© May 2016 | IJIRT | Volume 2 Issue 12 | ISSN: 2349-6002

Estimation of Crash Risk Index for Urban Arterial street – A Case Study of RTO Circle to Shivranjani Intersection

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***Abstract* – Road Safety is one of the crucial subject in transportation engineering. This study deals with the estimation of crash risk index for urban Arterial Street by safety levels considering Accident. Accident analysis covers the 8km stretch with 9 locations, in which the more accidents are occurs. The traffic classified volume count, spot speed, gradient, Road width, footpath width, geometrical conditions are the factors affecting the accident. Traffic accident data for three years (2013-2015) are used in development and testing the model. The regression model of Risk index i.e. an estimated score to rank the sites by using different road features is developed with R2 value and t vale using the above parameters.**

***Index Terms*- Accident, Crash risk index, traffic, Safety**

I. INTRODUCTION

The road accidents deaths and injuries are global phenomena but more sever situation in mixed traffic condition as prevailing on Indian multilane highways. Concept of quality management and sustainable safety have gained ground in the past two decades and may have been among the factors that led policymakers and project managers to realize the need for purely safety-oriented tools. Road Safety Audit (RSA) is one of the best tools for improvement of road safety; in which experts attempt to identify potentially dangerous features on the highway environment and urban roads as well and suggest remedial measures. (Dr. S. S. Jain 2011.)

Traffic accident prevention has been a consensus all the time around the World and in last several years large amount of money has been spent for traffic accident prevention.

Reduction of social and economic costs also associated with accidents and collisions in road transportation. Identification of sites requiring investigation for possible safety treatments is one of the most important aspects of infrastructure safety management. Road authorities need road safety management programs, designed to improve road safety performance for the system users. Most of the safety management programs include study of accident-prone locations. Significant accident history must exist and be identified before road improvements are recommended. Even though there are several reasons why accidents are not a good measurement for describing the traffic safety condition. The reasons include (1) many accidents are never reported to the police. The share reported varies from site to site and between different road user groups, (2) the number of accidents at a specific site is usually small. Small accident numbers go hand in hand with large random variations. Many years have to be included to get a good picture of the situation. This means that many factors are changed during the period of observation and (3) often a countermeasure is introduced at a site because the number of reported accidents there has been large. A drop in the number of accidents may be attributed either to a successful countermeasure, or to the fact that the period before the measure was introduced had a randomly high number of accidents.

Road safety audit is one of the road safety engineering programs widely used. Experience has shown that an effective road safety engineering program requires three times as much effort being put in to black spot programs as is put in to road safety audit and can yield benefits in terms of reduction in likelihood crashes, severity of crashes, reduction in need for costly remedial works etc. To carry out road safety audit, it is essential to know the characteristics and risk by considering the fundamental elements that can describe road safety in a quantifiable manner. Risk index is an estimated score to rank the sites using different road features to formulate the exposure, probability and consequence components. Development of risk index produces a technique to support road safety analysis and can be useful to rank the sites and for in depth study of road safety audit. (Venkata Ganesh Babu Kolisetty 2004.)

II. CRASH RISK FACTORS FOR ROAD TRAFFIC ACCIDENTS

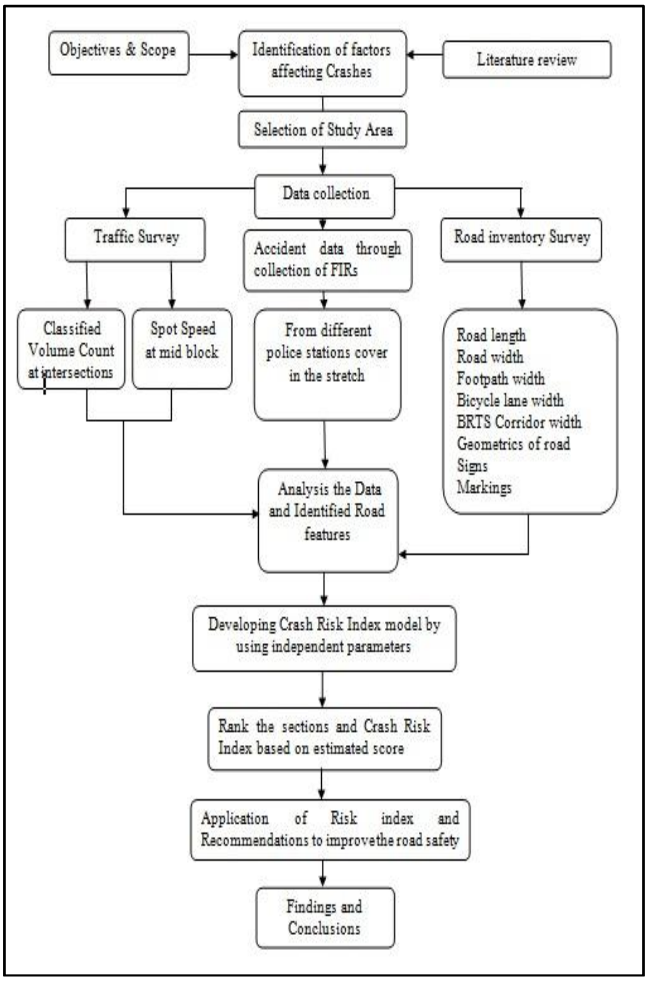
A safe road traffic system can be defined as the one that accommodates and compensate for human vulnerability and fallibility (Muhlrad and Lassarre, 2005). During the last decades, many resources have been spent by automotive industry for the improvement of road users' protection (both drivers and pedestrian). Several activities also led to the enhancement of the safety level that a vehicle may offer by means of numerous new technologies: ITS system, airbags, active safety systems like advanced brake systems, the ESC (Electronic Stability Control) are just some examples. However, these efforts seem to be not enough for a consistent reduction of traffic fatalities and crashes if they are conducted independent of an improvement of road infrastructure safety at all the stages of its lifetime: planning, design, construction and operation.

By introducing different tools such as Road Impact Assessment, Road Safety Audits and Inspections and Black Spots Management, an integrated concept of safety, also within the road infrastructure field, was promoted and developed (Perandones and Ramos, 2008). The possibility of informing drivers about the risk associated to the road segment they are travelling is aimed at preventing future road accidents, especially where road infrastructure must be improved and previous fatalities occurred (ETSC, 2001; Perandones & Ramos, 2008). A risk factor is any factor that, all else being equal, increases the probability of sustaining an accident or worsens the severity of injuries (ETSC, 2001). Previous studies have identified a number of risk factors influencing the possibility of being involved in a crash. Many of these parameters are summarized in Table 1 (Elvik et al, 2009; ETSC, 2001; Perandones and Ramos, 2008).

FACTORS	DESCRIPTIONS
ACCIDENT and ROAD USER BEHAVIOUR	Speed; Fatigue; Overtaking man oeuvres; Alcohol; Travelling in darkness; Age of drivers; Use of seat belts;
ROAD CONDITIONS	Road surface; Inadequate visibility; Road Alignment; Defects in road design; Road junctions; Super elevation; Defects in road maintenance; Private accesses; Consistency;
ROAD INVENTORIES	Road width, footpath width, no of lanes,
VEHICLE FACTORS	Vehicle defects; Vehicle number and size; Technical conditions;
TRAFFIC FACILITY	Classified volume count, Perfect rate of traffic sign; Serviceability rate of traffic marking; Traffic accident emergency rescue;

III. OBJECTIVE OF CRASH RISK INDEX AND METHODODLOGY

1. Identification of Parameters to rank the study section with reference to Road Safety.
2. To develop a mathematical model for estimation of risk index to support Road Safety.
3. To suggest remedial measures for minimizing the risk and severity of crashes for an Urban Section.



IV. STUDY AREA

Growth of road transport in Ahmadabad city is very fast. There is heavy volume and many big problem of traffic on urban road. The heavy vehicles and passengers are moving on the BRTS route in the Morning and evening peak hours. The Study is carried out on the stretch of BRTS route from RTO to SHIVRANJANI.

- A case study of Ahmadabad city – RTO circle to SHIVRANJANI intersection.
- The stretch is 8.8km long and 40m wide.

- It covers;
  1. One underpass
  2. Three flyovers
  3. Three major signalized intersections
  4. One round – about.

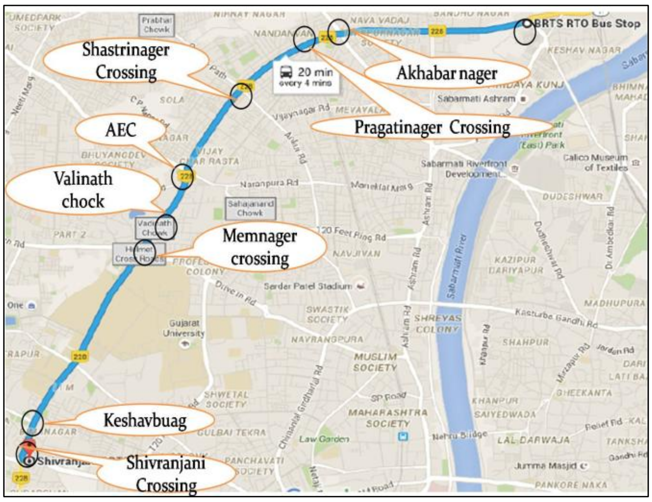


Figure 1: Study Area

V. DATA COLLECTION AND ANALYSIS

Estimation of risk index and road safety audit depends upon the characteristics of the data, particularly their type, quantity, quality and how the data is collected. The data that need to be acquired and the sources of such data must be identified as a matter of utmost importance.

The accident situation in general is very serious and more worrisome in large cities which accounts for maximum number of accidents. In most of the cases crashes occurs either due to carelessness or due to lack of road safety awareness of the road user. For this purpose the estimation of Risk index in road safety carried out on the stretch: "A corridor of 132 feet ring road from RTO circle to Shivranjani intersection." Ahmedabad is the largest city in the state of Gujarat and the seventh largest city in India.

The data collected for the study are FIR collections from respective police stations, Classified Volume Count, spot speed, Roadway inventory and required other probable parameters. Accident data for the period 2013-2015 are obtained from different police stations on the study area corridor.

Following data is to be collected for the estimation of crash risk index:

- Accident data are collected from respective police stations which covers the whole stretch.
  - Ranip (RTO) (RTO – Ranip T cross road)
  - Naranpura (Ranip T cross road – AEC)
  - University (AEC – starting of Helmet crossing)
  - Vastrapur (Helmet crossing – IIM intersection)
  - Satellite (IIM intersection – Shivranjani),for analysis, last 3 years accident data has been considered here.
- Length of section, Width of road, footpath width, Road condition, Signs and signals, Markings, Gradient are Collected using road inventory data.
- Traffic volume and Spot Speed are collected by manual method of survey and videography.

TABLE I: ACCIDENT DATA

Sr no	Year	Fatal	Major	Minor	Total accident
1	2013	5	16	24	45
2	2014	4	8	10	22
3	2015	4	11	12	27

TABLE II: INVENTORY SURVEY

Sr no	Location	Road width (m)	Footpath width (m)	Bicycle width (m)	Gradient
1	RTO	13.2	2m	_	-1.42
2	Akhabarnagr	11.5	2.5m	_	-0.45
3	Pragatinagar	9.2	2m	2.2m	0.37
4	Shastrinaagr	9.3	2.7m	1.7	-0.44
5	AEC	7.0	3.2m	_	0.37
6	Valinath chawk	13.3	2.3	_	0.34
7	Memnagar	8.0	2.7m	_	0.59
8	Keshavbaug	10.7	3.0m	2.7m	0.35
9	Shivranjani	8.5	2.5m	_	0.37

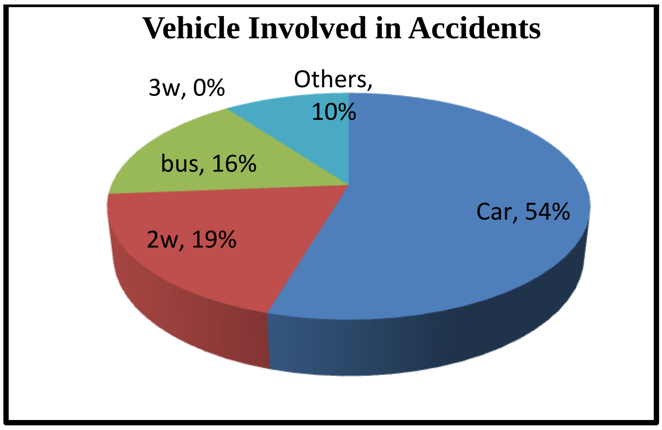
TABLE III:CLASSIFIED VOLUME COUNT SURVEY:

Sr no	Location	%2w	%3w	%car	% bus	Total Vol. (pcu/hr)
1	RTO	49	20	22	5	3902
2	Akhabarnagr	40	18	30	5	3749
3	Pragatinagar	35	19	35	5	4031
4	Shastrinaagr	37	9	39	4	5452
5	AEC	36	21	30	5	3993
6	Valinath chawk	34	19	31	6	3365
7	Memnagar	32	22	37	4	4430
8	Keshavbaug	32	12	42	4	5001
9	Shivranjani	35	18	36	4	4487

TABLE IV: SPOT SPEED SURVEY

Sr no	Location	2w	3w	car	bus	Aerage
1	RTO	42.5	42.6	42.7	42.5	42.6
2	Akhabarnagr	37.9	30.6	40.5	41.6	37.7
3	Pragatinagar	36.7	32.7	40.6	40.5	37.6
4	Shastrinaagr	35.7	30.6	37.5	46.8	37.7
5	AEC	36.8	34.6	38.5	44.7	38.6
6	Valinath chawk	33.6	31.6	42.6	42.6	37.6
7	Memnagar	33.3	32.6	35.7	43.6	36.3
8	Keshavbaug	42.6	35.8	38.7	42.6	39.9
9	Shivranjani	34.6	31.6	32.5	44.6	35.8

(All speed is in Km/hr)



VI. CAUSES OF ACCIDENTS

- Auto rickshaws and cars were also involved in unauthorized parking.
- Signals are not visible and the traffic is difficult to manage because of multiple intersections and type of vehicles.
- The traffic signals are present but not in working condition or nobody follow the rules of signal.
- There is no speed breaker ahead of intersection.
- There are no proper covering of manholes in between the roads and bad surface condition.
- It is observed that many vehicles were parked on the footpath and below the bridge.
- Road side activities have covered the road space. Vehicles users are forced to drive on the centre of the main road.
- There are no facilities available for pedestrian crossing and no pedestrian signal available.


Figure 2: Disobey the traffic rules create conflict


Figure 3: Ill legal parking on road, reduces the width


Figure 4: No Pedestrian crossing facility

Figure 5: Manhole and surface condition

VII. MODEL DEVELOPMENT

Model number -1 and model number -2 are developed by using LINEST function from the excel. This describes the formula syntax and usage of the LINEST function in Microsoft Excel. The LINEST function calculates the statistics for a line by using the "least squares" method to calculate a straight line that best fits your data, and then returns an array that describes the line. You can also combine LINEST with other functions to calculate the statistics for other types of models that are linear in the unknown parameters, including polynomial, logarithmic, exponential, and power series. Because this function returns an array of values, it must be entered as an array formula. Instructions follow the examples in this article. The equation for the line is:

y = mx + b –or–

y = m1x1 + m2x2 + ... + b (If there are multiple ranges of x-values)

Where the dependent y-values are a function of the independent x-values. The m-values are coefficients corresponding to each x-value, and b is a constant value. Note that y, x, and m can be vectors. The array that the LINEST function returns is {mn,mn-1,...,m1,b}. LINEST can also return additional regression statistics.

This model is developed by ranking the sections of the stretch by number of accidents in that section as per following and analyzing further with vehicle composition.

TABLE V: ESTIMATED CRASH RISK INDEX FOR THE STRECH

Sr No	Strata	(CRI)
1	0< N < =3	1
2	3< N < =6	2
3	6< N < =9	3
4	9< N < =12	4
5	12< N < =15	5

Where N = Number of Accidents/3year

Table VII: Level of risk associated to CRI values

Crash Risk index	1	2	3	4	5
	Very low	Low	Medium	High	Very High

Model 1: Considering vehicle composition and Speed

CRI=0.90**(tw)**+0.84**(au)**+0.76**(car)**+1.37**(LCV)** +0.95**(bic)** - 0.054**(Speed)**-77.1585

Model 2: Considering Road width and vehicle composition

CRI=-0.15**(W)**-0.16**(tw)**-0.40**(au)**-0.27**(car)**-0.089**(LCV)** - 0.045**(bic)** + 26.85395

Where,

- W = Road width
- tw = Proportion of two wheeler in %age
- au = Proportion of auto rickshaw/three wheeler in %age
- car = Proportion of Car in %age
- bus = Proportion of bus in %age
- LCV = Proportion of light commercial vehicle in %age
- bic = Proportion of bicycle in %age

TABLE V: SUMMARY OF MODEL 1

Vehicle type	b	m_i	t value	R^2	F value
2W	77.15	0.90	1.683	0.98	20.42
3W		0.84	1.398		
Car		0.76	1.580		
LCV		1.37	1.897		
Bicycle		0.95	1.602		
Speed		-0.054	-0.838		

TABLE VI: SUMMARY OF MODEL 2

Vehicle type	b	m_i	t value	R^2	F value
2W	26.85	-0.16	-0.712	0.98	189.9
3W		-0.40	-1.519		
Car		-0.27	-1.113		
LCV		-0.089	-0.288		
Bicycle		-0.045	-0.195		
Width		-0.15	-4.773		

VIII. REMEDIAL MEASURES FOR REDUSING THE ACCIDENT

- Vendors should be removed
- Signal must be in working condition
- Pedestrians crossing facilities should be developed throughout the road
- Proper resurfacing should be done on the road at regular interval
- Manholes should be properly covered

- Unauthorized parking should be prohibited
- Provision of Side street signal throughout the road
- Parking on foot path should be strictly prohibited
- Alternative routes are suggested for peak hour

IX. COCLUSION

- Total number of accidents is highest during 11 to 13 hours and 17 to 20 hours. The evening hours are more prone to fatal accidents especially from 16 to 21 hours. The reasons may be attributed to poor visibility, absence of recto-reflective traffic signs/messages, traffic delineators, blinkers, road markings etc on roads.
- More than 50 % of fatal accidents and more than 75 % of total accidents occurred during fine weather condition.
- Maximum number of accidents caused by Rear on collision. The head on collisions are mainly due to the reckless driving of vehicles at high speeds by the drivers. Very few accidents resulted from right angled collision.
- The study aimed at developing an indicator that can be used to identify hazardous locations respect to traffic conditions and speed of the different vehicle composition.
- Level of Risk associated to Crash Risk Index for the stretch like very low, low, medium, high, very high where CRI is 1,2,3,4,5 respectively.

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