Linear Analysis on Infill Wall with Openings Including Shear Wall at Building Core

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Abstract-*RC framed infilled structures are most common type of building these days. Masonry infill walls fulfill essential requirements of the building and make it functional. A lot of research work is done in last six decades on analysis of infill walls, their behavior when they are subjected to lateral seismic loads, but still there's much more to understand about the behavior of infill walls. The structural designers while designing a structure usually neglect the presence of infill walls in the design and analysis. They are treated as non-structural members. Further the presence of openings in masonry infill walls is an interesting part to be studied. Present work is an attempt to study linear static and dynamic analysis of infill wall with different percentage of openings including shear wall at the building core.*

Key Words: **Infill Walls, Openings In Infill Walls, Shear Wall, Equivalent Static Method, Response Spectrum Method, Base Shear, Time Period, Displacement, Drift, Stiffness**

1.0 INTRODUCTION

Reinforced concrete framed buildings are the most common type of multistory structures in India and other developing countries. The space between the frame members i.e. beams and columns are filled with the infill material, it may be either of brick, stone or concrete blocks. The infill material is composite in nature. Moment resisting frames with infill panels, this type of structures are used worldwide for residential, commercial and industrial buildings. The presence of the infill makes the building functional i.e. it is used for partitioning within the building as well as an external wall which safeguards us from the external environment. Also the construction of MI walls is very economic because of availability of materials and labor skills. Masonry infill walls confined by reinforced concrete frames play important role in resisting the lateral seismic loads on the building structure. Due to the complex nature of the masonry material, it is very difficult to predict the behavior of infill material when subjected to seismic loading. It is usually brittle in nature. Infill walls have their own strength and stiffness. Adding its strength and stiffness to the frames and whole building as well. Therefore it has become important to study the combined effect of frame and infill together against the lateral forces acting on them to reduce the damage risk on the building. Further the presence of openings in the infill panels, amount of the openings in panels, and position of openings in the panels have different effects on the performance of the building.

1.1 SCOPE OF THE STUDY

In this paper the study is done on the infill wall analysis with different percentage of opening and including shear walls at the core of building. That is, increasing the percentage of opening and including the shear wall to see how well the structure performs when the lateral road resisting systems like shear walls are included in the building models. Linear static and dynamic analysis is performed in ETABS 2013 version software for number of models. . The parameters studied are base shear, time period, displacement, drift and stiffness.

1.2 OBJECTIVES OF THE STUDY

The objectives of the present work are:

1. To understand the seismic performance of RC framed infilled structures.
2. To study the behavior of structure with different percentage openings in infill panel.
3. To study the performance of building by including shear walls for all models.
4. To compare results for various parameters like base shear, time period, displacement, drift and stiffness of the building models.

2.0 METHODOLOGY

The infill walls are modeled as equivalent diagonal strut for the ease of analysis. The equivalent diagonal strut model or a braced frame model is as shown in the figure below

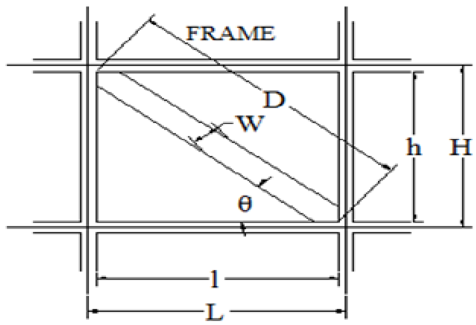

Fig 2.1- Infill panel as equivalent diagonal strut.

The following equation is proposed by Mainstone in the year 1971 for calculating the width of the diagonal strut

$$W=0.175(\lambda H)^{-0.4}D$$

$$\lambda = \sqrt[4]{\frac{E_i\, t\, \sin(2\theta)}{4\, E_f\, I_c\, h}}$$

Where, E_i=modulus of elasticity of infill material in N/mm^2
E_f=modulus of elasticity of frame material in N/mm^2
I_c=momemt of inertia of column in mm^4
Θ=slope of the infill diagonal to the horizontal
t= thickness of infill wall
h= height of infill wall

To account for the presence of opening, a reduction factor is applied to reduce the width of diagonal strut if openings are present.

$$\lambda = 1 - 2\alpha_w^{0.54} + \alpha_w^{1.14}$$

Where, α_w = Infill wall opening %

$$\text{Opening \%} = \frac{\text{Area of opening}}{\text{Area of infill wall}}$$

2.1 BUILDING MODELS AND LOADING DETAILS

Table 2.1- Building data

Particulars	Details
No. of floors	G+8
Plan dimensions	15mx15m
Beam size	230mmx450mm
Column size	300mmx600mm
Slab thickness	150mm
Floor height	3m
Thickness of infill wall	230mm
Thickness of shear wall	200mm
Parapet height	1m
Thickness of parapet wall	150mm
Foundation depth	2m

Table 2.2- Model configuration

No. of storey	Model no.	Type of model
G+8	Model 1	Bare frame(B-F)
	Model 2	Fully infilled frame(FI-F)
	Model 3	20% opening in IW(20%OIW)
	Model 4	40% opening in IW(40%OIW)
	Model 5	Bare frame with SW(BF+SW)
	Model 6	Fully infilled frame with SW(FIF+SW)
	Model 7	20% opening in IW with SW(20%OIW+SW)
	Model 8	40% opening in IW with SW(40%OIW+SW)

Table 2.3- Diagonal strut width

Type of model	Diagonal strut width
Bare frame	-
Infilled frame	416mm
20% opening in infill walls	133.5mm
40% opening in infill walls	55.1mm

2.2 BUILDING PLAN AND 3D VIEWS.

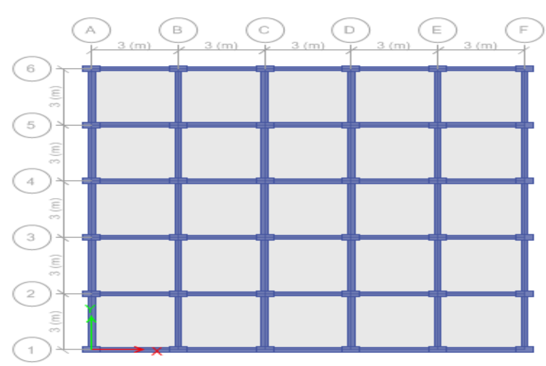

Fig 2.2– Bare frame plan view

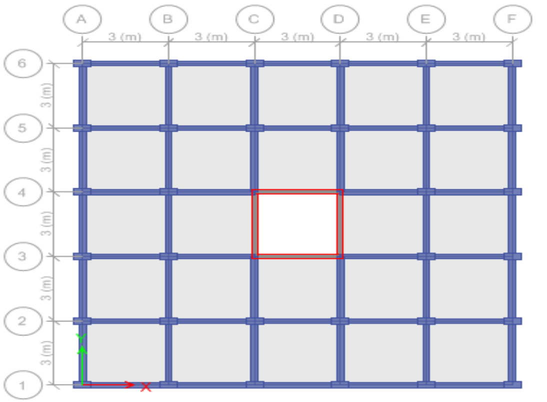

Fig 2.3– Bare with SW plan view

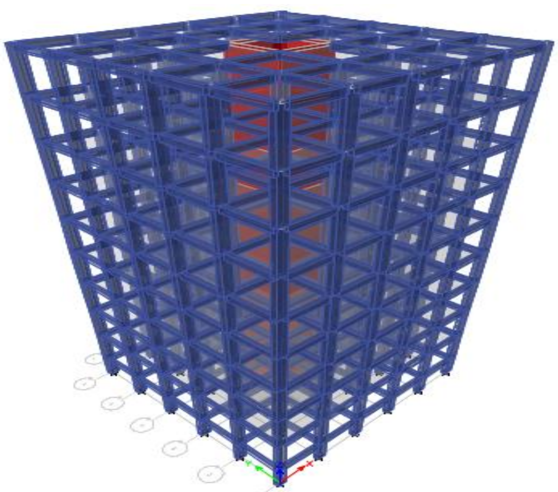

Fig 2.4- Bare frame with SW 3d view

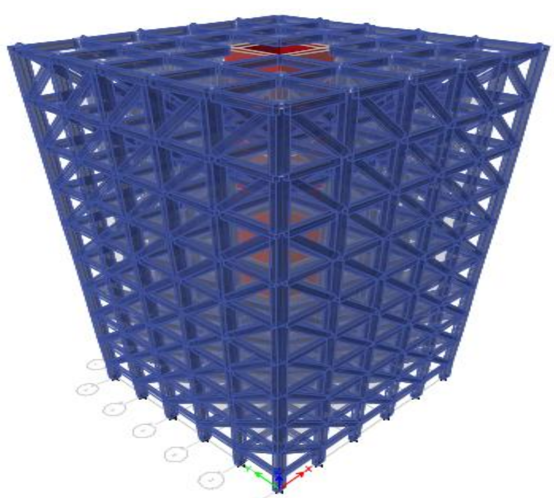

Fig 2.5-Infilled farme with SW 3D view

3. RESULTS AND DISCUSSION

3.1 COMPARISION OF BASE SHEAR

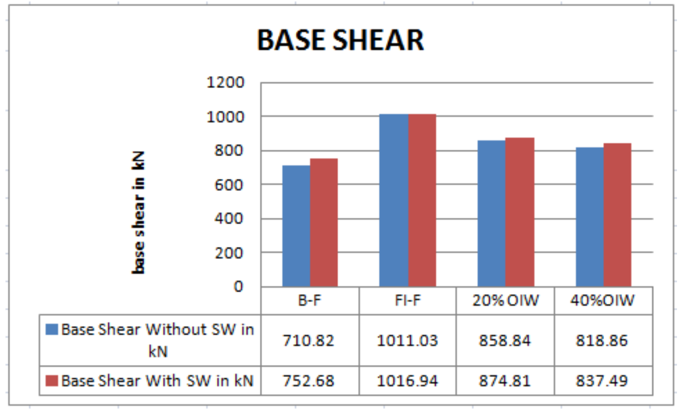

Fig 3.1-Comparision of base shear

- The percentage increase in base shear with respect to bare frame base shear is 42.23%, 20.82% and 15.22% for fully infilled frame, 20% opening in IW and 40% opening in IW respectively.
- The base shear of bare frame compared to bare frame with SW at building core is slightly higher, due to the presence SW. Similar variations can be seen in all the models.
- The base shears of 20%OIW and 40%OIW with and without SW are more than bare frame base shear and less than fully infilled base shear.

3.2 COMPARISION OF TIME PERIOD

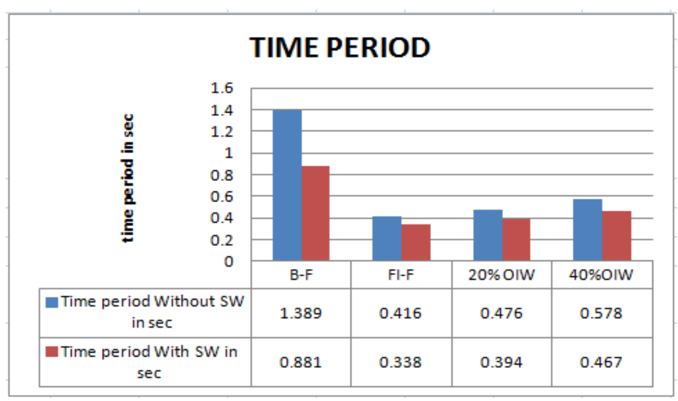

Fig 3.2-Comparision of time period

- The percenatge drop in the period with respect to bare frame is 70.05%, 65.73% & 58.39% for fully infilled frame, 20% in infill wall & 40% opening in infill wall respectively.

- When compared to bare frame the period BF+SW model reduced by 36.57%, period of FIF+SW reduces by 18.75% compared to FI-F model, period of 20%OIW+SW reduces by 17.23% compared to 20%OIW and period of 40%OIW+SW reduces by 19.20% compared to 40%OIW.

3.3COMPARISION OF STOREY DISPLACEMENT

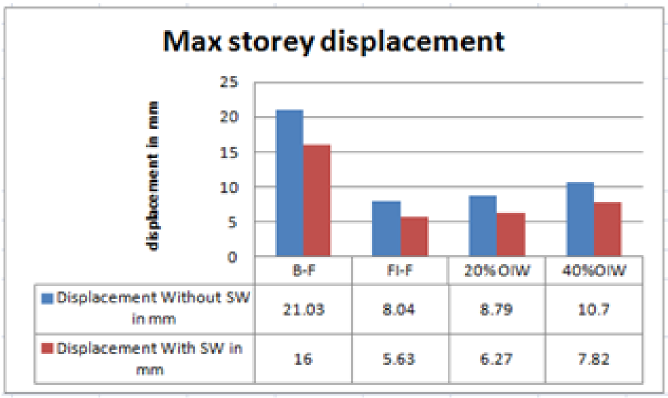

Fig 3.3-Comparision of storey displacement

- The displacement reduction with respect to bare frame are 61.77%, 58.20% & 49.12% for FI-F, 20%OIW & 40%OIW respectively.
- The displacement of BF+SW reduces by 23.92% compared to bare frame, FIF+SW reduces by 29.97% compared to FI-F, 20%OIW+SW reduces by 28.67% compared to 20%OIW, 40%OIW+SW reduces by 26.91% compared to 40%OIW.
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3.4 COMPARISION OF STOREY DRIFT

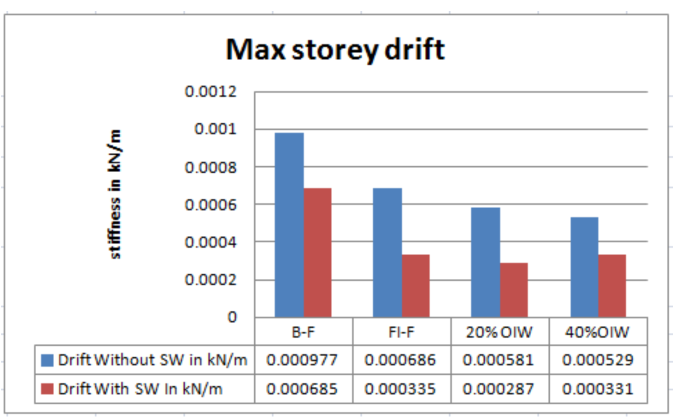

Fig 3.4-Comparision of storey drift

- The reduction in drift with respect to bare frame are 29.78%, 40.53% & 45.85% for FI-F, 20%OIW & 40%OIW respectively.
- The drift of BF+SW reduces by 29.88% compared to BF, FIF+SW reduces by 51.16% compared to FI-F, 20%OIW+SW reduces by 50.60% compared to 20%OIW and 40%OIW+SW reduces by 37.43% compared to 40%OIW.
- The percentage reduction in drift of BF+SW compared to B-F is less i.e. 29.88% compared to other models because other models include both IW and SW.

3.5 COMPARISION OF STOREY STIFFNESS

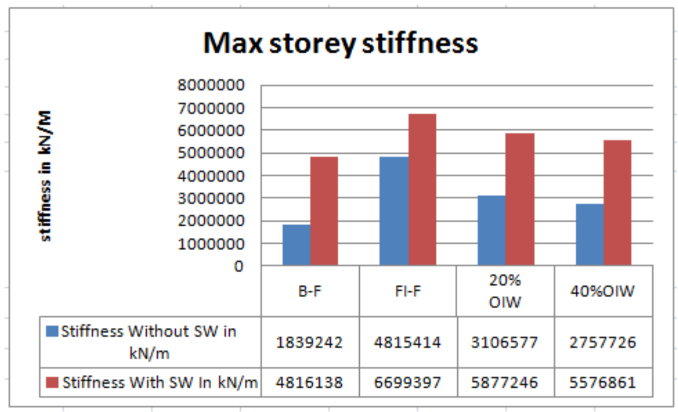

Fig 3.5-Comparision of storey stiffness

- The percentage increase in stiffness with respect to bare frame are 61.80%, 40.79% & 49.94% for FI-F, 20%OIW &40%OIW respectively.
- The stiffness of BF+SW increases by 61.81%% compared to BF, FIF+SW increases by 28.12% compared to FI-F, 20%OIW+SW increases by 47.14% compared to 20%OIW and 40%OIW+SW increases by 50.55% compared to 40%OIW.
- The percentage increase in the stiffness of FIF+SW with respect to FI-F is less i.e. 28.12% because the building is already stiff due to fully infilled IW. Hence the stiffness increase is less when SW is added.

4.0 CONCLUSIONS

Following are the conclusions made based on the results obtained for the work carried out.

- The base shear of bare frame is minimum and fully infilled frame is maximum. Further when openings are present in infill walls, base shear decreases with increase in percentage of opening in infill walls.

- The base shear of with shear wall models are slighlty higher than without shear wall models.
- The time period of bare frame is high and fully infilled frame is low. Time period of the building increases with increase in percentage of opening in infill walls. When infill walls are included in RC frames the time period reduces.
- Time period of models with shear wall further reduces. Presence of infill wall in frame and shear wall at building core reduces the time period.
- Storey displacement is maximum in bare frame but minimum in fully infilled frame. Presence of infill walls in the RC frames reduces the storey displacement effectively. As the percentage opening in IW increases, the storey displacements also increases.
- Storey displacement in with shear wall models is less than without shear wall models.
- Storey drift is more in bare frame. When infill walls are present the storey drift is minimal.
- Storey drift in with shear wall models is low than without shear wall models
- Storey stiffness is minimum for bare frame as there are no infill walls and it maximum for fully infilled frame.
- Storey stiffness of with shear wall models is very high. Therefore the presence of both IW ans SW increases the strength of building structure.

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