Design and Analysis of Multi Stored Residential Building (G+5) using Staad Pro V8i

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Abstract: The principle objective of this project is to analyse and design a High rise building [G +5) using STAAD Pro. The design involves load calculations manually and analyzing the whole structure by STAAD Pro. The design methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. STAAD.Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD.Pro is the professional's choice. STAAD. Pro has a very interactive user interface which allows the users to draw the frame and input the load values and dimensions. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for RCC frames. Our final work was the proper analysis and design of a G + 5 3-D RCC frame under various load combinations. The structure was subjected to self weight, dead load, live load, seismic loads under the load case details of STAAD.Pro. Seismic load calculations were done following IS 1893-2000. The materials were specified and cross-sections of the beam and column members were assigned. The supports at the base of the structure were also specified as fixed. The codes of practise to be followed were also specified for design purpose with other important details. Then STAAD.Pro was used to analyse the structure and design the members. In the post-processing mode, after completion of the design, we can work on the structure and study the bending moment and shear force values with the generated diagrams. We may also check the deflection of various members under the given loading combinations. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear. Strict conformity to loading standards recommended in this code, it is hoped, will ensure the structural safety of the buildings which are being designed. Structure and structural elements were normally designed by Limit State Method.

Key words: wind load, seismic load, limit state method, Staad pro V8i

1. Introduction

Our project involves *analysis* and design of multi-storeyed Residential Building [G+5] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

Easy to use interface,
Conformation with the Indian Standard Codes,
Versatile nature of solving any type of problem,
Accuracy of the solution

STAAD.Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD.Pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

2. STAAD.Pro consists of the following:

The STAAD.Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically. *The STAAD analysis and design engine*: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminum design.

To start with we have solved some sample problems using STAAD Pro and checked the accuracy of the results with manual calculations. The results were to satisfaction and were accurate. In the initial phase of our project we have done calculations regarding loadings on buildings and also considered seismic and wind loads.

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

3. Loads Consideration.

A) *DEAD LOADS*:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m” and 25 kN/m” respectively.

B) *IMPOSED LOADS*:

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo

C) *SEISMIC LOAD*:

Design Lateral Force

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.

Design Seismic Base Shear

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

$$V_b = A_h W$$

Where,

Ah = horizontal acceleration spectrum

W = seismic weight of all the floors

D) *Fundamental Natural Period*

The approximate fundamental natural period of vibration (T,), in seconds, of a moment- resisting frame building without brick in the panels may be estimated by the empirical expression:

$T_a=0.075\ h^{0.75}$ for RC frame building

$T_a=0.085\ h^{0.75}$ for steel frame building

Where

h = Height of building, in m. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

$$T=.09H/\sqrt{D}$$

Where,

h= Height of building

d= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

E) *Distribution* **of** *Design Force*

Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Qi=Design lateral force at floor i,

Wi=Seismic weight of floor i,

hi=Height of floor i measured from base, and n=Number of storeys in the building is the number of levels at which the masses are located. Distribution of Horizontal Design Lateral Force to Different Lateral Force Resisting Elements in case of buildings whose floors are capable of providing rigid horizontal diaphragm action, the total shear in any horizontal plane shall be distributed to the various vertical elements of lateral force resisting system, assuming the floors to be infinitely rigid in the horizontal plane. In case of building whose floor diaphragms can not be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram.

4. Dynamic Analysis-

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following

Buildings:

Regular buildings -Those greater than 40 m in height in Zones IV and V and those Greaterthan 90 m in height in Zones II and 111.

Irregular buildings – All framed buildings higher than 12m in Zones IV and V and thosegreater than 40m in height in Zones 11 and III.

The analytical model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities cannot be modelled for dynamic analysis. For irregular buildings, lesser than 40 m in height in Zones 11and III, dynamic analysis, even though not mandatory, is recommended. Dynamic analysis may be performed either by the Time

History Method or by the Response Spectrum Method. However, in either method, the design base shear (VB) shall be compared with a base shear (VB)

F) *Time History Method-*

Time history method of analysis shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

G) *Response Spectrum Method-*

Response spectrum method of analysis shall be performed using the design spectrum specified, or by a site-specific design spectrum mentioned.

5. Analysis and Design results

Some of the sample analysis and design results have been shown below for beam number 1 which is at the roof level of 1st floor.

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B E A M N O. 1 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 7500.0 mm SIZE: 300.0 mm X 600.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 1875.0 mm 3750.0 mm 5625.0 mm 7500.0 mm

TOP 1350.38 350.24 350.24 350.24 1468.12
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 350.24 402.32 417.24 350.24 350.24
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 1875.0 mm 3750.0 mm 5625.0 mm 7500.0 mm

TOP 12-12í 4-12í 4-12í4-12í 13-12í
REINF. 2 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 2 layer(s)

BOTTOM 5-10í 6-10í 6-10í 5-10í 5-10í
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í
REINF. @ 190 mm c/c @ 190 mm c/c @ 190 mm c/c @ 190 mm c/c @ 190 mm c/c

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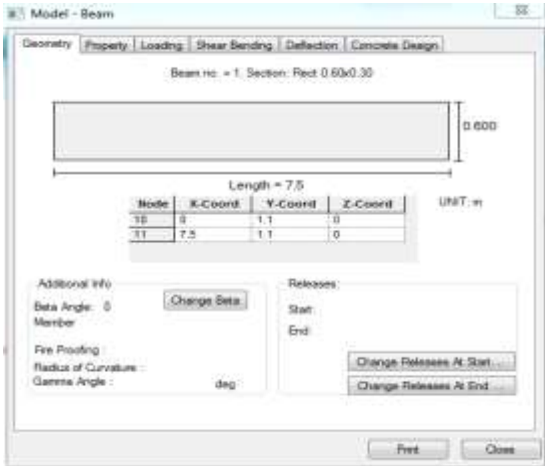

Fig 1: Geometry of beam no.1

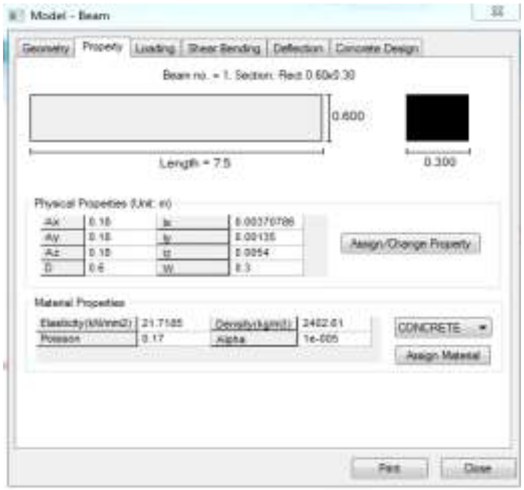

Fig 2: Property of beam no.1

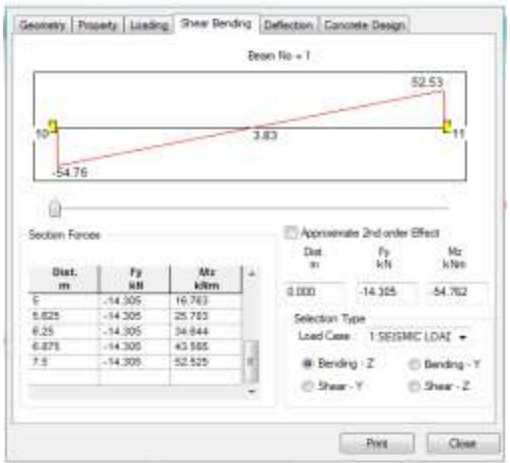

Fig 3: Shear bending of beam no.1

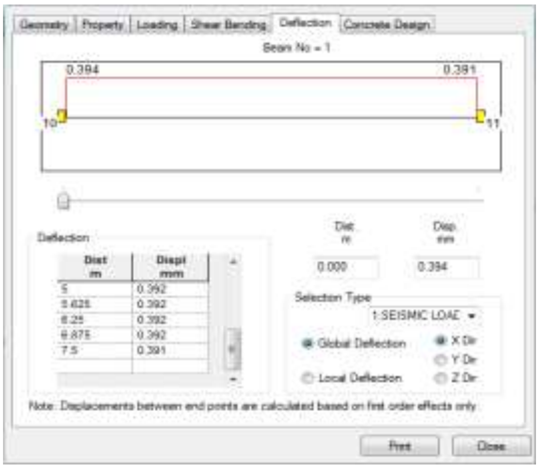

Fig 4: Deflection of beam no.1

Fig 5: Concrete design of beam no.1

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COLUMN NO.34 DESIGN RESULTS

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4100.0 mm CROSS SECTION: 500.0 mm X 500.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 30 END JOINT: 10 SHORT COLUMN

REQD. STEEL AREA : 3669.89 Sq.mm.
REQD. CONCRETE AREA: 246330.11 Sq.mm.
MAIN REINFORCEMENT: Provide 12 - 20 dia. (1.51%, 3769.91 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 3913.47 Muz1 : 266.51 Muy1 : 266.51

INTERACTION RATIO: 0.99 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 30
END JOINT: 10 Puz : 3943.47 Muz : 272.73 Muy : 272.73 IR: 0.96

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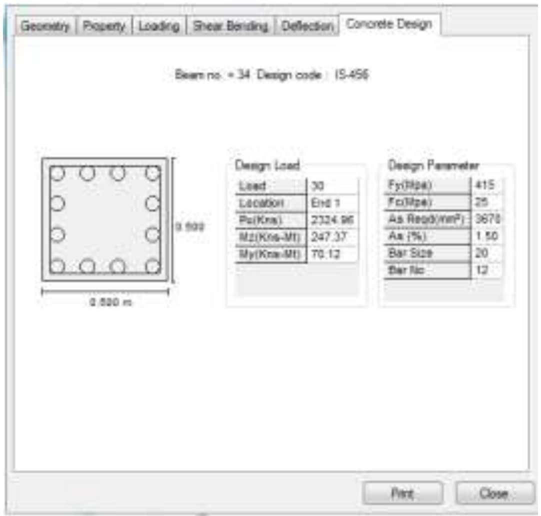

Fig 6: Concrete design of column no.34

6. **Post Processing Mode**

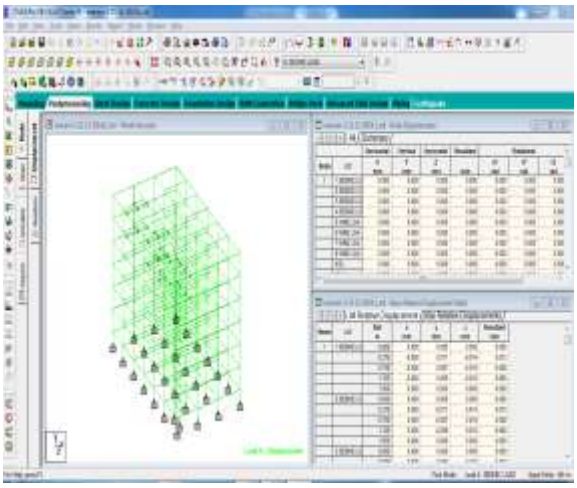

Fig 6.1: post processing mode in STAAD.Pro

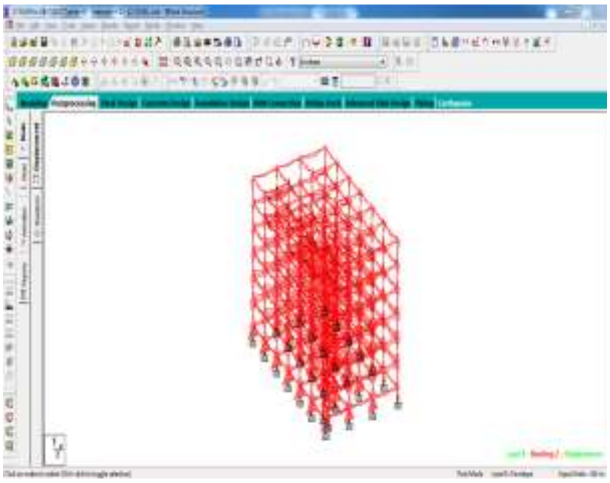

Fig 6.2: bending in Z

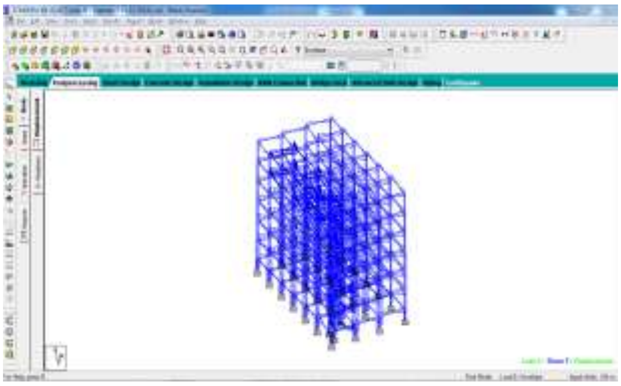

Fig 6.3: shear force in Y

Conclusion:

STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS:
456(2000). Beams are designed for flexure, shear and torsion.

Design for Flexure:

- Maximum sagging (creating tensile stress at the bottom face of the beam) and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above mentioned sections. Each of these sections are designed to resist both of these critical sagging and hogging moments. Where ever the rectangular section is inadequate as singly reinforced section, doubly reinforced section is tried.

Design for Shear:

- Shear reinforcement is calculated to resist both shear forces and torsional moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by STAAD program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.

Beam Design Output:

- The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.

Column Design:

- Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yield maximum reinforcement is called the critical load. Column design is done for square section. Square columns are designed with reinforcement distributed on each side equally for the sections under biaxial moments and with reinforcement distributed equally in two faces for sections under uni-axial moment. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of STAAD.

References:

- Dr. S.R. Karve&Dr. V.L. Shah - "**Illustrated** design **of Reinforcedconcrete Buildings**"
- N. Krishna Raju - "**Advanced Reinforced Concrete design**" "**STAAD Pro 2004 – Getting started & tutorials**" - Published by: R .E. I.
- "**STAAD Pro 2004 – Technical reference manual**" Published by: R.E.I.
- **IS 875** -BUREAU OF INDIAN STANDARDS MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG NEW DELHI 110002
- **IS 456** -BUREAU OF INDIAN STANDARDS MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG NEW DELHI 110002
- **IS 1893-2000** -BUREAU OF INDIAN STANDARDS
- MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG NEW DELHI 110002
- **IS 1893-2002** -BUREAU OF INDIAN STANDARDS
- MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG NEW DELHI 110002