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Earthquake Resistant Thin High Rise Building Design with SAP2000

Prathyusha.P, Student, JNTU, Ananthapur & India, prathyu0603@gmail.com

Ajitha.M, Assistant Professor, JNTU, Ananthapur & India, ajitha123.civil@jntua.ac.in

Abstract - **"Earthquake resistant area" there is no such area called an earthquake-resistant zone, the amount of earthquakes in our nation is becoming a major problem. The construction of a building structure that can effectively withstand seismic stress is one of the most crucial elements. In order to develop an effective, safe, earthquake-resistant building, several structural arrangements are studied to determine the most optimal approach. In the current analysis, a thin high-rise building with a height of 60 m and a width of 15 m is analysed. X bracings are placed at strategic locations throughout the building, and the results of displacement, shear, and moment are determined in three zones (Z-3, Z-4, and Z-5) in three soils (S-1, S-2, and S-3).Analyzing commercial buildings has been done using a commercial version of SAP 2000. Tables and graphs have been used to compare the results in order to choose the most optimal course of action. On the basis of this study and the comparison tables, a conclusion has been drawn.**

Keywords: Thin High Rise Building, SAP2000, X-Bracings.

I. INTRODUCTION

The bracing system has long been regarded as the most effective defence against the lateral stresses that seismic forces cause to be created in the building. The purpose of this study is to offer an effective bracing mechanism against such pressures. Decreasing the effective length of the columns can help to raise their stiffness and lower their net longitudinal reinforcement, but the issue is to do so without altering the overall building requirements (especially architectural) or the fundamental building frame structure as a whole.

Using a bracing mechanism to shorten the column's effective length

Using a bracing system can shorten the column's effective length. Incorporating a novel diamond-shaped bracing system into the primary building structure, thorough calculations are used to determine the system's applicability. Additionally, it is contrasted with the cross bracing system, another widely used bracing technique. In order to increase the overall stiffness and strength of steel and composite frames, bracing is a very effective worldwide upgrade method. It may lessen the demand caused by earthquake loads or boost the energy absorption of buildings. Strong ground vibrations can create stresses and deformations that structures can safely withstand if they have increased energy dissipation. The structural system is often modified globally such that the design demands, which are frequently indicated by goal displacement, on the existing structural and non-structural components are smaller than their capabilities. Lower demands may lessen the possibility of the structure failing brittlely and/or prevent the disruption of its operation. By making sure all other members and connections behave linearly and coercing inelasticity to happen in dissipative zones, it is possible to achieve global structural ductility within the design capacity. If the braces are not appropriately capacity-designed, bracing may be ineffective. Where they alter the building's original architectural elements, braces can be unsightly. Additionally, braces convey extremely strong forces to connections and foundations, which frequently require strengthening.

II. LITERATURE REVIEW:

In this study, A.B. Karnale et al researchers reported the results for alternative configurations of shear walls for 6 storey (low rise) and 14 storey (high rise) buildings using ETABs software. Shear walls are more effective in high rise structures than in low rise buildings, according to a comparison of the impacts observed due to the height of the structure. Comparative research was done by Natalino Gattesco et al. on timber shear walls with particle boards and one window opening. According to experiments, solid and perforated walls of equal dimensions exhibit relatively little variation in shear capacity, ductility, and dissipative capacity, but double number nailing panels exhibit a significant increase in shear capacity. According to the elastic and elasto-plastic behaviours of a multi-story building, a detailed study was undertaken by Ravi Kumar

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et al. He used ETABS to analyse a building with 10 stories and a height of 40 metres for its earthquake load. He came to the conclusion that shear walls are one of the most effective structural components for mitigating lateral stresses during earthquakes, and that shear wall construction is crucial for the development of the Indian construction sector. Chun Ni et al. tested 16 full-scale shear walls to determine the effects of hold owns, vertical load, and width of timber sheathing on in-plane shear capacity. They then evaluated the performance of shear walls with diagonal lumber sheathing. It was discovered that shear walls with double diagonal lumber sheathing had in-plane shear capacities that were two to three times higher than those of shear walls with single diagonal timber sheathing. Shahabodin. Zaregairizi looked at ways to enhance the seismic performance of existing structures utilising shear walls and infill. When static analysis was used to assess the efficacy of the two approaches, it was found that brick in-fills accepted larger displacements than concrete in-fills but that concrete in-fills demonstrated more strength. Therefore, their individual negative effects will be lessened if they are administered in conjunction. B. Ugale Ashish The building with steel plate shear wall showed very little deflection, shear force, and bending moment, and overall stiffness was found to be increased. Raut Harshlata R. and his team used STAAD Pro to analyse the behaviour of the steel plate shear wall in a G+6 building frame located in seismic zone III. Steel plate shear walls were discovered to take up less area than RCC shear walls.

III. PLANNING AND DESIGN:

A 15 m x 55 m x 60 m layout is imagined, with 5 bays in the X-Direction and 11 bays in the Y-Direction. The high rise building (HRB) with G+17 stories, where ground to ground height is 3.5m for all models and 3m from floor to floor height. These construction materials were examined utilising the Response Spectrum method, in accordance with IS 1893 (part I): 2002, and the SAP2000 programme procedure. The location of the building is thought to be in several zones with unusual types of soils. A natural constitution seen from an elevation and in plan. The creation of the 3D model and the analysis are both done using the SAP2000 programme. The buildings will be subjected to lateral loads based on Indian specifications. According to IS 456 (Dead load, Live load), IS 1893:2002 (Earthquake load), and IS 875: 1987, the study is carried out for seismic zones IV and V. (Wind Load).

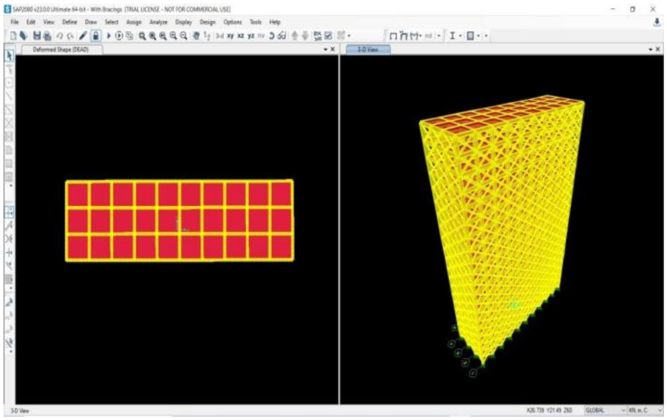


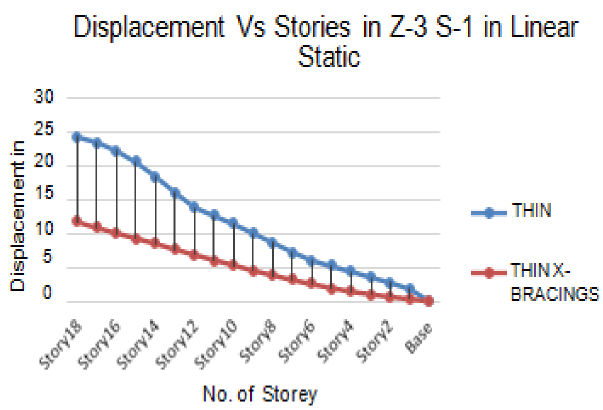
Fig 1. Building Model in SAP2000

Analysis of displacement in linear static analysis in three different zones and three different soils.

IV. RESULTS

Table 1.Comparative values of displacement in zone-3 soil-1 in linear static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	24.345	11.725
Storey 17	23.568	10.886
Storey 16	22.322	10.099
Storey 15	20.612	9.305
Storey 14	18.486	8.49
Storey 13	16.053	7.663
Storey 12	13.885	6.851
Storey 11	12.667	6.078
Storey 10	11.409	5.312
Storey 9	10.075	4.567
Storey 8	8.68	3.848
Storey 7	7.256	3.163
Storey 6	6.021	2.522
Storey 5	5.18	1.96
Storey 4	4.36	1.452
Storey 3	3.541	1.002
Storey 2	2.718	0.617
Storey 1	1.799	0.301
Base	0	0



Graph 1.Variation of displacement along Z-3 S-1 in Linear Static Analysis

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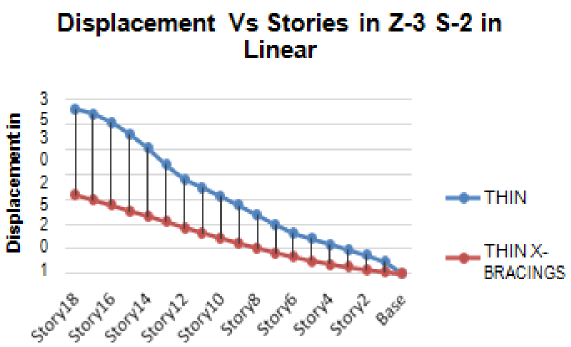
Table 2. Comparative values of displacement in Zone-3 Soil-2 in Linear Static Analysis

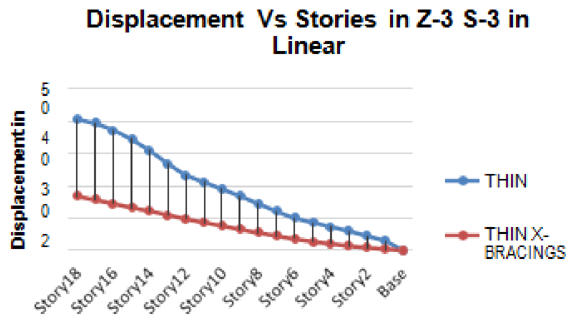
No of Stories	Thin Building	Thin Bracings Building
Storey 18	33.086	15.909
Storey 17	32.047	14.804
Storey 16	30.357	13.735
Storey 15	28.031	12.651
Storey 14	25.14	11.541
Storey 13	21.832	10.409
Storey 12	18.869	9.305
Storey 11	17.224	8.256
Storey 10	15.515	7.202
Storey 9	13.701	6.184
Storey 8	11.803	5.204
Storey 7	9.868	4.272
Storey 6	8.183	3.401
Storey 5	7.042	2.634
Storey 4	5.928	1.94
Storey 3	4.813	1.327
Storey 2	3.694	0.803
Storey 1	2.441	0.379
Base	0	0



Graph 2. Variations of displacement along Z-3, S-2 in Linear static analysis

Table 3. Comparative values of displacement in Zone 3 Soil 3 in linear static analysis

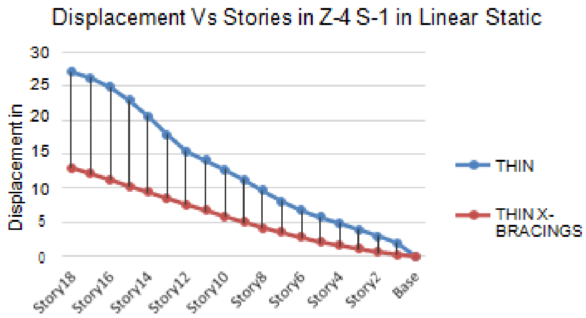
No of Stories	Thin Building	Thin Bracings Building
Storey 18	40.613	16.765
Storey 17	39.349	15.605
Storey 16	37.277	14.478
Storey 15	34.421	13.335
Storey 14	30.87	12.165
Storey 13	26.808	10.972
Storey 12	23.161	9.806
Storey 11	21.148	8.701
Storey 10	19.051	7.588
Storey 9	16.823	6.515
Storey 8	14.492	5.481
Storey 7	12.118	4.498
Storey 6	10.044	3.581
Storey 5	8.646	2.772
Storey 4	7.277	2.04
Storey 3	5.909	1.393
Storey 2	4.534	0.841
Storey 1	2.994	0.395
Base	0	0



Graph 3.Variation of Displacement along Z-3, S-3 in Linear static analysis

Table 4. Comparative values of displacement in Zone-4 Soil-1 in Linear Static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	27.043	13.016
Storey 17	26.185	12.095
Storey 16	24.802	11.221
Storey 15	22.902	10.338
Storey 14	20.54	9.432
Storey 13	17.837	8.51
Storey 12	15.424	7.609
Storey 11	14.074	6.75
Storey 10	12.677	5.895
Storey 9	11.194	5.066
Storey 8	9.644	4.266
Storey 7	8.063	3.505
Storey 6	6.689	2.793
Storey 5	5.755	2.168
Storey 4	4.844	1.602
Storey 3	3.934	1.102
Storey 2	3.019	0.674
Storey 1	1.997	0.325
Base	0	0



Graph 4. Variation of displacement along Z-4 S-1 in Linear Static analysis

Table 5. Comparative values of displacement in Zone-4 Soil-2 in Linear Static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	36.755	17.665
Storey 17	35.606	16.448
Storey 16	33.73	15.261
Storey 15	31.146	14.055

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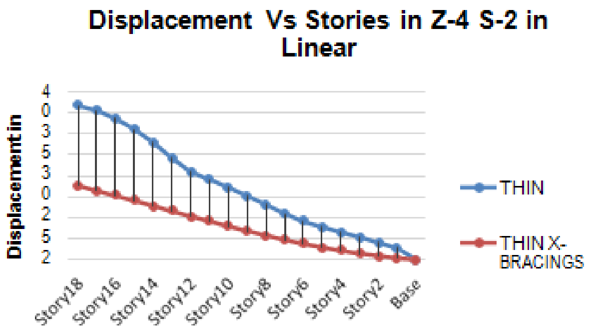
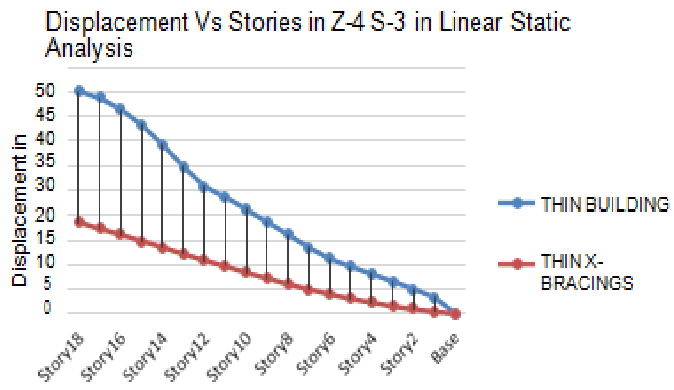
Storey 14	27.922	12.822
Storey 13	24.257	11.564
Storey 12	20.961	10.334
Storey 11	19.137	9.17
Storey 10	17.239	7.995
Storey 9	15.223	6.863
Storey 8	13.114	5.773
Storey 7	10.965	4.737
Storey 6	9.09	3.77
Storey 5	7.824	2.917
Storey 4	6.585	2.145
Storey 3	5.347	1.463
Storey 2	4.103	0.881
Storey 1	2.71	0.412
Base	0	0



Graph 5. Variation of displacement along Z-4 S-2 in Linear static analysis

Table 6 . Comparative values of displacement in Zone-4 Soil-3 in Linear Static analysis

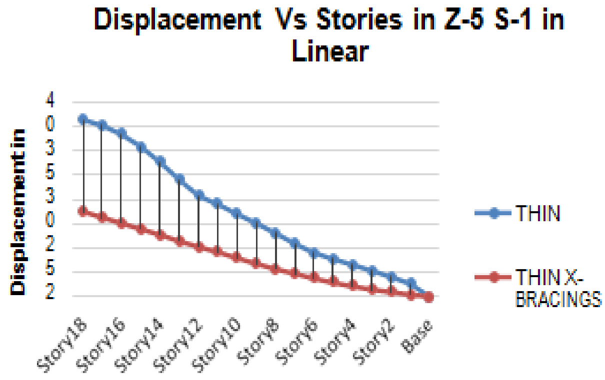
No of Stories	Thin Building	Thin Bracings Building
Storey 18	45.118	18.616
Storey 17	43.719	17.338
Storey 16	41.419	16.086
Storey 15	38.245	14.816
Storey 14	34.3	13.515
Storey 13	29.786	12.19
Storey 12	25.73	10.892
Storey 11	23.497	9.665
Storey 10	21.167	8.424
Storey 9	18.691	7.231
Storey 8	16.102	6.081
Storey 7	13.464	4.989
Storey 6	11.159	3.97
Storey 5	9.605	3.07
Storey 4	8.085	2.256
Storey 3	6.564	1.536
Storey 2	5.037	0.923
Storey 1	3.324	0.429
Base	0	0



Graph 6. Variation of displacement along Z-4 S-3 in Linear static analysis

Table 7 . Comparative values of displacement in Zone-5 Soil-1 in Linear Static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	36.485	17.536
Storey 17	35.345	16.327
Storey 16	33.482	15.148
Storey 15	30.917	13.952
Storey 14	27.728	12.728
Storey 13	24.079	11.479
Storey 12	20.807	10.259
Storey 11	18.997	9.103
Storey 10	17.112	7.937
Storey 9	15.111	6.813
Storey 8	13.018	5.731
Storey 7	10.884	4.703
Storey 6	9.024	3.743
Storey 5	7.766	2.896
Storey 4	6.537	2.13
Storey 3	5.308	1.453
Storey 2	4.073	0.875
Storey 1	2.69	0.409
Base	0	0



Graph 7.Variation of displacement along Z-5 S-1 in Linear static analysis

Table 8. Comparative values of displacement in Zone-5 Soil-2 in Linear Static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	49.597	23.813

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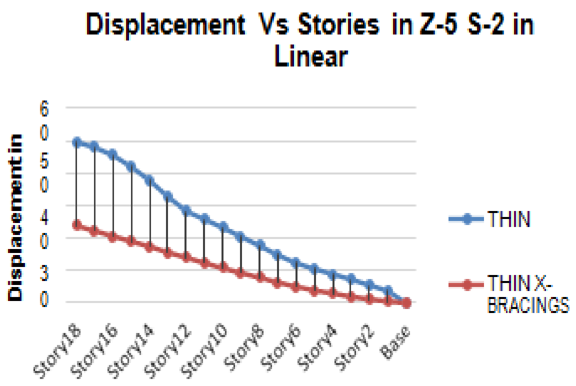
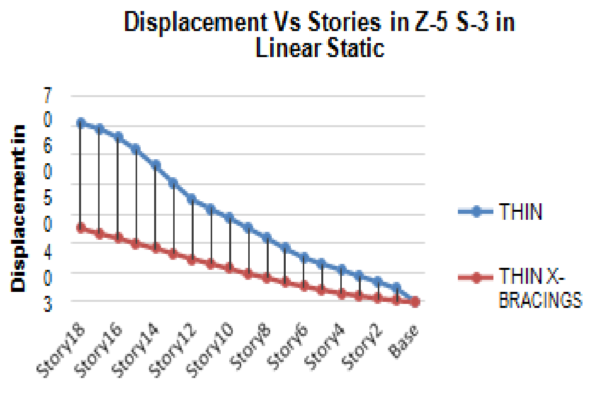
Storey 17	48.064	22.204
Storey 16	45.536	20.601
Storey 15	42.046	18.971
Storey 14	37.709	17.305
Storey 13	32.746	15.609
Storey 12	28.283	13.939
Storey 11	25.832	12.37
Storey 10	23.271	10.779
Storey 9	20.549	9.24
Storey 8	17.702	7.765
Storey 7	14.802	6.365
Storey 6	12.266	5.062
Storey 5	10.56	3.907
Storey 4	8.888	2.862
Storey 3	7.216	1.939
Storey 2	5.536	1.155
Storey 1	3.653	0.527
Base	0	0



Graph 8.Variation of Displacement along Z-5 S-2 in Linear static analysis

Table 9.Comparative values of displacement in Zone-5 Soil-3 in Linear Static analysis

No of Stories	Thin Building	Thin Bracings Building
Storey 18	60.887	25.096
Storey 17	59.016	23.405
Storey 16	55.915	21.716
Storey 15	51.63	19.997
Storey 14	46.304	18.241
Storey 13	40.21	16.453
Storey 12	34.72	14.691
Storey 11	31.719	13.038
Storey 10	28.574	11.361
Storey 9	25.232	9.736
Storey 8	21.736	8.18
Storey 7	18.176	6.705
Storey 6	15.058	5.332
Storey 5	12.965	4.114
Storey 4	10.912	3.012
Storey 3	8.859	2.039
Storey 2	6.796	1.212
Storey 1	4.484	0.553
Base	0	0



Graph 9. Variation of displacement along Z-3 S-3 in linear static analysis

CONCLUSIONS

1. The addition and placement of shear walls affect the centre of mass and the centre of stiffness. It may be said that all models are symmetric around the x-axis and that there is no torsion effect since the mass and stiffness centres are in the x-direction. Because the centre of mass and the centre of stiffness are brought closer together, a structure with X-Bracings performs better than a structure without them.

2. The presence of a shear wall often reduces displacement since the X-Bracings enhance the building's rigidity and withstand lateral stresses. When analysis is conducted using the linear static analysis approach, higher performance is shown, displacement is reduced in the x direction, and it exhibits superior performances with regard to displacement.

3. When X-Bracings are positioned optimally, 50% of displacement is seen to be decreased.

4. It is obvious that one of the best methods for ensuring earthquake protection in high rise structures is to use X-Bracings, which are installed from the foundation to the roof. Although rather pricey, these are desirable for secure structures.

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