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Non Linear Time History Analysis of Structure with and Without Shear Wall

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Abstract: ***Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants. Shear wall is one of the most commonly used lateral load resisting element in high rise building. In this study, the non-linear El-centro time history analysis is carried out for special moment resisting frame under earthquake loading using computer software E-TAB 2016.***

Keywords: Earthquake, shear wall, Non-linear time history, E-TAB 2016

1. Introduction

Earthquake has become a frequent event all over the world. It is very difficult to predict the intensity, location, and time of occurrence of earthquake. Structures adequately designed for usual loads like dead, live, wind etc may not be necessarily safe against earthquake loading. It is neither practical nor economically viable to design structures to remain within elastic limit during earthquake. The design approach adopted in the Indian Code IS 1893(Part I): 2016 'Criteria for Earthquake Resistant Design Of Structures' is to ensure that structures possess at least a minimum strength to withstand minor earthquake occurring frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur; and aims that structures withstand major earthquake without collapse.

Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Low lateral loads caused by wind and therefore, perform poorly under large lateral forces caused by even moderate size earthquake. These lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants. Shear wall is one of the most commonly used lateral load resisting element in high rise building. Shear wall (SW) has high in plane stiffness and strength which can be used simultaneously resist large horizontal load and support gravity load. The scope of present work is to study and investigate the effectiveness of RC shear wall in medium rise building. Reinforced concrete shear walls are used in Bare frame.

2. Theme of Investigation

The non-linear El-centro time history analysis is carried out for special moment resisting frame under earthquake loading using computer software E-TAB 2016. Seismic analysis of RC frame with bare and different position of shear wall in frame is carried out using Non-linear dynamic analysis method as per IS 1893 (Part I): 20016 by using E-TAB 2016 For this analysis different types of models will discussed in chapter are considered and comparison is carried out.

3. Time History Analysis

In order to examine the exact nonlinear behavior of structures, nonlinear time history analysis has to be carried out. In this method, the structure is subjected to real ground motion records. This makes this analysis method quite different from all of the other approximate analysis methods as the inertial forces are directly determined from these ground motions and the responses of the building either in deformations or in forces are calculated as a function of time, considering the dynamic properties of the structure.

In Etabs 2016, the nonlinear time-history analysis can be carried out as follows:

1. The models representing the buildings are created and vertical loads (dead load and live load), member properties and member nonlinear behaviors are defined and assigned to the model.

2. The ground motion record is defined as a function of acceleration versus time.
Here after, the analysis and the time history parameters are defined in order to perform a nonlinear time history analysis. The total time of the analysis is the number of output time steps multiplied by the output time-step size. To match time history to target response spectra, there are two options in

ETABS 2016. These are 'spectral matching by time domain' and 'spectral matching by frequency domain' options. In 'spectral matching by time domain' option, the damping values with the first and second periods are assigned. Using these values, the program calculates the mass proportional and stiffness proportional coefficients. 'Spectral matching by frequency domain' has the same interface but this time frequency values instead of periods are assigned. In the analysis of the analytical models 'spectral matching by time domain' option is used. In Figure 3.3.1 and Figure 3.3.2, the user graphic face of Etabs 2016 while defining the output steps and time step size for nonlinear time history analysis.

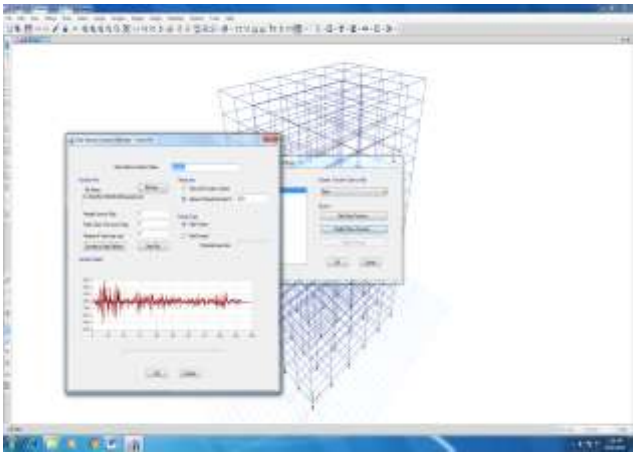

Figure 1: User Graphic Face of ETABS 2016 while Assigning Nonlinear Time History Analysis (El-centro ground motion)

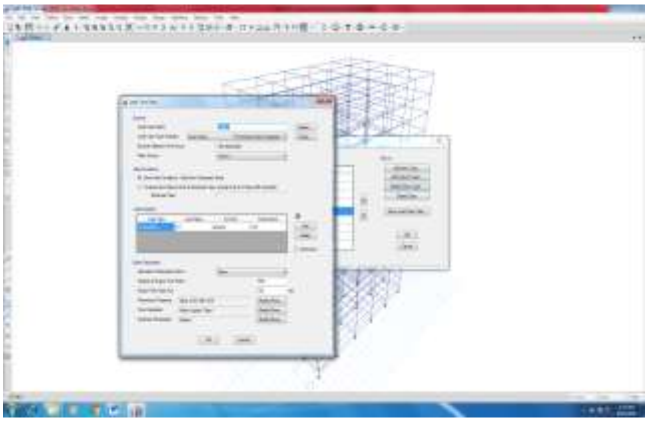

Figure 2: User graphic face of ETABS 2016 while defining the output steps and time step size for nonlinear time history analysis.

4. Problem Statement

The building is analyzed is G+15 R.C framed building of symmetrical rectangular plan configuration. Complete analysis is carried out for dead load, live load & seismic load using ETAB 2015. Non linear time history analysis is used. All combinations are considered as per IS 1893:2016.

Typical plan of building is shown in Figure 3

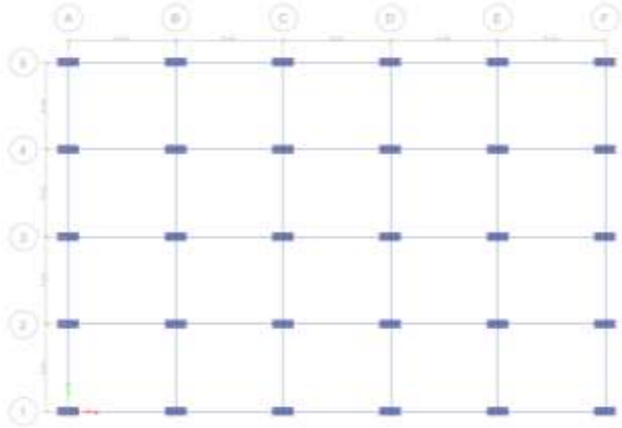

Figure 3: Plan of G+ 15 RC frame structure

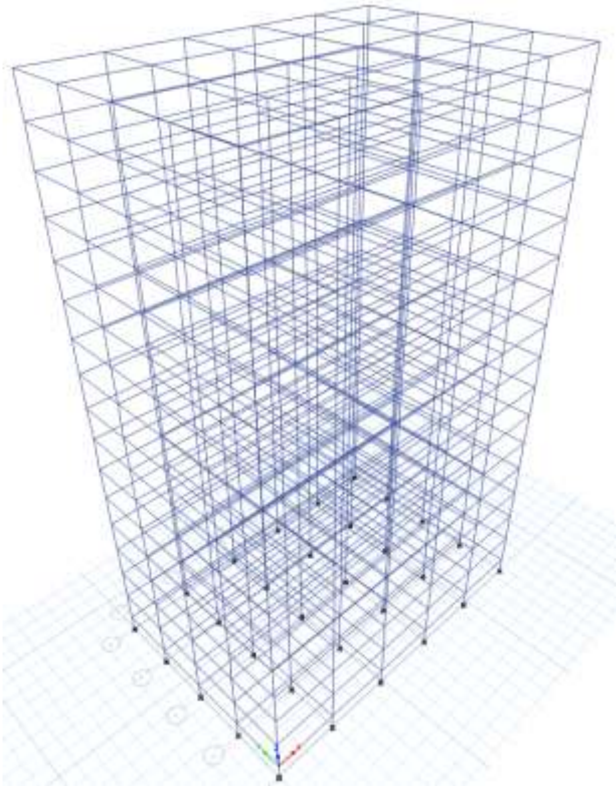

Figure 4: 3D view of G+ 15 RC Bare Frame

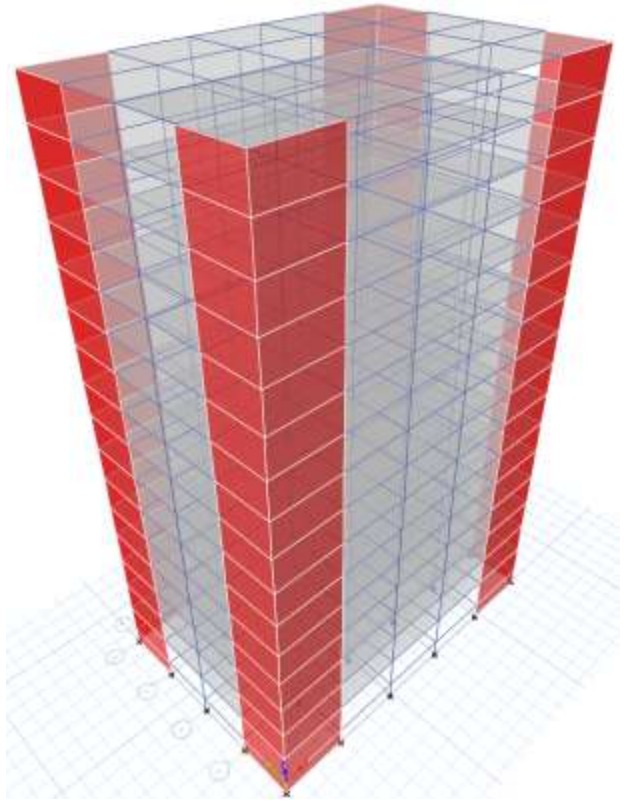

Figure 5: 3D view of G+ 15 RC frame with outer shear wall

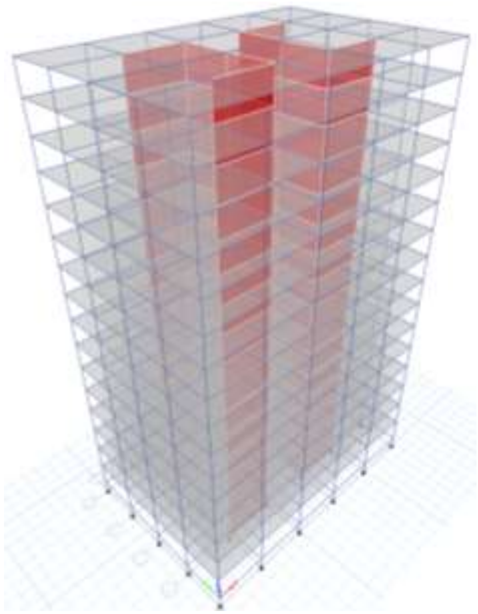

Figure 6: 3D view of G+ 15 RC frame with inner shear wall

Building properties
Details of building: G+15
Plan Dimension: 30m x 20m, 5m span in each direction.
Outer wall thickness: 230mm
Inner wall thickness: 230mm
Floor height: 3 m
Parking floor height: 3m

Seismic Properties
Seismic zone: IV
Zone factor: 0.24
Importance factor: 1.2
Response Reduction factor R: 5
Soil Type: medium

Material Properties
Material grades of M35 & Fe500 is used for the design.

Loading on structure
Dead load: self-weight of structure
Live load: Floor: 2.5 kN/m²
Roof: 1.5 kN/m²

Preliminary Sizes of members
Column:850mm x 350mm
Beam: 300mm x 650mm
Slab thickness: 125mm
Shear wall thickness: 250mm

5. Results and Discussions

Nonlinear time history is carried out to evaluate the seismic performance of special moment resisting (SMRF) structures. In this dynamic loading is applied to the structure. El-centro ground motion data is used for nonlinear time history analysis. ETAB 2016 software is used for analysis.

Table 1 represents comparison between base shear in X direction and Y direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method.

Table 1: Comparison of Base shear

Base shear (kN)			
Direction	Bare Frame	Outer shear wall	Inner shear wall
X- dir	261.066	272.784	267.1
Y-dir	251.938	302.34	289.728

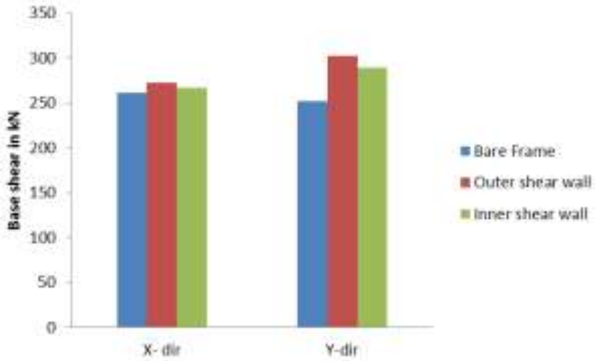

Figure 7: Comparison of base shear in kN

Figure 7 shows graphical representation between base shear in X direction and Y direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method. It shows that base shear is increased up to 30% in both directions by addition of shear wall.

Table 2 represents comparison between base shear in X direction and Y direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method.

Table 2: Comparison of Joint Displacement

Joint Displacement (mm)			
Direction	Bare Frame	outer shear wall	Inner shear wall
Ux	4.062	1.575	1.372
Uy	7.193	2.601	0.852
Uz	11.032	10.866	6.957

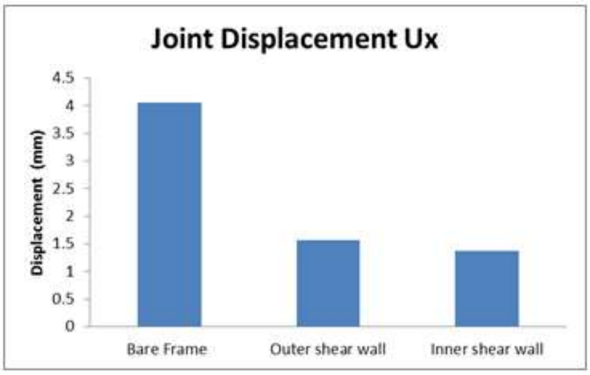

Figure 8: Comparison of Joint Displacement in mm in X-direction

Figure 8 shows graphical representation between joint displacement in X direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method. It shows that displacement is reduced up to 70% in X direction by addition of shear wall.

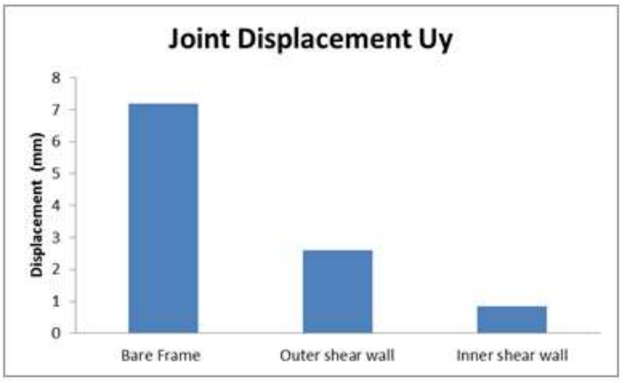

Figure 9: Comparison of Joint Displacement in mm in Y-direction.

Figure 9 shows graphical representation between joint displacement in Y direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method. It shows that displacement is reduced up to 80% in Y direction by addition of shear wall.

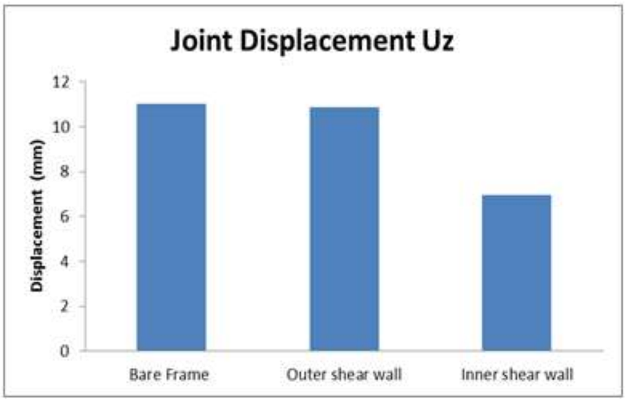

Figure 10: Comparison of Joint Displacement in mm in Z-direction.

Figure 10 shows graphical representation between joint displacement in Z direction for bare frame, outer shear wall and inner shear wall by nonlinear time history method. It shows that displacement is reduced up to 25% in Z direction by addition of shear wall.

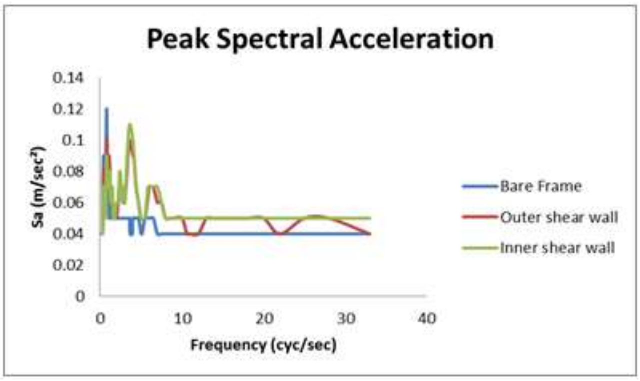

Figure 11: Comparison of Peak Spectral Acceleration in m/sec^2

Figure 11 shows graphical representation of peak spectral acceleration for bare frame, outer shear wall and inner shear wall by nonlinear time history method. It shows that peak story acceleration is reduced up to 40% in by addition of shear wall.

6. Conclusions

- By addition of shear wall base shear is increased than in bare frame.
- Inner shear wall reduced large displacement in both directions than outer shear wall.
- Also inner shear wall reduced peak spectral acceleration drastically than outer shear wall.

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