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Comparative Analysis of Multistory Building of Conventional Slab and Grid Slab with Shear Wall and Bracings on Seismic Zone Ⅴ

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Abstract: In the present study, response spectrum analysis is performed on various structural configurations using ETABS software. The primary objective is to investigate the seismic behaviour and response of different models subjected to earthquake forces as per the IS 1893:2002 standard. The structural configurations considered are as follows: Regular Structure: A basic building model with a regular grid of columns and beams. Grid Slab: The regular structure with the addition of a grid-type concrete slab system. Grid Slab with Shear Wall: The grid slab model augmented with shear walls. Grid Slab with Bracings: The grid slab model equipped with diagonal bracings. In the present project G+10 building having 3m storey height is considered. By considering the medium soil. Here the seismic analysis is conducted for the seismic zone Ⅴ as per IS 1893:2002. The analysis focuses on evaluating displacement, story shear, and auto lateral loads under seismic conditions.
Keywords: Grid Slab, Waffle Slab, Shear Wall (SW), X Bracings, Seismic Zone, Response Spectrum Analysis.

I. INTRODUCTION

An Rcc framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. A Grid slab is a type of reinforced concrete slab with a grid-like pattern of ribs and recessed panels. It is known for its lightweight, longer spans, and economical material usage. Grid slabs are widely utilized in commercial and residential construction, especially in areas where there is a need to reduce in general overall weight of the structure or achieve longer spans between supports. Shear walls are vertical load-bearing elements designed to withstand lateral forces. They are typically located at strategic positions within the building's layout to provide stability and resistance against lateral movements caused by seismic forces. X bracing consists of diagonal braces that are typically connected between vertical columns in the building's frame. These braces work to transmit lateral loads to the foundation, providing lateral stability to the structure.

II. BUILDING DISCRIPTION

Table 1 Shows the Material and Shell Property consideration for Modelling.

Table 1: Material Frame and Shell Property Consideration for Modelling

Sl No.	Parameter	Remarks
1	Multistorey building total height	30m
2	Plan Area	27.9mx23.25m
3	Total number of Floors	G+10
4	C/C distance between columns in X direction	4.65m
5	C/C distance between columns in Y direction	4.65m
6	Foundation level to ground level height	3m
7	Floor to floor height	3m
8	Live load	2kN/m^2
9	Dead load	1kN/m^2
10	Materials	M45 and Fe550
11	Column size	(600x600) mm
12	Beam size	(600x450) mm

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13	Slab thickness	200mm
14	Thickness of wall	230mm
15	Shear wall thickness	230mm
16	Damping ratio	5%
17	Seismic Zone V	0.36
18	Importance factor	1.5
19	Response reduction factor	5
20	Soil condition	II (Medium)

Table 2 Shows the Grid Slab properties.

Table 2: Grid Slab Properties

Sl No.	Parameter	Remarks
1	Modelling Type	Shell thin
2	Type Of Slab	Grid or Waffle
3	Overall Depth	925mm
4	Slab Thickness	75mm
5	Stem Width at Top	152mm
6	Stem width at Bottom	152mm
7	Rib Spacing Perpendicular	610mm
8	Rib Spacing Parallel	610mm
9	Drop panel thickness	925mm

Table 3 Shows the Models for Analysis

Table 3: Models for Analysis

Sl. No	Name of the Model	Description
1	Model 1	Regular Structure
2	Model 2	Grid Slab
3	Model 3	Grid Slab with Shear Wall
4	Model 4	Grid Slab with X-Bracings

III. MODELING AND ANALYSIS

Model 1 (Regular Structure)

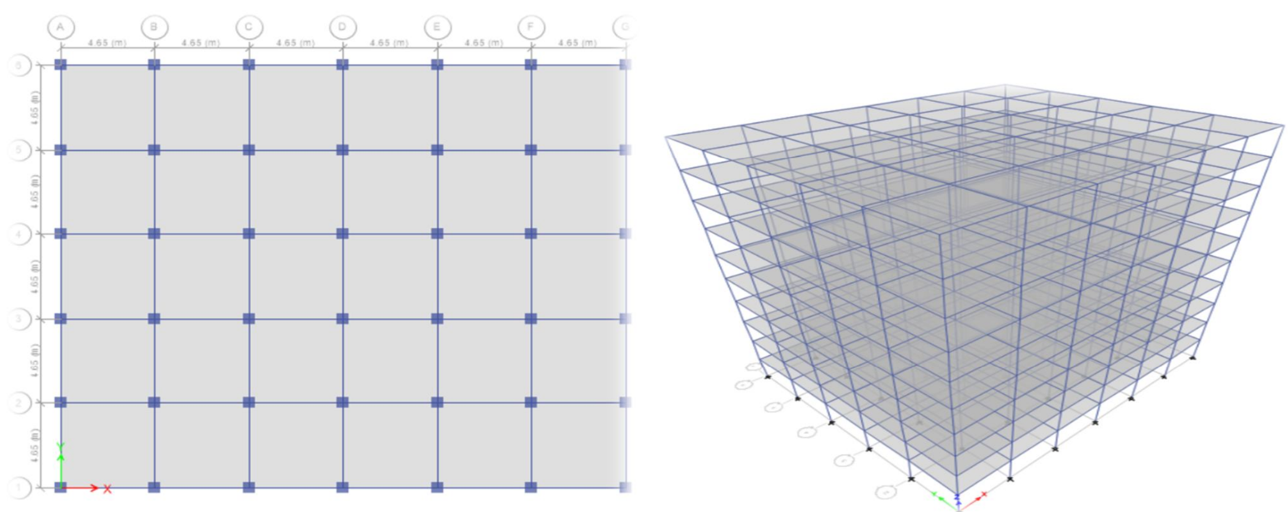

Fig 1: 2D Floor Plan and 3D Wire Frame

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Model 2 (Grid Slab)

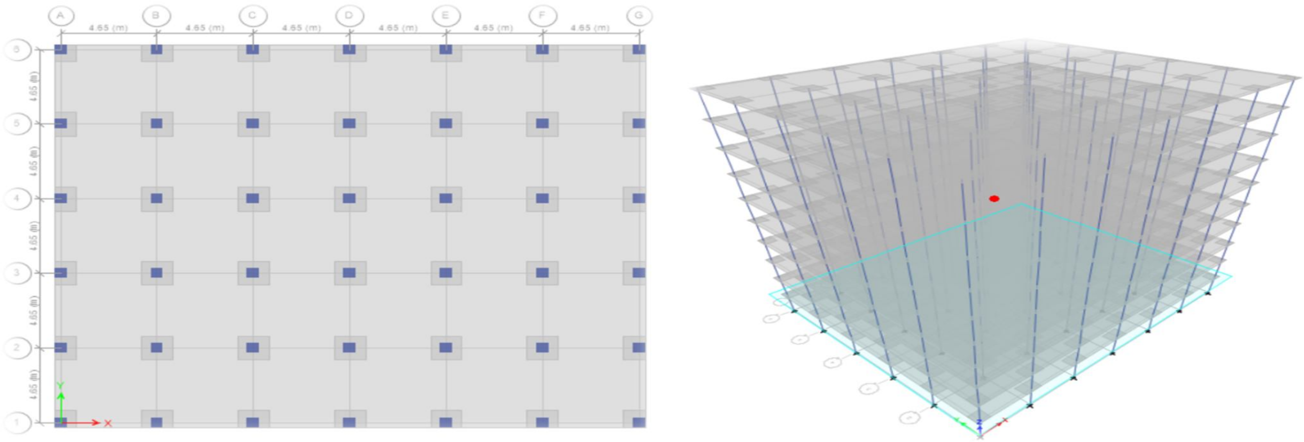

Fig 2: 2D Floor Plan and 3D Wire Frame

Model 3 (Grid Slab with Shear Wall)

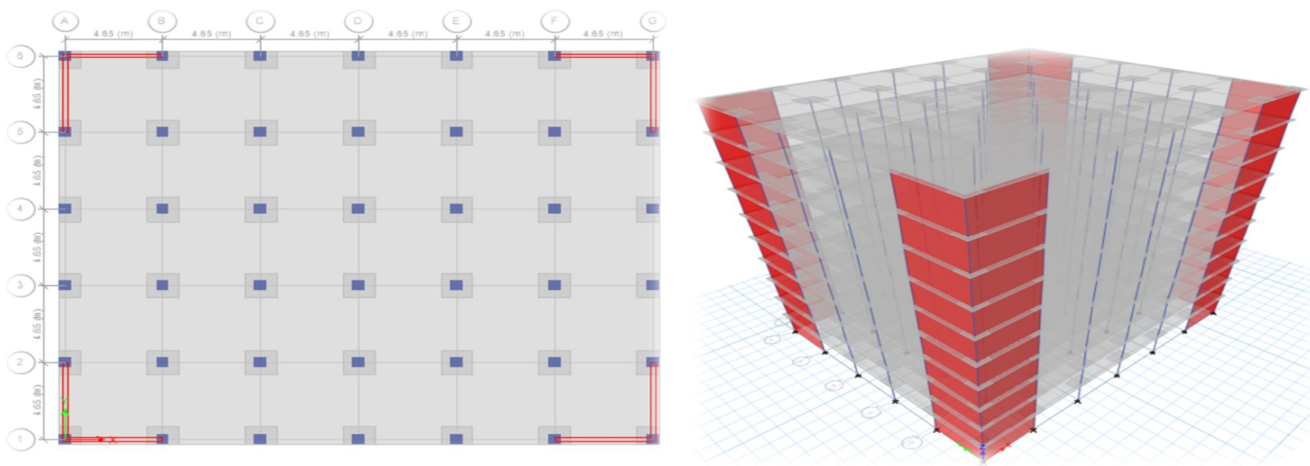

Fig 3: 2D Floor Plan and 3D Wire Frame

Model 4 (Shear Wall with X-Bracings)

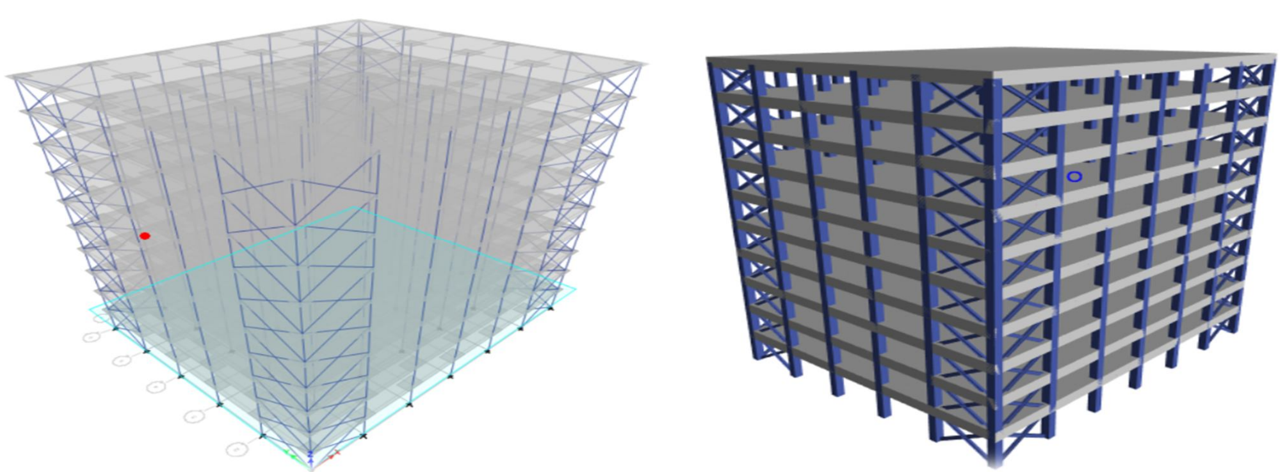

Fig 4: 2D Floor Plan and 3D Wire Frame

IV. RESULTS AND COMPARISION

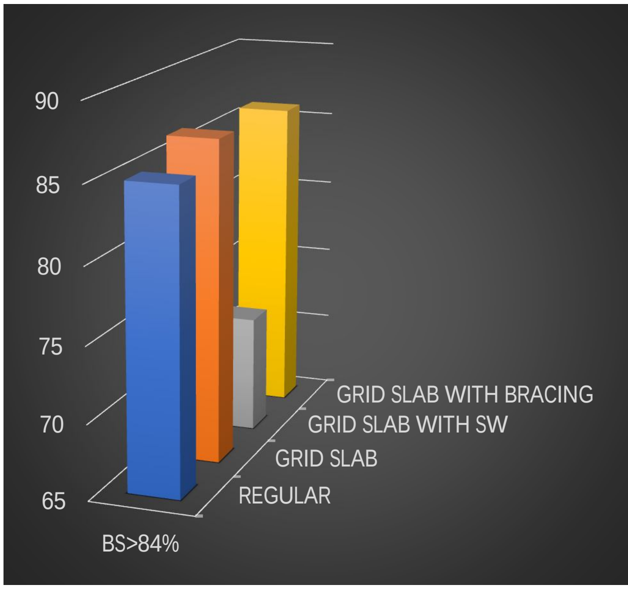

Fig 5: Base Reaction

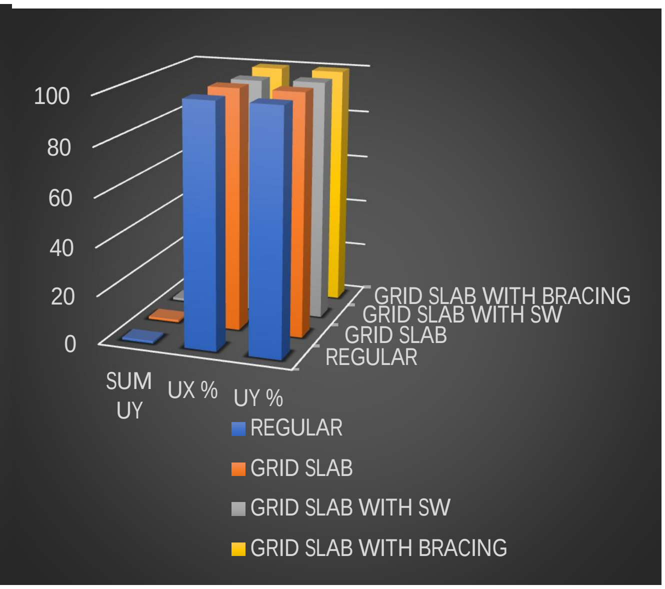

Fig 6: Response spectrum

Figure 5 Shows the "Grid slab with shear wall" model did not meet the requirement of achieving a base reaction of at least 84%, just grid slab, were able to achieve a base reaction above 84% with good performance.

On the other hand, the grid slab models performed well and achieved a base reaction above 84%. This indicates that the lateral resistance in these models is provided primarily by the overall grid slab system.

Figure 6 Shows all models have passed the response reduction factor using the modal participating mass ratio of 90% or above. This indicates that the structural systems in each model are providing adequate lateral resistance and damping under the response spectrum analysis.

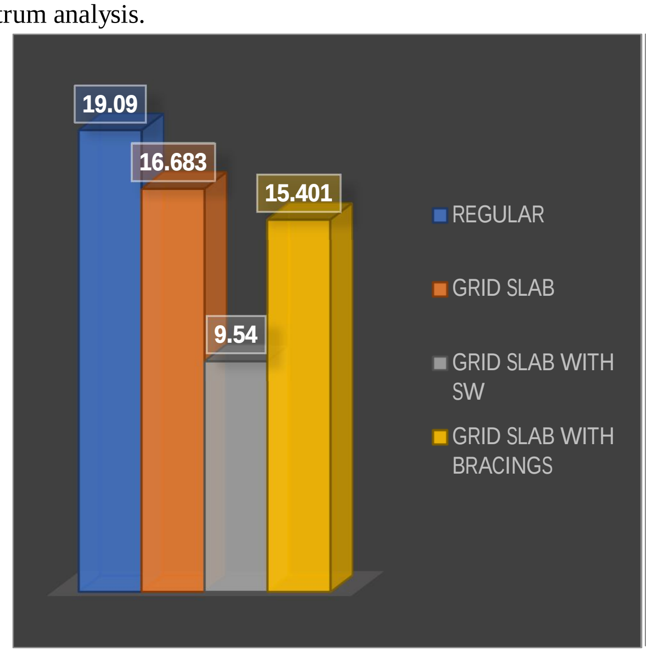

Fig 7: Displacement in X- Direction

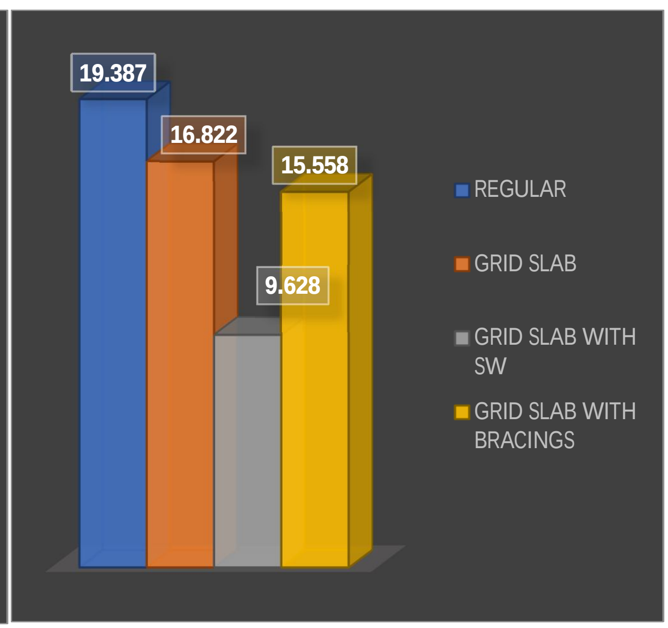

Fig 8: Displacement in Y- Direction

Figure 7 and 8 Shows the "Grid slab with shear wall" model is performing well in terms of displacement in the x-direction. However, since it did not pass the base reaction criteria, we are suggesting that the "grid slab with x bracings" model is a better option.

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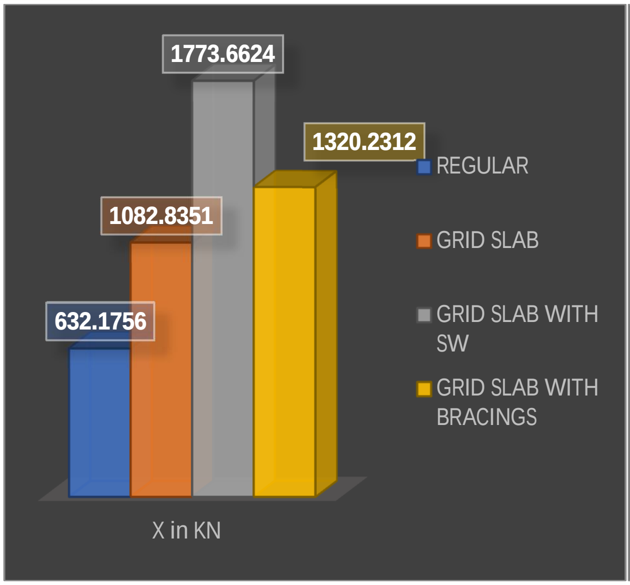

Fig 9: Story Shear in X- Direction

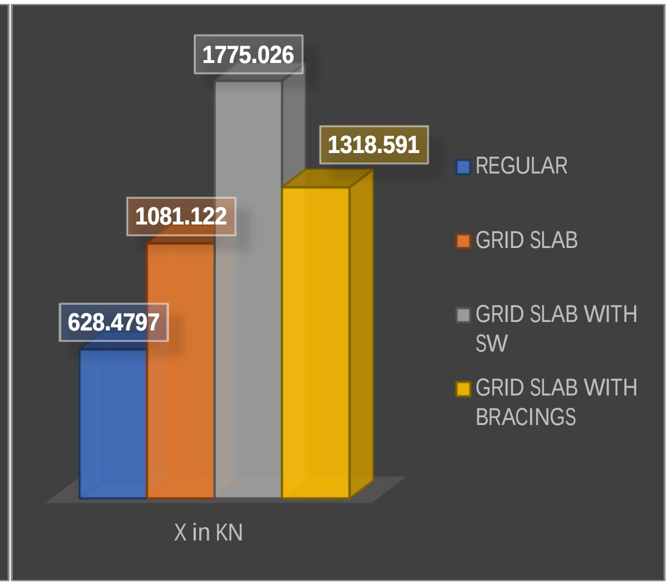

Fig 10: Story Shear in Y- Direction

Figure 9 and 10 shows the regular model is also showing the same level of good performance in terms of story shear in the X and Ydirection.

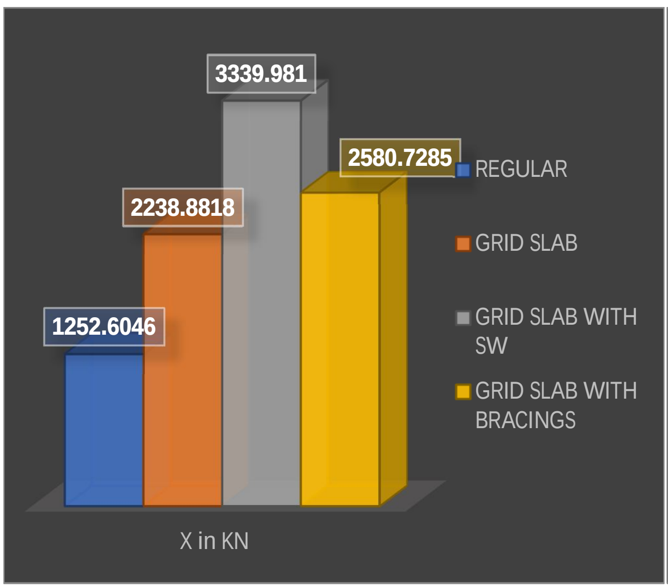

Fig 11: Auto lateral load in X-Directon

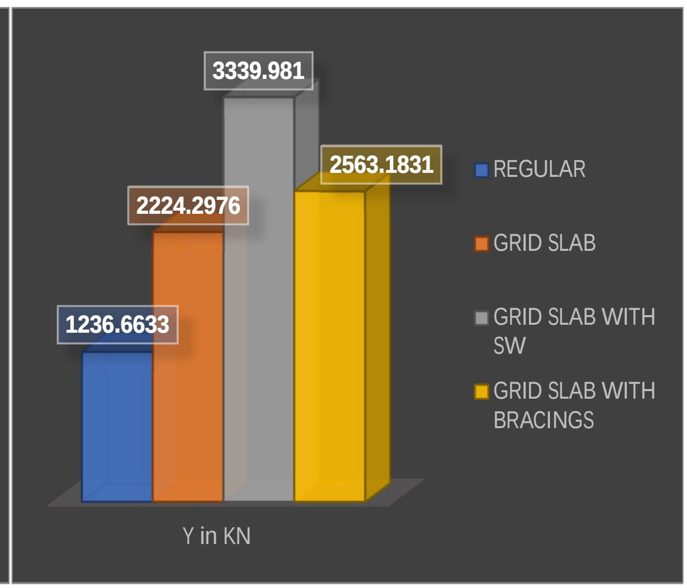

Fig 12: Auto lateral load in Y-Directon

Figure 11 and 12 Shows the regular model is also demonstrating good performance in terms of auto lateral loads in the y-axis. Consistent good performance in both the x and y directions is a strong indicator of the regular structure's stability and robustness under lateral forces.

RESULT SUMMARY

1) *Grid Slab Model:*

a) The grid slab model has demonstrated better performance in terms of displacement.

b) Consider the grid slab model as a favourable option if minimizing displacements is a critical design objective.

2) *Regular Structure:*

a) The regular structure has shown good performance in story shear and auto lateral loads.

b) If maintaining balanced and predictable lateral resistance is a key requirement, the regular structure is a suitable choice.

3) *Shear Walls and Bracings:*

a) The models with shear walls and bracings have not met certain performance criteria, such as base reactions.

b) If lateral resistance from shear walls or bracings is deemed essential, further optimization and design modifications are required to meet performance objectives.

V. CONCLUSION

After carefully evaluating the performance of various structural models under different criteria, the final recommendation is to consider the "Grid Slab Model" for the following reasons:

1) Superior Displacement Performance: The grid slab model has demonstrated better performance in terms of displacement when compared to the other models. Minimizing displacements is often a crucial design objective, especially in areas prone to seismic activity. The grid slab's efficient distribution of lateral loads allows it to exhibit reduced displacements, ensuring better occupant comfort and reduced structural damage during seismic events.
2) Feasibility and Simplicity: The grid slab model without shear walls or bracings offers a simplified and cost-effective solution for lateral load resistance. Without the need for additional lateral resisting elements, the construction process becomes more straightforward and less resource-intensive. This can result in reduced construction costs and shorter project timelines, making it an attractive choice for budget-conscious projects.
3) Optimal Regularity: The regularity of the grid slab model allows for a more predictable and balanced distribution of lateral forces. This inherent symmetry and uniformity contribute to stable lateral performance in both x and y directions. The regularity of the structural layout ensures that the structure can efficiently handle lateral loads, providing added reliability and safety during seismic events.
4) Flexibility in Architectural Design: The absence of shear walls or bracings in the grid slab model offers greater flexibility in architectural design. The lack of intrusive lateral resisting elements allows architects to explore a wide range of design possibilities without compromising structural integrity. This design freedom can lead to more aesthetically appealing and functional buildings.

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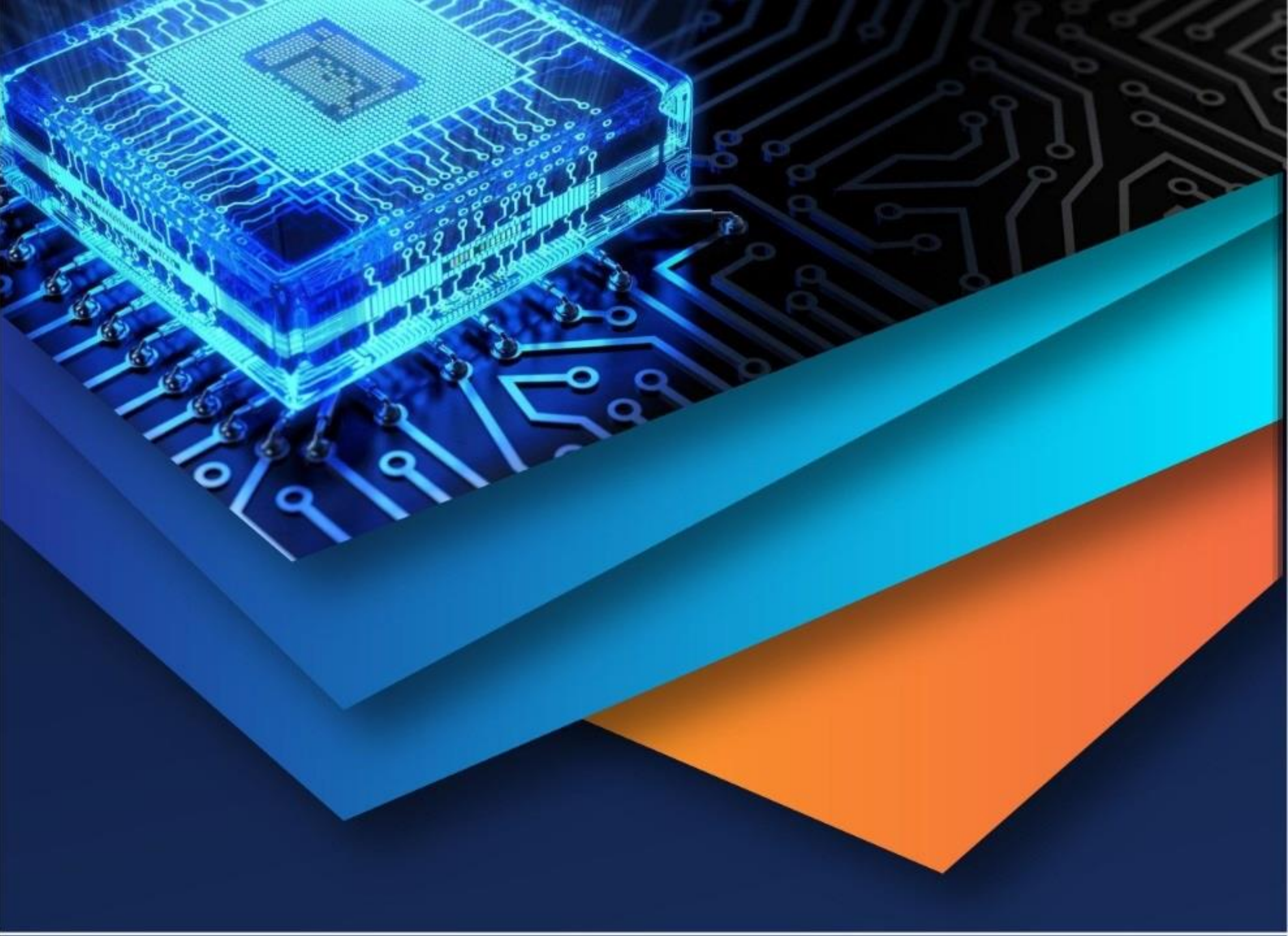

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