COMPARISON OF ANALYSIS RESULTS OF MULTI-STORIED RC STRUCTURE FOR SEISMIC AND WIND LOADS USING ETABS AND STAAD PRO

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Abstract - In the present times high-rise construction is preferred because of increasing urbanization, growing scarcity of available land and advancement in construction techniques. These structures are gigantic in nature thus demanding huge logistics, proper management, and require enormous financial investment. Thus, increasing the challenges in the construction day by day. Since, in developed and developing countries people started widely adopting multi-storied or high-rise construction, it becomes really important to make it safer for people residing there against the extremities of nature and also to reduce its overall cost to achieve more economy and efficiency. Earthquake & wind are the major natural forces which causes destruction worldwide. Many research studies are being carried out to mitigate excitations and improve the performance of high rise structures against wind loads & earthquake loads. Therefore, structural stability and integrity of any structure plays very important role. Once these structures are designed, they must fulfill basic aspects of safety and serviceability. Nowadays, the design methodology of buildings is also changing as much more complicated building geometries could be utilized as against the conventional approach of a rectangular shaped building. Because of all these challenges faced by structural engineers, various software packages such as STAAD, ETABS, and SAP 2000 etc. were introduced in the market. These software packages have revolutionized the structural analysis and design technology with great ease. The present study deals with the planning of a Basement+G+8 building using AutoCAD software which is simultaneously analyzed structure and simultaneously analysing it structural software's such as STAAD and ETABS. The analysis results of the structure such as shear forces, bending moments, deflections etc. will be used for comparison of earthquake and wind analysis from STAAD and ETABS.

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

I. INTRODUCTION

Reinforced concrete structures are adopted by people past many decades because of its stiffness, convenience, high durability and ease of construction. These structures are much more suitable for low rise constructions but when question arises for medium to high rise structures they are no longer economical as the loads are heavy, less susceptible, span restriction and difficult formwork. Population of the entire world is increasing at an alarming rate and people face shortage of land required for living, for that high rise structures are best option of construction especially in metropolis cities where less land is available. The term high-rise refers to a building or a structure which is significantly higher than the surrounding buildings providing appearance of a tall building. Building construction is a field which is directly linked to the economy and safety of human beings therefore; optimization in the form of investment along with safety is becoming a necessity thereby increasing challenges in the construction day by day. When we go any high rise structure, many structural problems arises, such as lateral load effect, lateral displacement and stiffness etc. Wind and earth quake loads are the most predominant of all other forces. In some areas the wind load is dominant while in others earthquake load may be critical. It depends upon the location and zone factor defined by codes. Therefore before going for design and construction of any high rise buildings one should have all the required knowledge of various loads and its effect on buildings.

Structural analysis is a field which mainly focuses on finding out the behaviour of a structure under some response. Properly designed structures ensure long- term safety and serviceability to structures along with strength. Nowadays, the design philosophy is also changing as complex geometries are being utilized. Therefore, structural engineers should possess required skills and sound knowledge. Such, complicated geometries require time taking and cumbersome calculations using conventional manual methods. Use of computer-based software programs available in the market has revolutionized design strategies to handle such challenges more efficiently in analysis and design of multi-storied building using computer analysis software's such as STAAD, ETABS and SAP 2000 etc. with great ease. The analysis and design procedures followed in STAAD.Pro and ETABS are Limit State based conforming to Indian Standard Code of Practice. These software's make the analysis & design process easier and less time consuming compared to manual calculations. It is possible to consider all possible load types and various geometric configurations. Both software's are primarily based totally on Finite Element Modelling and all modern Indian and different codes are included in them accordingly preserving the desired requirements of safety and serviceability.

In this study, seismic and wind analysis is performed on a typical Basement+G+8 residential building using structural analysis software's such as STAAD and ETABS. The objective of this study is to model a structure and apply wind and seismic loads loadings as per the Indian Codes such as IS-875:2015 {part 3} and IS-1893:2016 and compare the analysis results of the structure such as shear forces, bending moments, deflections etc. using STAAD and ETABS.

II. LITERATURE REVIEW

Manikanta and Venkateswarlu (2016), evaluated the design results using STAAD PRO and ETABS for a rectangular RCC building, for both regular and irregular plan configuration and compared the results. They aim was to derive advantages of using ETABS over current practices of STAAD PRO versions. It was stated that compared to STAAD PRO, ETABS is more user friendly, accurate, compatible for analysing design results.

Lallotra and Singhal (2017), designed basic structural elements of RCC structure using popularly used software's such as STAAD Pro, ETABS and SAP-2000 and compared the analysis results. Also, the design results were verified with manual calculations as per Indian standards. Results were found to differ by great extents for all the elements obtained from software when compared to the results obtained using manual calculations. Moments values obtained from STAAD Pro and ETABS were lower. The area of steel obtained from ETABS and SAP-2000 is was matching to the theoretical value of steel in case of portal frame but the steel results given by STAAD Pro are on lower side as recommended by I.S. codes. All these software's such as STAAD Pro, ETABS and SAP-2000 provides good approximation of the results for bending moments, shear forces, axial forces when compared to independent results designed manually for the same problem.

Firoj and Singh (2018), analyzed a G+10 storied building for the response spectrum method using three different computer software i.e. ETABS, STAD PRO and SAP2000. They evaluated the displacements of joints, axial forces, time period and mass participating factors. The design response spectrum curve suggested by the IS: 1893 Part-1 for seismic design is utilized to perform the dynamic analysis. It was observed that the considered building is stiff for earthquake excitation as modal mass participation factor was found to be quite 75 percent. From the response spectra study on multi-storey irregular building, it is observed that the dynamic analysis should be performed for high rise structure with vertical irregularities having height above 40 m. As the modal mass participating factor is more than 75% in the higher mode, the considered structure is stiff for earthquake excitation.

Kamble and Awchat (2018), conducted a study to analyze the high- rise (G +20 storied) building (3-D frame) using STAAD.Pro and ETABS designing software. This study consists of dynamic analysis (response spectrum) of RC building with shear wall to determine seismic behaviour of the structure and checking response of building system with long column in key plan. Seismic response of the structures was investigated under earthquake excitation which was expressed in the form of member forces and joint displacements. Test results of this study such as base shear, story drift and modal mass participation are calculated to get effective lateral load resisting system. After performing the analysis and design, results were obtained and it was concluded that STAAD-Pro and ETABS both the software's gives almost similar results, so both the software can be used for high rise modelling. It was also observed that changing the shear wall will affect the attraction of forces; as a result walls are required to be placed in proper position.

III. PROBLEM DETAILS

In this study a RCC framed structure of 31.88m in height is studied. The building is located in Goa, India. The various parameters considered in this study for the analysis and design of said structure is presented below in a tabular form.

Density of concrete	25 kN/m^3
Density of steel	7.85 KN/m^3
Grade of concrete	M30
Grade of steel	Fe550
Basic wind speed	39 m/s
Type of construction	RC framed structure
Total number of stories	7 nos.
Location	Goa
Seismic zone	III
Importance factor	1.5
Soil type	Medium (type II)
Response reduction factor	5 (SMRF)

Table.1 General details of structure

Section properties adopted in the model are given below.

Parameter	Values
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.2 Section properties

The different loads considered for analysis acting on this structure are given below.

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.3 Load details

In the present study, modelling of structure is done using Staad pro and Etabs as shown in Figure 1, Figure 2, Figure 3 and Figure 4 respectively. Comparison is done among the bending moments, shear forces and lateral deflections due to wind and earthquake in both the directions. All the supports of the building are assumed as fixed at the base. Figure 1, Figure 2, Figure 3 and Figure 4 shows the Plan view from STAAD, Rendered image from STAAD, Plan view from ETABS and rendered image from ETABS respectively.

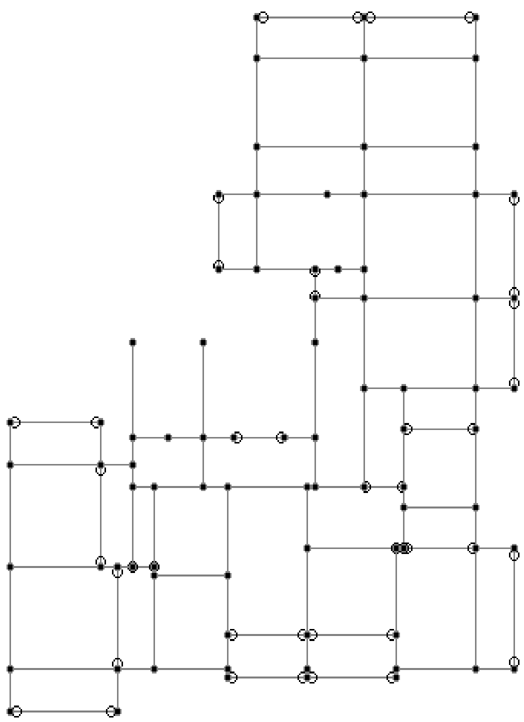

Figure 1: Plan view from STAAD

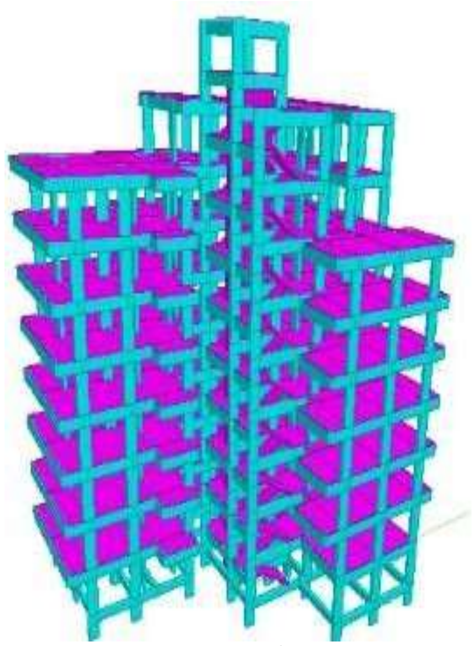

Figure 2: Rendered image from STAAD

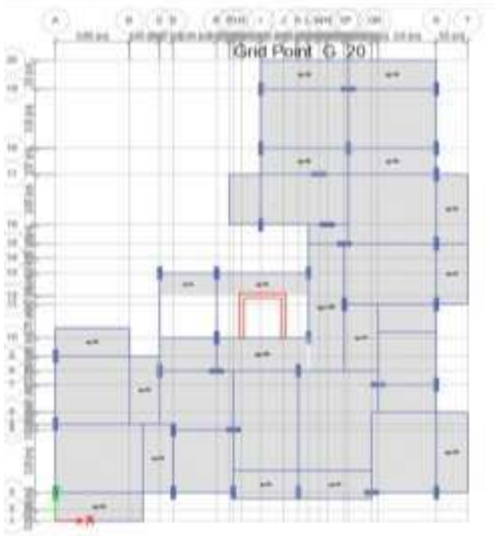

Figure 3: Plan view from ETABS

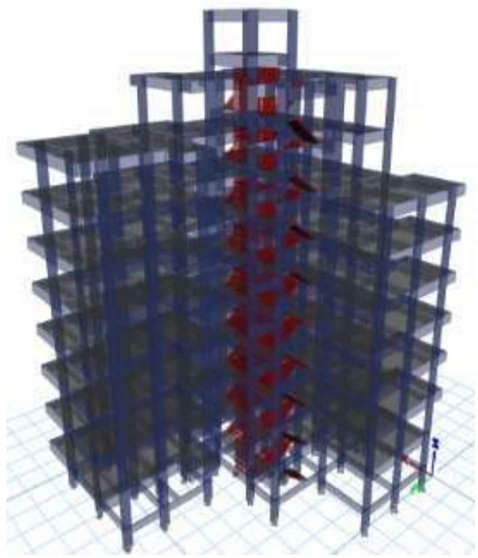

Figure 4: Rendered image from ETABS

IV. RESULTS & DISCUSSIONS

The structures are analyzed in both the software's simultaneously and the results are presented below in the form of charts and graphs. Figure 5 shows the comparison of axial forces under 1.5*(DL+LL) with respect to different columns in Staad Pro and Etabs. Here, X axis represents column numbers and Y axis represents axial force in KN.

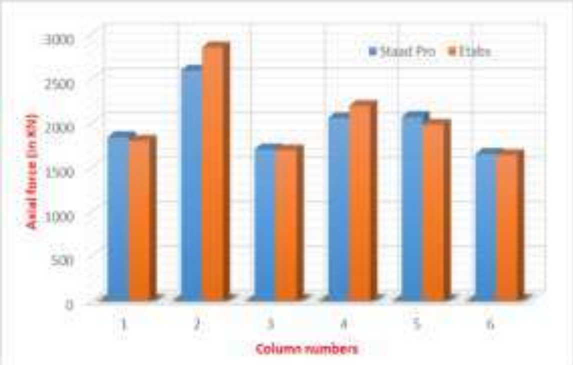

Figure 5: Comparison of axial force under 1.5*(DL+LL) load combination between STAAD and ETABS

Figure 6 shows the comparison of shear forces under 1.5*(DL+LL) with respect to different columns in Staad Pro and Etabs. X axis represents column numbers and Y axis represents shear forces in KN.

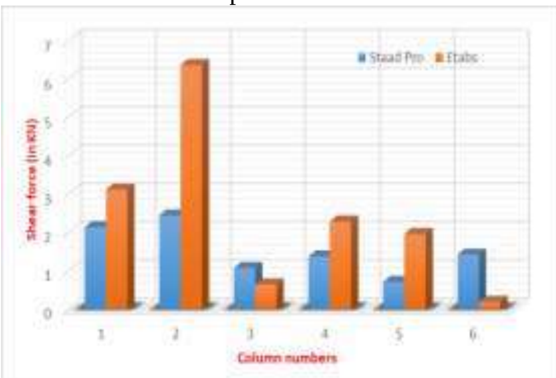

Figure 6: Comparison of shear force under 1.5*(DL+LL) load combination between STAAD and ETABS

Figure 7 shows the comparison of bending moments under 1.5*(DL+LL) with respect to different columns in Staad Pro and Etabs. X axis represents column numbers and Y axis represents bending moments in KNm.

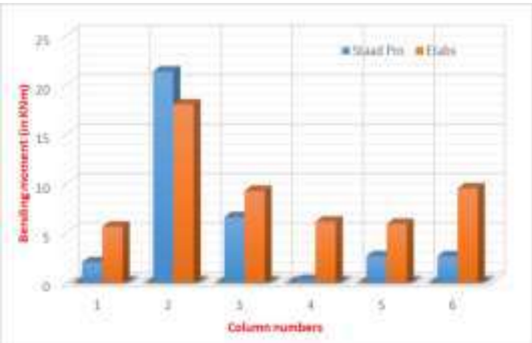

Figure 7: Comparison of bending moment under 1.5*(DL+LL) load combination between STAAD and ETABS

Figure 8 and Figure 9 shows the deflected shape of the structure in STAAD and Etabs under lateral wind load in X-direction and lateral earthquake load in X-direction respectively.

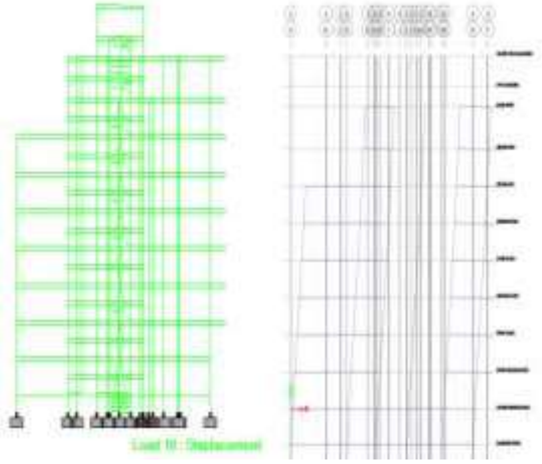

Figure 8: Deflection pattern of the models (left one is for STAAD and right one is for ETABS) under wind load in X-direction

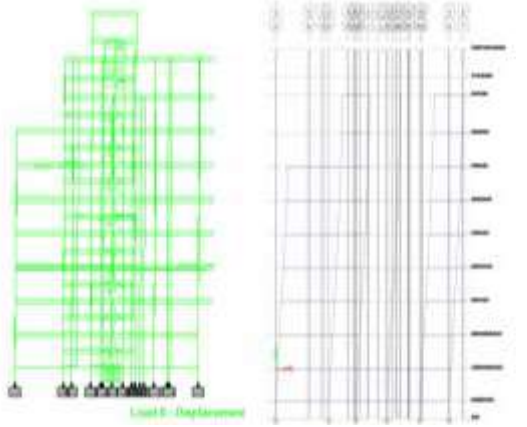

Figure 9: Deflection pattern of the models (left one is for STAAD and right one is for ETABS) under seismic load in X-direction

Figure 10 and Figure 11 shows the comparison of lateral displacements under earthquake loads in X-direction and Y-direction respectively between STAAD and ETABS. X axis represents storey levels and Y axis represents lateral storey displacements in mm.

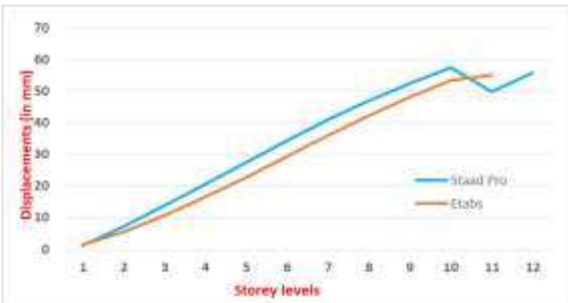

Figure 10: Comparison of lateral displacements under earthquake loads in X-direction between STAAD and ETABS

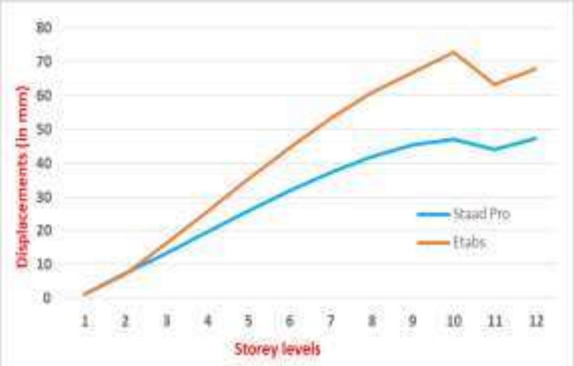

Figure 11: Comparison of lateral displacements under earthquake loads in Y-direction between STAAD and ETABS

V. CONCLUSION

The results obtained from this study are presented in a graphical form for comparing the results obtained from both the software's. Following points can be derived from the results.

1) Nowadays, high-rise construction is the most commonly adopted construction practice due to growing urbanization, scarcity of land faced by the people and advanced construction techniques introduced in the market day by day. Therefore, safety of people residing there and serviceability of the structure are of prime importance. Also, there is a need to reduce its overall cost to achieve more economy and efficiency.
2) Prior to considering the design and construction of any high-rise structure, one should have thorough knowledge about all the possible loads that are likely to act on the structure in the future and also the possible effects of natural hazards which may harm the structure in the future run. Earthquake & wind are the predominant of all the natural forces which are likely to cause destruction worldwide. Therefore, seismic and wind analysis of any structure is a must. The structure designed for all such forces should fulfill all the basic aspects of safety and serviceability.
3) In the present study, Figure 5, Figure 6 and Figure 7 shows the comparison of axial forces, shear forces and bending moments under 1.5*(DL+LL) with respect to different columns in Staad Pro and Etabs. Results from both the software's are in close proximity to each other with minor variations in some values of forces and bending moments. This signifies the model is geometrically fit for analysis.
4) Figure 8 and Figure 9 shows the deflected shape of the building under wind and earthquake load in X-direction which follows similar trend for both the software's.
5) Figure 10 and Figure 11 shows the comparison of lateral displacements under earthquake loads in X-direction and Y-direction respectively between STAAD and ETABS. It is observed that the deflections are within permissible limits of H/250. This indicates the structure is safe for lateral displacements caused due to earthquake loads. The values obtained for lateral displacements from both the software's are in close proximity to each other.
6) Provision of shear wall in the model helped to greatly absorb the utmost amount of lateral loads and transfer them to the bottom thus reducing total lateral deflections. These results in lower values of base shear developed in remaining column supports. This is very much important in terms of design criteria, because lesser the values of horizontal reactions developed due to lateral loads, lesser will be the amount of developed bending moment in columns. Therefore, the reinforcement requirement will also be less, which ultimately will make the whole structure economical.
7) Further detailed studies on wind and seismic analysis are in progress.

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