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Comparative Study of Tube in Tube Flat Slab with Tube in Tube Waffle Slab, Structures Under the Sesmic Loads

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Abstract: ***The tube in tube structure is one of the type that is been broadly used as structural system for tall structures. Considering the lateral loads due to the seismic force it gives more stiffness and gives more strength to the high-rise structures. Lateral loads are shared between the inner and outer tubes our aim is to make the structure stiff by its connectivity and comparing them by providing drops to the waffle. By adding tube in tube to the flat slab and waffle slab, concept is they both does not have the beams such that to know the comparison of both the models. This both models have been designed using e-tabs software and the dimensions, limitations are been taken from the provision Indian standard code book.***
Keywords: High-rise building, tube in tube, Response spectrum analysis.

I. INTRODUCTION

High rise buildings are usually elastic and are sensitive to dynamic loads. The accuracy of solution of free vibration and its natural frequencies depends on the selection of the mathematical model.as we go higher the lateral loads increases, to over-come this we are providing tube in tube structural system. Because of restricted region and expanding extension of urbanization it is possible to grow vertical way than even way. Furthermore, because of expanding vertical urbanization, it is critical to embrace to more steady construction. Here the tube in tube structure is more stable in lateral loads, allows more interior space and helps save the steel. Here two models are done having tube in tube structure with similar column spacing to them. Tube in tube -it is a type of structure which consist of inner and outer core wall which makes the structure stiff, it acts like a cantilever perpendicular to the ground. This system, often known as 'hull and core,' comprises of an inside core tube that houses services such as utilities and lifts, as well as an external tube system that bears the majority of gravity and lateral stresses.

In this project we are comparing flat slab with waffle slab structure with in the presence of tube in tube structure. Flat slab is type of structure in which two-way concrete slab which does not have beams and load is directly transferred to the supporting columns.

A. Tube in Tube Structures

The articulation “tube in tube” is for the most part basic in that second ring of portions, the ring including the central assistance focal point of the design, are used as an inner illustrated or upheld tube. The system has been used for incredibly tall constructions in both steel and concrete. If the middle goes probably as a clear cantilever, it may be shown as a lone similar segment. If it is penetrated, it very well may be treated as a divider with openings. Given that within focus can be shown by a similar plane development, it may reliably be associated with the outer laid out chamber model to get the movement of sidelong powers on each part. If the middle can’t be treated as a plane segment, or if the outside laid out chamber isn’t even, a three-dimensional assessment ought to again be performed. The points of within focus ought to either be constrained by an “unyielding floor” choice to keep away from equitably with the of the external packaging or be related with them by a developed level edge of vitally solidified associations. Both of these techniques will imitate the unyielding plane exercises of the floor pieces. The tubed super edge framework will contain immense vertical cylinders set at the edge of the structure associated together by belt dividers or cross dividers at specific stories. These cylinders will be the fundamental burden conveying components in this underlying framework. With the tubed uber outline framework

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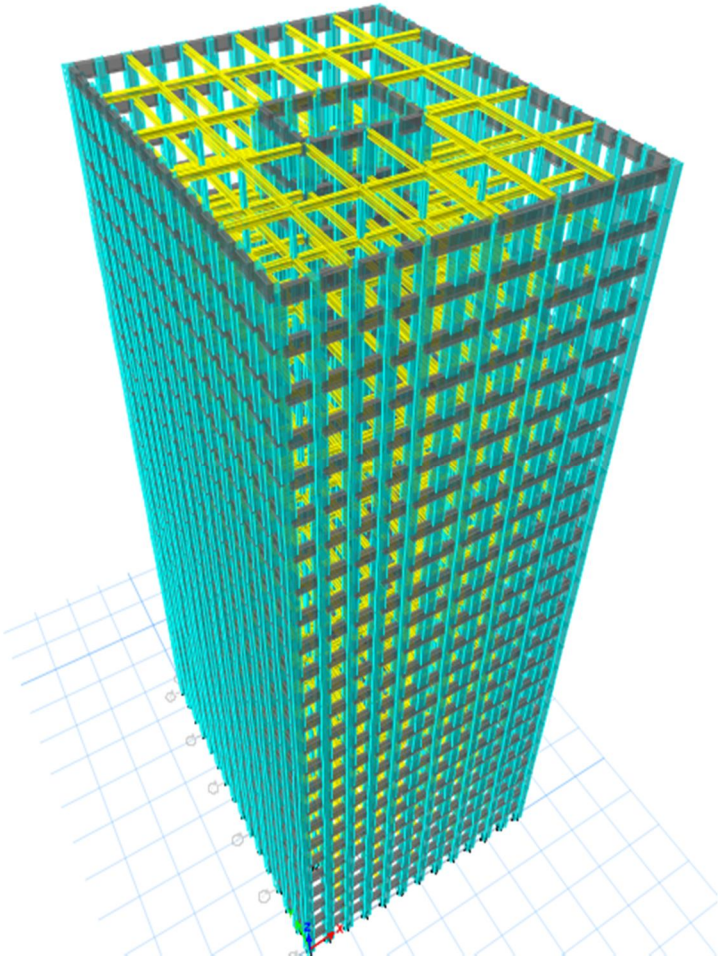

Figure 1:3D view of tube in tube structure

B. Flat Slab

Flat slabs are becoming common these days, and they are more cost effective than beam-column connections. The construction of RC frame buildings is very frequent. Architectural tractability, space use and simpler shaping of seismic loads provide several advantages compared to RC structures. Architects and clients favour flat slabs because of their creative and financial benefits. This type of reinforced concrete structure has more benefits than conventional structures, but it also has drawbacks such as punching failure and higher deformation. When employed in high seismic zones, many experts advise that the slab should be constructed to resist just gravity loads, with lateral loads carried by a lateral resisting system. Because of the excision of beams, the load transmission path alters. Building safety, on the other hand, must be examined.

C. Waffle Slab

Waffle slabs are frequently used for engineering reasons behind large spaces, such as halls, vestibules, theatre corridors, and exhibit rooms of shops, where section free space is frequently the primary requirement. Because of their stronger solidity and lower avoidance, they are used for heavy loads and long-range structures. The use of a void framed in the roof reduces dead weight and is ideal for covered design lighting. they are most commonly seen in business and modern structures. And they can bear a lot more weight than standard solid parts. ETAB programming will be used for testing and planning purposes. Waffle Slabs are defined as "a fortified solid chunk with similarly separated ribs corresponding to the sides. security without having to use a lot of additional material as a result, a waffle portion is appropriate for large level zones. The advantages of waffle slab systems for buildings with long column-to-column spans have been thoroughly documented in the literature. Waffle slabs are commonly used for architectural reasons in large areas like auditoriums, vestibules, and lobbies.

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II. METHODOLOGY

1) In this present project designing the tub in tube flat slab with waffle slab using E-tabs software aid.
2) This data is taken from the code book IS;16700-2017, CLAUSE -5.1.1 TABLE -1
3) Zone type –III
4) The maximum building height must not exceed -220M
5) The maximum slenderness ratio is (H/B) -10

No of stores	25
Height per floor	3M
Total height	75M
Width	37.5M
Length	30M
Height /width	2

6) The maximum plan aspect ratio (L/b) must not be exceed 6
7) Length (L)= 30; width (B)=37.5
8) L/B=1.25
9) The tube in tube structure is assumed to be the G+24 RCC structure
10) For the analysis purpose various is codes have been referred such as
IS: 456 FOR CONCRETE
IS: 875 FOR LOADS
IS: 893 FOR SESMIC DESINE

Dimensions of the columns-30”X30”
Dimensions of the beam-18”X24”
Dimensions of the deep beam-13’X48”
Slab thickness -6”
Grade of concrete -M30

This above data is assumed according to response spectrum analysis in E-tabs Software

a) A 25-story reinforced concrete frame is taken with tube-tube structural system with each story height of 3m with a total height of 75 m is considered and analysed for gravity as well as lateral loads.
b) The material properties as well as the sectional properties of tube-tube structures are kept same with similar story height in both models.
c) A linear dynamic (response spectrum analysis) analysis is done on all the models and a comparison is made in between them
d) The structure's behaviour has been analysed and it has been determined that the dnft and displacements are within the limits set by Indian standards.
e) The results obtained from analysis and the parameters associated with every model are compared as shown

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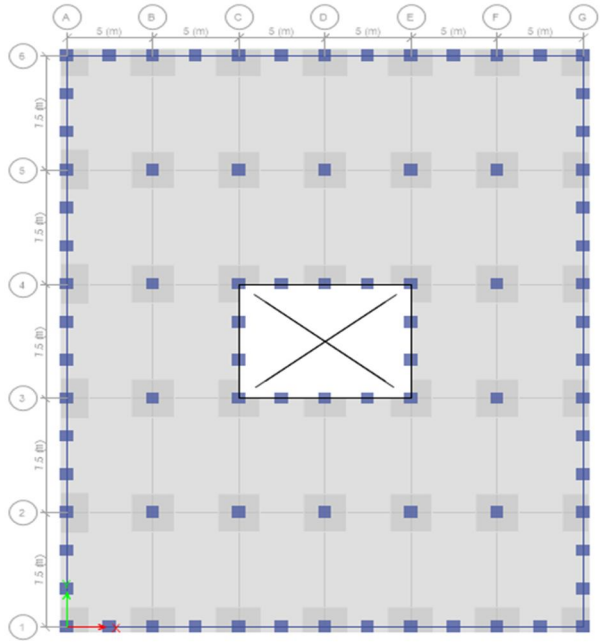

Figure 2: Plan view of structure with flat slab

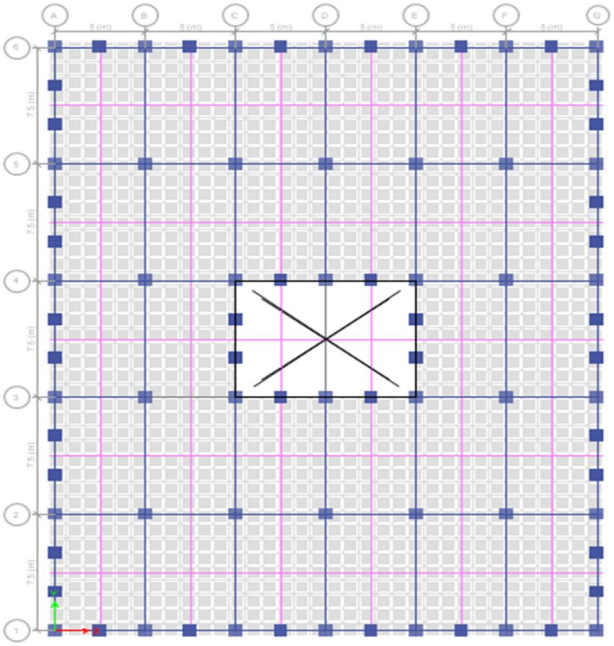

Figure 3: Plan view of structure with waffle slab

III. RESULTS AND DISCUSSIONS

A. Comparison of Both Structures

The results obtained from analysis and the parameters associated with every model has been compared and discussed as follows.

B. Comparison of Storey Displacement

In its widest sense displacement, the lateral displacement of the story relative to the base. The side force-resistant device can reduce the building's excessive lateral displacement. The results were achieved by performing an examination by the response spectrum of reaction by max story displacement in the typical framework of reinforced concrete.

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Table 3.1 Values of Story Displacement				
Storeys	Flat slab		Waffle slab	
	X	Y	X	Y
25	31.954	24.620	23.093	22.064
24	31.396	24.230	22.743	21.766
22	29.997	23.213	21.818	20.957
20	28.227	21.903	20.604	19.860
18	26.142	20.335	19.145	18.516
16	23.79	18.555	17.484	16.963
14	21.209	16.592	15.649	15.229
12	18.428	14.467	13.659	13.332
10	15.472	12.193	11.525	11.280
8	12.36	9.785	9.252	9.082
6	9.114	7.258	6.857	6.751
4	5.77	4.645	4.375	4.322
2	2.427	2.019	1.867	1.859
1	0.897	0.781	0.705	0.709
0	0	0	0	0

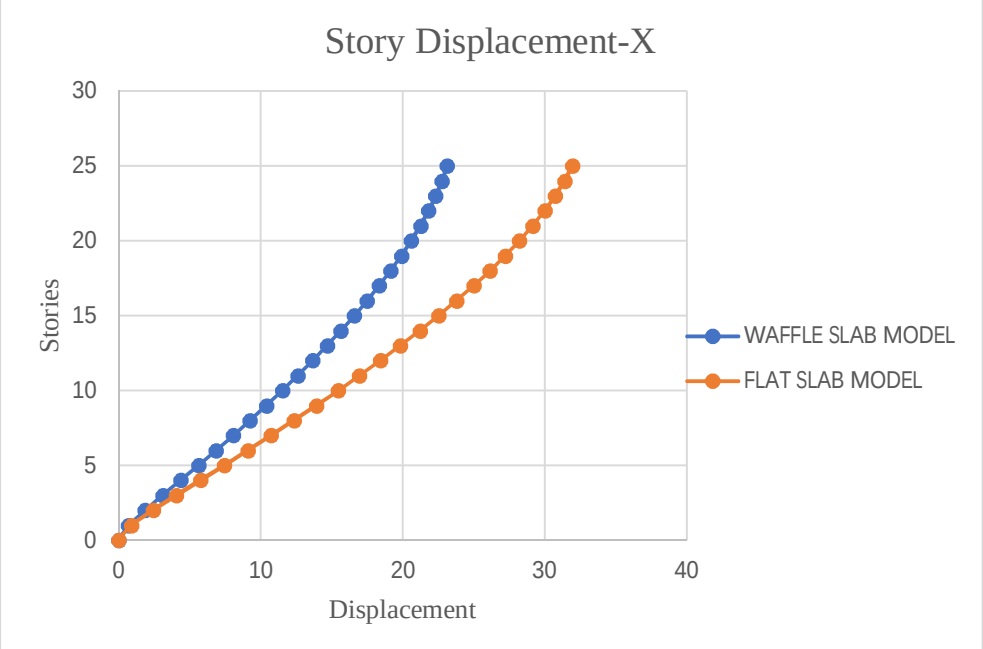

Figure 4: Represents comparison of story displacement in x direction

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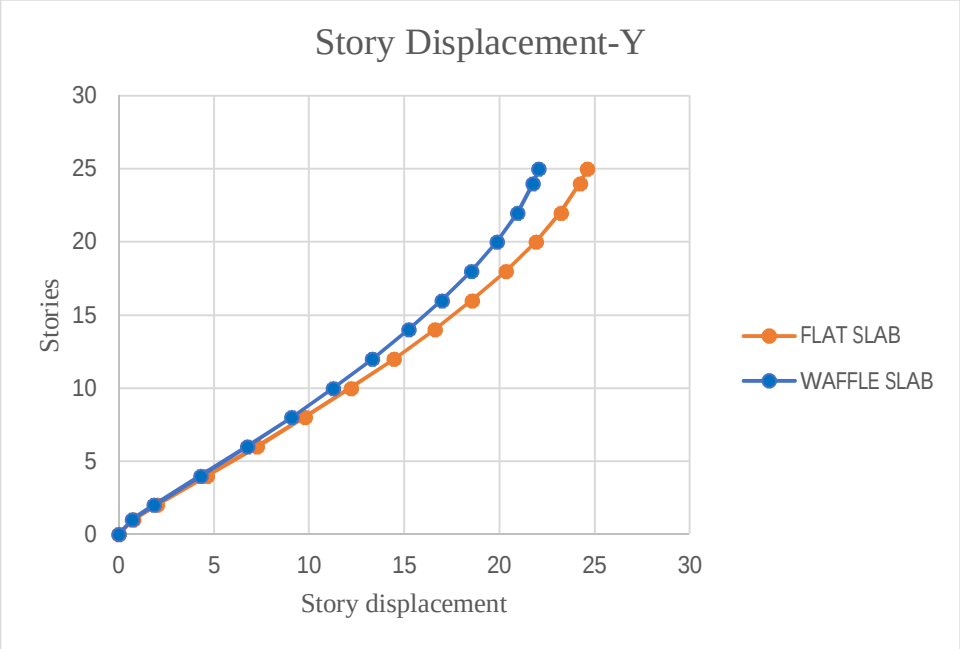

Figure 5: Represents comparison of story displacement in y direction

In x direction it was found that maximum story displacement obtained for structure with flat slab is 31.594 mm which is reduced to 23.093 mm in waffle slab where as in y- direction the maximum story displacement was found to be 24.620 mm in flat slab which is reduced to 22.064 mm in waffle slab.

C. Storey Drift

Table 3.2 Values of Story Drift		
Storeys	Flat slab	Waffle slab
25	0.000147	0.00013
24	0.000182	0.000164
22	0.000241	0.000232
20	0.000285	0.000283
18	0.000314	0.000321
16	0.000335	0.000347
14	0.00035	0.000365
12	0.000361	0.00038
10	0.000369	0.000393
8	0.000375	0.000405
6	0.000379	0.000416
4	0.000377	0.000421
2	0.000346	0.000387
1	0.000212	0.000235
0	0	0

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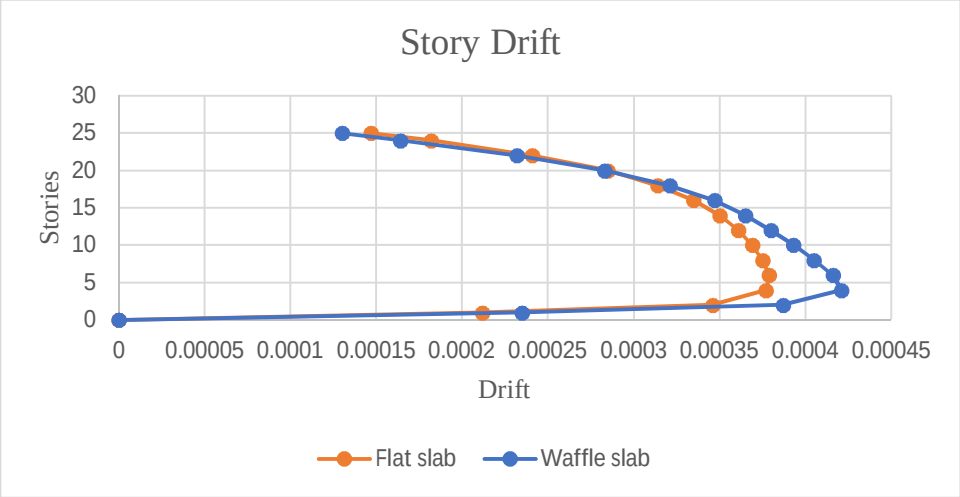

Figure 6: Represents comparison of story drift in x direction

As a result, the maximum story drift was found to be 0.000421 in structure with waffle slab.

D. Time Period

The values of time period for structure with gravity load are obtained and shown in below figure.

Table 3.3 Comparison of time period

Modes	Flat slab	Waffle slab
1	2.552	1.848
2	2.389	1.774
3	1.616	1.259
4	0.821	0.6
5	0.775	0.579
6	0.537	0.418
7	0.46	0.34
8	0.439	0.331
9	0.321	0.25
10	0.319	0.238
11	0.306	0.232
12	0.242	0.182

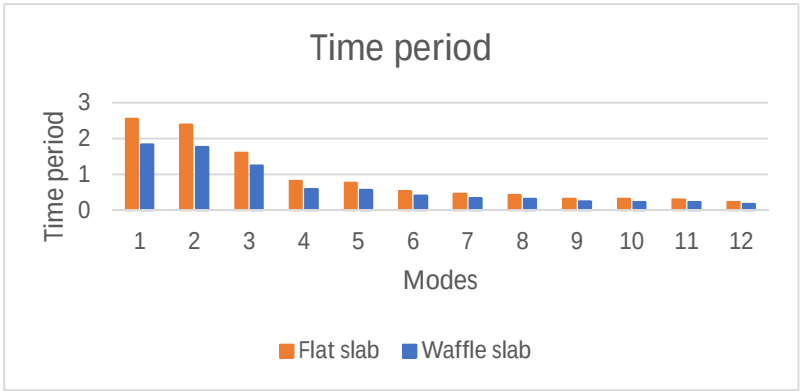

Figure 7: Graphical representation

Time period for waffle slab structure with tube in tube is least compared to flat slab structure with tube in tube.

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E. Comparison of Base Shear

The base shear for structure by response spectrum method in Flat slab and Waffle slab structure shown in below figure

Table 3.4 Values of base shear			
Flat slab		Waffle slab	
Fx	Fy	Fx	Fy
5085	5434	7546	7861

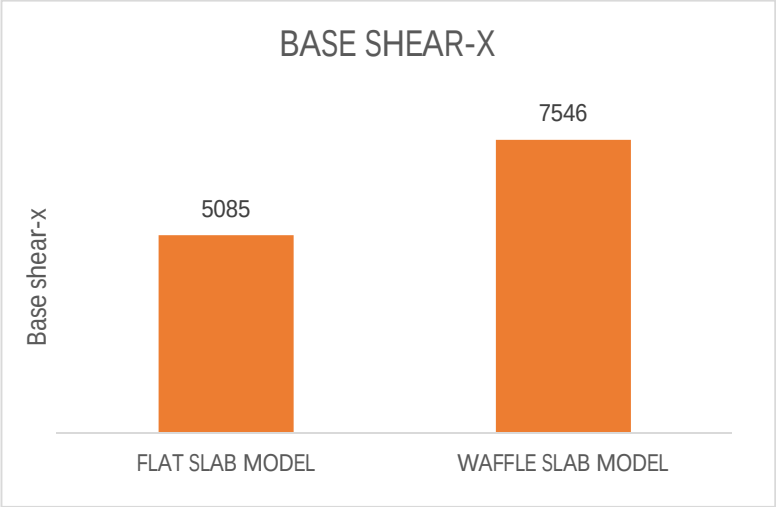

Figure 8: Graphical representation Base shear X

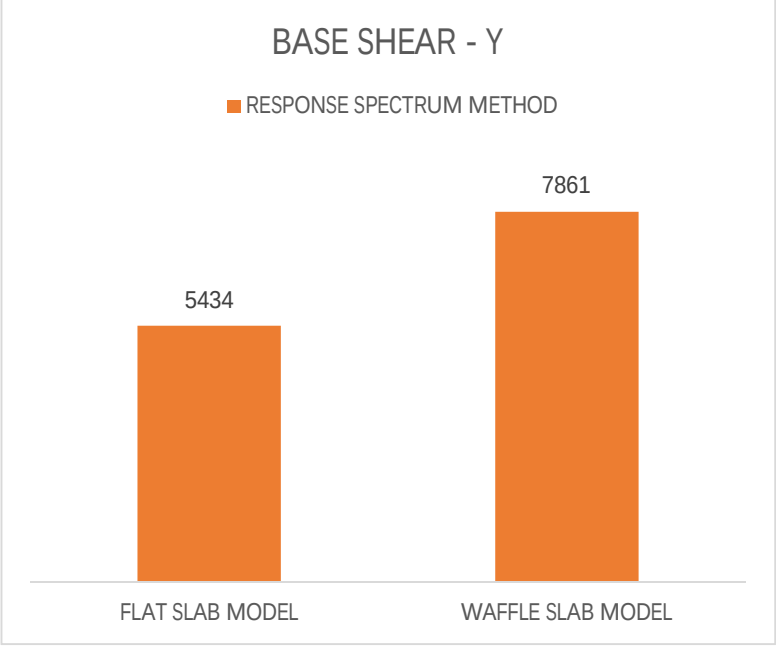

Figure 9: Graphical representation Base shear Y

From the results, the maximum base shear was found to be in y-direction i.e.; 7861 kN in tube in tube structure with waffle slab and in x-direction the minimum base shear was obtained from the analysis is 5085 kN in tube in tube structure flat slab.

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IV. CONCLUSION

In this project a 25-floor structure has been modelled and designed by applying response spectrum analysis in E-tabs software. Bothe the structures have two different types of slab viz flat slab and Waffle slab. The results are compared on the basis of certain parameters which are Max storey displacement, Storey drifts, time period, and base shear. The study leads to following conclusions.

A. The maximum story displacements obtained in x-direction of flat slab i.e. 31.954 and it is reduced to 23.093 in waffle slab, where as in y- direction maximum story displacement found to be 24.620 in flat slab and reduced to 22.064 in waffle slab
B. 27% of displacement increases in in x direction where as 10% of displacement increases in y direction of flat slab when compared to waffle slab.
C. Maximum story drift was found to be 0.000421, in waffle slab and it is reduced to 0.000379 i.e. 10.5% in tube-in-tube structure flat slab.
D. The difference between the time period in Flat slab to waffle slab is 32%.
E. Time period for tube in tube structure with waffle slab is least when compared to tube in tube structure flat slab
F. There is a 38% increase in base shear in x-direction of waffle slab when compared to flat Slab.
G. There is a 36% increase in base shear in y-direction of waffle slab when compared to flat Slab.
H. Hence waffle slab structure is more continent.

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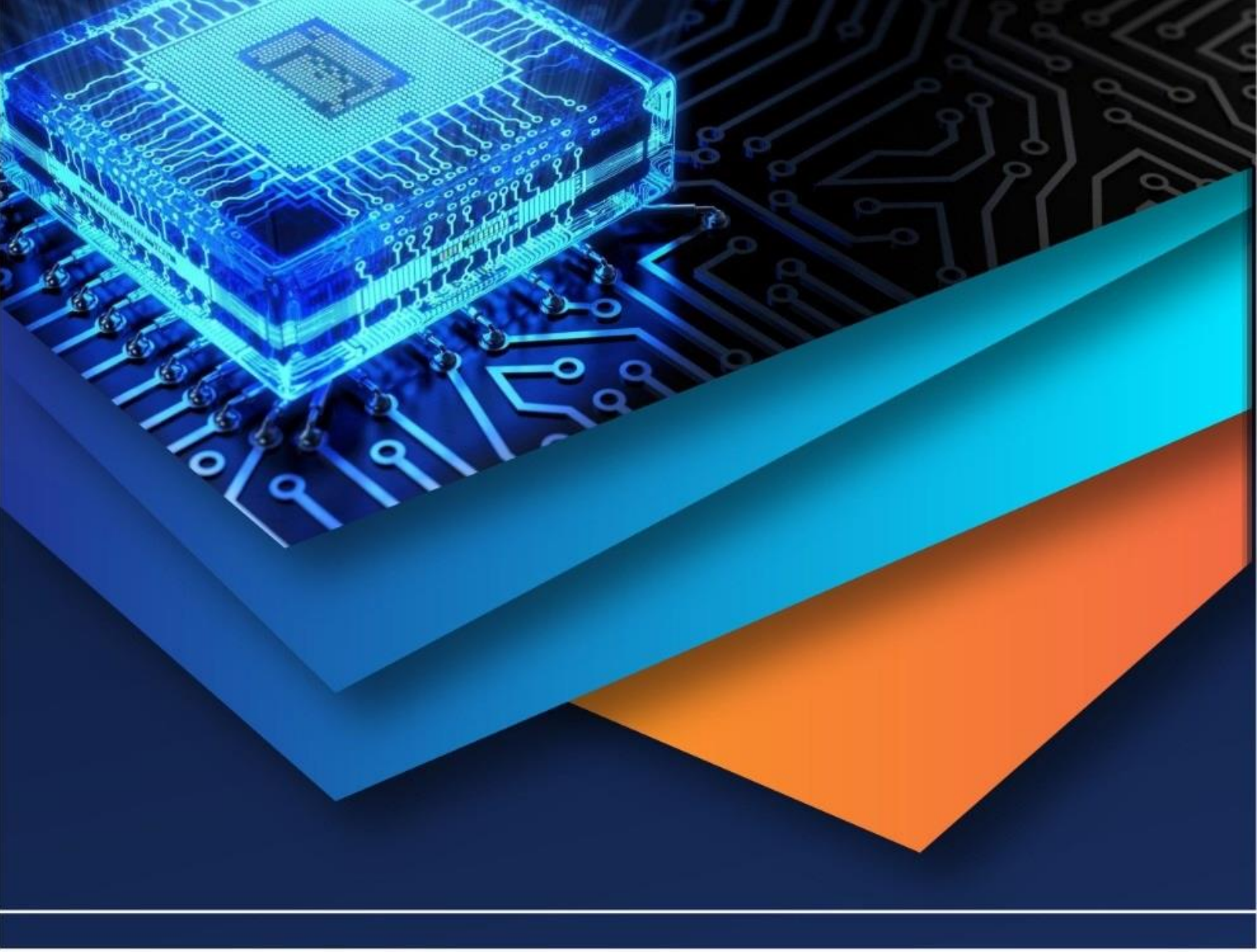

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