Study of Effective Positioning System of Shear walls in RC Buildings using Pushover Analysis

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Abstract - When moving towards high rise structures, it becomes important to adopt both linear and non-linear analysis procedures for design of structures. The responses of tall buildings are thus influenced by higher modes and torsion. Considering these effects, in this article, push-over analysis procedure is used to estimate the demands of a unsymmetrical-plan tall building. Seismic loads are taken from IS1893(part 1) -2002 using finite element analysis software ETABS 15.0.0. the software is used to model and analyze a 16 storey building with different positions of shear wall. This article also highlights best positioning system of shear wall along with plane rc frame with respect to displacement of the building.

Keywords: Pushover Analysis, Static Pushover Curve, Shear wall, Storey height, Displacement

I. INTRODUCTION

Several recent approaches are taken to tackle the problems associated with the performance-based earthquake engineering. In brief, performance based engineering deals with the estimation of quantities such as seismic capacity and seismic demands for different performance levels of the structure. Generally, the methods which are available to calculate seismic demands are either dynamic time history analyses or pushover analysis.

Pushover analysis is becoming a popular tool for seismic performance as it provides information on seismic demands imposed by design ground motion on the structure. pushover analysis is a nonlinear approximate analysis method in which the structure is subjected to increasing lateral forces with continuous height wise distribution until the target displacement is reached.

Pushover analysis consists of series of sequential elastic analysis to approximate force-displacement curve of the overall structure. A structural model is created and lateral forces are applied and increased until the members yield. The roof displacement is plotted with base shear to get the global capacity curve. The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. Shear walls are used to resist lateral forces, as they behave effective under this loading (wind or seismic) and assure acceptable seismic performance.

II. LITERATURE REVIEW

Romy *et al*.(2011) studied the effect of variation of the building height with the structural response of the shear wall. Dynamic responses under prominent earthquake, El-Centro have been investigated. This paper highlights the accuracy and exactness of Time History analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis

D.N. Shinde et al.(2009) presented the study of a building frame designed as per Indian standard i.e. IS 456:2000 and IS 1893:2002. The main objective of this study was to check the kind of performance a building can give when designed as per Indian Standards. The pushover analysis of the building frame was carried out by using structural analysis and design software SAP 2000.

P.B.Oni1 et al.(2013) presented work of 3 storey and 6 storey building models with plus shape Shear walls. equivalent static and response spectrum methods were carried out as per IS:1893 (Part 1) -2002 using finite element analysis software ETABS v9.1.1. Seismic performance was assessed by pushover analysis as per for earthquake zone V in India. The paper also deals with the effect of the variation of the building height on the structural response of the shear wall. The paper highlights the accuracy of Push over analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis

Alfa Rasikan et al.(2010) studied about Shear walls with specially designed structural walls which are incorporated in buildings to resist lateral forces that were produced in the plane of wall due to wind, earthquake and flexural members. The paper presents the study and comparison of the difference between the wind behavior of buildings with and without shear wall using Staadpro.

III. OBJECTIVE

The objective of present study include:

1. To model and analyse the RC structural building using Static Non linear Pushover analysis.
2. To analyze and calculate the displacements, base shears of the structure by software etabs 2015 version 15.0.0.
3. To study the behavior of building with and without shear walls at different locations.
4. To find out the most effective type of shear walled building to resist lateral forces , along with plane frame building

IV. METHODOLOGY

The methodology of the present study include:

1. A G+15 building will be analysed using Static Non linear Pushover analysis.
2. Structure with and without infill system will be used for analysis in the project.
3. Shear walls will be used at different locations and the best positioning system shall be obtained.
4. Critical members will be designed manually and checked with software.

V. STRUCTURAL MODELLING

A. General

1. The finite element analysis software ETABS 2015 version 15.0.0 is utilized to create 3D model and run the analysis.
2. The software is able to predict the geometric non-linear behavior of the frames under static or dynamic loadings.
3. The software accepts static loads(either forces or displacements) as well as dynamic(accelerations) actions and has ability to perform Eigen values, non-linear static pushover and non-linear dynamic analysis.
4. A model of 16 storey building is created , one plane rc frame and other with different locations of shear walls.
5. 5 different positions of shear walls are used in modelling of the building.

Table -1 : Structural Details

Plan Dimensions	20m x 30m
No. of bays in X-direction	6
No. of bays in Y-direction	4
Spacing in X-direction	5m
Spacing in Y-direction	5m
No.of storey	G + 15
Beam size	0.23m x 0.3m for all floors 0.23m x 0.4m at plinth

Column size	0.3m x 0.5m
Shear wall thickness	0.230m
Slab thickness	0.150m
Foundation height	2m
Height of all stories	3.1m
Modulus of elasticity of concrete	2.738×10^7 KN/m^2
Grade of concrete	M30
Grade of steel	Fe 415
Density of Reinforced concrete	25 KN/m2.

Table -2: Design Data

Live load	4 KN/m^2 (including ff) 2 KN/m^2 (at top storey)
Seismic load	IS1893(Part 1):2002
Type of soil	Type II (Medium soil)
Seismic zone	III (Chennai)
Importance factor, I	1
Response Reduction, R	5

B. Pushover Analysis Assignment Data

1. Non linear static analysis is used with incorporating p-delta effects.
2. 43 no. of joint is chosen for monitoring displacement in X-direction and Y-direction.
3. Results are saved at multiple states.
4. Seismic load is taken as per IS1893:2002 , in chennai (zone 3) and medium soil.
5. Hinges are provided according to ASCE-41-13
6. P-M2-M3 hinge assignment for concrete columns.
7. P-M3 hinge assignment for concrete beams.
8. Wall hinges are also provided according to P-M3 hinge assignment data.

VI. MODELLING AND ANALYSIS

A. Techniques

As seen from the floor plan, there were 6 models taken, out of which one was a plane rc frame and other included shear walls at different locations. Non-linear static pushover analysis in X- direction and Y-direction was performed for all the models and following displacements and base shears were plotted.

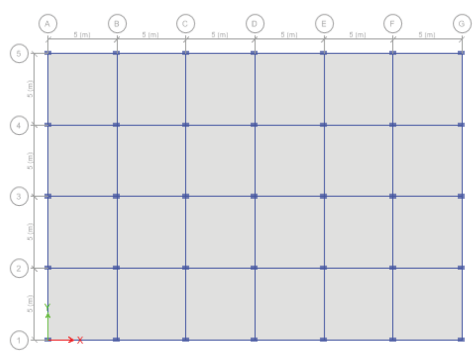

Fig 1.Model 1 - Plan

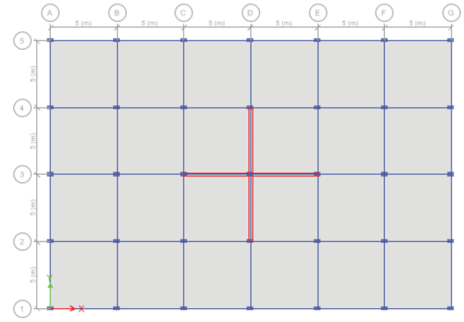

Fig 2.Model 2 - Plan

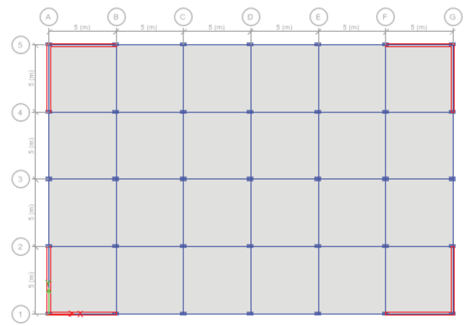

Fig 3.Model 3 - Plan

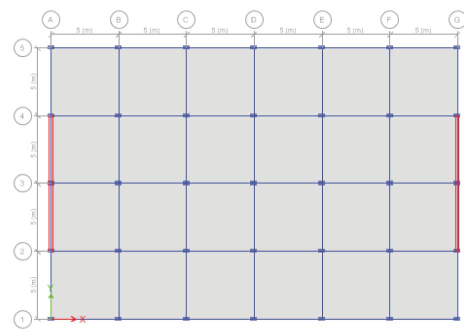

Fig 4. Model 4 - Plan

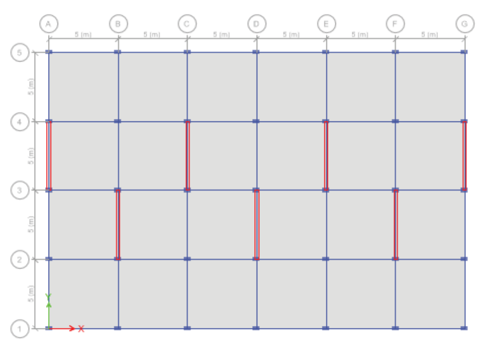

Fig 5.Model 5 - Plan

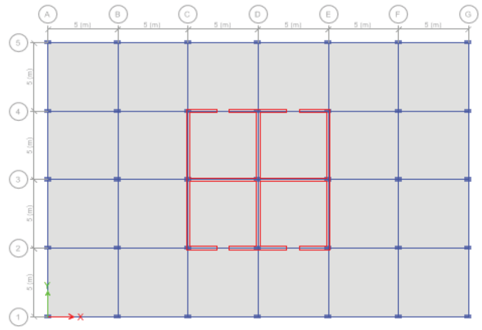

Fig 6.Model 6 - Plan

VII. RESULTS

It is seen that the structure without infill walls has more displacement after the application of lateral forces. RC Walled buildings are better in resisting lateral forces .

It is observed that square shaped shear wall is most effective positioning with respect to others positions of walls.

Table -3. Average Displacement and Base Shear

Model	Pushover Analysis Case	Roof Displacement (mm)	Base Shear (KN)
1	Push +X	433.1	577
	Push +Y	1349.1	
2	Push +X	42.87	1109.5
	Push +Y	132.2	
3	Push +X	73.17	2437.8
	Push +Y	597.1	
4	Push +X	422.08	578
	Push +Y	43.89	
5	Push +X	164.1	331
	Push +Y	133.89	
6	Push +X	21.03	1929.1
	Push +Y	30.29	

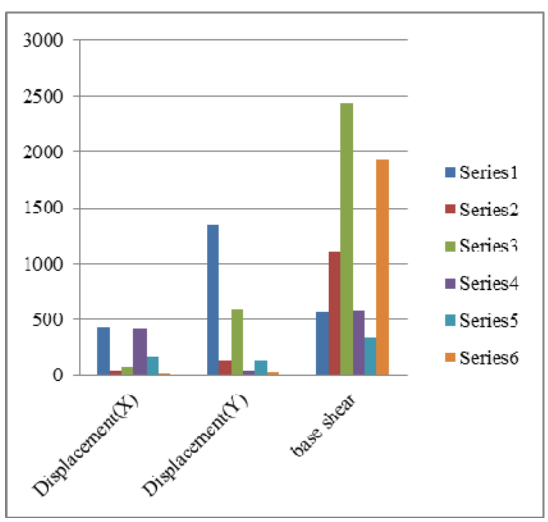

Fig7.Bar chart for displacements and base shear.

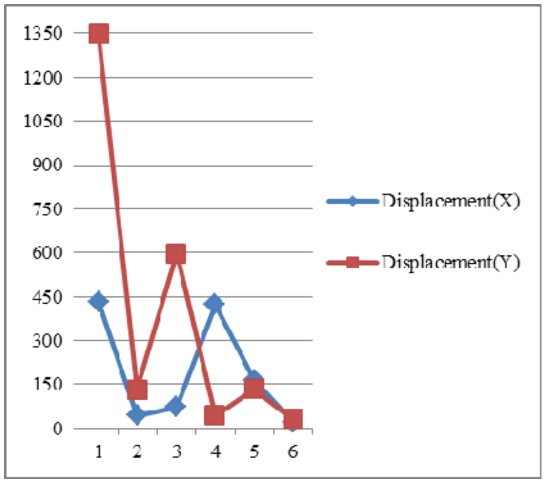

Fig 8.Graphical representation of displacement

VIII. DISCUSSIONS

Based on lessons learned during analysis, some discussions are made in this section. pushover analysis is numerically demanding and can cause some difficulties while run analysis. Simplify the model as possible in your way to reduce the run time. The elements must be modelled with least possible amount of meshing.

Generally walls, when modelled with shells have dense meshing. So it is required to reduce the mesh as possible.

Hinges also need to be assigned wherever necessary, but it doesn't affect that much to the run time.

IX. CONCLUSION

1. From the above studies, it is evident that square shaped shear wall (MODEL 6) and plus shaped shear wall(MODEL 2) are better choice than other shapes of shear walls as they are most effective in resisting lateral forces.
2. From the results observed, it is seen that pushover analysis is a useful tool for PBSE(Performance Based Seismic Engineering) to study post-yield behaviour of a structure.
3. It can also be concluded that pushover analysis should be performed for such buildings as it predicts structural response more accurately with incorporating p-delta effects and material non-linearity.

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