BEHAVIOURAL STUDY OF STIFFNESS IN SOFT STOREY BUILDINGS WITH DIFFERENT INFILLS

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Abstract - *Open ground storey or soft storey is a typical feature in multi-storey structures in urban areas. This open storey is provided to accommodate parking, reception lobbies, office, communication hall etc. Many of structure having soft storey suffered major damage and collapsed in recent earthquakes. During an earthquake, because of variation in stiffness in soft story and its adjacent floors the inter story drift can occur and the lateral forces cannot be well distributed along the height of building. Lateral forces concentrate on soft story causes large displacement. In this work, an attempt has been made to observe the behaviour of gradual decrease in stiffness of building, by using different types of infill material. This work discusses Optimum Earthquake response of tall buildings by response spectrum method as per IS 1893:2002 (Part- I) in ETAB'S software. Seismic parameters like storey stiffness and storey displacement are checked out.*

***Key Words*: Stiffness, Earthquake, Soft storey.**

1. INTRODUCTION

In present modern rigid frame building upper floor consists of large number of nonstructural rigid components such as a masonry rigid component which includes masonry walls, bricks, stones etc. are attached to the columns. The presence of infill in buildings increases the stiffness of the building. Due to increase of stiffness, the base shear demand on the building increases. In the building without soft storey this increased base shear is shared by both frame and infill walls in all stories. Whereas, in an open ground storey [soft storey] building, where the infill is not present in ground storey, the increased base shear is taken entirely by columns present in ground storey. The nonstructural elements help in reducing the deformation and displacement of columns of the building caused due to horizontal forces.

In this work, an attempt was made to gradual decrease of stiffness with soft storey building at ground floor by using different types of infill materials i.e solid blocks, porotherm blocks and aerated light weight blocks. Response spectrum analysis has been done by using ETABS 2015 software. The results like storey stiffness and displacement are tabulated.

2. LITERATURE REVIEW

Amit V Khandve (2012)[1]. Has worked on identifying the importance of the presence of an open story in G+7 storey building. The author argues for an immediate careful measurement of soft storey building failure, which is designed without considering to the increased displacement, ductility and force demands in the storey columns. He concluded saying that the buildings which are having an open storey shows poor performance during strong lateral force. This study suggests two solutions to avoid above problems they are (a) increasing the stiffness of first storey such that first story stiffness is at least 50% as stiff as second storey. (b) Providing adequate lateral strength in the first storey.

Momin Mohmedakil, P G Patel (2012)[2]. They worked on dynamic earthquake loading is applied on RC frame structure with both Aerated Light weight Concrete (ALC) brick and clay bricks. In this study the buildings are modeled in such a way that about 60% of ALC block infill and conventional bricks are arranged in different manner. Masonry infills are modeled as equivalent diagonal strut method. STAD PRO software was used for dynamic analysis to determine of an earthquake response of the structure. They concluded that the performance of ALC block infill was much better than the conventional brick infill RC frame and also saying that the infill material can also be replaced by ALC block in the earthquake prone region.

N Shivakumar, D Sarayandevi, K Sthish, P Prakash, C Shankardas (2013)[3]. In their study they analysed the variation in dynamic behaviour of buildings when infill incorporated in the model and results were studied in terms of mode shapes. In their analysis response spectrum method gives significant increase in column shear and moment as well as total base shear compared to equivalent static force method when presence of infill. They concluded saying that the design of ground floor columns would be safer if the columns are designed for shear and moment, twice the magnitude obtained from conventional equivalent static force method.

Umesh P, Patil, Suryanarayana M (2015)[4]. In this work the authors evaluated and compared the seismic performance of G+15 storey building. The building was modeled as RCC structure and also composite structure and ETABS 2013 software was used for this purpose. Response spectrum and equivalent static methods were used for analysis. The results obtained from two different models were compared and found that RCC shows poor performance in comparison with that of composite structure.

3. METHODOLOGY

The study includes effect in soft storey building with different type of infills over the height of building. There are three type of infills used in the present study i.e solid concrete block, porotherem block and aerated light weight block. Structures were modeled using ETABS 2015 and the infills were modeled as an equivalent diagonal strut member. Estimation of lateral forces on infill frames were estimated using IS 1893:2002.

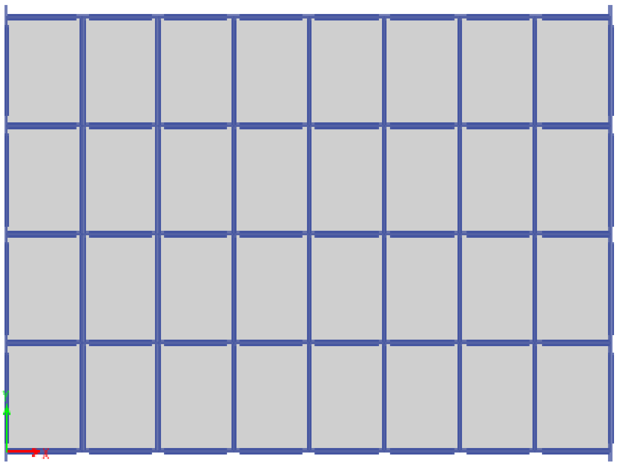


Fig 3.1: Plan of the model

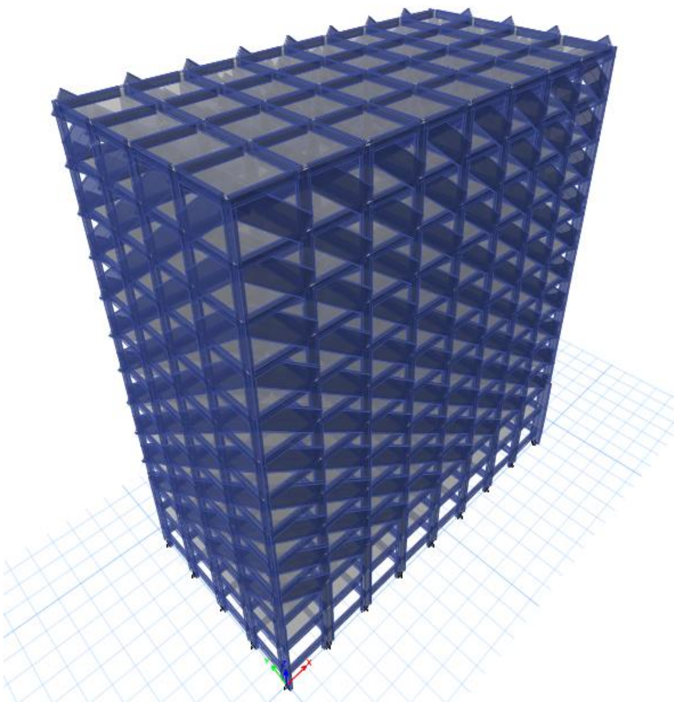


Fig 3.2: 3 D Model of building

Models considered are;

- M1- Solid blocks
- M2- Porotherm blocks
- M3- Aerated light weight block
- MC1- Solid blocks + Porotherm blocks
- MC2- Solid block + Aerated light weight block
- MC3- Solid block + Porotherm blocks + Aerated light weight block

3.1 Determination of the Equivalent Diagonal Strut Width:

The width of the equivalent diagonal strut (w) can be tabulated out by using given formula.

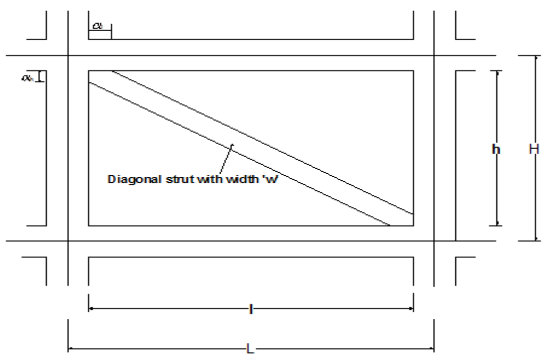


Fig 3.3: Equivalent Diagonal Strut

$$\alpha_h = \frac{\pi}{2}\left(\frac{E_f I_c h}{2E_m t \sin 2\theta}\right)^{\frac{1}{4}}$$

$$\alpha_L = \pi\left[\frac{E_f I_b L}{2E_m t \sin 2\theta}\right]^{\frac{1}{4}}$$

$$w = \frac{1}{2}\sqrt{\alpha_h^{\,2} + \alpha_L^{\,2}}$$

Whereas,
E_m = Elastic modulus of masonry wall.
E_f = Elastic modulus of frame material.
t = Thickness of infill wall.
h = Height of infill wall.
L = Length of infill wall.
I_c = Moment of inertia of column.
I_b = Moment of inertia of beam.
w = Width of diagonal strut.

3.2 Details of proposed building:

Size of building -20mX50m
Number of stories-G+12
Storey height -3.5m
Size of bay - 5m
Number of bays along X direction - 8
Number of bays along Y direction - 4
Floor finish at floor - 1.51 KN/m^2
Floor finish + water proof at roof - 3.71 KN/m^2
Live load at floor - 4 KN/m^2
Live load at roof - 1.5 KN/m^2

3.3 Section properties:

Column:
Grade of Concrete - M45
Density -25KN/m^3
Size - 230mmX1250mm, 230mmX900mm, 230mmX750mm
Modulus of elasticity- 33541.01N/mm^2
Poisons ratio- 0.2
Beam:
Grade of Concrete- M30
Density - 25KN/m^3
Size- 230mmX750mm, 230mmX600mm, 230mmX500mm
Modulus of elasticity- 27386.12N/mm^2
Poisons ratio- 0.2
Slab:
Grade of Concrete- M30
Density - 25KN/m^3
Thickness - 150mm
Modulus of elasticity -27386.12N/mm^2
Poisons ratio - 0.2

3.4 Material properties of an Infill:

Solid concrete block:

Density - 21KN/m^3
Compressive strength -15MPa
Young's modulus of elasticity - 19364.9 N/mm^2

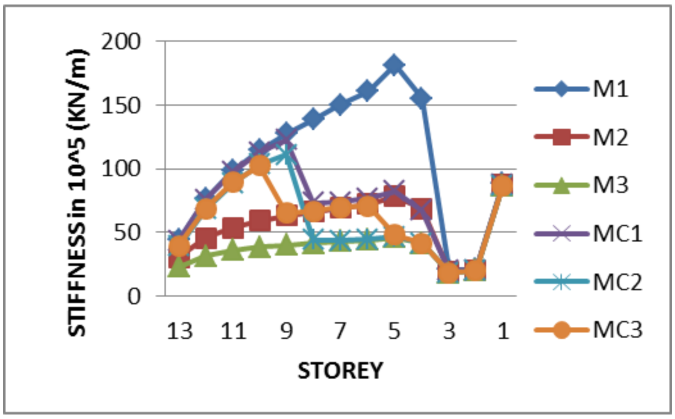
Porotherm block:

Density - 7.55 KN/m^3
Compressive strength -10.7 MPa
Young's modulus of elasticity – 4500 N/mm^2
Aerated light weight block:
Density - 6.5 KN/m^3
Compressive strength - 3 MPa
Young's modulus of elasticity – 1840 N/mm^2

3.5 Earthquake load parameters:

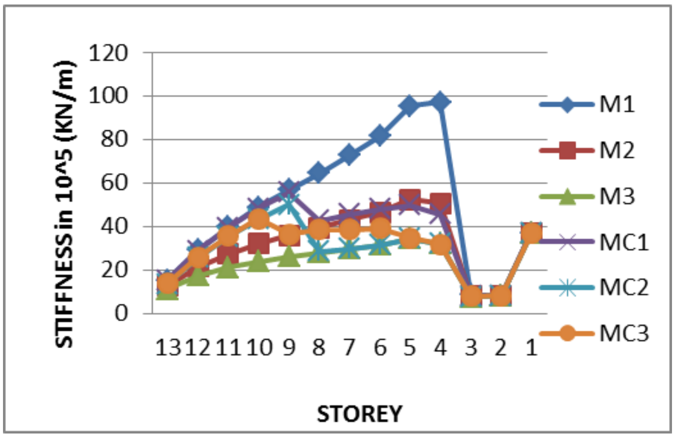
Zone, zone factor Z - III, 0.16
Importance factor, I - 1
Soil type - II
Response reduction factor R - 3
Time period - 0.635sec, 0.915sec(X, Y)
Method of analysis - Response spectrum analysis
Modal combination - CQC
Directional combination - SRSS
Damping ratio - 0.05
Eccentricity ratio - 0.05
Spectrum name – Spec X, Spec Y
Input response spectra - 9.81*I/2*R

4. RESULTS AND DISCUSSIONS

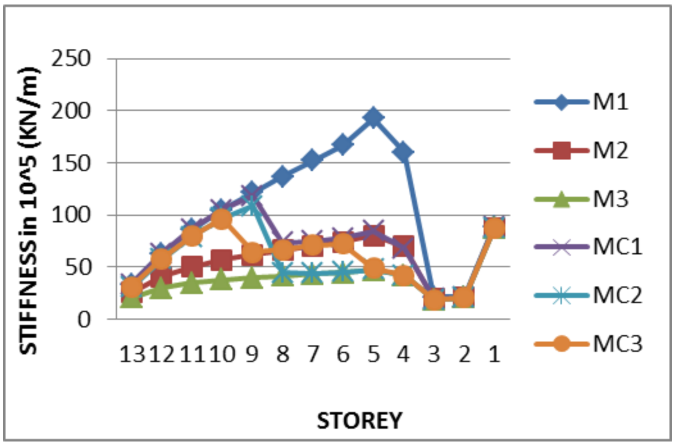


Graph 4.1: Storey stiffness for EQX

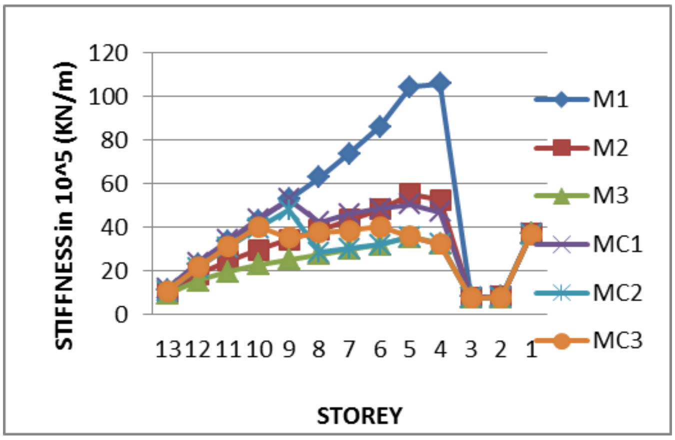
International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072



Graph 4.2: Storey stiffness for EQY

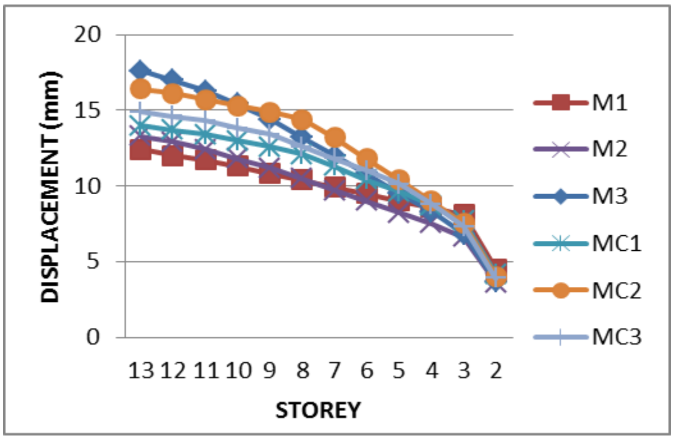


Graph 4.3: Storey stiffness for SPEC X

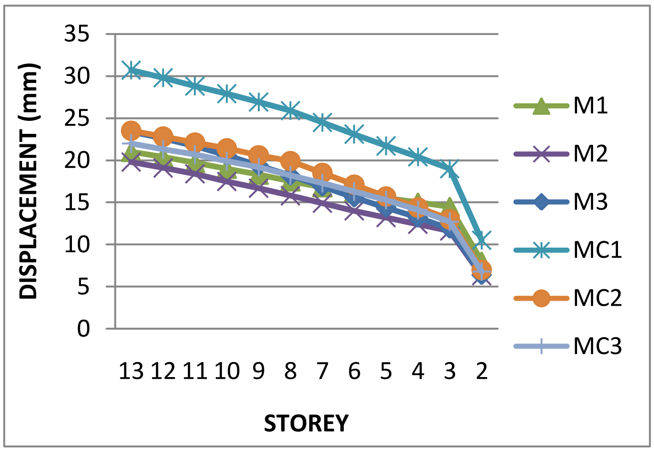


Graph 4.4: Storey stiffness for SPEC Y

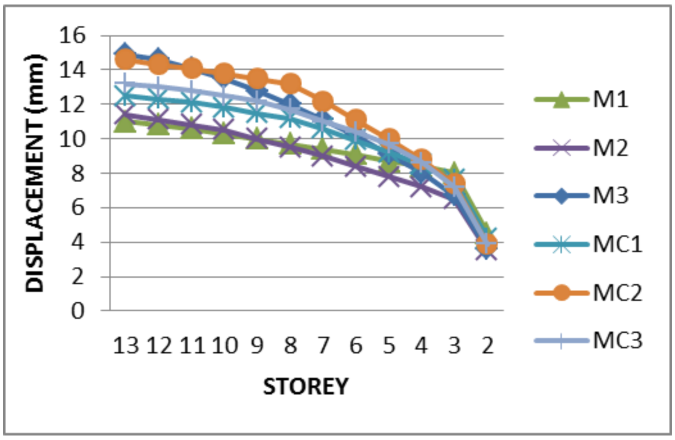
From the above results, it is observed that among M1, M2, M3 models, M1 model shows sudden change in stiffness at 3rd storey level because the bottom two stories are soft storey and the density of infill material used for the upper floors is high. Whereas in combination models MC1 and MC2 the change in stiffness is observed at 4th and 8th storey level. Compared to other models the graduval reduction in stiffness is observed in MC3 models.



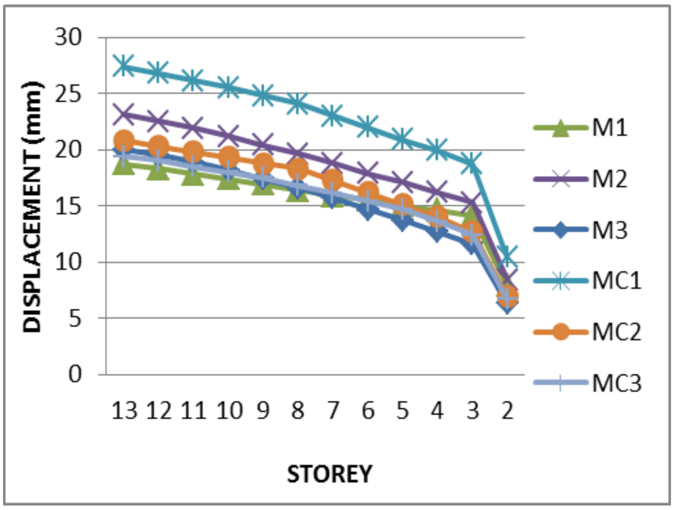
Graph 4.5: Storey displacement for EQX force



Graph 4.6: Storey displacement for EQY force



Graph 4.7: Storey displacement for SPECX force



Graph 4.8: Storey displacement for SPECY force

From the above results, it is observed that among M1, M2, M3 models, M1 model shows less displacement and M3 model shows higher the displacement values. In combination models i.e MC1, MC2, MC3 a change in displacement value is observed at 8th storey level. MC3 model shows good results compared to other models.

5. CONCLUSIONS

Based on the outcomes of the analysis following conclusions are drawn,

1.The models with same kind of infill over the full height of the structure shows sudden variation in stiffness at soft storey level whereas in models with combination of infills, the stiffness varies gradually. The uneven distribution of stiffness of the structure causes failure of the structure near the junction of soft storey and its above floor. The structural components like columns and beams get overstressed at the junction resulting in failure of the structure. This effect minimized by gradual varying the stiffness by using combination of infills. In this work model MC3 shows gradual reduction of stiffness in comparison with other models.

2. The displacement of the structure is a measure of stability of structure, i.e lesser the displacement, more stable. The displacement values of all the models are found within the limits specified by the Indian Codes. The combination model MC3 shows lesser values of storey displacement compared to other models.

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