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"A Fuzzy Decision Framework for Analysis of Accidental Black Spot"

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Abstract

The economic development of any country is directly and strongly related to transportation system and the main aim of transportation systemis to provide safe and efficient movement of fright and human from one place to another place. In transportation system traffic safety is more essential phenomenon and it is affected by numerous factors such as Structural defect and road condition. Prediction of road accidents plays very important role in human life and road safety. A Road accident causes a major problemon health and wealth of human being.Road safety is not measure by single parameter it involves an opinions of various decision makers involved in the decision processes.Multicriteria Decision Making (MCDM) in the decision process improves the quality of the decision especially for those which problems contain multiple criteria.

This paper consists of systematic procedure based on fuzzy set theory to evaluate accidental black spot severity indexand based on that index ranking of particular spot was done. Study aim to minimize road accidents by developing Multi Criteria Decision Making Model (MCDM) which consist of perception of experts' based on linguistic terms for the criteria road conditions and structural defects which are further classified in various parameters (parameters was selected based on IRC), relationship among the decision criteria, and finding out factor which is responsible for occurrence of accidents.

An illustration with evaluation of an accidental black spot exercise is presented to demonstrate the data requirements and the application of the method in selecting the rank of accidental black spots. The proposed model is notintended to supplant the work of decision-making teams in ranking the accidental black spot, but rather to help them make qualityevaluations of the available accidental data. One major advantage of the proposed method is that it makes the selection processmore systematic and realistic as the use of fuzzy set theory allows the DMs to express their views on accidental black spot on based on decision criteria in linguistic terms (Very Significant, Significant, and Average, lesssignificant, less significant) rather than as crisp values.

So the use of multi criteria decision making is most fitted method for determination of accidental black spot severity index. Occurrence of number of accidents may be reducing with prediction of right model.The purpose of this paper is to develop Accidental Black Spot Severity Index Model (ABSSIM) by usingFuzzy Multiple Criteria Decision Making (FMCDM).

The Accidental Black Spots can be, further, ranked through Accidental Black Spot Severity Index Model (ABSSIM) on the basis of their severity.

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I. INTRODUCTION

During last few decades it has been observed that there has been a steady increase in volume of traffic which may result in increase in number of accidents on road due to exponential growth in the economy and consumption habits which may leads to unsafe conditions on highways and expressways.Improvement in road surfaces and its routes in the past few years resulting in a reduction of travelling time between destinations due to considerable increase in speed of the vehicles travelling on these roads. Because of increase in speed and reduction of travelling time the number of accidents on these roads is considerable increase result in death and injuries of various peoples travelling of these roads. It has been observed that accidents seem to be concentrated at particular locations and such locations are identified as black spots If we consider the worldwide data near about 1.2 Million persons are killed in road crashes every year and as many as 50 million are injured [4].It has been observed that more than 13 people per hour are dying in road accidents over the roads [22]. According to road safety management the place where road traffic accidents have historically been concentrated is termed as accidental black spots [22].

II. IDENTIFICATION OF BLACK SPOTS

Identification of black spots is considered to be effective method for rectification. Many researcher investigate various methods for finding out accidental black spot some of them listed below :M Mohammed Fayz,et.al [35] Identify the accident prone zones using Accident Severity Index Method and to locate the hotspots using Arc GIS software. MahmoudrezaKeymanes, Hasan Ziari,et.al [30] .Identify potentially hazardous locations by Analytical Hierarchy Process (AHP) using Expert Choice Software and the black spots were identified and prioritized. Vivek and Rakesh Saini [57] emphasis on identification of the major accident black spots on National Highway -3 and improvement in it. Sunny Tawa, SachinDass [55] analyze the traffic safety situations and identify countermeasures so that the total harm caused by the road crashes can be reduced to some extent in future.SamiraRoudini, et.al. [50] Identify black spots with no use of accident information by an overview on the road; all factors that could potentially contribute into accidents along the road were determined. Athirao Mohan, et.al. [7] Identify Accident Black Spots on Amravati - Nagpur National

Highway by Weighted Severity Index Method and some suggestions are made to improve the transportation system. R.R.Sorate, et.al. [46] Found out accidental black spots on Pune Banglore highway from New Katraj Tunnel to ChandaniChowk and suggest remedial measures.B.Srinivasan et.al. [8] Observed that for identification of accident black spots on national highway in Kerala, Weighted Severity Index (WSI) was found to be most suitable. LiyamolIsen,shibuA,Saran M [26] attempts to identify the most vulnerable accident black spots using Geographic Information System. Sunny Tawa, SachinDass [55] presents a methodology for ranking road safety hazardous locations using analytical hierarchy process (AHP). Nirpinder Jain, Dr. Sanjiv Kumar Aggarwal [37] analyzes accidental black spot on NH 7, in the state of Punjab, India for analysis they has been used Accident Severity Index method to identify, analyze and prioritize the black spots.

Insist of finding or analyzing the number of accidents and causalities factor there is need to find out risk factors associatewith accidents. On priority basis there is need to develop an idea to enhance the level of road safety in the country. Due to urbanization and globalization communication and transport of peoples and goods are speeding up due to that transportation system become very complicated and crucial component of environment.

Incorporation of new technologies result in lots of cost, environmental pollution,deteriorating the quality of air and urban stress [4].Which above all negatively affect the environment safety and consider as important factor because it lost the travel time ,damage the property, loss of human life and serious injuries. Of all the systems with which people have to deal with every day transportation and traffic are one of the most dynamic and random phenomenon in the daily life [7]. Nowadays road trafficinjuries and fatalities have been recognizedone of the important parameter related to public health and requires lots of efforts for prevention of road accidents [12].Instead of all the recent developments accidents are occurred and continue to rise day by day. The main aim of this paper is to minimize the road accidents.

So, various researchers were used numerous methods such as, Geographic Information System (GIS), Analytical Hierarchy Process (AHP), Accident Severity Index method, Weighted Severity Index Method,etc.,there is need to identify some reliable and fast engineering techniques for identification and priotorization of accidental black spots. Even Though there is ample amount of road safety plans have been developed which basically focus on education, enforcement of law and emergency care, there is a lack of such balanced engineering measures which improve the road safety in our country.

III. MULTI-CRITERIA DECISION MAKING

Decision making mainly include proper choice or constrains under various conditions of uncertainty. Decision may be of two types it consist of either optimization of output functionunder various constraints oroptimization with multiple criteria by using mathematical programming[13].According to Hiptal decision making problem is difficult and complex if it consist of mulit criteria both quantitative and qualitative in nature, involved no. of experts and also include incomplete information ,imprecise data.

Evaluation of accidents, finding out which factor is responsible for occurrence of accident in practice a complex multicriteria decision making (MCDM) problem in which number of decision makers are involved in finding out Accidental Black Spot Severity Index (ABSSI)under the large number of the decision criteria.

Many researchers and practitioners have proposed different method and procedure for finding out accidental black spot in different location. To name a few of them:
DraganaNenadic, et.al.[3] Used MCDM model to rank dangerous section in road.Rehman et al. [14] investigate smart intelligence transport system by using fuzzy logic model.
FarzanehMirmohammadi, et.al. [6]ProduceMultiple Criteria Decision Making (MCDM) method prioritizationmodel. GholamrezaKhorasani,et.al. [7] Implement MCDM method in road safety and transportation for prioritization and ranking safety indicators in road.FatemehHaghighat, et.al. [5] Used MCDM approach to determine the safety position of the roads. LazimAbdullah,et.al.[11] Developed Fuzzy Approach for Ranking of Motor Vehicles Involved in Road Accidents.
To overcome all these shortcomings, the proposed accident evaluation method employs the fuzzy set theory to deal with theuncertainty and vagueness surrounding the subjective nature of the decision making and multiple attributes decision method to cater to the simultaneous consideration of the multiple decisioncriteria and multiple decision makers. The expected marginal contribution of each of the decision criteria to the overall goal of decision making, that is, to select a contractor who is technically and financially sound enough to deliver the project as specified, is obtained by using the Shapley value formula (Shapley 1953). A hypothetical problem is analyzed to illustrate the data requirements, mechanics, and solution nature of the proposed method. The research reported in this paper forms part of a larger study that aims to design a computer-based fuzzy decision model for contractor selection. The computer model will take into account the incomplete and imprecise information on which the experts' opinions are formed, a more realistic assessment option that uses linguistic variables instead of numerical values to express the experts' opinions, possible difficulty of comparing two alternatives with different level of performance on different decision criteria, and the interaction among decision criteria in order to rank different alternatives on a balanced scale of judgment. The main purpose of this paper is to develop a valid theoretical framework for the future development of a computer-based fuzzy decision model for contractor selection.

IV. TO DEVELOP A METHODOLOGY TO EVALUATE ACCIDENTAL BLACK SPOT SEVERITY INDEX FOR EXPRESSWAYS AND NATIONAL HIGHWAY IN A REGION

According to Hipel et.al.,[27] a decision making problem is said to be complex and difficult, if there exist multiple criteria–both qualitative and quantitative in nature, multiple decision makers, uncertainty, risk and vagueness surrounding the decision-making. Using Fuzzy Multiple Criteria Decision Making (FMCDM) approach this problem can be solved. In this study FMCDM approach will be developed as follows: FMCDM approach will be developed for the determination of ABSSI. By using FMCDM approach we are only able to find out the factor which is responsible for occurrence of accidents on particular spot but it does not give any indication about the severity of that spot i.e. particular spot is very highly sever, sever, medium or low. This approach will be used for the determination of ABSSI of existing accidental black spots. The overview of the fuzzy decision framework, for ranking accidental black spots, which is self-explanatory, is as shown in **Figure 1.**

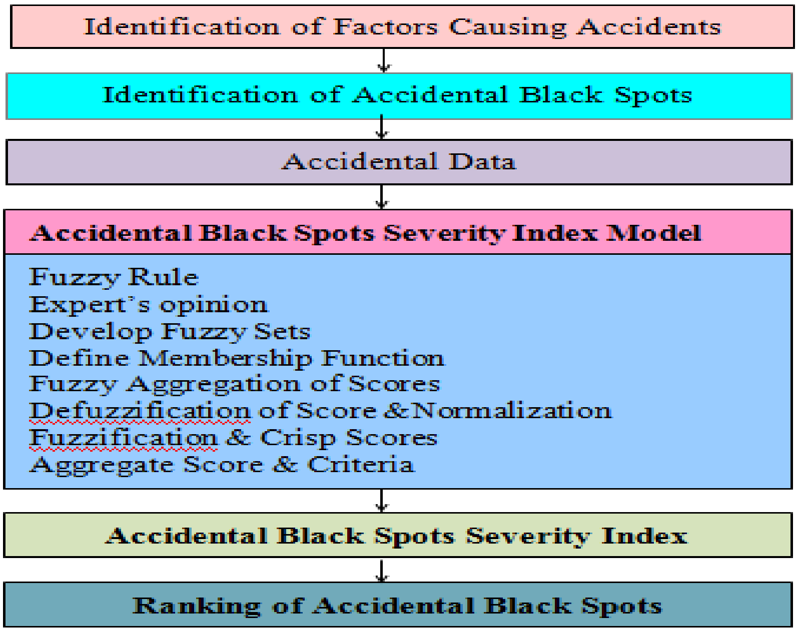

Figure -1 Fuzzy Decision Framework for Accidental Black Spots Index and Ranking.

Fig. 1 shows an overview of the fuzzy decision framework for finding out accidental black spot severity index and ranking them. For details about different types of fuzzynumbers, membership functions, aggregation, and defuzzificationmethods, interested readers are referred to Zimmerman (1985),Klir and Folger (1988), and Kaufmann and Gupta (1991).

V. MULTI-CRITERIA DECISION MAKING AND ANALYSIS OF ACCIDENTS

In the real-world situations decision making such as analysis of accidents is very complex subject by considering uncertainty and vagueness. Analysis of accidents has been largely based on experienceand subjective judgment of decision makers. So that it is quite easier for decision makers to avoid vague terms and express their opinions in terms of more realistic qualitative, linguistic terms, making the use of linguistic approximation more appropriate. To model such complex decision problem Fuzzy set theory can be best suited. In this method, the performance of parameters of each criterion is introduced as a fuzzy number. The assumption is made that the performances of parameter on criteria are fuzzy while the performances of the decision makers are not.
The main aim of the MCDM problemis to assess all possiblevalues of the alternatives on some permissible scale. Generally, first we have to clearly evaluate alternatives with respect to each of the decision criteria to obtain specific priority scores which are then aggregated into overall performance values. Selection of adecision maker's is also a crucial part which may base on their previous experience, judgment, and relevancy to the field.In practice, parameters are usually evaluated from different points of view whichcorrespond to decision criteria. Moreover, in real-life

situations, evaluations, based on past data and decision makers subjective judgment, are neither certain nor precise (Roy 1989).

In the analysis of accidents various parameters such as Structural Defects and Road Conditions plays vital role. MCDM problem involving human subjectivity and uncertainty. As discussed earlier the main aim of the MCDM problem is to assess all possible values of the alternatives, the ranking of alternatives must take into account. Then we have to consider fuzzy score on all criteria, the weight assigned to each decision criterion, possible difficulties arises while comparing two alternatives when one is superior to other on a subset of criteria but worse on at least one criteria from the complementary subset of criteria and the more importantly attitude of decision makers towards the associated risk. Therefore, for proper treatment of decision making the relationship between criteria plays crucial role because this relation reflect the structure of interaction between the criteria and preference given by decision makers to each criteria. Eventually, the importance of each criteria is not exclusively determined by the importance of only that criterion, but also by thevalue of all other criteria considered in the decision making processes.

VI. EVALUATION OF ACCIDENTAL BLACK SPOTS SEVERITY INDEX (ABSSI)

The proposed study emphasis on application of the MCDMmethod that involvesin the analysis of accidental black spot with respect to decisioncriteria, i.e., Structural Defects(c_1), and Road condition (c_2) of the Expressways and National Highways based on the informationsupplied by the five decision makers E_1, E_2, E_3, E_4 and E_5.

The past performance criterion may consist of a number of sub-criteriasuch as:

Table -1 Sub Criteria for Accidental Black Spot Potential.

Characteristics	Sub Criteria
Criteria: Structural Defects	
Road Geometric Design	Horizontal curve on downward slope
	Small subsidiary road meeting highway (Y-Junction)
	Downward slope followed by a horizontal curve
Road Impediments	Passenger pick up shades at junction
	Wayside bus stop without bus bays
Criteria: Road Conditions	
Road Surface Factors	Poor or defective Road Surface
	Cracks or Potholes on Road Surface
	Faded paint marking (center line or road edge marking)
Road Reduced Friction	Deposit on Road (oil, mud etc.)
	Slippery Road due to weather

For the determination of ABSSI, fuzzy MCDM approach was used. For the impotence weightage factors of sub criteria, experts' opinions (linguistic terms) are required to be taken from academicians and professionals, who are involved in the field of Civil and Highway Engineering, for sub criteria of Structural Defects& Road condition. To describe the level of performance on decision criteria, Saaty (1977) [12] has proposed fuzzy numbers for seven linguistic terms. Too few

linguistic1terms provide no more help; while too many linguistic terms may make the system too complex to be practical. The selection of linguistic terms is very important when an expert is familiar with the decision problem context. In general, there is no strong theorem (s) to support the argument that four linguistic terms are better than three or five or seven or nine etc. It can only say that selected linguistic terms are simple enough to be understood by an expert, easy to use by system analysts and yet thorough enough for real-world applications (Chen and Hwang, 1992)
Linguistic terms used are: Very Significant (VS) or Significant (S) or Average (A) or Less Significant (LS) or Not Significant (NS). Table-1 shows the linguistic terms and fuzzy numbers used in this study. Figure 3 shows the graphical representation of fuzzy sets for the linguistic terms.

Table-2Linguistic Terms and Fuzzy Numbers.

Linguistic Terms	Fuzzy Number
Very Significant **(VS)**	(0.777,0.888,0.999,1.000)
Significant **(S)**	(0.555,0.666,0.777,0.888)
Average **(A)**	(0.333,0.444,0.555,0.666)
Less Significant (LS)	(0.111,0.222,0.333,0.444)
No Significant (NS)	(0.000,0.000,0.111,0.222)

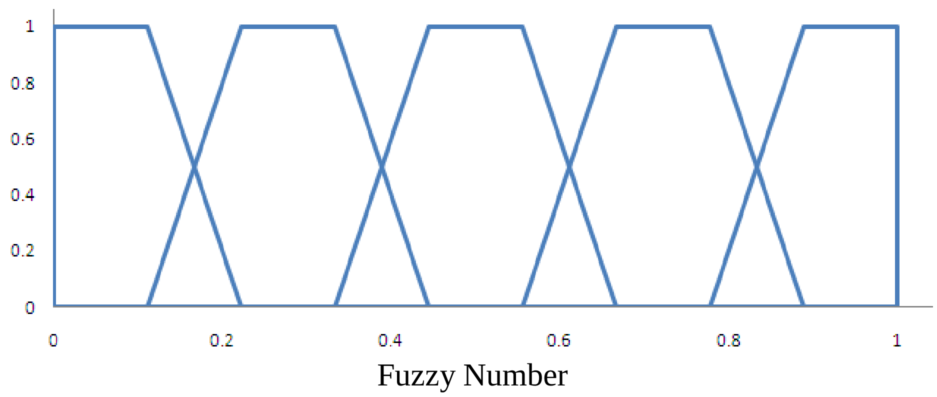

Figure-2 Fuzzy Sets.

Table -2 shows the linguistic variables with their correspondingfuzzy numbers defined by the Experts which to be used for theevaluation of the performance of Criteria (Parameter) on thedecision criteria. Fig. 3 shows the graphical representationof the fuzzy numbers for linguistic variables for the Experts touse in the evaluation processes.

VII. ESTABLISHING WEIGHTS FOR DECISION CRITERIA

For simplicity, let us assume that the decision criterionStructural Defect consists of following subcriteria, that is:

Table -3 Linguistic Terms by Expert for Structural Defect.

Sub Criteria	E1	E2	E3	E4	E5
Structural Defect (C1)					
Horizontal curve on downward slope	VS	VS	S	S	S
Small subsidiary road meeting highway (Y-Junction)	VS	VS	VS	S	VS
Downward slope followed by a horizontal curve	S	S	VS	VS	S
Passenger pick up shades at junction	A	A	LS	A	A
Wayside bus stop without bus bays	LS	LS	A	A	A

(Note: VS-very significant, S- significant, LS-less significant-no of experts involved in the evaluation process)

Table -3 shows the importance weights assigned to each of subcriteria by experts. For example, VS means that subcriterionis "very significant" in the evaluation processes.

VIII. FUZZY DECISION MATRIX

Using equation (3.1) the linguistic terms given by experts can be further simplified to calculate the Average Fuzzy Number (AFN). The linguistic terms as assigned by the experts can be converted to fuzzy numbers used in the above expression through **Table-2** and **Figure-2**.

Then the importance weightage factors for these sub criteria can be calculated as follows.
Equation-1 expresses the average fuzzy numbers for all the experts' opinions.

$$F_{ij}^{k} = \left(1/e\right) \cdot \left(f_{i1}^{k} + f_{i2}^{k} + \ ... + f_{ie}^{k}\right) \text{for } i = 1, 2, ..., n \text{ and } j = 1, 2, ..., e \qquad (1)$$

Where,

f_{ij}^{k} = the fuzzy number (weight) assigned to a sub criterion by expert for the decision criterion,

e = the number of experts involved in the evaluation process and

n = the number of fuzzy numbers to be used in the analysis.

As a sample calculation,by using eq. (1) the fuzzy decision matrix (F_{C1}), the average fuzzy score matrix (AF_{C_2}) and crisp score for sub criteria of Structural Defectsare shown as below.

$$F_{C_2} = \begin{bmatrix} (0.77,0.88,1.00,1.00) & (0.77,0.88,1.00,1.00) & (0.55,0.66,0.77,0.88) & (0.55,0.66,0.77,0.88) & (0.55,0.66,0.77,0.88) \\ (0.77,0.86,1.00,1.00) & (0.77,0.88,1.00,1.00) & (0.77,0.88,1.00,1.00) & (0.55,0.66,0.77,0.88) & (0.77,0.88,1.00,1.00) \\ (0.55,0.66,0.77,0.88) & (0.55,0.66,0.77,0.88) & (0.77,0.88,1.00,1.00) & (0.77,0.88,1.00,1.00) & (0.55,0.66,0.77,0.88) \\ (0.33,0.44,0.55,0.66) & (0.33,0.44,0.55,0.66) & (0.11,0.22,0.33,0.44) & (0.33,0.44,0.55,0.66) & (0.33,0.44,0.55,0.66) \\ (0.11,0.22,0.33,0.44) & (0.11,0.22,0.33,0.44) & (0.33,0.44,0.55,0.66) & (0.33,0.44,0.55,0.66) & (0.33,0.44,0.55,0.66) \end{bmatrix}$$

IX. AVERAGE FUZZY SCORE MATRIX

Now for the justification of aggregated fuzzy number defuzzification is require. The defuzzification is a non fuzzy or crisp value. In this study, trapezoidal fuzzy numbers are used to represent the experts' opinion. An importance of parameter was considered as a range value but not with specific value. So, only trapezoidal fuzzy sets were considered. Let a trapezoidal fuzzy number be parameterized by $x_{1,}$ x_2, x_3 andx_4 as shown in the **Figure-2**, then its defuzzified value (crisp score) 'd' for the sub criteria can be obtained by using equation (3.2) (Kaufmann and Gupta, 1991).

$$d= (x_1 + x_2 + x_3 + x_4) / 4 \qquad (2)$$

$$AF_{C_2} = \begin{bmatrix} 0.6438,0.7548,0.8662,0.9328 \\ 0.7326,0.8436,0.9554,0.9776 \\ 0.6438,0.7548,0.8662,0.9328 \\ 0.2886,0.3996,0.5106,0.6216 \\ 0.2442,0.3552,0.4662,0.5772 \end{bmatrix} \begin{array}{|l} \text{Horizontal curve on downward slope} \\ \text{Small subsidiary road meeting highway (Y-Junction)} \\ \text{Downward slope followed by a horizontal curve} \\ \text{Passenger pick up shades at junction} \\ \text{Wayside bus stop without bus bays} \end{array}$$

By using **Equation-2**, the crisp scores (defuzzified values) for sub-criteria are obtained as follows:

X. CRISP SCORE

The crisp scores of the parameter Structural Defect for each sub criteria can be obtained by using following equations:

Criterion, C_{11} (HC) = (0.6438 + 0.7548 + 0.8662 + 0.9328) /4 = 0.7994
Criterion, C_{12} (SSR) = (0.7326 + 0.8436 + 0.9554 + 0.9776) /4 = 0.8773
Criterion, C_{13} (DS) = (0.6438 + 0.7548 + 0.8662 + 0.9328) /4 = 0.7994
Criterion, C_{14} (PPJ) = (0.2886 + 0.3996 + 0.5106 + 0.6216) /4 =0.4551
Criterion, C_{15} (WB) = (0.2442 + 0.355 + 0.466 + 0.5772) /4=0.4107

XI. AVERAGE FUZZY NUMBERS (AFNS) AND CRISP SCORE

Average Fuzzy Numbers (AFNs) and crisp score respectively, for each sub criterion of Structural defect is as shown in Table-4.

Table- 4Average Fuzzy Number for Structural Defect.

Criteria	Sub Criteria	AFN-1	AFN-2	AFN-3	AFN-4	AFN-5
Structural Defects	Horizontal curve on downward slope	0.6438	0.7548	0.8662	0.9328	0.7994
	Small subsidiary road meeting highway (Y-Junction)	0.7326	0.8436	0.9554	0.9776	0.8773
	Downward slope followed by a horizontal curve	0.6438	0.7548	0.8662	0.9328	0.7994
	Passenger pick up shades at junction	0.2886	0.3996	0.5106	0.6216	0.4551
	Wayside bus stop without bus bays	0.2442	0.3552	0.4662	0.5772	0.4107
	$\sum C_{mk}$					**3.3419**

Similarly, the Average Fuzzy Numbers (AFNs) and crisp score respectively, for each sub criterion of Road Conditions arecalculated.

XII.NORMALIZED WEIGHT

The normalized weight for each sub criterion of Structural Defects and Road condition can be obtained by dividing the crisp score of each sub criterion $(C_{mk})$by the sum total of crisp score of all sub criteria $\left(\sum C_{mk}\right)$ where 'm' is the criterion and 'k' is the sub criterion. The normalized weight for each sub criterion of Structural Defects and Road condition are also calculated.

Table-5 Normalized Weight for Structural Defect.

Sub Criteria	Weight
Horizontal curve on downward slope	0.2392
Small subsidiary road meeting highway (Y-Junction)	0.2625
Downward slope followed by a horizontal curve	0.2392

Passenger pick up shades at junction	0.1361
Wayside bus stop without bus bays	0.1228

The next step was to determine the total score. To obtain the total score the fuzzy crisp scores of data and the normalized weight of sub criteria were operated by a matrix as shown below.

XII. TOTAL SCORE MATRIX

The next step was to determine the Total Score (TS_{mi}).To obtain the Total Score (TS_{mi}), the fuzzy crisp scores of data and the normalized weight of sub criteria were operated by a fuzzy decision matrix.

Using simple additive weighing method (Hwang and Yoon, 1981), the total score as (TS_{mi}), for each black spot of Structural Defects and Road condition criteria can be calculated separately using **Equation-3.**

$$TS_{mi} = \sum \left[X_{mk} \cdot W(C_{mk}) \right] \text{ for } k = 1, 2, ...n \tag{3}$$

Where,

TS_{mi} = total score of the black spot i against the criterion m

X_{mk} = crisp score of the black spot data against sub criterion k of the criterion m and

$W(C_{mk})$ = normalized weight (importance value) of sub criterion k of the criterion m.

Total Score Matrix for Structural Defect.

$$TS = \begin{array}{c} \begin{array}{ccc} L_1 & L_2 & L_3 \end{array} \\ \begin{bmatrix} 0 & 0.7 & 0 \\ 0.6 & 0 & 0.75 \\ 0 & 0.4 & 0.55 \\ 0.4 & 0 & 0 \\ 0.2 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} W_{C_k} \\ \begin{bmatrix} 0.2392 \\ 0.2625 \\ 0.2392 \\ 0.1361 \\ 0.1222 \end{bmatrix} \end{array} \left| \begin{array}{l} \textit{Horizontal curve on downward slope} \\ \textit{Small subsidiary road meeting highway} \\ \textit{Downward slope followed by a horizontal curve} \\ \textit{Passenger pick up shades at junction} \\ \textit{Wayside bus stop without bus bays} \end{array} \right.$$

$$TS_{mi} = \sum \left[X_{mk} \cdot W(C_{mk}) \right] \text{ for } k = 1, 2, ...n \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

TS_{mi} = total score of the black spot i against the criterion m

X_{mk} = crisp score of the black spot data against sub criterion k of the criterion m and

$W(C_{mk})$ = weight (importance value) of sub criterion k of the criterion m.

As a sample calculation, the total score for sub criteria horizontal curve on downward slope of Structural Defect is as shown below.

$$TS = (0\times 0.2392 + 0.6\times 0.2625 + 0\times 0.2392 + 0.4\times 0.1361 + 0.2\times 0.122)$$
$$= 0.2365.$$

Total score for sub criteria of Structural Defects and Road Conditions are also calculated. To determine the potential weightage for all criteria Structural Defects, Road Conditions (such that their summation was equal to 1), equation given below was used and the calculated weights are as shown in **Table 5**

Now, accident potential importance weight $[W(C_{mi})]$ of the criterion m for black spot i can be calculated as,

$$W(C_{mi}) = TS_{mi} / \sum TS_{mi} \text{ .... (5)}$$

Table 6 Total Score Matrix.

Chainage	Total Score			Accidental Potential ImportanceWeight		Overall Score ABSSI	Rank
	Structural Defect (C1)	Road Condition (C2)	(C1+C2)	Structural Defect	Road Condition		
830.1	0.26312	0.43	0.69312	0.379616	0.6203831	0.3666492	2
833.9	0.3164	0.4264	0.7428	0.425955	0.574044	0.4797942	1
835.4	0.2365	0.3854	0.6219	0.380286	0.619713	0.328775	3

The next step was to determine an overall score.To obtain an overall score the total score and the weightage of criteria were operated by a matrix as shown below:

XIII. OVERALL SCORE

Now, accidental potential importance weight $[W(C_{mi})]$ of the criterion m for sub criteria (Road geometric design and Road Impediment) for Structural Defect black spot i can be calculated by using equation 3.4 as,

$$W(C_{mi}) = TS_{mi} / \sum TS_{mi} \quad (6)$$

To determine the accidental potential importance weightage for all criteria Structural Defects, Road Conditions (such that their summation was equal to 1), equation given below was used and the calculated weights .

By using, accidental potential importance weight $\left[W(C_{mi})\right]$ overall accidental potential scores for n number of black spots can be calculated and on the basis of **Accidental Black Spots Severity Index** their ranking can be done.

i) Overall Score Matrix for Location (L $_1$)-835.4 km.

$$\begin{array}{cccl} & TS_{mi} & W_{C_{mi}} & \\ OS_{L1} = & \begin{bmatrix} 0.2365 \\ 0.4115 \\ 0.3854 \end{bmatrix} & \begin{bmatrix} 0.2288562 \\ 0.39820012 \\ 0.37294368 \end{bmatrix} & \begin{array}{l} \mathit{StructuralDefect} \\ \mathit{HumanError} \\ \mathit{RoadConditions} \end{array} \end{array}$$

ii) Overall Score Matrix for Location (L $_2$)-830.1s km

$$\begin{array}{cccl} & TS_{mi} & W_{C_{mi}} & \\ OS_{L2} = & \begin{bmatrix} 0.26312 \\ 0.159 \\ 0.43 \end{bmatrix} & \begin{bmatrix} 0.3087828 \\ 0.18659344 \\ 0.50462376 \end{bmatrix} & \begin{array}{l} \mathit{StructuralDefect} \\ \mathit{HumanError} \\ \mathit{RoadConditions} \end{array} \end{array}$$

iii) Overall Score Matrix for Location (L $_3$)-833.9 km

$$\begin{array}{cccl} & TS_{mi} & W_{C_{mi}} & \\ OS_{L3} = & \begin{bmatrix} 0.3164 \\ 0.411 \\ 0.4264 \end{bmatrix} & \begin{bmatrix} 0.37294368 \\ 0.50462376 \\ 0.36956145 \end{bmatrix} & \begin{array}{l} \mathit{StructuralDefect} \\ \mathit{HumanError} \\ \mathit{RoadConditions} \end{array} \end{array}$$

Using accident potential importance weight for both the criteria (such that their summation is equal to 1), an overall score (OS) as **Accidental Black Spots Severity Index** for the black spot can be calculated using equation (3.5).

$$OS = \sum \left[TS_{mi} \cdot W(C_{mi})\right] \text{ for } i = 1, 2, \ldots n \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

As a sample calculation, an overall score for Location 835.4 Km is as shown below.

$$\mathrm{OS}_{L1} = (0.2365 \times 0.2288562 + 0.4115 \times 0.39820012 + 0.3854 \times 0.37294368)$$
$$= 0.36171633.$$

Using equation 6, overall accidental potential scores for n number of black spots can be calculated and on the basis of Accidental Black Spots Severity Index their ranking can be done.

Table 7 Overall Score and Ranking of Chainages

Chainage	Total Score		Sum	Accidental Potential ImportanceWeight		Overall Score ABSSI	Rank
	Structural Defect (C1)	Road Condition (C2)	(C1+C2)	Structural Defect	Road Condition		
830.1	0.26312	0.43	0.69312	0.379616	0.6203831	0.3666492	2
833.9	0.3164	0.4264	0.7428	0.425955	0.574044	0.4797942	1
835.4	0.2365	0.3854	0.6219	0.380286	0.619713	0.328775	3

XIV. CONCLUSION

The economic development of any country is strongly dependingon transportationfacility. In this paper, aMulticriteria Criteria Decision Making (MCDM) framework is used to find out Accidental Black Spot Severity Index (ABSSI). The proposed method allows experts to express theiropinions about the linguistic terms on decision criteria in the more sensible manner as the use of fuzzy set theory facilitatesevaluation to be made in qualitative and estimatedterms which better correspond to road related situations. In this framework, it is assumed that the evaluations of accidental black spots are fuzzy, whereas the opinions of the experts are not. However, the proposed system also facilitates experts to express their opinions using linguisticterms. The interaction among the decision criteria is taken into consideration for adequate treatment of fuzzy decision making. In order to avoid the excessive importance of any one particular criteria, the importance of all other criteria is also considered in the evaluation process.

For this purpose, the minor contribution of each of the decisionCriteria is taken into consideration which is beneficial for an evaluation of accidental black spot and that is also reflects the relationships among the decision criteria and expert opinion concerns in the decision-making process.In an actual evaluation process, a decision criteria and sub criteria need tobe considered simultaneously and in most cases the experts' are less hesitant to handle the uncertainty associated with decision making directly in the scores of performance on particular criteria by using approximate values than by using crisp values and this makes the use of a fuzzy linguistic variable for the proposed evaluation system more appropriate.

Defining and specifying the type of fuzzy numbers for linguistic variables and establishing scale of preference structure to be used by decision makers would be a big challenge for proposed framework. It would be more difficult and complicated to establish the preference of scale structure when there are number of experts' involve in decision criteria of analysis of accidents as each of them have different opinion about the importance of decision criteria.

Therefore, the useof the proposed method, even though it is no universal remedy for alltroubles of decision making regarding the evaluation of accidental black spot process, will assist the each accident more carefully which will be further used for finding out accidental black spot severity index. However,it is recommended that the final ranking of each location by theproposed method be simply used as a guide for viewing the relativeimportance of each criteria which is responsible for occurrence of accidents and the final decision should be made on total score and accidental black spot potential importance weitages of each location.

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