A Case Study on Seismic Analysis of an Irregular Structure

SK Abid Sharief, M Shiva Rama Krishna, S V Surendhar

Abstract: The seismic behaviour of buildings with a different configuration in mass, stiffness and strength along the height may significantly differ from that of the similar properties of regular buildings. In many design codes adopted by different countries for Earthquake resistant and ductile design of structures, educational buildings are defined as important structures. Therefore, Design of such structures is carried out in a manner such that the damage due to ground motion is as minimal as possible with minor damages to the structural members being allowed. This is a case study on the seismic performance of irregular structure located in Andhra Pradesh (falling under seismic zone III). First, the results of reconnaissance studies regarding the seismic response of the college buildings are presented, this scenario indicates that the seismic effect depends upon type irregularity and site hazards but the seismic effect will be more in irregular structure rather than in regular structure. Three-types of analysis are performed for the buildings to understand the seismic response of the structure in an efficient manner. Linear static method, linear dynamic analysis & non-linear time history analysis has done. Then the seismic performance of the particular building is assessed by applying the procedures according to the latest design code. The final results displays that the seismic analysis of a particular vertically irregular buildings in terms of maximum story drift, story displacement, story shear, p-delta effect.

Key points: Vertical irregularity, Framed building, Reinforced concrete, Seismic risk, Drift hazard curve.

I. INTRODUCTION

With the current evolution of human mankind where a lot of progress has been accounted for in the recent past, technology is rapidly influencing the lifestyle leading to increase in the demand for sustainable development, in context with earthquake engineering of sustainable development earthquake resistant structures play a significant role. At the same time, as technology is growing rapidly, people are paying special interest to stay in urban areas rather than rural areas. Structures are mainly classified into two types (i.e. regular and irregular structures) as per IS 1893:2016. Irregular structure is one in which either mass or stiffness, geometric regularity is not uniform throughout the structure, with constant evolution we find that the construction of Irregular structures being increasing. These structures are more in developed countries and metro Politian cities as it increases the aesthetic nature and enhances the living conditions. From an architectural point of view these structures have become more complex and irregular in its shape, geometry, mass, stiffness, and vertical irregularity etc.

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As a result of this, these structures have become lighter in terms of their weight and flexibility resulting in a small amount of structural damping and other low natural frequencies causing a very low performance when compared to a conventional regular structure. Moreover they do not carry loads like transverse loads and other lateral loads caused due to seismic forces, but once they are subjected to structural deformation or vibration loads like the earthquake loads, wind loads it might lead to collapse of the structure when they undergo a little deformation which may become unacceptable from the perspective of serviceability and safety. Finally, leading to a collapse of the building, severe structural damage and loss of human life, In order to overcome these circumstances structural engineers have started a deep investigation to withstand a structure when it is subjected to strong earthquake motion. When an irregular structure is subjected to lateral forces, performance of the irregular structure is low when it is compared to a regular structure, for such a lower performance, there are some techniques that can withstand a structure, by providing some structural resisting systems like dampers (Base isolation damper, tune mass dampers, viscous elastic damper, when it undergoes some dynamic forces.

II. PROBLEM STATEMENT

An irregular structure with vertical geometric irregularity, floating columns, varying stiffness at different storeys of the building, vertical mass irregularity is considered for seismic analysis falling under seismic zone III of Andhra Pradesh, Linear elastic method (Equivalent static analysis), Linear dynamic method (Response Spectrum method) and Non Linear dynamic method (Acceleration time history method) are performed to understand parameters such as storey drift, storey displacement, Maximum shear force of beams and columns, Maximum bending moment of beams and columns, storey shear, PGA, time period variations with different modes of a building.

III. METHODOLOGY

Initially, an architectural plan is considered that contains locations of columns which is modelled using ETABS software considering structural plan of the building with assumed or appropriate dimensions, Loads are put on the structure as per IS 875, factors like zone factor, importance factor, response reduction factor play a major role to determine the value of Base Shear of the structure, Design check is performed on the structure for the given value of structural member dimensions,

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For varying load combinations as per IS codes once the design check passes all the members of the structure, three different types of analysis are performed resulting in output parameters like storey drift, storey displacement, storey shear etc.,

Flow chart representing the step by step procedure of the work done is shown in fig 1.

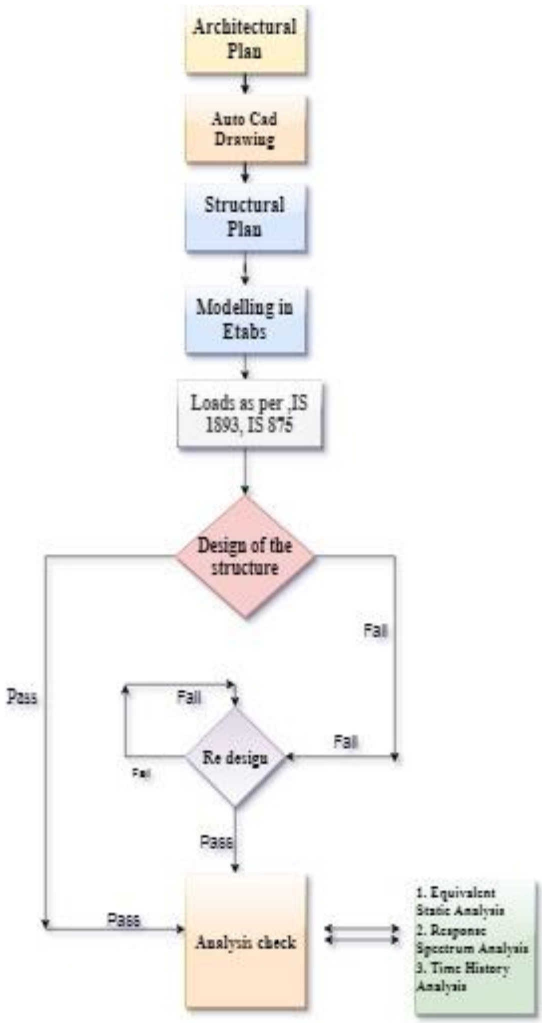

Fig1: Flowchart of the methodology adopted

IV. MODELLING

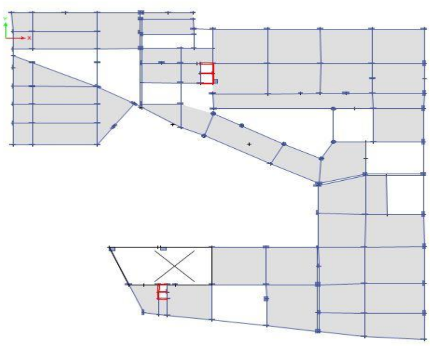

Fig2: Plan of the strucutre

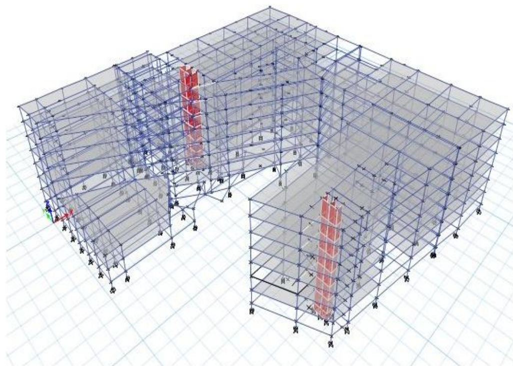

Fig3: 3D model of the structure

A. Considered inputs

Thickness of slab	= 0.150m
Density of concrete	= 25kN/m³
Density of brick	=20kN/m³

Different values of column dimensions are considered as per the structural plan such as 600 mm x 700 mm, 600 mm x 1200 mm, 1000 mm x 1500 mm etc., beam dimensions considered vary to eight different dimensions such as 600 mm x 400 mm, 900 mm x 800 mm, 1050 mm x 950 mm etc. Grade of concrete &steel used in R.C.C material is M 50 and HYSD 500 respectively with over all height of the building as 30 metres. Length along X & Y direction is 96.5 and 94 m respectively with number of storeys as eight, Plinth & floor story height is 2 and 4meters respectively, thickness of slab is 150mm and thickness of the shear wall is230mm. Loads are taken as per part 1& 2 of IS 875: 2015 and Seismic analysis is done as per IS 1893: 2016.

Wind Data: IS: 875 Part-3:2015

Location	= Guntur
Wind speed	= 50 m/s
Terrain category	= 2
Importance Factor	= 1
Risk Co-efficient factor	= 1
Topography factor	= 1

Seismic Data as per IS: 1893:2016

Zone type	=	III
Zone factor	=	0.16
Importance factor	=	1.2
Soil type	=	Medium soil
Reduction Factor	=	5

Analysis Performed

1. Equivalent Static analysis
2. Response spectrum analysis
3. Non-linear time history analysis

The above-mentioned details are used to design and analyse the structure using ETABS, Various parameters are considered to compare RCC and seismic risk of the structure such as story displacements, story drifts, story shears, and Beam axial forces, shear forces, bending moments and Column axial forces, shear forces, bending moments, Time period of the structure, Self-weight of the structure etc.,

V. RESULTS AND DISCUSSION:

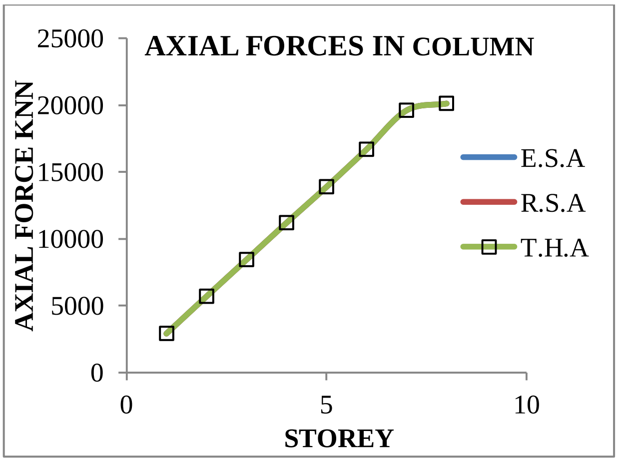

Fig.4: plot of axial forces in column

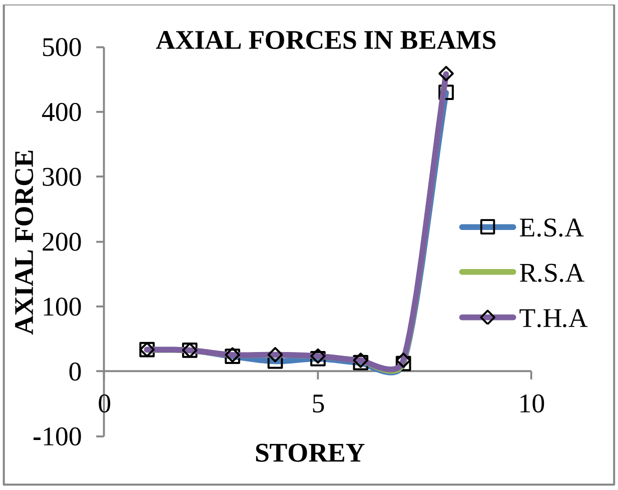

Fig.5: plot of axial forces in beams

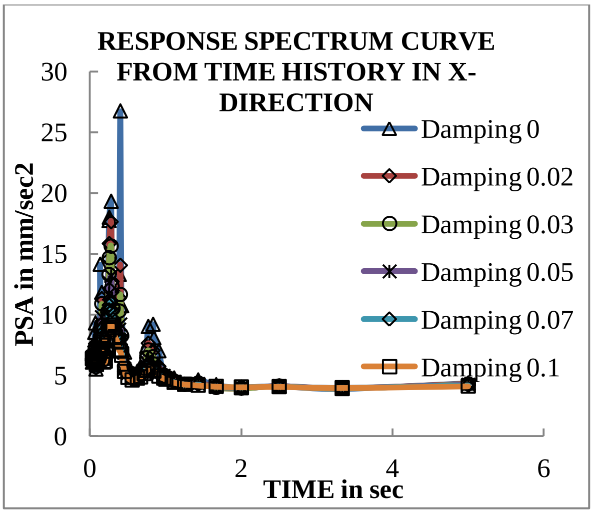

Fig.6: plot of response spectrum in x direction

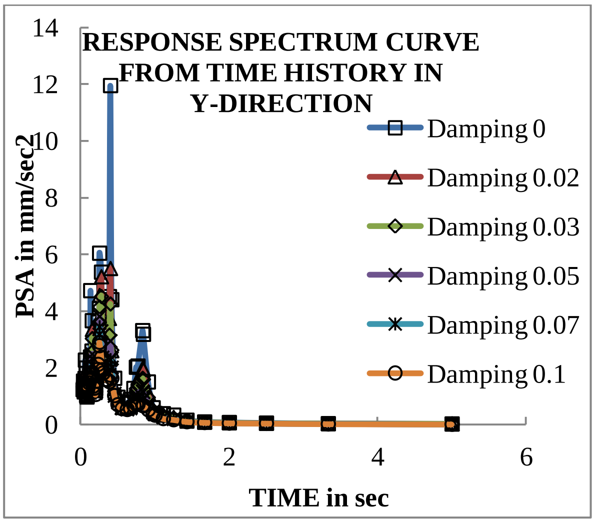

Fig.7: plot of response spectrum in y direction

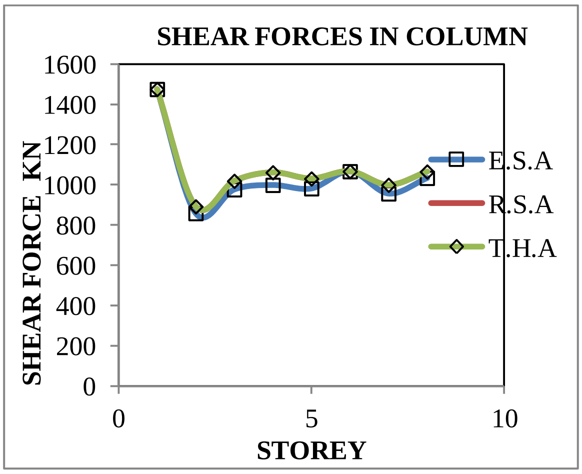

Fig.8: Plot of maximum shear force in column

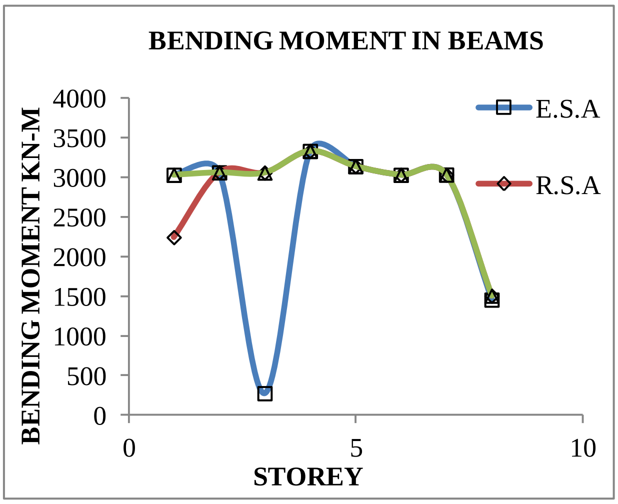

Fig.9: Plot of bending moment in beams

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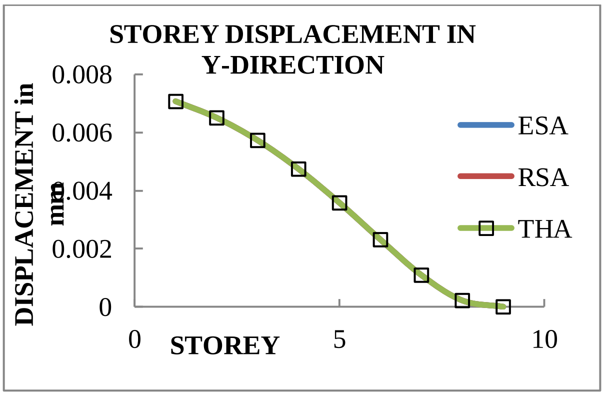

Fig10: Plot of maximum story displacement in y direction

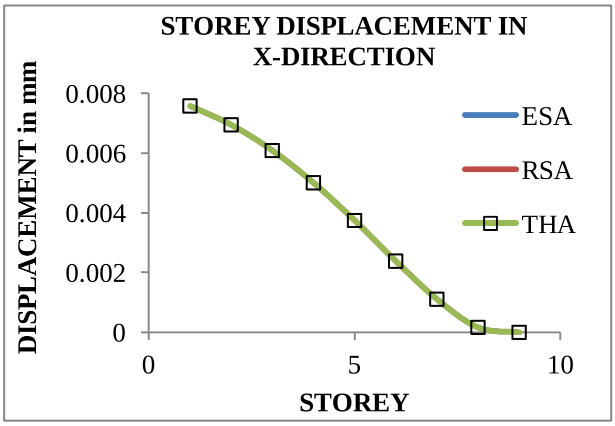

Fig11: Plot of maximum story displacement in X direction

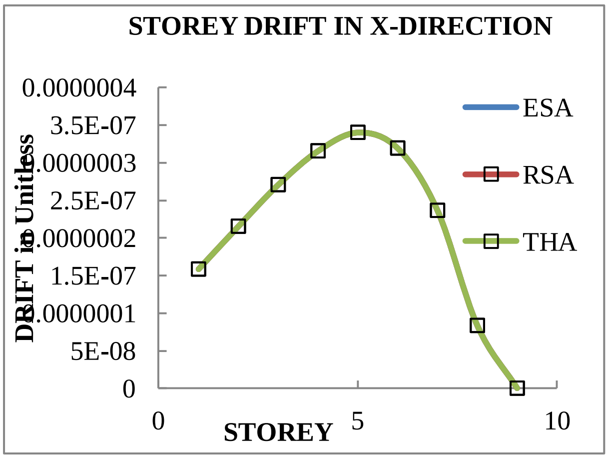

Fig12: Plot of maximum story drift in x – direction

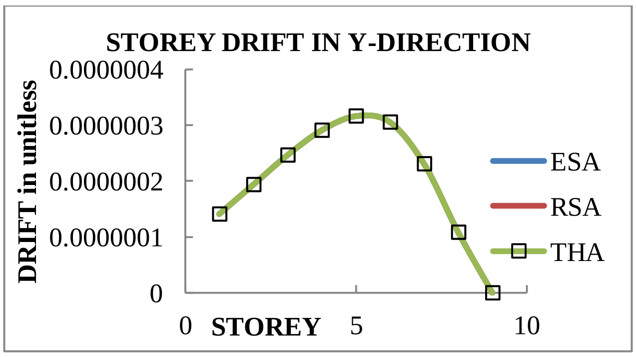

Fig13: Plot of maximum story drift in y – direction

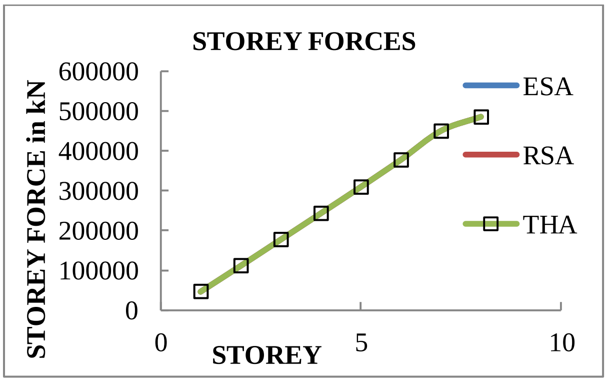

Fig14: Plot of maximum shear force in columns

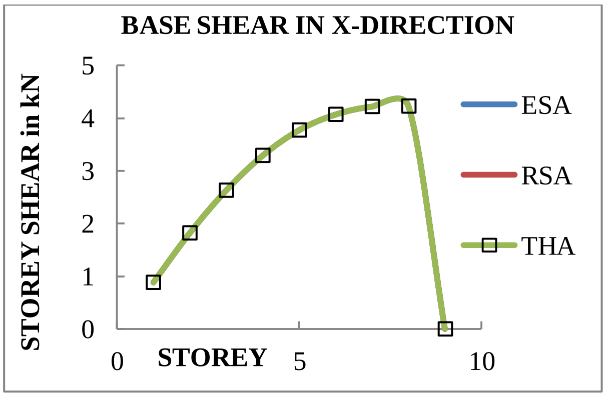

Fig15: Plot of maximum base shear in X – direction

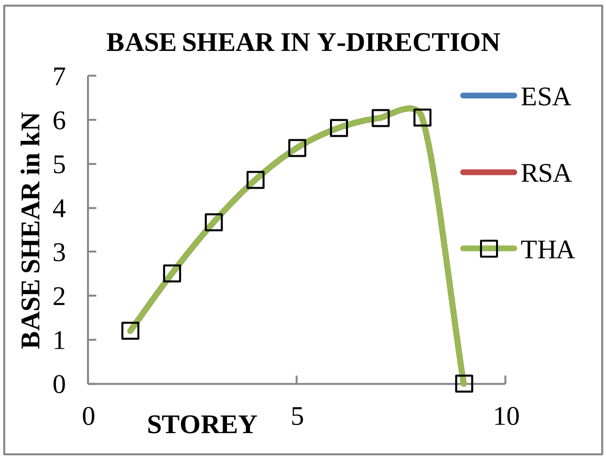

Fig16: Plot of maximum base shear in Y – direction

A. DISCUSSIONS

We can see the various curves for different parameters using different methods, few parameters does not have any variation of value such as storey drift, storey displacement, etc., where parameters such as shear force in beams for lower storeys is higher in Time history analysis compared to the other two, similarly we find from the graphs maximum bending moment in beams using time history analysis gives higher variation in results compared to other two methods of analysis, shear forces in columns are such that they become to be uniform with respect to increase in storeys though there is difference initially with lower storeys, response spectrum curve for different time history values is plotted in both x direction and y direction for varying damping values which gives values of Peak ground acceleration of the building.

VI. CONCLUSIONS

1. Accurate and reliable because time history analysis is a method of nonlinear dynamic analysis where it considers the material behaviour of the structure in plastic zone along with dynamic input loads i.e., earthquake loads in this case. Elcentro earthquake is considered as input due to its higher frequency values.
2. As we go to the higher storeys it is observed in the analysis performed that factors like storey drift and storey displacement are more sensitive.
3. Major Mode shapes identified have a modal mass contribution of greater than 90% to total mass of the structure.

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