SEISMIC IMPACT ANALYSIS IN MULTI- STOREY BUILDING USING INFILL

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Abstract- *The term "soft-story" refers to at least one level of a building that's significantly more flexible or weak in lateral load resistance than the stories above it and also the floors or the inspiration below it (70% or greater reduction from one floor to the subsequent in keeping with the fashionable, International codification (IBC) definition). This condition can occur in any of the standard construction types and is usually related to large openings within the walls or an exceptionally tall story height compared to the adjacent stories. These soft stories can present a really serious risk within the event of an earthquake, both in human safety and financial liability. In present scenario soft story building are generally provided . Primarily to come up with parking or reception lobbies. These varieties of buildings are highly undesirable in seismically active areas because various vertical irregularities are created in such buildings which have consistently performed very poor during past earthquake . The presence of infill walls within the entire upper storeys except within the ground storey makes the upper storeys rather more stiffer than the open ground storey. Thus the upper storeys move almost together as one block, and most of the horizontal displacement of the building occurs within the soft ground storey itself and hence the bottom storey columns and beams are heavily stressed.*

The objective of the thesis is to check the effect of infill strength and stiffness within the seismic analysis of mid rise open ground storey building. An existing RC framed building (G+7) with open ground storey located in Seismic Zone-IV is taken into account for this study. This building is analysed for 2 different cases (a) considering both infill mass and infill stiffness and (b) considering infill mass but without considering infill stiffness by equivalent static and response spectrographic analysis methods. Infill weights are modelled through applying static load and also the infill stiffness is modelled by equivalent diagonal strut approach. The results indicates that the magnification factor of two.5 is simply too high to be multiplied to column forces of the bottom storey of the given mid-rise open ground storey building. it's found that the infill panels increases the stiffness of the upper storeys of the structure, thereby increasing the forces, displacement, drift and ductility demand within the soft ground storey. this may possibly become the reason for failure for an open ground storey buildings during the earthquake

KEY WORDS: Response spectroscopic analysis, Equivalent static analysis ,Seismic design principle, structure modelling , Non-linear dynamic ,soft storey , infill wall, varying infill, lateral load

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I. INTRODUCTION

A soft story building may be a multi-story building within which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in places where a shear wall would normally be required for stability as a matter of earthquake engineering design. A typical soft story building is an apartment house of three or more stories located over a ground level with large openings, like a parking garage or series of retail businesses with large windows. concrete frame buildings became common kind of construction with masonry infills in urban and semi urban areas within the world. The term infilled frame denotes a composite structure formed by the mix of an instant resisting plane frame and infill walls. The infill masonry could also be of brick, concrete blocks, or stones. Ideally in nowadays the ferroconcrete frame is filled with bricks as non-structural wall for partition of rooms thanks to its advantages like durability, thermal insulation, cost and straightforward construction technique

Many such buildings constructed in recent times have a special feature - the bottom storey is left open, which suggests the columns within the ground storey don't have any partition walls between them. This styles of buildings having no infill masonry walls in ground storey, but having infill walls altogether the upper storeys, are called as ‘Open Ground Storey (OGS) Buildings’),. This open ground storey building is additionally called as building with ‘Soft Storey at Ground Floor’. they're also referred to as ‘open first storey building’ (when the storey numbering starts with one from the bottom storey it self ‘pilotis’ or ‘stilted buildings’. Open first storey is now a day’s unavoidable feature for the foremost of the urban multi-storey buildings because social and functional needs for vehicle parking, shops, reception etc. are compelling to produce an open first storey in high rise building. Parking floor has become an unavoidable feature for the foremost of urban multi-storeyed buildings because the population is increasing at a really fast rate in urban areas resulting in crisis of car automobile parking space. Hence the trend has been to utilize the bottom floor of the building itself for parking purpose

Severe structural damage suffered by several modern buildings during recent earthquakes illustrates the importance of avoiding sudden changes in lateral stiffness and strength. Recent earthquakes that occurred have shown that an oversized number of existing concrete buildings are at risk of damage or maybe collapse during a powerful earthquake. While damage and collapse thanks to soft story are most frequently observed in buildings, they'll even be developed in other sorts of structures. The lower level containing the concrete columns behaved as a soft story in this the columns were unable to supply adequate shear resistance during the earthquake. there's significant advantage of this sort of buildings functionally but from seismic performance point of view such buildings are considered to possess increased vulnerability. within the current apply of structural design in India infill walls are considered as non-structural components and their strength and stiffness contribution are neglected. The effect of infill panels on the response of ferroconcrete frames subjected to seismic action is well-known and has been subject tovarious experimental and analytical investigations over last five decades.

During an earthquake motion, the soft story behavior is predicated on the factors that the bottom motion will search for all possible weakness within the structure. This weakness could also be a pointy variation within the stiffness, ductility or within the strength parameters. These variations end in the poor distribution of masses throughout the ground, which itself is undesirable.

Many structural damages recorded because of earthquake had a serious problem of change in stiffness and strength along their vertical configuration. it's not only essential to own symmetry along the horizontal direction, i.e. within the plan, but also within the vertical direction. this can be an element that assures lateral stiffness. Abrupt changes within the vertical plan should be avoided to the utmost.

A typical example of the identical is an open story building, where the underside floor is built open for considering the parking utilities and other people spaces, as shown in figure.1. This floor hence incorporates a lower structural stiffness compared to the above floor. It represents a vertical symmetry

Fig. 1:* *Columns in the bottom open story of a six-story building, after undergoing plastic hinge due to the earthquake

II. OVERVIEW OF WORK

The methodology followed out to achieve the above-mentioned objectives is as follows:

- Review of the present literatures by different researchers and also by the Indian design code provision for designing the OGS building
- Selecting the building models for the case study.
- Modelling of the chosen buildings with and without considering their infill strength andstiffness. Models must consider the above mentioned two styles of end support conditions.
- Performing nonlinear analysis of the chosen building models and a comparative study on the results obtained from the analyses.
- Finally the observations of results and discussions

III. NEED FOR THE PROPOSED WORK

The presence of infill walls in upper storeys of open ground storey (OGS) buildings accounts for the following issues:

i) Will increases the lateral stiffness of the building frame.
ii) Decreases the natural period of vibration.
iii) Increases the bottom shear.
iv) Increases the shear forces and bending moments within the groundfloor columns.

The present study try to estimate typical variations in magnification factor of a midrise open ground storey building accounting for the variability of compressive strength and modulus of elasticity of infill walls with numerous infill arrangements in order that it can facilitate designers facing trouble with heavy designs for a structure of midsize, with the given material properties, geometry and loadings specifically.

IV. LITERATURE REVIEW

Since 1960s, studies are dole out to check the influence of infill on the instant resisting frames under lateral loads induced by earthquakes, wind and therefore the blast. Various experimental and analytical investigations are carried out; nevertheless, a comprehensive conclusion has been reached thanks to the complex nature of fabric properties, geometrical configuration and also the high cost of computation. Though the effect of infill is recognised widely, there's no explicit consideration within the modern codes, thus the practising/design engineers find yourself designing the buildings supported judgement.

Infill is generally considered to be the non-structural elements, inspite of its significant contribution of lateral stiffness and strength against the lateral load resistance of the frame structures. Conversely, there's a general misconception among the designers that the infill will increase the general lateral load carrying capacity. this could result in undesirable performance of the instant resisting frames because the infill which wasn't considered during design stage would modify the inherent properties of the concrete frame members. As a consequence, failure in numerous forms would be the result because of additional loads on the stiffened members.

Fig. 4.1: A multi-story at site with floating column

Sattar and Abbie (in 2010) in their study concluded that the pushover analysis has showed a rise in initial stiffness, strength, and energy dissipation of the infilled frames, as compared to the bare frames, despite the wall's brittle failure modes. Similarly, dynamic analysis results indicates that fully-infilled frames has rock bottom collapse risks and therefore the bare frames were found to be the foremost prone to earthquake-induced collapses. the higher collapse performance of fully-infilled frame was related to the larger strength and energy dissipation of the systems, related to the added walls.

J. Dorji and D.P. Thambiratnam (2009) concludes that the strength of infill in term of its Young's Modulus (E) has significant influence on global performance of the structures. The stresses within the infill wall decreases with increase in (E) values because of increase in stiffness of the models. The stresses varies with building height for a given E and seismic hazard.

Hashmi and Madan (2008) conducted non-linear time history and pushover analysis of OGS buildings. The study concluded that the MF prescribed by IS 1893(2002) for such buildings is adequate for preventing collapse. D Menonet. al. (2008) concluded that the MF increases with the peak of the building, primarily thanks to the upper shift within the fundamental measure. Also when large openings are present and thickness of infills is a smaller amount, there's a discount in MF. The study proposed a multiplication factor ranging from 1.04 to 2.39 because the number of storey will increases from four to seven.

Kaushik (2006) conducted a comparative study of the seismic codes particularly on the look of infilled framed structures. The study concealed that the foremost of the trendy seismic codes lack the vital information required for the planning of such buildings. Moreover, the relevant clauses of codes aren't consistent and vary from country to country. Such variations were attributed to the absence of an adequate research information on important structural parameters like determination of natural period of vibration of infilled structures, soft storey phenomenon related to the presence of infill, exclusion of strength and stiffness of infill and considerations of openings. the most reason of not considering the beneficial effects of the infill is because of variation in material property further as brittle nature of failure.

Asokan (2006) studied that how the presence of masonry infill walls within the frames of a building changes the lateral stiffness and strength of the structure. This analysis projected a plastic hinge model for infill wall to be used in nonlinear performance based analysis of a building and concluded that the final word load (UL) approach together with the proposed hinge property provides a far better estimate of the inelastic drift of the building

V. DESCRIPTION OF STRUCTURAL MODEL

Following five models are analyzed using equivalent static analysis and response spectroscopy –
i) Model I: Bare frame model (reinforced concrete frames taking infill masonry weights, neglecting the effect of stiffness).

ii) Model II: Building must no inclose the primary storey and one full brick infill masonary wall (230 mm thick) within the upper storeys .

iii) Model III: Building with one full brick infill masonary wall having openings (model II with openings at the certain panels).

iv) Model IV: Building has no enclose the primary storey and half brick infill masonary wall (115 mm thick) within the upper storeys.

v) Model V: Building with half brick infill masonary wall having openings (model IV with openings at the certain panels).

Details of Structure

Type of structure	*Residential building (G+7)*
Plan dimensions	*20 m X 15 m*
Total height of building	*28 m*

Height of each storey 3.5 m
Depth of foundation 1.3 m
Bay width in longitudinal direction 4 m
Bay width in transverse direction 3 m
Size of beams 230 mm X 400 mm
Size of columns 400 mm X 400 mm
Thickness of slab 125mm
Thickness of walls 230 mm & 115 mm
Seismic zone IV
Soil condition Medium (type II)
Response reduction factor 5
Importance factor 1
Floor finishes 1 kN/m2
Live load at roof level 1.5 kN/m2
Live load at all floors 3 kN/m2
Grade of Concrete M25
Grade of Steel Fe 415
Density of Concrete 25 kN/m3
Density of brick masonry 20 kN/m3
Design philosophy Limit state method conforming to IS 456-2000
It is basically a procedure which governs the vibrational

.Geometry
For the study five different models of a six storey building is considered. The building has five bays in X direction and four bays in Y direction with the plan dimensions 22.5 m × 14.4 m and a storey height of 3.5 m in all the floors and depth of foundation was taken as 1.5 m. The building is kept symmetrical in both orthogonal directions in attempt to avoid torsional response under lateral force. The column is made square and size of the column is kept same throughout the height of the structure to keep the discussion focused only on the soft 1ststorey effect without distracted by the issues like orientation of column.

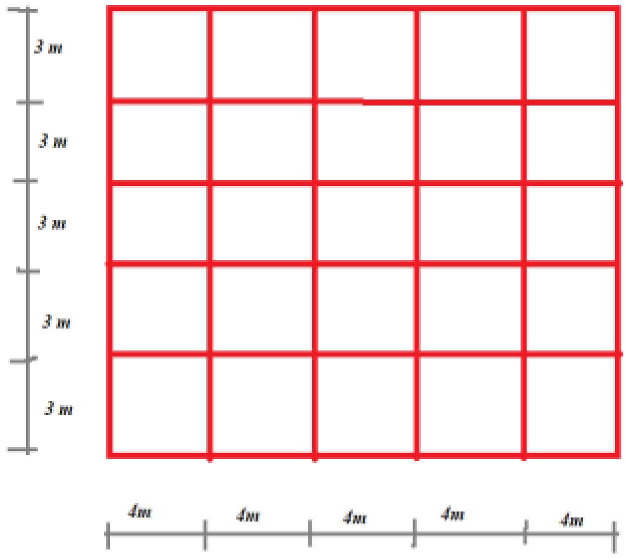
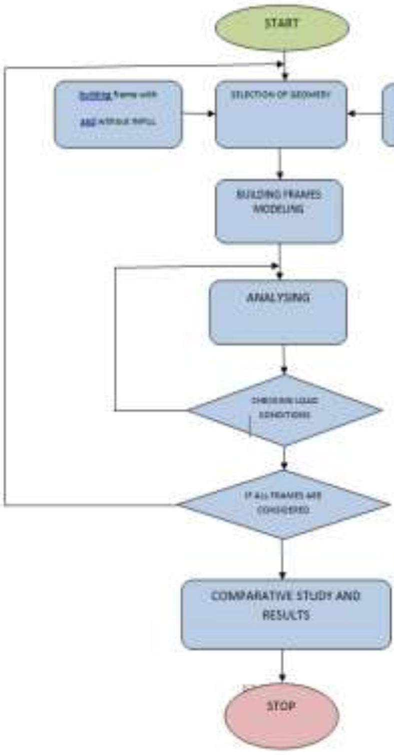


Fig. 5.1 : Plan of the structure

VI. WORKING FLOW CHART



VII. RESULT

Frame with consideration of infill provides a variation of 0.68 to 0.80 times in shear force as compared to frame without consideration of infill whereas a variation of 0.74 to 0.86 times is observed in bending moment due to introduction of infill element in the frame. Reduction in shear force and bending moment in the beams due to introduction of infill can be clearly observed.

	MODEL-I	MODEL-III
Node	FY	FY
1	928.409	916.01
2	1443.947	983.645
3	1453.81	982.401
4	1443.947	967.282
5	928.409	935.924
36	1516.555	1023.374
37	2334.884	740.197
38	2351.599	723.298
39	2334.884	736.157
40	1516.556	1049.532
71	1518.912	1092.209
72	2338.957	730.399
73	2355.742	713.103
74	2338.957	729.103
75	1518.912	1072.825
106	1518.912	1083.149
107	2338.957	729.466
108	2355.742	713.151
109	2338.958	729.122

110	1518.912	1073.635
141	1516.555	1049.684
142	2334.884	735.981

Frame with consideration of infill provides a variation of 0.92 to 0.98 times in vertical support reactions as compared to frame without consideration of infill however Effect of infill on vertical support reactions is found to be insignificant Change in torsional moment and bending moment at support due to introduction of infill is found to be insignificant for given load case.

	MODEL-I	**MODEL-IV**
Node	FY	FY
1	928.409	725.843
2	1443.947	743.767
3	1453.81	747.134
4	1443.947	743.813
5	928.409	726.721
36	1516.555	802.29
37	2334.884	716.755
38	2351.599	715.871
39	2334.884	716.761
40	1516.556	802.515
71	1518.912	823.881
72	2338.957	715.839
73	2355.742	714.239
74	2338.957	715.841
75	1518.912	823.953
106	1518.912	824.166
107	2338.957	715.846
108	2355.742	714.239
109	2338.958	715.847
110	1518.912	824.175
141	1516.555	803.254
142	2334.884	716.77
143	2351.599	715.858
144	2334.884	716.764
145	1516.555	803.244
176	928.409	722.242
177	1443.947	743.132
178	1453.81	746.314
179	1443.947	742.491
180	928.409	724.081

Frame with consideration of infill provides a variation of 0.78 to 0.84 times in the Lateral displacement as compared to frame without consideration of infill. There is a considerable reduction in lateral displacement of roof nodes where as rotation of the roof nodes either nullifies or reduces in most of the cases due to introduction of infill

	MODEL-I	**MODEL-V**
NODE	Ux	Ux
31	-2.196	-2.64
32	-3.048	-2.26
33	-3.064	-2.129

34	-3.048	-2.043
35	-2.196	-1.891
66	-3.262	-2.697
67	-4.235	-2.514
68	-4.254	-2.472
69	-4.235	-2.469
70	-3.262	-2.179
101	-3.265	-2.385
102	-4.24	-2.477
103	-4.259	-2.46
104	-4.24	-2.466
105	-3.265	-2.25
136	-3.265	-2.289
137	-4.24	-2.469
138	-4.259	-2.46
139	-4.24	-2.467
140	-3.265	-2.254
171	-3.262	-2.189
172	-4.235	-2.469
173	-4.254	-2.471
174	-4.235	-2.47
175	-3.262	-2.195
206	-2.196	-1.926
207	-3.048	-2.036
208	-3.064	-2.062
209	-3.048	-2.053
210	-2.196	-1.976

VIII. CONCLUSION

The following are the main findings of the present study –

i) The support forces, deformations do vary with the various parameters related to the infill walls. These kind variations don't seem to be considered in codes and thus the guidance for the planning of buildings having infill walls is termed to be incomplete and specifically for the buildings with soft ground storey, it’s imperative to possess design guidelines very well.

ii) Infill panels increases the stiffness of the structure and therefore the increase within the opening percentage ends up in a decrease on the lateral stiffness of infilled frame. Hence behaviour of building varies with the changes in infill arrangement. this means that modelling of ferroconcrete frame building without infill wall (panel) or bare frame model might not be appropriate for the analysis.

iii) When a bare frame model is subjected to lateral load, mass of every floor acts independently resulting each floor to drift with relation to adjacent floors. Thus the building frame behaves within the flexible manner causing distribution of horizontal shear across floors. In presence of infill wall (panel), the relative drift between adjacent floors is restricted causing mass of the upper floors to act together as one mass. In such case, the entire inertia of the all upper floors causes a big increase in horizontal shear force at base or within the ground floor columns. Similarly increases the bending moment within the ground floor columns.

iv) From this results it's found that, lateral displacement is incredibly large just in case of bare frame as compare to it of infilled frames. If the effect of infill walls are considered then the deflection got reduced drastically. The presence of walls in upper storeys makes them stiffer than open ground storey. Hence the upper storeys move almost together as one block and most of the horizontal displacement of the building occurs within the soft ground storey itself.

It's clear from above stated conclusions that building with soft storey will exhibit poor performance during a robust shaking. But the open ground storey is a vital functional requirement of just about all the urban multi-storey buildings nowadays and hence can not be eliminated. Alternative counter measures must be adopted for this specific situation. The under-lying principles of any solution to the present problem is in (i) increasing the stiffness of the bottom storey; (ii) providing adequate lateral strength in ground storey. The possible scheme to avoid the vulnerabilities of open ground storey buildings under earthquake forces are often by providing stiffer columns in open ground storey building or by providing adjacent infill walls at each corners of soppy ground storey buildings.

IX. SCOPE FOR FUTURE WORK

i) In this study building models are analysed only using linear static analysis and response spectrometry. Although nonlinear analysis methods are more realistic to linear analysis procedures, it's kept outside the scope of the current study because of time limitation.

ii) The effect of soil-structure interaction could also be considered for more realistic analysis.

iii) Building models considered during this study are of mid height. For high-rise buildings shift-in-period may be a further parameter that's not accounted within the present study..

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