Road Safety Ratings for Selected Accident-Prone Sections in Urban Areas

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Abstract. This study carries out a detailed analysis of Road Safety conditions at different junctions in Bengaluru. This study takes into account various factors both from Highway Engineering and Traffic Engineering. These factors govern the safety features of the roads. The factors include both the road attributes and the traffic data from various locations of which a detailed analysis is carried out.

The project proceeds with a detailed data collection and analysis of the collected data using an analytical model designed by International Road Assessment Programme (iRAP). This model uses the data collection and analysis technique to generate a Star Rating System (SRS) which is effective in keeping a track of the Road safety features. The system is suitable for all types of road users in terms of their safety and is destined to reduce road accidents. This study is very much important to know the basic flaws in the structure as well as in traffic management in order to improve the traffic facilities in India.

1. Introduction
India is the seventh largest country in terms of area. It has a huge Road network of over 5,897,671 kms. This huge road network requires a great maintenance. All the areas in India are being connected to the main districts through road networks and the government of India is spending a lot of money in the maintenance of this network as transportation plays an important role in maintaining continuity in the country. The road infrastructure in India costs over 8 Billion USD every year which is a great amount. Even after spending this much amount, the current road safety situation is not up to the mark mainly on the National Highways where the road users do not follow the guidelines issued by the Highway authorities. This is due to the negligence of the road users in India.

As per a semi structured administered questionnaire, around 75% of the road users didn’t know the correct side of pedestrian walking and only around 15% could recognize all the traffic signs. It also showed that 95.5% of the total road users agreed on the safety aspects of using helmets but only 37% use helmets in day to day road commute.

There are many ways in which the accidents can be reduced. One way is to rate the existing roads on the basis of their features and characteristics. This way, the road network can be improved further in a very detailed way as per the requirements of the area and the road users.
and accidents can be reduced further. In this paper, we have provided the road safety ratings at selected accident-prone areas in Bangalore, Karnataka on the guidelines issued by iRAP. This rating helps us in understanding the improvements which can be adopted in the given area of interest in order to reduce the no. of road accidents and improve the road safety conditions in India.

1.1. Motivation
A country’s development is based on a lot of factors in which Road safety plays an important role. As mentioned earlier, a country loses its man power as well as economy in the Road accidents.

The motivation towards choosing this as the research topic is to try finding solutions to the pre-existing major problems and take India a step forward towards development. This study involves the optimized use of both Highway Engineering and Traffic Engineering into our daily life in order to further motivate the Civil Engineers to carry more research in this field. The International Road Assessment Programme is an organisation with a group of Researchers who are motivated towards carrying research in this field and reduce road safety issues. The Road Safety Rating model is being used in many counties including India and our sole aim is to increase Road safety by using this model in and around Bangalore.

1.2. Literature review
Improvement in road safety is generally credited to introducing countermeasures related to the actions of utilities, automobiles and road users, and descriptions of such are outlined in manuals of best practice. Further rigorous analysis undertaken in particular countries have shown arithmetic correlations among accident reductions and road safety infrastructure initiatives, mandatory seatbelt use, drunken driving strategies, speed regulation etc. Some of the early technologies used in the past which were very useful in establishing a link between the road accidents and various different factors responsible for the same are discussed below:

According to Fukuda et al (2005), a new approach for improving public participation in developing a database of plant diseases across the country could be the Hiyari-Hatto method. Dynamic segmentation, geocoding of addresses and identification of intersections are the parameters on which the traffic accident situation is based. Furth (2005) used techniques, comprising simple sampling, estimated relationship beside a spread of possible auxiliary variables, representative sampling, cluster sampling, and combinations of those approaches. The later technique used on-off data from a travel sample to estimate the connection between passenger miles and potential passenger miles, a recently proposed auxiliary variable.

Chin and Quddus (2003) confirmed like others that in predicting crashes traffic volume is one of the most crucial factors to be considered. Even though these studies concluded traffic volume as the most crucial indicator variable, there are researchers who considered the effect of land use on road segment crashes, Valverde and Jovanis (2006) examined the consequences of demographic patterns and climate on shocks at the country level. Shankar et el (1996) applied a logical formulation to determine and verify the probability of accident severity conditioned on the occurrence of an accident. Their findings have the conclusion that there is a significantly higher chance of obvious injury or grievous hurt or fatality, relative to no obvious injury if the restraint system is not practiced by at least one driver at the time of occurrence of the accident.

Chand and Alex (2007) calculated the accident risk index and accident severity index for various Indian states. They are centred upon a series of accident indicators that are combined to form an index. The values of various India Stated indices are then compared with the values of these two indices. The number of accidents in a place and vehicles movements in that place are related to each other, rather than the population or the number of vehicles.

The accident rate fluctuates greatly from state to state. Different accident figures give different images. In this way, it aims to calculate the Accident Risk Index (ARI) for the states of...
India. It has been calculated using a series of accident ratios combined by assigning certain weights to it. ARI is one such indicator that shows the impact of vehicle, road length, area and population on the accident number and identifies the prevailing accident rate in the district or state. A seriousness index has been found of the accident number with accidents that gives more weight to the number of fatalities than to the number of incapacitated.

Edwards (1998) [23], examined the association between weather recorded at a place and automobile accidents in England and Wales. Accident intensity for different hostile weather classifications of precipitation i.e. rain, fog and intense wind were weighed against non-hazardous weather situations. The outcomes revealed that the severity of the accident during rain decreases significantly compared to good weather conditions.

Home and Reyner (2000), conducted a study which indicates that driver exhaustion accounts for at least 20% of the total road accidents on straight roads. It urges that a lot of accidents happen on the roads which are due to excess sleep of the driver at the wheel during travel. A previous study by Home and Reyner (1995) on traffic accidents between 1987 and 1990 concluded that accidents related to driver’s tiredness and sleep involved 16% of the overall traffic accidents and 23% of the accidents alone in UK.

To be precise, the main issues related to the behaviour of illegal drivers are speed, violations of priority rules, drunk driving, traffic lights, traffic lights across the road, distraction and fatigue, and illegal overtaking. It can be established from these studies that human factors are decisive in road accidents, but distraction and fatigue also appear to influence driving skills and driving behaviour (Delhomme et al 2009)

1.3. Need for star rating
There were some of the researches which focussed on reducing accidents and finding out the major reasons behind those accidents and to mitigate them. But not lot research has been done on linking the economy of a country to the road safety.

The iRAP Star Score is an unprejudiced indicator of occurrence and seriousness of an accident occurring on road. The prime focus of this study is on recognizing and documenting the characteristics of roads which, based on empirical evidence-based studies, affect the most common and serious accident types.

In this way, on a specific road section or network, the degree of road user risk can be evaluated without any detailed analysis of accident type data, that is common in low income and high accident rate countries having weak network of data availability. Evidence indicates that 1-star roads are least safe in terms of road accident and fatal injuries with 5-star (green) highways being the safest for daily travel and road usage.

2. Safety rating methodology
In order to ensure road safety, there is a need for accurate measurement of risk level that is actually considered detrimental to the safety of road section. Risk perhaps captures the combined risk arising from the interaction of road users, vehicles and road environment. This chapter aims to provide details of the procedures adopted in road safety rating system. Identifying the conditions of the road features leading to safety issues, design, plan and evaluation of the road section under consideration are explained in this section.

The process of how safe the road stretch/section is can be determined and expressed in various ways. Road safety rating through star rating for existing roads is one of many available methods which is a well-developed process through exhaustive data collection and its analysis. Since the process involves more time, most of the agencies do not follow this method and is limited to several countries. However, the outcome of this method is found beneficial in the countries wherever it is adopted. The sequential star rating process of any road section under consideration for road safety auditing is represented in Fig.1and is also listed below.

1. Data collection 2. Road coding 3. Data preparation 4. Data Analysis 5. Star Rating 6.
Investment planning

![Safety Rating process diagram](image)

**Fig. 1** Safety Rating process diagram

2.1. Data Collection

The data was collected by road survey for 4 accident prone sections of the Mysore road, namely RV College, Mylasandra Gate, Madhu Fuel Station and Kengeri Police Station. The following data was required for the project to give star rating:

- Width of lane, Road curvature, Curve Quality, Shoulder strips, Condition of Road, Skid resistance, Road side object, shoulder width etc.

2.2. Tabulation of data and calculation of star rating

All the above raw data is then tabulated and calculation is carried out. First, the star rating score is calculated. It is calculated for a 500-metre segment of the road using:

\[
\text{Star rating score (SRS)} = \text{product of (Average speed, Flow influence, severity, Median traversability, likelihood)}
\]

Where:

- Likelihood cite the risk factors which indicate the chances for initiation of a crash
- Severity cite the risk factors that indicate the crash severity
- Operating speed cite the risk factors that relate speed and the risks associated with it
- External flow influence relates the influence of one person on another while using the road, and the risks of crash involved.
- Median traversability indicates the chances of a person to cross the median.

Star rating scores are calculated using following equation:

\[
x - \text{Factors multiplied (to the right)} + \text{Factors added (to the right)}
\]

Factors are shown in Fig. 2. Star ratings are determined after calculation the SRS. They are calculated by matching the SRS to the range of star rating as shown:

| Star Rating | Star Rating Score |
|-------------|-------------------|
| 5           | 0 to < 2.5        |
| 4           | 2.5 to < 5        |
| 3           | 5 to < 12.5       |
| 2           | 2.5 to < 22.5     |
| 1           | 22.5 +            |

Where, 5 being the safest road and 1 being the most unsafe road.
Fig 2: Calculation of Star Rating
3. Road safety rating
This chapter presents the details of the physical features of various road stretches under study. The existing physical conditions of each road stretch are compared with the standard features of road geometrics to check the deviations that lead to road safety risk. This information is later used for the road safety rating. The study stretch is a part of National Highway 275, commonly referred to as NH 275, that connects Bantwal town with Bangalore through Mysore and Madikeri in Karnataka state, India. It is one of the important highways in Karnataka and India.

Table 2: Analysis of traffic data collected at RV College (12.9237° N, 77.4987° E)

| Risk factors                          | Category      | Risk factor | Score |
|---------------------------------------|---------------|-------------|-------|
| Road Attributes in likelihood         |               |             |       |
| Width of Lane                         | Wide          |             | 1.0   |
| Road Curvature                        | -             |             | -     |
| Curve Quality                         | Poor          |             | 1.25  |
| Delineation                           | Poor          |             | 1.2   |
| Shoulder strips                        | Not Present   |             | 1.25  |
| Condition of Road                     | Poor          |             | 1.4   |
| Skid Resistance                       | Unsealed Adequate|           | 3.0   |
| Product of the Risk factors            |               |             | 7.87  |

| Road Attribute in terms of severity   |               |             |       |
|---------------------------------------|---------------|-------------|-------|
| Road side Severity Distance         | 1-5 m         |             | 0.8   |
| Road side Severity Object           | Tree          |             | 60    |
| Width of paved shoulder              | 1.2 m         |             | 0.83  |
| Product of Road (severity) risk Factors|       |             |       |
| flow influence (External)            | 1500          |             | 0.50  |
| Traversibility of Median             | No            |             | 0     |
| Average Speed                        | 37.4          |             | 0.33  |

Runoff speed star rating score (passenger side)

| Road Attributes in terms of likelihood |               |             |       |
|---------------------------------------|---------------|-------------|-------|
| Width of Lane                         | Wide          |             | 1     |
| Road Curvature                        | -             |             | -     |
| Curve Quality                         | Poor          |             | 1.25  |
| Delineation                           | Poor          |             | 1.20  |
| Shoulder strips                        | Not present   |             | 1.25  |
| Condition of Road                     | Poor          |             | 1.4   |
| Type of Risk factors       | Category          | Risk factor | Score |
|---------------------------|-------------------|-------------|-------|
| Width of Lane             | Wide              | 1.0         |       |
| Road Curvature            | -                 | -           |       |
| Curve Quality             | Poor              | 1.25        |       |
| Delineation               | Poor              | 1.2         |       |
| Shoulder strips           | Not Present       | 1.25        |       |
| Condition of Road         | Poor              | 1.4         |       |
| Skid Resistance           | Unsealed Adequate | 3.0         |       |
| Product of the Risk factors in terms of likelihood |                    | 3.0         | 7.56  |

| Type of Median            | Physical median 1-1.5m | Score |
|---------------------------|------------------------|-------|
|                           | 80                     |       |
| Product of the Risk factors in terms of likelihood |                    | 80    |
| Flow influence (External) | 15000                  | 0.185 |
| Traversability of Median  | No                     | 0     |
| Average Speed             | 37.4                   | 0.33  |
| Head on Crash Star Rating Score |                    | 0     |

| Type of Risk factors       | Category          | Risk factor | Score |
|---------------------------|-------------------|-------------|-------|
| Skid resistance           | Unsealed Adequate | 3.0         |       |
| Varying Speed             | Not Present       | 1.2         |       |
| Risk factors                                      | Flow influence (External) | 15000 | 0  |
|--------------------------------------------------|---------------------------|-------|----|
| Average speed                                    | 37.4                      | 0.33  |    |
| Head on Crash (Overtaking) Star Rating Score     |                           |       | 0  |

| Intersection                                      |                           |       |    |
|---------------------------------------------------|---------------------------|-------|----|
| Type of Intersection                              | 4-leg signalized           | 15    |    |
| Quality of Intersection                           | adequate                  | 1     |    |
| Street Lighting                                   | Present                   | 1     |    |
| Skid Resistance                                   | Unsealed adequate          | 3.0   |    |
| Sight distance for road users                     | Adequate                  | 1     |    |
| Intersection characterization                     | Not present               | 1.2   |    |
| Speed Management                                  | Not Present               |       |    |
| Product of Risk Factors in terms of Likelihood    |                           | 54    |    |

| Road Attribute in terms of severity               |                           |       |    |
|---------------------------------------------------|---------------------------|-------|----|
| Risk factor                                      | Category                  |       |    |
| Type of Intersection                              | 4-leg signalized           | 15    |    |
| Product of Risk Factors in terms of Likelihood    |                           | 15    |    |
| Flow influence (External)                         | 1000-5000 vehicle         | 0.125 |    |
| Average speed                                     | 37.4                      | 0.33  |    |
| SRS (Intersection)                                |                           | 33.41 |    |

| Access to property                                |                           |       |    |
|---------------------------------------------------|---------------------------|-------|----|
| Property access point                             | Commercial access         | 2     |    |
| Service road for property access                  | Not present               | 1.5   |    |
| Product of Risk Factor in terms of Likelihood     |                           | 3     |    |

| Road Attribute in terms of severity               |                           |       |    |
|---------------------------------------------------|---------------------------|-------|----|
| Property access point                             | Commercial                | 50    |    |
### Product of Risk Factor in terms of Likelihood

| Flow Influence (External) | Default | 0.01 |
|---------------------------|---------|------|
| Average Speed             | 37.4    | 0.33 |
| Star Rating Score (Intersection) | | 0.495 |

### SRS and Vehicle occupant star rating

| Type of Crash                        | SRS | Star rating |
|--------------------------------------|-----|-------------|
| Driver side Road Runoff              | 0   |             |
| Passenger side Road Runoff           | 6.57|             |
| Head on crash due to lost control    | 0   |             |
| Head on Crash due to overtaking      | 0   |             |
| Intersection Score                   | 33.41|             |
| Access to property                   | 0.495|             |
| Total score and Star rating          | 40.475| 1          |

4. Conclusions

After completing the data analysis at all the four locations, namely RV College, Mylasandra Gate, Madhu Fuel Station and Kengeri Police Station, the star rating was found to be 1. This shows that the road network in Bangalore is least safe for daily commute. Some points were common and can be considered as common factors responsible for the bad Star Rating Score. The common factors found were the following:

1. Absence of proper Traffic Management System at the junctions.
2. Lack of maintenance of the junctions in terms of Road attributes.
3. Traffic diversion was not available at all the junctions.
4. A facility for pedestrian traffic was absent.
5. Speed controlling measures are not taken at the junctions.

All these factors show the general trends of Indian Roads in terms of safety. Most of the Indian roads fall under the category of least safe roads and require a lot of considerations and improvements towards Road Safety.
Fig 5: Tree in midst of the road features

Fig 6: Damaged Traffic lights

References
[1] T Fukuda, T Ishizaka and A Fukuda 2015 Empirical study on identifying potential black spots through public participation approach: a case study of bangkok J East Asia Soc. Transp. Stud vol. 6 no. January pp. 3683–3696 doi: 10.11175/easts.6.3683.
[2] J Aguero-Valverde and P P Jovanis 2006 Spatial analysis of fatal and injury crashes in Pennsylvania Accid. Anal. Prev. vol. 38 no. 3 pp. 618–625 doi: 10.1016/j.aap.2005.12.006.
[3] V Shankar and F Mannerling 1996 An exploratory multinomial logit analysis of single-vehicle motorcycle accident severity J. Safety Res. vol. 27 no. 3 pp. 183–194 doi: 10.1016/0022-4375(96)00010-2.
[4] V R Rengaraju and M Satyakumar 1994 Structuring category analysis using statistical technique J. Transp. Eng. vol. 120 no. 6 pp. 930–939 doi: 10.1061/(ASCE)0733-947X(1994)120:6(930).
[5] D Mohan and P S Bawa 1985 An analysis of road traffic fatalities in Delhi, India Accid. Anal. Prev. vol. 17 no. 1 pp. 33–45 doi: 10.1016/0001-4575(85)90006-5.
[6] H C Chin and M A Quddus 2003 Applying the random effect negative binomial model to examine traffic accident occurrence at signalized intersections Accid. Anal. Prev. vol. 35 no. 2 pp. 253–259 doi: 10.1016/S0001-4575(02)00003-9.
[7] Hashem R Al-Masaaid and Kumare C Sinha 1995 Analysis of accident reduction potentials of pavement markings J. Transp. Eng. vol. 120 no. 5 pp. 723–736.
[8] P P VALLI 2005 Road accident models for large metropolitan cities of India IATSS Res. vol. 29 no. 1 pp. 57–65 doi: 10.1016/s0386-1112(14)60119-9.
[9] A Mekky 1985 Effects of rapid increase in motorization levels on road fatality rates in some rich developing countries Accid. Anal. Prev. vol. 17 no. 2 pp. 101–109 doi: 10.1016/0001-4575(85)90013-2.
[10] J B Edwards 1998 The relationship between road accident severity and recorded weather J. Safety Res. vol. 29 no. 4 pp. 249–262 doi: 10.1016/S0002-4375(98)00051-6