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Effects of Masonry Infill in R.C. Structure

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Abstract—*Behavior of R.C structures can be sometimes unpredictable given the condition, misconceived design data which it may lead to severe damage to the life and property, on the other hand, it may undermine the inbuilt bearing capacity of the structural member for which huge monetary loss have to be incurred. In many countries, the lateral load resisting capacity of infill walls are usually neglected due to unreliable design procedure. In this paper, an attempt has been made to analyze and assess the effect of masonry infill wall in R.C building following certain claimed procedure. For the analysis, symmetrical eight-storey building is considered in earthquake zone-5th and the same is modeled as per IS 1893:2002 and IS 456:2000, the diagonal strut infill wall models are modeled as per FEMA 356 and the models are analyzed using SAP-2000[14]. Two types of analysis are carried out i.e. non-linear static analysis (pushover analysis) and non- linear time history analysis for both infill structure and without infill structure. In case of pushover analysis the buildings are found to be CP building in both the cases but the performance displacement of infill structure decreases by approximately 39% as compared to without infill structure and for time history case the maximum IDR% of infill structure decreases by approximately 19% with respect to the without infill structure.*

1. INTRODUCTION

It's been the endeavor of the engineers for the past many years to ascertain the actual effect of the infill wall in RC structure regarding the lateral load resisting capacity against the external lateral load and to establish the real time procedure for its design, if any. Over the years engineers have suggested many analytical models for the modeling of infill strut like diagonal strut model, 2-strut model, 3-strut model, finite element model etc. so, in continuation of the research and to find out the contribution of the infill wall in dissipating lateral load in RC structure, an analysis have been carried out on eight story building with or without infill. A symmetrical eight-storey building is considered in earthquake zone-5th and the same is modeled as per IS 1893:2002 and IS 456:2000, the diagonal strut infill wall models are modeled as per FEMA 356 and the models are analyzed using SAP-2000[14]. Two types of analysis are carried out i.e. non-linear static analysis (pushover analysis) and non- linear time history analysis for both infill structure and without infill structure.

2. DESIGN AND MODELING OF RC FRAMED BUILDING

The eight story buildings are designed and modeled as per IS-1893:2002 and IS-456:2000 with following details.

2.1 Sections used

Plinth beam (B1)	300×500	mm
Beams, (B2)	400×500	mm
Column, C1	400×600	mm
Column, C2	400×500	mm

2.2 Materials used

Concrete (M25)	Fck = 25 N/mm2
Steel (Fe415)	Fy = 415 N/mm2

2.3 Seismic parameters and Load combinations:

The seismic area considered is zone 5th and various other parameters are considered as per code IS 1893 (part-1)-2002. Following are the load combinations considered-

1.0 1.5(DL+LL)
2.0 $1.2(DL+LL\pm E_x)$
3.0 $1.5(DL\pm E_x)$
4.0 $0.9DL\pm 1.5E_x$
5.0 $1.2(DL+LL\pm E_y)$
6.0 $1.5(DL\pm E_y)$
7.0 $0.9DL\pm 1.5E_y$

3. MODELING OF INFILL STRUT

The masonry infill walls are modeled as diagonal strut as per FEMA-356. The equivalent diagonal strut width (a) is calculated by using the equation-

$$a = 0.175(\lambda_1 h_{col})^{-0.4} r_{infil}$$

$$\lambda_1 = [(E_{me} t_{inf} \sin 2\theta)/(4E_{fc} I_{col} h_{inf})]^{0.25}$$

Where,

h_{col} = height of column

h_{inf} =height of infill panel

E_{fc} = expected modulus of elasticity of frame materials.

E_{me} = expected modulus of elasticity of infill materials.

I_{col} = M.I of column

L_{inf} = length of infill panel

r_{inf} = diagonal length of infill panel

t_{inf} = thickness of infill strut.

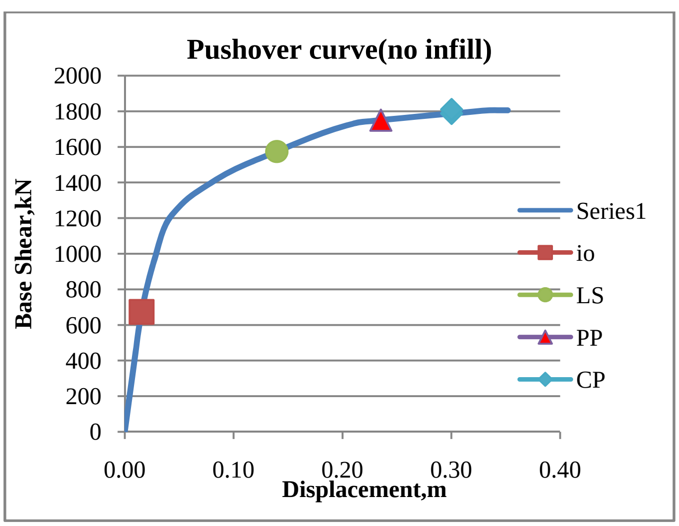
Note: - All lengths are in (inch) and the moduli of elasticity are in (ksi).

4. ANALYSIS OF THE MODEL BY PUSHOVER ANALYSIS

The basic principle of the Pushover analysis is to push the structure with certain increment of load until we get a desired displacement. The buildings are modeled for both infill wall as well as without infill wall in which the infill wall is modeled as an equivalent diagonal strut as per FEMA-356 and the model are analyzed for non-linear static condition using SAP2000[14]. The results of the analysis are appreciated by following performance points-

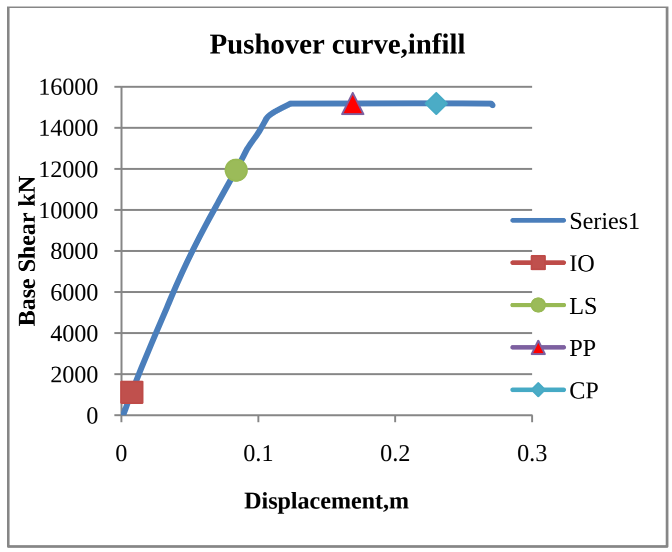
(i) IO=Immediate Occupancy
(ii) LS=life safety
(iii) PP=Performance point
(iv) CP=Collapse prevention

Graph 1.0 shows the results of the analysis carried out on symmetrical eight storey building by Pushover analysis on without Infill structure in which the various performance points are indicated on the curve. The curve which is plotted for joint displacement against base shear indicates that the performance point (PP) is lying between life safety (LS) and collapse prevention (CP). Therefore the building can be considered as collapse prevention (CP) building. Also the curve shows that the building starts yielding slightly at early stage of joints displacement but the performance point shown as immediate occupancy (IO) fall within the point of elastic zone but at the same time it is taking considerable displacement to reach life safety (LS) performance point and slightly shorter interval to reach the target performance point (PP).



Graph 1.0 (No infill)

Graph 2.0 shows the results of the analysis by Pushover analysis on with-Infill walled eight-story building wherein the infill is modeled as equivalent diagonal strut as per FEMA-356 in which the various performance points are indicated on the curve. The curve which is plotted for joint displacement against base shear indicates that the performance point (PP) is lying between life safety (LS) and collapse prevention (CP). Therefore the building can be considered as collapse prevention (CP) building. . The building reaches the yield point at joint displacement less than 0.09m and the performance point the immediate occupancy lies within the elastic zone, also, the performance point, the life safety (LS) falls within the range of elastic zone and yielding occurs at the displacement range of around 0.10m to 0.12m. The target displacement falls into plastic zone with a joint displacement of about 0.16m.



Graph 2.0 (infill)

5. ANALYSIS OF THE MODEL BY NON-LINEAR TIME HISTORY ANALYSIS

The building are modeled for both without infill and with infill where the infill wall is modeled as an equivalent diagonal strut model as per FEMA-356 and the model is analyzed for non-linear time history case in SAP2000[14]. The results obtained in terms of joint displacement and base shear are plotted as inter-storey drift (IDR %) versus base shear in both X –direction and Y-direction. The inter-storey drift is calculated as per the code in compliance with the permissible IDR % of 5% the story height. The IDR % is calculated as below-

IDR % = $(\Delta_{i+1}-\Delta_i)/h \times 100$.

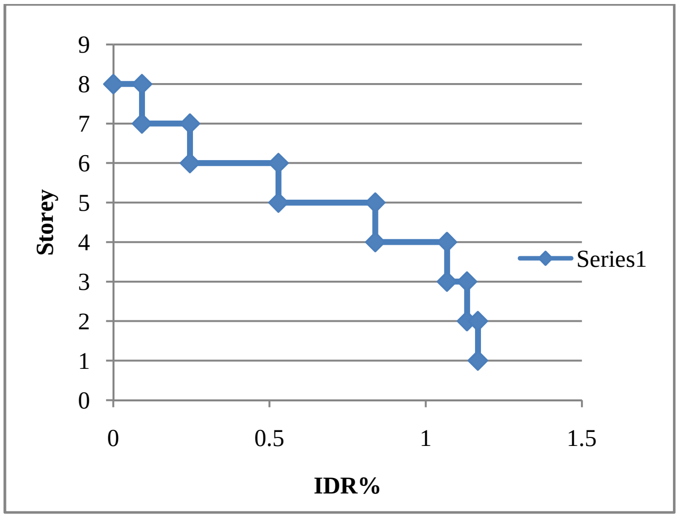
Where,

Δ_{i+1} = Displacement of (i+1)th floor,

Δ_i = Displacement of ith floor,

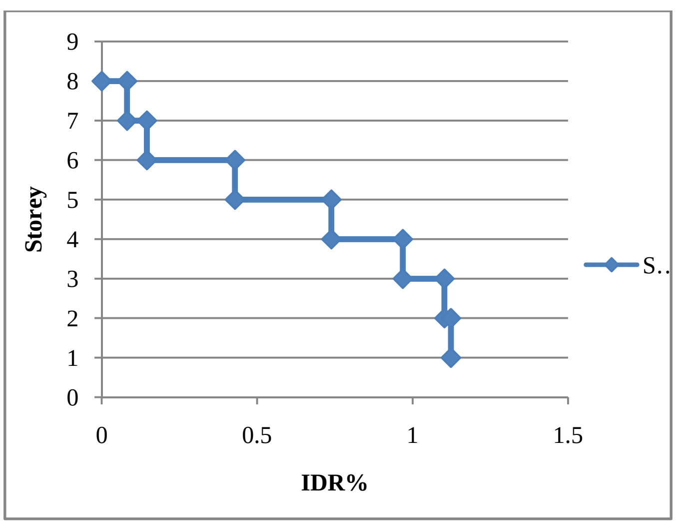
h = height between the ith and (i+1)th floor.

Graph 3.0 shows the result of the analysis for without infill strut in X-direction where the graph is plotted for inter-story drift (IDR %) versus base shear. The graph shows a maximum inter-storey drift percentage (IDR %) of an approximately 1.14%.



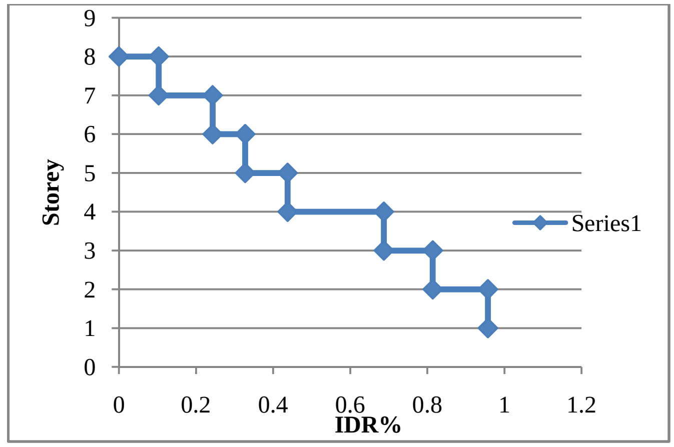
Graph 3.0 No infill in X-direction.

Graph 4.0 shows the result of the analysis for without infill strut in Y-direction where the graph is plotted for inter-story drift (IDR %) versus base shear. The graph shows a maximum inter-storey drift percentage (IDR %) of an approximately 1.11%.



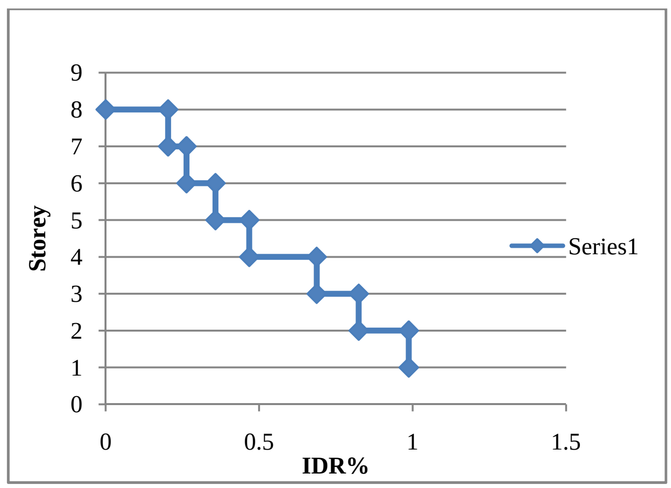
Graph 4.0: No infill in Y-direction.

Graph 5.0 shows the result of the analysis for with Infill strut in X-direction where the graph is plotted for inter-story drift (IDR %) versus base shear. The graph shows a maximum inter-storey drift percentage (IDR %) of an approximately 0.95%.



Graph 5.0: With infill in X-direction.

Graph 6.0 shows the result of the analysis for without infill strut in Y-direction where the graph is plotted for inter-story drift (IDR %) versus base shear. The graph shows a maximum inter-storey drift percentage (IDR %) of an approximately 0.98%.



Graph 6.0: With infill in Y-direction.

6. RESULTS AND DISCUSSION

In case of non-linear static analysis (pushover analysis) the buildings in both the cases i.e. with infill and without infill building, the result curve shows that the performance point of both the building lies between life safety and collapse prevention which means the building is collapse prevention (CP) building but as per as performance displacement is concern, there is remarkable reduction of approximately 39% in performance displacement in case of infill strut building compared to without infill building which implies that the infill wall modeled as equivalent diagonal strut is contributing to the lateral load or seismic load dissipation of the structure up to a certain extent due to its inbuilt stiffness and positioning of the strut in the structure. Moreover, from the graph 1.0 and graph 2.0 it indicates that the structural member of without infill strut attains the yield value little earlier than the structure with infill strut. In other words, the structure with infill strut gives slightly better performance than the structure with without infill structure with regard to the lateral load carrying capacity.

While, in case of non-linear time history analysis of the building in both the cases i.e. with infill and without infill building the result curve shows that the maximum IDR % of both the building lies well within the permissible limit in both X-direction as well as in Y-direction. But there is reduction in maximum IDR % for with-infill strut building in both X and Y direction by approximately 19% and 12% respectively with respect to that of without infill strut structure. It shows that the performance level of the building increases when the infill wall is taken into consideration, while design and analysis of the structure.

7. CONCLUSION

The need for an ideal procedure is vital for the effective assessment of lateral load resisting capabilities of infill structure. The analysis carried out above clearly shows that there is remarkable contribution of infill strut in lateral load dissipation which indicates that the load carrying capacity of an infill wall cannot be neglected in the design of structure so as to accommodate more accurate design details and to reduce the burden of cost of construction. But, more analytical as well as artificially simulated practical approach research need to be carried out in this field so as to ascertain the exact contribution of the infill strut in lateral load dissipation, in precise.

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