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Comparative Analysis of Heighted Structure Using Analysis Tools STAAD, Sap2000, ETABS Considering Lateral Loads

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ABSTRACT

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of Vertically Irregular structures. STAAD stands for Structural Analysis and Design any object which is stable under a given loading can be considered as structure. ETABS is the Acronym of EXTENDED 3D ANALYSIS OF BUILDING SYSTEMS, is software developed by Computers and Structures, Inc. (CSI). SAP2000 is general-purpose civil-engineering software ideal for the analysis and design of any type of structural system. Basic and advanced systems, ranging from 2D to 3D, of simple geometry to complex, may be modeled, analyzed, designed, and optimized using a practical and intuitive object-based modeling environment that simplifies and streamlines the engineering process. The aim of this study is to determine the most suitable and approximate software to generate structural analysis result. This can help the designer to have an authentic base to select analysis tool between STAAD, ETABS and SAP 2000 before performing analysis. To conclude the feasibility of these software's a G+10 building with irregular geometry has been analysed, designed and compared the results.

Keywords : SAP 2000, Staad.Pro, ETAB, Seismic Analysis, Structure Analysis and Cost Analysis

I. INTRODUCTION

STAAD.PRO, ETABS and SAP2000 are three design software's to design and analyse any kind of structure in static and dynamic approach. However these software's will give different design and analytical results for the same structural configurations, this is due to their different analytical mechanism and the way they do analyse the structure. This rise a need to do a comparative study between these two software to know the real advantages and disadvantages of these software's. In case of analysis and design of structures with geometrical irregularities there is much more need to compare design results of different software's to get safe as well as economical structures. This paper carry out a comparative study of design results of ETABS and STAAD Pro software's by taking structural irregularities in account.

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular. structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height- wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of Vertically Irregular structures.

To conclude the feasibility of these software's a G+10 building with irregular geometry has been analysed, designed and compared the results.

Structural Analysis

It is a method or tool by which we find out how a structure or a member of a structure behaves when subjected to certain excitation. In other words finding out internal forces (axial force, shear force, moment), stress, strain, deflection etc in a structure under applied load conditions.

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, furniture, attire, soil strata, prostheses and biological tissue. Load acting on a structure is ultimately transferred to ground. In doing so, various components of the structure are subjected to internal stresses. For example, in a building, load acting on a slab is transferred by slab to ground through beams, columns and footings. Assessing the internal stresses in the components of a structure is known as structural analysis and finding the suitable size of the structural components is known as design of structure. The structure to be analysed and designed may be of masonry, R.C or steel. Upton considerable improvements were seen in classical analysis. With the advent of computers numerical methods emerged and analysis and design packages are becoming popular. A civil engineer has not only to give a safe structure but he has to give economical sections. To get economical section mathematical optimization techniques are used. Frequent earthquakes in the recent years have brought importance of analysis of the structures for earthquake forces. Designing earthquake resistant structures is attracting lot of researches. All these aspects fall under structural engineering field.

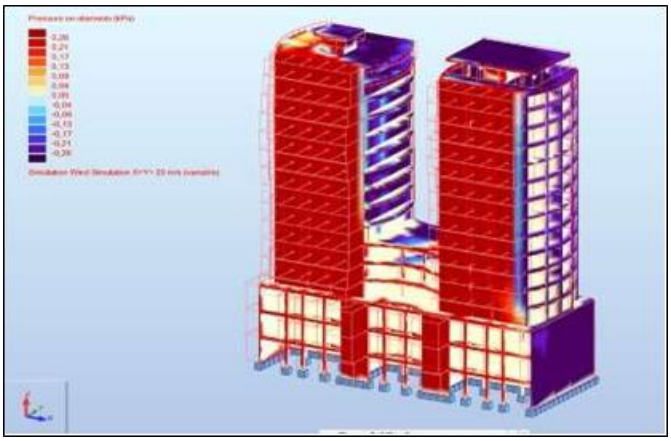


Figure 1. Structural Analysis

II. LITERATURE REVIEW

Richa Agarwal and Archna Tiwari (2017) the research paper depicted a relative plan of three different structures as 5 storey, 10 storey and 15 storey with various earthquake zones namely II, III, IV, V (as per IS code 1893 and 456-2000) of building, modelling and analysis of the structure was using structural programming STAAD.pro and ETABS.

The design result obtained gave lesser area of required steel as compared to STAAD PRO for the beam design result. Correspondingly the column design result also area of required was less in STAAD PRO software as compare to ETABS. Consequently, the final accomplish ETABS provided lesser area of steel as compare to STAAD PRO in both cases.

S .Vijaya Bhaskar Reddy and V. Madhu (2018) the research paper presented the detailed analysison simulation tools ETABS and STAAD PRO, which have been used for analysis and design of rectangular Plan with vertical regular and rectangular Plan with Vertical geometrically irregular multi-storey building. This study was focused on bringing out advantages of using ETABS over current practices of STAAD PRO versions to light. It was observed that ETABS was more user friendly, accurate, compatible for analysing design.

Results stated that Max reaction produced was 4572.12kN in ETABS and 4624.92kN in STAADPro due to load 1.5(Self +Dead +Live). The maximum displacement was along x- direction and its value was 106.25mm (in STAADPro.) for irregular building and 53.47mm (in ETABS) along z-direction for regular building. So, more precise results was generated by ETABS which leads to economical design of the building. The storey overturning moment decreases with increase in storey height along x-direction for EQ length load and they was more in regular building than the irregular building. The ETABS gave lesser area of steel reinforcement for irregular building as compared to regular building in case of beams and columns

Kai Hu et al (2012) in this paper, the response spectrum, time history and linking slab in- plan stresses analysis was executed combined with a practical project with inclined columns by several programs such as ETABS, SAP2000, MIDAS/gen and SATWE, and the main conclusions stated that all the results of response spectrum analysis calculated by different programs was basically similar, while ETABS may miss the statistic of oblique columns, which need to be paid attention to in future designs. The results of time history analysis by SAP2000 and ETABS was roughly similar. However, SAP2000 does not have the concept of “storey” which made the post-processing much more complicated. Therefore, to the regular structure, ETABS was recommended; and to those gymnasium or space truss structures, SAP2000 has its irreplaceable advantages. As for the slab stress analysis, ETABS and MIDAS/Gen have their respective advantages as ETABS’s good at preprocessing with automatically line constraint and area division; and MIDAS/Gen does well in the post-processing such as the stresses combinations. Slab, as the important lateral force resistant component, should not be ignored in design works. Especially to those complex structures, the slabs stress analysis at weaken positions is really essential.

III. Objectives

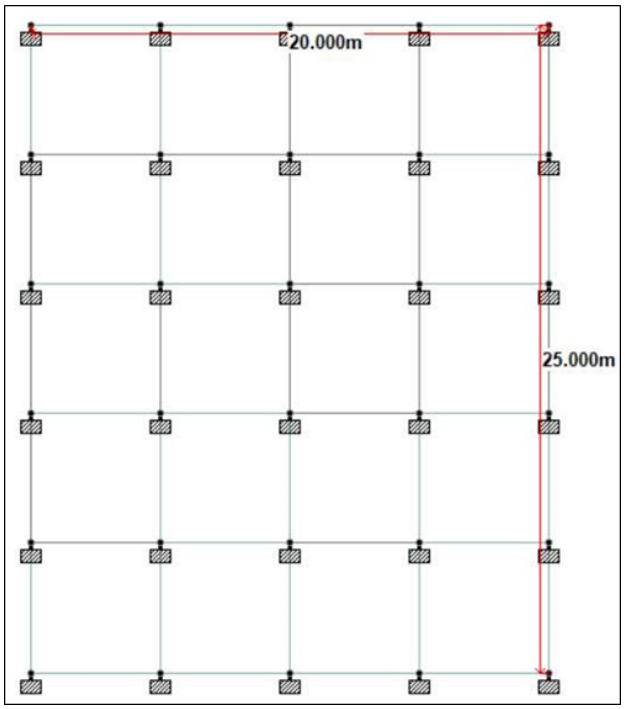
To carry out modeling and analysis of G+5, G+10 and G+15 R.C. framed structures using STAAD-PRO, ETABS & SAP2000

- To Design a regular and plan irregular multistorey structure as per IS-456 & IS-1893:2016
- To find out shear forces, bending moments and reinforcement details for the structural components of the building (beams and Columns) and compare the results.

- To compare results of ETABS, STAAD-PRO and SAP 2000.
- To observe which software gives more accurate results.

IV. Methodology:

Staad.Pro

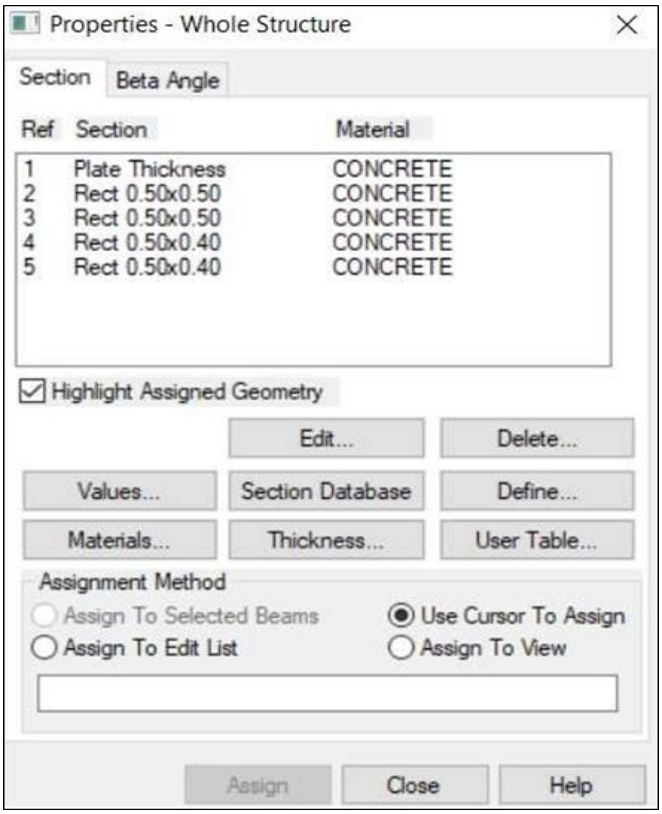


Step-1 To create Modelling in Staad.pro as per given dimensions.

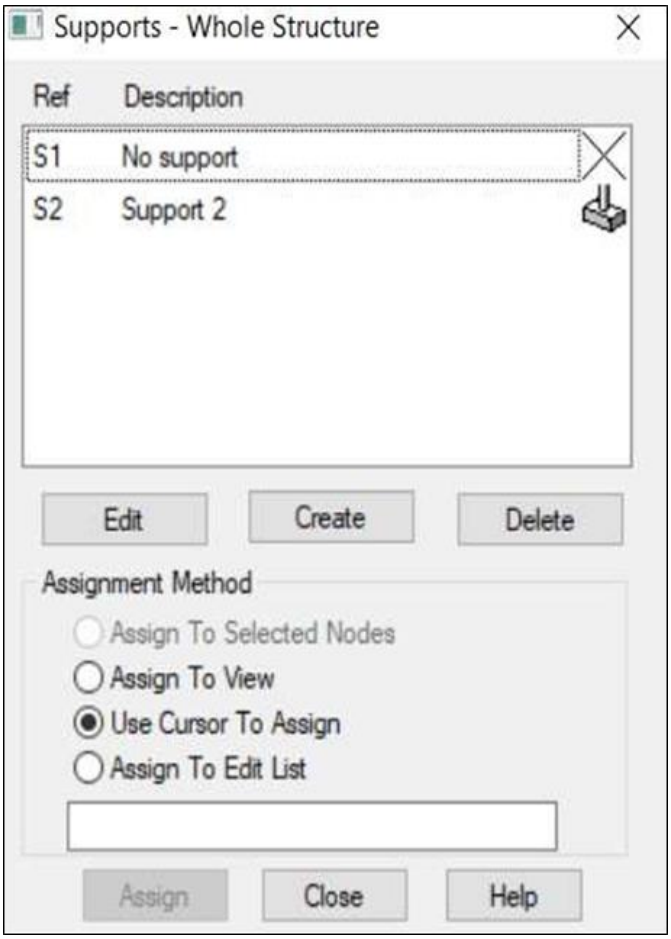
ETABS

Step-1: Create Modelling as per proposed dimensions.

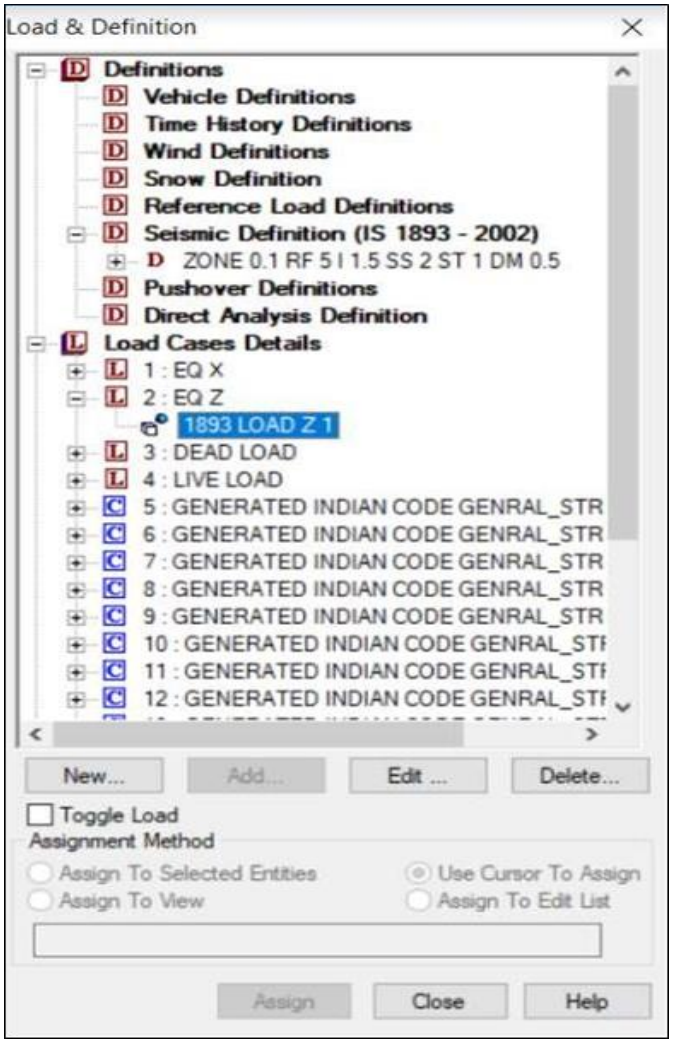
Step-2: To assign sectional data and properties



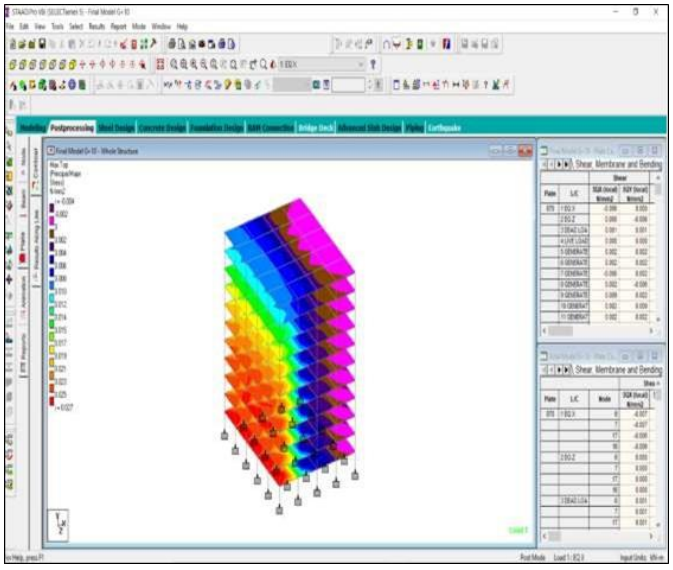
Step-3: Assign fixed end Condition.



Step-4: Assign seismic loading condition and load combinations.



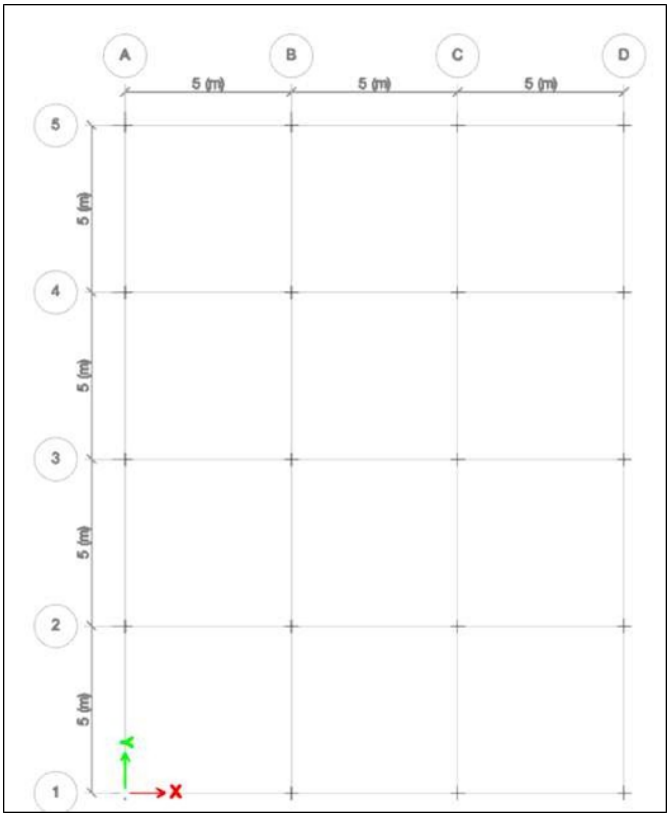
Step-5: Assigning Load pattern and combinations

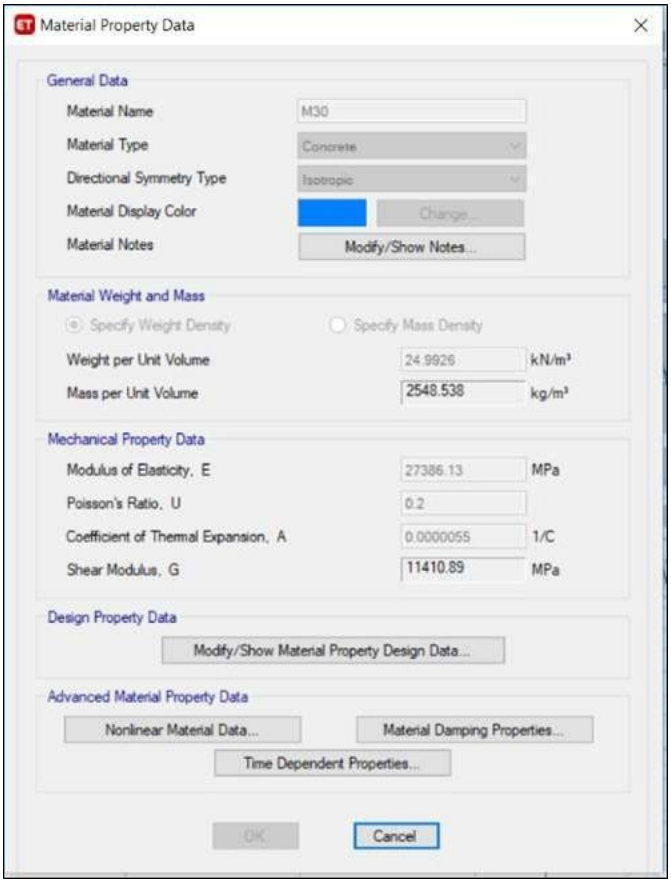


Step-6: Analysing for output.

ETABS

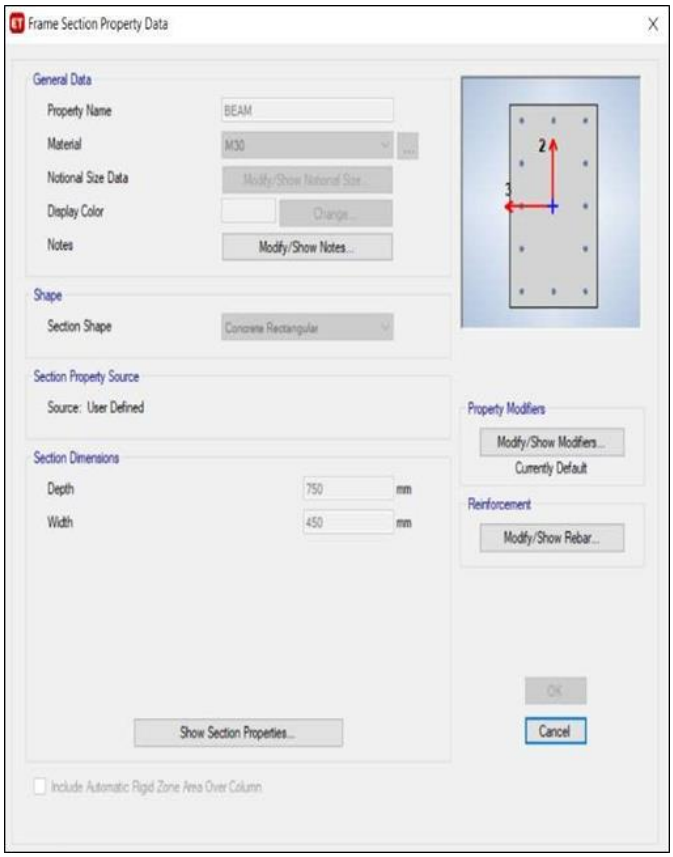
Step-1: Create Modelling as per proposed dimensions.





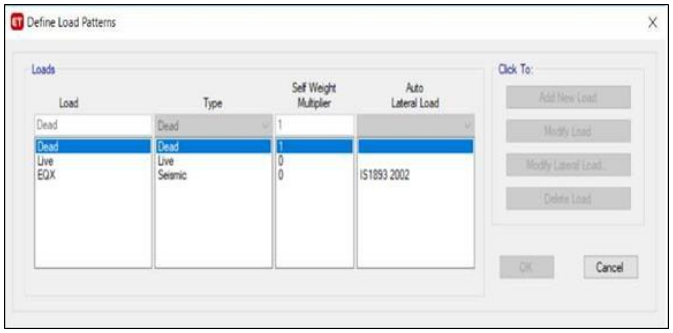
Step-2: Defining material property

Step-3: Creating sectional data

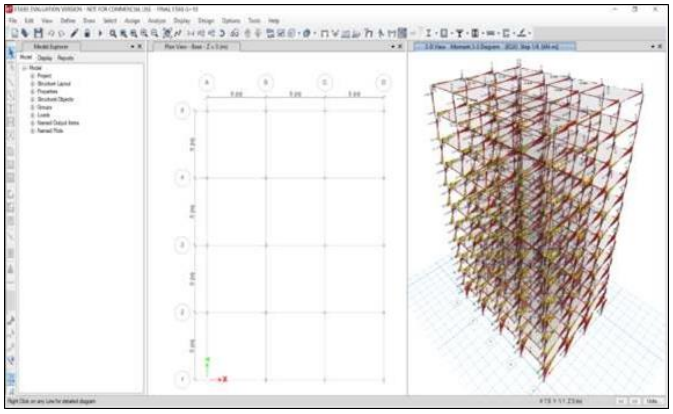


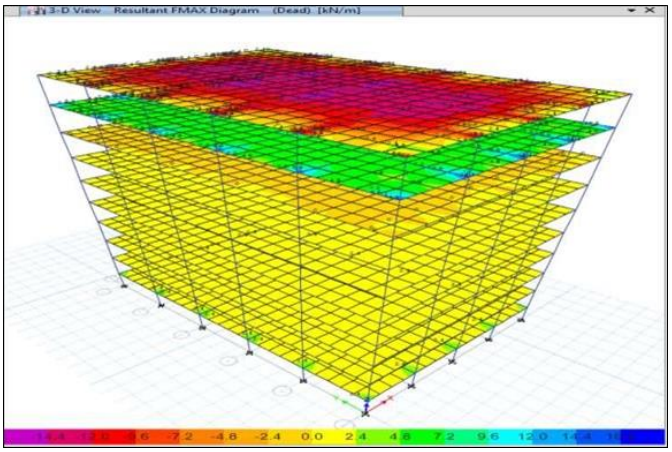
Step-4: Assigning Fixed end Condition

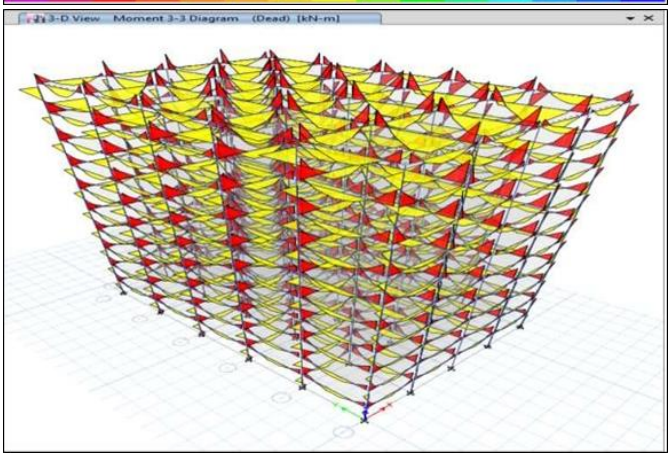
Step-5: Assigning Load pattern and combinations

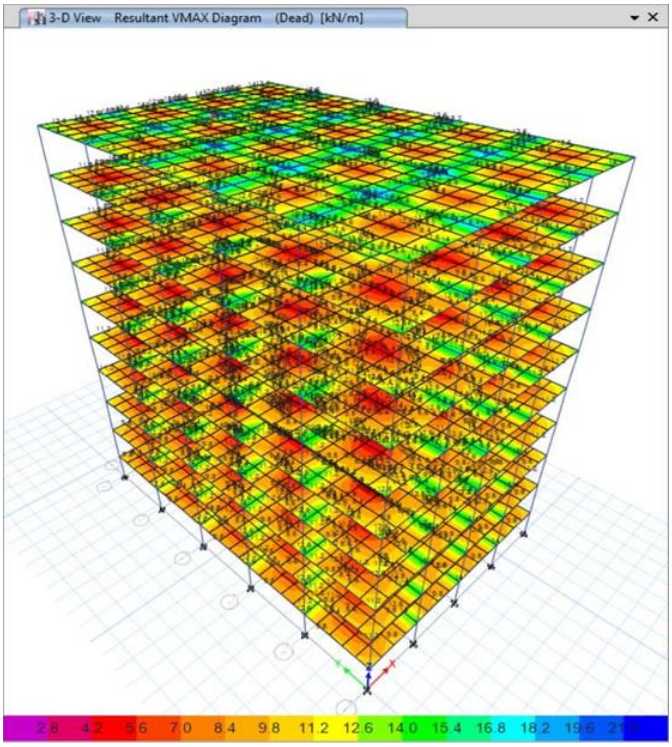


Step-6: Analyzing for output.



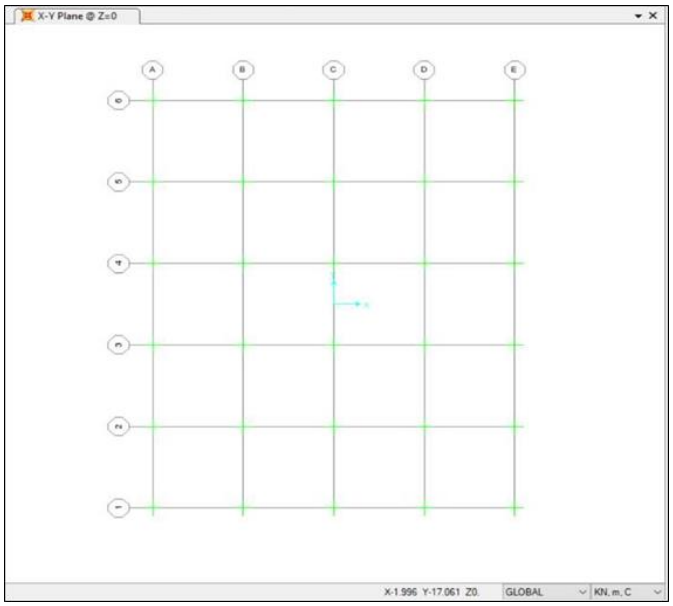






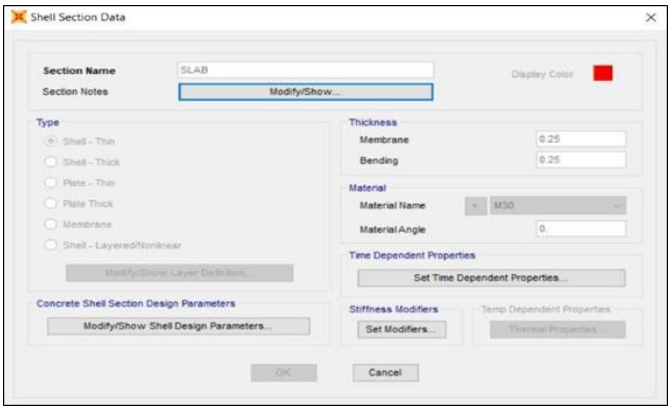
SAP2000

Step-1: Generating Structure modelling as per decided dimensions



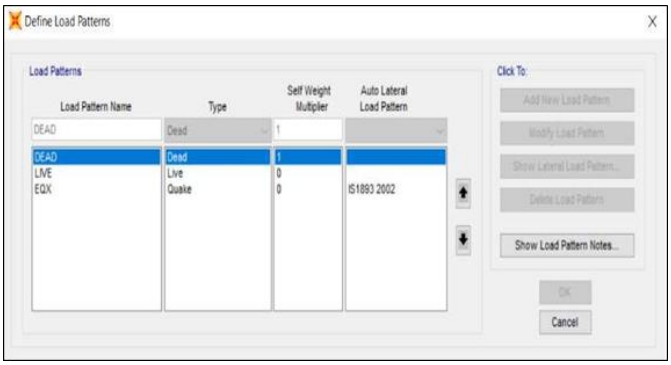
Step-2: Creating materials concrete & rebar

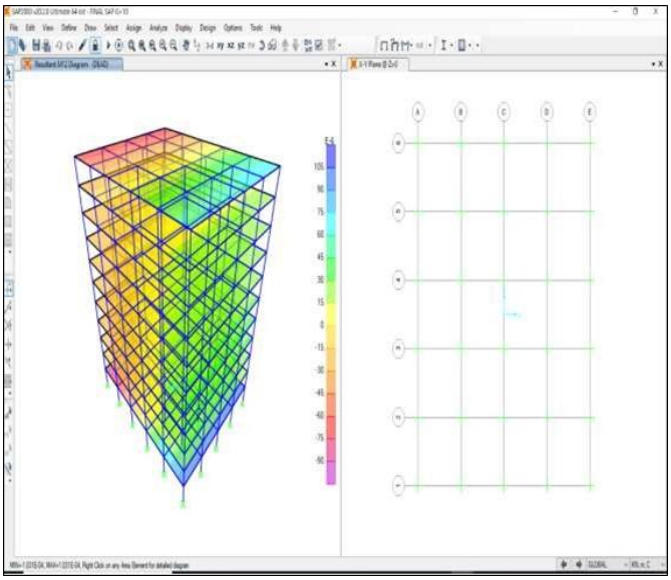
Step-3: Creating frame sections and slab sections



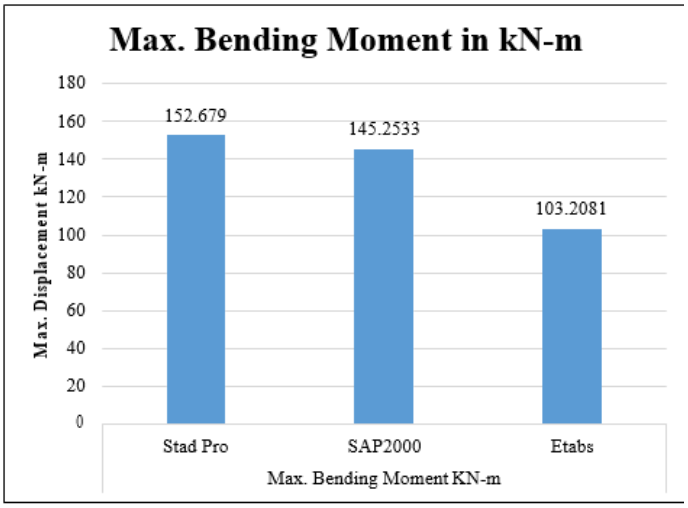
Step-4: Assigning end conditions

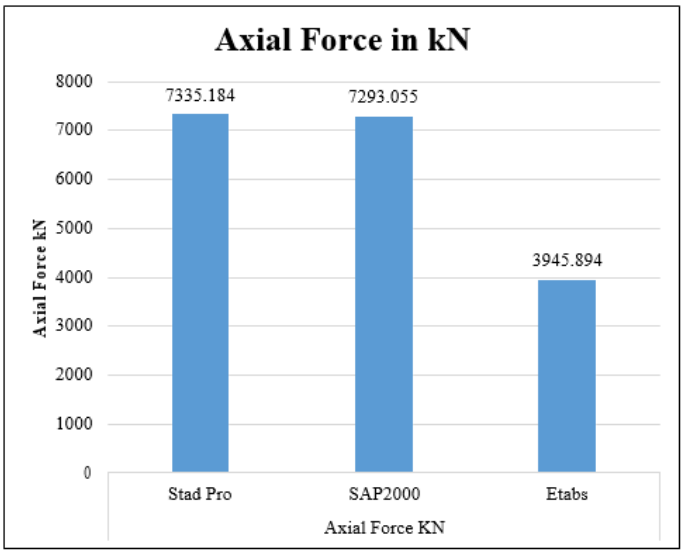
Step-5: Assigning Loading conditions

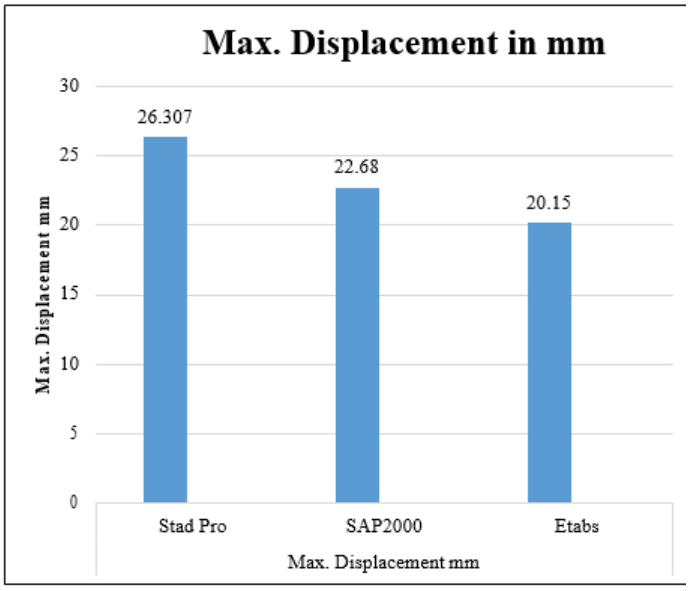


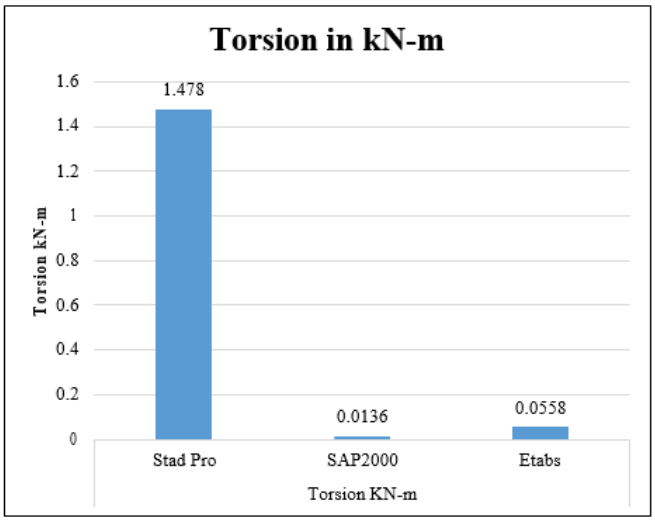


V. ANALYSIS RESULT









VI. COCLUSION

In this study we are comparing analysis result of three different analysis tools i.e. Staad.pro, Etabs and SAP2000. Here for comparative analysis we have compared G+5, G+10, G+15 and G+20 storey structure considering Seismic zone II (Bhopal City) and medium soil condition. In this study following outcomes has been observed as follows:

Structure Analysis G+5 Storey

In terms of bending moment we observed a variation of 32.62 %, where Staad value is
61.315 kN-m, Etabs value 44.322 kN-m and SAP2000 value is 41.314 kN-m.

In terms of Forces minute variation in analysis output of all the three softwares with value Staad 53.271kN, ETABS 48.937KN and SAP2000 41.314 KN.
In terms of deflection we observed almost similar value in Staad and Etabs output whereas in SAP2000 deflection observed is less in comparison.
G+10 Storey

In terms of bending moment we observed a variation of 19.86 %, where Staad value is

100.189 KN-m, Etabs value 86.537 kN-m and SAP2000 value is 107.988 kN-m.

In terms of Forces variation in analysis output of all the three softwares with value Staad 64.805 kN, ETABS 63.707 kN and SAP2000 60.072 kN.
In terms of deflection we observed almost similar value in Staad and Etabs output whereas in SAP2000 deflection observed is less in comparison.

G+15 Storey

In terms of bending moment we observed a variation of 20.12 % where Staad value is 131.924 kN-m, Etabs value 105.372 kN-m and SAP2000 value is 111.33 kN-m.
In terms of Forces minute variation in analysis output of all the three softwares with value Staad 79.013 kN, Etabs 73.138 kN and SAP2000 77.008 kN.
In terms of deflection we observed almost similar value in Staad and Etabs output whereas in Etabs (14.427 mm) deflection observed is less in comparison.
G+20 Storey
In terms of bending moment we observed a variation of 32.40 %, where Staad value is 152.679 kN-m, Etabs value 103.208 kN-m and SAP2000 value is 145.253 kN-m.
In terms of Forces variation in analysis output of all the three softwares with value Staad
91.561 kN, Etabs 72.228 KN and SAP2000 99.782 KN.
In terms of deflection we observed almost similar value in Staad and Etabs output whereas in Etabs (20.15 mm) deflection observed is less in comparison.

Cost Analysis

In case of G+5 structure, the total cost of rebar was found maximum in Staad.Pro whereas the SAP 2000 provided the lowest value of the Rebar.
In case of G+10 structure, the total cost of rebar was found lowest in Etabs whereas the SAP2000 provided the highest value in comparison to ETABS and Staad.Pro.
In case of G+15 structure, the total cost of rebar was found lowest in Etabs whereas the SAP2000 provided the highest value in comparison to Staad.Pro and SAP 2000.
In case of G+20 structure, the total cost of rebar was found lowest in Etabs whereas the SAP2000 provided the highest value in comparison to ETABS and Staad.Pro.
From the above results ETABS proved to provide the lowest quantity of rebar in comparison to other models using staad.pro and SAP 2000.

5.4 Summary

As per observations of results it can be said that SAP2000 is suitable and providing linear results up to G+10 structure
But as we raise the height above G+10 it is observed that ETABS is providing more precise result. Thus it is identified that
Etabs is more linear for analysis of tall structures in comparison whereas Staad.pro shows values higher for same loading condition in comparison.

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