Risk Rating Index For Prioritizing Of Road Accident Prone Segments On Highways

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Abstract: India has emerged as a fast developing economy in the world. This development has been possible with great improvements in road infrastructure. Improved road infrastructure has led to a tremendous increase in vehicular traffic on Indian roads. This increase in vehicular traffic has further led to a negative effect of road accidents. In India, an accident occurs at every 1 minute and a person is killed in every four minutes. Accident leads to social and economical suffering for a nation. Generally, accidents tend to cluster along particular points along the road segment known as blackspot. The main concern in road safety is the elimination of such accident locations. So, the study identifies and prioritizes the accident blackspots within the study stretch of SH-13, in the state of Punjab. An attempt has been made to develop risk rating index using road safety audit. The RRI was further used to develop RR (Risk ratio) to get an insight of safety standards of each section with respect to total study stretch. The ratio is hence used for prioritization of sections with more risk and suggests remedial measures.

Key Words: Risk, Blackspot, Audit, Accident, State Highway, Matrix

1. INTRODUCTION

India has seen spectacular growth in the sector of road transportation. This expansion has led to degradation of environment, increased road congestion, noise pollution and road accidents. Around 85% of road accidents in the world occur in developing countries and India constitutes for about 10% of total road accidents occurring in the world. The total loss from road accident is about 2 to 3 percent of the Gross Domestic Product (GDP) of India. WHO Global Status report on Road Safety (2016)[1], states that road injuries killed 1.4 million people in 2016, about three-quarters (74%) of whom were men and boys. Further, road statistics indicate a steep increase in deaths, casualities and number of accidents in last decade. The occurrence of accidents can be summed up as interaction among three major factors viz. road, road user and the vehicle (PIARC 2013)[2]. Road accidents are one of the leading contributors of disease and injury to humans globally. The increase in number of road casualities in India can be attributed to the tremendous growth of transport vehicles, heterogeneity of vehicles on Indian highways and absence of grade separators to eliminate conflicts. The situation gets worse due to poor road maintenance, bad driving habits and poor enforcement of laws. Thus identification of such high hazard location is an important aspect in road safety. It is necessary that road accident blackspots are identified and prioritized for treatment. The researchers in the past have worked on the identification of blackspots but the studies exploring the prioritization of the blackspots have been limited. Hence, in the present study an attempt has been made to identify the accident prone sections and prioritize the sections based upon Risk Rating Index by conducting RSA.

2. LITERATURE REVIEW

In past, researchers have developed methods for identification and prioritization of accident black spots. Srinivasan et.al [3] developed three models based on severity. In the development of models they have considered API (Accident prone index) method, WSI (Weighted Severity Index method) and Quantum of accident method. The API method considered three components for defining blackspot viz. a) Consistency- frequency of accidents b) Level-magnitude of accidents c) Tendency-occurrence of accidents with time. In WSI method weights were assigned according to severity level of the accident and the locations were ranked according to the numeric value of severity for the location. Quantum of accident method described about the improper interrelation among various factors concerned with vehicle, road, road user and weather conditions. Radin and Baguley [4] in their pilot project in Malaysia studied about accident diagnosis and prioritizing of blackspots. The authors utilized accident maps, link-node-cell system and coordinates for linking the hazardous locations to the system of kilometer post on rural highways in Malaysia. Moreover, they suggested use of stick and collision diagram for in-depth analysis of accident blackspot locations. Field investigations should be done to ascertain about the reasons for occurrence of accidents, concluded the study. A.Thube and D. Thube [5] in their work accident blackspot on rural highways in India have described the method of identification of blackspot on rural highway in Maharashtra, India. The method used by the accident prevention committee was by physically verifying the accident data available with the police stations. APC noted down the locations where accidents were occurring repetitively. The APC categorized the accident locations as priority-I, where immediate attention was sought for. The committee also suggested remedial measures for identified locations. K. Ratkeviciute et.al [6] developed accident prediction model using empirical Bayes method for the roads of national significance in Lithuania. The developed model based on empirical Bayes method was utilized to locate the hazardous road sections considering homogeneity of road sections. They summed up that road sections in built-up areas were more hazardous. G.Zovak et.al [7] in their research used the Croatian criteria of identifying blackspot for state roads. The criteria stated that blackspot could be an intersection or a segment of road of length 300m and further falls in category of having 12 or more road accidents in last three years. Karlaftis and Golias [8] deployed hierarchical tree to study interrelation between traffic, geometric features of road and accident rates for rural two lane highways. They concluded that average daily traffic (ADT) along with lane width was the prominent attributes for accidents on rural roads. N.Mor et.al [9] used linear regression technique to develop accident model. The developed model gave accuracy of 84%. The study observed that road length, motor vehicle density and population were the contributing factors for road accidents.

Sisodia et.al [10] in their research used GIS for identification of blackspot locations along Gurgaon-Jaipur National highway. The study has used Severity Index, Kernel density and Moran's-I statics for critical analysis of accident locations. The finding of the study was that there was tendency of clustering of accidents and 7 accident spots were identified. Elvik [11] in his study proposed computation of local risk factors for identification of accident hotspots. The proposed method utilized the site condition details for working out the decision whether a site under consideration is an accident hotspot or not. Further, the methodology clearly differentiated between true positives and false positives. K.Chung et.al [12] has presented an approach of continuous risk profile for identification of locations on congested highways having high collision concentration. The methodology was used for 413 miles of road length in California. It was demonstrated that CRP approach was better than traditional sliding window approach. This was concluded as CRP approach had found lower false positives. H.Yuha et.al [13] conducted Road Safety Audit according to Russian practice and suggested the important factor of human involvement in road rashes. They also studied the importance of traffic safety audit. G.Apparao et.al [14] in their study used GIS for identification of accident blackspots on NH-58. They concluded that during weekends the rate of occurrence increased and the months of August to December envisaged more accidents. Study also pointed that accidents predominantly occurred during day time. N. Chike H and N.Godwin.I [15] used statistical modeling for analysis of accident data in Nigeria. They have developed Poisson regression model, Negative Binomial regression and Generalized Poisson Regression for analysis of accident data. The study used AIC criterion for arriving at best model. It concluded with Negative Binomial Regression model as the best model.

3. OBJECTIVE OF STUDY

SH-13 in Punjab is an important highway providing connectivity to the industrial town of Ludhiana. The highway carries heavy traffic and is two laned for most of its stretch. The heavy and mixed traffic poses threat to the safety of road users. A stretch from Barnala to Ludhiana has been selected for the current study to fulfill the following:

- Carryout road safety audit for the selected stretch of highway.
- Development of risk rating index for individual stretches.
- Defining likelihood of risk based on probability and severity of accidents.
- Prioritize the stretches according to their safety performance.
- Identifying the issues responsible for accidents and suggesting remedial measure.

4. ROAD SAFETY AUDIT

It is a formal procedure for examining accident potential and safety performance of existing roads. It can further be used as a tool to minimize the risk of accident occurrence and also to minimize their severity. The main aim of RSA is to study the physical elements of road. Along with the road factors are present the human factors which are hardest to alter. In the current study, 60 km stretch of SH-13 between Barnala and Ludhiana has been selected. Approximately 260 accidents were reported during the study period with varying levels of severity. RSA guidelines of IRC SP 88:2010 have been adopted to develop the risk rating calculation sheet. The sheet is presented in Table 4. RSA has been conducted for finding the causes of high accidents on the stretch. Numerous visits were made to calculate the attributes listed in the risk rating sheet. The attributes in the sheet have been used to quantify the degree of risk and prioritize the sections.

5. RISK RATING AND LEVELS

Risk rating has been developed considering the accident severity and frequency of their occurrence.

Table 1: Assigned weightage for frequency of Accidents

Frequency	Definition	Assigned Weightage
Frequent	Reporting of five accidents per year	5
Occasional	Reporting of two accidents per year	2
Rare	Reporting of one accident in three years	0.3

Three severity levels of fatal, grievous and minor were identified. Numerical weights were given to them considering the average costs of accidents with severity levels [16]. Interpretation of severity levels, assigned weights and costs of accidents for three severity levels is shown in Table 2. Three different accident frequencies [17] have been used viz; frequent, occasional and rare. These frequencies were defined considering the accident occurred on the selected during the study period of SH-13 as tabulated in Table 1.

Table 2:-Severity Levels and Assigned Weightage

Severity Level	Interpretation	Accident Cost, US$	Severity weightage assigned
Fatal	One or More Fatalities	21892.7	25.75
Grievous(Injuries)	Grievous Injury(Hospitalization)	11520.32	13.55
Minor	Property Damage only	850	1

The analysis of accident data pointed that at least 6 spots were present in the stretch where repeatedly the accidents have occurred. Further, it was seen that average number of crashes reported on all the spots exceed five crashes per year. Hence the spots having 5 accident occurrences in a year was defined as "frequent". A spot with 2 accidents in a year was considered as "occasional" and with 1 accident in three years as "rare". A risk matrix as shown in Table 3 for prioritization was developed considering accident severity and frequency of accident occurrence. Based on risk matrix the risk weightage was assigned to different risk levels as follows:

Level of Risk	*Low*	*Medium*	*High*	*Serious*
Weightage	*1*	*10*	*20*	*50*

Table 3: Priority Matrix for Severity and Frequency

Severity	**Frequency**		
	Frequent	**Occasional**	**Rare**
Fatal	Serious	High	Low
Grievous	High	Medium	Low
Minor	Medium	Low	Low

6. METHODOLOGY

Traffic volume, spot speeds and road geometric data was obtained through field visit to the study stretch. Risk weighting performa along with weightage for sample stretch as shown in Table 4 was used to assign weightage to each attribute. The table was used to all other kilometer stretches to understand the risk weightings and develop risk rating index (RRI). The main aim of the study is to develop the risk rating index to compare the risk likelihood of different sections under consideration. Higher value of RRI indicates greater risk and immediate attention for safety of road users. RRI will

- Access the risk potential of the study stretch.
- Helps in prioritization of sections based on risk levels and severity.
- Can be used by authorities for controlling the road accidents.

RRI= sum of risk weightage's

Also, a risk ratio (RR) has been calculated to compare the risk among different stretch of highway under study.

RR= RRI/ Average RRI of entire stretch.

Table 4:-Data Sheet for computation of RRI[18]

Categories	**Attributes**	**Risk Weightage**
Land Use	Rural	50
	Urban	--
Road Alignment and Geometrics	Horizontal Alignment	50
	Vertical Alignment	--
	Sight Distance not proper	50
	Carriageway Width	--
	Shoulder Width	50
Intersections	Design of Junction	20
	Improper Visibility Triangle	--
	Traffic control not proper	10
	Improper Location	10
Users of Road	High Percentage of Pedestrians	--
	High Percentage of NMV	20
	Bus	10
	Car	10
	2 wheeler	10
Traffic Control Devices	Pavement Markings not present	10
	Shoulder Markings not present	10
	Chevron Marking for Alignment missing	--
	Speed Control Signs missing	--
	Delineators	1
	Inadequate Signs	1
Speed	Vehicles at posted speed limit	--
	Vehicles above posted speed limit (10%)	50
	Vehicles above posted speed limit (20%)	50
Pavement Surface	Rutting in pavement surface	10
	Potholes	10
Access/Side Roads (Signs and Markings)	Markings for access roads	--
	Location of bus stops	10
TOTAL RISK RATING INDEX		**442**
NUMBER OF DEFICIENT ATTRIBUTES		**21**
ATTRIBUTES UNDER CONSIDERATION		**29**

7. APPLICATION OF RRI

RRI was calculated for individual section and presented in Table 5. Sample computation for first stretch is as presented in Table 4. Figure 1 presents the RRI and mean risk weighting at every km stretch. The deficient parameters majorly observed are presented in Figure 2. Several visits were made to site to study and conclude the attributes majorly responsible for the safety of road users. Figure 3, 4, 5 and 6 shows about the deteriorated shoulder, existing road conditions, layout of Junction and posted speed limits on the study stretch.

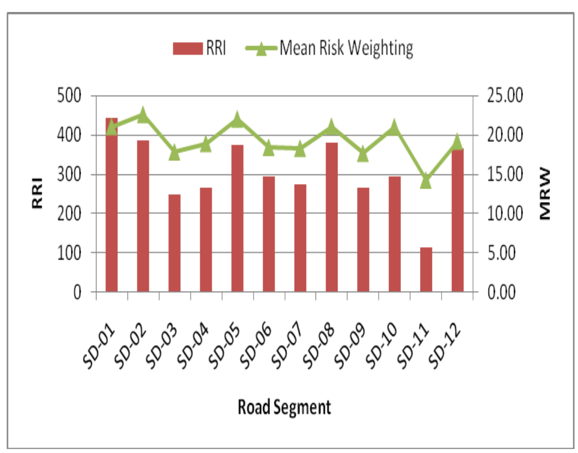

Fig 1: RRI and MRW for different stretches of Highway

The accident data from 2012 to 2016 has been used in the study. Further a correlation has been developed between RRI, total fatalities and total casualities as shown in Fig 7. There seems to be good correlation between RRI and fatalities of individual stretches.

Table 5: Risk Rating of Different Kilometer Stretches

Road Segment	**Deficient attributes in Segmnet**	**RRI**	**Mean Risk Weighting**	**RR**
(a)	*(b)*	*(c)*	*(d)= (c)/(b)*	*(e)=(c) /308.92*
*SD-01	21	442	21.10	**1.43**
SD-02	17	385	22.65	**1.25**
SD-03	14	250	17.86	0.81
SD-04	14	265	18.93	0.86
SD-05	17	375	22.06	**1.21**
SD-06	16	295	18.44	0.95
SD-07	15	275	18.33	0.89
SD-08	18	380	21.11	**1.23**
SD-09	15	265	17.67	0.86
SD-10	14	295	21.07	0.95
SD-11	8	114	14.25	0.37
SD-12	19	365	19.21	**1.18**
	15.67	**308.92**		

**Each Segment Length=5km.*

Fig 4: Speed limit on study Stretch

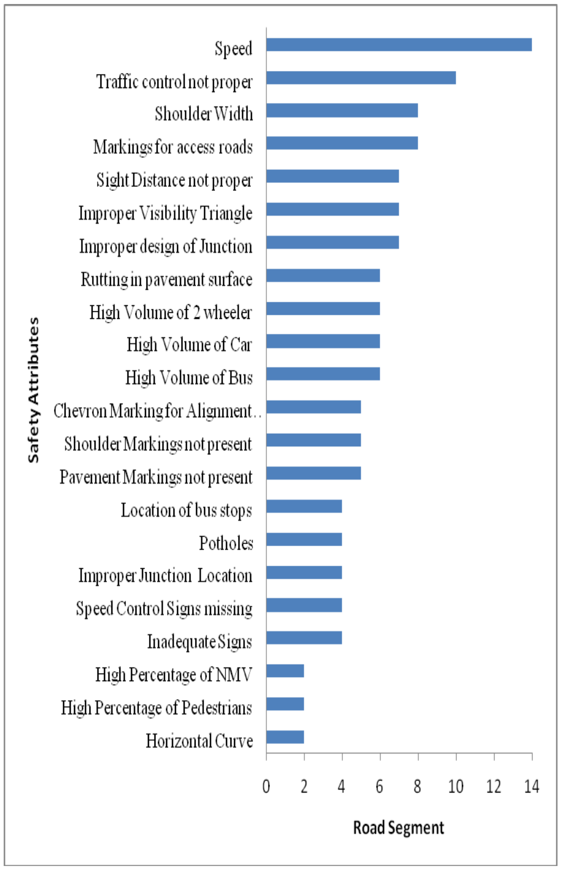

Fig 2: Major Deficiencies in the selected study stretch of SH-13

Fig 3: Shoulder deteriorated on Curve Section

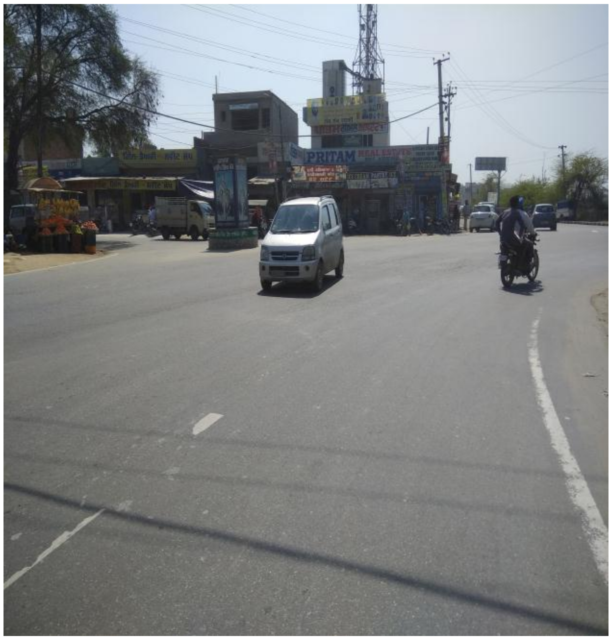

Fig 5: Improper Junction Design

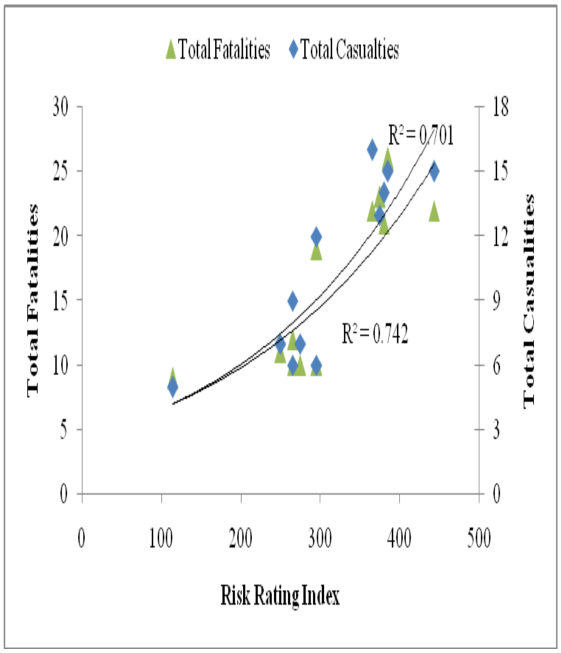

Fig 7: Relationship between RRI to TF and TC

Fig 6: Deteriorated Pavement and Missing Chevron Marking for Y Junction

8. CONCLUSIONS

Road Safety Audit was conducted for SH-13; risk ratings and risk ratio were derived to prioritize the individual stretches. The stretch with highest RRI is most unsafe whereas the segment with lowest RRI is the safest in study stretch. From RRI obtained for each stretch it can further be concluded:

- Lowest RRI of 114 was observed for stretch 11 indicating it to be safest and having least risk likelihood.
- Stretch 1 has highest RRI of 442 and RR of 1.43 indicating that a high number of deficient attributes existed in the stretch requiring immediate attention.
- Segments SD-02, SD-05, SD-08 and SD-12 were also found to have higher risk ratio indicating presence of fewer but critical attributes.
- The most critical factors which were majorly responsible for risk were speed, traffic control, shoulder width and markings for junction, intersections etc.
- The correlation between RRI, Total Fatalities and Casualities for individual segments proved that attributes were in good agreement.
- Proper design standards, traffic calming measures, layout of bus stops can help in enhancing safety.

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