Pushover Analysis of (G+10) Structure Using Various Software's & Codes

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Abstract- *Earthquakes do severe damage to the structure which is already built. The performance of structure best on seismic engineering can be calculated by various software's. The poor performance and high level of structural damage in structure during earthquake increased the need of evaluation and determination of damage in structure. In order to prevent such collapse mechanisms in structure non linear analysis must be determine accurately. The pushover analysis is the method for seismic evaluation in which static analysis is done that directly represent non-linear material characteristics. The equivalent static lateral loads approximately represent earthquake reproduced induced forces. This analysis includes capacity spectrum method and displaced coefficient method.*

The pushover curve for X & Y direction is obtain from SAP 2000 and CSi ETABS 2016 software's. The multi storied building (G+10) is drawn by AUTOCAD 2010 & analyzed and design by using STADD PRO V8i. The design in STAAD PRO using concrete mix M - 30 , and grade of steel Fe 500. The pushover curve is obtain by displacement control method, curve is obtain by pushing the top of structure to the limiting displacement and setting performance criteria .the capacity spectrum ,demand spectrum and performance point of structure was found in both X and Y direction, using SAP2000 and CSi ETABS 2016. From this analysis it was found that the base shear carried out by the structure is well above design base shear which indicate the transition of structure from elastic to plastic state have less chances.

I. INTRODUCTION

The sudden release of energy from earth core to its crust creates disturbance on the earth's surface. It causes random ground motion in all directions. Due to this many seismic deficient structure may collapse. The most common causes of earthquake are rupture of geological faults, volcanic activity , mine blast , land slide , nuclear test, collision of tectonic plates . the magnitude of earthquake experience during the time is define by seismicity and this seismicity is calculated by seismometer . the intensity of earthquake is most commonly calculated by Richter scale.

For ease in seismic analysis India is divided on four zones - I-II, III, IV,V . the basic earthquake design is done by using IS 1893 – 2002. the building which do not fulfill the design requirement by IS 1893-2002 may suffer collapse or heavy damage during earthquake. the seismic capacity of the structure is obtain by seismic evaluation. There are two methods for performing pushover analysis -i) force control ii) displacement control

The force control pushover analysis procedure is most often used when the load is known (gravity loading) in force control pushover analysis procedure all load combinations used. In displacement control method the displacement is calculated from target displacement it is generally 1.5 times of target displacement . and this target displacement is calculated using mathematical equation from FEMA 440 and ATC 40.

The pushover analysis is one of the method use for seismic evaluation which is use to determine force displacement relationship. In the analysis horizontal loads are applied to the computer model of the structure and incrementally increasing it. The plotting between total applied shear force and relative lateral displacement until the limit state of collapse conditions is done .

As the load and displacement increases beams and columns , other elements begin to yield and deform in elastically . the resulting graphic curve help to visualized the representation of capacity of structure .

In increasing order of structural displacement various performance levels are shown in table 1, FEMA 356-1, typical values for roof drifts for performance level are as follows-

1. Immediate occupancy : temporary drift is about 1% with negligible permanent drift. It is the damage state in which limited structural damage has occurred .there are negligible chances of fatal injury due to structural failure.

2. life safety : temporary drift is about 2% with 1% permanent drift. It is a state in which damage to the structure due to earthquake has occurred and some injuries during earthquake may occurred . but risk of fetal injuries due to structural damage is very low.
3. collapse prevention: in elastic drift is 4% , temporary or permanent . in this state the structure has experience extreme damage and large permanent drift .the risk of fetal injuries due to structural failure is high.

In the present study , reinforced concrete building G + 10 has been drawn in AUTOCAD 2010, modeled & design in STAAD PRO and analyzed using ETABS 2016 AND SAP2000. The following are specification of G+10 building.

The size of column = 300X 600mm & 600X 300mm
The size of beam= 230 x 430mm
The slab thickness= 125 mm
The floor to floor height = 3 m
Ground floor height = 3m
Location= Pune
Zone = III
Type of frame = OMRF
Density of concrete = 25 KN/M^3
Density of steel = 7850 KN/M^3
Damping ratio = 5%

The comparison between to various models SAP 2000 & CSi ETABS 2016 is made analysis of structure to produced pushover curve and modeling and design is done on STAAD PRO V8I. while drawing is done on AUTOCAD 2010

The main purpose of pushover analysis is to find out strength and deformation of the structure during earthquake and also its elastic behavior . The simplified nonlinear analysis procedure utilized for seismic performance evaluation considered pushover analysis curve . however it involves curtain approximation which are reliable and produced approximately accurate result.

II. LITERATURE REVIEW

To provide a detailed review of the literature related to modeling of structures in its entirety would be difficult to address in this chapter. A brief review of previous studies on the application of the pushover analysis of steel frames is presented is this section. This literature review focuses on recent contributions related to pushover analysis of steel frames and past efforts most closely related to the needs of the present work.

Vojko kilar and peter fajfar (2017), simplified pushover analysis of building structure on G+7 R.C.C. during the analysis the development of plastic hinges throughout the building is monitored .this analysis is appropriated for design of earthquake resistance structure.

Dakshes j. pambhar (2015), performance based pushover analysis of R.C.C frame G+5 &G+10 by SAP and ETABS . considering G+5 &G+10 R.C.C building in bare frame without infill have lesser lateral load capacity .

M.K. Rahman, M. Ajmal & M.H. Baluch (2015) , nonlinear static pushover analysis of G+8 R.C.C frame shear wall building in Saudi Arabia by SAP 2009

The major objective of study was to understand the effect of increasing no of storied of R.C.C building

Neethu K. N.I.,SAJI K. P 2 (2012), pushover analysis of R.C. C. building of existing structure.

The pushover analysis is the useful tool for assessing the inelastic strength and deformation demand and exposing design weakness.

Mirza Aamir Baig &Shahzeb Mohd. Danish (2011), pushover analysis of multistoried R.C.C. building G+10 for zone 2 and zone 3 as per IS 1890-2002 by SAP 2000 and IS 456-2000

Pushover analysis is the simplest way to get the response of existing or new structure . the performance of the pushover analysis is mostly depends on the material used in the structure.

H.S.Chore & S.B.Patil(2011), pushover analysis of R.C.C. structure of G+4 to G+6 by ETABS .

To study the major effects of the present study to understand the effects of increases in number of story of the R.C.C. building structure .

Ms. Nivedita N . Raut & Ms. Swati D. Ambedkar (2010), pushover analysis of multistory building on bare frame , infill wall and weak story.

The results of masonry infill wall at ground story resulting in the structure is said to be week. Formation of hinges in beam is more than in column .

III. METHODS AND MATERIAL

Section properties-

The size of column = 300X 600mm & 600X 300mm
The size of beam= 230 x 430mm
The slab thickness= 125 mm
The floor to floor height = 3 m
Ground floor height = 3m
Location= pune
Zone = III
Type of frame = OMRF
Density of concrete = 25 KN/M^3
Density of steel = 7850 KN/M^3
Damping ratio = 5%
Material properties-

Concrete

Specific weight density – 2400kg / m^3
Poisson's ratio – 0.2
Modules of elasticity – 27386125.589 KN /m^2
Coefficient of thermal expansion- $10x10^{-6}$ / ^0c

Steel

Specific weight density – 7850 kg / m^3
Modules of elasticity –2.1 $x10^5$ MPA
Coefficient of thermal expansion- $9.81x10^{-6}$ / ^0c

IV. METHOD

Define all the sectional properties including frame section ,slab section , deck section , wall section and define all material properties including concrete and steel .

Create 3D model and assign all sectional and material properties .

Define load cases including seismic load and form load combinations.

Assign load combinations the structure and define model cases.

Run analysis and unlock the model if no error is found .

Assign hinge properties for beams(M3, V2) and columns (PMM,V2)

Define static pushover cases (PUSH X ,PUSH Y).

Choose displacement control method .provide control displacement 1.5 times target displacement. calculate target displacement from ATC 40 .

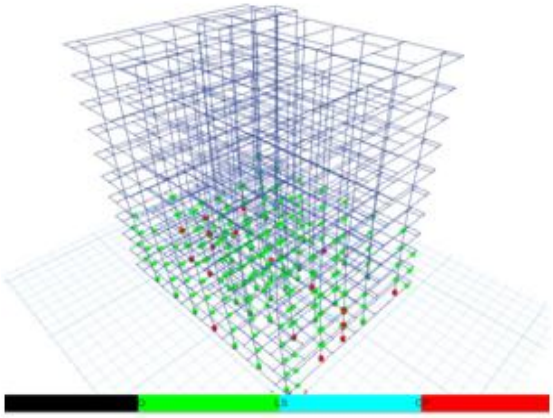
Define lateral load at center of mass .
Run analysis .

V. RESULTS

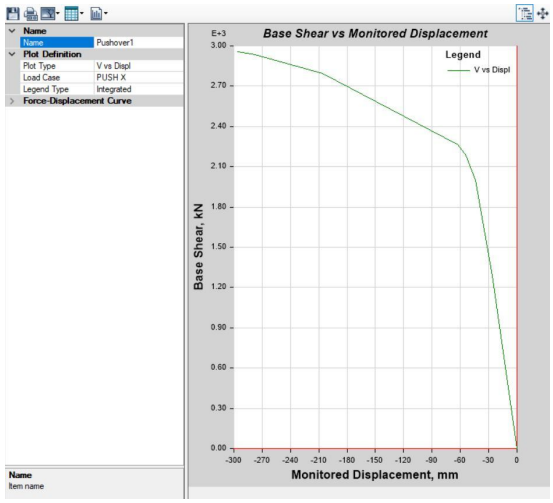
RESULT BY ETABS

The maximum displacement occurred in the building = 295 mm (X –direction) & 170 mm (Y- direction)

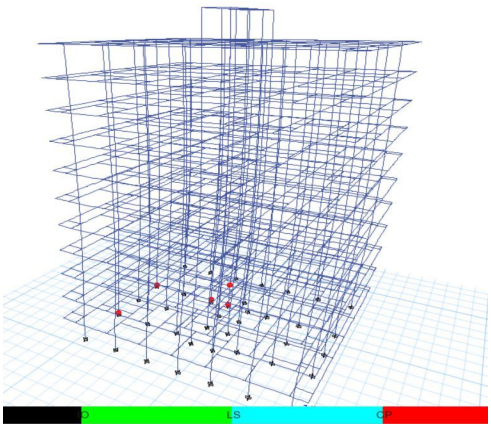
The maximum base share occurred in the building = 2.96 KN (X-direction) & 1.88KN (Y- direction) at base .



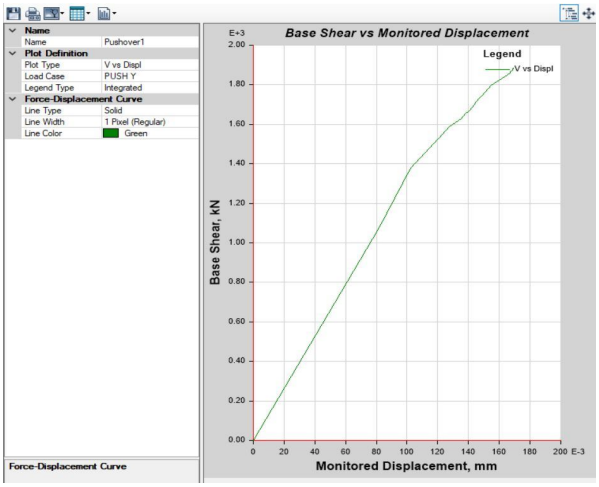
Plastic hinge formation



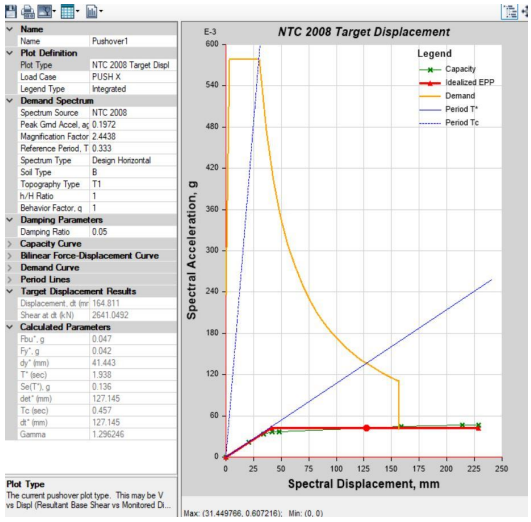
Base shear vs displacement curve
(push X)



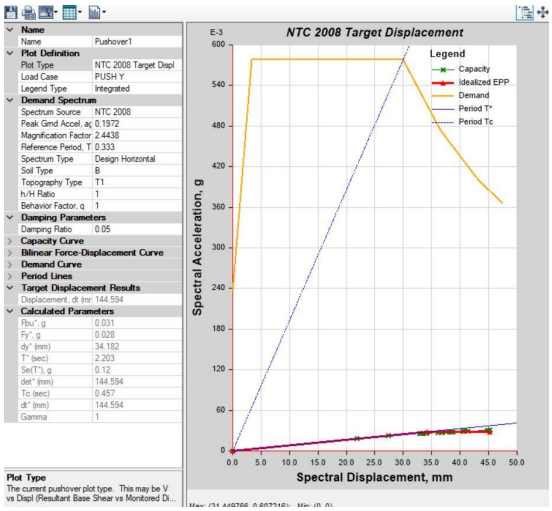
Plastic hinge formation



Base shear vs displacement curve (push Y)



Spectral displacement vs spectral acceleration



Target displacement

RESULT BY SAPP 2000 by ATC 40

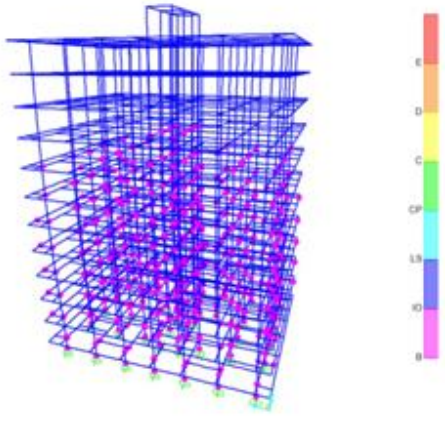
The maximum displacement occurred in the building = 200 mm (X –direction) & 150mm (Y- direction)

The maximum base share occurred in the building = 4.7 KN (X-direction) & 4.1KN (Y- direction) at base .

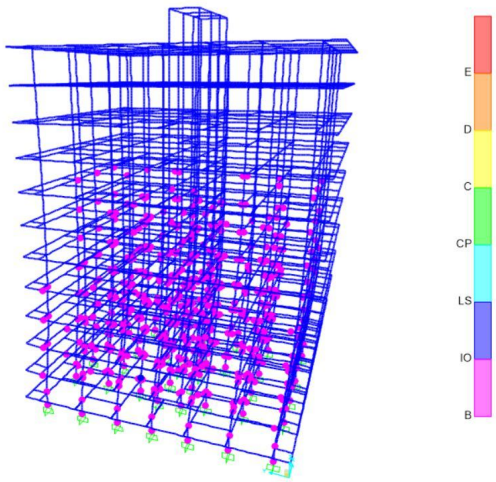
BY FEMA 356

The maximum displacement occurred in the building = 215 mm (X –direction) & 178mm (Y- direction)

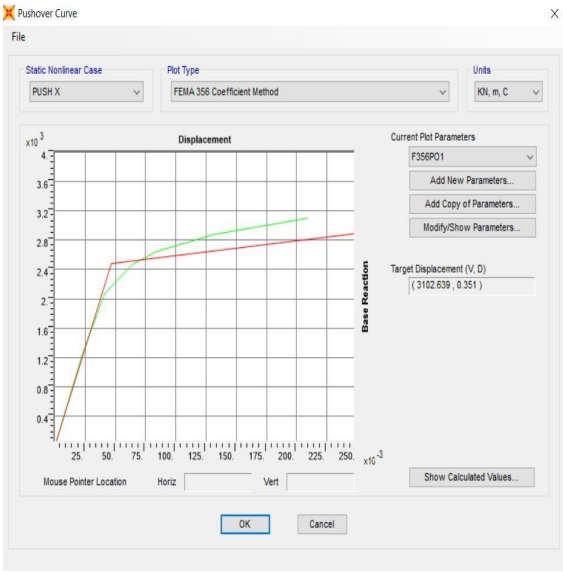
The maximum base share occurred in the building = 3.1 KN (X-direction) & 2.8 KN (Y- direction) at base .



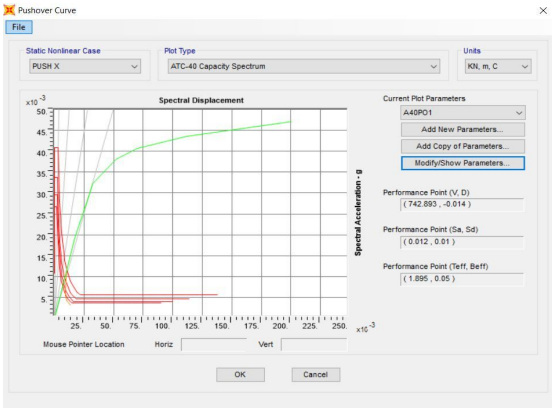
HINGES PUSH X



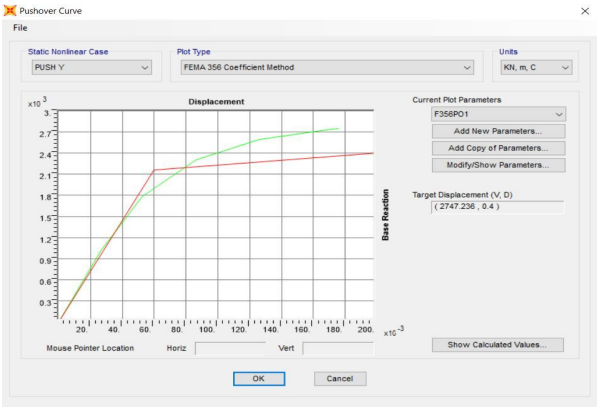
HINGES PUSH Y



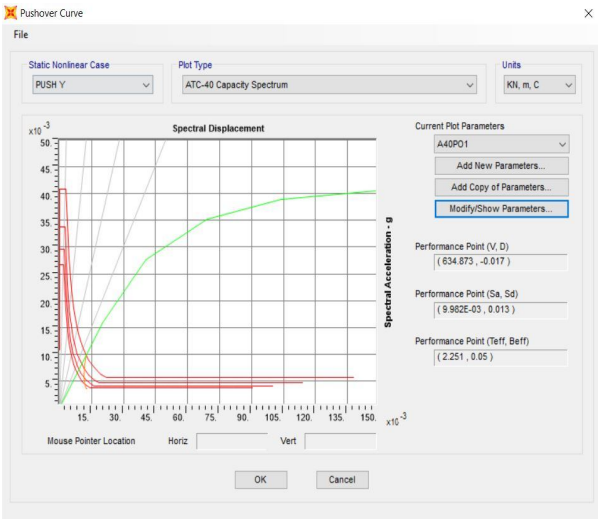
PUSH X (FEMA 356)



PUSH X (ATC 40)



PUSH Y (FEMA356)



PUSH Y (ATC 40)

VI. CONCLUSION

According to the comparison in above study we conclude that the displacement shown in ETABS software is comparatively larger than SAP 2000. In this study we used two standard codes ATC 40 and FEMA 356. The comparison between codes conclude us that the displacement in X & Y directions are not same ,displacement in FEMA 356 are larger than ATC 40

Sr.no.	softwares	Roof Displacement (MM)		Base shear force (KN)	
		X	Y	X	Y
1	ETABS	295	170	2.6	1.88
2	SAP 2000	200	150	4.7	4.1

P USHOVER CODE COMPARISON BY SAP 2000

Sr.no.	codes	Roof Displacement (MM)		Base shear force (KN)	
		X	Y	X	Y
1	FEMA 356	215	178	3.1	2.8
2	ATC40	200	150	4.7	4.1

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