The Influence of Infill Masonry Wall in RC Frames Subjected To Seismic Load for Sustainable Structure

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ABSTRACT. The masonry infill RC frames are the most recurrent type of structural element used in multi-storey constructions due to factors such as significant lateral stiffness, strength and overall ductility. With suitable adaptations to provide reinforcement in the masonry, it should be possible to also improve the seismic response of such infill.

The following study is conducted to investigate, analyze and compare the response of RCC structure i.e., with masonry infill and without masonry infill, subjected to earthquake loading. The analysis is conducted on a G+5 structure with the loading condition given in Indian Standard IS1893:2002 codal provisions incorporating ETABS[9] software. The analysis is studied under the categories like pushover curve, storey displacement, storey shear at base, and storey drift.

Results obtained from the analysis of structure with and without infill masonry walls shows that all the parameter discussed above, except storey shear, have a significant reduction for structure with infill wall which would result in over estimation of seismic influence on structure that could considerably optimize the seismic behaviour and sustainable impact of building on the environment.

1. Introduction

Even with all odds like accommodating for the sway and stretch of the skyscrapers due to wind loads, temperature, much deeper foundations etc., the researchers and the builders having been successful but to add to all these complexities, one of the most threatening odds against the construction of high-rise is due to frequently occurring earthquakes[1,2] which has to be tackled. The vibration of the ground takes place eccentrically in all the 3 directions – X and Y axis and third one along the height i.e., Z axis. Buildings are firstly designed for dead loads which are downward or vertical loads as the vertical acceleration for the period of seismic activity may be addition or subtraction with respect to some gravitational stimulation where the structures will be safe in comparison with vertical shaking but these lateral ground vibrations results in structure convulsions and induces inertia forces in the building. Hence, the structure should be designed to resist these horizontal forces to ensure structural safety[3,6].

In this project, a comparative study is done with and without infill’s wall where the response of the RCC frame with masonry wall under seismic[4] loading is studied. For G+5 structure, analysis of the RCC framed building is modelled where the method used to find out the strut is by equivalent strut method. The analysis of the structure is conducted on basis of different parameters such as shear force[7] at base, storey displacement, storey drift which are calculated and graphed using ETABS.
1.1 Objectives

- The performance of structural system by calculating the strength and deformation demand by the earthquake design in which method of non-linear static investigation.
- To establish the influence of storey heights on seismic performance of high-rise building with and without infill walls.
- To study the results of the structure on parameters such as base shear, storey drifts, storey shear and spectral displacement on the horizontal plane.
- To evaluate the stiffness of the structure with and without infill walls.

2. Literature Review

Numerous studies have been conducted in the past for analysis of structures under the influence of seismic loading. Some of them are discussed below.

[1] C. V. R. Murty et al. (2000), the paper shows the results of the cyclic tests of the RC frames with infill’s is stiffness, energy, durability, and also the ductile. The column is arranged by the anchored. For the improvement of cities the masonry infill’s is most popular for the construction of multi storey. It is also provides the design of procedure for the structure.

[2] Thomas, Lini M et al. (2015), in this review is taking the 5 and 10 storey building by taking the heights of building by using FEM program ASNYS 14.5. This is analysis the tall storey building is taken as with and without infill walls are taken for 3D to gives the accurate valve of deflection and stresses. The time is taken is not necessary in this study. It varies the 5 and 10 storied building compared with 2dimensional building. By using the strut method, the loading is taken as per IS 1893(part 1) 2002. By using infill RC structure it gives the less deflection.

[3] M.Danish et al. (2017) only considered the plane stiffness of masonry wall and the infill panels are modelled as equivalent diagonal strut elements. The behavior of buildings subjected to Gravity and Seismic loads with the help of Response Spectrum Analysis using FEM based software and the effect on Time Period, Mass Participation factor, and Storey Drift has been observed. Strength and Rigidity of RC bare frame structures is found increasing after the inclusion of infill panels and shear wall.

[4] Moreno Rosangel et al. (2004) in this review, the wall is damaged by earthquake reaction of the RCC slab of the building. They have analyzed the 3, 5, and 6 storey. Which is located in Barcelona, and the Spain. The spectra is capable of reacting the method of push over, they are also having the steps to carry by curves. It is provides the lesser breakage.

[5] Oni P B et al. (2013) the two of them studied on the behavior based on the calculation the buildings. They analyzed the effect of three to six storey building located in zone 5 with plus shaped in-filled shear walls under seismic loading using finite element analysis in ETABS 9.7.1. They also intended to compare the accuracy of static method, response spectrum method of analysis and push over method. The wall holds the horizontal loading passes on the building. The Equivalent static method was more effective up to 20m height. For taller and unsymmetrical structures, Response Spectrum Method is suitable and vital the analysis of the push over must be carried out the weather of the building highly reacts precisely when compared the remaining method. Hence induces the non-linearity of the material they are the actual conditions of the structures.

[6] ÖZTÜRK Mehmet Selim et al. (2005) this paper showing the behavior of hollow masonry infill’s wall of the horizontal behavior and by testing the RC frame. For the necessity of two different structures are taken for the study purpose. As an in filled structure 3 and 6 storey building are constructed. The testes are conducted for the column, infill wall for the overall of the storey. The influence of each study is calculated by storey drift k and comparison of each study.
3. METHODOLOGY
In the present study, the following procedure is adopted for modelling, analysis and comparison of the infill masonry walls in high rise RC frames subjected to seismic load for sustainable structure using ETABS[9] 2016 where Pushover analysis for the seismic- performance of RC framed-structure is considered.

3.1. Modelling
ETABS 2016 is the major tool used for this project which furnishes an extensive variety of analysis methods like static and nonlinear static, dynamic and nonlinear dynamic analysis etc.

![Plate 1: Plan and 3D view of Grid.](image-url)

3.2. Details of the structure and properties of the materials

| Support condition          | Fixed                        |
|----------------------------|------------------------------|
| Slab thickness             | 130mm                        |
| Column sizes:              | (300X600) mm                 |
| Beam sizes:                | (230X450) mm                 |
| Grade of Concrete & Steel  | M25 & HYSD 415               |
| Type of structure          | SMRF                         |
| Damping ratio              | 5%                           |
| Zone Factor                | 0.16                         |
| Importance Factor          | 1                            |
| Type of soil               | B type                       |
| Reduction Factor           | 5                            |
Table 1: Preliminary Data.
In this project, G+5 storey building is modelled with dimensions being 3.0m as typical floor height and plinth levelled at 1.5m from the base leading to a final height of the structures being 19.5m. Geometrical properties and Material properties are assigned to the model as shown in the Table 1.

3.3 Modelling of Masonry Infill Wall
To evaluate accurate behavior of the infill RC frame structure under seismic activity[5], the method of equivalent compression diagonal strut should be incorporated where properties of equivalent struts will be similar to that of masonry infill walls i.e., the depth of the strut and the thickness of wall is considered equal.

Plate 2: Masonry infill wall as equivalent diagonal compression strut.

3.4 Defining Load Cases
Loads such as dead, live, floor finish and also seismic loads by the static analysis is defined.
Plate 3: Defining Load Cases

3.5. Defining Mass Source
When seismic forces are studied, the total mass of the structure is taken into consideration as the vertical force activity are only effected by the weight on negligible levels. In case of ETABS, the mass of building is set as default when earthquake analysis is done.

Plate 4: Defining Mass Source

3.6. Hinge Properties and Its Location
The hinge properties provides the moment curvature of each elements’ analysis in the user defined when hinges are allocated at member ends. In case of columns, non-linear hinges i.e., P-M2-M3 at 0.1 and should be reused as P-M2-M3 at 0.9. In case of horizontal members i.e. beams, M3 at 0.1 and once again M3 at 0.9 should be considered.
Plate 5: Assigning of Hinges

3.7. Analysis in ETABS

Once the non-linear model is created, pushover analysis can be conveniently carried out using ETABS using the array of options provided by the software. The gravity loads are first applied before the structure is pushed. Parameter of various pushover in different analysis target displacement and pattern lateral load and linearity geometric is defined in the analysis of pushover after than run.

Plate 6: Analyzing the model
4. Results and Discussion

The structural analysis was conducted on the following types of masonry walls used in ETABS models:
To generate the analysis, nine parameters i.e., Storey Displacement, Pushover Curve, Storey Drift and Storey Shear, were evaluated on horizontal plane using ETABS models by comparing infill walls and without infill walls.

4.1. FEMA 440 EL (Pushover Curve Result) – PUSH X

Pushover Curve depicts the non-linear nature of the structure and shows a load-deformation curve of the base shear force and the horizontal displacement for the brink of the building. When infill walls are considered over without infill walls, there is 86.15% reduction in spectral displacement for Push X.

Graph 1: FEMA 440 EL (Pushover Curve Result) – PUSH X

4.2. FEMA 440 EL (Pushover Curve Result) – PUSH Y

In case of Push Y, a reduction of 76.40% in spectral displacement for model with infill walls in comparison with that without infill walls is observed.
Graph 2: FEMA 440 EL (Pushover Curve Result) – PUSH Y

4.3. Maximum Storey Displacement – PUSH X

Storey displacement can be termed to be the displacement of any storey of the structure in comparison to the base of a structure. With the use of infill walls, there is 88.88% reduction in storey displacement for model in comparison with that without infill walls in case of Push X.

Graph 3: Maximum Storey Displacement – PUSH X

4.4. Maximum Storey Displacement – PUSH Y

In case of Push Y, there is a reduction of 79.06% in storey displacement for model with infill walls in comparison with that without infill walls.

Graph 4: Maximum Storey Displacement – PUSH Y
4.5. Maximum Storey Drift – PUSH X

Storey drift is basically ratio between the displacement of two consecutive floor and height of that floor. In the considered models, there is 55.88% reduction in storey drift for model with infill walls in comparison with that without infill walls and that is for Push X.

4.6. Maximum Storey Drift – PUSH Y

When Push Y is considered, there is 18.91% reduction in storey drift for model with infill walls in comparison with that without infill wall.
4.7. Storey Shear At Base – PUSH X

Storey shear is a calculated ratio between the total dead load and a part of the live load acting at each floor level. There’s been a 76.00% increase in storey shear that is due to its increased self-weight for model with infill walls in comparison with that without infill walls and that is for Push X.

Graph 7: Storey Shear at Base – PUSH X

4.8. Storey Shear At Base – PUSH Y

In case of Push Y, an increment of 74.66% in storey shear is noticed that is due to the increased self-weight for model with infill walls in comparison with that without infill walls.

Graph 8: Storey Shear at Base- PUSH Y
4.9. *Hinge Status*

In structure without infill wall the pattern of hinge formation being from the ground floor then distributes through different storey level as the step proceeds whereas in structure with infill wall the hinge formation is primarily localized at P-Storey since it is a soft storey without infill. But there are no hinge formations in storey above as a recent of addition stiffness incorporated by infill walls.

![Plate 8: 3D view of the structure without infill (green) and with infill (blue) respectively](image)

For a structure without infill wall the hinge formation status indicates that the structure lies in IO-LS zone which implies that structure with infill wall for the provided target displacement is actual in IO level as compare to structure with infill wall is in LS level with few damages to structure member.

5. **CONCLUSION**

This project attempts to investigate the possibilities of using infill walls for an alternative to reduce the effect of seismic loading and activity. Based on simulations carried out in ETABS2016 and by comparison of results and materials’ properties, the following conclusions has been derived:

- All the parameter discussed in the project, except storey shear, have a considerable reduction for structure with infill wall which would result in over estimation of seismic influence on structure resulting in over considerate design, which could considerably be optimize with reference to the results discussed above.
- A consideration is necessary regarding the increment in storey shear in case of the presence of infill wall which is to be given new consideration in designing structure to resist seismicity.
- Influence of ductility ratio for structure with infill wall can be considered to analyse the seismic performance.
- The influence of percentage of opening in infill wall and effect of structural irregularity in plan and elevation can be studied.
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