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An Approach of Multi Criteria Decision Making in Analyzing Rural Road Safety in Nashik District

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Abstract: ***Rural road safety evaluations play a significant role in the transportation industry, and most fatal accidents happen on these types of roads. Road Safety Analysis (RSA), a process to evaluate a road's safety criteria and support overall road management decision-making, ensures the avoidance of loss of life and property damage. The "Pradhan Mantri Gram Sadak Yojana," which is primarily utilized in rural areas, is the main emphasis of this. In order to identify the most vulnerable roadways and implement mitigation measures, roads must be prioritized depending on safety ratings. This document presents the results of a study conducted to rank the safety criteria of Pradhan Mantri Gram Sadak Yojana (PMGSY) roads, a particular category of rural roads. A questionnaire survey was used for the study's analysis, and three MCDM methods were used to examine the relationships and interactions between the various factors. The study's findings indicated that the based on input from PMGSY engineers and contractors. From the perspective of the engineers in the Nashik area, we can determine the safety impact factor that influences the safety assessment of the PMGSY route.***

Keywords: Road safety, safety impact factor; RII, multi criteria decision making.

I. INTRODUCTION

Traffic accidents are a serious issue that cost society dearly in terms of lives lost. Every minute, a catastrophic accident occurs in India as a result of dangerous road conditions. Since the number of accidents is rising daily, raising public awareness of road safety across the nation is crucial for maintaining road safety. The United Nations has designated the years 2011–2020 as road safety years, which highlights the significance of road safety analysis (RSA). One of the most crucial steps in the growth process is road safety. RSA is a preventive strategy designed to find significant issues pertaining to road safety for all users of the road and make sure those issues are fixed. India boasts one of the largest road networks in the world, and the country's highway and rural road development is growing quickly these days. Rural roads are a crucial component that primarily influence the nation's economic development. The Indian government has launched a number of road development initiatives, including the north-south, east-west, and golden quadrilateral routes. The Pradhan Mantri Gram Sadak Yojana (PMGSY), which aims to create all-weather road connectivity in rural areas of the country, was launched by the Indian government. Launched on December 20, 2000, its goal was to connect every habitation in plain areas with 500 people or more, and all hilly states with 250 people or more.

Compared to metropolitan areas, rural areas are less safe from accidents and casualties. It is noted that accidents and fatalities in rural areas account for 53.5% and 63.4% of all incidents, according to 2011 figures. However, because metropolitan regions have better roads, greater security, and quicker access to medical facilities, their respective scales are 46.5% and 36.6%. Due to improper recording practices and a lack of knowledge of road safety, detailed accident records involving rural roads are difficult to come by. The idea of road safety analysis, or the safety performance assessment of an existing road, has gained popularity recently. Eighty percent of the road network in rural areas is PMGSY. Through this study, we hope to raise rural residents' awareness of road safety, as their lack of education has left them ignorant of the subject.

A. Need of study

Infrastructure plays a crucial role in the economy. Development greatly depends on road infrastructure, and in this context, road safety is crucial.

B. Objective of project

1) To establish the importance of a particular category of rural road's safety requirements.
2) To raise rural communities' understanding of PMGSY road safety.
3) To calculate the road's quantitative level of safety under PMGSY.
4) To examine the road safety analysis (RSA) concept in depth.

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II. DATA COLLECTION

A. Case studies

Case study for this project, we have select four old road of PMGSY in Kalwan taluka, Nashik district. The road has same length and topographic condition. General details of road selected are tabulated as shown below.

Table 1: Details of case study.

Particulars	Road 1	Road 2	Road 3	Road 4
Name of Road	Dapur Phata to Khambale	Kolgao to Kheldale Junga	Mendhi To Vadangali-Village Road	Somthane To Vadangali Village Road
Location	Dapur	Kolgaon	Vadangali	Vadangali
Taluka	Sinnar	Sinnar	Sinnar	Sinnar
Year Completion	2017-2018	2020-2021	2021-2022	2021-2022
Length of Road	8 KM	6 KM	9 KM	10.44
Cost of Road	175 Lakh	191.86 Lakh	497.31 Lakh	592.87

B. Accidents Record of Case Study

This information was gathered from the police station in the location where the case study was chosen in Kalwan taluka, Dist. - Nashik, as well as from locals who provided nformation. Four PMGSY roads that were completed at the same time and had the same topography were chosen for this case study.

Table 2: Accidents record of case study.

Year	Total Accidents.
2016	42
2017	28
2018	18
2020	23
2021	22

Table 3: Causes of accidents as per criteria of road.

Road characteristics	2016	2017	2018	2020	2021
Sight distance	5	3	2	3	2
Sharp curves	4		2	3	2
Super elevation	3				2
Severity of roadside environment	7	4	1	2	1
Drainage provision			1	2	
Shoulder width		3		2	3
Shoulder drop					2
Quality of shoulder					1
Pavement edge failure	6	4	2	1	
Pothole			2	1	2
Revelling and Spelling					
Cracking	2	3	1	2	1
Rutting					
Direct access from houses to roads	7	5	3	2	2
Sing and Marking			**2**	**2**	
Blind turn on road	8	6	2	2	2

According to this data it is observed that most of accidents are happened by this criteria.

- Sight distance
- Sharp curves
- Severity of roadside environment
- Shoulder width
- Pavement edge failure
- Cracking
- Direct access from houses to roads
- Blind turn on road

Table 4. Information of road regarding road safety criteria as below.

Sight distance	>90m (good)	=90m(medium)	<90m(poor)
Sharp curves	> 90° – (good)	90° – (Satisfactory)	< 90° - (poor)
Super elevation	< 7 percent (as per design) – (Good)	7 percent – (satisfactory)	> 7 percent – (poor)
Severity of roadside environment	< 10m – (Good)	(10-100)m – (satisfactory)	>100m – (Poor)
Drainage provision	High	Medium	Low
Shoulder width	>1.875m – (high)	1.875m – (medium)	<1.875m – (low)
Shoulder drop	0.25-0.5" (low)	0.5-1"(medium)	>1" (high)
Quality of shoulder	Good	Satisfactory	Poor
Pavement edge failure	<1%(low)	1-2%(medium)	>2%(high)
Pothole	<1"depth (low)	Potholes>2"deep and cover<1sqft area (Medium)	Potholes>2"deep and cover>1sqft Area (high)
Reveling and Spelling	Aggregate and/or binder has started to wear away (low)	Aggregate and/or binder has worn away, moderately pitted surface (Medium)	Aggregate and/or binder has worn away, severely pitted surface (high
Cracking	Mean width of Spall (crack) < 0.635cm	Mean width of Spall (crack) > 0.635cm	Severe spalling
Rutting	0.25-0.5" (low)	0.5-1"(medium)	>1" (high)
Direct access from houses to roads	1-3 no of houses	3-7 no of houses	>7 no of houses
Sing and Marking	Good	Medium	Poor
Delineation	High	Medium	Low
Blind turn on road	1-3 no of turns	3-7 no of turns	>7 of turns

As per the design standards of rural roads given by IRC guidelines shown in table, ratings for criteria viz., sight distance, sharp curves, super elevation and shoulder width have been taken. However, severity level ratings for the parameters-shoulder drop, pavement edge failure, pothole, raveling and spelling, cracking and rutting were not available in the Indian standards and thus have been adopted from FHWA guidelines.

Table 5: Road measurement as per criteria.

Road characteristics	Road 1	Road 2	Road 3	Road 4
Sight distance	< 90m	< 90m	< 90m	=90m
Sharp curves	<90°	<90°	=90°	=90°
Super elevation	7 percent	7 percent	<7 percent	<7 percent
Severity of roadside environment	>100m	>100m	>100m	>100m
Drainage provision	Low	Low	Low	Medium
Shoulder width	0.5 - 0.7 m	0.5 – 0.6 m	1 – 1.2 m	1.3 – 1.6 m
Shoulder drop	0.6''	0.5''	0.8''	0.2''
Quality of shoulder	Poor	Poor	Satisfactory	Satisfactory
Pavement edge failure	1.2%	>2%	1.2%	<1%
Pothole	>2'', 1-2 sqft Area	>2'', 2-3 Sqft Area	<1"	<1"
Revelling and Spelling	Medium	High	Medium	Low
Cracking	0.5-1 cm	0.5-1cm	1-1.5 cm	1-.5 cm
Rutting	0.7-1''	0.8-1''	0.5-0.8''	0.5-0.7''
Direct access from houses to roads	7 no	14 no	23 no	9 no
Sing and Marking	Low	Low	Low	Medium
Blind turn on road	6 no	4 no	9 no	11 no

III. METHEDOLOGY

In this project methodology include general introduction and objectives, scope of project. Then literature study about road safety analysis. For understand the whole concept of RSA using various method, the first method is used for analysis is Relative importance index (RII). By this method we had gave ranking to alternatives by priorities them. Then another important method used is Analytic hierarchy process.

A. Relative Important Index

For this analysis the questionnaire survey was done by field experts and PMGSY engineer. The questionnaire had designed so that respondents can give the rank to their opinions. For analysis of this data RII method is used. RII is calculated for each of the indicators and ranked accordingly.

$$RII = \frac{\sum W}{A \times N}$$

Here

W = Weighting given to each factor by the respondents (ranging from 1 to 5, where 1= no impacts, 2= negligible impact, 3=marginal impact, 4= moderate impact, 5= major impact),

A = Highest weightage given for that factor,

N = Total number of respondents.

Table 6 Analysis of ranking of factors.

FACTORS	RII	RANK
Sight distance	0.9641	1
Sharp curve	0.9641	2
Super elevation	0.8051	11
Sevarity of road side env	0.759	13
Drinage provision	0.7179	15
Shoulder width	0.8051	10
Shoulder drop	0.8205	8
Quality of shoulder	0.7333	14
Pavement edge failure	0.8513	5
Pothole	0.8462	6
Reveling and Spelling	0.6564	17
Cracking	0.641	18
Rutting	0.6051	19
Direct access from house	0.9026	4
Traffic volume	0.8051	9
Sign and Marking	0.8205	7
Blind turn	0.9231	3
Specific width	0.7692	12
Road side env	0.6667	16

Depending on this result, Alternative 1 (Sight distance) has the largest total score. Therefore, it is suggested as the very important factor among other of them to decide safety impact factors that affect safety assessment of PMGSY road from project managers point view in Nashik city, with respect to 4 main criteria and the RII model preferences of decision makers. Alternative 2(Sharp curve) has the second largest total score, Alternative 17 has the third largest total score, Alternative 14 has the fourth largest total score Alternative 9 has the fifth largest total score Alternative 10 has the sixth largest total score Alternative 16 has the seventh largest total score Alternative 7 has the eighth largest total score Alternative 15 has the ninth largest total score Alternative 6 has the tenth largest total score. This are the 10 most important factor which is mostly responsible for road safety as per road engineer's point of view.

IV. CONCLUSION

The constructed RII expert model is found to function well, produce findings that are acceptable, and demonstrate accurate decision-making when it comes to selecting safety impact factors for PMGSY roads in this research report. In order to determine the deployment of RII in the majority of rural road projects, a sample of safety factor selection was prepared. The output of each project manager for each safety factor made it evident that the pavement condition and road geometric characteristic criteria occupy the majority of the RII priority stack, indicating the intended dominance of these two criteria in the selection process. Additionally, this analysis is applied to the chosen case study in order to determine whether these elements are increasing the accident rate.

The alterative, sight distance, abrupt curve, direct access from the house to the road, blind turn, shoulder width, rutting, and pavement edge failure are noted in the analysis. These are crucial factors from a safety perspective that RII obtains. Currently, this study is being conducted on the four roads that were chosen for the case study in order to determine whether or not the measurements provided for these roads meet the criteria. and after that, to see how these variables affect the frequency of accidents.

For case study four rural road has select. All measurement had taken according to IRC guidelines.

1) According to Accidents record from 2016 to 2021 approximately 15 accidents were happened due to Sight distance is not provided as per IRC. According to IRC sight distance for rural road is above 90 Meter. But sight distance is actually provided at selected road is for Road 1: < 90M, Road 2: <90M, Road 3: <90M, which is poor as per IRC and for Road 4: =90 which is medium. According to IRC guidelines the sight distance is not provided properly so the accidents rates is increase.

2) According to Accidents record from 2016 to 2021 approximately 11 accidents were happened due to Sharp Curve is not provided as per IRC. According to IRC Sharp Curve for rural road is above 90°. But Sharp Curve is actually provided at selected road is for Road 1: <90°, Road 2: <90°, which is poor as per IRC and for Road 3: =90°, Road 4: =90° which is medium. According to IRC guidelines the Sharp Curve is not provided properly so the accidents rates is increase.

3) According to Accidents record from 2016 to 2021 approximately 15 accidents were happened due to Severity of roadside environment is not provided as per IRC. According to IRC Severity of roadside environment for rural road is below 90M. But Severity of roadside environment is actually provided at selected road is for Road 1: >100M, Road 2: >100M, is Road 3: >100M, Road 4: >100M which is poor. According to IRC guidelines the Severity of roadside environment is not provided properly so the accidents rates is increase.

4) According to Accidents record from 2016 to 2021 approximately 8 accidents were happened due to Shoulder Width is not provided as per IRC. According to IRC Shoulder Width for rural road is 1.875 or greater than 1.875. But Shoulder Width is actually provided at selected road is for Road 1: 0.5-0.7M, Road 2: 0.5-0.6M, is Road 3: 1-1.2M, Road 4: 1.3-1.6M which is poor. According to IRC guidelines the Shoulder Width is not provided properly so the accidents rates is increase.

5) According to Accidents record from 2016 to 2021 approximately 13 accidents were happened due to Pavement Edge Failure is not provided as per IRC. According to IRC Pavement Edge Failure for rural road is <1%. But Pavement Edge Failure is actually provided at selected road is for Road 1: 1.2%, Road 2: >2%, is Road 3: 1.2%, Road 4: <1% which is poor. According to IRC guidelines the Pavement Edge Failure is not provided properly so the accidents rates is increase.

6) According to Accidents record from 2016 to 2021 approximately 9 accidents were happened due to Cracking is not provided as per IRC. According to IRC Cracking for rural road is <0.635CM. But cracking is actually at selected road is for Road 1: 0.5-1CM, Road 2: 0.5-1CM, is Road 3: 1-1.5 CM, Road 4: 1-1.5 CM which is poor. According to IRC guidelines the Cracking is increases so the accidents rates is increase.

7) According to Accidents record from 2016 to 2021 approximately 19 accidents were happened due to direct access from houses to roads is Maximum. According to IRC Direct access from houses to roads for rural road is minimum, 1-3 no of houses. But Direct access from houses to roads is actually at selected road is for Road 1: 7 no, Road 2: 14 no, is Road 3: 23 no, Road 4: 9 no which is poor. According to IRC guidelines the direct access from houses to roads is increases so the accidents rates is increase.

8) According to Accidents record from 2016 to 2021 approximately 20 accidents were happened due to blind turn on road is Maximum. According to IRC Blind turn for rural road is minimum. Blind turn on road is actually at selected road is for Road 1: 6 no, Road 2: 4 no, is Road 3: 9 no, Road 4: 11 no which is poor. According to IRC guidelines the Blind turn on road is increases so the accidents rates is increase

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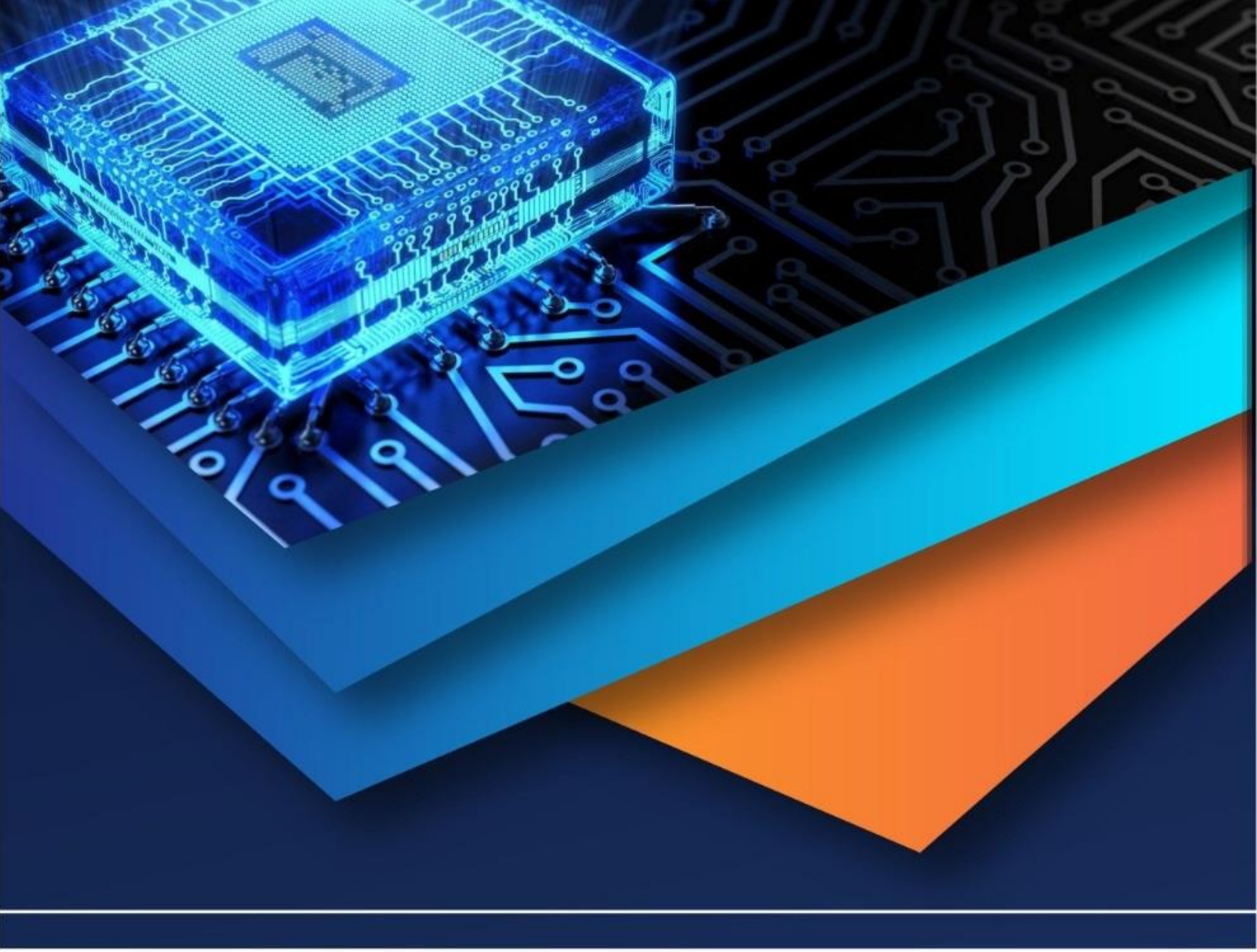

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