COMPARATIVE STUDY OF BUILDING PERFORMANCES WITH AND WITHOUT SHEAR WALL USING PUSHOVER ANALYSIS

Miss. Nair Veena V.[1], Prof. Dr. D. N. Shinde[2]

[1] *Author Student, Department of Civil Engineering, P.V.P.I.T. Budhgaon, Maharashtra, (India)*
[2] *Associate Professor, Department of Civil Engineering, P.V.P.I.T. Budhgaon, Maharashtra, (India)*

ABSTRACT

Pushover analysis is a static, nonlinear procedure using simplified nonlinear technique to estimate seismic structural deformations. It is an incremental static analysis used to determine the force-displacement relationship, or the capacity curve, for a structure or structural element. The analysis involves applying horizontal loads, in a prescribed pattern to the structure incrementally, i.e. pushing the structure and plotting the total applied shear force and associated lateral displacement at each increment, until the structure or collapse condition. In technique a computer model of the building is subjected to a lateral load of a certain shape (i.e., inverted triangular or uniform). The seismic response of RC building frame in terms of various parameters such as base shear, storey displacement, performance point and the effect of earthquake forces on multi storey building frame with the help of pushover analysis is carried out in this paper. In the present study a building frame without shear wall and with shear wall is designed as per Indian standard i.e. IS 456:2000 and IS 1893:2002. The main objective of this study is to check the kind of performance a building can give when designed as per Indian Standards and also to determine the effect of providing shear wall to building frame. The pushover analysis of the building frame is carried out by using structural analysis and design software SAP 2000.

Keywords: Base Shear, Capacity Curve, Non Linear Static Analysis, Performance Point, Pushover Analysis.

I. INTRODUCTION

Pushover analysis is an approximate analysis method in which the structure is subjected to monotonically increasing lateral forces with an invariant height-wise distribution until a target displacement is reached. Pushover analysis consists of a series of sequential elastic analysis, superimposed to approximate a force-displacement curve of the overall structure. A two or three dimensional model which includes bilinear or tri-linear load-deformation diagrams of all lateral force resisting elements is first created and gravity loads are applied initially. A predefined lateral load pattern which is distributed along the building height is then applied. The lateral forces are increased until some members yield. The structural model is modified to account for the reduced stiffness of yielded members and lateral forces are again increased until additional members yield. The process is continued until a control displacement at the top of building reaches a certain level of deformation or structure becomes unstable. The roof displacement is plotted with base shear to get the global capacity curve.Pushover analysis can be performed as force-controlled or displacement-controlled. In force-controlled pushover procedure, full load combination is applied as specified, that is, force- controlled procedure should be used when the load is known (such as gravity loading). Also, in force-controlled pushover procedure some numerical problems that affect the accuracy of results occur since target displacement may be associated with a very small positive or even a negative lateral stiffness because of the development of mechanisms and P-delta effects. Pushover analysis has been the preferred method for seismic performance evaluation of structures by the major rehabilitation guidelines and codes because it is conceptually and computationally simple. Pushover analysis allows tracing the sequence of yielding and failure on member and structural level as well as the progress of overall capacity curve of the structure [1].

II. CASE STUDY DETAILS

For obtaining performance point a building frame of G+10 floors is considered. It is consisting of two bays in both the directions. The spacing along X and Y directions is 5.0m and the storey height is taken as 3.0m. The frame is located in seismic zone III.

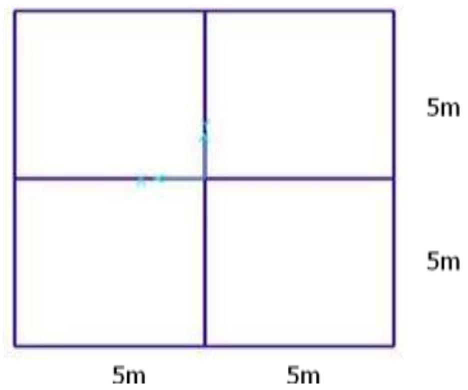
2.1 Design Data

- Live load : 4.0 kN/m^2 at typical floor
  : 1.5 kN/m^2 on terrace
- Floor finish : 1.0 kN/m2
- Water proofing : 2.0 kN/m^2
- Earthquake load : As per IS – 1893 : 2002 (part I)
- Type of soil : Type II, Medium As per IS – 1893
- Storey height : 3.0 m
- Walls : 230mm thick masonry wall
- Seismic zone : Zone III

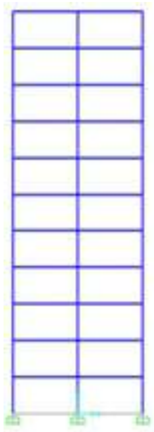
2.2 Description of Building Frame

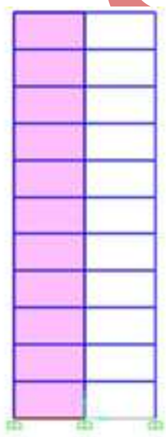
- No. Bays along X axis : 2
- No. Of bays along Y axis : 2
- Spacing along X axis : 5.0m
- Spacing along Y axis : 5.0m
- Storey height : 3.0m
- No. Of floors : G + 10
- Size of column : 600×500mm
- Size of beam : 300× 600mm
- Slab : 150mm thick

2.3 Plan of Building Frame



2.4 Elevation of Building Frame without and With Shear Wall





III. CALCULATION OF DESIGN BASE SHEAR

For obtaining the performance point of the building frame in terms of base shear the design base shear is calculated for determining the safety of the frame. The intersection of demand spectrum and capacity spectrum is the performance point of the structure. If the base shear at performance point is greater than design base shear then the structure is safer. The design base shear is calculated as per IS: 1893:2002 [2] as follows:

The seismic weight of building is found to be 25630.55 kN (Wi)

The infill walls in upper floors may contain large openings, although the solid walls are considered in load calculations. Therefore, fundamental time period (T) is obtained by using the following formula

$Ta = 0.075\ h^{0.75}$ (IS 1893 Part 1:2002, Clause 7.6.1)

$Ta = 0.075 \times (30)^{0.75}$

$Ta = 0.96$ sec.

Zone factor, Z = 0.16 for Zone III (IS: 1893 Part1:2002, Table 2)

Importance factor, I = 1.0,

Medium soil site and 5% damping

Sa/g =1.36/0.97 = 1.42 (IS: 1893 Part 1: 2002, Figure 2.)

Ductile detailing is assumed for the structure. Hence, Response Reduction Factor (R) is taken equal to 5.0. It may be noted however, that ductile detailing is mandatory in Zones III, IV and V. Hence, horizontal seismic coefficient is calculated as

$Ah = (Z/2) \times (I/R) \times (Sa/g)$ (IS: 1893 Part 1: 2002, clause 6.4.2)

$Ah = (0.16/2) \times (1.0/5) \times 1.42 = 0.022$

The design Base shear,

$VB = Ah \times Wi$ (IS: 1893 (Part 1): 2002, clause 7.7.1)

$VB = 0.022 \times 25630.55 = 563.87$ kN

In similar manner the designed base shear is calculated in case of building frame without shear wall and is found to be 516.58 kN

IV. RESULTS

On both building frames the non linear static pushover analysis is performed to investigate various parameters such as base shear, storey displacement, Storey drift and performance point of the building frame in terms of base shear and displacement. For pushover analysis the various pushover cases are considered such as push gravity, push X (i.e. loads are applied in X direction), push Y (i.e. loads are applied in Y direction). The various load combinations are also used for this purpose. After pushover analysis the demand curve and capacity curves are obtained to get the performance point of the structure. The performance point is obtained as per ATC 40 capacity spectrum method. The base shear for PUSH X load case is (1549.773 kN). And for PUSH Y base shear at performance point is (1549.773 kN) as shown in fig. 1 and fig. 2 in case of building frame without shear wall. In case of building frame with shear wall the base shear is found to be (1200.846 kN) for PUSH X and (1200.846 kN) for PUSH Y load case as shown in fig. 3 and fig. 4. The effect of providing shear wall on other parameters such as Storey displacement and Storey Drifts is shown in fig. 5.

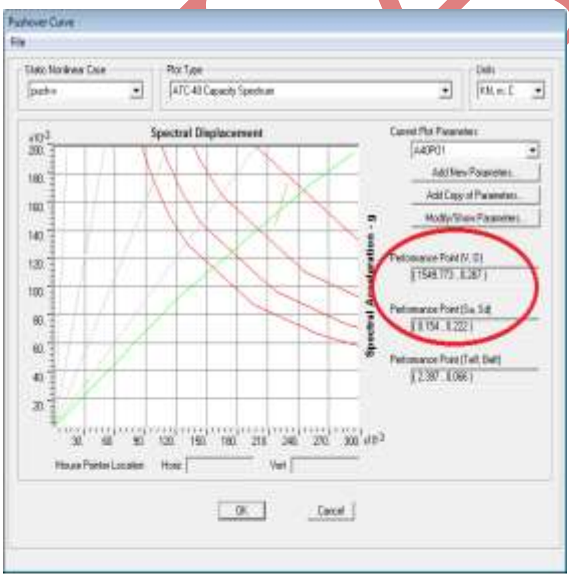


Fig. 1: Performance point of building frame without shear wall for PUSH X

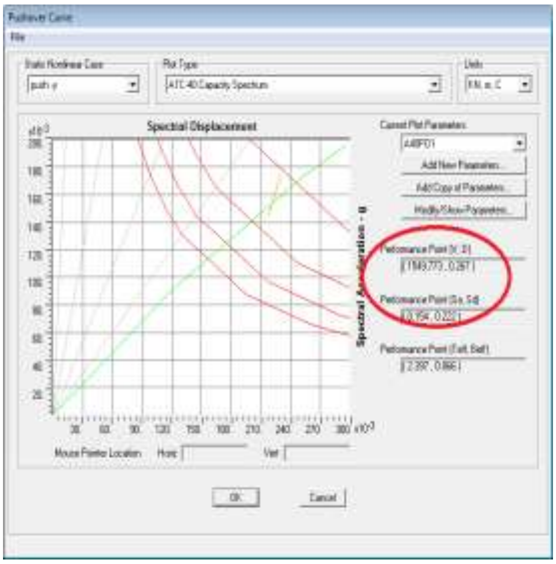


Fig. 2: Performance point of building frame without shear wall for PUSH Y

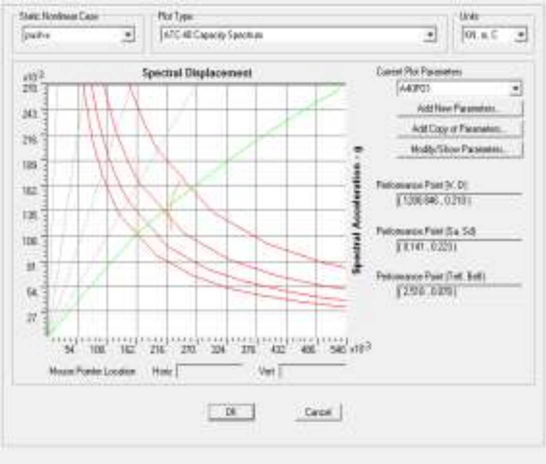


Fig. 3: Performance point of building frame with shear wall for PUSH X

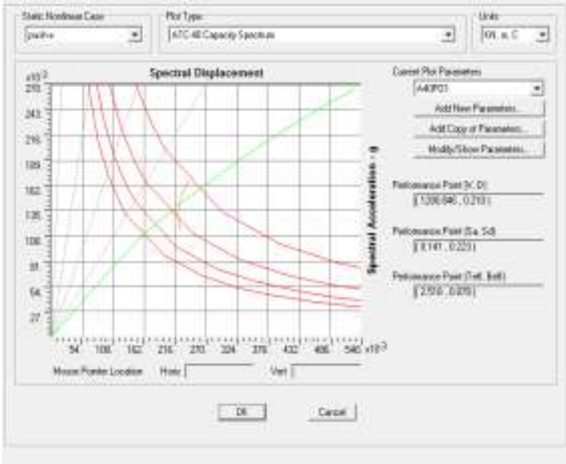


Fig.4: Performance point of building frame with shear wall for PUSH Y

V. COMPARISON OF BUILDING PERFORMANCES

After performing pushover analysis the building performances are compared in terms of various parameters. The parameters considered are base shear, Storey displacement and Storey drift. Base shear in case of both building frames with and without shear wall is considered at performance point. While the displacements and drifts are calculated at respective nodes. The comparison of the building frames is shown in table 1.

Table 1: comparison of building performances

From the results it can be seen that the building frame performance is better after providing shear wall. Due to provision of shear wall there is increase in the period of the building frame which results into reduction of base shear. The variation in above parameters is as shown in figure below.

Parameter	**Frame without shear wall**		**Frame with shear wall**	
	X	Y	X	Y
Base shear at performance point	1549.773 kN	1549.773 kN	1200.846 kN	1200.846 kN
Displacement at performance point	0.267 m	0.267 m	0.210 m	0.210 m
Storey displacement	0.48 m	0.48 m	0.46 m	0.0032 m
Storey drift	0.06 m	0.06 m	0.05 m	0.003 m
Spectral acceleration	0.154 m/s^2	0.154 m/s^2	0.141 m/s^2	0.141 m/s^2
Spectral displacement	0.222 m	0.222 m	0.223 m	0.223 m

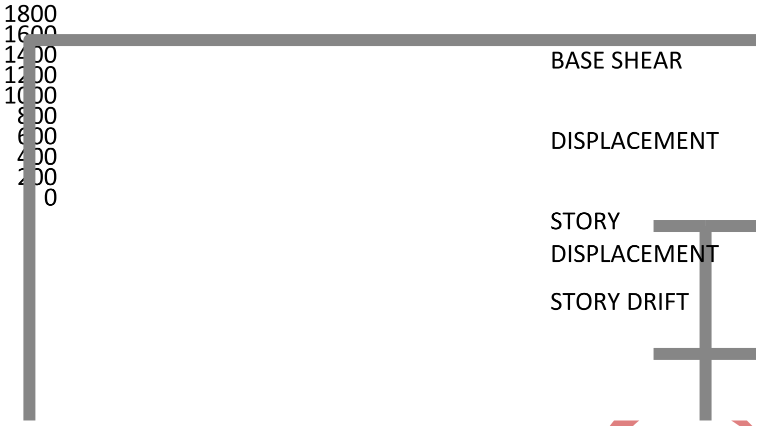


Fig. 5 Variation in Building Performances in Both Orthogonal Directions Due to Provision of Shear Wall

VI. CONCLUSION

- From the analysis results it can be seen that the base shear at performance point in case of building frame with shear wall is reduced up to 20% as compared to base shear in case of building frame without shear wall.[Table 1]
- After comparing the building parameters it can be seen that there is reduction of about 4.16% in storey displacement in case of building frame with shear wall.[Table 1]
- From the analysis results it can be seen that the storey drift in case of building frame with shear wall is reduced up to 16.16 % as compared to storey drift in case of building frame without shear wall in X direction and almost 90% reduction in storey drift along Y direction.[Table 1]
- In general it can be concluded that the provision of shear wall to building frame increases the rigidity of the structure, reduces the base shear , storey displacement and storey drift because increase in the period of the structure.

REFERENCES

[1] Konuralp Girgin and Kutlu Darılmaz "*Seismic Response of Infilled Framed Buildings Using Pushover Analysis.*" Department of Civil Engineering, Istanbul Technical University, 34469, Maslak, Istanbul, Turkey. .(December 2007) volume 54, number 5.

[2] IS:456:2000 Plain and Reinforced code of practice, IS: 875 Code of practice for design loads, IS:1893(Part-1):2002 Criteria for earth quake resistant design of structure, IS:13920:1993 Ductile detailing of RCC structure subjected to earth quake force.

[3] Chopra A.K. and Goel R.K. *"A Modal Pushover Analysis Procedure to Estimating Seismic Demands for Buildings: Theory and Preliminary Evaluation"*, PERR Report, Pacific Earthquake Engineering Research Centre, University of California (2001/03)

[4] Dalal Sejal P., Vasanwala S.A., Desai A.K *"Performance based seismic design of structure: A review"*, International Journal of Civil and Structural Engineering. (2011) Volume 1, No 4

[5] Mohammed S. Al-Ansari), *"Formulating building response to Earthquake loading"*, International Journal of Civil and Structural Engineering (2011) Vol. 2, No 1.

[6] Sudipta Chattopadyaya and Amlan K. Sengupta "*Modelling of tall walls for pushover analysis of reinforced concrete buildings" ,* The Indian concrete journal ,(2011), pp 7-14

[7] Y. Fahjan, B. Doran, B. Akbas, J. Kubin " *Pushover analysis for performance based – seismic design of RC frames with shear walls",* 15 WCEE, (2012)

[8] Murthy C.V.R, *Learning earthquake design*

[9] Agrawal, Shrikhande Mansih, *Earthquake resistant design of structures*

[10] Chopra A.K., *Dynamics of structures- theory and applications to earthquake engineering*

[11] Peter Fajafar M.EERI *"A non linear analysis method for Performance based seismic design",* Earthquake spectra, (2000) vol.16,no.3,pp 573-592