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Behavior of Drift in a Soft Storey Building with Masonry and Steel Bracings

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Abstract: Soft Storey is a common structural system of construction of RC frame in India. In this paper, a comparison has been made between the performance of the structure, braced with masonry and steel at the ground floor. This paper presents result from an extensive study investigating the seismic performance of soft storey building modelled in SAP2000. The infills are modelled as bracings. The bracings are provided at the outer peripheral columns. The response of the structure against lateral loading can be observed and the displacement is measured by using software SAP2000. The observation and results includes the drift analysis obtained by the analysis of the structure considering soft storey, masonry and steel braced wall. It was observed that inter-storey drift is maximum at the ground floor. In time history analysis inter-storey drift was found to be maximum in ground floor, then it gradually decrease in steel braced structure and lowest in masonry braced structure. In the case of pushover analysis the drift was found to be maximum in ground floor and it gradually decreases in masonry braced structure and lowest in steel braced structure.

Keywords: Pushover Analysis, Time-History Analysis, SAP2000, Soft Storey

I. INTRODUCTION

Soft storey floor is a typical feature in the modern multi-storey construction in India. Though multi-storeyed buildings with soft storey floor are inherently vulnerable to collapse due to earthquakes, their construction is still widespread in the developing countries like India. The North Eastern part of India, lying in seismic zone V is very prone to earthquakes. Many high intensity earthquakes have struck the area in the past causing major structural damages. With a steep increase in infrastructure development it has become important to design the structures considering the seismic forces in order to sustain during the high intensity earthquakes. RC frame building with open first storeys are known to perform poorly during strong earthquakes, the presence of Infill masonry walls influences the behaviour of the structure when subjected to lateral forces, when masonry Infill are considered to interact with their surrounding frames the lateral stiffness and lateral load carrying capacity of the structure largely increases. This paper possess modeling output (SAP2000), time history analysis, pushover analysis effect of drift and detailing of structural elements.

Definition of soft storey as per IS code

Cl 4.20 , IS1893 (part 1):2002

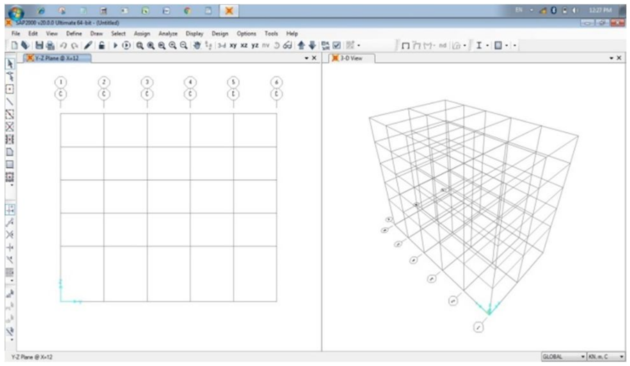
Lateral stiffness less than 70% of that in the storey above or less than 80% of the average lateral stiffness of three storeys above.

Cl 4.20.1 , IS1893 (part 1):2016

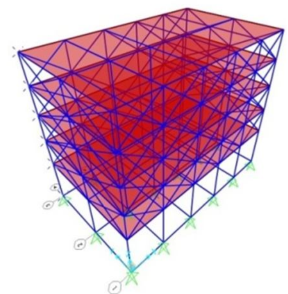
It is one in which the lateral stiffness is less than that in the above storey. The storey lateral stiffness is the total stiffness of all seismic force resisting elements resisting lateral earthquake shaking effects in the considered direction

II. SPECIFICATION OF BUILDING CONSIDERED FOR ANALYSIS

Number of stories	G+4	
Ground floor height	3.3m	
Floor to floor height	3m	
Size of footing	1500*1500mm	
Beam size	350mm*450mm	
	6-16D 8D@125mm c/c	
Column size	350mm*450mm	8-20D 8D@125mm c/c
Thickness of Infill	150mm	
Thickness of slab	125mm	
Grade of concrete	M20	
Grade of steel	Fe415	



Grid Line window



Modelled structure in SAP2000

III. ANALYSIS

A. Time History Analysis

Time history analysis is a step-by-step analysis of the dynamical response of the structure to a specified loading vary with time. It is done to obtain forces and deformation occurring in structures as a function of time due to ground motion acceleration. The basic objective of this analysis is to obtain a better response of a structure as it uses realistic simulation of actual earthquake shaking.

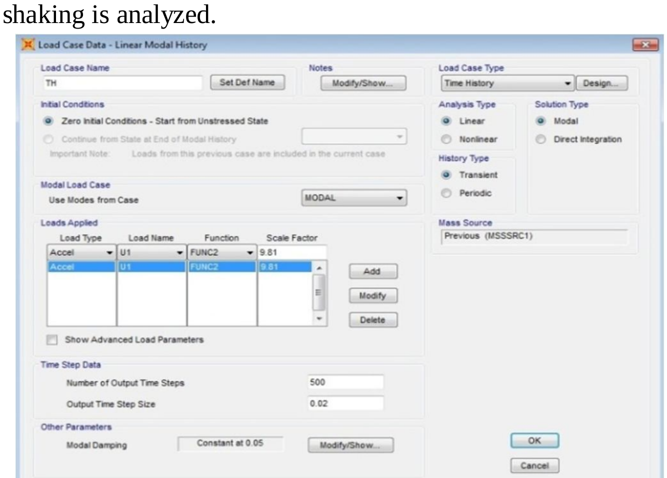
The ground motion data:

Station: Bokajan

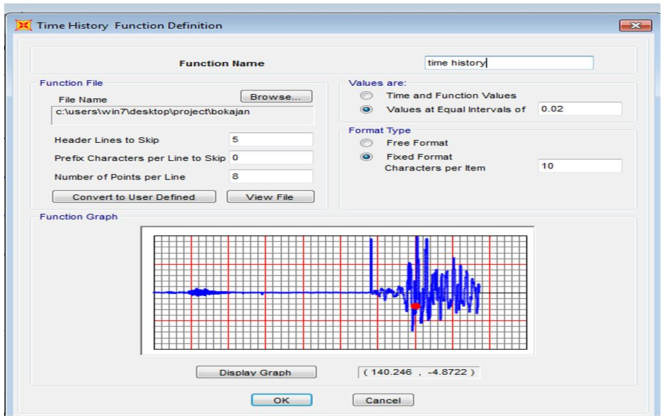
Year: 1987

Highest magnitude: 6.7

The ground motion data obtained from COSMOS VIRTUAL DATA CENTRE were used to analyze the force in the building and the deformation due to earthquake shaking is analyzed.



Load case



Window for Time History Input

1) *Effects of Drift on the open Storey Structure:* For calculation of drift value of any structure the difference in inter storey displacement was considered. The structure with flexural member with Infill walls are analysed and the drift is hence calculated
2) *Effects of time History Analysis on the Structure with Masonry Bracing:* The un-reinforced masonry walls are use as Infills in reinforced concrete (RC) buildings. Such walls enhance the resisting capacity of the lateral loads up to a certain level of structural response. The interaction between masonry Infill and RC structures highly affects the stiffness which is beneficial. The Infill masonry walls are idealized using equivalent strut methodology to account for the specific behaviour of the MI walls. These buildings have high stiffness and strength. Accordingly, several analytical models have been proposed to model the stiffness and strength of Infill walls. Seismic codes recommend modeling the Infills as equivalent struts.

Clause 7.91, IS 1893 (part1):2016

$I_c = \frac{350*450^3}{12} = 2657812500\ mm^4$

$L_{ds1} = \sqrt{3^2 + 4^2} = 5m$

$L_{ds2} = \sqrt{3^2 + 6.5^2} = 7.16m$

$L_{ds3} = \sqrt{3^2 + 5.5^2} = 6.26m$

$\Theta1 = \tan^{-1}\frac{3}{4} = 36.86$

$\Theta2 = \tan^{-1}\frac{3}{6.5} = 24.77$

$\Theta3 = \tan^{-1}\frac{3}{5.5} = 28.61$

$$\alpha = h*[\sqrt[4]{\frac{Em.t.sin2\theta}{4Ef.Ic.h}}]$$

$$\alpha1=3000*[\sqrt[4]{\frac{3114.07*150*sin(2*36.86)}{4*22360*2657812500*3000}}] = 2.67$$

$$\alpha2=3000*[\sqrt[4]{\frac{3114.07*150*sin(2*24.77)}{4*22360*2657812500*3000}}] = 2.52$$

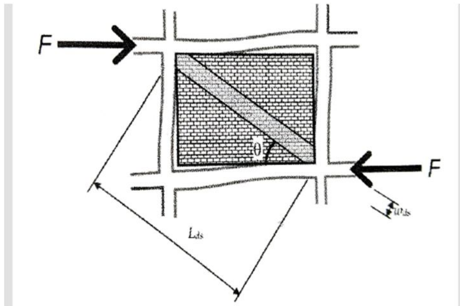
$$\alpha3=3000*[\sqrt[4]{\frac{3114.07*150*sin(2*28.61)}{4*22360*2657812500*3000}}] = 2.58$$

$$w_{ds}=0.175\alpha_h^{-0.4}L_{ds}$$

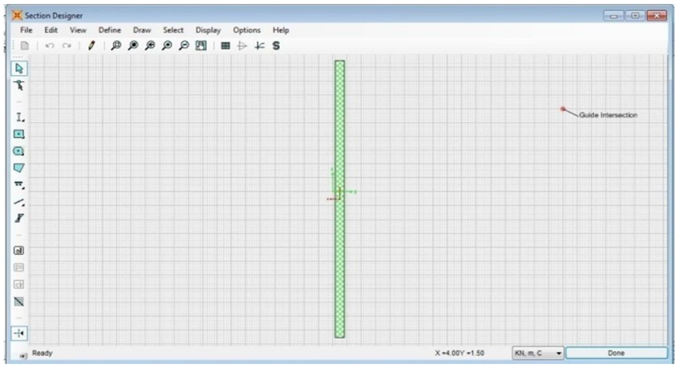
$w_{ds1}= 0.59m$

$w_{ds2}=0.86m$

$w_{ds3}=0.75m$



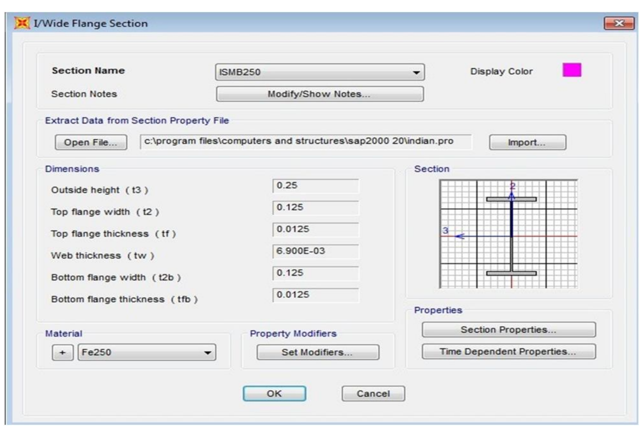
Equivalent diagonal strut of MI wall



Section for bracing

3) *Effects of time History Analysis on the Structure with steel Bracing***:** Braced frames are known to be efficient structural systems for buildings under high lateral loads such as seismic or wind loadings. The fact that the lateral resistance of frame can be significantly improved by the addition of a bracing system has led to the idea of retrofitting seismically inadequate reinforced concrete frames with steel bracing system. On a global basis of resisting earthquake loads, shear walls are commonly used in RC framed buildings, whereas, steel bracing is most often used in steel structures. In the last two decades, a number of reports have also indicated the effective use of steel bracing in RC frames.The steel bracings are modelled with the following specifications.

Designation = ISMB250
Sectional area = 47.55cm^2
Depth of section, D = 250mm
Width of flange, b_f = 125mm
Thickness of flange, t_f = 12.5mm
Thickness of web, t_w = 6.9mm



Steel Bracings Specification

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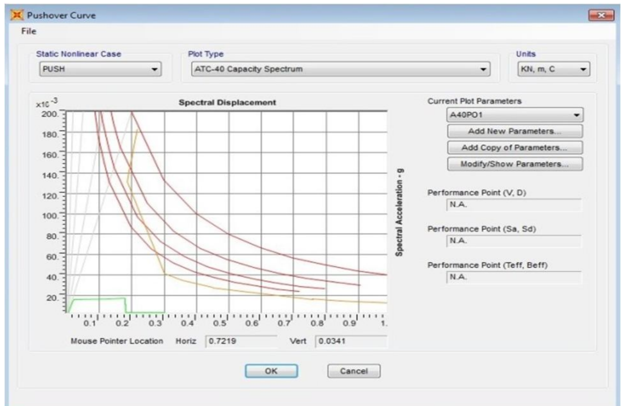
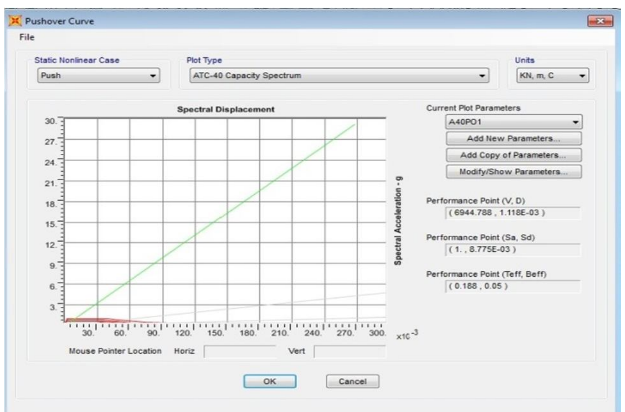
B. Pushover Analysis

Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. Due to these earthquakes large destruction was caused to the infrastructure and buildings. In order to resist the buildings from the severe motions many analysis methods were developed. Pushover analysis is a method to evaluate the performance level of building. The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral load. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity.

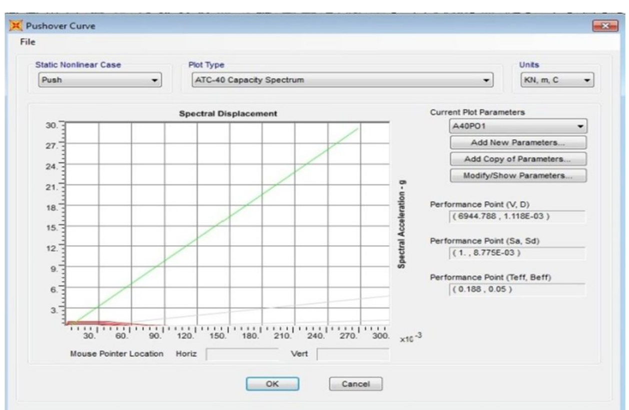
In this paper, pushover analysis is carried out for a G+4 building to check the seismicity effect and performance level of a building by SAP2000. Pushover Analysis produces a Pushover curve consists of capacity spectrum, demand spectrum and performance point. It shows the performance level of the building components and also maximum base shear carrying capacity of the structure.



Pushover Curve of Soft Storey



Pushover Curve of Storey with Masonry Bracings



Pushover Curve of Storey with Steel Bracings

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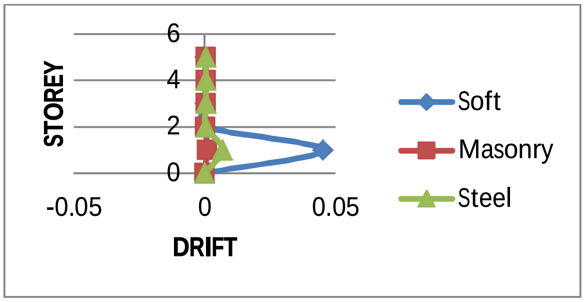
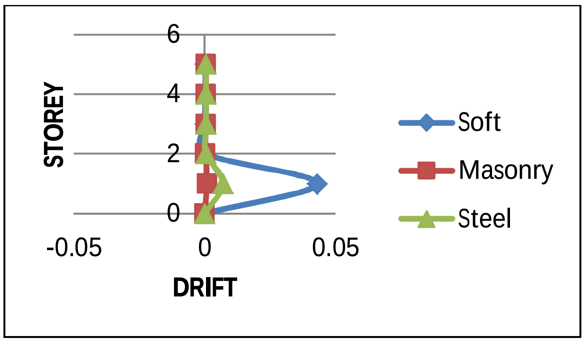
IV. RESULT

Analysis of Drift was considered at the exterior corner columns of the structure. The graph obtained after the analysis is shown below.

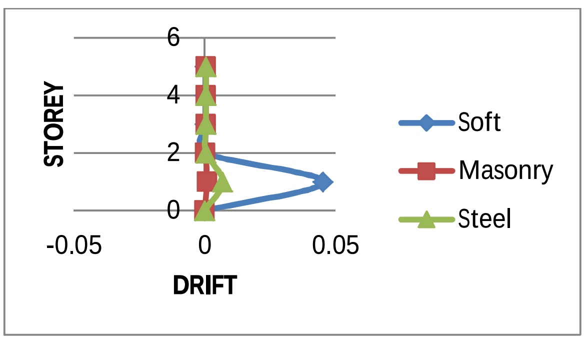
A. Time History Analysis



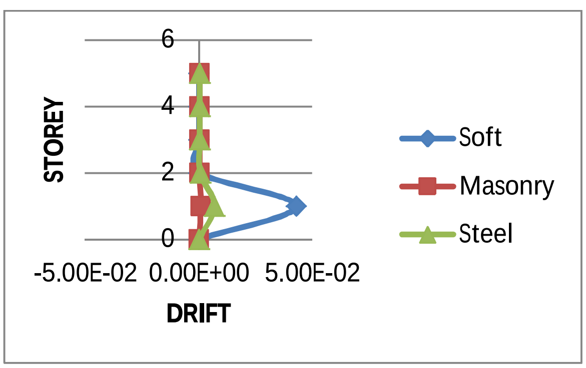
Drift of Exterior Column C1



Drift of Exterior Column C6



Drift of Exterior Column A1



Drift of Exterior Column A6

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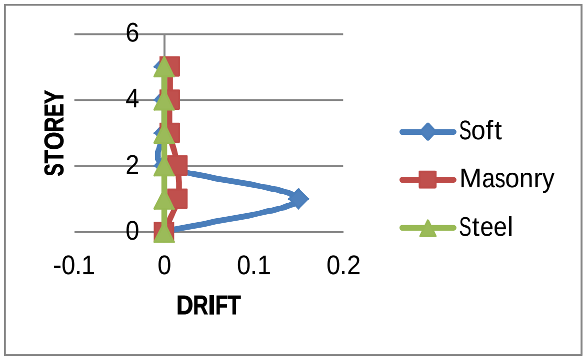
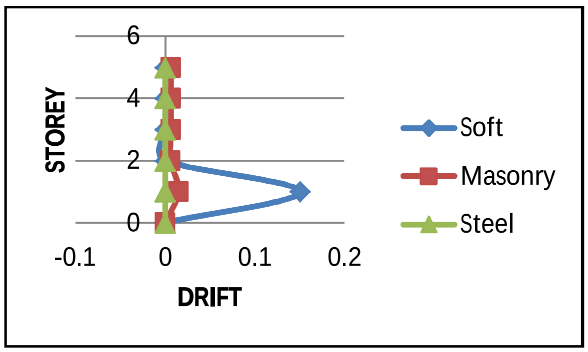
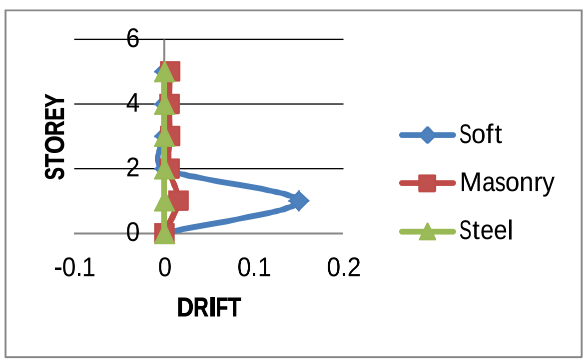
B. Pushover Analysis



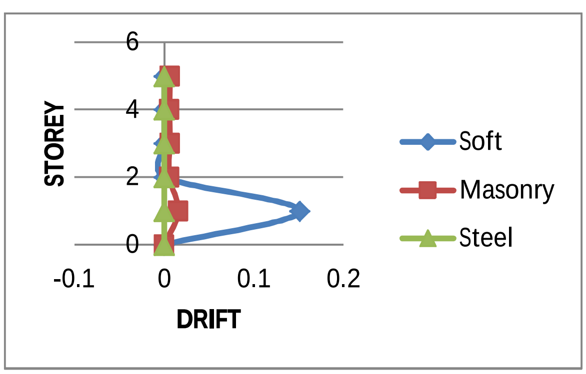
Drift of Exterior Column C1



Drift of Exterior Column C6



Drift of Exterior Column A1



Drift of Exterior Column A6

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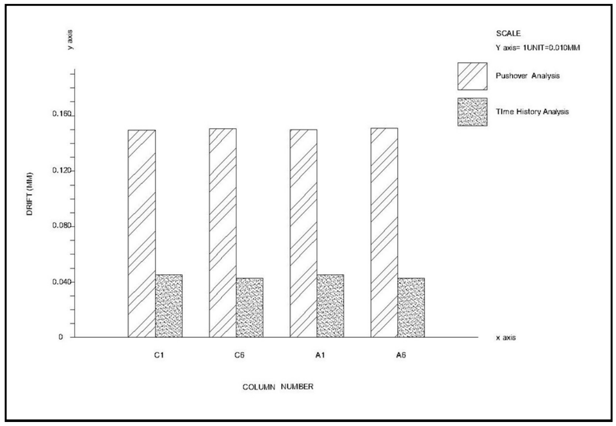
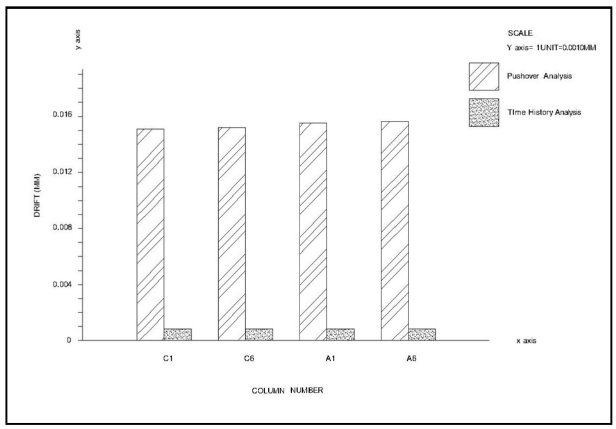
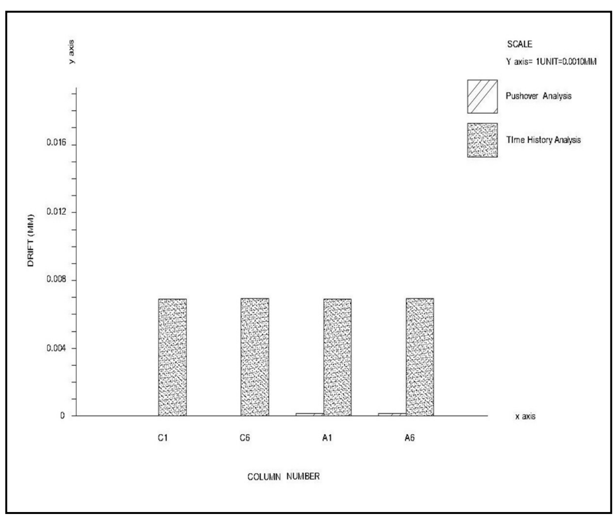
V. COMPARISON



Comparison of drift in Soft Storey by Time History and Pushover analysis



Comparison of drift in Storey with Masonry by Time History and Pushover analysis



Comparison of drift in Storey with Steel Bracings by Time History and Pushover analysis

VI. CONCLUSION

This paper includes modeling and analysis of soft-storey building using SAP2000'. The structural response was investigated by focusing on Seismic loads as the North-Eastern region of India falls under high earthquake zone. The investigation revealed that a soft storey building performs poorly under seismic loads. The drift so obtained is maximum in soft storey. By providing lateral load resistance component such as masonry and steel bracings, the strength of the structure can be increased and executes profoundly under seismic circumstances, thus minimizes the Seismic hazards. As for the structure exhibits limited drift as compared to soft storey. The time history analysis highlighted that the soft storey structure has maximum drift. Masonry bracings have the minimum drift as compared with steel bracings. In addition, drift can also be minimized by increasing the dimensions of steel bracings. On the contrary in pushover analysis the drift is maximum in soft storey and least in steel, by reason of considering steel's property of ductility.

Hence the observations can be listed as follows

A. The absence of bracings at the ground floor induces maximum drift also irregularity in strength. The upper floors are stiffer than open ground storey due to the presence of walls. Hence the building is vulnerable to collapse in a moderate or severe earthquake. Thus, we can state that when infill walls are not considered in modelling, vulnerability criteria would not be checked. Correct building safety can be achieved only after introducing bracings.
B. With the introduction of bracings, the storey drift reduces to 18% and almost reduces to 0% for steel bracings and masonry bracings respectively.
C. Maximum inter storey drift occurs specially on the ground floor while upper floors have less drift impact, implying that without bracings it is critical towards seismic conditions.
D. Performing Pushover Analysis, it is observed that hinges developed at ground floor beyond collapse prevention without bracings while hinges are formed within the immediate occupancy state with the presence of bracings.
E. Introduction of bracings reduces the drift to 10.5% after performing pushover analysis on the braced models.

VII. ACKNOWLEDGEMENT

We are highly grateful to Royal School of Engineering And Technology, Guwahati for providing this opportunity to carry out the paper in "Modeling and Analysis of Soft-Storey building with Infill masonry wall using SAP2000". We would like to express a deep sense of gratitude and heartiest thanks to Prof. Rishikesh Duarah, Assistant Professor Department of Civil Engineering without whose wise counsel and able guidance it would have been impossible to complete the paper in this manner.
Last but not the least we would like to thanks our family for their constant support.

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