Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 03, March-2016

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

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***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 ; sesimic 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 weakling analysis in foreseeing worldwide and neighborhood seismic requests for the sum total of what structures have been a subject of talk and enhanced weakling 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

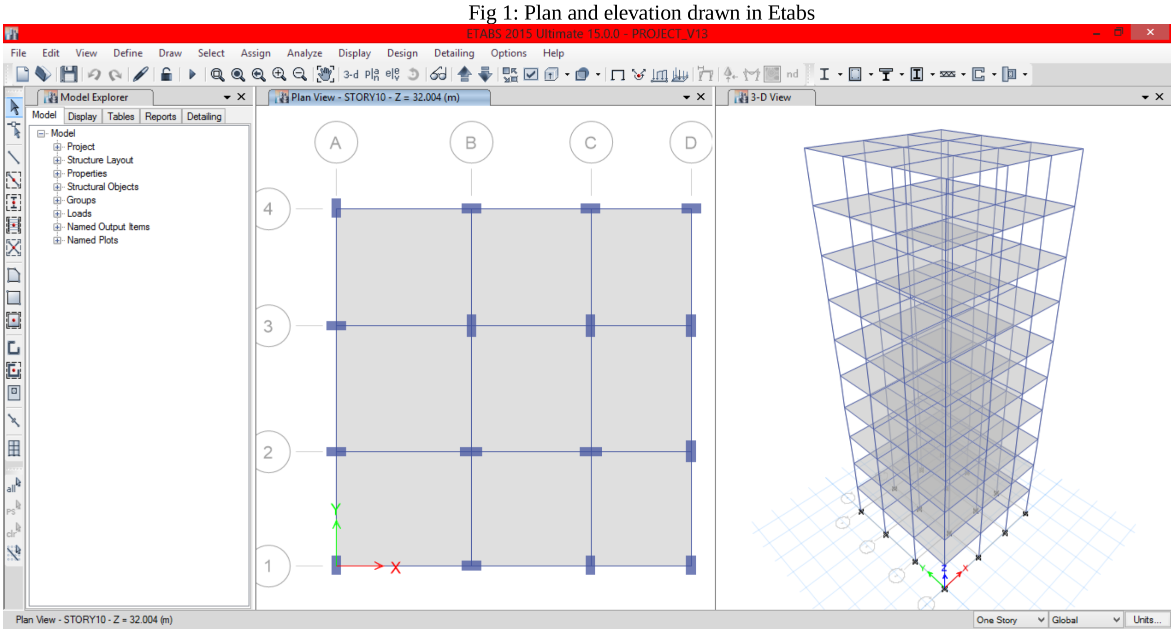
B. Dimensional properties

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

Fig 1: Plan and elevation drawn in Etabs



International Journal of Engineering Research & Technology (IJERT)
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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 (*Ta*) calculates from the expression

$Ta = 0.075h^{0.75}$ 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] $A_h = \frac{Z I S_a/g}{2R}$

Table 3: Calculated Base Shear and seismic weight of building

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)	V_b (kN)
X	1.375	25127.3798	1220.7084
Y	1.44	25127.3798	1165.3836

Fig 2: lateral loads in x direction

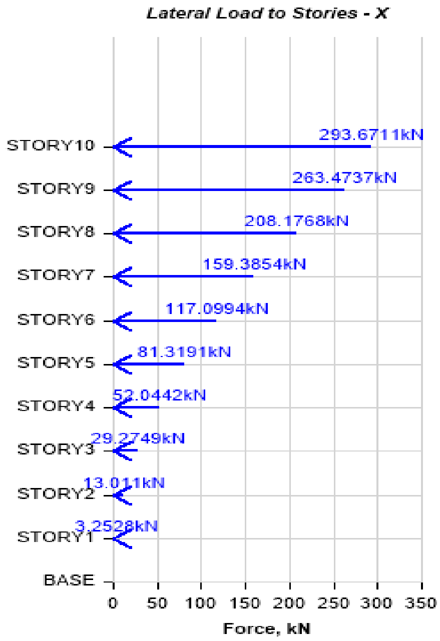
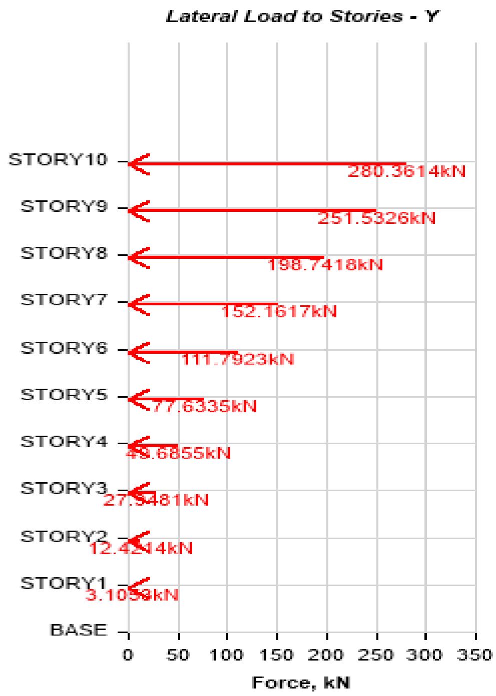


Fig 3 : lateral loads in y direction



IV. METHODOLOGY

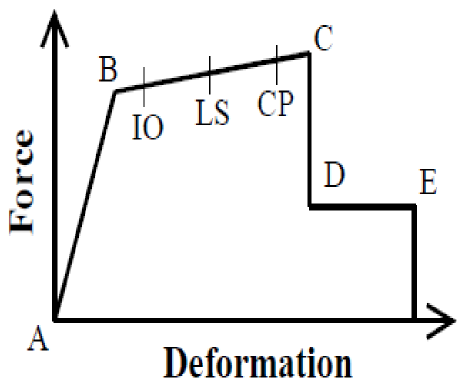
- Collect the detail sectional measurement of the plan for which the analysis is to be conducted
- Then a line diagram is to be drawn to make sure that the dimensional values are correct by the joints of beams and columns
- This same plan and raise of each floor values is to be imported to display the 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

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 03, March-2016

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 earth quake , 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 .

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

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International Journal of Engineering Research & Technology (IJERT)
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A. Pushover in x direction

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

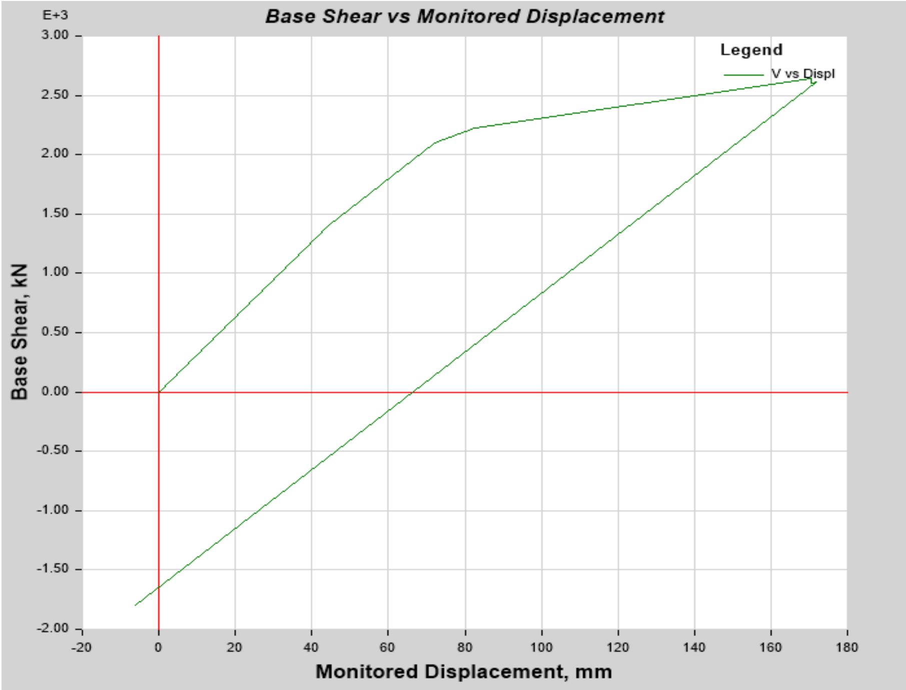

Table 5 : hinges positon on curve after the push in x-direction

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	0	480	0	0	0	480
1	44.4	1397.7456	478	2	0	0	0	480	0	0	0	480
2	72.1	2095.5565	408	72	0	0	0	480	0	0	0	480
3	82.5	2224.7642	372	108	0	0	0	480	0	0	0	480
4	170.5	2643.7196	326	153	1	0	0	368	62	28	22	480
5	170.5	2598.1813	326	153	0	1	0	368	61	27	24	480
6	172	2611.1218	326	150	3	1	0	368	56	31	25	480
7	-6	-1795.7541	326	145	0	7	2	368	54	26	32	480

Fig 6: performance point when push in x direction

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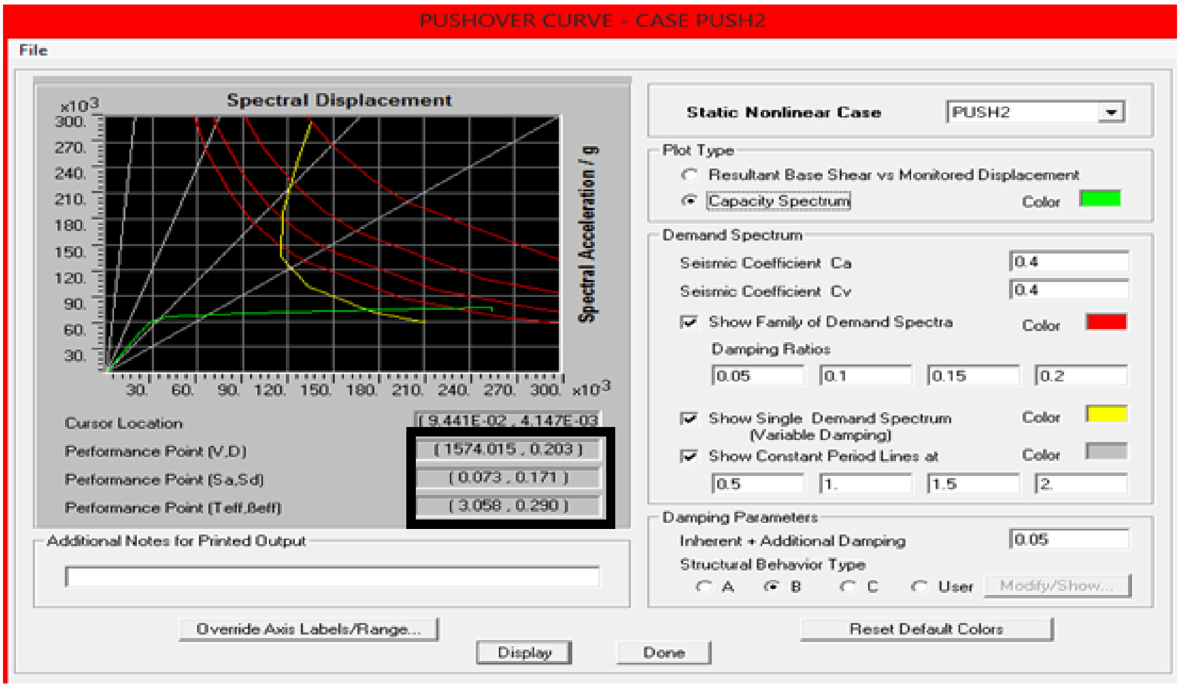

B. Pushover in y-direction

Fig 7: pushover curve due to load in y direction

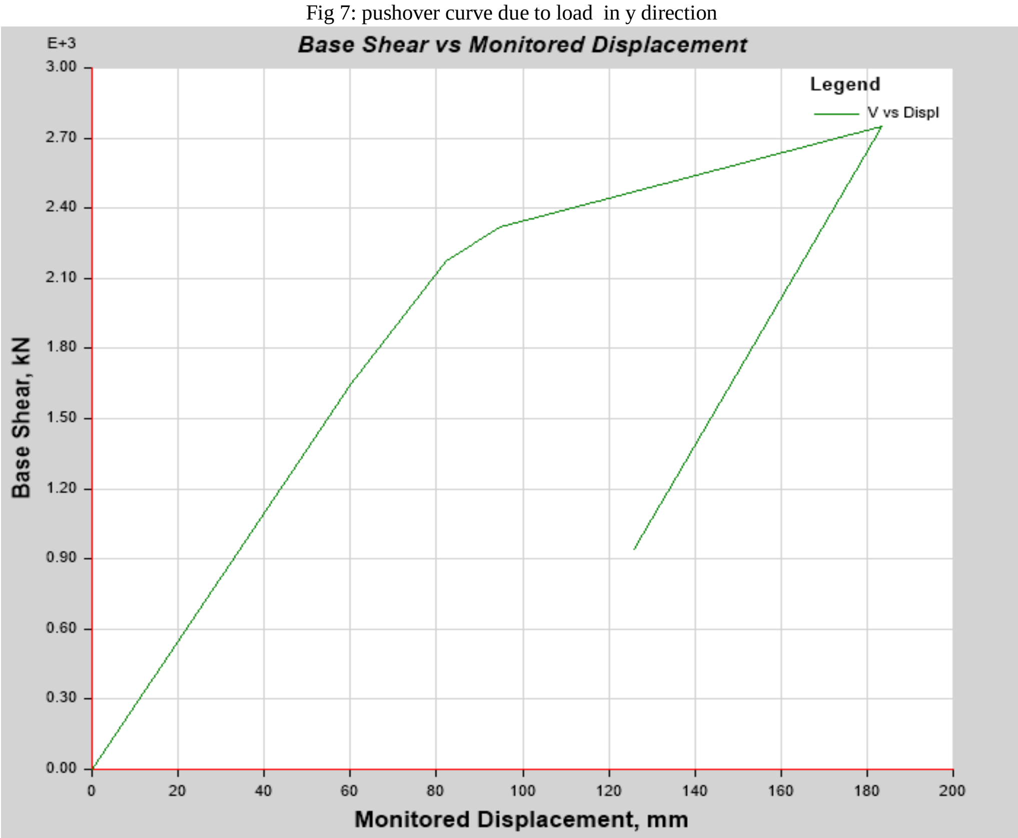

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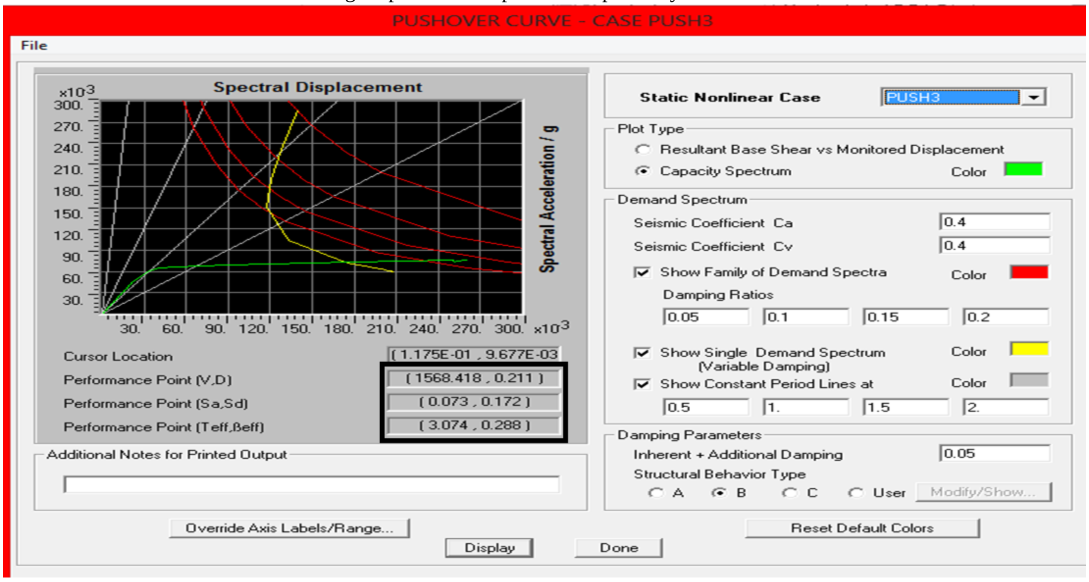
Table 6: hinge positon on the curve after the push in y direction

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	0	480	0	0	0	480
1	60.2	1650.2732	478	2	0	0	0	480	0	0	0	480
2	82.4	2173.0317	408	72	0	0	0	480	0	0	0	480
3	94.6	2321.1036	378	102	0	0	0	480	0	0	0	480
4	183.4	2750.3593	332	146	2	0	0	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 level 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

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