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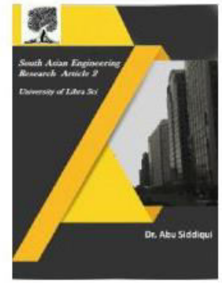

STRUCTURAL DETAILING OF A SINGLE STOREY RESIDENTIAL BUILDING WITH RETAINING WALL

[1]THANGULA HARISHKUMAR, [2]AMISIGADDA SAI NAGA MANIKANTA

[1]M-TECH, DEPT OF CIVIL, KAKINADA INSTITUTE OF TECHNOLOGICAL SCIENCES, RAMACHANDRAPURAM, ANDHRAPRADESH, INDIA, 533287

[2]ASSOCIATE PROFESSOR, KAKINADA INSTITUTE OF TECHNOLOGICAL SCIENCES, RAMACHANDRAPURAM, ANDHRAPRADESH, INDIA, 533287

ABSTRACT

The principle objective of this project is to design an educational building [G + 1 (3 dimensional frame)] using STAAD Pro. The design involves load calculations manually and analyzing the whole structure by STAAD Pro. The structural members slabs and stair case are designed manually as per IS 456-2000.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. Initially we started with the analysis of simple 2 dimensional frames and manually checked the accuracy of the software with our results. The results proved to be very accurate. We analysed and designed a G + 1storey building [2-D Frame] initially for all possible load combinations [dead, live loads].

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. We continued with our work with some more multi-storeyed 2-D and 3-D frames under various load combinations.Our final work was the proper analysis and design of a G + 1 3-D RCC frame under various load combinations.

1. INTRODUCTION

1.1 Overview Of Project

Our project involves design of an educational building using very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

1. Easy to use interface,

2. Conformation with the Indian Standard Codes,

3. Versatile nature of solving any type of problem,

4. 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, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

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.

1.2 Outline of Project

To achieve the objective of project, the work is outlined in the following stages

1. Study of basic definitions, various parameters involved in manual design and study of IS 875:1987 and IS 456:2000.
2. Study of design approach for structural members such as slabs, stair case, footings.
3. Study of design and analysis of beams and columns by using STADD pro software.
4. Calculation of load combinations as per IS 456:2000.
5. The analysis of the structure is done by using STADD pro software version 8.1 v.

2. RELATED WORK:

2.1 Introduction

A brief review of previous studies on the analysis of structures is presented in this section. This chapter also provides an overview of the literature related to analysis and design of various structures. This helps in line of action of present study which is useful in systematic completion of work.

2.2 Literature on Analysis and Design Using STAAD PRO

BedabrataBhattacharjee(2007)

In this paper the behaviour of G+21 RCC framed building subjected to earthquake and wind loads is discussed briefly using STAAD PRO software. The behaviour of building under earthquake and wind loads are compared and the reinforcement difference between them is shown. The design involves load calculations manually and analysing 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. And various steps involved in generating the structure in STAAD-Pro are described.

Bhanupratap(2006)

In this report design of concrete beams and columns of a two storey building is explained. The whole procedure of analysis and designing is done in STAAD-Pro. Various parameters involved in design of slabs and footings are explained. And all the specific results, reinforcement outputs of beams and columns are shown.

K. Hari Prasad(2011)

This project deals with the analysis of a multi storeyed residential building of G+6 consisting of 5 apartments in each floor. The dead load &live loads are applied and the design for beams, columns is obtained using STAAD Pro software.He concludes that staad pro is a very powerful tool which can save much time and is very accurate in designs. In this project footings are designed using STAAD foundation software. He concludes that designing using Software's like Staad reduces lot of time in design work.

3. DESIGN OF SLABS

3.1 Introduction

Slabs are plane members whose thickness is small as compared to its length and breadth. Slabs are most frequently used as roof coverings and floors in various shapes such as square, rectangle, circular, triangular etc in buildings. Slabs supports mainly transverse loads and transfers them to the supports by bending action in one or more directions. Beams or walls are the common supports for the slabs.

3.2 Layout of Project Plans

Site location = COLLEGE OF ENGINEERING

No of floors = G+4

Plinth Area = 2173.64 m^2

No of class rooms = 24

Area of class room = 8.9* 9.27 (82.503 m^2)

No of staff rooms = 9

Area of staff room = 4.3*9.27 (39.861 m^2)

No. of labs = 4

No of Auditoriums = 1 (165.87 m^2)

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The figure 3.1 represents the functional plan of ground floor. It consists of 3staff rooms, 2hod offices, 2 labs and 1 auditorium.

The figure 3.2 represents the functional plan of first floor. It consists ofarea for landscaping 2labs, 1 library with dimensions of (22.5m x 9.27m), 1 staff room.

The figure 3.3,3.4,3.5 represents the functional plan of second third fourth floors. Each floor consists of 8 class rooms and 2 staff rooms.

The figure 3.6 represents the functional plan of roof.

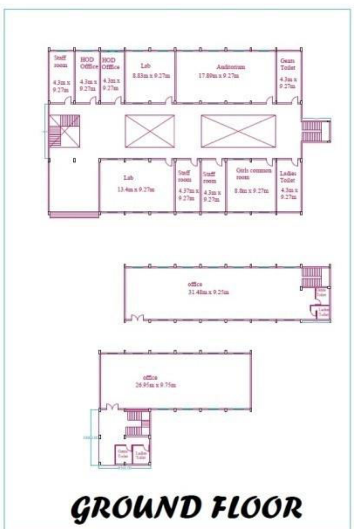

Fig 3.1 Layout of ground floor

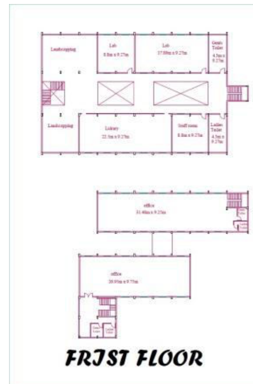

Fig 3.2 Layout of first floor

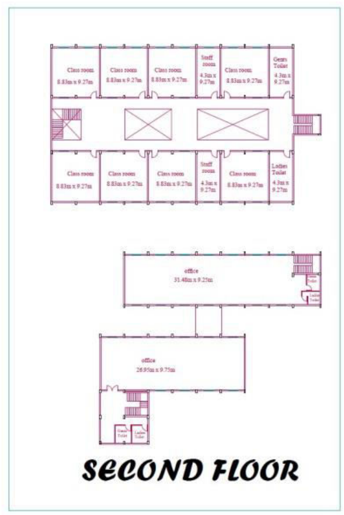

Fig 3.3 Layout of second floor

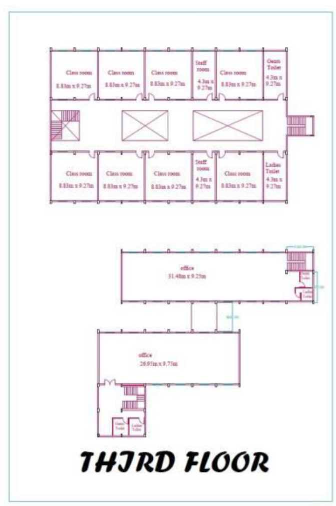

Fig 3.4 Layout of third floor

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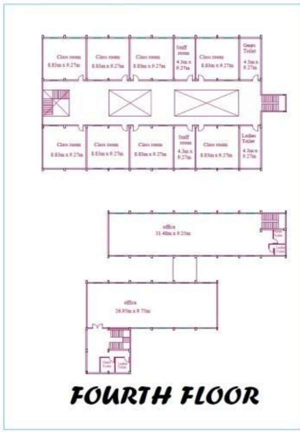

Fig 3.5 Layout of fourth floor

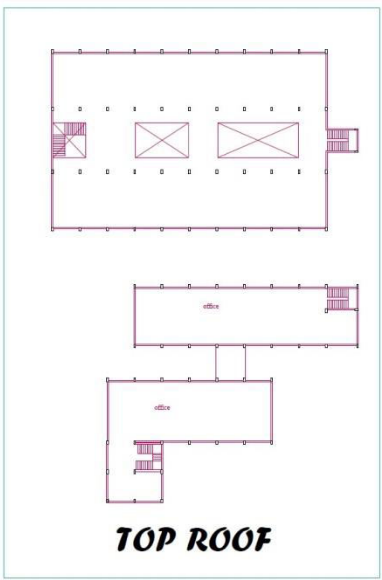

Fig 3.6 Layout of roof

3.3Design Requirements for Slabs as Per IS 456:2000

3.3.1. Effective Span

The effective span of a simply supported slab shall be taken as clear cover span plus effective depth of the slab or centre to centre distance between the supports whichever is less.The effective span of cantilever slab shall be taken as its length to the face of the support plus half the effective depth expect where it forms the end of a continuous slab where the length to the centre of support shall be taken.

3.3.2. Depth of Slab

The depth of slab depends on bending moment and deflection criteria. The trail depth can be obtained by using:

Effective depth $d = \frac{\text{span}}{\left(\frac{l}{d}\right)\text{basic X modification factor}}$

For obtaining modification factor, the percentage of steel for slab can be assumed from 0.2% to 0.5%. The effective depth d of two way slabs can be assumed using c l 24.1,IS 456 provided short span is <3.5m and loading class is<3.5kn/mm^2.

3.3.3. Load on Slab

The load on slab comprises of live load, dead load and floor finish .The loads are calculated per unit area (load/m^2)

Dead load =D x 25KN/m^2 (where D is thickness of slab in m)

Floor finish (assumed as) =1 to 2 KN/m^2

Live load (assumed as) =3 to 5 KN/m^2 (depending on the occupancy of the building).

3.3.4. Limiting Stiffness

The Stiffness of slab is governed by the span to depth ratio. As per C 1 23.1 IS 456 for

spans not exceeding 10m, the span to depth ratio(basic value)should not exceed the limits given below.

Cantilevers-7

Simply supported-20

Contionuous-26

Depending up on the type of steel and percentage of steel, the above values have to be modified as pre fig.4 of IS: 456

For two way slabs, the shorter span should be used for calculating the span to effective depth ratio.

3.3.5. Nominal Cover

For mild exposure -20mm

For moderate exposure-30mm

However, if the diameter of the bar must not exceed 12mm, cover may be reduced by 5mm.Thus for main reinforcement up to 12mm diameter bar and for mild exposure the nominal cover is 15mm.

3.3.6. Minimum Reinforcement

The reinforcement in either direction of span shall not be less than 0.15% of gross sectional area if mild steel is used. However, this value is reduced to 0.12% where high strength deformed bars or welded wire fabrics are used. (Clause 26.5.2.1 of IS 456).

3.3.7. Maximum Diameter Of Bar

The diameter of bars shall not exceed one eight of the total thickness of slab. (Clause 26.5.2.2 of IS 456).

3.3.8. Spacing of Main Reinforcement

The spacing of main reinforcement in slabs shall not be more than three times the effective depth of solid slab or 300mm whichever is less. (Clause 26.3.3 of IS 456).

3.3.9. Distribution Reinforcement

The area of distribution reinforcement shall not be less than 0.15% of gross cross sectional area if plain bars are used and 0.12% if high yield strength deformed bars are used. The spacing of distribution reinforcement in slabs shall not be more than five times the effective depth of slab or 450mm whichever is less.

3.4One Way Slab

It supports on opposite edges or when Ly/Lx>2, predominantly bends in one direction across the span and acts like a wide beam of unit width. If a continuous slab/beam loaded by using UDL has equals pans or if spans do not differ by more than15% of the longest they are designed using IS: code. For accurate analysis a continuous slab carrying ultimate load is analysed using elastic method with redistribution of moments.

3.5 Design of One Way Slab

One way slab

l/d = 26 (continues)

l/d = 20 (simply supported)

Hence for end span l/d = ½(26+20)= 23

Assume modification factor

Corresponding to P_t= 0.4 %

Modification factor = 1.26 for fe415 steel

d = L/23*1.26 = 4530/23*1.26 = 156.31 mmSay 157 mm

Provide 12 mm bar and cover 15 mm

Effective cover = 15+d/2 = 15+6 = 21 mm

Overall depth = 157+21 = 178 mm

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Provide overall depth = 180 mm [D]

Actual overall depth d =180-2= 159 mm [d]

Computation of design moments and effective depth

Self-weight = 0.180×25000 =4500 N/m^2

Floor finish = 1000 N/m^2

Total dead load = 5500 N/m^2

Factored dead load W_d =1.5×5500 = 8250

Live load = 4000

Factored live load = 1.5×4000 = 6000 N/m

Bending moment for end span :

B.M at the centre of the end span

$(W_d\ l^2/12 + W_l\ l^2/10) = 8250\times4.53^2/12 + 6000\times4.53^2/10$ = 26420.65 N-m

B.M over pen ultimate support :

$(W_d l^2/10 + W_l l^2/9) = 8250\times4.53^2/10 + 6000\times4.53^2/9$ = 30610.34N-m

Bending moment for intermediate span

B.M at the centre of the span

$W_d l^2/16 + W_l d^2/12 = 8250\times4.53^2/16 + 6000\times4.53^2/12$ = 20841.53N-m

B.M at the interior support

$W_d l^2/12 + W_l l^2/9 = 8250\times4.53^2/12 + 6000\times4.53^2/9$ = 27788.71 N-m

Max factored moment M_u = 30610.34 N-m

Equating $M_u$lim to M_u

$0.138 f_{ck} bd^2 = 30610.34 \times 1000$

$d = (30610.34\times1000/0.138\times25\times1000)^{0.5}$= 94.194 mm < 159 mm (Hence safe)

At middle of end span

$A_{st1}= 0.5f_{ck}/f_y[1-(1-(4.6M_u/f_{ck}bd^2))^{0.5}]*bd$

$0.5 \times 25/415 [1-(1-(4.6\times26420.65\times1000/25\times1000\times159^2))^{0.5}] \times1000 \times 1$ =485.02mm^2

At middle of intermediate span

$A_{st2}= 0.5\times25/415 [1-(1-(4.6\times M_u/f_{ck}bd^2))^{0.5}]*bd$

$= 0.5\times25/415 [1-(1-(4.6\times20841.53\times1000/25\times1000\times159^2))^{0.5}] \times1000 \times 150$ = 378.16 mm^2

Provide $A_{st1} = A_{st2}$

Spacing of 12mm bars = $1000\times113.04/485.02$ = 233.06 mm

Provide 230 mm spacing

Therefore 12mmØ@230mm c/c

Actual A_{st1} provided = $1000\times113.04/230$

A_{st1} = 492 mm^2

$P_t = 100\times492/1000\times159$= 0.3094 %

Which is less thanactual assumed

Therefore it is safe from serviceability condition

At penultimatesupport:

$A_{st1} = 0.5\times25/415 [1-(1-(4.6\times30610.34\times1000/1000\times25\times159^2))^{0.5}]$ = 567.05 mm^2

Area of steel available in the form of bent up bars from the adjacent spans

= $½(A_{st1}+A_{st2})= ½(2)(A_{st1})$

12mmØ bars = $1000\times113.04/75.05$= 1506 mm

It should in multiples of 230

Therefore provide extra bars of 12mmØ@ 920 mm c/c

(d) At interior supports

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A_{st2} = 0.5×25/415[1-(1-(4.6×27788.71×1000/25×159^2×1000))$^{0.5}$]×1000×159 = 511.63 mm^2

Extra bars area = 511.63-492 = 19.63 mm^2

12mmØ bars = 1000×113.04/19.3= 5758 mm

Which is very high

Provide 1bar for every one meter

Area of distribution steel = 0.12/100 × bD = 0.12/100 ×1000 × 180 =216 mm^2

Provide 8mm bars spacing = 1000×50/21= 232.87 mm

Provide 8mmØ@230mm c/c

Check development length at end support

The end support available L_d = 47×12 [47 × dia of bar]= 564mm

L_d/3= 188mm

Width of support available = 300mm

300-25 =275 >188(Hence safe)

At the end support the following relation should satisfy

$1.3M_u/V_u+L_0 \geq L_d$

$V_u = 0.4W_dL + 0.45W_dL$

= 0.4(8250×4.53) + 0.45(6000×4.53) = 14949 + 12231 = 27180 N

Area of steel available at support 492/2

A_{st} = 246 mm^2

X_u = $0.87f_yA_{st}/0.36f_{ck}b$= 0.87×415×246/0.36×25×1000 = 9.8687

M_u = $0.87f_yA_{st}$ ($d-0.416X_u$) = 0.87×415×246(159-0.416×9.8687) = 13.75×10^6 N-mm

$L_0 = b/2 - x^1$ = 300/2 – 25 = 125mm

$1.3M_u/V_u + L_0$ = 1.3 × 13.75×10^6/27180 + 125 = 782.65mm

L_d = 564mm

$L_d < 1.3M_u/V_u + L_0$ (Hence safe)

Check for shear

Maximum of $V_u = (0.6W_dL + 0.6W_dL)$

= 0.6 (8250×4.53 + 6000×4.53) = 38731.32 N

Nominal shear stress

τ_v = S_u/bd = 38731.32/1000×15= 0.243 N/mm^2

P_t = 0.3094 %

τ_c = 0.39 from IS 456:2000

$\tau_c > \tau_v$

Check for deflection

For P_t = 0.3094 %

Modification factor = 1.43

Allowable span to effective depth ratio = M_f × 23 = 1.43 × 23 = 32.89

Actual l/d ratio = span / effective depth = 4530/159= 28.49

Which is less than 32.89 (safe in deflection)

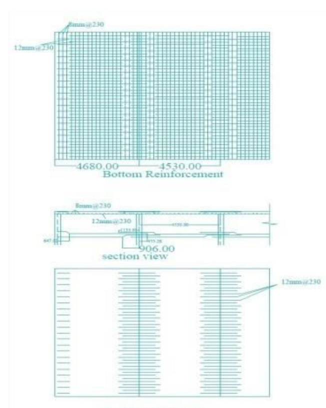

Fig 3.7 Reinforcement detailing of one way slab

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3.6 Two Way Slab

Arectangularslabsupportedonfouredges withratiooflongspantoshortspanless than2(Ly/Lx<2) deflectsintheformofadish. Ittransfers thetransverseloadtoits supportingedges bybendinginbothdirections.

3.7 Design of Two Way Slab

1)Nameofslab= Two long span discontinuous

2) Sizeofslab=4.230m× 4.530m

lx=4.230 mandly=4.530 m.

Taking over all depth is 180 mm

Effective depth is 180-cover-dia/2

d=159 mm

3)Effective span

lx =4.230+0.159=4.398 m

ly =4.530=0.159=4.689 m

ly/lx=4.689/4.398=1.06<2.

4) Loads:

Deadloadofslab=b×1×25= 25 × 0.18 =4 . 5 kN/m

Floorfinish =1 × 1=1.0kN/m

Liveload =4kN/m

Totalload =4 .5+1 +4=9.5kN/m

Factoredload =1.5×9.5=14.25kN/m.

5) FromISCODE456 2000 Table 26,

Shorter span coefficients

Edge α(x-)= 0.0

Mid α(x+) = 0.040

Longer span coefficients

Edge α(y-) 0.045

mid α(y+) 0.035

6) Designmoments:

$Mx(-)=\alpha(x-) \times WL_X \times L_X$ =0.0× 14250 × 4.3× 4.3=0.00 kN- m

$Mx(+)=\alpha(x+) \times WL_X \times L_X$= 0.040 × 14250 × 4.3 × 4.3 =11.056kN-m

$My(-)=\alpha(y-) \times WL_X \times L_X$=0.045× 14250 × 4.3× 4.3=-12.352kN-m

$My(+)=\alpha(y+) \times WL_X \times L_X$= 0.035 × 14250 × 4.3× 4.3= 9.605kN-m

We have to design for two momentsConsiderMy (-)=-12.352kN-m

Mx(+)=11.056 kN-m

Slabs are design for 1m width always

7) Check of depth:

$Mu=0.138 \times f_{ck} \times b \times d^2$

$12.352 \times 10^6 = 0.138 \times 25 \times 1000 \times d^2$

d=59.83<159mm (Hence safe)

Provide depth 159mm

8)Provision of steel

Main reinforcement

$A_{stx}=0.5f_{ck}/ f_y (1- \sqrt{1- [(4.6 M_u)/(f_{ck}bd^2)]})x bd$=196.74mm^2

Minimum reinforcement: $\frac{0.12}{100} * b * d$

Area of distribution reinforcement is 216 mm^2

Spacing of 12 mm dia bars $\frac{1000*113.04}{216}$=523.33 mm

Or 300mm

Or 3*d=477mm

Provide 12mmØ@300mmc/c

Area of steel provided A_{stx}=1000*113.04/300=376.8mm^2

% of steel provided

=1000*113.04/376.8*1000=0.3%

A_{sty1}=0.5f_{ck}/ f_y (1- √{1- [(4.6 M_u)/($f_{ck}bd^2$)]})x bd =220.35mm^2

A_{sty2}=0.5f_{ck}/ f_y (1- √{1- [(4.6 M_u)/($f_{ck}bd^2$)]})x bd =170.47mm^2

But A_{st}min =216mm^2

Provide A_{st}=376.8mm^2

Provide 12mmØ@300mmc/c

9) Torsional reinforcement

Area of torsional reinforcement=3/4(max area of steel in x-direction)

3/4 (376.8) =282.6mm^2

Size of torsional mesh=l_x/5=887.8mm

Spacing of torsional reinforcement=1000*50/282.6=176.9 say 170mm

Provide 8mmØ@170c/c

10) Check for shear

Factored shear force=wl_x/2=31.27kN

Nominal shear stress (factored shear force*1000/bd) =0.196

From IS 456:2000τ_c =0.39(Hence safe)

11)Check for deflection

Allowable span to effective depth ratio= mfx26

Mf from IS 456:2000 for 0.3% is 1.43

Allowable deflection is = 1.43x26 = 37.16 mm

Actual L/D ratio is =$\frac{\text{span}}{\text{effective depth}}$

L/D = 27.68 mm which is less than 37.16 mm(Hence safe)

1)Nameofslab=Slab with two sides discontinuous

2) Sizeofslab=4.840m× 5.570m

lx=4.840 mandly=5.570 m.

Taking over all depth is 180 mm

Effective depth is 180-cover-dia/2

d=159 mm

3)Effective span

lx =4.840+0.159=4.999m

ly =5.570+0.159=5.729 m

ly/lx=5.729/4.999 =1.14<2.

Hence it is two way slabs

4) Loads:

Deadloadofslab=b×1×25= 25 × 0.18 =4 . 5 kN/m

Floorfinish =1 × 1=1.0kN/m

Liveload =4kN/m

Totalload =4 .5+1 +4=9.5kN/m

Factoredload =1.5×9.5=14.25kN/m

5) FromISCODE456 2000 Table 26,

Shorter span coefficients

Edge	α(x-)	0.066
Mid	α(x+)	0.050

Longer span coefficients

Edge	α(y-)	0.000
mid	α(y+)	0.043

6) Designmoments:

Mx(-)=α(x-) × WL_X× L_X =0.066× 14250 × 4.9× 4.9=-22.85kN m

Mx(+)=α(x+) × WL_X × L_X= 0.050 × 14250 × 4.9 × 4.9 =17.10kN-m

My (-)=α(y-) × WL_X × L_X=0.000× 14250 ×

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4.9× 4.9=0.00kN-m

My (+)=α(y+) × WL_X × L_X= 0.043 × 14250 × 4.9× 4.9= 14.72kN-m

We have to design for two momentsConsiderMy(+)=14.72kN-m

Mx(-)=-22.85 kN-m

Slabs are design for 1m width always

7) Check of depth:

$Mu=0.138×f_{ck}×b×d^2$

$22.855×10^6 = 0.138×25×1000×d^2$

d=81.59 mm

Provide depth 159mm, so safe

8) Provision of steel

Area of steel at the support is

$A_{stx} = 0.5\ f_{ck}/\ f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\}})$ x bd=416mm²

Minimum reinforcement=$\frac{0.12}{100} * b * d$= 216 mm²

Area of steel at mid span is

$A_{stx} = 0.5\ f_{ck}/\ f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\}})$ x bd=308.05mm²

Provide reinforcement along short direction =416.24mm²

Spacing of bars is minimum of 3*159=477mm

Or 300 mm

Use 12mm bars=1000*113.04/416.24=271.57mm

Provide 12mmØ@ 270 mm c/c

Actual area steel provided is

$A_{stx}=\frac{1000*113.04}{270}$= 419 mm²

% of steel provided =$\frac{100*419}{159*1000}$=0.26%

$A_{sty}= 0.5\ f_{ck}/f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/(f_{ck}bd^2)]\}})$ x bd= 263.35mm²

Spacing of 12 mm dia bars $\frac{1000*113.04}{263}$= 423 mm

Or 300 mm

3xd= 477 mm

Provide 12mmØ@ 300 mm c/c

9)Torsional reinforcement

Area of torsional reinforcement=3/4(max area of steel in x-direction)

3/4 (419) =314.25mm²

Size of torsional mesh=l_x/5=970mm

Spacing of torsional reinforcement=1000*50/314.25=159.23 says 155mm

Provide 8mmØ@155c/c

10)Check for shear

Factored shear force = $\frac{w*lx}{2}=\frac{14250*4.99}{2}$ = 35.52kN

Nominal shear stress = (τ_v)=$\frac{\text{factored shear force}}{b*d}$

$\tau_v = 0.223$

From IS 456:2000 table τ_c=0.38

$\tau_v < \tau_c$ (Hence safe)

11) Check for deflection

Allowable span to effective depth ratio= mfx26

Modification factor from IS 456:2000 for 0.3% is 1.43

Allowable deflection is = 1.43x26= 36.46 mm

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Actual l/d ratio is $=\frac{\text{span}}{\text{effective depth}}$

l/d = 30.44 mm which is less than 36.4 mm(Hence safe)

1)Nameofslab=Two adjacent discontinuous

2) Sizeofslab=4.230m× 4.860m

lx=4.230 mandly=4.860 m.

Taking over all depth is 180 mm

Effective depth is 180-cover-dia/2

d=159 mm

3)Effective span

lx =4.230+0.159=4.398 m

ly =4.860+0.159=5.019 m

ly/lx=5.019/4.860=1.12<2.

It's a two way slab

4) Loads:

Deadloadofslab=b×1×25= 25 × 0.18 =4 . 5 kN/m

Floorfinish =1 × 1=1.0kN/m

Liveload =4kN/m

Totalload =4 .5+1 +4=9.5kN/m

Factoredload=1.5×9.5=14.25kN/m.

5)FromISCODE456 2000 Table 26,

Shorter span coefficients

Edge	α(x-)	0.055
Mid	α(x+)	0.042

Longer span coefficients

Edge	α(y-)	0.047
mid	α(y+)	0.035

6) Designmoments:

Mx(-)=α(x-) × WL_X× L_X =0.055× 14250 × 4.3× 4.3=-15.33kN m

Mx(+)=α(x+) × WL_X × L_X= 0.042 × 14250 × 4.3 × 4.3 =11.52kN-m

My (-)=α(y-) × WL_X × L_X=0.047× 14250 × 4.3× 4.3=-12.01kN-m

My (+)=α(y+) × WL_X × L_X= 0.035 × 14250 × 4.3× 4.3= 9.60kN-m

We have to design for two momentsConsiderMy(+)=-12.01 kN-m

Mx(-)=15.33 kN-m

Slabs are design for 1m width always

7) Check of depth:

$Mu=0.138\times f_{ck}\times b\times d^2$

$15.33\times10^6 = 0.138\times25\times1000\times d^2$

d=66.3 mm

Provide depth 159mm,so safe

8) Provision of steel

Area of steel at the support is

A_{stx}= 0.5 f_{ck}/ f_y (1- √ {1- [(4.6 M_u)/ ($f_{ck}bd^2$)]}) x bd=274.22mm^2

Minimum reinforcement= $\frac{0.12}{100} * b * d$=216 mm^2

Area of steel at mid span is

A_{stx}= 0.5 f_{ck}/ f_y (1- √ {1- [(4.6 M_u)/ ($f_{ck}bd^2$)]}) x bd=205.33mm^2

Provide reinforcement along short span=274.83mm^2

Spacing of 12 mm dia bars $\frac{1000*113.04}{274}$=411 mm

Or 300 mm

3xd= 477 mm

Provide 12 mmØ@300 mm c/c

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Actual area steel provided is

$A_{stx}=\frac{1000*113.4}{300}=376\ mm^2$

% of steel provided $=\frac{100*376}{159*1000}=0.23\%$

Area of steel at support in y direction

$A_{sty}= 0.5\ f_{ck}/\ f_y\ (1- \sqrt{} \{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\})$ x bd= 215.58mm^2

Minimum reinforcement$=\frac{0.12}{100}*b*d$=216 mm^2

Area of steel at mid span is

$A_{sty}= 0.5\ f_{ck}/\ f_y\ (1- \sqrt{} \{1- [(4.6\ M_u)/(f_{ck}bd^2)]\})$ x bd=170.4mm^2

Spacing of 12 mm dia bars $\frac{1000*78.2}{221}$= 363 mm

Or 300 mm

3xd= 497 mm

Provide 10 mmØ@300 mm c/c in y direction

Actual steel provided=1000*78.5/300=261.66mm^2

% of steel =100*216.66/1000*159=0.169%

9) Torsional reinforcement

Area of torsional reinforcement is = $\frac{3}{4}$(area of steel in x direction)

¾(376.8)=282.6 mm^2

Size of torsional mesh = $\frac{lx}{5}$= 877.8 mm

Spacing for torsional reinforcement is $\frac{1000*50}{282.6}$ = 176.2 mm

Provide 8 mmØ@175mmc/c

10) Check for shear

Factored shear force isV=$\frac{w*lx}{2}=\frac{14250*4.389}{2}$ = 31.2kN

Nominal shear stress is (τ_v) $=\frac{\text{factored shear force}}{b*d}$ =0.19

% of tensile steel =100*actual steel provided/bd=100*376.8/1000*159=.23%

From IS 456:2000 τ_c=0.348

$\tau_v < \tau_c$ (Hence safe)

11) Check for deflection

Modification factor for 0.23% of steel =1.481

Allowable span to effective depth ratio=1.482*26=38.506

Actual l/d=4389/159=27.6

Which is less than 38.506 (Hence safe)

1)Nameofslab=Three edge discontinuous

2) Sizeofslab=4.230m× 4.860m

lx=4.230 mandly=4.860 m.

Taking over all depth is 180 mm

Effective depth is 180-cover-dia/2

d=159 mm

3)Effective span

lx =4.230+0.159=4.398 m

ly =4.860+0.159=5.019 m

ly/lx=5.019/4.860=1.12<2.

It's a two way slab

4) Loads:

Deadloadofslab=b×1×25= 25 × 0.18 =4 . 5 kN/m

Floorfinish =1 × 1=1.0kN/m

Liveload =4kN/m

Totalload =4 .5+1 +4=9.5kN/m

Factoredload =1.5×9.5=14.25 kN/m.

5)FromISCODE456 2000 Table 26,

Shorter span coefficients

Edge $\alpha(x-)$ 0.066

Mid $\alpha(x+)$ 0.050

Longer span coefficients

Edge $\alpha(y-)$ 0.000

mid $\alpha(y+)$ 0.043

6) Designmoments:

$Mx(-)=\alpha(x-) \times WL_X \times L_X$ =0.066× 14250 × 4.3× 4.3=-18.33kN m

$Mx(+)=\alpha(x+) \times WL_X \times L_X$= 0.050 × 14250 × 4.3 × 4.3 =13.70kN-m

$My(-)=\alpha(y-) \times WL_X \times L_X$=0.000× 14250 × 4.3× 4.3=0.000kN-m

$My(+)=\alpha(y+) \times WL_X \times L_X$= 0.043 × 14250 × 4.3× 4.3= 11.30kN-m

We have to design for two momentsConsiderMy (+) =-11.30kN-m

Mx(-)=18.33kN-m

Slabs are design for 1m width always

7) Check of depth:

$Mu=0.138\times f_{ck}\times b\times d^2$

$18.33\times10^6 = 0.138\times25\times1000\times d^2$

d=72.9 mm

Provide depth 159mm, so safe

8) Provision of steel

Area of steel at support is

$A_{stx}= 0.5\ f_{ck}/\ f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\}})$ x bd=331.06mm^2

Minimum reinforcement=$\frac{0.12}{100} * b * d$=216 mm^2

Area of steel at mid span is

$A_{stx}= 0.5\ f_{ck}/\ f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\}})$ x bd=245mm^2

Provide reinforcement along x direction =331.06

Spacing of 12 mm dia bars $\frac{1000*113.04}{331.06}$=341 mm

Or 300 mm

3xd= 497 mm

Provide 12 mmØ@300 mm c/c

Actual area steel provided is

$A_{stx}=\frac{1000*113.04}{300}$=376.8mm^2

% of steel provided =$\frac{100*376.8}{159*1000}$=0.23%

Area of steel at support in y direction

$A_{sty}= 0.5\ f_{ck}/\ f_y\ (1- \sqrt{\{1- [(4.6\ M_u)/\ (f_{ck}bd^2)]\}})$ x bd=210.35mm^2

Minimum reinforcement=$\frac{0.12}{100} * b * d$=216 mm^2

Spacing of 10 mm dia bars $\frac{1000*78.5}{216}$= 363 mm

Or 300 mm

3xd= 497 mm

Provide 10mmØ@300mmc/c in y direction

Actual area of steel provided =1000*78.5/300=261.66mm^2

% of steel =100*261.66/1000*159=0.169%

9) Torsional reinforcement

Area of torsional reinforcement is = $\frac{3}{4}$(area of steel in X direction)

Area of torsional reinforcement is 282.6mm^2

Size of torsional mesh = $\frac{lx}{5}$= 877.8 mm

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Spacing for torsional reinforcement is $\frac{1000*50}{282.6}$ = 177.77 mm

Provide 8 mmØ@175mm c/c

10)Check for shear

Factored shear force is$V=\frac{w*lx}{2}=\frac{14250*4.389}{2}$ = 31.2kN

Nominal shear stress is(τ_v) $\frac{\text{factored shear force}}{b*d}$

=31200/1000*159=0.196

From IS 456:2000 table τ_c=023

$\tau_v < \tau_c$ (Hence safe)

11)Check for deflection

Allowable span to effective depth ratio= mfx26

Mf from IS 456:2000 for 0.3% is 1.43

Allowable deflection is = 1.48x26 = 38.16 mm

Actual l/d ratio is =$\frac{\text{span}}{\text{effective depth}}$

l/d = 27.68 mm which is less than 38.16 mm(Hence safe).

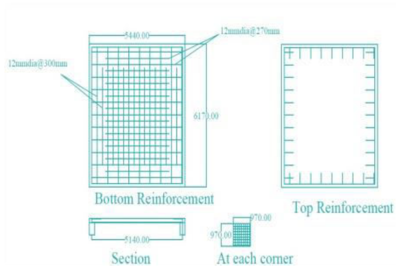

Fig 3.8 Reinforcement detailing of two way slab

4. DESIGN OF BEAMS AND COLUMNS

4.1 Introduction

In this chapter the design of column and beams are done using Stadd pro, generation of model,types of structure, supports, loadings are explained.

4.2 Input Generation

The GUI (or user) communicates with the STAAD analysis engine through the STD input file. That input file is a text file consisting of a series of commands which are executed sequentially. The commands contain either instructions or data pertaining to analysis and/or design. The STAAD input file can be created through a text editor or the GUI Modelling facility. In general, any text editor may be utilized to edit/create the STD input file. The GUI modelling facility creates the input file through an interactive menu-driven graphics oriented procedure.

4.3 Types of Structures

A structure can be defined as an assemblage of elements. STAAD is capable of analyzing and designing structures consisting of frame, plate/shell and solid elements. Almost any type of structure can be analyzed by STAAD. A space structure, which is a three dimensional framed structure with loads applied in any plane, is the most general.

A PLANE structure is bound by a global X-Y coordinate system with loads in the same plane.

A FLOOR structure is a two or three dimensional structure having no horizontal (global X or Z) movement of the structure [FX, FZ &MY are restrained at every joint]. The floor framing (in global X-Z plane) of a building is an ideal example of a FLOOR structure. Columns can also be modelled with the floor in a FLOOR structure as long as the structure has no horizontal loading. If there is any horizontal load, it must be analyzed as a SPACE structure.

4.4 Generation of the structure

The structure may be generated from the input file or mentioning the co-ordinates in the GUI. The figure below shows the GUI generation method.

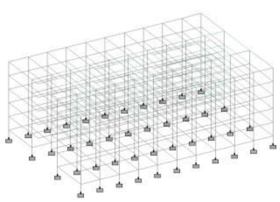

Fig 4.1 Generation of the structure

4.5 Physical parameters of building

Length and width are taken as per layout

Height=3.66m (floor to floor)

Live load on the floor is 4kN

Grade of concrete and steel used:

Used M30 concrete and Fe 415 steel.

4.6 Member Properties

Generation of member property can be done in STAAD.ProThe member section is selected and the dimensions have been specified. The beams are having a dimension of 0.3 * 0.7 m and the columns are having a dimension of 0.3 * 0.6 m , 0.35*0.7 m,0.3*0.7 m.

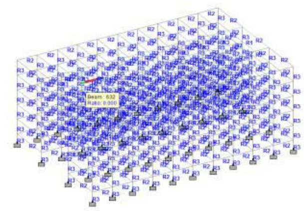

Fig 4.2 Member properties

4.7 Materials forthe Structure

The materials for the structure were specified as concrete with their various constants as per standard IS code of practice.

4.8 Loadingfor Educational Building

The loadings were calculated partially manually and rest was generated using STAAD.Pro load generator. The loading cases were categorized as:

Self-weight

Dead load from slab

Live load

Load combinations

4.8.1 Self-Weight

The self-weight of the structure can be generated by STAAD.Pro itself with the self-weight command in the load case column.

4.8.2 Dead load from slab

Dead load from slab can also be generated by STAAD.Pro by specifying the floor thickness and the load on the floor per sq m.

Weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls, internal walls and parapet over roof.

The load was found to be:

Wall loads 14 kN/m^2

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Floor load 5.5kN/m^2.

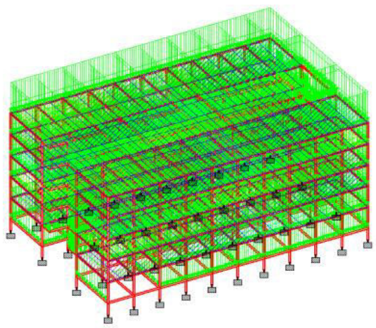

Fig 4.3Structure under DL from slab

4.8.3 Live Load

Live load is taken as 4kN/m^2 (as per is standards for educational buildings from IS 875).

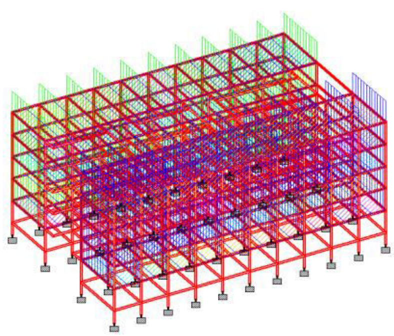

Fig 4.4Structure under live load

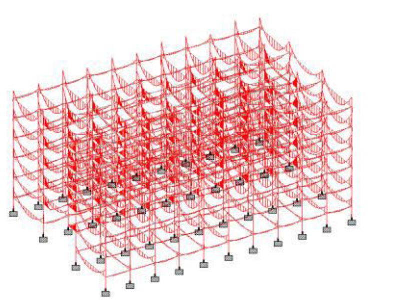

Fig 4.5 Structure under bending

4.9 Design of Beams and Column for Educational Building

4.9.1 Beam no 14 design results

Length: 4530.0mm Size: 300 X 700 mm Cover: 25.0mm

Table no 4.1 Summary of reinforcement for beam no 14

Section	0.0mm	1132.5mm	2265.0mm	3397.5mm	4530.0mm
Top Reinforcement(mm^2)	407.08	407.08	407.08	407.08	407.08
Bottom Reinforcement(mm^2)	407.08	407.08	407.08	407.08	0.00
Top Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer
Bottom Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	2-25Ø 1 layer

Provide 2 legged 10Ø@220mm c/c as a shear reinforcement

Shear design results at 815.0mm away from start support

V_y=40.43 M_x=5.12 LD =3

Provide 2 legged 10Ø@220mm c/c

Shear design results at 815.0mm away from end support

V_y=-41.99 M_x=-5.12 LD =3

Provide 2 legged 10Ø@220mm c/c

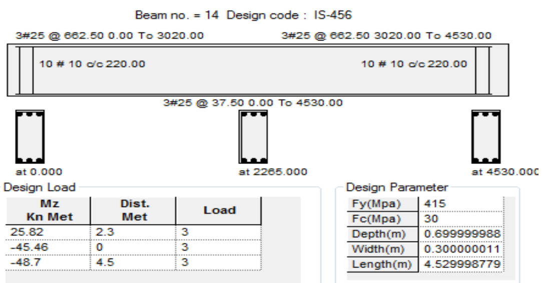

Fig 4.6 Concrete design of beam no. 14

4.9.2 Beam no: 769 design results

Length: 9500.0mm Size: 300 X 700 mm Cover: 25.0mm

Table no 4.2 Summary of reinforcement for beam no 769

Section	0.0 mm	2375.0mm	4750.0mm	7125.0mm	9500.0mm
Top Reinforcement(mm^2)	2598.38	0.00	0.00	0.00	3409.40
Bottom Reinforcement(mm^2)	0.0	1119.59	2348.18	737.28	631.96
Top Reinforcement	6-25Ø 2 layer	2-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	7-25Ø 2 layer
Bottom Reinforcement	2-25Ø 1 layer	3-25Ø 1 layer	5-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer

Provide2 legged 10Ø@220mm c/c as a shear reinforcement

Shear design results at 965.0mm away from start support

V_y=335.17M_x=0.07 LD =3

Provide 2 legged 12Ø@220mm c/c

Shear design results at 965.0mm away from end support

V_y=-368.65.17M_x=0.07 LD =3

Provide 2 legged 12Ø@220mm c/c

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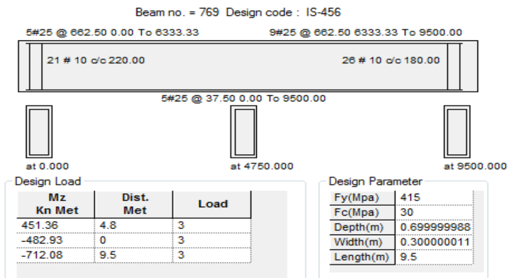

Fig 4.7 Concrete design of beam no. 769

4.9.3 Beam no 671 design results

Length: 2300.0mm Size: 300 X 700 mm Cover: 25.0mm

Table no 4.3 Summary of reinforcement for beam no 671

Section	0.0 mm	575.0mm	1150.0mm	1725.0mm	2300.0mm
Top Reinforcement(mm^2)	953.99	661.05	407.08	407.08	0.00
Bottom Reinforcement(mm^2)	407.08	407.08	407.08	407.08	407.08
Top Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	2-25Ø 1 layer
Bottom Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer

Provide 2 legged 8Ø@220mm c/c as a shear reinforcement

Shear design results at 965.0mm away from start support

V_y=98.94 M_x=-4.79 LD =3

Provide 2 legged 12Ø@220mm c/c

4.9.4 Column no 33 design results

Length: 2000.0mm Size: 700 X 350 mm Cover: 40.0mm

Guiding load case: 3 end joint: 23 short column

Required steel area =1799.17 mm^2

Required concrete area =243200.83mm^2

Main reinforcement: Provide 8-25Ø (1.6%, 3926.9mm^2) equally distributed

Tie reinforcement: Provide 10mmØ rectangular ties@300mmc/c

Section capacity based on reinforcement required (kN/m)

P_{uz}=3843.2 M_{uz1}=105.02 M_{uy1}=220.00

Interaction ratio=0.15(as per Cl. 39.6, IS456:2000)

Section capacity based on reinforcement provided (kN/m)

Worst load case=3

End joint 24P_{uz}=4476.76 M_{uz}=176.12 M_{uy}=390 IR=0.23

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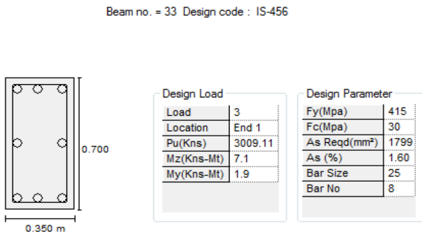

Fig 4.8 Concrete design of column no. 33

4.9.5 Column no 37 design results

Length: 2000.0mm Size: 700 X 350 mm

Cover: 40.0mm

Guiding load case: 3 end joint: 27 short column

Required steel area= 7552.58mm^2

Required concrete area= 237447.42mm^2

Main reinforcement: Provide 16-25Ø (3.21%, 7853.98mm^2) equally distributed

Tie reinforcement: Provide 10mmØ rectangular ties@300mmc/c

Section capacity based on reinforcement required (kN/m)

P_{uz}=5556.28 M_{uz1}=111.37 M_{uy1}=253.16

Interaction ratio=0.75(as per Cl. 39.6, IS456:2000)

Section capacity based on reinforcement provided (kN/m)

Worst load case=3

End joint 27P_{uz}=5646.02 M_{uz}=122.77 M_{uy}=280.97 IR=0.84

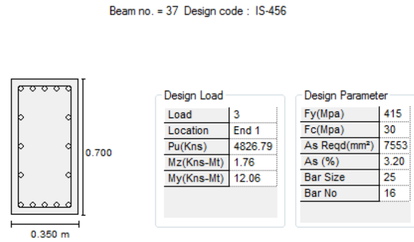

Fig 4.9 Concrete design of column no. 37

4.9.6 Column no 1 design results

Length: 2000.0mm Size: 600 X 300 mm

Cover: 40.0mm

Guiding load case: 3 end joint: 1 short column

Required steel area= 1146.73 mm^2

Required concrete area= 178853.27mm^2

Main reinforcement: Provide 8-25Ø (2.18%, 3926.9mm^2) equally distributed

Tie reinforcement: Provide 10mmØ rectangular ties@300mmc/c

Section capacity based on reinforcement required (kN/m)

P_{uz}=2771.44 M_{uz1}=84.05 M_{uy1}=176.23

Interaction ratio=0.16(as per Cl. 39.6, IS456:2000)

Section capacity based on reinforcement provided (kN/m)

Worst load case=3

End joint 2P_{uz}=3599.26 M_{uz}=147.12 M_{uy}=343.85 IR=0.27

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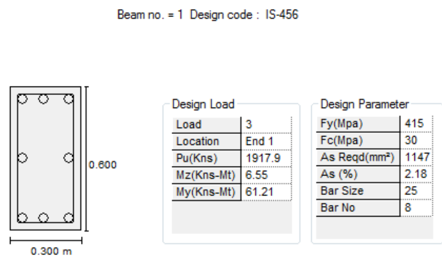

Fig 4.10 Concrete design of column no. 1

4.10 Loading for Office Building

The loadings were calculated partially manually and rest was generated using STAAD.Pro load generator. The loading cases were categorized as:

Self-weight

Dead load from slab

Live load

Load combinations

4.10.1 Self-weight

The self-weight of the structure can be generated by STAAD.Pro itself with the self-weight command in the load case column.

4.10.2 Dead load from slab

Dead load from slab can also be generated by STAAD.Pro by specifying the floor thickness and the load on the floor per m^2. weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls, internal walls and parapet over roof.

The load was found to be:

Wall loads 14kN/m^2

Floor load 5.5kN/m^2

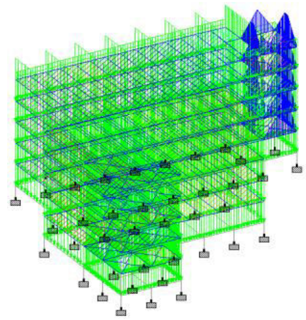

Fig 4.11 Structure under DL from slab

4.10.3 Live Load

Live load is taken as 4kN/m^2 (as per is standards for educational buildings from IS 875).

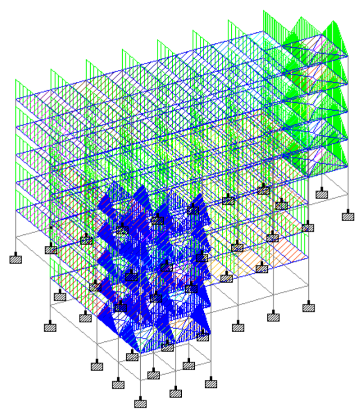

Fig 4.12 Structure under live load

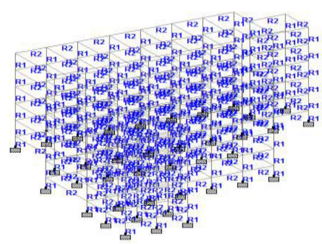

Fig 4.13Member properties

4.11 Design of Beams and Column for Office Building

4.11.1 Beam no 430 design results

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Length: 9850.0mm Size: 300 X 600 mm

Cover: 25.0mm

Table no 4.4 Summary of reinforcement area beam no 430

Section	0.0 mm	2462.5mm	4925.0mm	7387.5mm	9850.0mm
Top Reinforcement(mm²)	3424.24	0.00	0.00	0.00	3181.73
Bottom Reinforcement(mm²)	840.15	620.17	1890.39	617.46	1084.49
Top Reinforcement	7-25Ø 2 layers	2-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	7-25Ø 2 layers
Bottom Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	4-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer

Provide 2 legged 10Ø@190mm c/c as a shear reinforcement

Shear design results at 865.0mm away from start support

V_y=287.81 M_x=0.02 LD =3

Provide 2 legged 10Ø@180mm c/c

Shear design results at 865.0mm away from end support

V_y=-288.02 M_x=0.02 LD =3

Provide 2 legged 10Ø@180mm c/c.

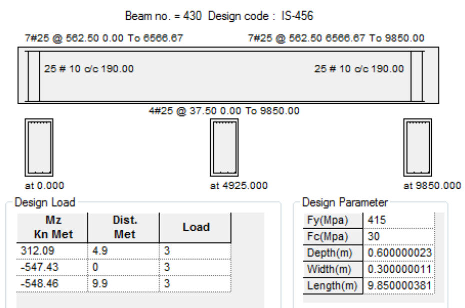

Fig 4.14 Concrete design of beam no. 430

4.11.2 Beam no 422 design results

Length: 4530.0mm Size: 300 X 600 mm

Cover: 25.0mm

Table no 4.5 Summary of reinforcement area beam no 422

Section	0.0 mm	1132.5mm	2265.0mm	3397.5mm	4530.0mm
Top Reinforcement(mm²)	348.92	0.00	0.00	0.00	345.63
Bottom Reinforcement(mm²)	0.00	348.92	348.92	348.92	0.00

Top Reinforcement	3-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	3-25Ø 1 layer
Bottom Reinforcement	2-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	2-25Ø 1 layer

Provide 2 legged 8Ø@190mm c/c as a shear reinforcement

Shear design results at 715.0mm away from start support

V_y=43.99M_x=0.03 LD =3

Provide 2 legged 10Ø@190mm c/c

Shear design results at 715.0mm away from end support

V_y=-40.83M_x=-0.03 LD =3

Provide 2 legged 10Ø@190mm c/c.

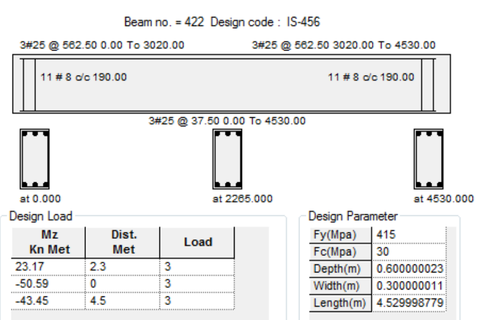

Fig 4.15 Concrete design of beam no. 422

4.11.3Beam no 447 design results

Length: 10350.0mm Size: 300 X 600 mm Cover: 25.0mm

Table no 4.6 Summary of reinforcement area beam no 447

Section	0.0 mm	2587.5mm	5175.0mm	7762.5mm	10350mm
Top Reinforcement(mm^2)	3778.17	0.00	0.00	0.00	3493.48
Bottom Reinforcement(mm^2)	1195.96	685.14	2120.79	678.40	1425.53
Top Reinforcement	8-25Ø 2 layers	2-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	8-25Ø 2 layers
Bottom Reinforcement	3-25Ø 1 layer	3-25Ø 1 layer	5-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer

Provide 2 legged 10Ø@190mm c/c as a shear reinforcement

Shear design results at 865.0mm away from start support

V_y=305.39 M_x=-0.45 LD =3

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Provide 2 legged 10Ø@160mm c/c

Shear design results at 865.0mm away from end support

V_y=-305.89M_x=-0.45 LD =3

Provide 2 legged 10Ø@160mm c/c.

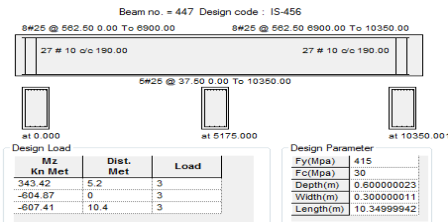

Fig 4.16 Concrete design of beam no. 447

4.11.4Beam no 554 design results

Length: 4530.0mm Size: 300 X 600 mm Cover: 25.0mm

Table no 4.7 Summary of reinforcement area beam no 554

Section	0.0 mm	1132.5mm	2265.0mm	3397.5mm	4530.0mm
Top Reinforcement(mm^2)	345.63	0.00	0.00	0.00	403.54
Bottom Reinforcement(mm^2)	0.00	345.63	383.82	345.63	0.00
Top Reinforcement	3-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	2-25Ø 1 layer	3-25Ø 1 layer
Bottom Reinforcement	2-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	3-25Ø 1 layer	2-25Ø 1 layer

Provide 2 legged 8Ø@190mm c/c as a shear reinforcement

Shear design results at 715.0mm away from start support

V_y=78.22M_x=-2.44 LD =3

Provide 2 legged 10Ø@190mm c/c

Shear design results at 715.0mm away from end support

V_y=-68.97M_x=-2.44 LD =3

Provide 2 legged 10Ø@190mm c/c

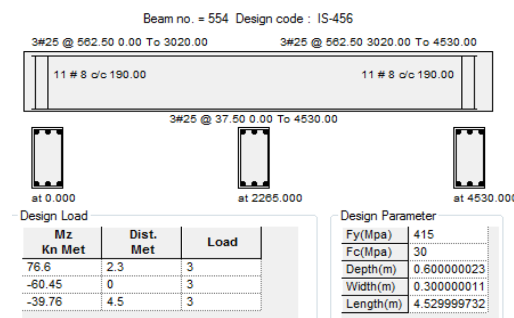

Fig 4.17 Concrete design of beam no. 554

4.11.5 Column no 7 design results

Length: 2000.0mm Size: 600 X 300 mm Cover: 40.0mm

Guiding load case: 3 end joint: 7 short columns

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Required steel area 1207.59 mm^2

Required concrete area 178792.41mm^2

Main reinforcement: Provide 8-25Ø (2.18%, 3926.9mm^2) equally distributed

Tie reinforcement: Provide 18mmØ rectangular ties@300mmc/c

Section capacity based on reinforcement required (kN/m)

P_{uz}=2789.56 M_{uz1}=78.22 M_{uy1}=164.32

Interaction ratio=0.11(as per Cl. 39.6, IS456:2000)

Section capacity based on reinforcement provided (kN/m)

Worst load case=3

End joint 8P_{uz}=3599.26 M_{uz}=142.12 M_{uy}=330.79 IR=0.23

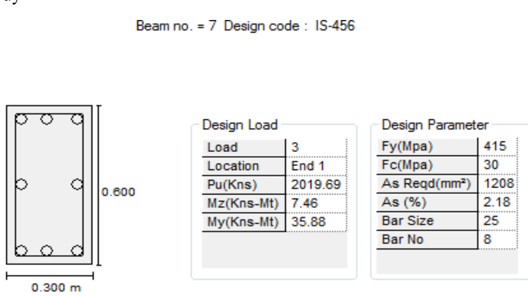

Fig 4.18Concrete design of column no. 7

4.11.6 Column no 77 design results

Length: 2000.0mm Size: 600 X 300 mm Cover: 40.0mm

Guiding load case: 3 end joint: 66 short column

Required steel area =3312.0 mm^2

Required concrete area=176688.00 mm^2

Main reinforcement: Provide 8-25Ø (2.18%, 3926.9mm^2) equally distributed

Tie reinforcement: Provide 8mmØ rectangular ties@300mmc/c

Section capacity based on reinforcement required (kN/m)

P_{uz}=3416.15 M_{uz1}=66.07 M_{uy1}=146.32

Interaction ratio=0.93 (as per Cl. 39.6, IS456:2000)

Section capacity based on reinforcement provided (kN/m)

Worst load case=3

End joint 65P_{uz}=3599.26M_{uz}=85.29M_{uy}=195.19 IR=0.58.

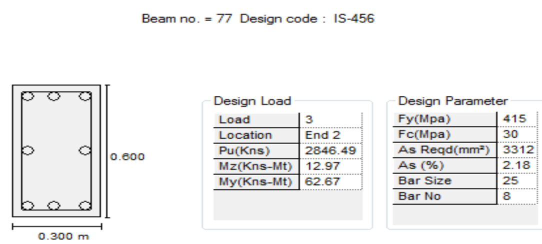

Fig 4.19 Concrete design of column no. 77

5. DESIGN OF STAIR CASE

5.1 Introduction

Stair case grew out of the necessity of securing an easy and safe passage from one level, or floor, to another. Such a passage might therefore be regarded in its inception as an inclined plane which connects two horizontal planes and provided with a series of equal risers or steps formed for the purpose of giving a sufficient footing to facilitate travel.

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5.2 Design of Stair Case

Design of open well stair case

Distance between floors is 3.66 m

Hall dimensions: B = 4.2 m L = 4.2 m

Provide waist slab is 200 mm

Dead load of waist slab = 200x1x25= 5 kN

Ceiling floor = 0.3 kN

Liveload(LL) =4000N/m^2

f_{ck} = 25 N/mm^2 f_y = 415 N/mm^2

Assume R=150mm T=300mm

Load per m^2 on plan is 5.3x√[(0.15^2 + 0.30^2)/0.30] = 5.9 kN/m

Dead load of steps = ½ x 0.15 x 25 = 1.875 kN/m

LL = 4.0 kN/m

FL = 1 kN/m

Total factored load = 1.5 x (5.9 + 1.875 + 4.0+ 0.3) = 12.100kN/m

Since landing on two sides the load on landing slab may be= 6.05kN/m

Design of Flight BC

Effective span is 4.5 m

Reaction at each support =(12100*1.2)+(6050.29*3.3)/2= 17.34 KN

Bending moment =(17243.32*2.25)-(6050.29*1.65*1.425)-(12100.5*0.6*0.3)=22.39kN-m

Ultimate moment=1.5*22.39=33.59kN-m

Check for Depth of waist slab

d = √[33.49 x 10^6/0.138 x 25 x 1000] = 98.6 mm

Effective depth is 200-15-5=180 mm

100>180 hence safe

Area of steel

A_{st} = 0.5 x 25/415 x{1-√[1- (4.6 x 33.59 x 10^6)/(25 x 1000 x 150^2)]}x1000 x150 □ 544.45 mm^2

Provide 10mmØ@140mmc/c

Design of flight AB

Effective span is 4.2 m

R_a+R_b=40.83kN

R_a=23.40kN R_b=17.38kN

Shear force is zero from A=23450.27/12100.58=1.93m

Maximum bending moment =(23450.27*1.93)-(12100.58*1.93*0.96)=22.72kNm

Ultimate moment M_u=34.08kN-m

A_{st} = 0.5 x 25/415 x{1-√[1- (4.6 x 34.08 x 10^6)/(25 x 1000 x 150^2)]}x1000 x150=552.9 mm^2

Provide 10mmØ@140mmc/c

Design of flight CD

Since AB&CD are same we provide same reinforcement for CD

Provide 10mmØ@140mmc/c

Distribution steel

Provide 8mmØ@200mmc/c

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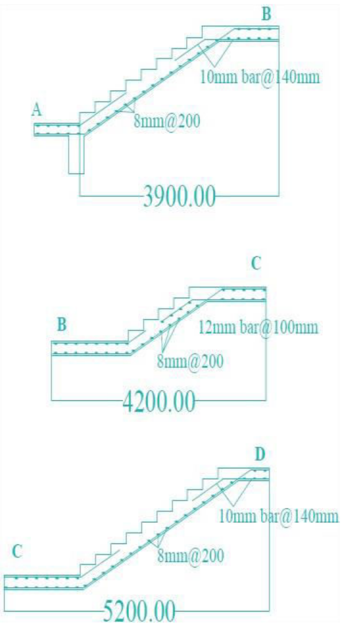

Fig 5.1 Reinforcement detailing of stair case

Distance between floors = 3.6 m

Hall dimensions: B = 5.0 m L = 5.6 m

Provide waist slab is 200 mm

Dead load of waist slab = 200x1x25= 5 kN

Ceiling floor = 0.3 kN

Live load (LL) = 4000 N/m^2

f_{ck} = 25 N/mm^2 f_y = 415 N/mm^2

Assume R = 150 mm T = 300 mm

Load per sqm on plan is 5.3x√[(0.15^2 + 0.30^2)/0.30] = 5.9 kN/m

Dead load of steps = ½ x 0.15 x 25 = 1.875kN/m

Live load = 4.0kN/m

Floor load = 0.3kN/m

Total factored load = 1.5 x (5.9 + 1.875 + 4.0+ 0.3) = 12.100 kN/m

Since common landing two sides the load on each landing is 6.05 kN/m

Design of Flight AB

Effective span is 5.0 m

R_a+R_b=49.3kN

R_a=28.18kN R_b=21.12 kN

Bending moment =(28180.73*2.32)-(12100.58*2.32*1.16)= 32.814kN-m

Ultimate bending moment=32.81kN-m

Check for Depth of waist slab

d = √[33.49 x 10^6/0.138 x 20 x 1000] = 98.60 mm

Effective depth is 200-15-5=180 mm

100>180 hence safe

Area of steel

A_{st} = 0.5 x 25/415 x{1-√[1- (4.6 x 49.22 x 10^6)/(25 x 1000 x 150^2)]}x1000 x150 □ 819.2 mm^2

Provide 12mmØ@130mmc/c

Design of flight BC

Effective span is 5.6 m

R_b+R_c=56.57kN

R_b=24.50kN R_c=32.03 kN

Shear force from c=32032.76/12100.58=2.64m

Bending moment=(32032.76*2.64)-(12100.58*2.64*1.32)=42.39kN-m

Ultimate bending moment =63.59kNm

Area of steel

A_{st} = 0.5 x 25/415 x{1-√[1- (4.6 x 63.59 x 10^6)/(25 x 1000 x 150^2)]}x1000 x150=1088.2 mm^2

Provide 12mmØ@100mmc/c

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Distribution steel is= $\frac{0.12}{100} * b * d$=0.12*1000*200/100 = 240mm^2

Provide 8mm bars @200mmc/c

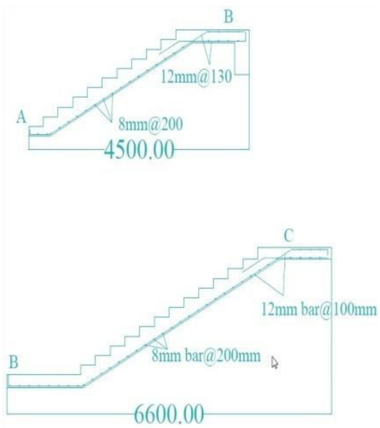

Fig 5.2 Reinforcement detailing of stair case

Design of dog legged stair case

Distance between floors = 3.6 m

Hall dimensions: B = 4.3 m L = 5.41 m

Live load (LL) = 4000 N/m^2

f_{ck} = 20 N/mm^2f_y = 415 N/mm^2

Assume R = 150 mmT = 300 mm

Height of each flight = 3.66/2 = 1.83 m

Number of rises = 1.8/0.15 = 12

Number of threads = 12 – 1 = 11

Width of landing = 1.5 m

Effective span

l_{eff} = 5.56m

D.L of Waist slab:

Assume thickness = 250 mm(assumed at 40 mm to 50 mm per metre run)

D.L of waist slab= 6250 N/m^2

Ceiling finish (12.5mm) = 300 N/m^2

D.L per sq.m on plan =((R^2 + T^2)^0.5/T) * 6550 = 6965.31 N/sq.m

D.L of Steps:

D.L of steps including finish = 2206.25 N/m^2

Live load = 4500 N/m^2

Total Load (factored) = 20057.34 N/m^2

Maximum bending moment =$\frac{w*l*l}{8}$=77057.57 Nm

Effective depth

M_u=0.138xf_{ck}xbxd^2

d = 149.88 mm

Provision of steel

Using 12 mm dia bars

Overall depth = 171 mm <250 mm

Eff.depth= 250 – 21=229 mm

Main Reinforcement

A_{stx} = 0.5 f_{ck}/ f_y (1- √{1- [(4.6 M_u)/(f_{ck}bd^2)]}) x bd = 1012.16 mm^2

Spacing of 12 mmØ@110 mm c/c

Distribution Reinforcement= $\frac{0.12}{100} * b * d$=300 mm^2

Spacing of 8mmØbars $\frac{1000*50}{300}$=166 mm

Spacing of 8mmØ@ 160 mm c/c.

6. CONCLUSION AND FUTURE SCOPE

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 rectangular section. Rectangular 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.

Future Scope

The same building is to be designed by considering the wind loads and the earthquake loads by using the STADD pro.

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