# Analysis of a Six Storey Steel Frame Structure using AutodeskRevit, Staadpro and SAP2000

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***Abstract* - In this present century, greater aesthetics values and limited land space have been possible because of tall buildings. However,these tall buildings demands high frame structure stability for safety purpose and design purpose. This paper presents a modelling and design example of a six (6) storey steel structure under a wind force using three (3) different software for analysis. These softwares include Autodesk Revit for modelling, while Staadpro and SAP2000 were used for analysis. The purpose of the softwares was to evaluate wind load on the multistory steel structure. In the end the results offered by the SAP2000 analysis offered the least deflection of 0.29mm as against Staad pro and manual calculations of 0.33mm and 0.31mm respectively. Also the bending moment obtained for the SAP2000 analysis was the least 19.58kNm as against 23.5kNm obtained from the StaadPro**

***Keywords - Steel; Wind load; Software; shear force; Bending moment*.**

## I. INTRODUCTION

A structure or a building has to perform many functions adequately. Some of these functions includes; the utility of the building for the intended use, fire safety, structural safety, compliance with hygienic, ventilation and daylight standards. Loading codes covers the minimum requirements pertaining to the structural safety of structures by way of laying down minimum design loads which have to be assumed for wind loads, imposed loads, dead loads, and other various external loads the structure would bear. Complying with loading standards will ensure the structural safety of the buildings and structures, decrease the risk to property and life caused by unsafe structures and also decrease the wastage caused by unnecessarily heavy loadings without proper evaluation (Prem et al., 2013).

According to Shamshinar et al. (2013), Stability is very important in tall building because it is made of structural frames with varying width and height. Building will be unstable and likely collapse if inadequate of lateral support. To achieve lateral support and stability in buildings and structures, either shear system or bracing system or both such as wall to ensure the stability and durability of the building. Also, software to be used in analysis of tall building or structural and wind speed on construction area to avoid collapse in future are to be considered.

Steel framing in structure is code approved to improve limitations that are faced these days when using traditional building materials. The durability and strength of structural steel make it the ideal material for construction in seismic and high wind speed zones. Some benefits of steel structure includes over traditional building materials includes its ease to modify and reinforce if architectural changes are made to a facility over its life, incredibly versatile and can be formed into various shapes, lightweight and can reduce foundation, durability, long-lasting and recyclable, makes construction faster because its quick and easy to erectand environmental friendly.

## II. LITERATURE REVIEW

Mills (1999) stated that Engineers realized that tall buildings can be affect by wind. When designing the Eiffel Tower, French structural engineer Alexandre Gustave Eiffel recognized the effects of wind on the structure. The Eiffel Tower at 986 feet was the tallest structure in the whole world between 1889 and 1931until it was later exceeded by the Empire State Building. In the design of the Eiffel Tower the base pylons curve was accurately calculated for an assumed wind loading distribution so that the shearing force and the bending of the wind were progressively transformed into forces of compression, which the bents could withstand more effectively.

According to (Prem et al., 2013), Wind can be defined as air in motion relative to the surface of the earth. Difference in terrestrial radiation and earth's rotation are the primary cause of wind. The radiation effects are responsible for convection current both upwards and downwards. The wind usually blows at high speed horizontally to the ground. The speed of wind is measured with the aid anemographs or anemometers which are installed at meteorological observatories at heights generally ranging from 10 to 30 meters above ground.

Base on investigation by Shamshinar et al. (2013), recommendation was made to consider the wind load and the area to construct tall building which able to decrease the effect of wind that may affect the building and increases the sway values. A threshold restriction of wind speed is important to make sure the building is safe and secure prior use.

The action of wind on structures and buildings as well as wind induced dynamic response are taken care of by means of random modal analysis and vibration theory. Gust Factor Technique is one of the widely used analytical methods to evaluate the wind induced dynamic response. In the design codes and standards, results of analytical and experimental research have been incorporated (Ileana, 2013).

## III. METHODOLOGY

The methodology used to achieve this paper is broad due to different softwares and design used. Firstly, a six (6) storey steel structure was modelled on Autodesk revit which was exported to staadpro for analysis. Secondly, same plan was used to modelled and analysed on SAP2000. And finally, a manual design of a continuous steel beam taken from the models was done which was further compared to the results gotten from the softwares.

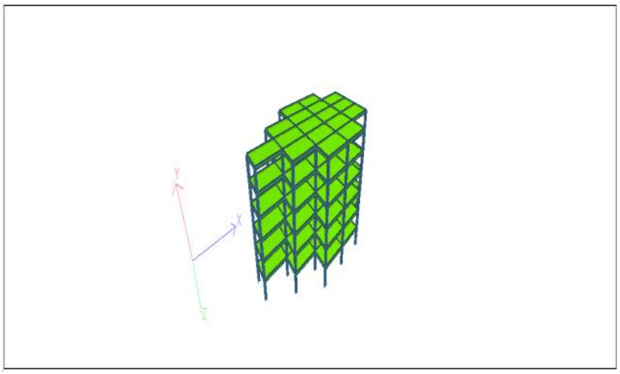

*Fig.1: 3D Rendered View*

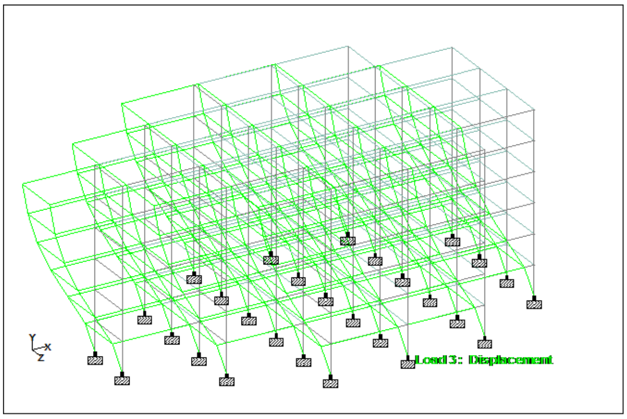

*Fig. 2: Deflection Due to Wind in -Ve X DIRECTION*

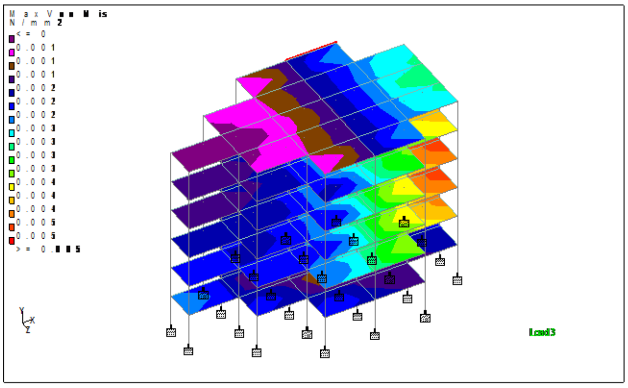

*Fig. 3: Stresses On Slab Members*

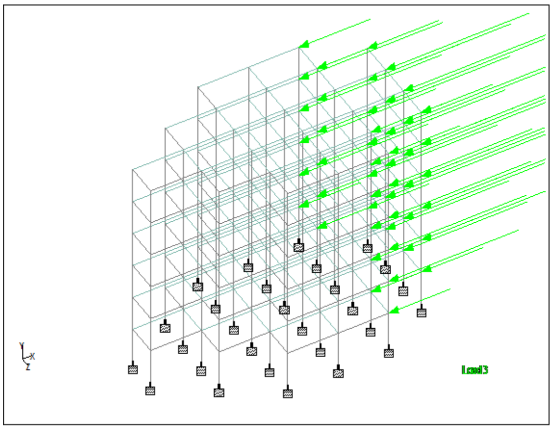

*Fig. 4: Whole Structure WL -VE X*

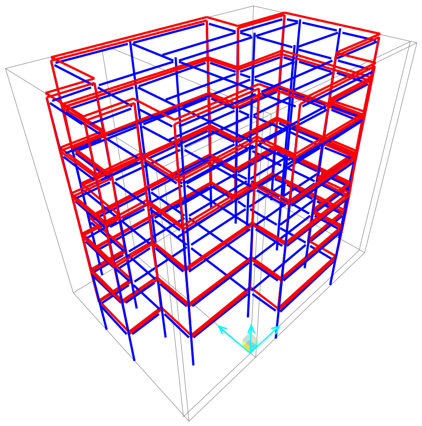

*Fig. 5: Finite element model*

The Manual calculation of a single span of 6.5m beam

LIVE load =2kN/m
DEAD load= 5kN/m
Designed UDL for Beam (1.4 x 5) + (1.6 x 2)
7 + 3.2 = 10.2kN/m

Both beams having an equal span of 6.5m

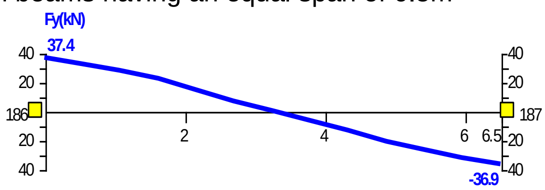


*Fig. 6: The shear force diagram is ahow for all the spans analyzed together at once using the Staad Pro software.*

Now for the Manual calculations of just a span of 6.5m the following results were obtained for the shear force.

The vertical reaction at point A $V_A = \frac{10.2\times6.5}{2}$=33.15kN

The vertical reaction at point B $V_B = \frac{10.2\times6.5}{2}$=33.15kN

The Bending Moment

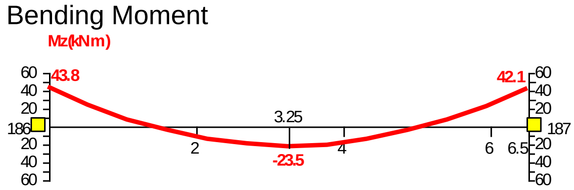


*Fig. 7: The bending moment diagram for all the spans analyzed at once using staad pro.*

Now taking just a span for the manual calculations we have. The maximum bending moment occurs at the point of zero shear This is given as $\frac{wl^2}{8}$

For beam $\frac{10.2\ X\ 6.5^2}{8}$ =53.87kNm

The compression flange is fully restrained and assumed low shear

Beam section UB 457 X 152 X 67 is tried
SECTION PROPERTIES
D=458.0m B=153.8mm A 8560mm$^2$
t=9.0mm d=407.6mm $r_x$=18.9mm
$R_y$= 1.97mm Sx=1453 x10$^3$mm$^3$ $Z_X$=1263 x10$^3$ mm3 d/t = 45.29 b/t = 6.5 T =15.0mm

Flange thickness *t* □□16 mm ∴□*py* = 275 N/mm2

Section classification

$$\varepsilon = \left(\frac{275}{py}\right)^{0.5} = 1.0$$

Flange: Compression due to bending
*b*/t = 6.5 < 9.0**ε**

Web: Neutral axis at mid-depth (i.e. bending only) d/t = 45.29 < 64ε Clause 4.2.3 < 70ε therefore no need to check shear buckling
Shear:
Clause 4.2.3 Design shear force Fv = 33.15 kN
Pv = (0.6pyAv) = [(0.6pytD)
Pv = [(0.6 x 275 x 9.0 ×458)/1000 = 680.13 kN
Pv >> 33.15 Hence section is adequate

Check for defelection $\frac{PL^3}{48EI}$

$$\frac{66.3 \times 10^3 \times (6.5\times1000)^3}{48 \times 210\times10^5 \times 5810 \times 10^4}$$

0.31mm
Bending:
60% Pv = 0.6 x 680.13 = 408.1
Mc ≤ 1.2Py Zx for simply supported beams= (1.2 x 275 ×1263 x 10$^3$)/ 10^6= 416.79 kNm
Mc = py Sx = (275 x 1453 x 1000)/10^6 = 399.58 kNm
Maximum applied moment = Mx = 26.4 kNm and 48.06 respectively.
Mc > Mx

From the analysis of the six storey building using SAP and StaadPro the software analysis were compared with the manual calculations for the shear force and bending moment in order to verify the suitability of the sections of the beam to withstand the applied load on the structure. From the manual calculations and the results obtained from the software used the results are shown in the table below.
The manual calculations done involved taken just a section of the beam and the results obtained for the deflections, bending moment and the shear force is shown in the table above. For the software analysis the whole span of the beam was analysed at once i.e. the span of the beam over all the supports. Now comparing the results of the analysis done by SAP2000 and Staad Pro we obtained higher values for the shear force deflection and bending moment.
In all the method of analysis used the beam section was just found adequate to withstand the applied load. However to be on a safer side the results obtained from the analysis using SAP2000 gave us

the least deflection. This should therefore be preferred above others in the execution of the building project

Table 1 comparing the results of the software analysis and that of the manual analysis

| | **Software Calculations** | | **Manual Calculations** |
|---|---|---|---|
| | **Staadpro** | **SAP2000** | |
| **SHEAR FORCE(kN)** | 37.1 | 34.30 | 33.I5 |
| **BENDING MOMENT(kNm)** | 23.5 | 19.58 | 53.87 |
| **DEFLECTIONS(mm)** | 0.33 | 0.29 | 0.31 |

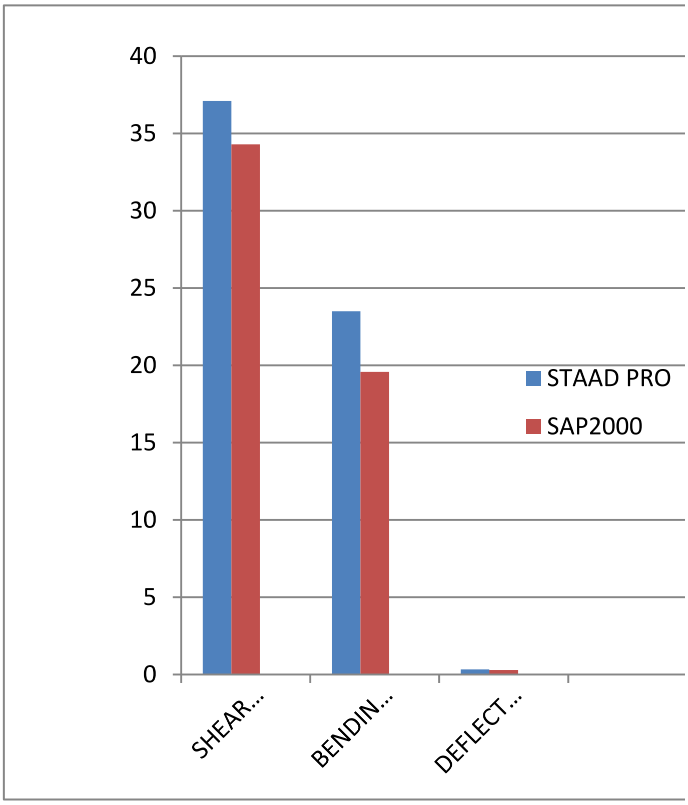


Fig. 8: showing the comparison of the analysis of the StaadPro and SAP2000

IV. CONCLUSIONS

From the results obtained we could see that deflections due to the applied load is lesser using the analysis offered by SAP2000.

The section can be reduced for economy considerations although this will increase the deflections but the structure will still perform well in service.

V. RECOMMENDATIONS

The beam sections should be reduced has the design analysis obtained from the manual calculations showed that the section chosen is still much and it is not economical.

V. REFERENCES

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