EVALUATION OF THE CODAL PROVISION FOR ASYMMETRIC BUILDING

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ABSTRACT

The research on asymmetric buildings has been extensive primarily focusing on the stability of a structure when subjected to earthquake. Based on them numerous guidelines are laid out for to make sure safety. I have during this paper tried to guage the effectiveness of the rules provided within the IS: 1893 (2000). Asymmetric buildings are more common now than they have ever been and their popularity has been growing primarily due to the functionality they provide. Due to the frequent earthquakes that India suffers, being at the junction of two tectonic plates it has become increasingly important to review Indian buildings for seismic safety. The buildings are analyzed supported the effect of torsion which is that the main explanation for damage for Asymmetric Buildings.

Keywords: Asymmetric Building, Mass Eccentricity, Dynamic Analysis, Pushover analysis, Torsional Rigidity

INTRODUCTION

Structures are susceptible to earthquakes since the primary structure was built. Earlier accredited to the wrath of gods there are many elaborate rituals in civilizations round the globe to stay the Gods appeased and cities safe which then evolved into festivals but we now know otherwise. Earthquakes, which are a number of the foremost severe natural catastrophes known to man, are still a contemporary menace and though we do not pray our way for safety anymore Earthquake resistance of buildings has taken a more scientific turn and still may be a major area of research. However, one among the foremost catastrophic events in nature earthquakes themselves do not kill people although they will end in a number of the very best price known. The first damage caused by an earthquake is to a building or a natural structure and not people. The collapses of such man-made structures like buildings cause people using them getting crushed or trapped by the debris. the upper the increase the greater is that the fall, thanks to its unique nature earthquakes are more menacing to the more developed urban areas than rural areas as these tend to be more dense populated with more high-rise buildings during a concentrated space for utilizing the expensive commodity effectively. Rapid urbanization has propelled the priority of Earthquake resistance.

The limitation of space in urban cities has caused many new changes within the structure of buildings. The apartment complexes wont to be a set of apartments form the bottom up while the limitation of parking spaces within the current decade has led to the transformation of the lower floors into parking spaces for the residents. The planning though provides utility but also makes the building asymmetric. Seismic damage surveys and analyses conducted after the earthquakes have shown that the modes of failure of the structures. It is apparent that the foremost vulnerable structures are those, which are asymmetric in nature. Hence, the seismic behavior of an asymmetric structure has become important.

METHODOLOGY

The structure was modeled in SAP 2000 for the aim of study the building design and other analysis were also conducted with Etabs. The structures are two models on of 4 stories of 12.5m tall and other is of 10 stories with 30.5m tall structure with 4 bays within the X direction of spans lengths of 4m at the two spans at the periphery and therefore the central span is about 3m long . The structure has 3 spans within the Y direction with the two spans at the periphery being 4m each and therefore the central span is about 3m long .

the fabric assumed is Concrete of grade M20 and therefore the Steel used is Fe 415. The Beams are considered to possess a cross-section size of about 300x600m and therefore the columns are made from an equivalent cross section sizes with the longer side along the longer span. The Structure is loaded with a superload of about 3KN/m2 as per the superload requirements form IS 845 Part II assuming the structure to be a residential building. The load was applied to the middle of mass at the primary go for asymmetric building. the middle of mass (CM) was then applied at some extent 1.9m faraway from the Centroid of the structure. the planning of the structure was designed in Etabs as per IS:456. The designed reinforcements were then taken imported into the SAP 2000 software and Pushover analysis was conducted on the structure. The Hinge utilized in the model was supported FEMA 356 for the respective columns and beams. The Degrees of Freedom for the Beams was M3 and for the Columns was P-M2-M3. The Pushover analysis is then conducted and therefore the occurrence of hinges is observed. Two Load Cases were constructed to conduct the analysis in both directions the force is applied as an acceleration.

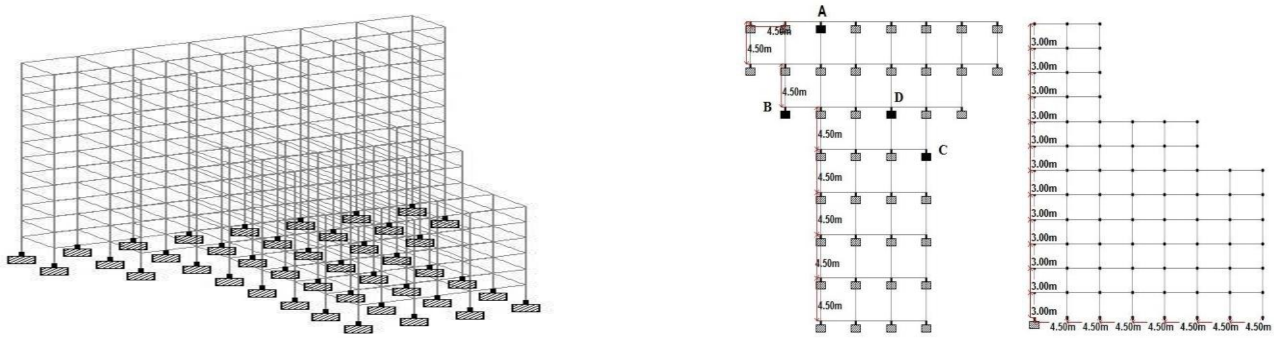


Figure: Basic Building Structure

CODAL PROVISIONS

The basic approach of design codes is application of linear static or dynamic load meth- ods for design based on Earthquake Loading. Some of the codal provisions are studied in the following.

As per [IS 1893 (Part 1), 2002] the Static Eccentricity (e) is defined in the design codes as the distance between the Center of Mass (CM) and Center of Rigidity (CR) of the structure. The Center of Rigidity is defined as "The point through which the resultant of the restoring forces of a system acts." . The Center of Mass is defined as "The point through which the resultant of the masses of a system acts. This point corresponds to the center of gravity of masses of system."

The Design Eccentricities (e_{di},e_{si}) are obtained based on the values of the static ec- centricity after accounting for the dynamic amplification of torsion and allowance for accidental torsion induced by rotational component of ground motion. Most design eccentricities are based on the formula

$$e_{di} = \alpha e + \beta b$$

$$e_{si} = \gamma e - \beta b.$$

TABLE - Values in different codes

	IS 456	IBC 2003	NZ 4203:1992	NBCC 1995
α	1.5	1	1	1.5
β	0.05	$0.05A_x$	0.1	$.01A_x$
γ	1	1	1	0.05

INDIAN STANDARD 1893: 2002

The IS 1893: 2002 assumes the inertial force caused by the Earthquake to act at the Center of Mass (CM) of the structure. The Static Eccentricity (e) is the distance between the Center of Mass (CM) and

Center of Rigidity (CR) of the structure. The Design Eccentricity is obtained by using the formula for $e_d = 1.5e_s + 0.5b$. The code has been modified to correctly include the stiffness of the infill walls in calculation of the Time Period (T) of the structure. Neglecting the stiffness of the infill wall causes the calculated period to be higher leading a reduced calculated Earthquake Load .The code has been revised to calculate the Time Period (T)of the building as $T = .009h/\sqrt{d}$ instead of the old code.

RESULT & ANALYSIS

Building Geometry

The plan of the building is taken from The building plan is symmetric. The columns are along the aligned to the face of the building as shown in Figure . The model is based on the plan geometry in [Kilar, 2001]

MATERIAL PROPERTIES

The material to be modeled is assumed to be M20 concrete with the reinforcements to be of Fe415 Steel. The Material properties were modeled after the provision in IS 456: 2000.

MODELING

The model was first analyzed through Etabs to check the design calculations. The mode was then again redesigned in SAP 2000 for analysis. The model was divided into sections. The model consists of frame sections B1 for Beams and C1,C2 for Columns respectively. The beam section has a dimension of 300 mm in width and 600 mm in depth of M20 concrete. The re-bars were modeled in HYSD415 bars for the longitudinal reinforcement and Mild steel Fe 250 bars for the confinement reinforcements. The beams were not divided as the changes in the beam reinforcement was not the priority. The Model was then analyzed in a pushover analysis and Time History Analysis.

REINFORCEMENT PROVIDED IN MODELS

The reinforcements are compared between the 3 models which are based on the same building model and are identical in all respects except the application and position of the Lateral Earthquake force applied. The reinforcements in the columns are of special interest.

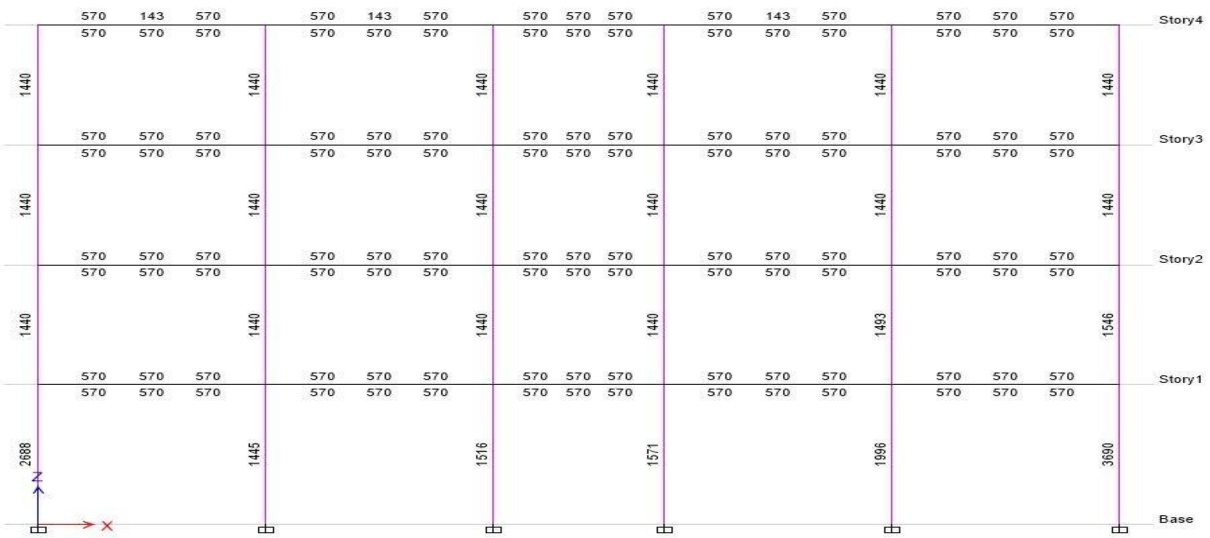


Figure: Reinforcements required for 12.5 m Model, considering Mass Eccentricity (Outer Face)

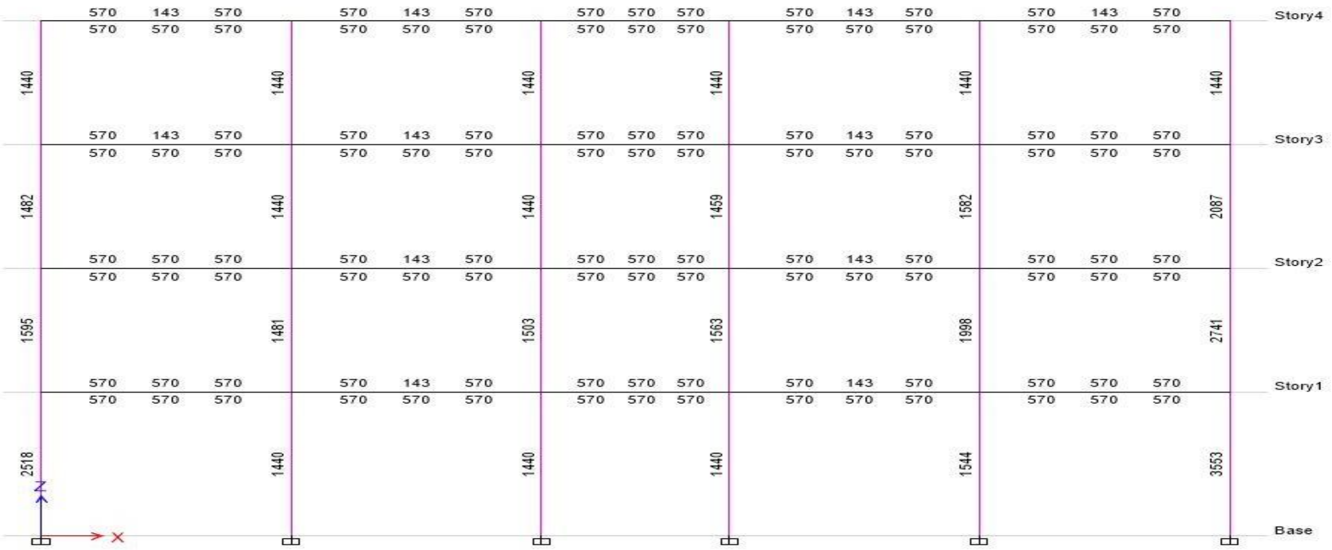
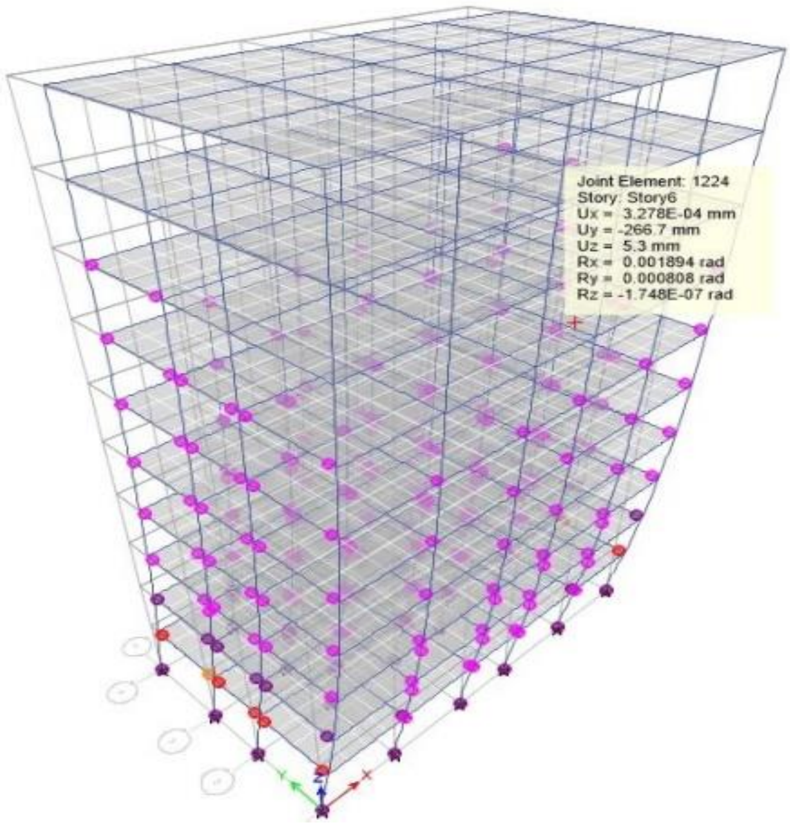


Figure: Reinforcements required for 12.5 m Model, considering Mass Eccentricity (Inner Face)

PUSHOVER ANALYSIS



The Figure show the response of the different models with respect to pushover analysis. As shown in Figure the Pushover Analysis was conducted on 3 models .The Asy1 model was designed considering the accidental eccentricity only as in Figure while the Asy2 was designed considering the effect of Mass eccentricity as shown in Figure . The Control was designed without considering the effect of eccentricities and earthquake forces and has minimum reinforcements.

Similarly as in the 30.5m model the Control was designed without considering the earth- quake forces with the Asy1 model considering the effect of accidental eccentricity and

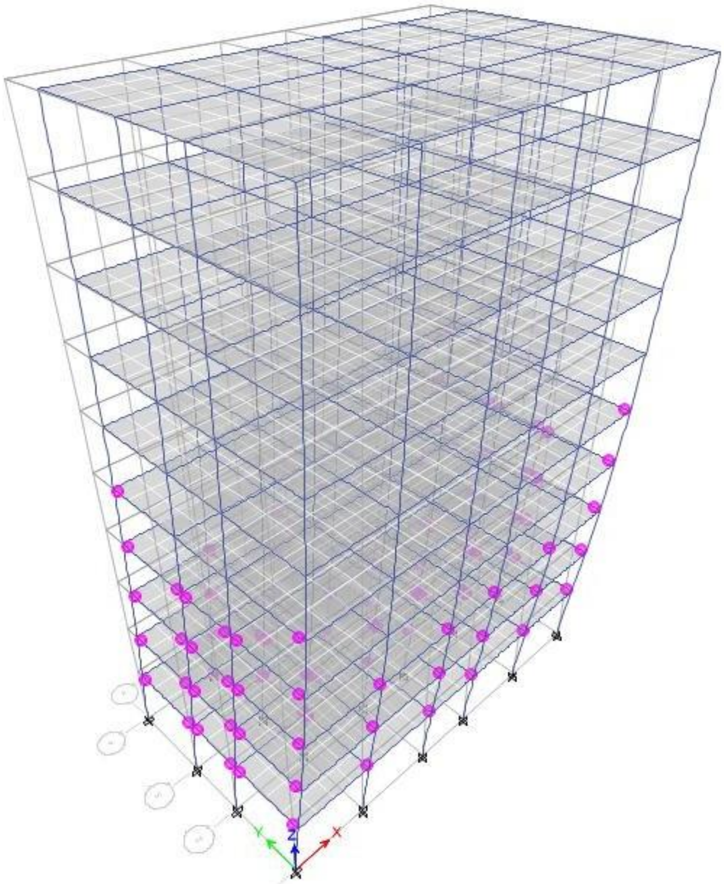


Figure: Pushover analysis of Asy1 Model (5th Time step)

the Asy2 model considering the effects of accidental and mass eccentricities as shown in.
The Pushover analysis was performed over all the 3 models in both the X and the Y direction. The eccentricity though in the model is only considered in one directions which is the Y direction in this case as the eccentricity is in Y axis.

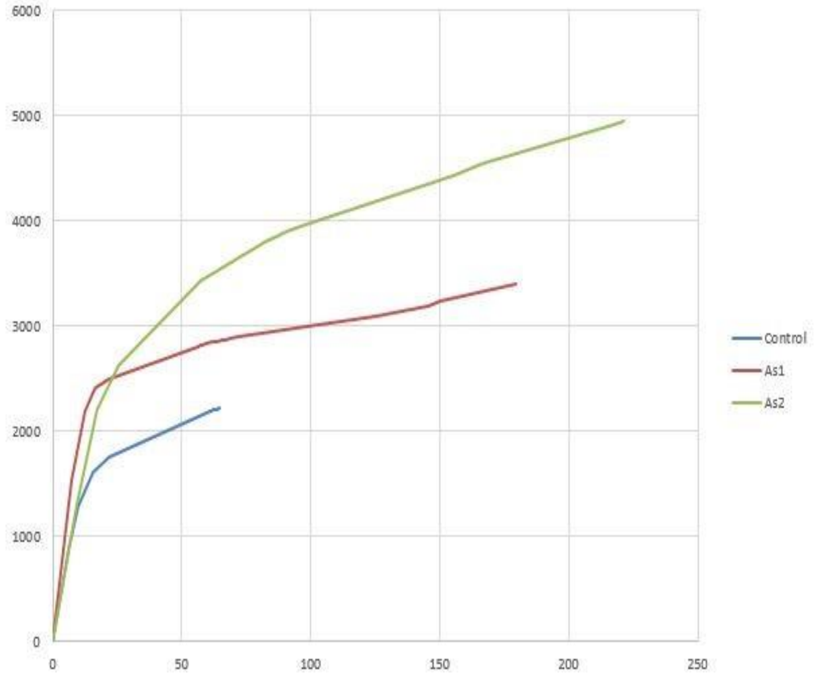


Figure: Pushover Analysis for 12.5m Model

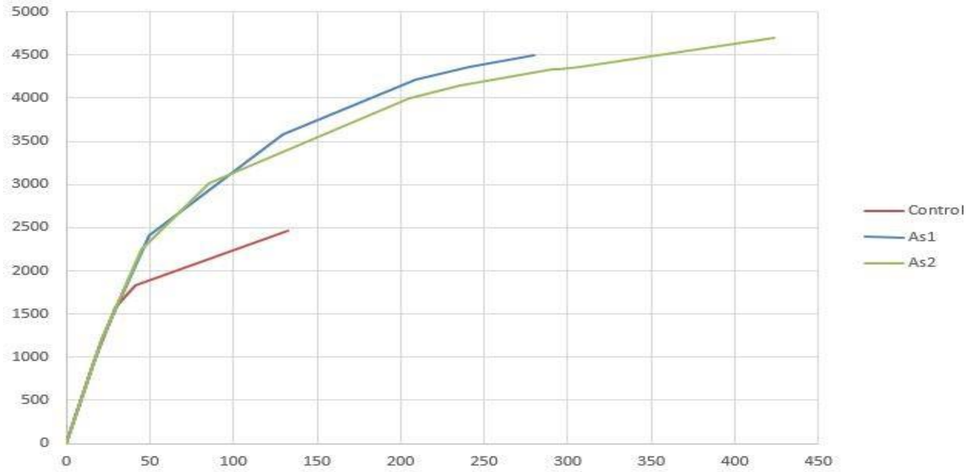
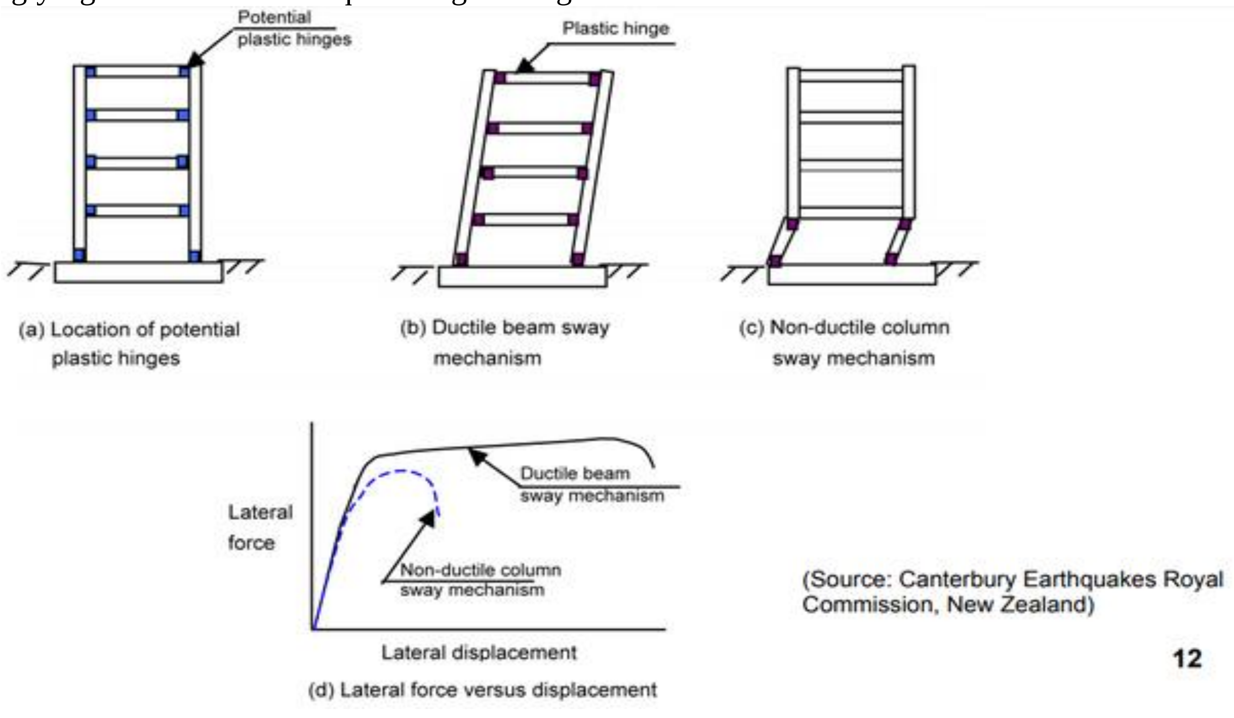


Figure: Pushover Analysis 30.5m Model

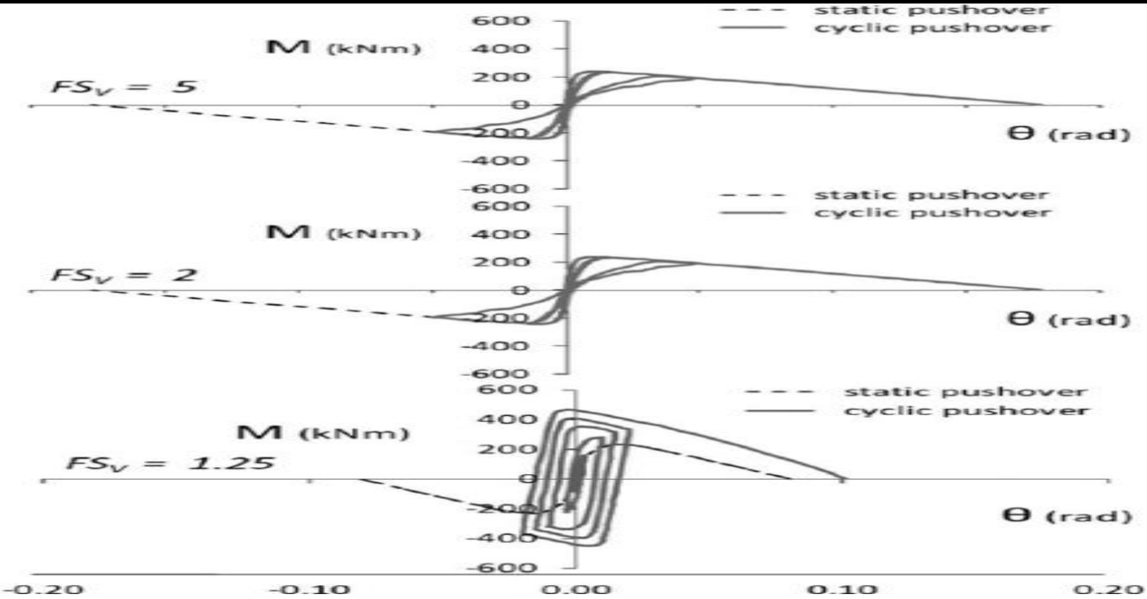
PLASTIC HINGES

The Plastic Hinges are mainly used in performing the pushover analysis. The plastic hinges are raised at the edges of each structural member such that they divide the frame into the individual members. The beams have an M3 type hinge at the end, which take only the moment into account while the Columns have the P2-M2-M3 hinge type assigned to them, which include the effect of axial force and therefore the effects of bi-axial bending. Their primary purpose is to serve as an energy-damping device for allowing deformations of seemingly rigid sections in earthquake engineering.



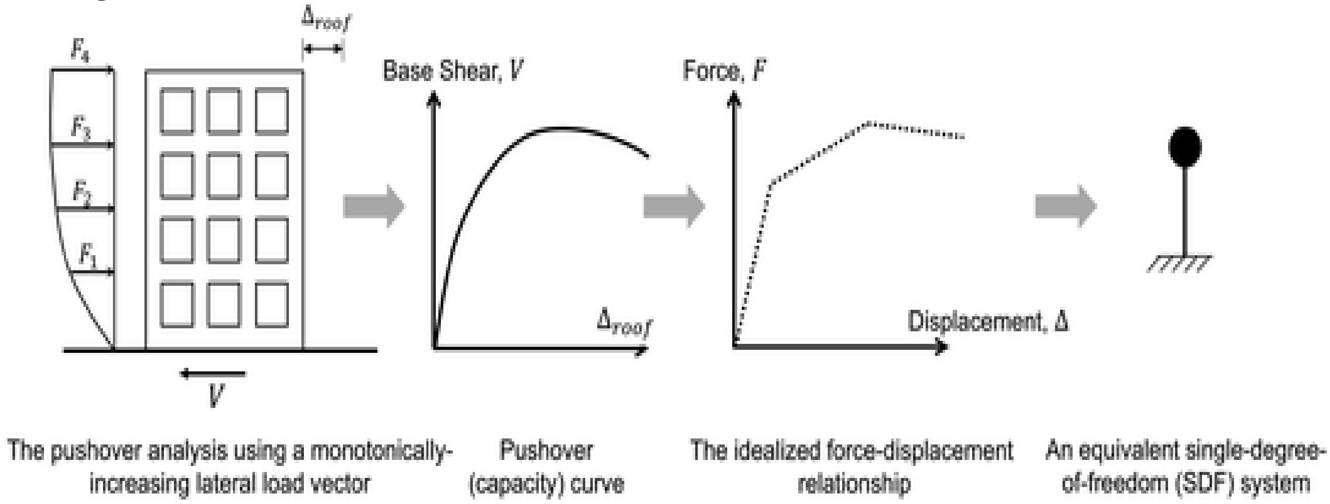
STATIC PUSHOVER ANALYSIS

The Pushover analysis is a Nonlinear Static analysis in which the structure is subjected to a displacement controlled lateral load pattern which continuously increases till the structure is forced form its elastic behavior to nonelastic behavior till the collapse condition is reached. There is also another variant of the static pushover analysis during which the structure is first subjected to the lateral load in one direction then an equivalent stressed structure is subjected to similar loading in the opposite direction. This approach is understood as a Cyclic Pushover Analysis it has been replaced by the utilization of your time History Analysis using periodic functions.



NON-LINEAR STATIC PUSHOVER ANALYSIS

A pushover is a static-nonlinear analysis method where a structure is subjected to gravity loading and a monotonic displacement-controlled a lateral load pattern which continuously increases through elastic and inelastic behavior until an ultimate condition is reached. Lateral load may represent the range of base shear induced by an earthquake loading, and its configuration could also be proportional to the distribution of mass along building height, mode shapes, or another practical means. The static pushover analysis is becoming a well-liked tool for seismic performance evaluation of existing and new structures. The expectation is that the pushover analysis will provide adequate information on seismic demands imposed by the planning a ground motion on the structural system and its components. The purpose of the paper is to summarize the basic concepts on which the pushover analysis can be based, assess the accuracy of pushover predictions, identify conditions under which the pushover will provide adequate information and, perhaps more importantly, identify cases during which the pushover predictions are going to be inadequate or maybe misleading.



SUMMARY

All codes examined use the concept of minimum eccentricity to be assumed during design calculation for safety. The worth of the dynamic eccentricity is additionally generally calculated supported an equivalent formula involving the static eccentricity the width of the structure supported the direction of the eccentricity in question. the idea of difference among the codes is totally on the values of the coefficients utilized in the formula while some codes prescribe an immediate formula for calculation others codes prescribe a specific constant value

CONCLUSION

As per the data presented in the previous Section 7.4 it can be concluded that though the impact of the earthquake force is great on the 12.5 m model the resultant effect of the eccentricity is small for the 12.5 story model while the the 30.5m model experiences a more significant change when the mass eccentricity is applied . Hence the useful for tall structures like the 30.5m model but not so effective for the smaller 12.5m model. The change in the inner section of the building is small for the 12.5 and the 30.5 model

While the difference increases as we approach the periphery hence it is proposed that to save time, the inner most columns can be designed for the column to the periphery and the design can be applied to all the innermost columns as the variation is very small while the outer columns at the buildings periphery need to be designed separately. The rise in the reinforcement required with the height of the building makes it possible for a simpler formula for calculation of the reinforcements of the structure thought the exact formulation of the formula will require study of more models and further study.

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