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Effect Of Infill Walls On Lateral Load Resistance Of RC Structure In Afghanistan

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Abstract: ***Masonry infilled walls are provided within the reinforced concrete structures without being analyzed as a combination of concrete and brick elements, though in reality they act as a single unit during earthquakes. The performance of such structures during earthquakes has proved to be superior in comparison to the bare frames in terms of stiffness, strength and energy dissipation. Though it has been understood that the infills play significant role in enhancing the lateral stiffness of complete structure. This paper intends to highlight the need of knowledge on infilled frames and the composite action. In this study infill walls have been converted to struts based on formula in 26- storey RCC Model in Afghanistan and analyzed by Response spectrum method based on Afghanistan Building Code (ABC) for one way symmetric plan, considering following cases.***

- ✓ ***Moment resisting frame***
- ✓ ***Moment resisting frame with infill wall consideration***

By using ETAB 2016 the models analyzed and the performance of building is evaluated in terms of Lateral Displacement and storey drift.

Keywords: ***R.C. frame, Lateral displacement, storey drift, Bracing System (BR), Moment resisting system (MR), Afghanistan Building Code (ABC) etc.***

I. INTRODUCTION

It is a general practice in Afghanistan and other developing countries to provide brick masonry infill walls within the columns and beam of Reinforced concrete frame structures. Such composite structures formed by the combination of a moment resisting plane frame and infill walls is termed as "infilled frames". Infill walls provide durable and economical partitions having relatively excellent thermal and sound insulation with high fire resistance. In the areas where the burnt clay bricks are easily available, these infills are made in brick masonry and in other areas, hollow or solid concrete blocks are used. Infill walls are usually provided for functional and architectural reasons and they are normally considered as non-structural elements and their strength and stiffness contributions are ignored in the analysis works despite significant advances in computer technology and availability of modern computational resources. The reasons for ignoring their presence may be due to the complication involved in analysis and also the uncertainty about the non-integral action between infill and the frame. Thus, the analyses of structures are being based on the frames.

When subjected to gravity loads only, the infill walls only add their self-weight. However, an infill wall tends to interact with the frame when subjected to seismic forces. The performance of structures can be greatly improved by the increase in strength arising from the non-structural components; on the contrary, this increase in strength also accompanies an increase in initial stiffness of the structure, which may consequently attract additional seismically induced lateral inertia forces [1]. An infill wall also exhibits energy dissipation characteristics under earthquake loading as the frame members compress the infills at some locations. The infill walls when compressed carry a part of the load by providing strut action to the frame. As such, the infill walls contribute as a surplus benefit during the times of earthquakes.

Generally, all parts of the frame may not include infills as they are provided as per the functional and architectural needs. It has been observed from past earthquakes that the infills contribute in the enhancement of overall lateral stiffness of the structure. Strong infills have often prevented collapse of relatively flexible and weak reinforced concrete frames. Brick

II. REVIEW OF LITERATURE

Sucuoglu & McNiven [2] studied seismic response of reinforced masonry piers that reveal a shear mode of failure. Their study consisted of two parts: first, the results of an experimental program on reinforced masonry piers under cyclic lateral loads were presented. Then some seismic code provisions about seismic design of masonry were evaluated under the light of the experimental observations. They focused on the seismic shear response of reinforced masonry piers. Shear is the dominant failure mode due to the low aspect ratios and high gravity load imposed on piers. They proposed a shear design concept for masonry piers based on experimental observations and analytical evaluation of masonry behavior at ultimate shear resistance level. Their design method was based on diagonal cracking strength of masonry piers. Also web reinforcement was used in design method to provide post cracking capacity.

III. OBJECTIVE AND SCOPE OF STUDY

The objective of this study is to evaluate lateral load resistance parameters of bare frame and bare frame with infill walls.

A. ANALYZED MODELS

Two models have been analyzed

a. BARE FRAME MODEL

This model is 26 storey moment resisting frame

RC Frame Structural Elements properties		
No	**Structural Elements**	**Size**
1	Columns up to 10th floors	(1000x400)mm
2	Columns 10th to 25th floors	(600x400)mm
3	Columns around the elevator	(400x400)
4	Beams	(400x500)mm
5	Floor slab	120mm
6	Cantilever beam	(400x500)mm

Table 1

b. BARE FRAME WITH INFILL WALL CONSIDERATION (DIAGONAL STRUTS) PARAMETERS

This model has been considered as a RC frame with infill wall effect. The infill walls are Autoclaved Aerated Concrete bricks, all outer walls are considered 300mm thick without finishing and all interior walls considered 100mm without finishing. Autoclaved aerated concrete (AAC) is made with fine aggregates, cement, and an expansion agent that causes the fresh mixture to rise like bread dough. In fact, this type of concrete contains 80 percent air. In the factory where it is made, the material is molded and cut into precisely dimensioned units. Below are the [Shree Shakti AAC] Products Technical specification

Density (over dry)	550-650kg/Cum
Compressive Strength	3 - 4.5 N/mm^2
Resistant to Fire	4-6 hrs.
Sound Reduction Index	37-49 dB
Design Density	850 kg/cum.

Table 2

The Modulus of Elasticity "E" of brick Masonry has been considered based on International Journal of Chemical, Environmental & Biological Sciences (IJCEBS) Volume 1, Issue 2 (2013) ISSN 2320 –4087 (Online). This Journal describes Figure.3-1 for "ACB" Modulus of elasticity about (3000 Mpa). Testing programs investigating the elastic properties of high strength lightweight concrete have reported an average Poisson's ratio of (0.2), with only slight-variations due to age, strength level, curing environment, or aggregates used. Hoff et al. (1995) reported similar values for Poisson's ratio for specified density concrete and normal weight concrete.

Bare Frame With Infill Walls Consideration Parameters

This is the same as bracing systems, because infill walls modelled as equivalent diagonal struts for resisting lateral loads. The presence of infill affects the distribution of lateral loads in the framed structure because of the increase of stiffness. The study of interaction of infill with frames has been attempted by using rigorous analysis like finite element analysis or theory of elasticity. But due to uncertainty and complexity in defining the interface conditions between infill and the frames, many approximate methods are being developed. One of the most common and popular approximations is, replacing the masonry infill by equivalent diagonal strut whose thickness is equal to the thickness of the masonry infill, originally proposed by Polyakov (1956) [1].

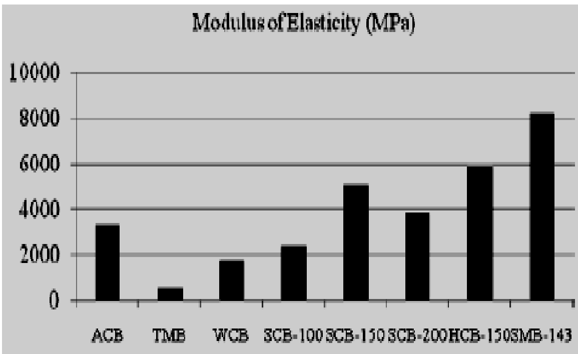

Figure 1

The main problem in this approach is to find the effective width of the equivalent diagonal strut. Many researchers have suggested different method to find the width of equivalent diagonal strut. The width of strut depends on the length of contact between the wall and the columns, 'αh', and between the wall and beams,'αL' as shown in (Figure 3-7). The width of the equivalent diagonal strut varies between, one-third to one-tenth of the diagonal length of masonry infill.

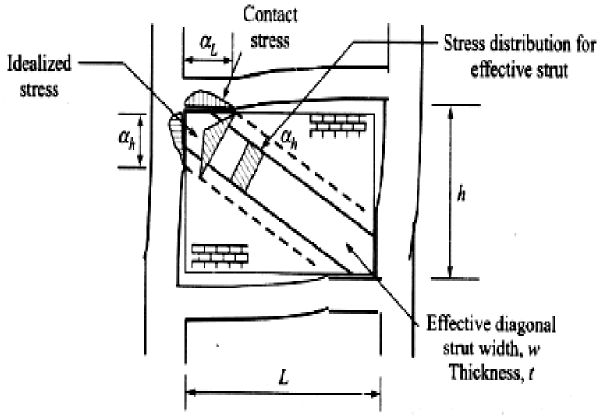

Figure 3- 1: Equivalent diagonal strut (Drydale, Hamid and Baker, 1994)

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

$$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}} \qquad (3.2)$$

(α_h) Length of contact between the wall and columns
(α_L) Length of contact between the beam and wall
(E_f) Modulus of elasticity of frame material
(E_m) Modulus of elasticity of masonry material
(I_c) Moment of inertia for the column
(I_b) Moment of inertia for the beam
(t) Thickness of wall
(W) Width of wall
$\theta = \tan^{-1}(\frac{h}{L})$

After getting these parameters we can find width of strut due to infill walls.

$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$

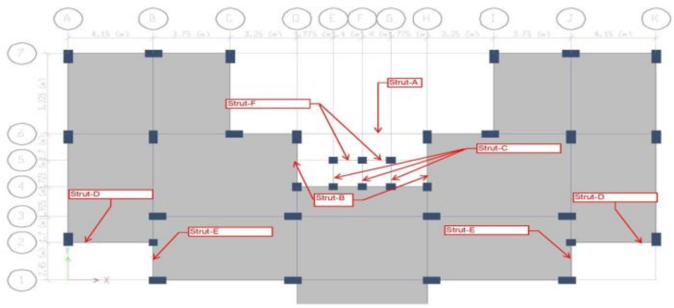

Figure: Plan for diagonal strut locations

IV. CALCULATION OF STRUT WIDTH

STRUT - A

(I_c)=32.66x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L} = \tan^{-1}(\frac{2.5}{6.35})$=21.48 2θ =42.97
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm,$\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =996mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=3182mm,
$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1667mm

STRUT - B

(I_c)=41x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L}) = \tan^{-1}(\frac{2.5}{3.42})$=36.16
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm,$\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =974mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=2507mm
$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1344mm

STRUT - C

(I_c)=21x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L}) = \tan^{-1}(\frac{2.5}{1.72})$=55.39
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm,$\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =828mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=2112mm
$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1134mm

STRUT - D

(I_c)=21x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L}) = \tan^{-1}(\frac{2.5}{4.15})$=31.06
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm,$\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =814mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=2279mm
$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1210mm

STRUT – E

(I_c)=21x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L}) = \tan^{-1}(\frac{2.5}{1.72})$=45.57
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm,$\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =814mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=2279mm
$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1210mm

STRUT - F

(I_c)=21x10^{8}mm^4, (I_b)=41x10^{4}mm^4 , (E_m)=3000 Mpa
$\theta = \tan^{-1}(\frac{h}{L}) = \tan^{-1}(\frac{2.5}{1.72})$=60.75
(E_f)=$57000\sqrt{4000\ psi}$=24855.58 M$_{pa}$

(t)=300mm, h=2500mm, $\alpha_h = \frac{\pi}{2}\left[\frac{E_f \times I_c \times h}{2\times E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$ =848mm

$\alpha_L = \pi \times \left[\frac{E_f \times I_b \times L}{E_m \times t \times \sin 2\theta}\right]^{\frac{1}{4}}$=2063mm

$W = 0.5x\sqrt{\alpha_h{}^2 + \alpha_L{}^2}$=1115mm

V. ANALYSIS METHOD

Response spectrum analysis method has been used during this investigation.

VI. RESULTS

A. 26 STOREY MODEL ANALYSIS RESULTS

Below diagram shows lateral displacements of both systems (bare frame, bare frame with infill walls) under response spectrum analysis.

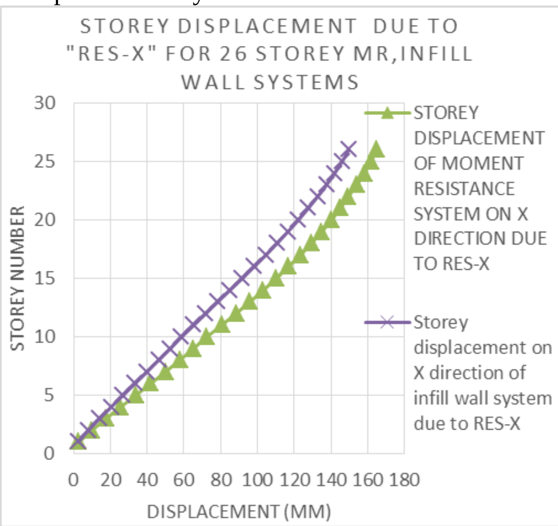

Diagram 1

B. 26 STOREY MODEL STOREY DRIFT RESULTS

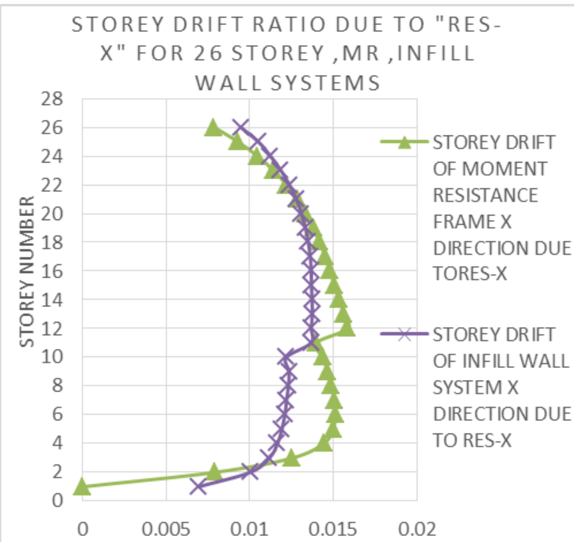

Diagram 2

VII. CONCLUSION

As per results above some important points have been concluded.

- ✓ The results show, infill wall reduced lateral displacement of structure when model as diagonal strut compare to moment resisting system due to lateral loads.
- ✓ Maximum storey displacement on X direction for infill walls, and moment resisting systems are 150mm and 167 mm respectively.
- ✓ It show about 11 % decrement compare to moment resisting frame.
- ✓ Maximum storey drift ratios on X direction for infill wall and moment resisting systems are 0.0136, 0.0158 respectively
- ✓ The design storey drift for infill wall, MR systems are 51mm, 58mm respectively .this results shows that infill wall reducing lateral displacements because of mass and stiffness increment to the structure.
- ✓ As we modeled only some walls as diagonal struts, but if we consider all walls as diagonal struts we may achieve lower results then above, but as we cannot define the real property of all types of infill materials so it will be hard to consider infill walls for lateral stability under seismic loads.

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