Abstract

Road accidents have increased and reached to an alarming point in past few years in most of the developing countries including India. The continued steep increase in the number of road accidents indicates that these losses are undoubtedly inhibiting the economic and social development of the countries and adding to the poverty and hardships of the poor. Thus, there is an urgent need to take preventive measures to reduce accidents and to develop road safety improvement program. This study proposes a basic frame work for formulation of road safety improvement program. The framework consist of four major stages i.e Stage I ranking of safety hazardous location, stage II evaluation of safety hazardous condition at different Section in road network, Stage III prioritization of remedial safety measures and Stage IV selection of safety measures (formulation of road safety improvement program). This study also presents the basic concepts to develop a methodology for formulation of road safety improvement program. Thus, this study will be useful for researcher and policy makers to develop a methodology for formulation of road safety improvement program to select remedial safety measures to improve safety on hazardous location in the road network.
1. **INTRODUCTION**

According to the World Health Organization (WHO, 2014), road traffic injuries are a leading cause of death, killing nearly 1.3 million people annually. By 2030, this figure is predicted to rise and become the fifth leading cause of death in the world. Road accidents have increased and reached to an alarming point in past few years in developing countries like India. Eighty-eight countries have reduced the number of deaths on their roads – but the total number of road traffic deaths remains unacceptably high at 1.24 million per year. However, less than 35% of low- and middle-income countries have policies in place to protect these road users. Every year around 1.24 million people lost their life every year on the world’s roads, and another 20 to 50 million people injured as a result of road traffic crashes (WHO, 2014). The number of road accidents, road accident fatalities and persons injured in road accidents in India during 2002 and 2012 is shown in Table 1. (MORT&H, 2013).

**Table 1: Number of Road Accidents and Number of Persons Killed: 2002-2012**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Accidents</th>
<th>Number of Persons Killed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Fatal</td>
</tr>
<tr>
<td>2002</td>
<td>4,07,497</td>
<td>73,650</td>
</tr>
<tr>
<td>2004</td>
<td>4,29,910</td>
<td>79,357</td>
</tr>
<tr>
<td>2006</td>
<td>4,60,920</td>
<td>93,917</td>
</tr>
<tr>
<td>2008</td>
<td>4,84,704</td>
<td>93,917</td>
</tr>
<tr>
<td>2010</td>
<td>4,99,628</td>
<td>1,19,558</td>
</tr>
<tr>
<td>2012</td>
<td>4,90,383</td>
<td>1,23,093</td>
</tr>
</tbody>
</table>

It is required to improve the road safety condition by reducing the number of accident on hazardous locations. A road safety improvement program (RSIP) is identification of a set of remedial safety measures, to be implemented on identifies sections in the road network to reduce the injuries, fatalities, deaths and loss of public properties because of road accidents on the basis resources available. It is required that various corporate houses can collaborate this road safety improvement program under public private partnership to improve road safety in India. The selection of safety remedial measures should be made considering the effectiveness of each remedial measure considered in reducing the rate for the similar type of accident being considered and safety hazardous condition of that location in a road network (Mehar, 2013). Thus, there is an urgent need to develop a methodology to formulate road safety improvement program. However, literature does not suggest any comprehensive and simple methodology to select remedial safety measures to improve hazardous condition of different section in the road network. A critical review of the literature (Agarwal, 2015, Andrew, 2004, Meeghat, 2011 and Mohammed, 2012) indicated that most of the methodologies for improving road safety require accident data.

The preparation of such comprehensive accident data is, however, expensive and time consuming; specially, when the data is prepared for a road network. Hence, hardly any
meaning full analysis is done to find out the accident hazardous location, vulnerable road users, road users involved in accidents, causes of accident etc. which are so essential to select remedial measures to improve safety of road network. Thus, there is an urgent need to develop a methodology to improve safety of road network. Further it is required that such methodology can evaluate safety hazardous condition at different section in road network in a simple manner and also able to rank these safety hazardous locations considering the safety hazardousness at that location. It is also required that the methodology should select the remedial safety measure on the basis of its effectiveness in improving safety hazardous condition of the sections in the road network.

Looking to the importance of the issue, Hon'ble Supreme Court of India has constituted a Committee on Road Safety vide their Order dated 22-04-2014 in W.P.No. 295 of 2012. The Committee has been interacting with different Ministries of Government of India and State Governments. Four Working Groups were set up by the Government of India to submit recommendations and suggestions on short term and long term measures to curb road accidents in the country. These four Working Groups were required to go into four ‘Es’ of road safety, namely, Engineering, Enforcement, Education and Emergency Care. Hence the Engineering is first and most important aspect of Road Safety. Thus, this study presents a basic framework for formulation of Road Safety Improvement Program in India, particularly the Engineering aspect of Road Safety. The study proposes a framework to rank safety hazardous locations, evaluation of safety hazardous condition and framework for prioritization of remedial safety measures.

This paper consists of three sections. The first section presents the introduction of the study and critical review of relevant literature and identifies the important deficiencies in present state of the art for formulation of a framework for road safety improvement program. Third second section presents the basic framework and sub stages of the proposed framework for formulation of road safety improvement program in India. The last section presents the important conclusions made from this study.

2. BASIC FRAMEWORK FOR FORMULATION OF ROAD SAFETY IMPROVEMENT PROGRAM

A basic framework for formulation of road safety improvement program is developed and presented in Figure 1. Based on this framework, the major stages identified are i.e. Stage I- Ranking of safety hazardous locations, Stage II- Evaluation of Safety Hazardous Condition at different Section in road network, stage III prioritization of remedial safety measures and stage IV formulation of road safety improvement program.

Some basic concepts and details of various sub stages for each of the stages of basic framework for formulation of road safety improvement program is presented in the following sections:
2.1 Stage-I Ranking of Safety Hazardous Locations

The first stage in the framework for development of road safety improvement program is the ranking of safety hazardous location. The main purpose of this stage is to rank the safety hazardous location because it is generally not possible to implement all remedial measures identified due to limited budget available for road safety improvement. Hence, it is required to rank the hazardous locations so that depending on the available budget, the hazardous locations can be treated. Further, it is proposed to develop two methodology for ranking of safety hazardous location i.e. stage I(ARA) when accident record is available (ARA) and stage II(ARN) when accident record is not available. Details are as follows.
2.1.1 Stage I (ARA): Ranking of Safety Hazardous Locations (Accident record available)

This stage presents the framework of ranking of safety hazardous location when accident record is available. Details of sub stages is presented in Figure.2

![Figure 2: Details of Sub stages of stage I (ARA) (Ranking of Safety Hazardous Locations)]

2.1.2 Stage I (ARN): Ranking of Safety Hazardous Locations (Accident record is not available)

The stage I (ARN) present the sub stages framework of ranking of safety hazardous location if accident record is not available. The safety hazardous locations can be a specific location or a spot (one or more distinctive, adverse geometric feature such as horizontal or vertical curve, bridge, underpass, intersection) or a road section (i.e. an identified length of road possessing uniform geometric, traffic and culture, and homogeneous as to cross section, surface type, access control, and urban rural characteristics). Therefore, a comprehensive methodology is developed which can rank various hazardous location considering safety hazardous conditions at that locations. Details of sub stages is presents in Figure.3

![Figure 3: Details Sub Stage of Stage I (ARN) (Ranking of Safety Hazardous Locations)]
2.2 Stage II: Evaluation of Safety Hazardous Condition at Different Section in Road Network

The second stage of basic frame work for formulation of road safety improvement program is evaluation of safety hazardous condition at different section in road network. The purpose of this stage is to identify the basic factors which affect the safety on road network. Further, the methodology is developed to evaluate the safety hazardous condition at different section in road network. Factors affecting safety like carriageway surface, shoulder, side slope, obstacle, drainage road width, sight distance, median, lighting, traffic sign, road marking and over speed. Further, various indices to evaluate the condition of these factors at different section are also developed. The rationale behind formulation of indices is that the distress condition of the safety hazardous factor is divided by the total condition of that particular factor on the particular section. These indices are developed in such a way that safety hazardous condition of different section of the road network can be compare. Details of sub stages is presents in Figure.4

![Figure 4: Details Sub Stage of Stage II (Evaluation of Safety Hazardous Condition)](image)

2.3 Stage III: Prioritization of Remedial Safety Measures

After the evaluation of safety hazardous locations, the next stage for is the prioritization of remedial safety measures to be implemented on the different safety hazardous locations. The objective of this stage is to identify appropriate and effective remedial measure to alleviate the identified safety deficiencies on identified safety hazardous locations in the road network. Safety remedial measures should be prioritize considering that how much it is more important to improve safety at different sections in the road network. The Figure.5 presents the sub stages of prioritization of remedial safety measure.
2.4 Stage IV Formulation of Road Safety Improvement Program

The last stage of the framework for is the formulation of road safety improvement program. The purpose of this stage is to evaluate the effectiveness of the selected remedial safety measure on the identified hazardous location considering the effectiveness of road safety improvement program and availability of resource. It is required to develop performance measures to evaluate the effectiveness of road safety improvement program. Performance measures should be able to identify the effectiveness of utilizing resources. Performance measures must be sensitive enough to assess change in safety performance after road safety improvement program implemented. Agency should also be capable of collecting or accessing timely and accurate data relevant to the performance measures. Figure 6 presents the sub stages of stage IV i.e. formulation of road safety improvement program.

<table>
<thead>
<tr>
<th>Sub Stage IV - A</th>
<th>Selection of remedial safety measure on the basis of priority index and availability of resources (Formulation of RSIP)</th>
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</table>

<table>
<thead>
<tr>
<th>Sub Stage IV - B</th>
<th>Determination of Effectiveness of Road Safety Improvement Program</th>
</tr>
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</table>

Figure 6: Details of Sub Stages of Stage IV (Formulation of Road Safety Improvement Program)

The outcome of these stages presents the basic framework for formulation of Road Safety Improvement Program. Analysis and result using the proposed framework is presented elsewhere (Agarwal, 2015; Agarwal, 2015). Further, various corporate houses can collaborate this road safety improvement program under public private partnership to improve road safety in India. This framework will be useful for improving safety on Indian roads.
4. CONCLUSIONS

Study presents basic frame work for formulation of a road safety improvement program in India. The following conclusions may be drawn based on the present study:

- There is an urgent need to develop a methodology to formulate road safety improvement program. Further it is required that such methodology can evaluate safety hazardous condition at different section in road network in a simple manner and also able to rank these safety hazardous locations considering the safety hazardousness at that location. It is also required that the methodology should select the remedial safety measure on the basis of its effectiveness in improving safety hazardous condition of the sections in the road network. However, literature does not suggest any comprehensive and simple methodology to select remedial safety measures to improve hazardous condition of different section in the road network.

- This study proposes a basic frame work for formulation of Road Safety Improvement program. The framework consist of four major stages i.e Stage I ranking of safety hazardous location, stage II evaluation of safety hazardous condition at different Section in road network, Stage III prioritization of remedial safety measures, Stage-IV formulation of road safety improvement program . This study also presents the details of sub stages of various stages identified and some basic concepts so that road safety improvement program can be formulated.

It is expected that this basic framework will be useful for the formulation of Road Safety Improvement Program and thus pave the way for improving safety on Indian roads.

5. REFERENCES


