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COMPARISON OF ANALYSIS AND DESIGN OF G+3 BUILDING BY USING STAAD PRO AND MANAUAL DESIGN

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Abstract – *The planning and designing is the main aspect of the build a structure. Some assumptions are required for the analysis and design of the building. In this project we can design a G+3 Model building by using STAAD Pro. In this model we can design the beams and columns of the building. For this model initially we can investigate in the site and collect the data about the size and parameters of the building components. By using that data, we can design a G+3 model in STAAD Pro. After that we can make the manual design of the building model. Now we can compare the STAAD Pro design values and manual design values of the building. Finally, we can conclude with the comparison of the STAAD Pro values and the manual design values.*

***Key Words*: STAAD Pro, Manual Design, G+3 Building, Analysis and Design,**

1.INTRODUCTION

The main scope of this project is to apply classroom knowledge in the real world by designing a multi-storied residential building. STAAD.Pro is the most popular structural engineering software product for model generation, analysis and multi-material design. For static or dynamic analysis of bridges, containment structures, embedded structures (tunnels and culverts), pipe racks, steel, concrete, aluminum or timber buildings, transmission towers, stadiums or any other simple or complex structure, STAAD.Pro has been the choice of design professionals around the world for their specific analysis needs.

Our project involves analysis and design of multi-storied [G+3] building using a very popular designing software STAAD Pro (V8i)

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.

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 not only ensure the structural safety of the buildings which are being designed.

1.1 Literature Review

Rashmi Agashe (April2020)- To Study Analysis and Design of Multi-Storey building using STAAD-pro. and comparing with Manual Calculations

From the work carried out in SADD Pro. can conclude that, Comparison between manual calculation and STADD Pro. Software analysis and design, conclude that the analysis is same but design is some different. Using STADD Pro., analysis and design of multistorey building has completed much quickly and easier than the manual calculation. Building plan was developing and draft in Auto-CAD with required dimension. During designing G+4 storey residential building structure is capable to sustain all loads acting on building. The design of slab, beam, column, rectangular footing and staircase is done with IS 456-2000 as limit state method.

Kavya H K (Jan2020) - Analysis & Design of Multi-Story Building Using Staad Pro And E-Tabs

In this project design of the residential building is done by manually, Staad pro and Etabs. In the manual process the time taken is more where as in the Staad pro and Etabs the program is predefined and accuracy is maintained. Designing using software's like Staad pro, Etabs reduces the lot of time in design work in manual process the understanding of the structure becomes easy and the amount of steel is also maintained less where as in the Staad pro and Etabs the percentage of steel becomes more. Details of each and every member can be obtained using Staad pro, and Etabs Staad pro and Etabs are advanced software which is easy to design. In this the time is saved and all the design can be accurately. All the list of failed beams can be obtained and also better section is given by the software. In designing the sections manually, we can't predict which load combination is critical and also loads taken are linear static whereas by using software we can design for dynamic loads and also non-linear analysis can be done the comparison between Staad pro, Etabs and manual design. Reinforcement required is uneconomical in Staad pro, when compared with Etabs and manual design.

Arjun Sahu - Design & Analysis of Multistorey (G+3) Residential Building Using Staad.Pro & AutoCAD –

Planning, analysis and design of G+3 multi-storey residential building was done. It's a G+3 storied building with parking in the basement and the rest of the floors are occupied with apartments. All the structural components were designed manually and detailed using AutoCAD. The analysis and design were done according to standard 8 specifications using STAAD.Pro for static and dynamic loads. The dimensions of structural members are specified and the loads such as dead load, live load, floor load and earthquake load are applied. Deflection and shear tests are checked for beams, columns and slabs. The tests proved to be safe. Theoretical work has been done. Hence, I conclude that we can gain more knowledge in practical work when compared to theoretical work.

2. WORK PROGRESS

2.1. Design Data

The design data shall be as follows:
Type of Building: School building
Type of Structure: G+3 building
Live load: 5.0 KN/m2
Location: A.A.N.M.& V.V.R.S.R. Polytechnic College, Gudlavalleru, Vijayawada city (Zone - III)
Depth of foundation below ground: 6m
Floor to floor height: 4 m
Floors: G + 3 Walls: 230 mm thick brick masonry walls only at Periphery.

2.2. Plan of building

2.3. STAAD Pro Model

2.3.1. Model of building

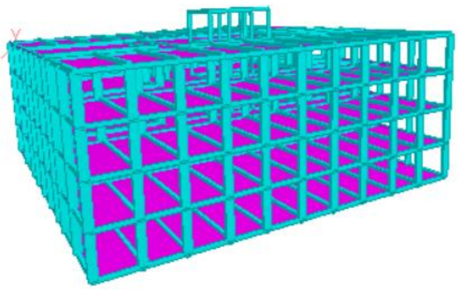

Fig1: Building Model

2.3.2. Dead Load

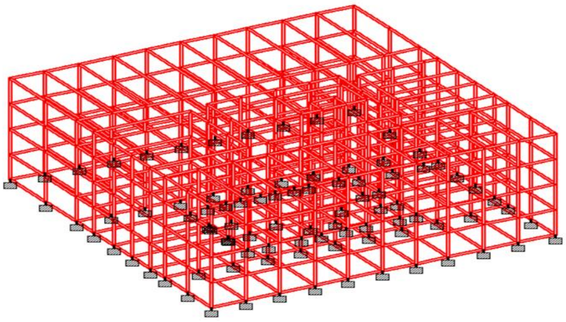

Fig2: Dead Load Case

2.3.3. Live Load

CON GY-5kN

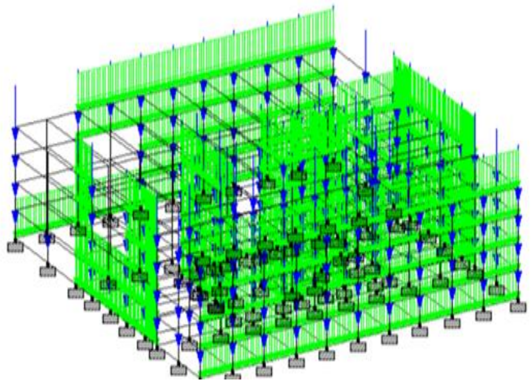

Fig3: Live Load Case (i)

ii) UNI GY -5kN/m

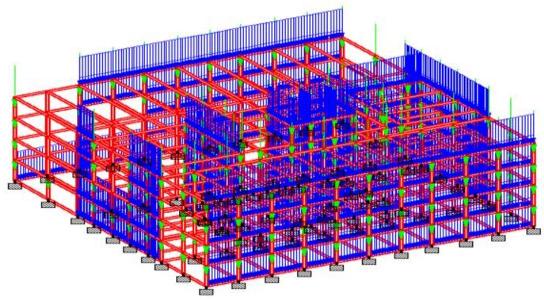

Fig3: Live Load Case (ii)

2.3.4. Shear Force

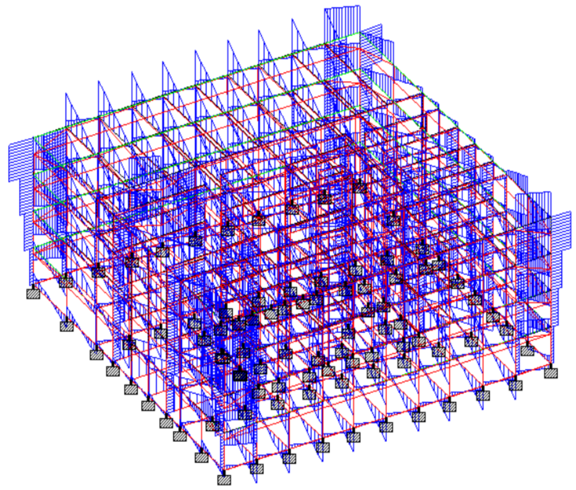

Fig 4: Shear Force

2.3.5. Bending Moment

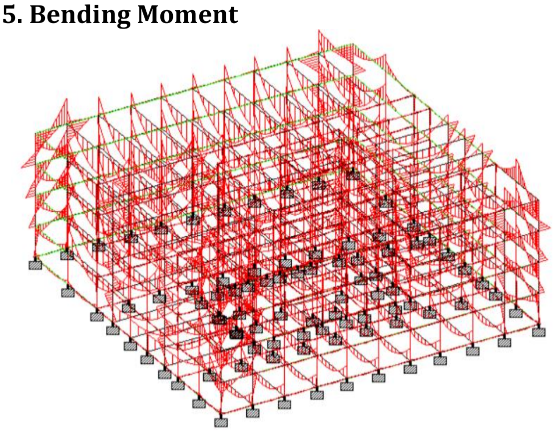

Fig5: Bending Moment

2.4. Manual Design of Elements

2.4.1. Design of Beam

Step1 : Parameters of the Beam

Breadth of the Beam = 300mm
Depth of the beam= 750mm
Clear Cover= 25mm
Effective depth = 725mm
Dead load = 5.625kN/m
Live load = 5kN/m
Total load = 10.625kN/m
Factored load = 1.5× Total load = 15.937kN/m
Length of the beam = 13.32m
Bending Moment = $WL^2/8$ = 353.45kN-m
Shear force = 106.14 kN

Step2 : Check for Required Depth

M_u=0.133 × fck × b × d^2
d = 665.52<725mm
Hence it is safe

Step3 : Tension Reinforcement (Pg no:96,IS 456:2000)

$$Mu = 0.87 \times fy \times Ast \times d \times \left(1 - \left(\frac{fy \times Ast}{fck \times b \times d}\right)\right)$$

$353.45 \times 10^6 = 0.87 \times 500 \times Ast \times 725 \times \left(1-\left(\frac{500\times Ast}{20\times 300\times 725}\right)\right)$

$A_{st\,(req)}$ = 1321.44mm^2
Assume
Diameter of bar = 20mm, Area of single bar = 314.15mm^2
n= A_{st}/ Area of Single bar = 1321.44 / 314.15 = 4.20 ~ 5bars

Step 4 : Shear Reinforcement (Pg no:72,IS 456:2000)

Лv = $\frac{Vu}{bd}$ =106.

Лv = 0.48N/mm^2

Percentage of Steel = $\frac{Ast}{bd} = \frac{(1321.44)}{300\times725} \times 100$ = 0.60%

Лc = 0.512 N/mm^2 **(Pg no:73, Table 19, IS456:2000)**

Лc max = 2.8 N/mm^2 **(Pg no:73, Table 20, IS 456:2000)**

Лv > Лc ; Лv < Лc max

Hence Shear has to be design

Step5 : Vertical Stirrups (Pg no:73, IS 456:2000)

$V_{us} = V_u - V_{uc}$= 110.59 – 0.512 ⨉ 300 ⨉ 725

V_{us} = 4785 N

By using two legged 8 mm Stirrups

A_{sv} = 100.53 mm^2

Step 6 : Spacing of Vertical Stirrups (Pg no:73,IS 456:2000)

$S_v = \frac{0.87\times fy\times Asv\times d}{Vus} = \frac{0.87\times500\times100.53\times725}{4785}$ = 6625.84mm

$S_v = \frac{0.87\times fy\times Asv}{0.4\times b}\ \frac{0.87\times500\times100.53}{0.4\times300}$ = 364.42mm

S_v = 0.75 ⨉ d= 0.75⨉725= 543.75mm

S_v = 300mm

We consider which ever is small i.e., Sv=300mm

Hence we provide Two legged 8mm Φ stirrup with 300mm c/c spacing

Step 7 : Check for Deflection (Pg no:37,IS 456:2000)

$f_s = 0.56 \times f_y \times A_{st\,req} / A_{st\,prov}$

f_s = 235.55 N/mm^2

For Continuous beams L/d =26

L/d= 13320/750 =17.76

Max permitted = 1.1 ⨉ 26 = 28.6

Hence it is Safe.

Step 9 : Detailing of Beam

Top reinforcement -2#20mm Φ

Bottom reinforcement – 3# 20mm Φ

Shear Reinforcement – 2 legged 8mm Φ stirrup @ 300mmc/c

2.4.2. Design of Column

Step1 : Given Data

P=1500kN, L=4m

P_u = 2250kN

f_{ck} = 20N/mm^2, f_y = 500 N/mm^2

Step 2: Calculation of Cross-section of Column (pg no. 71)

$P_u = 0.4 \times f_{ck} \times A_c + 0.67 \times f_y \times A_{sc}$

According to IS 456:2000 we take Asc=0.01A, (A= gross section area)

1500 = 0.4 ⨉ 20 ⨉ (A- 0.01A) + 0.67 ⨉ 500 ⨉ 0.01A

A=199645mm^2

By taking b= 1/3 D, We getting D=800mm, b=300mm

Step3 : Check for Eccentricity (pg no. 42, IS456 :2000)

e_{min} =(Length /500)+(Lateral Dimension/30)

Check With D= 800mm

e_{min} = (4000/500) + (800/30) = 35mm

From pg no71. IS 456:2000

e min <= 0.05 of Lateral Dimension = (0.05 ⨉ 800)

35 < 40

Hence it is ok

Now Check with b=300mm

e_{min} = (4000/500)+(300/30) = 20mm

e_{min} <= 0.05 b =0.05 ⨉ 300

20 > 15

Hence it is not satisfied

For Satisfy the eccentricity condition we have to redesign the section

Let us take b=400mm

0.05b=0.05 ⨉ 400 =20

e = 0.05b

If b= 400mm, then D= 500mm

0.05D=0.05 ⨉ 500= 25

e < 0.05D

Hence the section is ok

Now A= 200000mm^2

A_{sc}= 2000 mm^2

Now take 25mmΦ , Then Number of bars = A_{sc}/a_{sc} =4 bars (asc= area of bar = 490.08mm^2)

Provide 4bars # 25mm Φs

Step 4 Design of Lateral Ties (pg no. 49, IS 456:2000)

Diameter =1/4th of largest longitudinal bar= ¼*25 = 6.25

Provide 8mm bars as lateral ties

Spacing

Least lateral dimension = 400mm

16 Φ =16* 25 = 400mm

300mm

Provide 8mm bars @300mm c/c

Step5 : Detailing

Main reinforcement: Provide 4bars # 25mm Φ

Lateral ties: Provide 8mm bars @300mm c/c

2.4.3Design of a Slab

Step1: Given data

L_y = 12m, L_x = 8m, f_{ck} = 20N/mm², f_y = 500N/mm²
L_y/L_x = 1.5 > 2
So, we provide Two-Way slab
Live Load = 3kN/m²
Floor Finishing = 1kN/m²

Step2: Thickness of Slab

L_x / d = 26
8000/d = 26
d=300mm
d` = 25mm
D = 325mm

Step3: Effective Span

$L_{x\,eff} = L_x + d$ = 8000+300 = 8300mm
$L_{y\,eff} = L_y + d$ = 12000+300 = 12300mm
L_y / L_x = 1.48

Step4: Calculations of loads

Self-weight of Slab = D × b × Unit weight = 0.325× 1× 25 = 8.125 kN/m
Live Load = 3 kN/m
Floor Finishing = 1 kN/m
Total Load = 12.125 kN/m
Factored load = 18.187 kN/m

Step 5: Calculations of Moments

$M_x = \alpha_x \times W \times L_x^2$
From Table 27, IS 800 :2007
α_x = 0.103
$M_x = 0.103 \times 18.187 \times 8.3^2$
M_x = 129.04 kN-m
$M_y = \alpha_y \times W \times L_x^2$
From Table 27, IS 800 :2007
α_y = 0.047
$M_y = 0.047 \times 18.187 \times 8.3^2$
M_y = 58.88 kN-m
$V_u = \frac{W \times Lx}{2} = \frac{18.187 \times 8.3}{2}$ = 75.47kN

Step 6: Calculation of Depth Required

$M_u = 0.133 \times f_{ck} \times b \times d^2$
$129.04 \times 10^6 = 0.133 \times 20 \times 1000 \times d^2$
d= 220<300
Hence it is safe

Step 7: Calculation of area of reinforcement (pg. no: 96, IS456:2000

$M_{u(x)} = 0.87 \times fy \times Ast \times d\left(1 - \frac{fy \times Ast}{fck \times b \times d}\right)$

129.04×10^6 =
$0.87 \times 500 \times Ast \times 300\left(1 - \frac{500 \times Ast}{20 \times 1000 \times 300}\right)$
$A_{st(x)}$ = 1087.33 mm²
58.88×10^6 =
$0.87 \times 500 \times Ast \times 300\left(1 - \frac{500 \times Ast}{20 \times 1000 \times 300}\right)$
$A_{st(y)}$ = 469.56 mm²
Spacing between bars in X-direction (short span):
Assume 10mmΦ bars
ast = $\frac{\pi}{4} \times 10^{\wedge}2$ = 78.53mm²
$S_v = (a_{st}/A_{st}) \times 1000$ = (78.53/1087.33) × 1000 = 72.22mm ~ 75mm
S_v = 3d = 3× 300 = 900mm
300mm
Hence provide 10mmΦ bars @75mm spacing c/c
Spacing between bars in Y-direction (long span):
i) $S_v = (a_{st}/A_{st}) \times 1000$
Assume 10mmΦ bars
ast = $\frac{\pi}{4} \times 10^{\wedge}2$ = 78.53mm²
$S_v = (a_{st}/A_{st}) \times 1000$ = (78.53/ 469.56) × 1000 = 167.24mm
ii) S_v = 3d = 3× 300 = 900mm
iii) 300mm
Hence provide 10mmΦ bars @170 mm spacing c/c
Edge Strip reinforcement
A_{st} = 0.12% of gross area
= (0.12/100) × 1000 × 300
=360mm
Spacing between bars
Assume 8 mm Φ bars
$a_{st} = \frac{\pi}{4} \times 8^2$ = 50.26mm
i) $S_v = (a_{st}/A_{st}) \times 1000$ = (50.26/ 360) × 1000 = 139.61 mm
ii) 5d = 5× 300 = 1500 mm
iii) 450mm
Hence provide 8mmΦ bars @140 mm spacing c/c

Step8: Check for deflection

For simply supported slabs
L/d = 26
Percentage of steel = $\frac{ast}{S \times d} \times 100 = \frac{78.53}{75 \times 300} \times 100$ = 0.35%
$f_s = 0.58 \times f_y$ = 0.58× 500 =290
Modification factor = 1.2
l/d =1.2×26 = 31
$(l/d)_{provided}$ = 8300/300 = 27<31
Hence it is safe
Area of reinforcement
In Short span = 1087.33mm²
provide 10mmΦ bars @75mm spacing c/c
In long span = 469.56mm²
provide 10mmΦ bars @170mm spacing c/c

Table -1: Comparison of Beam Results

Property	**STAAD Pro**	**Manual Calculations**
Size in mm	300 x 750	300x750
Clear Cover in mm	25	25
Effective Depth in mm	725	725
Load in kN/m	5	5
Bending Moment kN-m	439.17	353.45
Shear Force kN	36.88	106.52
Top reinforcement	5 #10mm Φ	2#20mm Φ
Bottom reinforcement	5 #10mm Φ	3#20mmΦ
Shear reinforcement	2 legged 8mm Φ stirrup bars with spacing 240 mm	2 legged 8mm Φ stirrup @ 300mmc/c

Table -2: Comparison of Column Results

Property	STAAD Pro	Manual Calculations
Load (P) kN	1587	1500
Area of steel (%)	0.8	1
Length of the Column in meters	4	4
Size	300x750	400x500
Area of reinforcement in mm²	1360	2000
Main reinforcement	Provide 12bars #12mmΦ	Provide 4bars # 25mm Φ
Tie reinforcement	Provide 8mm Φ rectangular ties @190mm spacing	Provide 8mm bars @300mm c/c spacing

3. RESULTS AND CONCLUSIONS

We have done the design of a G+3 building by using STAAD Pro. We done with manual design of the beams and columns by using IS 456:2000. We compared the design values of the STAAD Pro and Manual design.

The reinforcement detailing of the beam by STAAD Pro
Top reinforcement - 5 # 10 @ 30 to 13320mm
Bottom reinforcement - 5 # 10 @ 720 to 3840mm
Shear Reinforcement - 2 legged 8mm Φ stirrup bars with spacing 240 mm
The reinforcement detailing of the beam by Manual design
Top reinforcement -2#20mm Φ
Bottom reinforcement – 3# 20mm Φ
Shear Reinforcement – 2 legged 8mm Φ stirrup @ 300mmc/c
The reinforcement detailing of the Column by Manual design
Main Reinforcement Provide 12#12mmΦ (equally Distributed)
Tie Reinforcement Provide 8mm Φ rectangular ties @190mm spacing
The reinforcement detailing of the Column by Manual design
Main reinforcement: Provide 4bars # 25mm Φ
Lateral ties: Provide 8mm bars @300mm c/c
The reinforcement detailing of the Slab
Area of reinforcement
In Short span = 1087.33mm^2 provide 10mmΦ bars @75mm spacing c/c
In long span = 469.56mm^2 provide 10mmΦ bars @170mm spacing c/c

By comparing both the design values we conclude that they're a lot of variation in the area of reinforcement in percentage. In case of beam design, the area of reinforcement in STAAD Pro is 0.4% and the area of reinforcement in manual design is 0.70%. In case of Column design, the area reinforcement in STAAD Pro is 0.8% and the area reinforcement in Manual design is 1%. We conclude with the diameter of the bars which are given by STTAD Pro varied from the bar diameters which are given by manual design, due to this variation the shear force and bending moment also varied but both the conditions are satisfying the IS code book.

REFERENCES

- IS: 875 (Part 1) – 1987 for Dead Loads, Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.
- IS: 875 (Part 2) – 1987 for Imposed Loads, Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.
- IS 456-2000, Indian standard code of practice for plain and reinforced concrete (fourth revision), Bureau of Indian Standards, New Delhi, July 2000.
- SP: 16-1980, Design aids for reinforced concrete
- IS: 456: 2000, Bureau of Indian standards, New Delhi, 1980.

- SP: 34-1987, Hand Book of Concrete Reinforcement and Detailing, Bureau of Indian Standards, New Delhi, 1987.
- Study Analysis and Design of Multi-Storey building using STAAD-pro. and comparing with Manual Calculations Rashmi Agashe, Marshal Baghele, Vaishanvi Deshmukh, Sharad Khomane, Gaurav Patle, Kushal Yadav.
- Analysis & Design of Multi-Story Building Using Staad Pro And E-Tabs Kavya H K.
- Design & Analysis of Multistorey (G+3) Residential Building Using Staad.Pro & AutoCAD by Arjun Sahu, Anurag Verma, Ankit Singh, Aryan Pal, Mohd. Shariq