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# Performance of High-Rise Structure with Optimized Location of Shear Wall and with Special Shaped Columns under Seismic Effect

Ujwal s shetty[1], Shanmukha Shetty[2]
[1]Post Graduation Student, [2]Assistant Professor, Department of civil Engineering, NMAM Institute of Technology, Nitte, India.

***Abstract: The behavior of a structure with shear walls and with special shaped columns subjected to a seismic activity is studied in this paper. So, in the current study is aimed to model the shear wall and special shaped columns for different storey heights of the structure in zone III. The analysis of structures is performed by using ETABS 17.0.1 Software. The analysis of structural models was done using response spectrum analysis method. The results obtained from the comparison of structures the various parameters such as storey drift, storey displacement and storey shear has been studied by replacing the special shaped column in shear wall structures. The seismic load is determined as per IS: 1893(part 1)-2016 and applied to the (G+15) and (G+20) storey structure in zone III. From results concluded that all the storey heights will give less displacement, less drifts and more base shear for high rise structure with shear wall compared to the structure with special shaped columns for zone III.***
***Keywords: Shear wall, special shaped columns, design, analysis, displacement, drift, base shear.***

## I. INTRODUCTION

The necessity and demand of the modern era and increasing population has made the designers forced towards planning of structures which needs additional careful structural analysis so that acceptable behaviour of the high-rise structure can be ensured throughout a devastating earthquake. The behavior of a high-rise structure at the time of seismic activity depends on the several aspects, ductility and lateral strength, stiffness, regular and simple configurations. High rise structures experiences lateral deflections under seismic, which are in general designed for gravity loads. A Shear wall can be used to counteract the seismic forces acting on structures. The main purpose of the shear wall for the structure being considered here is to increase the stiffness of the structure for lateral load resistance. The shear walls generally start from the foundation level and it continue throughout the structure height. Shear walls are like the wide beams that carry seismic forces downwards to foundation. Shear wall which provide the large strength and stiffness to high rise structure in direction of their positioning, which significantly reduces the lateral deflection and damage to the high rise structure. Special shaped columns are column with T shaped, L shaped and cross (+) shaped sections are placed in the corners of the structure. The static behavior of T shaped and L shaped columns subjected to the bi-axial eccentric load and some correlation curves of resistance is mainly focused. The structure with special shaped columns is extensively used in the field of the structural engineering because of the benefit of saving indoor space and suitable arrangement for the furniture.

Ozmen, et al. (2014) has studied the analysis performed on 6 similar plan layouts of building with the various positions of the shear walls and for same storey height. From result it was noted that when shear was placed near the center of the high rise structure gives better performance compared to other cases. Mallika.K et al. (2016) evaluated a study the behaviour of the shear wall at various locations of structure in the zone 3 & 5 subjected to earthquake loads. From study it was concluded that storey displacement is less and base shear is more and more efficient when shear wall is placed at the corners of the structure. S.K Mohammed Azam et.al. (2013) presented a study on the high rise structure with shear wall for different storey heights under seismic loads. From paper it was observed that shear wall placed in the outer most moment resisting frames gives better performance when compared to other locations of the shear wall.. Anju Nayas and Minu Antony (2017) has studied the effect of shape and orientation of column when structure is subjected to a horizontal force. It is concluded that the base shear is maximum in L column in H shaped structure and T shaped columns in T shaped structure. Pu Yang et.al (2016) presented a study on earthquake performance of the structures with the special shaped (L, T, +) column and rectangular columns. It was concluded that, the structure with special shaped column are designed with help of Chinese code which could resist the seismic action efficiently as the structure with the rectangular columns do. Aditya Gumble et al. (2015) was investigated on seismic performance of structure with rectangular columns and with specially shaped columns for different heights of the structure. It is concluded that structure with special shaped column gives less displacement and drift, provides economy when compare to structure with rectangular columns.

The current study has an emphasis on the behavioral analysis of structures with optimized location of Shear walls subjected to earthquake with those having specially shaped columns. The analysis results including base shear, storey shear, storey drifts and storey displacements will be compared.

## II. OBJECTIVES

*A.* To study the effect of seismic load on high rise structure with shear wall and with specially shaped column.
*B.* To minimize lateral displacement of the high rise structures during earthquake.
*C.* To analyze the structure with shear walls placed at optimum locations and to have a comparative analysis with the structure having special shaped columns to present the performance.
*D.* To study the seismic parameters such as storey shear, inter storey drifts, storey displacements of the structure for zone III.

## III.METHODOLOGY

Structures with shear walls and with special shaped columns are modelled for the same layout and it is compared by using ETABS 17.0.1 software. G+15 and G+20 storey RCC building are considered for the analysis and study the behaviour of structure. Material and sectional properties are assigned as per IS 456-2000 and seismic loads are generated with dead load and live load as per specifications of IS: 1893(part 1)-2016 and IS: 875-1987 Part 1, Part 2 and Part 5. Dead loads are taken from IS: 875 (Part 1) and includes the self weight of the members, wall loads, slab loads, staircase loads, lift machine room loads. Live load includes floor loads, terrace loads, balcony loads, staircase loads and lift machine rooms and these loads shall be taken as per IS: 875 (Part 2). The results obtained such as inter storey drifts, storey displacement and storey shears of the structure with shear wall are studied and compared with structure with special shaped columns.

TABLE 1. BUILDING DATA

| | |
|---|---|
| Type of structure: | Residential building |
| Building Plan | 25.6m x 18 m. |
| Storey Height | 3 m each floor. |
| Height of building | 47m and 62m. |
| Number of storey's | G+15and G+20. |
| Column size | 500x500mm (Rectangular)<br>500x500x300mm (L shape) |
| Beam size | B1 300X450mm<br>B2 300X600mm<br>B3 300X750mm |
| Slab thickness | S1 125mm, S2 175mm |
| Wall thickness | 200mm |
| Shear wall thickness | 250mm |
| Grade of concrete | M30, M40 |
| Grade of steel | Fe500 |
| Density of concrete | 25 $kN/m^3$ |
| Density of light weight blocks | 11 $kN/m^3$ |

TABLE 2. SEISMIC LOADS

| | |
|---|---|
| Zone | II and III |
| Zone factor | 0.16 (IS 1893(Part 1)-Table2) |
| Importance factor | 1.0 (Refer Table 6) |
| Response reduction Factor | 3.0(Refer Table 7) (OMRF) |
| Soil Type | Medium |
| Structure Type | RC Frame Structure |

TABLE 3. DEAD LOADS

| | |
|---|---|
| Wall load, (under 450mm beam) | 5.61 kN/m |
| Wall load, (under 600mm beam) | 5.28 kN/m |
| Wall load, (under 750mm beam) | 4.95 kN/m |
| Staircase load | 18.2 kN/m |
| Floor Finish | 1.5 $kN/m^2$ |

TABLE 4. IMPOSED LOADS

| | |
|---|---|
| Typical Floor load | 2 $kN/m^2$ |
| Roof load | 1.5 $kN/m^2$ |
| Staircase load | 3.81 $kN/m^2$ |
| LMR load | 5 $kN/m^2$ |

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TABLE 5. LOAD COMBINATIONS AS PER IS 1893(PART 1):2016

| |
|---|
| 1.5((DL-(ELx+0.3Ely)) |
| 1.5((DL-(ELy+0.3Elx)) |
| 1.5((DL+ (ELx+0.3Ely)) |
| 1.5((DL+ (ELy+0.3Elx)) |
| 1.2(DL+LL-(ELx+0.3Ely)) |
| 1.2(DL+LL-(ELy+0.3Elx)) |
| 1.2(DL+LL+ (ELx+0.3Ely)) |
| 1.2(DL+LL+ (ELy+0.3Elx)) |

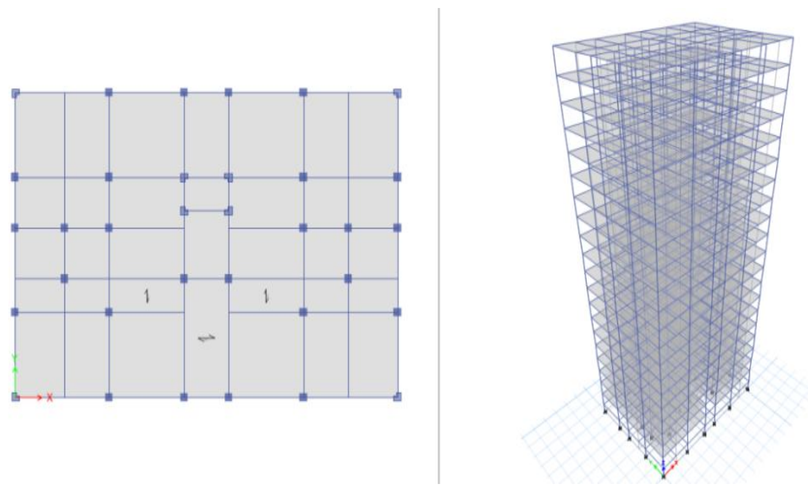

Fig 1. Plan and 3D view of Structure with Special shaped columns

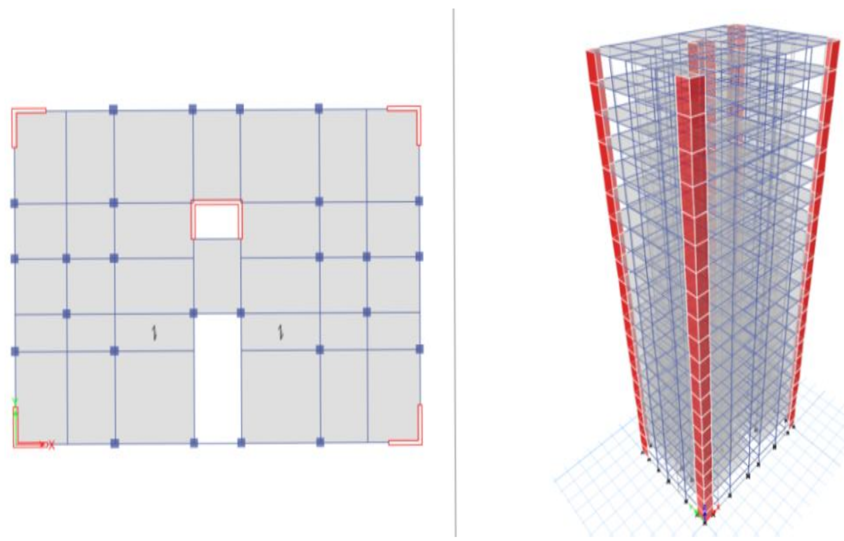

Fig 2. Plan and 3D view of Structure with shear wall

## IV. RESULTS AND DISCUSSIONS

The following outcomes have been obtained from the analysis of G+15 storey structure with special shaped columns and with shear wall subjected to seismic loads in the Zone III.

### *A. Storey Displacement*

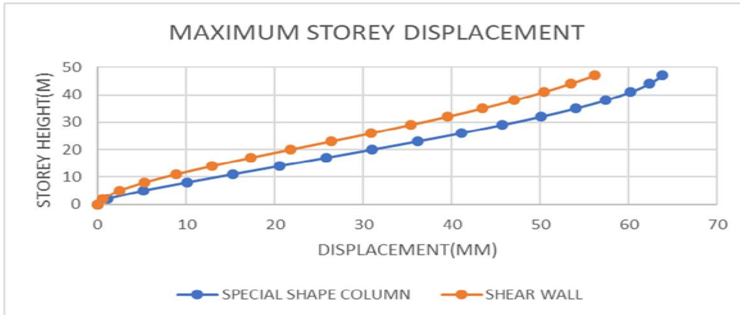


Fig 3. Storey displacement of special shaped columns and shear wall in G+15 storey building

The above graph represents a maximum storey displacement of 63.15 mm for special shaped columns, whereas a maximum storey displacement of 56.75 mm has been recorded for shear wall in G+15 storeyed structure which was subjected to seismic loads in zone III. Max Storey displacement plot shows that the total stiffness of the structures with shear walls is considerably higher than that with special shaped columns which results in the reduced displacement in top storey's of the structure, enhancing seismic capacity in structure due to the presence of shear wall. From graph the displacement in structure with shear wall are reduced by 11.96% compare to structure with special shaped columns.

### *B. Storey Drift*

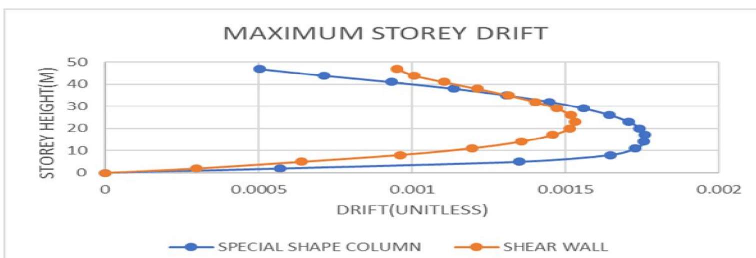


Fig 4. Storey drift of special shaped columns and shear wall in G+15 storey building

The above graph represents a maximum inter storey drift of 0.00176 for special shaped columns, whereas a storey drift of 0.001533 has been recorded for shear wall in G+15 storeyed structure which was subjected to seismic loads in the zone III.The storey drift of the building under seismic forces keeps on increasing with the height of the building up to some extent and then keeps on decreasing with increase in storey height. The storey height from around 20- 30m height, the drift is maximum in both cases, but the special shaped column shows maximum drift than shear walls representing better uniformity in structural stiffness of various floors. From graph the drift in structure with shear wall are reduced by 12.89% compare to structure with special shaped columns.

### *C. Base shear*

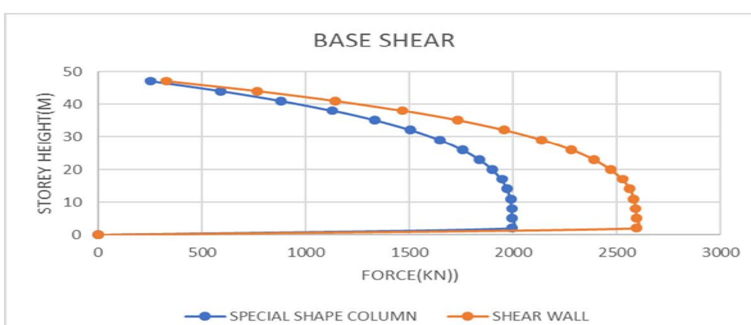


Fig 5. Base shear of special shaped columns and shear wall in G+15 storey building

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The above graph represents a maximum storey shear of 1995.232 kN for special shaped columns, whereas a maximum storey shear of 2592.485 kN has been recorded for shear wall in G+15 storeyed structure which was subjected to seismic loads in zone III.The storey shear is maximum for shear walls and special shaped columns at the base, but the storey shear is more for shear walls than that of special shaped columns. As the storey height increases the difference in storey shear values between the 2 structures enhances with increase in storey height up to 30m beyond which there is a reduction in difference of storey shear. From graph the storey shear in structure with shear wall are increased by 29.33% compare to structure with special shaped columns.

The following results have been obtained from the analysis of G+20 storey structure with special shaped columns and with shear wall subjected to seismic loads in the Zone III.

*D. Storey Displacement*

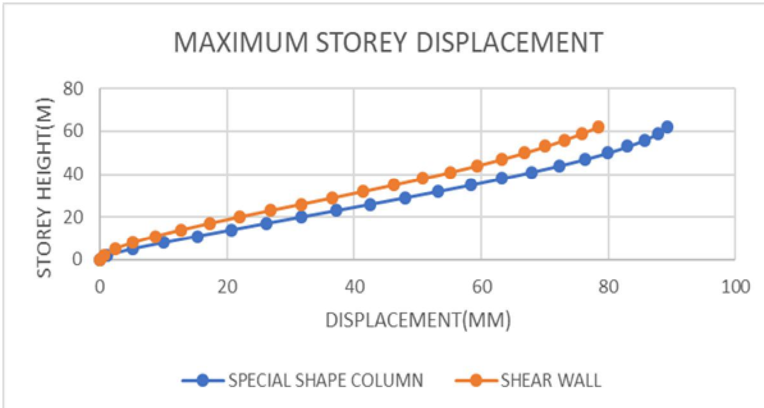


Fig 6. Storey displacement of special shaped columns and shear wall in G+20 storey building

The above graph represents a maximum storey displacement of 87.302 mm for special shaped columns, whereas a maximum storey displacement of 78.357 mm and has been recorded for shear wall in G+20 storeyed structure which was subjected to seismic loads in zone III.Max Storey displacement plot shows that the total stiffness of the structure with1. Shear walls is considerably higher than that with special shaped columns which results in the reduced displacement in top storey's of the structure, enhancing seismic capacity in structure due to the existence of shear walls. From graph the displacement in structure with shear wall are reduced by 12.25% compare to structure with special shaped columns.

*E. Storey Drift*

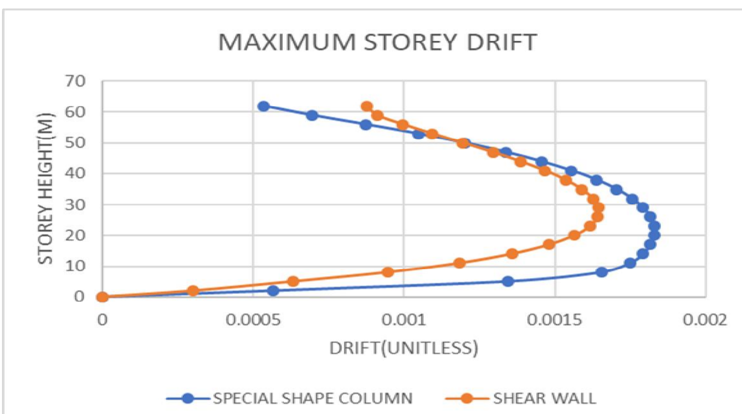


Fig 7. Storey drift of special shaped columns and shear wall in G+20 storey building

The above graph represents a storey drift of 0.001829 for special shaped columns, whereas a maximum storey drift of 0.001644 has been recorded for shear wall in G+20 storeyed structure which was subjected to earthquake loads in zone III.The storey drift of the building under seismic forces keeps on increasing with the height of the building up to some extent and then keeps on decreasing with increase in storey height. The storey height from around 20- 30m height, the drift is maximum in both cases but the special shaped column shows maximum drift than shear walls representing better uniformity in structural stiffness of various floors. From graph the drift in structure with shear wall are reduced by 10.11% compare to structure with special shaped columns.

### *F. Base Shear*

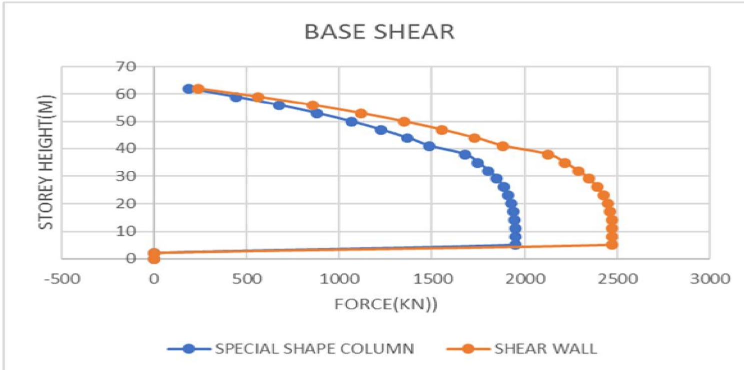


Fig8. Base shear of special shaped columns and shear wall in G+20 storey building

The above graph represents a maximum storey shear of 1951.288 kN for special shaped columns, whereas a maximum storey shear of 2474.219 kN has been recorded for shear wall in G+20 storeyed structure which was subjected to seismic loads in zone III. The storey shear is maximum for shear walls and special shaped columns at the base, but the storey shear is more for shear walls than that of special shaped columns. As the storey height increases the difference in storey shear values between the 2 structures enhances with increase in storey height up to 30m beyond which there is a reduction in difference of storey shear. From graph the storey shear in structure with shear wall are increased by 26.79% compare to structure with special shaped columns.

## V. CONCLUSIONS

The present study indicated the possibility of using special shaped columns instead of shear walls in high rise structure construction. The following conclusions can be drawn out:

*A.* Shear walls increases the strength and stiffness of the structures due to its weight, size and arrangement of reinforcement.
*B.* As per analysis, it is concluded that drift in both (G+15) and (G+20) storey structure with the shear wall is less than the structures with specially shaped columns.
*C.* From the results, it was noted that base shear increases in the structure with shear wall when compared to the special shaped columns in (G+15) and (G+20) storey structure. This is mainly due to increase in the stiffness and weight of structure.
*D.* The significant reduction in storey displacement is noted in the shear wall structure when compared to the special shaped columns in both (G+15) and (G+20) storey structure. The decrease of storey displacement of storey is due to increase in weight and stiffness of structure.
*E.* It was concluded that structure with shear walls gives better performance than structure with special shaped columns.

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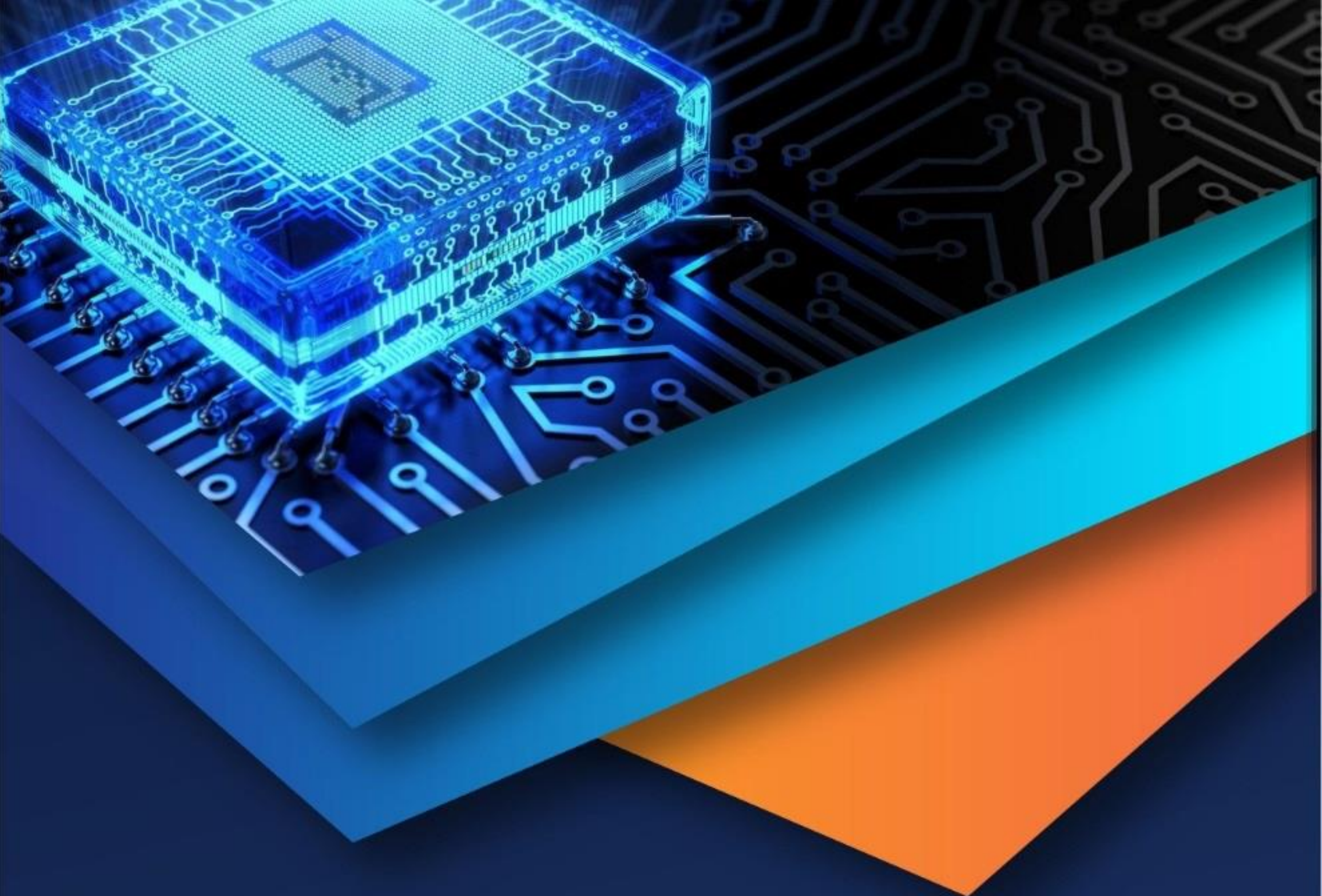


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