Optimum Location of a Shear Wall in High Rise U-Shape Building

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Abstract— **In this paper on study on the optimum location of shear walls in U-shaped high rise building(G+15).Shear walls are structural members used to augment the strength of RCC structures.It is very necessary to determine effective, efficient and ideal location of shear wall. 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. 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. It is necessary to provide these shear walls when the allowable span-width ratio for the floor or roof diaphragm is exceeded. In present study done by a high rise building with different locations of shear walls is considered for analysis. Determining seismic behavior in different type of soils like as a medium, soft, hard for use Parameters like top displacement, base shear, storey drifts,time Period, center of mass and rigidity. The seismic analysis has been performed by Equivalent Lateral Force Method (ELF) and analysis of the building is carried out using ETABS 2013 application software**

Keywords—ETABS 2013, Shear wall, displacements, Base shear, Story drift, torsion, center of mass and rigidity

I. INTRODUCTION

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. 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. It is necessary to provide these shear walls when the allowable span-width ratio for the floor or roof diaphragm is exceeded. The present work deals with a study on the optimum location of shear walls 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 shear walls are placed such that there is no torsion in the second mode shape. The results of the analysis on the shear force, bending moment and torsion are compared. The results are presented in tabular and graphical form. The results on the drift and displacement are checked with service ability condition and are compared and presented in tabular form.

II.METHODOLOGY

1.1Equivalent Static Lateral Force Method (pseudo static method)

This method of finding lateral forces is also known as the static method or the equivalent static method or the seismic coefficient method. The static method is the simplest one and it requires less computational effort and is based on formulae given in the code of practice. In all the methods of analyzing a multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at this floor is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution, of mass and stiffness in a structure, together with its damping characteristics of the ground motion

- According to IS 1893(part-l): 2002 , the base shear (Vb) is given by the following formula:

$$V_B = A_h \times W$$

where,

- Ah = Design horizontal acceleration spectrum value using the fundamental natural period 'T' in the considered direction of vibration
- W = seismic weight of the building
- The Ah shall be determined by the following expression

$$A_h = \frac{Z\,I\,S_A}{2\,R\,g}$$

Where,

- Z= Zone factor as per Table 2 of IS: 1893
- I= Importance factor as per Table 6 of IS: 1893

(1.5nimpotant structure and 1 for all other buildings)

R= Response reduction factor as per IS: 1893

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This value varies between 3 and 5 with respect to ductile reinforcement detailing.

Sa/g- Average response acceleration coefficient as per Clause 6.4.5 of the Indian standard IS 1893 (Part-1):2002

As given and is based on appropriate natural periods and Damping of the structures.

Design of a base shear As per IS 1893: 2002 Obtained from Eq. 3.1 shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

III.EXPERIMENTAL STUDY

Geometrical_Properties

1. Height of typical storey -3 m
2. Height of ground storey - 4 m
3. Length of the building - 60.0 m
4. Width of the building - 54.0m
5. Span in both the direction is - 6 m
6. Height of the building - 46.0 m
7. Number of storey's G+14
8. Wall thickness 0.23 m
9. Slab Thickness:-
   a. From 1st floor to 14th floor - 150 mm
   b. 15th floor – 100 mm
10. Grade of the concrete - M40
11. Grade of the steel – Fe415
12. Thickness of shear wall -230 mm
13. Support – fixed.

1LOADS

a).Live load From 1st floor to 14th floor - 4 kN/m^2

b).Live load on 15th floor – 1 kN/m^2

2. DEAD LOAD

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

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 = 19.2x0.23x2.4= 10.6 kN/m.

3. Zone factor (Z)

Zone factor = 0.36 from IS 1893 (Part-I)-2002.

Response reduction factor (R)

Reduction factor = 5.0 from IS 1893 (Part-1)-2002.

Importance factor (1) = 1 from IS 1893-2002

4. Soil type

Soil site factor (1 for hard soil, 2 for medium soil, and 3 for soft soil) depending on type 'of soil average response acceleration coefficient Sa/g is calculated corresponding to 5% damping Refer Clause 6.4.5 of IS 1893-2002. In the present work three type of soil are used.

The following Load Combinations have been considered for the design

1. 1. 1.5(DL+ LL)
2. 1.5(DL ± EQXTP)
3. 1.5(DL ± EQYTP)
4. 1.5(DL ± EQXTN)
5. 1.5(DL ± EQYTN)
6. 1.2(DL + LL ± EQXTP)
7. 1.2(DL + LL ± EQYTP)
8. 1.2(DL + LL ± EQXTN)
9. 1.2(DL + LL ± EQYTN)
10. 1.5(DL ± WLX)
11. 1.5(DL ± WLY)
12. 1.2(DL + LL ± WLX)
13. 1.2(DL + LL ± WLY)

DL – Dead Load

LL – Live Load

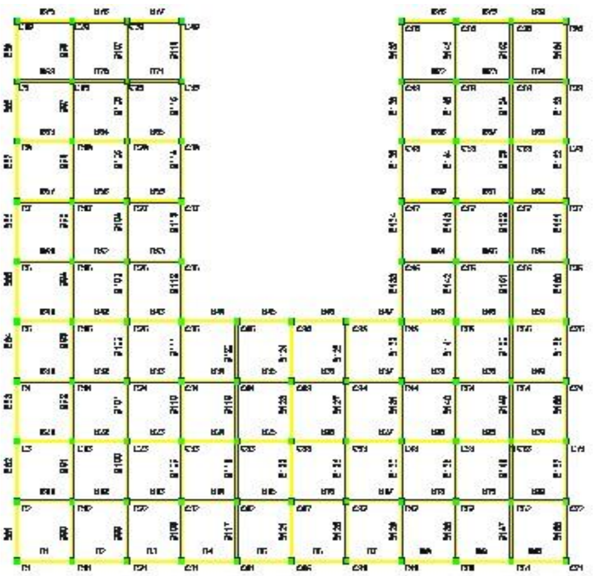
EQTP–Earthquake load With torsion positive

EQTN–Earthquake load With torsion negative

WL- Wind load

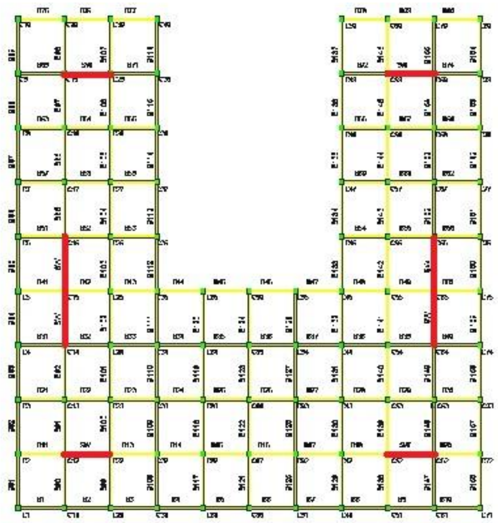
Structure	Center of mass		Center of rigidity	
	XCM	YCM	XCR	YCR
Structure-1	30	24.163	30	22.588
Structure-2	30	24.205	30	23.456
Structure-3	30	24.157	30	23.806
Structure-4	30	24.335	30	24.65
Structure-5	30	24.252	30	23.263

Center Of Mass And Rigidity For All Structure In Hard, Medium & soft Soil

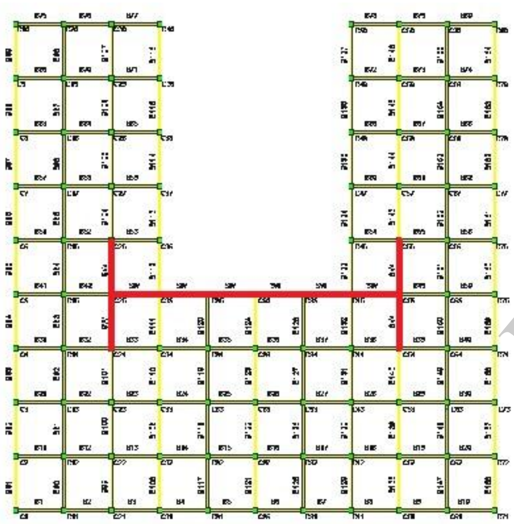


Plan of u-shaped building

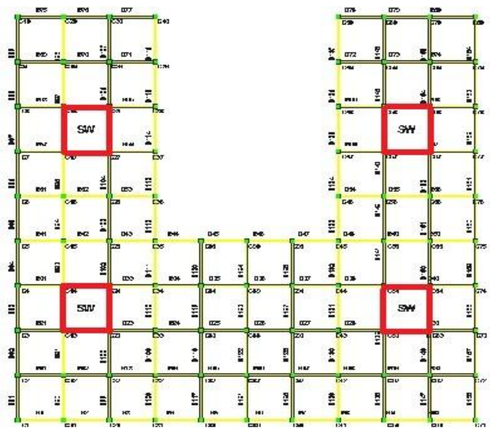
NOTE: Red colour indicates the shear wall in each plan



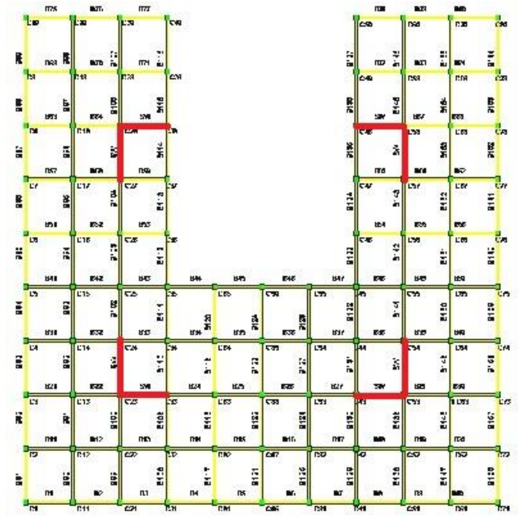
Plan of structures 2 at Basement level



Plan of structures 3 at Basement level



Plan of structures 4 at Basement level



Plan of structures 5 at Basement level

IV. RESULTS

A.Time Period For All Structure In Hard , Medium And Soft Soil

Mode	Time Period ,Tk (sec)				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
1	1.413185	1.076808	1.018958	0.847353	1.014567
2	1.351922	0.903551	0.907869	0.823547	0.972968
3	1.302014	0.858686	0.475832	0.774616	0.931864
4	0.464139	0.306592	0.304731	0.220815	0.28406
5	0.445287	0.252031	0.253313	0.212302	0.276197
6	0.429479	0.235236	0.158827	0.20657	0.265189
7	0.26828	0.150531	0.153608	0.106732	0.141434
8	0.259487	0.124913	0.125567	0.100146	0.136947
9	0.251516	0.114086	0.104723	0.097585	0.131468
10	0.185722	0.093954	0.085621	0.06826	0.091236
11	0.180219	0.081097	0.081517	0.063532	0.087436
12	0.175037	0.072576	0.077729	0.061922	0.084554

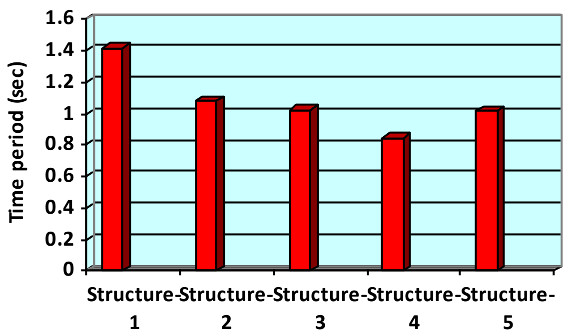


Figure 6.1 modal natural time period for all stucture in hard , medium and soft soil

B. Base shear for different structure with the combination =1.2(LL+DL+EQXNE)

Type of soil	Base shear (kN)				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
Hard	7344	10097	23109	13414	10716
Medium	9988	13732	27490	18243	14574
Soft	12265	16862	27490	22402	17897

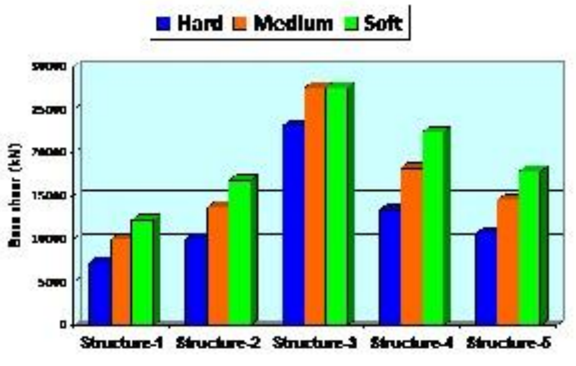
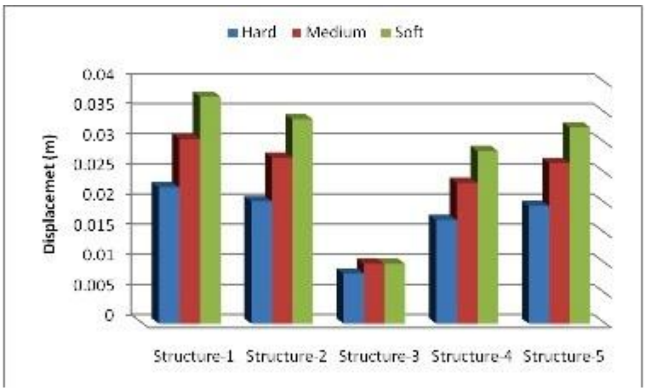


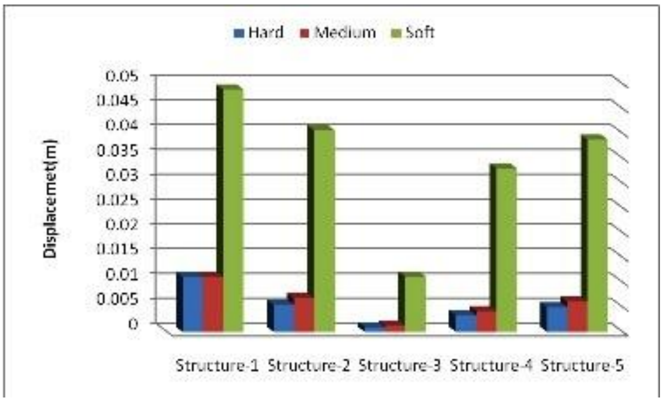
Figure 5.2 variations in base shear for all structure with load combination 1.2 (LL+DL+EQXNE)

C. Diaphragm CM Displacement , Maximum Ux (M) For All Structures With Load Combination (DL+LL+EQXNE)

Type of soil	Maximum Displacement				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
Hard	0.0226	0.0203	0.0083	0.0172	0.0195
Medium	0.0307	0.0276	0.0099	0.0234	0.0266
Soft	0.0377	0.0339	0.0099	0.0287	0.0326



D. diaphragm CM displacement , maximum Ux (m) for all structures with load combination (DL+LL+WLX)



V. DISCUSSIONS

The percentage of time period decreased by adding shear wall as shown below:-

1- 24.3% for structure2 compared with structure1.
2- 28% for structure3 compared with structure1.
3- 40% for structure4 compared with structure1.
4- 28.2% for structure3 compared with structure1.

It is observed that

1- The percentage of base shear is more by 40% for all structures in soft soil and 26.5% for all structures in medium soil compared with structures in hard soil.
2- The percentage of base shear is increase by placing shear wall as shown below
   a- 27.3% for structure2 compared with structure1.
   b- 62.44% for structure3 compared with structure1.
   c- 45.2% for structure4 compared with structure1.
   d- d-31.46% for structure3 compared with structure1.

It is observed that

1- The percentage of displacement in x- direction is more by 40% for all structures in soft soil and 26.4% for all structures in medium soil compared with structures in hard soil.
2- The percentage of displacement in x- direction is decreased by placing shear wall as shown below :-
   a- 10 % for structure2 compared with structure1.
   b- 68.23 % for structure3 compared with structure1.
   c- 23.8 % for structure4 compared with structure1.
   d- 13.4 % for structure3 compared with structure1.

VI.CONCLUSIONS

1- The shear wall and it is position has a significant influenced on the time period. Time period is not influenced by type of soil and the better performance for structure 4 because it has low time period.

2- The center of mass and center of rigidity is influenced by adding and positioning of shear wall but is not depended on type of soil. It can be concluded that all structure is 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 structure with shear wall is better than structure without shear wall because center of mass and center of rigidity become close.

3- Base shear is effected marginally with placing of shear wall , grouping of shear wall and type of soil. The base shear is increasing by adding shear wall due to increase in seismic weight of the building.

4- Provision of shear wall generally results in reducing the displacement because the shear wall increase the stiffness of building. The better performance for structure 3 because it has low displacement.

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