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EFFECT OF PRESENCE OF INFILLS IN GROUND STOREY ON SEISMIC PERFORMANCE OF R.C. BUILDINGS

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Abstract - *The multi storeyed Reinforced Concrete (R.C.) buildings are constructed with brick masonry as infills. Commonly, the ground storeys of buildings are used for the parking purpose. The presence of masonry significantly effects on the non-linear behaviour of the building. In this research, the G + 6 storeyed building is considered for the study of behaviour of building with open storey and without open storey in ground floor (G.F.). The non-linear pushover analysis has been performed on building model by using SAP 2000 v 15. The brick masonry infill is modelled as single diagonal strut. By analyses it was observed that, the structures with open storey in ground floor are vulnerable to earthquake lateral load. While the presence of infill increases the strength and stability of the building.*

Key Words: *Pushover analysis, soft storey, Base shear, Masonry infill, Natural Time Period, R.C. frame.*

1. INTRODUCTION

The multi-storeyed R.C. buildings are constructed with infill walls of brick masonry. The brick masonry is easily available and simple for construction. The brick masonry have better heat insulation and waterproofing properties. In R.C. structure design procedures, the infill walls are considered as non-structural elements and their strength and stiffness contributions are ignored [19]. When the lateral load is acting on the infilled R.C. frame, the infill interacts with surrounding frame and acts as the compression member. These members can be considered as diagonal strut between the frame joints [19]. The infill panels under compression can be modelled as single diagonal strut, double diagonal strut etc. [17]. In the multi-storeyed buildings, the ground floors are kept without infill walls and used for vehicle parking. Due to the many functional needs, large openings or large assembly halls etc. are created in buildings which are major causes of the irregular distribution of infill in building. From the many experimental studies, it is observed that due to irregular distribution of masonry in elevation creates soft storey effect and induces torsion in plan of building. Thus, an upper floor acts as a single unit and large displacement is occurs in the open storey.

2. DESCRIPTION OF THE BUILDING MODELS

In the present study, three-dimensional G+6 storeyed R.C. building is considered. The plan of the building model is as shown in Fig.1. The bottom storey height is 3.3m and upper storey height is 3.1m. The building is assumed to be located in seismic zone IV, the soil strata is hard and building is considered as special moment resisting frame (SMRF) type. The material properties are as shown in Table1.

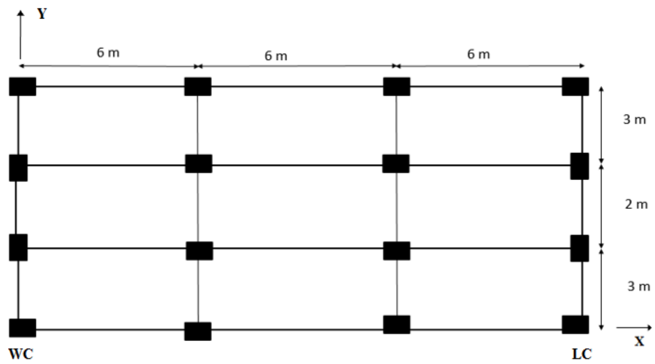

Fig-1: Plan of the building

Table-1: Properties of Materials

Materials	Modulus of Elasticity (N/ mm²)	Poisson's ratio (μ)	Wt. per unit volume (KN/m³)
Concrete M20	22360	0.2	25
Rebar HYSD 415	200000	0	76.97
Brick Masonry	3500	0.19	20

An outer 2D R.C. frame is considered for seismic analysis. The brick masonry infill wall is modelled as single diagonal pin-jointed equivalent strut. The linear and non-linear static analysis is performed on these models. The frame is fixed at the bottom. The R.C. building frame models developed as mentioned below, The building frame with soft storey - The building has no walls in the ground storey but the upper storeys has infill walls.

The building frame without soft storey - The building has brick masonry infill walls in all storeys.

3. METHODOLOGY

3.1 Soft Storey Effect

The IS 1893:2002[10], defines the soft storey as, The storey, in which the lateral stiffness is less than 70% the lateral stiffness of the storey above or less than 80% of the average lateral stiffness of storeys above. The irregular provision of infill is the major cause of the soft storey effect. Due to the lateral load, the sway mechanism is created in soft storeys.

3.2 Modelling of Infill

The infill is in compression under the action of lateral loadings. The brick masonry infill is modelled as equivalent single diagonal strut. This model is simple and represents the global behaviour of infilled R.C. frame satisfactorily [17]. The strut joints are considered as pinned joints. The width of the strut is calculated by Pauley and Priestley's equation,

$$W= 0.25d \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where, d is diagonal length of masonry panel between frame joints.

3.3 Pushover Analysis

Non-linear static pushover analysis involves the pushing structures laterally until a pre-specified lateral force or displacement is reached [13]. In the present study SAP 2000v15 was used for pushover analysis as per capacity spectrum method given in FEMA 440 [4]. The non-linearity to the frame elements was introduced by assigning the plastic hinges defined as per FEMA 356 [19]. For the masonry struts axial hinges were assigned. The displacement controlled pushover analysis was performed. 4% of height of building was taken as maximum displacement at roof level and the same was defined in several steps [18]. The applied lateral forces and lateral displacement at each step were plotted to obtain pushover curve. Pushover curve is a base shear versus roof displacement curve. The pushover curve represents the maximum load carrying capacity of the structure. It also represents the inelastic behaviour of building structure.

4. RESULTS AND DISCUSSIONS

The non-linear static pushover analysis was performed on the building models. The comparison between the soft storey and uniformly infilled R.C. frame building models was carried out.

4.1 Natural Time Period

A comparison between the natural time periods of models with soft storey and without soft storey was made. By performing the modal analysis the natural time periods were obtained. The natural time periods of building models are tabulated in Table 2.

Table-2: Natural Time Periods of Buildings

Fundamental Natural Time Period (sec)	
Building frame with soft storey	0.89
Building frame without soft storey	0.37

From the above table, it is observed that, due to the presence of infill in ground storey the stiffness of structure is increases. The increase in the stiffness of frame reduces the time of vibration. The time period of frame observed to be reduced by 52% in the model without soft storey.

4.2 Base Shear

The non-linear static pushover analysis was performed on the building models. The design base shear is the total design lateral force at the base of a structure. The base shear of the building models are tabulated in Table 3.

Table-3: Base Shear of Buildings

Base shear (kN)	
Building frame with soft storey	403.238
Building frame without soft storey	1102.048

Due to the presence of infill in ground storey, the total mass of the building structure is increases. Heavy mass attracts more earthquake forces as a result base shear is also increased.

4.3 Pushover Curves

The pushover curve is the load-deformation curve. It can be seen from Fig. 2, due to the presence of the infill in ground storey strength of structure increases. Similarly, the stiffness of the frame is also seem to be increased. The inelastic displacement of building frame with soft storey is greater than building frame without soft storey.

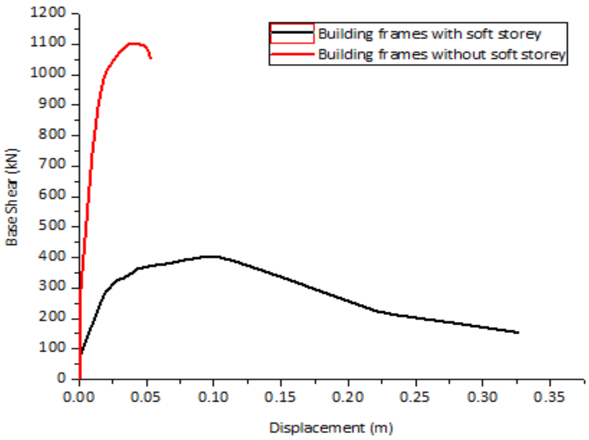

Fig – 2: Comparison of Pushover curve for building models

4.4 Yield Pattern

A yield pattern of building frames with and without soft storey has been studied. It has been observed that the hinges formed in infill before in beams and columns, in case of buildings without soft storey. The formation of hinges at performance point are as shown in Fig. 3.

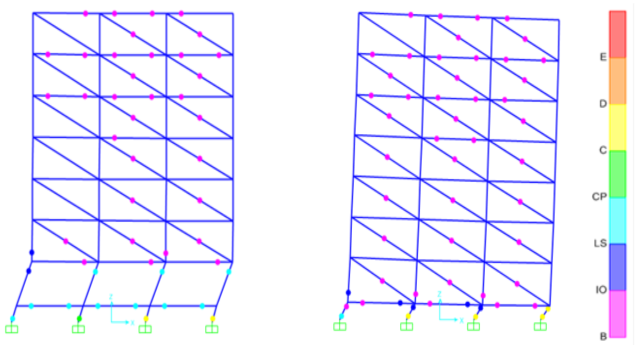

Fig.3 Failure mechanism of buildings with soft storey and without soft storey

It has been observed that the hinges formed in ground floor columns of building with soft storey which shows the weak storey phenomenon. This phenomenon was due to irregularity of infill mass distribution in building.

5. CONCLUSIONS

Based on the results obtained by performing pushover analysis of building models, the following conclusions were made.

1. Due to presence of infill the strength capacity of frame increases predominantly. The building with infill in ground storey shows 63% more strength than soft storey building model.

2. The ductility capacity of buildings reduces by 84% in fully infilled wall building than building with soft storey.

3. The presence of infill significantly effects on the failure mechanism of building. The storey without infill develops column sway mechanism.

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