© 2017 IJSRSET | Volume 3 | Issue 8 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

Seismic Evaluation of GFRG Panel and Brick Infill Step-Back Set-Back and Step-Back Building

Arun Deshwali[*1], Dr. Raghvendra Singh[2]
[*1]M. Tech Student - Department of Civil Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India
[2]Professor - Department of Civil Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

ABSTRACT

Hilly area is more prone to seismic activity; e.g. northeast region of India. In this hilly region, traditionally material like, the adobe, brunt brick, stone masonry which is locally available is used for the construction of houses but nowadays GFRG panel are also used for construction of houses because of its low cost of construction. A scarcity of plain ground in hilly area compels the construction activity on sloping ground. Hill buildings constructed with different infill without conforming to seismic codal provisions have proved unsafe and, resulted in loss of life and property when subjected to earthquake ground motions. Therefore, the present research work is to analyze a 3D numerical model of 10 stories Glass fiber reinforced gypsum panel and Brick infill step back and step-back set-back building constructed on a sloping ground and performed the analysis by using software SAP 2000 (ver.16.0) using static nonlinear method for comparing and investigating the changes in structural behavior subjected to seismic load. The result of the analysis for displacement and base shear have been studied and compared for all the structure models.

Keywords: GFRG Panel, Brick Infill, Step-Back Set -Back Building, Step-Back Building, Pushover Analysis.

I. INTRODUCTION

GFRG panel was designed and developed in Australia in the early 1990s. GFRG takes natural gypsum or by-product, chemical waste gypsum and turns it into a 12m x 3m glass-fibre gypsum plaster, single panel, load bearing walling system. 100% Recyclable and water, rot and termite resistant. The panel contain cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility.

GFRG panel is the ideal building product for fire, cyclone and earthquake prone regions as well as for providing housing solutions for impoverished people. In India GFRG panel has been rigorously tested by the University IIT Madras and certified by Structural Engineering Research Centre (SERC) for use in the construction of buildings in earthquake prone areas of up to 15 storeys'. The panels, which are extremely strong yet lightweight, compared to other building methods, are ideal for a wide range of building applications from high-rise, residential, commercial and industrial building construction to low cost relocation housing. Now a day's large number of building are constructed using GFRG panel due to its lower cost than brick masonry, Easy to construct, light in weight, high thermal insulation, high fire protection, high sound insulation, lower water absorption, eco-friendly.

Therefore, it is essential to analysis the GFRG panel and brick infill building subjected to earthquake using SAP 2000 (ver. 16.0) and compare the response of structure in terms of base shear and displacement.

II. MODELLING OF INFILL

Macro models are used to investigate the overall response of the infill wall. The behaviour of macro models is based on physical behaviour of infill walls. Mortar joints and units are recognized together considering collective mechanical and physical properties to obtain more simplified solution especially for large scaled models. Diagonal strut model for infilled frames is shown in Figure 1.

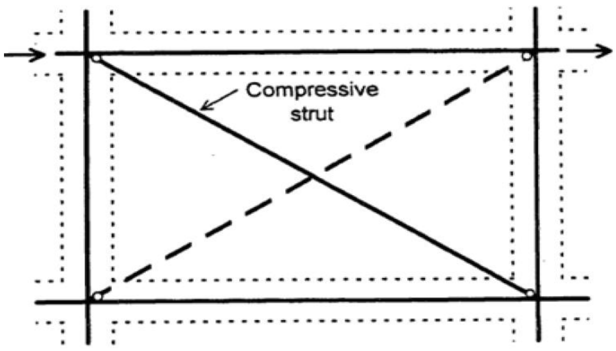


Figure 1. Diagonal strut model for infilled frames [7,8,16]

The Empirical equation developed by Mainstone and Weeks [3] subsequently, included in FEMA 274, FEMA 306[7], FEMA 356[8], Turkish Seismic Code-2007[12] and widely used nowadays. The equivalent strut has the same thickness and modulus of elasticity as the infill panel it represents. The equivalent strut width w, can be determined by

$$w = 0.175.(\lambda_1.h_{col})^{-0.4}.r_{inf}$$

The expression of non-dimensional λ is given by

$$\lambda = \frac{E_{inf.}\ t_{inf.}\ \sin 2\theta}{4.E_{fr.}\ I_{col.}\ h_{inf}}$$

Where, h_{col} is column height between centrelines of beam, h_{inf} is height of infill panel, E_{fr} is expected modulus of elasticity of frame material, E_{inf} is expected modulus of elasticity of infill materials, I_{col} is moment of inertia of column, r_{inf} is diagonal length of infill panel, t_{inf} is thickness of infill panel and equivalent strut, θ is angle whose tangent is the infill height-to-length aspect ratio in radians.

III. PUSHOVER ANALYSIS

Pushover analysis is a technique by which a computer model of the building is subjected to a lateral load of a certain shape (i.e., inverted triangular or uniform). The intensity of the lateral load is slowly increased and the sequence of cracks, yielding, plastic hinge formation, and failure of various structural components is recorded. Pushover analysis can provide a significant insight into the weak links in seismic performance of a structure. A series of iterations are usually required during which, the structural deficiencies observed in one iteration, are rectified and followed by another. This iterative analysis and design process continues until the design satisfies a pre-established performance criterion. The performance criteria for pushover analysis is generally established as the desired state of the building given a roof-top or spectral displacement amplitude. Non-linear or pushover analysis option will allow engineers to perform pushover analysis as per FEMA-356 (2000) and ATC-40 (1996).

IV. DETAILS OF STRUCTURE CONSIDERED

The buildings of plan area 20.0 m x 28.0 m are considered having 5 bays of 4 m width in X-direction and 7 bays of 4.0 m in Y-direction. For the analysis, story height of 3.0 m (floor to floor) is considered in this work. For the analysis, particulars and details of building model of G + 9 story structure for four different cases are listed in the Table 1.

Table 1. Particular and details for all building models

Particulars	**Details**
Plan size	28.0 m x 20.0 m
No. of bays in X-Direction	5 Bays @ 4.0 m each
No. of bays in Y-Direction	7 Bays @ 4.0 m each
Storey height	3.0 m
Depth of foundation below ground	1.5 m
Type of soil	Type II, Medium as Per IS:1893
Grade of concrete	M25
Grade of steel	Fe-500
Column size	500 mm x500 mm
Beam size	250 mm x 350 mm
Slab thickness	150 mm
Brick strut thickness	230 mm
Brick strut width	610 mm
GFRG strut thickness	124 mm
GFRG strut width	583 mm
GFRG wall load	4.2408 kN/m^2
Brick wall load	11.82 kN/m^2
Roof live load	1.0 kN/m
Floor live load	3.0 kN/m
Building importance factor	1
Response reduction factor	1.5
Zone factor	0.16

A view of plan, elevation and 3D view of Step-Back Set-Back and Step-Back GFRG panel and Brick infill structures are shown below from Figure 2 to Figure 6

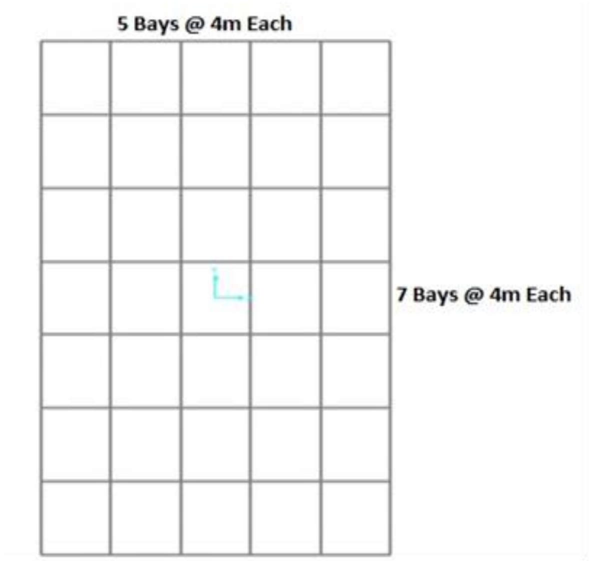


Figure 2. Plan area of building consider for the analysis of 20.0 m x 28.0 m

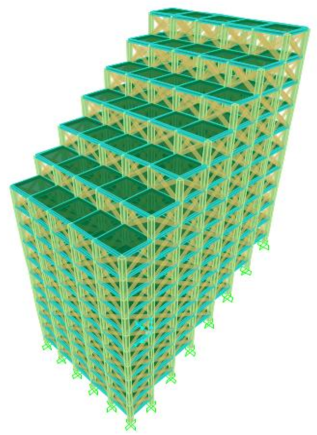


Figure 3. 3D view of GFRG panel equivalent strut set-back step-back building.

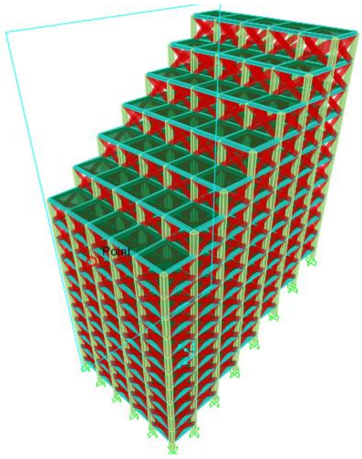


Figure 4. 3D view of Brick infill equivalent strut set-back step-back building.

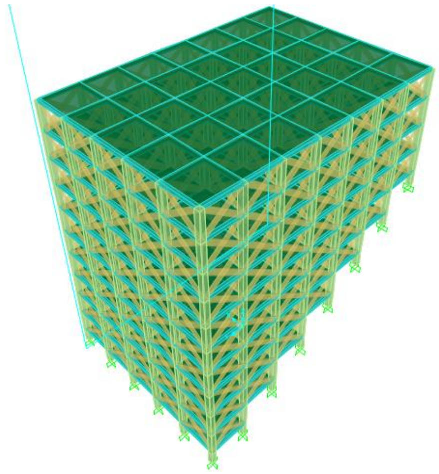


Figure 5. 3D view of GFRG panel equivalent strut step-back building.

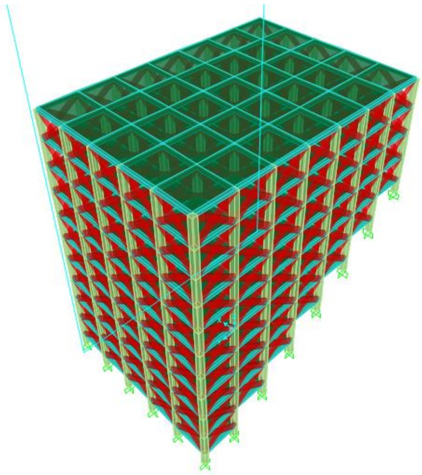


Figure 6. 3D view of Brick infill equivalent strut step-back building.

V. ANALYSIS DETAILS

For the analysis of all four the cases for the nonlinear condition, it consists of dead load (self-weight of structure), floor load, roof load, wall load which is acting in the gravity direction and seismic earthquake load is taken as per is IS 1893-2002 code. The beams are assigned as M3 hinges while columns are assigned P-M2-M3 hinges since column consists of interaction between axial load and bending moment at relative distance zero and one and axial hinge P in strut at centre is assigned and pushover analysis is performed on structures using SAP 2000.

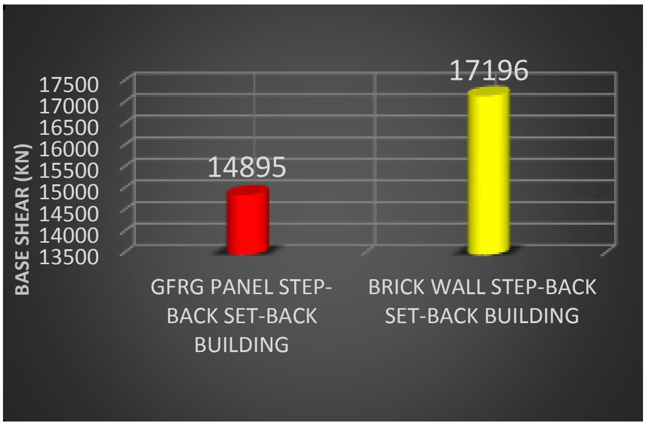
VI. RESULTS

The results include base shear and top displacement at performance point obtained from nonlinear analysis of GFRG Panel and Brick Infill under static loading condition using SAP2000 and is shown in table and graph below. comparisons between base shear and displacement of all the four cases are presented in the tabular form in Table 2.

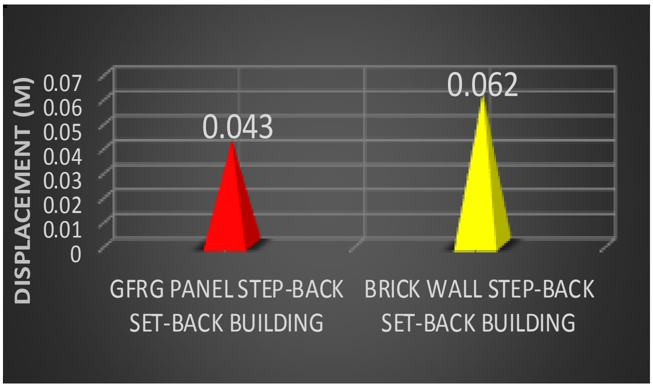
Table 2. Comparison of base shear and displacement of all 4 cases at performance point

SN.	Building type	Base shear	Displacement
1	GFRG panel step-back set-back building	14895 kN	0.043 m
2	Brick infill step-back set-back building	17196 kN	0.062 m
3	GFRG panel step-back building	12401 kN	0.020 m
4	Brick infill step-back building	14146 kN	0.29

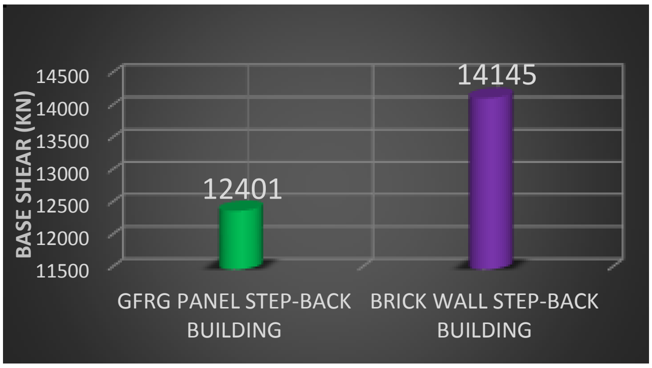
A. **Comparison of Base Shear of GFRG panel and Brick wall step-back set-back building**



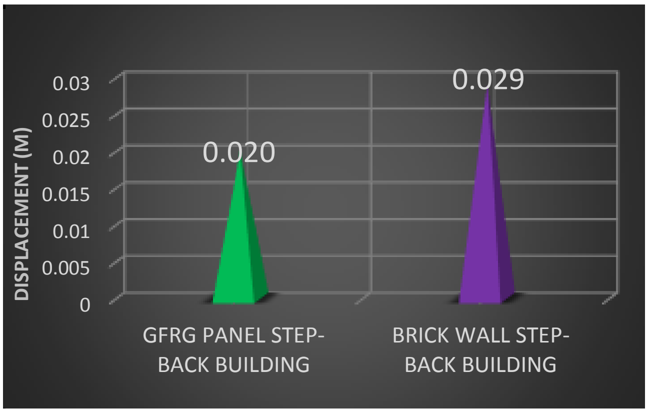
B. **Comparison of Top displacement of GFRG panel and brick wall step-back set-back building**



C. **Comparison of Base Shear of GFRG panel step-back building**



D. **Comparison of Top displacement of GFRG panel and brick wall step-back building**



VII. CONCLUSION

The results obtained from the analysis concluded that the base shear of GFRG panel step-back set-back building is fifteen percent less than the base shear of brick wall set-back step-back building and top displacement of GFRG panel step-back set-back building is forty four percent less than the top displacement of brick wall set-back step-back building.

Similarly, the results obtained from the analysis concluded that the base shear of GFRG panel Step-back building is fourteen percent less than the base shear of brick wall step-back building and top displacement of GFRG panel step-back building is forty five percent less than the top displacement of brick wall step-back building.

Hence, overall this research findings concluded that beside lower cost of construction GFRG panel step-back set-back and step-back structures has also higher lateral stiffness, rigidness against lateral load minimizing the maximum lateral deformation then Brick infill step-back set-back and step-back structures.

VIII. REFERENCES

[1]. Holmes,M.(1961).Steel frames with brickwork and concrete infilling,Proceedings of the Institution of Civil Engineers,473-478.

[2]. Smith,B.S.and Carter,C.(1969).A method of analysis for infilled frames,Proceedings of the Institution of Civil Engineers,Vol.7218,31-48.

[3]. Mainstone,R.J.and Weeks,G.A.(1970).The influence of bounding frame on the racking stiffness and strength of brick walls,in Proc.2nd International Brick Masonry Conference,Building Research Establishment,Watford,England,165-171.

[4]. ATC(1996).Seismic Evaluation and retrofit of Concrete buildings,Vol.1,ATC-40 Report,Applied Technology Council,Redwood City,California.

[5]. Federal Emergency Management Agency(1998).Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual,FEMA-306,Applied Technology Council,Washington DC.

[6]. FEMA-356(2000).Prestandard and Commentary for the Seismic Rehabilitation of Buildings,Building Seismic Safety Council,Washington DC.

[7]. Wu,Y.F.(2004).The effect of longitudinal reinforcement on the cyclic shear behaviour of glass fiber reinforced gypsum wall panels: Tests,Engineering Structures,ELSEVIER,Vol.26(11),1633-1646.

[8]. Wu,Y.F.and Dare,M.P.(2004).Axial and Shear Behaviour of Glass Fibre Reinforced Gypsum Wall Panels: Tests,Journal of Composites for Construction,ASCE,8(6),569-578.

[9]. Birajdar,B.G.and Nalawade,L.(2004).Analysis of buildings resting on sloping ground",13thWorld Conference on Earthquake Engineering,Vancouver,B.C.,Canada,1472.

[10]. Turkish Republic the Ministry of Public Works and Settlement,Turkish Earthquake Design Code TEC-2007,Ankara,Turkey,2007.

[11]. Liu,Z.and Ying,H.(2010).Elastic Lateral Features of a New Glass Fibre Reinforced Gypsum Wall,World Academy of Science,Engineering and Technology International Journal of Civil and Environmental Engineering,Vol.4(3).

[12]. Janardhana,M.,Prasad,A.M.and Menon,D.(2013).Studies on The Behaviour of Glass Fiber Reinforced Gypsum Wall Panels,Structural Engineering Division,Department of Civil Engineering,Indian Institute of Technology Madras.

[13]. Menon,D.and Prasad,A.M.(2013).Development of Building Systems using Glass Fibre Reinforced Gypsum(GFRG) Panels,The Masterbuilder.

[14]. Niruba,S.(2014).Analysis of Masonry Infill in a Multi-Storied Building,Civil & Environmental Engineering,Vol.4(2).

[15]. IS 1893: Part 1(2002); "Criteria for earthquake resistant design of structures",Bureau of Indian Standards,New Delhi.

[16]. GFRG construction manual,FACT/RCF building product limited,Cochin- Government of India public undertaking.

[17]. Use of glass fibre reinforced gypsum(GFRG) panel in the building,Structural design manual prepared by Structural engineering division,Department of civil engineering IIT madras.

[18]. Prospective Construction Systems for Mass housing(2014),Technology profile glass fibre reinforced gypsum(GFRG) system,Building Materials & Technology Promotion Council Ministry of Housing & Urban Poverty Alleviation Government of India,New Delhi

[19]. CSI,(2010),Structural Analysis Program(SAP) 2000,Version 14,Computers and Structures Inc.,USA

[20]. Murty,C.V.R.,Goswami,R.,Vijayanarayanan,A.R. and Mehta,V.(2012).Some Concepts in Earthquake Behaviour of Buildings,Gujarat State Disaster Management Authority,Government of Gujarat.