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Analysis of Tall Building by Various Types of Structural Forms under Earthquake Analysis

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Abstract: In the current world scenario, high-rise buildings are favoured due to the rapid rise in land values, land shortages, and to conserve land in rural areas for agricultural use. The construction of high-rise buildings primarily depends on wind and seismic loads.

The performance of buildings depends on the structural configuration. The structural system of a high-rise building is designed to work with vertical gravity loads and mainly with lateral loads caused by wind and seismic activity. The structural system consists only of elements designed to transfer loads, all other elements that are not involved in the transfer of loads are called non-structural element.

The research assist the analysis of G+16 Storey level with various mode of structural form used in tall building construction. The G+16 Tall building is modelled on CSI ETBAS for Zone 4 under seismic analysis by Response spectrum analysis. The various types of struural form used in the model 1 to model 6.

The structural form consists of 1) Moment resisting frame 2) Building with Braced Frame Structure 3) Building with Hull-Core (Tube-in-Tube Structure) 4) Building with Shear Wall 5) Building with Composite 6) Building with Outrigger Structure. The research concluded that the model cases no 3 is optimised under the G+16 Storey building. Other than model 2, 4, 1 & 6 recommended for optimised case in descending order.

Keywords: G+16, Tall Building, On CSI ETBAS, Zone 4, Structural Form, Response Spectrum Analysis

I. INTRODUCTION

Building systems are also known as structural systems - a system that ensures the structural stability of a building. Depending on the nature of the building, one or more architectural systems can be applied to a single high-rise building. The adequacy of the lateral load bearing system must be determined by a structural engineer competent in the structural analysis and design of high-rise structures.

Tall buildings have become increasingly popular as a term in development and it has become a trend to build a tall building. Due to the scarcity of land in enclosed areas, the easiest option is to build a tall building to accommodate all the services. High-rise buildings are constructed as mixed developments, residential buildings, office functions, and other important features that must be included when designing high-rise buildings. In addition, depending on the characteristics of the building the structural engineer must select the building to proceed with the design. In addition, these structures described below can be identified as load-resistant systems.

There are various types of reinforcing structures such as reinforcing frame structures, Dry frame structures, Wall Structures, Tube in Tube and others.

II. OBJECTIVE OF THE RESEARCH

1) Study of various structural forms 1) Moment resisting frame 2) Building with Braced Frame Structure 3) Building with Hull-Core (Tube-in-Tube Structure) 4) Building with Shear Wall 5) Building with Composite 6) Building with Outrigger Structure. Analysis of G+16 Storey level with various mode of structural form used in tall building construction.
2) To model the G+16 Tall building with various structural form cases in CSI ETBAS
3) Seismic analysis under Response spectrum analysis for Zone 4.
4) To find out the optimised model cases of structural form of G+16 Storey building.

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III. METHODOLOGY & MODELLING

The different models are to be proposed for the in the building Tall Building taken: **G+16**

Table 1: Proposed Models details

S. No.	Model Description	Model Code
1	Building with Moment resisting frame	Model 1
2	Building with Braced Frame Structure	Model 2
3	Building with Hull-Core (Tube-in-Tube Structure)	Model 3
4	Building with Shear Wall Structure.	Model 4
5	Building with Composite Structure	Model 5
6	Building with Outrigger Structure	Model 6

Table 2: Building Parameters for All Models

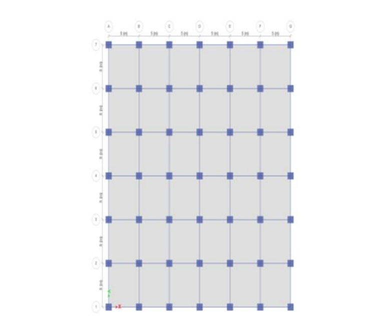
Building Parameters for All Models		
S. No.	Particular	Details
1	Grid Spacing X-direction	5.00 m c/c
2	Grid Spacing Y-direction	5.00 m c/c
3	Storey Height	3.50 m
4	Plan Dimension	30.00 x 30.00 m
5	Building Height (G+16)	59.50 m
6	Slab thickness	150 mm thick
8	Partition Wall Density	20.00 KN/m^3
9	Concrete	M-20
10	Rebar	HYSD 500
11	Column-Foundation Joint	Fixed at base

Table 3: Seismic Data Taken

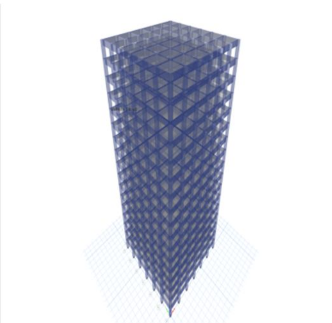
S. No.	Description	Details
1	Seismic Zone	Zone- IV
2	Zone Factor	0.24
3	Soil Type	Medium
4	Importance Factor	1.15
5	Response Reduction Factor	5
6	Direction	Both X & Y

A. Model Description

1) Model 1:- Building with Moment resisting frame



Plan



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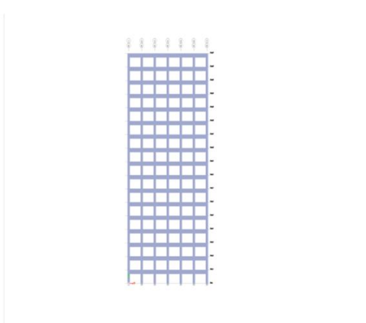
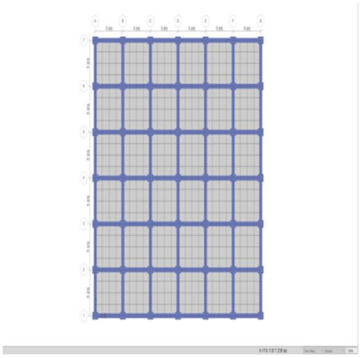


Side View

2) Model 2:- Building with Braced Frame Structure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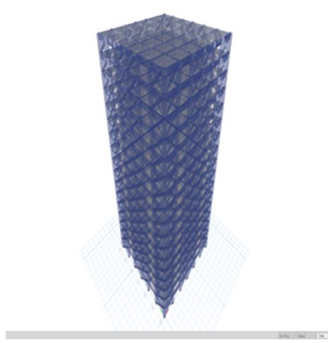
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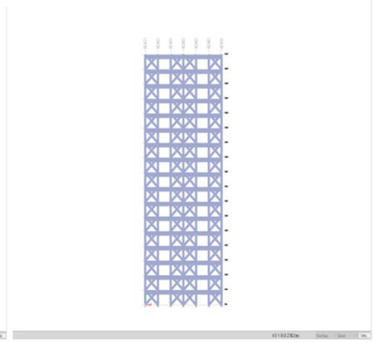
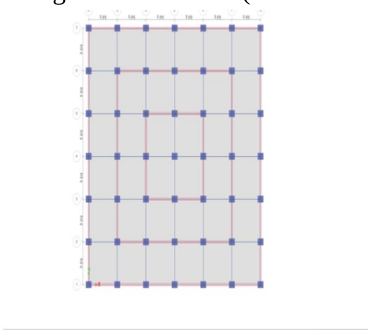

Side View

3) Model 3: Building with Hull-Core (Tube-in-Tube Structure)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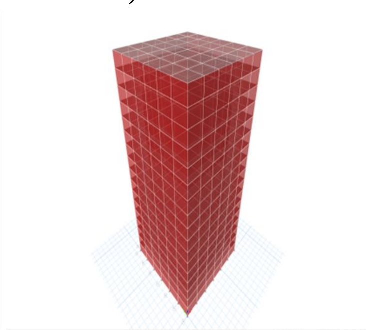
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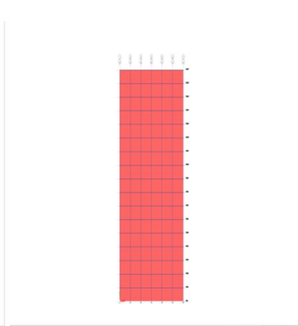
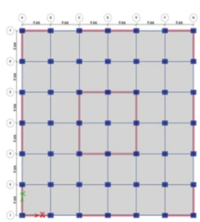

Side View

4) Model 4: Building with Shear Wall Structure.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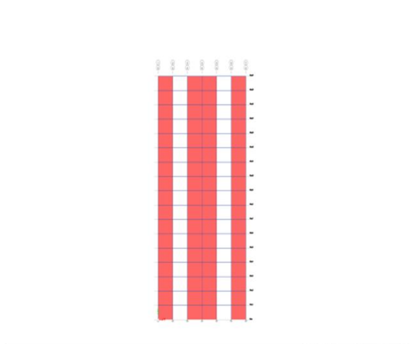
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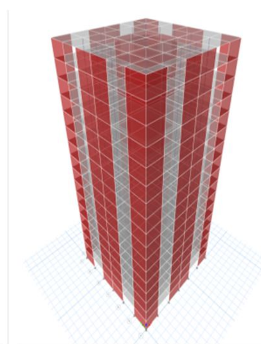
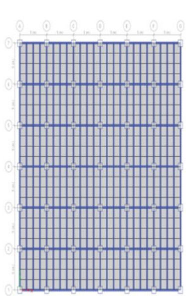

Side View

5) Model 5: Building with Composite Structure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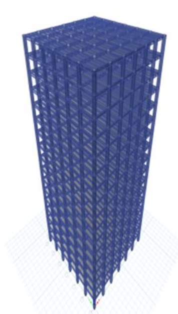
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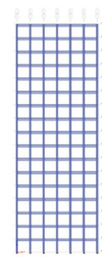
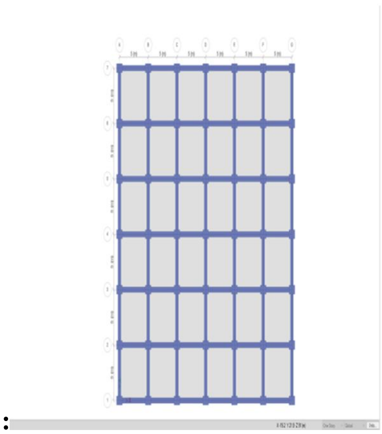

Side View

6) Model 6: Building with Outrigger Structure



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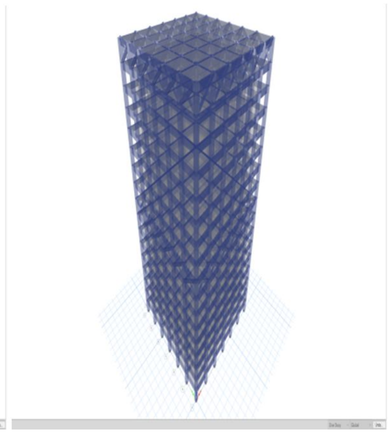

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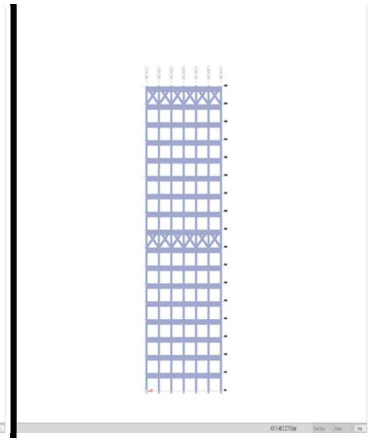


Side View

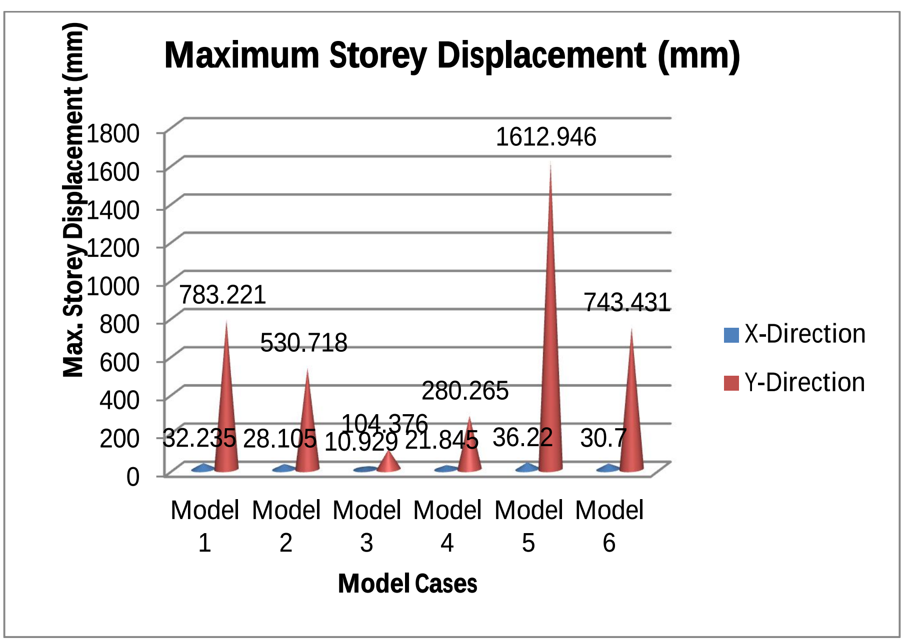
IV. RESULT PARAMETERS

A. Parameter 1: Maximum Storey Displacement level

1) Maximum Storey Displacement

Table 4 : Maximum Storey Displacement

S. No.	Model Cases	X-Direction	Y-Direction
1	Model 1	32.235	783.221
2	Model 2	28.105	530.718
3	Model 3	10.929	104.376
4	Model 4	21.845	280.265
5	Model 5	36.22	1612.946
6	Model 6	30.7	743.431



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2) Storey Level Displacement

Table 5: Storey level Displacement of G+16 Storey in X-Direction for all Cases

S. No.	Case/Storey Level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	G+16	32.235	28.105	10.929	21.845	36.22	30.7
2	G+15	31.383	27.104	10.367	20.787	35.466	30.119
3	G+14	30.265	25.908	9.757	19.625	34.509	29.027
4	G+13	28.889	24.536	9.102	18.374	33.306	27.596
5	G+12	27.287	23.005	8.41	17.036	31.85	25.923
6	G+11	25.493	21.336	7.689	15.621	30.152	24.053
7	G+10	23.538	19.551	6.948	14.141	28.223	22.033
8	G+9	21.454	17.674	6.194	12.615	26.078	19.944
9	G+8	19.27	15.731	5.436	11.06	23.726	18.117
10	G+7	17.013	13.745	4.685	9.496	21.178	17.298
11	G+6	14.709	11.742	3.948	7.946	18.443	15.517
12	G+5	12.501	9.749	3.234	6.435	15.539	13.319
13	G+4	10.312	7.791	2.553	4.989	12.494	10.988
14	G+3	8.064	5.912	1.914	3.637	9.361	8.588
15	G+2	5.776	4.168	1.325	2.413	6.246	6.148
16	G+1	3.49	2.509	0.799	1.358	3.348	3.713
17	Ground	1.342	1	0.343	0.517	1.037	1.428

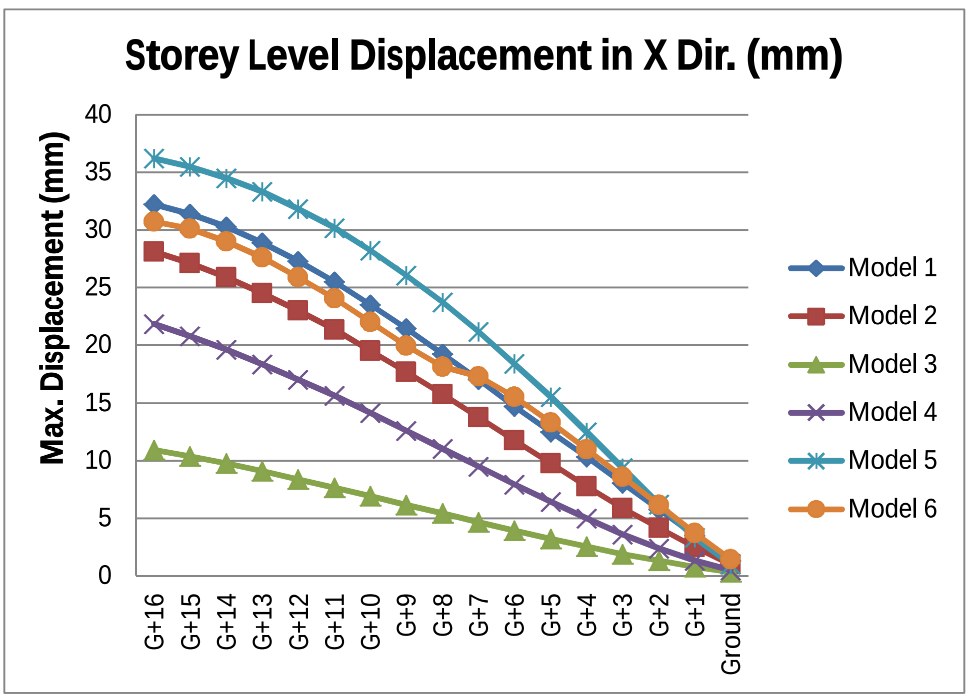

Fig. : Storey level Displacement of G+16 Storey in X-Direction for all Cases

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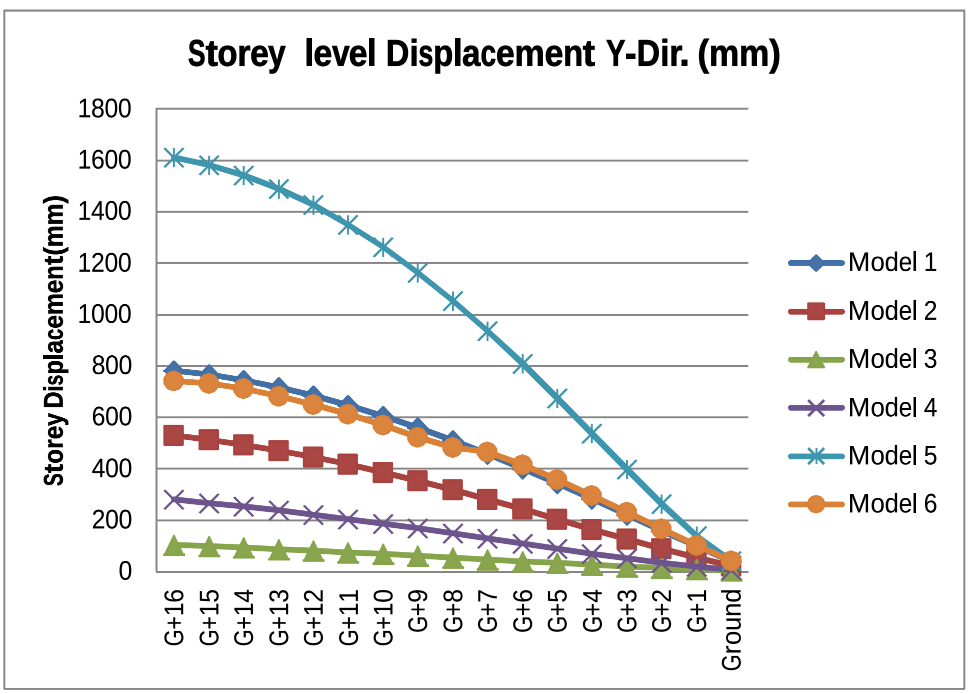
Table 6: Storey level Displacement of G+16 Storey in Y-Direction for all Cases

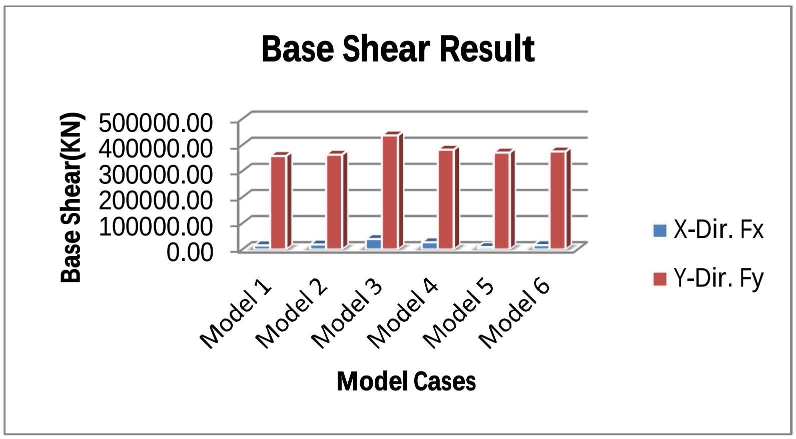
S. No.	Case/ Storey level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	G+16	783.221	530.718	104.376	280.265	1612.946	743.431
2	G+15	766.727	514.022	99.296	267.423	1582.123	732.262
3	G+14	744.987	494.263	93.811	253.445	1542.242	711.15
4	G+13	717.8	471.535	87.944	238.388	1490.918	683.351
5	G+12	685.403	445.899	81.73	222.225	1427.279	650.183
6	G+11	648.101	417.489	75.217	205.006	1351.268	612.126
7	G+10	606.245	386.513	68.459	186.835	1263.291	569.686
8	G+9	560.222	353.239	61.521	167.862	1164.04	524.081
9	G+8	510.45	317.985	54.47	148.281	1054.411	482.493
10	G+7	457.372	281.119	47.378	128.322	935.477	465.611
11	G+6	401.458	243.063	40.323	108.261	808.529	416.848
12	G+5	343.209	204.294	33.387	88.413	675.169	357.639
13	G+4	283.153	165.357	26.657	69.143	537.525	295.44
14	G+3	221.852	126.882	20.226	50.874	398.663	231.68
15	G+2	159.924	89.607	14.197	34.104	263.415	167.13
16	G+1	98.237	54.416	8.686	19.433	139.984	102.731
17	Ground	39.368	22.439	3.81	7.564	43.073	41.193



B. Parameter 2: Base Shear Result

Table 7: Base Shear of G+16 Storey for all Cases

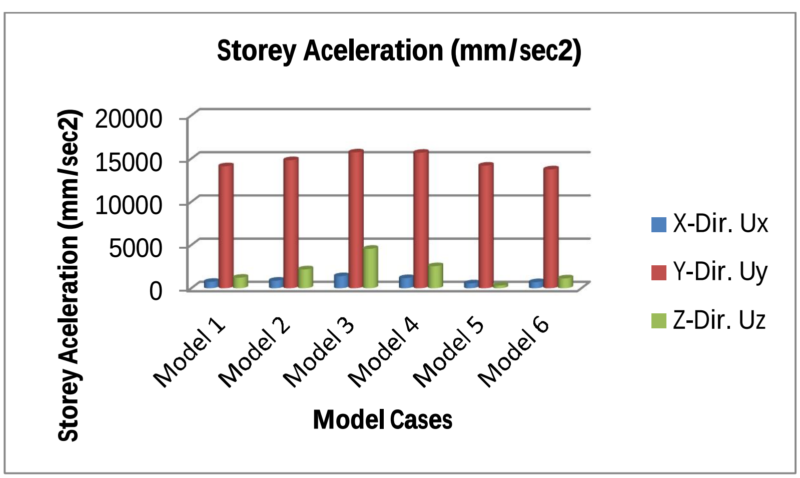
Base Shear		
Case	X-Dir.	Y-Dir.
	Fx	Fy
Model 1	15414.73	358246.81
Model 2	18720.86	363139.79
Model 3	39676.64	436754.04
Model 4	27425.88	382085.15
Model 5	9119.78	371020.43
Model 6	16395.56	375211.13



C. Parameter 3: Storey Acceleration Result

Table 8: Storey Acceleration

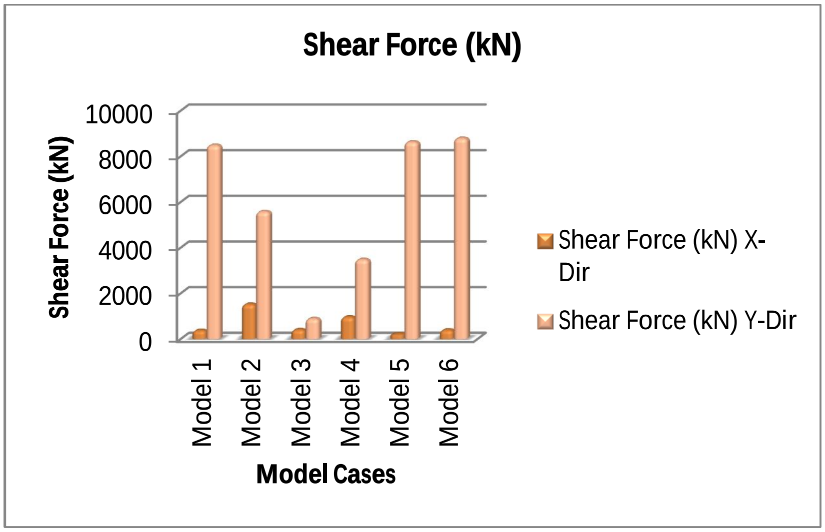
Case	X-Dir.	Y-Dir.	Z-Dir.
	Ux	Uy	Uz
Model 1	743.77	14121.87	1221.64
Model 2	876.2	14829.28	2184.48
Model 3	1399.27	15726.64	4568.56
Model 4	1174.66	15686.23	2554.85
Model 5	565.99	14194.8	311.66
Model 6	706.98	13762.42	1140.55



D. Parameter 4: Shear Force Result

Table 9: Shear Force in Column Result

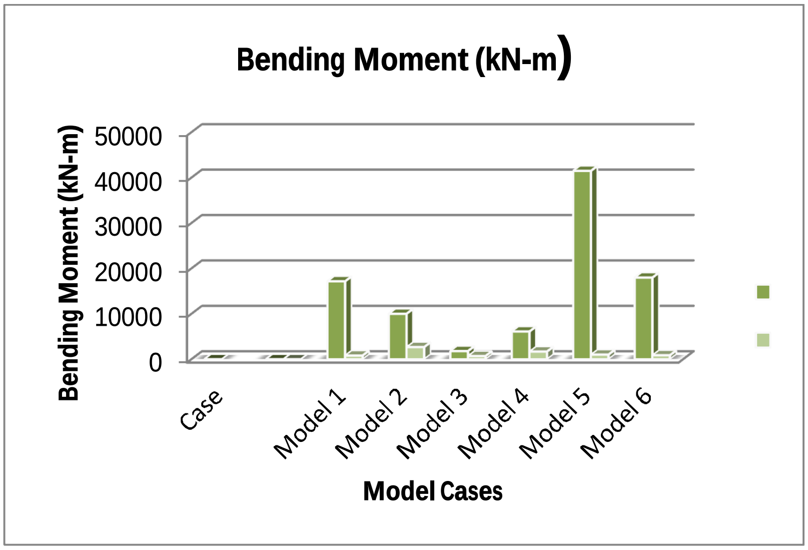
Case	Shear Force (kN)	
	X-Dir	Y-Dir
Model 1	366.9446	8477.0402
Model 2	1517.6012	5572.2995
Model 3	400.7235	885.3599
Model 4	956.6469	3475.938
Model 5	208.0086	8626.1483
Model 6	387.4115	8784.1646



E. Parameter 5: Bending Moment Result

Table 10: Bending Moment in Column Result

Case	Bending Moment (kN-m)	
	X-Dir	Y-Dir
Model 1	17148.4739	812.6099
Model 2	9994.5861	2654.8709
Model 3	1794.3518	702.5513
Model 4	6094.9559	1676.0734
Model 5	41471.999	1002.011
Model 6	17960.0665	863.5613



V. CONCLUSIONS

The list out conclusions made under the analysis of G+16 Storey level with various mode of structural form used in tall building construction. These conclusions are valid for this project only.

1) The Maximum Storey Displacement is reduced in Model 2,3,4,6 in X- direction with respect to Case 1. In Y direction Maximum Storey Displacement is reduced case 2,3,4,6. The higher value found in case 5.
2) Under deflection check in X & Y direction, X direction all case found satisfactory but in Y direction case 3 is under the limit.
3) On comparing Storey level Displacement model 5 found not recommended for construction.
4) In X direction shear value in column is found least in model 5, slightly increment found in the value for model 3, 4, 6. The higher value found in Model 2 as compare to Model 1 (Normal structural case). The same case found in Y direction also.
5) There is reduction in bending moment value in column found from model 2 to 5, there is increment found in the value for model 6 in X direction. For Y direction the higher value found in Model 2, 4, 5,6 as compare to Model 1 (Normal structural case). Least value found in Model 3.
6) Increment in Base shear is found in new structural forms cases, due to extra elements introduced in the forms.

Over all it is concluded that model case 3 Building with Hull-Core (Tube-in-Tube Structure) is optimised structure under G+ 16 storeys under respective location and zone. Other than model 2, 4, 1 & 6 recommended for optimised case in descending order.

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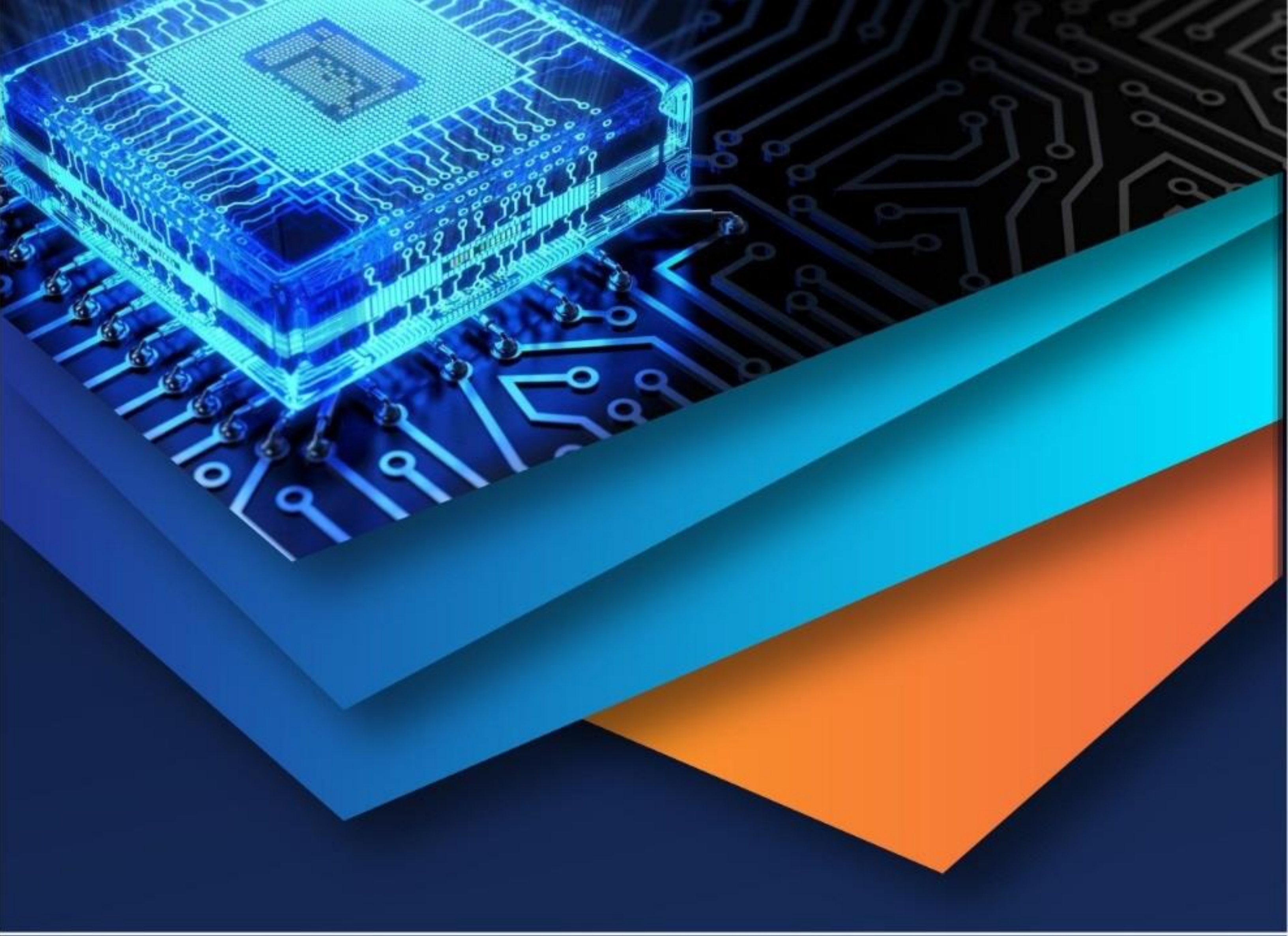

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