Article

Effects of Providing Shear wall and Bracing to Seismic Performance of Concrete Building

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Abstract

System strengthening and stiffening are the most common seismic performance improvement strategies adopted for buildings with inadequate lateral force resisting systems. most retrofit systems that increase structural strength, such as the addition of walls or frames, will also increase structural stiffness. Exceptions to this are relatively local-retrofit measures that strengthen existing elements without greatly altering their stiffness. The effect of strengthening a structure is to increase the amount of total lateral Force required initiating damage events within the structure. If this strengthening is done without stiffening, then the effect is to permit the structure to achieve larger lateral displacements without damage. 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 Bracing, shear wall and with Bracing, shear wall is designed as per Indian standard. 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 and Bracing to building frame. The pushover analysis of the building frame is carried out by using structural analysis and design software SAP 2000. Further, the importance of Shear wall and bracing and its contribution for strengthening is also discussed.

Keywords: *Moment resistance, Shear Wall, Bracing, Base Shear, Capacity Curve, Performance Point*

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Introduction

1.1. 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 are 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. Roof displacement is plotted with base shear to get the global. It is generally believed that the conventional elastic design analysis method cannot capture many important aspects that control the seismic performance of the building. The capacity of building to undergo inelastic deformations governs the structural behavior of building during seismic ground motions. For that reason, the evaluation of building should consider the inelastic deformation demanded due to seismic loading. On the other hand, linear elastic analysis does not provide information about real strength, ductility and energy dissipation in the structure [1]. Nonlinear dynamic analysis is principally convenient approach. However, it is very complex and not practical for every design. It needs time history of ground motion data and detailed hysteretic behavior of structural members which cannot be predicted. This analysis is appropriate for research work and for design of important structures [2]. To estimate seismic demands for building, the structural engineering profession is now using the nonlinear static procedure, known as pushover analysis. It is a commonly used technique, which provides acceptable results. The term static implies that a static analysis is applied to represent a dynamic Phenomenon [3].

Review of the conventional lateral load resisting systems and to adopt innovative and modified lateral load resisting Systems for effective and efficient mitigation of earthquake forces. Moment resting frames and shear wall elements have gained significant popularity in the recent years as effective construction methods in high seismicity areas. The significant improvement in the seismic capacity achieved by buildings by the introduction of shear walls have led to the concept of buildings built entirely of reinforced concrete walls popularly called as RC walled buildings.

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 [4].

Non-linear static (Pushover) analysis is considered as a powerful tool to assess the capacity of structure and hence is able to predict the actual behavior of the structure during earthquake. Pushover analysis essentially consists of subjecting the structure to a monotonically increasing load in a direction and plotting the base shear versus monitored displacement at the roof top which forms the capacity curve. The curve in then superimposed on the demand imposed by the earthquake forces to assess the level of performance of the structure.

One of the important pre-requisites for layered shell model is adopting a suitable non-linear material model for concrete and steel. Here, RC wall is modeled using a fine mesh of smeared multi-layer shell elements. The multi-layer shell element is based on the principles of composite material mechanics.

2. Description of Model: An Analysis

2.1. Geometry

The building model is as shown in the Fig.1 having 8 bays in the X and 6 bays in the Y directions with a bay width of 6m and 5m. The building is a residential building having G+10 floors with 3.5m storey height. Infill walls of thickness 250mm are located in the outer frames in each floor with the ground floor. The plan of the building is kept symmetrical in both orthogonal directions to avoid the torsion irregularity. The building elements are modeled using SAP2000. The columns are of uniform size of 60cm x 40cm while the dimensions of the beams are 40cm x 50 cm, Shear Wall thickness 20cm and bracing 30cm x 40cm. The response spectrum is adopted as per IS1893-2002. For seismic zone IV and soil type II.

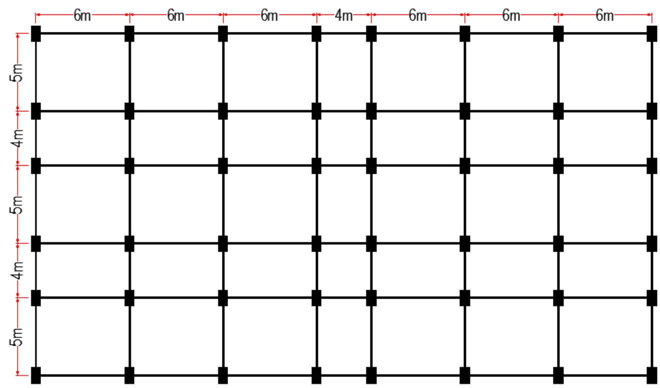

Figure 1: *Building Plan.*

2.2. Material Properties

M25 and M30 grade of concrete for Slab, beam and Columns. Fe415 grade of reinforcing bars are used for all the members considered under study. Unit weights and load details respectively.

Unit Weight of Concrete	25 KN/M3
Clear height of infill wall	3.0 m
Unit Weight of infill wall	18 KN/m3
LL	3.0 KN/m2
DL (Floor Finish and Partition wall)	2 KN/m2
Dead Load on beams from infill wall	14 KN /m
Dead Load on beams from infill wall	14 N /m

Table 1: *Material Properties.*

3. Models Considered for Analysis

A total of three Type of models are considered for analysis

(a) OMRF: ordinarily moment resistance frame without and lateral resistance system

(b) BMRF: Bracing Moment resistance frame providing bracing symmetric bracing in both direction X cross type of bracing.

(c) WMRF: wall moment resistance frame system. Shear Wall in both directions as symmetric for X and Y.

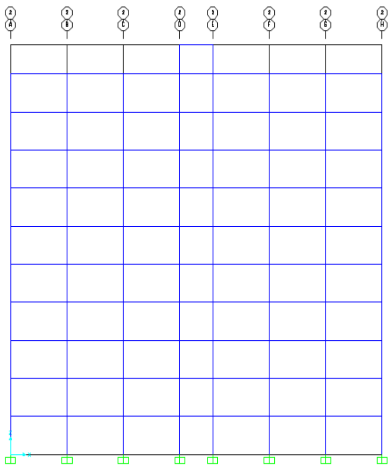

Figure 2: *(a) OMRF 2D model.*

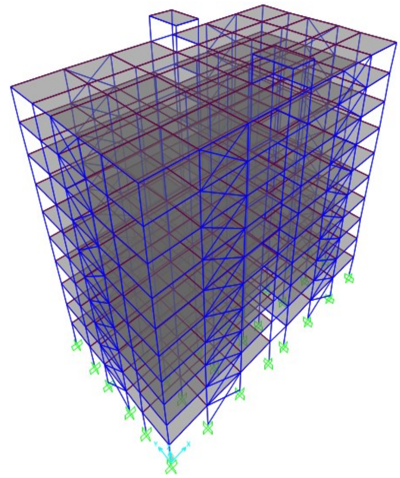

Figure 3: *(b) BMRF 3D Model.*

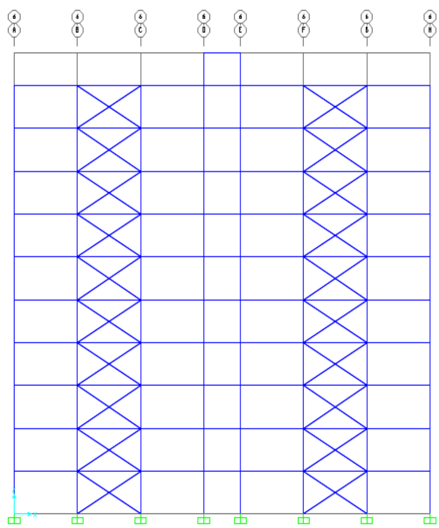

Figure 4: *(c) BMRF 2D Model.*

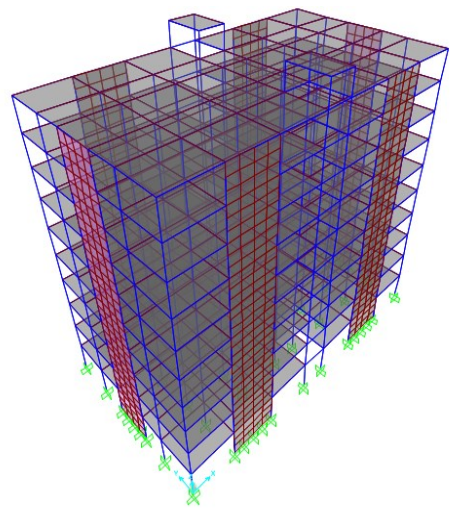

Figure 5: *(d) WMRF 3D model.*

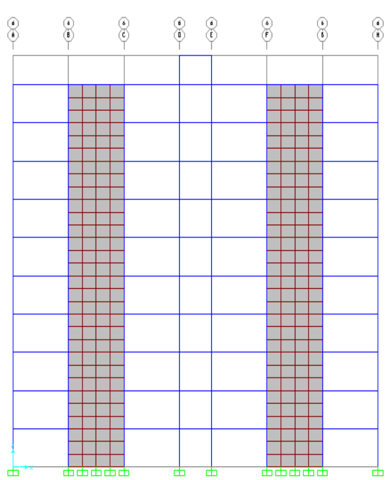

Figure 6: *(e) WMRF 3D Mode.*

4. Pushover Analysis of Structure

(Moment Resistance Frame and Bracing moment resistance frame and Shear wall moment resistance frame)

The nonlinear static analysis (Pushover) is performed using capacity spectrum method along with performance levels defined in ATC-40 to understand its seismic performance characteristics using SAP 2000 software version 18. With the default hinge properties in SAP 2000, these built-in properties can be useful for preliminary analyses, but user defined properties are recommended for final analyses. It shows the performance level, behaviour of components and failure mechanism in a building. it also shows the type of hinges formation, the strength and capacity of the frame.

At every deformation step of pushover analysis determine plastic rotation hinge location in the elements and which hinges reach the FEMA limit state, which are IO, LS, and CP using colors for identification. Plastic hinges formation has been obtained at different displacement levels or performance points. The hinging patterns for each region are plotted.

All type of Models Pushover analysis in X direction for OMRF, BMRF and WMRF and shown the Plastic hinge distribution. In Figure.3 Plastic hinge distribution (X-direction).

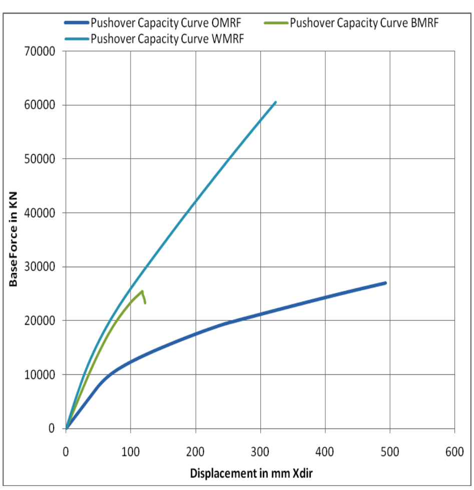

Diagram 1: *Pushover Capacity Curve X-axis.*

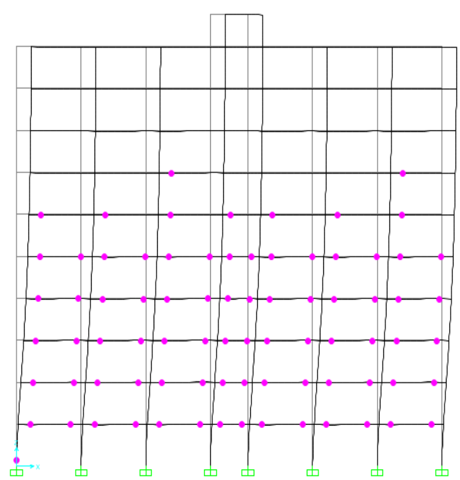

Figure 7: *(a) Plastic hinge distribution of OMRF.*

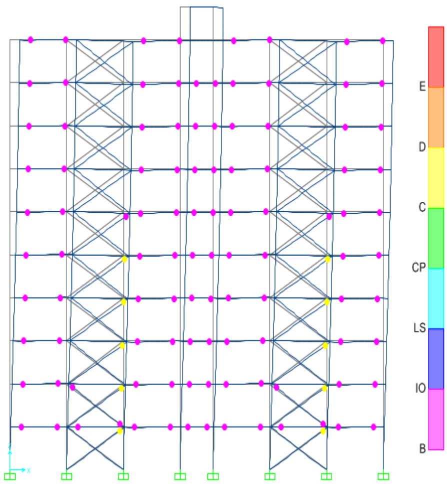

***Figure 8:** (b) Plastic hinge distribution BMRF X- axis.*

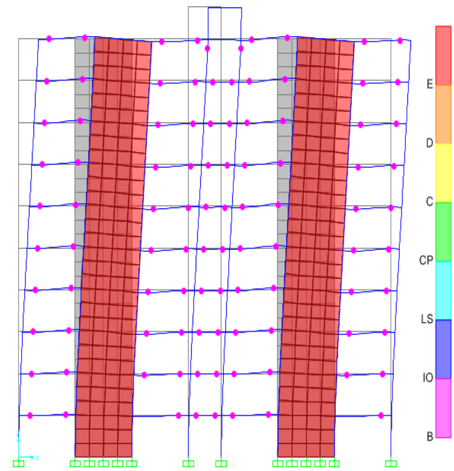

***Figure 9:** (c) Plastic hinge distribution of WMRF.*

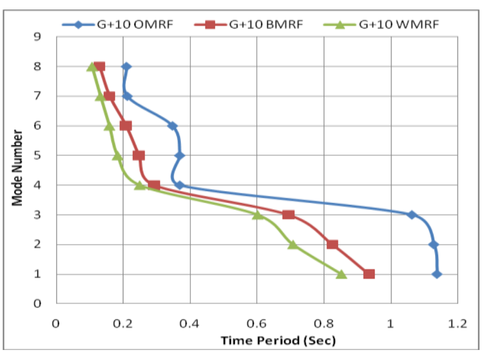

***Diagram 2:** Storey drift ratio Push-IO (Immediate Occupancy).*

G+10 Paramente Zone-IV	OMRF	BMRF(Bracing)	WMRF (Shear Wall)
	X_axis	X_axis	X_axis
Base Shear at Performance Point	**14646.393 KN**	**24765.078 KN**	**26166.792 KN**
Displacement at Performance Point	140.649 mm	110.78 mm	98.718 mm
Spectral Acceleration	0.119 m/sec^2	0.21m/sec^2	0.253 m/sec^2
Spectral Displacement	113.913 mm	79.496 mm	68.087 mm
Performance State	IO	IO	IO

***Table 2:** Comparison of Performance.*

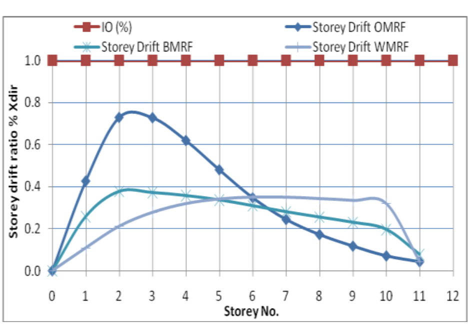

***Diagram 3:** Time Period vs. mode number.*

Global Stiffness of G+10			
Stiffness Ke [KN/m] at Performance	OMRF	BMRF	WMRF
[Kp]_Push-X	104134.285	223551.887	265066.067
[Ki]_Push-X	150903.016	276974.442	372425.788

KP: Global Stiffness at performance point.
Ki: Initial Stiffness of Building.

***Table 3:** Comparison of Stiffness of Building.*

4. Results

On all building frames, the nonlinear static pushover analysis is performed to investigate various parameters, such as storey displacement, Storey drift at 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), 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 IS 1983 capacity spectrum method. The base shear for PUSH-X load case is (14646.383kN). As shown in 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 (26166.792 KN) for PUSH X. In case of building frame with bracing the base shear is found to be (24765.078 KN) for PUSH X The effect of providing shear wall and bracing on other parameters such as Storey displacement, Base shear and Storey Drifts at performance point are shown in figure 11.

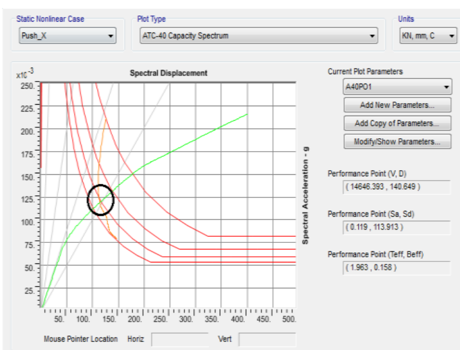

Figure 10: *Performance point of building frame of OMRF for PUSH-X.*

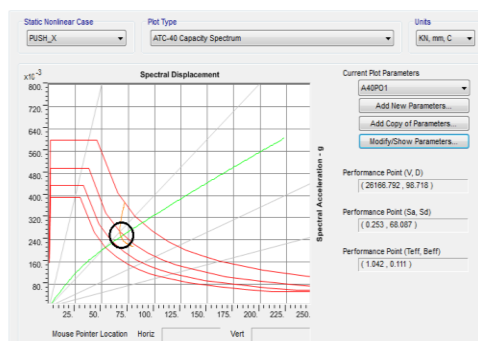

Figure 11: *Performance point of building frame* of BMRF for PUSH-X.

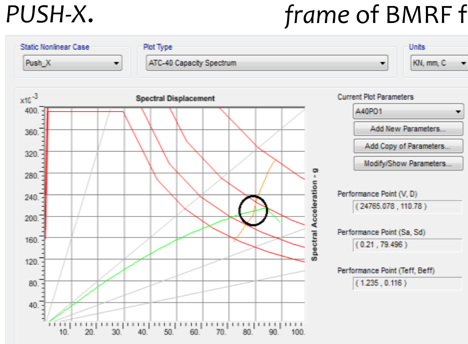

Figure 12: Performance point of building frame of WMRF for PUSH-X.

5. Conclusion

a) Linear analysis could not give useful information because if gravity load of structure combines with lateral load, it has large displacement, large amount of moment and it reduces the capacity of structure. Finally, more damage is caused.

b) From the analysis results, it can be seen that the base shear at performance point in case of building frame with shear wall and bracing are increased compared to base shear in case of building frame without shear wall and Bracing [Table-4.1].

c) The OMRF, BMRF and WMRF frame are found to be at a performance state of immediate occupancy as per the storey drift ratios given in ATC40. Hence, strengthening strategies are adopted to increase the performance state of the WMRF and BMRF frames.

d) Building with shear wall and bracing reduced the natural time period of building and increased the base shear.

e) Strengthened or stiffened building the Performance point and capacity of building Predominate increased. OMRF the lateral load 14646.383KN by added bracing and shear wall to the building lateral load capacity 24765.078 KN, 26166.792 KN. spectral acceleration also promoted from 0.119 m/sec^2 To $0.21 m/sec^2$, 0.253 m/sec^2 , lateral displacement at performance point decreased from 140.649mm To 110.78 mm, 96.716 mm.

f) Global stiffness of building increased when provided the Shear wall and Bracing to the building in Pushover analysis (104134.285KN/M, 223551.887 KN/M, 265066.067 KN/M).

g) Plastic Hinges distribution observed from BMRF and WMRF Uniformly to all stories than OMRF. The damages distribution also in all stories uniformly.

h) As per time period comparing it is brightly seen the deference of each frame OMRF, BMRF and WMRF. If the building or structure strengthened and stiffened time period has been decreasing by providing lateral resistance system as well increased base shear [Table-4.2].

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