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Formulation of Rating System for Existing Highways in India for Their Sustainable Performance

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Abstract: India is a developing country and with the growing awareness regarding climate change and other environmental factors, it has become a necessity to incorporate sustainable practices in our construction, operation and maintenance practices. It is also important to understand that sustainability is about balancing what is beneficial to people, while considering what is economically sound, and environmentally compatible. The building sector presently offers a variety of sustainable and environmentally friendly techniques and processes. Different rating and certification systems like LEED, GRIHA, GEM and IGBC are available that assess the level of sustainability of Buildings. Because this idea worked so well for buildings it has now being implemented for Highways also.

India's road network is the second largest and densest in the world with 62.16lakh kilometers and construction of highways directly results in the removal and destruction of existing ecosystems, as well as the modification of regional landforms. Thus, the aim of this study is development of a green rating framework for existing highways by identifying the critical factors. The factors in the study are obtained with the amalgamation of research findings and expert knowledge. The data for the study is collected from a series of structured questionnaire, which is circulated amongst the professionals In Highway and Environment fields in India and 105 responses were recorded. In accessing reliability of our questionnaire, Cronbach's Alpha is used, a statistical tool that allowed us to evaluate the internal consistency and reliability of the questions pertaining to highway sustainability. The data is then analyzed using SPSS (Statistical Package for the Social Sciences) calculating mean value analysis and finding Factor loading by factor analysis. The objective of the factor analysis is to find the factor loading i.e., weightage of each factor which will help us in determining the factor score. The factor score for the Factors are obtained by multiplying the mean with their respective weightage score which will help us in developing the rating system based on these crucial factors.

Keywords: Green rating system, SPSS, Factor Analysis, Mean Value Analysis, Highways.

I. INTRODUCTION

The growth of a country's economy is governed by its industrial and infrastructure sectors. Since roads serve as the main arteries of a country's development, their development is one of the primary contributors to infrastructure development. In the production-distribution-consumption, chain of goods distribution plays a crucial role and therefore effective distribution is efficient transportation i.e., Roads and highways. India's road network is the second largest and densest in the world with 62.16lakh kilometres. India's connectivity has improved because of the development of infrastructure to satisfy the country's expanding transport needs, but more work remains to be done to ensure efficient traffic flow and the smooth movement of goods. Little emphasis is paid to increasing the effectiveness of the infrastructure being developed i.e., making a sustainable highway. The construction of highways directly results in the removal and destruction of existing ecosystems, as well as the modification of regional landforms. Additionally, the development of roads has a variety of ecological consequences on the topography of land. The construction operations have a substantial impact on the air quality and serve as a large source of particulate matter entering the atmosphere. Land clearance, ground excavation, cut-and-fill work, and the actual construction of a facility all significantly increase the amount of PM in the air. Additionally, it has been determined that these activities are a significant source of pollutants for natural water bodies such rivers, lakes, and streams. The building sector has been at the forefront of this revolution, embracing a diverse array of sustainable techniques and processes.

Recognizing this success, the same concepts that have revolutionized sustainable building practices are now being applied to our vast highways and road networks. Just as green building rating systems like LEED, GRIHA, GEM, and IGBC have significantly raised the bar for sustainability in the construction and operation of buildings, this proven idea is being adapted for the expansive realm of highways. There is currently no worldwide accepted green rating for highways however, various countries, including the United States and the United Kingdom, have taken proactive steps to develop their own distinctive highway sustainability rating systems but countries like the US and the UK have developed their own rating system like Greenroads, INVEST, GreenLITES, STARS, CEEQUAL each contributing to the global narrative of sustainable infrastructure.

II. ADOPTED METHODOLOGY

With the increased awareness on the environment and climate change, it has become a necessity for us to use sustainable practices in our construction Sector. The factor for this study will be obtained with the amalgamation of research findings and expert knowledge and a structured questionnaire will be formed which will be circulated amongst the professionals In Highway and Environment fields in India and their response is recorded. After data collection through a structured Questionnaire, it is proceeded to transform the qualitative responses, obtained through the rating scale, into a structured numerical format using Likert chart. In assessing the reliability of our questionnaire, Cronbach's Alpha is used, a statistical tool that allowed us to evaluate the internal consistency and reliability of the factors pertaining to highway sustainability. The data is then analysed using SPSS (Statistical Package for the Social Sciences) calculating mean value analysis and finding Factor loading by factor analysis by calculating the mean of these Factors, the average opinion or perception of the participants regarding different factors could be understood. Statistical tests such as the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test within SPSS are performed to ensure the suitability and adequacy of our dataset for the factor analysis. The objective of the factor analysis is to find the factor loading i.e., weightage of each factor which will help us in determining the factor score. The factor score for the Factors are obtained by multiplying the mean with their respective weightage score which will help us in developing the rating system for existing highways.

III. DATA ANALYSIS AND COMPILATION

A. Questionnaire Formation

The factors for this study are obtained with the amalgamation of research findings and expert knowledge and a structured questionnaire is formed. A total of 105 data has been collected from the professionals In Highway and Environment fields in India. The factors are listed below:

1) Road Safety & traffic Management

- Road signs and Road markings should be clearly visible and adequately placed along the road and well-maintained.
- Safety barriers and guardrails should be present along the road to prevent accidents
- Traffic calming measures, such as speed breakers and speed humps, should be effectively implemented
- Intelligent Transportation Systems (ITS), such as traffic cameras and real-time data analysis should be properly integrated for real-time monitoring of road conditions and incidents
- Adequate street lighting should be provided, especially in rural areas.
- Traffic signals should be effectively timed and coordinated based on traffic conditions
- Dedicated lanes for public transportation, such as buses, should be provided
- Construction zones should be well-managed to minimize traffic disruptions.
- Road surface should be free of pot holes
- Side clearance should be present i.e., clearance of trees, shrubs electric poles etc.

2) Environmental Impact

- Measures to reduce air pollution from road traffic, such as promotion of clean fuels and emission control technologies, should be effectively implemented.
- Noise reduction measures, such as noise barriers and low-noise road surfaces, should be effectively implemented
- Green infrastructure, such as tree planting and landscaping, should be integrated along the roads.
- Sustainable stormwater management practices, such as bio-retention basins and rainwater harvesting, should be implemented
- Consideration of the impact on natural habitats and ecosystems during road maintenance and operation should be given priority

3) Energy Efficiency
- Energy-efficient lighting technologies, such as LED lights, should be used for road illumination.
- Renewable energy sources, such as solar panels, should be integrated for road infrastructure needs.
- Energy-saving technologies, such as automatic dimming or switching off of lights during low-traffic periods, should be implemented
- Energy management systems should be in place to optimize energy usage in road facilities.

4) Sustainable Materials
- Locally available and sustainable materials should be used for road maintenance and construction
- Eco-friendly construction practices, including reduced material wastage and recycling of construction and demolition waste, should be adopted
- Sustainable pavement technologies, such as warm mix asphalt and porous asphalt, should be used to improve longevity and reduce resource consumption life cycle costing of material should be considered.

5) Water Management
- Sustainable drainage systems should be implemented to manage stormwater runoff and prevent flooding.
- Measures to minimize water pollution from road runoff, such as sedimentation ponds and filtration systems, should be effectively implemented
- Water conservation practices should be promoted in road construction and maintenance activities
- Low-impact development techniques, such as permeable pavements and green infrastructure, should be integrated to enhance water infiltration and recharge.

6) Maintenance and Durability
- Use of high-quality materials should be used in road construction to ensure durability and longevity.
- Implementation of effective maintenance practices, including regular inspections and timely repairs should be done
- Adequate resurfacing and rehabilitation should be done to address pavement distress and prevent further deterioration.
- Implementation of preventive maintenance measures, such as crack sealing and pothole repairs should be done
- Integration of asset management systems should be done to monitor road condition and plan maintenance activities effectively

7) Accessibility and Community Impact
- Sidewalks and pedestrian pathways should be well-maintained and designed to accommodate pedestrians of all ages and disabilities, including wheelchair accessibility and tactile indicators.
- Integration of road infrastructure with surrounding communities, considering the needs and aspirations of local residents should be kept in mind i.e., Service lanes.
- Mitigation of potential negative social impacts, such as displacement of communities or disruption of livelihoods during widening projects should be considered.
- Integration of amenities and facilities that cater to the needs of road users and nearby communities, such as rest areas, public toilets, and facilities for street vendors

8) Innovation and Technology
- Use of advanced materials and construction techniques should be considered that improve road performance and reduce environmental impact
- Implementation of innovative solutions for energy efficiency, such as energy-generating road surfaces or energy recovery from vehicles should be considered
- Integration of emerging technologies, such as connected and autonomous vehicles, for improved road safety and efficiency

B. Reliability Analysis
For this study Cronbach's Alpha Analysis is considered to evaluate internal consistency, researchers calculate Cronbach's alpha using statistical software. A high alpha suggests that the scale or questionnaire is reliable for measuring the intended construct. Researchers typically aim for an alpha value of 0.70 or higher. Tabel, I show the Cronbach value of each factor calculated with the help of SPSS software. For all the factors Cronbach value is greater than 0.70 and hence our data is reliable.

Table I Reliability Analysis

Factors	Cronbach's Alpha	No of Sub factors
1.Road Safety & traffic Management:	0.792	10
2.Environmental Impact	0.847	5
3.Energy Efficiency	0.754	4
4.Sustainable Materials	0.769	4
5. Water Management	0.744	4
6. Maintenance and Durability	0.801	5
7.Accessibility and Community Impact	0.778	4
8.Innovation and Technology	0.735	3

C. Mean Value Analysis using SPSS software

Mean value analysis is a fundamental statistical technique, often used to summarize and interpret numerical data in various research and analytical contexts. By calculating the mean of these Factors, the average opinion or perception of the participants regarding different factors could be understood.

D. Factor Analysis

Before factor analysis Kaiser-Meyer-Olkin (KMO) and Bartlett's Test are performed. The test is used to assess the sampling adequacy of your data for factor analysis. It is performed to ensure the suitability and adequacy of our dataset for the factor analysis. Generally, a KMO Value ranges should be in range from 0-1 with higher values indicating greater suitability, a value greater than 0.50 is much better. For Bartlett Test statistical significance value α should be less than value significance level $\alpha = 0.001$ (0.1%), indicating that your data is suitable for factor analysis. Table II shows the values obtained of KMO & Bartlett’s test.

Table II KMO and Bartlett’s test Value Obtained

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.755
Bartlett's Test of Sphericity Significance value	0.000

E. Factor loading

After the KMO and Bartlett’s test factor analysis is done to find the factor loadings of the variables Table III shows the factor loading of each Sub-Factor which is used further in development of our rating system. Factor loading below 0.3 have been removed as they don’t have much impact.

Table III Factor loading of each Sub-factor

Variables	Factors							
	1	2	3	4	5	6	7	8
RSTM1	0.846							
RSTM2	0.780							
RSTM3	0.718	0.357						0.341
RSTM4	0.543					0.344		
RSTM5	0.815							
RSTM6	0.554	0.383						0.302
RSTM7	0.577						0.323	
RSTM8	0.631			0.428				0.351
RSTM9	0.749							

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RSTM10	0.797							
EI1		0.748		0.401			0.399	
EI2		0.635						
EI3	0.435	0.611						
EI4		0.562						
EI5		0.591		0.333			0.470	0.440
EE1			0.524		0.375			0.332
EE2			0.775					
EE3	0.475		0.507			0.358	0.462	
EE4		0.440	0.663	0.495			0.430	
SM1		0.459		0.428				
SM2				0.722				0.468
SM3	0.364			0.647			0.354	
SM4				0.617		0.364		
WM1	0.410			0.305	0.529			
WM2	0.383				0.792		0.304	
WM3				0.397	0.576		0.380	
WM4					0.814			
MD1	0.368					0.745		
MD2						0.528	0.315	
MD3		0.349				0.520		0.313
MD4	0.324					0.457		
MD5		0.389			0.369	0.620		0.340
ACI1	0.356	0.451				0.335	0.586	
ACI2							0.646	
ACI3	0.306						0.663	
ACI4							0.820	
IT1			0.475		0.321			0.720
IT2		0.313		0.304				0.865
IT3				0.418			0.376	0.754

F. Development of Scale Model

The models consist of Factor Loading and the grouping of the respective factors, and will be used in calculating the Factor Score. Factor Score can be made by multiplying the mean scores, with the Factor Loading, FL as shown below.

$$\text{FS } (\textit{Factor Score}) = \overline{\text{x}} \ (\textit{mean}) * \text{FL } (\textit{Factor loading})$$

The Ratio of each variable is calculated by dividing each of the variable factor score by the total sum of each variable in a factor which give us the weightage of each variable i.e., Sub factors.

G. Formation of the Rating System

The ratio weight of each sub-factor/variable is known so further as a part of designing a rating system 100-point scale has been chosen and based on the factor ratio the points are assigned to each Factors and sub factors. Table IV shows the Corrected Allocated Points. Table IV show the mean, factor loading, factor score of each variable and the ratio which is used to calculate the points for each sub-factors and factors.

Table IV Allocated Points for each Factors

Factor	sub-Factors	Mean	Factor loading	Factor score	Ratio	Corrected Points	Total Points
RSTM	RSTM1	4.80	0.85	4.06	0.13	4	27
	RSTM2	4.68	0.78	3.65	0.11	3	
	RSTM3	4.41	0.72	3.17	0.10	3	
	RSTM4	4.48	0.54	2.43	0.08	2	
	RSTM5	4.38	0.81	3.57	0.11	3	
	RSTM6	4.62	0.55	2.56	0.08	2	
	RSTM7	4.19	0.58	2.42	0.08	2	
	RSTM8	4.45	0.63	2.81	0.09	2	
	RSTM9	4.84	0.75	3.62	0.11	3	
	RSTM10	4.60	0.80	3.66	0.11	3	
EI	EI1	4.60	0.75	3.44	0.24	3	11
	EI2	4.46	0.64	2.83	0.20	2	
	EI3	4.66	0.61	2.85	0.20	2	
	EI4	4.51	0.56	2.54	0.18	2	
	EI5	4.49	0.59	2.65	0.19	2	
EE	EE1	4.56	0.52	2.39	0.21	2	10
	EE2	4.58	0.78	3.55	0.32	3	
	EE3	4.38	0.51	2.22	0.20	2	
	EE4	4.55	0.66	3.02	0.27	3	
SM	SM1	4.49	0.43	1.92	0.18	2	9
	SM2	4.59	0.72	3.31	0.31	3	
	SM3	4.44	0.65	2.87	0.26	2	
	SM4	4.47	0.62	2.76	0.25	2	
WM	WM1	4.56	0.53	2.41	0.20	2	10
	WM2	4.60	0.79	3.64	0.30	3	
	WM3	4.48	0.58	2.58	0.21	2	
	WM4	4.30	0.81	3.50	0.29	3	
MD	MD1	4.53	0.74	3.38	0.26	3	11
	MD2	4.65	0.53	2.45	0.19	2	
	MD3	4.51	0.52	2.35	0.18	2	
	MD4	4.64	0.46	2.12	0.16	2	
	MD5	4.42	0.62	2.74	0.21	2	
ACI	ACI1	4.59	0.59	2.69	0.22	2	11
	ACI2	4.47	0.65	2.88	0.24	3	
	ACI3	4.39	0.66	2.91	0.24	3	
	ACI4	4.45	0.82	3.65	0.30	3	
IT	IT1	4.45	0.72	3.20	0.31	3	9
	IT2	4.40	0.86	3.80	0.37	3	
	IT3	4.22	0.75	3.18	0.31	3	

IV. RESULT

After the assigning of corrected points to all the factors a rating system is developed based on the the wisdom and experience of established rating systems. Figure I show the Distribution of points all the factors as a percentage of whole. With Road and Safety management have the highest percentage of 28% for 27 points. Figure 1 shows the percentage distribution of each factor.

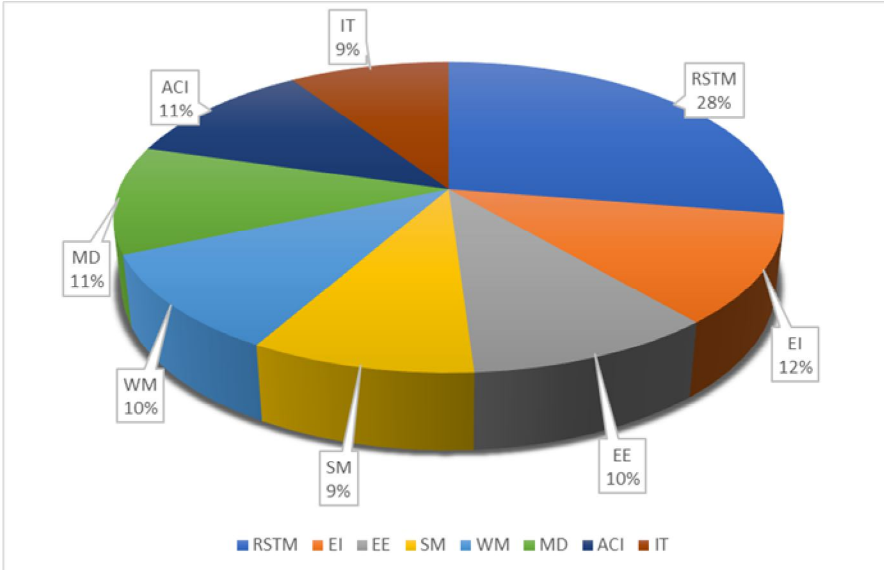


Fig I Percentage of each Factor

The Table V show the distribution of different certification which has been developed

Table V Distribution of points for certification

Bronze	25-35
Silver	35-55
Gold	55-75
Evergreen / Platinum	>75

V. CONCLUSION

1) Two factors Road surface should be free of pot holes and Road signs and Road markings should be clearly visible and adequately placed along the road and well-maintained have the highest mean.
2) Dedicated lanes for public transportation, such as buses, should be provided has the lowest mean.
3) Road safety and traffic management has the highest point allotted to it and is the most important parameter in existing highway ratings
4) Innovation and technology and sustainable material has the lowest point awarded in existing highway rating.
5) Based on the existing rating system it calculated that a minimum of 25-35 points are required for getting certified.

In conclusion, the existing highway rating system prioritizes road safety and traffic management as the most critical parameters, allocating the highest points to these factors. A well-maintained road surface free of potholes and clear, adequately placed road signs and markings also hold significant importance, securing a high mean in the rating system. Conversely, dedicated lanes for public transportation, though important, receive the lowest mean. Furthermore, the system places minimal emphasis on innovation, technology, and sustainable materials. To attain certification, highways must accumulate a minimum of 25-35 points.

REFERENCES

[1] M. Ashfaque Alam, Mt. Scholar, and A. Professor, "An analytical study on highway construction projects in India for probability formulation distribution functions: a review," 2021.Available: www.ijsdr.orgs.

[2] World bank Green National Highways Corridor Project Environmental Management Framework A Guidance Document to deal with Environmental Issues during Planning, Design and Construction of Roads Under the Project Revised Draft Version Ministry of Road Transport and Highways Government of India," 2019.

[3] K. Walia, R. K. Aggarwal, and S. K. Bhardwaj, "Environment Impact Assessment of Highway Expansion – A Review," Current World Environment, vol. 12, no. 3, pp. 507–519, Dec. 2017, Doi: 10.12944/CWE.12.3. 04..

[4] R. R. R. M. Rooshdi, N. A. Rahman, N. Z. U. Baki, M. Z. A. Majid, and F. Ismail, "An Evaluation of Sustainable Design and Construction Criteria for Green Highway," Procedia Environ Sci, vol. 20, pp. 180–186, 2014, doi: 10.1016/j.proenv.2014.03.024J. Schofield, "Case Study: Capital Gate, Abu Dhabi ," CTBUH Journal, no. II, pp. 13–17, 2012.

[5] A. das Mulmi, "Green Road Approach in Rural Road Construction for the Sustainable Development of Nepal," 2009

[6] S. I. Sarsam, "Sustainable and Green Roadway Rating System," International Journal of Scientific Research in Environmental Sciences, vol. 3, no. 3, pp. 99–106, Mar. 2015, doi: 10.12983/ijsres-2015-p0099-0106

[7] K. Nikumbh1 and P. D. Aher, "a review paper-study of green highway rating system," 2017. [Online]. Available: www.dot.ny.gov/progr/green

[8] S. T. Muench, J. Anderson, and T. Bevan, "Greenroads: A Sustainability Rating System for Roadways," 2010. [Online]. Available: www.greenroads.us

[9] J. Singh and D. A. K. Jain, "Development of Framework for Rating System for Indian Green Highways," American Journal of Engineering Research (AJER, no. 8, pp. 250–259, 2019, [Online]. Available: www.ajer.org

[10] J. W. Park and Y. H. Ahn, "Development of a green road rating system for South Korea," International Journal of Sustainable Building Technology and Urban Development, vol. 6, no. 4, pp. 249–263, Oct. 2015, doi: 10.1080/2093761X.2015.1117404

[11] Fatin Najwa Mohd Nusa, Intan Rohani Endut, Roshana Takim, and Siti Zaharah Ishak, "Green Highway for Malaysia: A Literature Review," Journal of Civil Engineering and Architecture, vol. 9, no. 1, Jan. 2015, doi: 10.17265/1934-7359/2015.01.008.

[12] D. Patel, "Design & construction of Green Highway in India considering the Sustainable Development Conference Paper · September 2020 citations 0 reads 77." [Online]. Available: https://www.researchgate.net/publication/359648551

[13] M. Bujang, M. R. Hainin, M. Z. Abd Majid, M. K. Idham Mohd Satar, and W. N. A. W. Azahar, "Assessment framework for pavement material and technology elements in green highway index," J Clean Prod, vol. 174, pp. 1240–1246, Jan. 2018, doi: 10.1016/j.jclepro.2017.11.002.

[14] W. N. Aifa, M. AbdMajid, R. MohamadZin, R. Zakaria, and M. Bujang, "Jurnal Teknologi Pavement Technology Elements in Green Highway," 2015. [Online]. Available: www.jurnalteknologi.utm.my

[15] N. A. Mustafa et al., "An Assessment of Green Rural Road Criteria and Elements for My Green Rural Road Index: A Case Study in Pengerang, Johor," in IOP Conference Series: Earth and Environmental Science, IOP Publishing Ltd, Feb. 2022. doi: 10.1088/1755-1315/971/1/012001.

[16] A. H. Ibrahim and M. A. Shaker, "Sustainability index for highway construction projects," Alexandria Engineering Journal, vol. 58, no. 4, pp. 1399–1411, Dec. 2019, doi: 10.1016/j.aej.2019.11.011.

[17] T. Mattinzioli, M. Sol-Sánchez, G. Martínez, and M. Rubio-Gámez, "A critical review of roadway sustainable rating systems," Sustainable Cities and Society, vol. 63. Elsevier Ltd, Dec. 01, 2020. doi: 10.1016/j.scs.2020.102447

[18] M. Minea and C. M. Dumitrescu, "On the Feasibility and Efficiency of Self-Powered Green Intelligent Highways," Energies (Basel), vol. 15, no. 13, Jul. 2022, doi: 10.3390/en15134693

[19] Y. Yan-Gang, X. Jian-Ping, Z. Ran, and L. Chen, "Research on evaluation index system of green highway in reconstruction and expansion projects," in E3S Web of Conferences, EDP Sciences, Jan. 2021. doi: 10.1051/e3sconf/202123301136.

[20] R. Szpotowicz and C. Tóth, "Revision of sustainable road rating systems: Selection of the best suited system for hungarian road construction using topsis method," Sustainability (Switzerland), vol. 12, no. 21, pp. 1–28, Nov. 2020, doi: 10.3390/su12218884.

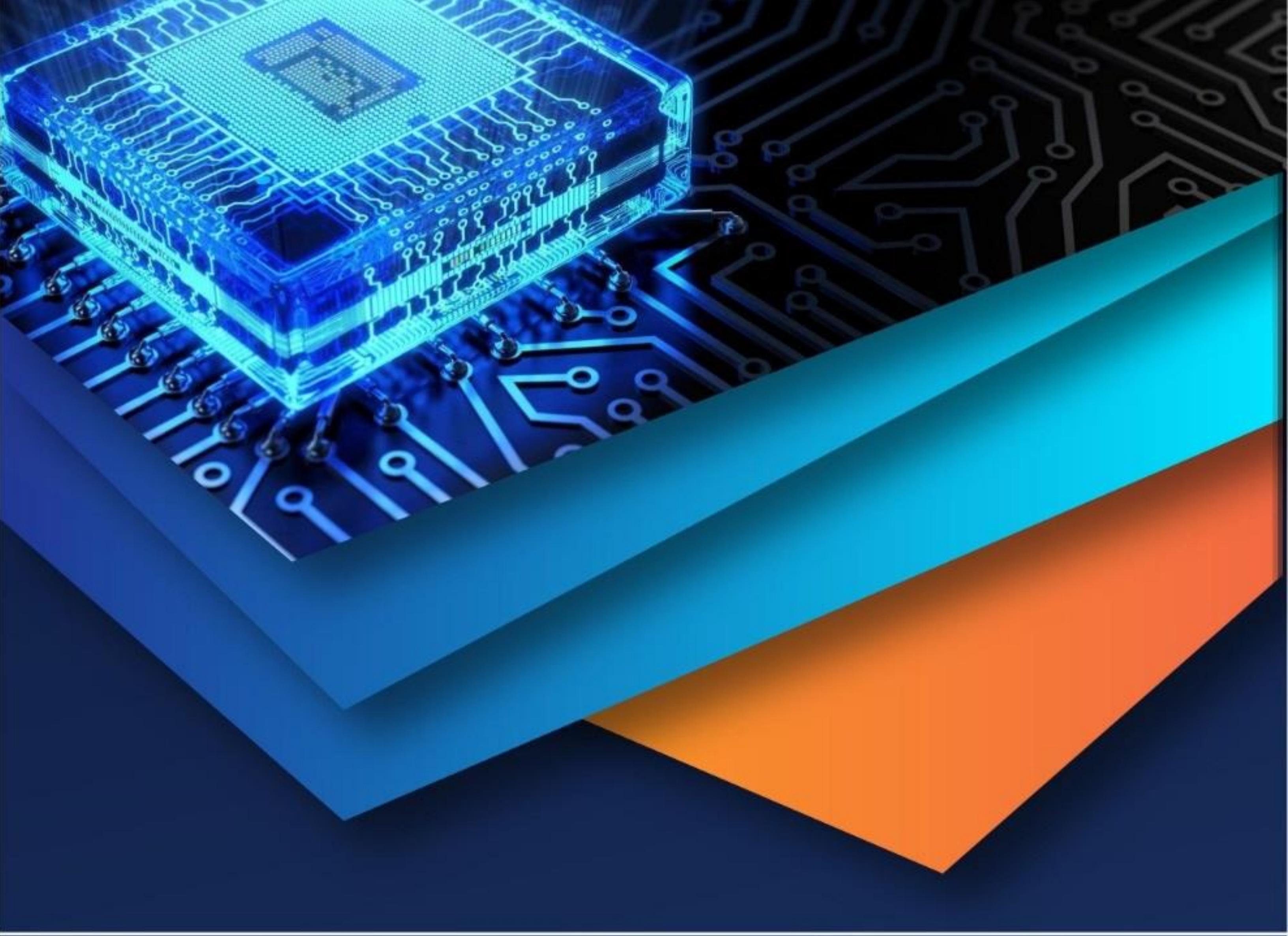
[21] A. Umer, K. Hewage, H. Haider, and R. Sadiq, "Sustainability assessment of roadway projects under uncertainty using Green Proforma: An index-based approach," International Journal of Sustainable Built Environment, vol. 5, no. 2, pp. 604–619, 2016, doi: 10.1016/j.ijsbe.2016.06.002.

[22] N. Zabihi and M. Saafi, "Recent developments in the energy harvesting systems from road infrastructures," Sustainability (Switzerland), vol. 12, no. 17, Sep. 2020, doi: 10.3390/SU12176738.

[23] Kim, J.-O., & Mueller, C. W. (1978). Factor Analysis: Statistical Methods and Practical Issues. Sage Publications.

[24] Hays, W. L. (1994). Statistics. Holt, Rinehart, & Winston.

[25] Jolliffe, I. T. (2002). Principal Component Analysis. Springer.



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