COMPARATIVE STUDY ON DESIGN RESULTS OF A MULTI-STORIED BUILDING USING STAAD PRO AND ETABS FOR REGULAR AND IRREGULAR PLAN CONFIGURATION

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Abstract - STAAD.Pro and ETABS are the present day leading design softwares in the market. Many design companies use these softwares for their project design purposes. So, this project mainly deals with the comparative analysis of the results obtained from the design of a regular and a plan irregular (as per IS 1893) multi storey building structure when designed using STAAD.Pro and ETABS softwares separately. The principle objective of this project is the comparative study on design and analysis of multi-storeyed building (G+8) by STAAD.Pro and ETABS softwares. STAAD.Pro is one of the leading softwares for the design of structures. In this project we analyze the G+8 building for finding the shear forces, bending moments, deflections & reinforcement details for the structural components of building (such as Beams, columns & slabs). ETABS is also leading design software in present days used by many structural designers. Here we had also analyzed the same structure using ETABS software for the design.

KEY WORDS*: *Regular, Irregular, Comparison, STAAD.PRO and ETABS.

1. INTRODUCTION:

STAAD.PRO and ETABS are two design software's to design and analyse any kind of structure in static and dynamic approach. However these software's will give different design and analytical results for the same structural configurations, this is due to their different analytical mechanism and the way they do analyse the structure. This rise a need to do a comparative study between these two software to know the real advantages and disadvantages of these software's. In case of analysis and design of structures with geometrical irregularities there is much more need to compare design results of different software's to get safe as well as economical structures. This paper carry out a comparative study of design results of ETABS and STAAD Pro software's by taking structural irregularities in account. To conclude the feasibility of these software's a G+8 building with irregular geometry has been analysed, designed and compared the results.

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of Vertically Irregular structures.

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. There are two types of irregularities-

- **Plan Irregularities**
- **Vertical Irregularities**

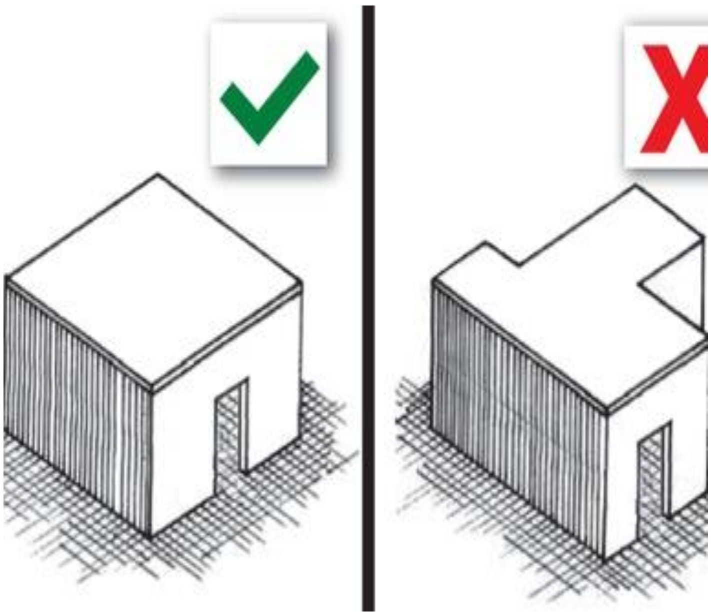

FIG1.1: PLAN IRREGULARITY

FIG1.2: MASS IRREGULARITY

1.1 OBJECTIVE OF THE STUDY

To carry out modeling and analysis of G+8 R.C. framed structures using STAAD-PRO & ETABS

- To Design a regular and plan irregular multi-storey structure as per IS-456 & IS-1893:2002
- To find out shear forces, bending moments and reinforcement details for the structural components of the building (beams and Columns) and compare the results.
- To compare results of ETABS and STAAD-PRO
- To observe which software gives more accurate results.

1.2 OVERVIEW OF SOFTWARE

1.2.1 STAAD.PRO

Staad is powerful design software licensed by Bentley .STAAD stands for Structural Analysis and Design any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis.

To calculate shear force diagram and bending moment diagram of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour. Staad is a best alternative for high rise buildings.

Now a day's most of the high rise buildings are designed by staad which makes a compulsion for a civil engineer to know about this software.

This software can be used to design Reinforced Concrete Structure, steel Structure or bridge, truss etc. according to various country codes.

1.2.2 ETABS

ETABS is the Acronym of EXTENDED 3D ANALYSIS OF BUILDING SYSTEMS, is software developed by Computers and Structures, Inc. (CSI); a Berkeley, California based engineering software company founded in 1975. ETABS is an engineering software product that can be used to analyze and design multi-story buildings using grid-like geometry, various methods of analysis and solution techniques, considering various load combinations.

ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, making it the tool of choice for structural engineers in the building industry. ETABS can be effectively used in the analysis and design of building structures which might consists of structural members like beams, columns, slabs, shear walls etc, With ETABS you can easily apply various construction materials to your structural members like concrete, structural steel, Reinforced Concrete etc. ETABS automatically generates the self-weights and the resultant gravity and lateral loads.

2. METHODOLOGY

2.1 EQUIVALENT STATIC METHOD

The equivalent static method is the simplest method of analysis because the forces depend on the code based fundamental period of structures with some empirical modifiers. The design base shear is to be computed as whole, and then it is distributed along the height of the building based on some simple formulae appropriate for buildings with regular distribution of mass and stiffness. The design lateral force obtained at each floor shall then be distributed to individual lateral load resisting elements depending upon the floor diaphragm action.

Inherently, equivalent static lateral force analysis is based on the following assumptions,

- Structure is rigid.
- Perfect fixity exit between structure and foundation.
- During ground motion every point on the structure experience same accelerations
- Dominant effect of earthquake is equivalent to horizontal force of varying magnitude over the height.
- Approximately determines the total horizontal force (Base shear) on the structure

However, during an earthquake structure does not remain rigid, it deflects, and thus base shear is disturbed along the height.

2.2 MODELLING OF G+8 STRUCTURE

Plan:

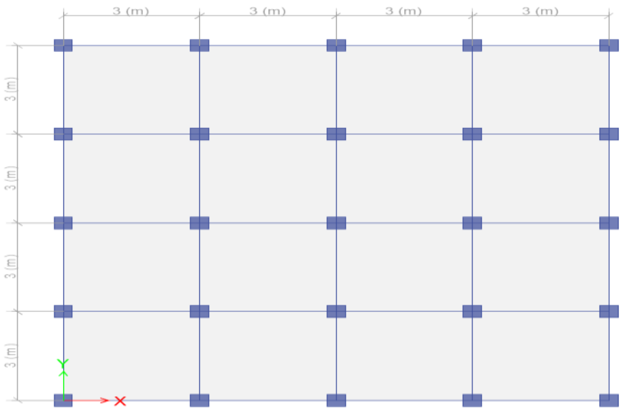

FIG 2.1: PLAN OF G+ 8 STRUCTURES

Elevation:

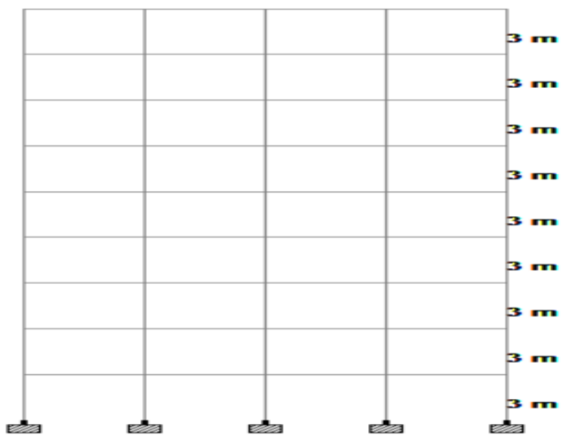

FIG2.2: REGULAR STRUCTURE

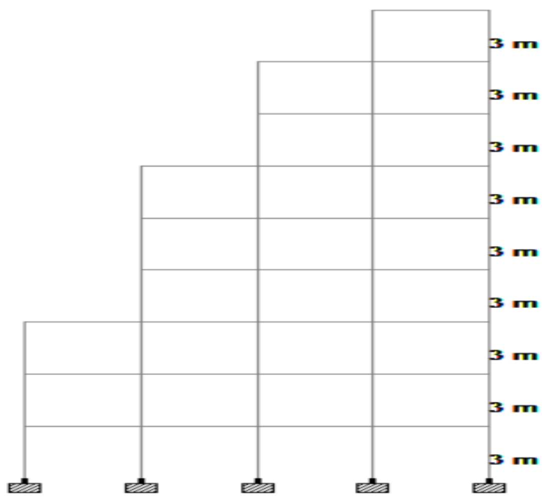

FIG2.3: IRREGULAR STRUCTURE

2.3 PRELIMINARY DATA:

- Type of frame :Ordinary RC moment resisting frame fixed at the base
- Seismic zone :II
- Number of storeys :9
- Floor height :3 m
- Plinth height :1.5 m
- Depth of Slab :125 mm
- Spacing between frames :3m along both directions
- Live load on floor level :3 kN/m^2
- Live load on roof level :1.5 kN/m^2
- Floor finish :1.0 kN/m^2
- Terrace water proofing :1.5 kN/m^2
- Thickness of infill wall :230mm (Exterior walls)
- Thickness of infill wall :150mm (Interior walls)
- Density of concrete :25 kN/m^2
- Density of infill :20 kN/m^2
- Type of soil :Rocky
- Response spectra :As per IS 1893(Part1):2002
- Damping of structure :5 %

**Live load on floor level and roof level are taken from IS-875 (Part-) considered RC framed buildings as residential usage.

2.4 MEMBER AND MATERIAL PROPERTIES:

Dimensions of the beams and columns are determined on the basis of trial and error process in analysis of Staadpro and Etabs softwares by considering nominal sizes for beams and columns and safe sizes are as show in the table below.

Beams : 230mmx400mm
Columns : 400mmx400mm

Material properties of the building are like M20 grade of concrete, FE415 steel and 13800N/mm^2 of modulus of elasticity of brick masonry in the buildings.

Dead Load:

Floor finish : 1. 5 kN/m^2
Internal wall load : 2.7x0.15x20 = 8.1KN/m
External wall load : 2.7x0.23x20 =12.42KN/m
Parapet Wall : 1x0.15x20= 3KN/m

Live Load:

For typical floors : 3 kN/m^2
For top floor : 1.5 kN/m

3. RESULTS AND DISCUSSION

3.1 Comparaison of Base Shear and Time Period

TABLE 3.1.1: COMPARISON OF BASE SHEAR AND TIME PERIOD

Model	Software's	Base Shear (KN)	Time Period (Sec)
Regular	STAADPRO	271.9	0.8
Irregular		207.37	0.85
Regular	ETABS	548	1.8
Irregular		498	1.87

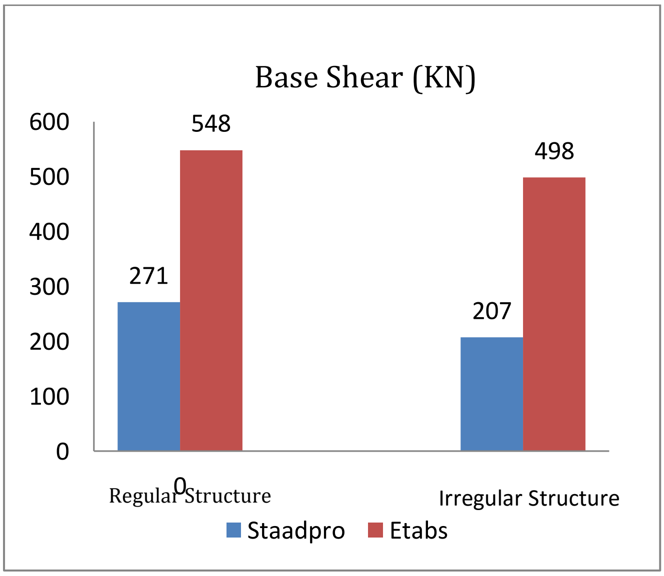

FIG3.1: COMPARISION OF BASE SHEAR

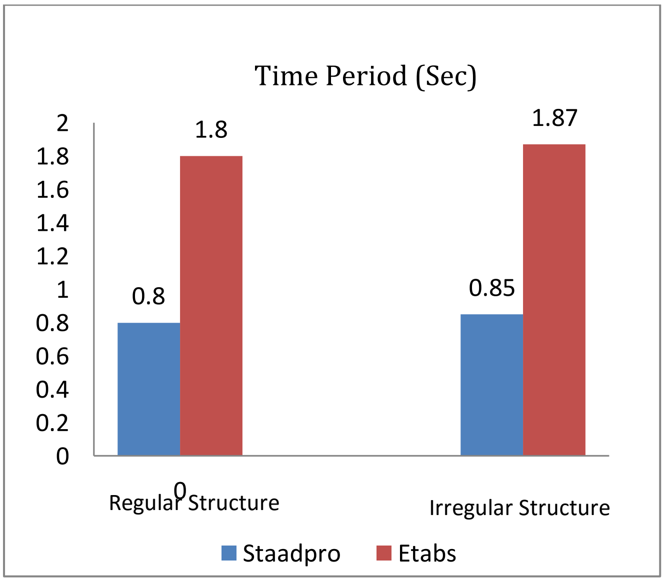

FIG3.2: COMPARISION OF TIME PERIOD

3.2 Bending Moment, Shear Force, Axial Force, Reinforcement details comparision for Regular Structure

TABLE 3.2.1: COMPARISION OF BENDING MOMENT AND SHEAR FORCE OF A SAMPLE BEAM

Load Combinations	STAADPRO		ETABS	
	Bending Moment (kN-m)	Shear Force (kN)	Bending Moment (kN-m)	Shear Force (kN)
1.5(D.L+L.L)	22.40	44.05	11.7	32.4
1.2(D.L+L.L+EQ X)	17.91	35.23	9.8	25
1.2(D.L+L.L+EQ Z)	38.03	49.36	33.1	44.6
1.2(D.L+L.L-EQX)	17.93	35.25	11.5	28.8
1.2(D.L+L.L-EQZ)	40.52	49.6	32.2	45.25
1.5(D.L+EQX)	19.4	38.94	10.5	27.4
1.5(D.L+EQZ)	44.91	56.8	39.6	52.3
1.5(D.L-EQX)	19.31	38.9	12.7	32.3
1.5(D.L-EQZ)	47.29	56.69	38.6	53
0.9D.L+1.5EQX	11.61	23.3	8.6	16
0.9D.L+1.5EQZ	37.18	41.3	35.6	40.5
0.9D.L-1.5EQX	11.58	23.26	10.8	20.8
0.9D.L-1.5EQZ	39.68	41.19	34.6	41.8

TABLE 3.2.2: AXIAL FORCE OF SAMPLE COLUMN FOR DIFFERENT LOAD COMBINATIONS

Load Combinations	STAADPRO	ETABS
	Axial Force(kN)	Axial Force(kN)
1.5(D.L+L.L)	989.5	964.8
1.2(D.L+L.L+EQX)	695.59	593.2
1.2(D.L+L.L+EQZ)	695.59	950.5
1.2(D.L+L.L-EQX)	887.73	950.5
1.2(D.L+L.L-EQZ)	887.73	593.2
1.5(D.L+EQX)	757.66	641.6
1.5(D.L+EQZ)	757.66	1088
1.5(D.L-EQX)	997.8	1088
1.5(D.L-EQZ)	997.8	641.6
0.9D.L+1.5EQX	406.5	295.6
0.9D.L+1.5EQZ	406.5	742.3
0.9D.L-1.5EQX	646.7	742.3
0.9D.L-1.5EQZ	646.7	295.6

TABLE 3.2.3: TOTAL REINFORCEMENT OF A SAMPLE BEAM AND COLUMN

Section	Total Reinforcement(sq.mm)	
	STAAD PRO	ETABS
Beam	1856	2482
Column	905	1280

3.3 BENDING MOMENT, SHEAR FORCE, AXIAL FORCE, REINFORCEMENT DETAILS COMPARISON FOR IRREGULAR STRUCTURE

TABLE 3.3.1: COMPARISION OF BENDING MOMENT AND SHEAR FORCE

Load Combinations	STAADPRO		ETABS	
	Bending Moment (kN-m)	Shear Force (kN)	Bending Moment (kN-m)	Shear Force (kN)
1.5(D.L+L.L)	23.66	44.92	12.12	32.3
1.2(D.L+L.L+EQX)	18.93	35.94	9.9	25.01
1.2(D.L+L.L+EQZ)	26.59	41.32	26.36	39.4
1.2(D.L+L.L-EQX)	18.92	35.93	11.5	28.6
1.2(D.L+L.L-EQZ)	24.96	39.69	26.5	40.3
1.5(D.L+EQX)	20.6	39.81	10.6	27.5
1.5(D.L+EQZ)	30.17	46.53	31.3	45.6
1.5(D.L-EQX)	20.59	39.8	12.7	32.02
1.5(D.L-EQZ)	28.29	44.6	31.4	46.6
0.9D.L+1.5EQX	12.36	23.84	6.5	16.6
0.9D.L+1.5EQZ	21.94	30.61	27.5	34.4
0.9D.L-1.5EQX	12.35	23.88	8.6	20.5
0.9D.L-1.5EQZ	21.22	29.45	27.2	35.2

TABLE 3.3.2: AXIAL FORCE OF COLUMN FOR DIFFERENT LOAD COMBINATIONS

Load Combinations	STAADPRO	ETABS
	Axial Force(kN)	Axial Force(kN)
1.5(D.L+L.L)	314.22	323.7
1.2(D.L+L.L+EQX)	215.5	184.7
1.2(D.L+L.L+EQZ)	227.2	330.19
1.2(D.L+L.L-EQX)	287.2	333.15
1.2(D.L+L.L-EQZ)	275.5	187.7
1.5(D.L+EQX)	238.3	198.3
1.5(D.L+EQZ)	252.9	383.84
1.5(D.L-EQX)	327.9	202.15
1.5(D.L-EQZ)	313.2	380.5
0.9D.L+1.5EQX	125	81.9
0.9D.L+1.5EQZ	139.7	264.11
0.9D.L-1.5EQX	214.6	267.8
0.9D.L-1.5EQZ	200	85.6

TABLE 3.3.3: TOTAL REINFORCEMENT OF A SAMPLE BEAM AND COLUMN

Section	Total Reinforcement(sq.mm)	
	STAAD PRO	ETABS
Beam	1277	1880
Column	905	1280

4. CONCLUSIONS

The analytic study is carried out in order to compare the behaviour of regular structure with irregular structure by using STAAD-PRO& ETABS. The structures are designed using IS: 456:2000 and IS 1893:2002 codes. From the study the following conclusions are obtained.

• STAAD.PRO software is Suitable for G+ 8 structures when compared to Etabs software.

• The time period and base shear of regular and irregular structure in ETABS software is twice than that of STAAD.PRO software.

• After completion of design of the structure in both the software's, the design results shows 0.4-0.5% more steel in ETABS..

• By comparing the results of two structures (regular and irregular), the frame element of regular has shown maximum bending moments, shear forces and axial forces for different loading conditions in both software's.

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