Comparative Study on Analysis of G+2 Residential Building by STAAD.Pro V8i(SELECT series 5) and ETABS 2018 Software's

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Abstract – *In this paper, analysis and design of G+2 Residential building is presented in STAAD and ETABS software's. STAAD and ETABS are renowned software's which are extensively used in the field of structural designing for analyzing and designing simple and complex structures for a wide range of loading conditions including gravity loads such as dead and live loads to lateral loads such as seismic and wind loads. The analysis is done using limit state method and design of the members of the structure is done as per the guidelines of IS:456 - 2000. The loading and load combinations for design are considered as per IS:875 (Part 1, 2 and 5), seismic forces were taken as per IS:1893-2016. Vertical loads on supports, responses (deflection, axial force, shear force and bending moment) are compared for column and beam members obtained from both the software's.*

Key Words: **AutoCAD, STAAD, ETABS, slope deflection, moment distribution method.**

1.0 INTRODUCTION

Civil Engineering is a branch of engineering sciences which is related to the design, construction, and maintenance of buildings, bridges, tunnels, highways etc. with the help of laws of physics, mathematical equations and theories of mechanics. The term structure analysis refers to the prediction of the response of structures to the external loads applied on them. During the preliminary stages of design the loads that are being applied on the structure are estimated and the size and the reinforcement to be used for the various members are calculated using the estimated external loads. Structure analysis develops a relationship between these external loads applied on the members and the internal forces and displacements generated within the members to counter-balance these external loads when in service.

A structure consists of various individual members which are interconnected with each other to form a network. The main members in a structure are as follows:

1. Beams
2. Columns
3. Frames
4. Trusses

Proper designing of the members is important to ensure the safety and serviceability requirements given as per the provision of IS:456- 2000. A structural engineer has the task to correctly estimate the external loads generated on the structure which includes the dead, live, wind and seismic loads. The design forces generated in the structure helps the engineer to design the members ensuring an adequate section and proper reinforcement. The engineer also has to keep in mind the economy of the structure as the resources available are limited.

With the help of STAAD and ETABS software's the modelling and the designing process has become very time efficient where the entire structure can be modelled and designed using different methods of analysis in a matter of hours contrary to earlier times when the same job took weeks or even months to complete.

1.1 OBJECTIVES

1. Analysis and designing of a G+2 residential building by STAAD and ETABS.
2. Comparison of vertical loads on supports and responses (deflection, axial force, shear force and bending moment) obtained from the two software's.

1.2 METHODS OF ANALYSIS

- **Slope deflection method**

The slope deflection method is a structural analysis method used for the analysis of continuous beams and plane rigid frames developed by Axel Bendixon in 1914. By forming slope deflection equations and applying joint and shear equations the rotation angles are obtained which are back substituted in the slope deflection equations to obtain the end moments of the members. The further development and generalization of the method resulted in a more refined method called "stiffness matrix method" which is suited for computer analysis of all the skeletal structures.

- **Moment distribution method**

The moment distribution method is used for the analysis of statically indeterminate beams and frames developed by Hardy Cross in 1930. In the method every joint of the structure to be analyzed is fixed to generate fixed end moments and then are sequentially released and the fixed end moments are distributed to the adjacent members until equilibrium is achieved.

1.3 CRITIQUE OF SOFTWARE'S

- **AutoCAD**

AutoCAD is a commercial computer-aided design (CAD) and drafting software application developed and marketed by Autodesk. AutoCAD is used in the industry by architects, project managers, engineers, graphic designers, city planners and other professionals. AutoCAD is used as a preliminary software to draft out the drawings (plans, elevations, cross sectional drawings etc.), various inbuilt features of the software are used to obtain greater accuracy during the modelling stages in both STAAD and ETABS.

- **STAAD.Pro V8i (SELECT series 5)**

STAAD is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, research Engineers International was brought by Bentley systems. It can make use of various forms of analysis from the traditional static analysis to more recent p-delta analysis. It supports over 90 international steel, concrete, timber and aluminum design codes. STAAD can further be used to initiate advanced concrete design, advanced slab design, steel design as per the respective codes.

- **ETABS 2018**

ETABS is an engineering software product developed by Computers and Structures, Inc. (CSI); a Berkeley, California based engineering software company founded in 1975. It caters to multi-story building analysis and design using a grid like geometry unique to this class of structure. It is highly acclaimed for static and dynamic analysis of multi-story frames and shear wall buildings. It automatically generates the self weight of the slab and other members unlike from STAAD where we have to manually apply floor loads for the slabs. ETABS can be used to design steel frames, concrete frames, composite beams and columns and shear walls as well.

1.4 LITERATURE REVIEW

Mohammad Kalim, Abdul Rehman, B S Tyagi (2018):
A comparative study on analysis of a G+14 building by STAAD and EATBS. They concluded for a G+14 building the axial forces obtained were same in both the cases, also the obtained economical sections in both software's however ETABS gave a lesser amount of steel reinforcement as compared to that obtained in STAAD.

K Venu Manikanta, Dr. Dumpa Venkateswarlu (2016):
They did a comparative study on the design results of a multi-storied building using STAAD and ETABS for regular and irregular plan configuration, at the end of the study they compared the maximum vertical reactions for the two software's which are almost equal however STAAD computed a higher value.

Sayeed Ur Rahman, Dr. Sabih Ahmad (2019):
Proposed a comparative study on dynamic analysis of a multi-story building by STAAD and ETABS. They found the results obtained in both the software's to be approximately same also the study concluded that ETABS is a more user friendly, accurate, more compatible and less time consuming as compared to its counterpart.

Shubham Srivastava, Mohd. Zain, Vineet Pathak (2018):
They did an analysis on a multi-story building (G+7) due to seismic loading in ETABS and compared the results with those obtained using STAAD. The study was briefly done and the bending moment values for each floor showed higher values in case of STAAD and therefore ETABS gave lesser values for displacement since the bending moment for the overall structure was less.

2.0 MODELLING OF THE STRUCTURE

2.1 ARCHITECTURAL DRAWING

An architectural drawing is a technical drawing of a building that falls within the definition of architecture. The drawing helps the engineers to identify the architectural details such rooms, lobbies, staircases, kitchen, thickness of walls balconies, water closet etc.

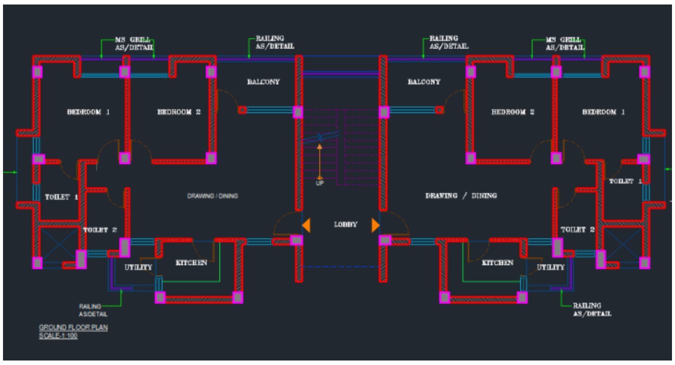

Fig-2.1 Typical Floor Architectural Drawing

2.2 RCC FRAMED STRUCTURE

A RCC framed structure was adopted for this building which is basically a network of interconnected structural members such as slabs, beams and columns. RCC structure is a composite structure made from concrete and steel reinforcement, since concrete is weak in tension hence steel reinforcement in concrete helps to improve the tensile strength of concrete. The load transfer takes place from the

slabs to the beams, from the beams to the column, from the columns to the foundation and finally to the soil.
There are various advantages of using RCC as a building material:

a) It has high compressive strength as compared to other materials.
b) The steel reinforcement provides a high tensile strength as well.
c) It is a good fire and weather resistant structural member.
d) RCC structures are much more durable.
e) The maintenance cost of a RCC structure is low.
f) It acts like a rigid member with minimum deflection.
g) It is also an economical construction material.

2.3 PLAN, ELEVATION AND 3-DIMENSIONAL VIEW

Plan
A plan is a top view of a building or object, it is the most important drawing showing how the area has been utilized. The plan area for the structure is 22.75m X 8.95m.

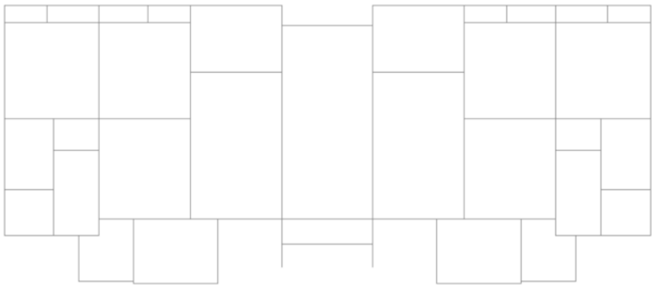

Fig-2.2 Plan of G+2 Structure in STAAD

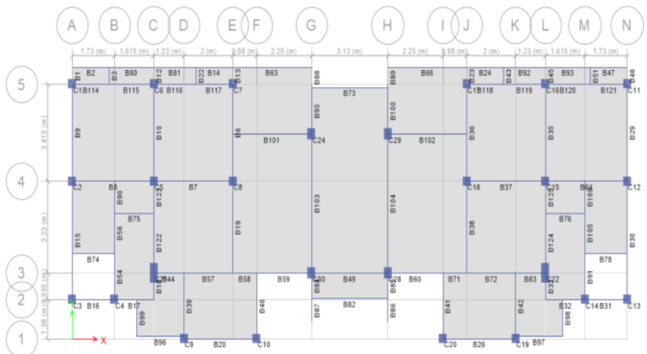

Fig-2.3 Plan of G+2 Structure in ETABS

Elevation
An elevation is an orthographic projection drawing that shows one side of the building.. For the structure the height of typical floor is 3.15m, the plinth height is 2m and the height of the mumty is 3m.

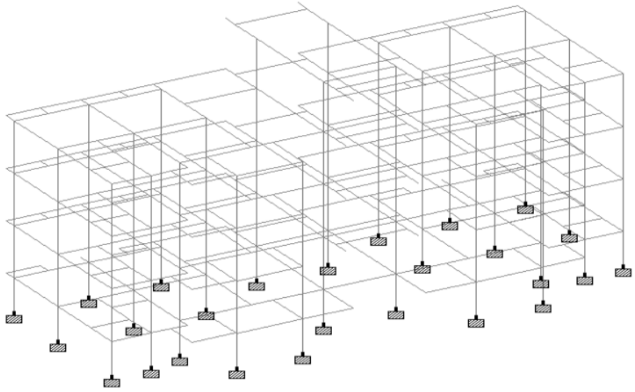

Fig-2.4 Typical Elevation of the Structure

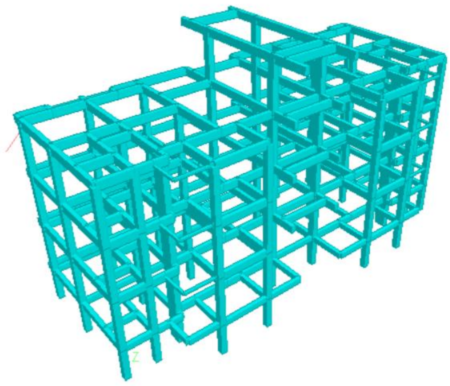

Fig-2.5 3-Dimensional View in STAAD

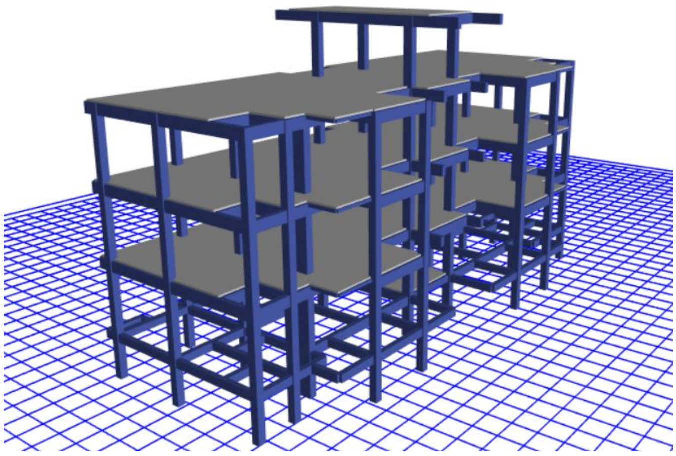

Fig-2.6 3-Dimensional View in ETABS

2.4 PRELIMINARY DATA

- **DEAD LOAD**
  Dead load on the structure are taken from IS:875 (part 1)

Concrete grade used : M25
Steel grade used : Fe 500
Density of concrete : 25kN/ m^2
Density of infill : 2kN/m^2
Density of floor finish : 22kN/m^2
Floor load : 4.35kN/m^2
Staircase load : 8.3kN/m^2
Sunk load (450mm thick) : 9kN/m^2
Wall load (230mm thick) : 13.5kN/m
Wall load (115mm thick) : 7.5kN/m
Parapet wall load : 5kN/m
For railings : 1.6kN/m

- **LIVE LOAD**
  Live load on the structure are taken from IS:875 (part 2)

  Live load on floors : 2kN/m^2
  Live load on staircase and Balcony : 3kN/m^2
  Live load on terrace level : 1.5kN/m^2
  Live load on mumty : 0.75kN/m^2

- **SEISMIC LOAD**
  Seismic load on the structure are taken from IS:1893 (part 1)

  special RC moment resisting frame fixed at base
  Seismic zone : IV
  Z : 0.24
  I : 1.0
  R : 5
  Sa/g curve : as per spectrum
  Time period : $0.09h/(d)^{0.5}$
  Damping of structure : 5%
  Ah : Z I Sa/(2gR)

2.5 MEMBER PROPERTY AND DEAD LOADS

- Beams
  B2- 0.45m X 0.23m
  B3- 0.35m X 0.23m
- Columns
  C1- 0.32m X 0.32m
  C2- 0.32m X 0.40m
  C3- 0.32m X 0.71m
- Slabs
  S1- 125mm thick
  S2- 150mm thick(for staircase)

2.6 LOAD COMBINATIONS

The load combinations were taken as per IS:456 and IS:875(part 5). The load combinations are given below:

1. 1.5(DL + LL)
2. 1.2(DL + LL + ELX)
3. 1.2(DL + LL - ELX)
4. 1.2(DL + LL + ELZ)
5. 1.2(DL + LL - ELZ)
6. 1.5(DL + ELX)
7. 1.5(DL – ELX)
8. 1.5(DL + ELZ)
9. 1.5(DL – ELZ)
10. 0.9 DL + 1.5 ELX
11. 0.9 DL – 1.5 ELX
12. 0.9 DL + 1.5 ELZ
13. 0.9 DL – 1.5ELZ

DL- Dead load.
LL- Live load.
ELX- Earthquake load in X direction.
ELZ- Earthquake load in Z direction.

3.0 RESULTS AND DISCUSSION

The comparison of the all the given responses has been done for one frame in both the software's.

3.1 COMPARISON OF DISPLACEMENT AND AXIAL FORCE FOR COLUMNS A4, C4 AND E4

Table 3.1.1: Comparison of Displacement on Top Floor

COLUMN NAME (FROM GRIDS)	DISPLACEMENT (STAAD) in mm	DISPLACEMENT (ETABS) in mm
A4	6.71	6.05
C4	7.30	6.05
E4	8.19	6.05

Table 3.1.2: Comparison of Axial Force on Each Floor

FLOOR LEVEL	STAAD AXIAL FORCE(kN)	ETABS AXIAL FORCE(kN)
COLUMN A4		
BASE	774.1	780.6
PLINTH	624.9	629.9
1^{ST}	378.6	381.1
2^{ND}	133.5	133.9
COLUMN C4		
BASE	863.1	855.9
PLINTH	738.1	728.5
1^{ST}	462.3	454.5
2^{ND}	194.1	188.5
COLUMN E4		
BASE	689.7	733.6
PLINTH	614.0	648.8
1^{ST}	403.0	422.7
2^{ND}	193.8	198.4

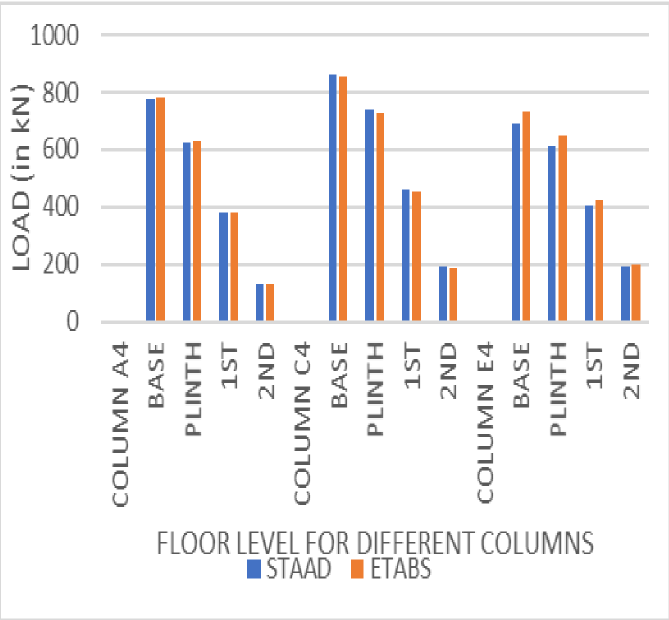

Chart 3.1 Comparison of Loads on Columns on Each Floor

3.2 COMPARISON OF SHEAR FORCE AND BENDING MOMENT OF BEAMS RESTING ON COLUMNS A4, C4 AND E4

Table 3.2.1 Shear Force and Bending Moment at Different Floor Levels

FLOOR LEVEL	REACTION IN STAAD		REACTION IN ETABS	
	SHEAR FORCE (kN)	BENDING MOMENT (kN-m)	SHEAR FORCE (kN)	BENDING MOMENT (kN-m)
PLINTH	46.5	30.2	45.3	31.5
1ST	93.3	65.7	90.4	66.4
2ND	94.9	67.2	88.8	66.8
TERRACE	46.5	33.2	44.5	32.9

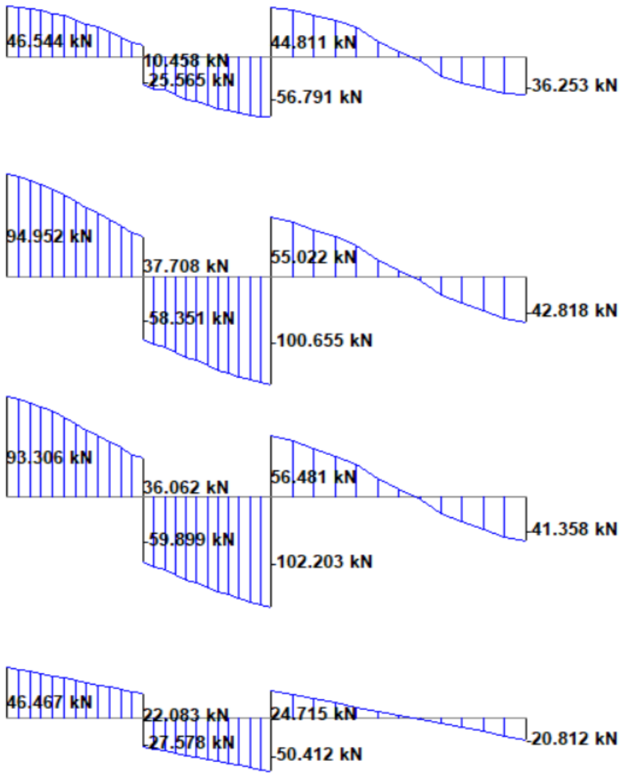

Fig- 3.1 Shear Force Diagrams for the Beam at Different Floor Levels as per STAAD

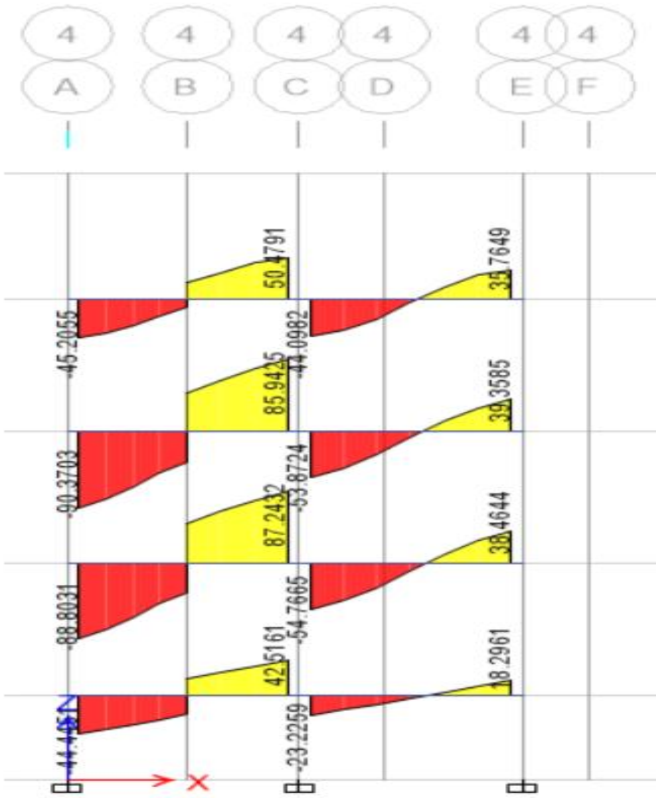

Fig-3.2 Shear Force Diagrams for the Beam at Different Floor Levels as per ETABS

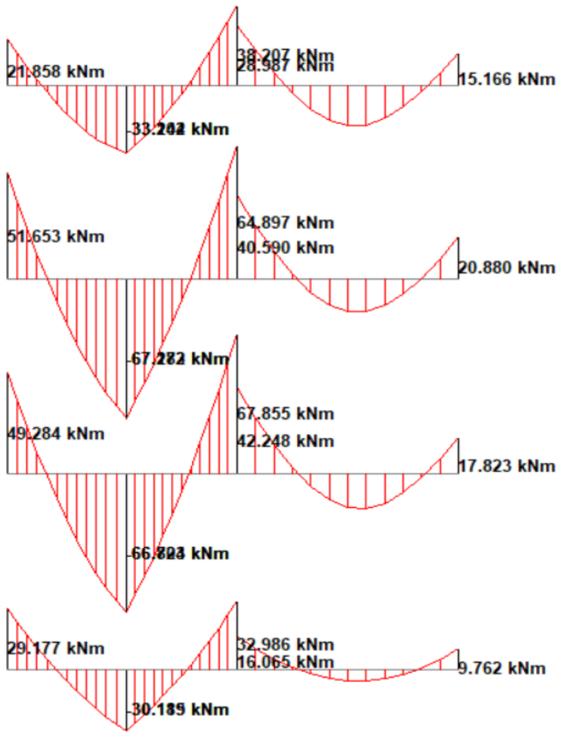

Fig-3.2 Bending Moment Diagrams for the Beam at Different Floor Levels as per STAAD

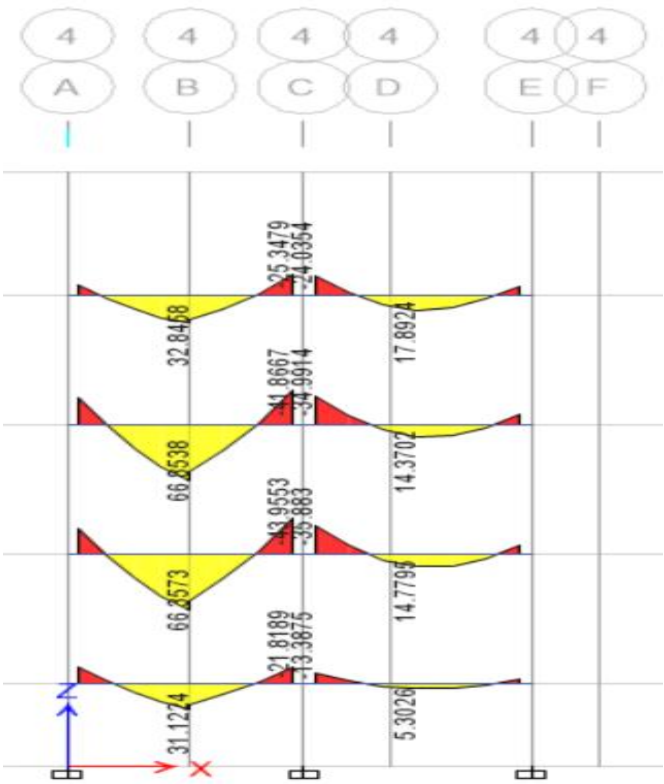

Fig-3.4 Bending Moment Diagrams for the Beam at Different Floor Levels as per ETABS

3.3 COMPARISON OF VERTICAL LOADS ON SUPPORTS

Due to the symmetry of the structure the same loads will be obtained on the other side of the symmetry plane, hence comparing the results for the left side only.

Table 3.3.1 Comparison of Vertical Loads on Supports

SUPPORT NUMBER	STAAD LOAD (in kN)	ETABS LOAD (in kN)
1	546.2	541.3
2	732.7	683.2
3	775.5	886.9
4	1454.1	1392.0
5	774.1	780.6
6	863.1	855.9
7	689.7	733.6
8	971.8	929.0
9	1264.1	1188.6
10	362.3	373.6
11	505.9	477.9
12	428.1	445.3
13	508.7	550.9

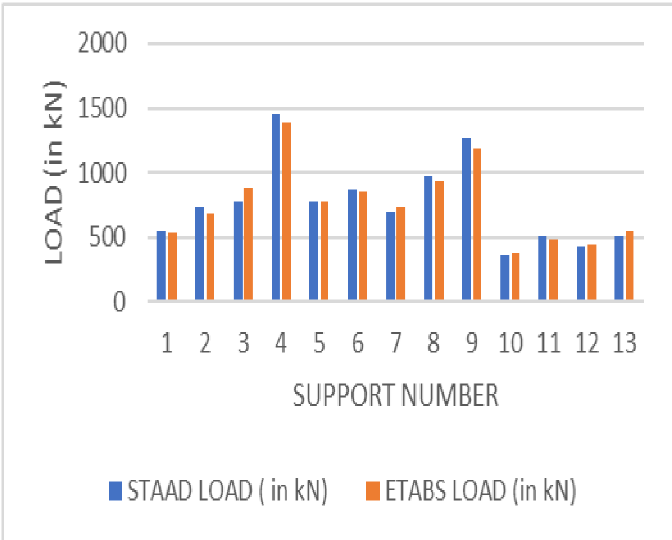

Fig-3.6 Comparison of Vertical Loads on Supports

4. CONCLUSIONS

From the analysis and design the G+2 Residential building in STAAD.Pro and ETABS software's, following conclusions have been drawn:

- The displacement shown for the columns A4, C4 and E4 in both the software's are within design limits and are approximately same.
- STAAD shows higher values for axial force for column C4 on each floor and ETABS shows

higher values for axial force for column A4 and E4.

- The maximum values for shear force and bending moment on each floor level are compared and the values were approximately same with ETABS software showing less values as compared to STAAD.
- The vertical loads on support were compared and are found to be approximately same for both the software's.
- ETABS software has a more user friendly interface and minimizes efforts.
- It is much easier to model and design the structure in ETABS also assigning the loads is much easier and less time consuming.
- Overall both the software's are very helpful in analyzing and designing of the structure.

REFERENCES

[1] Mohammad Kalim, Abdul Rehman, B S Tyagi "Comparative study on analysis and design of regular configuration of building by Staad Pro and Etabs" 5[3], 1793-1797, IRJET, March-2018.

[2] K Venu Manikanta, Dr. Dumpa Venkateswarlu "Comparative study on design results of a multi-storied building using Staad Pro and Etabs for regular and irregular plan configuration"2[15], 204-215, IJRSAE, September-2016.

[3] Sayeed ur Rahman, Dr. Sabih Ahmad "A comparative study on dynamic analysis of tall buildings using Staad Pro and Etabs"6[4], 350-358, JETIR, April- 2019.

[4] Shubham Srivastava, Mohd. Zain, Vineet Pathak "Analysis of multi-storey building (G+7) due to seismic loading using Etabs and compare its results with Staad Pro "5[7], 642-648, JETIR, July-2018.

[5] Gurudath C, Arun Kumar Sah, Manoj Kumar Sah, Ram Babu Sharma, Ramesh Sah "Analysis and design of commercial building using Etabs"5[12], 678-683, IJIRT, May-2019.

[6] Staad.Pro, Bentley Systems.

[7] Etabs Software, Integrated Building Design Software, University Avenue Berkeley California.

[8] IS:456-2000, "Code of Practice Plain And Reinforced Concrete", Bureau of Indian Standards, New Delhi.

[9] IS:875 (part 1)-2015, "Code of Practice for Design loads (other than earthquake) for buildings and structures", Bureau of Indian Standards, New Delhi.

[10] IS:875 (part 2)-2015, "Code of Practice for Design loads (other than earthquake) for buildings and structures", Bureau of Indian Standards, New Delhi.

[11] IS:875 (part 5)-2015, "Code of Practice for Design loads (other than earthquake) for buildings and structures", Indian Standard Institution, New Delhi.

[12] IS:1893 (Part 1): "Indian Standard code of practice for criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi.