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Analysis of Seismic Behaviour of Symmetrical and Unsymmetrical Structure with Cantilever Section

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ABSTRACT

In this research two buildings of storey (G+12) are used, likes Symmetrical with cantilever section and Unsymmetrical with cantilever section. As a result, research into the seismic behavior 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. In this research we have compare the result parameters like overturning moment, support reaction, storey drift, storey stiffness, storey displacement & storey shear

Keywords: Torsion, Support Reaction, Overturning Moment

INTRODUCTION

This study also focuses on the deflection characteristics of cantilevers of large span in unsymmetrical structures under different loading conditions. Hence the study of seismic behavior of large span cantilevers is one of a major part of seismic analysis and design of unsymmetrical structures. Unsymmetrical buildings are more vulnerable to damage due to seismic excitation or earthquakes because of the coupled torsional effects and unsymmetrical edge deformation. Eccentric mass due to temporary storage of materials leads to an unsymmetrical distribution of lateral loads causing torsional failures. A loss of symmetry causes torsional effects that might be difficult to detect and have serious consequences. The subject of earthquake-induced torsion in buildings is extremely old, and despite a lot of attention in recent decades, it remains unsolved. This is evidenced not only by the diversity of relevant provisions in many modern codes but also by the literature's inconsistent results. However, in the recent decade, multi-story inelastic building response has become increasingly realistic. Some interesting conclusions have been obtained as a result of this research, correcting prior notions concerning the inelastic response of structures based on one-story simplified model results.

2. OBJECTIVE OF STUDY

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.

3. METHODOLOGY & MODELLING APPROACH

3.1 METHODOLOGY OF THESIS

This research work includes various stages for analysis and design of unsymmetrical frame with cantilever section .

Stage-1 Planning of structure.

- SYMMETRICAL STRUCTURE WITH CANTILEVER.

- SYMMETRICAL STRUCTURE WITH CANTILEVER.
- UNSYMMETRICAL STRUCTURE WITH CANTILEVER.

Stage-2 Modeling of structure frame.

- Identification of material & geometric properties in all structure.
- Assessment of the loads & load combinations on frames similarly in all structure.

Stage-3 Analysis of all structure frames.

Stage-4 Conclusion of all structure.

3.2 Validation through Software

The importance of software is as follows:

- Software is necessary for comparison of manual calculation and calculation done by software which helps in being confident about the work done.
- This also helps for further work on software with confidence. Otherwise, it will be difficult to trust the validity and correctness of the results and outputs given by the software.
- This section deals with the software for understanding the behaviour of symmetrical structure & unsymmetrical structure with cantilever section subjected to seismic loading in zones (III, IV).

3.3 Methodology of ETABS

The study's goal is to assess and design a commercial building that meets the essential characteristics of safety, durability, economy, aesthetic appearance, feasibility, practicability, and acceptability utilising ETABS and manual methods.
It was done in accordance with the following procedure.

- Site survey
- Soil investigation
- Structural planning
- Analysis in ETABS
- Verification by manual method.

PROCEDURE FOR DETERMINING THE ETABS

Step - 1*:* Initially setup of standard codes and country codes.
Step - 2*:* Creation of Grid points & Generation of structure
To begin, open ETABS and select a new model. A window will appear, prompting us to enter the grid measurements and storey dimensions of our structure.
Step - 3*:* Defining of property
We had first defined the material property by selecting define many material characteristics and then added new material for our structural components(such as beams, columns and slbs) by specifying the required specification in defining. Then we determine section size by picking frame, beams, and column sections, among other things.
Step - 4*:* Assigning of Property
We use the command menu to draw the structural components after defining the properties of each material. Draw a beam line for beams and build columns in a region for columns to finish the property assignment for beams and columns.
Step - 5*:* Assigning of Supports
We assigned supports by going to the allocated menu joint/frame restraints fixed and selecting all the columns while keeping the selection at the base of the structure.
Step - 6*:* Defining of loads
In ETABS, while defining loads, all load considerations are first defined and then allocated. The static load cases command in the define menu ic

used to define the loads in ETABS.

Step - 7*:* Assigning of Dead loads

Dead loads are assigned for external walls and internal walls in staad.pro, but they are automatically taken care of by the programme in ETABS, i.e., inbuilt only.

Step - 8*:* Assigning of Live loads

Following the assignment of dead loads, live loads for the entire structure, including floor finishing, must be assigned.

Step - 9*:* Assigning of wind loads

According to IS 875 1987 PART 3, wind loads are specified and assigned by providing wind speed and wind angles. However, because this is a residential building with a total height of less than 12 meters, no wind or earthquake loads must be assigned.

Step - 10*:* Assigning of Seismic loads

According to IS 1893:2016, seismic loads are established and assigned by specifying the zone, soil type, and response reduction factor in Xand Y directions.

Step - 11*:* Assigning of load combinations

After all of the loads have been assigned, the total load must be calculated. Using the load combinations command in the define menu, 1.5 times the dead load and live load will be calculated as previously stated.

Step - 12*:* Analysis

We run the analysis and checked for mistakes after completing all of the preceding procedures.

Step - 13*:* Design

Following the completion of the analysis, we designed the structure with concrete in accordance with IS 456:2000. Every structural component is designed by ETABS.

3.2 Modelling Approach In ETABS

3.2.1 Modelling of Symmetrical Structure.

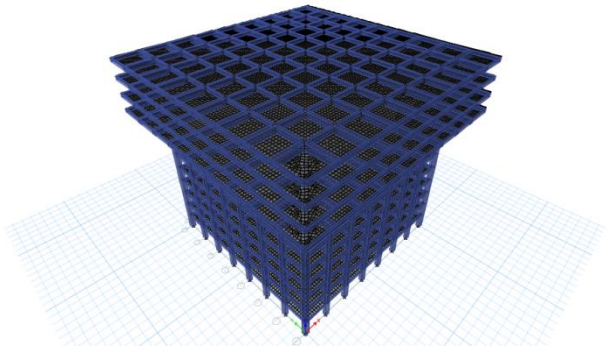

Fig. (3.1) Isometric view Symmetrical structure plan.

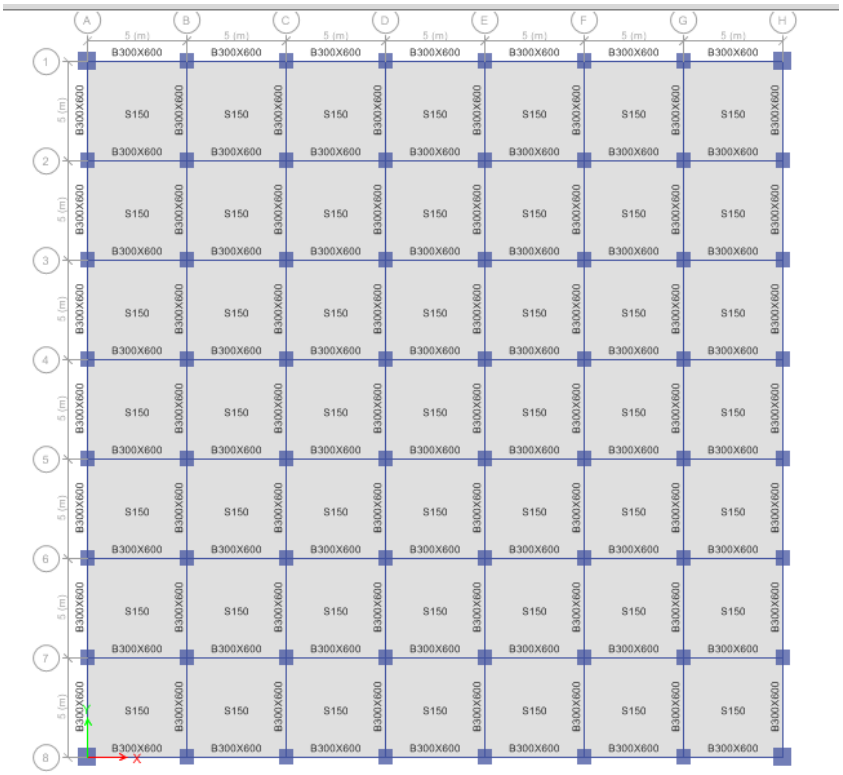

Fig.(3.2) Symmetrical structure plan upto storey 8.

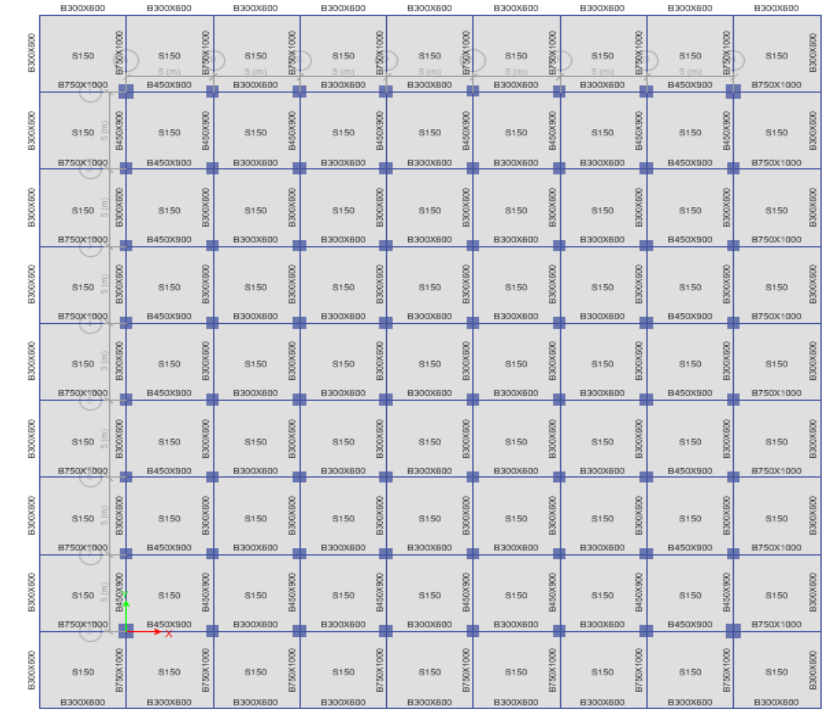

Fig.(3.3) Symmetrical structure plan storey 9 & Above.

MODEL INFORMATION

3.2.2 Modelling Of Unsymmetrical Structure.

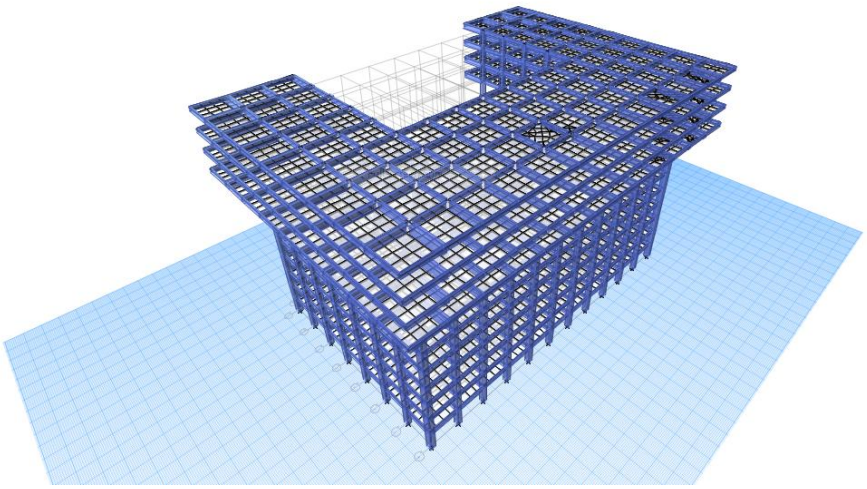

Fig. (3.4) Isometric view Unsymmetrical Structure.

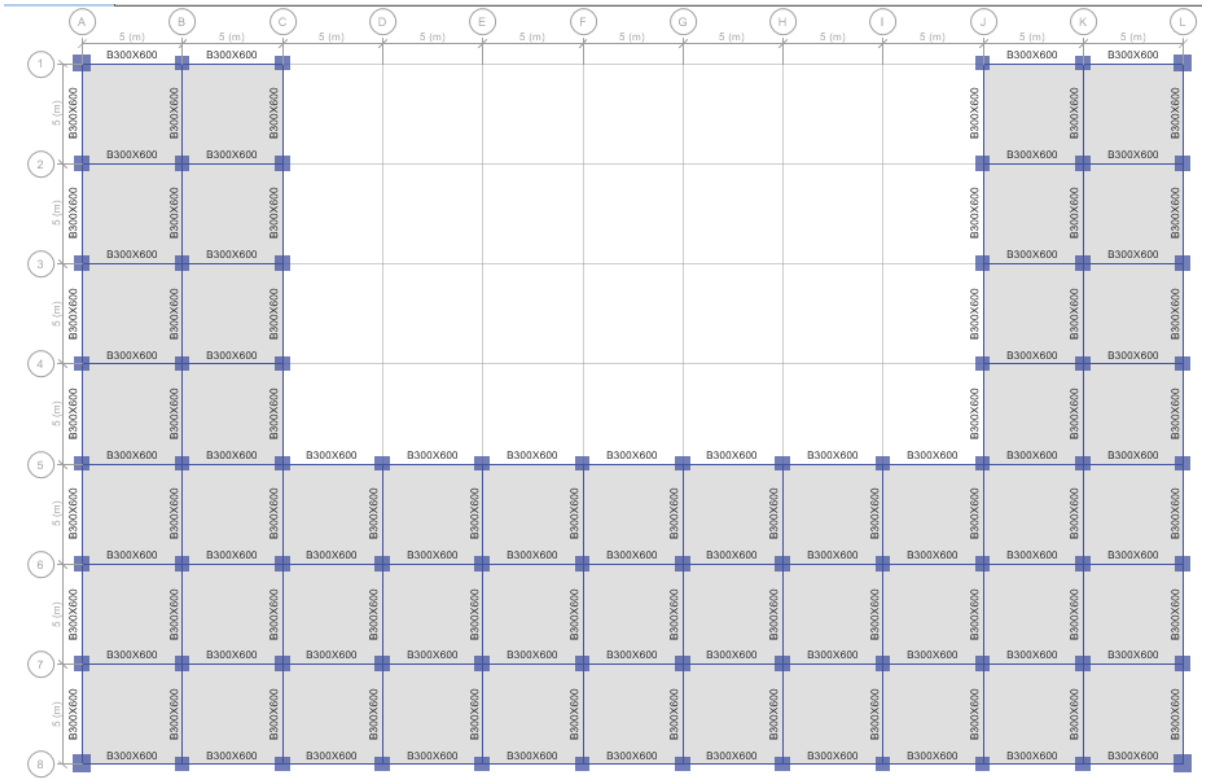

Fig. (3.5) Unsymmetrical structure plan upto storey 8.

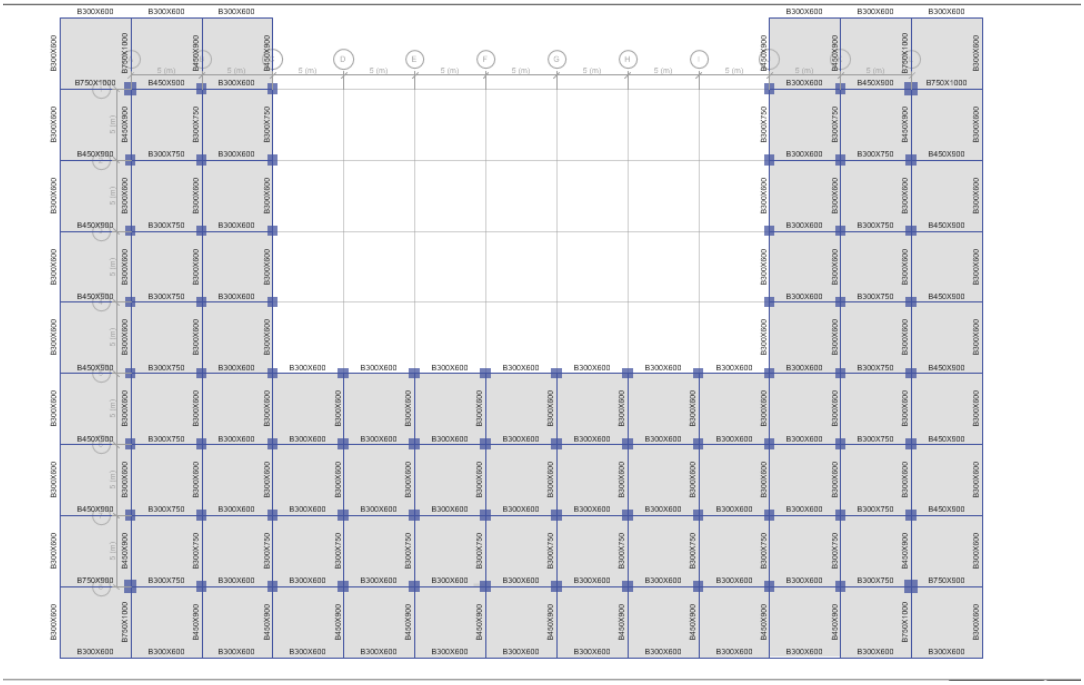

Fig. (3.6) Unsymmetrical structure plan storey 9 & above.

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 BEAM SECTION DETAIL OF STRUCTURE

4.1.1 BEAM SECTION OF SYMMETRICAL STRUCTURE IN BOTH ZONES

S. NO.	ZONE 3			ZONE 4		
1	Shear force (kN)	Bending moment (kN-m)	Deflection (mm)	Shear force (kN)	Bending moment (kN-m)	Deflection (mm)
	628.2	2060.12	1.924	629.7797	2065.175	1.939

4.1.2 BEAM SECTION OF UNSYMMETRICAL STRUCTURE IN BOTH ZONES

S. NO.	ZONE 3			ZONE 4		
1	Shear force (kN)	Bending moment (kN-m)	Deflection (mm)	Shear force (kN)	Bending moment (kN-m)	Deflection (mm)
	637.1589	2143.6361	2.054	648.6107	2172.3892	2.077

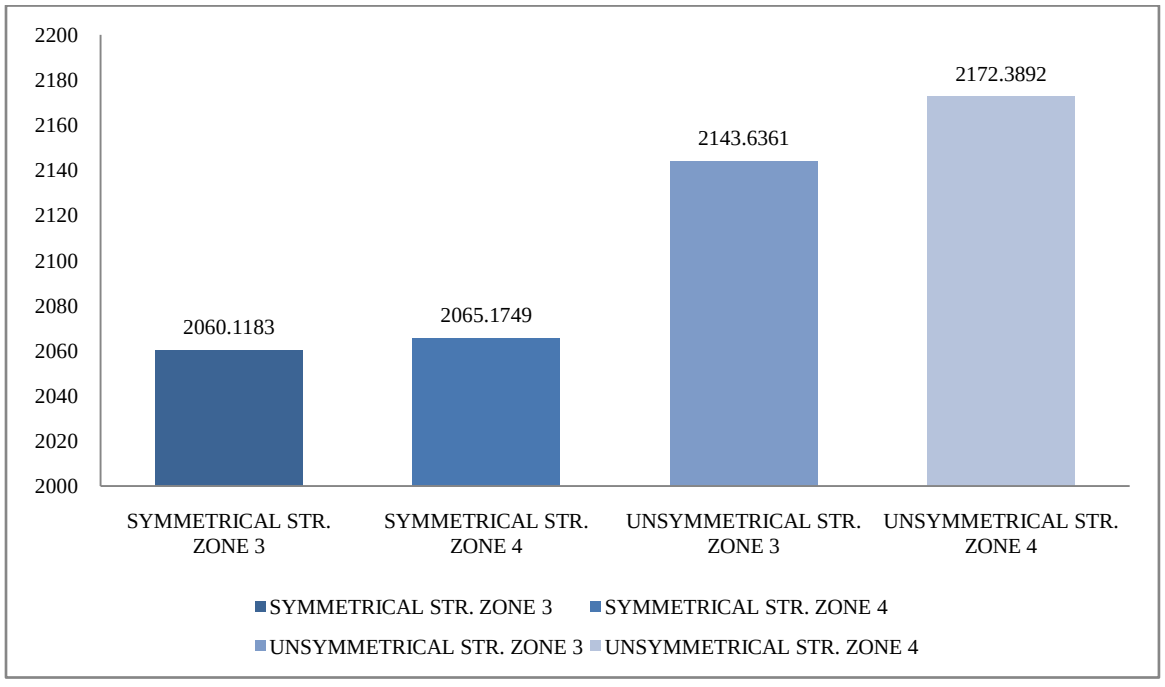

Fig.(4.1A)

The variation of bending moment in beam throughout the span of unsymmetrical structure with respect to the seismic zone is shown in Fig.(4.1A). The bending moment is found to be higher in the case of seismic zone 4, in the unsymmetrical structure when analyzed by dynamic analysis respectively. And also fig.(4.1A) shows that the bending moment in symmetrical structure is less with compare to unsymmetrical structure with their earthquake zones, respectively.

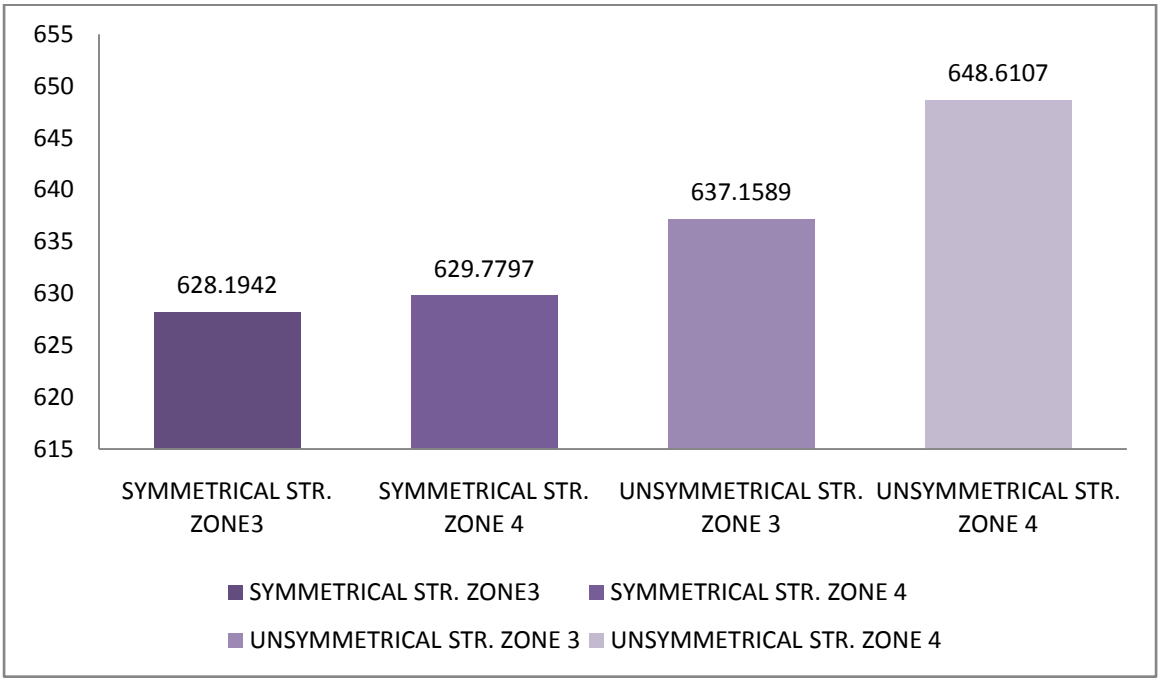

Fig.(4.1B)

The variation of shear force in beam section of symmetrical structure & unsymmetrical structure with respect to the seismic zone is shown in Fig.(4.1B). The shear force is found to be higher in the case of seismic zone 4, in the symmetrical structure & unsymmetrical structure when analyzed by dynamic analysis respectively. And also fig.(4.1B) shows that the shear force in a symmetrical structure is less than an unsymmetrical structure with their earthquake zones, respectively

4.2 STORY DISPLACEMENT DETAIL OF STRUCTURE

Table 4.2.1 STORY 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 4.2.2 STORY 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.

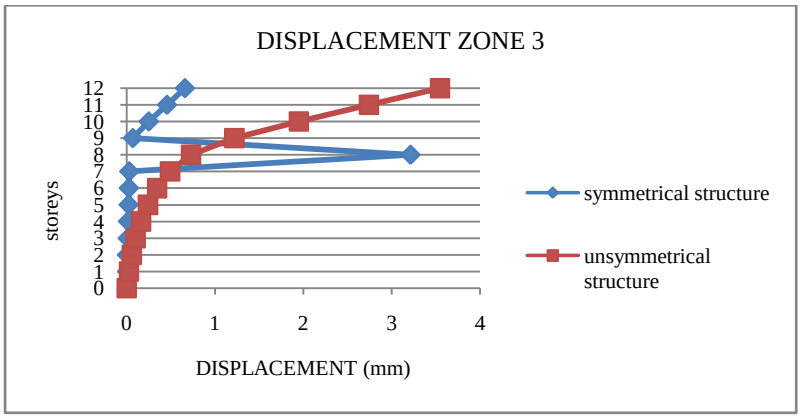

Fig.(4.2)

Table 4.3 STORY 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 STORY 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.

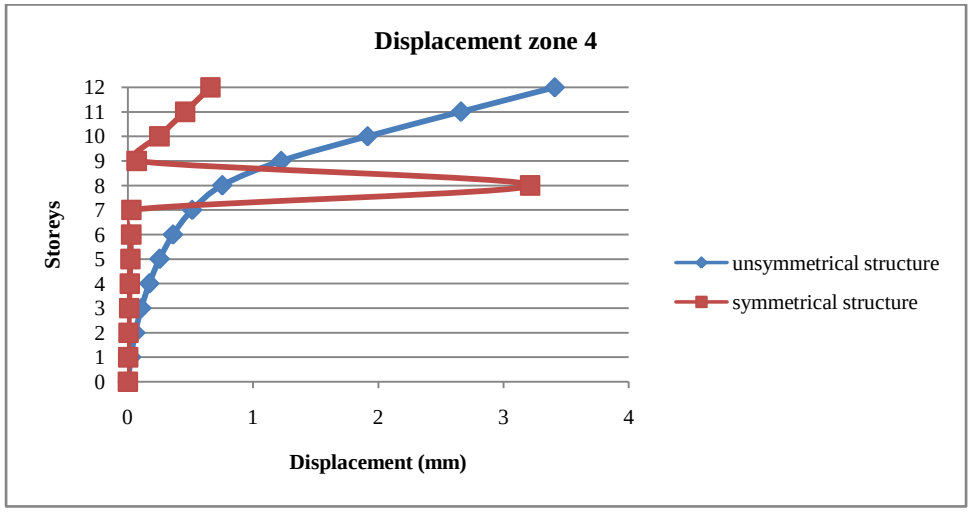

Fig.(4.3)

4.2 STORY DRIFT DETAIL OF STRUCTURE

Table 4.5 STORY 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.

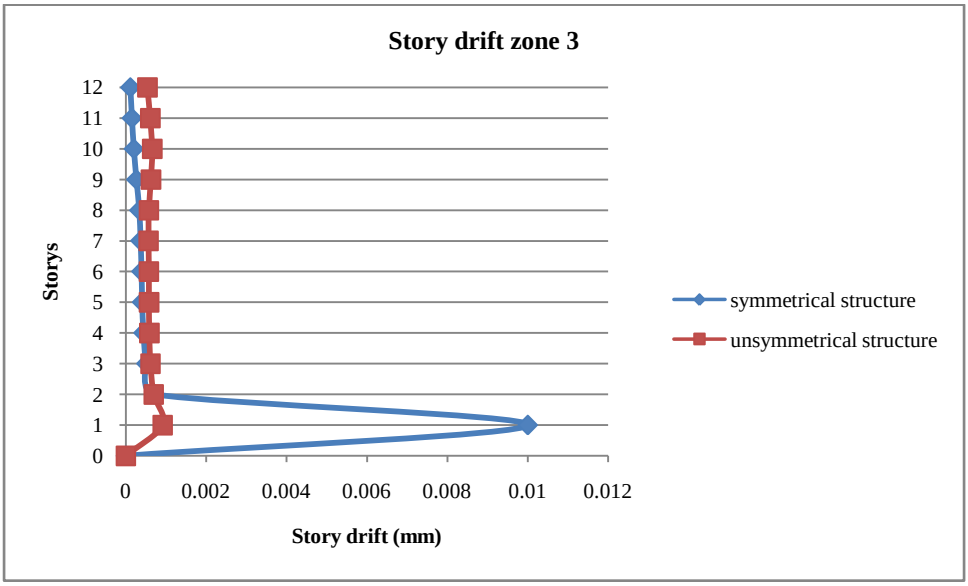

Fig.(4.4)

Table 4.7 STORY 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 STORY 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.

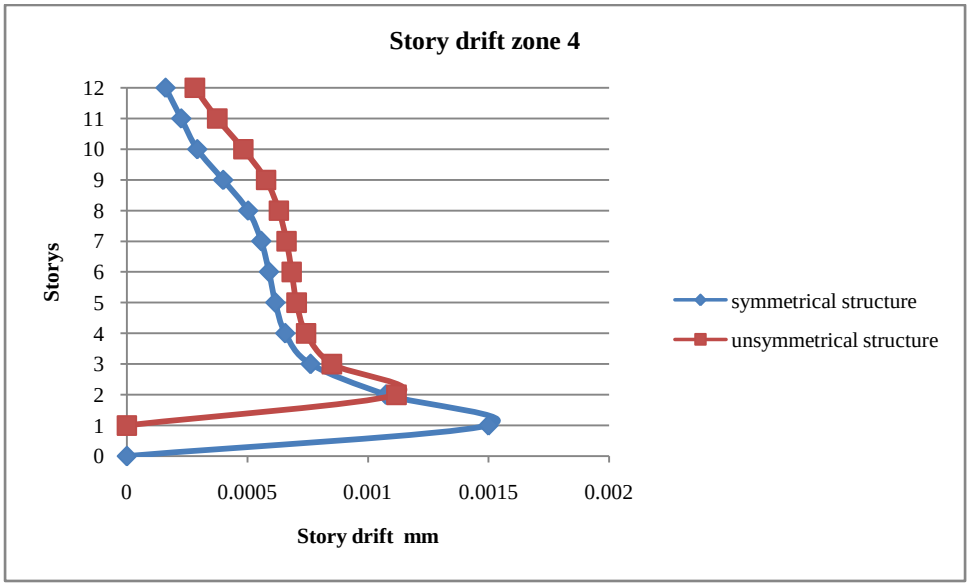

Fig.(4.5)

4.3 STORY SHEAR DETAIL OF STRUCTURE

Table 4.9 STORY 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 STORY 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.

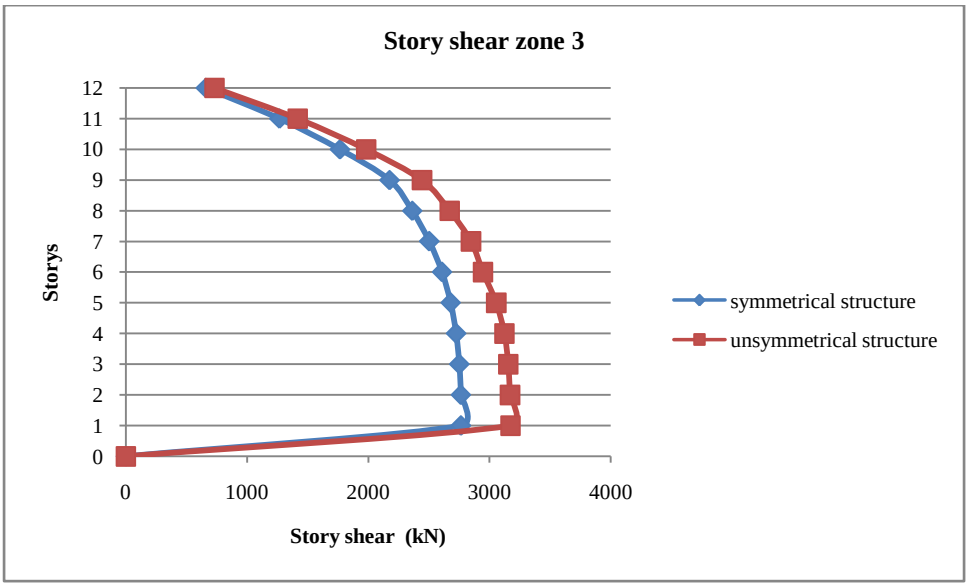

Fig.(4.6)

Table 4.11 STORY 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 STORY 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.

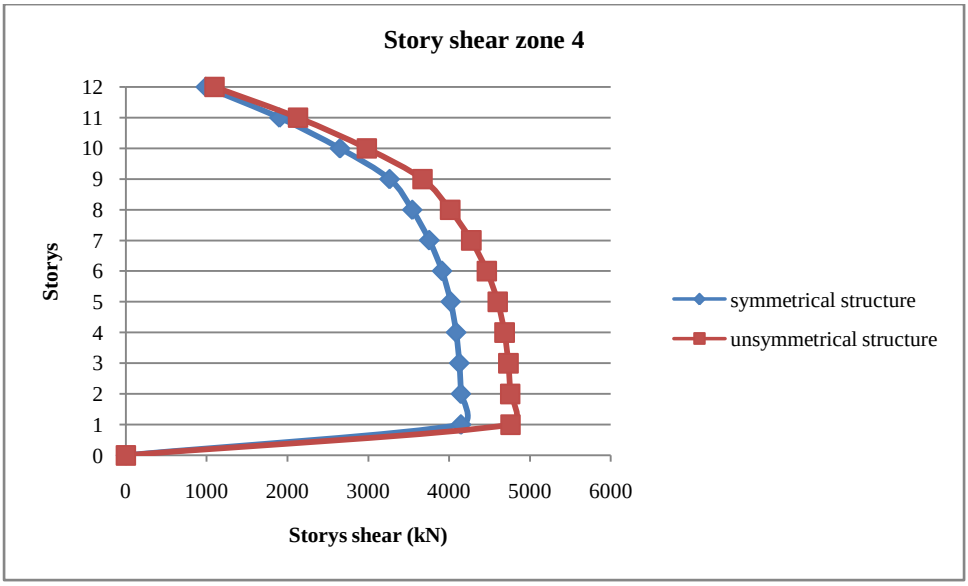

Fig.(4.7)

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 performance of a Symmetrical building is better than an unsymmetrical building.

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