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Study on Road Safety Index

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ABSTRACT: The major cause for global deaths and injuries are mainly due to road crashes. It is worst in developing countries due to rapid and unplanned urbanisation. It was estimated in 2010 that about 1, 60,000 persons have died due to road crashes in India. Since, road safety is influenced by many factors it involves complex studies to arrive at the reasons for accidents. As a result the accident study itself remains underestimated in many of the countries especially in developing countries. In recent years several indicators are developed in order to study the factors influencing the accident and based on which the improvement measures can be adopted to reduce accident rate. In the present study three stretches were selected to validate the Road safety Index (RSI) equation and to suggest the improvements to the selected road stretches. Also an analysis was made to check if there is any improvement in the RSI value.

KEYWORDS: global deaths, indicators, Road safety Index (RSI), validation, improvements.

I. INTRODUCTION

Road safety is a multi dimensional issue. In order to improvise the safety of road it incorporates the development and management of road infrastructure, rules and regulations, law enforcement to the road users etc.,. The accident rate has increased rapidly with increase in road network, motorisation and urbanisation in the country. Worldwide, over 1.2 million people are killed in road crashes each year and 20 to 50 million are injured according World health Organisation, 2009. It means that every day around the world, more than 3000 people die from road traffic injury. WHO estimates road accidents will become the world's third leading cause of death by the year 2020. India has a well established road network of about 33 kilometer. At the same time, India has one of the highest accident rates in the world with more than 14 accidents per thousand vehicles every year.

Table 1 describes the accident rate in India year wise

Table 1: Number of Road Accidents and Persons Involved: 2001 to 2009

Year	Number of Accidents		Number of Persons		Accident Severity*
	Total	Fatal	Killed	Injured	
2001	405,637	71219 (17.6)	80,888	405,216	19.9
2002	407,497	73650 (18.1)	84,674	408,711	20.8
2003	406,726	73589 (18.1)	85,998	435,122	21.1
2004	429,910	79357 (18.5)	92,618	464,521	21.5
2005	439,255	83491(19.0)	94,968	465,282	21.6
2006	460,920	93917(20.4)	105,749	496,481	22.9
2007	479,216	101161(21.1)	114,444	513,340	23.8
2008	484,704	106591(22.0)	119,860	523,193	24.7
2009	486,384	110993(22.8)	125,660	515,458	25.8

Figures within parenthesis indicate share of fatal accidents (i.e. involving death) to total accidents.

* Accident Severity : No. of Persons Killed per 100 Accidents

Sources: Road Accidents in India 2009, MoRTH

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II. BENGALURU ACCIDENT SCENARIO

In Bengaluru city, there is a tremendous increase in the population. the population in Bengaluru was around 1.59 lakhs in the year 1901, there was an increase in population to 65.37 lakhs in the year 2001, and the population has shoot up to 88.59 in the year 2011.

Bengaluru is branded as “Silicon Valley of India” as most of the Information technology industries are based in Bengaluru. It has witnessed a drastic growth on the radial and circumferential pattern due to increase in population since last two decades due to industrialisation. In 1901, the city spread area was 28.85 sq km. In 2001 the area was spread to 451.08 sq km. In 2011 the growth is 1309 sq km.

Due to increase the population and standard of living of the people there has been increase in the number of vehicles in the city. Bengaluru is one of the accident prone cities in India.

Table 2 Describes the total number of accidents occurred in Bangalore from 2003- 2010

Table 2: Year wise Total number of accidents for Bengaluru

Sl. No.	Year	Fatal	Killed	Non-Fatal	Injured	Total
1	2003	843	883	9662	7980	10505
2	2004	875	903	8226	6921	9101
3	2005	796	836	6782	5899	7578
4	2006	880	915	6681	6048	7561
5	2007	957	981	7469	6591	8426
6	2008	864	892	6908	6150	7772
7	2009	737	761	6138	5668	6875
8	2010	816	858	5667	5343	6483

Source: Transport Department GOK, Bengaluru Traffic Police

III. ROAD SAFETY INDEX

Since road accidents are due to several factors, study on the same involves many parameters which have its own significance in arriving at the road safety index. Certain indicators and indexes are being developed in the recent years. Although the aspect of road safety is the aim of any design process, it does not cover all the requirements to ensure accident free section in any road network. Road safety audit is a formal procedure for assessing accident potential and safety performance in the provision of new schemes, the improvement and rehabilitation of existing roads and in the maintenance of existing roads. The road safety audit, when used for applications on existing roads, is more appropriately termed as **Road Safety Index (RSI)**. RSI is a proven and highly cost effective process that assists with the production of safer roads. It should become a part of road design process in most of the road authorities in developed countries.

IV. RELATED WORK

An attempt was made by Prof. M.N. Sreehari and his team to develop a methodology to aggregate all the road safety parameters on to a common based scale by developing value score charts, after interviewing 100 traffic engineering experts in the country.

Many factors influence the rate of the accidents either separately or jointly. In his study, various factors affecting the causes of the accidents were identified and studied in detail.

The five main factors considered were:

- Roadway Characteristics
- Traffic Characteristics
- Roadside Characteristics

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- Pavement Characteristics
- Miscellaneous Characteristics

Out of several engineering factors identified, certain important quantifiable parameters were measured and aggregated to a common base scale.

The unbiased responses from the field experts were collected based on the scientific questionnaire. Each of the sixteen parameters was rated on 100 based on their crucial role played in case of accidents. Rating on a scale from 0 to 100, 100 depicts the safest condition of the road and hence presumed to be the best, whereas, assigning 0 for a particular parameter implies the worst condition of the road. Thus the responses were gathered to develop the trend charts.

Likewise, the responses for the relative weightage needed for the five main factors were collected from the same hundred traffic engineering experts and field engineers, on the scale of 0 to 100. The 100 responses obtained were averaged to get the relative weightage. The relative weightages of the five main factors which governs the Road Safety Index is as listed below.

- Roadway Characteristics-0.34
- Traffic Characteristics-0.26
- Roadside Characteristics-0.18
- Pavement Characteristics-0.13
- Miscellaneous Characteristics-0.09

Based on the scientific questionnaire, the value scores were given by the experts. These value scores were used for preparing the charts. (Road safety and traffic engineering experts, number in 100 are interviewed) Based on these value scores, trend charts were developed. These charts act as ready reckoner to arrive at the value scores of the parameters under study.

Gradation of roads based on Road Safety Index

The roads were classified based on their safety conditions. In his work, the gradation of the road depends on the Road Safety Index (RSI) obtained from the RSI equation. Accordingly, the road is graded as **Excellent, Very Good, Good/Average, Poor and Very Poor**.

The gradation of road based on the level of service offered is shown in the Table 3.

Table 3: Gradation of roads based on RSI

RSI in %	Level of Service
0.80-1.00	Excellent
0.60-0.80	Very Good
0.40-0.60	Good/Average
0.20-0.40	Poor
0.00-0.20	Very poor

$$RSI = \frac{\sum_{i=1}^n W_i \times V_{ei}}{\sum_{i=1}^n W_i \times V_{si}} \dots$$

Where 'n' is number of groups that define the overall factors to contribute accident.
'W_i' is the relative weightage allocated with ith service characteristics.

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' V_{ei} ' is the value score for i^{th} service characteristics of the existing situation
' V_{si} ' is the value scores for i^{th} service characteristics.

V. PRESENT STUDY

The main objectives of the present study are to validate the Road safety Index. Five road sections were selected for validation of RSI equation. Based on road safety inspections and to measure safety index for different type of roads in Bengaluru, the following roads were selected. The selected stretch of roads measured 1km.

- **Sadhashivanagar road**
- **Marasandra road**
- **Sir MVIT road**

In the present study the parameters as suggested in the development of RSI equation such as carriageway width, number of curves, gradient, number of intersections, type of intersections etc., are evaluated. For the same parameters the valued scores are applied by making use of the charts and the average values are obtained. Based on the average values obtained for different characteristics the RSI value is obtained using the equation as mentioned above. Based on the RSI value the road is categorised from excellent to very poor.

Case study 1: Sadashivnagar road

Table 4 describes the roadway characteristics of Sadashivnagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 4: Study on Roadway characteristic of Sadashivnagar road stretch

Roadway characteristic			
Parameters	Observed data	Valued scores	Average values
Carriageway width	4 lane with median	100	73.00
Number of curves	2	70	
Gradient	Flat	80	
Number of intersections/km	2	75	
Type of intersection	Perfect right angle	40	

Table 5 describes the Traffic characteristics of Sadashivnagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 5: Study on Traffic characteristic of Sadashivnagar road stretch

Traffic characteristic			
Parameters	Observed data	Valued scores	Average values
Speed	10% more than the speed limit	90	79.16
On- street parking	No parking	100	
Road markings	Centerline marking, Lane marking, Zebra crossing & Stop line, edge marking.	100	
Speed Breakers/km	2	75	

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Number of Fatalities/km	Serious Injury	50	
Signs	No adequate signs	60	

Table 6 describes the Roadside characteristics of Sadashivanagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 6: Study on Roadside characteristic of Sadashivnagar road stretch

Roadside characteristic			
Parameters	Observed data	Valued scores	Average values
Presence of Obstacles	Advertisement Board, trees, distracting road users	40	51.66
Shoulder	With average kerbs and levelled	60	
Street Lighting Interval	20m	55	

Table 7 describes the pavement characteristics of Sadashivanagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 7: Study on Pavement characteristic of Sadashivnagar road stretch

Pavement characteristic			
Parameters	Observed data	Valued scores	Average values
Pavement status	Average	40	65.00
Potholes/km	4	70	

Table 8 describes the Miscellaneous characteristics of Sadashivanagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 8: Study on Miscellaneous characteristic of Sadashivnagar road stretch

Miscellaneous characteristic			
Parameters	Observed data	Valued scores	Average values
Bus-stop distance from Intersection	120m	100	78.75
Intersection visibility	Very Good	80	
Presence of median	Median of 30 cm height	35	

RSI= 0.7

We can see that the obtained RSI lies within a range of 0.6 to 0.8, and hence the road is graded as **Very Good**

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Case 2: Marasandra road

Table 9 describes the roadway characteristics of Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 9: Study on Roadway characteristic of Marasandra road stretch

Roadway characteristic			
Parameters	Observed data	Valued scores	Average values
Carriageway width	2 lane without median	30	67.00
Number of curves	3	40	
Gradient	1.4%	95	
Number of intersections/km	7	10	
Type of intersection	t- junction	20	

Table 10 describes the Traffic characteristics of Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 10: Study on Traffic characteristic of Marasandra road stretch

Traffic characteristic			
Parameters	Observed data	Valued scores	Average values
Speed	35% more than speed limit	30	76.33
On- street parking	No parking	95	
Road markings	No marking.	00	
Speed Breakers/km	1	90	
Number of Fatalities/km	Property damage	40	
Signs	No adequate signs	60	

Table 11 describes the roadside characteristics of Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 11: Study on Roadside characteristic of Marasandra road stretch

Roadside characteristic			
Parameters	Observed data	Valued scores	Average values
Presence of Obstacles	No	00	00
Shoulder	Not adequate	00	
Street Lighting Interval	no	00	

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Table 12 describes the Pavement characteristics of Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 12: Study on Pavement characteristic of Marasandra road stretch

Pavement characteristic			
Parameters	Observed data	Valued scores	Average values
Pavement status	Poor	20	87.50
Potholes/km	4	80	

Table 13 describes the miscellaneous characteristics of Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 13: Study on Miscellaneous characteristic of Marasandra road stretch

Miscellaneous characteristic			
Parameters	Observed data	Valued scores	Average values
Bus-stop distance from Intersection	10m	20	6.67
Intersection visibility	Poor	00	
Presence of median	No Median	00	

RSI= 0.34

We can see that the obtained RSI lies within a range of 0.2 to 0.4, and hence the road is graded as *poor*

Case 3: Sir MVIT road

Table 14 describes the roadway characteristics of Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 14: Study on Roadway characteristic of Sir MVIT road stretch

Roadway characteristic			
Parameters	Observed data	Valued scores	Average values
Carriageway width	2 lane without median	20	28.00
Number of curves	6	00	
Gradient	0.233%	90	
Number of intersections/km	5	10	
Type of intersection	T & two way junction	20	

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Table 15 describes the Traffic characteristics of Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 15: Study on Traffic characteristic of Sir MVIT road stretch

Traffic characteristic			
Parameters	Observed data	Valued scores	Average values
Speed	28% more than speed limit	50	50.00
On- street parking	No parking	90	
Road markings	No marking.	00	
Speed Breakers/km	2	80	
Number of Fatalities/km	Minor damage	80	
Signs	No adequate signs	80	

Table 16 describes the roadside characteristics of Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 16: Study on Roadside characteristic of Sir MVIT road stretch

Roadside characteristic			
Parameters	Observed data	Valued scores	Average values
Presence of Obstacles	No	00	00
Shoulder	not adequate	00	
Street Lighting Interval	No Lighting	00	

Table 17 describes the Pavement characteristics of Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 17: Study on pavement characteristic of Sir MVIT road stretch

Pavement characteristic			
Parameters	Observed data	Valued scores	Average values
Pavement status	Poor	20	55.00
Potholes/km	4	90	

Table 18 describes the Miscellaneous characteristics of Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

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Table 18: Study on Miscellaneous characteristic of Sir MVIT road stretch

Miscellaneous characteristic			
Parameters	Observed data	Valued scores	Average values
Bus-stop distance from Intersection	20m	30	23.33
Intersection visibility	Fair	40	
Presence of median	No	00	

RSI= 0.35

We can see that the obtained RSI lies within a range of 0.2 to 0.4, and hence the road is graded as *poor*

Based on the studies conducted on the selected stretches it was observed that the safety index varies from poor to good condition. Some suggestions are made to the existing condition and studies are conducted to check the improvement in the RSI value.

- **SADHASHIVANAGAR Road**

Table 19 describes the improvement suggested for Sadashivanagar road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 19: Improvement suggested to Sadashivnagar Road

Improvement suggested	Improved RSI	Valued score
Traffic characteristics		
By installing adequate signs	100	85.83
Roadside characteristics		
By constructing Footpath	100	78.33
By removal of obstacles	80	
Pavement characteristics		
By providing overlay	100	85
Miscellaneous characteristics		
By improving the median	100	95
Improved RSI = 0.8	Very Good to Excellent	

- **Marasandra Road**

Table 20 describes the improvement suggested for Marasandra road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 20: Improvement suggested to Marasandra Road

Improvement suggested	Improved RSI	Valued score
Traffic characteristics		
By installing adequate signs	100	70
Provide speed breakers	60	
Provide road markings	95	
Roadside characteristics		
By installing street lights	80	26.66

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Miscellaneous characteristics		
By construction of the median	100	63.33
Shifting bus stop location	90	
Improved RSI = 0.52	Poor to good	

• **Sir MVIT Road**

Table 21 describes the improvement suggested for Sir MVIT road stretch and the valued scores obtained as per the recommendations of the experts and the average scores are obtained.

Table 21: Improvement suggested to Sir MVIT Road

Traffic characteristics		
Improvement suggested	Improved RSI	Valued score
By installing adequate signs	100	26.66
Roadside characteristics		
By constructing footpaths	80	28.00
Pavement characteristics		
By providing overlay	80	85
Miscellaneous characteristics		
By construction of the median	60	66.66
Shifting bus stop location	100	
Improved RSI = 0.48	Poor to good	

VI. EXPERIMENTAL RESULTS

The RSI value for the selected stretches ranges between 0 and 1. The higher values indicate higher levels of safety for that road. The lower values indicate the worst performance of the road in terms of road safety level. The target value of RSI is 1 and it shows how far the road has to be developed to ensure safety. This direct and simple ranking is quite useful to policy makers and ordinary people since it will show the scale of the problem clearly and easily.

VII. CONCLUSION

The experimental model developed by Prof. M.N Sreehari to analyse the road safety by aggregating several parameters on to a common based charts is one of the simple tool to measure the RSI and correlate the same to the level of service at which the road is catering as regard to safety. The RSI model developed is validated by analysing the parameters considered in developing the model on the selected stretches, also the suggestion have been made to improve the RSI value of the existing road condition.

VIII. ACKNOWLEDGEMENT

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BIOGRAPHY



Mr. Sunil Kumar. U is an under graduate student studying 8th semester, B.E. Civil Engineering in Sai Vidya Institute of Technology. His area of interest lies in the study of highway and traffic design and maintenance. Also, he is a sportsman and has represented the college in many events and has won many awards and prizes.



Mr. Gowtham. T is an under graduate student studying 8th semester, B.E. Civil Engineering in Sai Vidya Institute of Technology. His area of interest lies in the study of highway safety, design and maintenance.



Mrs. Pooja.M has completed her Bachelor of Engineering from Sri Venkateshwara College of Engineering, Bengaluru affiliated to VTU and Masters in Highway Engineering from UVCE, Bengaluru affiliated to Bengaluru University. The researcher has been part of consultancy work since 2011 and has worked in analysis of over-bridge of Bengaluru International Airport, and has been part of the periodic measurement of functional evaluation of the Bengaluru Outer ring Road and is in continuous research work regarding the pavement performance evaluation.