International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

LINEAR AND NON-LINEAR DYNAMIC ANALYSIS OF MULTI STORIED R.C FRAME BUILDINGS WITH PLAN AND VERTICAL IRREGULARITIES USING ETABS

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Abstract - *This project aims for studying the seismic actions by considering various codal requirements, which are mainly provided for the analysis of RC regular and irregular frame buildings by linear and non-linear dynamic analysis. Analysis made for G+14 storey RC frame building for different plan configuration like rectangular, C-shape, H-shape and L-shape and with soft storey at ground, ground and intermediate, intermediate and top, and top storey by response spectrum method for medium soil at zone 5 and time history method for time history function of Bhuj. Both the analysis are carried out using ETABS computer program. The various structural response parameters such as, storey displacement, storey drift, storey shear and time period are determined by considering plan irregularity and vertical irregularity in the model and the structural parameters specified above are compared for the models having different irregularities*.

***Key Words*: plan irregularity, vertical irregularity, Response spectrum method, Time history method, ETABS.**

1. INTRODUCTION

From recent past earthquakes have presented that if structures are constructed without considering the seismic forces, are said to be not correctly designed and they will undergo huge destruction and also loss of life. The structures will frequently remain built in having one of the irregularities i.e. stiffness, diaphragm, mass, re-entrant corner, and torsion irregularity. Most buildings are outlined by irregular in both plan and vertical configurations. Irregular structures design and analyze done under earthquake accounting to specified seismic design philosophies. Seismic analysis procedure that should be used to analyze the structure depends upon the external action, the behavior of structure and structural materials i.e. static, dynamic, linear and non-linear. The study is carried out for the behaviour of G+14 storied R.C frame buildings with Rectangular, L shape, H shape and C shape plan and with soft storey at different storey of building. Floor height provided is 3m and plinth height as 1.8m and properties are defined for frame structures. Analysis is done by Response spectrum and time history method of analysis using "ETABS Software" as per IS 1893:2002.

A great amount of buildings with soft storey at several levels have been built in India in recent year. But it shows poor interpreting during past earthquakes. Hence it is necessity of time to take instant steps to prevent the unselective use of soft storey in buildings, the increased displacements and force demands in soft storey at different levels of the building. Masonry infill usually contains of bricks or concrete blocks constructed between beams and columns of a reinforced concrete frame. The existence of masonry infill walls has an important impact on the seismic zone response of a reinforced concrete frame building, increasing structural strength and stiffness. The structural influence of infill wall outcomes into stiffer structure thus reducing the storey drifts. This improved performance makes the structural design more realistic to consider infill walls as a structural element in the earthquake resistant design of structures.

2. OBJECTIVES

1. The main objective of this project is to study seismic response of the multistorey buildings (G+14) with irregularities i.e. plan and vertical irregularities.
2. Study of Linear and Non-linear Dynamic Analysis of structure having different plan configuration using ETABS computer programming according to IS 1893 (part-1):2002.
3. To study the response of buildings of different plan configuration when soft storey is provided at different floors of buildings.
4. To find the structural behaviour of multistorey buildings like storey shear, storey drift, storey displacement, and time period.
5. Comparative study of the results of linear and non-linear dynamic analysis and to study which building is performed well in each cases.

3. METHODOLOGY

The study is carried out for the behaviour of G+14 storied R.C frame buildings with Rectangular, L-shape, H-shape and C-shape plan. Floor height providing is 3m and plinth height as 1.8m and properties are defined for frame structures. 20 models are shaped in ETABS software with plan and vertical irregularities for dynamic analysis. Post analysis of structures, storey shear, storey drift, displacement and overturning moment are computed and equated for all the analyzed cases. Modelling of RCC frames contains a gathering of slabs, beams, columns and foundation interconnected to each other as a unit. Load transferal mechanism in these structures is from slabs to beams, from beams to columns, then columns to foundation and permits the load to soil. In this structural analysis study, we have assumed four cases of different shapes for same structures i.e.

1. Rectangular plan
2. L-shape plan
3. H-shape plan
4. C-shape plan

And these cases also analyzed by adopting stiffness irregularity i.e. soft storey

1. Soft storey at ground floor
2. Soft storey at ground and intermediate floor
3. Soft storey at intermediate and top floor
4. Soft storey at top floor

3.1 MODEL DESCRIPTION:

Plan	: 25x25 mm
X-direction grid spacing	: 5m
Y-direction grid spacing	: 5m
Number of stories	: G+14
Height of each storey	: 3m
Plinth height above GL	: 1.8m
Support condition	: Fixed
Total height of building	: 46.8m

3.2 MATERIAL PROPERTIES:

Grade of concrete	: M30
Grade of steel	: Fe500
Density of concrete	: 25 KN/m^2
Density of steel	: 78.5 KN/m^3

3.3 MEMBER PROPERTIES

Beam	: 300x450 mm
Column (plinth – 7)	: 550x550 mm
Column (8 – 14)	: 350x350mm
Beam cover	: 30mm
Column cover	: 40mm
Thickness of brick wall	: outer 230mm
	Inner 150mm
Thickness of slab	: 150mm
Height of parapet wall	: 0.9m

3.4 GENERAL LOADINGS

Live load [IS 875, part 2]	:3kN/m^2
Floor finish	: 1.5kN/m^2
Wall load	: 11.73kN/m^2
Parapet wall load	: 4.14kN/m^2

3.5 MODELLING

Models are prepared for the plan dimensions 25x25m of G+14 storey building different plan configuration of rectangular, L-shape, H-shape and C-shape and soft storey at different floors for configuration of buildings using ETABS software.

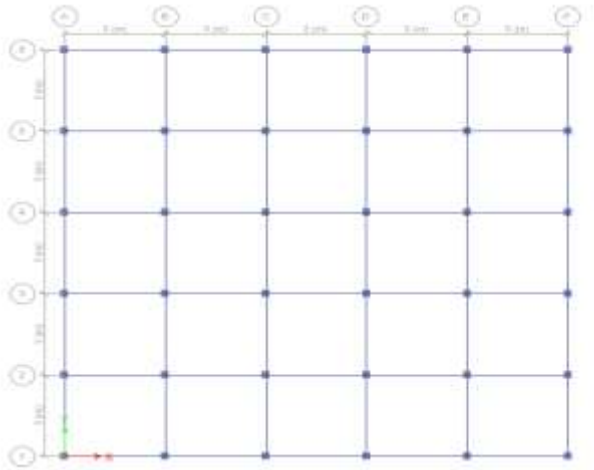


Fig-1: Plan of rectangular model

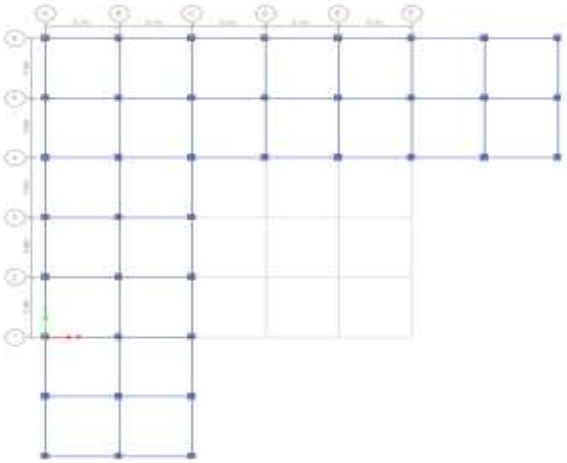


Fig-2: Plan of L-shape model

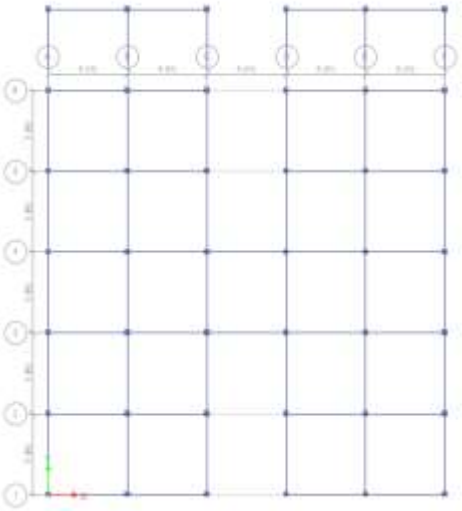


Fig-3: Plan of H-shape model

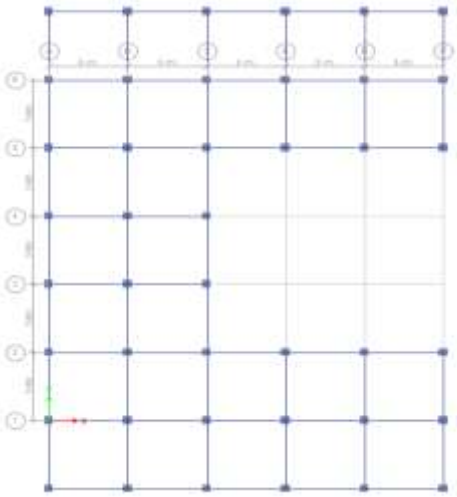


Fig-4: Plan of C-shape model

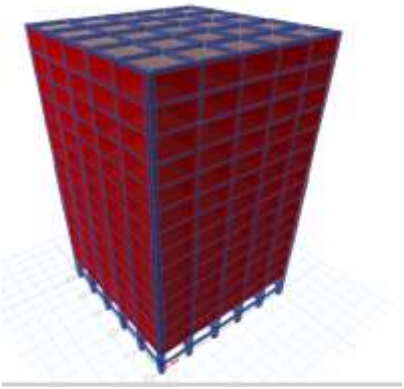


Fig-5: Rectangular model with soft storey at GF

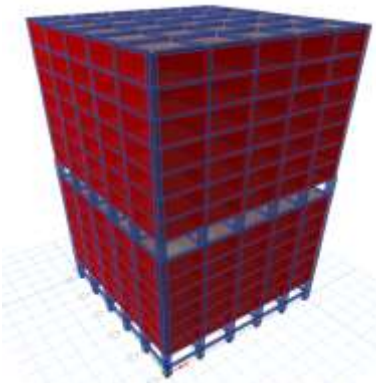


Fig-6: Rectangular model with soft storey at GF and intermediate storey

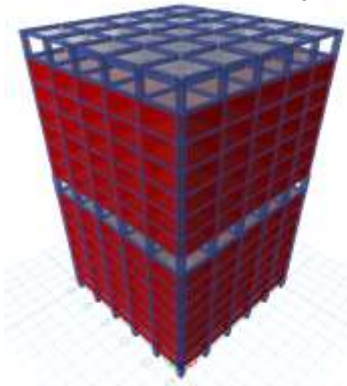


Fig-7: Rectangular model with soft storey at intermediate and top storey

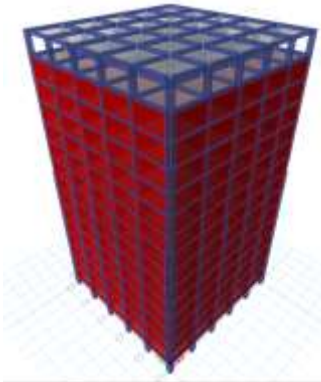


Fig-8: Rectangular model with soft storey at top storey

3.6 BUILDING MODELS

Model 1: Rectangular frame

Model 2: L – shape frame

Model 3: H – shape frame

Model 4: C – shape frame

Model 5: Rectangular frame with soft storey at ground storey

Model 6: Rectangular frame with soft storey at ground and intermediate storey

Model 7: Rectangular frame with soft storey at intermediate and top storey

Model 8: Rectangular frame with soft storey at top storey

Model 9: L- shape frame with soft storey at ground storey

Model 10: L- shape frame with soft storey at ground and intermediate storey

Model 11: L- shape frame with soft storey at intermediate and top storey

Model 12: L- shape frame with soft storey at top storey

Model 13: H- shape frame with soft storey at ground storey

Model 14: H- shape frame with soft storey at ground and intermediate storey

Model 15: H- shape frame with soft storey at intermediate and top storey

Model 16: H- shape frame with soft storey at top storey

Model 17: C- shape frame with soft storey at ground storey

Model 18: C- shape frame with soft storey at ground and intermediate storey

Model 19: C- shape frame with soft storey at intermediate and top storey

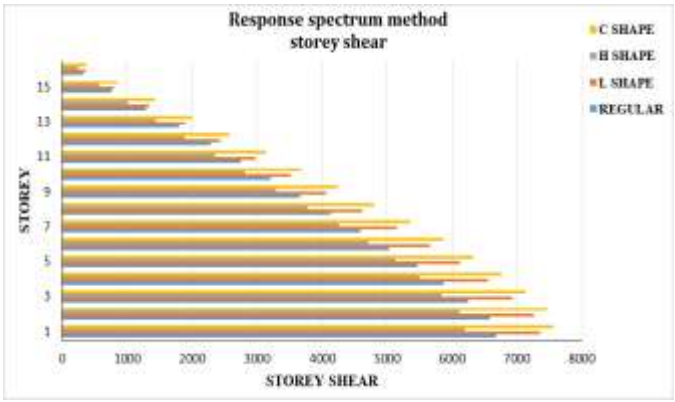
Model 20: C- shape frame with soft storey at top storey

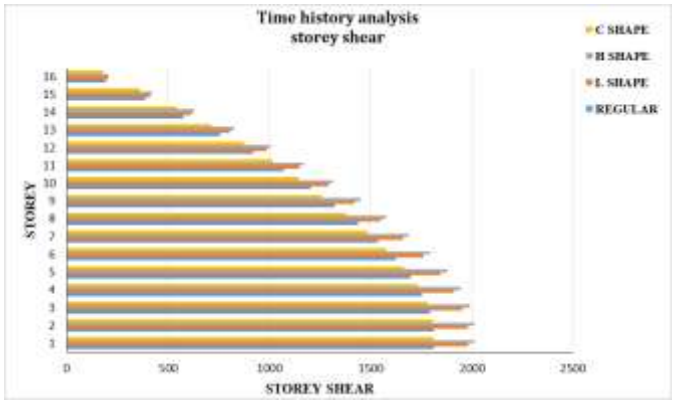
4. ANALYSIS AND RESULTS

The seismic response of multi storied building of plan configuration Rectangular, L-shape, H-shape and C-shape and plans with soft storey at ground storey, ground and intermediate storey, intermediate and top storey and top storey is determined to obtain the response quantity of building such as storey drift, displacement by carrying out Response spectrum method and Time history analysis using ETABS. The results are extracted for various parameters such as Storey shear, Displacement, Storey drift.

4.1 PLAN IRREGULARITIES

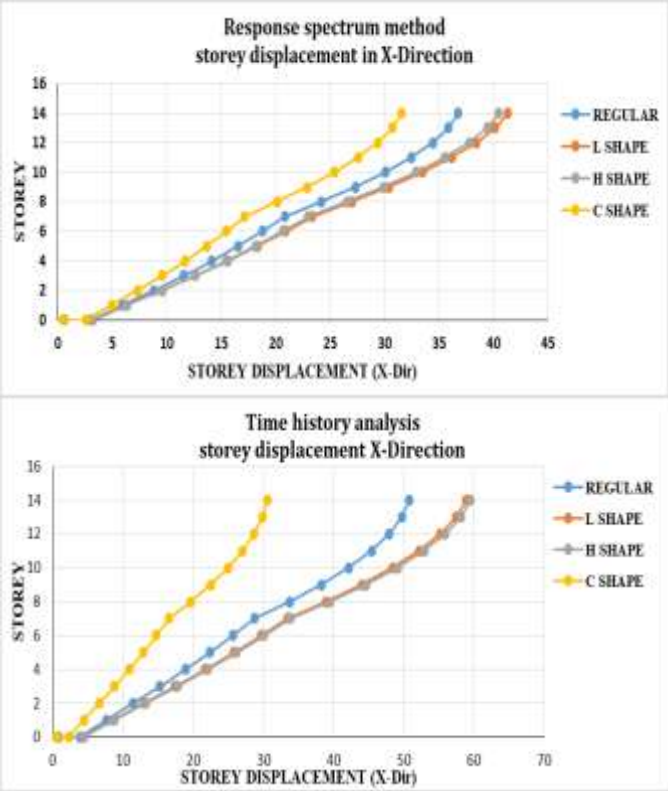
STOREY SHEAR OF PLAN IRREGULARITIES



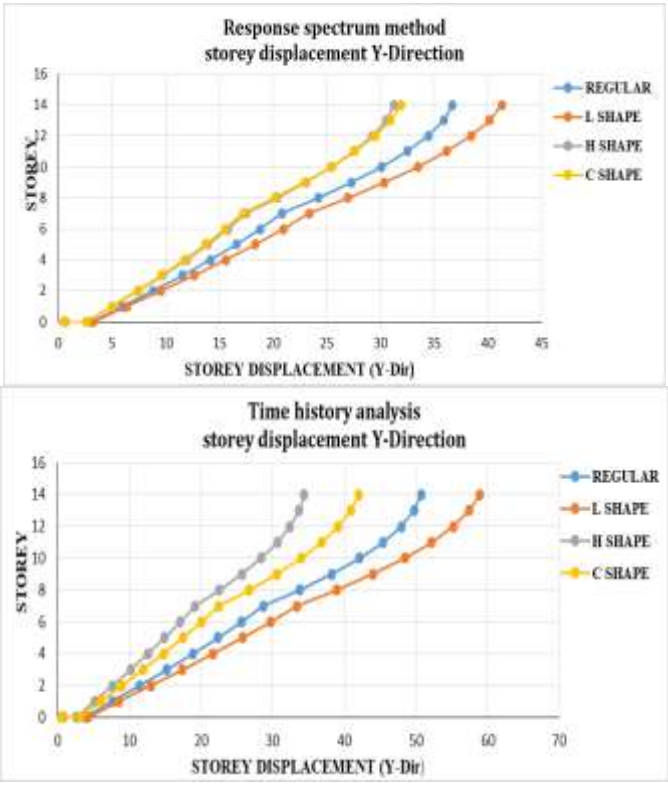


Story shear is a force that acts on any storey in a direction perpendicular to its extension and is measured in "kN". It is observed that the storey shear decrease with the increase in height of storey. It is observed that storey shear increases, so the maximum storey shear is in C and H shape model which is vulnerable.

STOREY DISPLACEMENT IN X-DIR OF PLAN IRREGULARITIES

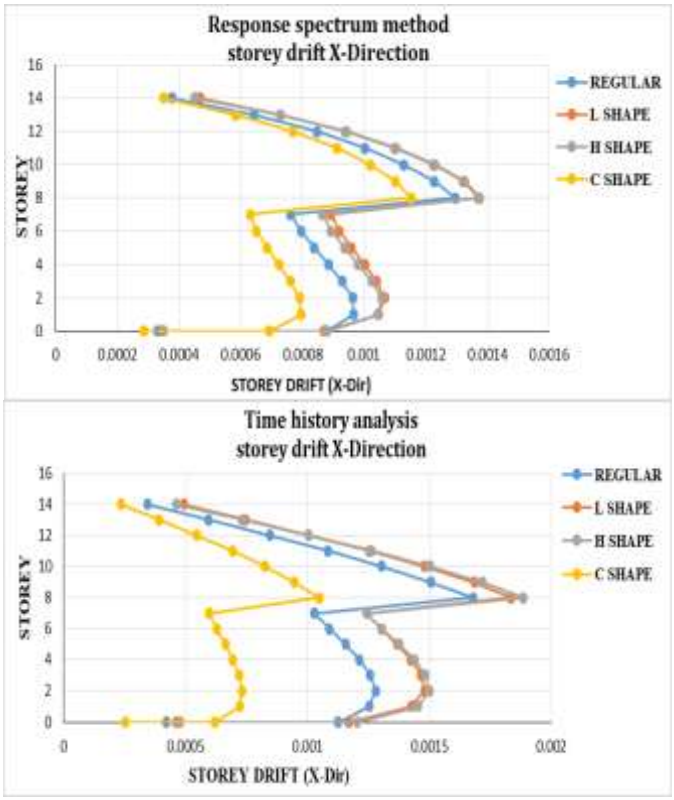


STOREY DISPLACEMENT IN Y-DIR OF PLAN IRREGULARITIES

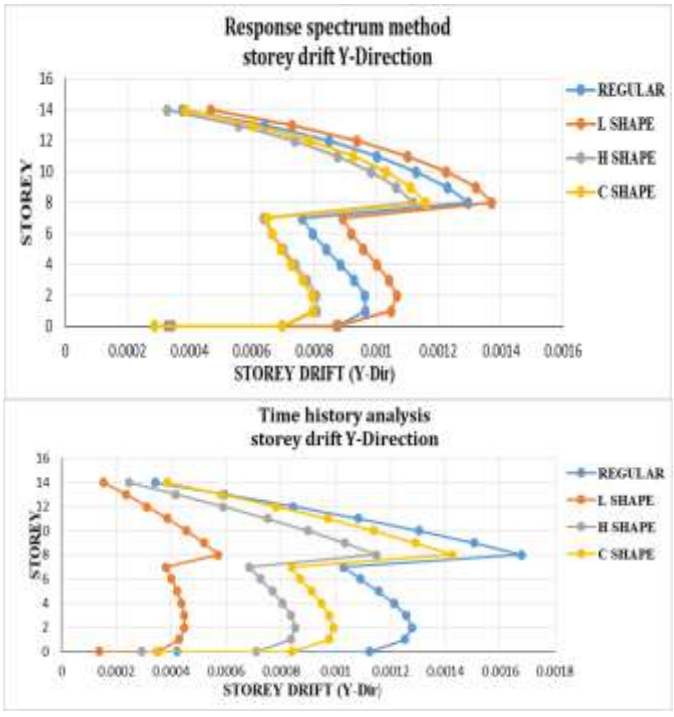


It is observed that the storey displacement increase with the increase in height of storey. Displacement for L shape model is more compare to other shape of models.

STOREY DRIFT IN X-DIR OF PLAN IRREGULARITIES

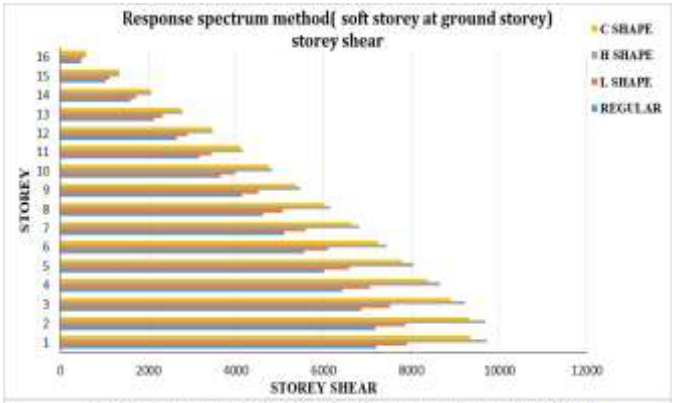


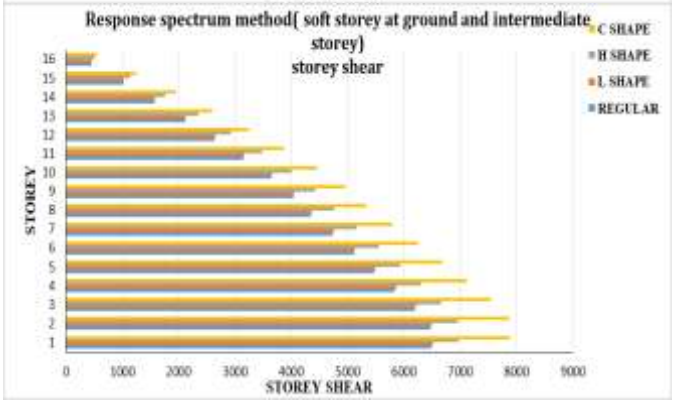
STOREY DRIFT IN Y-DIR OF PLAN IRREGULARITIES

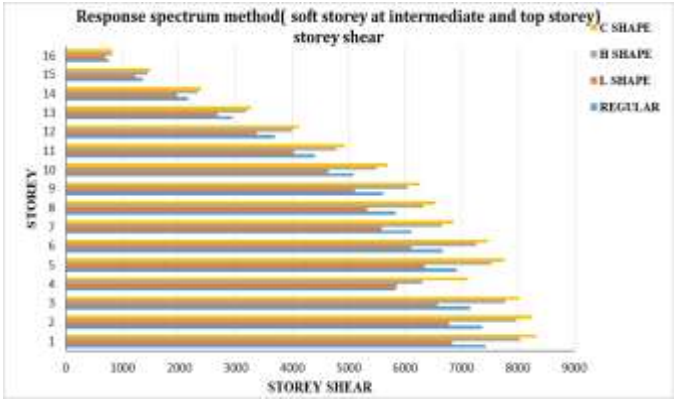


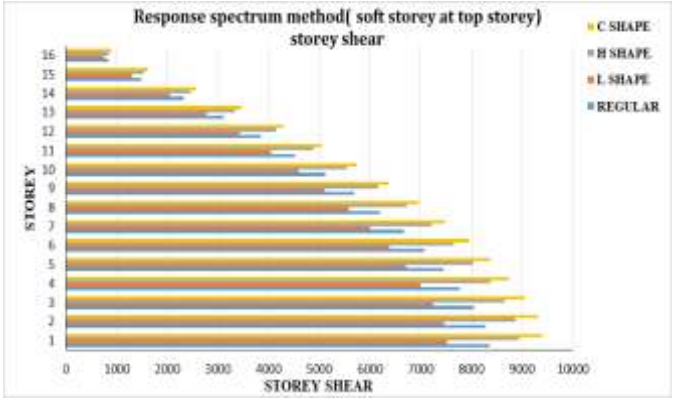
4.2 VERTICAL IRREGULARITIES

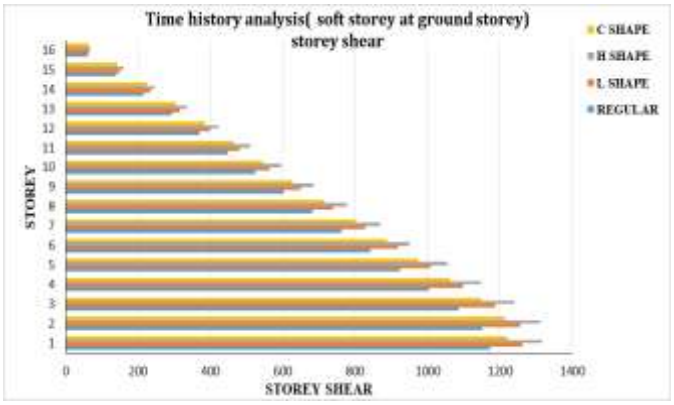
STOREY SHEAR OF VERTICAL IRREGULARITIES

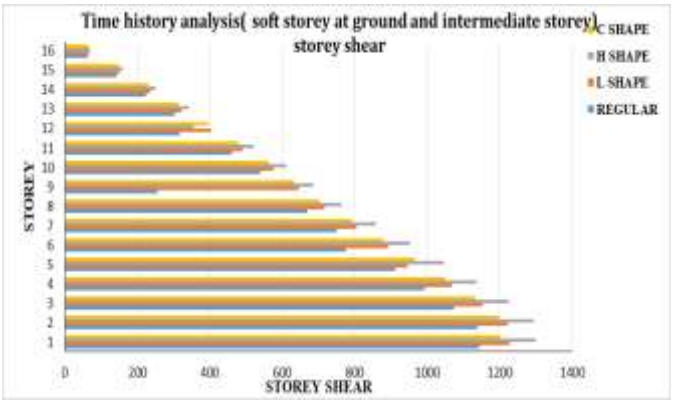


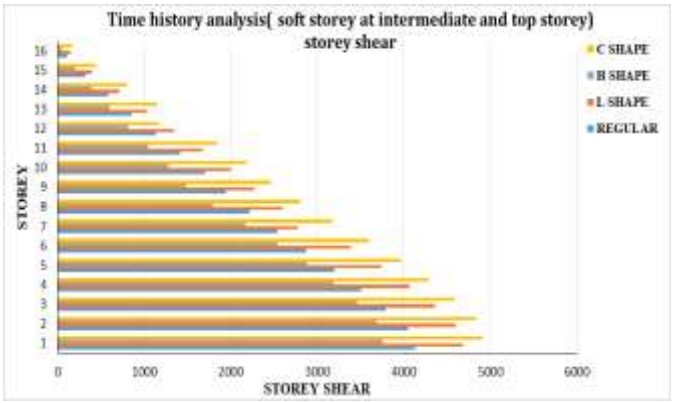


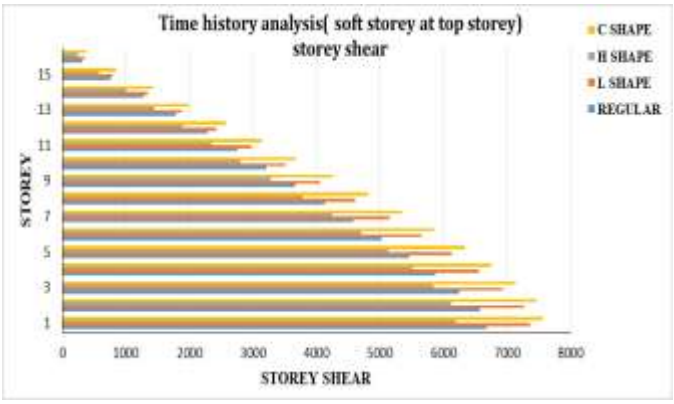












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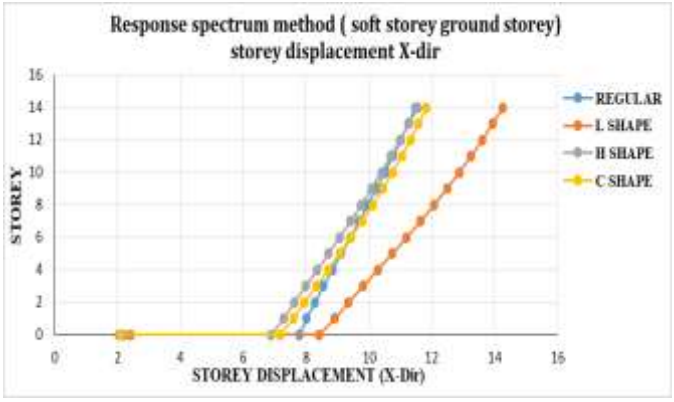

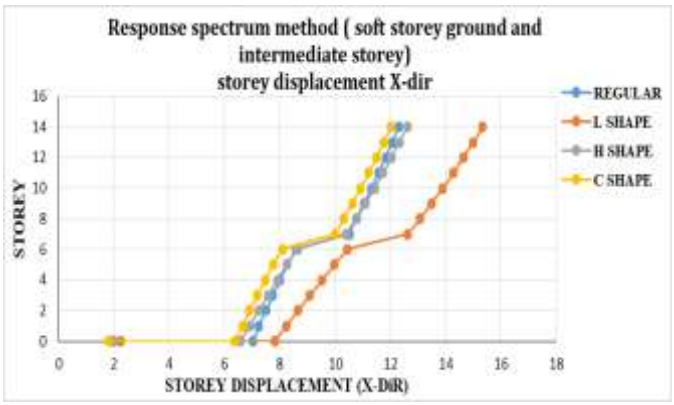

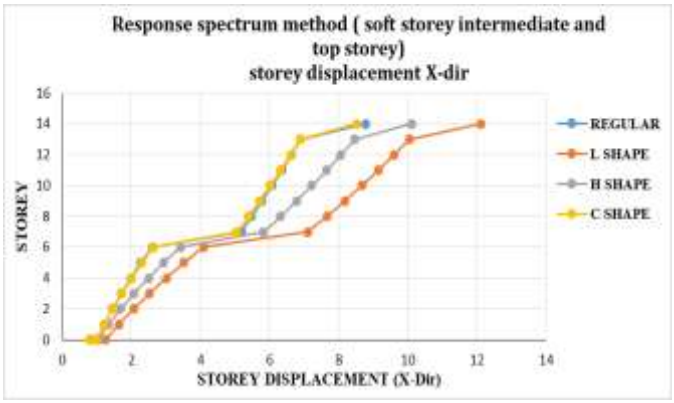

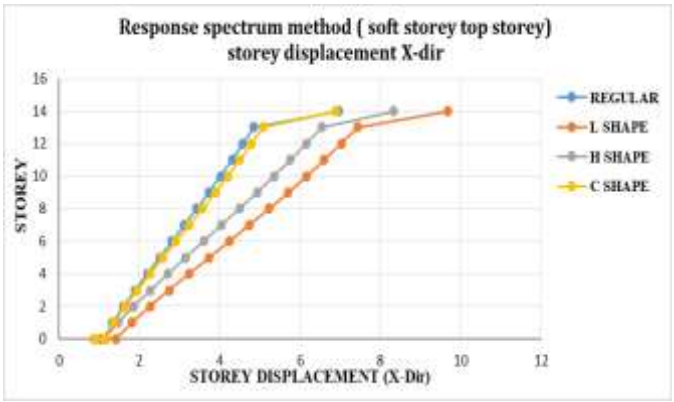

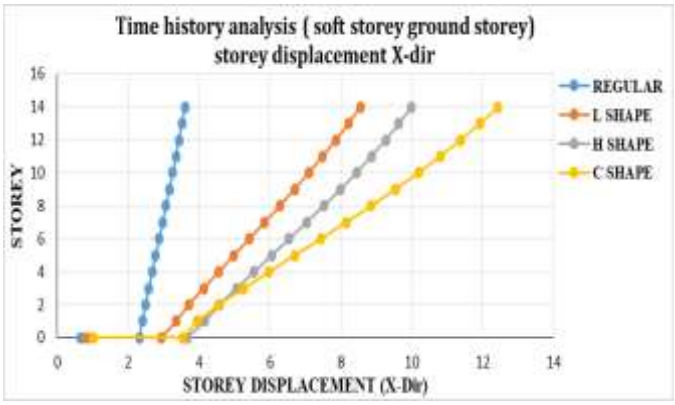

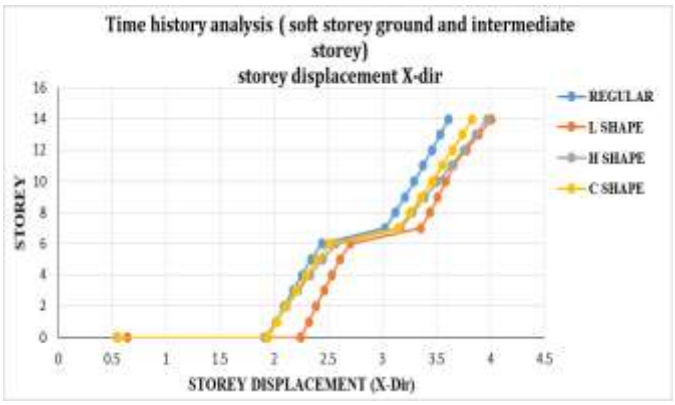

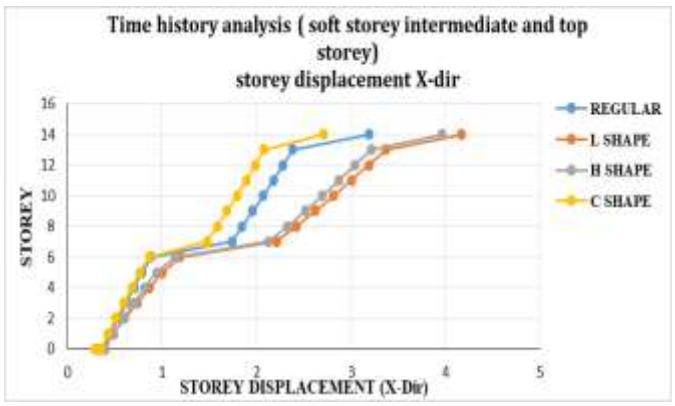

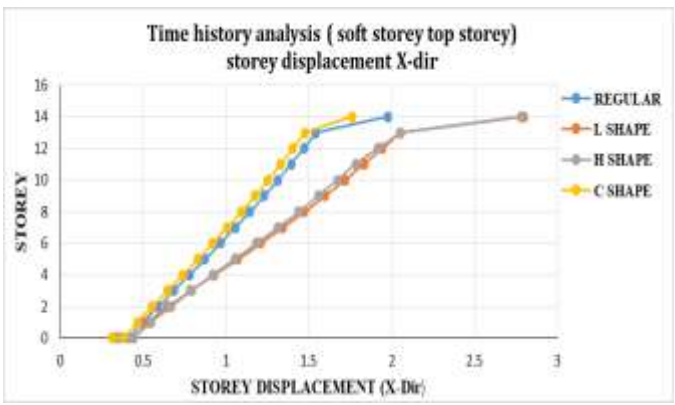

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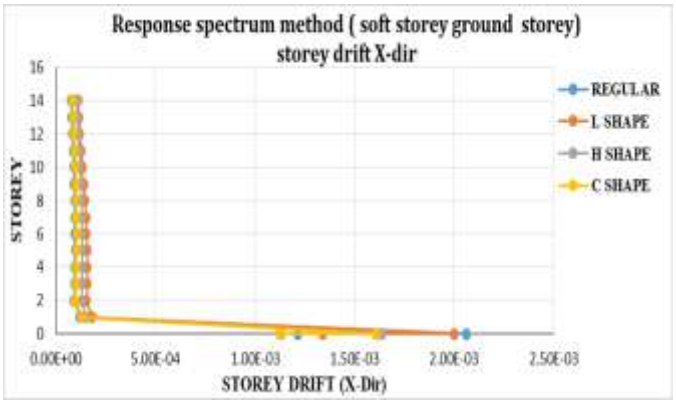
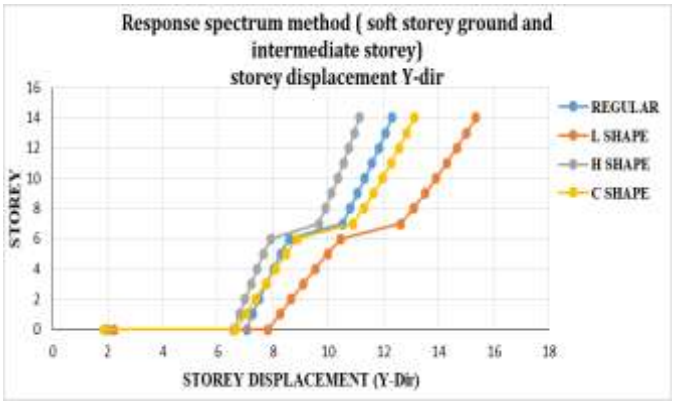
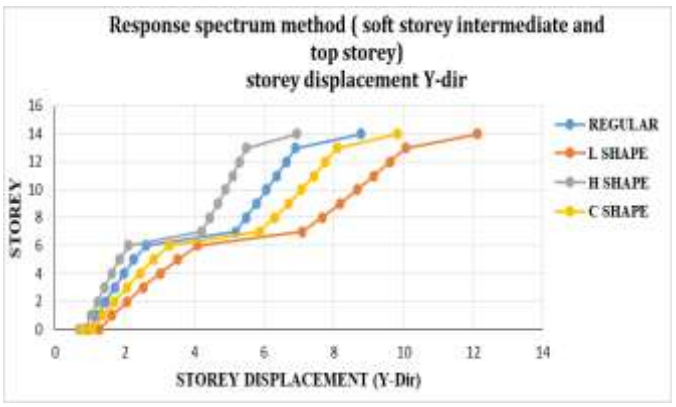
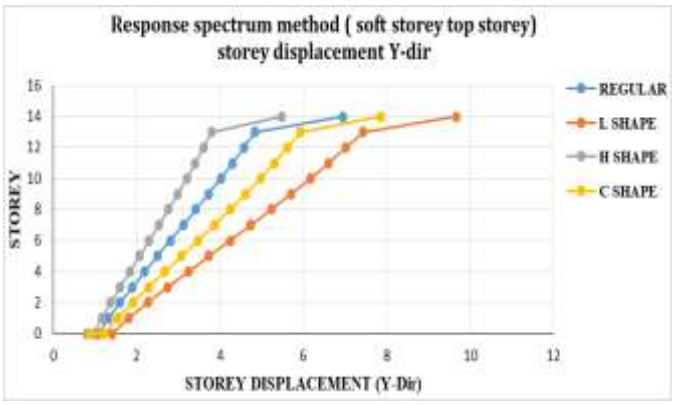
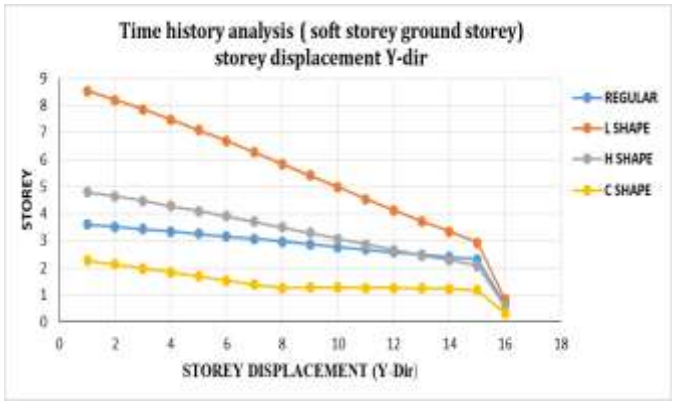
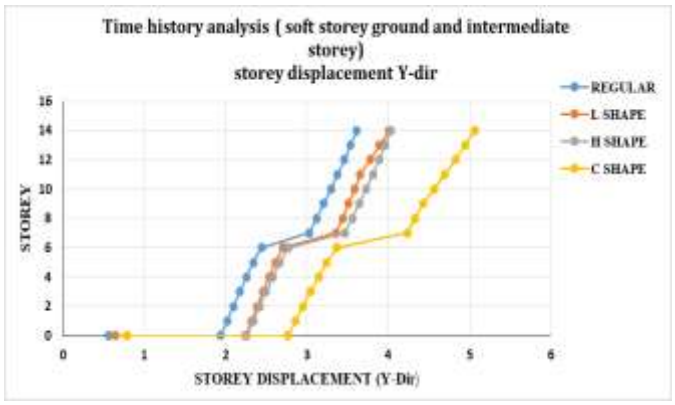


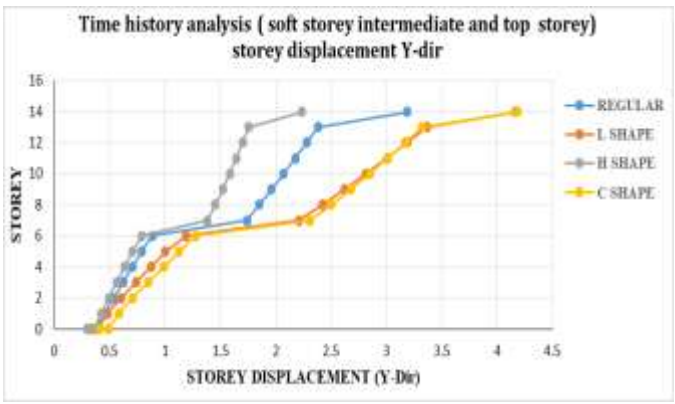


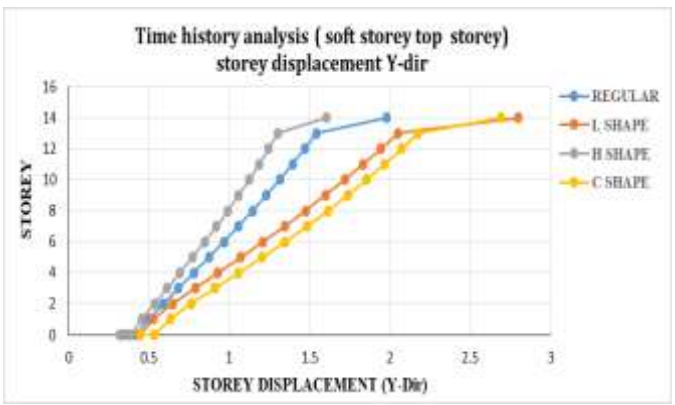




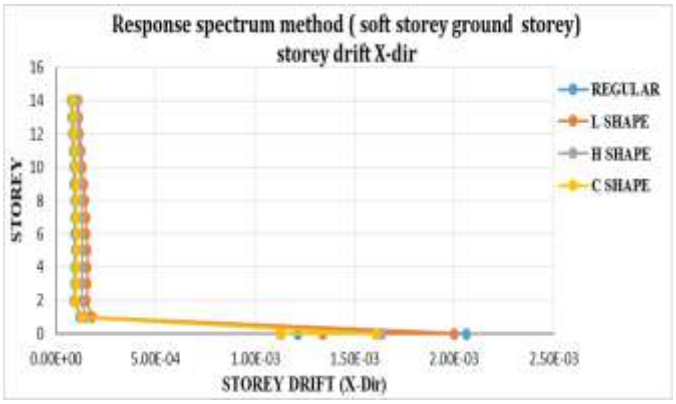


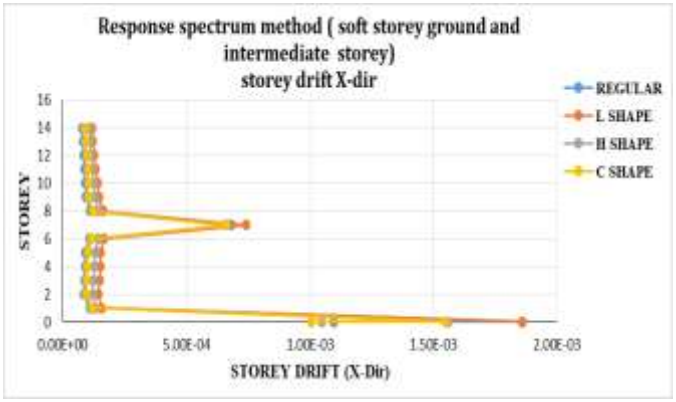


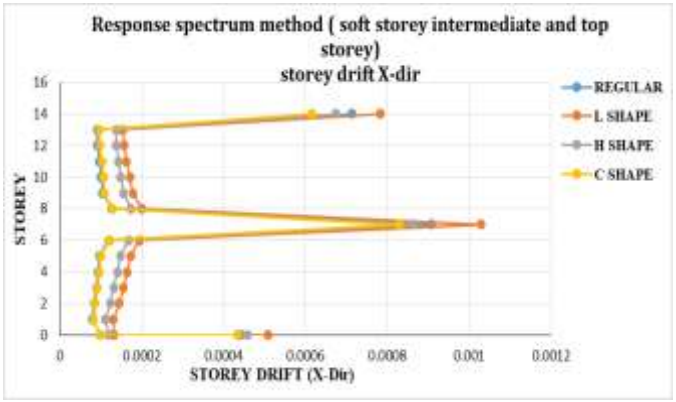


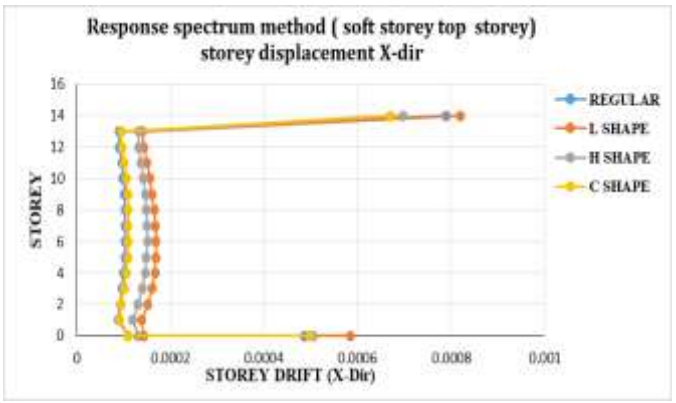


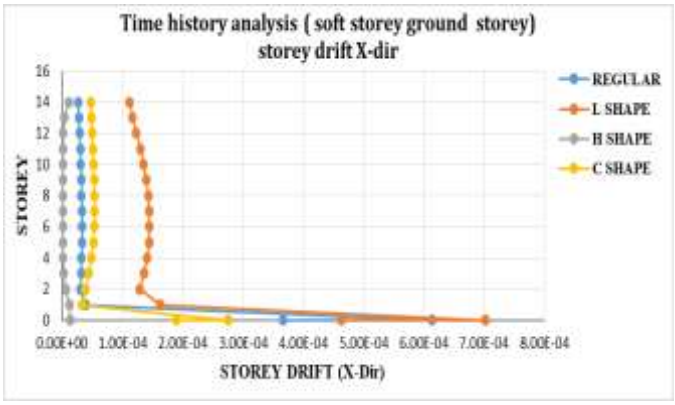
STOREY DRIFT IN X-DIR OF VERTICAL IRREGULARITIES

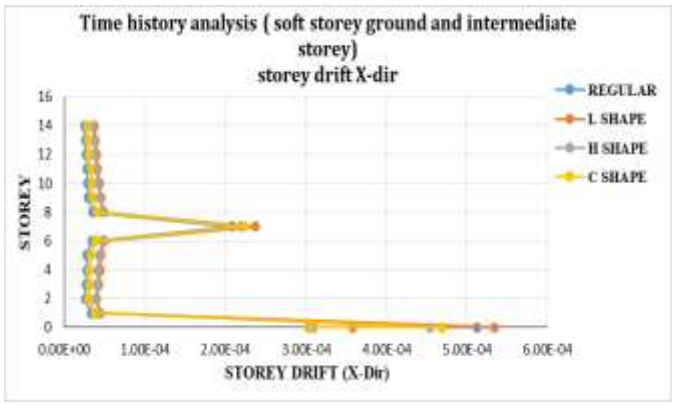


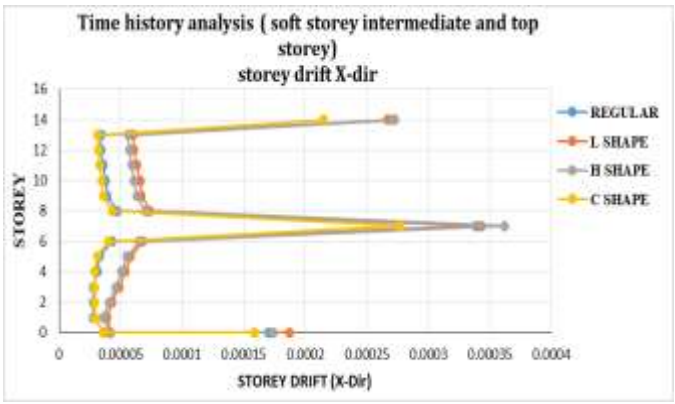


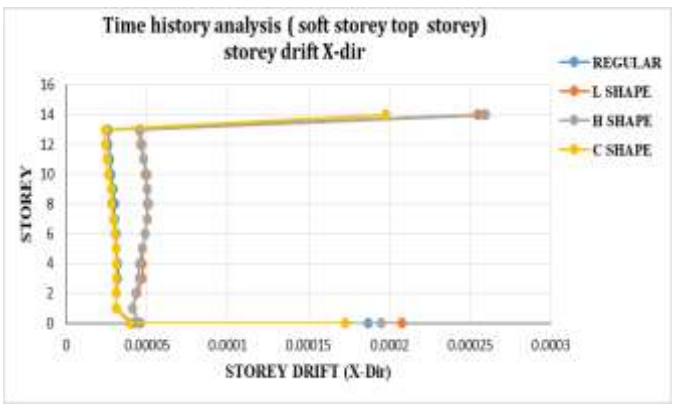




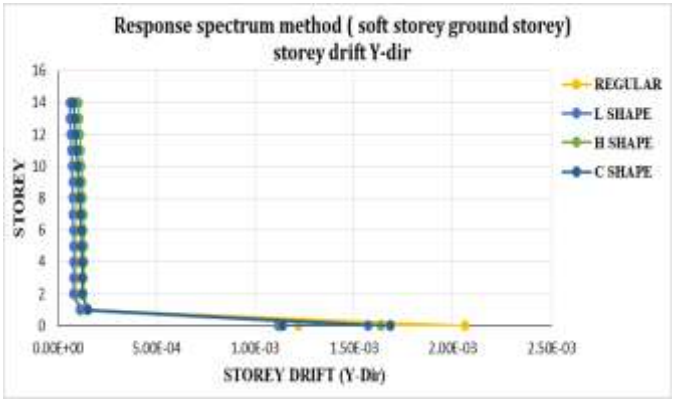


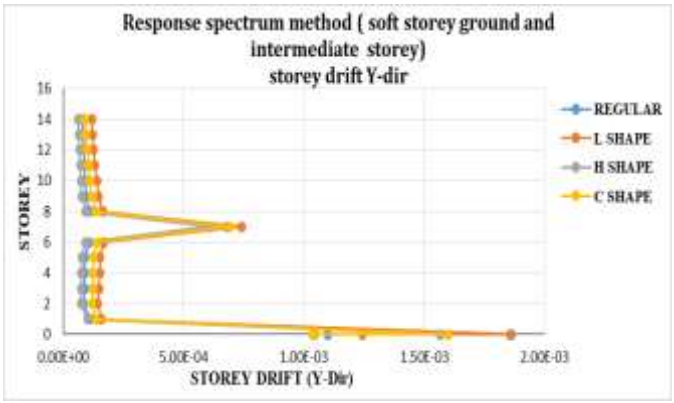


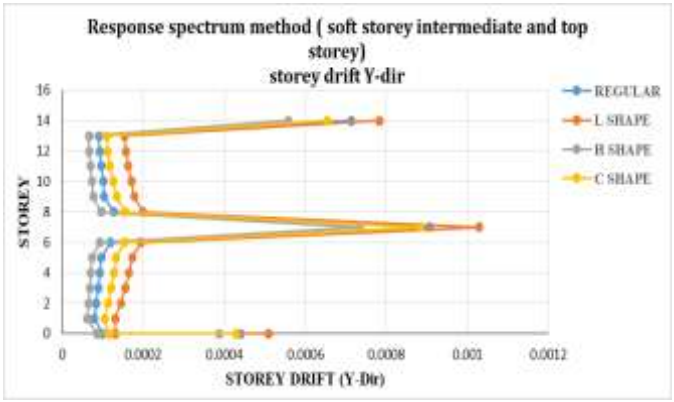


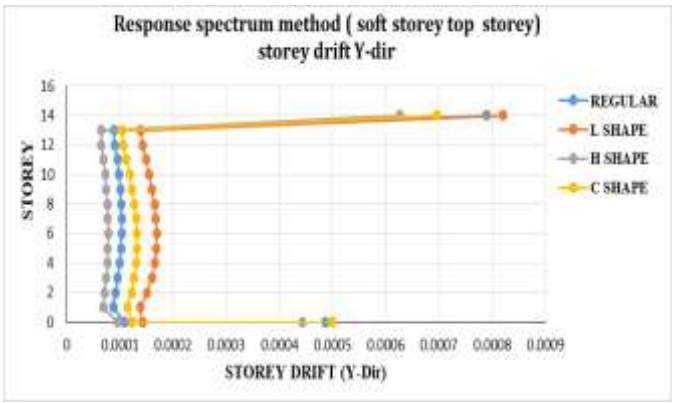


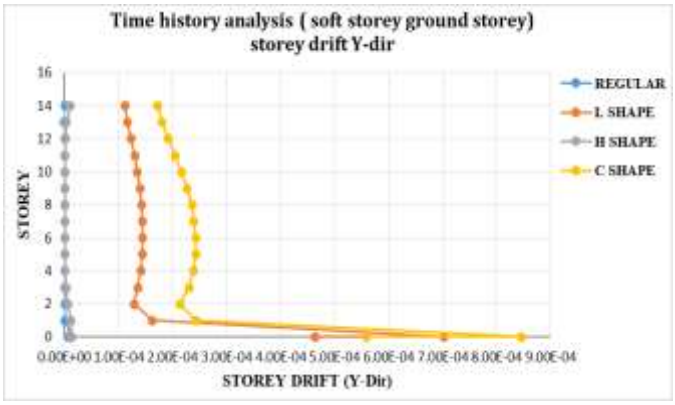
STOREY DRIFT IN Y-DIR OF VERTICAL IRREGULARITIES

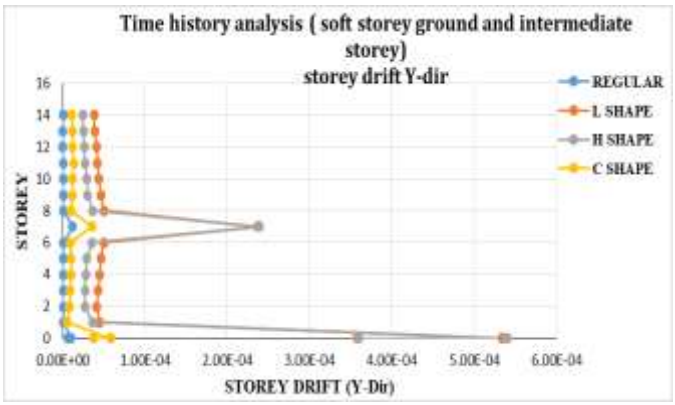


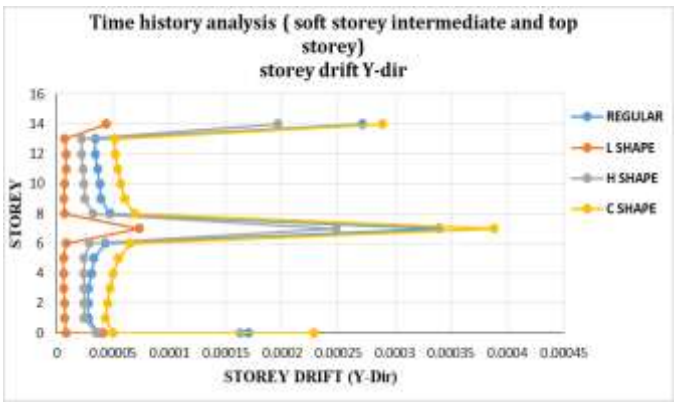


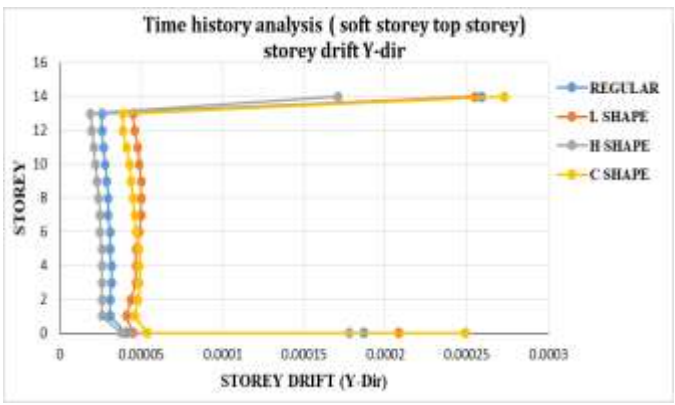












4.3 TIME PERIOD

Table 1: Time period of all models

MODEL	TIME PERIOD sec
1	2.046
2	2.022
3	1.999
4	1.81
5	0.76
6	0.792
7	0.488
8	0.406
9	0.752
10	0.784
11	0.498
12	0.418
13	0.761
14	0.792
15	0.518
16	0.444
17	0.712
18	0.743
19	0.48
20	0.403

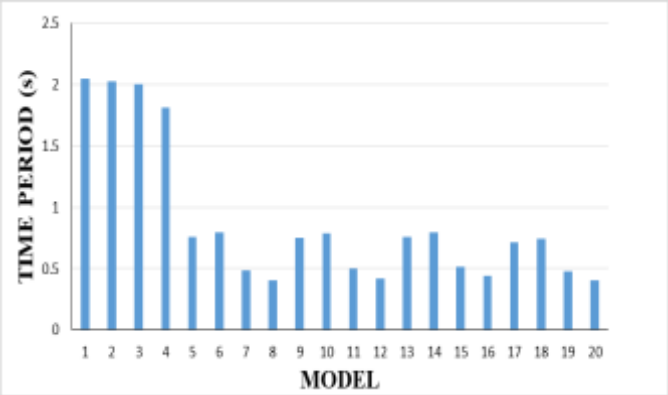


Fig-19: Time period of all models

5. CONCLUSIONS

1. The plan configuration of structures has important influence on the seismic response of structure in terms of storey shear, displacement, storey drift.
2. According to results of Response spectrum and Time history method of analysis, the storey shear force is found maximum in C shape and H shape model respectively 19% and 9% increase than Regular building in the cases of plan irregularities.
3. Lateral displacement is observed in L shape model 13.8% increase than regular model. It describes that building with severe irregularities shows maximum displacement and storey drift.
4. According to results of Response spectrum and Time history method of analysis, the storey drift found to be maximum in L shape and H shape building in the case of both plan and vertical irregularities. It is observed that the storey drift for all stories are found to be within the permissible limits.
5. Lateral displacement and storey drifts are considerably reduced while contribution of infill brick wall is taken into account. Presence of masonry infill wall influences the overall behavior of structures when subjected to lateral forces.
6. Storey shear of soft ground storey in H shape model is (25% increase compared to regular model) maximum than other models due to sabbatical of infill in ground storey. Storey displacement of soft ground and intermediate storey in L shape model is (19.8% increase compared to regular model) maximum than other models.
7. The modal time period decreased by 1.1% in irregular building as compare to regular building.
8. From the result comparison between time history and response spectrum method observed that storey shear and top storey displacement values from response spectrum method is higher than time history analysis.
9. It is recommended that time history analysis should be performed as it predicts the structural response more accurately than response spectrum analysis.

ACKNOWLEDGEMENT

The authors sincerely thank professors and head prof. Narendra Kumar H, Department of Civil engineering and Dr. Puttaraju Principal, SJBIT, Bangalore for their encouragement and for providing facilities to carry out this research work as a part of M.Tech project.

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