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:
Structural Analysis and design are predominant in finding out significant threats to integrity and stability of a structure. Multi storied structures, when designed, are made to fulfill basic aspects and serviceability. Since Robustness of structure depends on loads imposed, it requires attention. All the challenges faced by structural engineers were taken as opportunities to develop software’s such as STAAD PRO, ETABS & SAFE, SAP etc., with ease of use. Software such as ETABS and STAAD-pro are leading commercial software’s worldwide for structural analysis. The design results using STAAD PRO and ETABS of a rectangular RCC building, for both regular and irregular plan configuration, are obtained and compared. The main purpose of this study is to carry out a detailed analysis on simulation tools ETABS and STAAD PRO, which have been used for analysis and design of rectangular Plan with vertical regular and rectangular Plan with Vertical geometrically irregular multi-storey building. This study is focused on bringing out advantages of using ETABS over current practices of STAAD PRO versions to light. It was observed that ETABS is more user friendly, accurate, compatible for analysing design results and many more advantages to be discussed in this study over STAADPRO. Pros and cons of using these software’s will also be mentioned in this study.

1. INTRODUCTION

1.1 RCC FRAME STRUCTURES
An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer, in such a structure takes place from the slabs to the beams, from the beams to the columns and then to the lower columns and finally to the foundation which in turn transfers it to the soil. The floor area of a R.C.C framed structure building is 10 to 12 percent more than that of a load bearing walled building. Monolithic construction is possible with R.C.C framed structures and they can resist vibrations, earthquakes and shocks more effectively than load bearing walled buildings. Speed of construction for RCC framed structures is more rapid.

Reinforced concrete is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and ductility. The reinforcement is usually embedded passively in the concrete before the concrete sets. The reinforcement needs to have the following properties at least for the strong and durable construction:

- High relative strength
- High toleration of tensile strain
- Good bond to the concrete, irrespective of pH, moisture, and similar factor.
- Thermal compatibility, not causing unacceptable stresses in response to changing temperatures.

1.2 OBJECTIVE

1. To check the behaviour of multi-storey regular and irregular building on software (STAADPro. & ETABS).
2. To understand the accuracy of softwares for analysis and design for plan and elevation Irregularity.
To compare the results and behaviour of structures on both the software.

DIFFERENT METHODS USED FOR DESIGN

1. Working stress method
2. Limit state method
3. Ultimate load method

**Working Stress Method**

It is based on the elastic theory assumes reinforced concrete as elastic material. The stress strain curve of concrete is assumed as linear from zero at neutral axis to maximum value at extreme fibre. This method adopts permissible stresses which are obtained by dividing ultimate stress by factor known as factor of safety. For concrete factor of safety 3 is used and for steel it is 1.78. This factor of safety accounts for any uncertainties in estimation of working loads and variation of material properties. In Working stress method, the structural members are designed for working loads such that the stresses developed are within the allowable stresses. Hence, the failure criterions are the stresses. This method is simple and reasonably reliable. This method has been deleted in IS 456-2000, but the concept of this method is retained for checking the serviceability, states of deflection and cracking.

**Limit State Method**

In this method, the structural elements are designed for ultimate load and checked for serviceability (deflection, cracking etc.) at working loads so that the structure is fit for use throughout its life period. As in working stress method this method does not assume stress strain curve as linear. This method gives economical sections.

**Ultimate Load Method**

In this method structural elements are designed for ultimate loads which are obtained by multiplying the working loads with a factor known as load factor. Hence, the designer can able to predict the excess load the structure can carry beyond the working loads without collapse. Hence, this method gives the true margin of safety. This method considers the actual stress strain curve of concrete and the failure criteria is assumed as ultimate strain. This method gives very economical sections. However it leads to excessive deformations and cracking. This method is failed to satisfy the serviceability and durability requirements. To overcome these drawbacks, the limit state method has been developed to take care of both strength and serviceability requirements.

**STAADPro Vi8.**

One of the most famous analysis methods for analysis is “Moment Distribution Method”, which is based on the concept of transferring the loads on the beams to the supports at their ends. Each support will take portion of the load according to its K; K is the stiffness factor, which equals (EI/L). E, and L is constant per span, the only variable is I; moment of inertia. I depend on the cross section of the member. To use the moment distribution method, you have to assume a cross section for the spans of the continuous beam. To analyze the frame, “Stiffness Matrix Method” is used which depends upon matrices. The main formula of this method is $[P] = [K] \times [\Delta]$. $[P]$ is the force matrix = Dead Load, Live Load, Wind Load, etc. $[K]$ is the stiffness factor matrix. $K= (EI/L)$. $[\Delta]$ is the displacement matrix.

STAAD was the first structural software which adopted Matrix Methods for analysis. The stiffness analysis implemented in STAAD is based on the matrix displacement method. In the matrix analysis of structures by the displacement method, the structure is first idealized into an assembly of discrete structural components (frame members or finite elements). Each component has an assumed form of displacement in a manner which satisfies the force equilibrium and displacement compatibility at the joints.

STAAD stands for Structural Analysis and Design. STAAD.Pro is a general purpose structural analysis and design program with applications primarily in the building industry – commercial buildings, bridges and highways structures, and industrial structures etc. The program hence consists of the following facilities to enable this task:-

Graphical model generation utilities as well as text editor based commands for creating the mathematical model. Beam and column members are represented using lines. Walls, slabs and panel type entities are represented using triangular and
quadrilateral finite elements. Solid blocks are represented using brick elements. These utilities allow the user to create the geometry, assign properties, orient cross sections as desired, assign materials like steel, concrete, timber, aluminium, specify supports, apply loads explicitly as well as have the program generate loads, design parameters etc.

Analysis engines for performing linear elastic and p-delta analysis, finite element analysis, frequency extraction and dynamic response.

Design engines for code checking and optimization of steel, aluminium and timber members. Reinforcement calculations for concrete beams, columns, slabs and shear

**ETABS**

ETABS stands for Extended Three dimensional Analysis of Building Systems. ETABS was used to create the mathematical model of the Burj Khalifa, designed by Chicago, Illinois-based Skidmore, Owings and Merrill LLP (SOM). ETABS is commonly used to analyze: Skyscrapers, parking garages, steel & concrete structures, low rise buildings, portal frame structures, and high rise buildings. The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. A complete suite of Windows graphical tools and utilities are included with the base package, including a modeller and a postprocessor for viewing all results, including force diagrams and deflected shapes.

2. REVIEW OF LITERATURE

Most of the work for analysis of multi storey building has been done on STAADPro. Evaluation of forces and moments for Dead load, Live load and Seismic load considered. But there is very less work has been done using load combination.

M C Griffith and A V Pinto (2000) have investigated the specific details of a 4-story, 3-bay reinforced concrete frame test structure with unreinforced brick masonry (URM) infill walls with attention to their weaknesses with regards to seismic loading. The concrete frame was shown to be a “weak-column strong-beam frame” which is likely to exhibit poor post yield hysteretic behaviour. The building was expected to have maximum lateral deformation capacities corresponding to about 2% lateral drift. The unreinforced masonry infill walls were likely to begin cracking at much smaller lateral drifts, of the order of 0.3%, and completely lost their load carrying ability by drifts of between 1% and 2%.

Sanghani and Paresh (2011) studied the behaviour of beam and column at various storey levels. It was found that the maximum axial force generated in the ground floor columns, max reinforcement required in the second floor beams.

Poonam et al. (2012) Results of the numerical analysis showed that any storey, especially the first storey, must not be softer/weaker than the storeys above or below. Irregularity in mass distribution also contributes to the increased response of the buildings. The irregularities, if required to be provided, need to be provided by appropriate and extensive analysis and design processes.

Prashanth.P et al. (2012) investigated the behaviour of regular and irregular multi storey building structure in STAADPro. and ETABS. Analysis and design was done according to IS-456 and IS-1893(2002) code. Also manually calculations were done to compare results. It was found that the ETABS gave the lesser steel area as that of STAADPro. Loading combinations were not considered in the analysis and influence of storey height on the structural behaviour was not described.

3. MODELLING OF RCC FRAMES RCC FRAME STRUCTURE

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation interconnected to each other as a unit. The load transfer, in such a structure takes place from the slabs to the beams, from the beams to the columns and then to the lower columns and finally to the foundation which in turn transfers it to the soil.

General

Case I Regular Building

Case II Irregular Building

*Case I: Regular Building*
A 32m x 20m 12-storey multi storey regular structure is considered for the study. Size of the each grid portion is 4m x 4m. Height of each storey is 3m and total height of the building is 36m. Plan of the building considered is shown in the figure 3.1.

**Case II: Irregular Building**

A 32m X 20m 12-storey multi storey irregular structure is considered for the study. Size of each grid portion is 4m x 4m. Plan of the building considered is shown in the figure 3.2.

### Loading

Loads acting on the structure are dead load (DL), Live load and Earthquake load (EL). Dead load consists of Self weight of the structure, Wall load, Parapet load and floor load.

**Live load:** 3kN/m² is considered. Seismic zone: V, Soil type: II, Response reduction factor: 5, Importance factor: 1, Damping: 5%. Members are loaded with dead load, live load and seismic loads according to IS code 875(Part1, Part 2) and IS 1893(Part-1):2002.

**Self weight**

Self weight comprises of the weight of beams, columns and slab of the building.

**Dead load**

All permanent constructions of the structure form the dead load. The dead load comprises of the weights of walls, partition floor finishes, floors and other permanent constructions in the building. Dead load consists of:
**Table 3.4: Load Combination**

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>LOAD COMBINATION</th>
<th>PRIMARY LOAD</th>
<th>FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DCON1</td>
<td>Self load</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dead load</td>
<td>1.50</td>
</tr>
<tr>
<td>2.</td>
<td>DCON2</td>
<td>Self load</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dead load</td>
<td>1.50</td>
</tr>
<tr>
<td>3.</td>
<td>DCON3</td>
<td>Self load</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dead load</td>
<td>1.20</td>
</tr>
<tr>
<td>4.</td>
<td>DCON4</td>
<td>Self load</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dead load</td>
<td>1.20</td>
</tr>
<tr>
<td>5.</td>
<td>DCON5</td>
<td>Self load</td>
<td>1.20</td>
</tr>
</tbody>
</table>

**3. RESULTS AND DISCUSSION**

3.1. ETABS software

a) Case I: Regular Building

![Fig-3.3: Regular building](image)

![Fig-3.4: Irregular building](image)

![Fig 4.1: (a) B.M. Diagram for Selfweight (b) Shear Force diagram for Selfweight](image)

Fig 4.1 (a) shows that the beams undergo largest in middle portion and curves in and portion due to Selfweight. Beam below the girder are beams

![Fig 6.2: Max Stress Diagram for load 0.9Self+0.9Dead+1.6EQ(length)](image)

Figure shows that the max stress in the range 60 - 70kN/m² is produced at the
CONCLUSION

After Discussion of results and observation some of results are summarized. Based on the behaviour of RCC frames on STAAD.PRO and ETABS some important conclusions are drawn

1. Results of max vertical reactions of a 12-storey regular building. As per table 5.1 it has been concluded that the max reaction produced is 4572.12kN in ETABS and 4624.92kN in STAAD.Pro due to load 1.5(Self+Dead+Live).

2. Max Deformation of members of 12-storey regular and irregular building

As per above table it has been concluded that the maximum displacement is along x-direction and its value is 106.25mm (in STAAD.Pro.) for irregular building and 53.47mm (in ETABS) along z-direction for regular building. So, more precise results are generated by ETABS which leads to economical design of the building.

3. Design Results of sample beam and column

Column C13 of storey 6 from ETABS and Column 851 of storey 6 from STAAD.Pro. Of 12 storey – regular building are taken for comparison.

As per above table it has been concluded that the ETABS gave lesser area of steel required as compared to STAAD.Pro. in case of beam whereas in case of column steel calculated is same by both softwares.

4. Comparison of Storey Overturning Moments

<table>
<thead>
<tr>
<th>Section</th>
<th>Total Reinforcement (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam (450 x 450mm)</td>
<td>1257</td>
</tr>
<tr>
<td>Column (dia=800 mm)</td>
<td>4021</td>
</tr>
</tbody>
</table>
As per above graph it has been concluded that the storey overturning moment decreases with increase in storey height along x-direction for EQlength load and they are more in regular building than the irregular building.

5. Maximum Steel Reinforcement of beam and column of regular and irregular building in ETABS.

<table>
<thead>
<tr>
<th>Section</th>
<th>Total Reinforcement (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam</td>
<td></td>
</tr>
<tr>
<td>Regular Building</td>
<td>1595</td>
</tr>
<tr>
<td>Irregular Building</td>
<td>1283</td>
</tr>
<tr>
<td>Column</td>
<td></td>
</tr>
<tr>
<td>Regular Building</td>
<td>4931</td>
</tr>
<tr>
<td>Irregular Building</td>
<td>4500</td>
</tr>
</tbody>
</table>

As per above table it has been concluded that the ETABS gave lesser area of steel reinforcement for irregular building as compared to regular building in case of beams and columns.

**REFERENCE**


