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Earthquake Resistance Design Of Open Ground Story Building

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Abstract – *In today's time open ground building (OGS) has taken its place in the Indian urban environment due to the fact of that it provides much needed parking facility in the ground floor of the buildings. Many surveys of buildings failed in past earthquakes show that this types of buildings are found to be one of the most vulnerable. Presence of infill walls in the frame alters the behavior of the building under lateral loads. Infill wall in the frame are frequently contained in door and window openings at the different locations which reduces stiffness and load carrying capacity of the diagonal strut depending upon the size of opening and its locations.*

In this study the seismic behavior and the earthquake resistance design of open ground building is analyzed by the software namely SAP2000v20.2.0. The analysis of different models of different symmetrical structures namely G+8, G+10, G+12, and G+16 flours with equivalent diagonal strut and with the multiplication factor of 2.5 according to the IS CODE 1893-2016 (Part I provisions.. Different models of symmetrically regular shaped buildings analyzed by the method of push over analysis and calculate the desire results of the considered models.

***Key Words*: - Open ground building, infill wall, equivalent diagonal strut, equivalent static analysis, push over analysis.**

1. INTRODUCTION

In 21st century with the increasing population of the world there is a huge requirement of the use of the shelter and vehicle parking. For fast growing country like India there is much needed arising lots of problem for the people and vehicle parking is used as a parking space for the multi-storey building, and this type of building is also known as open ground storey building or open first storey buildings. There is lots of advantages of these type of building but from the earthquake point of view these types of buildings are having some problems In stability and durability of the buildings so this study considered these problems.

Due to increasing population since the last ten years or before this car parking space for residential apartments in populated cities is a matter of major parking space problems concern. Hence the trend has been to utilize the ground storey of the building itself for parking. These types of buildings having no infill masonry walls in ground storey, but infilled in all upper storeys, are called Open Ground Storey (OGS) buildings. They are also known as 'open first storey building' (when the storey numbering starts with one from the ground storey itself), 'pilotis', or 'stilted buildings'.

1.1 EQUIVALENT DIAGONAL STRUT METHOD:-

In this method the infill is modeled as equivalent diagonal strut, having same thickness as infill but its effective width may depend upon number of factors. Table 1 shows empirical expressions available for width of strut on the basis of studies conducted by various investigators.

Table 1. Empirical expressions available for width of strut

Investigator	Formula
Stafford smith and Hendry (1963)	$w = 1/2\sqrt{(\alpha_h^2 + \alpha_L^2)}$
Holmes (1963)	$w = d/3$
Smith and Carter (1969)	$w = 0.58\left(\frac{l}{h}\right)^{-0.445}(\lambda H)^{0.335d}\left(\frac{l}{h}\right)^{0.064}$
Mainstone, R.J. (1971)	$w = 0.175(\lambda_h H)^{-0.4}d$
Bazan and Meli, R (1982)	$w = (0.35 + 0.22\beta)h$
Liauw and Kwan (1984)	$W = \frac{0.95h\cos\theta}{\sqrt{\lambda H}}$
Paulay, T and Priestly (1991)	$w = 0.25d$
Angle, R (1994)	$w = d/8$

Where, W= effective width of strut
β= (Ec Ac)/ (Gm Am) is a dimensionless parameter

λ= contact length parameter
Ei = Modulus of elasticity of infill material
Ef = Modulus of elasticity of frame material
Ic= Moment of inertia of column
t = thickness of infill Fig 2.1 shows the variable h, d and ɵ
A. Stafford smith and Hendry

W = 12 x $\sqrt{\alpha h}$ 2+αl2

1.2 OBJECTIVES:-

The equivalent diagonal struts are required for the conventional braced frame analysis to determine the increased stiffness of infilled frame. The geometrical properties are of effective width and thickness of strut, the thickness and material properties of strut are similar to the infill wall. The width of strut depends on the length of contact between the wall and the column, αh , and between the wall and beam, αl.

- The effect of masonry infill stiffness in the seismic analysis of Open ground storey buildings.
- Strengthening of Open Ground Story RC buildings.
- Push over non- linear static analysis of the different height of the buildings.
- To Study the applicability of the Multiplication Factor of 2.5 as given by IS 1893-2016 Part-1, for Low Rise and Medium Rise Open ground storey Building.

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1.3 METHODOLOGY

- First, models of different heights and symmetrically regular structure considered for the analysis.
- Then performed push over non-linear statical analysis on each taken models.
- Analysing and calculate the desire results on the software *SAP2000v20.2.0*
- Presentation of results in the form graphs and tables.
- Detailed discussion on the results with the help of graphs and tables considering all the parameters.

2. LITERATURE REVIEW

In 2017, Akshay Paidalwar and G.D. Awchat investigates the soft storey behavior due to lack of infills at ground floor storey and existence of this case by means of linear static and nonlinear static analysis for midrise reinforced concrete building. Soft storey behavior due to change in infill's amount is evaluated in view of the displacement, drift demand and structural behavior. The idealized form of a typical 5 bay x 2 bay 4 storey building frame with infill wall and a bare frame is modeled to see how correctly the influence of open ground storey on Seismic behavior can be predicted. Followings are the salient conclusions obtained from the present study- 1. Stiffness of the structure is an important factor in case of OGS type building, in the present study infill can improve stiffness of structure but in to some extent, that is not enough to save structure against seismic effect. 2. Problem of OGS buildings cannot be identified properly through elastic analysis as the stiffness of OGS building and Bare-frame building are almost same. RC frame building with open first storeys are known to perform poorly during in strong earthquake shaking. In this study, the vulnerability of building with soft storey is shown an example building.

In 2016, Mr. Deepak, Mr. Vaibhav Gupta examined a Building an open ground floor are considered vertically irregular buildings to IS 1893: 2002 requires a dynamic analysis considering the strength and rigidity of infill walls. IS 1893: 2002 also allows the equivalent static analysis (ESA) of CGO buildings ignoring the strength and rigidity of infill walls, provided a multiplication factor of 2.5 is applied to the design forces (moments bending and shear forces) in the columns and beams of a floor on the ground. A framed existing RC building (G + 3) open floor land located in seismic zone V is analyzed for two different cases: (a) given the filling strength and stiffness and (b) without taking into account the filling strength and rigidity (frame). The infill weight (and associated masses) has been modeled in both cases by applying the static dead load. Non-integral filler walls subjected to lateral load behave like diagonal struts. Nonlinear static (pushover) analysis is performed for all building models considered. They concluded that - IS Code gives a value of 2.5 to increase the beam floors ground forces and column when a building must be designed as building walk-in open ground or a building on stilts. The ratio of IR values for columns and beams of DCR values for the two support conditions and model building were found using ESA and RSA and the two analyzes argues that a factor of 2, 5 is too high to be multiplied to the beam and column forces of the ground floor. This is especially true for low-rise buildings CGO**.**

In 2015, PiyushTiwari, P.J.Salunke, N.G. Gore had done the study to check the applicability of multiplication factor of 2.5 and to study the effect of infill strength and stiffness in seismic analysis of OGS buildings. Three Different models of existing RC framed building with open ground story located

in Seismic Zone V is considered for the study using commercial Etabs Software. Infill Stiffness with openings was modeled using a Diagonal Strut approach. Linear and Nonlinear analysis is carried out for these models and results were compared. The results are - 1) Linear (Static/Dynamic) analysis shows that column forces at the ground storey increase for the presence of infill wall in upper storeys. But design force Multiplication factor found to be much less than 2.5. 2) ESA and RSA results shows that, Multiplication factor for (G+4) varies 41.2 %(Column) and 42.8 %(Beam) less than what is prescribed by IS Code of 2.5 Value. Similarly For (G+7) its 36% and 40% and for (G+10) its 32.4 and 40% less value than which is given by IS Code of 2.5.

3. STRUCTURAL MODELLING

For this present study there are six different models of different heights G+8, G+10 and G+12 with equivalent diagonal strut and G+8, G+10 and G+12 without equivalent diagonal strut modeling using software SAP2000v20.2.0.

1. Model 1 is the rectangular G+8 without equivalent diagonal strut shown fig.1
2. Model 2 is the rectangular G+10 without equivalent diagonal strut shown fig. 2
3. Model 3 is the G+8 with equivalent diagonal strut as shown in fig. 3
4. Model 4 is the rectangular G+10 with equivalent diagonal strut as shown in fig. 4

Table -1: Design details

S. No.	Particulars	Dimension/Value
1.	No. of Stories	G+8, G+10
2.	Floor to Floor height	3.3m
3.	Beam Size	300mmX400mm
4.	Column Size	750mmX750mm
5.	Thickness of Slab	150
6.	Equivalent diagonal strut	Length=5.99m Width=2m
7.	Height of Building	29.7m, 36.3m
8.	Wall Thickness	230mm
9.	Grades of Concrete	M20, M25, M30
10.	Grade of Steel	Fe415
11.	Response Reduction Factor	5
12.	Importance Factor	1.2
13.	Soil Condition	Medium (II)
14.	Seismic Zone	IV (0.24)
15.	Software Used	SAP2000v20.2.0.
16.	Live Load	2KN/m²
17.	Floor Finish	1.8KN/m²
18.	Earthquake Load	As per IS-1893-2016(Part-I)
19.	Analysis Method	Push over analysis
20.	Grade of strut	M20

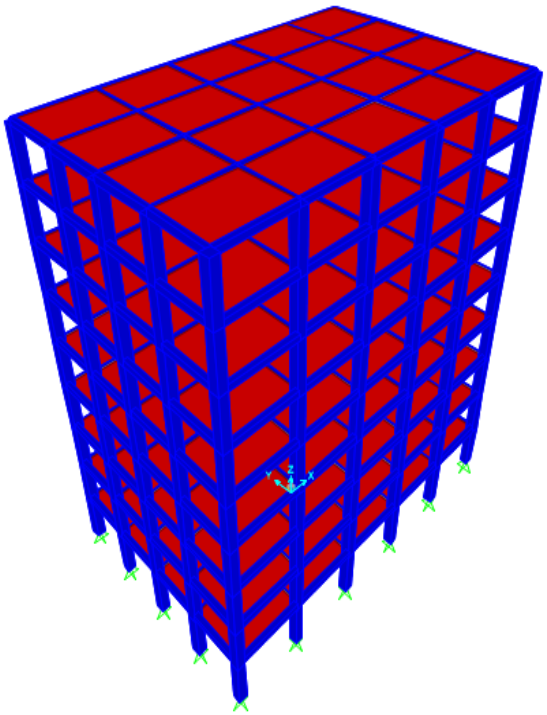


Fig. 1 G+8 without strut

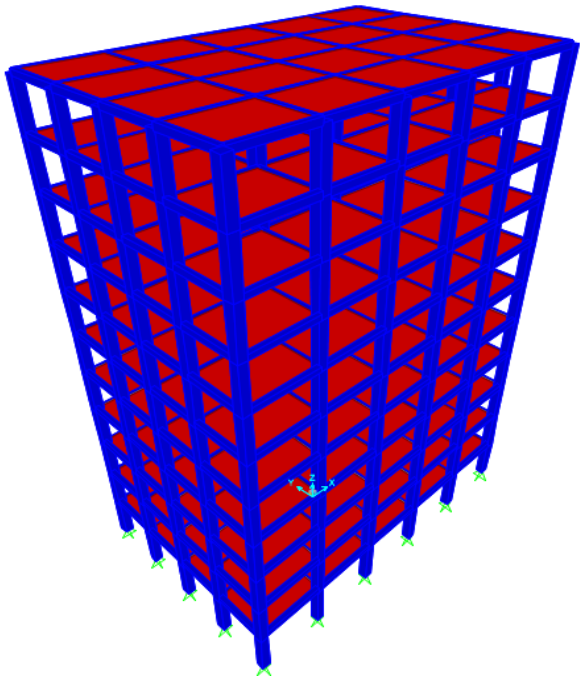


Fig. 2 G+10 without strut

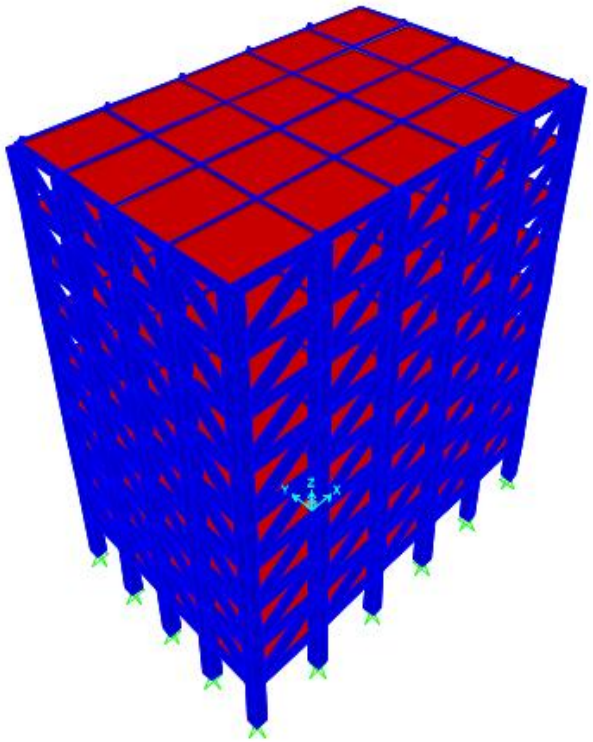


Fig.3 G+8 with strut

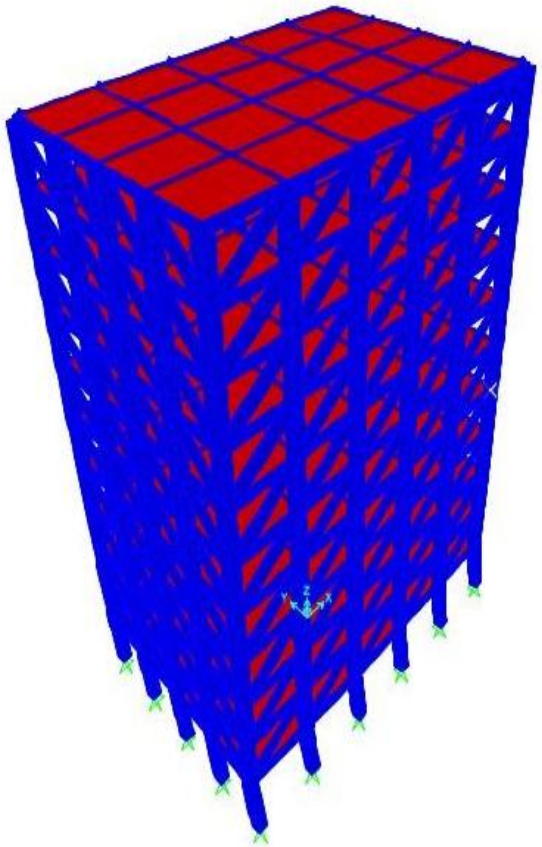
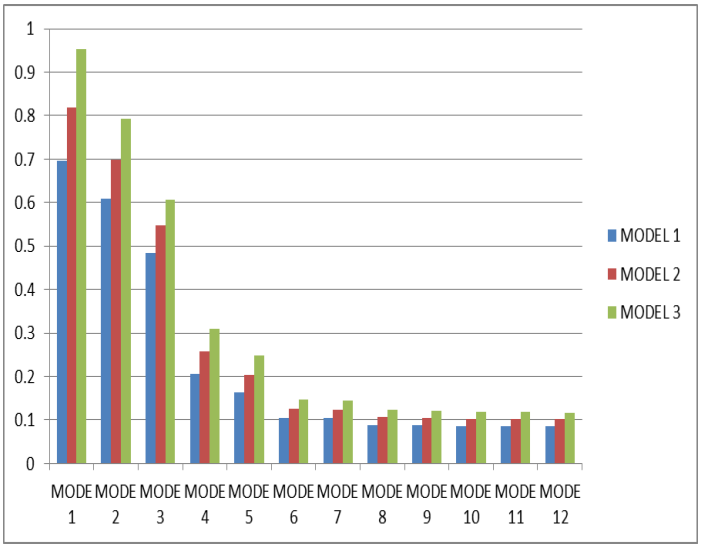
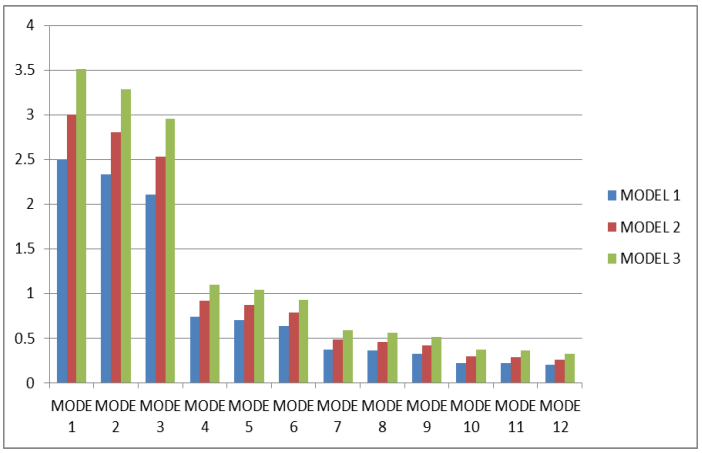


Fig .4 G+10 with strut

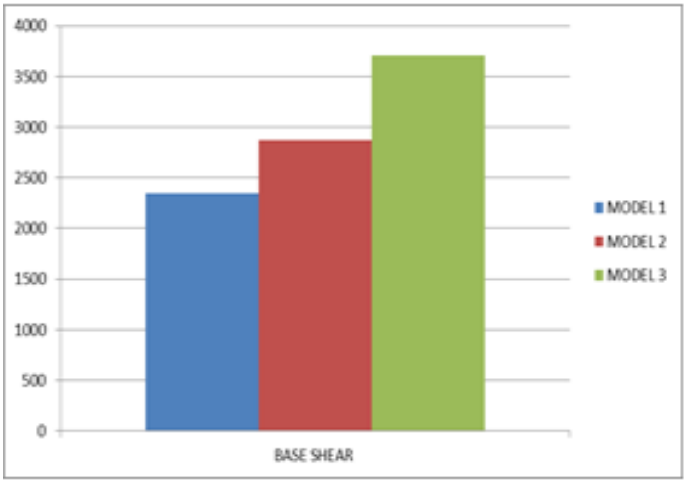
4. RESULTS



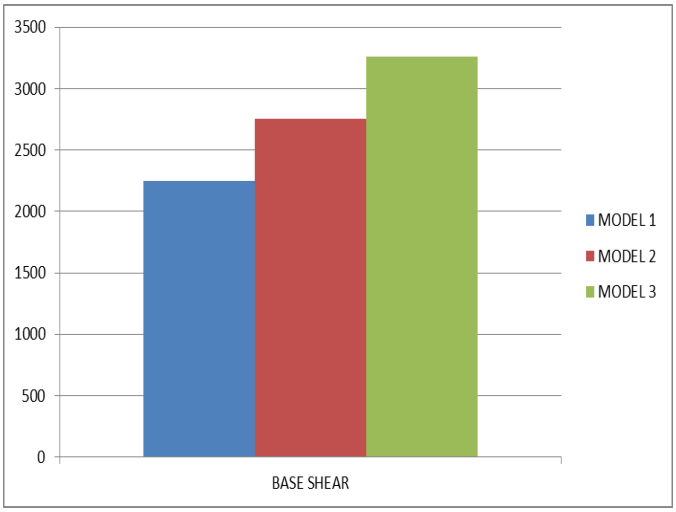
TIME PERIOD WITH STRUT



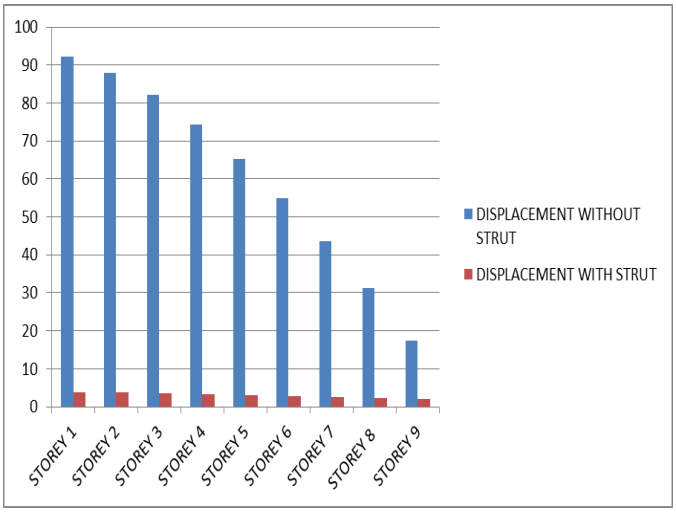
TIME PERIOD WITHOUT STRUT



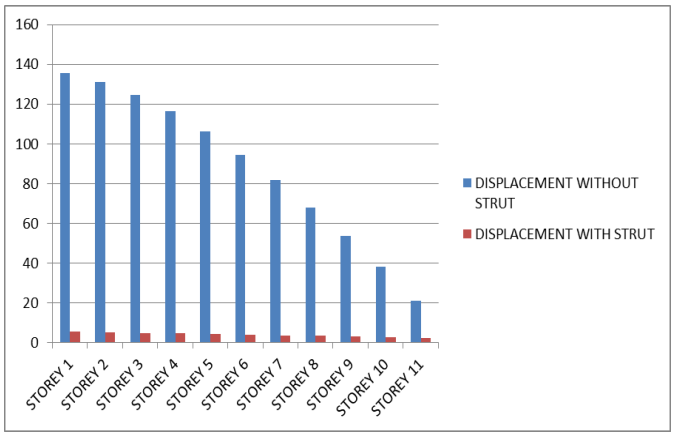
BASE SHEAR FOR EQX WITHOUT STRUT (KN)



BASE SHEAR FOR EQX WITH STRUT (KN)

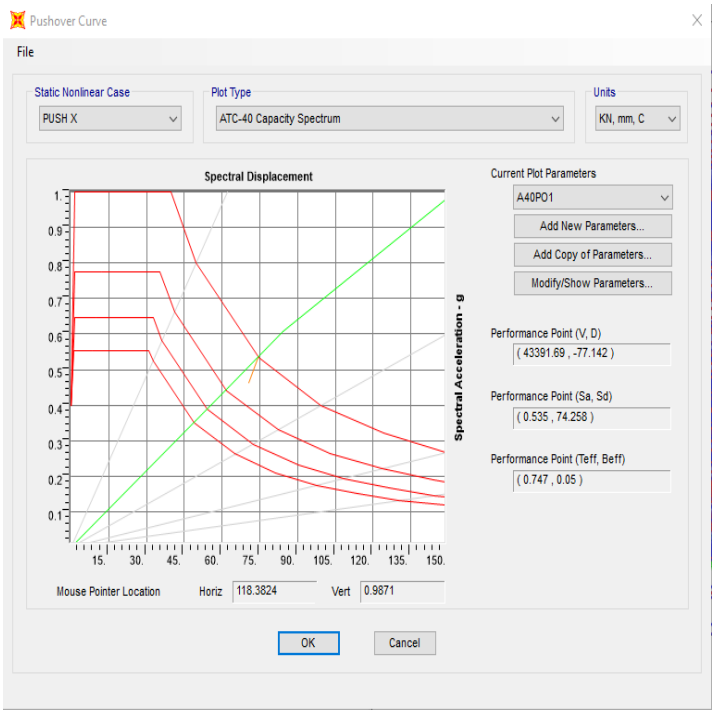


LATERAL DISPLACEMENT IN X-DIRECTION FOR G+8 MODEL (mm)

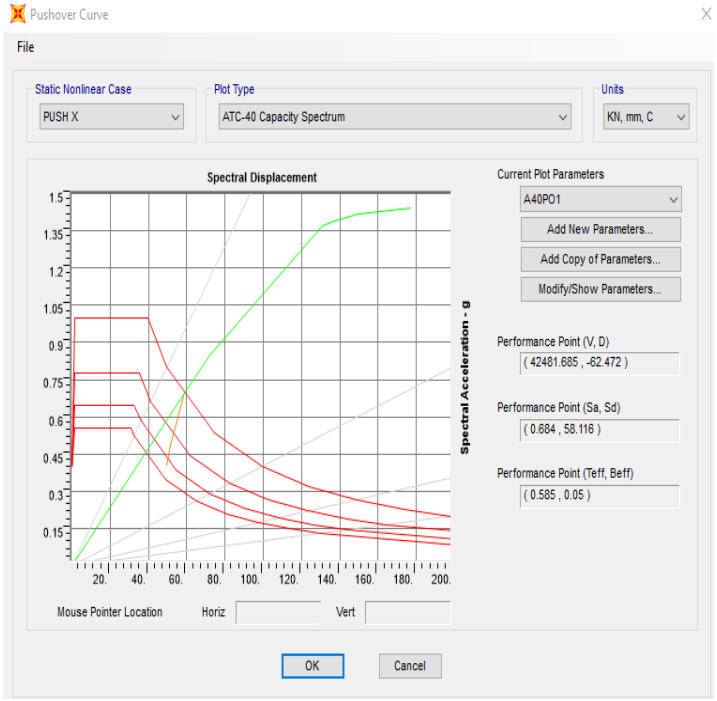


LATERAL DISPLACEMENT IN X-DIRECTION FOR G+10 MODEL (mm)

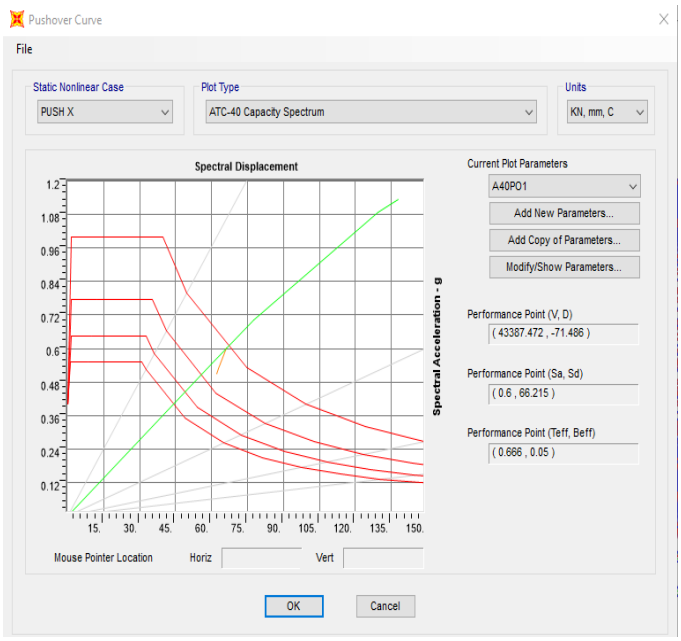
CAPACITY SPECTRUM GRAPHS



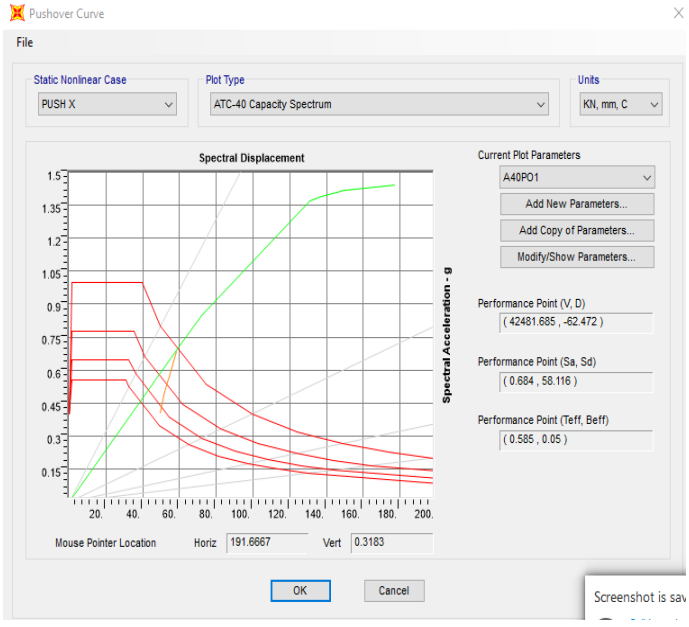
CAPACITY SPECTRUM FOR G+8 WITHOUT STRUT



CAPACITY SPECTRUM FOR G+8 WITH STRUT



CAPACITY SPECTRUM FOR G+10 WITHOUT STRUT



CAPACITY SPECTRUM FOR G+10 WITH STRUT

5. CONCLUSIONS

The following conclusions are drawn from the results: -

- According to results the time period of without equivalent strut is greater than the value of time period of with equivalent strut.
- According to result the base shear value of taken model without equivalent diagonal strut is greater than the value of with equivalent diagonal strut.
- According to results the lateral displacement in in x-direction without strut is higher than the displacement value of with equivalent strut.
- According to capacity spectrum graph the value of performance point without strut is occurs high as compare to value of with strut.
- From the results according to IS CODE 1893-2016 PART-1 provisions standard value which is not exceed 0.004 times of (h) is higher in structure without strut and value is low in with equivalent strut.

6. REFRENCES

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