

THE ANALYSIS AND DESIGN OF G+40 STOREY REGULAR STRUCTURE WITH DIFFERENT SHEAR WALLS FOR LOOSE SOILS

K Crown Mojes¹, B. Ajitha²

¹PG Student in Computer Aided Structural Engineering, JNTUCEA, Anantapur (India)

²Assistant Professor, Department of Civil Engineering, JNT University, Anantapur (India)

ABSTRACT

Shear walls are structural members used to augment the strength of RCC structures. These shear walls will be built in each level of the structure, to form an effective box structure. Equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building.

The present work deals with a study on the optimum location of different shapes of shear walls in symmetrical high rise building. Position of shear walls in symmetrical buildings has due considerations. In symmetrical buildings, the center of mass and center of rigidity coincide, so that the shear walls are placed symmetrically over the outer edges or inner edges (like box shape). It is very necessary to determine efficient and ideal location of shear walls in symmetrical buildings to minimize the torsion effect. In this work a high rise building with different locations of shear walls and different shapes of shear walls is considered for analysis. The high rise building with 40 storeys is analyzed for its displacement, torsion, strength and stability using ETABS software. For the analysis of the building for seismic loading Zone 2 Zone 3 Zone 4 & Zone 5 is considered with soil type 1. The analysis of the building is done by using equivalent static method and response spectrum method. The results from the analysis obtained from both the methods are presented in tabular form and the results are compared using graphical form.

The results of the analysis on the shear force, bending moment and torsion are compared. Zone wise results are also compared. The results are presented in tabular and graphical form. The results on the drift and displacement are checked with serviceability conditions and are compared and presented in tabular form.

I. INTRODUCTION

Adequate stiffness is to be ensured in high rise buildings for resistance to lateral loads induced by wind or seismic events. Reinforced concrete shear walls are designed for buildings located in seismic areas, because of their high bearing capacity, high ductility and rigidity. In high rise buildings, beam and column sizes work out large and reinforcement at the beam-column junctions are quite heavy, so that, there is a lot of clogging at these joints and it is difficult to place and vibrate concrete at these places which does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in High rise buildings. Concrete or masonry continuous vertical walls may serve both architecturally as partitions and structurally to carry gravity and lateral loading. There will be no architectural difficulty in extending them through the height of the

building; their very high in plane stiffness and strength had proved them to be ideally suited for resisting lateral loads. Compared to frame type structures, shear-wall structures offer less distortion and less damage to nonstructural elements. Care shall be taken to have symmetrical configuration of walls in the building so that torsion effect in plan could be avoided.

In a shear wall structure, shear walls are entirely responsible for the lateral load resistance of the building due to seismic and wind loadings. These shear walls act as vertical cantilevers in the form of separate planar walls, and also as non planar assemblies of connected walls around stair case, elevators and service shafts

Structural systems for concrete buildings																	
No.	System	Number of stories										Ultra-tall buildings 120–200 stories					
		0	10	20	30	40	50	60	70	80	90		100	110			
1	Flat slab and columns	█															
2	Flat slab and shear walls	█	█														
3	Flat slab, shear walls and columns	█	█	█													
4	Coupled shear walls and beams	█	█	█	█												
5	Rigid frame	█	█	█	█	█											
6	Widely spaced perimeter tube	█	█	█	█	█	█										
7	Rigid frame with haunch girders	█	█	█	█	█	█	█									
8	Core supported structures	█	█	█	█	█	█	█	█								
9	Shear wall—frame	█	█	█	█	█	█	█	█	█							
10	Shear wall—Haunch girder frame	█	█	█	█	█	█	█	█	█	█						
11	Closely spaced perimeter tube	█	█	█	█	█	█	█	█	█	█	█					
12	Perimeter tube and interior core walls	█	█	█	█	█	█	█	█	█	█	█	█				
13	Exterior diagonal tube	█	█	█	█	█	█	█	█	█	█	█	█	█			
14	Modular tubes, and spine wall systems with outrigger and belt walls	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█

II. LITERATURE REVIEW

2.1 Rosinblueth and Holtz “Analysis of shear walls in tall buildings” (1960) considered completely uniform structure suggested a solution of a differential equation and presented tables which are useful for symmetric buildings. The method requires assumption of first approximation which is improved in successive iterations which describes shear wall with entire load if it is much more rigid than the rest of structure and if it is not then the initial distribution of horizontal shear among walls and frames may differ widely. Therefore more number of iterations are required to approach the actual result considering the following assumptions

2.2 Clough.R, King I.P and Wilson E.I-“Structural analysis of multi storied buildings” (1964) had given presentation on efficient digital method for structural analysis of large multi stored building frames with arbitrary system of shear wall. Loading on the structure can be both vertical and lateral but except torsion, they assumed (1) floor diaphragms are rigid in own plane (2) Axial deformations of beams are neglected and for columns and shear walls are considered.

2.3 Khan, F.R. and Sbrounis, J.A,⁽⁷⁾ ‘Introduction of shear wall with frames in concrete structure under lateral loads’ (1964) had considered shear wall and frame as two separate analytical components and done analysis by iterative method to satisfy equilibrium and compatibility conditions at the points of connection of wall and frame. Initially entire lateral load is carried by the individual shear wall and the corresponding deflection at each floor are determined, next the shear wall is individually forced to the deflected shape of the first shear wall, negative shear wall individual shear walls are computed these are applied to first wall and so on

2.4 Girijavallabhan⁽²⁾ - “Analysis of shear walls” (1969) found that finite element method is more advantageous than the finite difference method. The method mainly focus on structural continuum to be analyzed into small finite elements interconnected to specific nodal points. This method of finite element produces same properties done in the continuum.

2.5 Paulay,T., and Priestley , "Seismic design of reinforced concrete and masonry buildings" (1992). Presented most reinforced concrete buildings with shear walls have columns. These columns primarily carry gravity loads. Shear walls provide high strength and stiffness to the structure in the direction of its orientation focusing in significantly helps in reducing lateral sway of the building and thereby reduces damage to the structure and its contents.

III. METHODOLOGY

3.1 Geometrical Properties

- | | | |
|--------------------------------|----|--|
| [1] Height of typical storey | = | 2.7 m |
| [2] Height of ground storey | = | 3.2 m |
| [3] Length of the building | = | 28 m |
| [4] Width of the building | = | 20m |
| [5] Span in both the direction | = | 28 m |
| [6] Height of the building | = | 108.5 m |
| [7] Number of stores | = | 40 |
| [8] Wall thickness | = | 230 mm |
| [9] Slab Thickness | = | 115 mm |
| [10] Grade of the concrete | = | M30 |
| [11] Grade of the steel | = | Fe415 |
| [12] Thickness of shear wall | = | 230 mm |
| [13] Support | = | fixed |
| [14] Column sizes | = | 1.5m X1.5 m up to 10 story |
| | a. | 1.2m X 1.2 m from 11 th to 20 th storey |
| | b. | 0.8 m X 0.8 m from 31 st to 40 th storey |
| [15] 15. Beam size | = | 0.4 m X 0.6 m |

3.2 Loads:

3.2.1 Live load

$$\text{Live load from 1st floor to 30th floor} = 2 \text{ kN/m}^2$$

$$\text{Live load on 30th floor} = 2 \text{ kN/m}^2$$

3.2.2 Dead load

Dead load is taken as prescribe by the IS: 875 -1987 (Part-I) [3] Code of Practice Design Loads (other than earthquake) for Buildings and structure.

$$\text{Unit weight of R.C.C.} = 25 \text{ kN/m}^3$$

$$\text{Unit weight of brick masonry} = 20 \text{ kN/m}^3$$

$$\text{Floor finish} = 0.8 \text{ kN/m}^2$$

$$\text{Water proofing} = 2 \text{ kN/m}^2 \text{ on terrace roof}$$

$$\text{Wall load} = 13 \text{ kN/m on all floors expect terrace}$$

Roof

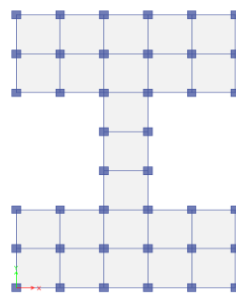
$$= 6.9 \text{ kN/m on terrace roof}$$

3.2.3 Wind load

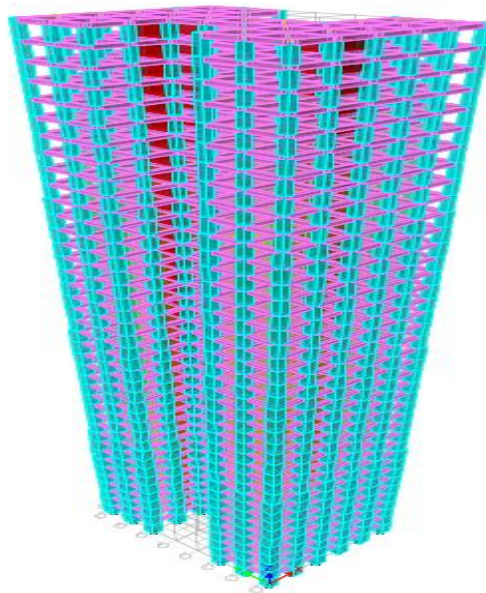
The basic wind speed (V_b) for any site shall be obtained from IS 875(Part 3 -1987) [4] it is 44 m/sec and shall be modified to include the following effects to get design wind velocity at any height (V_z) for the chosen the structure.

Risk level Terrain roughness, height and size of structure, and Local topography It can be mathematically expressed as follows:

IV. PLANS AND LAYOUT OF MODELS



Plan of Model 1 at storey 40 level



Isometric view of Model

V. RESULTS

5.1 Results from the equivalent static method

The following tables and graphs are obtained from ETABS and analysis is done by using Equivalent static method.

For each shape of shear wall the optimum model is selected and the values of those models are only compared with the model without shear wall.

Maximum Displacement of Different Models for load combination 1.2 (DL+LL+EQX) in Earth Quake Zone-2& Site Type 1

STOREY	NORMAL	U SHAPE SW	BOX SHAPE SW	L SHAPE SW
40	17.9	27.3	27.2	18.8
39	17.6	26.8	26.7	18.4
38	17.4	26.3	26.2	18
37	17.1	25.8	25.6	17.5
36	16.9	25.2	25	17.1
35	16.6	24.6	24.4	16.6
34	16.2	24	23.8	16.2
33	15.9	23.4	23.1	15.7
32	15.5	22.7	22.5	15.2
31	15.1	22	21.8	14.7
30	14.7	21.3	21	14.2
29	14.3	20.6	20.3	13.7
28	13.9	19.8	19.5	13.1
27	13.4	19.1	18.7	12.6
26	13	18.3	17.9	12.1
25	12.5	17.5	17.1	11.5
24	12.1	16.7	16.3	10.9
23	11.6	15.9	15.4	10.4
22	11.1	15	14.6	9.8
21	10.6	14.2	13.7	9.3
20	10.1	13.3	12.9	8.7
19	9.6	12.5	12	8.2
18	9	11.7	11.2	7.6
17	8.5	10.9	10.3	7.1
16	8	10	9.5	6.5
15	7.5	9.2	8.7	6
14	7	8.4	7.9	5.4
13	6.5	7.6	7.1	4.9
12	6	6.9	6.3	4.4
11	5.5	6.1	5.6	3.9
10	5	5.4	4.9	3.5
9	4.5	4.7	4.2	3.1
8	4	4.1	3.6	2.6
7	3.5	3.4	3	2.2
6	3.1	2.8	2.4	1.8
5	2.6	2.3	1.9	1.5

4	2.1	1.8	1.4	1.1
3	1.6	1.3	1	0.8
2	1.2	0.9	0.6	0.6
1	0.6	0.5	0.3	0.3
BASE	0	0	0	0

5.2 Graph showing Maximum Storey Displacement Values for 1.2(DL+LL+EQX) in Zone-2 & Soil-1

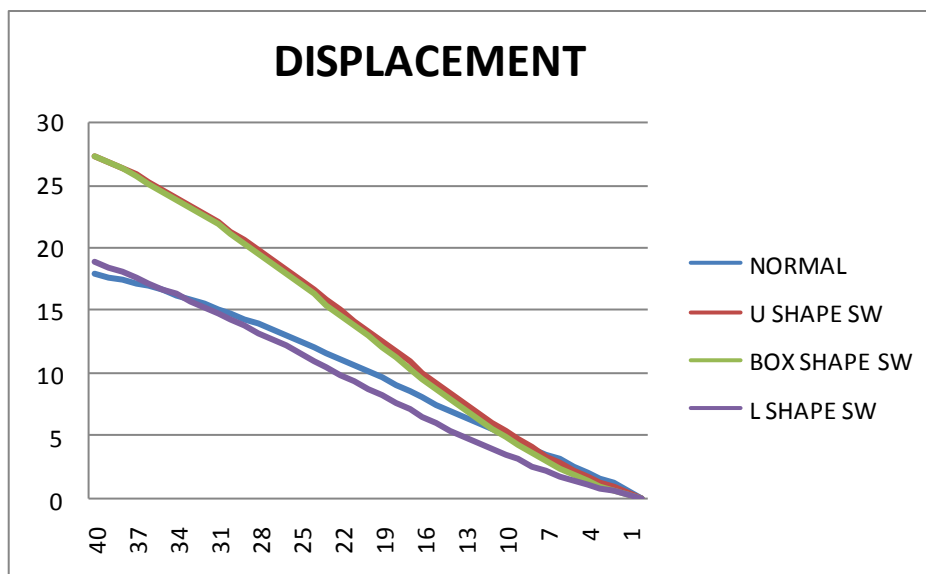
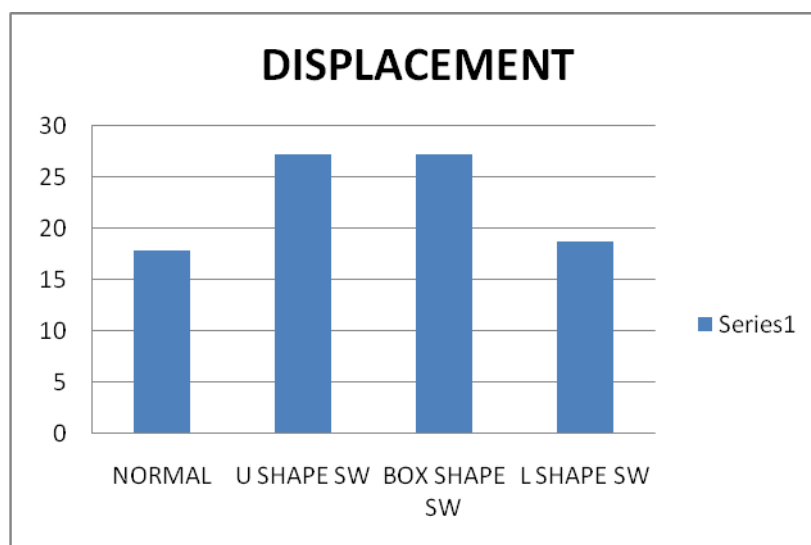


Table showing Maximum Storey Displacement Values for 1.2(DL+LL+EQX) in Zone-2 & Soil-1

STOREY	NORMAL	U SHAPE SW	BOX SHAPE SW	L SHAPE SW
40	17.9	27.3	27.2	18.8



VI. DISCUSSION OF RESULTS

A 40storied building with shear wall & rigid frame structure with symmetrical shape (i.e. 'I' shape in plan) is considered for analysis. Different shapes of shear walls with different locations in plan of the building were analyzed in ETABS v2013 and results are obtained and compared.

Model 1: In this model building with 40 floors is modeled as a "Rigid frame" with only, beams, columns & slabs as shown .The dead loads of other elements (slabs, stairs and walls) are taken as member loads on the respective beams.

Model 2: In this model building with 40 floors is modeled as Dual frame system with shear wall of Box shape as shown. Shear wall acts as vertical cantilever with fixed end connected to the foundation. The loads are taken same as in Model 1.

Model 3: In this model building with 40 floors is modeled as Dual frame system with shear wall of U shape as shown . The loads are taken as same in Model 1.

Model 4: In this model building with 40 floors is modeled as Dual frame system with shear wall of 'L' shape as shown .The loads are taken as same in Model 1.

The building is analyzed using both the static and dynamic analysis methods for all models with different shapes of shear walls

VI. CONCLUSIONS

The following conclusions are made from the present study

- [1.] Provision of shear wall generally results in reducing the displacement because the shear wall increases the stiffness of building and sustains the lateral forces. The better performance is observed in model 1 with respect to diaphragm displacement because it has low displacement in both x and y directions than the model without shear wall.
- [2.] The shear force resisted by the column frame is decreasing by placing the shear wall and the shear force resisted by the shear wall is increasing. This can be concluded indirectly by observing the maximum column shear force and moment in both directions.
- [3.] For the columns located away from the shear wall the Bending Moment is high and shear force is less when compared with the columns connected to the shear wall. Torsion in the columns is decreased in the model 3 with shear walls when compared to the model 1 without shear walls, from both the methods. The torsion is also affected by the position and the shape of shear wall. For certain models it is increased and for certain models it is decreased.

REFERENCES

- [1.] IS: 456-code of practice for plain and reinforced concrete
- [2.] IS: 875(part 1-5) - code of practice for structural safety of Building loading standards
- [3.] IS 1893(Part-1):2002, Criteria for earthquake resistant design of structures.
- [4.] IS 13920:1993, Ductile detailing of reinforced concrete structure subjected to seismic forces-code of practice.
- [5.] SP: 16-design aids for reinforced concrete