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SEISMIC BEHAVIOUR OF SYMMETRICAL AND UNSYMMETRICAL STRUCTURE WITH CANTILEVER SECTION USING ETABS SOFTWARE

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ABSTRACT

In this project two buildings of storey (G+12) are used, likes Symmetrical with cantilever section and Unsymmetrical with cantilever section. The distribution of mass, stiffness, and strength in both the horizontal and vertical planes of a multi-story framed building affect its performance during study seismic events. Strong earth shaking occurs during earthquakes, necessitating earthquake-resistant structural design. As a result, research into the seismic behaviour of unsymmetrical structures with cantilever sections is required. The building's centre of mass does not match to the centre of resistance in such structures. In comparison to symmetrical structures, this causes excessive edge deformation and shear forces in unsymmetrical structures. The goal of this research is to compare the sections used in wide span unsymmetrical cantilever constructions in order to reduce torsion analyzing wide span cantilevers with asymmetrical structures.

Keywords: ***Mass, Stiffness, Eccentricity, Earthquake, Multistoried Frame. ETABS, Torsion***

1. INTRODUCTION

In the current situation, an asymmetrical building with a long span cantilever section is being built, resulting in abnormalities such as soft storey, asymmetrical layout, and torsion irregularity, among others. As a result, seismic analysis of a long-span cantilever in an asymmetrical structure is critical. Because strong earth shaking occurs during earthquakes, seismic analysis and structure design are required to withstand this shaking. The seismic behaviour of unsymmetrical structures with cantilever sections has been investigated in this article. The centre of mass of the building does not match to the centre of resistance in this type of structure, resulting in excessive edge deformation and shear force in unsymmetrical buildings. The torsion effects increase as the eccentricity between the centre of stiffness and the centre of mass increases. Torsion effects can thus be minimised by minimising the difference between the centre of mass and the centre of stiffness. This research also looks at the deflection characteristics of broad span cantilevers in asymmetrical structures under various loading circumstances.

2. OBJECTIVE OF STUDY

The major goal of this work is to investigate the seismic response of unsymmetrical structures with cantilever sections and examine the behaviour of the structures using response spectrum analysis as a tool to reduce the effects of seismic forces.

- To study seismic behavior of symmetrical structure & unsymmetrical structure with cantilever section based on material and geometry.
- To study the effect of torsion for symmetric and unsymmetric multi-storied R.C.C. building in a high seismic zone.
- To compare the response parameters such as storey drift, storey shear, displacement, of Symmetrical and conventional building.
- To compare the torsional moment & overturning moment of Symmetrical and unsymmetrical structure with cantilever section.

- To analyze parameters such as bending moments and shear forces in symmetrical structures & unsymmetrical structures with cantilever sections.
- To study the response of the symmetrical structure & unsymmetrical structure with cantilever sections subjected to gravity loads and seismic loading using computer-aided software.

3. MODELLING APPROACH

3.1 Modelling Approach In ETABS

3.1.1 Modelling of Symmetrical Structure.

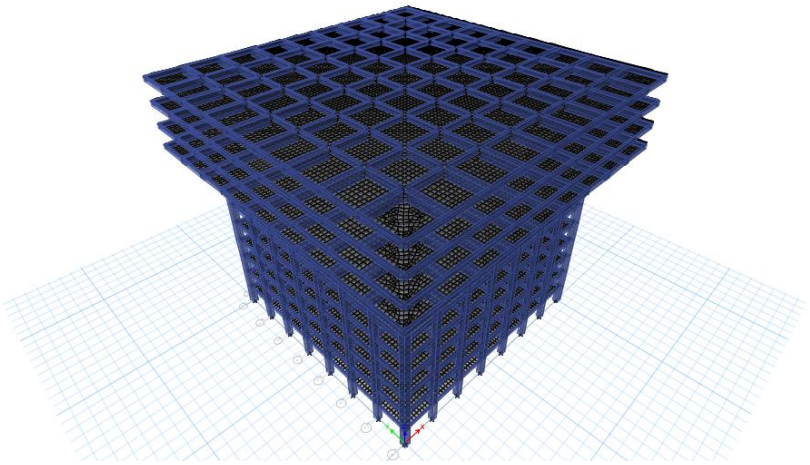

Fig. (3.1) Isometric view Symmetrical structure plan.

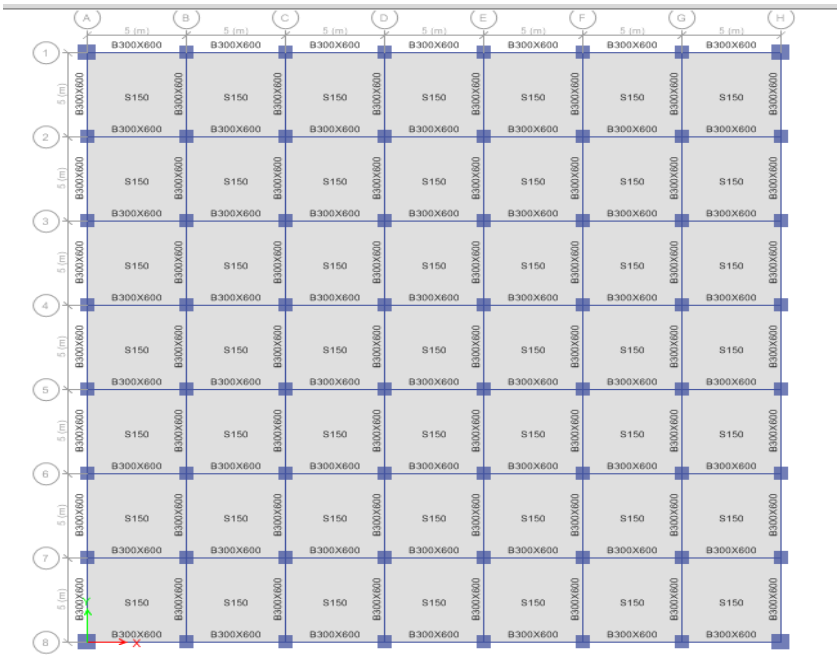

Fig.(3.2) Symmetrical structure plan upto storey 8.

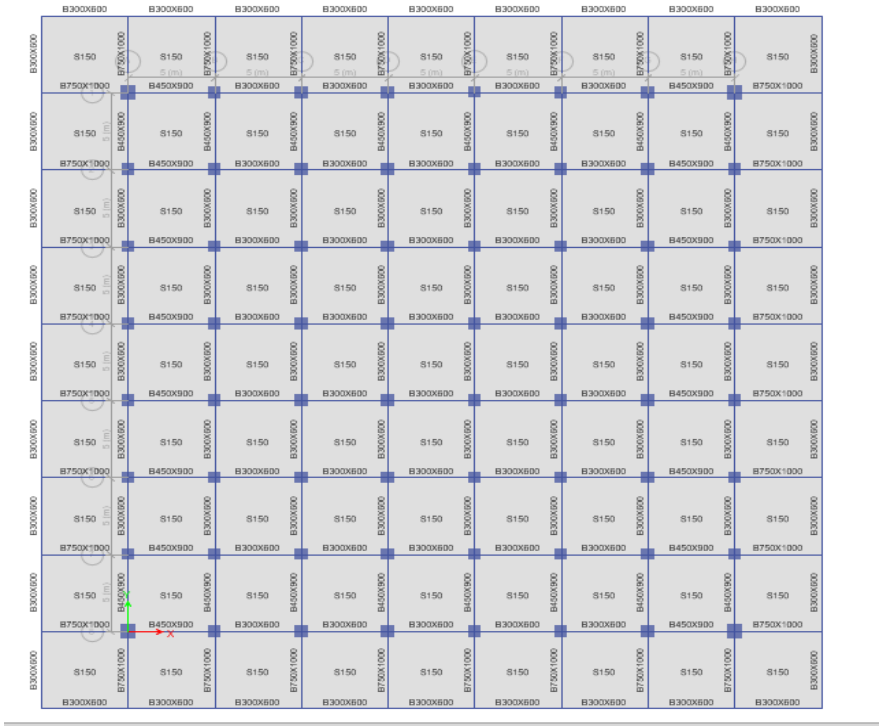

Fig.(3.3) Symmetrical structure plan storey 9 & Above.

MODEL INFORMATION

3.2.2 Modelling Of Unsymmetrical Structure.

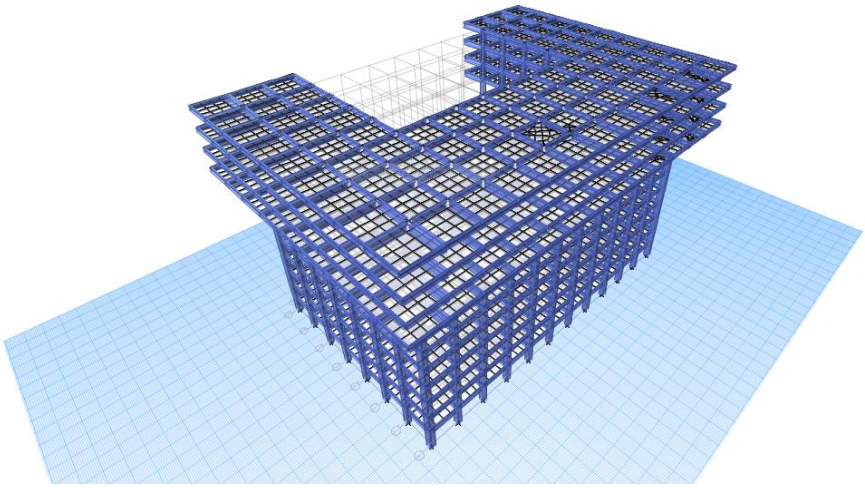

Fig. (3.4) Isometric view Unsymmetrical Structure.

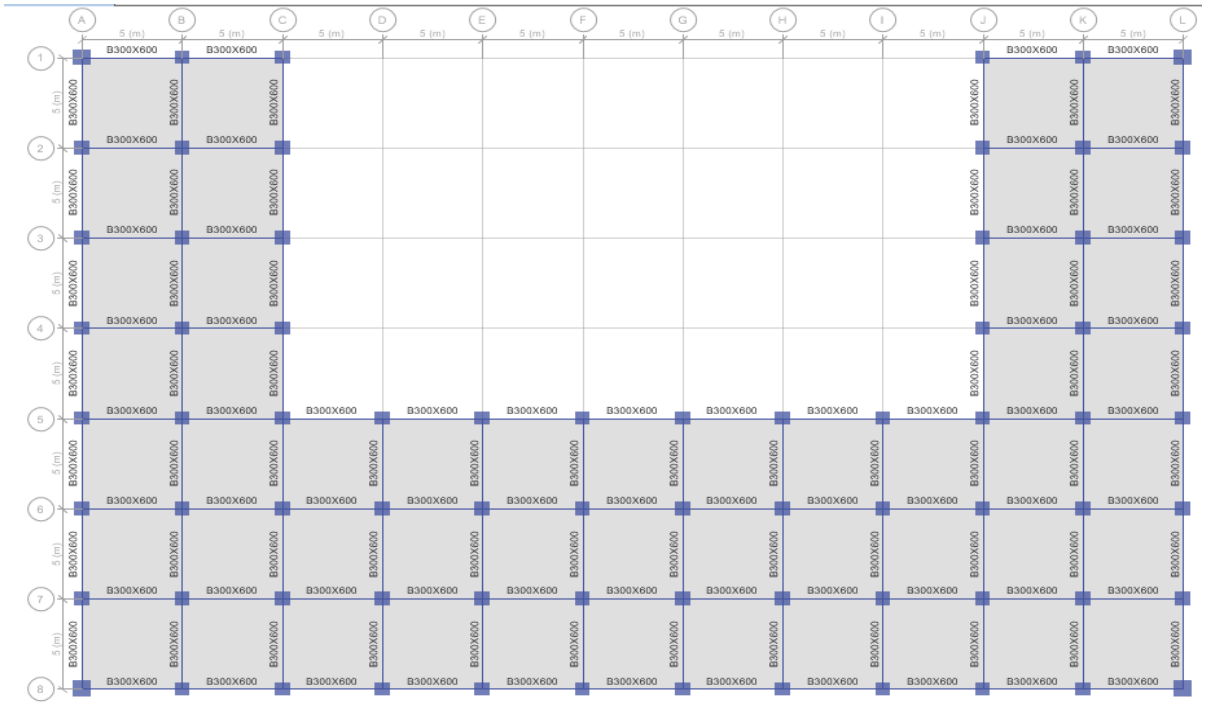

Fig. (3.5) Unsymmetrical structure plan upto storey 8.

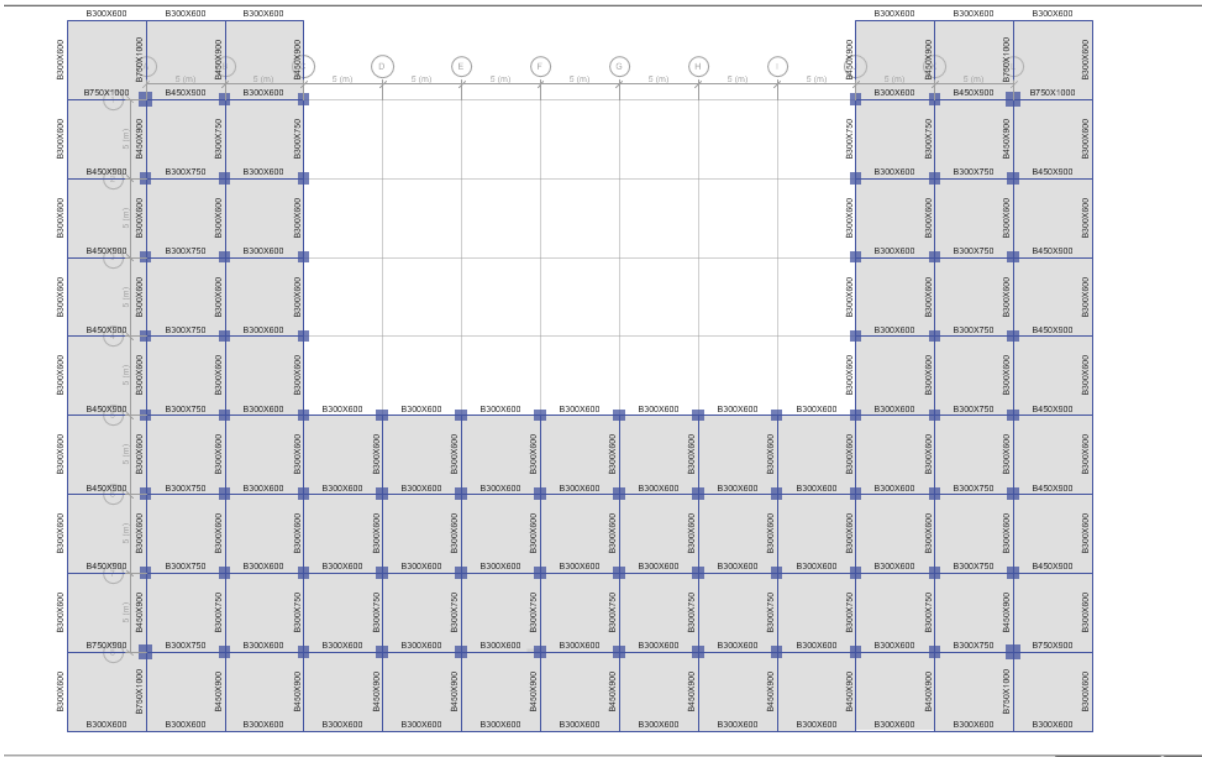

Fig. (3.6) Unsymmetrical structure plan storey 9 & above.

Loads Combination

Load combination for design purpose shall be those produce maximum forces and effects and consequently maximum stress and deformations. As per IS: 456 (Table 18), IS: 875 (Part 5) and IS: 1893 (Table 6.3.1.2) the following load combinations are considered.
Load combination:-

1. DL+LL
2. 1.5(DL+LL)
3. 1.2(DL+LL-0.5WLX)
4. 1.2(DL+LL+0.5WLX)
5. 1.2(DL+LL-0.5WLY)
6. 1.2(DL+LL+0.5WLY)
7. 1.2(DL+LL-0.5EQLX)
8. 1.2(DL+LL+0.5EQLX)
9. 1.2(DL+LL-0.5EQLY)
10. 1.2(DL+LL+0.5EQLY)
11. 1.5(DL-WLX)
12. 1.5(DL+WLX)
13. 1.5(DL-WLY)
14. 1.5(DL+WLY)
15. 1.5(DL-EQLX)
16. 1.5(DL+EQLX)
17. 1.5(DL-EQLY)
18. 1.5(DL+EQLY)
19. 0.9DL-1.5WLX
20. 0.9DL+1.5WLX
21. 0.9DL-1.5WLY
22. 0.9DL+1.5WLY
23. 0.9DL-1.5EQLX
24. 0.9DL+1.5EQLX
25. 0.9DL-1.5EQLY
26. 0.9DL+1.5EQLY

4. RESULT & DISCUSSION

4.1 STOREY DISPLACEMENT DETAIL OF STRUCTURE

Table 4.1 STOREY DISPLACEMENT OF SYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story12	38.2	Top	0.104	0.659
Story11	35	Top	0.071	0.457
Story10	31.8	Top	0.038	0.252
Story9	28.8	Top	0.008	0.07
Story8	25.6	Top	0.027	3.212
Story7	22.4	Top	0.006	0.028
Story6	19.2	Top	0.005	0.027
Story5	16	Top	0.004	0.021
Story4	12.8	Top	0.003	0.015
Story3	9.6	Top	0.002	0.01
Story2	6.4	Top	0.001	0.006
Story1	3.2	Top	0.001	0.003
Base	0	Top	0	0

Table 4.2 STOREY DISPLACEMENT OF UNSYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story12	38.4	Top	0.008	3.545
Story11	35.2	Top	0.006	2.742
Story10	32	Top	0.004	1.947
Story9	28.8	Top	0.003	1.218
Story8	25.6	Top	0.001	0.729
Story7	22.4	Top	0.001	0.491
Story6	19.2	Top	0.001	0.345
Story5	16	Top	0.0004911	0.241
Story4	12.8	Top	0.0003293	0.162
Story3	9.6	Top	0.0002065	0.101
Story2	6.4	Top	0.0001167	0.057
Story1	3.2	Top	5.302E-05	0.026
Base	0	Top	0	0

The variation of displacement throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of storeys in the structure is shown in fig (4.1). The maximum displacement is found to be higher in storey 8 of the structure, in symmetrical structure with seismic zone 3. And also the maximum displacement is found to be higher in the highest storey of the structure, in unsymmetrical structure with seismic zone 3.

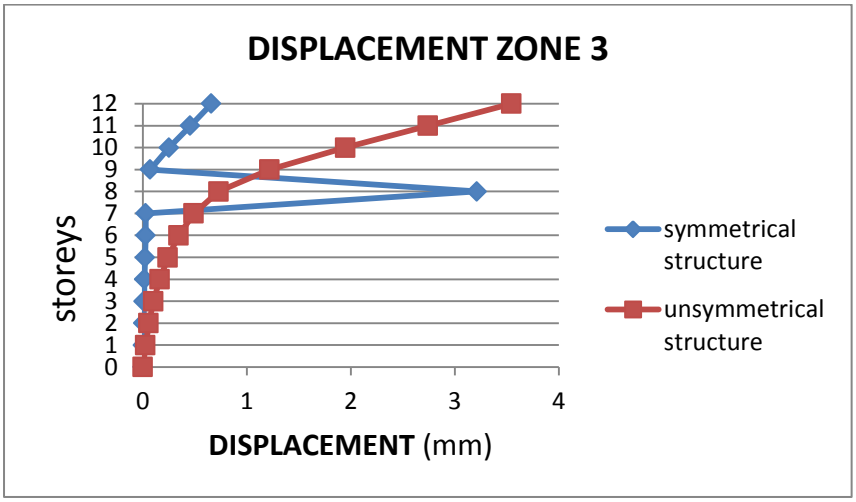

Fig.(4.1)

Table 4.3 STOREY DISPLACEMENT OF SYMMETRICAL STRUCTURE IN ZONE 4

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story12	38.2	Top	0.104	0.659
Story11	35	Top	0.071	0.457
Story10	31.8	Top	0.038	0.252
Story9	28.8	Top	0.008	0.07
Story8	25.6	Top	0.027	3.212
Story7	22.4	Top	0.006	0.028
Story6	19.2	Top	0.005	0.027
Story5	16	Top	0.004	0.021
Story4	12.8	Top	0.003	0.015
Story3	9.6	Top	0.002	0.01
Story2	6.4	Top	0.001	0.006
Story1	3.2	Top	0.001	0.003
Base	0	Top	0	0

Table 4.4 STOREY DISPLACEMENT OF UNSYMMETRICAL STRUCTURE IN ZONE 4

Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story12	38.4	Top	0.044	3.409
Story11	35.2	Top	0.035	2.661
Story10	32	Top	0.025	1.913
Story9	28.8	Top	0.016	1.224
Story8	25.6	Top	0.008	0.753
Story7	22.4	Top	0.003	0.513
Story6	19.2	Top	0.0002817	0.362
Story5	16	Top	0.0001794	0.254
Story4	12.8	Top	0.0001547	0.171
Story3	9.6	Top	0.0001067	0.107
Story2	6.4	Top	6.301E-05	0.06
Story1	3.2	Top	2.919E-05	0.027
Base	0	Top	0	0

The variation of displacement throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of storeys in the structure is shown in fig.(4.2). The maximum displacement is found to be higher in the storey 8 of the structure, in symmetrical structure with seismic zone 4. And also the maximum displacement is found to be higher in the highest storey of the structure, in an unsymmetrical structure with seismic zone 4.

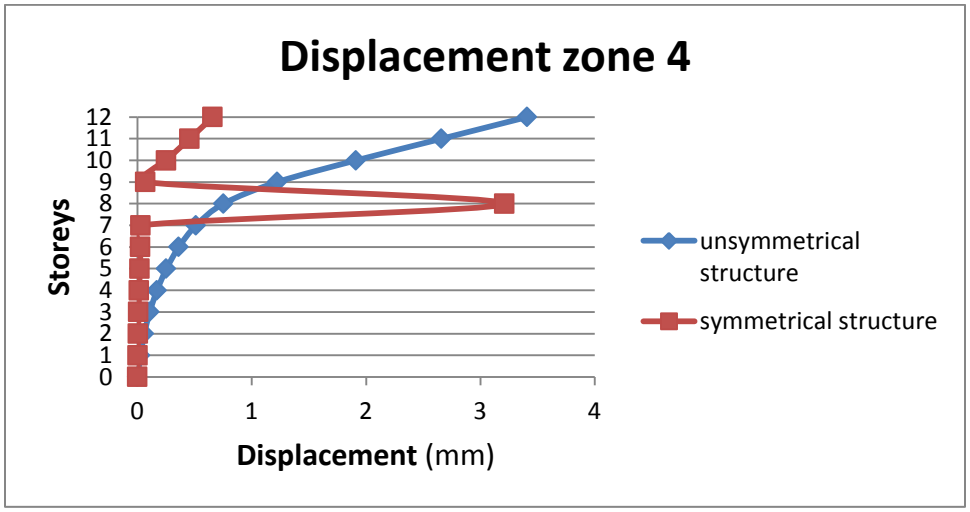

Fig.(4.2)

4.2 STOREY DRIFT DETAIL OF STRUCTURE

Table 4.5 STOREY DRIFT OF SYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir	Y-Dir
Story12	38.2	Top	0.000112	0.000101
Story11	35	Top	0.000156	0.000102
Story10	31.8	Top	0.000199	9.7E-05
Story9	28.8	Top	0.000268	0.001526
Story8	25.6	Top	0.000335	7E-06
Story7	22.4	Top	0.000371	1E-06
Story6	19.2	Top	0.000393	3E-06
Story5	16	Top	0.000411	3E-06
Story4	12.8	Top	0.000438	3E-06
Story3	9.6	Top	0.000508	2E-06
Story2	6.4	Top	0.000717	2E-06
Story1	3.2	Top	0.001	2E-06
Base	0	Top	0	0

Table 4.6 STORY DRIFT OF UNSYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir	Y-Dir
Story12	38.4	Top	1E-06	0.000537
Story11	35.2	Top	1E-06	0.000608
Story10	32	Top	1E-06	0.000656
Story9	28.8	Top	4.585E-07	0.000625
Story8	25.6	Top	2.632E-07	0.000572
Story7	22.4	Top	1.848E-07	0.000567
Story6	19.2	Top	1.462E-07	0.000572
Story5	16	Top	1.225E-07	0.000578
Story4	12.8	Top	1.048E-07	0.000586
Story3	9.6	Top	9.139E-08	0.000611
Story2	6.4	Top	8.575E-08	0.000693
Story1	3.2	Top	9.746E-08	0.000917
Base	0	Top	0	0

The variation of storey drift throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of storeys in the structure shown in fig (4.3). The maximum storey drift is found to be higher in storey 1 of the structure, in symmetrical structure with seismic zone 3.

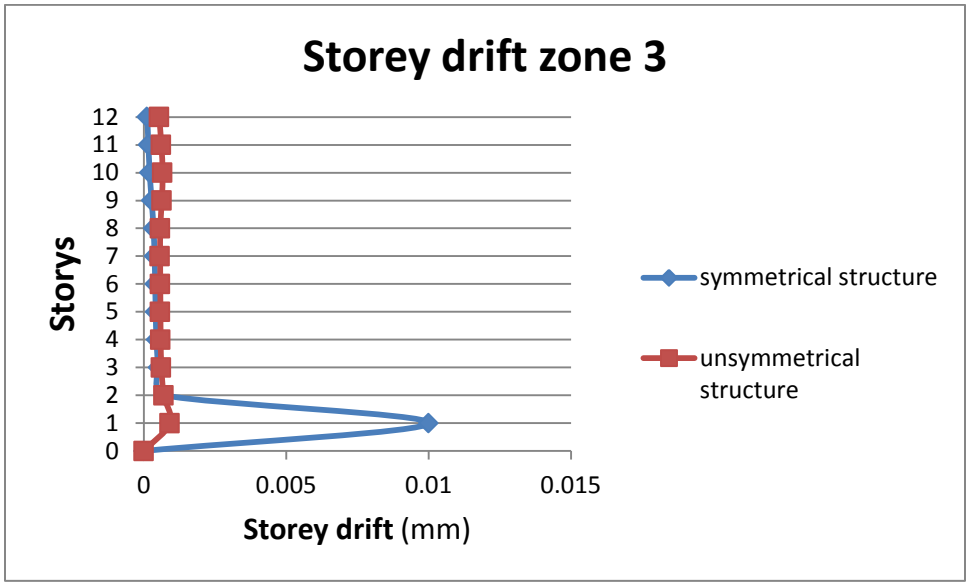

Fig.(4.3)

Table 4.7 STOREY DRIFT OF SYMMETRICAL STRUCTURE IN ZONE 4

Story	Elevation m	Location	X-Dir	Y-Dir
Story12	38.2	Top	0.000161	0.000101
Story11	35	Top	0.000226	0.000102
Story10	31.8	Top	0.000292	9.7E-05
Story9	28.8	Top	0.0004	0.001526
Story8	25.6	Top	0.000503	7E-06
Story7	22.4	Top	0.000557	1E-06
Story6	19.2	Top	0.000589	4E-06
Story5	16	Top	0.000616	4E-06
Story4	12.8	Top	0.000657	3E-06
Story3	9.6	Top	0.000762	3E-06
Story2	6.4	Top	0.001075	2E-06
Story1	3.2	Top	0.001499	3E-06
Base	0	Top	0	0

Table 4.8 STOREY DRIFT OF UNSYMMETRICAL STRUCTURE IN ZONE 4

	Story	Elevation m	Location	X-Dir	Y-Dir
▶	Story12	38.4	Top	0.000197	0.000387
	Story11	35.2	Top	0.000282	0.000385
	Story10	32	Top	0.000375	0.000356
	Story9	28.8	Top	0.000483	0.000257
	Story8	25.6	Top	0.000577	0.000155
	Story7	22.4	Top	0.00063	0.000116
	Story6	19.2	Top	0.000662	9.7E-05
	Story5	16	Top	0.000683	8.3E-05
	Story4	12.8	Top	0.000704	7.3E-05
	Story3	9.6	Top	0.000743	6.3E-05
	Story2	6.4	Top	0.00085	5.6E-05
	Story1	3.2	Top	0.001118	4.7E-05
	Base	0	Top	0	0

The variation of storey drift throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of storeys in the structure shown in fig (4.4). The maximum storey drift is found to be higher in storey 1 of the structure, in symmetrical structure with seismic zone 4.

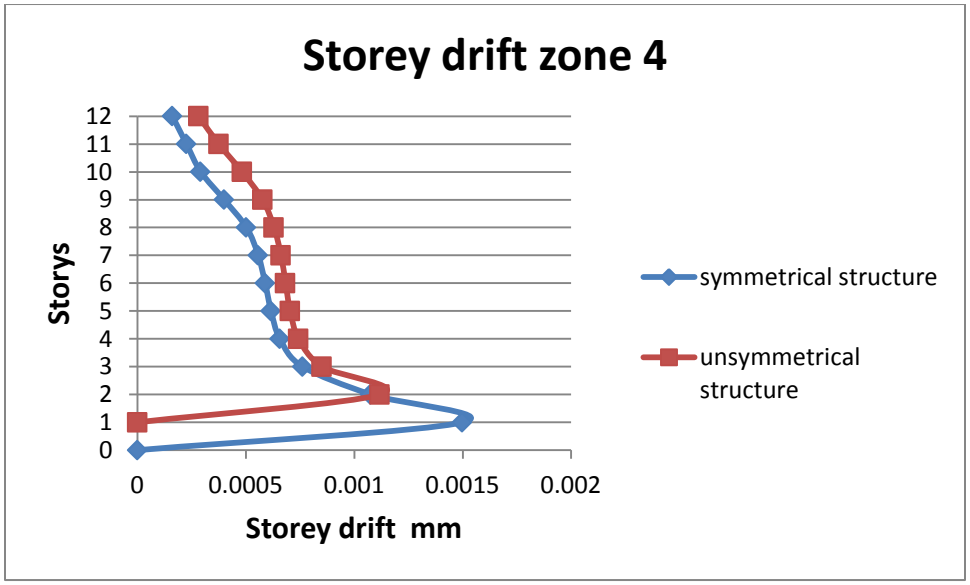

Fig.(4.4)

4.3 STOREY SHEAR DETAIL OF STRUCTURE

Table 4.9 STOREY SHEAR OF SYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story12	38.2	Top	660.9322	0
		Bottom	660.9322	0
Story11	35	Top	1268.5222	0
		Bottom	1268.5222	0
Story10	31.8	Top	1767.3674	0
		Bottom	1767.3674	0
Story9	28.8	Top	2176.5305	0
		Bottom	2176.5305	0
Story8	25.6	Top	2361.399	0
		Bottom	2361.399	0
Story7	22.4	Top	2502.939	0
		Bottom	2502.939	0
Story6	19.2	Top	2606.9275	0
		Bottom	2606.9275	0
Story5	16	Top	2679.1418	0
		Bottom	2679.1418	0
Story4	12.8	Top	2725.3589	0
		Bottom	2725.3589	0
Story3	9.6	Top	2751.356	0
		Bottom	2751.356	0
Story2	6.4	Top	2762.9103	0
		Bottom	2762.9103	0
Story1	3.2	Top	2765.0609	0
		Bottom	2765.0609	0
Base	0	Top	0	0
		Bottom	0	0

Table 4.10 STOREY SHEAR OF UNSYMMETRICAL STRUCTURE IN ZONE 3

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story12	38.4	Top	731.8564	0
		Bottom	731.8564	0
Story11	35.2	Top	1417.2084	0
		Bottom	1417.2084	0
Story10	32	Top	1983.615	0
		Bottom	1983.615	0
Story9	28.8	Top	2442.4043	0
		Bottom	2442.4043	0
Story8	25.6	Top	2671.3443	0
		Bottom	2671.3443	0
Story7	22.4	Top	2846.6265	0
		Bottom	2846.6265	0
Story6	19.2	Top	2975.4052	0
		Bottom	2975.4052	0
Story5	16	Top	3064.8349	0
		Bottom	3064.8349	0
Story4	12.8	Top	3122.0699	0
		Bottom	3122.0699	0
Story3	9.6	Top	3154.2646	0
		Bottom	3154.2646	0
Story2	6.4	Top	3168.5733	0
		Bottom	3168.5733	0
Story1	3.2	Top	3171.5521	0
		Bottom	3171.5521	0
Base	0	Top	0	0
		Bottom	0	0

The variation of story shear throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of story in the structure is shown in fig (4.5). The maximum storey drift is found to be higher in story 1 of the structure, in unsymmetrical structure with seismic zone 3.

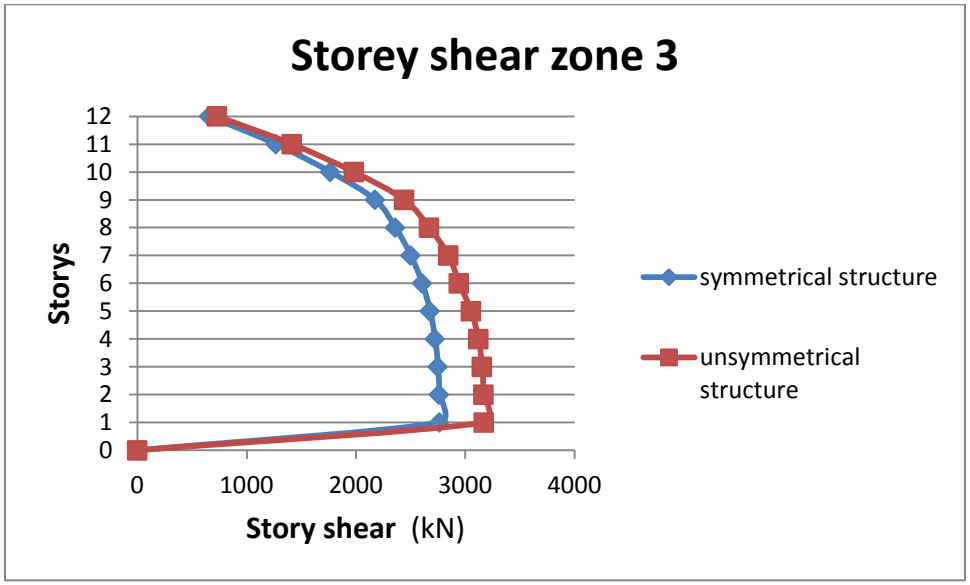

Fig.(4.5)

Table 4.11 STOREY SHEAR OF SYMMETRICAL STRUCTURE IN ZONE 4

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story12	38.2	Top	991.3983	0
		Bottom	991.3983	0
Story11	35	Top	1902.7834	0
		Bottom	1902.7834	0
Story10	31.8	Top	2651.0511	0
		Bottom	2651.0511	0
Story9	28.8	Top	3264.7958	0
		Bottom	3264.7958	0
Story8	25.6	Top	3542.0986	0
		Bottom	3542.0986	0
Story7	22.4	Top	3754.4085	0
		Bottom	3754.4085	0
Story6	19.2	Top	3910.3913	0
		Bottom	3910.3913	0
Story5	16	Top	4018.7127	0
		Bottom	4018.7127	0
Story4	12.8	Top	4088.0384	0
		Bottom	4088.0384	0
Story3	9.6	Top	4127.0341	0
		Bottom	4127.0341	0
Story2	6.4	Top	4144.3655	0
		Bottom	4144.3655	0
Story1	3.2	Top	4147.5913	0
		Bottom	4147.5913	0
Base	0	Top	0	0
		Bottom	0	0

Table 4.12 STOREY SHEAR OF UNSYMMETRICAL STRUCTURE IN ZONE 4

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story12	38.4	Top	1097.9853	0
		Bottom	1097.9853	0
Story11	35.2	Top	2128.882	0
		Bottom	2128.882	0
Story10	32	Top	2980.8628	0
		Bottom	2980.8628	0
Story9	28.8	Top	3670.9672	0
		Bottom	3670.9672	0
Story8	25.6	Top	4012.6214	0
		Bottom	4012.6214	0
Story7	22.4	Top	4273.964	0
		Bottom	4273.964	0
Story6	19.2	Top	4465.9581	0
		Bottom	4465.9581	0
Story5	16	Top	4599.4167	0
		Bottom	4599.4167	0
Story4	12.8	Top	4684.8303	0
		Bottom	4684.8303	0
Story3	9.6	Top	4732.8754	0
		Bottom	4732.8754	0
Story2	6.4	Top	4754.2288	0
		Bottom	4754.2288	0
Story1	3.2	Top	4758.6741	0
		Bottom	4758.6741	0
Base	0	Top	0	0
		Bottom	0	0

The variation of storey shear throughout the height of symmetrical structure & unsymmetrical structure with respect to no. of storeys in the structure is shown in fig (4.6). The maximum storey drift is found to be higher in storey 1 of the structure, in unsymmetrical structure with seismic zone 4.

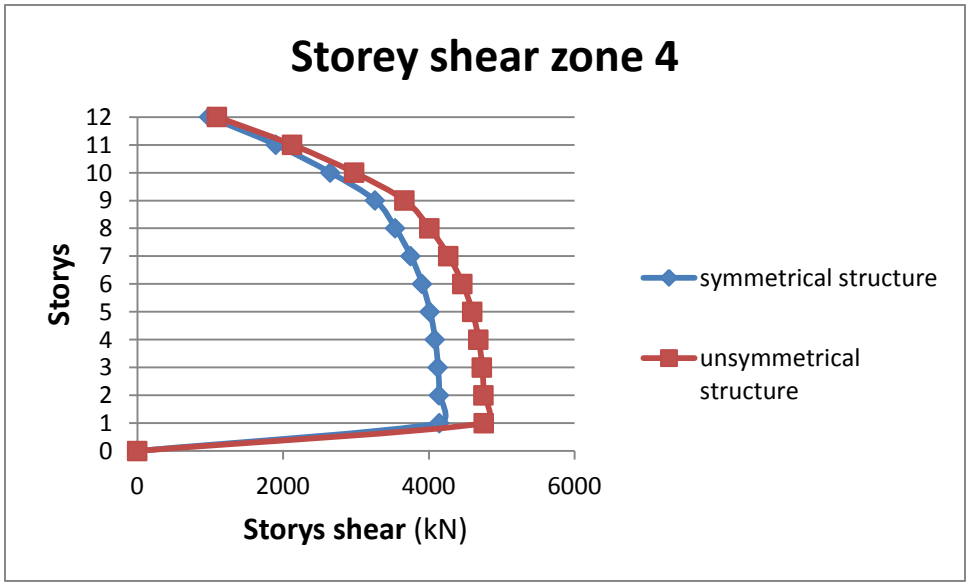

Fig.(4.6F)

4. CONCLUSIONS

From the above discussion following conclusions can be made.

- Storey Displacement of unsymmetrical structure is more as compared to a symmetrical structure.
- Storey Drift of unsymmetrical structure is more as compared to a symmetrical structure.
- Storey shear of unsymmetrical structure is more as compared to a symmetrical structure.
- The Load Distribution in the Symmetric model is more uniform as compared to the Unsymmetrical model.
- The requirement of reinforcement is more in the Unsymmetrical frame than the symmetric frame.
- The Symmetric model is More Cost-Effective with respect to the Unsymmetrical model as the volume of material being used is more in the Unsymmetrical model.
- The performance of a Symmetrical building is better than an unsymmetrical building.

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