4	2.2	0.92	2.03	1.00	2.20
5	1.9	1.00	1.90	1.00	1.90
6	3.8	0.46	1.75	0.55	2.09
7	2.3	0.61	1.41	0.60	1.38
8	2.5	0.70	1.70	0.75	1.88
9	2.3	0.77	1.76	0.70	1.61
10	3.1	0.92	2.86	0.30	0.93
11	3.0	0.77	2.30	0.75	2.25
12	3.0	1.00	3.00	1.00	3.00
13	1.7	0.85	1.44	0.60	1.02
14	3.3	0.92	3.04	1.00	3.30
15	3.8	1.00	3.80	1.00	3.80

V. SUMMARY AND CONCLUSION

Karamana – Kaliyikkavila road project is for widening the existing two lanes to four lanes in NH 66 of Thiruvananthapuram district, For this study a 13 km stretch from Karamana to Balaramapuram was selected in which 6 major areas are in construction stage and remaining areas in pre-construction stage. Accident data of the stretch over the past 5 years were collected from SCRB (State Crime Records Bureau) and analyzed. From the analysis 4 major areas, Pappanamcode, Kaimanam, Nemom and Pravachambalam were identified as black spots on the basis of the accident frequencies in those spots. Of this, Kaimanam and Pappanamcode are under construction stage. Hence it is necessary to check the challenges to the road safety of these spots. IRC specifies speed limit between 20 kmph - 40 kmph

for the vehicles in a road stretch when it is under construction stage. A spot speed study was conducted by which it is found that vehicles often violates the speed limit which can be said to be a challenge to the safety aspect of that stretch.

The major defects and problems other than speed limit were studied by a Road Safety Audit using checklist 4 (RSA on road under construction) of IRC SP88. The results of the audit showed that there are a number of factors which results in the unsafe condition of the road. These include uncovered and unsafe drainages, lack of proper warning signs, construction materials stack along the road sides which reduces usable shoulder width, pot holes and electric and telephone posts on carriageway, signs boards placed closer to the road etc. These factors were identified based on negative response survey and expert opinion survey was conducted. On the basis of these surveys a weight was calculated for each factor from which the significance of each factor can be estimated. It is found that following factors seemed to be most important in the road stretch under construction stage.

1. Lack of information regarding construction zone approaching Lack of warning signs
2. Lack of adequate parking facilities
3. Insufficient road width
4. Pollution

It is found that following factors seemed to be most important in the road stretch pre-construction stage.

1. Edge Drop
2. Lack of Proper drainage Facilities
3. Speed reduction measurements
4. Road Surface condition
5. Insufficient road width

Suitable remedial measures were also proposed for the above mentioned problems which are found to be relevant in the safety aspects of the road stretch.

From the accident data of the road stretch after the commencement of the construction work it seems that at Kaimanam and Pappanamcode the number of accidents increased by 54% & 33% respectively. Thus the proper implementation of the suggested remedial measures may bring down the accident rates in the remaining areas of the stretch were the construction is yet to begin.

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