

Planning, Analysis and Designing of Modern Police Head Quarters with Distinct Helipad Features

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ABSTRACT: The modern police Headquarters of two storey RCC structure with 1547.72m² plot area with provision of helipad at the top of the building is to be analyzed and designed by manually. By the use of computerized software they are poratyed in AutoCAD for floor plan and 2D elevation and STAAD pro Vsi SS6 for analysis. As per Indian standard the design of basic requirements for the RCC is referred to IS 456-2000. The Police Head Quarters project is to use the room knowledge into real time project. Our Modern Police Head Quarters, have introduced BIPV glass elevation. (Building Integrated photo voltaic) with centralized AC and helipad at the top of the G+2 (terrace), construct eco-friendly to produce electricity we have provided the parking area with kinetic Road.

KEYWORDS: Autocadd, layout, STAAD pro, BIPV glass, kinetic Road.

I. INTRODUCTION

Police are one of the most ubiquitous organisations of the society. Police headquarters plays a pivotal role as the key functional unit in order to maintain law and order, investigations, law enforcement, patrolling neighbourhoods, responding to emergency calls, crime detections, delivering warrants, arresting the violators, etc.... The headquarters serves to be the head for all the police stations and acts as a primary source of interaction for both the public and the police. Specified helicopter detail are taken which is used for load analysing. The design part involves limit state method, code books used (IS-456, IS-875 SP-16), civil aviation (section-4) and by considering FOS is 1.5. Police acts as a primary source of interaction for both the public and the police. Hence the necessary modernized comfort to the building is provided in all aspects.

II. SIGNIFICANCE

2.1 AIM

To plan and design an official building for comfortable occupancy with helipad provision. The layout is done in AutoCAD and the load analysis is done in STADD and manually too.

2.2 SCOPE

To Lean how to apply codal provision in real time projects and to apply class room knowledge in the real world designing.

2.3 OBJECTIVE

To plan the building by using AUTOCADD, to analyze the entire plan in STADDPRO and to evaluate manually.

III. FEATURES

3.1 PROVISIONS PROVIDED

Total Area	= 1547.72 sq.m
Building Net Area	= 852 sq.m (BIPV Glasses)
Structure	= RCC Framed Structure
Parking area	= 87.74 sq.m (Kinetic Road)
Total Building Height	=11.5 m
No. of Floors	= G+2
Terrace	= Helipad

3.2 HELICOPTER DETAILS (for load analysis)

Helicopter Model	-Bell 407
Length	-12.7m
Height	-3.56m
Empty Weight	-120 kg
Max take of weight	-1065 kg
Rotar Diameter	-10.67m

3.3 HELIPAD DETAILS

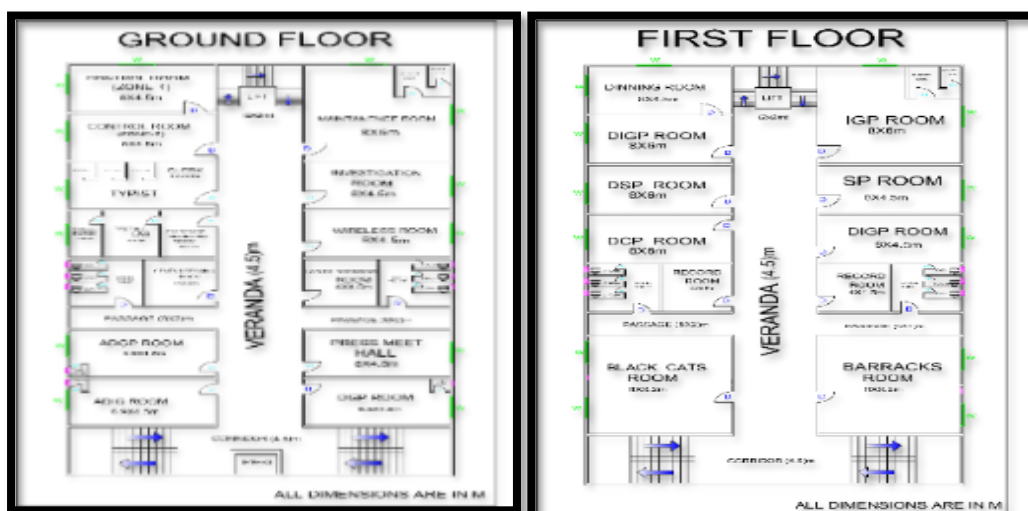
Beam	-230 x 600mm
Column	-230 x 750 mm
Roof Slab	-5KN/m ²
Helipad Slab	-280 KN/m ² m

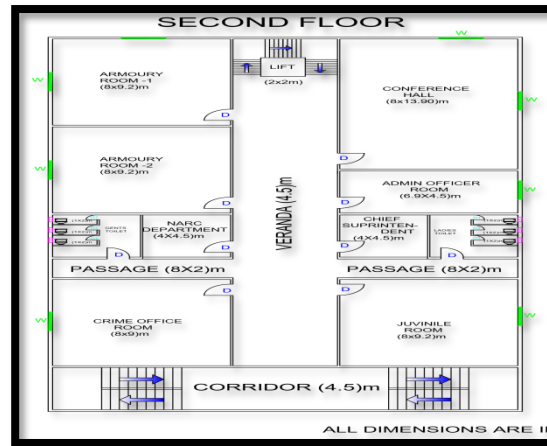
3.4 SEPECIFICATION

Beam size	: 230x300mm
Column size	: 230x450mm
Slab thickness	: 150mm
Helipad Beam size	: 230x 600mm
Helipad Column size	: 230x750mm
Helipad Slab Thickness	: 200mm
Grade of concrete	: M25
Grade of steel	: Fe415
Type of soil	: Hard rock (laterite soil)
Type of slab	: Two Way Slab
Type of column	: Rectangular Column
Type of foundation	: Mat Foundation
Type of staircase	: Dog – Legged Stairs

IV. LAYOUT

The floor plan is drawn using AutoCADD. The layout planning with is done for 1547.72 sq.m. The plan are drawn for each floor separately with column marking.





V. STADD ANALYSIS

The load analysis of G+2 building of conventional beam, column and slab; helipad beam column and slab at comers of the structure is done using stadd.pro.

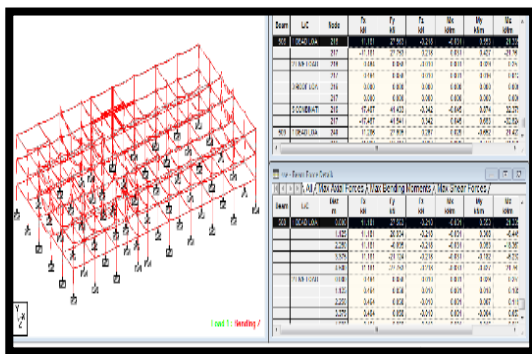


Fig 5.2 Load analysis of G+2 Building

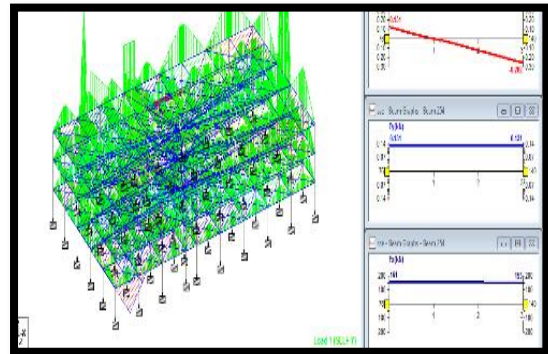


Fig 5.2 Beam, Column Analysis of G+2 Building

VI. MANUAL DESIGNS

The load calculation of building of conventional beam column, slab & helipad beam, column & slab are done separately. The manual design calculation are done by using the limit state method.

6.1 DESIGN OF BEAM (Conventional)

STEP - 1

Size = 0.23 x 0.3

Span = 4.5m

BM = 32.26x10⁶

D = 300mm = 300 + 50 = 350mm

M25 & Fe415

STEP - 2

$M_{a(lim)} = 0.138 f_{ck} b d^2 = 0.138 \times 25 \times 230 \times 300^2 = 71.416 \times 10^6 \text{ N-mm}$

$M_u(lim) > M_u$ Hence the base is designed as singly reinforced beam

STEP - 3

DL of beam = $b \times d \times \text{unit wt. of concrete}$

$$= 0.23 \times 0.3 \times 25 = 1.725 \text{ KN/m}$$

L.L. = 5 KN/m

Total Load = 6.725 KN/m

Factored Load $W_u = 1.5 \times 6.725 = 10.087 \text{ KN/m}$

STEP - 4

$$V_u = \frac{W_u l_e}{2}$$

$$l_e = L + d = 4500 + 300 = 4800$$

$$V_u = \frac{10.087 \times 4.8^2}{2} = 24.208 \text{ KN}$$

STEP - 5 REINFORCEMENT CALCULATION

$$M_u = 0.87 f_y A_{st} d \left(1 - \frac{A_{st} 415}{300 \times 1000 \times 25} \right)$$

$$32.26 \times 10^6 = 0.87 \times 415 \times A_{st} 300 \left(1 - \frac{A_{st} 415}{300 \times 1000 \times 25} \right)$$

$$M_u = 108315 A (1 - 5.5333 \times 10^{-5} A_{st}) = 10.8315 A_{st} - 5.9934 A_{st}^2$$

$$A_{st} = 302.92 \text{ mm}$$

Provide 12mm bars at = 113.06 mm²

$$\text{No of bars} = \frac{A_{st}}{a_{st}} = 2.67 \sim 3 \text{ Nos}$$

Provide 2 Nos of 16mm bars at hanger bars.

STEP - 6: CHECK FOR SHEAR STRESS

$$\tau_v = \frac{V_u}{bd} = \frac{24.208 \times 10^3}{1000 \times 300} = 0.08 \text{ N/mm}^2$$

$$P_t = \frac{100 A_{st}}{bd}$$

$$= \frac{100 \times 302.92}{1000 \times 300} = 0.10\%$$

$$\tau_c = 0.29 \text{ N/mm}^2$$

$$\tau_c > \tau_v$$

Hence Safe Provide 2 legged 8mm ϕ stirrups @ 300mm C/C spacing

STEP - 7: CHECK FOR SERVICEABILITY

$$(L/d)_{\max} = (L/d)_{\text{basic}} \times K_c \times K_f \times K_t$$

$$(L/d)_{\text{basic}} = 20$$

$$K_c = 1$$

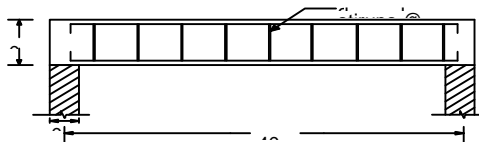
$$K_f = 1$$

$$K_t = 1.1$$

$$(L/d)_{\max} = 4500 \times 20 \times 1 \times 1 \times 1.1$$

$$(L/d)_{\text{actual}} = 15$$

$$(L/d)_{\max} > (L/d)_{\text{actual}}$$



Single reinforced details of Beam Longitudinal section (Conventional)

6.2 DESIGN OF SLAB FOR GROUND FLOOR AND FIRST FLOOR

$$L_x = 4 \text{ m}$$

$$L_y = 4.5 \text{ m}$$

$$\frac{L_y}{L_x} = \frac{4.5}{4} = 1.125$$

1.125 < 2 Hence has to be designed two way slab

STEP - 1: CROSS SECTION DIMENSIONS

$$\frac{l_x}{d} = 40 = 40 \times 0.8 = 32$$

$$D = \frac{l_x}{32} = \frac{4000}{32} = 125 \text{ mm Assume } d^1 = 30 \text{ mm}$$

$$D = d + d^1 = 150 + 30 = 180 \text{ mm}$$

$$B = 1 \text{ m} = 1000 \text{ mm}$$



Step 2: EFFECTIVE SPAN

$$L_x = l_x + d = 4000 + 15 = 4150 \text{ mm}$$

STEP - 3: LOAD CALCULATION

i) Self wt. of Slab = $B \times D \times \text{self wt. of concrete} = 1 \times 0.18 \times 25 = 4.5 \text{ KN/M}$
 Live Load / m = $4 \text{ KN/m}^2 = 4 \text{ KN/m}$

ii) F.L.L. = 1 KN/M

Total Load(W)= 9.5 KN/M

$W_u = 1.5 \times w = 1.5 \times 9.5 = 14.25 \text{ KN/m}$

STEP - 4: BENDING MOMENT AND SHEAR FORCE Refer Pg. No. 91 Table 26 Is 456

$$\alpha_x = 0.040 M_{ux} = \alpha_x \times W_u \times l_e = 0.040 \times 14.25 \times 4150^2 = 9.816 \times 10^6 \text{ Nmm}$$

$$\alpha_y = 0.035 M_{uy} = \alpha_y \times W_u \times l_e = 0.035 \times 14.25 \times 4150^2 = 8.589 \times 10^6 \text{ Nmm}$$

STEP- 5: SHEAR FORCE

$$\frac{W_u L_e x}{2} = \frac{14.25 \times 4150}{2} = 29.56 \times 10^3 \text{ N}$$

STEP - 6: CHECK FOR SECTION

Refer Annex G.1.1.c of is 456 pg. No. 9

$$M_{u,lim} = 0.36 \frac{x_u \max}{d} \left(1 - 0.42 x \frac{x_u \max}{d} \right) \times f_{ck} b d^2$$

$$= \frac{x_u \max}{d} F_e 415 \text{ Pg. No. 70 } \frac{x_u \max}{d} = 0.48 = 0.138 \times f_{ck} b d^2 = 77.62 \times 10^6 \text{ Nmm}$$

$M_{u,lim} > M_{ux} > M_{uy}$ Hence the section is under reinforced section

STEP - 7: REINFORCEMENT CALCULATION ALONG X DIRECTION

Refer Annex 1.1.1 of is 456 Pg. No. 96

$$M_{ux} = 0.87 f_y A_{stx} d \left(1 - \frac{f_y A_{stx}}{f_{ck} b d} \right)$$

$$9.816 \times 10^6 = 0.87 \times 415 \times A_{stx} \times 150 \left(1 - \frac{415 A_{stx}}{25 \times 1000 \times 150} \right) A_{stx} = 185.03 \text{ mm}^2$$

$$\text{Spacing} = \frac{1000 \times A_{st}}{A_{stx}} = \frac{1000 \times 50.26}{185.03} = 271.63 \sim 250 \text{ mm}$$

$$M_{uy} = 0.87 F_y A_{sty} d^1$$

$$8.589 \times 10^6 = 0.87 \times 415 \times A_{sty} \times 150 \left(1 - \frac{415 A_{sty}}{25 \times 1000 \times 150} \right) A_{sty} = 161.49 \text{ mm}^2$$

STEP - 8: PROVIDE 6mm DIA BARS

$$A_{st} = \pi/4 \times 6^2 = 28.27 \text{ mm}^2$$

$$\text{Spacing} = \frac{1000 \times A_{st}}{A_{sty}} = \frac{1000 \times 28.27}{101.49} = 175.05 \text{ mm} = 170 \text{ mm}$$

STEP - 9: CHECK FOR SHEAR STRESS

$$\tau_v = \frac{V}{b d} = \frac{29.56 \times 10^3}{100 \times 150} = 0.19 \text{ N/mm}^2$$

$$P_t = \frac{100 A_{st}}{b d} = \frac{100 \times 150}{100 \times 150} = 0.12\%$$

Refer table 19 of IS 456 Pg. No. 73

$$\tau_c = 0.28$$

$$\tau_v > \tau_c$$

STEP - 10: CHECK FOR SERVICEABILITY

$$(L/d)_{max} = (L/d)_{basic} \times K_t \times K_c \times K_f$$

$$(L/d)_{basic} = 20 K_c = 1 \times 1 \times 1 \quad (K_t \text{ IS 456 Refer Pg. No.38})$$

$$K_t = 1.8$$

$$(L/d)_{max} = 20 \times 1 \times 1 \times 1 = 36 \quad (L/d)_{actual} = \frac{4000^2}{150} = 26.66$$

$(L/d)_{max} > (L/d)_{actual}$ Hence is serviceability are with in permissible limits



STEP - 11: TORSION REINFORCEMENT

$$A_{st} \text{ for tension} = 75\% A_{stx} = \frac{75}{100} \times 205.01 = 153.75 \text{mm}^2$$

Provide 8mm dia @ 180mm dia in the form of mesh in 4 layer for a distance of $L_x/5$

STEP - 12: EDGE REINFORCEMENT

PROVIDE MINIMUM REINFORCEMENT $= \frac{0.12}{100} \times B \times D = \frac{0.12}{100} \times 1000 \times 180 = 216 \text{mm}^2$

Provide 8mm dia bars @ the provide 300mm C/C for a span of LK/8 in ax - direction any LY/8 in Y-direction

6.3 DESIGN OF HELIPAD SLAB

$$L_x = 4 \text{m}$$

$$L_y = 4.5 \text{m}$$

$$\frac{L_y}{L_x} = \frac{4.5}{4} = 1.125$$

$$1.125 < 2$$

Hence has to be designed two way slab

STEP - 1: CROSS SECTION DIMENSION

$$\frac{L_x}{d} = 40 \text{ (Modification Factor Fe 415)}$$

$$\frac{L_x}{d} = 40 \times 0.8 = \frac{L_x}{d} = 32$$

$$D = \frac{L_x}{32} = \frac{4000}{32} = 125 \sim 150 \text{mm}$$

Assume $d = 30 \text{mm}$ $D = d + d1 = 150 + 30 = 180 \text{mm}$

$$B = 1 \text{m} = 1000 \text{mm}$$

STEP - 2: EFFECTIVE SPAN

$$L_{ex} = l_x + d = 4000 + 150 = 4150 \text{mm}$$

STEP - 3: LOAD CALCULATION

Self wt of Slab = $B \times D \times \text{self wt of concrete}$
 $= 1 \times 0.18 \times 25 = 4.5 \text{ KN/M}$

i) Live Load / m = 19.025 KN/M^2

ii) F.L.L. = 1 KN/M

Total Load (W) = 24.52 KN/M

$W_u = 1.5 \times w = 1.5 \times 24.52 = 36.78 \text{ KN/M}$

STEP - 4: BENDING MOMENT AND SHEAR FORCE Refer Pg. No. 91 Table 26 IS 456

$$M_x = 0.028 \frac{1000 \times A_{st}}{A_{st_y}} M_{ux} = \square \times W_u \times l_{ex} = 0.028 \times 36.78 \times 4150^2 = 17.73 \times 10^6 \text{Nmm}$$

M_y Pg. No. 91 Table 24 $M_y = 0.024 M_{uy} = 15.20 \times 10^6 \text{Nmm}$

STEP - 5 : SHEAR FORCE

$$\frac{W_u L_{ex}}{2} = \frac{36.78 \times 4150}{2} = 76.31 \times 10^3 \text{N}$$

STEP - 6: CHECK FOR SECTION

Refer Annex G.1.1.C of IS 456 Pg. No. 96

$$M_{ulim} = 0.36 \frac{X_u \text{max}}{d} \left(1 - 0.42 \times \frac{X_u \text{max}}{d} \right) \times f_{ck} b d^2 \frac{X_u \text{max}}{d} = 0.48$$

$$M_{uLim} = 0.138 \times f_{ck} b d^2 = 77.62 \times 10^6 \text{Nmm}$$

$M_{uLim} > M_{ux} > M_{uy}$ Hence the section is under reinforced section.

STEP - 7: REINFORCEMENT CALCULATION ALONG X DIRECTION

Refer Annex G 1.1.C of is 456 Pg. No. 96

$$M_{ux} = 0.87 F_y A_{st_x} d \left(1 - \frac{F_y A_{st_x}}{f_{ck} b d} \right)$$

$$17.73 \times 10^6 = 0.87 \times 415 \times A_{st_x} \times 150 \left(1 - \frac{415 A_{st_x}}{25 \times 1000 \times 150} \right)$$

$$17.73 \times 10^6 = 54.157 \times 10^3 A_{st_x} (1 - 1.106 \times 10^{-4} A_{st_x})$$

$$Ast_x = 370.17mm^2$$

$$Spacing = \frac{1000 \times Ast}{Ast_x} = \frac{1000 \times 78.53}{340.17} = 230.85mm \text{ -} 230mm \text{ C/C}$$

$$M_{uy} = 0.87 F_y Ast_y d \frac{1 - F_y Ast_y}{FCKbd} = 15.20 \times 10^6 = 0.87 \times 415 \times Ast_y \times 150 \left(1 - \frac{415 Ast_x}{25 \times 1000 \times 150} \right)$$

$$Ast_x = 292.5mm^2$$

STEP - 8: PROVIDE 6mm DIA BARS

$$Ast = \pi/4 \times 82 = 50.26mm^2$$

$$Spacing = \frac{1000 \times 50.26}{292.5} = 171.82m = 150 \text{ mm C/C}$$

STEP 9 : CHECK FOR SHEAR STRESS

$$\tau_v = \frac{V}{bd} = \frac{76.31 \times 10^3}{1000 \times 150}$$

$$P_t = \frac{100 Ast}{bd} = \frac{100 \times 340.17}{1000 \times 150} = 0.22\% \text{ Refer table 19 of IS 456 Pg. No. 73}$$

$$\tau_c = 0.33$$

$$\tau_v > \tau_c$$

STEP - 10: CHECK FOR SERVICIBILITY

$$(L/d)_{max} = (L/d)_{basic} \times K_t \times K_c \times K_f$$

$$(L/d)_{basic} = 20$$

$$K_c = 1, K_f = 1, K_t = 14$$

$$(L/d)_{ma} = 20 \times 1 \times 1 \times 1.4 = 28$$

$$= \left(\frac{L_x}{d} \right) \frac{4000}{150} = 26.66$$

(L/d) max > (L/d) actual Hence is serviceability are with in permissible limits.

STEP - 11: TORSION REINFORCEMENT

$$Ast \text{ for tension} = 75\% Ast_x = \frac{75}{100} \times 340.17 = 255.12mm^2$$

Provide 8mm dia @ 180mm dia in the form of mesh in 4 layer for a distance of $L_k/5$

STEP - 12: EDGE REINFORCEMENT PROVIDE MINIMUM REINFORCEMENT

$$= \frac{0.12}{100} \times B \times D = \frac{0.12}{100} \times 1000 \times 180 = 216mm^2$$

Provide 8mm dia bars @ the provide 300mm C/C for a span of $L_k/8$ in ax - direction any $L_y/8$ in Y-direction.

TWO WAY CONTINUOUS SLAB SECTION DETAILING

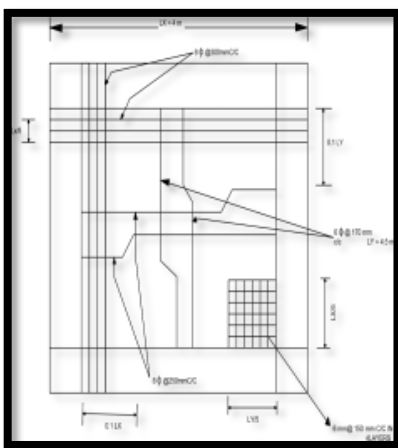


Fig 6.2 Ground, 1st & 2nd floor plan

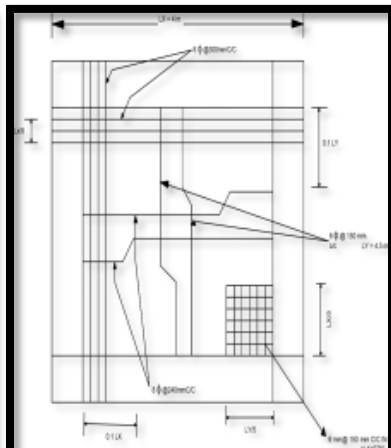


Fig 6.3 Helipad Slab

6.4 DESIGN OF COLUMN

Column size : 230mm x 450 mm B = 230 mm D = 450 mm
 Ultimate Axial load (PLL) = 158.86 kn.
 $M_{ux} = 14.62 \text{ KN-m}$ $M_{uy} = 7.28 \text{ KN-m}$ $F_{ck} = 25 \text{ N/mm}^2$ $F_y = 415 \text{ N/mm}^2$

STEP - 1: LONGUDINAL REINFORCEMENT

Assume PC = 2%
 $P_c = 100 A_{sc} / b \times D = 100 A_{sc} / 230 \times 450$
 $A_{sc} = 230 \times 450 \times 2 / 100 = 2070 \text{ mm}^2$ Provided 25mm dia bars,
 $a_{sc} = \pi/4 \times 20^2 = 314.15 \text{ mm}^2$ $A_{sc} \text{ No. of bars} = 2070 / 314.15 = 6.5 \sim 8 \text{ nos}$

STEP - 2: CHECK FOR LONGUDINAL REINFORCEMENT

($M_{ux} = M_{uy}$)
 Along 'x' axis,
 $P_u = 158.86 \times 10 = 0.07$
 $F_{ck} b D = 25 \times 230 \times 450$
 $P_c = 2/20 = 0.08 < 0.1$
 $M_{ux1} = 0.15 \times 25 \times 230 \times 450^2 = 139.72 \times 10^6 \text{ N-mm}$
 $A_g = B \times L = 230 \times 450 = 103500 \text{ mm}^2$
 $A_g = A_c + A_{sc} \text{ pro}$
 $A_c = 103500 - 2070 = 101.43 \times 10^3 \text{ mm}^2$
 $P_{uz} = 0.45 \times 25 \times 101.43 \times 10^3 + 0.75 \times 415 \times 2070 = 912.87 \times 10^3 + 644.28 \times 10^3 = 1.55 \times 10^6 \text{ N}$
 $P_u = 158.86 \times 10^3 \text{ N} = 158.86 \times 10^3 / 1.55 \times 10^6 = 0.20$

ALONG 'Y' AXIS $d^1 / h = 50 / 230 = 0.21$

$M_{uy1} / f_{ck} b^2 D = 0.14$
 $P_u / f_{ck} b D = 0.07$ $P_c / f_{ck} = 0.10$
 $M_{uy1} = F_{ck} b^2 D M_{uy1} = 25 \times 230^2 \times 450 \times 0.21 = 66.65 \times 10^6 \text{ N-mm}$
 $M_{ux1} = 139.72 \times 10^6 \text{ N-mm}$ $M_{uy1} = 66.65 \times 10^6 \text{ N-mm}$
 $P_{uz} = 0.45 f_{ck} A_c + 0.75 F_y A_{sc}$

ALONG 'X' AXIS, $(0.06)^1 + (0.064)^1 = 1.0$ Hence safe

STEP - 3: DESIGN OF LATERAL TIES

- i) Dia of Lateral ties = 1/4 x dia of longitudinal
 i. = 1/4 x 20 = 5mm.
- ii) Spacing Lateral ties
- iii) Least Lateral dimension = 230mm
- iv) 16 x dia of longitudinal bars = 16 x 25 = 400mm
- v) 300mm (Spacing = 300mm)

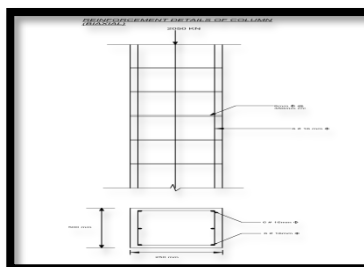


Fig 6.4 Reinforcement details of Column (Biaxial)

VII. CONCLUSION

- The structural members were drafted using AUTOCADD & analysed for safety in STAAD Pro.
- For safety purpose both manual and software analysis method are done successfully.
- Beam, column and slab are calculated for both for conventional & helipad.



- It is found to be safe against bending moment and shear force.
- The planning, design and the analysis is successfully completed.

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