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Earthquake Resistant Design & Comparison of (G+7) OMRF Building at Meerut by Using Equivalent Lateral Force & Response Spectrum Method

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Abstract: ***Earthquake is a type of disaster which causes of all damages and great impact on the living human, material lifeline and buildings. We cannot stop the earthquake shaking but we can easily reduce the effects of earthquake. So we use the techniques of earthquake resistant structures before the construction. Earthquake lateral force analysis is mostly done for seismic structures which are useful for analyze the forces acted on buildings during the earthquakes. In this thesis the analysis of seismic design structures to be built at the zone IV (Meerut) location. The research work mainly focused on the comparison of earthquake lateral forces of (G+7) buildings. This is beneficial for future work of OMRF buildings which are well planned of upcoming needed.***

The earthquake lateral forces act on whole building is carried out by the use of Equivalent static and Response spectrum method as per IS 1893(Part-1): 2002 for the IV zone. This comparative study is also beneficial for regular and irregular building because both method static and dynamic method well used. The most parameters to be find this comparative study to observe the seismic conduct of zone IV. And the response is read from the design of response spectrum and it gives the natural frequency of the structures which is calculated by the building code. The applied modification factor reduces the design forces (e.g. force reduction factor). The results performance and analysis of the structures are represented by numerically and theoretically.

The shear forces and lateral forces are obtained by the use these methods for regular or irregular buildings.

Keywords: Equivalent static method, Response spectrum method, Base shear, lateral forces, IS 1893: 2002 (Part-1)

I. INTRODUCTION

Mostly we know about the earthquake and have personally experienced. Earthquake is shaking of earth i.e. the causes of earthquake. When earthquake have come then the structures starts trembling i.e. natural vibration of earth crust. Earthquake also caused great disasters in the form of destroy to all thing which present on earth planet. The most powerful outline for well develop of seismic safe structure significantly more prominent in this zone because of quick improvement and grouping of population in urban areas. A subset of analysis is seismic analysis.

Currently, we are comparative study about the methods of linear analysis i.e. equivalent lateral force method and response spectrum method which is much suitable for computing the design lateral force for the building as a whole. These forces shall be distributed to all floor levels. This is focused on these two methods which are-

A. Equivalent Lateral Force Method

Seismic analogy is the most structures still outline on the assumptions that the horizontal (lateral) force is equivalent to the real loading (dynamic). This method requires less effort because except for the fundamental natural periods and natural modes of ground shaking is not required. The base shear which is the net horizontal force on the structure and calculated by the mass of building, fundamental natural periods of vibration and modes shape. The base shear is distributed with the height of buildings in the form of seismic forces based on the code formulae. This is mostly use in the conservation for the low to medium height of buildings with a regular approval. Equivalent static lateral force analysis is based on the following assumptions:-

1) Assume that the structure is rigid.
2) Assume perfect fixity between structure and foundation.
3) During ground motion every point on the structure experience same accelerations.
4) Dominant effect of earthquake is equivalent to horizontal force of varying magnitude over the height.

5) Approximately determines the total horizontal (Base Shear) on the structure.
6) *Limitations of Equivalent Static Lateral Force Analysis*

B. Response Spectrum Method

Response spectrum method stands from modal method or mode superposition method. It is most suitable for the type of structure where modes fundamental single importantly influencing the response of the building. Basically this method is use for the dynamic analysis of building. It has broadly areas of discontinuity or irregularity i.e. as symmetrical. It is available for the analysis of forces and deformations in the multi-story buildings cause of avg. intensity ground shaking which is related to the moderately huge but in linearly response in the buildings. In its form, this method for linear response is suitable to arbitrary 3-D structures. A complete modal analysis defines the history of responses. The complete history of responses is must needed for designing.

The method used to attach the results in the Response spectrum method which is more critical to obtain the accurate values. In the analysis, when every effective mode used then the appropriate technique most probable for combining the result. In which the method Square-root-of-sum-of –square method mostly used because in which the simply squares sum of all own results and after that takes the square root of the result. And also most accurate technique is CQC (complete quadratic combination). In which the spectral results using for damping and weight ratio of relative frequencies. The concept is a dynamic analysis into partly static and partly dynamic for finding the maximum displacement. Is restricted only to a single mode of vibration of structure

1) *Assumptions for Response Spectrum Method:* Seismic analysis based on the modal analysis or response spectrum method. Whole information of data defined the same path as in response spectrum or modal analysis. Additional parameters required by a specific national code to establish the response spectrum shape must be particularized. Calculations and results are the same as those for spectral analysis. In include with the results got the modal analysis, for everyone Eigen form the seismic analysis provides the following values-
7) Seismic innervation multiplier (value of the acceleration excitation spectrum).
8) Seismic or modal participation factor calculated.
9) Seismic mode coefficients in the form of seismic excitation factor and several seismic participation factor for everyone dynamic degree of freedom.
10) In this the most (peak) responses of building at that time of earthquake is directly obtained from design responses spectrum.
11) This procedure gives an approximate peak response and this is also too well for building design applications. Different types of modes of responses of a building to an earthquake given to account.
12) Story shear forces and lateral forces at each story shall be considered.
13) The external loads generated according to the seismic method assumptions.
14) The complete response history is mostly needed for design; the maximum values of response over the periods of earthquake usually suffice.

C. Errors in Evaluation of Response Spectrum Method

The following errors are introduced in evaluation of response spectra –

1) Straight Line Approximation
2) Truncation or Shortage of Error
3) Error due to Rounding the Time Record
4) Error due to discretization

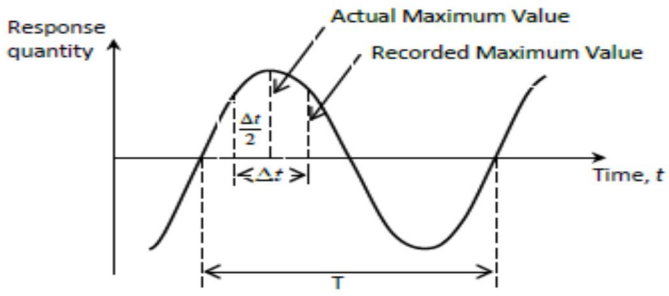

Fig.1 Error in response spectra due discretization

II. METHODOLOGY

The research objectives are intended to be achieved by conducting the following steps;

A. The comparative study of two methods and review available researches related to the subject of this paper.
B. Establish the structural model process for multi-story buildings using the earthquake lateral force methods and response spectrum method.
C. Expose the structure to specific seismic load and analyze it by the static force method.
D. Expose the structure to identical seismic load and analyze it by a dynamic analysis.
E. To compare the results of response spectrum method using the most accurate technique known as the Complete Quadratic Combination (CQC) method; this is also calculating the seismic forces.
F. Collection the outputs from these methods.
G. Come up with recommendations related to the use of two methods and based on the obtained results.

III. PROBLEM DESCRIPTION

A (G+7) story RC building is to be constructed in an area of seismic Zone IV having hard soil. The plan dimension of the building is 15m x 20m with story height of 3.6m. Determine the base shear as per the IS: 1893-2002 (Part 1) code. Use both Equivalent Static force method and Response Spectrum Method. Take the inter-story lateral stiffness of floors i.e. $k_1 = k_2 = k_3 = k_4 = 671.52 \times 106$ N/m and $k_5 = k_6 = k_7 = k_8 = 335.76 \times 106$ N/m. The loading on the floors shall be taken as:

Roof:

Self-weight + Dead Load = 5 KN/m^2
Live Load = 1.5 KN/m^2

Floors:

Self-weight + Dead Load = 10 KN/m^2
Live Load = 4 KN/m^2

A. Equivalent Lateral Force Method

In this method the lateral forces and story shear forces can be easily calculated because any same type of problem based on only formulae. These formulae is taken from the IS code 1893: 2002. This is too much help for calculating the seismic forces. Here, we draw the table of lateral shear forces and story shear forces which obtained through the IS code (part -1)1893: 2002.

TABLE 1
Values of Base Shear at Various Floor Level by Equivalent Lateral Force Method

Floor/Roof	h_i(m)	W_i(kN)	$W_i h_i^2/\Sigma W_i h_i^2$	Q_i(kN)	Base Shear, $[V_i]$ (kN)
Roof	28.8	1500	0.16	183.27	183.27
7	25.2	3600	0.294	336.75	520.02
6	21.6	3600	0.216	247.41	767.43
5	18	3600	0.15	171.81	939.25
4	14.4	3600	0.096	109.96	1049.21
3	10.8	3600	0.054	61.85	1111.06
2	7.2	3600	0.024	27.49	1138.55
1	3.6	3600	0.006	6.87	1145.42

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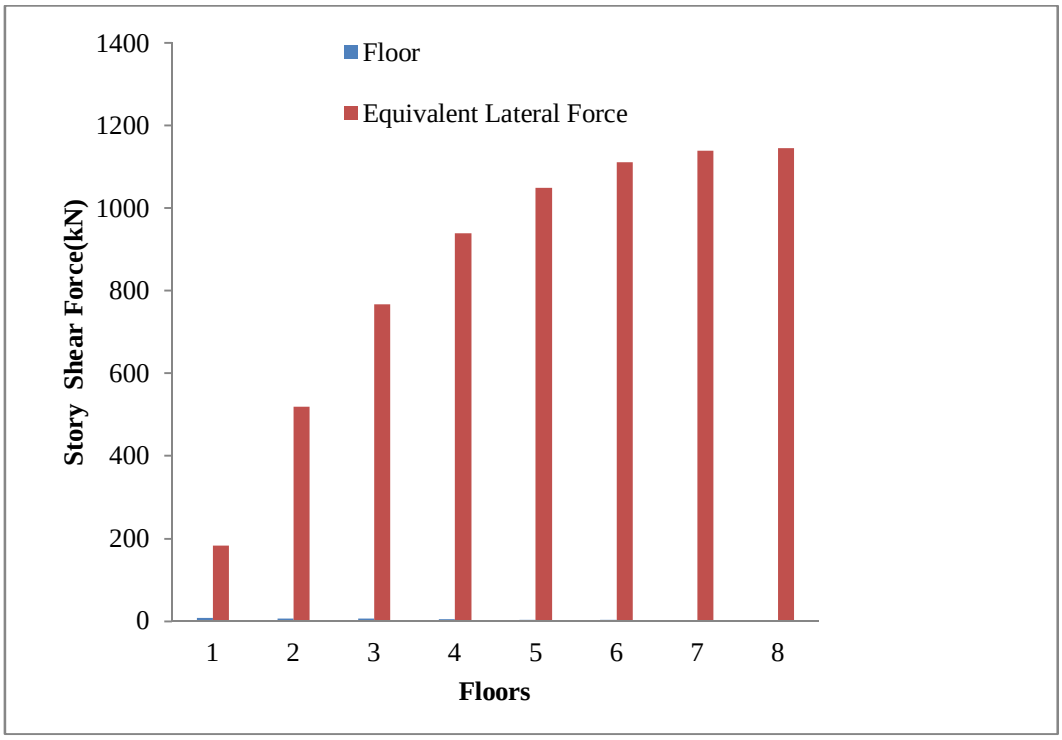

Fig. 2 Story shear Forces by Equivalent lateral method

B. Response Spectrum Method

The same may be used for the design at the discretion of the project authorities. It is also code based analysis i.e. IS code 1893:2002. The seismic forces also represented in given below table up to down respectively. The responses of different modes are combined to distribute the estimate of total response of the building. By the use of SRSS and CQC in the comparison table shows the all forces to obtain.

TABLE 2
Values of Base Shear at Various Floor Level by Response Spectrum Method

Floor/Roof	Height h_i (m)	Lateral Forces Q_i(KN)	Base Shear V_i(KN)
Roof	28.8	140.70	140.70
7	25.2	283.89	424.50
6	21.6	205.95	629.55
5	18	143.37	772.93
4	14.4	105.70	878.65
3	10.8	109.45	988.08
2	7.2	96.08	1084.21
1	3.6	61.16	1145.40

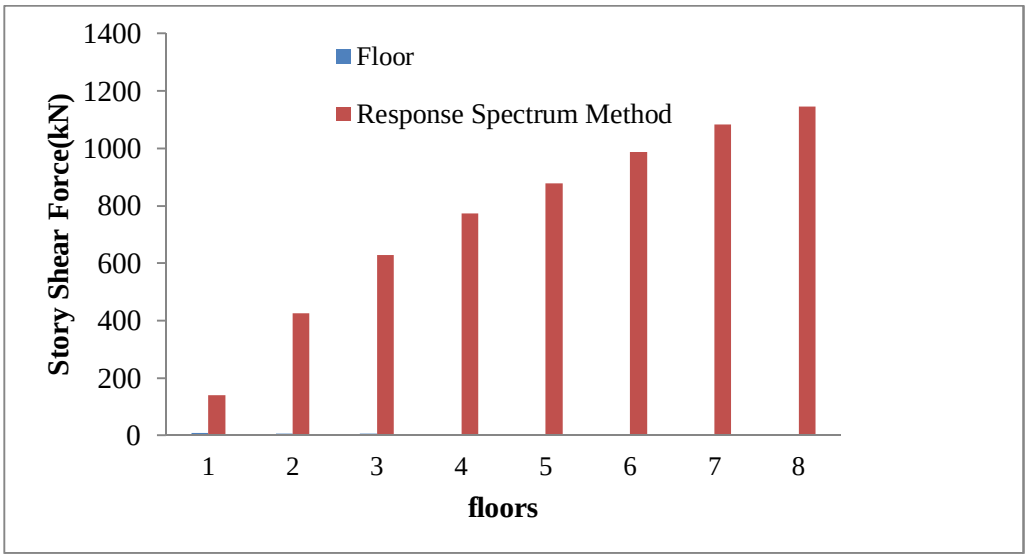

Fig. 3 Story shear Forces by Response Spectrum Method

C. Complete Quadratic Combination (CQC) Method

The method used for to combine results in the response spectrum method is also critical to obtaining the correct answer. The results for each of the effective modes used in the analysis must be combined using an appropriate technique. The method most commonly used is the square-root-of-sum-of-square (SRSS) method. This simply sums the squares of all of the individual spectral results and then takes the square root of the result. The most accurate technique is known as the Complete Quadratic Combination (CQC) method which is also calculating the seismic forces. Here, we compared this approach to other methods which are represented in table. The values of lateral forces and story shears we obtained by these methods. Hence we compared CQC methods also to draw a table which is as –

TABLE 3 Comparison of Methods

Floor/Roof	Equivalent Static Method		Response Spectrum Method		CQC Method	
	Q_i(KN)	V_i(KN)	Q_i(KN)	V_i(KN)	Q_i(KN)	V_i(KN)
Roof	183.27	183.27	140.70	140.71	136.65	136.65
7	336.75	520.02	283.89	424.50	288.59	425.24
6	247.41	767.43	205.05	629.55	192.58	617.82
5	171.81	939.25	143.37	772.93	152.25	770.07
4	109.96	1049.21	105.70	878.66	98.56	868.63
3	61.85	1111.06	109.45	988.09	115.25	983.88
2	27.49	1138.55	96.08	1084.22	86.52	1070.4
1	6.87	1145.42	61.16	1145.40	72.54	1144.94

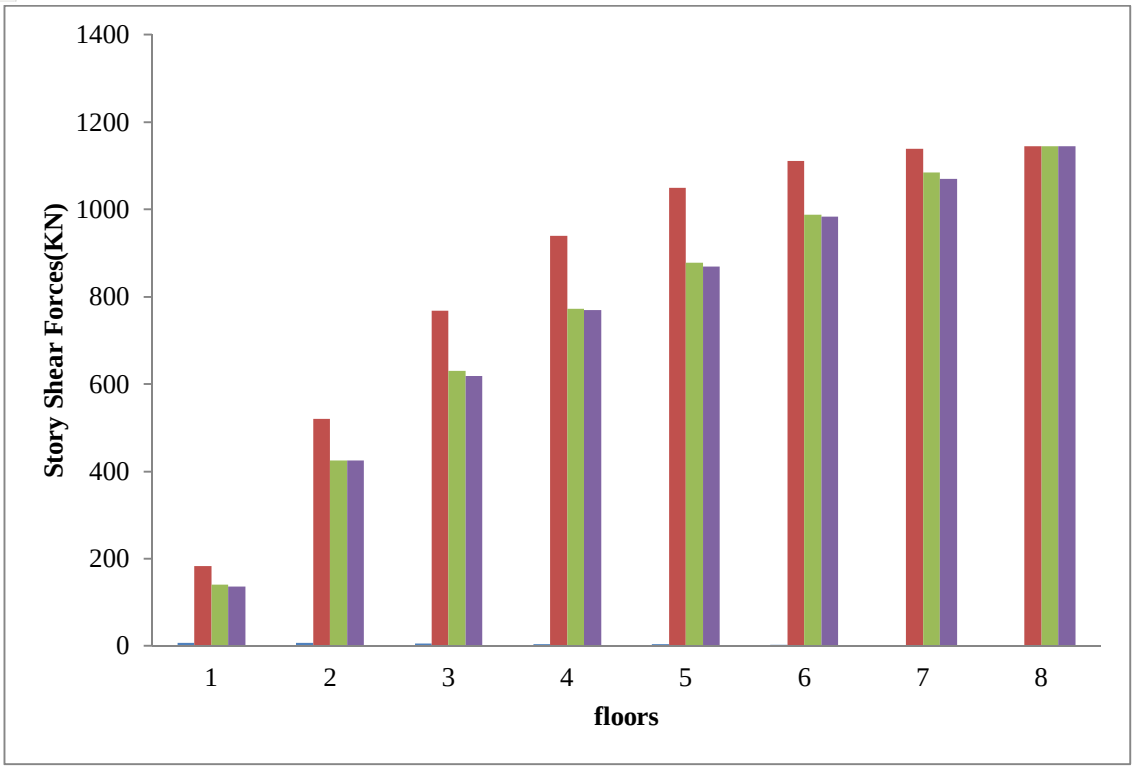

Fig. 4 Graphical Comparison of Equivalent Lateral Force, Response Spectrum & CQC Method

IV. CONCLUSIONS AND FUTURE SCOPE

A. *Conclusions*

In this paper, the analysis of regular and irregular (G+7) story buildings have been carried out by using the earthquake lateral force i.e. Equivalent Static method and Response Spectrum method. After that the results of these methods obtained and compared with the most accurate technique is known as the Complete Quadratic Combination (CQC) method together easily. This also includes the main properties shown from the comparison of methods.

Followings are the main points:

1) The earthquake lateral force analysis i.e. Equivalent lateral method gives most conservative result relative to the Response spectrum method.

2) By comparison of both methods equivalent lateral force varies on the computations of natural periods and basic formulae for carried out the forces. On the other hand response method or modal method varies on the mode shapes, frequencies and fundamental periods of the different mode of ground motion.

3) Response spectrum method is more suitable for the building with regular distribution of mass and stiffness with extra height.

4) On comparison we found that the base shear force at top floor using response spectrum method is reduced by 23.22 % lesser than equivalent lateral force method.

5) We have also obtained the percentage reduction of base shear forces at floors 7^{th},6^{th},5^{th},4^{th},3^{rd},2^{nd} and 1^{st} by using response spectrum method as compare to the equivalent method are 18.36%,17.96%,17.70%,16.25%,11.06%,4.77% and 2% respectively.

6) Using complete quadratic combination method the percentage reduction of base shear forces at floors 8^{th},7th,6^{th},5^{th},4^{th},3^{rd},2^{nd} and 1^{st} by using response spectrum method as compare to the equivalent lateral force methods are 25.43%,18.22%,19.49%,18.01%,17.21%,11.44%,5.98% and 0.04% respectively.

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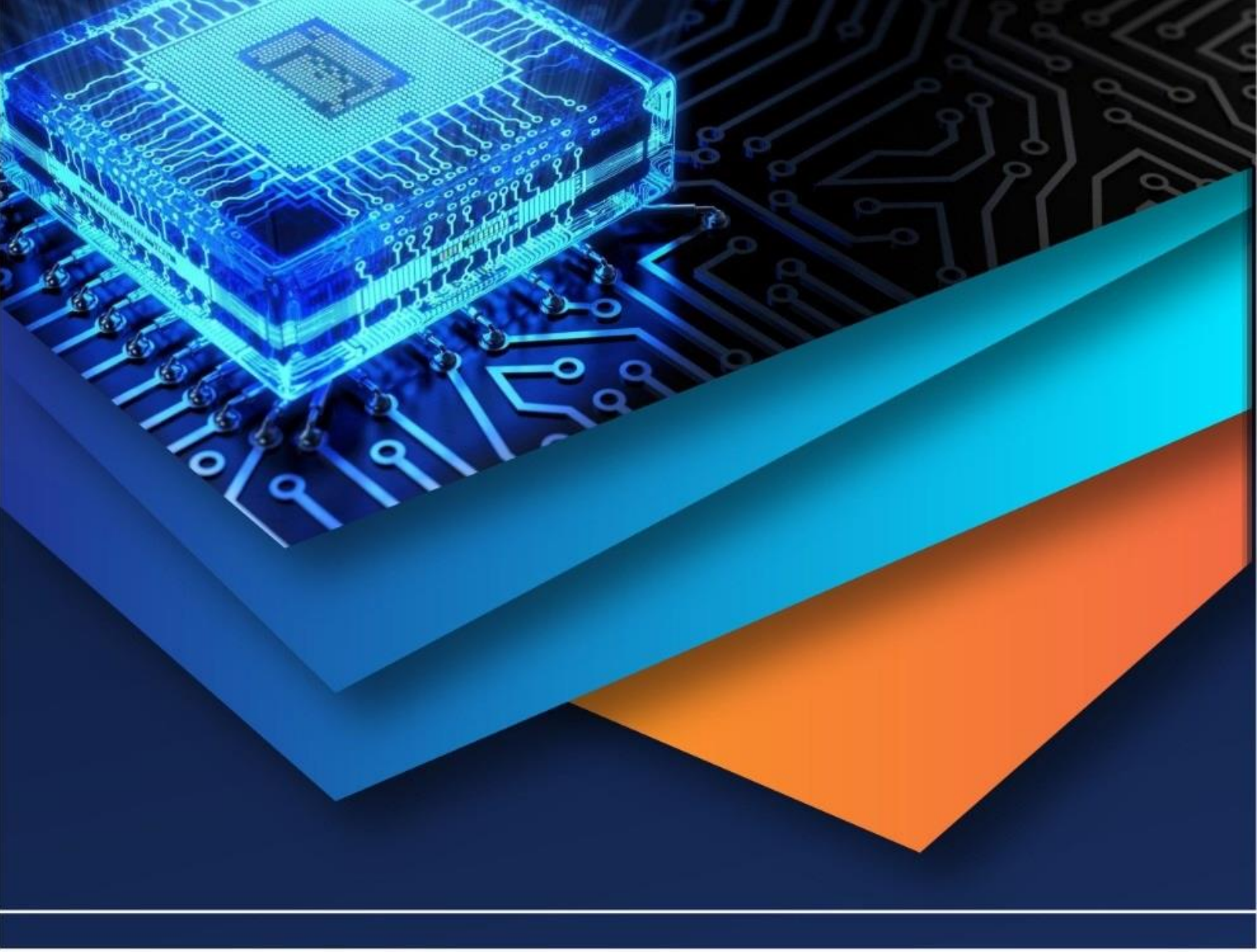

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