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COMPARTIVE STUDIES ON ANALYSIS AND DESIGN OF G+4 BUILDING BY USING MANNUAL AND STAAD PRO

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Abstract : The design and analysis of buildings are critical processes in civil engineering, and advancements in technology have allowed for computer-aided design (CAD) software like STAAD Pro to be used for these tasks. This study compares the manual design and analysis process with STAAD Pro software for a G+4 building. The manual process involves calculations, drawings, and codes to determine loads and forces, select materials, and design structural members. STAAD Pro is a powerful software that uses finite element analysis to model and analyze structural behavior under various loads. To compare the two methods, we analyzed a G+4 building using both manual calculations and STAAD Pro.

The study found that the manual process required more time and effort, while STAAD Pro provided more accurate results, optimized member sizes, and generated detailed reports and drawings. However, the manual process offered more flexibility in design and allowed for detailed customization. The use of STAAD Pro can significantly reduce the time required for design and analysis, but manual processes still have a place in civil engineering. Overall, the study highlights the benefits and drawbacks of each method and suggests that the optimal approach may vary depending on the complexity and customization requirements of the building.

Key words: Auto CAD, STAAD Pro, Bending moment, Shear force..

I. INTRODUCTION

The design and analysis of buildings are critical aspects of civil engineering, with a significant impact on the safety, cost, and performance of a structure. In recent years, computer-aided design (CAD) software like STAAD Pro has gained popularity in the field, offering a powerful tool for analyzing and designing structures. However, traditional manual methods of analysis and design remain prevalent, and their efficacy relative to computer-aided methods is an area of ongoing research. This study aims to compare the manual design and analysis process with STAAD Pro software for a G+4 building, analyzing the benefits and drawbacks of each method. By comparing the two approaches, we hope to identify which method is more efficient, accurate, and cost-effective and to determine the optimal approach for different types of structures. Ultimately, this study will contribute to the ongoing research on computer-aided design and analysis and inform best practices for civil engineering projects.

II. WORK FLOW

1. Literature study
2. Architectural drawings developed by auto CAD
3. Calculation of load on critical column
4. Design of slab,beam and column
5. STAAD pr analysis
6. Comparative study
7. Conclusions
8. References

III. PROPERTIES OF BUILDING

Height of structure = 15 m
Height of each story = 3 m
No.of storys = 5
Column size = 0.3 x 0.6 m
Beam size = 0.23 x 0.45 m
Slab thickness = 0.125 m
Parapet wall height = 1 m
Wall thickness (interior) = 0.1 m
Wall thickness (exterior) = 0.23 m
Grade of concrete = M_{25}

Grade of steel = F_e 415

Fig. 1 Typical floor plan

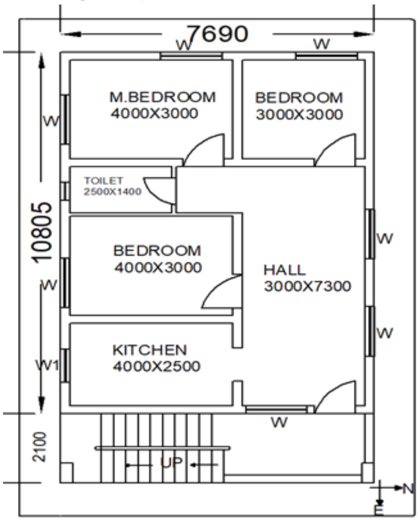
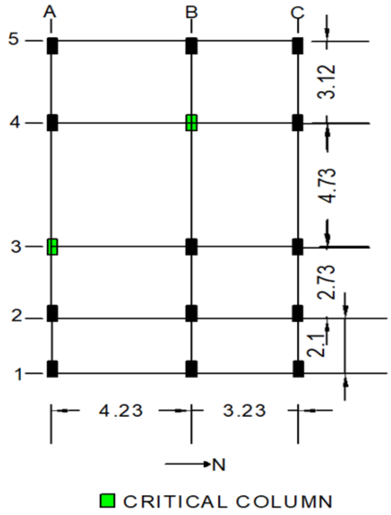


Fig. 2 Column layout



3.1 DESIGN OF SLAB

Consider Room Size: -

Step 1: -

ly=4.73m lx=4.23m

ly/lx=4.73/4.23

=1.11<2

Hence it is designing a Two-Way Slab

Step 2:-

Ly/d =32 (for ssb)

d=lx/32

=132.75mm

D=130mm

d'=10mm

D=d'+d =10+130 =140mm

Step 3: -

Effective Span: -

lx = lx + d

= 4230 + 140

= 4.370m

Ly = ly + d

= 4730 + 140

= 4.87 m

Step 4: -

Loads: -

Self-weight of Slab = 0.14 x 1 x 25 = 3.5 kN/m2

Total = 3.5+4+1 =8.5 kN/m2

Factored Load 'w' = 1.5x8.5

W=12.75 kN/m2

Step 5: -

Design of moments: -

(Bending moment and Shear Force)

Moments: -

Mx= αxWlx2

My= αyWly2

To find αx :-

ly/lx =1

αx=0.047(As per IS 456-2000) table -27

Mx =αx Wlx2

= (0.047)(12.75)(4.37)2

Mx = 11.44 kN-m

To find αy :-

ly/lx = 1

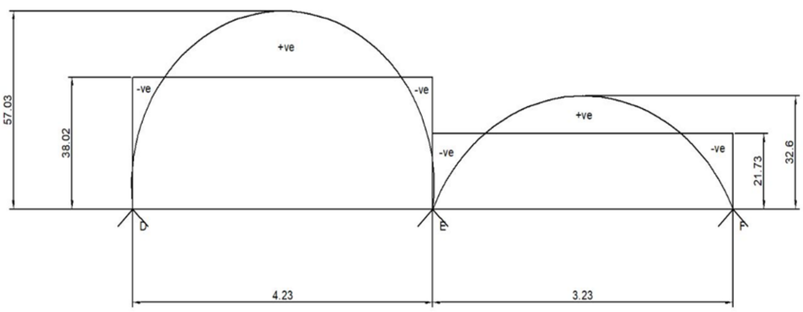
αy=0.035 As per Is 456-2000 table 27

My = αyWlx2

=0.035 x 12.75 x (4.37)2

My =8.52 kN-m
Among Mx & My which is max that is taken as Momentum
M = 12 kN-m
Shear force =
wl/2
Vu=25 x 4.37/2
= 54.6 kN
To Check Depth: -
Mu, Limit =0.138 fckbd2
12 x 106=0.138 x 25 x 1000 x d2
d = 58.9<120mm
Hence Safe
Step 6 :-
Tension Reinforcement: -
Along x- direction
Mux = 0.87fyAstd[1-Astfy/bdfck]
12 x 106 = 0.87x415 x Astx140 [1-Ast(415)/(1000)(140)(25)]
Astx = 244.49 mm2
Astmin = 0.12% gross Area
= (0.12 x 100 x 103)/100
= 120mm2
Assume 8mm Dia meter: -
N x π/4 x 102 = 156.25
N = 4.86
say n = 5
ast (prov)= 2 x π/4 x 82
= 251.32 >req
= ast (prov) > ast (req)
Hence ok.
1)Spacing of bars: -
= ast/Ast d x 1000
= π/4x 102/156.25 x 1000
=2 05.6mm
2) 3 x d = 3 x 130
= 390mm
3) 300mm whichever is less
hence provide 2bars 8mm dia @ 210 mm c/c
Along y-direction: -
Muy = 0.87fy x Ast x d[1-fy x Ast/fck x b x d]
8.52 x 106=0.87 x 415 x Ast x 130[1-415Ast/25 x 1000 x 140]
Ast=172.02 mm2
Assume dia of 8mm
115.62 = n x π/4 x 82
n = 4 bars
(i)spacing of bars = (ast/Ast) x 1000
= 292 mm
(ii)3 x d = 3 x 130=390mm
(iii) 300 mm whichever is less
Hence provide 8mm dia @ 290mm c/c
Step 7: -
Check for Deflection: -
l/d = 29.23 (Code book -pg37)
% of Steel = (ast/Bd) x100
=(261.80/1000*130)x100
=0.2%

3.3 DESIGN OF BEAM



Beam DE = +57.03 kN-m
Beam EF = +32.60 kN-m
On span DE: -
Max +M =57.07-38.02 = +19.01 kN-m
On span EF: -
Max +M =32.30-21.73 = +11.52 kN-m
On span DE: -
-Mu = -38.02 x 1.5 = -57.02 kN-m
+Mu = +19.01 x 1.5 = +28.5 kN-m
On span EF: -
-Mu = -21.73 x 1.5 = -32.5 kN-m
+Mu = +11.52 x 1.5 = +17.28 kN-m
Assume Beam size 0.23x0.45m
Mu limit = 0.138 Fck bd^2
= 0.138 x 25 x 230 x 450
= 109.2 kN-m
Beam EF (At supports): -
R= 1.5
Pt =0.466%
Area of steel = 482.31 m^2
Beam DE (At mid span): -
R = 0.77
Pt = 0.221%
Area of steel = 228.735 m^2
Beam EF (At supports): -
R = 0.88
Pt =0.261%
Area of steel = 270.13 m^2
Beam EF (At mid span): -
R = 0.46
Pt = 0.127%
Area of steel = 131.445 m^2
Area of steel from limiting moment of resistance: -
R = 1.77
Pt =0.5%
Area of steel = 517.5 m^2
Factored shear force = 80.89 kN
Nominal shear stress (Ʈv): - From pg. – 72 IS 456 2000
Ʈv = 0.78 N/mm^2
Now % of tension reinforcement
P = 0.5 %
Design shear strength of concrete (Ʈc): - From pg. - 73 table 19 IS 456 2000
for M20
Ʈc = 0.49 N/MM2
Ʈv > Ʈc
Shear reinforcement has to be designed in this case we shall provide vertical stirrups Now shear resistance of concrete
Vuc = Ʈc bd
= 0.49 X 230 X 450
Vuc = 50.71 kN
Now,
Shear to be carried by stirrups: -
Vus = Vu - Vuc = 80.89 – 50.71
Vus = 30.17 kN
Provide 8 mm Ø 2 legged stirrups as vertical stirrups.
Asv = π/4 x 82 x2 = 100.53 mm2
Spacing of 2 legged stirrups: - (pg-73)
Vus = $0.87fyA_{sv}d$ / Sv
30.17*103 = 0.87 x 415 x 100.53 x 300 / Vus
SV = 541.37 mm c/c
Asv/bsv = 0.4 / 0.87fy (pg-48)
Sv = Asv0.87fy / 0.4 x b
= 100.53 x 0.87 x 415 / 0.4*230
= 394.53 mm c/c
0.75d = 0.75*300 = 225 mm
Consider whichever is less
Provide 8 mm Ø 2 legged stirrups @ 225 mm c/c

3.3 DESIGN COLUMN

Width of the column(b) =300mm
Overall depth (d) =600mm
Load on the column=833 kN
Factored load (Pu)=1.5 x 833 kN
Length =3000mm
Effective length (l eff) =0.65*3000=1950mm
Take M25 grade of concrete &Fe 415 Steel
Check For Slenderness Ratio: -
=6.5<12
So, it is short column Has to be designed
Minimum Eccentricity: -
ex = 13.39 mm
ey = 13.39 mm
E min/D = 13.39/300
=0.046<0.05
Hence Design a Bi Axially Loaded Short column.
Fixed end moment for beam B4 – A4
Mb_3-a_3= 37.29 kN-m
W = equivalent load due to BM consideration
$[I/L]_C$ = 1800
$[I/L]_B$ = 1516.12
Moment in column: -
Mc = 16.30 kN-m
Mu = 16.30 X 1.50 = 24.45 kN-m = 25 kN-m
Pu = 831.90*01.5 = 1247.89 kN-m = 1218 kN-m
Mu/Fck bd = 0.237
Pu / Fckbd^2 = 0.009
minimu area of steel
For d'/d = = 0.1 (Assume d' = 50 mm)
From SP 16 charts: -
Fy 415 & d'/d =0.1
Percentage of steel = 0 %
Therefore, provide minimum area of steel.
Minimum area of steel from IS 456 2000
Minimum area of steel: -
0.8 % of gross cross-sectional
= 1440 mm^2
Lateral Ties: -
1) D/4 =4mm
2)6mm
Hence provide 6mm Día Bars
Pitch Of Ties: -
1) D=300mm
2) 16*diameter=16*16=256mm
3) 300mm Whichever is less
Hence provide 4bars of 6ϕ@256mmc/c

IV. STAAD PRO ANALYSIS

Fig. 4.1 FRAME

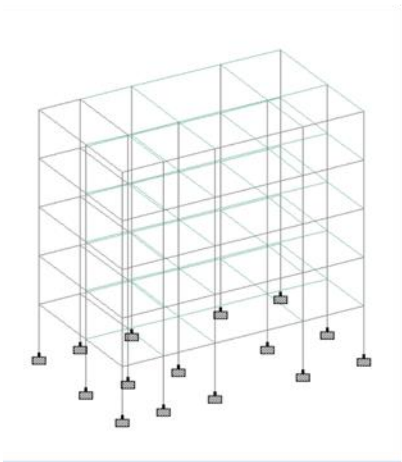


Fig. 5.3 Roof load

Fig. 4.2 3D STRUCTURE

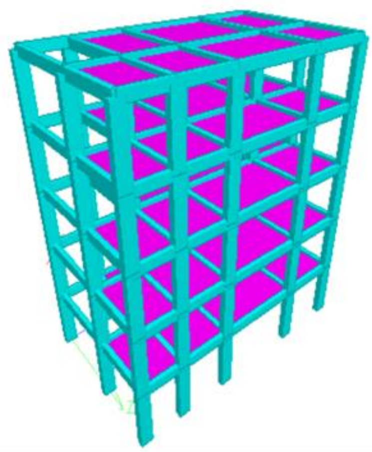


Fig. 5.4 Roof load

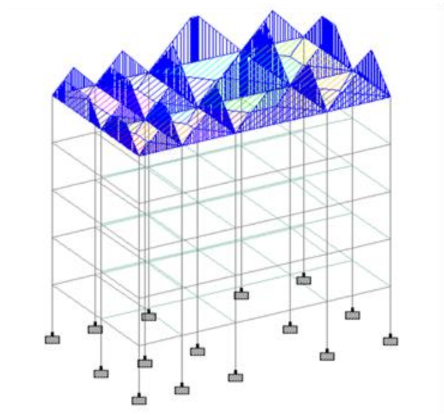


Fig 5.5 Reinforcement details of beam

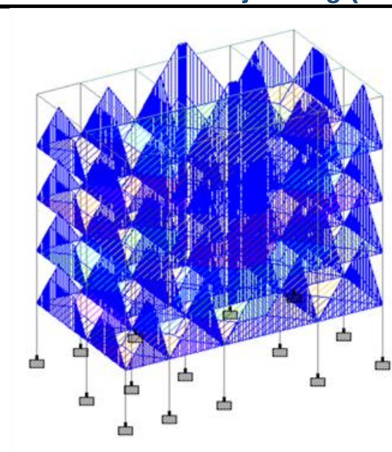
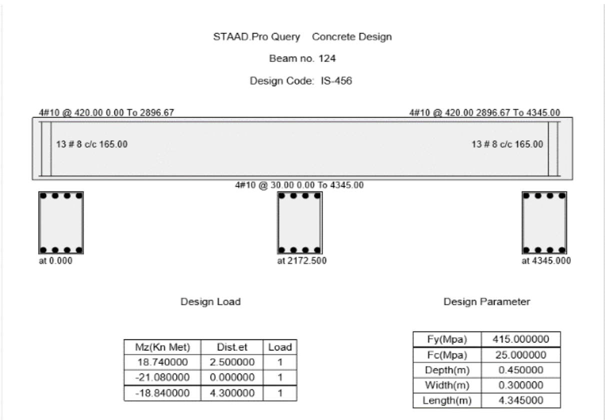
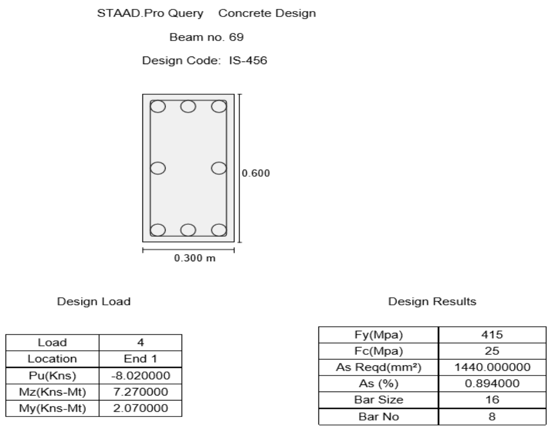


Fig 5.6 Reinforcement details of column





ANALYSIS	LOAD ON B4	LOAD ON A3
MANNUAL	831.93 kN	509.09 kN
STAAD PRO	833.86 kN	544.24

Percentage variation between manual and STAAD.pro (B4) = 0.12 %
Percentage variation between manual and STAAD pro (A3) = 6.30 %

V. COMPARATIVE STUDY

6.1 Comparison Of Results Manually And STAAD pro.

Table-6.1 Comparison of results

PARAMETERS	MANNUAL	STAAD PRO	PERCENTAGE VARIATION (%)
LOAD ON CRITICAL COLUMN (kN)	831.93	833.47	0.128534
MOMENT IN BEAM (kN-m)	38.022	40.96	7.43
AREA OF STEEL IN COLUMN (mm2)	1440	1440	0
AREA OF STEEL IN BEAM (mm2)	517.50	628	19.29

VI. CONSLUSIONS

- The percentage difference between the critical column load calculations done manually and those done with STAAD pro software is 0.16 %.
- The percentage difference between manually calculating moment in a beam and doing it using STAAD pro software is 7.43 %.
- The percentage difference between manually calculating an area of steel in a column and doing it using STAAD pro software is 0 %.
- The percentage difference between manually calculating an area of steel in a beam and doing it using STAAD pro software is 19.29 %.

VII. REFERENCES

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