Analysis of Building with Soft Storey during Earthquake

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Abstract - *Nowadays soft storey is a typical feature in the modern construction in urban India. At the soft storey in building, there is a discontinuity in the rigidity of the structure due to absence or lack of infill walls. Generally, the soft or weak storey exists at the ground floor level, but it could be at any other storey level of the building. In this study, seismic analysis of effects of soft storey building frames considering G+6 building, 5 models by varying the soft storey to different floors have been carried out. Soft storeys have been considered by same floor heights and effect of infill walls is ignored. For the analysis of building STAAD PRO v8i is used. Results are collected in terms of storey drift, storey, displacements & base shear.*

Key Words: **Storey, Stiffness, Lateral Displacement, Storey Drift.**

1. INTRODUCTION

In recent time, reinforced-concrete framed structure in has a special feature that is the ground storey is left open for the purpose of social needs like vehicle parking, reception lobbies, a large space etc. Such buildings are often called open ground storey buildings or soft storey buildings. Soft storey buildings, having first storey's much less rigidity than the storey's above are particularly susceptible to earthquake damage because of large, unreinforced open space on their ground floors. Soft storey buildings are characterized by having a storey which has a large open space & as per IS 1893(part 1):2002, clause No.4.20, page No.10. It is one in which the lateral stiffness is less than70% of that in the storey above or less than 80% of the average lateral stiffness of the three storey above.

1.1 General Behavior of Soft Storey

Open ground storey buildings have consistently shown poor performance during past earthquakes across the world. Presence of wall in upper storey makes them much stiffer than the open ground storey. Thus, the upper storey moves almost together as a single block, and large horizontal displacement of the building occurs in the soft storey level. Such a building behaves as an Inverted Pendulum which swing back and forth as shown in fig. 2(a), producing high stresses in columns and if columns are incapable of taking these stresses or do not posses enough ductility, they could get severely damaged. This is also known as inverted pendulum. Storey drift is the displacement of one level relative to the other level above or below.

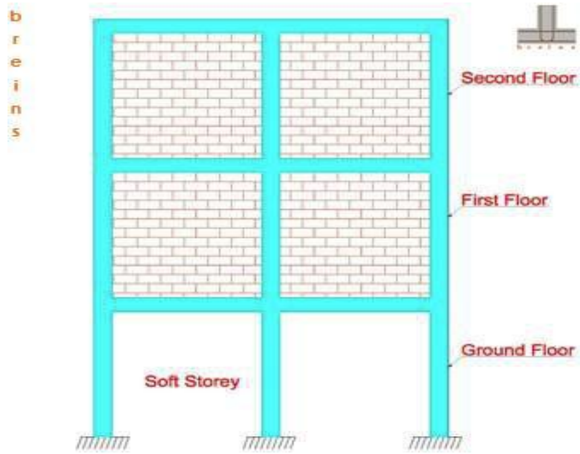

Fig -1: Building with soft storey

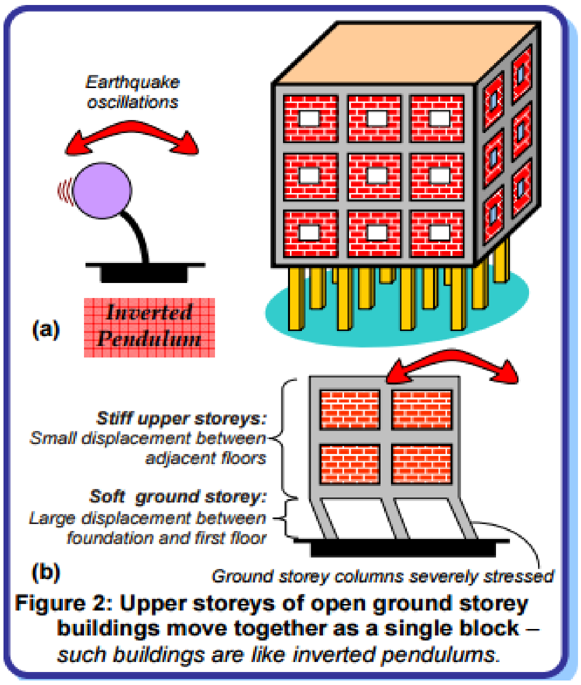

Fig -2: Behavior of soft storey during earthquake

2. LITERATURE REVIEW

- Gaurav Joshi, K.K. Pathak and Saleem Akhtar(2013): In this study, seismic analysis of soft storey building frames have been carried out considering 15 soft storey. Soft storeys have been created by varying the floor heights and effect of infill is ignored. In this way, total 45 frames are analyzed. Results are collected in terms of max. Displacement, max. Moments, max. Shear force, max. Axial force and max. Storey Drift, which are critically analyzed to quantify the effects of various parameters.

- Amit V. Khandve (2012): This study highlights the importance of explicitly recognizing the presence of the open storey in the analysis of the building. The error involved in modelling such buildings as complete bare frames, neglecting the presence of infills in the storeys, is brought out through the study of an example building with different analytical models. This paper indicates measures to prevent the indiscriminate use of soft storeys in buildings.
- Silpa Rani M V, Aiswarya S (2013): This study deals with the study of seismic response of a building with soft storeys at different storey levels. This paper consists the modelling of a G+6 storied irregular RC building. The building is modelled by using the computer program STAAD.Pro V8i software. Parametric studies on displacement, inter storey drift and base shear have been carried out using equivalent static analysis to investigate the influence of these parameter on the seismic behaviour of buildings with soft storey.
- Vipin V. Halde, Aditi H. Deshmukh (2015): In this study the focus is on the investigation of the effect of a soft storey on the behavior of a structure and effect of masonry infill on structure.
- Devendra Dohare, Dr.Savita Maru: In this paper an investigation has been made to study the seismic behavior of soft storey building during earthquake with different arrangement in the soft storey building when subjected to static and dynamic earthquake loading. It is observed that, providing infill improves resistant behavior of the structure when compared to soft storey provided.
- Jaswant N. Arlekar, Sudhir K. Jain and C.V.R. Murty: This study shows about measures to prevent the indiscriminate use of soft storey at ground floor in buildings, which are designed without regard to the increased in displacement, ductility and force demands in the first storey columns. Alternate measures which involve stiffness balance of the open ground storey and the storey above are proposed to reduce the irregularity introduced by the open ground storey.
- Ghalimath.A.G, Hatti M.A (2015): In this paper the study is carried out on difference between soft storey and weak storey by considering IS code provision related to soft storey.

4. BUILDING MODELLING & ANALYSIS

Here is the model of G+6 storey moment resisting RCC frame building having the plan dimensions of 13.78x11.81 m with the floor height of 3.2 m is considered. 5 different models have been made & analyzed which are listed below,

- Model 1: Building without soft storey
- Model 2: building having soft storey at ground floor
- Model 3: Building having soft storey at 2nd floor
- Model 4: Building having soft storey at 4th floor
- Model 5: Building having soft storey at 6th floor

4.1 Other Building Parameter

- Isolated footings (2m X 2m)
- M20 and Fe415
- Column size : 300 mm X 600mm
- Beam size : 300mm X 450mm
- Residential Building

4.2 Loading Conditions

- Dead Loads:
  - a) Self wt. of slab considering 150mm thick. Slab = 0.15x25 = 3.75 KN/m^2
  - b) Floor Finish load = 1 KN/m^2
  - c) Masonry Wall Load (outer) = 0.23 x 3.2 x 18.85 = 13.873 KN/m
  - d) Masonry Wall Load (inner) = 0.115 x 3.2 x 18.85 = 6.94 KN/m

- Live Load = 3 KN/m^2

- Earthquake Loads: As per IS 1893-2002
  - a) Earthquake Zone-III
  - b) Response Reduction Factor : 5
  - c) Importance Factor : 1
  - d) Soil Type: Medium Soil
  - e) Damping : 5%

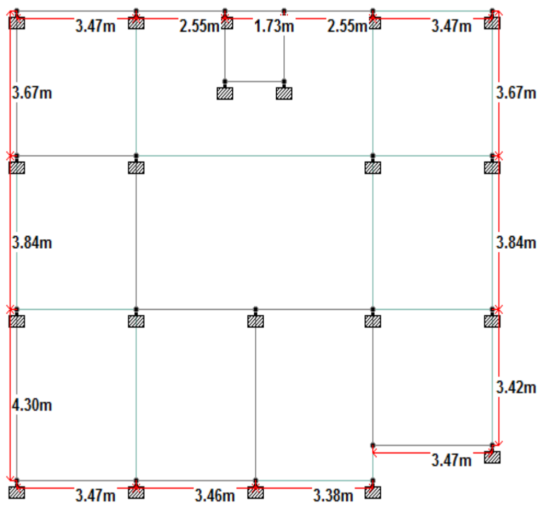

Fig -3: Plan of G+6 residential building

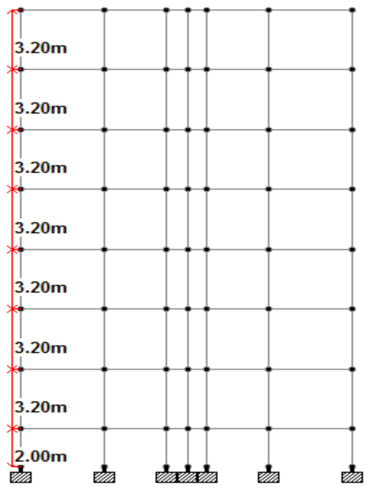

Fig -4: Elevation of G+6 residential building

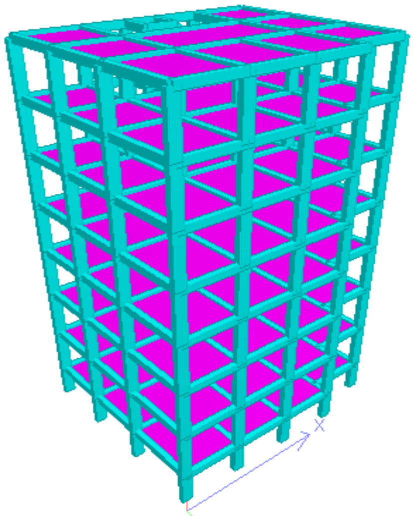

Fig -5: 3D view of G+6 residential building

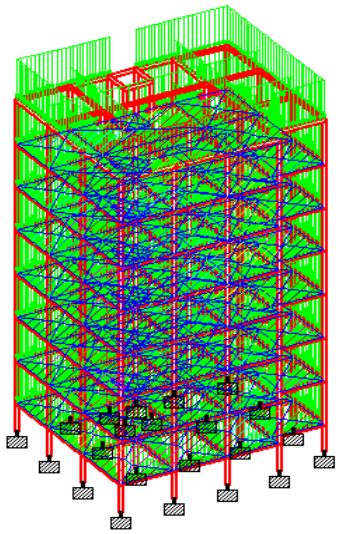

Fig -6: Model 1

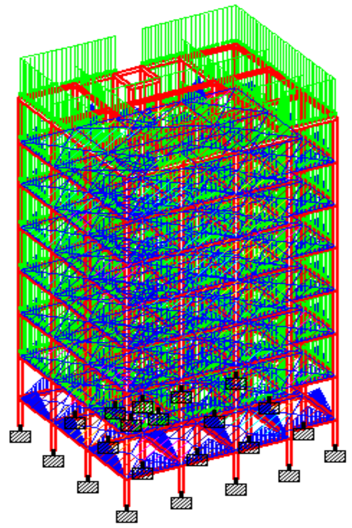

Fig -7: Model 2

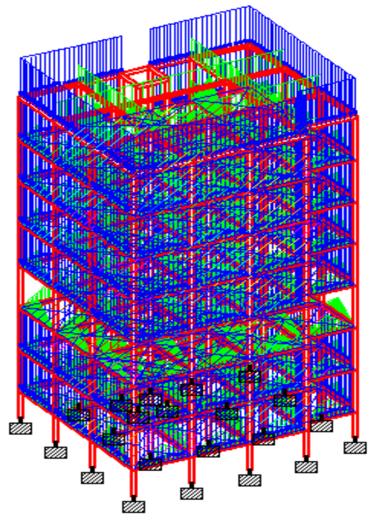

Fig -8: Model 3

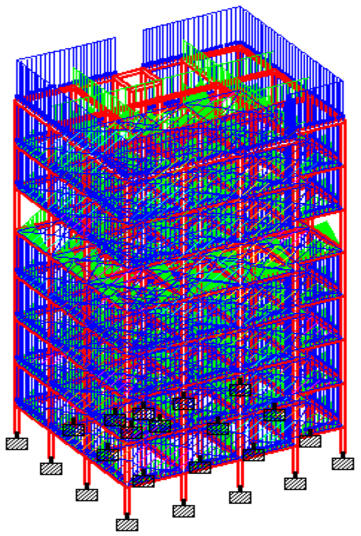

Fig -9: Model 4

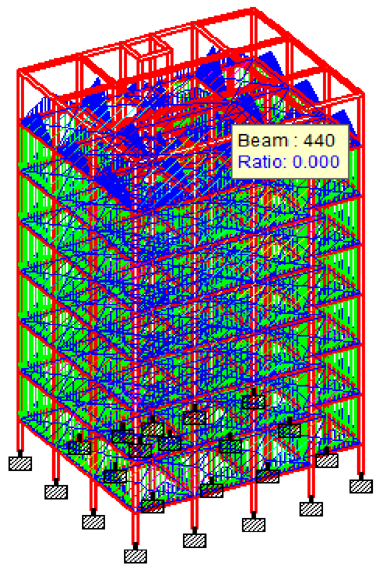

Fig -10: Model 5

5. RESULTS

5.1 Storey Drift in X-direction (cm):

Model / Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Ground floor	0.003	0.0045	0.003	0.003	0.003
1	0.0117	0.022	0.0231	0.0086	0.0232
2	0.0135	0.0273	0.0258	0.0272	0.0272
3	0.0135	0.0135	0.0225	0.022	0.0235
4	0.0127	0.0234	0.0232	0.0206	0.023
5	0.0112	0.0256	0.0218	0.0219	0.0249
6	0.0088	0.0222	0.0221	0.0062	0.02

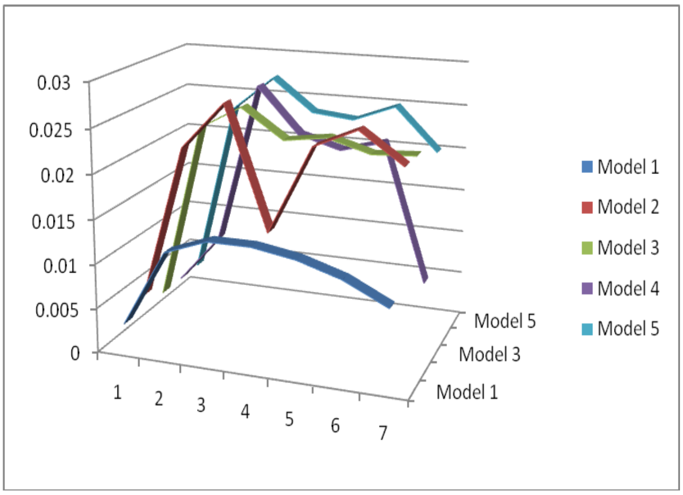

Chart -1: Drift in x-direction (Floor Vs Drift)

5.2Storey Drift in Z-direction (cm):

Model /Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Ground floor	0.0064	0.0093	0.0064	0.0064	0.0064
1	0.0252	0.0456	0.0468	0.0468	0.0467
2	0.0271	0.0534	0.0515	0.0541	0.048
3	0.0269	0.0269	0.0493	0.0504	0.0549
4	0.0253	0.0522	0.0519	0.0506	0.0512
5	0.0223	0.0529	0.0525	0.0464	0.0512
6	0.0176	0.0325	0.0467	0.0335	0.0433

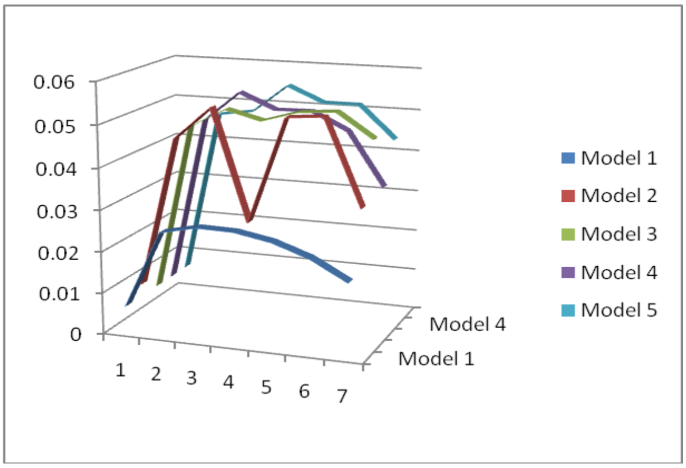

Chart -2: Drift in z-direction (Floor Vs Drift)

6. CONCLUSIONS

In this paper the study done to find the seismic responce of RC frame buiding of G+6 with & without soft storey at different storey levels. After analysis the conclusion which obtained are as follows;

- The building without soft storey is found to be safer during strong ground motions as compared to building having soft storey at any floor.
- The building having soft storey at any floor is vulnerable for damage during earthquake due to lack of stiffness of soft storey. The drift is maximum at the floor having soft storey as compared to adjacent floor levels.
- This type of RCC frame building can safely withstand against seismic activity by providing shear wall or steel bracing or dampers.

ACKNOWLEDGEMENT

It is a great pleasure and moment of immense satisfaction for us to express our sense of profound gratitude and indebts towards our project guide "Asst. Prof. Harshala Agale." Who inspired encouraged and guided us on this project.

We would also like to thanks to our entire civil department of J.D. COLLEGE OF ENGINEERING, "RTMNU" for their full support and also thanks to my all group members of civil engineering department to equally contribution in this project.

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