



Study on the Optimum Location and Type of Shear Wall in U-Shape Building under Different Types of Soils

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Abstract: Shear walls are structural members used to augment the strength of RCC structures. Equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building. Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness. The present work deals with a study on the optimum location and type of shear wall in U-shape building. In this work a high rise building with different locations of shear walls is considered for analysis. The high rise building is analyzed for its torsion, strength and stability. The results of the analysis on the shear force, bending moment and torsion are compared for different types of soils. The results on the storey drift and displacement are checked with serviceability condition for different types of soils.

Keywords: U-Shape Building, RCC Structures.

I. INTRODUCTION

Reinforced concrete framed buildings are adequate for resisting both the vertical and the horizontal loads acting on them. However, when the buildings are high rise, beam and column sizes work out large and reinforcement at the beam-column junctions works out quite heavy, so that, there is a lot of congestion at these joints and it is difficult to place and vibrate concrete at these places, which fact, does not contribute to the safety of buildings. These practical difficulties, call for introduction of shear walls in high rise buildings. There will be no architectural difficulty in extending them though the height of the building; care shall be taken to have a symmetrical configuration of walls in plan so that torsional effect in the plan could be avoided. Further, shear walls should get enough vertical load from floors, for which reason, nearby columns should be omitted and the load taken to the shear walls by means of long span beams if required.

A. The Role of Floor Diaphragm in Framed Buildings

The role of floor diaphragm is as important as it is in the case of framed buildings. The floor diaphragm forces all the vertical elements like frames and shear walls to share the incumbent horizontal shear in the ratio of their rigidities or stiffness. In a building with rigid floor diaphragm, the following three situations may arise with respect to the centre of mass and the centre of rigidity.

- Coincident centre of mass and the centre of rigidity of each floor lie on the same vertical axis. In this case the building does not undergo torsional motion under lateral excitation and the standard stiffness approach

for each storey is applicable. This is applicable to regular and symmetrical buildings.

- Center of mass of each floor lies on the same vertical axis, whereas the centre of rigidity of each floor does not lie on the same vertical axis. In this case the stiffness of each storey are formulated about a common vertical axis.
- Center of mass of each floor does not lie on the same vertical axis and the centre of stiffness of each floor also does not lie on the same vertical axis.

B. Geo-Technical Consideration

1. Site selection

The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock. For soft soils the earthquake vibrations can be significantly amplified and hence the shaking of structures sited on soft soils can be much greater than for structures sited on hard soils. Hence the appropriate soil investigation should be carried out to establish the allowable bearing capacity and nature of soil. The choice of a site for a building from the failure prevention point of view is mainly concerned with the stability of the ground. The very loose sands or sensitive clays are liable to be destroyed by the earthquake, so much as to lose their original structure and thereby undergo compaction. This would result in large unequal settlements and damage the building. If the loose cohesion less soils are saturated with water they are likely to lose their shear

resistance altogether during ground shaking. This leads to liquefaction. Although such soils can be compacted, for small buildings the operation may be too costly and the sites having these soils are better avoided.

B. Bearing capacity of foundation soil

Three soil types are considered here:

Hard: Those soils, which have an allowable bearing capacity of more than 10 t/m².

Medium: Those soils, which have an allowable bearing capacity less than or equal to 10 t/m²

Soft: Those soils, which are liable to large differential settlement or liquefaction during an earthquake.

Soils must be avoided or compacted to improve them so as to qualify them either as firm or stiff. The allowable bearing pressure shall be determined in accordance with IS: 1888-1982 load test (Revision 1992). It is a common practice to increase the allowable bearing pressure by one-third, i.e. 33%, while performing seismic analysis of the materials like massive crystalline bedrock sedimentary rock, dense to very dense soil and heavily over consolidated cohesive soils, such as a stiff to hard clays.

II. LITERATURE REVIEW

Anand, N., Mightraj, C and Prince Arulraj, based on their work concluded that found that the base shear values were same for all the three types of soils. the base shear values increase when the soil type changes from hard to medium and medium to soft.. The lateral displacement value increases when the type of soil changes from hard to medium and medium to soft for all the building frames. The axial force and moment in the column increases when the type of soil changes from hard to medium and medium to soft. Since the base shear, axial force, column moment and lateral displacement increase as the soil type changes, soil structure interaction must be suitably considered while designing frames for seismic force. M. Gloria Gomes, A. Moret Rodrigues and Pedro Mendes were studied the pressure distribution on commonly used irregular-plan buildings, wind tunnel tests were conducted on L- and U-shaped models over an extended range of wind directions. It was found that pressure distribution can considerably change with the building shape and wind incidence angle. Moreover, the numerically obtained flow patterns in the immediate vicinity of the inner faces of these irregular plan buildings are consistent with the measured pressure distributions. Flow pattern and velocity magnitude should be analysed together when both pedestrian comfort and environmental air quality are required.

III. SHEAR WALL

Shear wall is a concrete wall made to resist lateral forces acting on high rise buildings. It is provided, when the centre of gravity of building area & loads acted on it differs by more than 30%. In order to bring the center of gravity in the range of 30% concrete wall is provided i.e. lateral forces may not increase much. The Shear Wall sections are classified as seven types (fig 1):

- a. Box Section

- b. L – Section
- c. U – Section
- d. W – Section
- e. I-Section \
- f. T – Section
- g. Rectangular Section

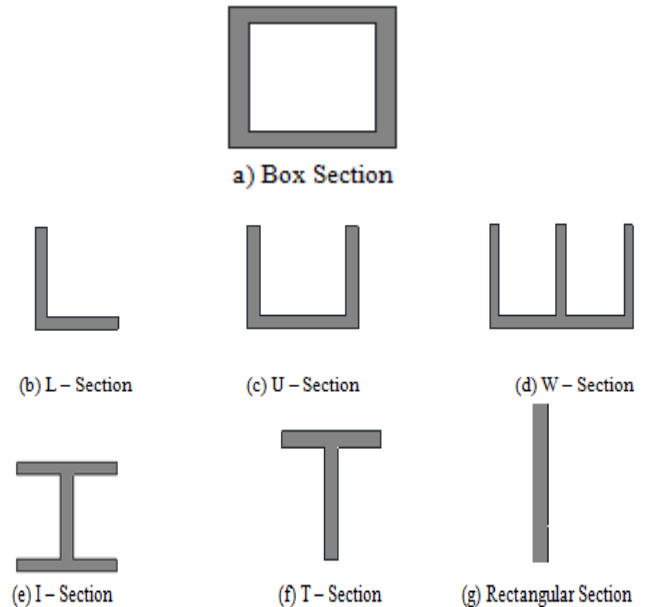


Figure 1: Shown the shear wall section.

IV. METHODOLOGY

For the purpose of knowing the optimum location of shear wall we have to add the shear wall in different places in the building under three soil conditions (hard, medium and soft) and study the impact of the center of mass, center of rigidity, base shear, storey drift, axial force, shear force, torsion and moment by changing the location, type of shear wall and types of soils. Four types of shear wall were selected and placed in different locations in the building. Twelve 3D space buildings were modelled using four types of shear wall and the soil conditions are three, three 3D space buildings were modelled without shear wall under three soil conditions to understand the effect of shear wall in the building and behavior of the building with and without shear wall. The models had carried out for U – shaped building with and without shear wall using ETABS Software as shown follows:

Structure 1: In this model building with 15 floors is modelled as a (Rigid frame) with only, beams, columns & slabs as shown in figure 2. The dead loads of other elements (slabs, stairs and walls) are taken as member loads on the respective beams. The wall load is considered as a uniformly distributed load on beams. In this case the effect of rigid floor diaphragm is taken into consideration.

Structure 2: In this model building with 15 floors is modeled as (Dual system with shear wall (Rectangular section) as shown in figure 3). The loads are taken as same in structure1.

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Structure 3: In this model building with 15 floors is modeled as (Dual system with shear wall (I - section) at the middle span of the building as shown in figure 4). The loads are taken as same in structure 1.

Structure 4: In this model building with 15 floors is modeled as (Dual system with shear wall (Box section) as shown in figure 5). The loads are taken as same in structure 1.

Structure 5: In this model building with 15 floors is modeled as (Dual system with shear wall (L - section) as shown in figure 6). The loads are taken as same in structure 1.

The geometrical properties of the structures :

1. Height of typical storey 3 m
2. Height of ground storey 4 m
3. Length of the building 60 m
4. Width of the building 54 m
5. Span in both the direction is 6 m
6. Height of the building 46 m
7. Number of storey's G +14
8. Dimension of beams $0.3 \text{ m} \times 0.6 \text{ m}$
9. Dimension of columns $0.6 \text{ m} \times 0.6 \text{ m}$
10. Wall thickness 0.23 m.
11. Slab Thickness:-
 - A. From 1st floor to 14th floor 0.15 m
 - B. 15th floor 0.1 m
12. Grade of the concrete M 40
13. Grade of the steel Fe 415
14. Thickness of shear wall 0.23 m
15. Support fixed
16. Modulus of elasticity: 31622.777 N/mm^2
17. Poisson's ratio 0.2
18. Loads

A. Live load

Live load From 1st floor to 14th floor 4 kN/m^2
 Live load on 15th floor 1 kN/m^2

B. Dead load

Dead load is taken as prescribed by the IS: 875 - 1987 (Part-1)

Unit weight of R.C.C. = 25 kN/m^3
 Unit weight of brick masonry = 19.2 kN/m^3
 Floor finish = 2 kN/m^2
 Wall load = 10.6 kN/m .

C. Wind load

Wind load is taken as prescribed by the IS: 875 (part 3) - 1987

Wind coefficients
 Wind speed = 44 m/s
 Terrain category = 2
 Structure class = C
 Risk coefficient (k_1) = 1
 Topography coefficient (k_3) = 1

D. Seismic loading

In the present work the building is located in Hyderabad which comes under -zone-II, using the IS 1893 (Part-1) - 2002 the following are the various values for the building considered:

Zone factor = 0.1

Response reduction factor = 5

Importance factor (I) = 1

Soil type: Soil site factor (I for hard soil, II for medium soil and III for soft soil).

Damping - 5%

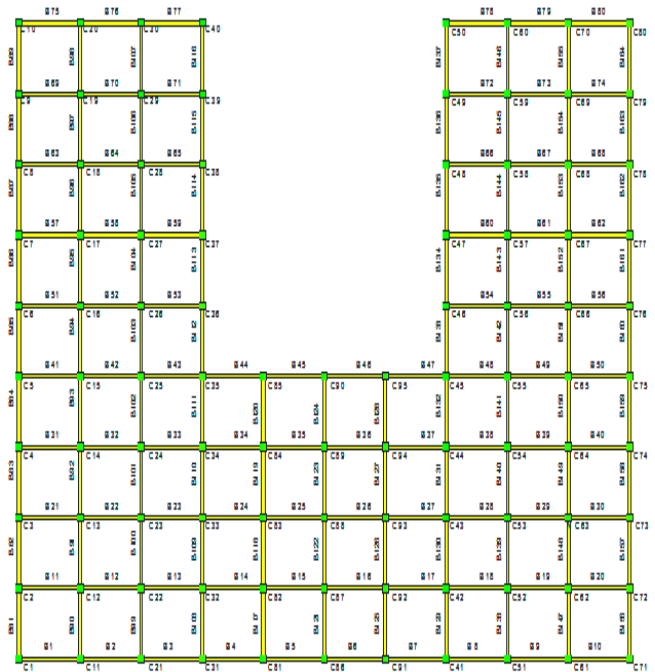


Figure 2: Plan of structures 1 at basement level.

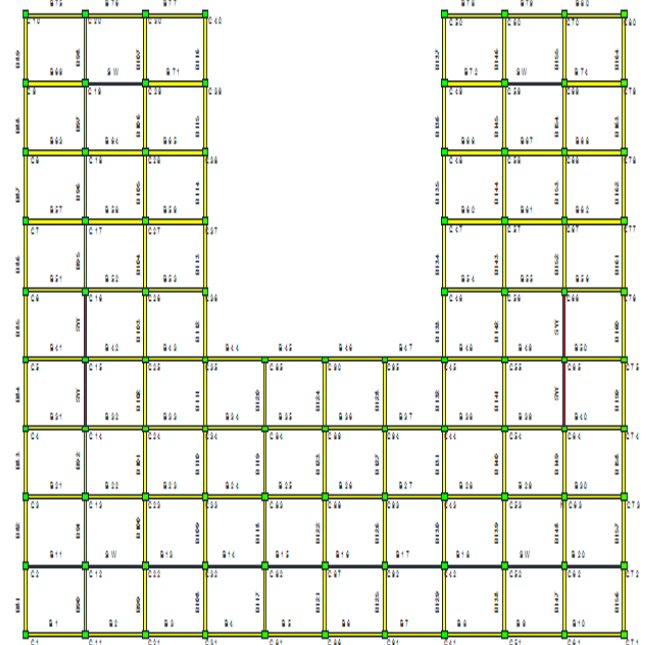


Figure 3: Plan of structures 2 at basement level.

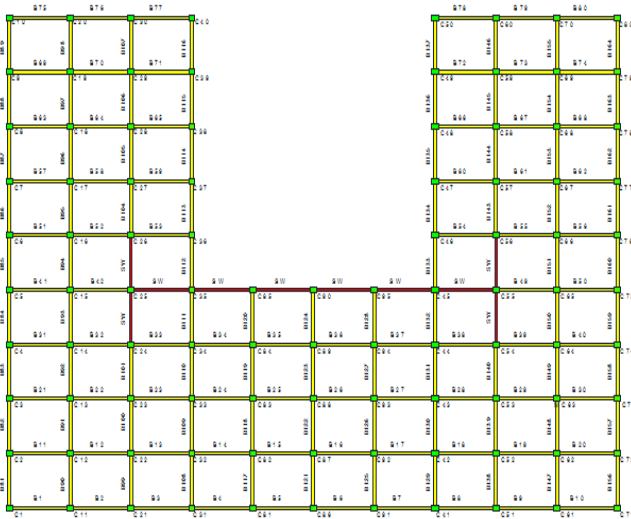


Figure 4: Plan of structures 3 at basement level.

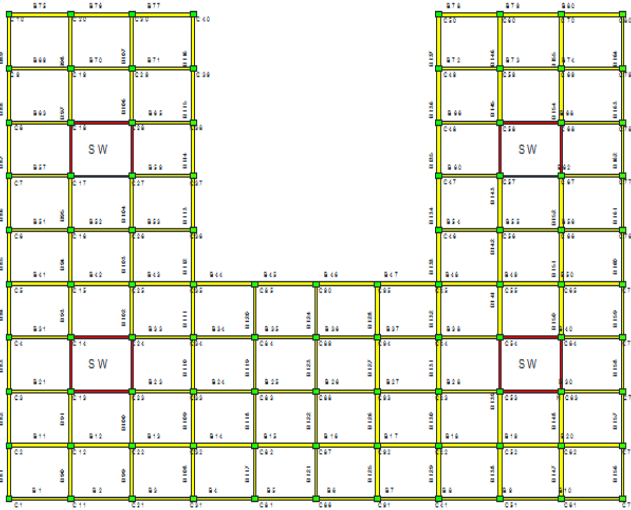


Figure 5: Plan of structures 4 at basement level.

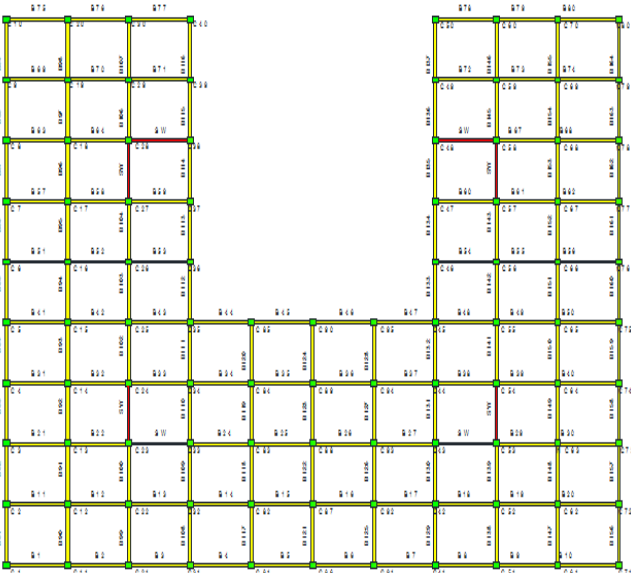


Figure 6: Plan of structures 5 at basement level.

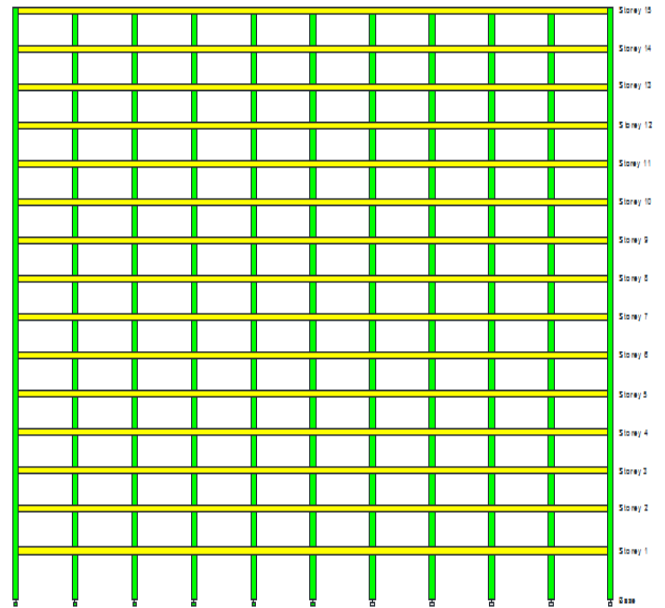


Figure 7: Elevations of structures 1,2,3,4 and 5.

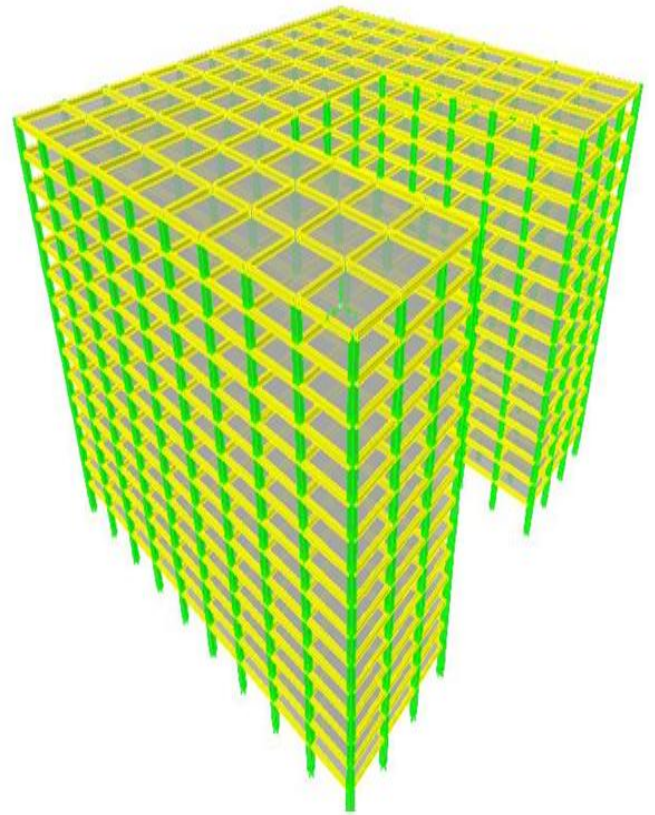


Figure 8: (3D) View of structures 1,2,3,4 and 5.

IV. RESULTS AND DISCUSSION

The dynamic analysis is carried out for all models with different types of soils (hard, medium and soft) and the storey masses, base shear, storey drift, column axial force, column shear force in both directions (x,y), column torsion, column moment in both directions (x,y), storey axial force, storey shear force, storey torsion and storey moment in both directions (x,y) are presented in tables and figures from 9 to 21 as follows:

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TABLE 1: Center Of Mass And Rigidity for All Structure In Hard, Medium And Soft Soil

Structure	Center of mass		Center of rigidity	
	XCM	YCM	XCR	YCR
Structure-1	30	24.163	30	22.588
Structure-2	30	24.205	30	23.456
Structure-3	30	24.157	30	23.806
Structure-4	30	24.335	30	24.65
Structure-5	30	24.252	30	23.263

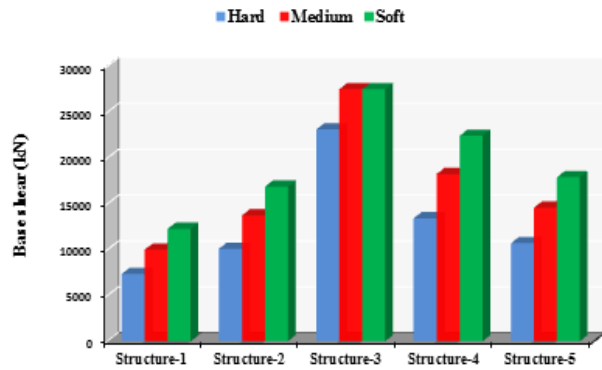


Figure9. Variations in base shear for all structure with load combination 1.2 (LL+DL+EQXNE).

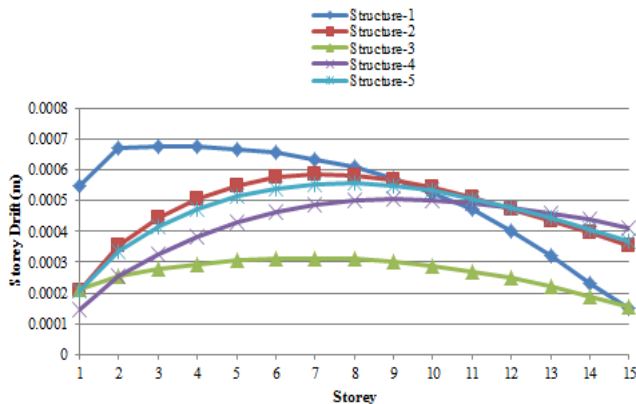


Figure10: Variations in storey level with storey drift for all structure with load combination (LL+DL+EQXNE) in hard soil.

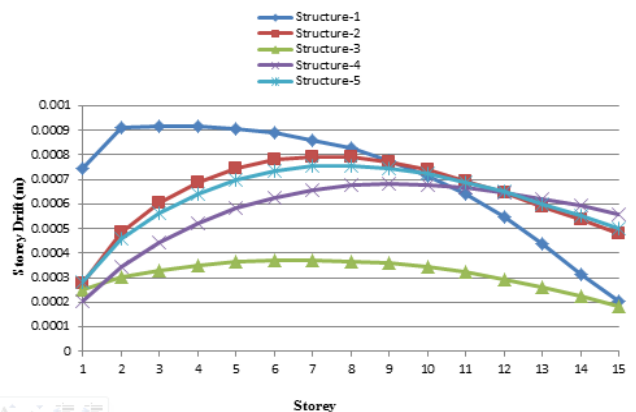


Figure 11. Variations in storey level with storey drift for all structure with load combination (LL+DL+EQXNE) in medium soil.

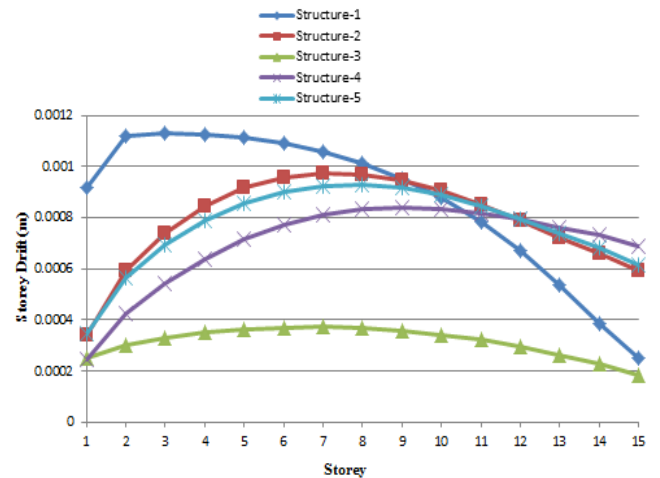


Figure12. Variations in storey level with storey drift for all structure with load combination (LL+DL+EQXNE) in soft soil.

The percentage of storey drift in x- direction is decreased by adding the shear wall to the building as shown below:

1. 13.61 % for structure2 compared with structure1.
2. 60 % for structure3 compared with structure1.
3. 25.6 % for structure4 compared with structure1.
4. 17.7 % for structure5 compared with structure1.

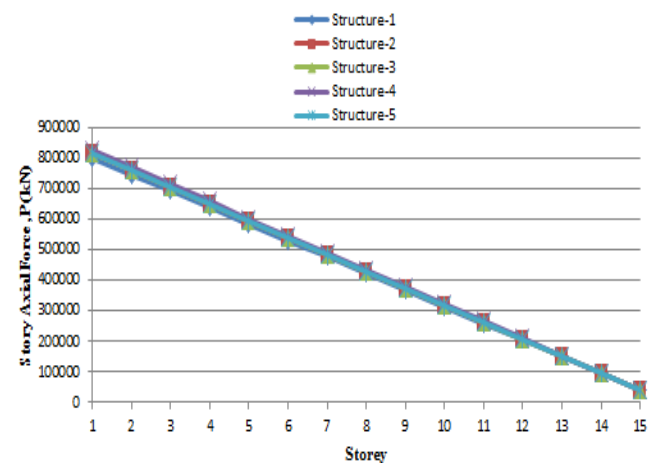


Figure13. Variations in storey axial force with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in hard , medium and soft soil.

In the present work columns (C1, C5, C10, C19, C23, C35, C40, C86, C88, C90) had been studies for load combination 1.2(DL+LL+EAXNE) and the resulted observed:

1. The maximum column axial force, maximum column shear force in x – direction, maximum column torsion and maximum column moment in y-direction are influenced by the types of soils, locations and types of the shear wall.
2. The maximum column shear force in y-direction and maximum column moment in x-direction are same for the columns (C86, C88, C90) with a different types of soils and shear wall. The columns (C86, C88, C90)

which are located in the center of the building along y - axis has no influence on the types of soils and shear wall.

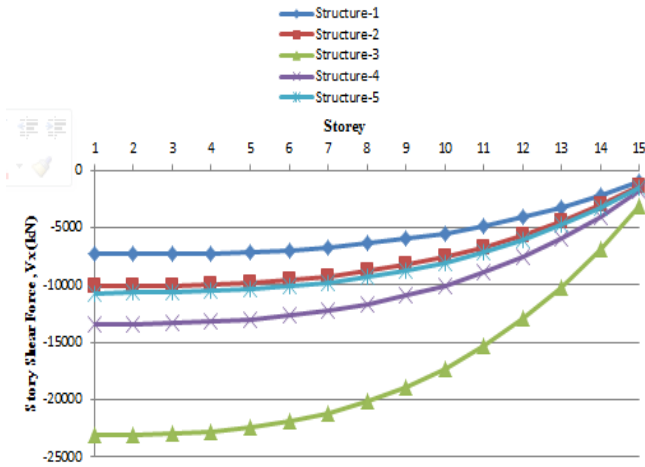


Figure14. Variations in storey shear force with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in hard soil.

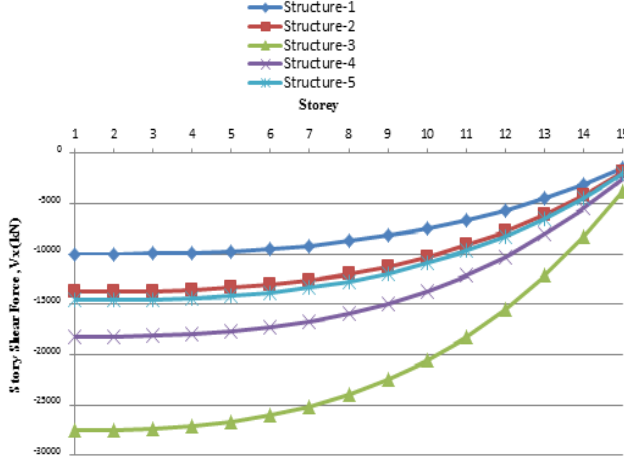


Figure15. Variations in storey shear force with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in medium soil.

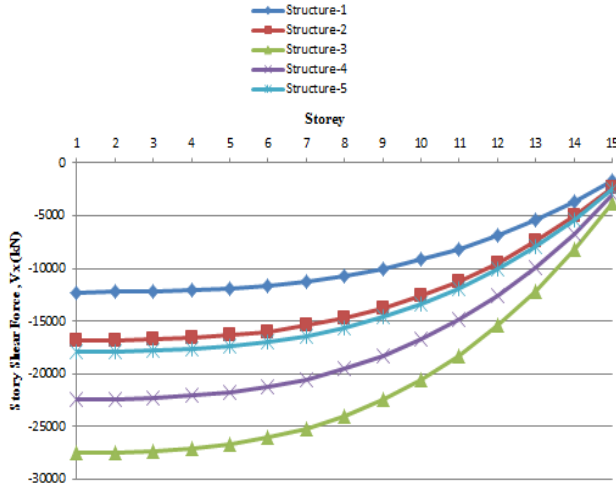


Figure16. Variations in storey shear force with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in soft soil.

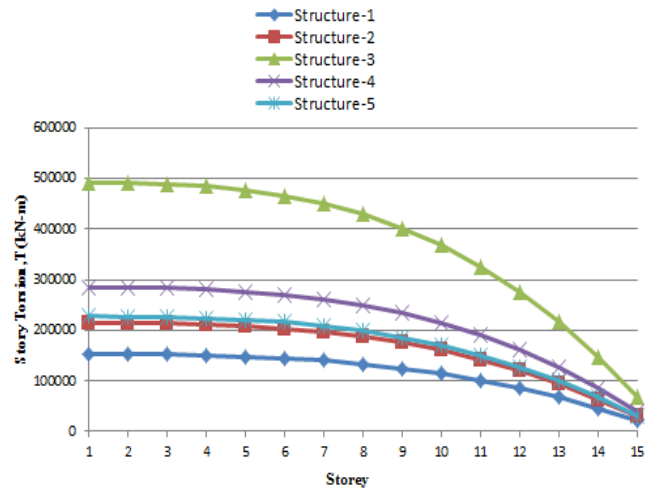


Figure17. Variations in storey torsion with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in hard soil.

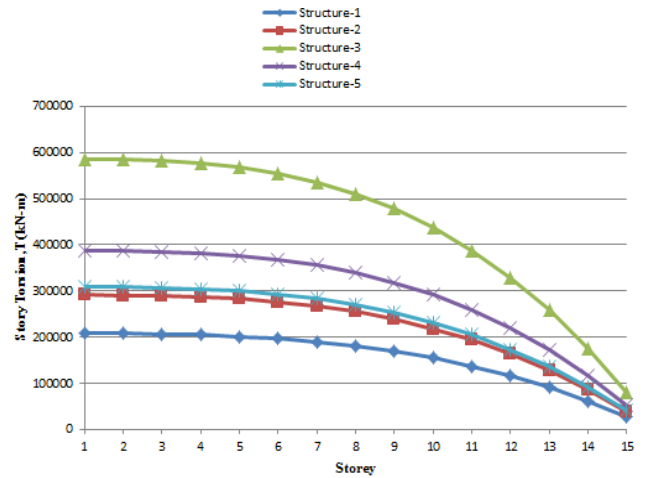


Figure18. Variations in storey torsion with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in medium soil.

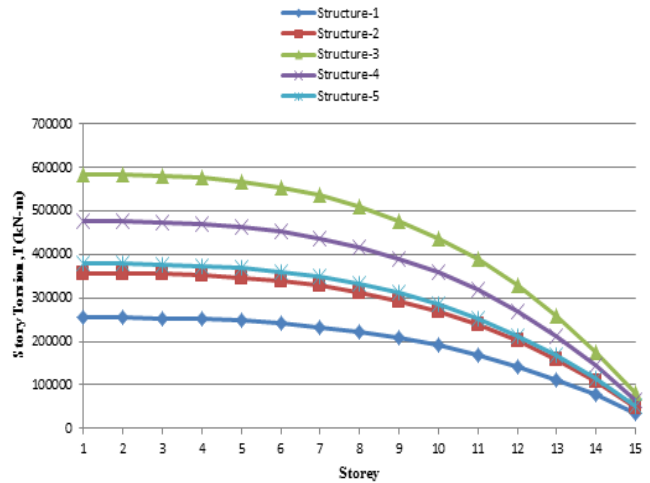


Figure19. Variations in storey torsion with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in soft soil.

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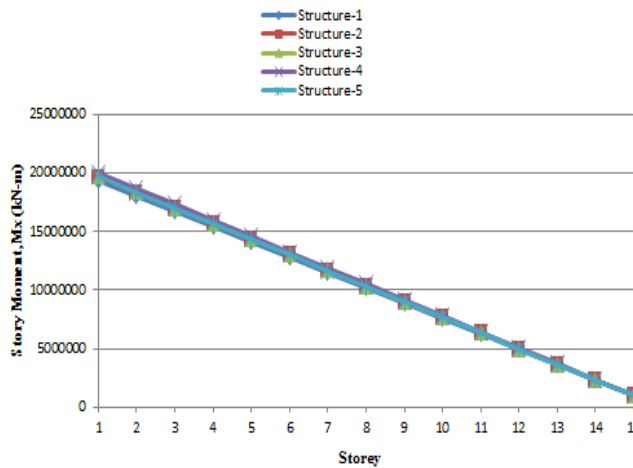


Figure 20. Variations in storey moment with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in hard, medium and soil.

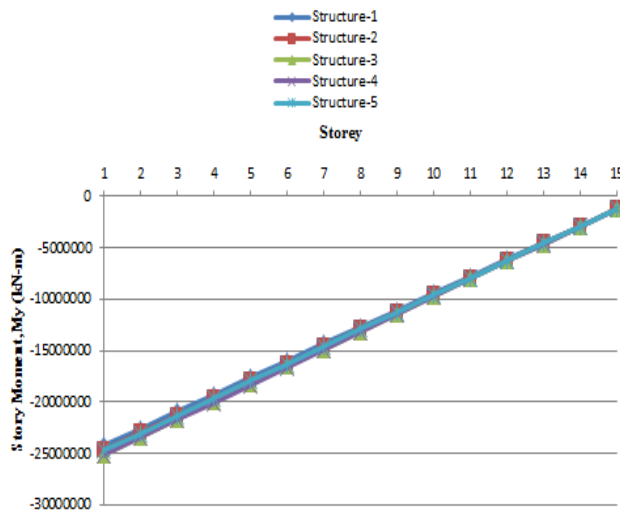


Figure 21. Variations in storey moment with storey level for all structure with load combination 1.2(LL+DL+EQXNE) in hard, medium and soft soil.

V. CONCLUSIONS

The following conclusions are made from the present study:

1. The shear wall and its position has a significant influence on the time period. The time period is not influenced by the types of soils. The better performance for structure 4 because it has a low time period.
2. The center of mass and center of rigidity is influenced by adding, positioning and type of the shear wall, but does not depend on the type of soil. It can be concluded that all structures are symmetric in x-direction and there is no effect of torsion due to center of mass and center of rigidity is same in x-direction. The performance of the structure with shear wall is better than a structure without shear wall because the center of mass and center of rigidity becomes close.
3. Base shear is affected marginally by placing of the shear wall, grouping of shear wall and type of soil. The

base shear is increased by adding shear wall due to increase the seismic weight of the building.

4. Provision of the shear wall, generally results in reducing the displacement because the shear wall increases the stiffness of the building. The displacement is influenced by type and location of the shear wall and also by changing soil condition. The better performance for structure 3 because it has low displacement.
5. As per code, the actual drift is less than permissible drift. The parallel arrangement of shear wall in the center core and outer periphery is giving very good result in controlling drift in both the direction.
6. 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.
7. The moment resisting frame with shear walls are very good in lateral force such as earthquake and wind force. The shear walls provide lateral load distribution by transferring the wind and earthquake loads to the foundation. And also impact on the lateral stiffness of the system and also carries gravity loads.
8. It is evident that shear walls which are provided from the foundation to the rooftop, are one of the excellent means for providing earthquake resistant to multistory reinforced building with different types of soils. These are little expensive by (5.4 % for structure 2, 6.7 % for structure 3, 10.8 % for structure 4, 5.4 % for structure 5 of overall cost) but desirable.
9. 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.

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