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"Design, Analysis and Cost Comparison of Steel and Concrete of A G+14 Multistorey Building W.R.T. Same Building with Different Bracing Patterns"

Govind Pallod [1], Prof. Salman Shaikh [2], Er. Alok Kumar[3]
[1](*M. Tech Student, Department of Civil Engineering, Sanmati Engineering College, Washim (M.S.), India)*
[2](*Asst. Proff., Department of Civil Engineering, Sanmati Engineering College, Washim (M.S.), India)*
[3](*Civil Engineer, Construction Department, Millenium Real Infra Pvt. Ltd., Gr. Noida (U.P.), India)*

Abstract:
Due to earthquake major losses can occurred it may give damages to structure and in worst Case it may collapse. For avoiding this damage of structure, bracings are provided to high rise buildings to provide strength and also for resist lateral load imposed by earthquake and wind. Bracing system is installed between column members to resist the lateral load. Bracing system is easy to installed, economical and occupies less space. Bracing system is provided for stiffness, strength and energy dissipation to resist the lateral load. Structural system development has evolved continuously to overcome the problems related to lateral stability and sway, there are many ways developed and adopted now these days to overcome this. One such structural system is bracing system. Structures are connected with various activities like sport, healthcare, transport, residence and power generation. All the structure posing adequate strength. The frame structure transfers the gravity load and lateral load to the foundation. Colum and beam distribute the gravity load in to the structure but there are not significant for stability of structure. They provide the different bracing system to transfer the seismic wave in to the structure.
The Bracing system has proved to be most promising structural system in resisting problem related to lateral stability and sway. The present study is conducted for G+14 storied high rise building with different kinds of Bracing patterns introduced in building outer periphery. High rise building with floor plan of 48m x 45m. Five types of models were decided to analyses the structure for all seismic Zones. Model Type I - For the reference base model, a regular reinforced concrete moment resisting bare frame model is considered. Model Type II – In base model introducing the Model with X-Bracing. Similarly Model Type III, Model Type IV & Model Type V – In base model introducing the Model with V-Bracing, Λ-Bracing & Single Diagonal -Bracing respectively. Static Earthquake analysis is carried out to study parameter's maximum storey displacement, Base shear, Base moment, Axial Force and Bending Moment to compare building with application of concrete outrigger at various position varying with the height of building and the software used for this analysis is Staad-pro V8i version. The load condition is applied as per IS 1893:2002. Bracing system improve the displacement capacity of the structure.
Key Words: *Multi-stories building, Bracing System, lateral stability, sway, Nodal displacement, Base shear, Base moment, Axial Force and Bending Moment.*

I. Introduction

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. Strengthening of structures proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of buildings. Moreover, it has been often seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction. Therefore, seismic retrofitting or strengthening of building structures is one of the most important aspects for mitigating seismic hazards especially in earthquake prone areas. Here we are going to study about the different bracing system (diagonal type, V type, inverted and X type) and arrangement of bracing system. To build the seismically safe structure with adequate lateral resistance. Bracing system is installed between column members to resist the lateral load. Bracing system is easy to installed, economical and occupies less space. The structure is analyzed for all Indian seismic zone with different types of bracing system and compared with the bare frame with the using of Staad-pro v8i software. The load condition is applied as per IS 1893:2002. Bracing system improve the displacement capacity of the structure. Seismic analysis is calculating the response of structure to the earth quake. Nowadays high-rise building is constructed for the purpose of stiffness and lateral load resistance. Larger seismic waves strike the earth surface caused shaking the earth surface in all possible direction. In recent year growth of the cities have been on rise and any RC building depend on many factors like strength of material, used soil and amount of mass. Bracing are the most prominent method used by structural engineers to increase the lateral load resistance by bracing. There are many braced systems in RC structure like V, K and X. But concentric bracing mostly used by structure engineer. Structures are connected with various activities like sport, healthcare, transport, residence and power generation. All the structure posing adequate strength. The frame structure transfers the gravity load and lateral load to the foundation. Colum and beam distribute the gravity load in to the structure but there are not significant for stability of structure. They provide the different bracing system to transfer the seismic wave in to the structure.

II. Results And Discussion

A G+14 Multi-storied RCC building for all Seismic Zones is modeled using STADD-Pro software and the results are computed. The configurations of all the models are discussed in previous chapter. From the values mentioned in the problem definition, the present study is conducted for 14 storied high rises building with & Without Bracing in building at outer periphery. High rise building with floor plan of 45m x 48m. Five types of models are generated to study the behavior of earthquake resistant structure for all seismic zones. Figure 4.1 shows plan of the structure generated in STADD-Pro. Following are the models generated. Model type 1 is simple structure and is configured as per the problem statement as stated in previous chapter. All the loads and details are same as mentioned conforming to IS 456:2000, IS 875Part1 & Part 2 & IS 1893:2002/2005. It is a simple structure analyzed for earthquake resistant conforming to the Indian design standard codes. Model 2, Model 3, Model 4 & Model 5 are the modification over the first model. These Model X-Bracing, V-Bracing, Inv-V-Bracing & SD-Bracing simultaneously introduced in all side of Structure with symmetrical building on outer walls side of structure a new method is adopted as Bracing patterns in building Structure. As per the Indian Standard code specification Bracings are introduced for achieving proper stiffness to the structure. Equivalent Static Earthquake analysis is carried out to study parameter's maximum Nodal displacement, Base shear, Base moment, Axial Force and Bending Moment to compare building with application of concrete Bracings. Software used for this analysis is Staad-pro V8i version. These models are analyzed and designed as per the specifications of Indian Standard codes IS1893, IS 13920, IS 875 and IS 456: 2000. The equivalent static method or seismic coefficient method had been used to find the design lateral forces along the storey in X and Z direction of the building since the building is unsymmetrical. Models created in Staad-pro are shown in figure below:

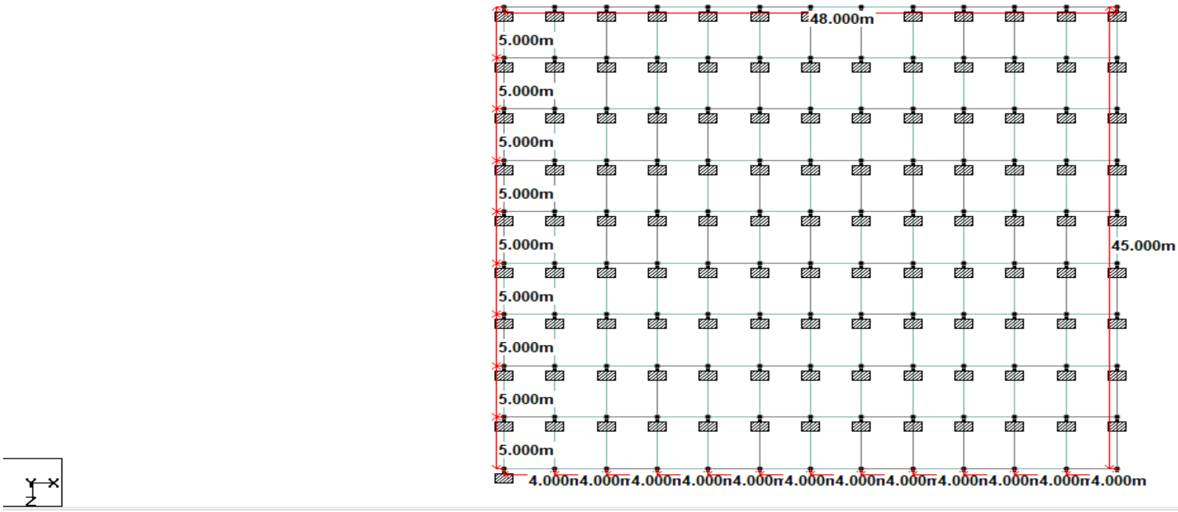


Figure 5.1 Plan of Building Generated In Staad-Pro

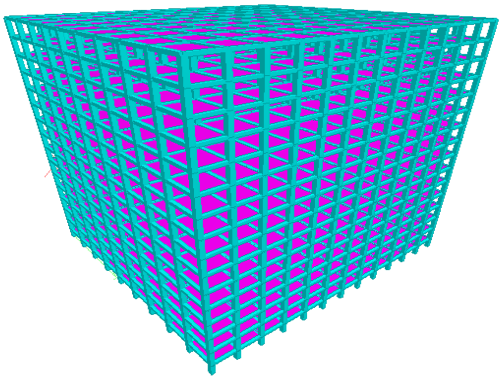


Figure: 5.2 (a) Model type 1
Conventional Concrete Building

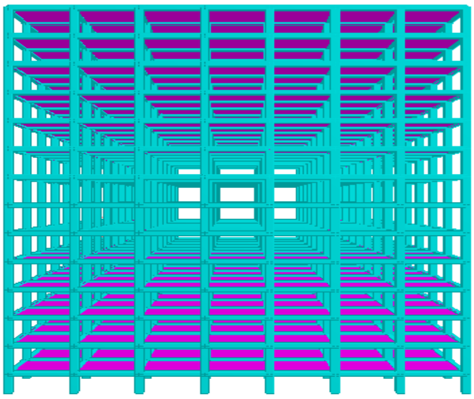


Figure 5.2 (b) Model type 1 (Front)

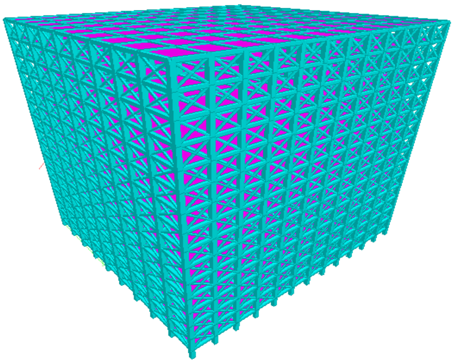


Figure 5.3 (a): - Model type 2
Building with X-Bracing

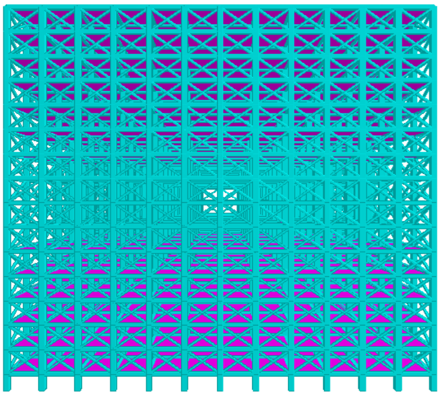


Figure 5.3 (b): - Model type 2 (Front)

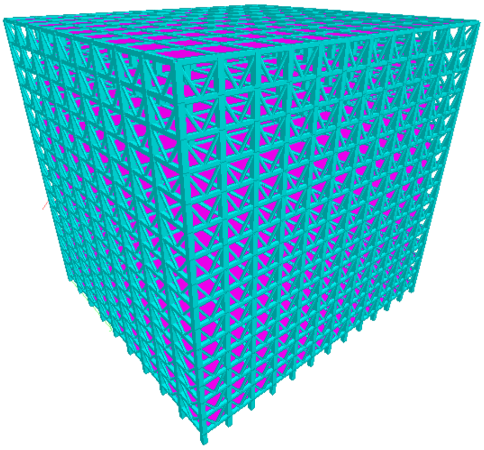


Figure 5.4 (a) Model type 3
Building with V-Bracing

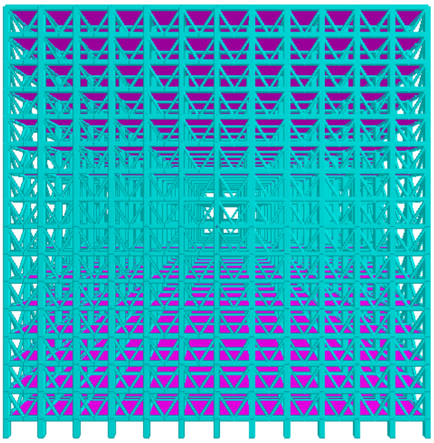


Figure 5.4 (b): - Model type 3 (Front)

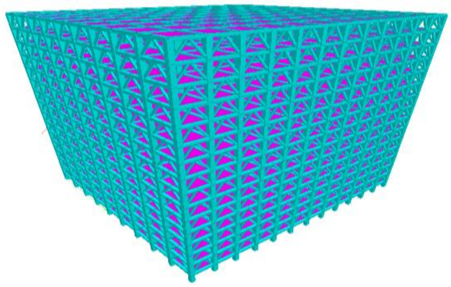


Figure 5.5 (a): - Model type 4 Building with Inv-V-Bracing

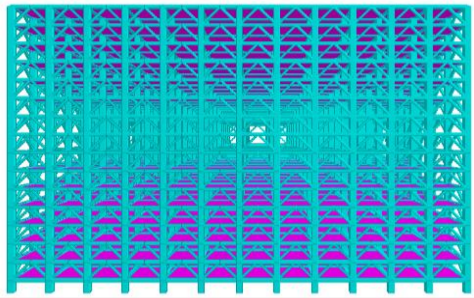


Figure 5.5 (b): - Model type 4 (Front)

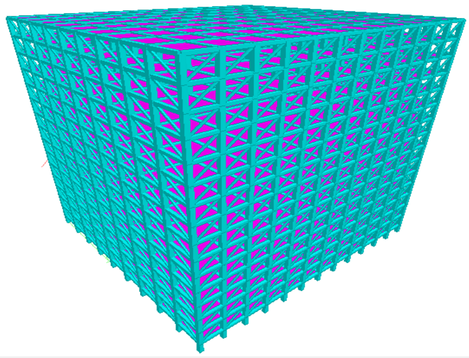


Figure 5.6 (a) Model type 5 Building with SD-Bracing

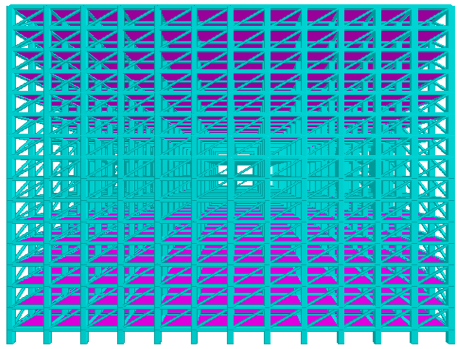


Figure 5.6 (b): - Model type 5 (Front)

5.2 Maximum Node Displacement:

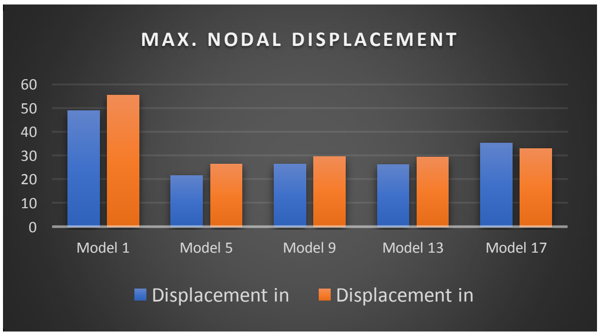
Node displacement of any structure represents the deflection of the structure whenever any load or load combination is applied on the structure. Since the building is analyzed for earthquake resistance, displacements in horizontal directions are shown in table 5.1. Maximum displacements in X- Direction and Z- Direction for load combinations are stated in the table.

A graphical representation of the table displacement in X and Z direction is shown in the figure. The figure clearly shows that, there is a pattern of increase in node displacement for model type 2. This briefly states that the building is stiff with Bracing Patterns. Whereas the model type 5 becomes economical as the concrete is reduced being approximate similar stiffness is acquired.

Table 5.1 Maximum Node Displacement for ZII

Model	**Displacement in X (mm)**	**Displacement in Z (mm)**
Model 1	48.827	55.483
Model 5	21.669	26.469
Model 9	26.407	29.598
Model 13	26.136	29.263
Model 17	35.244	32.937

Figure 5.7 Maximum Node displacement for ZII



DOI: 10.9790/1684-1903010514

Table 5.2 Maximum Node Displacement for ZIII

Model	Displacement in X (mm)	Displacement in Z (mm)
Model 2	78.094	88.734
Model 6	34.649	42.322
Model 10	42.23	47.329
Model 14	41.789	46.786
Model 18	52.977	54.269

Figure 5.8 Maximum Node displacement for ZIII

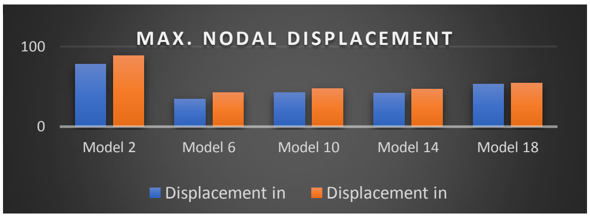


Table 5.3 Maximum Node Displacement for ZIV

Model	Displacement in X (mm)	Displacement in Z (mm)
Model 3	117.118	133.069
Model 7	51.956	63.459
Model 11	63.328	70.97
Model 15	62.66	70.15
Model 19	76.62	82.715

Figure 5.9 Maximum Node displacement for ZIV

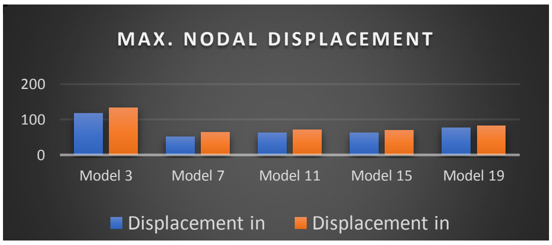
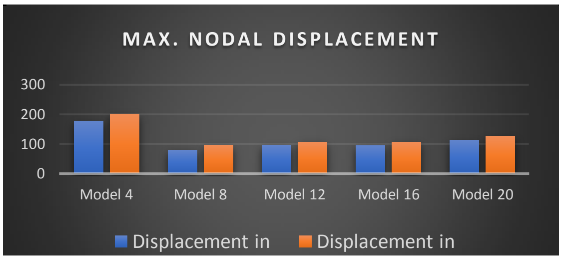


Table 5.4 Maximum Node Displacement for ZV

Model	Displacement in X (mm)	Displacement in Z (mm)
Model 4	175.654	199.57
Model 8	77.916	95.166
Model 12	94.975	105.589
Model 16	93.967	105.197
Model 20	112.086	125.383

Figure 5.10 Maximum Node displacement for ZV

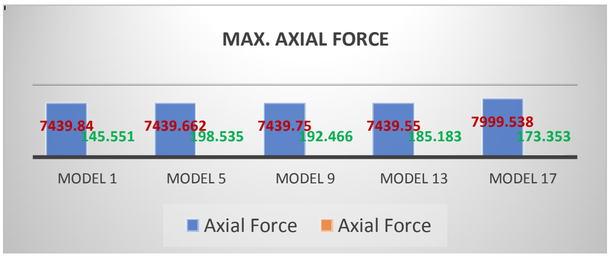


5.3 Axial Force Calculation

Table 5.5 Maximum Axial Force for ZII

Model	Axial Force X (KN)	Axial Force Z (KN)
Model 1	7439.84	145.551
Model 5	7439.662	198.535
Model 9	7439.75	192.466
Model 13	7439.55	185.183
Model 17	7999.538	173.353

Figure 5.11 Maximum Axial Force for ZII



5.4 Bending Moment calculation

Table 5.6 Maximum Bending Moment for ZII

Model	Bending Moment X (KN-M)	Bending Moment Z (KN-M)
Model 1	1.508	224.65
Model 5	2.983	252.973
Model 9	2.6	238.344
Model 13	2.583	233.352
Model 17	5.905	241.049

Figure 5.12 Maximum Bending Moment for ZII

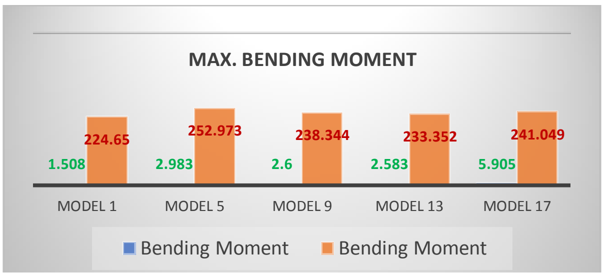


Table 5.7 Maximum Axial Force for ZIII

Model	Axial Force	Axial Force
	X (KN)	Z (KN)
Model 2	7439.84	229.959
Model 6	7531.581	313.997
Model 10	7439.75	290.708
Model 14	7555.814	294.698
Model 18	8965.671	284.048

Figure 5.13 Maximum Axial Force for ZIII

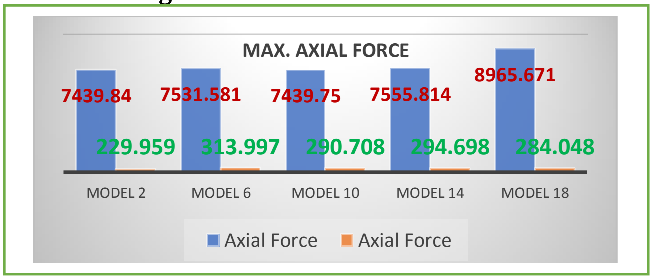


Table 5.8 Maximum Bending Moment for ZIII

Model	Bending Moment	Bending Moment
	X (KN-M)	Z (KN-M)
Model 2	2.41	358.302
Model 6	4.182	396.214
Model 10	3.641	366.849
Model 14	3.61	371.139
Model 18	8.828	389.477

Figure 5.14 Maximum Bending Moment for ZIII

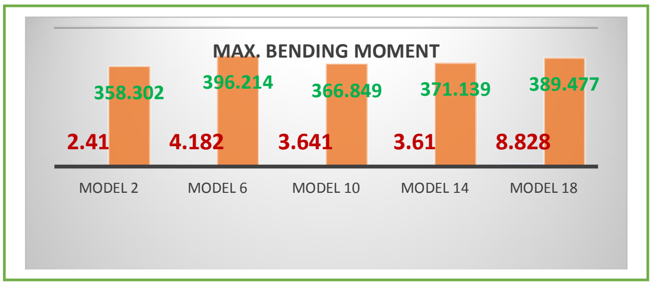


Table 5.9 Maximum Axial Force for ZIV

Model	Axial Force	Axial Force
	X (KN)	Z (KN)
Model 3	7601.775	343.101
Model 7	8796.211	467.948
Model 11	8407.546	435.021
Model 15	8882.39	440.719
Model 19	10253.848	431.642

Figure 5.15 Maximum Axial Force for ZIV

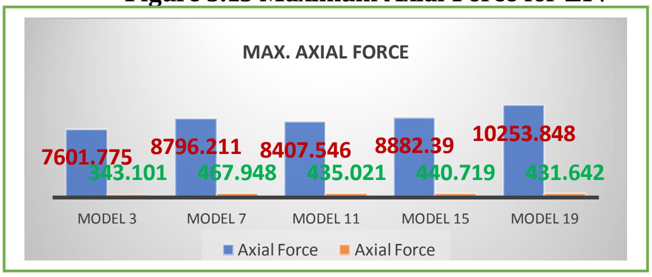


Table 5.10 Maximum Bending Moment for ZIV

Model	Bending Moment	Bending Moment
	X (KN-M)	Z (KN-M)
Model 3	3.615	537.434
Model 7	6.173	587.201
Model 11	5.448	548.662
Model 15	5.403	554.855
Model 19	13.084	587.381

Figure 5.16 Maximum Bending Moment for ZIV

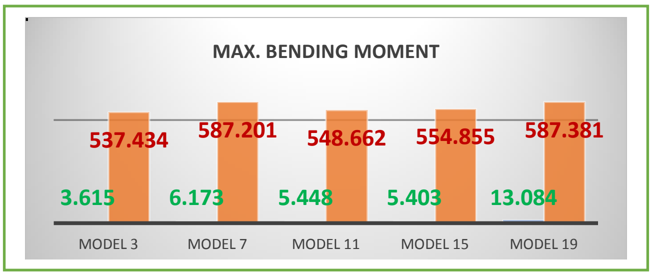


Table 5.11 Maximum Axial Force for ZV

Model	Axial Force	Axial Force
	X (KN)	Z (KN)
Model 4	8787.447	514.629
Model 8	10693.157	698.873
Model 12	10189.873	651.49
Model 16	10872.253	659.749
Model 20	12186.113	653.032

Figure 5.17 Maximum Axial Force for ZV

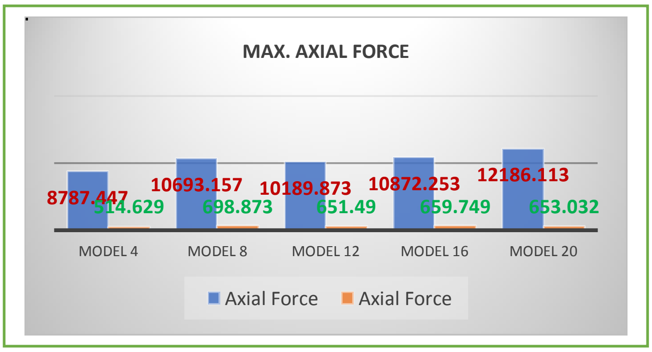
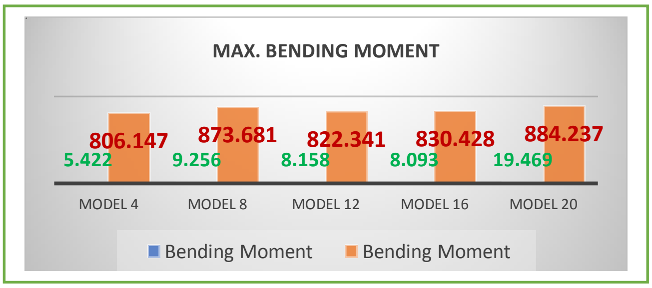


Table 5.12 Maximum Bending Moment for ZV

Model	Bending Moment X (KN-M)	Bending Moment Z (KN-M)
Model 4	5.422	806.147
Model 8	9.256	873.681
Model 12	8.158	822.341
Model 16	8.093	830.428
Model 20	19.469	884.237

Figure 5.18 Maximum Bending Moment for ZV

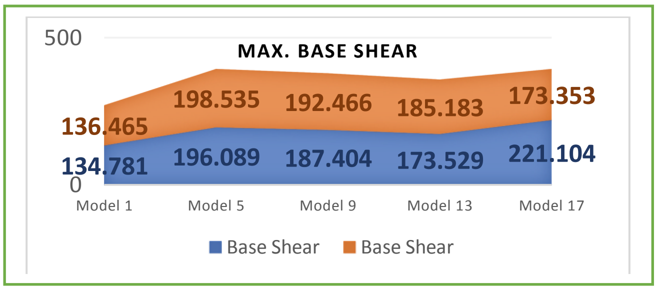


5.5 Base Shear

Table 5.13 Maximum Base Shear for ZII

Model	Base Shear X (KN)	Base Shear Z (KN)
Model 1	**134.781**	**136.465**
Model 5	196.089	198.535
Model 9	187.404	192.466
Model 13	173.529	185.183
Model 17	221.104	173.353

Figure 5.19 Maximum Base Shear for ZII



5.6 Base Moment

Table 5.14 Maximum Base Moment for ZII

Model	Base Moment X (KN-M)	Base Moment Z (KN-M)
Model 1	217.266	203.052
Model 5	265.944	252.973
Model 9	256.978	238.344
Model 13	254.708	233.352
Model 17	260.311	241.049

Figure 5.20 Maximum Base Moment for ZII

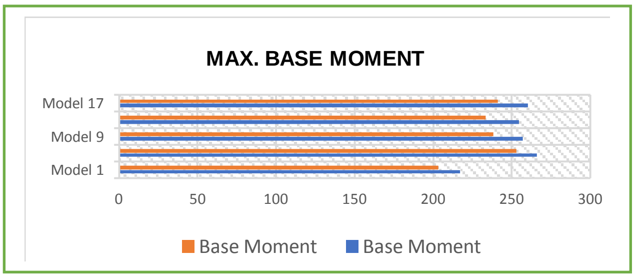


Table 5.15 Maximum Base Shear for ZIII

Model	Base Shear X (KN)	Base Shear Z (KN)
Model 2	215.419	217.815
Model 6	306.802	313.997
Model 10	275.993	290.708
Model 14	275.945	294.698
Model 18	328.636	284.048

Figure 5.21 Maximum Base Shear for ZIII

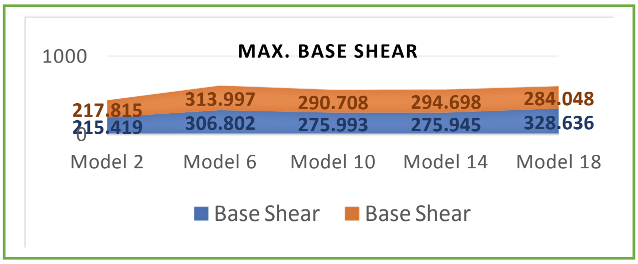


Table 5.16 Maximum Base Moment for ZIII

Model	Base Moment X (KN-M)	Base Moment Z (KN-M)
Model 2	347.213	324.85
Model 6	420.815	396.214
Model 10	401.664	366.849
Model 14	405.427	371.139
Model 18	418.347	389.477

Figure 5.22 Maximum Base Moment for ZIII

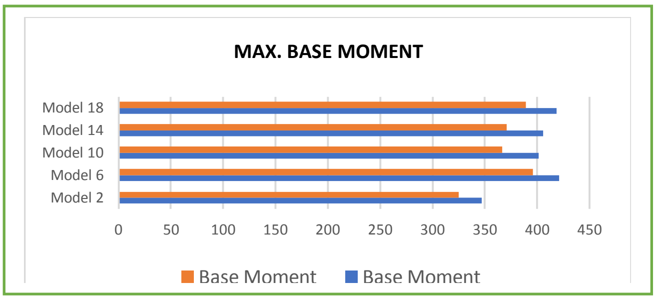


Table 5.17 Maximum Base Shear for ZIV

Model	Base Shear	Base Shear
	X (KN)	Z (KN)
Model 3	323.128	326.282
Model 7	454.418	467.948
Model 11	408.201	435.021
Model 15	412.5	440.719
Model 19	472.012	431.642

Figure 5.23 Maximum Base Shear for ZIV

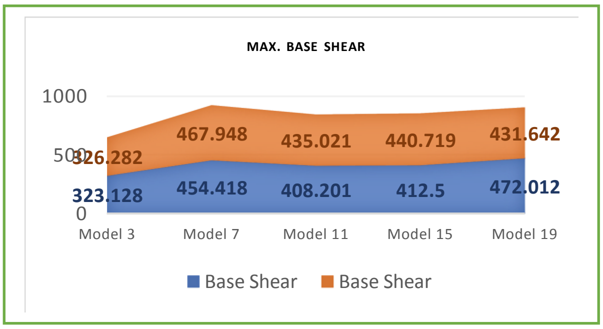


Table 5.18 Maximum Base Moment for ZIV

Model	Base Moment	Base Moment
	X (KN-M)	Z (KN-M)
Model 3	520.523	487.271
Model 7	627.308	587.201
Model 11	600.838	548.662
Model 15	606.386	554.855
Model 19	629.063	587.381

Figure 5.24 Maximum Base Moment for ZIV

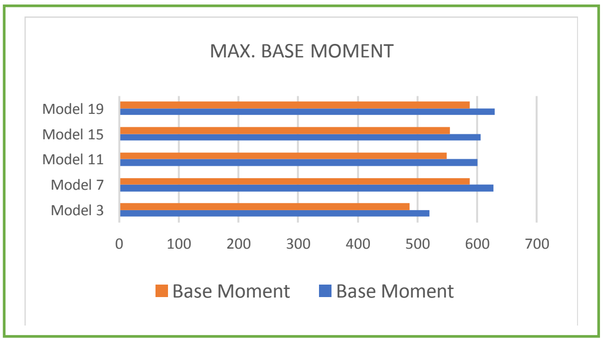


Table 5.19 Maximum Base Shear for ZV

Model	Base Shear	Base Shear
	X (KN)	Z (KN)
Model 4	484.693	488.982
Model 8	675.842	698.873
Model 12	611.914	651.49
Model 16	617.333	659.749
Model 20	687.076	653.032

Figure 5.25 Maximum Base Shear for ZV

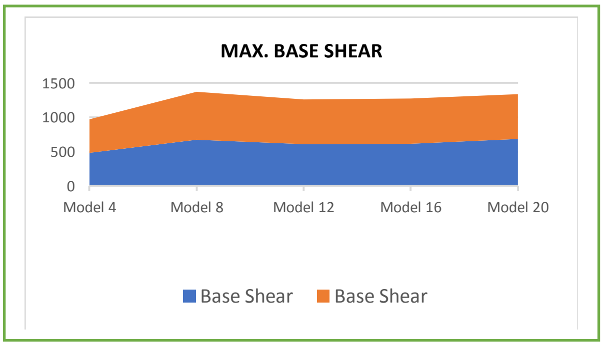
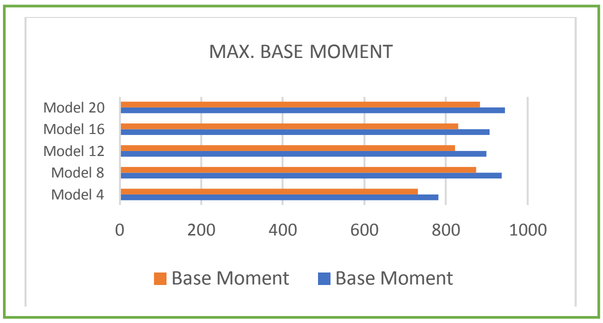


Table 5.20 Maximum Base Moment for ZV

Model	Base Moment	Base Moment
	X (KN-M)	Z (KN-M)
Model 4	780.758	730.906
Model 8	937.049	873.681
Model 12	899.599	822.341
Model 16	907.824	830.428
Model 20	945.136	884.237

Figure 5.26 Maximum Base Moment for ZV



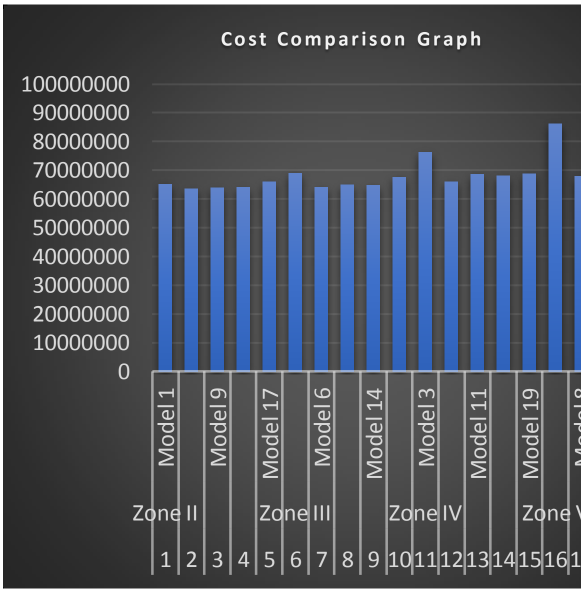
5.7 Cost comparison of Structural all models

Table 5.21 Cost comparison of Structural all models.

Sr. No.	Model	Vol. of Concrete (m3)	Weight of Steel (N.)	Weight of Steel (Kg.)	Total Amount (INR)
1	**Model 1**	5650.2	4121415	412141.5	65177460
2	**Model 2**	5650.2	4601742	460174.2	69020076
3	**Model 3**	5628.6	5526464	552646.4	76294732
4	**Model 4**	5375.2	6953683	695368.3	86268104
5	**Model 5**	5650.2	3919686	391968.6	63563628
6	**Model 6**	5647.4	4000038	400003.8	64190484
7	**Model 7**	5641.6	4245001	424500.1	66117128
8	**Model 8**	5597	4503464	450346.4	67930612
9	**Model 9**	5650.3	3958018	395801.8	63870854
10	**Model 10**	5650.3	4090883	409088.3	64933774
11	**Model 11**	5641.6	4553751	455375.1	68587128
12	**Model 12**	5597	4874476	487447.6	70898708
13	**Model 13**	5650.3	3991150	399115	64135910
14	**Model 14**	5647.4	4084432	408443.2	64865636
15	**Model 15**	5641.6	4487938	448793.8	68060624
16	**Model 16**	5597	4792773	479277.3	70245084
17	**Model 17**	5649.5	4222139	422213.9	65979262
18	**Model 18**	5645.6	4433673	443367.3	67649304
19	**Model 19**	5616.1	4604343	460434.3	68846514
20	**Model 20**	5525	5206862	520686.2	73147396

Assume Rate of concrete= 5700/m3 & Rate of Steel= 80/kg.

Figure 5.27 Cost comparison of Structural all models.



This chapter clearly states about the result obtained after the analysis of the all the models. The results for Base shear, Base Moment, Axial force, bending moment and Node displacement are compared for different models. Graphical representations and Tables for elaborating the values are made in this chapter. A special Comparison has been established for Cost of individual models.

III. Conclusion

The present study is conducted for G+14 Multi-storied RCC building for all Seismic Zones is modeled using STADD-Pro software and the results are computed. The results parameter adopted for this research of all the models are discussed in previous chapter. From the values mentioned in the problem definition, the present study is conducted for 14 storied high-rises building with & Without Bracing in building at outer periphery. High rise building with floor plan of 45m x 48m. Five types of models are generated to study the behavior of earthquake resistant structure for all seismic zones. Static Earthquake analysis is carried out to study parameter's maximum storey displacement, Base shear, Base moment, Axial Force and Bending Moment to compare building with application of Bracing pattern and the results obtained were satisfactory and following are the concluded remarks that can be established from the results.

- There is a pattern of reduction in node displacement for model 5, model 9, model 13 and model 17 when compared with model 1 for Zone II. In which it can be observed model 5 is much less displaced structure compared to other. For economical purpose model 17 can also be preferable for this Zone as results is Satisfactory.
- Similarly, there is a pattern of reduction in node displacement for model 6, model 10, model 14 and model 18 when compared with model 2 for Zone III. In which it can be observed model 6 is much less displaced structure compared to other. For economical purpose model 18 can also be preferable for this Zone as results is Satisfactory.
- Similarly, there is a pattern of reduction in node displacement for model 7, model 11, model 15 and model 19 when compared with model 3 for Zone IV. In which it can be observed model 7 is much less displaced structure compared to other. For economical purpose model 18 can also be preferable for this Zone as results is Satisfactory.
- Similarly, there is a pattern of reduction in node displacement for model 8, model 12, model 16 and model 20 when compared with model 4 for Zone V. In which it can be observed model 8 is much less displaced

structure compared to other. For economical purpose model 20 can also be preferable for this Zone as results is Satisfactory.

- Overall, we can say that, Structure with X-Bracing is much efficient for all seismic Zones compared to bare frame model. For economical purpose Single diagonal bracing pattern can also be preferable for this Zone as results is Satisfactory.
- After observing table of Axial force for all Seismic Zones, it can be said that Axial force in X-direction is much greater up to 8000KN and similar for all types of structure, while in Z direction its value is much small less than 200KN and difference can be observed for Zone II. Also, observing while Zone is increasing Value of Axial force increases for the same model in X-direction as well as in Z-direction.
- After observing table of Bending Moment, it can be said that Bending Moment in X-direction is much lesser and similar for all types of structure, while in Z direction its value is much greater and difference can be observed for Zone II. Also, observing while Zone is increasing from Zone II to Zone V, Value of Bending Moment increases for the same model in X-direction as well as in Z-direction.
- After observing table of Base Shear & Base Moment for all Seismic Zones, it can be said that Base Shear & Base Moment in X-direction & Z direction are mostly similar there is negligible difference can be observed in both values. Also, observing while Zone is increasing Value of Base Shear & Base Moment increases for the same model in X-direction as well as in Z-direction.
- By observing cost comparison table, we can conclude that model 5 Structure with X-bracing is most economical structure in Zone II, while in this structure having much structural elements.

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