Roadway Safety Assessment and Star Rating using iRAP along SH-11A (Jind-Kaithal) in Haryana.

Sunil 1, Abhishek Sharma 2

1 Master of Engineering (Transportation), Department of Civil Engineering, Chandigarh University, Punjab, India.

2 Assistant Professor, Department of Civil Engineering, Chandigarh University, Punjab, India.

Abstract: Figures cross 3,500 deaths and casualties on roads all around world every day in low- and middle-income countries and contribute about 90% of the 1.25 million road deaths. This number of road deaths is projected to increase by 50 percent by 2020. The compound problem for developing countries is caused by the rapid development of roads, irrespective of design or security, lack of attention to vulnerable road users and lack of a culture of road safety (i.e., safe behaviour, vehicle safety regulations, road safety policy, road safety assessment, and enforcement). This paper deals with the star rating and road safety assessment of State Highway -11A, Jind-Kaithal, Haryana though the section is straight but numerous causalities were reported on the route in recent years. ViDA, an online road safety assessment and star rating analysis tool is used to get the Star Rating Scores and Safer Roads Investment Plans.

1. Introduction

The iRAP is an organisation committed to the worldwide enhancement of road safety. To achieve this aim, the evaluation and improvement of road safety requirements are the important factors. They have been able to perform multiple road safety checks, evaluation reports, produce star ratings and risk maps in over 70 countries, thus allowing countries to obtain a star rating of at least 3 or higher. A ‘safe system’ based on complementary route, vehicle and behavioural actions is a priority of iRAP Compliance with seat belt rules, speed limits, prohibition of drunk driving, active and passive driver, and car safety as well as self-explanatory and pardoning road systems all work with this secure scheme [1–3].

iRAP measured safety for the sample road parts in the ten States of India in partnership with the Global Road Safety Facility of the World Bank (GRSF), State Public Works Agencies, local engineering companies and research institutes. From 2010-2014 it was examined road parts for Uttar Pradesh, Telangana, Rajasthan, Kerala, Tamil Nadu, Haryana and Andhra Pradesh.

The original results found that most of the roads had safety scores or say star rating of 1 or 2 stars, with about 76,000 deaths and injury annually. After the star rating results, the Safer Roads Investment Plan provide a workable alternative with a suitable economic case. The losses associated with collisions can be saved by saving about USD 52.3 million (INR3.3 million).

The first stage of the iRAP process involved inspecting the road network and conducting road traffic surveys [4–6]. In 10 states with 10,446 km, comprehensive and detailed surveys of attributes were performed. Road features include road cross-sections and signage, crossing style and form, pavements, extreme roadside threats, and the availability of walkways for disabled road users, etc. 20 (iRAP 2015).
In this Haryana pilot study, the equipment used in other countries was identical to the previous iRAP safety evaluation reports. A manual survey has been performed on the road network using the camera with GPS feature which was installed to record videos in real time, and coordinates. Using the on-line coding interface of iRAP, as data is obtained in the under-consideration road network, it is used to analyse, encrypt, and process the data to produce plans and investments accordingly [7,8], see figure 1.

2. Practical Applications.

Raising the standard of the world's roads to three stars or higher for all road users helps to focus policy and investment. With crash costs typically halving with each incremental improvement in star rating, 3-star or better roads have a significant potential to save lives.

Many countries and project managers are now setting goals to increase the percentage of travel on three-star or better roads, as well as to establish three-, four-, or five-star standards for new and upgraded roads. The star rating is a powerful metric for specifying and tracking road safety performance at the network and project levels, much like road authorities set targets for pavement roughness or other asset performance.

iRAP's methodology is being used on road infrastructure projects as a complementary measure with the road safety audit and widely accepted in India and other countries. Recent news cleared that Brazil adopted the 3 star or better roads policy throughout the country and following practice is on the verge of acceptance in other countries so that economic investment can be effectively utilized so that no low stars roads are built [9–11].

3. Data Collection

Imagery and Video data was collected along the route for a section of 1 km consisting of the reported blackspots and road attributes. The road survey data and video helped to code the attributes manually into the online software. Speed data have also been obtained from previous survey data for 15-minute periods on the same path to track drivers' travel/velocity behaviour. No pace or forward warning signs were identified in the area. There are no stop-and-slow vehicles available to stop or enter the section and junction [12–14], see figure 2.
4. Data Input and Processing

Videos were processed after data collection on the entire project path and road centre lines were produced and using iRAP's coding interface attributes were coded, from the start of the project region Titram Mod (29.7181671; 76.4065887) to the end of Kaithal-Tohana Flyover (29.7209304; 76.40509099), which was eventually segmented into 11 roads to balance current video segments. The entire length of each stretch has its own video feed. This provides the coder with more versatility when concurrently coding road attributes for multiple road segments. Using the Star rating Demonstrator (Star Coding Process) and attributes for each 100 m section for roadside, mid-block, intersecting flux, VRU facilities and land use including speed data [15–17]. The above figure shows how attributes can be coded into the ViDA toolkit online to generate the star rating for various sections of the road. The star rating demonstrator shows the chart responsible for the particular star rating, see figure 3.

![Star Rating Demonstrator](image-url)

Figure 3: iRAP’S Interface to code attribute (Star Rating Demonstrator)
5. Coding File (ViDA Attributes) uploaded as .csv in ViDA tool.

Road Coding irap see table 1 and 2

| Table 1: Road Coding as per iRAP’s Coding Manual—Driving on the left Edition. |
|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

6. Quality Assurance (QA)

Check of errors or error data in every part of the path is carried out following the road coding method of Quality assurance. The QA search in conjunction with iRAP has resulted in a range of code errors that had to be corrected to carry out the study to receive star ratings to validate the results [18–20].

7. Results and Observations

For car drivers, motorcycles, pedestrians, and bicyclists a Star Ranking Score (SRS) was determined for each 100 m highway section. These ratings are then assigned for each 100-meter path to the Star Ranking bands. But 100 meters is too detailed to create a network level map with Star Ratings. Therefore, star scores are smoothened to (or averaged) longer ranges such that meaningful outcomes can be obtained.

7.1 Star Rating is calculated for 4 user groups.

1. Vehicle Occupants
2. Motorcyclist
3. Pedestrians
4. Bicyclist

Table 3: Star rating Scores

| Star Rating | Star Rating Score | Vehicle occupants and motorcyclists | Bicyclists | Pedestrians | Along roadside | Crossing |
|-------------|-------------------|-----------------------------------|------------|-------------|----------------|----------|
| 5           | 0 to < 2.5        | 0 to < 5                          | 0 to < 5   | 0 to < 0.2  | 0 to < 4.8     |          |
| 4           | 2.5 to < 5        | 5 to < 10                         | 5 to < 15  | 0.2 to < 1  | 4.8 to < 14    |          |
| 3           | 5 to < 12.5       | 10 to < 30                        | 15 to < 40 | 1 to < 7.5  | 14 to < 32.5   |          |
| 2           | 12.5 to < 22.5    | 30 to < 60                        | 40 to < 90 | 7.5 to < 15 | 32.5 to < 75   |          |
| 1           | 22.5 +            | 60+                               | 90+        | 15 +        | 75 +           |          |

The value for the star rating score band vary for each user type depending on the SRS equation, see table 3.

A Star Rating Score (SRS) is calculated for each 100 metre segment of road and each of the four road users, using the following equation:

\[
\text{SRS} = \sum \text{Crash Type Scores}
\]

- the SRS represents the relative risk of death and serious injury for an individual road user; and
- Crash Type Scores = Likelihood x Severity x Operating speed x External flow influence x Median traversability
STAR RATING TABLE (RAW) – BEFORE

Table 4: Star rating before

| Star Ratings | Vehicle Occupant | Motorcyclist | Pedestrian | Bicyclist |
|--------------|------------------|--------------|------------|-----------|
|              | Length (km)      | Percent      | Length (km)| Percent   |
| 5 Star       | 0.00             | 0.00%        | 0.00       | 0.00%     |
| 4 Star       | 0.00             | 0.00%        | 0.00       | 0.00%     |
| 3 Star       | 0.00             | 0.00%        | 0.00       | 0.00%     |
| 2 Star       | 0.00             | 0.00%        | 0.00       | 0.00%     |
| 1 Star       | 0.00             | 0.00%        | 0.00       | 0.00%     |
| Not applicable | 0.00            | 0.00%        | 0.00       | 0.00%     |
| Total        | 1.10             | 100.00%      | 1.10       | 100.00%   |

Table 4 and 5 shows clearly, that only 54.3% of the roads for vehicle occupants, 36.36% for motorcyclists, is rated 3 star or above, rest is below 3 Star.

STAR RATING TABLE (RAW) – AFTER

Table 5: Star rating after

| Star Ratings | Vehicle Occupant | Motorcyclist | Pedestrian | Bicyclist |
|--------------|------------------|--------------|------------|-----------|
|              | Length (km)      | Percent      | Length (km)| Percent   |
| 5 Star       | 0.10             | 9.09%        | 0.00       | 0.00%     |
| 4 Star       | 0.30             | 45.45%       | 0.00       | 0.00%     |
| 3 Star       | 0.10             | 9.09%        | 0.40       | 36.36%    |
| 2 Star       | 0.40             | 36.36%       | 0.20       | 27.27%    |
| 1 Star       | 0.30             | 9.09%        | 0.20       | 18.18%    |
| Not applicable | 0.00           | 0.00%        | 0.20       | 0.00%     |
| Total        | 1.10             | 100.00%      | 1.10       | 100.00%   |

This table clearly shows that that around 65% of the road for vehicle occupants is rated 3-star or above and for motorcyclists and pedestrians this is about 40%. About 64% of the roads for motorcyclist is rated safe after the implementation of the countermeasures.

There is a significant increase in the safety characteristics of the roads in comparison to the existing situation.

Star rating analysis (raw) – before
Figure 4: Star Rating Analysis before

Figure 5: Star Rating Analysis after
STAR RATINGS, SMOOTHED – BEFORE

Table 6: Star Rating S,ppthed After

| Star Ratings | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent |
|---------------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|
| 5 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 4 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 3 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 2 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 1 Star        | 1.10        | 100.00% | 0.00        | 0.00%   | 1.10        | 100.00% | 1.10        | 100.00% |
| Not applicable| 0.00        | 0.00%   | 0.20        | 10.00%  | 0.00        | 0.00%   | 0.00        | 0.00%   |
| Totals        | 1.10        | 100.00% | 1.10        | 100.00% | 1.10        | 100.00% | 1.10        | 100.00% |

STAR RATINGS, SMOOTHED – AFTER

Table 7: Star Rating S,ppthed After

| Star Ratings | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent | Length (km) | Percent |
|---------------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|
| 5 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 4 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 3 Star        | 1.10        | 100.00% | 0.00        | 0.00%   | 1.10        | 100.00% | 1.10        | 100.00% |
| 2 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| 1 Star        | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   | 0.00        | 0.00%   |
| Not applicable| 0.00        | 0.00%   | 0.20        | 10.00%  | 0.00        | 0.00%   | 0.00        | 0.00%   |
| Totals        | 1.10        | 100.00% | 1.10        | 100.00% | 1.10        | 100.00% | 1.10        | 100.00% |

Why smoothing is necessary? For each 100 metres of roads, a Star Rating Score (SRS) for each user type. The Star Rating Bands will then allocate the values for each 100 metres of traffic to determine the Star Rating. However, 100 metres is too detailed to produce a road map. So Star Ratings are lengthy (or averaged) to give relevant results. In this way they are lengthy, see figure 4 & 5 and table 6 & 7.
This graphs clearly shows that there is a significant increase in the safety characteristics of the roads in comparison to the existing situation. All 1-star rated roads turned to be 3-star or better for 3 vehicle occupants, motorcyclist and bicyclists, see figure 6 and 7.
SAFER ROADS INVESTMENT PLAN (COUNTER MEASURES AND COSTS)

Safer road investment plan see table 8 and 9.

Table 8: Safer Roads Investment Plan

| Countermeasure | Length (km) | FIs saved | FIs of Safety Benefits | Estimated Cost | Cost per FI saved | Program BCR |
|----------------|-------------|-----------|------------------------|----------------|------------------|-------------|

Strip (systematic transfer investment plan) Table

State Highway 11-a Jind- Kaithal , Haryana

Table 9 : State Highway jind-kaithal Analysis
8. Discussion

From the graphs and the star ratings tables it is clear that the analysed road section is 100% 1–star for vehicle occupants, pedestrians and bicyclists whereas it is about 82% unsafe or 1-star rated for pedestrians due to the land use pattern. After the implementation of the Safer Roads Investment Plans and countermeasures implementation the unsafe roads/ 1 star roads becomes rated 3-star for the 3 road user types and 2 star for the pedestrians with and investment of about Rs.24,223,977 giving the Benefit Cost Ratio as 58. The total FSI (Fatal and Serious Injuries) saved will be 1,351 in the analysis period of 20 years with the potential value of Rs. 1,393,250,998.3 signalised crossing at 3-legged intersections are suggested and 1 is suggested at 4-legged intersection, other countermeasures includes the widening the centerline and improving delineation, traffic calming, shoulder rumble strips etc.

9. Conclusion

iRAP Road Safety Evaluation for Haryana Section helped to understand the safety condition as regards quality of roadside infrastructure and opened new directions to further solve the safety questions of Highways. In assessing the current state of the road sections and in offering suggestions about change based on star ratings, the star rating process proved to be successful. The targets have been accomplished successfully. The training module led to a very strong understanding of every iRAP attribute and how they are coded, which substantially enhances the coding skills of the team. And it established appropriate confidence values indicating that the coders are familiar with the iRAP method to achieve potential star scores in the paths.

10. Limitations and Future Scope.

While this approach is internationally known and used, only a few validation studies have been carried out proving how Star Ratings are related to crashes. In addition, the previous studies rely only on the data reported from the police for crash rates or crash costs per kilometre. Attempted negative binomial regression analysis (i.e. crash prediction, but concluded (without providing further details) that modelling effort did not provide any meaningful relationships between crash frequency and star rating levels”. In addition, previous studies have relied on crash rates, whose methodological insufficiency has been known for several decades. An illustrative comparison confirmed that using crash rates can lead to mixed results. In contrast the empirical Bayes approach led to results, which clearly confirm the relationship between increasing Star Ratings and decreasing crash frequencies. However, it should be noted that Star Rating as an explanatory variable in the crash prediction model turned out to have a minor influence and an unexpectedly positive relationship with crash frequency.

Future Scope for the quick coding tools and using the Artificial Intelligence to code the roadside attributes and generation of the coding file for the ViDA analysis.

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