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Analysis of Soft Storey Building with Different Percentages of Openings in Shear Walls by Using Etabs Software

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Abstract Concrete building heights have expanded in the last few decades as the most common structural forms have been shear walls and tube constructions. This suggests that the structural behavior of the latter is more sophisticated than that of earlier RC skyscrapers. As a result, learning more about the structural systems and associated behavior of such buildings would be fascinating. This research will examine the structural characteristics of one of the world's tallest reinforced concrete structures, situated within the seismic zone of Hyderabad. Because the construction uses a shear wall system with uneven apertures, the shear walls, coupling beams, and other structural elements may react abnormally when subjected to lateral and gravitational pressures.

Buildings typically have shear wall apertures for ventilation shafts, windows, and doors, among other functional purposes. Depending on architectural and practical factors, apertures can have varying sizes and placements. Most apartment buildings do not take into account the potential effects on the building's structural behavior that the location and amount of shear wall apertures may have. For this reason, ETABS V 9.7.4 is being used to conduct a reaction spectrum analysis on a 15-story frame wall building. The models with 15%, 18%, and 28% extra gaps in their shear walls are examined, going down from the highest to the lowest values. This study looks into the relationship between the location of an opening in a shear wall and the drift, shear, and moment values.

1. Introduction

A "soft storey" building is a multi-story structure with one or more "soft" levels. A large shop area, a level with lots of windows, or a parking garage are all signs of a soft story in a building. Soft stories, which are found on a building's lower levels and are usually connected to parking garages and retail areas, constitute a significant weak point during an earthquake. On the other hand, most structures' upper stories are stronger than their foundation floors. The basement's seismic reactions differ significantly from the top stories' as a result. A phenomenon known as "soft-storey irregularity" is responsible for this.

To be classified as a "soft storey building," a floor must be 70% less rigid than the floor above it. The soft storey's lack of obstructions may be appealing aesthetically or commercially, but it also means fewer opportunities to install shear walls, which are specially built to distribute lateral forces to help a building withstand the swaying that occurs during an earthquake. Even the floors in between, called "soft" floors because of the way they're built, have soft storey. The lateral pressures created by the building wobbling during an earthquake make these floors particularly hazardous. In this case, the soft storey could potentially collapse, leading to a soft storey failure.

Shear wall

Shear walls are made to prevent damage from earthquake and wind-induced lateral strains. The position and shape of the shear wall have a major impact on how they will respond structurally to lateral loads. The structure acts as a horizontal diaphragm by transferring lateral loads to shear walls that are perpendicular to the direction of the applied force. Because of their great rigidity as deep beams, these shear walls are reactive to shear and flexure, which keeps them from falling when subjected to horizontal stresses. The central core that provides support for tension, bending, and direct shear needs to be positioned eccentrically in relation to the building's forms. Torsion can still happen in symmetrical buildings with shear wall layouts, though, if the wind blows through the building's center of mass or strikes on the facades with direct surface textures (roughness) (Schueller, 1977).Horizontal rigid frames are not nearly as sturdy as shear walls. Shear walls are therefore cost-effective for up to 35 floors. Shear walls and frames work well together in low- and medium-rise buildings since it is reasonable to expect that the shear walls will sustain all lateral stress and the frame will only need to withstand gravity loads. A shear wall's resistance is determined by its thickness. But width makes a considerably greater difference.

A connected shear wall structure is one kind of shear wall architecture that is extremely common. At the floor level, stiff beams or slabs connect two or more shear walls on the same plane, or almost the same plane. When the walls function as a single, cohesive cantilever, the resulting horizontal stiffness is significantly lower. The main objectives of the research were to assess the seismic behavior of soft-story buildings with different percentages of shear wall apertures (0, 15, 28, and 38%, respectively) and to compare the results with IS 1893:2002.

2. Response spectrum method

In the context of earthquake ground motions, the maximum response of an idealized one-degree-of-freedom system with a specific period and damping is shown. The analysis was carried out in compliance with IS 1893-2002 (part 1) standard. Here is where you enter the seismic zone factor and soil type specified in IS 1893-2002 (part 1). ETABS 2013 uses the typical response spectra of the considered soil type for the study. The typical response spectrum for a medium soil type is represented by time versus spectral acceleration coefficient (Sa/g) in Figure 1.

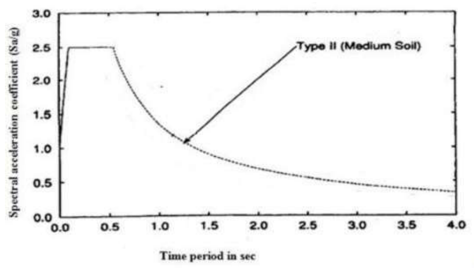


Fig 1: Normal reaction spectrum for medium-sized soil types with 5% dampening

In the frequency domain, this method allows for consideration of the building's numerous modes of response. Many building codes stipulate this, with the exception of the most basic and complicated buildings. Using computer analysis, one may identify the particular forms (modes) that make up a structure's reaction, which correspond to the "harmonic" vibrations of a vibrating string. The entire response of the structure can be estimated by adding the responses of the individual modes, which are calculated using the modal frequency and the modal mass from the design spectrum. The X, Y, and Z magnitudes of forces are determined, and the resulting consequences on the structure are documented. The following are examples of combination techniques:

- Absolute - peak values are added together
- Square root of the sum of the squares (SRSS)
- Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The process of generating the response spectrum loses phase information, so the result of a response spectrum analysis based on the ground motion response spectrum usually differs from the result obtained directly from a linear dynamic analysis based on that ground motion.

Sometimes complicated analyses, like non-linear static analysis or dynamic analysis, are needed for the reaction spectrum technique to be appropriate for buildings that become too tall, too irregular, or too essential to the community in the event of a disaster.

3. Model specifications and models used

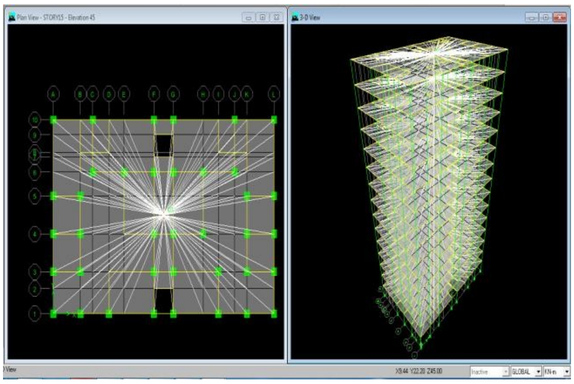
Shear wall openings of 15%, 28%, and 38% are analyzed in this study for a G+14 structure in Zone II. Using ETABS, a 3D model of the structure is created.

Basic parameters considered for the analysis are

1. Utility of building : Residential building
2. Number of stories : G+14
3. Shape of building : Rectangular
4. Shear wall opening : 0%, 15%, 28%, 38%
5. Geometric details
   a. Ground floor : 3m
   b. floor to floor height : 3m
6. Material details
   a. Concrete Grade : M40 (COLUMNS AND BEAMS)
   b. All Steel Grades : HYSD reinforcement of Grade Fe415
   c. Bearing Capacity of Soil : 200 KN/m^{2SS}
7. Type Of Construction : R.C.C FRAMED structure
8. Column : 0.4m X 0.6m
9. Beams : 0.6m X 0.6m
10. Slab : 0.150m
11. Thickness of Shear wall : 120mm

Building models

The various building models with different percentages of shear wall openings are presented in below figures 2.1 to 2.4



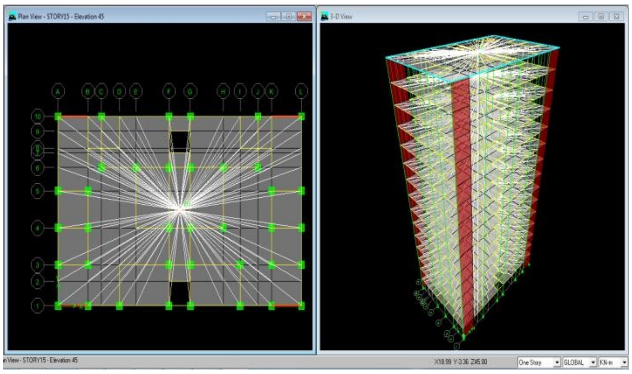
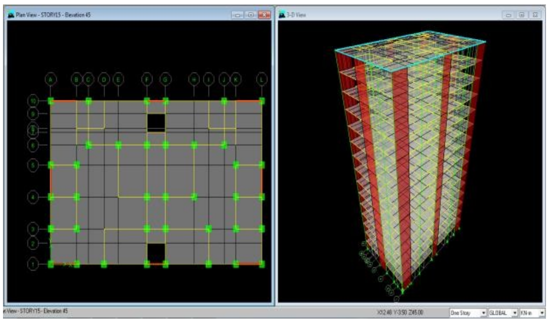


Fig 2.1 Building with 0% Shear wall opening **Fig 2.2** Building with 15% Shear wall opening



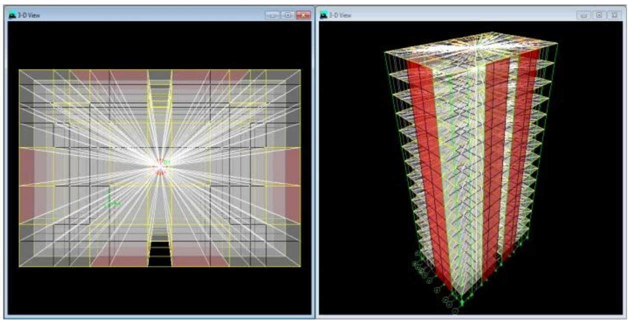


Fig 2.3 Building with 28% Shear wallopening**Fig 2.4**Building with 38% Shear wallopening

4. Results and analysis

The analysis results are shown below, along with a comparison of other significant parameters.

4.1 : Drift X: The difference in drift in X any Y directions are shown in Fig 3.1 & 3.2

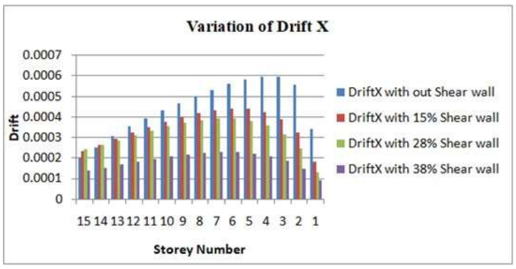


Fig 3.1 Drift variation in X direction

Figure 3.1 shows that in zone II seismic conditions, the value of the drift decreases for a building with a shear wall opening percentage of 38%, compared to the rest scenarios. Due to the great seismic resistance of the shear wall, the intensity of drift lessens as its percentage rises.

Drift Y

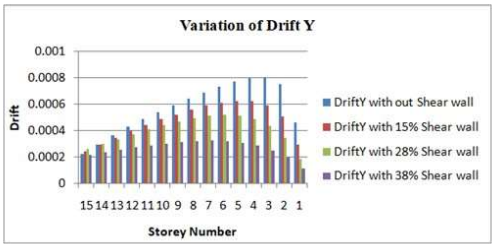


Fig 3.2 Drift variation in Y direction

Figure 3.2 shows that in zone II seismic conditions, the value of the drift decreases for a building with a shear wall opening percentage of 38%, compared to the rest scenarios. Due to the great seismic resistance of the shear wall, the intensity of drift lessens as its percentage rises.

4.2 Shear Force (Vx)& (Vy):

Shear force variations Vx and Vy are seen in Figs. 3.3 & 3.4.

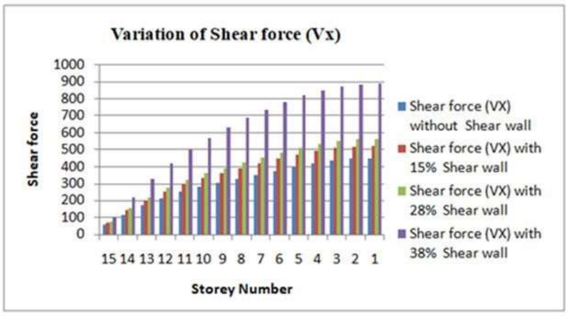


Fig 3.3 Shear force variation in X direction

Since the value of the shear force increases with the number of apertures in the shear walls, a building with no shear wall openings will fare better in a zone II earthquake than one with more openings, as shown in Fig. 3.3. The weight on the structure increases as the proportion of shear wall increases, raising the shear force value.

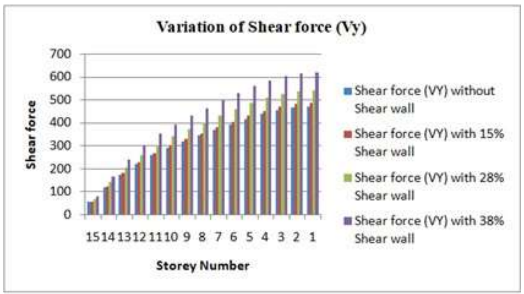


Fig 3.4 Shear force variation in Y direction

Because the shear force increases with opening size in zone II seismic conditions, the construction with 15% shear wall apertures outperforms the other cases, as shown in Fig. 3.4 above. As the percentage of shear wall grows, the weight on the structure also increases, increasing the shear force value.

4.3 Building Torsion (T)

The variation of building torsion is presented in Fig 3.5

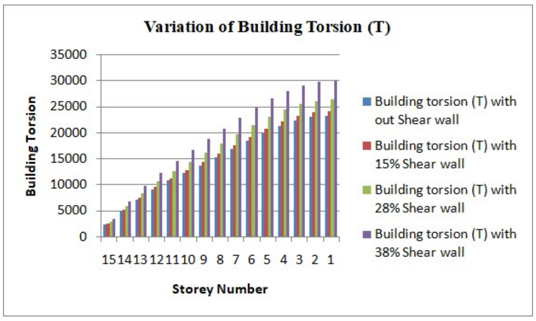


Fig 3.5 Building torsion variation

Buildings in zone II seismic circumstances perform better because, as Fig. 3.5 illustrates, the value of torsion rises as the fraction of shear wall openings in a building increases. The torsion value rises in tandem with the increase in the shear wall percentage and the structure's load.

4.4 Bending moment (Mx& My)

The variation of bending moments Mx and My are presented in Fig 3.6

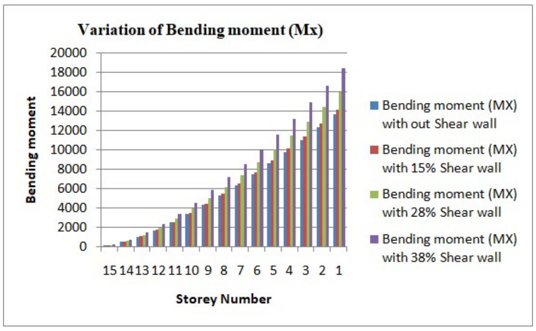


Fig 3.6 Variation of bending moment in X direction

Figure 3.6 shows that in zone II seismic condition, the building with 15% shear wall apertures performs better than the other examples due to an increase in the magnitude of the bending moment in the X direction as the number of openings increases.In this case, when the shear wall % rises, the stress on the structure rises, and the bending value rises with it.

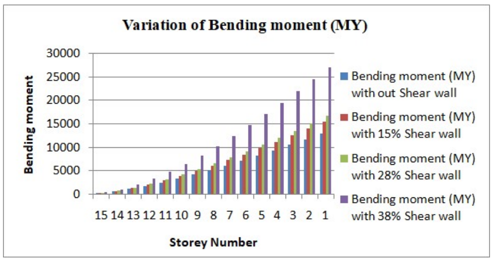


Fig 3.7 Variation of bending moment in Y direction

As can be seen in Fig. 3.7, the value of the bending moment in the Y direction increases as the percentage of shear wall apertures increases, leading to better results for the building constructed under zone II seismic conditions. In this case, when the shear wall % rises, the stress on the structure rises, and the bending value rises with it.

5. Conclusions

The aforementioned study led to the following conclusions.

1. In the absence of shear wall apertures, drift values are observed to be larger in both the X and Y directions. This confirmed that a higher shear wall opening % will reduce the Drift.

2. A building with a 38% shear wall aperture is found to have higher shear force values in both the X and Y axes than other buildings. This proved that a stronger shear force will follow from a higher opening percent.

3. The torsion values (T) of the buildings with 38 percent openings were found to be higher than those of the other buildings. It was discovered that the torsion of the building directly correlated with the percentage of shear wall apertures.

4. It was discovered that the building with the 38% opening had greater bending moment (M) values than the other structures. This confirmed the hypothesis that a larger bending moment would be produced by a higher percentage of holes.

5. Shear force and bending moment in the columns attached to shear wall apertures rise noticeably; the percentage increase decreases in proximity to the shear wall's top.

6. The findings indicate that increasing the percentage of shear wall apertures improves shear force, bending moment, and building torsion while decreasing drift.

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