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# Comparative Analysis of Multi Storey Buildings with Seismic and Pushover Methods

Chetan Sharma[1], R. K. Dixit[2]
[1]*Student, Civil Engineering, NITTTR Bhopal, Rajiv Gandhi Technical University*
[2]*Professor, Civil Engineering, NITTTR Bhopal, Rajiv Gandhi Technical University*

***Abstract:** With the immense loss of life and property witnessed in the last couple of decades alone in India, due to failure of structures caused by earthquakes, attention is now being given to the evaluation of strength in framed steel structures to resist strong ground motions. Pushover analysis has been the favoured method for seismic performance evaluation due to its simplicity. It is a static analysis that directly incorporates nonlinear material characteristics.*

***The structure has been evaluated using equivalent static analysis & pushover Analysis, the latter is a non-linear static procedure, which may be considered as a series of static analysis carried out to develop a pushover curve for the building. The pushover curve is generated by pushing the top node of structure to the predefined base shear and setting appropriate performance criteria. The roof displacement and the base shear for the structure is calculated by the linearization of the obtained pushover curve according to ASCE 41-06. In this project work, a comparative study has been carried out between equivalent static analysis and pushover analysis with the help of structural analysis and design program (STAAD.Pro V8i). Analysed results have been compared with bending moment, shear force, maximum displacement and story displacement.***

***Keywords**: Pushover analysis, Seismic analysis, base shear, bending moment, shear force.*

## I. INTRODUCTION

The term earthquake can be used to describe any kind of seismic event which may be either natural or initiated by humans, which generates seismic waves. Earthquakes are caused commonly by rupture of geological faults; but they can also be triggered by other events like volcanic activity, mine blasts, landslides and nuclear tests. An abrupt release of energy in the Earth's crust which creates seismic waves results in what is called an earthquake. The buildings which do not fulfil the requirements of seismic design, may suffer extensive damage or collapse if shaken by a severe ground motion. The seismic evaluation determines the seismic capacity of buildings vulnerable to the earthquake for the future use. The methods for seismic evaluation are based on the background data of the building and its location on the zones of earthquake, which requires some or few documents like drawings, visual inspection report, past performance of the analogous buildings under seismic activities, and certain destructive and non-destructive test results. The analytical methods for evaluation are focused on the consideration of the ductility and capacity of buildings on the basis of drawings which are available

### *A. Pushover Analysis*

Pushover analysis is an estimated analysis method where the structure is subjected to different monotonically increasing lateral forces, which is distributed height-wise invariantly, until the defined base shear or target displacement is touched. Pushover analysis consists of a series of successive elastic analysis, compiled with the non-linearity of structure to estimate a force-displacement curve of overall structure.

First, a two or three dimensional model that includes bi-linear or tri-linear load-deformation figures of all the lateral force resisting elements is created and gravity loads are applied. Then, a predefined lateral load pattern which is distributed according to the methods given in FEMA 356:2000 along the building height is applied. Until some members yield, the lateral forces are amplified. The structural model is altered in order to account for reduced stiffness of the failed members and the lateral forces are increased again till additional members yield. This process is continued till a control base shear at top of the building reaches a particular level of deformation or else the structure becomes unsteady. The base shear is plotted with respect to the roof displacement so that the pushover capacity curve is obtained.

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## II. LITERATURE REVIEW

[1] Kadid A., Boumrkik A. (2008) the aim of this paper is to propose the use of Pushover Analysis as a viable method to assess damage vulnerability of a building designed according to Algerian code. Pushover analysis was a series of incremental static analysis carried out to develop a capacity curve for the building. Based on the capacity curve, a target displacement which was an estimate of the displacement that the design earthquake would produce on the building was determined. [2] Benyamin Monavari et al [2012] used a nonlinear static analysis for local and overall yields and failure criteria to estimate seismic demands of buildings. The failure is directed towards losing structure's performance during the earthquake or subsequent effects. Because of the consequent excitations of an earthquake or lateral imposed loads on a structure, the stiffness of some elements of structure reduced and the structure started to fail and lose its performance; although failure happened either in small parts of structure or at the whole. [3] Haroon Rasheed Tamboli [2012] performed seismic analysis using Equivalent Lateral Force Method for different reinforced concrete (RC) frame building models that included bare frame, in filled frame and open first story frame. In modelling of the masonry infill panels the Equivalent diagonal Strut method was used and the software ETABS was used for the analysis of all the frame models. In filled frames should be preferred in seismic regions than the open first story frame, because the story drift of first story of open first story frame is very large than the upper stories, which might probably cause the collapse of structure. The infill wall increases the strength and stiffness of the structure. The seismic analysis of RC (Bare frame) structure lead to under estimation of base shear. Therefore other response quantities such as time period, natural frequency, and story drift were not significant. The underestimation of base shear might lead to the collapse of structure during earthquake shaking.

## III. METHODOLOGY

### *A. Modeling of building frames*

In this project work two unsymmetrical bays of steel frame G+3 and G+6 storey building of height 9.0m and 18.0m respectively are chosen. Two different geometries are also adopted i.e. rectangle geometry of one width of 3.0m and Square geometry of two width, each of 3.0m. The height of each floor is taken 3.0m and depth of foundation is 3.0m for simplification, as shown in Fig , Fig3.1 (b), Fig3.1(c) and Fig3.1 (d). All the analyses are performed using the parameters for the designing as per IS 1893 (Part 1): 2002 and non-linear static analysis as per FEMA 356:2000. The post processing results obtained are presented in the form of tables and graphs to get some important concluding remarks.

### *B. Analysis cases*

1) Seismic Analysis
2) Pushover Analysis

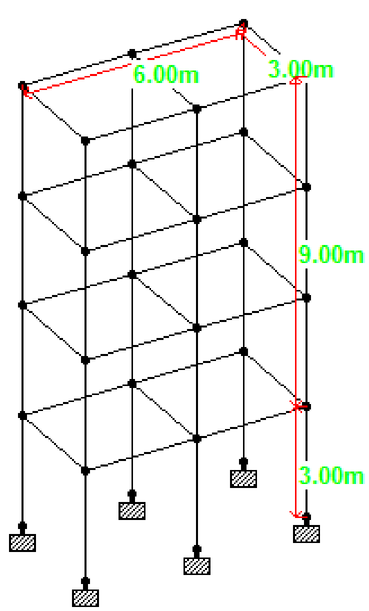


Fig 1 Isometric view of G+3(Rec geometry) building

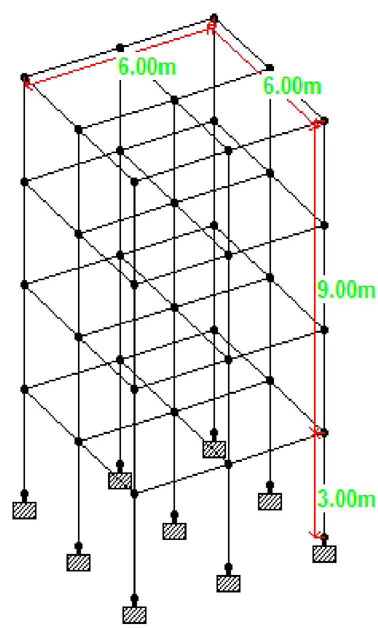


Fig 2 Isometric view of G+3(Sq. geometry) building

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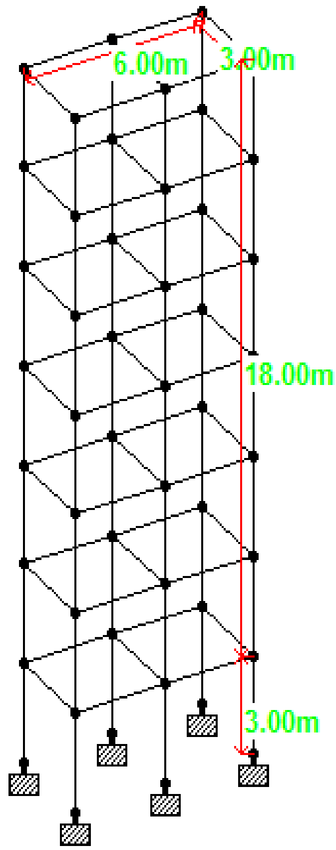


Fig 3 Isometric view of G+6(Rec geometry) building

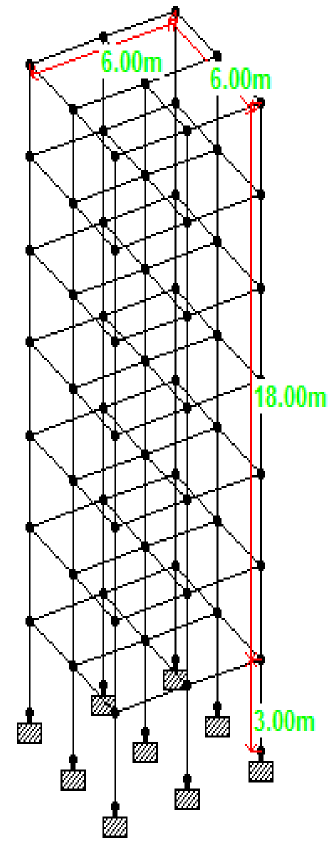


Fig 4 Isometric view of G+6(Sq. geometry) building

## IV. RESULTS

*A.* The base shear of different geometry is shown in Table 1 and Fig 5

*B.* The moment of different geometry is shown in Table 2 and Fig 6

*C.* The shear force of different geometry is shown in Table 3 and Fig 7

TABLE I
Base Shear for Different Geometry

| Base shear of different geometry | | | | |
|---|---|---|---|---|
| Analysis method | G+3 REC | G+3 SQ | G+6 REC | G+6 SQ |
| Seismic | 31.02 | 52.22 | 47.8 | 79.84 |
| Pushover | 142.91 | 216.15 | 100.84 | 122.22 |

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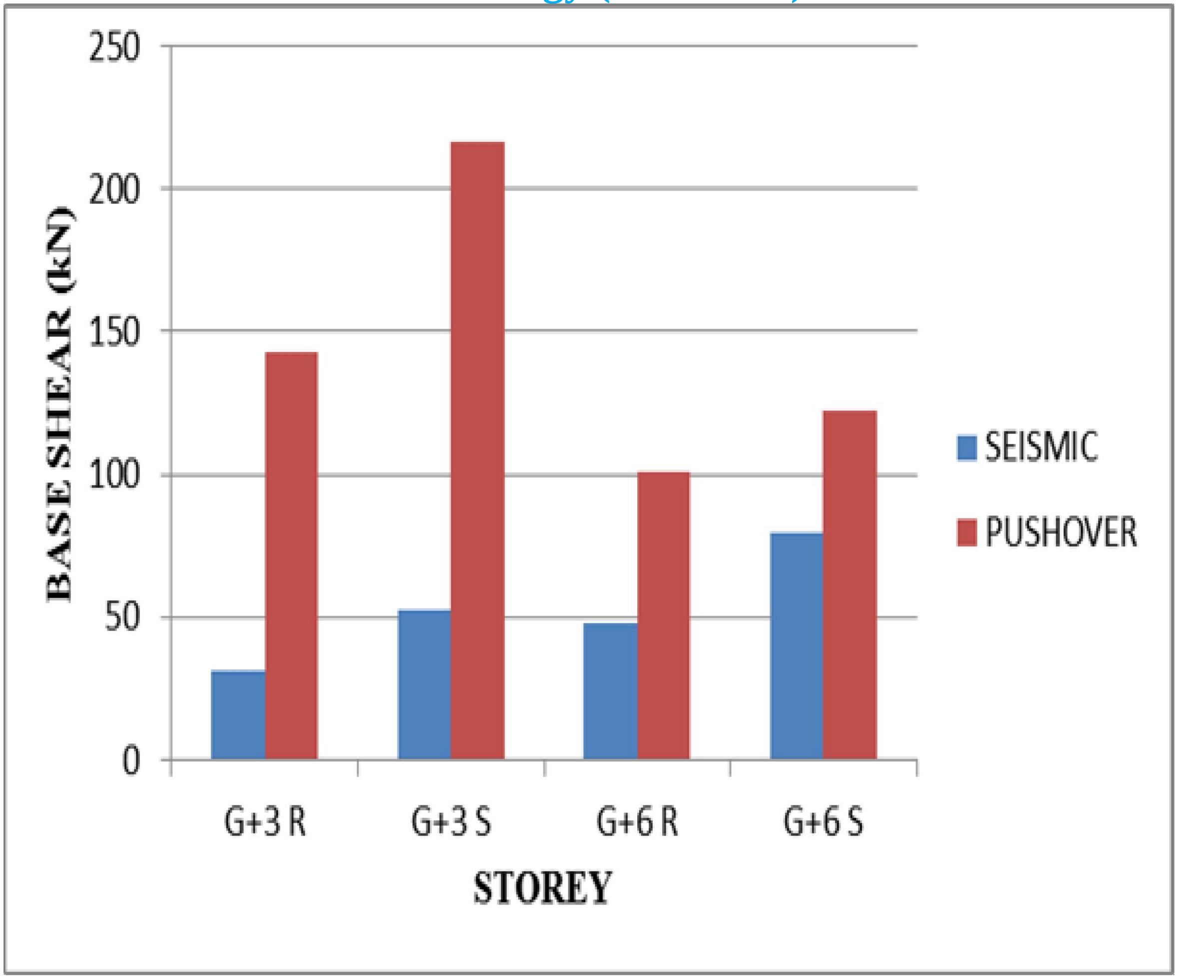


Fig 5 Base Shear for Different Geometry

TABLE III
Moment of Different Geometry

| Moment of different geometry | | | | |
|---|---|---|---|---|
| Analysis method | G+3 REC | G+3 SQ | G+6 REC | G+6 SQ |
| Seismic | 34.543 | 42.491 | 48.591 | 50.972 |
| Pushover | 16.305 | 16.306 | 20.956 | 20.96 |

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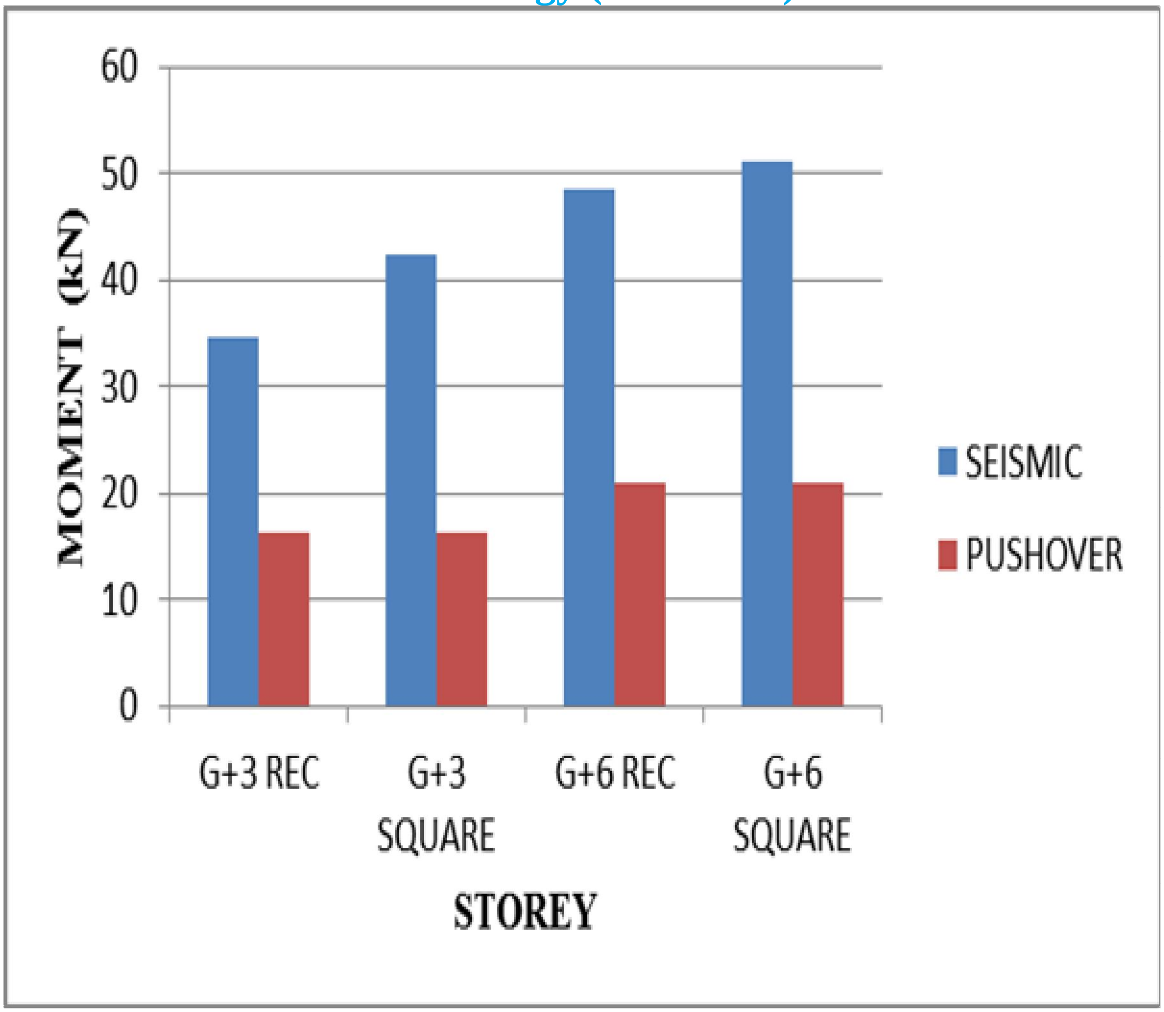


Fig 6 Moment of Different Geometry

TABLE IIIII
Shear Force of Different Geometry

| Shear Force of different geometry | | | | |
|---|---|---|---|---|
| Analysis method | G+3 REC | G+3 SQ | G+6 REC | G+6 SQ |
| Seismic | 52.180 | 57.591 | 56.717 | 63.48 |
| Pushover | 29.508 | 31.707 | 32.783 | 32.785 |

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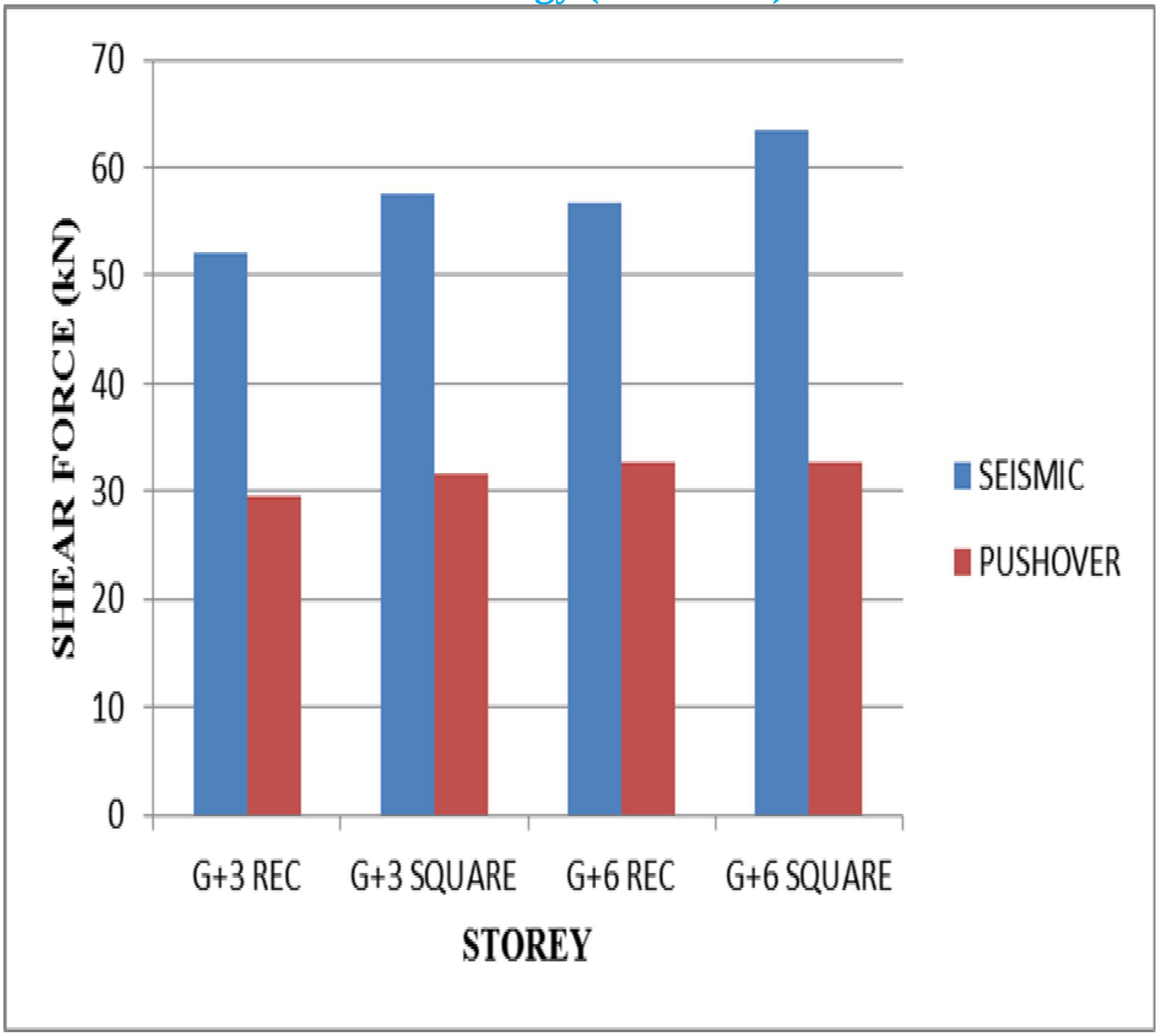


Fig 7 Shear Force of Different Geometry

From the above table and graph it is observed that maximum shear force is observed in seismic analysis in G+6 building of square geometry.

Among rectangle and square geometry, rectangle geometry is preferable because of its lesser base shear value and thus Pushover analysis is critical than seismic analysis. Maximum moment is directly proportional to area of the steel and in G+6 building of square geometry in seismic analysis is critical and uneconomical. In seismic analysis moment is increased by 2.3 times as compared to pushover analysis. And the shear force in seismic analysis is 50% more as compared to that of pushover analysis.

## V. CONCLUSION

The conclusions are basically drawn on the basis of structural behavior under Linear and Non-Linear conditions. After performing Seismic and Pushover analysis, the results are tabulated and summarized. Following are the major concluding remarks obtained-

*A.* From the obtained results it is observed that pushover forces are more critical than seismic forces, because our result parameter i.e. base shear is more in pushover as compared to seismic analysis

*B.* It is concluded that seismic analysis is critical in moment and shear force as compared to pushover analysis

*C.* It is also concluded that pushover analysis is not critical in low and mid-rise buildings, but seismic analysis is critical and uneconomical. So for low and mid-rise buildings pushover analysis isn't recommended.

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## VI. FUTURE SCOPE OF THE WORK

*A.* In STAAD.Pro V8i other methods are also there to design the seismic resistant structure (like Response spectrum analysis, Time-History method), the same structure can also analysed by the different methods and compare the result for appropriation.

*B.* This study is subjected to steel structure only, for further same study may be carried out for RCC structure also.

*C.* In this project work, STAAD.Pro V8i is used for the analysis the same could be done on other structural analysis software's.

*D.* Comparative analysis could also be done on high rise buildings as well.

*E.* Comparison could also be done between linear static method and Non-linear dynamic methods.

## VII. ACKNOWLEDGMENT

We take this opportunity to thank our teachers and our guide who provided constant encouragement and made it possible for us to take up challenge for doing this project. We are grateful to Prof. R.K.DIXIT for his technical support, valuable guidance, encouragement and consistent help. He is constant source of inspiration and information for us. Last but not least, we are thankful to our entire staff of civil and environmental engineering department for their timely help and guidance at various stages of the project.

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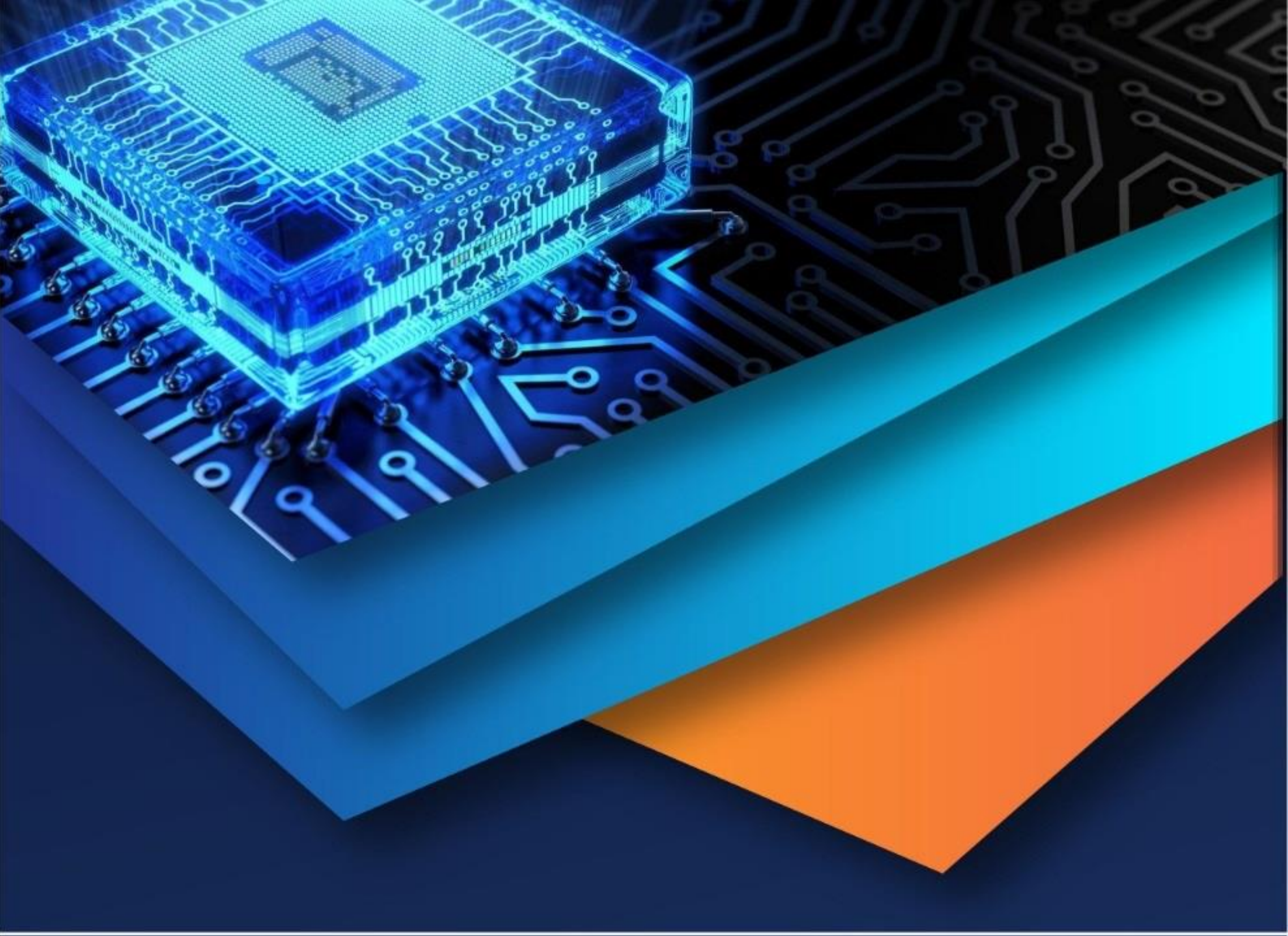


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