International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

Performance Based Evaluation of Medium Rise RC Structures under the Influence of Infilled Walls

Prof. D.N.Kakde, Hasvi Mohd Aquib, Prof. Sayed Shoeb Iliyas

- *Prof. D.N.Kakde is currently working as an associate professor and an active researcher in PES college of Engineering, Aurangabad, Maharashtra. India. PH-+9190491055005. E-mail: deepak.kak06@gmail.com*
- *Hasvi Mohd. Aquib is currently pursuing his masters in structural engineering from PES college of Engineering, Aurangabad, Maharashtra. India. PH-+9190491055005. E-mail: deepak.kak06@gmail.com*
- *Prof. Shoeb Iliyas is currently working as an assistant professor in PES college of Engineering, Aurangabad, Maharashtra. India.*

Submitted: 01-06-2021 Revised: 14-06-2021 Accepted: 16-06-2021

ABSTRACT—This study enlightens the research study made on the performance based evaluation of medium rise structures. This is the partial development published under this article, the other part of the research which dealt with the performance based evaluation of low rise structures has been published under a different journals head. The performance based evaluation was done in accordance withFEMA-356's guidelines and procedures in the analytical soft computing tool, ETABS-2016. Post evaluation reports lead to the conclusions based upon the performance point and the hinge patterns developed during the failure mechanism.

Index Terms— Performance based analysis, Pushover analysis, Performance point, ETABS, FEMA-356, ETABS, Plastic hinges.

I. INTRODUCTION

Although elastic analysis gives a good indication of elastic capacity of structures and shows where yielding will first occur, It cannot predict the redistribution of forces during the progressive yielding that follows and predict its failure mechanisms. A non-linear static analysis can predict these more accurately. It can help identify members likely to reach critical states during an earthquake for which attention should be given during design and detailing.

Pushover Analysis is a non-linear analysis procedure to estimate the strength capacity of a structure beyond its Limit State up to its ultimate strength. It can help demonstrate how progressive failure in buildings most probably occurs, and identify the mode of final failure. The method also predicts potential weak areas in the structure, by keeping track of the sequence of damages of each and every member in the structure.

Pushover analysis can be adopted under two situations, the first one is when the structure is deficient in resisting the seismic forces due to negligence of seismic point of view during the design or if the structure becomes incompetent due to the later updating of the design codes. In such cases the structure needs to be retrofitted and hence the pushover analysis predicts the capacity for which the structure is to be retrofitted. If a structure is in its design phase, the pushover analysis helps in tweaking the design for adequate seismic resistance.

1.1 PROCEDURE FOR PUSHOVER ANALYSIS

Pushover Analysis is basically a second stage analysis. The first stage analysis being the conventional seismic analysis which is required for calculating the reinforcement demand of the structure which in turn is the needed for defining the exact hinge properties.

Thus the emerging methodology to an accurate seismic design is

1. First a conventional linear seismic analysis based on which a primary structural design is done;
2. Insertion of hinges determined based on the design/detail and then
3. A pushover analysis is done, followed by
4. Modification of the design and detailing, wherever necessary, based on the latter analysis.
5. The above steps may have to be iterated, if required.

1.2 DIFFERENT PUSHOVER APPROACHES

The pushover analysis can be performed by two methods,

1. The displacement control method and
2. The capacity spectrum method

The displacement control method procedures estimates a target displacement prior to the analysis, to which the model has to be pushed, and on analysis,

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

checked for the intended (good) performance at that displacement. The method is nevertheless, iterative. On the other hand in the capacity spectrum method the analysis is done, and each pt. on the pushover curve (known as Capacity curve) is consecutively checked to see whether the Sa-Sd at that pt. meets (or intersects) the Response Spectrum curve (known as Demand curve), reduced by a factor. The point at which the curves intersects is called as the performance point.
This study basically intended in predicting the performance points of the structures analyzed. The points and their relative properties has been specified in the subsequent part.

II. PRECURSORY LITERATURES

There has been numerous studies carried out with the perspective of performance based design of different structure, this study basically was interested in regards of the medium rise structures which were integrated with infills in the form of diagonal struts. The literatures studied as a part of this researches are discussed below:

A.S. Elnashai [1] In-elastic analysis nowadays is considered to be a very popular and strong tool, in contrast there are some short comings needs to be addressed. In this research, the author has made an attempt to address these critical issues in the application of inelastic static (pushover) analysis which were discussed and their effect on the obtained results appraised. Discussions were made regarding areas of possible developments that would render the methods more applicable to the prediction of dynamic response. Some curtains were raised for the new developments towards a fully adaptive pushover method accounting for spread of inelasticity, geometric nonlinearity, full multi-modal, spectral amplification and period elongation, within a framework of fiber modelling of materials were also discussed. The preliminary results were compared and conclusion was derived that developments lead to static analysis results that are closer than ever to inelastic time-history analysis. It was lastly concluded that there is great scope for improvements of this simple and powerful technique that would increase confidence in its employment as the primary tool for seismic analysis in practice. Dr. Vasant Matsagar [2] In this research the researcher had discussed regarding performance based design due its excessive popularity in the structural engineering stream. The described objective was to study the predictable seismic performance. The prediction of ductility, capacity and demand being very important to understand the seismic performance and inelastic responses of buildings subjected to earthquake ground motions was carried out. The nonlinear static analysis of a G+15 reinforced concrete building was carried out in SAP-2000 software. The building was subjected to six different earthquake ground motions. Two models were considered for analysis as frame with infill walls and frame without infill walls effect. Infill walls are provided throughout the building frame except the ground storey to study the open ground storey effect. The comparison was done with respect to parameters as maximum base shear, drift ratios and top storey displacement for three different performance levels as immediate occupancy (IO), life safety (LS) and collapse prevention (CP). Analysis showed that due to open ground storey damage is localized to members in the ground storey alone, which is not captured by the bare frame analysis. Ductility requirement for frames without infill walls is higher than for frames with infill walls. The ductility requirement increases as they moved towards lower performance objective (i.e. from IO to CP). Inelastic displacement demand ratio (IDDR) value for frame with infill was lower as compared to frame without infill walls. IDDR value increased from lower performance level to higher performance level. (I.e. from IO to CP). For frame without infill effect, the base shear is lower as compared with frame with infill walls and the displacement of storey is much higher for frame without infill walls as compared to frame with infill walls. The infill walls effect showed a major change in the performance of building and was suggested to be considered in the analysis. Performance based design technique helped to determine how the building performed under seismic effects so as to decide the measures in advance. A.K. Chopra and R.K. Goel [3] under this research developed an improved pushover analysis procedure based on the structural dynamics theory, which retains the conceptual simplicity and computational attractiveness of current procedures with invariant force distribution. In this modal pushover analysis (MPA), the seismic demand due to individual terms in the modal expansion of the effective earthquake forces was determined by a pushover analysis using the inertia force distribution for each mode. Combining these 'modal' demands due to the first two or three terms of the expansion provided an estimate of the total seismic demand on inelastic systems. When applied to elastic systems, the MPA procedure indicated to be equivalent to standard response spectrum analysis (RSA). When the peak inelastic response of a 9-storey steel building determined by the approximate MPA procedure was compared with rigorous non-linear response history analysis, it was demonstrated that MPA estimated the response of buildings responding well into the inelastic range to a similar degree of accuracy as RSA in estimating peak response of elastic systems. The MPA procedure was suggested to be very useful as it is accurate enough for practical application in building

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

evaluations and designs. N. Jitendra Babu [4] Explained non-linear analysis of various symmetric and asymmetric structures constructed on plain as well as sloping grounds subjected to various kinds of loads. Different structures constructed on plane ground and inclined ground of 30o slope is considered in the present study. Various structures are considered in plan symmetry and also asymmetry with difference in bay sizes in mutual directions. The analysis has been carried out using SAP-2000 and ETABS software. Pushover curves have been developed and compared for various cases. It has been observed that the structures with vertical irregularity are more critical than structures with plan irregularity. The nonlinear static procedure or pushover analysis is increasingly used to establish the estimations of seismic demands for building structures. Since structures exhibit nonlinear behavior during earthquakes, using the nonlinear analysis is inevitable to observe whether the structure is meeting the desirable performance or not (ATC 40). The pushover procedure consists of two parts. First, a target displacement for the building is established. The target displacement is an estimation of the top displacement of the building when exposed to the design earthquake excitation. Then a pushover analysis is carried out on the building until the top displacement of the building equals to the target displacement and the second one force controlled type in which the total amount of force acting is estimated and applied to the structure and the analysis is carried out. In order to consider the torsion effects in the nonlinear static analysis of the asymmetric buildings is carried out by defining the target displacement for each resisting element until failure (Emrah erduran (2008)). The base shear is applied in incremental order until the target displacement is reached. The main objective of the thesis was to consider the effects of the changes in the structures modal properties of asymmetric-plan buildings during the pushover analysis (Chatpan Chintanapakde (2004)) and the application of the displacement based adaptive pushover procedure (Kazem shakeri (2012)). The analysis part of structures was carried out in ETABS, SAP and STAAD. Results obtained in all the cases are compared with remaining two cases and found satisfactory results, so as to carry out the analysis in ETABS and SAP. Nonlinear analysis has been carried out for structures with irregularities in both plan and elevation which went under torsional effect due to vertical irregularity. The various results obtained from the analysis were presented.

III. SYSTEM DEVELOPMENT

In all a total of 9 buildings were simulated for this study which were considered to meet the research objectives specified in the precursory module. The simulations were modelled in the finite element analysis package of CSI America, ETABS-2016. To execute performance based analysis in ETABS, pushover method was adopted. The pushover analysis was done using FEMA-356 so as to achieve performance curves. Reinforced concrete buildings were considered in this study. This structures were designed according to IS 456-2000. The material properties were M30 Grade concrete, Fe 500 steel for the yield strength of longitudinal and transverse reinforcement. The plan layouts of the buildings modelled has been illustrated in the subsequent parts. The height of the first storey was kept to be 2.1 meters, and the remaining storeys were kept at 3.0 m each

- BFT- I: 2 x 2 G+12 Storied Bare Framed Structure.
- BFT- II: 4 x 4 G+12 Storied Bare Framed Structure.
- BFT- III: 6 x 6 G+12 Storied Bare Framed Structure.
- DST- I: 2 x 2 G+12 Storied Framed Structure integr-ated with Diagonal Strut.
- DST- II: 4 x 4 G+12 Storied Framed Structure integr-ated with Diagonal Strut.
- DST- III: 6 x 6 G+12 Storied Framed Structure integ-rated with Diagonal Strut.
- IWT-I: 2 x 2 G+12 Storied Framed Structure integrated with Infill walls.
- IWT-II: 4 x 4 G+12 Storied Framed Structure integr-ated with Infill walls.
- IWT-III: 6 x 6 G+12 Storied Framed Structure integrated with Infill walls.

TABLE 1
STRUCTURAL SPECIFICATIONS

1.	Type of sections	R.C.C.
Sizes of Column sections		
2.	Columns (C1)	230 X 450
3.	Columns (C2)	230 X 500

4.	Columns (C3)	230 X 600
Sizes of beam sections		
5.	Primary Beams	230 X 500
6.	Secondary beams	230 X 450
7.	Diagonal Struts	230 X 450

TABLE 2
LOADING SPECIFICATIONS

1.	Floor load	1.0 KN/m2
2.	Live load	3.0 KN/m2
3.	External wall load	12.9 KN/m
4.	Internal wall load	12.9 KN/m
5.	Code for RCC	IS 456 (2000)
6.	Code for seismic analysis	IS 1893 (2002)
7.	Code for Pushover	FEMA-356 (2000)
8.	Zone	IV (severe)
9.	Zone factor (Z)	0.24
10.	Importance factor	1.0
11.	Moment resisting frame	SMRF
12.	Response reduction factor	5.0
13.	Site soil type	Medium (II)

IV. PUSHOVER PARAMETERS

As stated above the seismic performance of building can be evaluated in terms of pushover curves, performance points, displacements, and plastic hinge formations. Here in this head the performance points of the pushover performed structures has been indicated and discussed in brief.

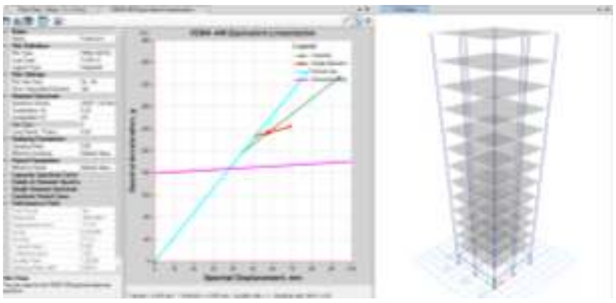

Fig. 1. Performance Point of BFT-I

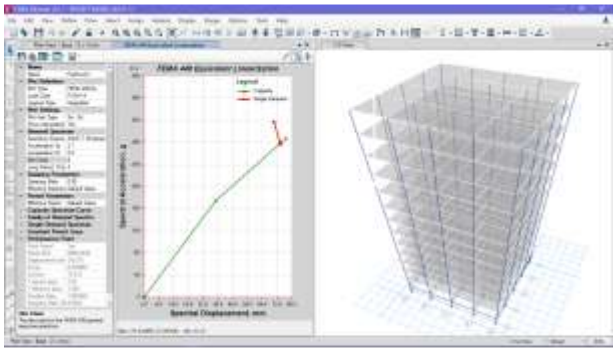

Fig. 2. Performance Point of BFT-II

Figure axis labels are often a source of confusion.

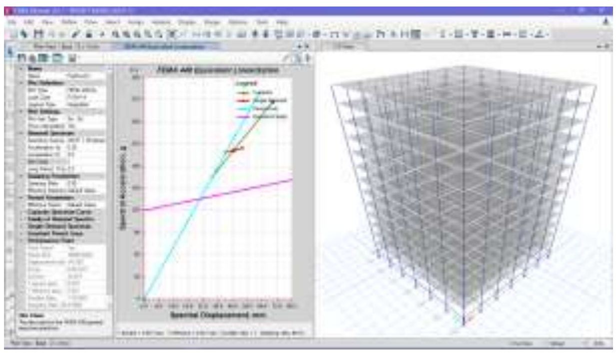

Fig. 3. Performance Point of BFT-III

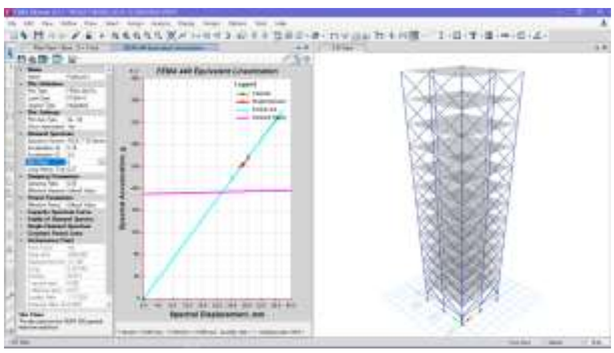

Fig. 4. Performance Point of DST-I

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

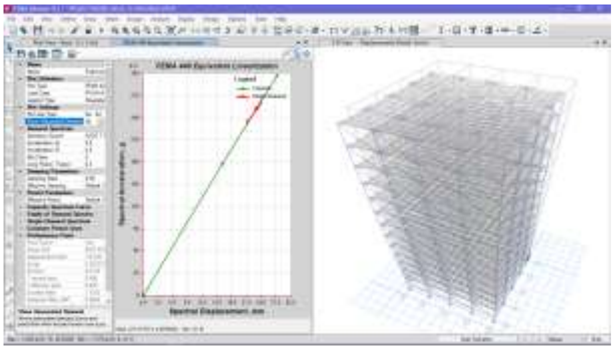

Fig. 5. Performance Point of DST-II

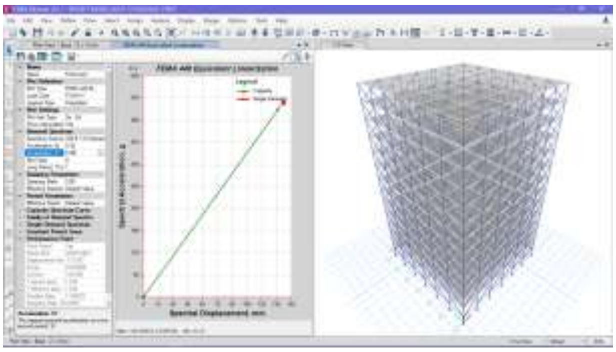

Fig. 6. Performance Point of DST-III

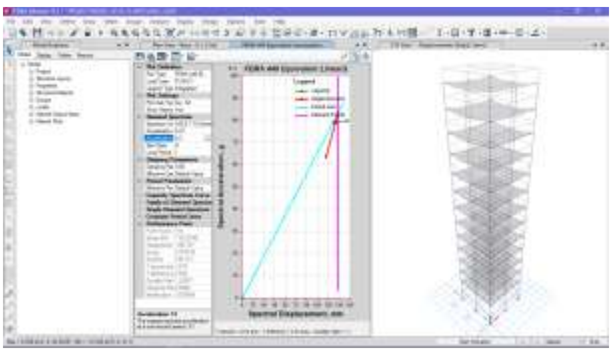

Fig. 7. Performance Point of IWT-I

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

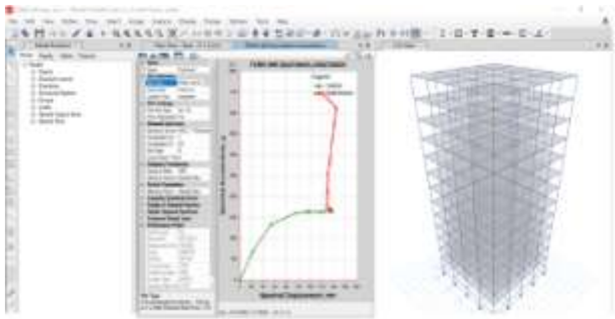

Fig. 8. Performance Point of IWT-II

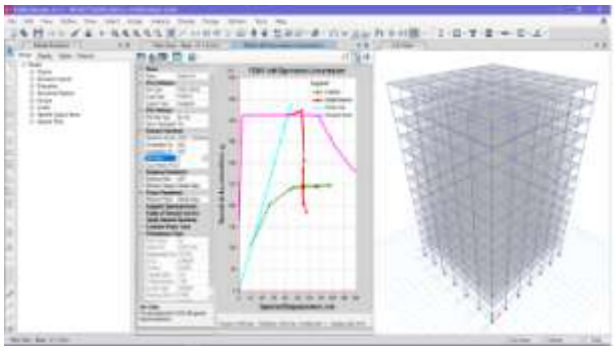

Fig. 9. Performance Point of IWT-III

TABLE 2COMPARISON OF PERFORMANCE POINTS & DISPLACEMENTS

MODEL NO/TYPE	**2x2 (I) (kN)/ (mm)**	**4X4 (II) (kN)/ (mm)**	**6X6 (III) (kN)/ (mm)**
BFT	1509	6800	10600
	79.78	98.218	64.265
DST	1690	6497	34033
	41.06	33.44	123.97
IWT	1132	7338	14878
	168.78	153.22	100.12

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 1275-1282 www.ijaem.Net Issn: 2395-5252

V. CONCLUSION

As specified in the precursory parts, this study was objected to make an evaluation of medium rise structures under the influence of pushovers. After the analysis was performed some conclusions were drawn on the basis of observations, which has been specified as under:

1] Unlike as in the low rise structures the performance point of the structures with diagonal strut converged to approximately similar values in 2X2 frame where as it dip to an additional low in 4X4 frame and it jumped to an exceptionally high value in the 6x6 frame, hence it can be concluded that it doesn't follow a linear relation.

2] The structures with diagonal struts reflected to be best effective in controlling the displacement values for the performance points achieved.

3] It can also be concluded that the performance point follows a linear relation with the number of bays, i.e. as the bays goes on increasing the performance points crawls to a higher value.

4] In case of infilled bays, the structure reflects a better performance point in the 4X4 and 6X6 frames whereas the 2X2 frame shows a considerable dip in its values.

5] Lastly it can be concluded that pushover analysis indicates the weak links of the structures which can be favorable in designing or retrofitting the same, Also ETABS is a fairly good code for performing pushovers on RC structures.

REFERENCES

[1] A.S. Elnashai, "Advanced inelastic static (pushover) analysis for earthquake applications", Structural Engineering and Mechanics, Vol. 12, No. 1 (2001), PP-51-69

[2] Dr. Vasant Matsagar, P.D. Pujari, S.N. Madhekar, "Advances in structural engineering, dynamics", Module-74, Volume 2, September 2014.

[3] A.K. Chopra and R.K. Goel, "A modal pushover analysis procedure for estimating seismic demands for buildings", Earthquake engineering and structural dynamics, August 2001.

[4] N. Jitendra Babu, "Pushover analysis of unsymmetrical framed structures on sloping ground", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD), Vol. 2 Issue 4 Dec – 2012. PP-45-54

[5] Applied Technology Council (ATC-40) (1996) Seismic evaluation and retrofit of concrete buildings, vol. 1. California Seismic Safety Commission, California.

[6] IS 1893 (2002) Criteria for earthquake resistant design of structures. Part 1 General Provisions and Buildings Bureau of Indian Standards, New Delhi.

[7] IS 456 (2000) Code of practice for plain and reinforced concrete. Bureau of Indian Standards, New Delhi.

[8] American Society of Civil Engineers (ASCE) (2000) Pre standard and commentary for the seismic rehabilitation of buildings, FEMA-356. Washington, DC.