Comparative Study of G+13 Multistorey Building With Soft Storey By Changing Positions of Shear Wall Using Pushover Analysis

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Abstract- *Buildings with asymmetry and various classes of irregularity are found to be a major cause for collapses of structure, property loss, and casualties during earthquakes. Although a considerable research effort was directed at asymmetric buildings, well-accepted guidelines for multistory asymmetric structures are still yet to be framed. A soft storey, also known as a weak storey, is a level in a structure with insufficient rigidity or ductility to sustain earthquake-induced damage. The Pushover analysis has been widely studies by the researchers since the 1994 Northridge Earthquake and other major earthquakes around the world. The objective of pushover analysis is to develop design methodologies that produce seismic performance of structures under stated levels of seismic hazards. The objective of paper is to study the pushover analysis for a framed structure with shear wall at corner, at center and for a framed structure with soft storey. This study will address the analysis of the RC building frame, i.e., the PUSHOVER analysis, which is a static nonlinear process that estimates seismic structural deformations using a simplified nonlinear technique. Pushover analysis may give substantial information into the weak links of a structure's seismic performance. Shear walls are often employed to counteract lateral forces. The composite action of the beam, column, and wall increases the strength and rigidity of the structure. With the use of Shear walls, lateral deflection in both directions is significantly reduced. When shear walls are added to a structure, it becomes more rigid than it was before. This study evaluated the performance of R.C.C structure with or without soft storey with respect to different parameters such as story drift, story displacement, base shear, etc.*

According to IS 1893:2016, a pushover study was conducted on models of 13-story buildings of bay size 40 X 40 m. Structure having grade of concrete M25 and grade of steel Fe500. Floor to floor height is 3 m and for soft storey it's 4m. Using ETABs, five unique models were selected for testing. The results of each model's storey displacement, storey drift, storey stiffness, and base shear are acquired, and a comparative analysis is undertaken to choose the model with the best performance.The greatest yielding occurs at the softest storey; hence, the greatest plastic hinges form despite the increasing base force. Therefore, soft storeys are safer on high-rise building upper levels. The bulk of hinges found on beams, whereas just a handful appeared on columns. The use of plastic hinges in columns of soft storeys at ground level is not an acceptable safety design requirement. The shear wall gives the structure with high stiffness, ensuring its stability. Shear walls may minimize the displacement and drift of a building's storeys effectively. This will reduce the destruction caused by lateral loads, such as an earthquake. Prior research has shown that the performance of shear walls varies depending on their position inside a structure.

Keywords- Soft storey, shear wall, pushover analysis, response spectrum, storey drift

I. INTRODUCTION

The behavior of multistory framed structures subjected to large earthquake vibrations is determined by how their mass, stiffness, and strength are distributed in both horizontal and vertical planes. Damage from earthquake ground motion often begins in such structures at places of structural weaknesses found in the lateral load-resisting frames. In some circumstances, these flaws may be caused by differences in stiffness, strength, or mass between neighboring storeys. Major international design regulations divided irregularity into two types: vertical and horizontal. Vertical geometric irregularity exists if the horizontal dimension of the Seismic force resisting system(SFRS) in any storey exceeds 130 percent of that in an adjacent level.

A soft storey known as weak storey is defined as a storey in a building that has less stiffness or inadequate ductility to resist the earthquake induced in building. The soft storey is storey having lot of open space. According to IS-1893(part I):2016 a soft storey is one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average lateral stiffness of the three storey above. In building with soft first storey the upper storey being stiffundergo smaller inter- storey drift however the interstorey drift in the soft first storey is large. The strength demand on the column in the first storey is also large as the shear in the first storey is maximum. The experience in the past earthquake has shown that the building with simple and uniform configuration is subjected to less damage. Regularity and continuity of stiffness in the horizontal planes as well as in the vertical direction is very important from earthquake safety point of view. A building with discontinuity is subjected to concentration of forces and deformation at the point of discontinuity which may leads to failure of member. The total seismic bases hear as experienced by building during earthquake depends upon the natural time period.

The R.C.C. Shear wall as widely used to resist lateral forces. The composite action of beam, column and wall provides additional strength & stiffness. Lateral deflection in both the direction decreases considerably with the introduction of Shear walls. It indicates that the stiffness of the structure is increased. Remarkable reduction in the storey drift has also been observed in past studies. Drastic reduction in the storey shears has been observed instructures. Storey shears increases considerably after the addition of shear walls. After the addition of Shear walls the building become stiff as compared to the bare frame structure, it will attract large amount of lateral forces as compared to the bare frame structure.

Misam Abidi, 2012, highlights the importance for immediate measures to prevent the indiscriminate use of soft first story in buildings, which are designed without regard to the increased displacement,ductility and force demands in the first story and this paper argues the importance of novel designapproachwhichhasanadvantageofinteractionbetweenrigi dframesandshearwalls. EjazAhmadBhat,2020 concluded that in case of response spectrum analysis it is observed that base shear values are increasing with increase in shear wall area to floor area ratios for all the models. Storey Displacement case of Response Spectrum indicates that, the decrease in displacement with increasing shear wall area to floor area ratios is in between 1.2% (X) 0.7% (Y).It is observed that from Response spectrum that the storey drift decreases with increase in shear wall area tofloor area ratios. Hiral.D. Adhiya,2017 got a conclusion that, introducing shear wall in a building is a effective method to reduce the soft storey effectThesteelquantityincolumniseffectivelyreducedbyinducin gshearwallsinsoftstorey buildings. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. Storey drift of soft storey building provided with shear wall is lesser than that with out shear wall.

The aim of the paper is to Study the analysis, the effect of soft storey in a multistory building at different floor level with or without considering shear wall at different locations.

II. SYSTEM DEVELOPMENT

General

In the Present work three building models of G+13 has been developed for RCC, for different position of shear wall situated in corner and center of the building, Shear wall having 200mm were analyzed in ETAB software. All the buildings are subjected to same earthquake loading to check their seismic behavior for same storey and storey height. For the analysis of these models various methods of seismic analysis are available but for present work both linear static and non-linear static method is used. Details of the methods are as given below in fig 1.

III. MODELS IN ETABS 2016

Modeling structure description and detailing

No. of storeys	**G+13**
Bay Size	40 x 40 m
Storey	G+13
Concrete	M25
Steel	Fe500
Column Size	380 x 400 mm
Beam Size	250 x380 mm
Slab Thickness	150 mm
Shear Wall	200 mm
Floor to floor height	3m

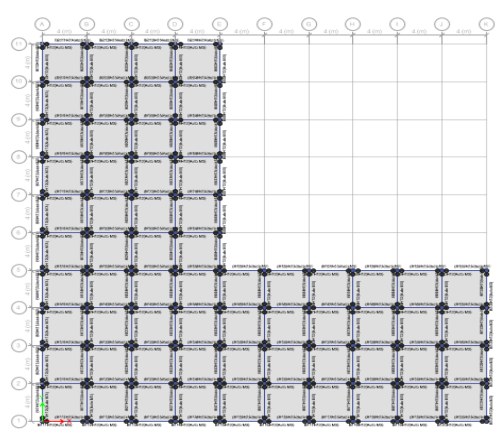

Fig2: plan view

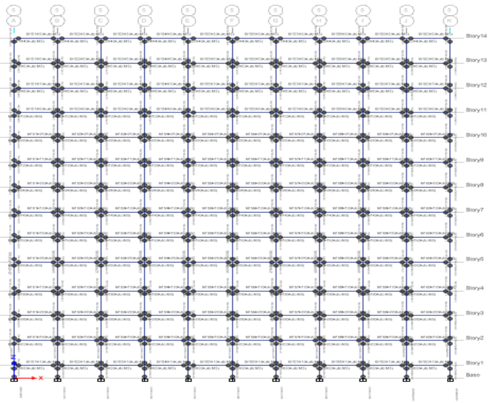

Fig3: floor Without soft storey

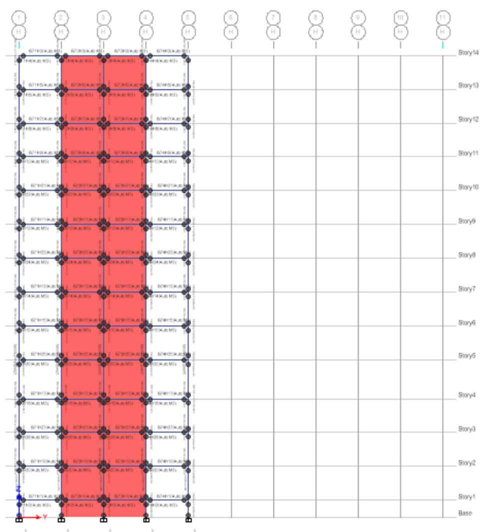

Fig 4: 3 floor soft storey-Shear wall at center

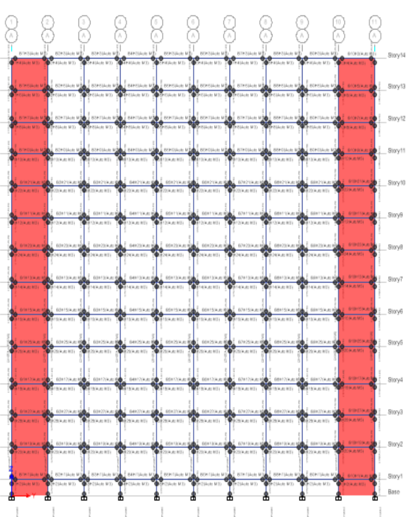

Fig5: 3 floor soft storey-Shear wall

At corner

3.1 PUSH OVER ANALYSIS:

Pushover analysis which is an iterative procedure is looked upon as an alternative for the conventional analysis procedures. Pushover analysis of multi-story RCC framed buildings subjected to increasing lateral forces is carried out until the present performance level (target displacement) is reached. The promise of performance based seismic engineering (PBSE) is to produce structures with predictable seismic performance.

The recent advent of performance based design has brought the nonlinear static pushover analysis procedure to the forefront. Pushover analysis is a static non-linear procedure in which the magnitude of the structural loading along the lateral direction of the structure is incrementally increased in accordance with a certain pre-defined pattern. If is generally assumed that the behavior of the structure is controlled by its fundamental mode and the predefined pattern is expressed either in terms of story shear or in terms of fundamental mode shape. With the increase in magnitude of lateral loading, the progressive non-linear behavior of various structural elements is captured, and weak links and failure modes of the structure are identified. After this progressive post elastic analysis of the structure the designer can make necessary changes in the design configuration in order to obtained desired plastic hinge sequence under the applied lateral loads. In addition, pushover analysis is also used to ascertain the capability of the structure to withstand a certain level of input motion defined in terms of a response spectrum. Fig 2 shows the pushover curve.

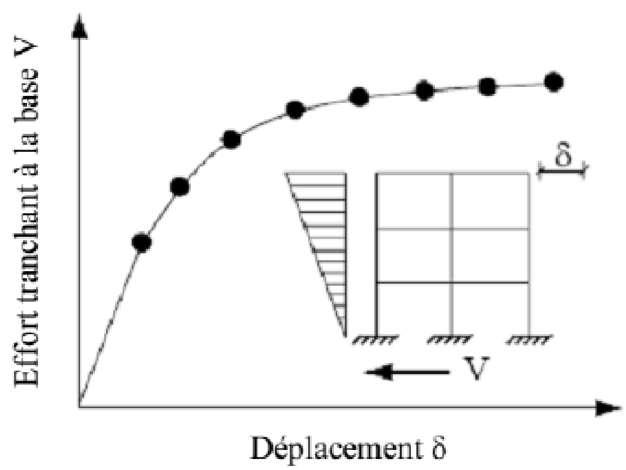

Fig 6: Pushover Curve

The pushover analysis is more convenient than full dynamic analysis because of computational time. With pushover analysis, results took considerably much lesser time than dynamic analysis. Thus, pushover analysis is more practical for use in a design office. After the structure has been designed or retrofitted using appropriate codes or design guidelines, is that it yields additional information on the limit states, the plastic hinge sequence and the force redistribution caused by a seismic event. The designer can make changes in the design configuration in order to obtain a desired plastic hinge sequence under applied lateral loads. The pushover analysis also yields detailed member information such as maximum inter-story drift demands and plastic hinge rotations, thereby increasing the effectiveness and efficiency of design. The performance of the structure was a phenomenon that structure must have the capacity to resist demands of the earthquake. Performance point represents the condition for which seismic demand imposed on the structure was equal to the seismic capacity. The graphical representation of performance levels with pushover curve is shown in figure 3.

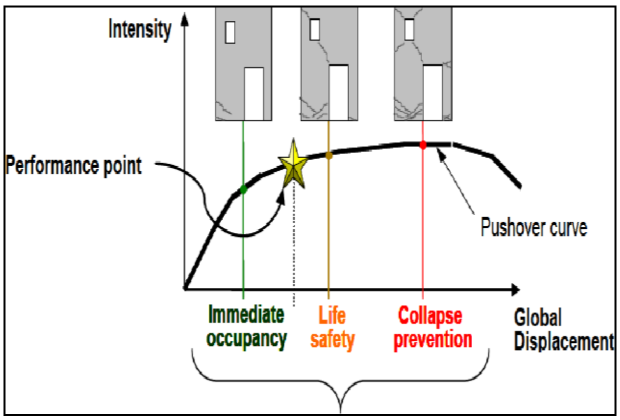

Fig 7**:** Performance levels with pushover curve

Assumptions in Pushover Analysis

Following assumptions are made while analyzing a structure:

1. The material is homogeneous and isotropic and all column supports are fixed at the foundation.
2. The tensile strength of concrete is ignored in sections subjected to bending.
3. The superstructure is analyzed independently from foundation and soil medium, on the assumptions that foundations are fixed.
4. Pushover hinges are assigned to all the member ends. In case of columns PMM hinges (e.g. Bending moment hinge) are provided while in case of beams M_3 hinges (Axial Force and Biaxial Moment) are provided.
5. The maximum target displacement of the structure is calculated in accordance with the guidelines given by FEMA 356 for maximum roof level.

IV. RESULT AND DISCUSSION

4.1 Storey Displacement

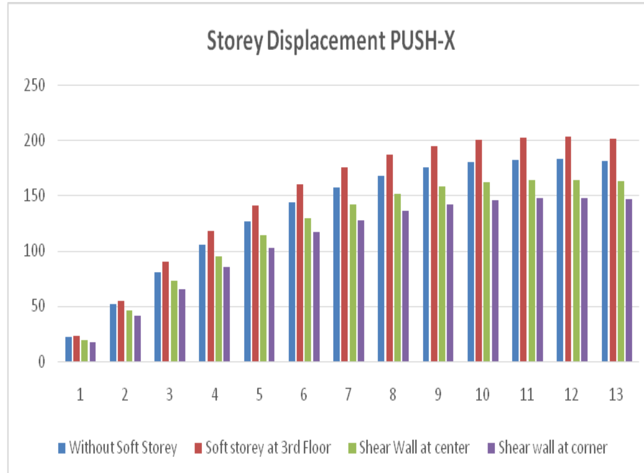

Fig 8: Storey displacement for X-direction

Figure 8 shows the value of storey displacement in X direction from One to thirteen storey irregular building without shear wall, shear wall at center and corner. As the shear wall condition changes from without to shear wall at center and corner to center, it is observed that the storey displacement in member decreases. Without shear wall has higher storey displacement than the shear wall at corner and shear wall at center by 15% and 23.5% respectively.

4.2 Storey Drift:

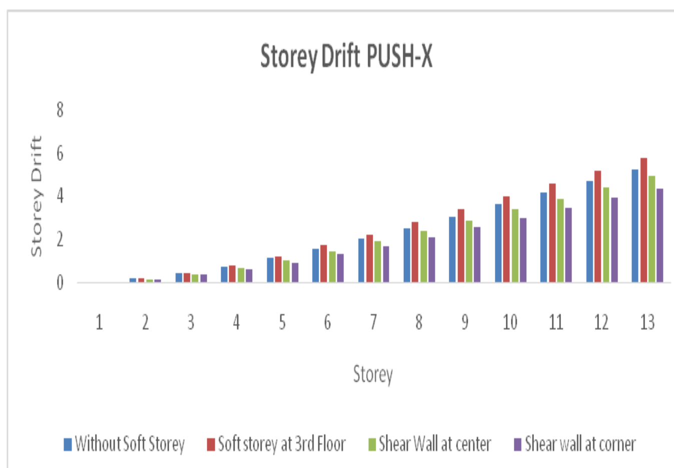

Fig 9: Storey Drift for X-direction

As the shear wall condition changes from without to shear wall at center and center to corner, it is observed that the storey drift in member decreases. Without shear wall has higher storey drift than the shear wall at corner and shear wall at center by 10% and 19% respectively shown in figure 9.

4.3 Base Shear

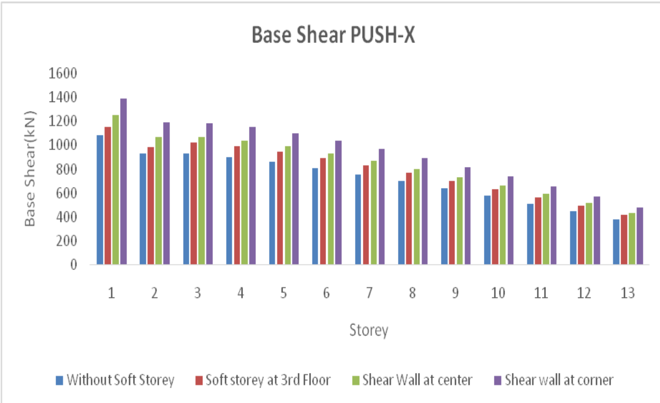

Fig 10: Base Shear(kN) for X-direction

As the shear wall condition changes from without to shear wall at center and center to corner, it is observed that the base shear in member increases. Without shear wall has lower base shear than the shear wall at corner and shear wall at center by 9.09% and 17.35% respectively shown in figure 10.

V. CONCLUSION

Pushover study was performed on 13-story building models in accordance with IS 1893:2002. (part 1). Five distinct models were chosen for examination using ETABs 2016. The findings of each model's storey displacement, storey drift, storey stiffness, and base shear are obtained, and a comparison research was conducted to identify the model with superior performance.

- Maximum yielding occurs at the softest storey; as a result, maximum plastic hinges develop despite the rising base force.
- As we transferred soft storey to higher levels, yielding decreased relative to soft storey at lower levels, and at the maximum number of pushover steps, weaker hinges formed.
- Therefore, soft storeys are safer at upper floors of high-rise buildings. The majority of hinges evolved in the beams, whereas few appeared in the columns.
- The development of plastic hinges in columns of ground-level soft storey is not an acceptable safety design criterion.
- Shear wall provides the structure with great rigidity so that the structure will be stable. Shear walls may efficiently limit the displacement and drift of a structure's stories. This will decrease the damage caused by lateral loads, such as an earthquake. Prior research shown that the performance of shear walls varies according on their location inside buildings.
- The positioning of shear walls at the structure's centers in a symmetrical manner provides the highest performance for reducing displacement, according to the research. It can minimize displacement by up to 25% (X-direction) and 35% (Y-direction), hence we recommend allocating shear walls and soft storeys to the building's lower and middle levels.

VI. RECOMMENDATIONS

- After retrofitting of all the models with shear walls hinges are not developed in any of the columns.
- In medium high-rise buildings (i.e. greater than 10 storeys) provision of shear walls is will be effective in enhancing the overall seismic capacity characteristics of the structure.

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