Comparative Study of Multi-storeyed RC Building With Open Ground Storey Having Different Type Infill Walls

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Abstract—The concept of soft storied buildings has taken its place in the Indian urban environment due to the fact that it provides the parking facility in the lower stories of the buildings. Surveys of buildings failed in the past earthquakes show that this types of buildings are found to be one of the most vulnerable to seismic forces. The collapse mechanism of such type of building is predominantly due to the formation of soft-storey behaviour in the ground storey of this type of building. The sudden reduction in lateral stiffness and mass in the ground storey results in higher stresses in the columns of ground storey under seismic loading. In conventional design practice, the contribution of stiffness of infill walls present in upper storeys of open ground storey framed buildings are ignored in the structural modelling. In this study, static and dynamic analysis of open ground storey RC frame with different infill materials using ETABS will be evaluated and the results compared. The three dimensional RC frame will be considered with assumed sizes of structural members like size of columns, size of beams and thickness of slab. Initially, the material properties are assumed as per code specified. The response simulations will be performed for different categories of bare frame and in filled frame. In this project two types of blocks are used, that is clay brick and fly ash brick. Masonry infill walls have been used in reinforced concrete frame structures as interior and exterior partition walls. Infill substantially alters the behaviour of the building subjected to lateral loads such as wind and earth quake forces. However when subjected to a strong lateral loads, infill panels tends to interact with bonding frame and may induce a load resistance mechanism that is not accounted for the design. From the studies fly ash infilled structure having low value of displacement, drift and period of vibration, due to this it is hypothetically concluded as fly ash is better infill material than brick infill.

Keywords—Soft storey, Infill, Dynamic analysis

1. INTRODUCTION

Reinforced-concrete framed structure in recent time has a special feature i.e. the ground storey is left open for the purpose of parking etc. Such building are often called open ground storey buildings or building on stilts. Open ground storey system is being adopted in many buildings presently due to the advantage of open space to meet the economical and architectural demands. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below. In such buildings the dynamic ductility demand during probable earthquake gets concentrated in the soft storey and the upper storey tends to remain elastic. Hence the building is totally collapsed due to soft storey effect.

In order to prevent such collapse mechanisms in the building structures, seismic demands must be determined accurately. For this reason, many evaluation methods are proposed for the accurate determination of the inelastic behaviours and seismic demands of the building structures. The earthquake codes of many countries such recommend these methods in the analysis of the buildings. Reinforced Concrete (RC) frame buildings with masonry infill walls have been widely constructed for commercial, industrial and residential uses in worldwide. Masonry infill typically consists of brick, clay tile or concrete block walls, constructed between columns and beams of a RC frame. However the presence of masonry walls has a significant impact on the seismic response of an RC frame building, increasing structural strength and stiffness, butintroducing brittle failure mechanisms associated with the wall failure and wall-frame interaction. These help to increase the strength and stiffness of RC frame and hence to decrease lateral drift, higher energy dissipation capacity due cracking of infill and friction between infill and frame. This in turn increases redundancy in building and reduces bending moment in beams and columns. Masonry infill has disadvantages like very high initial stiffness and compressive strength. For a proper design of masonry infilled reinforced concrete frames it is necessary to completely understand their behaviour under repeated horizontal loading.

II. METHODOLOGY

- RC frame buildings (20 models) were modelled using the computer software ETABS, 2009.
- Analysis include model the selected building with and without considering infill wall for different height levels
- Frame elements were modelled with inelastic plastic hinges using point plastic models
- Infills are modelled as equivalent diagonal strut elements
- Analysis of the selected models and comparative study of on the result obtained from analysis
- Analysis includes static and dynamic analysis
III. BUILDING DESIGN AND MODELLING

The study includes effect of height in building with and without infill wall and effect of different type of infill material of building. The present study is based on analysis of number of reinforced concrete multi storied building with and without infill wall. Infills are modelled using clay brick and fly ash brick. Structures were modelled using ETABS. The design lateral force on the infilled frame was estimated using the Indian Seismic Code [1].

Models considered are,
- G+5 Bare frame
- G+5 Brick Infilled frame
- G+5 Fly ash brick Infilled frame
- G+5 Open ground storey Brick infilled
- G+5 Open ground storey Fly ash Brick infilled
- G+10 Bare frame
- G+10 Brick Infilled frame
- G+10 Fly ash brick Infilled frame
- G+10 Open ground storey brick infilled
- G+10 Open ground storey Fly ash brick infilled
- G+15 Bare frame
- G+15 Brick Infilled frame
- G+15 Fly ash brick infilled
- G+15 Open ground storey brick infilled
- G+15 Open ground storey Fly ash brick infilled
- G+20 Bare frame
- G+20 Brick Infilled frame
- G+20 Fly ash brick infilled
- G+20 Open ground storey brick infilled
- G+20 Open ground storey Fly ash brick infilled

A. Details of hypothetical building

Spacing of frames in x direction 5m
Spacing of frames in y direction 4m
Number of bays in x direction 4
Number of bays in y direction 4
Each storey height: 3.5m
Grade of concrete: M30
Grade of Steel: Fe415
Thickness of brick infill: 230mm
Size of beams: 230 x 450mm
Live Load: 3.5kN/m²
Floor Finish: 1.5kN/m²
Soil type: medium

Seismic zone: zone 5
Response reduction factor: 5
Size of columns
For G+5, 300mmX300mm
G+10, 600mmX600mm
G+15, 900mmX900mm
G+20, 1000mmX1000mm

B. Load Combinations

Design of the structures would have become highly expensive in order to maintain either serviceability and safety if all types of forces would have acted on all structures at all times. Accordingly the concept of characteristic loads has been accepted to ensure at least 95 percent of the cases, the characteristic loads considered will be higher than the actual loads on the structure. However the characteristic loads are to be calculated on the basis of average/mean load of some logical combinations loads.

IS specifications [2] and [3] stipulates the combination of the loads to be considered in the design of the structures. The different combinations used were:

- 1.5 (DL + LL)
- 1.2(DL + LL + EQX)
- 1.2 (DL + LL - EQX)
- 1.2 (DL + LL + EQY)
- 1.2 (DL + LL - EQY)
- 1.5 (DL + EQX)
- 1.5 (DL - EQX)
- 1.5 (DL + EQY)
- 1.5 (DL - EQY)
- 0.9 DL + 1.5 EQX
- 0.9 DL - 1.5 EQX
- 0.9 DL + 1.5 EQY
- 0.9 DL - 1.5 EQY

All these combinations are built in the ETABS. Analysis results from the critical load combinations are used for the design of the structural members.

DL - Dead Load
LL - Live Load
EQX – Earthquake Load in X-Direction
EQY – Earthquake Load in Y-Direction
C. Procedure for Masonry Infill Wall Modelling

The frame was assumed to be fixed at the bottom, and the columns and beams were modelled using two noded frame or beam elements. Masonry infill walls were modelled as equivalent diagonal strut using two noded beam elements. The transfer of bending moments from frame to masonry wall was prevented by specifying the moment releases at both ends of the struts. For the beams, the moment hinge and the shear hinge were provided, and for the columns the moment hinge, shear hinge and axial force moment interaction hinge were provided.

D. Properties of infill materials

1) Brick Masonry Infill

Type of material - Isotropic
Mass per Volume -1800 kg/m$^3$
Weight per volume-18 kN/m$^3$
Modulus of elasticity-2625 N/mm$^2$
Poisson’s ratio-0.16
Compressive strength -3.5 N/mm$^2$

2) Fly ash brick infill

Type of material - Isotropic
Mass per Volume-1450 kg/m$^3$
Weight per volume-14.5 kN/m$^3$
Modulus of elasticity-6750 N/mm$^2$
Poisson’s ratio-0.2
Compressive strength -9 N/mm$^2$

E. Determination of The Equivalent Diagonal Strut Width

The width of the equivalent diagonal strut (w) can be found out by using a number of expressions given by different researchers. Recommendations given by ASCE 2006 and by several other provisions and guidelines such as FEMA -356 w can be calculated as,

\[
w = 0.175 \times (\lambda \times h_{col})^{0.4} \times \gamma_{inf}
\]

Where

\[
\lambda = \left( \frac{E_m \times h_{inf} \times \sin 2\theta}{4 \times E_c \times h_{col} \times h_{col}} \right)^{0.12}
\]

\[
\gamma_{inf} = \text{diagonal length of infill panel}
\]
\[
h_{col} = \text{height of column}
\]
\[
h_{inf} = \text{height of infill panel}
\]
\[
E_m = \text{modulus of elasticity of infill}
\]
\[
E_c = \text{modulus of elasticity of concrete}
\]
\[
\tau_{inf} = \text{thickness of infill}
\]
\[
I_{col} = \text{moment of inertia of column section}
\]
B. Dynamic Analysis
C. Non Linear Static Analysis

V. CONCLUSIONS

As earthquake affect the stability of structures we should have take consideration on all possible effect of earthquake and its effects are one of the important criterion for the design of building. In order to reduce the effect of earthquake in building there are lots of methods, in which we are discussed with method includes increasing lateral stiffness of building. For this study different models with different type of infill materials and different heights are analysed. For this linear static analysis, dynamic analysis, and non linear static analysis were considered.

- From all the three analysis displacement, base shear, and drift variation shows the same pattern in each height levels.
- Bare frame structure shows higher value displacement and it is lesser in case of fly ash infilled structure. i.e., in conventional design procedure we are taking a higher value of displacement than the actual structural representation.
- Base shear is lower in case of bare frame, and it is higher in fly ash infilled structure
- Drift is higher for bare frame and it is smaller for fly ash infilled structure
- Period of vibration is higher in case of bare frame and it is lesser in case of fly ash infilled structure.
- The bare frame does not give actual behaviour, which under estimate base shear values and over estimate displacement,drift and period of vibration.
- Fly ash infilled structure having low value of displacement,driftand period of vibration, due to this it is hypothetically concluded as fly ash is better infill material than brick infill

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REFERENCES

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[3]. IS: 875 (part 1and 2)-1987Code of practice for design loads (other than earthquake) for buildings and structures