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SEISMIC ANALYSIS OF RC FRAMES USING LATERAL LOAD RESISTING SYSTEM

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Abstract— **Reinforced concrete (RC) frame buildings tend to get impared due to seismic disturbances. Provision of extra structural elements like Lateral Load Resisting System (LLRS) that includes infill walls, shear walls and bracings could improve structural capabilities. In this study all this approaches and alternatives are being studied and verified to understand how best the various elements of lateral load resisting system perform when subjected to an Earthquake loads using ETABS software. Also similar approaches were considered on long and short columned RC frame structures.**

Keywords—Reinforced concert Frames, Lateral Load Resisting System.

I. INTRODUCTION

Earthquake is an unexpected vibration or tremor of the earth's crust that originate obviously on or below the surface. Most of earthquakes result from tectonic activities, initial movements on the faults.

Most reinforced concrete (RC) frame buildings in developing countries are infilled with masonry walls. Where masonry walls are generally considered as a non structural element. However throughout the decade various researches have suggested that infill walls are better at resisting lateral loads subjected on the frames to an extent. Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls or structural walls. Shear wall is also another component of the lateral load resisting system. Hence shear wall could also prove to be a better approach towards increasing the performance of the frames in resisting the seismic forces. Another approach is adding new structural elements such as structural walls or steel bracing. Summing up, all this approaches and alternatives are being studied and verified to understand how best the various elements of lateral load resisting system perform when subjected to an Earthquake loads.

II. OBJECTIVES

- To determine displacement and response acceleration at various ground levels in various structures relative to ground displacements in vertical and horizontal directions using ETABS.
- Evaluation of 3D RC frames with and without infill structures under dynamic parameters of loading.
- Comparison of Bare Frames with load resisting system in X direction subjected to load combinations.

III. METHODOLOGY

A. General

The computational models were developed by using ETABS (Finite element package). The beams and columns were modelled using one dimension frame element. The ground story columns are assigned to be fixed at bottom. Slabs were modelled using membrane element. The gravity loads acting on the slab are assigned to supporting beam using the method given in clause 24.5 IS 456:2000.The diaphragm action of the slab under lateral load was accounted for by assigning a rigid diaphragm at each level.

B. Method of analysis

Methods of analysis adopted in present study are response spectrum method and the linear static lateral force method. For a simple regular structure analysis by linear static methods is often considered. This is acceptable in the code of practice for regular, low and medium rise buildings.

Seismic codes are different for a particular region or a country. In India, Indian standard criterion for earthquake resistant design of structures IS 1893(part 1): 2002 is the main code that provides outline for calculating seismic design forces. The code recommends the following method of analysis-

1) Equivalent static analysis method
2) Dynamic method
    i) Response spectrum analysis

C. Steps involved in ETABS

ETABS involves three main steps in finite elemental analysis of structural component. They are:

1) Preprocessor- this step includes defining the element, assigning real constants and material properties, modeling and meshing.
2) Solution- in this step analyzing the model, applying the load, altering the applied load, creating the load steps etc., are done.
3) Postprocessor- here data and the file options are provided to read results, store and use it as per requirement.

D. Calculation of infill width

Width of Equivalent diagonal strut,

$$W = 0.175[\lambda H]^{-0.4} (H^2+L^2)^{1/2} \quad (1)$$

Where, λH is an empirical parameter expressing the relative stiffness of the column to the infill and is given by;

λ (2)

Where; *t* = Thickness infill, *h*= Height of infill, H = Height of frame, *l*= Length of infill, L = Length of frame, *d* = diagonal length of infill, *Em*= Modulus of elasticity of infill, *Ec*= Modulus of elasticity of column, *Ic*= Moment of inertia of column, *θ*= Slope of the infill diagonal to the horizontal.

IV. MODELLING AND ANALYSIS

A. *Scope of project*

Present analysis is carried out in detail for 3-Dimensional models in case of g+5 storey frame and g+5 storeys with long and short column. Two models were developed as given below:

1) Model 1- 3-Dimensional structure with base on plane ground provided with columns of similar height.
2) Model 2- 3-Dimensional structure with base on sloping grounds provided with long column and short column.

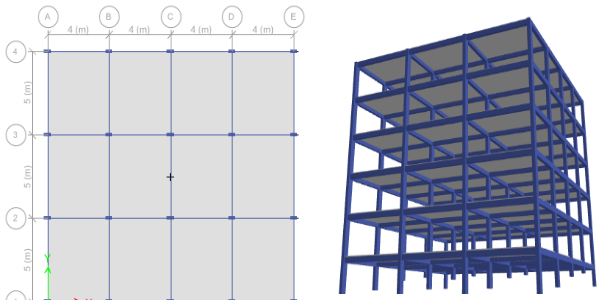
TABLE I. CONSTANT PARAMETERS

MODEL-1	
Description	**Detail**
Number of storey's	G+ 5storey's
Height of typical floor	3 m
Masonry wall thickness	230 mm
Grade of rebar	HYSD 500
Grade of concrete	M30
Density of wall material, ρ	19.8 KN/m^3
Earth quake Zone	Zone III
MODEL-2	
Description	**Detail**
Number of storey's	G+ 5storey's
Height of typical floor	3.5 m
Heights of columns at the base	3.5m,2.5m,1.5m,1m,2m
Masonry wall thickness	230 mm
Grade of rebar	HYSD 500
Grade of concrete	M30
Density of wall material, ρ	19.8 KN/m^3
Earth quake Zone	Zone III

TABLE II CROSS SECTIONS OF STRUCTURAL ELEMENTS

MODEL-1	
Description	**Sizes**
Rectangular column	230mm X 450mm
Rectangular beam	230mm X 500mm
Slab shell thin	150mm
Masonry Wall thickness	230mm
MODEL-2	
Description	**Sizes**
Rectangular column	230mm X 450mm
Rectangular beam	230mm X 4450mm
Slab shell thin	200mm
Masonry Wall thickness	230mm

The numbers of bays in Model-1 were designed as 4 x 3 bays that are 3 bays along Y direction of span 4.5 m and 4 bays along X direction of span 4m each and 6 x 3 bays that are 3 bay along Y direction of span 4.5 m and 6 bays along X direction of 4m each. Similarly for Model-2 as 4 x 3 bays that are 3 bay along Y direction of span 5 m and 4 bays along Y direction of



4m each.

Fig.1. Typical Plan and 3D view of Model-2 of 4 x 3 bays bare frame.

B. *Infill wall*

The infill walls were converted into struts by calculating the width of the strut using equivalent diagonal strut method.

TABLE II OPENING PERCENTAGES OF THE DIAGONAL STRUTS

Opening percentage %	Fully infill 0% opening		25% opening	35% opening	60% opening
Stiffness Reduction factor λ	1.00		0.32	0.22	0.18
Width of strut W, mm	X	620	200	137	112
	Y	595	192	132	108

Different patterns of placement of infill walls in the frame system were imparted in order to find out which pattern has maximum capacity and which has minimum and to differentiate between two extreme ends. Also to determine which particular pattern is feasible enough to bear the load.

P1 – Infill provided throughout all frames.

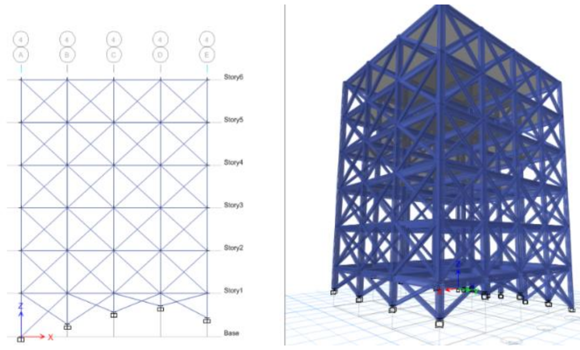


Fig.2. Typical plan and 3D view of Model-2 provided with complete infill wall

P2- Infill provided at vertical alternate variation

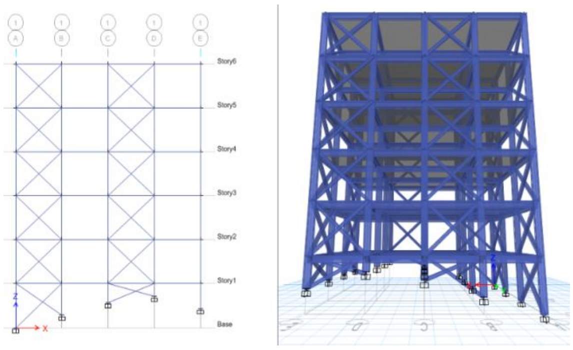


Fig .3. Typical plan and 3D view of Model-2 provided with alternate positioning of infill wall.

P3- Infill provided at alternate intervals across vertical direction

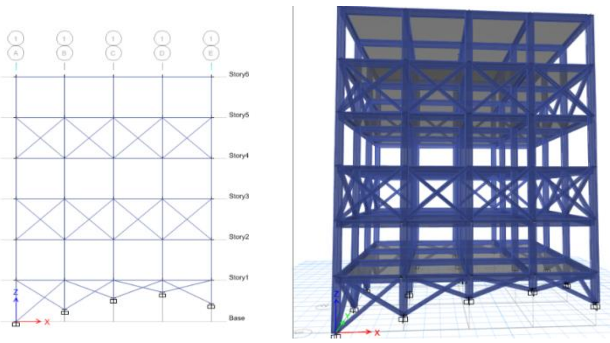


Fig .4. Typical plan and 3D view of Model-2 provided with vertical positioning of infill wall

P4- Infill provided at the corners only

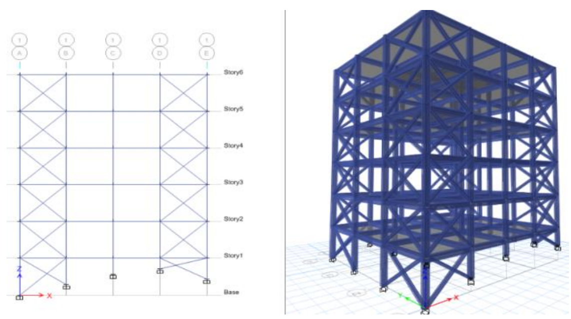


Fig .5. Typical plan and 3D view of Model-2 provided with Corner positioning of infill wall

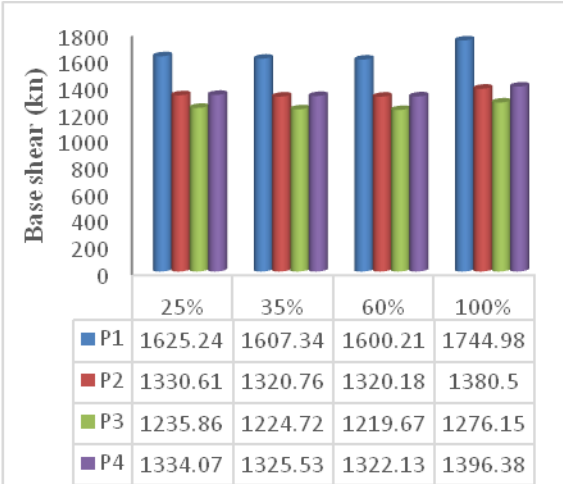
V. RESULTS

The results obtained for bare frames for different bay combinations and also structures provided with and without infill walls were compared. The study determines which among the various patterns of infill wall is found to be more adaptable to the structure.

Fig .6. 4x3 EQX linear Base Shear Vs. Models of infills

Fig .7. 5x3 EQX linear Base Shear Vs. Models of infills

From the above graphs it can be observed that P1 has higher base shear than other pattern of infills. The increase in base shear is because, when pattern P1 is provided there is increase in stiffness, hence attracting higher force. Even though the mass is low for P4, it attracts high base shear. And hence it acts as an efficient pattern for infill. However pattern P3 with vertical variations shows slight dip in values of base shear compared to the rest of the patterns.



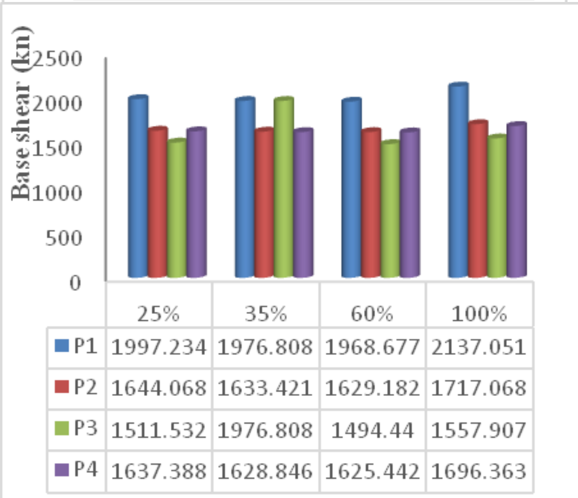
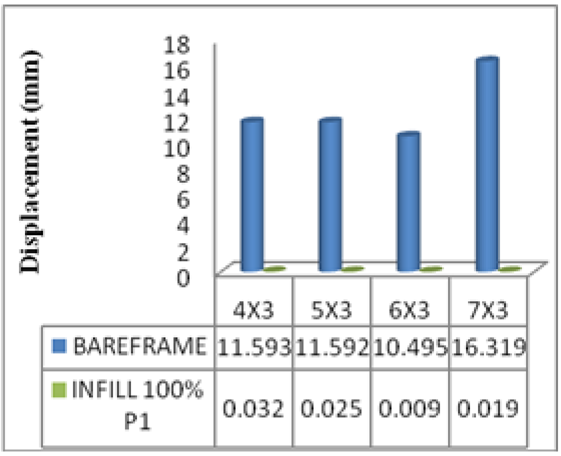


Fig .8. Displacement as the parameter Model-1 for Bare Frames and Infills

The highest deflection is observed in bay 7x3 bareframe structures. Also the lowest deflection is observed in 6x3 completely infilled structures.



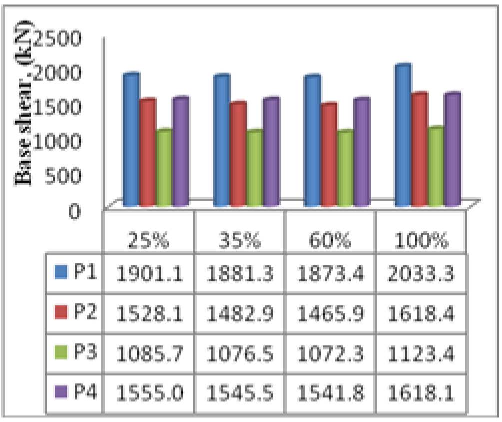


Fig .9. Base Shear as the parameter of Model-2 for infills

The infill walls when provided completely without any opening provided highest values of base shear when compared to rest of the combinations. However amongst all the patterns of placement of infill walls P3 showed least base shear values even with and without the presence of infill walls.

VI. CONCLUSIONS

In this study an effort has been made to compare the behavior of 6 storey bare framed structure and structures with additional structural elements when subjected to lateral loads. All the extra structural elements considered, provided effective results in resisting lateral loads generated from earth quake. Adopting infill throughout the structure has the ability to resist more lateral loads compared to others, since it has high capacity base shear. Cornered infills were efficient in terms of feasibility, as they stat similar results as of alternate variations.

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