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Behaviour of RC Building with Soft Storey due to Seismic Load

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Abstract*—Behaviour of RC building is investigated under seismic load at different seismic zones in Bangladesh for soft storey existence. A six storied building with identical plan is analysed. Soft story is facilitated by Infill brick wall assigning which is modelled using equivalent diagonal struts.

Keywords— Soft Storey, Drift, Seismic Load, RC Building, Infill Wall

I. Introduction

Car parking facility is a basic demand in modern buildings at the cities as a part to facilitate one of the modern amenities. So that constructions of multi-storeyed buildings with open first storey is a common practice over the world (Dohare and Maru, 2014). In addition to that, different floor of the building is left vacant and glass partition is being used in order to beautify the architectural shape of the building. These types of buildings having no infill masonry walls in ground storey, but all upper storeys infilled by masonry walls are called soft first storey (Dohare and Maru, 2014; BNBC-2006; FEMA-273). Soft story irregularity is one of the main reasons of building damages during recent earthquakes in the world as mentioned in almost all reconnaissance reports and studies (Inel and Ozmen, 2008; Adalier and Aydingun, 2001; Dogangun, 2004; Kaplan et al., 2004; Sezen et al., 2003). The most destructive and unfortunately the most general irregularity in building structures that lead to collapse is certainly the soft story irregularity (Pokar et al., 2013). Soft story may arise not only because of sudden changes in structural system (like height of the stories) but also due to abrupt changes in amount of infill walls between stories which are usually not considered as a part of load bearing system (Inel and Ozmen, 2008).

Dohare and Maru, (2014), investigated the seismic behavior of soft storey building with different arrangement in soft storey building when subjected to static and dynamic earthquake loading in India. They found that, providing infill improves resistant behaviour of the structure when compared to soft storey provided. Santosh, (2014), investigated and conducted nonlinear pushover analysis to the building models using ETABS and evaluation is carried for non-retrofitted normal buildings and retrofitting methods are suggested like infill wall, increase of ground story column stiffness and shear wall at central core. The study concluded that the storey drift values for soft storey models were maximum values as compared to other storeys and the values of storey drift decreases gradually up to the top. Banerjee et al., (2014), Analysed response parameters such as floor displacement, storey drift, and base shear. Modelling and analysis of the building are performed by nonlinear analysis program IDARC 2D. The study concluded that the lateral roof displacement and maximum storey drift is reduced by consideration of infill wall effect than a bare frame.

Current study aims to investigate soft story behaviour using linear static analyses for a six storied RC buildings. Soft story models of the reference buildings are obtained considering less amount of infill at floor story. Analyses are performed using ETABS V9.7.4. Effect of infill walls is modelled through diagonal struts as suggested in FEMA-356 (FEMA 2000). The main objective of the study was to explore the behaviour of reinforced concrete building when a soft storey is facilitated with the following parameters such as: (i) Different Seismic Zone in Bangladesh, (ii) Different exposure category and (iii) Position of soft storey.

II. Material and Methodology

The software used for the present study is ETABS 9.7.4. It is product of Computers and Structures, Berkeley, USA. ETABS 9.7.4 is used for analyzing general structures including bridges, stadiums, towers, industrial plants, offshore structures, buildings, dam, silos, etc. It is a fully integrated program that allows model creation, modification, execution of analysis, design optimization, and results review from within a single interface. ETABS 9.7.4 is a standalone finite element based structural program for analysis and design of civil structures. It offers an intuitive, yet powerful user interface with many tools to aid in quick and accurate construction of models, along with sophisticated technique needed to do most complex projects. The analysis is carried out by linear static method in accordance with BNBC-2006 (Part-6), to study the behavior of the building. Building data used for modeling of the buildings are described below:

For analytical application, a sample RC three dimensional building is selected. In order to concentrate on the effects caused by the distribution of infill the prototype bare frame structure is regular throughout its height and bay length. The structure is six storeys high, with a storey height of 10 ft [Fig. 1]. The bay lengths are 12 ft -12 ft -12 ft in both directions. The slab thickness is 5 in and the column sizes are 20 in x 20 in for interior columns and 16x16 in for exterior column. All the beams are of the same size with a width of 10 in and depth including slab thickness of 20 in. The building is as assumed to have isolated column footing.

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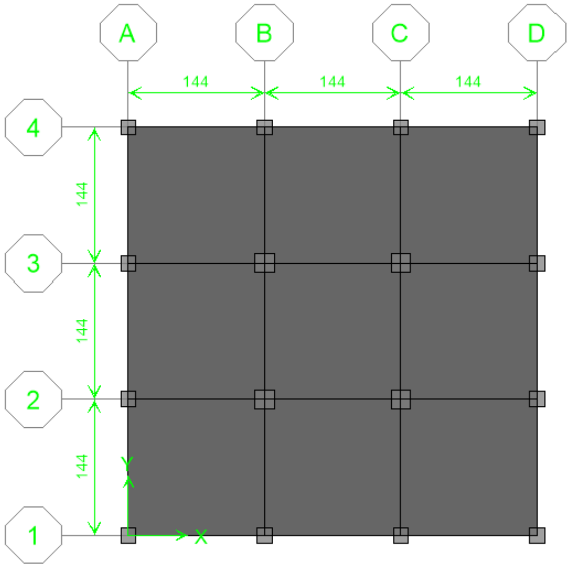


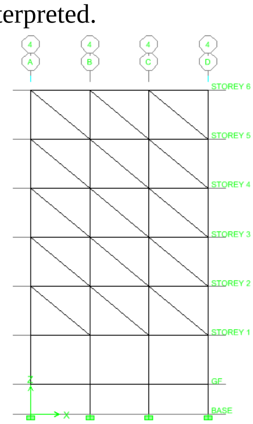
Plan

Fig. 1: Details of the study building

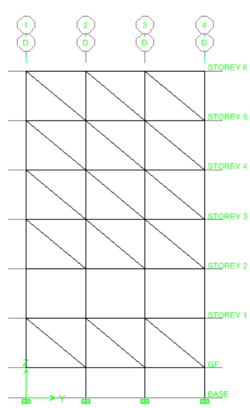
The concrete strength was assumed to be 4000 psi with yield strength of steel to be 60000 psi. Young's modulus of elasticity for concrete is 3600 Ksi. As regards the masonry infill, they were modeled as equivalent diagonal strut, as mentioned earlier, with a width of 24 in and thickness of 5 in. The masonry infill considered is representative of a weak masonry having a compressive strength of 145 psi. The sample structure is assumed to be located in Zone I, II and III according to BNBC (2006). Considering standard occupancy structure and exposure category A, B and C equivalent earthquake loads are determined. The geometry and the material characteristic together with the fact that the infill is in direct contact with the fact reflect common practices of Bangladesh were in-filled frames are not engineered to resist earthquakes.

Model Description

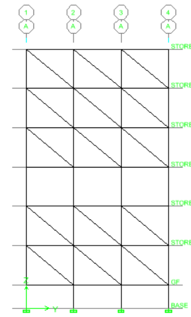
Name is given for each model as presented below [Fig. 2] which is used in defining the building model when results are interpreted.



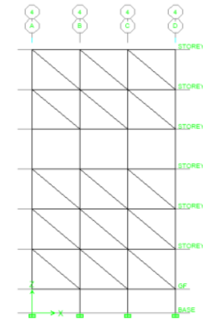
GSS= Soft storey at Ground storey



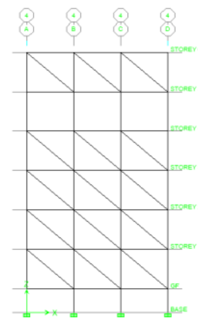
1SS= Soft storey at 1st storey



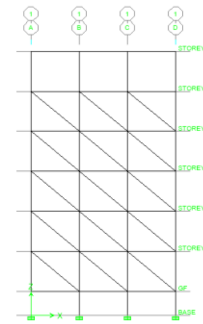
2SS= Soft storey at 2nd storey



3SS= Soft storey at 3rd storey



4SS= Soft storey at 4th storey



5SS= Soft storey at 5th storey

Fig. 2: Definition of Building Models

III. Results and Tables

From the models of six (6) storied building, data of storey drift was collected for a particular 2D frame in long direction for seismic loading from that particular direction. Time period was calculated from static formula and ETABS model and, both are compared in the subsequent section. Changing pattern of base shear was compared with in different seismic zone at different positions of soft storey.

Soft Storey position and Storey Drift

Storey drift is defined as the relative sway of frame to the adjacent floor. It is observed that Storey drift is greater in the adjacent upper floor of the soft Storey position. It is concluded from the above study that soft Storey would never be harmful if it is located at upper Storey. Effect of soft Storey position is shown below [Fig. 3].

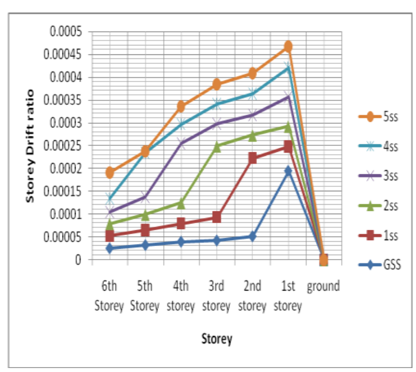


Fig. 3(a): Storey drift and soft storey position (Zone-I)

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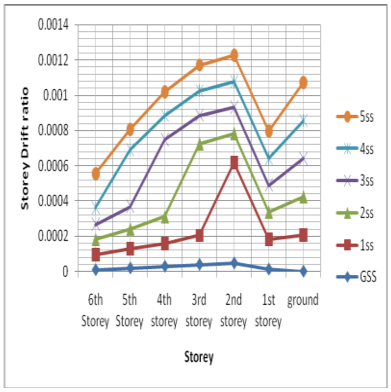

Fig. 3(b): Storey drift and soft storey position (Zone-II)

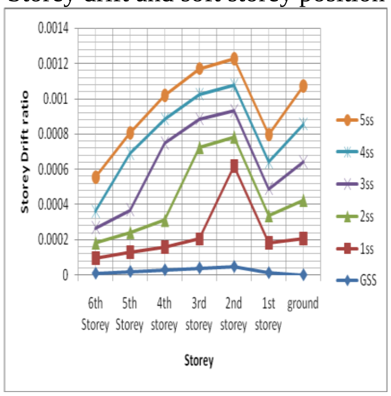

Fig. 3(c): Storey drift and soft storey position (Zone-III)

It has been measured that average 66% lateral sway increased/decreased when seismic zone is altered.

Soft Storey position and Time Period

It is seen from the study that time period of building is gradually decreased than the actual one when soft storey position is goes up [Fig. 4 and Fig. 5].

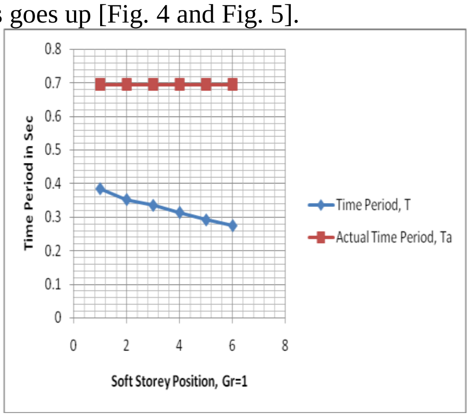

Fig. 4(a): Soft storey position and Time period (Zone-I)

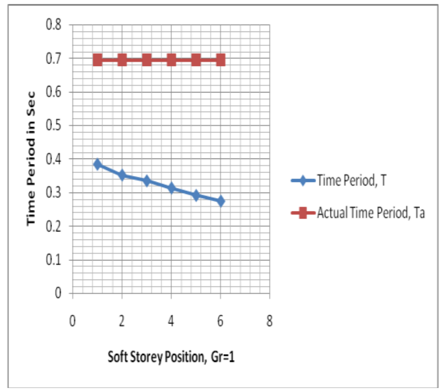

Fig. 4(a): Soft storey position and Time period (Zone-II)

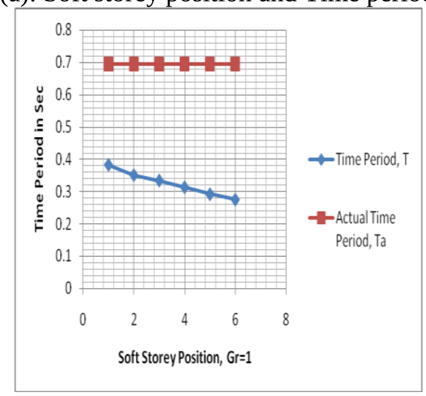

Fig. 4(a): Soft storey position and Time period (Zone-III)

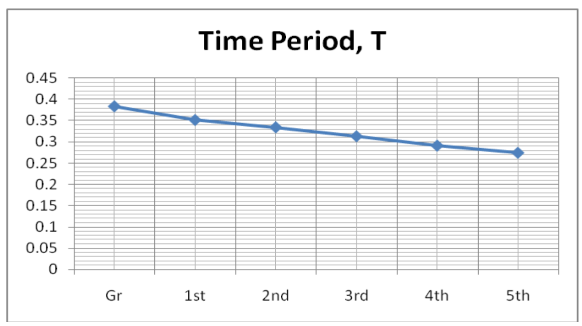

Fig. 5: Effect of Soft storey position in Time period (Zone-I, II and III)

Soft Storey Position and Base Shear

The parameter which has been considered in this section to study the soft story effect in the building is the base shear. Base shear at each level for earthquake force is obtained for six positions of soft storey and three seismic zones in BNBC after performing the analysis on computer program ETABS 9.7.4. Plots of the storey shear versus soft storey position are made for the six positions, all imposed on the same graph. These are presented in Fig. 6. Base shear is found 35.03, 70.06 and 116.45 kips in Zone-I, Zone-II and Zone-III respectively. Base shear in the building for six soft storey position located at seismic zone-II is increased by 100% from zone-I and 232% when located in zone-III. However, no change is noticed due to the change of soft storey position in the same seismic zone.

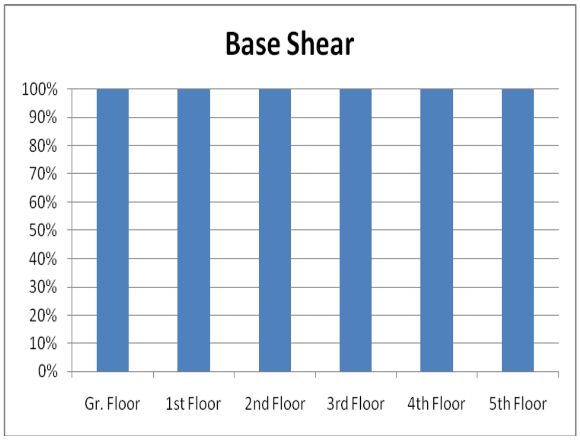

Fig. 6: Base shear variation due to soft storey position.

IV. Conclusion

Storey drift are found maximum on the adjacent upper floor of the soft storey position floor. Base shear is similar for all soft storey position. Time period is found decreasing when position of soft storey goes in upward directions. Exposure category has a minor role in sway and drift.

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