# Seismic Evaluation of Irregular Multistorey Building with Prefabricated Walls

**Gulam Mohd[1], Senthil Pandian M[2]**

[1]*PG Student, School of Mechanical and Building Science, VIT Chennai, Chennai-600127, Tamil Nadu.*
[2]*School of Mechanical and Building Science, VIT Chennai, Chennai-600127, Tamil Nadu.*

**ABSTRACT**

***Pre-cast construction is gaining more popularity due to rapid urban infrastructure growth. To meet the demands of current rapid growing industry Pre-cast is one of the best alternatives. The main aim of this study is to found out the contribution of Prefabricated Wall to lateral strength and lateral stiffness of multistorey building subjected to seismic excitations. In the current study two G+14 storey buildings are designed according to Indian seismic code IS 1893-2002. The buildings are asymmetric, residential and have reinforced concrete structural systems. In the first building model infill wall is considered as masonry infill wall and in the second building model masonry infill is replaced with prefabricated wall panel. Response spectrum analysis is performed for both the building models and compared the linear dynamic properties such as (Fundamental Period, Natural frequencies and Storey shear). Non linear static pushover analysis is carried out in ETABS for both the models and building with prefabricated wall as an infill performs well under different earthquake loading as compared to normal building with masonry infill walls.***

***Keywords: Dynamic analysis, prefabricated wall, pushover analysis, response spectrum analysis, asymmetrical building, ETABS.***

## 1. INTRODUCTION

Now a day, there is an increase in housing requirement with increased population and urbanization. Building sector has gained increasing prominence. There is a need for faster construction methods to meet the demands of the industry. Prefabricated wall panel are light weight walls which reduces the self weight of the structure. Many researchers have investigated the properties of prefabricated 3D wall panel Mohammed Z. Kabir [1] studied the structural properties of Pre-cast concrete sandwich panels under shear and bending loads and concludes that these panels carry the load as partial composite panel under service loads. Bernard A. Frankl [2] describes the behavior of precast, prestressed concrete sandwich wall panels and found out the various parameters such as, the type of insulation, presence of solid concrete zones, panel configuration, and shear grid reinforcement ratio.

To mimic the behavior of infill frames, different types of analytical models were developed over the years. Das and Murthy [3] proposed single strut model for behavior of an infill panels in frames. Thus RC frames with unreinforced masonry walls can be modeled as equivalent braced frames with infill walls replaced by equivalent diagonal strut which can be used in rigorous nonlinear pushover analysis.

In the present study, seismic performance of prefabricated wall panel in RC frame building compared with masonry infill frame model using nonlinear analysis. The main objectives of this study were to investigate the behavior of multistory infill frame and to evaluate their performance levels when subjected to earthquake loadings.

## 2. DESCRIPTION OF BUILDING MODEL

The building considered for study is proposed residential building in Bangalore. It consists of seventeen storied moment resisting RC framed building, having the plan dimensions around two acre. It is an asymmetrical building with mass and stiffness irregularities. The 3D view of the building is shown in Fig. 1. The floor height of 3 m is considered in the study. The material properties of building components are shown in Table 1. Input details of building components are shown in Table 2

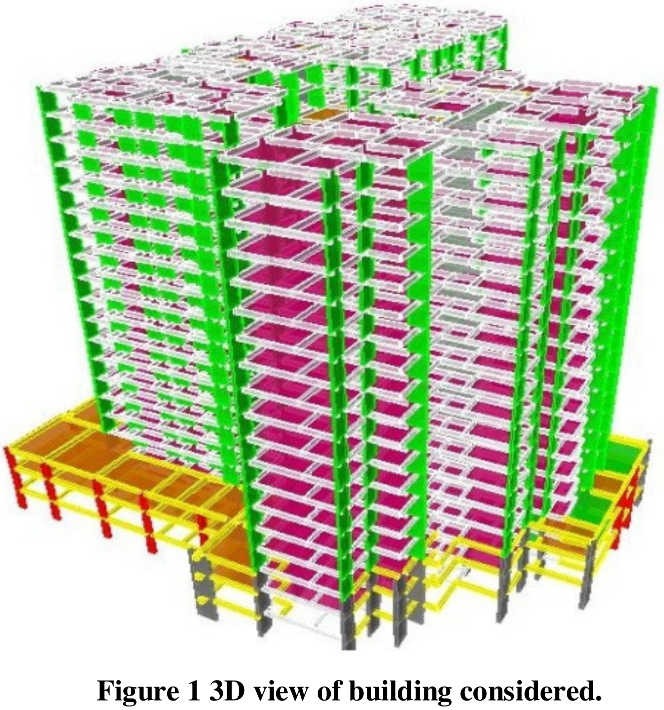

**Figure 1 3D view of building considered.**

The structures are modeled as 3D frame. The two models each of seventeen storied RC framed building are prepared. Model I (Basic Model) which include Masonry wall as infill. Model II (Prefabricated Wall Model) has Prefabricated Wall as an infill walls.

**Table 1 Material Property of Building Components.**

| Properties | Building Components | | | |
|---|---|---|---|---|
| | **Concrete** | **Reinforcement Steel** | **Masonry Wall** | **Prefabricated Wall** |
| Young's Modulus of Elasticity [MPa] | 27387 | 210000 | 3500 | 4250 |
| Poisson's Ratio | 0.2 | 0.3 | 0.2 | 0.26 |
| Density [Kg/M3] | 2500 | 7850 | 2000 | 26.98 |

**Table 2 Input Details for Building.**

| Building Components | Dimension [mm] | Grade of Concrete |
|---|---|---|
| Beams | 300 X 600 | M25 |
| Columns | 300 X 750 | M30 |
| Slab thickness | 150 | M25 |
| Masonry wall thickness | 230 | ---- |

## 3. PREFABRICATED 3D WALL PANEL

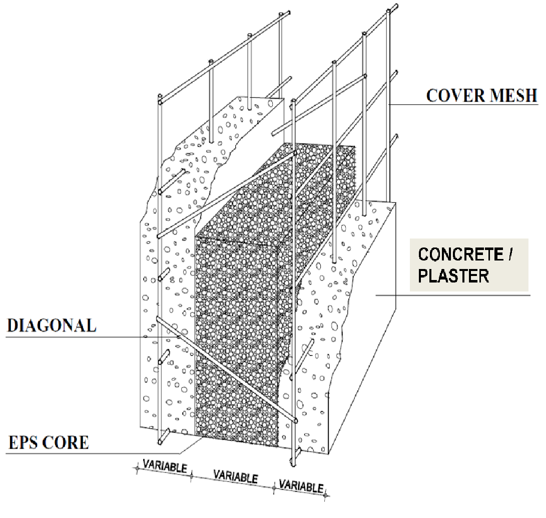


**Figure 2 Cross Section of Prefabricated 3D Wall Panel**

Prefabricated wall panel considered for study was manufactured by Beardsell Limited Chennai. It consists of a Super-insulated core of rigid Expanded Polystrene Sandwiched between two engineered sheets of steel welded wire fabric mesh. The wall panel is placed in position and wythes of concrete are applied to both sides. Wall panel receives its strength and rigidity by the diagonal cross wire welded to the welded-wire fabric on each side. This combination produces a truss behavior, which provides rigidity for full composite behavior. Dimensions of wall panel are 1210 mm X 3000 mm with thickness of 150 mm. Fig. 2, shows the cross section of the prefabricated wall panel.

## 4. MODELLING AND ANALYSIS OF BUILDING STRUCTURES

The frame elements are modeled as beam elements. The masonry infill is modeled as quadrilateral shell elements (with in-plane stiffness) of uniform thickness of 0.23mm. The nonlinear properties for columns are assumed to be plastic P-M-M hinge and for the beams as plastic moment hinge. The plastic hinges are defined according to FEMA 356 [5] with the designed rebar distribution. The prefabricated wall 3D panels are modeled with Mid-pier frame elements with P-M-M Interaction hinge. The slab is modeled as rigid diaphragm.

The non linear static Pushover analysis is performed for RC frame building with masonry infill and prefabricated walls. The software, ETABS CSI 2004 [6] was used for the elastic analysis using response spectrum approach, and to perform pushover analysis.

## 5. RESULTS AND DISCUSSION

The structure is analysed for the seismic loads and load combinations as per the Indian standards, IS-1893 (Part-1)-2002, for seismic zone = Zone II, Importance factor= 1, Soil type = II, Live load= 2 KN/m2 and designed as per IS- 456-2000. Full dead load (Self Weight) and 50% of live (Imposed) load constitute the seismic weight.

The "Seismic Analysis" using "Response Spectrum Analysis" and "Nonlinear Static Pushover Analysis" are performed on two models namely Model I – Basic Model (BM) and Model II- Prefabricated Wall Model (PFW). The Results of the elastic analysis using "Response Spectrum Method", namely the lateral displacement in mm are presented in Fig. 3.The Storey Shear are presented in Fig. 4.The fundamental period and Natural frequencies are shown in Table 3. The results of inelastic analysis using the "Non Linear Static Pushover Analysis" namely, the Displacement in mm and Storey Base Shear are presented in Fig. 5.

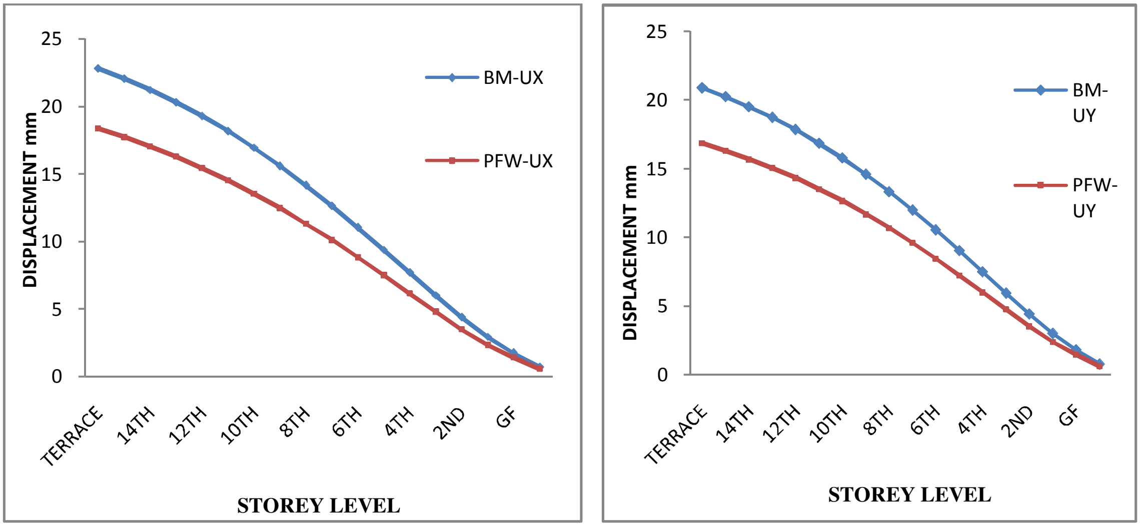


**Figure 3 Lateral Displacement in X and Y Direction.**

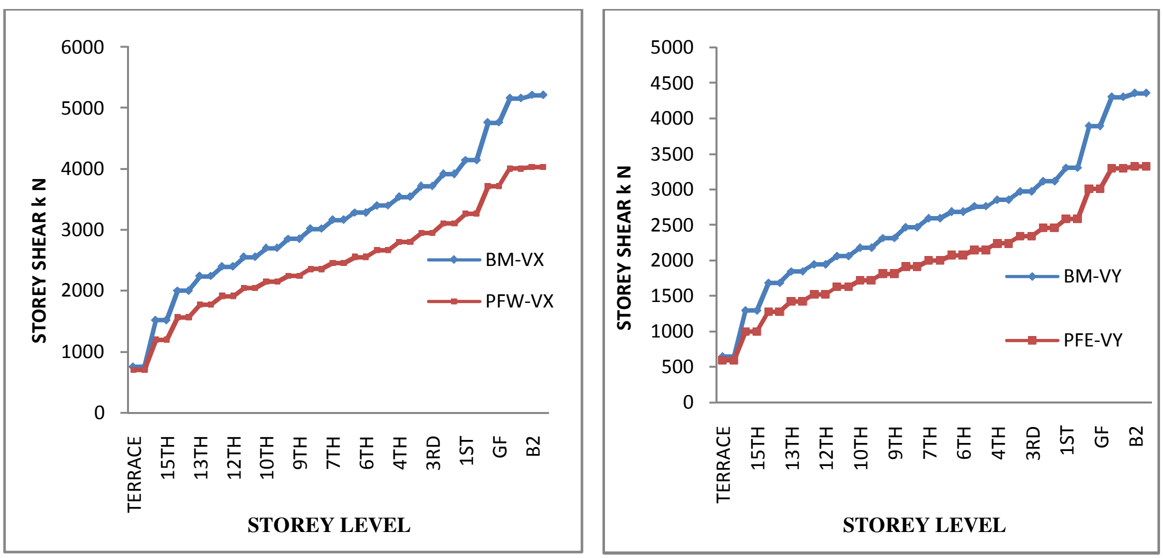


**Figure 4 Storey Shear in X and Y Direction.**

| Dynamic Property | Basic Model | Prefabricated Wall Model |
|---|---|---|
| | Model -I | Model-II |
| Fundamental Period [Sec] | 3.25 | 2.62 |
| Natural Frequency | 0.31 | 0.38 |

**Table 3. Fundamental period and Natural frequency of Model I and Model II.**

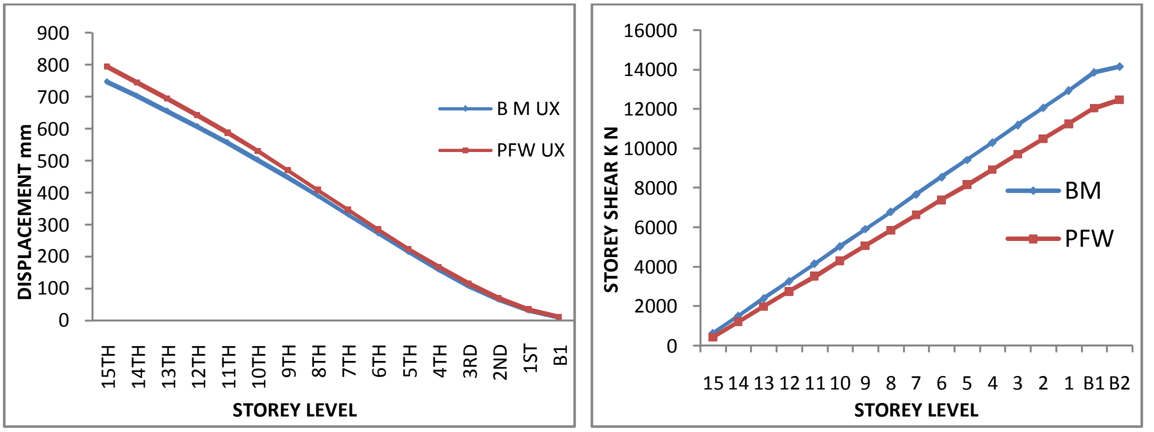


**Figure 5 Displacement Curve and Storey shear from Pushover Analysis.**

Observations on the results of elastic analysis using “Response Spectrum Analysis”:

- It is observed from the storey displacement graph that, top displacement in X- direction for Model-I(Basic Model) is more than Model-II(Prefabricated Wall Model), similar trends are followed in Y- direction, top displacement, in general lesser in Y- direction as compared to top displacement in X-direction. This is because the building is more lateral stiffness in X-direction as more plan dimension in Y-direction as compared to X-direction.
- It is noted that top displacement of Model I (Basic Model) is 20 % more than the top displacement of Model II (Prefabricated Wall Model) in X- direction and followed similar trends of 19.3 % in Y-direction.
- It is observed from the storey shear graph that, storey shear at basement level for Model I (Basic Model) is more than Model-II (Prefabricated Wall Model) in X-direction, Similar trends are followed in Y-direction also.
- It is noted that storey shear of Model-I (Basic Model) is 23 % more than storey shear of Model II (Prefabricated Wall Model)
- It is observed from Table 3.that; Basic Model has less Frequency and more time period than the Prefabricated wall Model.

Observations on the results of in-elastic analysis using “Nonlinear Static Pushover Analysis” procedure:

- The lateral stiffness is inversely proportion to lateral displacement. It is inferred from fig. 5 that Model-II (Prefabricated Wall Model) has less stiffness and Model-I (Basic Model) have comparatively large stiffness.

- The lateral load resistance capacity (base shear at performance point) of the Prefabricated wall frame is less than the frame with masonry wall which is evident from the fig. 5

## 6. CONCLUSIONS

In general, the provision of Prefabricated Wall has significant influence on lateral displacement of the building while it has less influence on lateral strength of building. The frame with masonry infill exhibited inferior structural performance in terms of lateral displacement. Hence Prefabricated Wall Model will have better seismic performance as compared with frame with masonry infill walls.

## REFERENCE

[1] Mohammed Z. Kabir, Mohsen Hashemi Nasab. : Mechanical properties of 3D wall panels under shear and flexural loading, 4 th structural Specialty Conference of the Canadian Society of Civil Engineering 2002; 34(1):335–342.

[2] Bernard. A. Frankl, Gregorg W. Lucier, Tarek. K. Hassan, Sami H, Rizkalla.: Behaviour of Precast, Prestressed Concrete Sandwich Wall Panels Reinforced With CFRP Shear Grip PCI Journals Spring 2011; 34(1):42–54.

[3] Das, D., Murty, C.V.R.: Brick masonry infills in seismic design of RC framed buildings: Part 1-Cost implications The Indian Concrete Journal July 2004; 78(7):39-43

[4] I.S. 1893(Part I)-2002, Criteria for Earthquake Resistant Design of Structure, General Provisions and Buildings, *Bureau of Indian Standards, New Delhi.*

[5] FEMA 356 (2000), "Prestandard and Commentary for the Seismic Rehabilitation of Buildings, *Federal Emergency Management Agency",* Washington D.C.

[6] CSI (2008) CSI Analysis Reference Manual for SAP 2000, ETABS and SAFE, Computers and Structures Inc., Berkeley CA.