SOIL STRUCTURE INTERACTION OF RC FRAMED IRREGULAR BUILDING WITH SHEAR WALLS.

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Abstract - *Earthquake has a high potential to cause a wide-spread damages in densely populated areas which causes heavy loss of human life and high economic losses. This cause of damage is due to lack of knowledge of the engineers and hence resulting in improper design of structures. The vertical load resisting system which is the main criteria in case of low rise buildings is not recommended for high rise buildings. As a result the inclusion of shear walls becomes imperative in case of high rise buildings. Shear walls are the lateral load resisting system which resist large horizontal forces. Conventional analyses of the buildings is done by taking the base of the structure to be fixed but in the real life the scenario will be different as compared to a fixed end condition because the soil beneath the foundation will make vary the earthquake forces and thus varying the lateral forces acting on the structure. Hence the effect of shear walls which when placed at different locations is studied in this paper. The effect of shear walls and also the soil structure interaction is studied for different heights of buildings to study the difference in parameters like time period, spectral acceleration co-efficient (Sa/g), base shear, storey shear, storey displacement and storey drift when considered against conventional fixed analyses. Study shows the base shear value increases building with shear wall 02 i.e shear walls placed at the centre along with corners.*

Key Words: Soil structure interaction, Shear wall, Spectral acceleration co-efficient, Natural period, Base shear.

1. INTRODUCTION

The structural engineer who designs earthquake-resistant structures needs to know as to how exactly the soils respond during an earthquake; not only is this important for the foundation design itself, but the nature of soil overlaying bedrock may have a crucial modifying influence on the overall seismic response of the site. Seismic soil-structure interaction is an important part in the understanding of failure of the structure, but then it is quite very complex to analyze. A soil-structure interaction analysis may comprise of combining the input motion with the far field, the local site (near field) and the structure. These far field, the near field and the structure have to be simulated by using of different models which is very complex in formulating and so also is the solution. Hence, in order that we simplify the solution, many assumptions have been introduced of lately. At present, two methods are most widely used in soil-structure interaction analysis are the discrete element method and the finite element method .Generally, the discrete element method assumes a linear response of the soil to the seismic excitation and replaces the half space with a spring and dashpot boundary. This method becomes simple and can be easily implemented, but then has several disadvantages. One disadvantage is that the soil has to be idealized as a linear elastic material, and the other is that the response from free field is used directly as input motion. The finite element method, is but suitable for the analysis of nonlinear materials and difficult geometry. When considering the recorded data from the many earthquakes, the finite element method becomes almost a better alternative for indicating the near field foundation. This finite element method has been very popular in studying soil structure interaction, but however the soil model most commonly used to simulate seismic soil performance is still a linear soil model or an equivalent linear soil model in the past several simplified models have been implemented for investigating seismic behavior, but they cannot directly calculate pore pressure, which is a very vital parameter in geo-technology, hence in using of linear soil model, most of the investigations contemplate on the effect of a layered soil and flexible or rigid foundation on the structural response. B. R. Jayalekshmi and H. K. Chinmayi [1] studied the comparison between IS1893 and EUROCODE8 for soil structure interaction of RC buildings. Mengke Li et al. [2] studied the influence of soil interaction on seismic collapse resistance of Shangai tower. Study showed that SSI will increase the time periods of vibration modes of lower orders, and longer time periods will be seen due to stiffness of foundation soil. Also it was shown that the SSI effect enhances the collapse resistance capacity of the Shanghai Tower. The response of asymmetric wall-type building system for altered position of stiffness and strength eccentricity, torsional investigation which when subjected to El Centro 1940 earthquake was studied by H. Shakib and G.R.Atefatdoost [3]. The decrease in strength reduction factors in case of soft soils when soil structure interaction is taken in to account, and therefore when fixed-base condition was considered strength reduction factors for interacting systems lead to non-conservative design forces was shown by M. ESER et al. [4]. Pandey A.D et al. [5] studied in case of changing topography, with increasing time, response reduction factor decreased.

In the present work, a parametric study is carried out for determining natural period of RC frame irregular building with shear walls placed at different locations for varying building heights and comparison is carried out for building incorporating effect of soil structure interaction to building with fixed base.

1.1 SOIL STRUCTURE INTERACTION

Soil-structure interaction analysis is carried out on 4, 6, 8, 12, and 16 storeyed buildings with and without shear wall resting on isolated foundation.

To study the effect of shear wall, shear walls of same size were placed at the core and all four sides in the exterior frames of building at corners. For incorporating the effect of soil flexibility, four soil types classified based on shear wave velocity are considered in the study.

Structural Idealization- Multi-storey reinforced concrete Framed buildings of 4, 6, 8, 12, and 16 storeys with and without shear wall are considered in present analysis. Buildings with vertical irregularity is considered. Shear walls of same size were symmetrically placed in both directions of the building in plan at the core and all four corners of building to study the effect of shear walls. The column size for six storey building is 0.3x0.3(m) and the corresponding shear wall thickness is 0.15m and the column size for nine storey building is 0.4x0.4(m) and the corresponding shear wall thickness is 0.2m and similarly the column size for 15 storey building is 0.6x0.6(m) and the corresponding shear wall thickness is 0.25m. The storey height considered is 3m and the bay length taken is 4m. The beam size for all buildings is taken as 0.25x0.3(m) and the thickness of slab is taken 0.12m. The live load at the floor level is taken to be 3kN and that at the roof level is 1.5KN. The concrete material property taken is M30 and steel grade chosen is Fe 415.

2. METHODOLOGY

The conventional method of analysis of a foundation of a structure is to consider the foundation as a fixed one rather a flexible foundation because in the real condition the soil will influence the structure to respond due to its ability to deform. Hence it is imperative to consider soil as a flexible one. The study will be done in the following ways: 1.) The effects of soil structure interaction base over the conventional fixed base of the building structures. 2.) The effects of shear wall and there effects depending on the different locations. 3.) To study parameters such as time period, spectral acceleration coefficient, base shear, storey shear, displacements, and drifts. 4.) To compare the above said parameters for conventional fixed case against flexible base.

3. MODELLING AND ANALYSIS

In the present study, vertical irregular three dimensional building of varying storey and of plan size 31.5mx31.5m is considered with the beam size 0.25mx0.3m and column size varying from 0.3mx0.3m to 0.6mx0.6m. The buildings of various storey have been considered like 6,9 and 15 storey to compare the analysis results for fixed base and flexible base condition. The slab is taken to be of 0.15m thick and is considered to be modelled as membrane. Here the building is first modelled as fixed end conditions and then the springs are assigned based on the size of footing in the fixed case, to counter act for soil structure interaction. The shear walls are provided in two ways i.e with the shear walls at the four corners and the other with shear walls at four corners along with shear wall at the centre. The shear walls of different dimensions are used with 0.15m thickness in case of six storey building, 0.20m thickness in case of nine storey building, and 0.25m thickness in case of fifteen storey building and analysed for different load cases as per code specification in ETABS software.

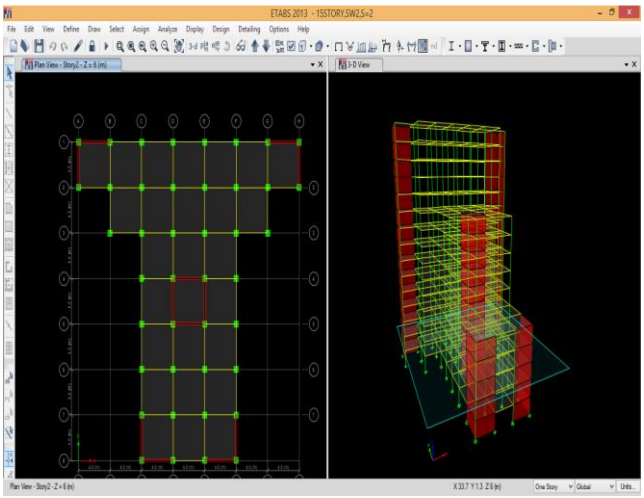

Fig -1: Plan and elevation of 15 storey building with shear walls considered at the corners and at the center with fixed base condition

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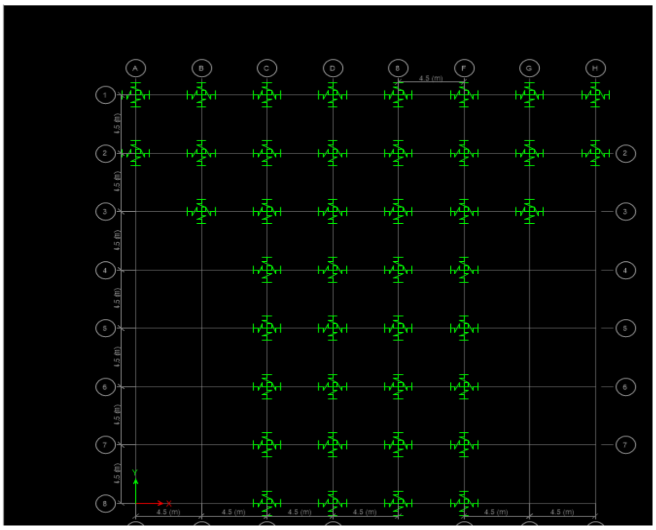

Fig-2: Springs assigned at the base of the footing.

4. RESULTS

Following are the graphs which are produced after analyzing in the software, the graphs shown here are only of 15 storey building and similar work is carried out for 6 and 9 storey building. The results and the graphs shown are of Spectral acceleration co-efficient, Base shear, Storey shear, Storey displacement and Storey drift for soft soil S3. The notations used here are:
1) S1-hard soil (S=1) 2) S2-medium soil(S=2) 3) S3-soft soil(S=3) 4) Sa/g-spectral acceleration coefficient 5) BF-bare frame 6) SW1- shear wall 01-shear wall at the four corners 7) SW2-shear wall 02-shear wall at four corners and at the center.

Chart-1: Graphical representation of Spectral acceleration co-efficient (Sa/g) for soft soil(S3) pertaining to fixed and flexible base of 6 9 and 15 storey building.

Chart-2: Graphical representation of Base shear(kN) form soft soil(S3) pertaining to fixed and flexible base of 6 9 and 15 storey building.

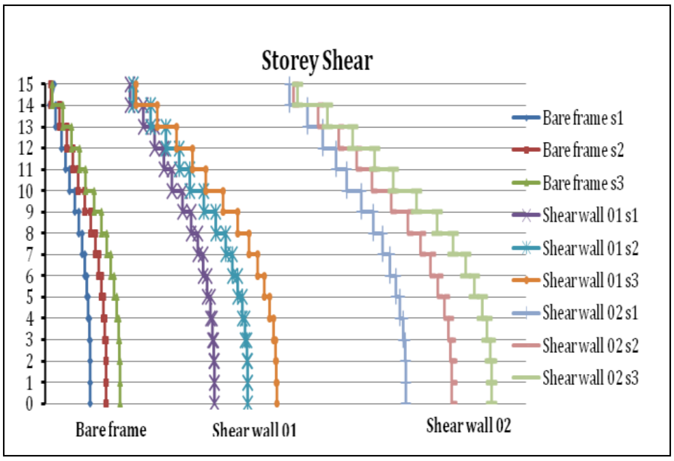

Chart-3:Graphical representation of storey shear pertaining to 15 storey fixed base.

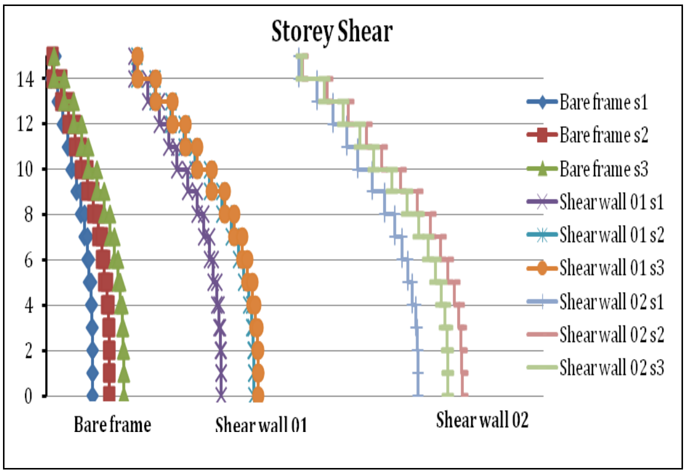

Chart-4:Graphical representation of storey shear pertaining to 15 storey flexible base.

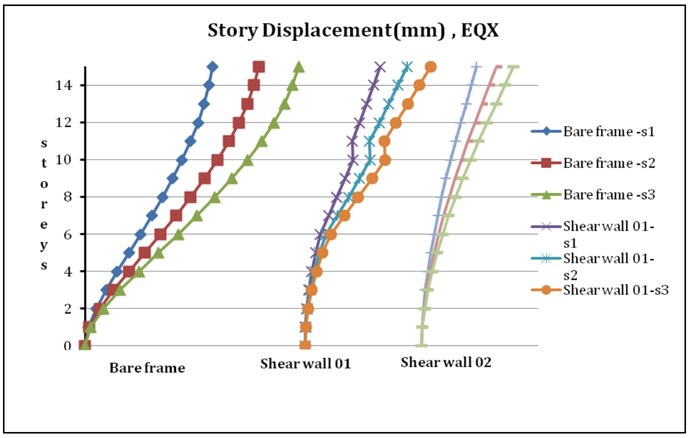

Chart-5:Graphical representation of storey displacement pertaining to 15 storey fixed base.

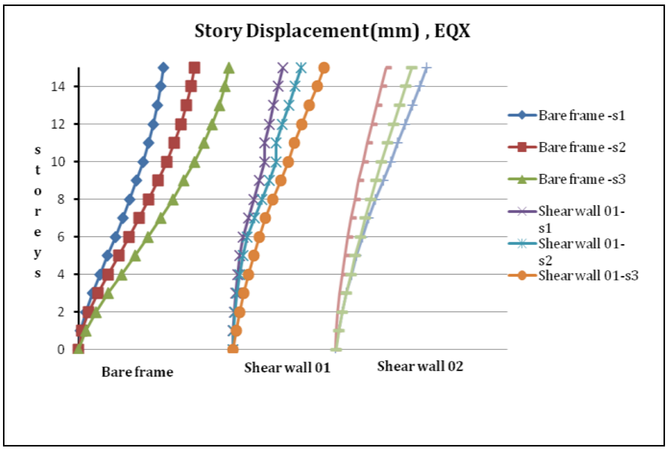

Chart-6:Graphical representation of storey displacement pertaining to 15 storey flexible base.

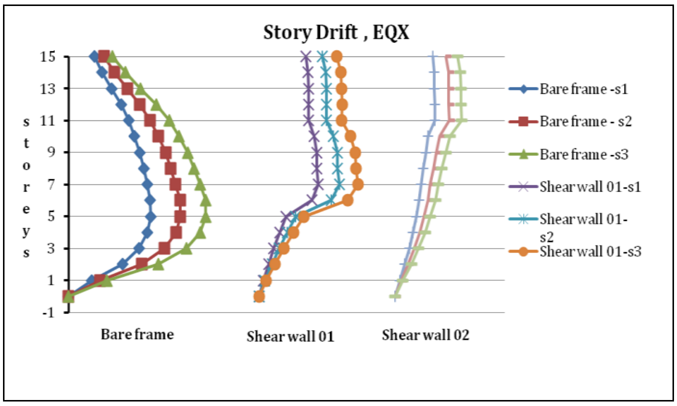

Chart-7:Graphical representation of storey drift pertaining to 15 storey fixed base.

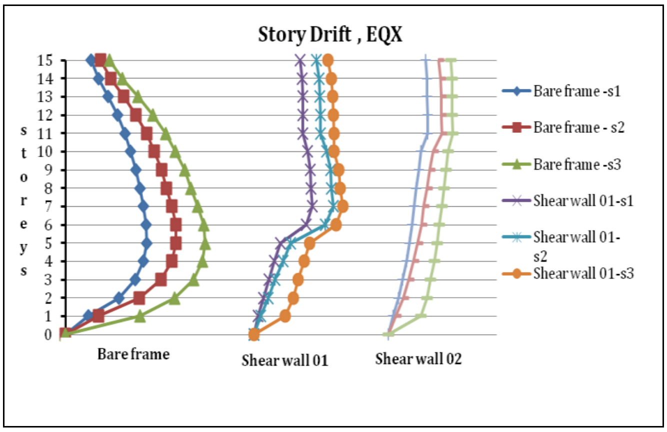

Chart-8:Graphical representation of storey drift pertaining to 15 storey flexible base.

5. CONCLUSIONS

In the present study the reinforced irregular building is analysed for different storeys and positioning of shear walls at different locations by including and not including soil structure interaction. The results lead to following conclusions.

1. Fundamental natural period of the flexible building system is more when compared to conventional fixed base. It also increases with the soft soil i.e with flexibility and increase in storeys and decreases with adding of shear walls.
2. Fundamental natural period of shear walls placed at four corners is more compared to that when shear wall placed at the center along with corners.
3. The adding of shear walls which is required for stiffness in lateral direction, increases the stiffness but also increases Spectral acceleration coefficient value.
4. Spectral acceleration coefficient is found lower in case of bare frames then that compared to shear wall buildings. It is maximum for shear walls placed at center along with four corners.
5. The shear wall 02 building has maximum response acceleration coefficient causing higher base shear values.
6. The base shear and Spectral acceleration coefficient values are smaller in case of flexible base compared to fixed case which is highly expected.
7. It was seen in old and conventional fixed base the base shear value was increasing with increase in flexibility of soil but where as it is decreasing in case of flexible base.
8. Storey displacement and storey drifts are maximum in case of bare frame building with or without soil structure interaction.

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