Analysis of Regular and Plan Irregular Flat slab structure with and without Lateral force Resisting System (LFRS)

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***Abstract*— In recent days Flat slab have been taking over conventional slab for tall buildings. Flat slab can be constructed in fast pace. Flat slab construction is the perfect choice as it offers that flexibility to the owner. In case the client plans to changes in the interior and wants to use the accommodation to suit the need. In the present work a multi-storey building having flat slab of regular and plan irregular(shear wall & bracing system) has been analyzed using ETABS software for the parameters like storey displacement, storey drift and storey shear. The main objective of the present work is to compare the seismic behaviour of multi storey buildings of regular and plan irregular having flat slab with and without shear wall & bracing system (Lateral Force Resisting System) in seismic zone IV with type soil type II. Dynamic response spectrum analysis was performed on the structure to get the seismic behaviour.**

Keywords*— Regular building, Plan irregular building, Shear Wall, Bracing, Flat slab, Response Spectrum analysis, Etabs.

I. INTRODUCTION

The flat slab system has been adopted in many buildings construction taking advantage of the reduced floor height to meet the economical and architectural demands. Flat slab RC buildings exhibit several advantages over conventional beam column building. However, the structural effectiveness of flat-slab construction is hindered by its alleged inferior performance under earthquake loading. In tall multistoried structures the flat slab floor system has week resistance to lateral loads , hence special features like shear walls is to be provided if they are to be used in High rise constructions. Shear wall are a structural element which are used to resist horizontal (lateral) forces parallel to the plane of the wall. Shear wall has high in plane stiffness and strength which is used to resist large forces generated due to seismic action. Shear Walls are specially designed RCC walls that are included in buildings to resist horizontal and vertical forces and that are induces in the plane of the wall due to wind, earthquake and other forces. Steel braced frame can absorb a greater degree of energy exerted by earthquakes. Bracing members are widely used in steel structures to reduce lateral displacement and dissipate energy during strong ground motions. Modern construction demands the architect to plan irregular buildings in plan and elevation. The structural engineer on the other hand has a major responsibility to make the structure safe against all external forces; when irregular buildings are constructed in a high seismic zone, the structural engineers role becomes further challenging. So ideal and clear understanding of the behavior of irregular structures during earthquake is significant for structural engineers.

II. BEHAVIOR OF IRREGULAR STUCTURES

Building Plans with re-entrant corner forms are a most useful set of building shapes for urban sites, particularly for residential apartments and hotels, which enable large plan areas to be accommodated in relatively compact form, yet still provide a high percentage of perimeter rooms with access to air and light. L-shaped and C-shaped buildings with re-entrant corners are common for school buildings to accommodate spaces for playgrounds and assembly areas. But these configurations pose a great deficiency in the seismic behavior of the structure. There are two problems created in L–shape buildings. The first is that they tend to produce differential motions between different wings of the building that, because of stiff elements that tend to be located in this region, result in local stress concentrations at the re-entrant corner, or notch. The second problem of this form is torsion, which is caused because the center of mass and the center of rigidity in this form cannot geometrically coincide for all possible earthquake directions. The result is a rotation. The resulting forces are very difficult to analyze and predict. Therefore, Irregular structures need a more careful structural analysis to reach a suitable behavior during a devastating earthquake

III. THE PRESENT STUDY

The focus of the present study is to carry out seismic analysis on Flat slab symmetrical and asymmetrical structure with and without shear wall and steel bracing. Considering seismic effect from both regular (Symmetric) and plan irregular (Asymmetric) structure.

A. . Methodology of the present study

In the present study seismic behavior of multistoried building with flat slab of symmetric and asymmetric structure is studied for various models (buildings).Dynamic analysis for zone IV is carried out. Dynamic response spectrum analysis includes Displacement in structures, Storey drift and Storey shear. Modelling is carried out in ETABS software. Model for Flat slab with & without shear wall and bracing is made. Dynamic analysis is carried for each case and analyzed.

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B. . Modeling and Analysis

In the present study, G+9 building is considered for different cases. Fig. 1&2 shows the typical plan considered for the study.

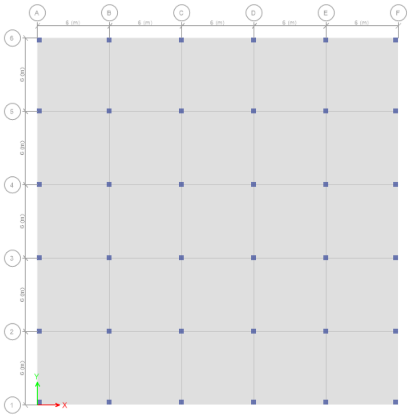

Fig. 1. Typical plan for the regular structure considered

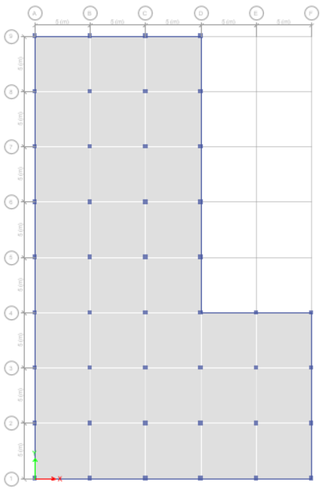

Fig. 2. Typical plan for the plan irregular structure considered

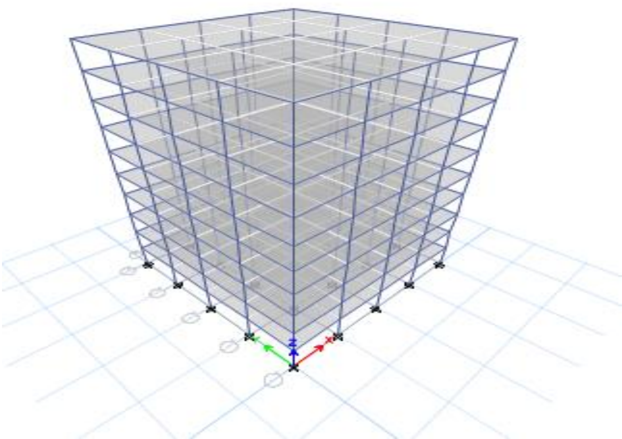

Fig. 3. 3D view of regular structure without shear wall

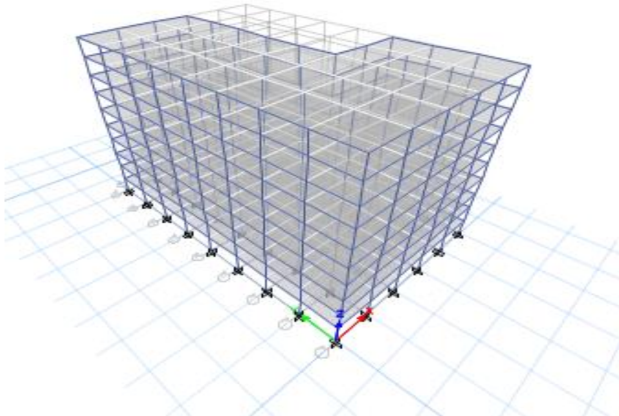

Fig. 4. 3D view of asymmetric structure without shear wall

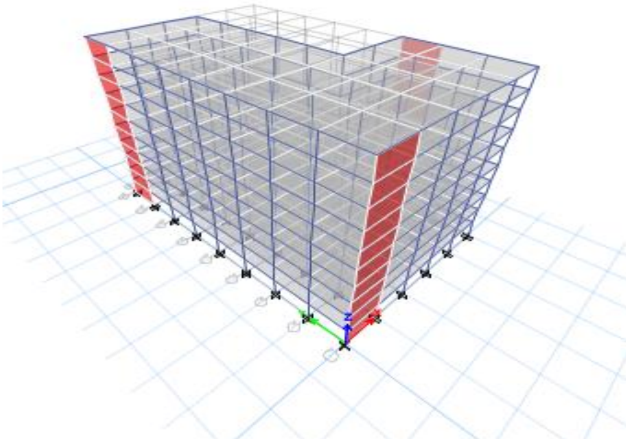

Fig. 5. 3D view of plan irregular structure with shear wall

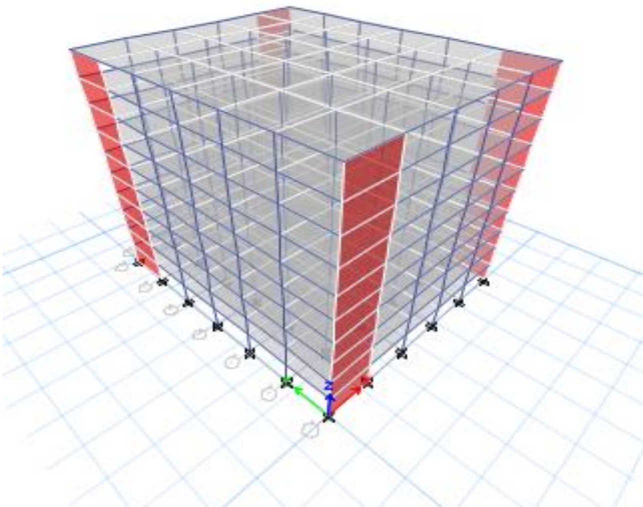

Fig. 6. 3D view of regular structure with shear wall

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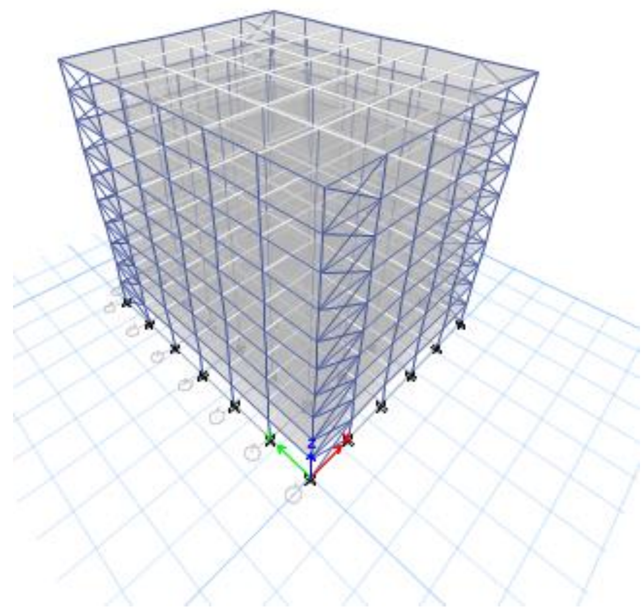

Fig. 7. 3D view of regular structure with X Braceing

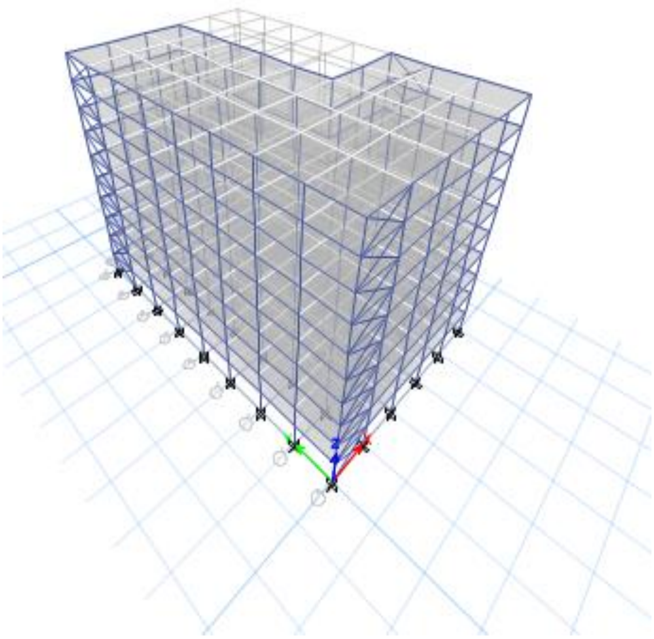

Fig. 8. 3D view of plan irregular structure with X Braceing

TABLE 1. STRUCTURAL PARAMETERS CONSIDERED IN ANALYSIS

Material and Geometry Data		Loading Data	
Span of the slab	5m x 5m	Live Load	4 kN/sqm
Built up Area	750 m^2	Finishing Load	1 kN/sqm
Typical storey height	3m	Seismic Zone	Zone 4
No of storeys	G+9	Soil Type	Type 2 (Medium soil)
Grade of concrete	M30	Importance Factor	1
Grade of Steel	Fe500	Response reduction Factor	5 (OMRF)
Beam Size	300x400		
Column Size	550X550		
Slab Thickness	270 mm		
Shear wall thickness	200 mm		
Bracing Type	X Bracing- ISMB 400		

The 3D view of the structures considered for the analysis are shown in Fig 3-8 and the detailed structural parameters considered in the analysis of the structure are presented in Table 1.

IV. RESULTS AND DISCUSSION

The structures modeled using the above mentioned data are analyzed for gravity load as well as seismic loading for regular and plan irregular building with and without Shear Wall and bracing system and the results are analyzed. Each of the buildings is analyzed for seismic parameters like storey displacement, storey drift and storey shear

A. Storey displacement

Storey displacement is significant in seismic analysis when the structure is subjected to lateral load. Storey displacement is represented in Fig. 9 & 10. From Fig it can be observed that storey displacement is more in plan irregular building and minimum in regular building with shear wall. From Fig. 9 & 10 it can be observed that storey displacement is reduced when compared to structure without shear wall & X brace. Sudden fall in displacement is observed when Shear Wall is introduced. When the shear wall is located at the corners top displacement of the structure is lowest compared to structure without Shear Wall and slightly higher with X brace.

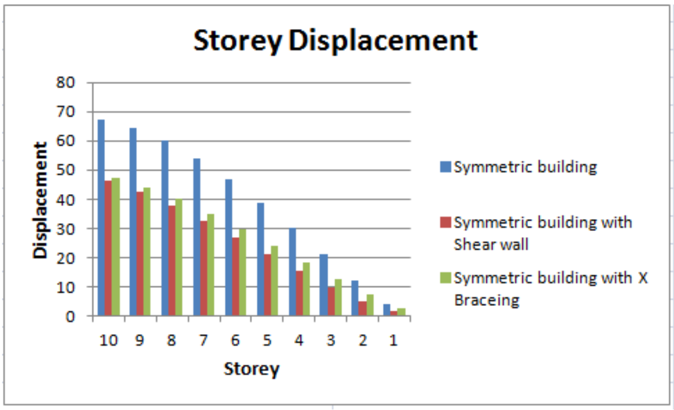

Fig. 9. Storey Displacemeny without Shear Wall

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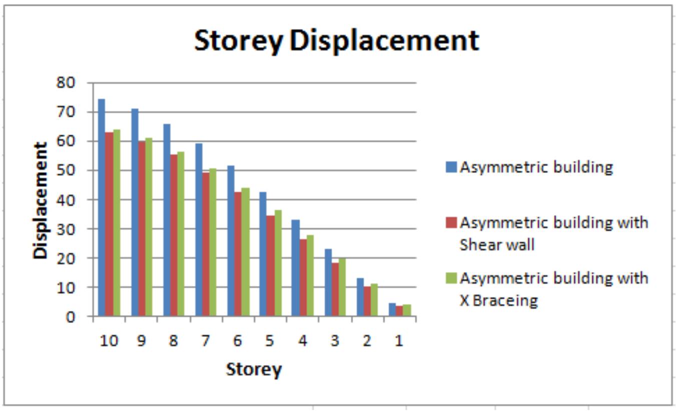

Fig. 10. Storey Displaceneny with Shear Wall

B. Storey Drift

Storey Drift is the lateral displacement of one floor relative to the other floor. Storey Drift is represented in Fig.11 & 12. From Fig. it can observed that Storey Drift is maximum in middle storey and drift is maximum in plan irregular building and it can observed that Storey Drift increase as story height increases and again decreases for higher stories. Storey Drift is maximum in storey four & decrease in below storey. From below figures, plan irregular building has more drift compared to regular building. When compared to bracing, shear wall perform better.

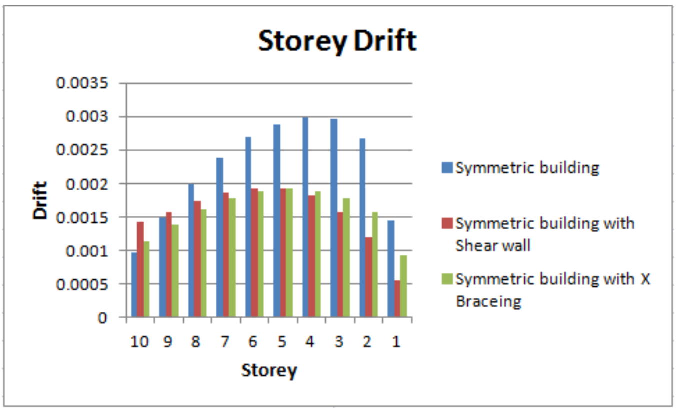

Fig. 11. Storey Drift without Shear Wall

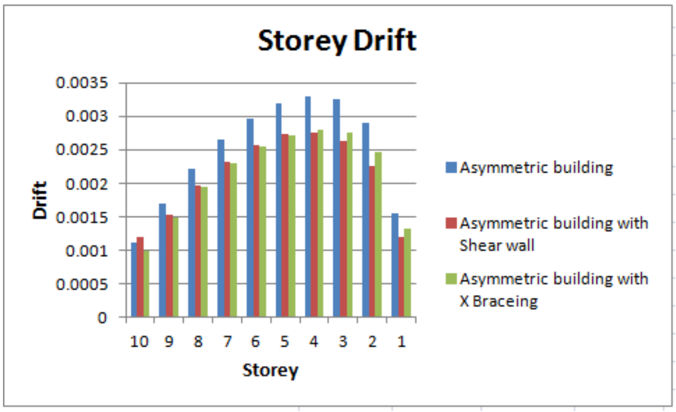

Fig. 12. Storey Drift wih Shear Wall

C. Storey Shear

Seismic forces will create total reactive forces at column base in direction opposite to that of lateral load. Storey shear is represented in Fig.13 & 14. From the Fig shown below it can be observed that Storey shear is maximum at ground floor and decreases in the above storey. Shear is maximum in regular building and minimum in plan irregular building. Shear is reduced in case of shear wall & X bracing.

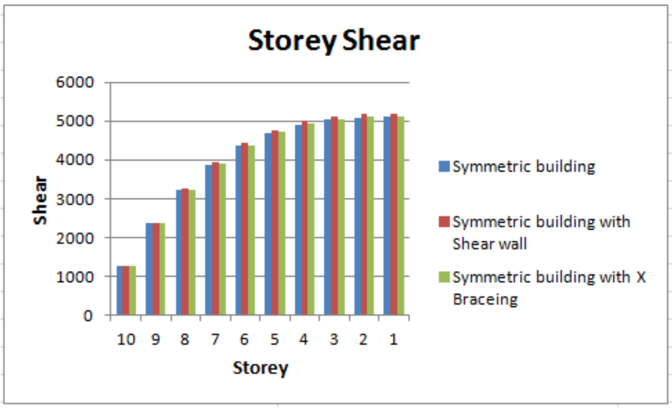

Fig. 13. Storey Shear without Shear Wall

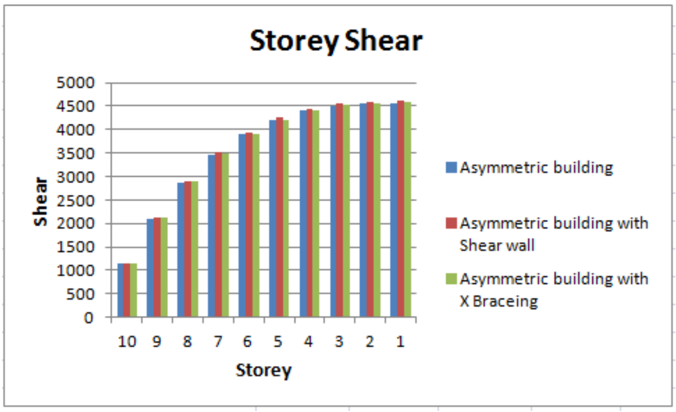

Fig. 14. Storey Shear with Shear Wall

E. Discussion

Following inferences can be made from the comparison of displacement, drift and shear of regular building and plan irregular building with and without Shear Wall & Bracing.

1. Storey displacement is maximum in top storey and storey displacement is more in plan irregular building with LFRS and minimum in regular building with shear wall. Displacement is decreased with X brace. Between shear wall and X brace minimum displacement in shear wall
2. Storey drift is maximum near the middle storey and drift is maximum in plan irregulare building without LFRS & minimum in regular building with shear wall
3. Storey shear is maximum at the ground in plan irregular building and minimum at top storey in both cases.

From the above inference building with Shear wall will have slightly more resistance to seismic force than X brace.

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