Analysis and Design of G+10 Residential Building using Staad.PRO

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Abstract*— Computer aided design and analysis of G+10 residential building involves analysis of building frames by using staad pro. conventional method of analysis involves lot of complications and tedious calculations such analysis is a time consuming task. analysis can be made quickly by using software Staad pro is the leading design software in the market many design companies use this software for their project design purpose. hence this project mainly deals with the analysis of building by using staad pro Considerably improvement in the earthquake resistant design has been observed in resent past. As a result Indian seismic code IS 1893 has been revised in year 2002, after a gap of 18 years. This project present the seismic load and wind load estimation for residential building as per IS:1893-2002 and IS:875-2015 Part 3 recommendations. For RC framed residential buildings of G+10 are consider and analyzed as per IS:456-2000. The seismic forces computed by IS:1893-2002 are found to be significantly higher when compared with wind forces for analyzed a residential building one has to consider all the possible loadings and see that the structure is safe against all possible loading conditions. There are several methods for analysis of different frames like kanis method, cantilever method, portal method, matrix method. the present project deals with the analysis of a residential building of G+10.

Keywords- Analysis, Design, Staad.pro, Building, IS 456:2000 etc.

1. INTRODUCTION

In modern civil engineering, the design and analysis of high-rise residential buildings demand sophisticated tools and techniques to ensure structural integrity, safety, and efficiency. STAAD Pro, a widely-used software package, offers engineers the capability to perform comprehensive structural analysis and design for various types of structures, including high-rise buildings.

Initial Data Collection the first step involves gathering all necessary data, including architectural drawings, site conditions, material properties, and loading requirements. Modelling Engineers create a digital model of the building within the STAAD Pro environment. This involves defining the geometry, structural components, supports, and connections accurately.

Load analysis is a crucial step where engineers apply various loads such as dead loads, live loads, wind loads, and seismic loads as per relevant building codes and standards. STAAD Pro allows for the precise application of these loads and provides tools for load combination and analysis. Structural Analysis once the loads are applied, STAAD Pro performs structural analysis using advanced computational algorithms. This analysis assesses the response of the structure to the applied loads, determining stresses, displacements, and internal forces in each structural component.

Design Optimization based on the analysis results, engineers refine the design to ensure that the structure meets safety requirements while optimizing material usage and cost. STAAD Pro offers design optimization tools that assist in achieving an efficient and economical design.

Code Compliance the design process involves ensuring compliance with relevant building codes and standards. STAAD Pro facilitates this by allowing engineers to specify design criteria according to the applicable codes, ensuring that the final design meets all necessary regulations. Documentation and Reporting Engineers generate comprehensive reports and documentation detailing the analysis and design process, including drawings, calculations, and structural specifications. This documentation serves as a reference for construction and regulatory approval.

In our project the analysis for G+10 residential building having 4 flats on each floor is done and loads considered are Earthquake loads, Wind loads, Dead loads and Live loads.

1.1 Objective of the study

To study complete analysis and design of building using software. The effects of earthquake loads on the structure.

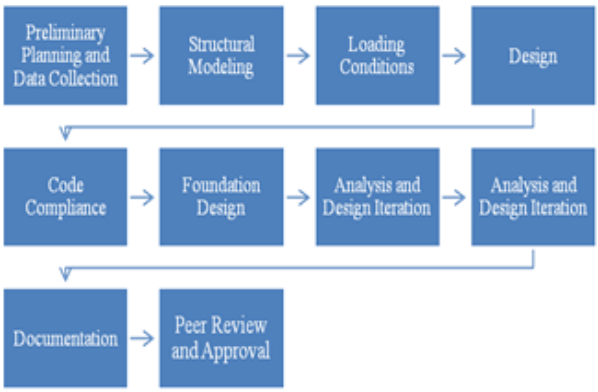
Software uses.

- AutoCAD
- Staad.pro V8i

1.2 About the project

- Type of building: Residential
- Type of Construction: RCC Framed Structure
- Type of wall: AAC blocks wall
- Apartment type: 2BHK
- Plot size: 38.5 m X 25.35 m
- No. of Storey: 11(G+10)
- No. of Staircase: 1
- No. of lifts: 2
- Floor to Floor Height: 3m
- Wall Thickness: 150mm
- Height of plinth: 0.6m
- Slab thickness: 125mm

2. MATERIALS AND METHODS

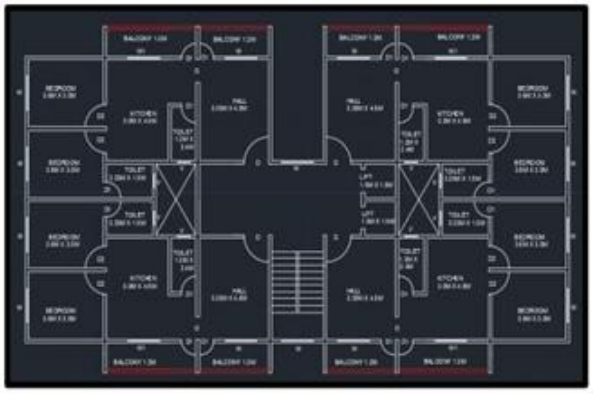


- Preliminary Planning and Data Collection: Gather architectural drawings, structural plans, and specifications. Collect information on site conditions, including soil reports and seismic data. Determine design criteria, such as occupancy loads, wind loads, and seismic requirements.
- Structural Modelling: Create a 3D model of the building using STAAD Pro's modelling tools. Define structural elements such as columns, beams, slabs, walls, and braces. Input material properties including concrete, steel, and reinforcement specifications.
- Loading Conditions: Apply various loads to the structural model based on design codes and standards. Include dead loads (self-weight, finishes), live loads (occupancy, furniture), wind loads, and seismic loads. Consider different load combinations as per applicable building codes.
- Analysis: Perform structural analysis using STAAD Pro's analysis engine. Conduct linear or nonlinear static analysis to determine member forces and displacements. Consider dynamic analysis for seismic response if required. Check for stability and adequacy of the structure under applied loads.
- Design: Design structural members based on analysis results and code requirements. Size columns, beams, and slabs to withstand applied loads and satisfy strength and serviceability criteria. Ensure adequate reinforcement detailing for concrete elements. Design connections to ensure structural integrity and load transfer between elements.
- Code Compliance: Verify compliance with relevant design codes and standards (e.g., ACI, AISC, ASCE). Check member capacities against code-prescribed limits for strength, deflection, and stability. Ensure seismic design meets requirements specified by the local building code.
- Foundation Design: Analyze foundation systems including footings, piles, or mat foundations. Size and design footings based on soil bearing capacity and applied loads. Consider factors such as settlement, overturning, and uplift resistance.
- Analysis and Design Iteration: Review analysis and design results for compliance and optimization. Make necessary adjustments to the structural model, loading conditions, or design parameters. Iterate through analysis and design steps until an optimal solution is achieved.
- Documentation: Prepare comprehensive design calculations, reports, and drawings. Document analysis assumptions, input parameters, and design methodology. Include detailed construction drawings for use during the construction phase.
- Peer Review and Approval: Conduct peer review of the design by experienced structural engineers. Address any feedback or recommendations from the peer review process. Obtain approval from relevant

authorities and stakeholders before proceeding with construction.

2.1 BUILDING PLAN USING AUTOCAD

- Typical all Floors Plan



- ANALYSIS AND DESIGN USING STAAD PRO

Model: G +10 Storey building
Properties:
Beam size : 450mm X 220mm
Column size :500mm X 220mm
Shear wall thickness: 300mm

Materials:
Concrete grade : M30
All steel grades : Fe415

Loads:
Seismic loads
Wind loads
Dead loads
Live loads

Live loads:
Staircase load:
6.775 KN/m (along length)
3.65 KN/m (along width)
Residential building: 2 KN/m3

Seismic loads:
Seismic zone:
Zone V i.e Zone factor 0.36
Response reduction factor : 5
Importance factor : 1
Soil type : Medium
Damping ratio : 5%
Px (period in x direction) : 0.587 sec
Pz (period in z direction) : 0.836 sec

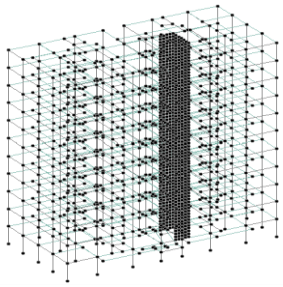
Wind loads:
Basic wind speed : 50m/sec
Terrain category : III
Exposure factor : 0.8

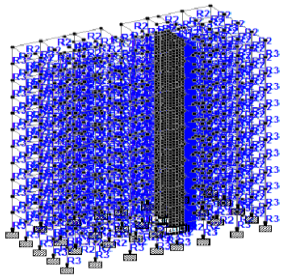
Dead loads:
Self weight of structure
Wall loads :
4.025 KN/m (Main wall)
0.992 KN/m (Parapet wall)
Slab load for staircase:
16.39 KN/m (along length)
8.81 KN/m (along width)

Floor load including slab load : 4.7 KN/m3
Shear wall load : 7.5 KN/m2

2.2 MODELING AND ANALYSIS

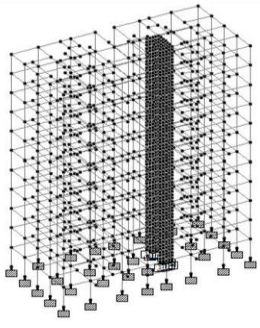
- MODELING IN STAAD PRO
- Geometry of whole structure
- Properties assigned

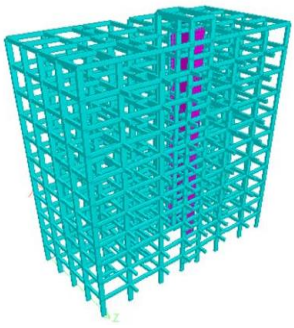




1. Geometry of whole structure 2.Properties assigne

- Supports assigned
- D Rendered View

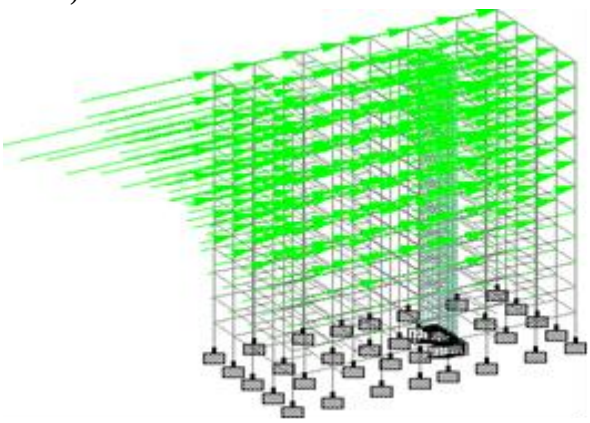




3.Supports assigned 4. 3 D Rendered View

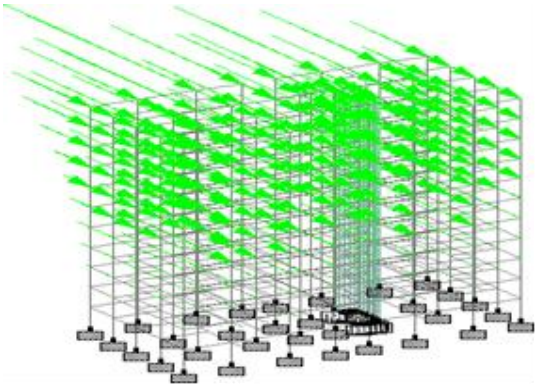
- ASSIGNING LOADS
- Primary Load cases

- Load Case 1: Earthquake Load in X direction (EQ X)



5. Structure under EQ in X direction

- Load Case 2 : Earthquake Load in Z direction (EQ Z)



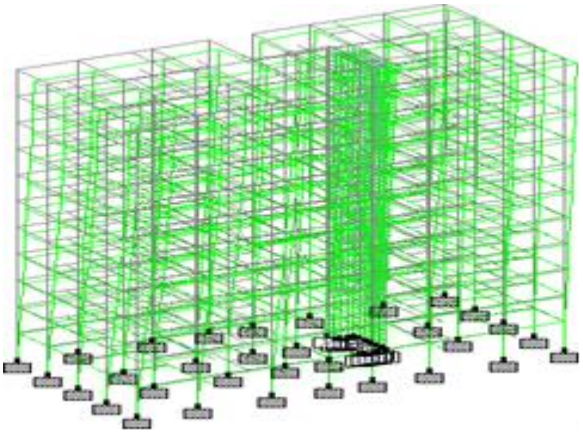
6. Structure under EQ in Z direction

- Load Case 3 : Wind Load (WL)
- Load Case 4 : Dead load (DL)
- Load Case5 : Live Load (LL)

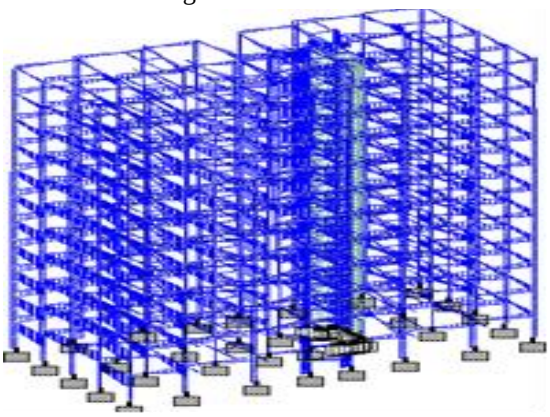
- Combination Load Cases
- 1.5(DL+LL)
- 1.2(DL+LL+WL)
- 1.2(DL+LL)-1.2WL
- 1.2(DL+LL+EQX)
- 1.2(DL+LL+EQZ)
- 1.2(DL+LL)-1.2EQX
- 1.2(DL+LL)-1.2EQZ
- 1.5(DL+WL)
- 1.5(DL+EQX)
- 1.5(DL+EQZ)
- 1.5DL-1.5EQX
- 1.5DL-1.5EQZ
- 0.9DL+1.5WL
- 0.9DL-1.5WL
- 0.9DL+1.5EQX
- 0.9DL+1.5EQZ
- 0.9DL-1.5EQX
- 0.9DL-1.5EQZ

- ANALYSIS

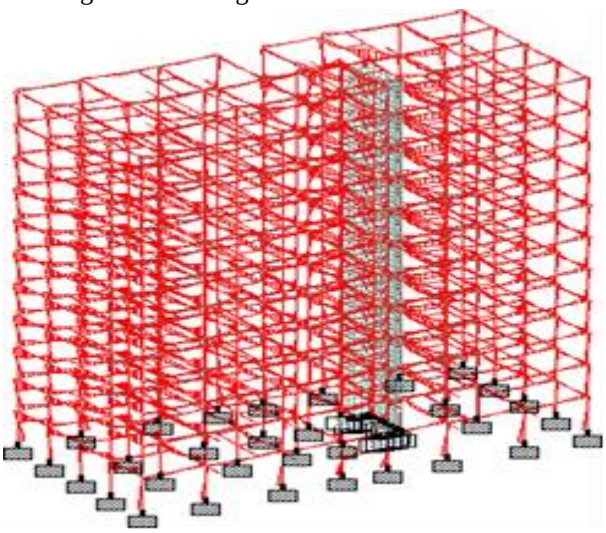
- Deflection Diagram



- Shear Force Diagram



- Bending Moment Diagram



3. RESULTS

- Design of beam
- Beam reinforcement
- Design of Column
- Column Reinforcement

3.1Design of beam

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                    IS-456   L I M I T   S T A T E   D E S I G N
                  B E A M  N O.    3493   D E S I G N  R E S U L T S

      M30                        Fe415 (Main)                 Fe415 (Sec.)

   LENGTH:  3500.0 mm      SIZE:   230.0 mm X  460.0 mm   COVER: 40.0 mm


                          SUMMARY OF REINF. AREA (Sq.mm)
-------------------------------------------------------------------------------
SECTION      0.0 mm      875.0 mm     1750.0 mm     2625.0 mm     3500.0 mm
-------------------------------------------------------------------------------
 TOP         1945.72      808.29       193.14        607.49       1624.67
REINF.      (Sq. mm)     (Sq. mm)     (Sq. mm)      (Sq. mm)     (Sq. mm)

BOTTOM       1557.81      768.69       193.14        694.90       1508.54
REINF.      (Sq. mm)     (Sq. mm)     (Sq. mm)      (Sq. mm)     (Sq. mm)
-------------------------------------------------------------------------------


                       SUMMARY OF PROVIDED REINF. AREA
-------------------------------------------------------------------------------
SECTION      0.0 mm      875.0 mm     1750.0 mm     2625.0 mm     3500.0 mm
-------------------------------------------------------------------------------
 TOP         4-25d        2-25d        2-25d         2-25d         4-25d
REINF.    2 layer(s)   1 layer(s)   1 layer(s)    1 layer(s)    2 layer(s)

BOTTOM       5-20d        3-20d        2-20d         3-20d         5-20d
REINF.    2 layer(s)   1 layer(s)   1 layer(s)    1 layer(s)    2 layer(s)

SHEAR    2 legged  8d  2 legged  8d  2 legged  8d  2 legged  8d  2 legged  8d
REINF.  @ 135 mm c/c  @ 135 mm c/c  @ 135 mm c/c  @ 135 mm c/c  @ 135 mm c/c
-------------------------------------------------------------------------------


SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT
-------------------------------------------------------------------------------

SHEAR DESIGN RESULTS AT    645.0 mm AWAY FROM START SUPPORT
  VY =    130.66 MX =      1.06 LD=   17
  Provide 2 Legged  8d  @ 135 mm c/c

SHEAR DESIGN RESULTS AT    645.0 mm AWAY FROM END SUPPORT
  VY =   -119.49 MX =     -1.16 LD=   15
  Provide 2 Legged  8d  @ 135 mm c/c

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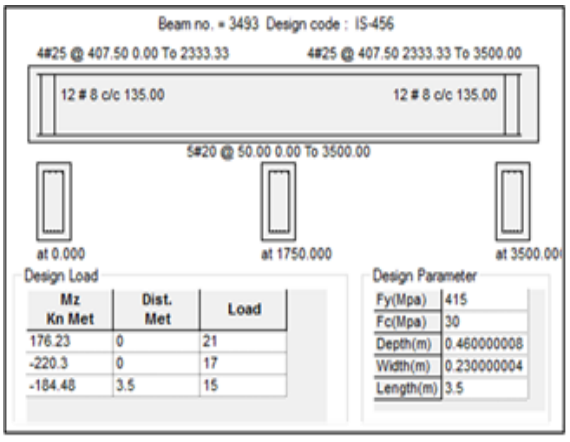
3.2 Beam reinforcement



3.3 Design Of Column

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                    IS-456   L I M I T   S T A T E   D E S I G N
                  C O L U M N   N O.   4560   D E S I G N   R E S U L T S

      M30                        Fe415 (Main)                 Fe415 (Sec.)

   LENGTH:  3000.0 mm   CROSS SECTION:  230.0 mm X  500.0 mm   COVER: 40.0 mm

   ** GUIDING LOAD CASE:   16  SHORT(Z)          /BRACED LONG(Y)

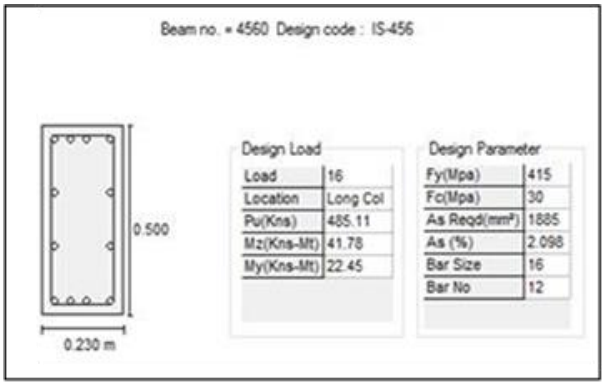

   REQD. STEEL AREA    :      1885.32 Sq.mm.
   REQD. CONCRETE AREA:    113114.69 Sq.mm.
   MAIN REINFORCEMENT : Provide  12 - 16 dia. (2.10%,    2412.74 Sq.mm.)
                        (Equally distributed)
   TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 230 mm c/c
-------------------------< PAGE 1282 Ends Here >-------------------------
  STAAD SPACE                                                -- PAGE NO. 1283

   SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
   ----------------------------------------------------------
   Puz :    2113.85   Muz1 :     183.05   Muy1 :      70.53

   INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

   SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
   ----------------------------------------------------------
   WORST LOAD CASE:   16
   Puz :    2270.89   Muz :     210.65   Muy :      78.03   IR: 0.91
```

3.4 Column Reinforcement



4. CONCLUSION

This project includes G +10 building with parking at ground floor and rest of the floors occupied with 2BHK flats. The response of a RCC high rise building under wind load and seismic load is studied as per IS 1893(Part 1): 2002 and IS 875 (Part 3) :1987 respectively. Reinforcement details for each member i.e beams and columns can be obtained directly after the process of analysis is carried out. While designing with STAAD Pro the time required for designing is reduced, accuracy is improved. While designing some of the column and beams section, the reinforcement percentage exceeds the maximum limit of reinforcement percentage. Total volume of concrete required for beams, columns is 360.5 cu.m.

REFERENCE

[1] IS 456-2000 Plain and Reinforced Concrete Code of Practice.

[2] IS 875(Part 1):1987 This is a Code of practice for design loads (other than earthquake) for buildings and structures Part 1 Dead loads Unit weights of

building material and stored materials (second revision) (Incorporating IS:1911-1967).

[3] IS 875(Part 2):1987 This is a Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads (second revision).

[4] International journal of Advanced Engineering, Management and science volume 3 issue no 3 Design and analysis of multi-storeyed building (G+10) by using Staad Pro March2017.

[5] SSRG Intenational journal of civil engineering volume 6 issue 6 Design and analysis of high rise building using STAAD.Pro june 2019 Illustrated Design Of Reinforced concrete buildings by Dr. V.L. Shah and Dr. S.R.Karve Reinforced concrete design B.C.Punmia Laxmi Publication.