COMPARATIVE STUDY OF MULTI-STORIED RC STRUCTURE FOR SEISMIC AND WIND LOADS USING STRUCTURAL ANALYSIS SOFTWARE'S

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Abstract - This High-rise construction is commonly adopted in today's world due to growing urban development, scarcity of land and advancement in construction technology. Worldwide people are going for multi-storied or high-rise buildings so it is really important to make it safer for people residing there and also to reduce its overall cost to achieve more economy and efficiency. Thus, increasing the challenges in the construction day by day. The new ideas are discovered day by day so that we can easily live our life without being afraid of hazards or extremities of nature such as wind, earthquake etc. Earthquake & wind are the major natural forces which causes destruction worldwide. Therefore, Structural stability and integrity of any structure plays very important role. Structural analysis & design are the most important steps in evaluating significant threats to integrity & stability of any structure. Once these structures are designed, they must fulfil basic aspects of safety and serviceability. Nowadays, the design strategy of buildings is also changing as much more complicated building geometries are utilized. Because of all these challenges faced by structural engineers, various software packages such as STAAD, ETABS, SAP 2000 etc. were developed. These software packages have revolutionized the structural analysis and design technology with great ease. The present project deals with the planning of a Basement+G+8 building using AutoCAD software which is simultaneously analyzed using structural analysis software's such as STAAD and ETABS. The analysis results from STAAD and ETABS will be used to derive the results of earthquake and wind analysis on these structures.

Keywords - High-rise, AutoCAD, STAAD, ETABS, Earthquake, Wind

I. INTRODUCTION

Any structure is referred to as a high-rise when it is substantially higher than the surrounding buildings giving appearance of a tall building (Usually greater than 15 meters in height). People adopt high rise construction in today's world due to growing urbanization, scarcity of land and advancement in construction technology. Construction and Engineering are the fields which are directly linked to the economy and safety of human beings therefore, optimization in the form of investment along with safety is becoming a necessity. Thus, the construction is becoming challenging day by day. The new ideas are discovered day by day so that we can live our life without being afraid of hazards or catastrophes of nature such as wind, earthquake etc. For analysing and designing any multi-storied building one has to consider all the possible loadings against all the possible safe loading conditions. The various types of loads acting on the structure can be due to weight of objects such as people, furniture, snow etc. or some other kind of excitation forces such as earthquake, wind, ground shaking due to a nearby blast, etc.

Structural analysis & design are the most important steps in evaluating significant threats to integrity & stability of any structure Structural analysis mainly focuses on finding out the behaviour of a structure when subjected to some action. Properly designed structures ensures adequate safety and ductility to structures along with strength and they are easier to construct at greater heights than steel structures.

Nowadays, the design strategy of buildings is also changing as much more complicated building geometries are utilized. Therefore, designers should possess better skills and sound knowledge. Use of computer-based software programs available in the market developed by different software organizations helps to handle such challenges more efficiently in analysis and design of multi-storied building such as STAAD, ETABS, SAP 2000 etc.

These software packages have revolutionized the structural analysis and design technology with great ease. The main aim of using these analysis and design software's is that they not only make construction economic but also make it easier and less time consuming. It is possible to incorporate all possible load types and geometric configurations in these software. Software's make it simpler to perform 3 dimensional frame analysis with great ease against manual calculations. Both software adopt Finite Element Modelling. Negligible manual calculationsare required as all latest Indian and other codes are integrated in both the software's thus maintaining the required standards of safety and serviceability. In this study, a typical Basement+G+8 residential building was analyzed simultaneously using STAAD and ETABS for seismic and wind loads. The objective of the analysis was to model a structure and apply wind and seismic loads loadings as per Indian Codes (IS456, IS-875 {part 1, 2, 3}, IS-1893) to
obtain the reactions and forces using both the software's and present the overall comparison of the results.

II. LITERATURE REVIEW

Kishore et.al. (2015), analyzed irregular buildings for their stability. They modelled a multi-storey horizontally irregular building as per IS 875-1987(Part III) in Staad.pro. Irregular plans like L-shape, U-shape were considered for study in addition to Regular Building. Each building was considered upto 15 storeys height and assessment was done for each shape. Buildings were analyzed for dead loads, live loads and wind loads as described in IS 875-1987(Part I, II, III) respectively. Parameters like bending moment, nodal displacement, and storey drift were used for assessment. Results were plotted for beams, columns and structure as a whole for different shapes. It was observed that bending moments in Beams and columns show a rise in the Regular Shape, L shape, U shape with reduction in storey height, with L shape having the greatest value. Bending moments in continuous beams increases in U shaped building as the storey height decreases. Nodal displacements Z directions falls gradually as the storey height decreases. Displacements in U shaped building are twice compared to displacements in Regular Shape building. Storey drift in Z directions increase gradually as the storey height reduces. Drift in U shape building increases to more than 4.5 times compared to Regular Shape building. Lateral bracings were adopted for the RCC structure as the calculated drift is more than the allowable drift (h/500) due to combination of loads. Bending moments in Beams and Columns due to wind forces were observed to have much larger values compared to that due to static loads.

Natarajan and Veeraragavan (2016), considered a residential building of G+15 irregular structure for the analysis. To evaluate the seismic response of the buildings, response spectrum method of analysis was adopted using Finite element-based software-ETABS. They conducted a study on an irregular high-rise building with shear wall and without shear wall to understand the lateral loads, story drifts and torsion effects. From the results it was observed that shear walls are more resistant to lateral loads in an irregular structure. Lateral forces reduce when the shear walls are added at appropriate locations in the structure. They are more resistant to lateral loads in an irregular structure. They reduce the effects of torsion. Base shear and the story drift value is more in the regular configuration as compared to irregular configuration. Shear wall in core and corners reduces displacement values in both X and Y directions when compared to all other models. With provision for shear walls, size of members like column can be reduced economically. Displacement at different level in multi-storied building with shear wall is found to be comparatively lesser as compared to R.C.C. building Without Shear Wall. Stiffness as well as seismic responses of structures is affected by the size of the openings and their locations in shear walls. It was observed that the maximum storey displacement of the building reduces by 50% when shear wall is provided.

Lallotra and Singhal (2017), conducted a study with the objective of the designing basic structural elements of Reinforced Cement Concrete (RCC) using popularly used software STAAD Pro, ETABS and SAP-2000 and checking the compatibility of results. Also, the software design results are validated with manual calculations as per Indian standards to gain the confidence of the users.

There was a great variation in the results for all the elements obtained from software compared to the results obtained through manual calculations using Kani's method. The comparison of analysis of force for the fixed and cantilever beams is closer to the theoretical value in case of SAP-2000. Moments obtained from STAAD Pro and ETABS are on the lower side. The area of steel obtained from ETABS and SAP-2000 is similar to the theoretical value of steel in case of portal frame but the steel results given by STAAD Pro are less than minimum recommended by I.S. code. All the three software STAAD Pro, ETABS and SAP-2000 give good approximation of the results for bending moments, shear forces, axial forces with the independent results designed manually for the same problem. There is a large variation of order of more than 5% even for the same moments for the area of steel. It is therefore desired that more expertise is required to a Civil Engineer when more complicated structures are designed.

III. PROBLEM DETAILS

In the present study a RCC framed structure having an elevation of 31.88 m is studied. The location of the building is selected at Goa, India. In this study, the design parameters adopted for the building are presented below in a tabular form.

Density of concrete	25 kN/m^3
Density of steel	7.85 kg/m^3
Grade of concrete	M30
Grade of steel	Fe550
Poisson ratio	0.2
Damping factor	0.05
Basic wind speed	39 m/s
Location	Goa
Seismic zone	III
Importance factor	1.5
Soil type	Medium (type II)
Response reduction factor	5 (SMRF)

Table.1Basic data for analysis

Dimensional details and different source of masses are also tabulated below.

Parameter	Values
Elevation from depth of fixity	31.88 m
Total number of story	B+G+8
Size of columns	0.23m × 0.70m
Size of beams	0.23m × 0.5m for plinth and 0.23m × 0.65m for other floors
Depth of slab	120 mm
Thickness of shear wall	230 mm

Table.2Dimensional details

Following loads are considered on the structures.

Parameter	Values
Dead load	Self-weight of the structure
	Wall load based on height of wall
	1.2 kN/m^2 (Floor finish including plaster)
Live load	As per IS 875-Part 2 1987 for residential buildings
Wind load	As per IS 875-2015 for location Goa
Seismic load	Dynamic analysis (response spectrum) is carried out following guidelines from IS 1893-2016

Table.3Load details

In the present study, mainly the vertical loading of structure is considered for comparison between the two models from STAAD and ETABS. In addition to this, horizontal loads due to wind and earthquake in both the directions are also presented. Behaviour of the structure is studied under the vertical and horizontal loads. All the supports of the building are assumed as fixed at the base. Figure 1 and Figure 2 shows the rendered image from STAAD and rendered image from ETABS respectively.

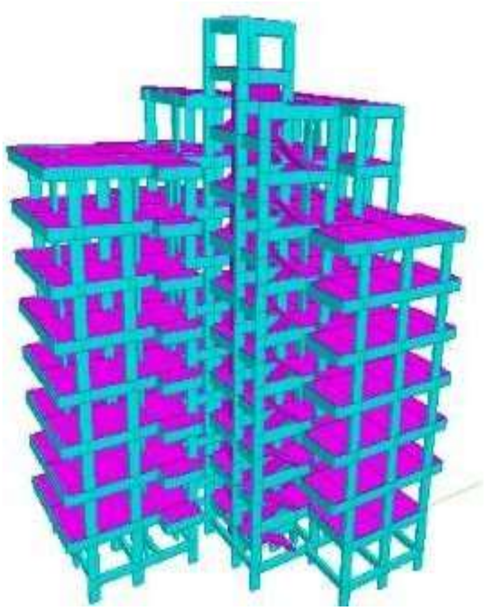

Figure 1: Rendered image from STAAD

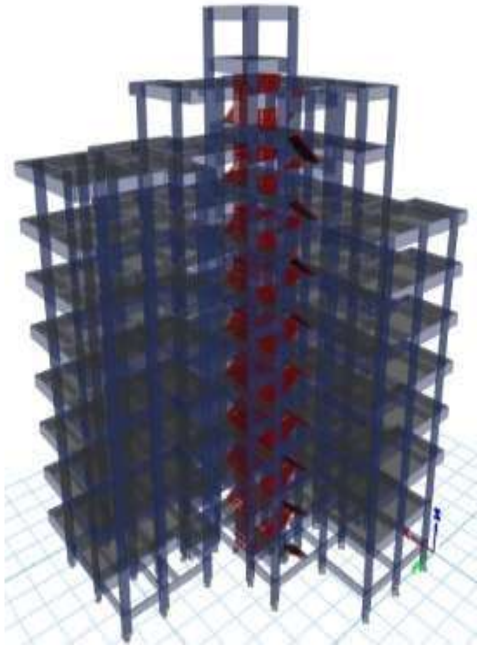

Figure 2:Rendered image from ETABS

III. RESULTS

The structures are analyzed in both the software's simultaneously and the results are presented below. For all the graphs shown below, along X axis is column numbers and along Y axis is the support reactions in KN.

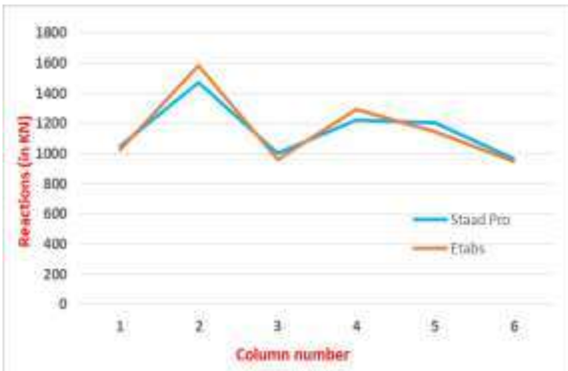

Figure 3:Comparison of vertical reactions at base under dead loads between STAAD and ETABS

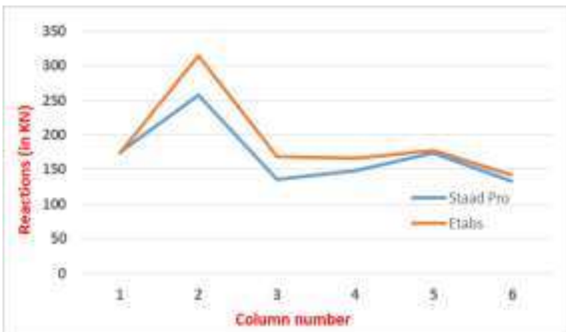

Figure 4:Comparison of vertical reactions at base under live loads between STAAD and ETABS

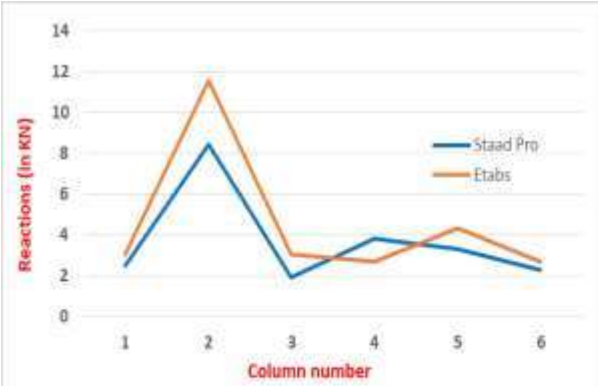

Figure 5:Comparison of reactions under wind load along X direction between STAAD and ETABS

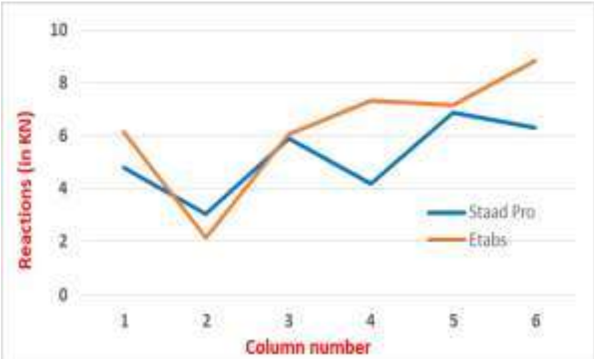

Figure 6:Comparison of reactions under wind load along Y direction between STAAD and ETABS

Figure 7 and Figure 8 shows the deflected shape of the models in STAAD and Etabs under horizontal wind and earthquake load in X-direction respectively.

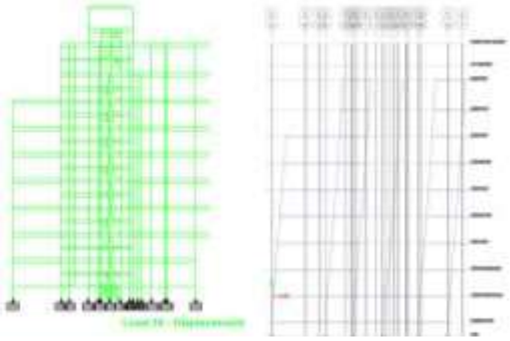

Figure 7: Deflection pattern of the models (left one is for STAAD and right one is for ETABS) under wind load in X-direction

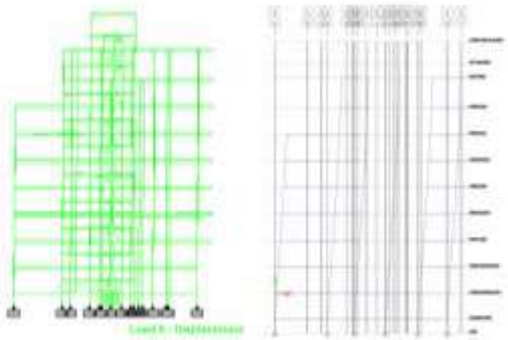

Figure 8: Deflection pattern of the models (left one is for STAAD and right one is for ETABS) under seismic load in X-direction

IV. INTERPRETAION OF RESULTS

The results obtained are presented in a graphical form for better comparison of results derived from both the software's. Following points can be derived from the results.

1. High-rise construction is commonly adopted in today's world due to growing urban development, scarcity of land and advancement in construction technology. Therefore, it is really important to make it safer for people residing there and also to reduce its overall cost to achieve more economy and efficiency.
2. Before undertaking design and construction of any high-rise structure, one has to consider all the possible effects of natural hazards which are likely to affect the structure in the future run. Earthquake & wind are the major natural forces which causes destruction worldwide. Therefore, it is very much essential to perform seismic and wind analysis of any structure. The structure designed should fulfil all the basic aspects of safety and serviceability.
3. In this study, Figure 3 and 4 shows the variation of reaction forces under dead load and live loads respectively at different column positions. Results from both the software are close to each other signifying the model is geometrically fit for analysis.
4. Figure 5 and Figure 6 represents the developed horizontal reaction forces under wind load at the base. Here it is found that the support reactions are slightly varied. In case of ETABS, on an average the values of reactions are slightly higher compared to that of STAAD Pro. In STAAD model, wind load is applied directly on the structure whereas in case of ETABS, it is applied using a diaphragm. Hence the load is presented in a better way.
5. Figure 9 shows the deflected shape of the building under wind and earthquake load in X-direction which shows same pattern for both the cases.
6. The presence of shear wall in the model greatly helps to absorb the maximum amount of horizontal load and transmits it to the ground. This factor results in lesser amount of developed base shear in remaining column supports. This is highly beneficial in terms of design criteria, because lesser amount of horizontal reactions will lead to lesser amount of developed bending moment in columns. Lesser the values of the bending moments, lesser will be the requirement of reinforcement, which ultimately will make the whole structure economical.
7. Further detailed studies on wind and seismic analysis are in progress.

REFERENCE

Some of the literature papers referred by the authors are mentioned below. ([1]-[7]). These literature papers were found useful to have some idea about the types of comparison that can be made for analysis.

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