

Comparative Assessment of G +10 Building, Reinforcement Specifications using ETABS & STAAD-PRO RCDC Softwares

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Abstract - This project involves the comparative assessment of reinforcement specifications for a G+10 building using ETABS and STAAD Pro software. The analysis focuses on determining bending moments, shear forces, and reinforcement requirements for the structure. The results obtained from both software platforms, ETABS and STAAD Pro, are compared to evaluate their consistency and accuracy in structural design. Additionally, reinforcement details are generated using STAAD Pro's RCDC software, and these results are compared with those from the STAAD Pro model to ensure alignment in design outcomes. The project aims to enhance the reliability and efficiency of structural reinforcement design.

Key Words: G+10 building, Analysis, design, ETABS, STAAD Pro, STAAD Pro RCDC.

1. INTRODUCTION

A building is any man-made structure that is supported by a foundation and has permanent features like a veranda, balcony that is attached to a building or forms a section of a building, as well as walls made of architectural cladding systems, floors, roofs, chimneys, plumbing, and other building services. The foundation, plinth, slab, wall and other structural elements are the most important parts of a building and must be properly designed and constructed to guarantee both structural and functional performance. Buildings can be residences, workplaces, retail centers, medical facilities, educational institutions, and more.

1.1 Types of Building

The types of buildings are categorized based on their function, design, and the activities they support. These categories help to understand the diverse needs of human life and the built environment. Each type of building serves a distinct role, whether it's a home for individuals and families, a workplace, a place for learning, or a venue for entertainment. Understanding these different types is crucial for urban planning, architecture, and development, as each type addresses specific requirements in terms of space, accessibility, and functionality. The "National Building Code of India," which groups buildings according to occupancy, serves as the basis for the list of building kinds that follows

1. Residential building
2. Institutional building
3. Educational building
4. Assembly building
5. Business building
6. Mercantile building
7. Hazardous building
8. Storage building
9. Industrial building

1.2 Structural Analysis

Steel structural analysis uses models and computation techniques to examine the steel's stability and load-bearing capabilities. Equipment or a structure is designed using the analytical approach to ensure that it is safe to use and capable of supporting the predicted loads that it is planned to support.

Methods of structural analysis

1. Analytical methods
2. Limit state analysis
3. Finite element
4. Moment distribution method
5. Column analogy method
6. Stiffness matrix method
7. Slope deflection method
8. Thermomechanical Analysis

2. STRUCTURAL DESIGN

The systematic study of a structure's stiffness, strength, and stability is referred to as structural design. Building a framework that is capable of supporting all applied loads without breaking during its intended life is the main objective of structural analysis and design.

Any structure's design must primarily adhere to five fundamental steps

1. Modelling
2. Analysis of load
3. Analysis of structure
4. Design of structure
5. Detailing

Software Implemented to perform the analysis

1. AUTO CADD
2. ETABS
3. STAAD PRO, STAAD PRO RCDC

AUTO CAAD: Engineering plans and blueprints are produced in the domains of architecture, construction, and manufacturing using AutoCAD, a 2D and 3D computer-aided drafting tool.

ETABS: It is 3D (three dimensional) analysis of structure systems which used for structural analysis & design. For users, ETABS is a quick and efficient program, for the purpose of creating models for any kind of construction.

STAAD PRO: STAAD PRO is frequently used for cold-formed steel, concrete, steel, and aluminum in factories, tunnels, bridges, multi-story buildings, and many more applications.

STAAD PRO RCDC: STAAD PRO RCDC (Reinforced Concrete Design and Detailing) is a comprehensive software developed by Bentley Systems for the design, analysis, and detailing of reinforced concrete structures.

Objectives

1. Analysis of the building using STAAD PRO and ETABS software.
2. To ascertain bending moments, shear forces, and reinforcing information.
3. To compare results between STAAD PRO and ETABS.
4. To achieve the reinforcement details using STAAD PRO RCDC software and compare the results with STAAD PRO.

Methodology

The methodology for this dissertation involves a detailed comparison of the reinforcement design of a G+10 commercial building using STAAD PRO, ETABS, and STAADPRO RCDC software. The first step is selecting the dissertation topic, which emphasizes evaluating the efficiency and accuracy of these tools in reinforcement detailing.

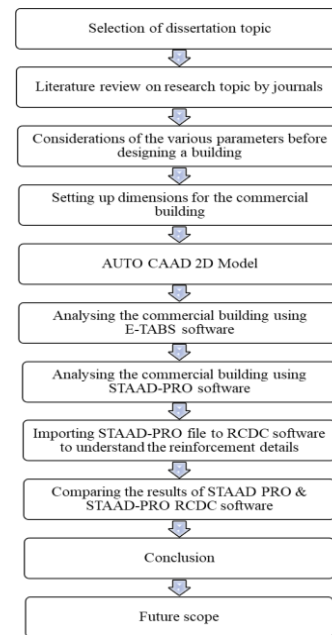


Chart -1: Methodology sequence in form of flow chart

Manual calculation

1. Data:

- Breadth, B = 400 mm
- Overall depth, D = 500 mm
- Effective cover, d' = 25 mm
- Effective depth, d = 500 - 25 = 475 mm
- Clear span of room = 1.465 m
- Wall thickness = 150 mm
- Live load = 14.54 kN/m
- fck = 30 N/mm²
- fy = 500 N/mm²

2. Calculation of constants:

$$\frac{X_u \max}{d} = 0.48 \text{ for } f_{y500} \text{ (IS 456: 2000)}$$

$$R_{u \max} = 0.36 \times f_{ck} \times \frac{X_u \max}{d} \left(1 - 0.42 \times \frac{X_u \max}{d}\right)$$

$$= 4.13 \text{ N/mm}^2$$

3. Calculation of loads:

- D.L. of beam = (0.4 x 0.5 x 1) 25000 = 5000 N/m
- L.L. = 14.54 kN/m = 14540 N/m
- Total load, W = 19540 N/m
- Ultimate load, Wu = W x 1.5 = 29310 N/m

4. Effective span:

The effective span is taken as the least of following

- a. Clear span + effective depth =
1.465 + 0.475 = 1.94 m
 - b. C/C distance between the supports =
0.075 + 1.465 + 0.075 = 1.615 m
- Effective span = 1.615 m

5. Calculation of bending moment:

$$M_u = \frac{Wu l^2}{8} = 9.55 \text{ kN/m}$$

6. Calculation of shear force:

$$V_u = \frac{Wu l}{2} = 23.66 \text{ kN}$$

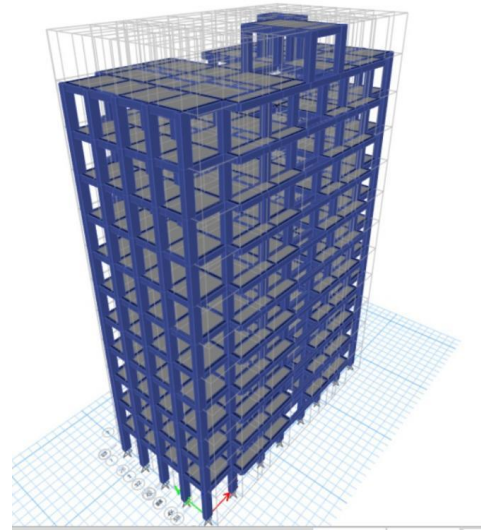


Fig - 1: 3D rendered view

AUTO CADD PLAN

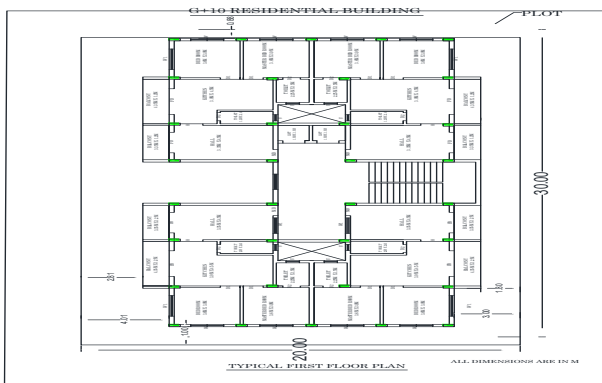


Fig -1: Typical floor plan

ETABS SOFTWARE RESULTS

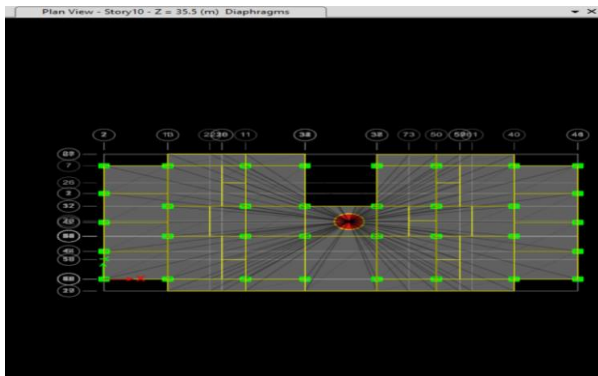


Fig - 1: CG of building

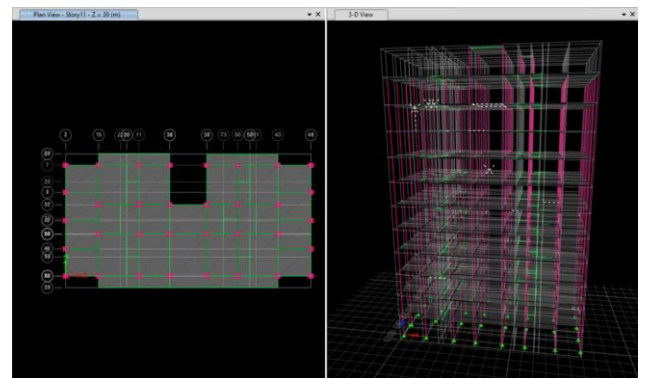


Fig - 1: Structural members specify safe for columns

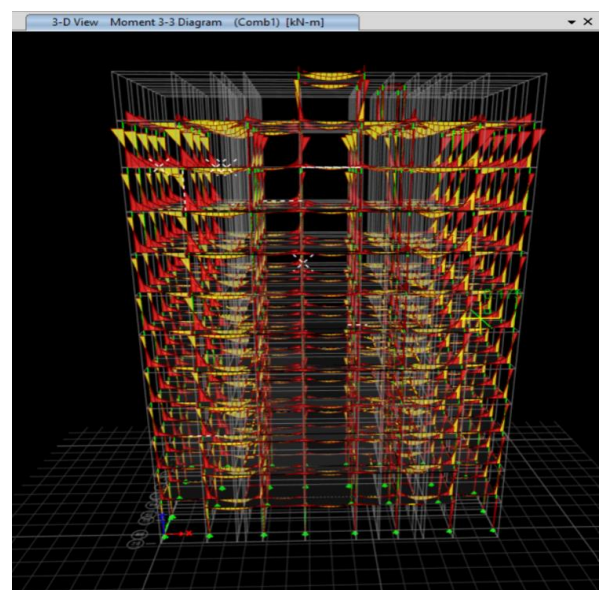


Fig - 1: Model representing bending moment

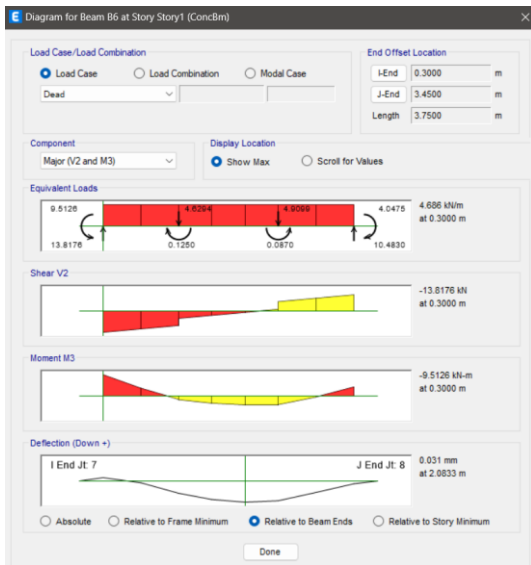


Fig - 1: Values of bending moment, shear force & deflection for the B6

Results of STAAD PRO

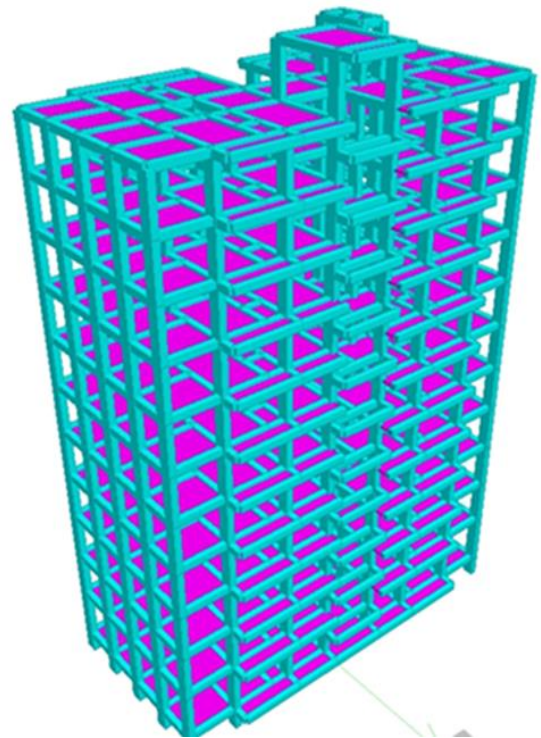


Fig - 1: 3D Rendered view

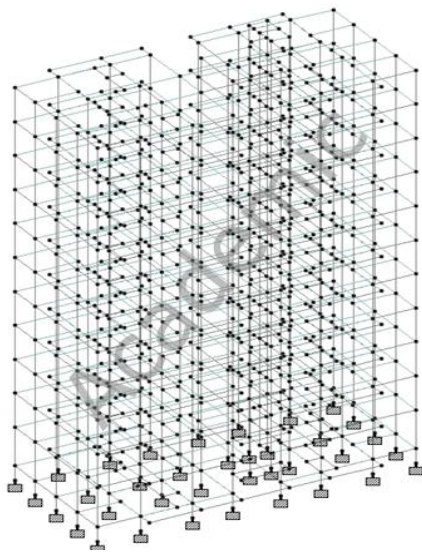


Fig - 1: Geometry of whole structure

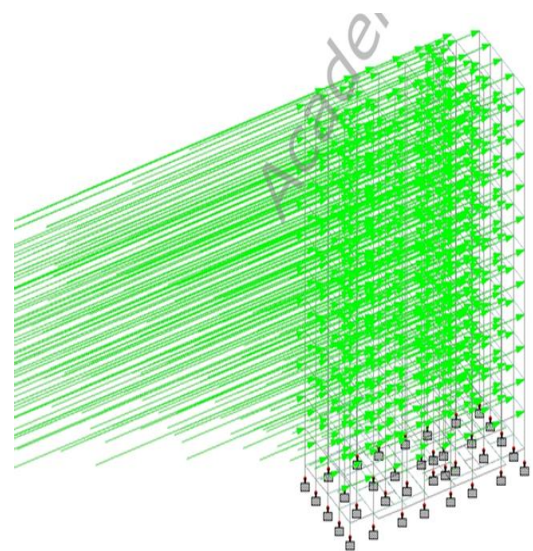


Fig - 1: Structure under EQ in X direction

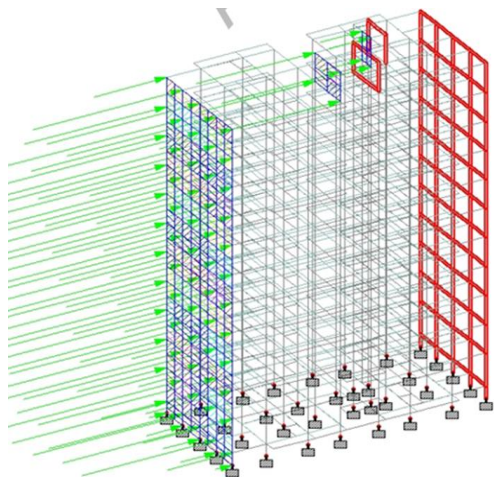
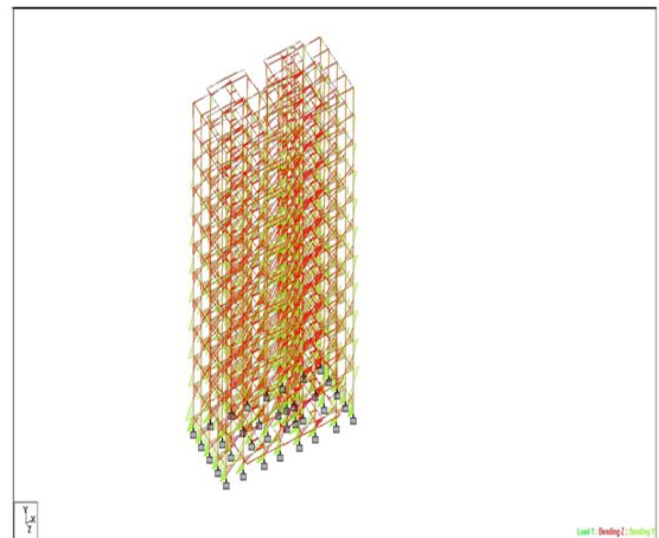


Fig - 1: Structure under wind load in X+ direction



Whole Structure My 100kN-m:1m Mz 100kN-m:1m 1 EQX

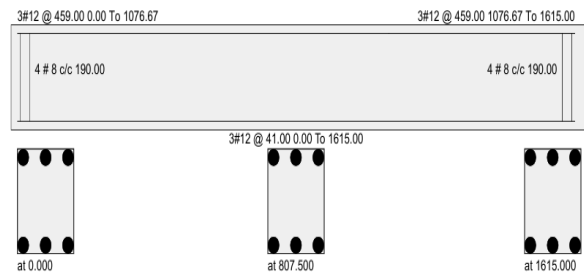
Fig - 1: Bending moment

Observed bending moments is $M_y = 100 \text{ kN/m}$ and $M_z = 100 \text{ kN/m}$ for whole structure, indicating the moments acting on the structure around the Y and Z axis, respectively.

Design of beam

Beam no. 1894

Design Code: IS-456



Design Load

Design Parameter

Mz(Kn Met)	Dist.let	Load
8.470000	1.600000	3
-20.260000	0.000000	3
-1.320000	1.600000	16

Fy(Mpa)	500.000000
Fc(Mpa)	30.000000
Depth(m)	0.500000
Width(m)	0.400000
Length(m)	1.615000

Fig - 1: Beam reinforcement

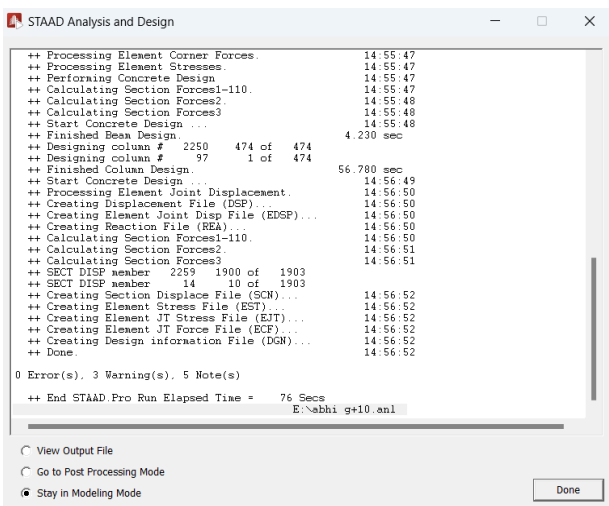
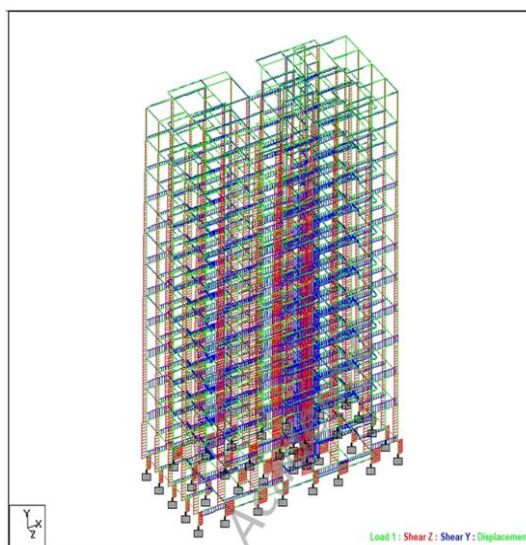


Fig - 1: Check for zero errors



Whole Structure Fz 110kN:1m Fy 110kN:1m Displacements 410000mm:1m 1 EQX

Fig - 1: Shear force

IS-456 LIMIT STATE DESIGN
BEAM NO. 1894 DESIGN RESULTS

M30 Fe500 (Main) Fe500 (Sec.)
LENGTH: 1615.0 mm SIZE: 400.0 mm X 500.0 mm COVER: 35.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	403.8 mm	807.5 mm	1211.3 mm	1615.0 mm
TOP REINF.	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)
BOTTOM REINF.	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)	312.12 (Sq. mm)

DXF IMPORT OF CENTERLINE DWG -- PAGE NO. 2343

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	403.8 mm	807.5 mm	1211.3 mm	1615.0 mm
TOP REINF.	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)
BOTTOM REINF.	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)	3-12d 1 layer(s)

SHEAR 2 legged 8d @ 190 mm c/c 2 legged 8d @ 190 mm c/c 2 legged 8d @ 190 mm c/c 2 legged 8d @ 190 mm c/c 2 legged 8d @ 190 mm c/c

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

SHEAR DESIGN RESULTS AT 709.0 mm AWAY FROM START SUPPORT
VY = -0.85 MX = 5.12 LD= 16
Provide 2 Legged 8d @ 190 mm c/c

Fig - 1: Summary of beam

Design of Column

Beam no. 443
Design Code: IS-456

Design Load		Design Results	
Load	11	Fy(Mpa)	500
Location	End 2	Fc(Mpa)	30
Pu(Kns)	-14.140000	As Reqd(mm2)	2365.000000
Mz(Kns-Mt)	77.400002	As (%)	0.804000
My(Kns-Mt)	147.080002	Bar Size	16
		Bar No	12

Fig - 1: Column reinforcement

IS-456 LIMIT STATE DESIGN
COLUMN NO. 443 DESIGN RESULTS

M30 Fe500 (Main) Fe500 (Sec.)
LENGTH: 3500.0 mm CROSS SECTION: 500.0 mm X 600.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 11 END JOINT: 434 TENSION COLUMN

REQD. STEEL AREA : 2365.28 Sq.mm.
REQD. CONCRETE AREA: 297634.72 Sq.mm.
MAIN REINFORCEMENT : Provide 12 - 16 dia. (0.80%, 2412.74 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 255 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 4905.05 Muz1 : 260.28 MUY1 : 212.21

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

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 11
END JOINT: 434 Puz : 4922.21 Muz : 266.24 MUY : 216.89 IR: 0.97

Fig - 1: Summary of column

Result of STAAD PRO RCDC

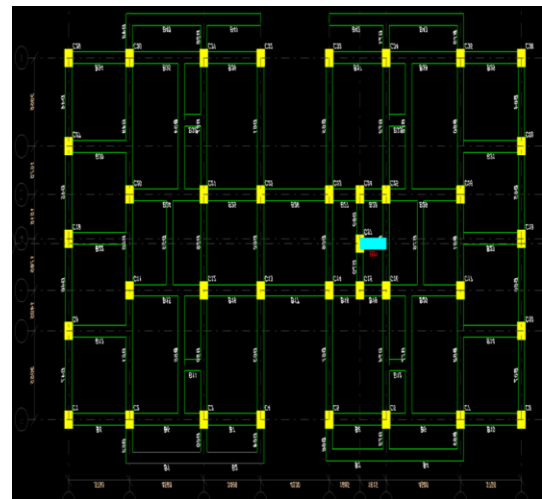


Fig - 1: Position of beams

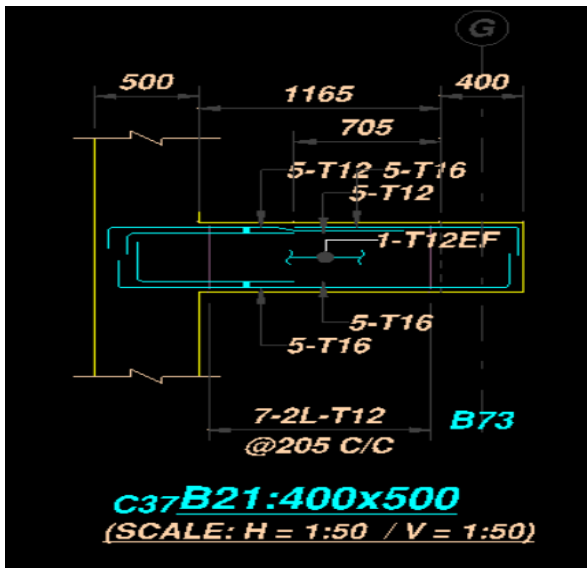


Fig - 1: Beam Reinforcement

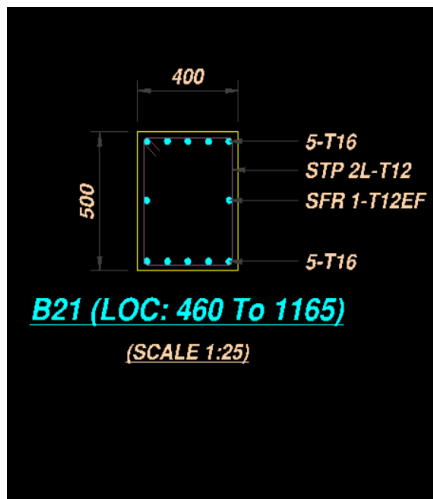


Fig - 1: Beam Reinforcement @CS

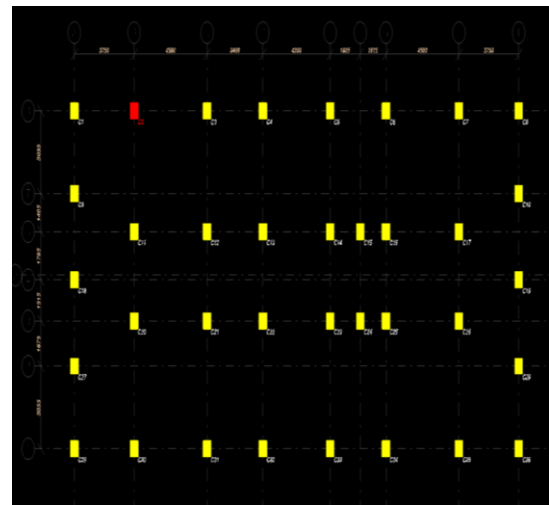


Fig - 1: Position of Columns

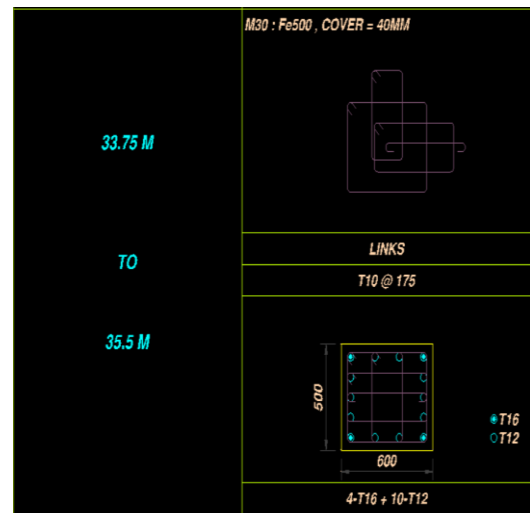


Fig - 1: Column reinforcement

Beam No	:	B21	
Group No	:	G10	
Analysis Reference(Member)	4 m	:	586
Breadth	:	400	mm
Depth	:	500	mm
Concrete Grade	:	M30	N/sqmm
Grade Of Steel (Main)	:	Fe500	N/sqmm
Grade Of Steel (Shear)	:	Fe500	N/sqmm
Top/Bottom Clear Cover	:	25	mm
Side Clear Cover	:	25	mm
Design Code	:	IS 456 : 2000 + IS 13920 : 2016	
Beam Type	:	Regular Beam	

Flexure Design

	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Mud (kNm)	306.1	210.28	57.67	184.93	132.2	104.86
PtClc (%)	1.086	0.69	0.2	0.596	0.412	0.322
AstCalc (sqmm)	1932.83	1228.28	356	1061.33	733.56	572.57
Ast Prv (sqmm)	2010.6	1407.42	1005.3	1131	1005.3	1005.3
Reinforcement	5-T16 5-T16	5-T16 2-T16	5-T16	5-T12 5-T12	5-T16	5-T16

Fig - 1: Summary of Beam

Comparative Result

The bending moment value obtained from STAAD PRO and ETABS is 8.47 kN/m and 9.51 kN/m respectively, whereas the bending moment computed manually is 9.55 kN/m which is nearer to ETABS results. The shear force value obtained from STAAD PRO and ETABS is -20.26 kN and -13.81 kN respectively, whereas the shear force calculated manually is 23.66 kN which is nearer to STAAD PRO results. Manual calculation is done to verify the accuracy of software results. The displacement value obtained from STAAD PRO and ETABS is -1.32 mm and 0.031 mm respectively.

DISCRPTION	STAAD-PRO	ETABS	MANUAL CALCULATION
Bending moment (kN/m)	8.47	9.51	9.55
Shear force (kN)	20.26	13.81	23.66
Displacement (mm)	-1.32	0.031	-

Table: 1

Conclusion

1. While STAAD PRO reported a slightly lower value (8.47 kN/m), the manually calculated bending moment values (9.55 kN/m) showed close agreement with ETABS (9.5126 kN/m). This draws attention to slight differences in the tool's computational strategies.

2. There were notable discrepancies in the shear force values, with ETABS reporting -13.81 kN and STAAD PRO calculating -20.26 kN. This suggests that the two software's analysis techniques or load assumptions may differ.

3. The displacement values were significantly different, with ETABS reporting 0.031 mm and STAAD PRO reporting -1.32 mm. This implies variations in boundary condition settings, stiffness considerations, or modeling methods.

4. STAAD PRO tends to provide more economical designs by optimizing the number of reinforcement bars based on the structural analysis. This often results in fewer bars compared to STAAD PRO RCDC, which may be more conservative in its reinforcement recommendations.

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