IFERP

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 5, May 2021

A Study of Nonlinear Static(Pushover) Analysis of RCC Building with Shear Wall and without Shear Wall

[1] Tushar Donga, [2] Dr. Vinay Agrawal, [3] Dr. Rajesh Gupta

[1] MTech Student, Mnit, Jaipur
[2][3] Associate Professor, Mnit, Jaipur
Email: [1] 2019PCS5031@mnit.ac.in,[2] vagarwal.ce@mnit.ac.in, [3] rgupta.ce@mnit.ac.in

Abstract--- **Performance based seismic engineering (PBSE) is become very popular now a days, where inelastic structural analysis is combined with seismic hazard assessment to calculate expected seismic performance of the structure. Which is useful in determining expected performance of any structure under large forces and modifying design accordingly. PBSE usually involves nonlinear static analysis (pushover), also known as pushover analysis. Pushover analysis is a static, nonlinear procedure in which the magnitude of the lateral force is incrementally increased, maintaining the predefined distribution pattern along the height of the building. In the present study the pushover analysis of G+6 storey RCC frame building with shear wall and without shear wall is carried out using ETABS software, for that different models with shear wall prepared with different configuration. Parameters such as difference in the push-over curves, deflection, base shear, storey drift of different model is compared.**

Keywords--- **Base shear, Displacement, pushover analysis, storey drift**

I. INTRODUCTION

Earthquake is known to be one of the most devasting phenomenon experienced on the earth. It is caused due to a sudden release of huge amount energy in the earth's crust which will results into the seismic waves. When the seismic waves reach the foundation level of the building structure, it experiences horizontal as well as vertical motion at ground surface level. Due to this, earthquake is responsible for the damage to various manmade structures like buildings, bridges, dams, thermal power plant etc. It also causes landslides, liquefaction, slope-instability and overall loss of life and property. The expectation is that the pushover analysis will provide adequate information on seismic demands imposed by the design ground motion on the structural system and its components Which is useful in determining expected performance of any structure under large forces and modifying design accordingly. PBSE usually involves nonlinear static analysis (pushover), also known as pushover analysis. Pushover analysis is a static, nonlinear procedure in which the magnitude of the lateral force is incrementally increased, maintaining the predefined distribution pattern along the height of the building

1) Pushover Analysis:

Pushover is a static-nonlinear analysis method where a structure is subjected to gravity loading and also monotonic displacement-controlled lateral load pattern which continuously increases through elastic and inelastic behavior until an ultimate condition is reached. It can help demonstrate how progressive failure really occurs, and identify the mode of final failure. Lateral load may represent the range of base shear induced by earthquake loading, and its configuration may be proportional to the distribution of mass along building height, mode shapes or another practical means. Putting simply, PA is a non-linear analysis procedure to estimate the strength capacity of a structure beyond its elastic limit up to its ultimate strength in the post-elastic range.

2) types of pushover analysis

Types of Pushover Analysis Presently, there are two non-linear static analysis procedures available, Both methods depend on lateral load-deformation variation obtained by non-linear static analysis under the gravity loading and idealized lateral loading due to the seismic action. This analysis is called Pushover Analysis.

1) Displacement Coefficient Method (DCM), documented in FEMA-356

Displacement Coefficient Method is a non-linear static analysis procedure which provides a numerical process for estimating the displacement demand on structure using a bilinear representation of the capacity curve and a series of modification factors to calculate a target displacement. The point on capacity curve at target displacement is the equivalent of performance point in the capacity spectrum method

2)Capacity Spectrum Method (CSM), documented in ATC-40.

Capacity Spectrum Method $dp$is a non-linear static analysis procedure which provides a graphical representation of the expected seismic performance of the structure by intersecting the structure's capacity spectrum with the response spectrum (demand spectrum) of the earthquake. The intersection point is called as the performance point, and the displacement coordinate dp of performance point is the estimated displacement demand on structure for the specified level of seismic hazard.

3) different hinge properties in pushover analysis

There are mainly three types of hinge properties in ETABS software

They are

1St) Default hinge properties,

2nd) User-defined hinge properties and

3rd) Generated hinge properties.

Only first two hinge properties (default hinge properties and user-defined hinge properties) can be assigned to frame elements. When these hinge properties are assigned to a frame element, the program automatically creates a different generated hinge property for each and every hinge and Default hinge properties cannot be modified by us. They also cannot be viewed because the default properties are depending on section and also the default properties cannot be fully defined by the program until the section that they apply to is identified. Thus to see the proper effect of the default properties, the default property should be assigned to the frame element first, and then the resulting generated hinge property should be viewed. The built-in default hinge properties are mainly based on FEMA-273 and ATC-40 criteria. For example, for default properties, we have Default-M3, Default-P, Default-P-M-M and Default-V2 hinges. Generally, moment hinge properties (Default-M3) are assigned to beams and interacting hinge properties (Default-P-M-M) are assigned to columns.

4) Building performance level

Building performance is the combined performance of both structural and non-structural components of the building. Different performance levels are used to describe the building performance using the pushover analyses, which are described below.

5) Operational level (OL): As per this performance level building are expected to sustain no permanent damages. Structure retains original strength and stiffness. Major cracking is seen in partition walls and ceilings as well as in the structural elements.
6) Immediate occupancy level (IO): Buildings meting this performance level are expected to sustain no drift and structure retains original strength and stiffness. Minor cracking in partition walls and structural elements is observed. Elevators can be restarted. Fire protection is operable.

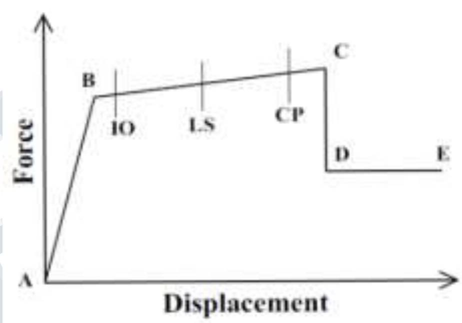

Fig. 1 Force-Displacement Curve of Hinge

7) Life Safety Level (LS): This level is indicated when some residual strength and stiffness is left available in the structure. Gravity load bearing elements function, no out of plane failure of walls and tripping of parapet is seen. Some drift can be observed with some failure to the partition walls and the building is beyond economical repair. Among the non-structural elements failing hazard mitigates but many architectural and mechanical and mechanical systems get damaged.
8) Collapse Prevention Level (CP): Buildings meeting this performance level are expected to have little residual strength and stiffness, but the load bearing structural elements function such as load bearing walls and columns. Building is expected to sustain large permanent drifts, failure of partitions infill and parapets and extensive damage to non-structural elements. At this level the building remains in collapse level.

9) Modelling of Building

a. MODELLLING in ETABS

Modelling of G+6 storey building has been done in ETABS software. Different five models were developed. In which one model is framed structure and in others four model shear wall was placed at different position in

IFERP
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 6, Issue 5, May 2021

addition to frame structure in the building. All the models having floor area 20 X 12 m (each bay 4 meter in length) and equal storey height 3 meter.

- Model 1: Bare frame Model (Without shear wall)
- Model 2: frame with Shear wall placed in core.
- Model 3: frame with shear wall placed at outer periphery of shorter dimension of building.
- Model 4: frame with shear wall placed at outer periphery of longer dimension of building.
- Model 5: frame with shear wall placed at two diagonal corners (As per shown in figure)

(In all Model with shear wall total length of shear wall have been kept equal 16 meter)

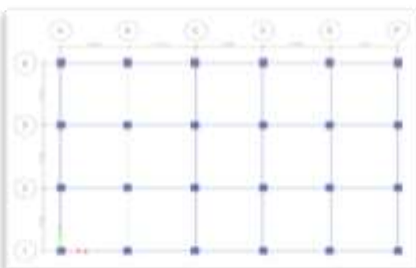

Fig. 2 plan of Model 1

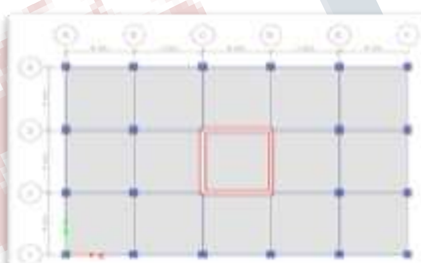

Fig. 3 Plan of Model 2

Fig. 4 Plan of Model 3

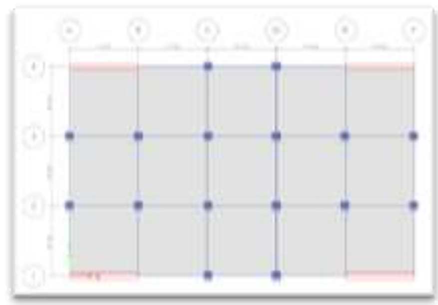

Fig. 4 Plan of Model 4

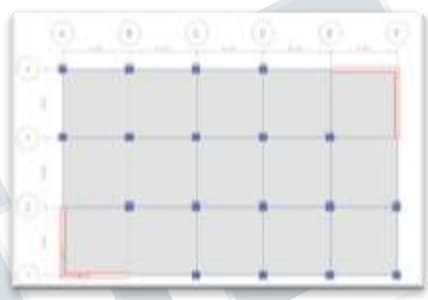

Fig. 5 Plan of Model 5

B. Material Property

- M30 grade concrete was used in all member for analysis purpose.
- Fe 415 grade of steel was used for analysis purpose.
- For shear reinforcement Fe250 was used.
- Nonlinearity of material was taken as per software.

C. Data and Assumption

Property	Comments
Beam Size	300X500mm
Column Size	500X500mm
Slab Thickness	150mm
Shear wall thickness	300mm
Dead Load	2 KN/m^2
Live load	4 KN/m^2
Importance Factor	1

In pushover analysis loading type is displacement controlled and building is Pushed to 4% of total height of building as per ATC 40. In our case height of all building model is same =3 X 6 =18 meter, so building was pushed to 0.04X18=0.720 meter or 720mm.

- Default M-3 hinge was assigned to all beams.
- Default P- M_2-M_3 hinge was assigned to all columns.
- For shear wall auto fiber P-M_3 hinge was used.

IFERP

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 5, May 2021

10) Result

a. Base shear and displacement at Performance Point for Load case (PA-X).

Building Model	Base Shear (Pa-x) at Performance point	Displacement (Pa-x) at Performance point
Model 1	9062 KN	116mm
Model 2	12840 KN	40mm
Model 3	8527 KN	116mm
Model 4	11380 KN	58mm
Model 5	11320 KN	62mm

Table 1. Performance Point for (PA-X)

b. Base Shear and Displacement at Performance Point for Load Case (PA-Y)

Building Model	Base Shear (Pa-Y) at Performance point	Displacement (Pa-Y) at Performance point
Model 1	9215 KN	134mm
Model 2	11582 KN	42mm
Model 3	10296KN	57mm
Model 4	11661 KN	127mm
Model 5	10880 KN	65mm

Table 2. Performance Point for (PA-X)

c. Maximum Storey Drift

Building Model	Maximum Storey Drift
Model 1	0.001815 @ storey **2**
Model 2	0.000544 @ storey **4**
Model 3	0.0002008 @ storey **2**
Model 4	0.000390 @ storey **4**
Model 5	0.000559 @ storey **4**

Table 3 Maximum storey Drift of the models for push forces in X(Pa-x) direction

Building Model	Maximum Storey Drift
Model 1	0.001838 @ storey **2**
Model 2	0.000523 @ storey **4**
Model 3	0.000729 @ storey **4**
Model 4	0.001373 @ storey **2**
Model 5	0.000029 @ storey **4**

Table 4 Maximum storey Drift of the models for push forces in Y(Pa-y) direction

II. CONCLUSION

1) From the pushover curves, it can be concluded that RCC Frames with Shear Walls are able to resist more base-shear than that of normal RCC Frames without shear wall and in pushover analysis in X direction (Pa-X load case) Model 2 resist maximum base shear 12840KN and In Y direction (Pa-y load case) model 4 resist maximum base shear.

2) RCC frame building with shear wall shows less displacement compare to normal RCC frame building and shear wall placed in any one direction X or Y (Model 3 and Model 4) are only able to reduce displacement in that particular direction only. Model 2 shows least displacement in both cases (40mm in Pa-x case &42mm in Pa-y case).

3) Maximum storey drift is maximum for model 1 in both load cases (Pa-x &Pa-y) and in Model 4 it is minimum for load case Pa-X. in model 5 it is minimum for load case (Pa-Y).

REFERENCES

[1] Achyut S. Naphade, Prof. G. R. Patil, "Pushover Analysis of RCC Building with Soft Storey at Different Levels", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320–334X PP 100-108(2015).

[2] Shaik Kamal Mohammed Azam, Vinod Hosur, "Seismic Performance Evaluation of Multistoried RC framed buildings with Shear wall", International Journal of Scientific & Engineering Research Volume 4, Issue 1, January-2013, ISSN 2229-5518.

[3] 3. Neethu K.N., Saji K. P., "Pushover Analysis of RC Building", International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064, Index Copernicus Value (2013): 6.14.

[4] Parishith J, Mrs. V. Preetha., "Pushover analysis on RC frames with and without shear wall", International Journal of Intellectual Advancements and Research in Engineering Computations, ISSN:2348-2079, Volume-5 Issue-1.

[5] Ketan Kulkarni, Rupen Goswami, "Comparative Study on Modelling of RC Structural Walls for Nonlinear Static Analysis", National Conference on Technological Innovations for Sustainable Infrastructure, Paper No.: T0009.

[6] Jasim Anamangadan, Glani G. Maria, "Pushover analysis of a Multistoried Shear wall Under Seismic Load", Asian Journal of Science and Technology, Volume 07, Issue,11, PP 3712-3715, November 2016.

[7] Asna Yani, Dr. Harpal Singh, "Performance of Different Shear Wall Position in Building Using Pushover Analysis", Journal of Civil Engineering and Environmental Technology, p-ISSN:2349-8404; Volume 6, Issue 3; April-June2019, pp. 123-127.

[8] G. S. Saisaran, T. Venkat Das, “Push Over Analysis for Concrete Structures at Seismic Zone-3 using Etabs Software”, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-018.
[9] ETABS User’s Manual, “Integrated Building Design Software”, Computer and Structure Inc. Berkeley, USA.
[10] IS: 1893(Part 1): 2002, " Criteria for Earthquake Resistant Design of Structures." Part-1, Bureau of Indian Standards.
[11] ATC-40 - “Seismic Evaluation and Retrofit of Concrete Buildings”, Applied Technology Council, November 1996. 14. 15.