Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 6, Issue 4; April-June, 2019, pp. 194-199

http://www.krishisanskriti.org/Publication.html

Seismic Analysis of Brick Infill RCC Framed Buildings in Hilly areas using Equivalent Diagonal Strut Method

Saraj Saha[1] and S.K Madan[2]

[1]M.Tech Scholar, Department of Civil Engineering, NIT Kurukshetra, Kurukshetra, Haryana, India 136119
[2]Professor, Department of Civil Engineering, NIT Kurukshetra, Kurukshetra, Haryana, India 136119
E-mail: [1]sarajsaha1993@gmail.com, [2]mail:skmadan62@yahoo.co,in

Abstract—*Unreinforced Masonry infill walls (URM) are a common form of construction used in a three-dimensional RCC framed building structure. In the design and assessment of building, the infill walls are usually treated as nonstructural element and they are ignored in analytical models because they are assumed to be non-beneficial to the structural response. URM, however, has a significant contribution as it not only increases the strength and stiffness of the structure but also imparts higher seismic force to the building due to its stiffening effect. In the present study the influence of URM on the seismic response of RCC buildings resting on hill slopes is studied. The hill slopes considered are 20°, 30° and 40°. The analysis is conducted for hills in seismic zone IV. Equivalent strut methodology given by IS 1893:2016 (part-1) is used to model the infill walls. Linear dynamic Response spectra analysis of building model is performed using ETABS 16 software. Analysis has been carried out for Step back, Step back-Set back building with and without the infill walls on varying hill slopes. The performance of the building is evaluated in terms of storey drift, lateral deflection andstorey stiffness.*

Keywords: *Unreinforced Masonry Infill Walls(URM), IS 1893 (part1)-2016, Step Back building, Step back-Set back Building, Storey Drift, Base Shear, Storey Stiffness, Equivalent Diagonal Strut*

Introduction

Due to the lack of flatlands in hilly areas, construction activities are compelled to sloping grounds resulting in the construction of various important buildings such as hospitals, schools, etc, on hilly slopes. Also because of the rapid growth and urbanization in hilly regions, real estate development market has also observed major leaps in its construction activities. Due to this, population density in the hilly region has increased enormously. Therefore, there is popular and pressing demand for the construction of multistorey buildings on hill slope in and around the cities.Such buildings in slopes are exposed to higher shear and torsion as compared to buildings on plain lands. An inaccurate modelling of the structure can lead to unacceptable circumstances resulting in failure of the building.

The infill walls were considered as a non-structural element in the analysis and contributed only as dead load that was superimposed on the beams. However, it has been observed that the presence of infill walls in multistorey buildings has a much greater significance in the analysis. The overall stiffness and strength of the frame increases greatly due to the in-plane stiffness and strength of the infill walls. Also, the energy absorption capacity of the frames with infill walls is higher than their bare frame counterparts due to their bracing functions.IS 1893-2016 (Part 1) provides guidelines for the inclusion of the Unreinforced masonry infill wall into the analysis of the structure using "Equivalent Diagonal Strut "method. In the present study, analysis has been carried out on 8 storey Step back and Step back- Set back building resting on hilly areas with slopes of 20, 30 and 40 degrees using ETABS 2016. Various seismic parameters of the building have been computed and compared with and without the presence of infill walls.

Methodology

The simplest way to define the infill panel in a frame is the Equivalent diagonal strut. The principle behind the method is that the infill frame can be assumed as a brace frame and it functions similar to the diagonal strut. As per IS1893: 2016 (Part 1), in RC buildings with URM infill walls, consideration of in-plane strength and stiffness of URM infill walls is important in order to examine the variation of storey strength and stiffness. The estimation of in-plane stiffness and strength of the URM infill walls is calculated by considering the following provisions-

(i) The modulus of elasticity E_m(in MPa) of masonry infill wall shall be taken as:

$$\mathbf{E_m} = 550\, f_m$$

$$\mathbf{f_m} = 0.433\, f_b^{0.64} f_{mm}^{0.36}$$

where

f_b = compressive strength of brick in MPa: and

f_{mo}= compressive strength of mortar, in MPa

(ii) URM infill walls are modelled by using Equivalent diagonal strut as below-

a) The ends of the diagonal strut are considered to be pin – jointed to the RC frame.

b) For URM infill walls without any opening, width $w_{ds}$of equivalent diagonal strut is taken as:

$$w_{ds} = 0.175\ \alpha_h^{-0.4} L_{ds}$$

where

$$\alpha_h = h\ (\ E_m t \sin 2\theta \ /\ 4\ E_f I_c\ h)^{-0.25}$$

where E_m and E_f are the modulii of elasticity of the materials of the URM infill and RC MRF; I_c is the moment of inertia of the adjoining column; t is the thickness of the infill wall; and θ the angle of the diagonal strut with the horizontal.

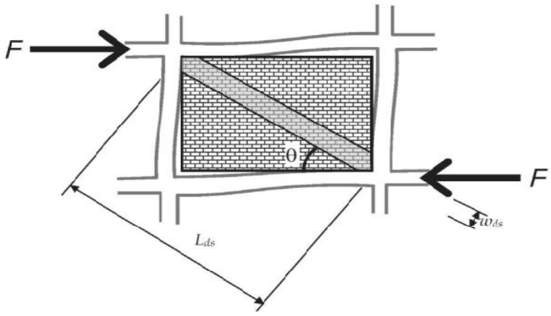

Figure 1: Equivalent diagonal strut model of URM infill wall.

Modelling

In this study, model of an eight storey Step back building and Step back- Set back building shown in figure having storey height of 3.5 m with and without the addition of infill panel as a structural member have been modelled and analyzed using ETABS16 software. Properties of the material considered have been mentioned in table-1 and the dimensional properties have been mentioned in table-2. The figure of the various models considered are shown in the figures below.

Table 1: Material Properties

	Materials		
	Concrete	**Steel Reinforcement**	**Brick Masonry Infill**
Grade Strength (N/mm²)	**M25**	**Fe500**	**10.5**
Density(kN/m³)	**25**	**78.5**	**20**
Modulus of Elasticity(N/mm²)	**25000**	**200000**	**2457.04**
Poisson's ratio	**0.2**	**0.28**	**0.2**

Table 2: Dimensional Properties

Specification of Model Element	
Total Height	**28 m for Step Back** **28 m for Step back- Set back**
Column Size	**550x550 mm**
Beam Size	**300x500 mm**
Slab Thickness	**150 mm**
Masonry Wall Thickness	**230 mm**
Equivalent width of Strut	**0.7011 m** **5.367 m span length**

Step back building model

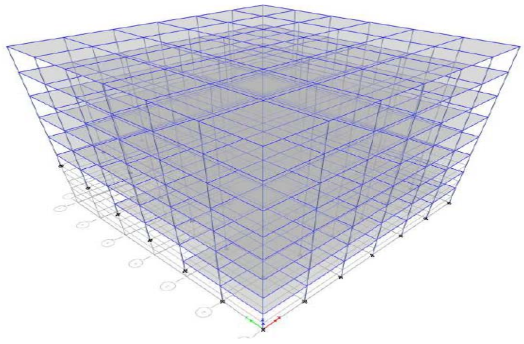

Fig. Bare frame model on 20° slope

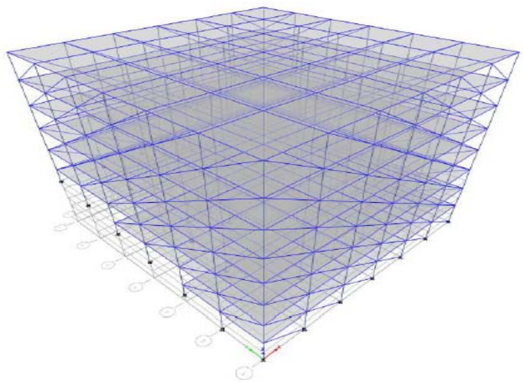

Fig. Brick infill model on 20° slope

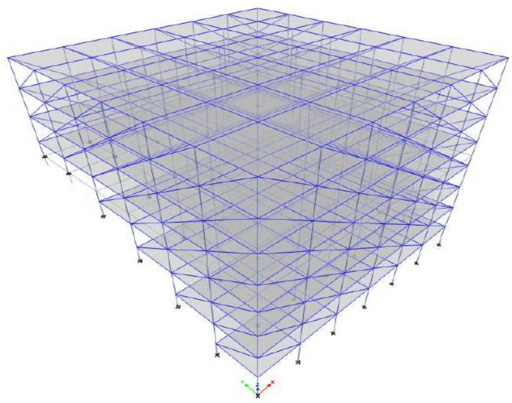

Fig. Brick infill model on 30° slope

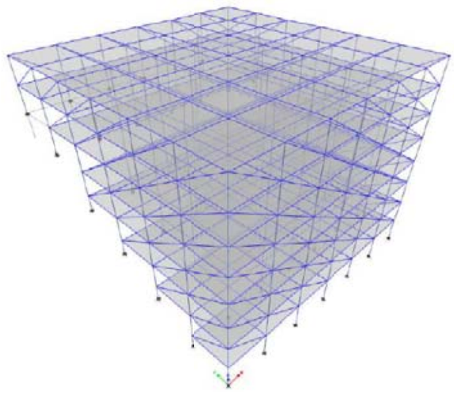

Fig. Brick infill model on 40° slope

Step back-Set back model

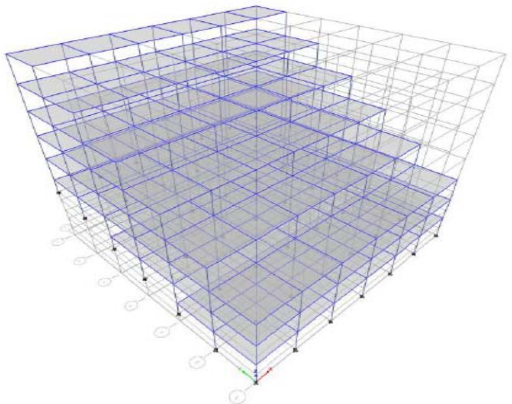

Fig. Bare frame model on 20° slope

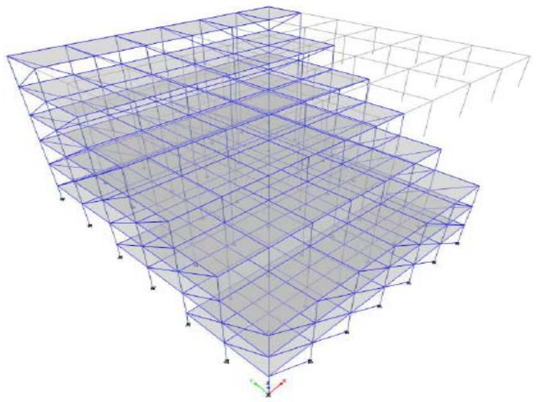

Fig. Brick infill model on 20° slope

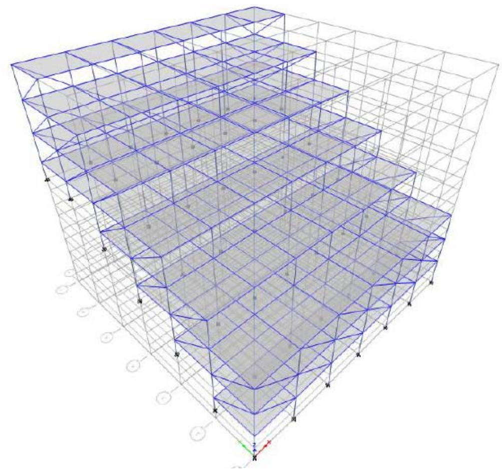

Fig. Brick infill model on 30° slope

Analysis

Modelled frames have been assigned the general loading as per IS 875 (part1, part2) and seismic loading as per IS 1893(Part1):2016. The loading data and the seismic factors used for analysis are shown in table-3. Various models of Step back building and Step back- Set back building are analyzed using the linear dynamic response spectra method and their results are obtained using ETABS16 software.

Calculation of width of Equivalent Diagonal Strut

Considering brick of compressive strength = **10.5Mpa**

And mortar of grade H1(as per IS 1905:1987) having compressive strength=**10Mpa**

$\mathbf{f_m}$ = 0.433 x $10.5^{0.64}$ x $10^{0.36}$ = **4.4673 Mpa**

$\mathbf{E_m}$= 550 x 4.4673 = **2457.04 Mpa**

$\boldsymbol{\alpha_h}$= 3000 [{2457.04 x230 x sin(2x3/4.45)/4 x 25000 x 7.6 x 10^9 x 3000}$^{1/4}$]=**2.0769**

Length of Equivalent diagonal strut = **5.367 m**

$\mathbf{W_{ds}}$ = 0.175 x $2.0769^{-0.4}$ x 5.367 = **0.7011m**

Ends of the equivalent diagonal strut are connected to RCC frame via pin connection.

Table 3: Loading data

Seismic data and loading	
Earthquake load	**As per IS 1893 (part1):2016**
Seismic zone	**IV**
Zone factor	**0.24**
Importance factor	**1**
Response reduction factor	**5**
Soil type	**Medium stiff soil**
Damping	**5%**
Live load	**3 KN/m²**
SIDL	**75mm thick floor finishing 1.875 KN/m²**

Results and Discussions

The analysis results for the buildings considered with and without the unreinforced masonry infill walls have been compared below. In the figures shown, the change in the lateral deflection, storey drift and storey stiffness **in x-direction** of Step Back building and Step back-Set back building after the introduction of Equivalent diagonal strut have been represented with the help of line graphs. Bare frame considered is of the building on 20 degree slope.

Comparing results for Step Back building

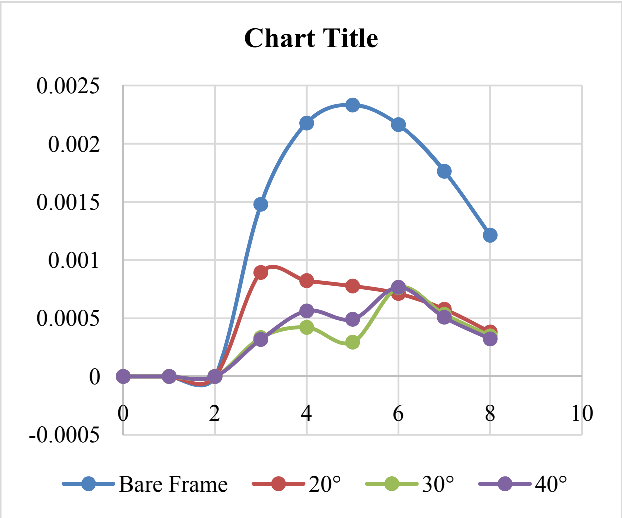

Fig 5: Comparison of Storey Drift in x direction

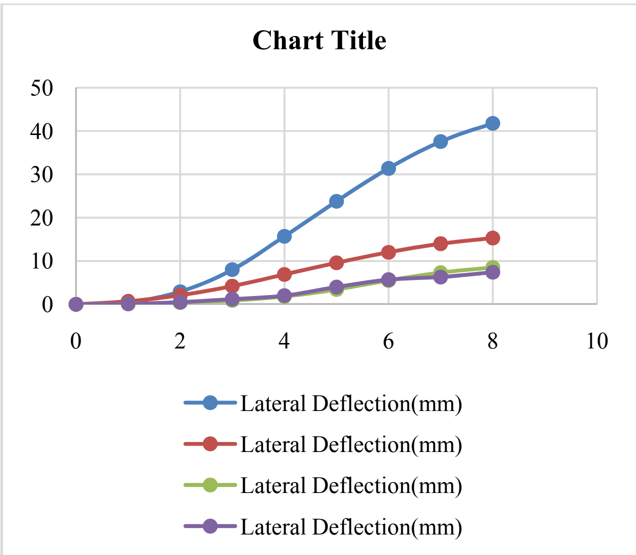

Fig 6 : Comparison of lateral deflection in x direction

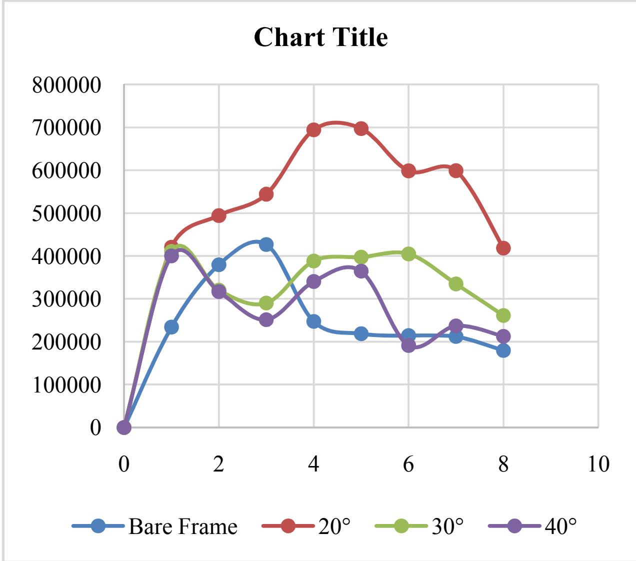

Fig 7: Comparison of Storey Stiffness in x direction

Comparing results for Step Back-Set Back building

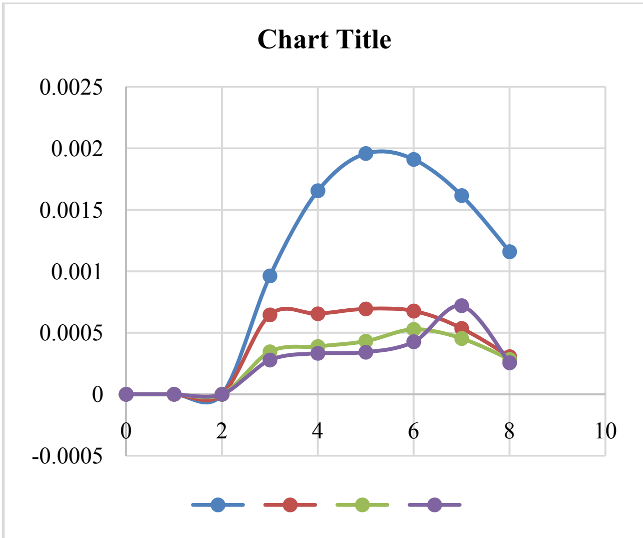

Fig 8: Comparison of Storey Drift in x direction

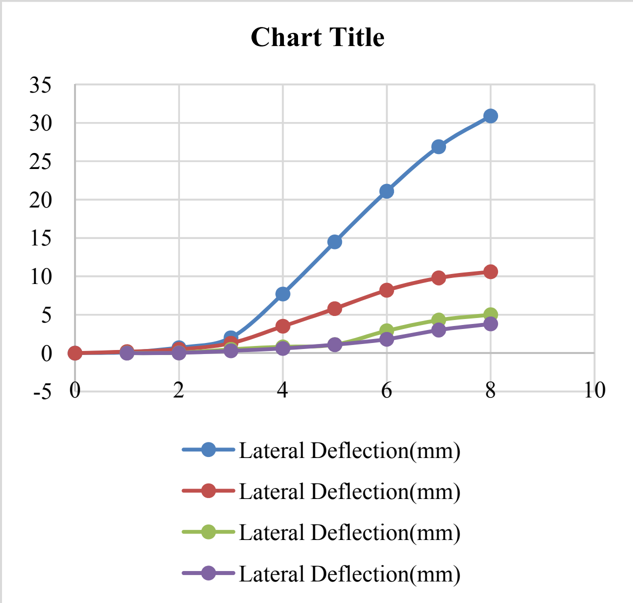

Fig 9 : Comparison of lateral deflection in x direction

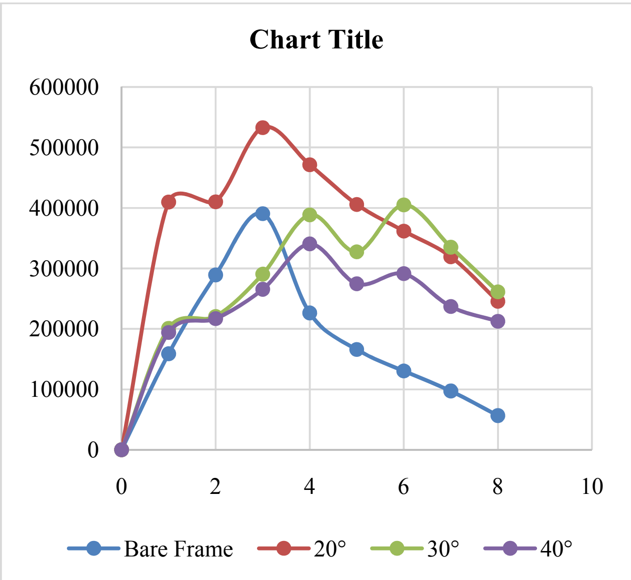

Fig 10: Comparison of Storey Stiffness in x direction

CONCLUSIONS

This study focusses on the structural response of masonry infilled RC structures analyzed using the linear dynamic response spectra analysis. From the results obtained, it is clearly seen that the inclusion of unreinforced masonry infill walls (URM) as a structural member in the analysis contributes heavily in resisting the in-plane lateral loads. Various conclusions are drawn from the data obtained in the analysis which are mentioned below.

- As the hill slope is increased, the storey displacement and the storey drift gradually decreases.
- Due to the effect of unreinforced masonry wall, the lateral stiffness at first floor is 1.8 times for 20 degree slope, 1.7 times for 30 degree slope and 1.65 times for 40 degree slope in the X direction.
- Storey drift values for all the configurations Is found to be less than the permissible value,i.e, less than 0.004 times the storey height as per IS 1893:2016(part 1).
- Finally , as per the observations of this paper, it is recommended to consider the contribution of the unreinforced masonry infill wall in the seismic analysis of the R.C.C framed building

References:

[1] Alokmadan (2013), Seismic vulnerability of masonry infilled reinforced concrete frame structures, Int. J. Of Safety and Security Eng., Vol. 3, No. 3 (2013) 174–183.

[2] Arshad k. Hashmi and Alok Madan (2017), Seismic performance of masonry infilled reinforced concrete structures, The Indian Concrete Journal, May 2017, Vol. 91, Issue 5, pp. 24-33.

[3] AniendhitaRizki Amalia and Data Iranata(2017), Comparative Study on Diagonal Equivalent Methods ofMasonry Infill Panel, Green Process, Material, and Energy: A Sustainable Solution for Climate Change AIP Conf. Proc. 1855, 030011-1–030011-11; doi: 10.1063/1.4985481

[4]

[5] C.V.R. Murthy and Sudhir K Jain (2000), Beneficial Influence of Masonry Infill Walls On Seismic Performance Of RC Frame Buildings, proceedings of twelfth world conference of earthquake engineering, 2000.

[6] Diptesh Das and C.V.R. Murthy (2004), Brick Masonry Infills in Seismic Design of RC Frame Buildings: part 1- cost implication, Part 2- Behaviour, Indian Concrete Journal, 2004.

[7] AniendhitaRizki Amalia and Data Iranata(2017), Comparative Study on Diagonal Equivalent Methods ofMasonry Infill Panel, Green Process, Material, and Energy: A Sustainable Solution for Climate Change AIP Conf. Proc. 1855, 030011-1–030011-11; doi: 10.1063/1.4985481

[8] Hemant B. Kaushik, Durgesh C. Rai and Sudhir K. Jain(2006), Code Approaches to Seismic Design of Masonry-Infilled Reinforced Concrete Frames: A State-of-the-Art Review, Earthquake Spectra, Volume 22, No. 4, pages 961–983, November 2006; © 2006, Earthquake Engineering Research Institute.

[9] K. H. Abdelkareem, F. K. Abdel Sayed, M. H. Ahmed, N. AL-Mekhlafy(2013) , EQUIVALENT STRUT WIDTH FOR MODELING R.C. INFILLED FRAMES, N. AL-Mekhlafy et al., Equivalent strut width for modeling R.C. infilled frames, pp. 851 - 866

[10] IS 1893:2016 (part 1), criteria for earthquake resistant design of structure part-1 general provisions & buildings (sixth revision) B.I.S New Delhi.

[11] IS 1905:1987, code of practice for use of unreinforced masonry B.I.S New Delhi

[12] P. G. Asteris, M. ASCE (2003), Lateral stiffness of brick masonry infilled plane frames, Journal of structural engineering 2003, 129(8): 1071-1079.
[13] Shriyanshu Swarnkar1 and Dr. Debarati Datta(2015), Analysis of Building with Infill Walls, Journal of Civil Engineering and Environmental Technology Print ISSN : 2349-8404; Online ISSN