Push Over Analysis for Concrete Structures at Seismic Zone-3 using Etabs Software

G. S. SaiSaran
B.TECH final year
civil engineering
KL University, GUNTUR
India
V. Yogendra Durga Prasad
B.TECH final year
civil engineering
KL University, GUNTUR
India
T. Venkat Das
Assistant Professor
civil engineering
KL University, GUNTUR
India

Abstract --- In this paper we are going to discuss about the analysis on the RC building frame, i.e., 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 of 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 loads at each increment until the structure or collapse condition. In technique a computer model of the building is subjected to a lateral loads of a certain shape (i.e., inverted triangular or uniformly). The intensity of the lateral load is slowly increased and the sequence of cracks, yielding, plastic hinge formation and failure of various structural components is recorded. Pushover analysis can provide a significant insight into the weak links in seismic performance of the structure.

The seismic response of RC building frame in terms of performance point and the effect of earthquake forces on multi story building frame with the help of pushover analysis is carried out in this paper. In the present study a building frame 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. The pushover analysis of the building frame is carried out by using structural analysis by software E-tabs at only zone-3 earthquake.

Keywords: Pushover Analysis ; Non linear Static analysis ; Performance point ; Capacity curve ; Displacement ; Drift of stories ; seismic zones ; Etabs software.

I. INTRODUCTION

Structures endure critical inelastic distortion under a strong earthquake and dynamic qualities of the structure change with time, so examining the execution of a structure requires inelastic scientific strategies representing these dynamics. Inelastic analytical methods comprehend the real conduct of structures by recognizing disappointment modes and the potential for dynamic breakdown. Inelastic analysis methods fundamentally incorporate inelastic time history analysis and inelastic static analysis which is otherwise called pushover analysis.

The inelastic time history analysis is the most exact technique to anticipate the force and deformation requests at different components of the structure. In any case, the utilization of inelastic time history analysis is constrained in light of the fact that dynamic reaction is exceptionally delicate to displaying and ground movement qualities. It requires appropriate demonstrating of cyclic burden disfigurement qualities considering weakening properties of exceedingly vital components. Additionally, it requires accessibility of an arrangement of delegate ground movement records that records for instabilities and contrasts in seriousness, frequency and length of time attributes. Additionally, calculation time, time required for info arrangement and interpreting voluminous output make the utilization of inelastic time history analysis impractical seismic execution assessment.

Inelastic static analysis, or pushover analysis, has been the favored strategy for seismic execution assessment because of its effortlessness. Nonlinear static analysis, or pushover analysis, has been produced in the course of recent years and has turned into the favored analysis method for configuration and seismic execution assessment purposes as the methodology is generally straightforward and considers post versatile conduct. In any case, the method includes certain approximations and improvements that some measure of variety is constantly anticipated that would exist in seismic interest forecast of pushover analysis.

In spite of the fact that, in writing, pushover analysis has been appeared to catch crucial auxiliary reaction attributes under seismic activity, the exactness and the unwavering quality of weakening analysis in foreseeing worldwide and neighborhood seismic requests for the sum total of what structures have been a subject of talk and enhanced weakening systems have been proposed to conquer the specific restrictions of conventional pushover strategies. In any case, the enhanced methodology are for the most part computationally requesting and theoretically complex that utilization of such systems is unrealistic in engineering profession and codes.

As conventional pushover analysis is generally utilized for configuration and seismic execution assessment purposes, its constraints, shortcomings and the exactness of its expectations in routine application ought to be recognized by considering the components influencing the pushover forecasts. As it were, the materialness of pushover analysis in anticipating seismic requests ought to be explored for low, mid and skyscraper structures by distinguishing certain issues, for example, demonstrating nonlinear part conduct, computational plan of the method, varieties in the forecasts.
of different horizontal burden designs used in customary pushover analysis, proficiency of invariant parallel burden designs in speaking to higher mode impacts and precise estimation of target uprooting at which seismic interest expectation of pushover technique is performed.

II. DATA USED
A. Materials properties
In the model, the support condition was assumed to be fixed and soil condition was assumed as soft soil. Building was a symmetric structure with respect to both the horizontal directions. And other data used is tabulated

| Table 1: data description in etabs |
|-----------------------------------|
| Dead load over slab/ floor finishing | 1 KN/m^2 |
| Imposed load                       | 2 KN/m^2 |
| Wind velocity                      | 50 m/sec |
| Seismic loads                      | As per IS:1893 (Part-1) 2002 |
| Wind loads                         | As per IS:875 (Part-3) 1987 |
| Critical damping                   | 5%      |
| Important factor                   | 1.5     |
| Response reduction factor          | 3       |
| Soil zone                          | III     |
| Seismic zone                       | 3       |
| Zone factor (Z)                    | 0.16    |

B. Dimensional properties
All the dimension values of the selected structure is tabulated as follows with the drawing in E tabs

| Table 2: dimension values and building |
|----------------------------------------|
| No. of stories                        | G+9 |
| Beam                                   | 0.3048x0.6096 mt |
| Column                                 | 0.3048x0.6096 mt , 0.3048x0.6858 mt |
| Slab thickness                         | 0.22 mt |
| Height of base                         | 3.2004 mt |
| Height of each floor                   | 3.2004 mt |
| Total elevation of building            | 32.004 mt |
III. STATIC CALCULATION OF THE BUILDING

A. Seismic load calculation in x and y direction

This calculation presents the lateral seismic loads for load pattern EQX according to IS1893 2002, as calculated.

Fundamental Natural Time Period- The fundamental natural time period \( (T_a) \) calculates from the expression

\[
T_a = 0.075h^{0.75} \text{ for RC frame building}
\]

Direction = X

Seismic Response

Spectral Acceleration Coefficient, \( S_a/g \) [IS 6.4.5] = 1.67/T = 1.21452

Direction = Y

Seismic Response

Spectral Acceleration Coefficient, \( S_a/g \) [IS 6.4.5] = 1.67/T = 1.159476

Equivalent Lateral Forces

Seismic Coefficient, \( A_h \) [IS 6.4.2] \( A_h = \frac{(ZI S_a/g)}{2R} \)

| Story | Elevation | X-Dir | Y-Dir |
|-------|-----------|-------|-------|
|       | m         | kN    | kN    |
| STORY10 | 32.004 | 293.6711 | 280.3614 |
| STORY9  | 28.8036 | 263.4737 | 251.5326 |
| STORY8  | 25.6032 | 208.1768 | 198.7418 |
| STORY7  | 22.4028 | 159.3854 | 152.1617 |
| STORY6  | 19.2024 | 117.0994 | 111.7923 |
| STORY5  | 16.002 | 81.3191 | 77.6335 |
| STORY4  | 12.8016 | 52.0442 | 49.6855 |
| STORY3  | 9.6012 | 29.2749 | 27.9481 |
| STORY2  | 6.4008 | 13.011 | 12.4214 |
| STORY1  | 3.2004 | 3.2528 | 3.1053 |
| BASE    | 0        | 0     | 0     |

Table 4: lateral loads applied on building respect to direction

| Direction | Period Used (sec) | W (kN) | Vx (kN) |
|-----------|------------------|--------|---------|
| X         | 1.375            | 25127.3798 | 1220.7084 |
| Y         | 1.44             | 25127.3798 | 1165.3836 |

IV. METHODOLOGY

- Collect the detail sectional measurement of the plan for which the analysis is to be conducted
- Then a line diagram is to be drawn to make sure that the dimensional values are correct by the joints of beams and columns
- This same plan and raise of each floor values is to be imported to display the model in both 2d and 3d in ETABS
- By using the options available material and section values is to be created and assigned to the respective
elements by selecting them individual, even the slab thickness

- Then after static load cases are to be created as DL, LL, FF, EQ, WL with self-weight factor -1 all dead loads and for earthquake, wind loads are assigned with their respective coded like IS1893, IS875
- And load of live load and floor finish loads are assigned by selecting the floor area as uniform distributed
- For this to apply the EQ and W loads diaphragm is to be created as rigid and assigned by selecting the slab area then the displacement can be calculated ad uni-member at floor level
- Now the static push over details are to be created at standard valued displacement magnitude in all three directions i.e., Z (dead loads, live loads), X (earthquake, wind loads), Y (earthquake, wind loads) as PUSH1, PUSH2, PUSH3.

\[ \text{Fig 4: standard push curve} \]

- Point A corresponds to unloaded condition.
- Point B represents yielding of the element.
- The ordinate at C corresponds to nominal strength and abscissa at C corresponds to the deformation at which significant strength degradation begins.
- The drop from C to D represents the initial failure of the element and resistance to lateral loads beyond point C is usually unreliable.
- The residual resistance from D to E allows the frame elements to sustain gravity loads.
- Beyond point E, the maximum deformation capacity, gravity load can no longer be sustained.

- Then selecting all the beam elements and columns elements to create the non-linear hinges with shear, moment and bi axial moment conditions respectively
- Then run general analysis to lock the values assigned and later run the static non-linear analysis i.e., PUSHOVER analysis
- After all we get all the push over curves comparison, story drift and displacement values for different seismic zones
- This is done at the earthquake load defining with the zone factor from 0.16, zone 3
- Then required values can be obtained at different condition and comparison is to be drawn

V. RESULTS AND DISCUSSIONS

The Push over curve are mainly explained using standard pushover curve in which categorization stress points are done
A. Pushover in x direction

Fig 5: pushover curve due to load in x-direction

Table 5: hinges position on curve after the push in x-direction

| Step | Monitored Displ | Base Force | A-B | B-C | C-D | D-E | >E | A-IO | IO-LS | LS-CP | >CP | Total Hinges |
|------|-----------------|------------|-----|-----|-----|-----|----|------|-------|-------|-----|--------------|
|      | mm              | kN         |     |     |     |     |    |      |       |       |     |              |
| 0    | 0               | 0          | 480 | 0   | 0   | 0   | 480| 0    | 0     | 0     | 480|              |
| 1    | 72.1            | 2095.5565  | 478 | 2   | 0   | 0   | 480| 0    | 0     | 0     | 480|              |
| 2    | 82.5            | 2224.7642  | 408 | 72  | 0   | 0   | 480| 0    | 0     | 0     | 480|              |
| 3    | 170.5           | 2643.7196  | 372 | 108 | 0   | 0   | 480| 0    | 0     | 0     | 480|              |
| 4    | 170.5           | 2598.1813  | 326 | 153 | 1   | 0   | 368| 62   | 28    | 22    | 480|              |
| 5    | 172             | 2611.1218  | 326 | 150 | 3   | 1   | 368| 56   | 31    | 25    | 480|              |
| 6    | -6              | -1795.7541 | 326 | 145 | 0   | 7   | 368| 54   | 26    | 32    | 480|              |

Fig 6: performance point when push in x direction
B. Pushover in y-direction

Fig 7: pushover curve due to load in y direction
Table 6: hinge position on the curve after the push in y direction

| Step | Monitored Displ | Base Force | A-B | B-C | C-D | D-E | >E | A-IO | IO-LS | LS-CP | >CP | Total Hinges |
|------|-----------------|------------|-----|-----|-----|-----|----|------|-------|-------|-----|-------------|
|      | mm              | kN         |     |     |     |     |    |      |       |       |     |             |
| 0    | 0               | 0          | 480 | 0   | 0   | 0   | 480| 0    | 0     | 0     | 480 |             |
| 1    | 60.2            | 1650.2732  | 478 | 2   | 0   | 0   | 480| 0    | 0     | 0     | 480 |             |
| 2    | 82.4            | 2173.0317  | 408 | 72  | 0   | 0   | 480| 0    | 0     | 0     | 480 |             |
| 3    | 94.6            | 2321.1036  | 378 | 102 | 0   | 0   | 480| 0    | 0     | 0     | 480 |             |
| 4    | 183.4           | 2750.3593  | 332 | 146 | 2   | 0   | 5  | 364  | 56    | 36    | 24  | 480         |
| 5    | 125.8           | 941.5893   | 332 | 133 | 2   | 8   | 5  | 364  | 56    | 29    | 31  | 480         |

Fig 8: performance point when push in y direction

VI. CONCLUSION

1. Pushover analysis was carried out separately in the X and Y directions. The resulting pushover curves, in terms of Base Shear – Roof Displacement (V-Δ), given for X and Y separately in both the zones. The slope of the pushover curves is gradually changed with increase of the lateral displacement of the building. This is due to the progressive formation of plastic hinges in beams and columns throughout the structure.

2. From the results obtained in Y-direction there are 32 elements in zone 3 exceeding the limit level between life safety (LS) and collapse prevention (CP), This means that the building requires retrofitting at extreme failure.

3. It was found that the seismic performance of studied building is inadequate in zone 3 X-X direction, because there are some elements exceeding the limit between life safety (LS) and collapse prevention (CP), while that of zone 3 Y-Y direction is adequate, because some elements were not reached the Immediate Occupancy (IO) level and most of them had not reached the collapse point as well.

4. As the performance point of the building lies within the limit no need of retrofitting are recommended. Hence the structure is safe

VII. REFERENCE

[1] Yousuf Dinar, Md. Imam Hossain, Rajib Kumar Biswas, Md. Masud Rana, “Descriptive Study of Pushover Analysis in RCC Structures of Rigid Joint “, Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684

[2] Harshitha. R, A.Soundarya, Krishnareddygari Prathima, Y.Guruprasad, “SEISMIC ANALYSIS OF SYMMETRIC RC FRAME USING RESPONSE SPECTRUM METHOD AND TIME HISTORY METHOD”, International Journal Of Scientific Research And Education ISSN (e): 2321-7545

[3] Jayesh. A. Dalal, Atul. K. Desai , “WIND AND SEISMIC TIME HISTORY ANALYSIS FOR LATTICE SHELL TUBE RCC FRAMED BUILDINGS “ , International Journal of Advances in Engineering & Technology, May 2013. ©IJAEET ISSN: 2231-1963

[4] Anurag JAIN, PhD, CE;Gary C. HART, PhD, CE ;Chukwuma EKWUEME, PhD, SE ;Alexis P. DUMORTIER, CE ; “PERFORMANCE BASED PUSHOVER ANALYSIS OF WOOD FRAMED BUILDINGS”, 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 1217

[5] D.N. Shinde, Nair Veena V, Pudale Yojana M, “ PUSHER ANALYSIS OF MULTY STORY BUILDING “ , International Journal of Research in Engineering and Technology eISSN: 2319-1163
[6] N.K. Manjula, Praveen Nagarajan, T.M. Madhavan Pillai, “A COMPARISON OF BASIC PUSHOVER METHODS”, International Refereed Journal of Engineering and Science (IRJES) ISSN (Online) 2319-183X

[7] A.E. Hassaballa a*, M.A. Ismaiel b, A.N. Alzeade, Fathelrahman M. Adamd, “Pushover Analysis of Existing 4 Storey RC Flat Slab Building”, International Journal of Sciences: Basic and Applied Research (IJSBAR) ISSN 2307-4531

[8] Rahul RANA, Limin JIN and Atila ZEKIOGLU, “PUSHOVER ANALYSIS OF A 19 STORY CONCRETE SHEAR WALL BUILDING”, 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 133

[9] Ashraf Habibullah, S.E., Stephen Pyle, S.E; “Practical Three Dimensional Nonlinear Static Pushover Analysis”, Structure Magazine, Winter, 1998

[10] Srinivasu A, Dr. Panduranga Rao B, “Non-Linear Static Analysis of Multi-Storied Building”, International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 10 - Oct 2013