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Decision Making for Site Selection Using Fuzzy Modelling

Tejaswini Potdar[1], Yogita Fulse[2]
[1, 2]Civil Department, Sandip University

***Abstract:** We know nowadays selection of appropriate site for any project is influenced by several factors that can be ecological and environmental awareness, social acceptance of land development activity, geological factors and many more. And selection of land is considered as very important phase of whole process of land development. Many times we see that number of experienced decision makers makes decision for site selection randomly on the basis of prior experiences, But due to numerous factors influence the choice of site selection some times decision may go wrong when took randomly. Hence the scope of this paper deals with formulating a preliminary model for primary site selection of the residential building and then developing an support system that can be used by decision makers for site selection. Which complies the large data required to take the decision. F-AHP uses a hierarchical structure comprising factors that are based on factual data and the knowledge and experience of the decision makers. This data was collected by conducting a questionnaire survey amongst the decision makers.*
***Keywords:** F-AHP (triangular fuzzy scale), Residential project, Site selection, decision makers, Fuzzy logic*

I. INTRODUCTION

The selection of site is foremost thing that has to considered before commencement of any project. The factors that influence the process of site selection can physical factors, economical factors, environmental factors, geological factors. Despite having all the data the decision makers make the decision based on there gut feelings and experiences, reason behind this is the data is very complex and not in proper format which can be help full for the decision makers to take the quick decision. Hence to make multi criteria decision easy, We are trying to implement Fuzzy-Analytical Hierarchy Process. Fuzzy-Analytical Hierarchy Process method is one of the best methodology based on triangular fuzzy scale. It is used to solve the Multi Criteria Decision Making problems (MCDM).

II. FUZZY-ANALYTICAL HIERARCHY PROCESS

F-AHP enables evaluation of MCDM and uses triangular fuzzy scale. F-AHP is an analytical approach that provides measurement and assessment using pairwise comparison between criteria and then alternatives, developed by Thomas Saaty. FAHP helps to provide a mechansim that helps the decision makers to reduce confusion and baisness in decision making. Here by using F-AHP method we proposed new method for safety impact factors selection problem. By considering different residential projects in city, knowledge of the project manager. In simple words we can say that that this mechanism consist of objective, criteria and alternatives levels and each criteria is divided in sub-criteria. And we give priority weights to each criteria, then by doing pair-wise comparison weights are given to each alternative and then final site selection is done.

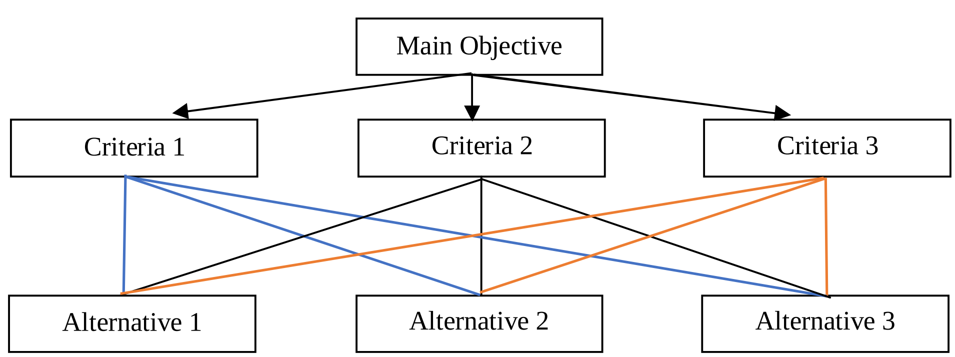

Fig. 1 F-AHP Hierarchy Model [1]

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A. Criteria

Criteria for F-AHP which was decided on the basis of interviews taken of various decision makers, project managers and knowledgeable persons. And further those criteria were considered while application of F-AHP model for site selection of residential project.

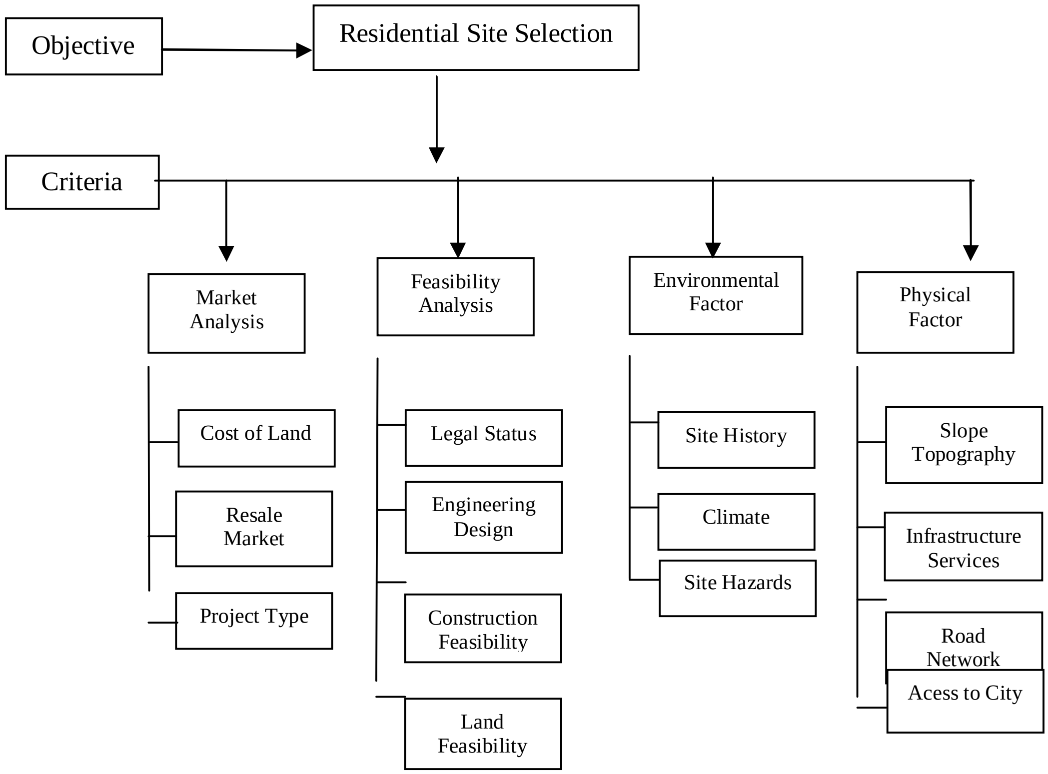

Fig.2 Hierarchy of Criteria

III.FUZZY ANALYTICAL HIERARCHY MODEL (F-AHP)

1) Step 1-Compare each factor in the F-AHP hierarchy. Decision makers use the fuzzy scale to compare factors shown in Table for criteria and alternatives. The data collected by decision makers is used to make comparison.

TABLE I

LINGUISTIC TERMS AND THE CORRESPONDING TRIANGULAR FUZZY NUMBERS[1]

Saaty Scale (Score)	Scale of Relative Imporatance	Fuzzy Triangular Scale
1	Equally Important	(1,1,1)
3	Weakly Important	(2,3,4)
5	Fairly Important	(4,5,6)
7	Strongly Important	(6,7,8)
9	Absolutey Important	(9,9,9)
2	The intermittent values between two adjacent scales	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

According to knowledge of decision maker select the scale and respective fuzzy triangular scale. For example if criteria 1 is weakly important than criteria 2 then it will have score as 3 and hence fuzzy triangular scale as (2,3,4) and if vice versa than (1/2,1/3,1/4).

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2) Step 2-According to averaged preferences, pair wise contribution matrices is prepared.
3) Step 3-According to Buckley, the geometric mean of fuzzy comparison values (ri) of each criteria is calculated. It still represents triangular values.
4) Step 4-The fuzzy weight of each criteria is found by
a) Finding vector summation of each fuzzy value
b) Find (-1) power of summation vector and arrange in increasing order.

5) Step 5-The fuzzy weight of quality criteria is found by multiplying each relative weight with values arranged in increasing order.
6) Step 6-The relative non-fuzzy weight of each criteria is calculated by taking average of fuzzy numbers for each criteria.
7) Step 7-By using non-fuzzy weight normalized weights of each criteria is calculated.
8) Step 8-Weight of alternatives is calculated with respect to each criteria.

IV. APPLICATION OF FUZZY ANALYTICAL HIERARCHY MODEL

Questionnaire survey was carried out among project managers, contractors, owners, small construction firms which are located in Nashik district of Maharashtra. This firms majorly works in residential project. Survey was carried face to face and through online forms. Here we have selected four alternatives sites in Nashik District of Maharashtra for residential building construction. And by using F-AHP best alternative will selected with highest normalized weight for residential site construction.

TABLE II
PAIRWISE COMPARISON OF MAIN CRITERIA

	MA	FA	EF	PF
MA	(1,1,1)	(1,1,1)	(1/9,1/9,1/9)	(4,5,6)
FA	(1,1,1)	(1,1,1)	(1,1,1)	(6,7,8)
EF	(9,9,9)	(1,1,1)	(1,1,1)	(6,7,8)
PF	(1/4,1/5,1/6)	(1/6,1/7,1/8)	(1/6,1/7,1/8)	(1,1,1)

Geometric mean of Fuzzy comparison values (ri)
MA= (1x1x1/9x4)1/4; (1x1x1/9x5)1/4; (1x1x1/9x6)1/4 = 0.816,0.863,0.903
FA= (1x1x1x6)1/4; (1x1x1x7)1/4; (1x1x1x8)1/4 = 1.56,1.626,1.681
EF= (9x1x1x6)1/4; (9x1x1x7)1/4; (9x1x1x8)1/4 = 2.710,2.817,2.912
PF= (1/4x1/6x1/6x1)1/4; (1/5x1/7x1/7x1)1/4; (1/6x1/8x1/8x1)1/4= 0.28,0.252,0.22

TABLE III
RELATIVE WEIGHTS

Criteria	ri		
MA	0.816	0.863	0.903
FE	1.56	1.626	1.681
EF	2.710	2.817	2.912
PF	0.288	0.252	0.225
Total	5.374	5.558	5.721
Power of -1	0.186	0.179	0.174
Increasing order	0.174	0.179	0.186

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TABLE IV
FUZZY WEIGHTS OF EACH CRITERIA (WI)

Criteria	Wi		
MA	0.147	0.154	0.167
FA	0.271	0.291	0.312
EF	0.471	0.504	0.541
PF	0.05	0.045	0.041

TABLE V
NON-FUZZY WEIGHT AND NORMALISED WEIGHT

Criteria	Mi	Ni
MA	0.156	0.156
FA	0.291	0.291
EF	0.508	0.508
PF	0.045	0.045

Level 2 - Determining the weight of each aletrnative with respect to each criteria

1) Criteria- Market Analysis

TABLE VI
PAIR-WISE COMPARISON

Market Analysis	Site 1	Site 2	Site 3	Site 4
Site 1	(1,1,1)	(1/5,1/6,1/7)	(1/7,1/8,1/9)	(1,1,1)
Site 2	(5,6,7)	(1,1,1)	(1/4,1/5,1/6)	(5,6,7)
Site 3	(7,8,9)	(4,5,6)	(1,1,1)	(7,8,9)
Site 4	(1,1,1)	(1/5,1/6,1/7)	(1/7,1/8,1/9)	(1,1,1)

TABLE VII
RELATIVE WEIGHTS

Market Analysis	ri		
Site 1	0.411	0.379	0.354
Site 2	1.581	1.638	1.690
Site 3	3.741	4.229	4.695
Site 4	0.411	0.379	0.354
Total	6.144	6.625	7.093
Power of -1	0.162	0.150	0.140
Increasing order	0.140	0.150	0.162

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TABLE VII
FUZZY WEIGHTS OF EACH CRITERIA (WI)

Market Analysis	Wi		
Site 1	0.057	0.056	0.057
Site 2	0.221	0.245	0.273
Site 3	0.523	0.634	0.760
Site 4	0.057	0.056	0.057

TABLE IX
NON-FUZZY WEIGHT AND NORMALISED WEIGHT

Market Analysis	Mi	Ni
Site 1	0.056	0.057
Site 2	0.246	0.249
Site 3	0.639	0.635
Site 4	0.056	0.057

2) Criteria- Feasibility Analysis

TABLE X
PAIR-WISE COMPARISON

Feasibility Analysis	Site 1	Site 2	Site 3	Site 4
Site 1	(1,1,1)	(1/6,1/7,1/8)	(1/9,1/9,1/9)	(1,1,1)
Site 2	(6,7,8)	(1,1,1)	(1/4,1/5,1/6)	(5,6,7)
Site 3	(9,9,9)	(4,5,6)	(1,1,1)	(7,8,9)
Site 4	(1,2,3)	(1/5,1/6,1/7)	(1/7,1/8,1/9)	(1,1,1)

TABLE XI
RELATIVE WEIGHTS

Feasibility Analysis	ri		
Site 1	0.368	0.354	0.343
Site 2	1.654	1.702	1.747
Site 3	3.987	4.355	4.695
Site 4	0.411	0.379	0.354
Total	6.420	3.790	7.139
Power of -1	0.155	0.263	0.140
Increasing order	0.140	0.155	0.263

TABLE XII
FUZZY WEIGHTS OF EACH CRITERIA (WI)

Feasibility Analysis	Wi		
Site 1	0.051	0.054	0.090
Site 2	0.231	0.263	0.459
Site 3	0.558	0.675	1.234
Site 4	0.057	0.028	0.093

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TABLE NO XIII
NON-FUZZY WEIGHT AND NORMALISED WEIGHT

Feasibility Analysis	Mi	Ni
Site 1	0.065	0.051
Site 2	0.317	0.250
Site 3	0.822	0.650
Site 4	0.059	0.046

3) Criteria- Environmental Factor

TABLE XIV
PAIR-WISE COMPARISON

Environmental Factor	Site 1	Site 2	Site 3	Site 4
Site 1	(1,1,1)	(1/1,1/2,1/3)	(1/5,1/6,1/7)	(1,1,1)
Site 2	(1,2,3)	(1,1,1)	(1/4,1/5,1/6)	(3,4,5)
Site 3	(5,6,7)	(4,5,6)	(1,1,1)	(4,5,6)
Site 4	(1,1,1)	(1/3,1/4,1/5)	(1/4,1/5,1/6)	(1,1,1)

TABLE XV
RELATIVE WEIGHTS

Environmental Factor	ri		
Site 1	0.668	0.537	0.467
Site 2	0.930	0.945	0.955
Site 3	2.990	3.499	3.984
Site 4	0.537	0.472	0.427
Total	5.125	5.453	5.833
Power of -1	0.195	0.183	0.171
Increasing order	0.171	0.183	0.195

TABLE XVI
FUZZY WEIGHTS OF EACH CRITERIA (WI)

Environmental Factor	Wi		
Site 1	0.114	0.098	0.091
Site 2	0.159	0.172	0.186
Site 3	0.511	0.640	0.776
Site 4	0.091	0.086	0.083

TABLE NO XVII
NON-FUZZY WEIGHT AND NORMALISED WEIGHT

Environmental Factor	Mi	Ni
Site 1	0.101	0.1008
Site 2	0.172	0.171
Site 3	0.642	0.641
Site 4	0.086	0.085

4) *Criteria- Physical Factor*

TABLE XVIII
PAIR-WISE COMPARISON

Physical Factor	Site 1	Site 2	Site 3	Site 4
Site 1	(1,1,1)	(1/7,1/8,1/9)	(1/9,1/9,1/9)	(1/2,1/3,1/4)
Site 2	(1/7,1/8,1/9)	(1,1,1)	(1/2,1/3,1/4)	(5,6,7)
Site 3	(9,9,9)	(2,3,4)	(1,1,1)	(5,6,7)
Site 4	(2,3,4)	(1/5,1/6,1/7)	(1/5,1/6,1/7)	(1,1,1)

TABLE XIX
RELATIVE WEIGHTS

Physical Factor	ri		
Site 1	0.298	0.260	0.235
Site 2	1.654	1.702	1.747
Site 3	3.984	4.355	4.695
Site 4	0.411	0.379	0.354
Total	6.347	6.696	7.031
Power of -1	0.157	0.149	0.142
Increasing order	0.142	0.149	0.157

TABLE XX
FUZZY WEIGHTS OF EACH CRITERIA (WI)

Physical Factor	Wi		
Site 1	0.042	0.038	0.036
Site 2	0.234	0.253	0.274
Site 3	0.565	0.648	0.737
Site 4	0.058	0.056	0.055

TABLE XXI
NON-FUZZY WEIGHT AND NORMALISED WEIGHT

Physical Factor	Mi	Ni
Site 1	0.0386	0.0386
Site 2	0.2536	0.2539
Site 3	0.6500	0.6509
Site 4	0.0563	0.0563

TABLE XXII
WEIGHT OF EACH ALETRNATIVE W.R.T EACH CRIETRIA

	MA (0.156)	FE (0.291)	EF (0.508)	PF (0.045)
Site1(MA)	0.057			
Site2(MA)	0.249			
Site3(MA)	0.635			
Site4(MA)	0.057			
Site1 (FE)		0.051		
Site2 (FE)		0.250		
Site3 (FE)		0.650		
Site4 (FE)		0.046		
Site1 (EF)			0.1008	
Site2 (EF)			0.171	
Site3 (EF)			0.641	
Site4 (EF)			0.085	
Site1 (PF)				0.0386
Site2 (PF)				0.2539
Site3 (PF)				0.6509
Site4 (PF)				0.0563

TABLE XXIII
FINAL WEIGHTS OF EACH ALTERNATIVE

Alternatives		Final Weight
Site 1	(0.057x0.156) + (0.051x0.291) + (0.1008x0.508) + (0.0368x0.045)	0.0765
Site 2	(0.249x0.156) + (0.250x0.291) + (0.171x0.508) + (0.0386x0.045)	0.2001
Site 3	(0.635x0.156) + (0.650x0.291) + (0.641x0.508) + (0.6509x0.045)	0.6430
Site 4	(0.057x0.156) +(0.046x0.291) + (0.085x0.508) + (0.0563x0.045)	0.0679

IV. CONCLUSIONS

The objective of this study is to identify, compare and define the optimization of site selection that leads to economical factor and safe use of workers and ultimately the site success in the construction industry. And major three objectives were 1.To determine various criteria for selection of site of residential project.2.To decide the impact of various factors responsible for site selection of residential project by using FAHP modelling.3.And finally suggesting best alternative.

Hence from the research we conclude that-

1) Determined various criteria for site selection of residential buildings. Environmental factors, Physical factors, Market analysis, Feasibility Analysis are most important factors considered while selecting site for any residential project.
2) Determined relative importance of each factors and score was given to each factors with pair wise comparision of each factor. And application of F-AHP model was done.
3) According to ranking of each alternative, Alternative 3 have highest weightage. Hence alternative 3 is best suited site for residential project

V. ACKNOWLEDGMENT

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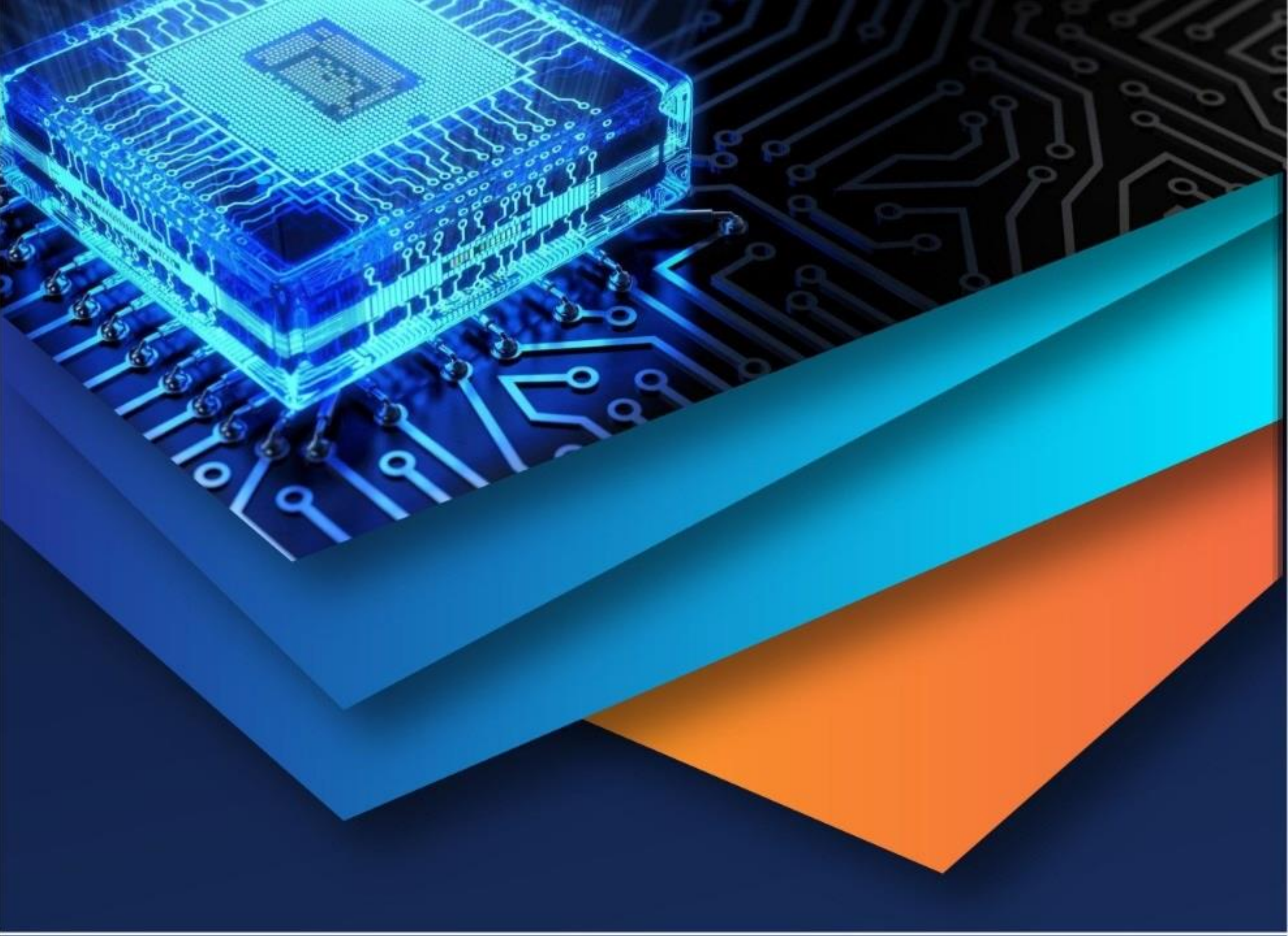

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