COMPARISON OF COMPUTER AIDED ANALYSIS AND DESIGN OF MULTISTOREY HOSPITAL BUILDING USING ETABS 9.5 AND STAAD PRO.2005

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ABSTRACT: *STAAD Pro and ETABS are the leading design softwares in today's market. Not only it is being used in many design and consultant companies for designing purposes but also it is also being taught at different study levels. For these reasons, a good knowledge of both softwares is necessary. This paper mainly deals with the design of a Multi-storey hospital with both ETABS 9.5 and STAAD PRO .2005 and their comparison afterwards. This would include the designing of columns and beams with both softwares and the results will be compared in the end.*

Keywords*:* Structure Design, STAADPro and ETABS.

1. INTRODUCTION

A structure is an assembly of members each of which is subjected to bending or direct force (either tensile or compressive) or to a combination of bending and direct forces."

These primary influences may be accompanied by shearing forces and sometimes by torsion. Effects due to changes in temperature, shrinkage and creep of the concrete, the possibility of damage resulting from overloading, abrasion, local damage, vibration frost, chemical attack and similar causes may also have to consider. Design includes the calculations of, or other means of accessing and providing resistance against the moments, forces and other effects on the members. An efficiently design structure is one in which the members are arranged in such a way that the weight, load and forces are transmitted to the foundation by the cheapest means consistent with the intended use of structure of the site. Efficient design means more than providing suitable sizes for the concrete members and the provisions of the calculated amount of reinforcement in the economical manners.

The application of loads to a structure causes the structure to deform. Because of the deformation, various forces are produced in the components that comprise the structure. Calculating the magnitude of these forces, and the deformations that caused them is referred to as structural analysis, which is an extremely important topic to society. Indeed, almost every branch of technology becomes involved at some time or another with questions concerning the strength and deformation of structural system.

The structural design of a project can usually be broken down into the following four steps:

- Selection of the type of structural form to be used and the material out of which the structure is to be made.
- Determination of the external loads that can be expected to act on the structure.
- Calculation of the stresses and deformations that are produced in the individual members of the structure by the external loads.

1.1 Structural Components

All structural systems are composed of components. The following are considered to be the primary components in the structure:

- ***Ties:*** those members that are subjected to axial tension forces only. Load is applied to ties only at the ends. Ties cannot resist flexural forces.
- ***Struts:*** those members that are subjected to axial compression forces only. Like a tie, a strut can be loaded only at its end and cannot resist flexural forces.
- ***Beams and Girders:*** those members that are primarily subjected to flexural forces. They usually are thought of as being horizontal members that are primarily subjected to gravity forces; but there are frequent exceptions (e.g., rafters).
- ***Columns:*** those members that are primarily subjected to axial compression forces. A column may be subjected to flexural forces also. Columns usually are thought of as being vertical members, but they may be inclined.
- ***Diaphragms:*** Structural components that are flat plates. Diaphragms generally have very high in-plane stiffness. They are commonly used for floor and shear resisting walls. Diaphragms usually span beams or columns. They may be stiffened with ribs to better resist out-of-plane forces.

Structural components are assembled to form structural systems. We will be dealing with typical framed structures. A girder is considered to be a large beam with smaller beams framing into it.

A truss is a special type of structural frame. It is composed entirely of struts and ties. That is to say, all of its components are connected in such a manner that they are subjected to axial forces only.

1.2 Loads

The structure is acted upon by different loads that are given below.

1.2.1 Dead Load

Dead loads acting on a structure consist of the weight of the structure itself and any other immovable loads that are- constant in magnitude and permanently attached to the structure.

1.2.2 Live Load

Live loads are the one which vary in position and magnitude. They consist chiefly of occupancy loads in a building and traffic loads on bridge. The Minimum live loads for which the floors and roofs of the building should be designed are usually specified in the building code that governs at the site of construction.

1.2.3 Snow Load

Snow loads are often of Importance, particularly design of roof. Snow should be considered as a moving load. The density, of snow will vary greatly, as will the fall of snow, to be expected at different regions.

1.2.4 Wind Load

Wind loads are important in design of large structures such as tall buildings, towers and long span bridges.

1.2.5 Earthquake Load

Structures located in seismic zones are to he designed to resist earthquake effects along With other loads. During an earthquake, foundation of a structure undergoes horizontal acceleration which causes the failure of the structure.

2. STAAD PRO

STAAD/Pro is an integrated engineering software package capable of structural analysis, design and drafting, all within the same program. It is the leading Structural Analysis and Design software from Research Engineers. STAAD/Pro addresses the entire process of structural engineering. It can do anything from model development to analysis, design, drafting, detailing and even component design. STAAD/Pro is designed to work the way the Structural Design Office works.

2.1 Assumptions of the Analysis

For a complete analysis of the structure, the necessary matrices are generated on the basis of the following assumptions:

1. The structure is idealized into an assembly of beam and Plate type elements joined together at their vertices (nodes). The assemblage is loaded and reacted by concentrated loads acting at the nodes. These loads may be both forces and moments, which may act in any specified direction.
2. A beam member is a longitudinal structural member having a constant, doubly symmetric or near-doubly symmetric cross-section along its length. Beam members always carry axial forces. They may also be subjected to shear and bending in two arbitrary perpendicular planes, and they also be subjected to torsion. From this point these beam members are referred to as “members” in the natural.
3. A plate element is a three or four nodded element having constant thickness. These plate elements are referred to as “elements” in the natural.
4. Internal and external loads acting on each node are in equilibrium. If tensional or bending properties are defined for any member, six degrees of freedom are considered at each node (i.e. three translational and three rotational) in the generation of relevant matrices. If the member is defined as truss member (i.e. carrying only axial forces) then only the three degrees (translational) of freedom are considered at each node.

Two types of coordinate systems are used in the generation if the required matrices and are referred to as local and global systems.

3. ETABS 9.5

For nearly thirty years, the TABS and ETABS series of computer programs have defined the standard for building analysis and design software, and the tradition continues with this latest release of ETABS.

These programs were the first to take into account the unique properties inherent in a mathematical model of a building, allowing a computer representation to be constructed in the same fashion as a real building: floor by floor, story by story. ETABS uses terminology familiar to the building designer such as columns, beams, braces and walls rather than nodes and finite elements.

Figure 1 ETABS 9.5 Example Design

4. Data input to STAAD PRO

The building that was selected for this paper is a Multi-storey hospital building situated in Rawalpindi. The following figure shows the 3D view of the hospital building designed in STAAD Pro.

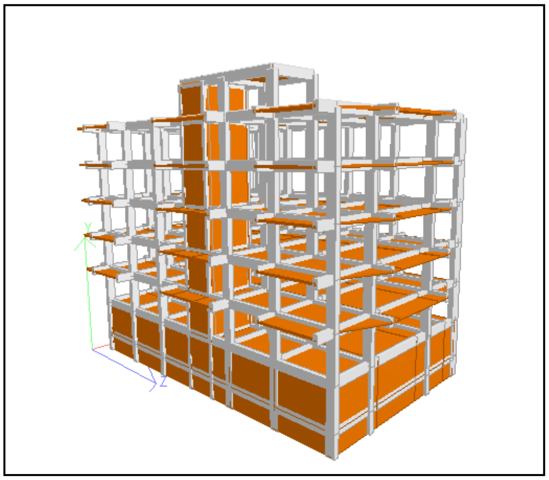

Figure 2 3D view of designed building

The next few figures show the parts of the building designed on STAAD PRO.2005

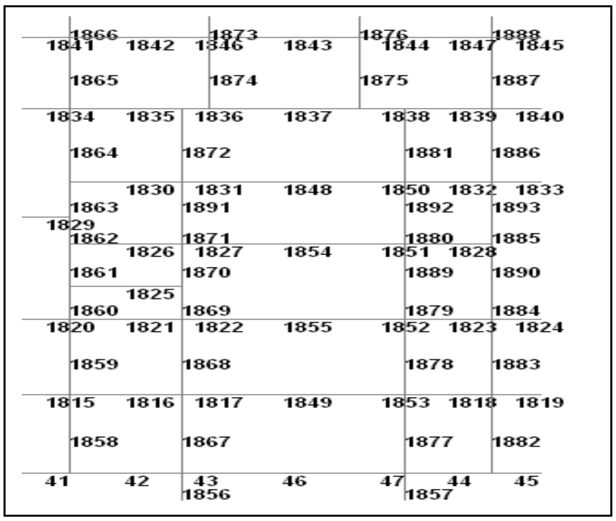

Figure 3 Plan of 3rd floor

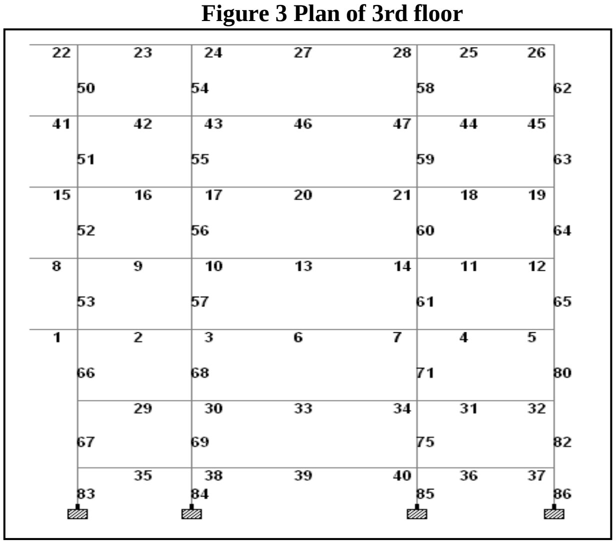

Figure 4 Elevation of grid 1

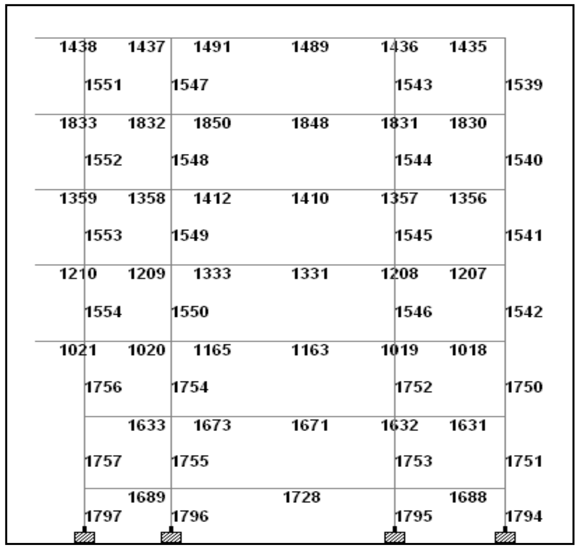

Figure 5 Elevation of grid 5

The beams and columns dimensions which were used as input data in STAAD were the same as they are in the building. The loads were calculated manually on how much the loads will be imposed on the designed columns and the data was inputted accordingly. Keeping in mind the elevation of the building it can be judged that the columns and beams would have been the ones with more load bearing capacities as they are the ones to carry more load as compared to the end ones.

5. Data input to ETABS 9.5

The following figures shows the 3D view of the hospital building designed and plan of 3rd floor in ETABS 9.5.

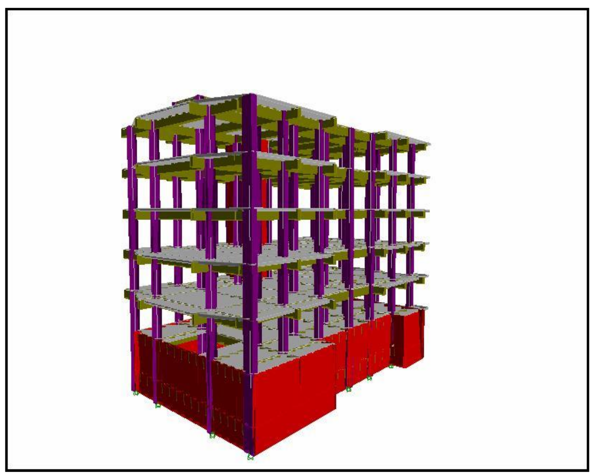

Figure 6 3D view of designed building

The loadings that were used in the design were calculated manually and were input into the software. The beams and column details that were used in ETABS were exactly the same as the ones used in STAAD for exact comparison.

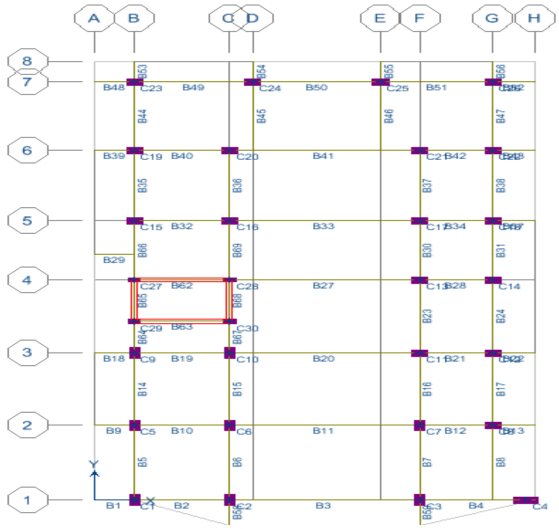

Figure *7 Plan of 3rd floo*r

6. RESULTS AND DISCUSSION

After inputting all the necessary data, the design was analysed using both softwares and results obtained were noted. The following figures show the output of shear force from STAAD and ETABS.

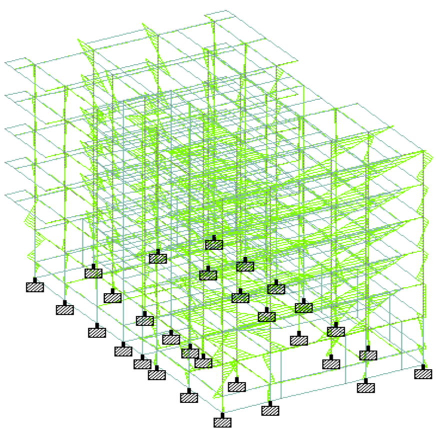
Figure 8 Shear forcé in Y-direction (STAAD)

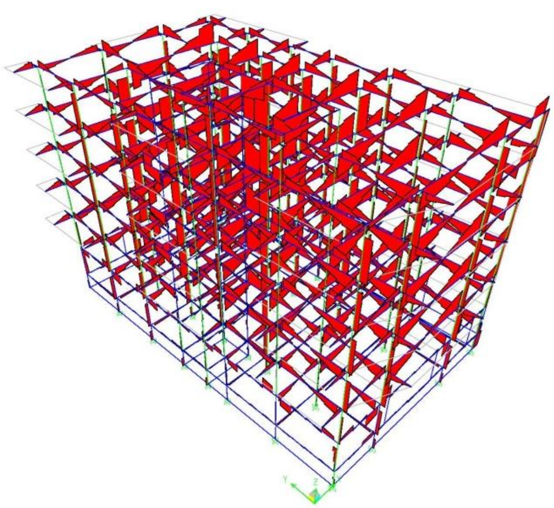
Figure 9 Shear forcé in Y-direction (ETABS)

The following figures show the outputs for bending moments in both Y and Z directions.

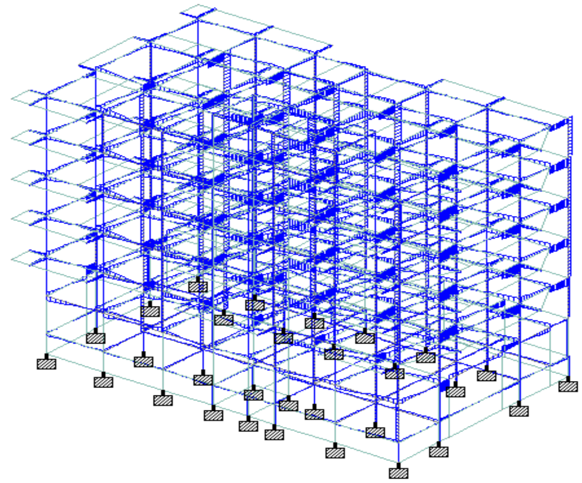
Figure 10 Bending momento in Y-direction (STAAD)

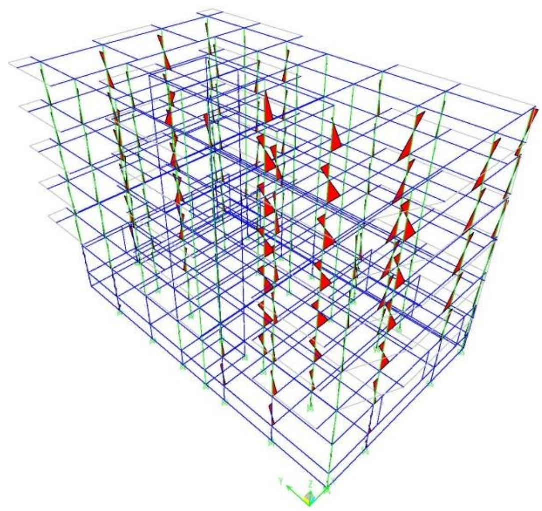
Figure 11 Bending Moment in Y (ETABS**)**

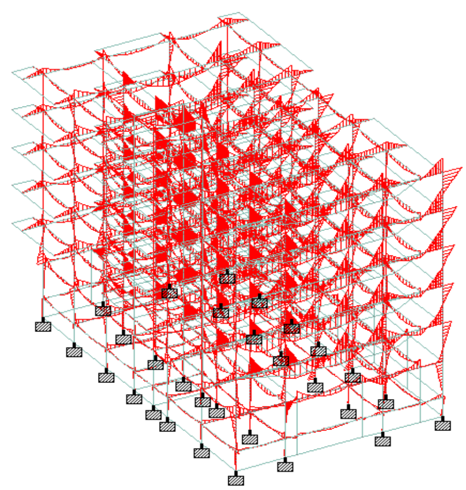
Figure 12 Bending Moment in Z (STAAD)

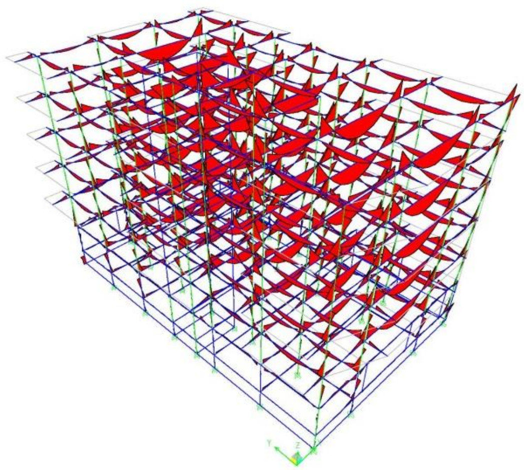

Figure 13 Bending Moment in Z (ETABS)

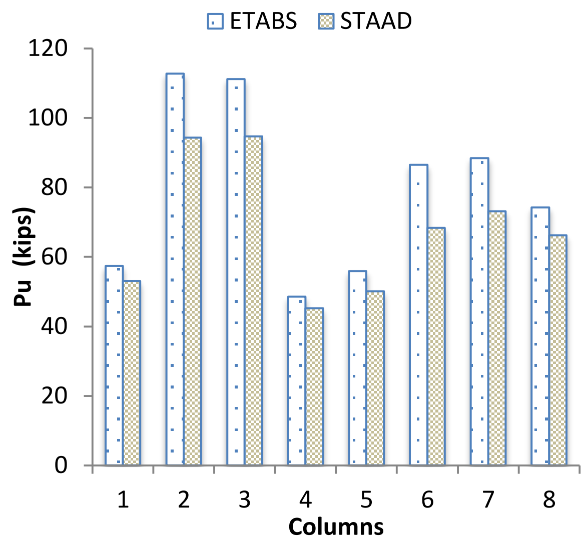

Figure 14 Graphical Comparison of Shear Force

6.1 Comparison

6.1.1 End forces of Columns

Table 1 Shear force comparison

Sr No.	Column		Dimen (in x in)	Pu (Kips)	
	ETABS	STAAD		ETABS	STAAD
1	C1	Beam no. 51	15 x 24	57.36	53.02
2	C2	Beam no. 55	15 x 24	112.74	94.34
3	C3	Beam no. 59	15 x 24	111.13	94.62
4	C4	Beam no. 63	15 x 36	48.53	45.24
5	C15	Beam no. 1540	15 x 24	55.89	50.11
6	C16	Beam no. 1544	15 x 24	86.44	68.3
7	C17	Beam no. 1548	15 x 24	88.39	73.12
8	C18	Beam no. 1552	15 x 24	74.21	66.22

Table 2 Comparison of bending moment

Sr No.	Column		Dimen (in x in)	My (kips.in)		Mz (kips.in	
	ETABS	STAAD		ETABS	STAAD	ETABS	STAAD
1	C1	Beam no. 51	15 x 24	53.1	39.84	151.81	160.8
2	C2	Beam no. 55	15 x 24	287.05	342.96	148.82	107.04
3	C3	Beam no. 59	15 x 24	307.4	360.48	146.7	93.96
4	C4	Beam no. 63	15 x 36	65.85	79.56	417.99	404.16
5	C15	Beam no. 1540	15 x 24	75.93	84	161.67	188.4
6	C16	Beam no. 1544	15 x 24	199.91	216	381.28	463.56
7	C17	Beam no. 1548	15 x 24	74.06	50.16	479.28	619.32
8	C18	Beam no. 1552	15 x 24	90.19	75.96	148.36	194.16

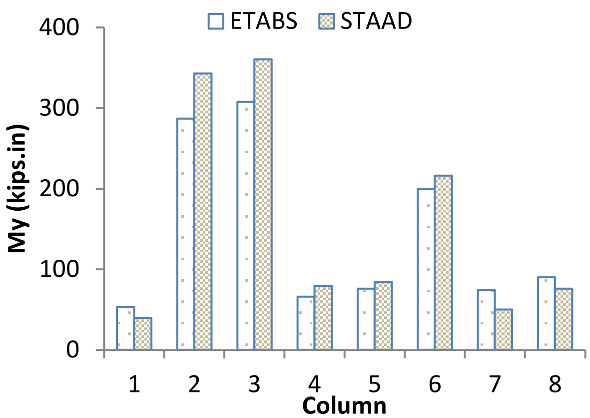

Figure 15 Graphical Comparison of Bending Moment in Y

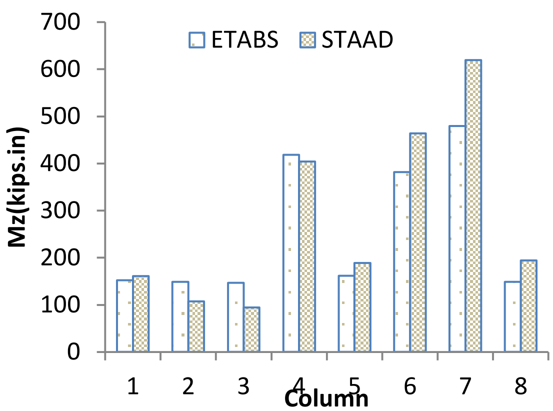

Figure 16 Graphical Comparison of Bending Moment in Z

6.1.2 Design Steel

Table 3 Comparison of Design Steel

Sr No.	Column		Dimen (in x in)	As req (in^2)		As (%)	
	ETABS	STAAD		ETABS	STAAD	ETABS	STAAD
1	C1	Beam no. 51	15 x 24	3.6	3.6	1	1.033
2	C2	Beam no. 55	15 x 24	3.6	3.6	1	1.033
3	C3	Beam no. 59	15 x 24	3.6	3.6	1	1.148
4	C4	Beam no. 63	15 x 36	5.4	5.4	1	1.148
5	C15	Beam no. 1540	15 x 24	3.6	3.6	1	1.033
6	C16	Beam no. 1544	15 x 24	3.6	3.6	1	1.033
7	C17	Beam no. 1548	15 x 24	3.6	3.6	1	1.033
8	C18	Beam no. 1552	15 x 24	3.6	3.6	1	1.033

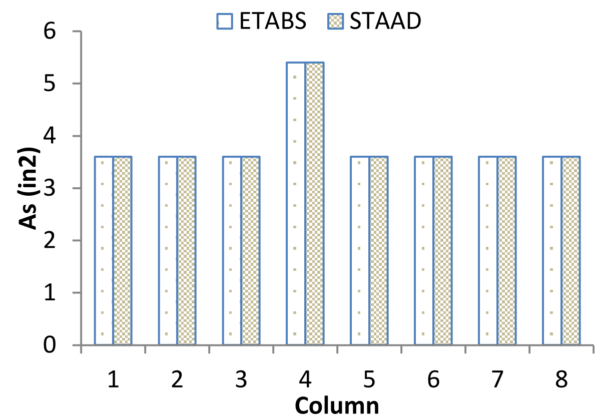

Figure 17 Graphical Comparison of Area of Steel required

6.1.3 Beam Design

Sr No.	BEAM		Dimen (in x in)	As Neg (max) In^2		As Pos (max) In^2	
	ETABS	STAAD		ETABS	STAAD	ETABS	STAAD
1	B1	Beam no. 41	12 x 24	0.263	0.86	0.131	0.86
2	B2	Beam no. 42	12 x 24	0.703	0.86	0.347	0.86
3	B3	Beam no. 43,46,47	12 x 24	1.225	1.15	1.251	0.86
4	B4	Beam no. 44,45	12 x 36	1.202	1.33	0.24	0.86
5	B32	Beam no. 1830	12 x 24	0.802	0.86	0.396	0.86
6	B33	Beam no. 1831,1848,1850	12 x 24	1.221	1.34	1.208	0.86
7	B34	Beam no. 1832	12 x 24	0.9	0.97	0.522	0.86
8	B35	Beam no. 1833	12 x 24	0.251	0.86	0.125	0.86

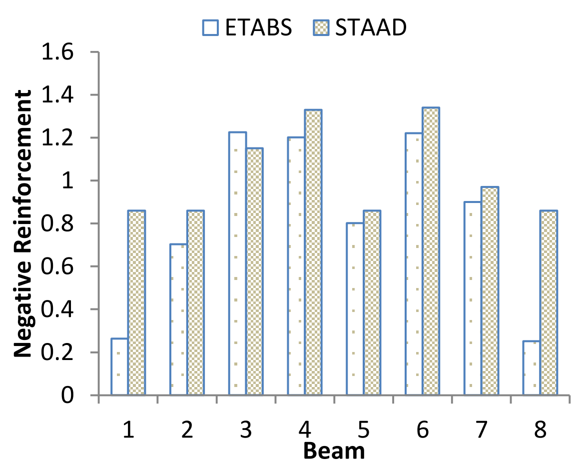

Figure 18 Graphical Comparison of Negative Reinforcement of Beam

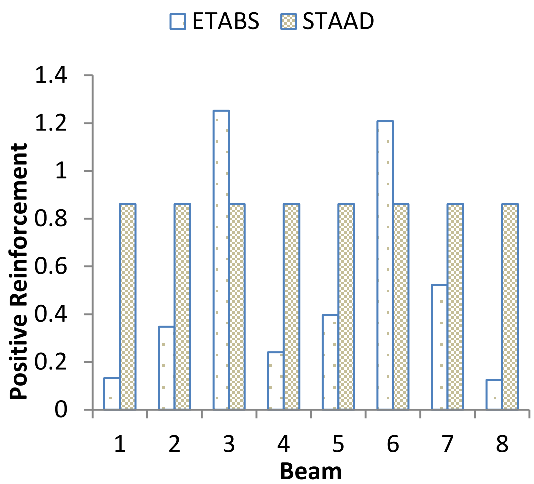

Figure 19 Graphical Comparison of Positive Reinforcement of Beam

The main objective of the project was to design the Hospital Building by ETABS & STAAD and compare their results. As for the results it has been found that ETABS giving more economical structure. While using the both well-known software in market we observed that it is better to use ETABS for simple building as that were in this case.

It can be seen from the graphs shown that STAAD calculates comparatively more bending moment in both Y and Z directions but in case of column design, this doesn't affect the amount of steel requirement as it can be seen that the steel requirement is the same in both softwares used.

7. CONCLUSION

From the above comparison, we can conclude the following points;

a. The STAAD gives more conservative design then ETABS, as the reactions given by STAAD are more than ETABS, also the end forces at the ends of beam and column given by STAAD are more than ETABS.
b. ETABS designs are more economic then STAAD.
c. In the ETABS we can model slabs and mesh them, without the breaking of beams into small pieces. But in STAAD if we model plate and mesh it, the beams also break into small pieces, which is not desire and it also increase the size of output file. So we have to calculate the self-weight of slabs and add it to the applied loads.
d. Both ETABS and STAAD give input file but in STAAD we can easily work in the input file while modeling.
e. The modeling in the ETABS is easy as compared to STAAD.
f. ETABS have option like "auto end offsets" which is not included in STAAD.
g. Both software give output files in text form both are easily printable and copy able.
h. In STAAD we can model footing, but only the individual footings but ETAB cannot design footings.
i. The ETABS results tables shows the value of shear at distance d from the face of support and the value of critical moment at the face of the column support. But the STAAD results tables shows the value of both shear and moment at the extreme ends. To view the values at different locations there is option in both ETABs and STAAD.
j. ETABS is most suitable for building frame systems as it is EXTENDED 3D ANALYSIS AND DESIGN OF BUILDINGS SYSTEMS.

8. RECOMMENDATIONS

Both the softwares are universally used and well known. Both have their own limitations and assumptions for design therefore results are different of both the software. The results of STAAD are more than ETABS due to it stricter limitations.

The goal of this paper was not to approve or disprove any software but to check the differences in the results and to try to find the reason of these differences. The design of ETABS is economic due to its less conservative approach as compared to STAAD, and due to its easy working it can be said that ETABS is better than STAAD PRO.2005.

9. REFERENCES

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