"STUDY ON SEISMIC BEHAVIOR OF IRREGULAR BUILDING WITH AND WITHOUT SHEAR WALL IN SEISMIC ZONE-4 USING DYNAMIC ANALYSIS"

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Abstract – The behavior of multi-Storey buildings during strong earthquake motion depends on the structural configuration. Most structures today have asymmetrical plans and vertical arrangements. A high degree of engineering designerners' effects is necessary to adequately analyze and understand irregular construction.

From the observation of past earthquake structures with regular configuration, structures stay safe in earthquakes than structures with irregularities. Structure experience lateral displacements under earthquake loads. These works focus on studying the multi-Storey structure with the same area as an irregularly shaped building with Square, L, C and I shapes against seismic loads and seismic vibrations. The various structural behavior parameters such as displacement, base shear, story drift & time-period are needed to be studied.

Key Words: **Response spectrum, Static Equivalent & E-Tabs.**

1. INTRODUCTION

Earthquakes have historically occurred on the Indian subcontinent. The Indian plate is moving into Asia at a pace of about 47 mm/year, which is the main cause of the earthquakes' high frequency and intensity. Nearly 54% of India's terrain is earthquake-prone, according to geographic statistics. According to World Bank and United Nations research, by 2050 there will be 200 million city inhabitants in India who will be at risk of earthquakes and storms. The earthquake-resistant design code of India's [IS 1893 (Part 1) 2002] newest version of the seismic zoning map of India assigns four levels of seismicity for India in terms of zone factors.

Zone II: This is the least seismically active zone.

Zone III: The moderate seismic zone encompasses it.

Zone IV: This area is classified as a high seismic zone.

Zone V: It is the most seismically active region.

1.1 IRREGULARITIES

Most structures today have asymmetrical plans and vertical arrangements. An unsafe coupled lateral reaction results from a lack of symmetry in structures, which implies a critical eccentricity between the mass and stiffness centers. A faulty designer might design and analyze a structure by ignoring various criteria, leading to a hazardous design. High degrees of engineering and designer efforts are necessary to adequately analyze and understand an irregular construction.

Effectively designing and evaluating an irregular building requires a high level of technical and design skills. Therefore, a second more detailed structural analysis will be required for irregular structures to improve their complicated reaction to an earthquake.

Vertical abnormalities are one of the most frequent reasons for structure failure during earthquakes. The most common constructions to fall, for instance, were those with flimsy levels. The effect of vertical differences on structural seismic performance thus becomes of essential importance. Due to variations in stiffness and mass as they increase in height, these buildings' dynamic properties differ from those of typical buildings. According to the description in IS 1893: 2016, the irregularity in building structures is brought on by uneven distributions of mass, weight, and stiffness along the height of the building. When such buildings are constructed in high seismic zones, their analysis and design are more challenging.

A structure's collapse usually starts with components that are most unstable during an earthquake. This weak spot is brought on by the irregularity of the structure's mass, stiffness, and geometry. These faults are seen in irregular formations. The infrastructure of the city is mostly made up of irregular systems. One of the main reasons systems fail during earthquakes is irregularity. The effect of deviations on a system's total seismic output will be more and more crucial. Maximum changes in stiffness and mass set these structures apart from regular buildings in terms of their dynamic properties. Uneven mass, weight, and stiffness distributions along the height of the building may be the cause of the irregularity in the building structures. The research and design are more challenging when such buildings are built in seismically active regions.

Building irregularities can be of two types:

1. Vertical Irregularities
2. Plan Irregularities

2. SCOPES AND OBJECTIVES OF THE PROJECT

Using the structural engineering program ETABS version 18, this study seeks to study a multi-story structure with the same area as an irregularly shaped building with SQUARE, L, C, and I shape against seismic loads and seismic vibrations. The objective is to create a structure that is efficient, dependable, and has enhanced ductility. Several significant goals must be achieved to ensure this achievement:

By evaluating a building's ability to withstand seismic loads and researching its capabilities and flaws, such as general displacements and unintended brittle breakdowns.

A global analysis can be used to evaluate the structure's general behavior in terms of safety, effectiveness, and ductility. Additionally, by examining the findings of the frequencies and gathering the critical displacements, as well as by upgrading the structure using an appropriate seismic retrofitting approach by IS 1893-2016 & IS 13935-2009, the weak spots of the structure may be verified. The approach used will take into account the structural behavior of the structure and its present capacity.

Achieving these objectives can also help us better comprehend the idea of seismic analysis of plan irregularity structures. A limitation is imposed by disregarding the neighboring structure's exclusion and taking into account that the building is constructed on the ground since a portion of it is supported by it. The capability of the capabilities in the employed software, such as ETABS's ability to apply loads to more complicated shapes, is the second restriction. Due to this restriction, extra undefined beams, sometimes known as fake beams, are used to create a simpler geometry.

- The majority of structures in zones II and III are typically built to withstand seismic activity.
- Analysis of a conventional building with a regular layout
- In this project effort, irregular shapes including L, I, and C form structures were taken into consideration.
- Identification of abnormal building behavior in seismic zones II, III, and IV.

3. LITERATURE REVIEW

Mohammed Rizwan Sultan,D. Gouse Peera(2015): This paper presents the study on dynamic analysis of multi-storied structure for different shapes this study is to grasp the behavior of the structure in a high seismic zone and also to evaluate Storey overturning moment, Storey Drift, Displacement, Design lateral forces. They have considered different shapes like Rectangular, L-shape, H-shape, and C-shape The complete models were analyzed with the assistance of ETABS 9.7.1 version The results indicate that, building with severe irregularity produces more deformation than those with less irregularity, particularly in high seismic zones. And conjointly the storey overturning moment varies inversely with height of the storey. The storey base shear for regular building is highest compare to irregular shape buildings.

Milind V. Mohod(2015):- This paper studied the effects of plan and shape configuration on irregular shaped structures. The effect of irregularity (plan and shape) on structure has been carried out by using structural analysis software STAAD Pro. V8i. And he concluded that considering the effect of lateral displacement on different shapes of the building of the structure. He has been observed that, Plus-shape, L-shape ,H-shape,Escapee, T-shape and C-shape buildings have displaced more in bothdirectionsn (X and Y) in comparison to other remaining simple shaped building (Core-rectangle, Coresquare, Regular building).The storey drift being the important parameter to understand the drift demand of the structure is considered while collecting the results from the software.

Dr. Okay. R. C. Reddy, Sandip A. Tupat et., al. (2014) :- This research has stated that the wind hundreds and earthquake masses are estimated for a twelve storied RC framed constitution. Established on the results bought the following conclusions are made. The earthquake and wind hundreds rises with height of constitution. Wind loads are more valuable for tall structures than the earthquake loads. Constructions will have to be designed for loads obtained in each recommendation independently for important forces of wind or earthquake.

Mohammed yousuf et al. (2013) [2]:- The aim of this paper is to study on dynamic analysis of reinforced concrete building with plan irregularity for Four models of G+5 building with one symmetric plan and remaining irregular plan have been taken for the investigation. The analysis of R.C.C. building is carried out with the FE based software ETABS 9.5.Estimation of response such as; lateral forces, base shear, storey drift, storey shear is carried out. Four cross sectional variation in columns section are considered for studying effectiveness in resisting lateral forces.

Yogesha A V and dr. Jagadish G. Kori (2018):- This aim of the paper is comparative analysis on symmetrical and unsymmetrical RC framed building using different type of dampers. Comparative analysis of symmetrical and asymmetric buildings using various dampers such as fluid viscous dampers and viscoelastic dampers. Code specification IS 1893 (Part I): 2002 is used to analyze the structure according to the equivalent static and response spectrum methods. Modeling and analysis are performed using the software ETAB 2016. The results, namely seismic parameters such as displacement, floor displacement, and floor thrust, are tabulated and a comparative study of structures with and without dampers and in combination with fluid viscoelasticity is performed. I made a viscoelastic damper.

4. METHODOLOGY

The aim of this thesis is to provide information based on seismic analysis of normal and irregular buildings in accordance with IS1893-2016, as well as those that have been constructed in accordance with codes and procedures.

More specifically, the equivalent lateral load method and response spectrum approach is used for this thesis to analyse the building globally and check the entire behaviour of the system; concentrating mostly on the structure's responses such as displacement, storey drift ,base shear and time period after using the seismic analysis, which is required by the code.

In order to gain knowledge about common seismic analysis of plane and irregular buildings for different zones, a large amount of data, such as research papers, journals, and previous theses, has been collected and thoroughly studied.

The 3d Models of 4 buildings were modelled for seismic zones II, III & IV in total 12 fem models are made and it is designed for gravity as well as seismic loads using the Indian standards such as IS 456:2000,IS 875:2015,IS893:2016 and IS 13920:2016.

Prepare E-Tabs models with plan irregularities having same plan area

↓

Defining seismic loads for various seismic zones

↓

Plotting tables and graphs obtained from E-Tab models

↓

Comparing the results of various plan irregularities for best results.

Figure 5.1 Flow Chart of methodology

Twelve models are made to compare the results

A. Square Model.

Three square shapes (for Zone II, III, and IV) models are made to scale in etabs and it is subjected to gravity loads as per IS1893-2016 and the the seismic response of the buildings.

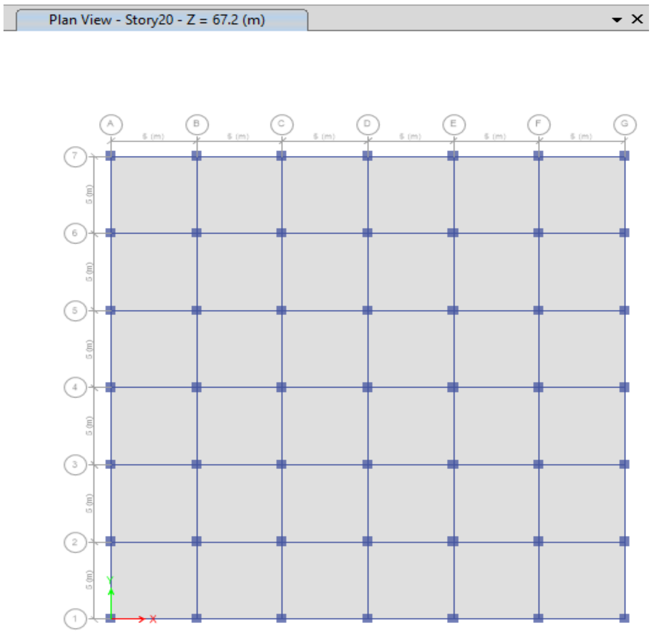

Figure 5.2 E-Tabs Square Model

B. Model L- Shape

Three L shapes (for Zone II, III, and IV) models are made to scale in etabs and it is subjected to gravity loads as per IS1893-2016 and the the seismic response of the buildings IV are noted.

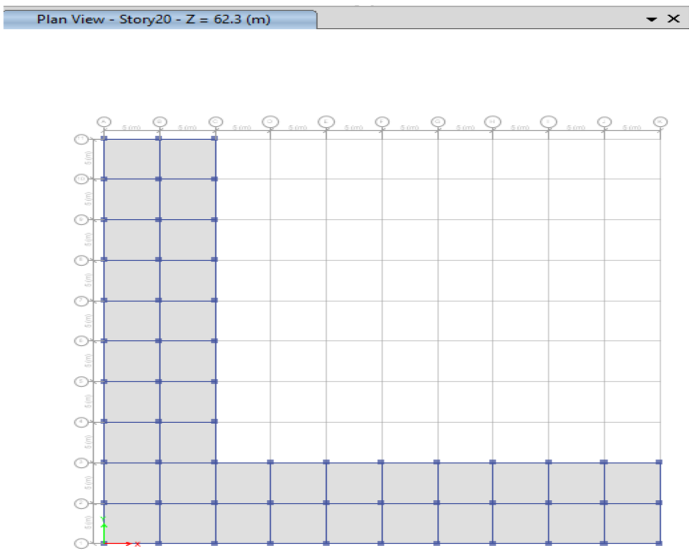

Figure 5.3 E-Tabs L- Shape Model

C. Model C- Shape

Three C shapes (for Zone II, III, and IV) models are made to scale in etabs and it is subjected to gravity loads as per IS1893-2016 and the the seismic response.

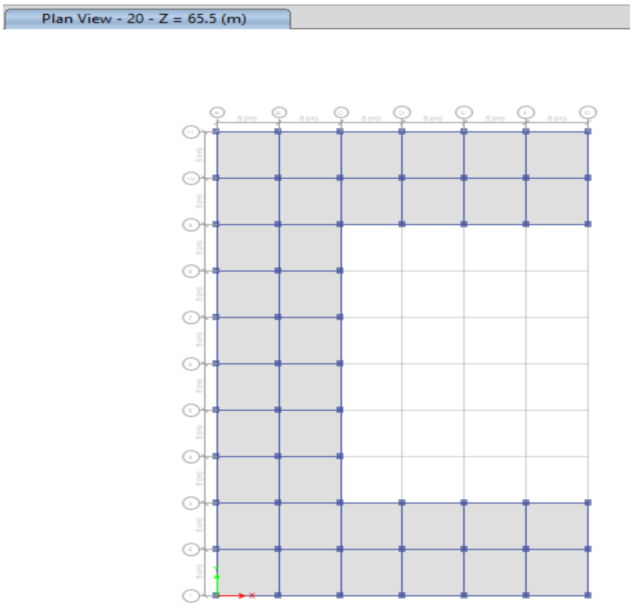

Figure 5.3 E-Tabs C- Shape Model

D. Model I- Shape

Three T shapes (for Zone II, III, and IV) models are made to scale in etabs and it is subjected to gravity loads as per IS1893-2016 and the the seismic response.

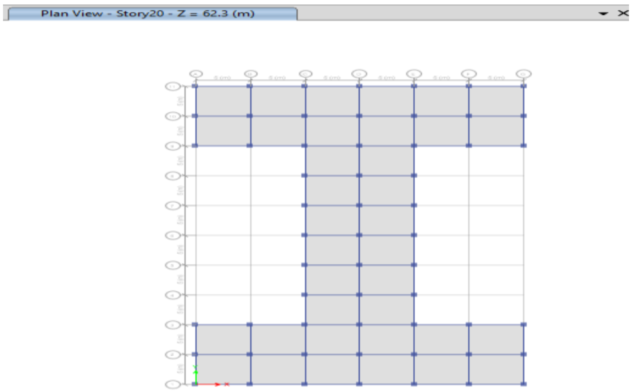

Figure 5.4 E-Tabs I- Shape Model

E. Design loads

The loads which have been used for the modelling are as follows:

- Self-weight of the structure
- Floor finish
- Wall load
- Typical live load
- Roof live load
- Seismic load

1. Dead load as per IS: 875 (Part I)-1987

i) Self weight of slab (150 mm thick) - 3.75 kN/m2
ii) Loading due to Floor Finishes - 1.50 kN/m2

2. From masonry walls – 5.72kN/m 3.

3. Live load as per IS: 875 (Part-II)-1987

i) Live load on floor – 3.00 kN/m2
ii) Live load on roof - 1.50 kN/m2

4. Earthquake load. IS: 1893-2016

i) Zone factor - 0.1
ii) Zone factor - 0.16
iii) Zone factor - 0.24

ii) Soil type - II

iii) Importance factor - 1

iv) Time period in X direction – 1.05

Time period in Y direction – 1.05,0.81

The structure was analyzed for dead load, live load, seismic load and their combinations. The structural adequacies of existing members were checked as per the guidelines in IS: 456-2000 and SP-16.

5. RESULT AND DISCUSSION

This chapter presents results of seismic analysis of all the models considered as per the model analysis. The results and discussions given are considered in detail with reference to required tables and figures.

5.1 Results

5.1.1 Displacement

The maximum values of displacements are tabulated by comparing X and Y directions. The values of displacement of different models are obtained by subjecting the models to response spectrum analysis shows max displacement. Further the tabulated results are plotted in a graph and can be seen in the figures.

A. Maximum story Displacement for square shape

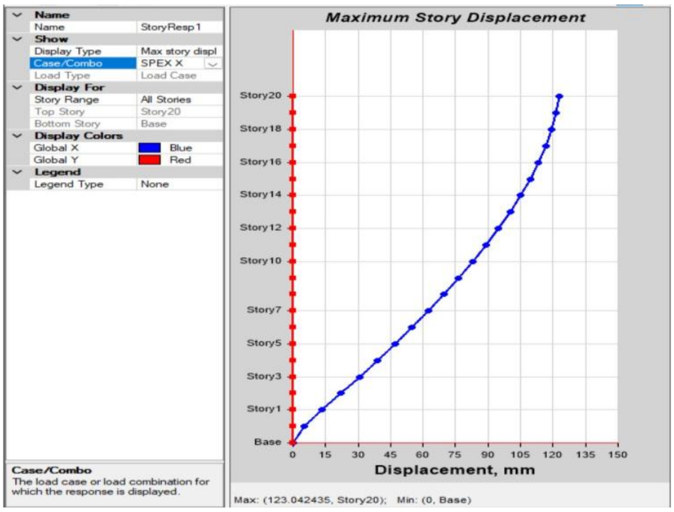

Fig5.1.1 Square shape building without shear wall

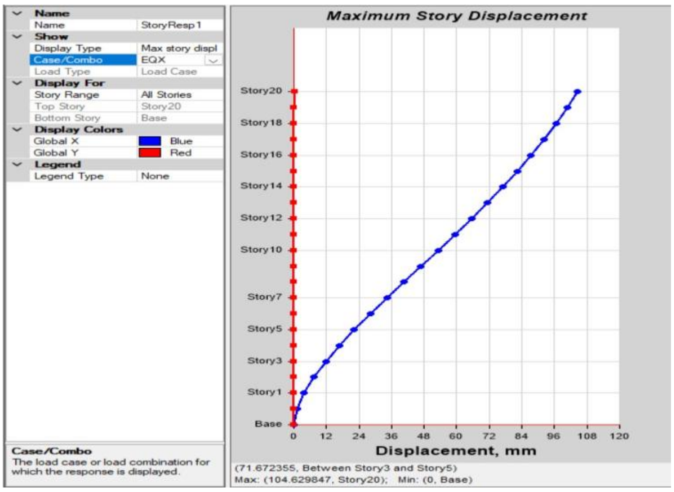

Fig5.1.2 Square shape building with shear wall at Corners

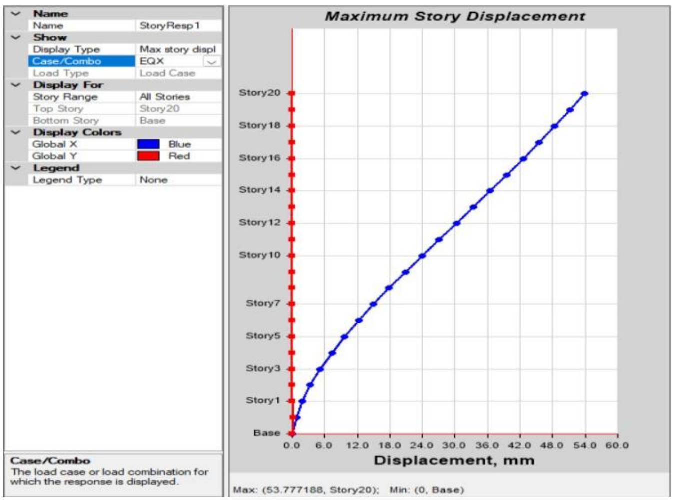

Fig5.1.3 Square shape building with shear wall at Centre

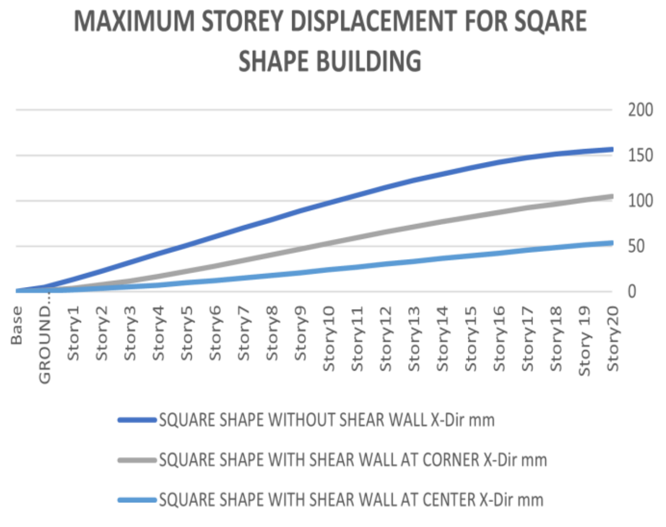

Fig5.1.4 Square shape building displacement

B. Maximum story displacement for C- shape building

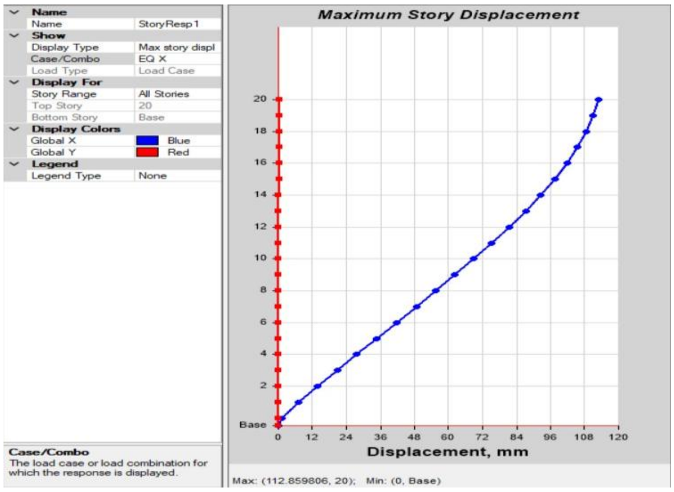

Fig5.1.5 C- shape building without shear wall

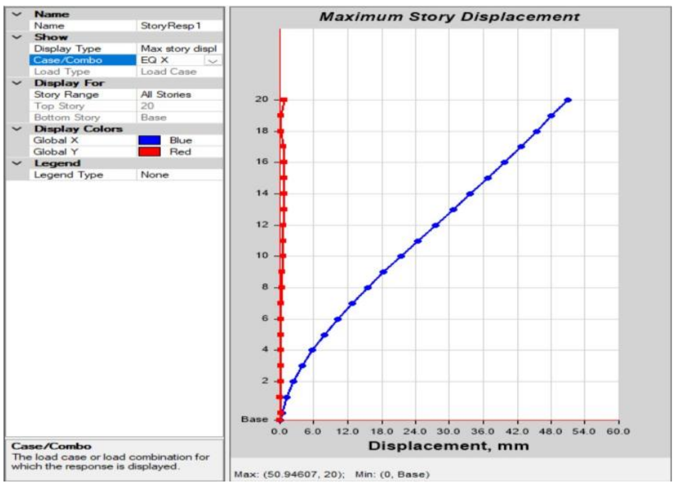

Fig 5.1.6 C- shape building with shear wall at center

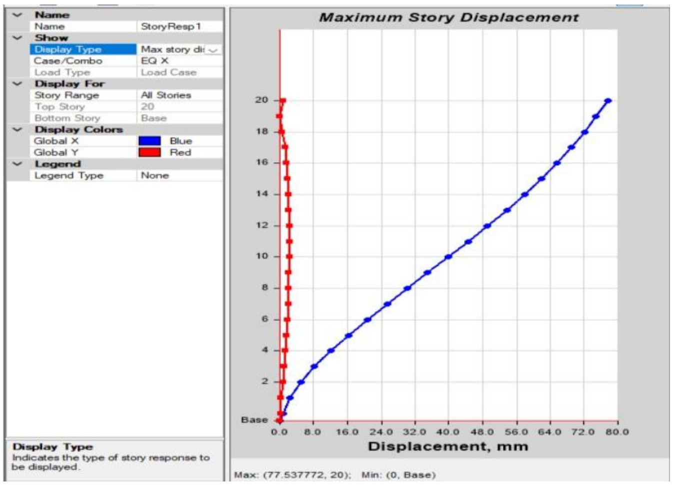

Fig5.1.7 C- shape building with shear wall at corner

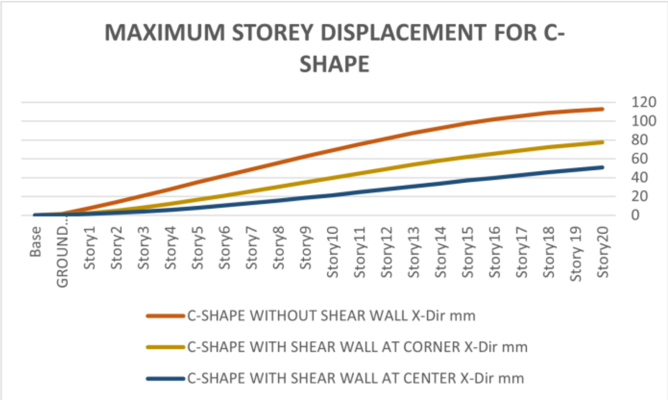

Fig5.1.8 C- shape building Maximum story displacement

C. Maximum story displacement for L- shape building

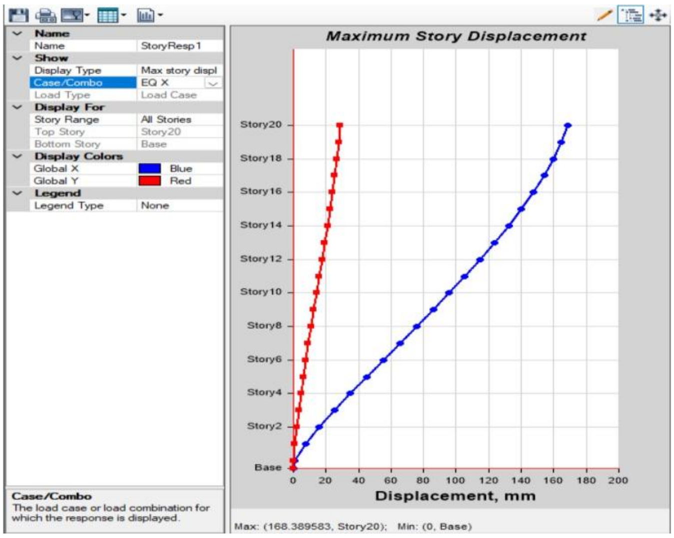

Fig5.1.9 L- shape building without shear wall

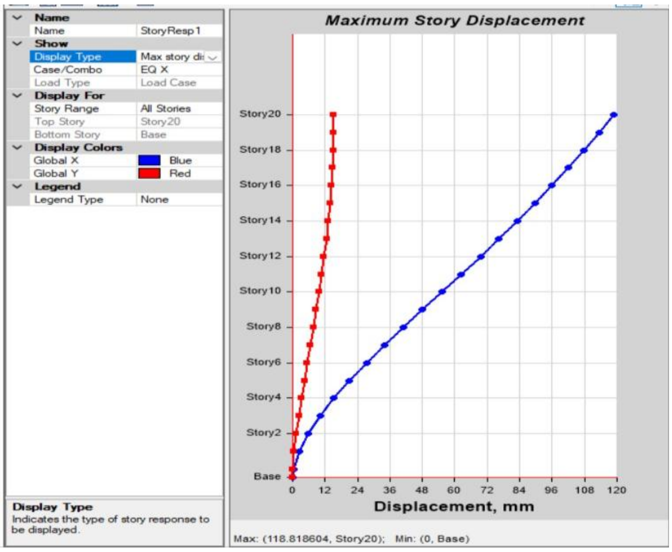

Fig5.2.0 L- shape building with shear wall at corner

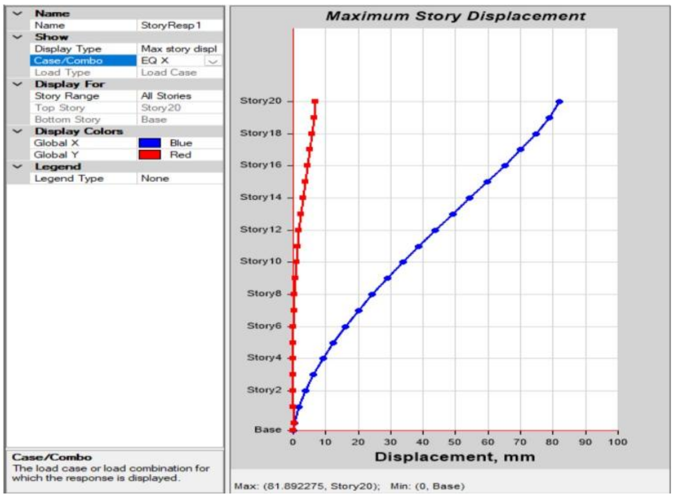

Fig5.2.1 L- shape building with shear wall at center

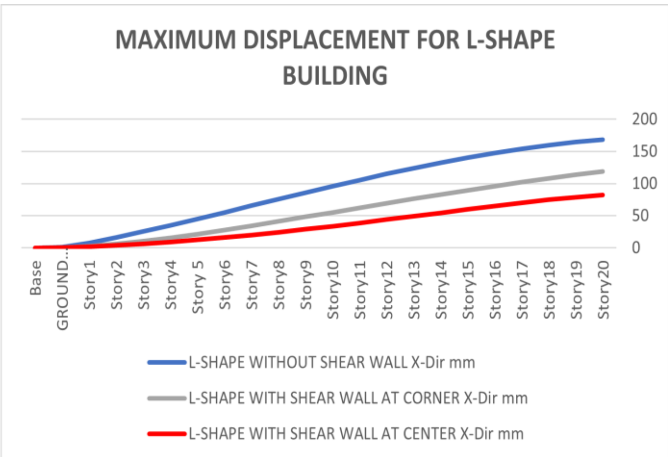

Fig5.2.2 L- shape building Maximum story displacement

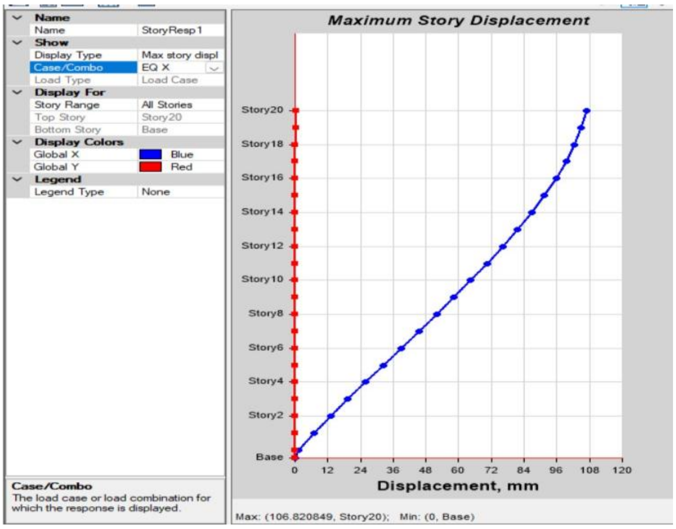

Fig5.2.3 I- shape building without shear wall

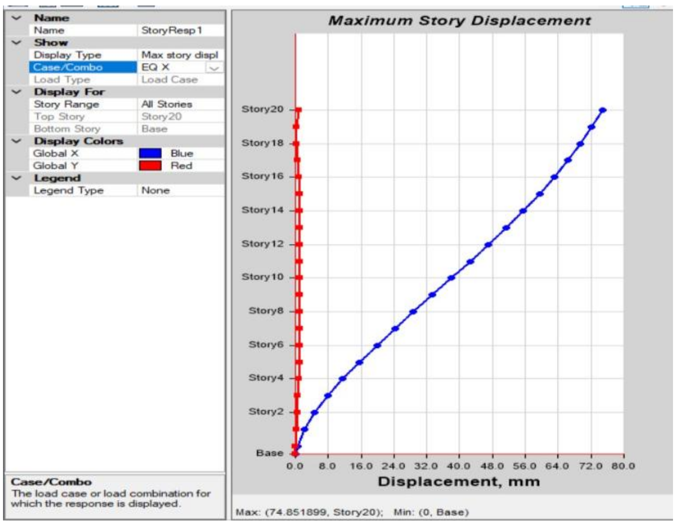

Fig 5.2.3 I- shape building with shear wall at corner

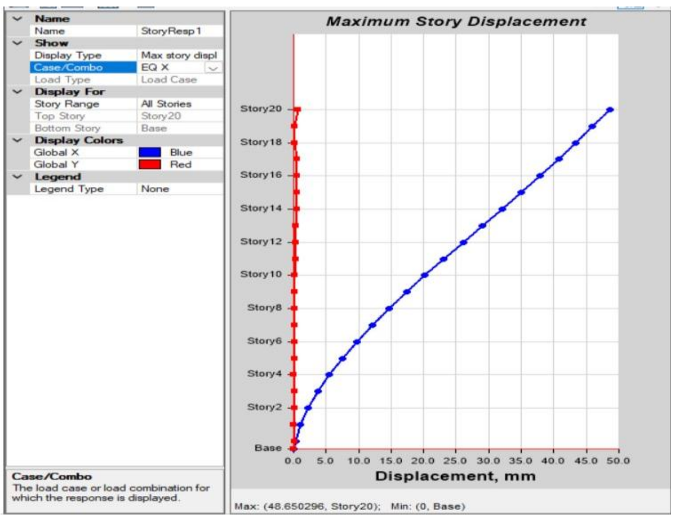

Fig 5.2.4 I- shape building with shear wall at center

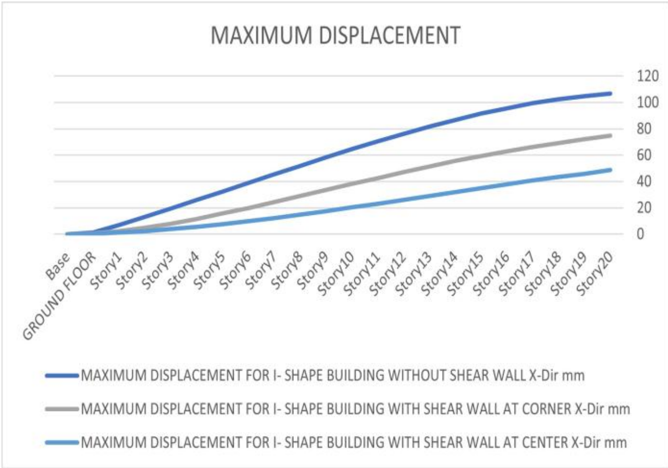

Fig 5.2.5 I- shape building Maximum story displacement

6.1.2 MAXIMUM STORY DRIFT

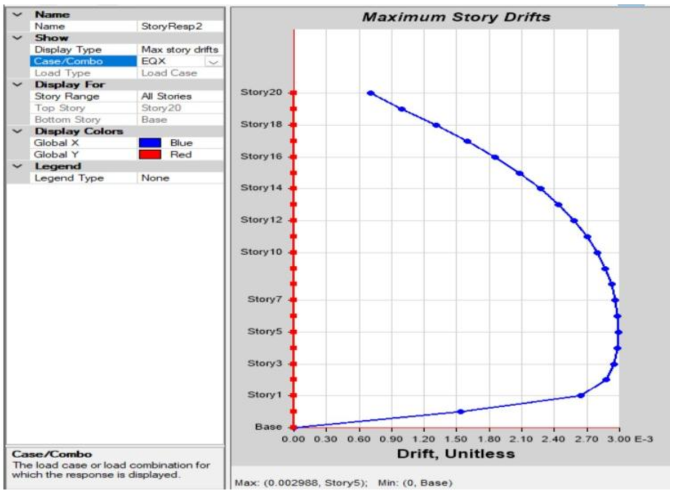

Fig 5.2.6 Square shape building without shear wall

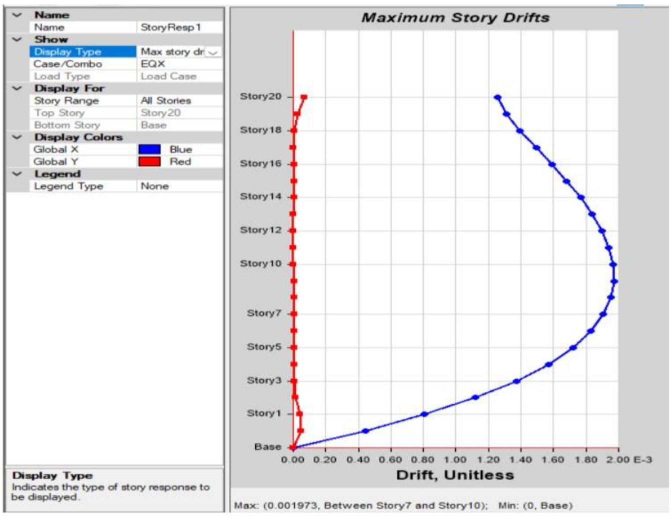

Fig 5.2.7 Square shape building with shear wall at corner

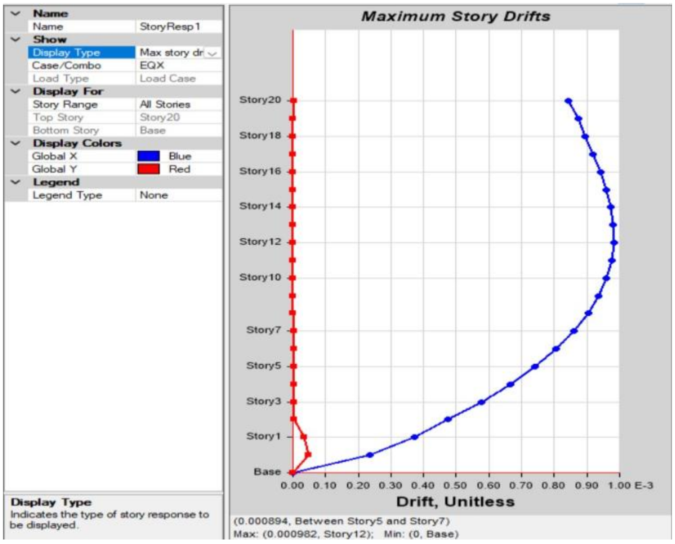

Fig 5.2.8 Square shape building with shear wall at center

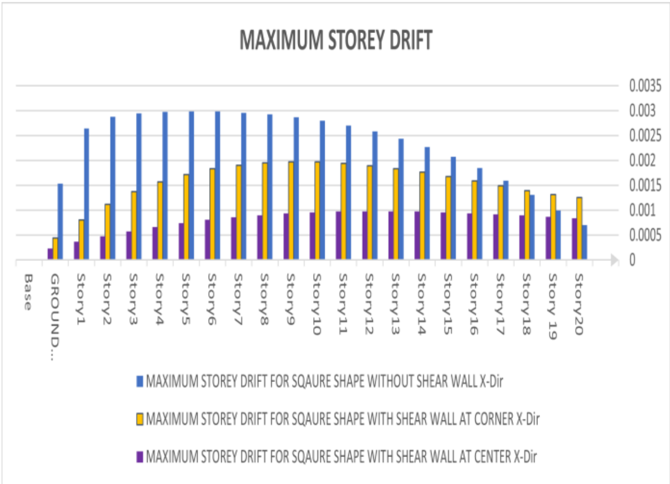

Fig 5.2.9 Square shape building Maximum Story Drift

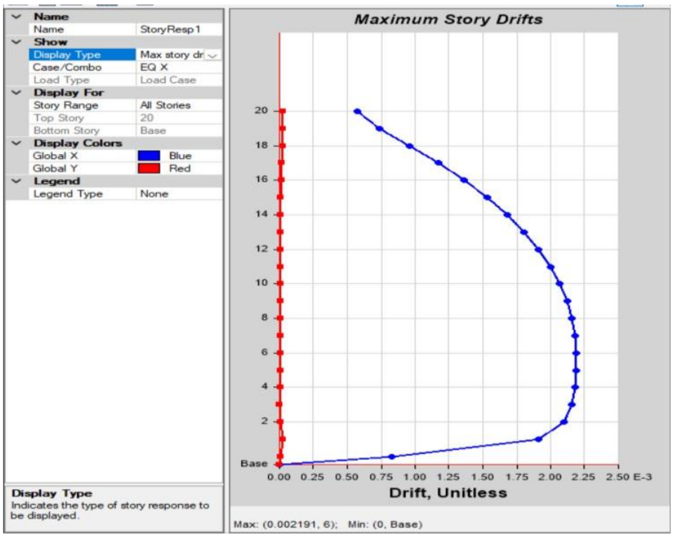

Fig 5.3.0 C- Shape building without shear wall

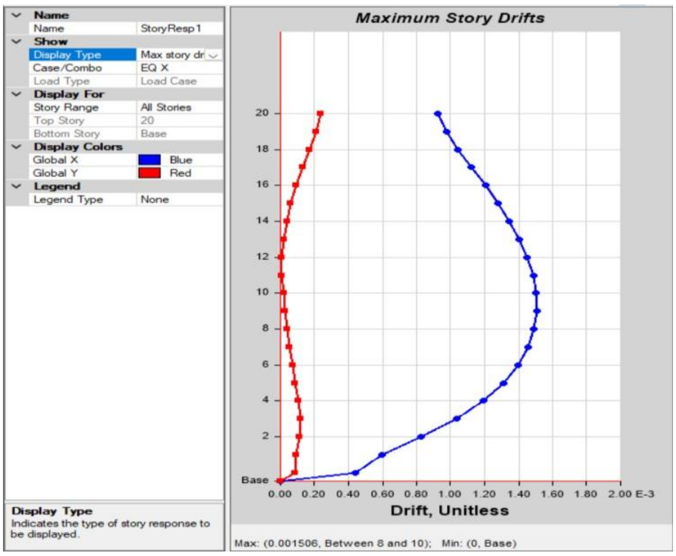

Fig 5.3.1 C- Shape building with shear wall at Corner

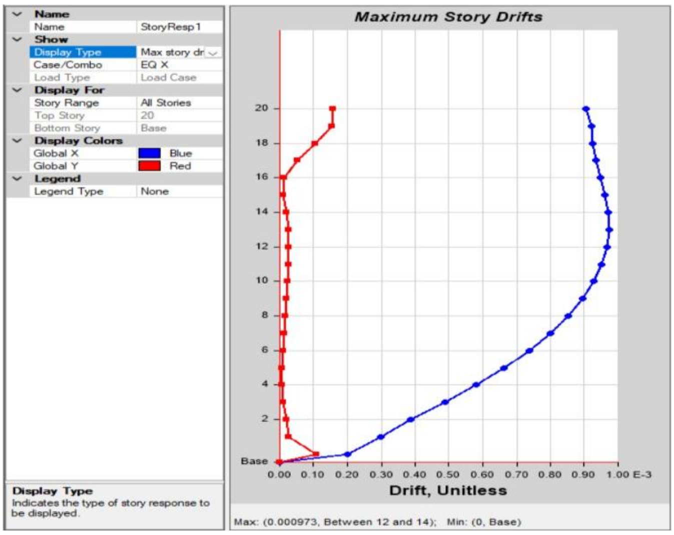

Fig 5.3.2 C- Shape building with shear wall at Center

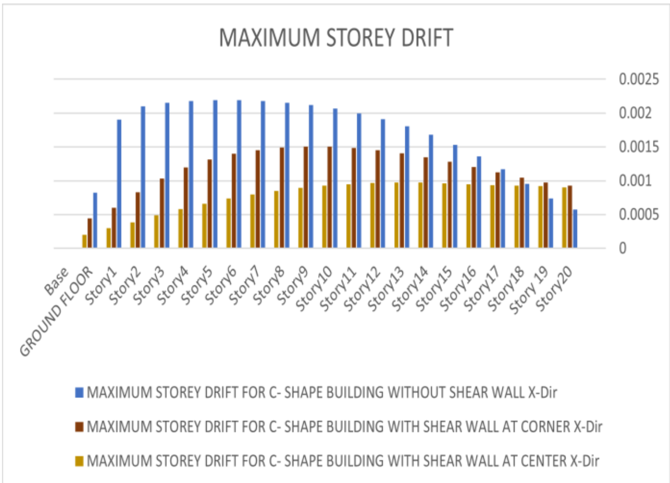

Fig 5.3.3 Maximum storey drift for C-Shape building

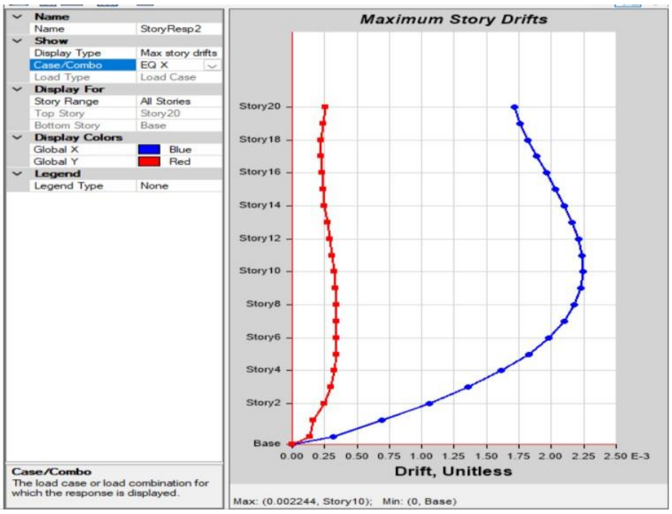

Fig 5.3.4 L- Shape building without shear wall

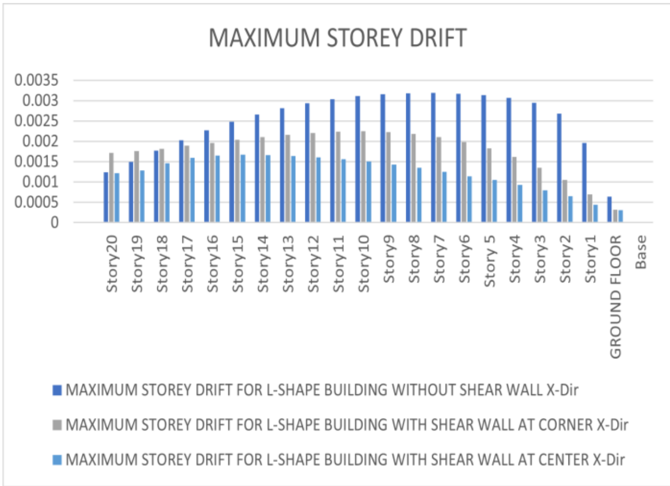

Fig5.3.7 Maximum Storey Drift for L-Shape Building

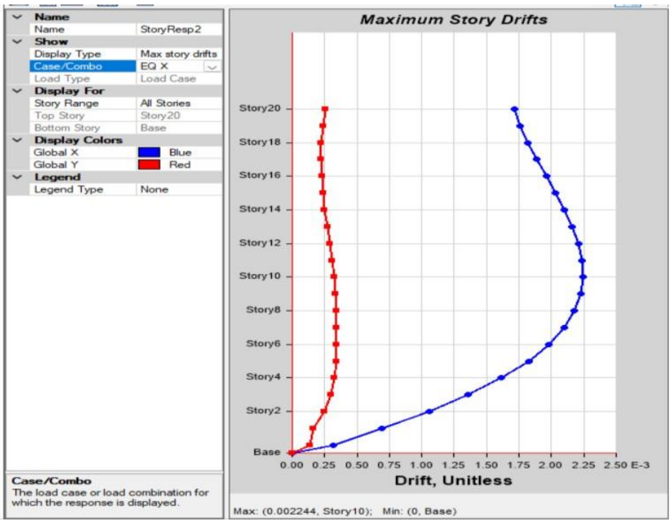

Fig 5.3.5 L- Shape building with shear wall at Corner

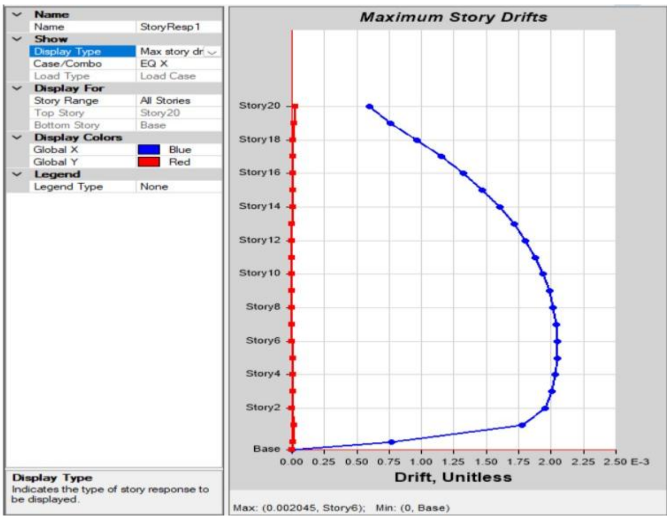

Fig 5.3.8 I- Shape building without shear wall

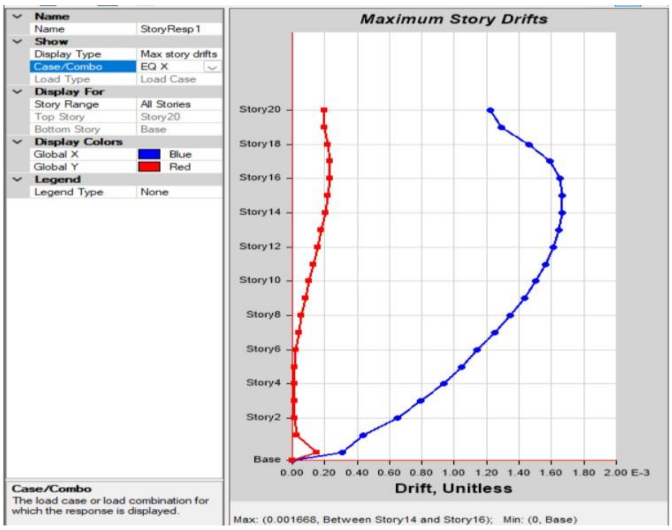

Fig 5.3.6 C- Shape building with shear wall at Center

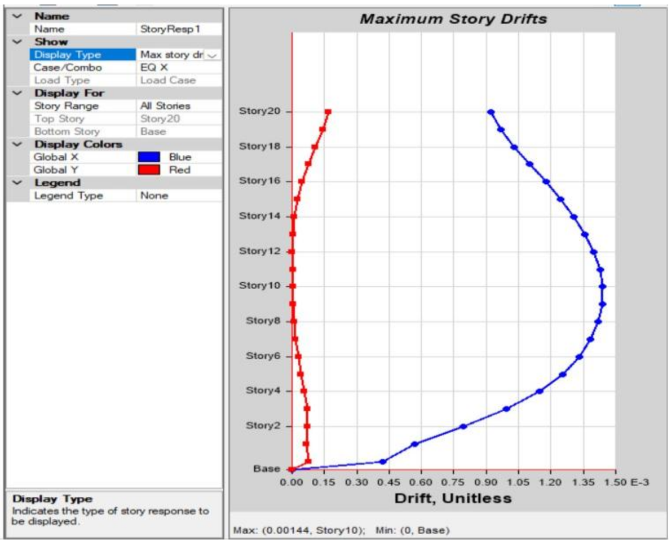

Fig 5.3.9 I- Shape building with shear wall at Corner

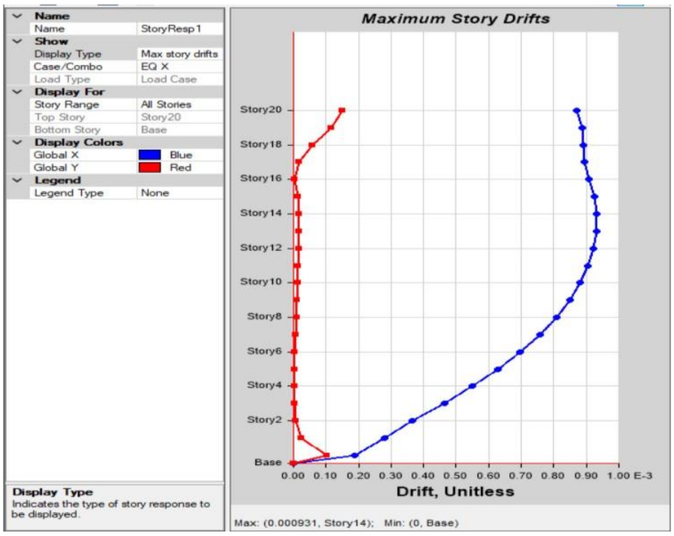

Fig 5.4.0 I- Shape building with shear wall at Center

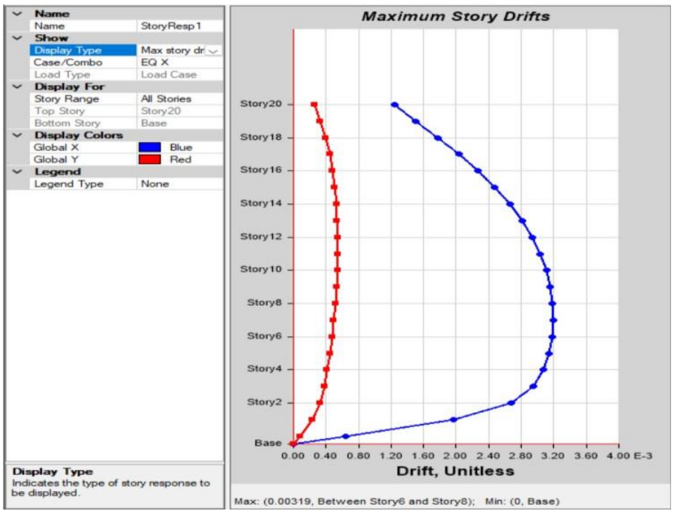

Fig 5.4.1 L- Shape building without shear wall

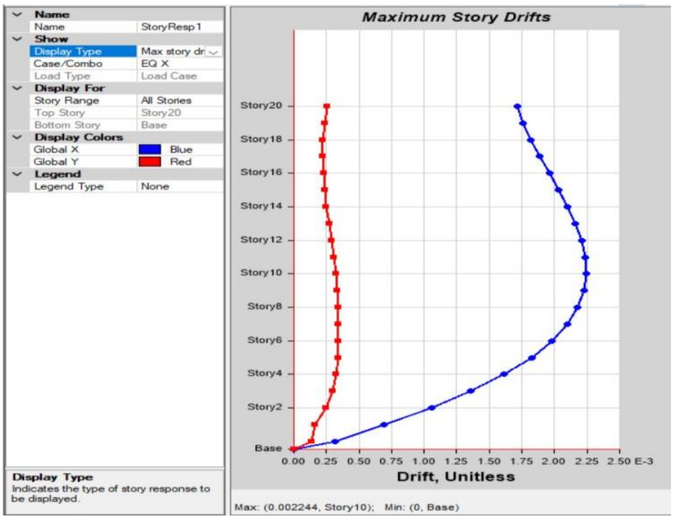

Fig 5.4.2 L- Shape building with shear wall at Corner

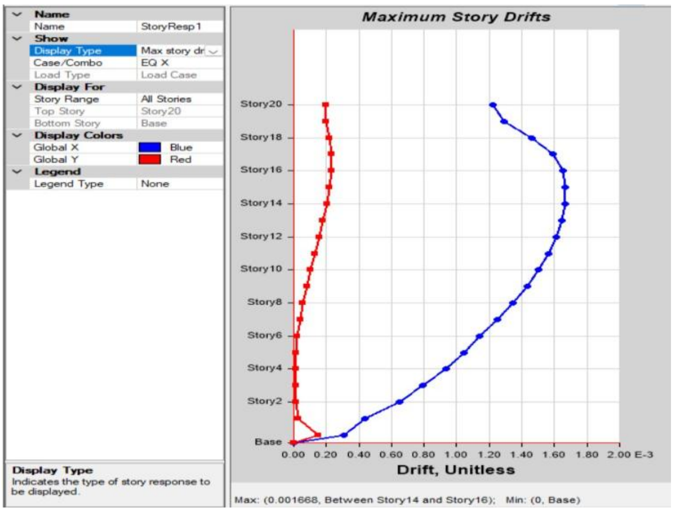

Fig 5.4.3 I- Shape building with shear wall at Center

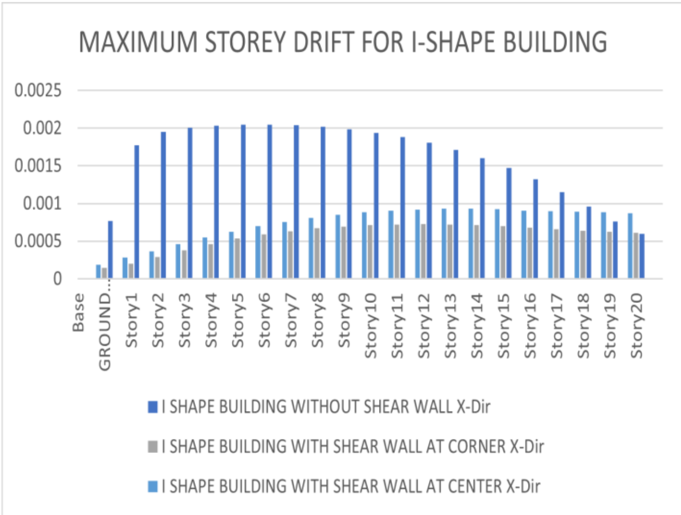

Fig5.4.5 Maximum Storey Drift for I-Shape Building

6.1 MAXIMUM BASE SHEAR

SL NO	MODEL	MAXIMUM BASE SHEAR WITHOUT SHEAR WALL	MAXIMUM BASE SHEAR WITH SHEAR WALL AT CORNER	MAXIMUM BASE SHEAR WITH SHEAR WALL AT CENTER
1	SQUARE SHAPE	8859.78	8882.65	9123.75
2	C-SHAPE	7680.59	7857.18	7772.62
3	L-SHAPE	9323.68	9686.01	9751.33
4	I-SHAPE	7157.05	7537.42	7352.32

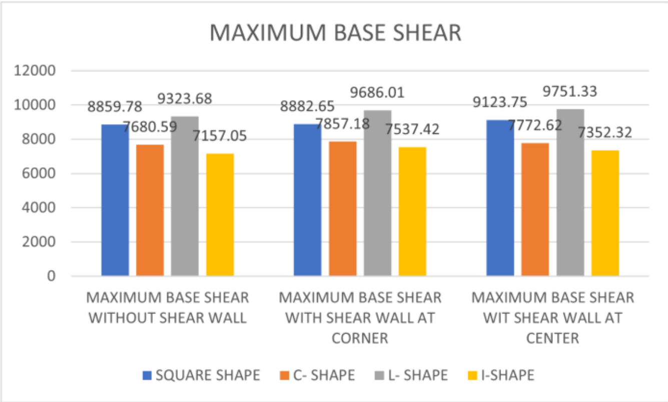

Fig 6.1 Maximum base shear

6.2 TIME PERIOD

MODEL	SQUARE SHAPE	C- SHAPE	L- SHAPE	I- SHAPE
MAXIMUM TIME PERIOD FOR WITHOUT SHEAR WALL	2.89	2.82	2.87	2.71
MAXIMUM TIME PERIOD FOR WITH SHEAR WALL AT CORNER	2.2	2.166	2.16	2.14
MAXIMUM TIME PERIOD FOR WITH SHEAR WALL AT CENTER	2.11	2.2	2.22	2.04

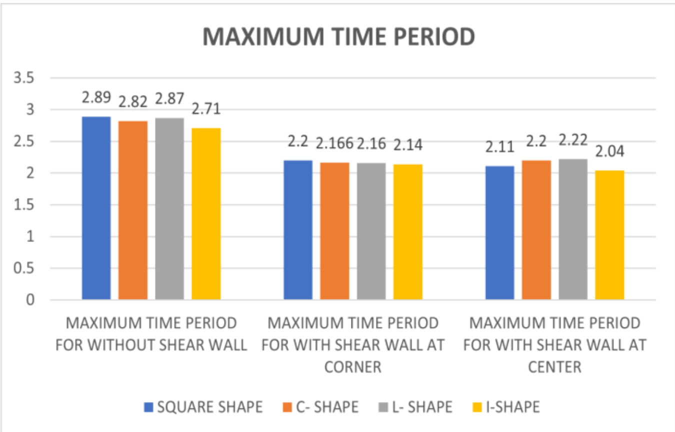

FIG. 6.2 Maximum time period

7. CONCLUSIONS

Following salient observations are derived from the analysis of G+20 story RC frame building with and without the provision of shear walls:

1. The inclusion of a shear wall in an RC Frame Structure minimizes Story Drift, making it safer compared to an RC Frame Structure without a shear wall. Shear walls in a multi-story building minimize the Story Drift.

2. The appropriate location of shear walls significantly reduces the structure's maximum drift. Summarily provision of properly designed shear walls is the essential need for RC Framed structures in higher earthquake zones.

3. By considering the twelve models in seismic zone 4 and using response spectrum and equivalent static method of analysis. It is concluded that Model I- Shape with shear wall at center (with zone 4) Gives the most suitable results. As it tends to to reduce the Displacement , storey drift and time period in both in X and Y direction by good margin.

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