Planning, Analysis, and Designing of Modern Police Station Building

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Abstract- In designing a structure, technical expertise and artistic vision are combined to guarantee cost-effectiveness, durability, utility, and safety. It needs inventiveness, critical thinking, and a thorough comprehension of building codes, practical factors, and structural engineering concepts. This project made the plans to be as cost-effective as possible. This project has suitable designs and plans, as well as provisions for electricity, water supply, and sanitary facilities. For the design, we employed the limit state design method. According to the IS code suggestion, all slabs have been designed as both simply supported and in-condition slabs. Next, we used one of the design programs, STAAD pro, to analyse our building. This project makes use of AUTOCAD to display building blueprints for a variety of applications. The suggested Indian codes are IS 875-1987 (PART2), IS-456:2000, and SP-16. For design, M60 grade concrete and Fe 500 steel grades are used.

Keywords: Limit state method, Staad Pro, Autocad, Is code

1. INTRODUCTION

Police station exist as one of the most common organizational entities that belong to society. The key operational unit, police headquarter, maintains law and order, conducts investigations, and performs law enforcement duties while patrolling neighborhood and responding to emergencies for criminal detection and warrant service, arrest operations, etc. The headquarters remains at the top of all police stations while functioning as the main point of contact for the public and police elements. The specified helicopter detail produces information for load analysis. The design aspect utilizes the limit state method together with IS-456 and IS-875 SP-16 code books, and civil aviation section-4 standards operating at FOS 1.5. Public and police members participate in their main communication channel through the Police. All parts of the building receive the required modern comfort services.

1.1 Scope of Project

This project aims to design an up-to-date police station facility with analysis and planning. The systematic arrangement of building elements forms a functional, meaningful structure during building planning processes. Constructors as well as subcontractors deliver the construction of various building types. Executive planning helps project teams determine project expenditure requirements and develop financial budgets because of its utility in proposed initiatives. The fundamental aspects designers should consider when creating residential buildings are occupants, ventilation, and lighting. All factors are examined during the scaled plan's design process. The floor space distribution remains proficient because no area goes to waste. An exact cost projection maintains everyone's attention on completing the project, both on schedule and within budget.

1.2 Objectives of The Project

The Objectives of The Project Are Mentioned Below:

- Use AutoCAD to develop the design plan for the new structure.
- Analyze and design all the principal structural components of a multistory building starting from slabs to columns to beams until reaching a complete understanding of AUTOCAD and STAAD PRO.
- The objectives include structural analysis of multi-stored RCC building using software (STAAD PRO) prior to that manual calculation will be done by appropriate structural analysis methods. Design of beam, column, footing and slab are done.

1.3 Necessity of the Project

Now a day’s the urban development plays an important role in development of country. Police station 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

building serves to be acts as a primary source of interaction for both the public and the police

1.4 Role of AutoCAD

The commercial software application AutoCAD provides capabilities for 2D and 3D computer-aided design and drafting. This program enables designers to construct 3D elements like walls, doors, and windows and attach intelligent computer data to these shapes rather than using basic objects. Users can program building industry products within this data system or extract it to file formats suitable for material pricing estimations. Drafting and modelling for the structure were thoroughly completed through AutoCAD applications during this project. The production of foundation details through AutoCAD has reached completion. The implementation of AutoCAD software cuts down the total drafting time required, which would otherwise be spent doing it manually, freeing up time for additional productive tasks.

1.5 Role of Staad Pro

STAAD Pro V8i maintains its position as one of the primary computer programs utilized for concrete, steel, and timber design code implementations. STAAD Pro enables users to analyze and design every style of structure because of its flexible modeling system, data automation features, and advanced functionality.

2. METHODOLOGY

- We have been provided with the design for contemporary police station facilities. The project team determines various combinations and loads, referencing IS 875 Part 1—Part 5 and IS 1893 Part 1:2002 for earthquake load regulations.
- The dimensions of the structure, including beams, slabs, columns, and footings, are determined based on the applied loading requirements. The number of columns must be selected based on the architectural plan's design specifications. A column must be placed at every junction point of the structure.
- The building will be analyzed using manual procedures and computer software evaluation. Two types of analysis will occur: one using the manual approaches described in the literature review and another using STAAD Pro software.
- The methods will conduct an analysis, and then the results will be cross-examined. The design of a duplex house progresses only after the results match.

3. STRUCTURAL DESIGN

3.1 Design of Simply Supported Two-Way Slab

f_{ck} = 60 N/mm²

f_y = 500 N/mm²

Room size = 3.8 x 6.8 m

Support = 300 mm

Thickness of slab = 150 mm

MAIN REINFORCEMENT:

For shorter span (max mom in shorter span)

$M_x = 0.87 f_y A_{st} d (1- f_y A_{st} / f_{ck} bd)$

$29.58 \times 10^6 = 0.87 \times 500 \times A_{st} \times 130 (1- 500 \times A_{st} / 60 \times 1000 \times 130)$

$3.625 A_{st}^2 – 56.550 \times 10^3 A_{st} + 29.58 \times 10^6 = 0$

A_{st} min = 541.90 mm²

3.2 Design of Simply Supported Beam for Archive Storage

Center to center distance l_{eff}=6.98 m

B=300 mm, d = 360 mm & D = 400 mm (assumption)

F_y = 500 N/mm² & f_{ck} = 60 N/mm²

Q=3.45 & % A_{st} = 1.197 %

M_u = 203.487 KNm (From Staad pro)

REINFORCEMENT

$A_{st1} = M_{ulim} / (0.87 \times f_y \times (d-0.42 X_{umax}))$

$= 134.1 \times 10^6 / (0.87 \times 500 \times (360-0.42 \times 0.48 \times 360)$

A_{st1} = 1072.54 mm²

$A_{st1} = M_{UA} /(0.87 \times fy \times (d-d'))$

$= 69.387 \times 10^6 /(0.87 \times 500 \times (360-40))$

A_{st2} = 498.46 mm²

TOTAL $A_{st} = A_{st1}+A_{st2}$

A_{st} = 1571 mm²

Provide 20 mm dia bars

A_{st} = 314.16 mm²

NOS = A_{st} / a_{st} = 1571 / 314.16 = 6 nos

$A_{st} = 6 \times \pi \times 20^2/4$ = 1884.95 mm²

Provide 6 nos of 20 mm dia bars as tension reinforcement

3.3 Design of Rectangular Column to Support Beams

Size of column = 300 x 450 mm

f_{ck} = 60 N/mm²

f_y = 500 N/mm²

P_u = 271 KN

AREA OF COLUMN

A_g = l x b = 300 x 450 = 135x 10^3 mm²

TRANSVERSE REINFORCEMENT

MINIMUM DIAMETER

1) 1/4 x dia = 1/4 x 16 = 4 mm
2) Not less than 6mm

PITCH

1) LLD = 300 mm

2) 16 x 16 = 256 mm say 260mm

3) 300mm

Provide 6 mm dia laterals at 260 mm c/c

RESULT

Size of column = 300 x 450 mm

Longitudinal reinforcement = 6 nos of 16 mm dia bars

Transverse reinforcement = 6 mm dia at 260 mm c/c

3.4 Design of Isolated Rectangular Footing for Rectangular Column

SIZE OF FOOTING

Axial load of footing = 271 KN

Assume the self wt of footing as 10% of the column load

W1 = 10/100 x 271

= 28 KN

Total load on soil = 270 + 28 = 300 KN

Area of footing required = Total load /sbc

= 300 /200

= 1.5m²

Since it is a square column

B x L= 1.5m²

B x (1.5B) = 1.5m²

A_{stL} = 655.822 mm²

A_{stmin} = 0.12/100 x (b x D)

= (0.12/100) x 1500 x 250

A_{stmin} = 450 mm²

a_{st} = π x 12^2/4= 113.09 mm²

NOS = A_{stL} / a_{st} = 655.822 /113.09 = 6 nos

Provide 6 nos of 12 mm dia bars in long direction at uniform spacing

A_{st} = 6 x π x12^2/4 = 678.58 mm²

4. ANALYSIS RESULTS

Table 1. The forces at each beam's end B have the opposite signs. For instance, this indicates that the maximum tension value for a beam is provided by the Min Fx product.

			Axial	Shear		Torsion	Bending	
	Beam	Node	Fx (N)	Fy (N)	Fz (N)	Mx (kNm)	My (kNm)	Mz (kNm)
Max Fx	60	12	271E 3	-5.68E 3	-34E 3	-0.118	54.640	-6.056
Max Fy	19	12	0.000	154E 3	0.000	0.000	0.000	203.487
Max Fz	73	25	209E 3	5.87E 3	35.5E 3	0.129	-55.737	4.791
Max Mx	122	55	2.92E 3	26E 3	-8.589	1.194	0.024	20.460
Max My	65	17	202E 3	3.02E 3	-35.6E 3	-0.111	56.639	3.732
Max Mz	19	12	0.000	154E 3	0.000	0.000	0.000	203.487

4.1 Beam Analysis & Design

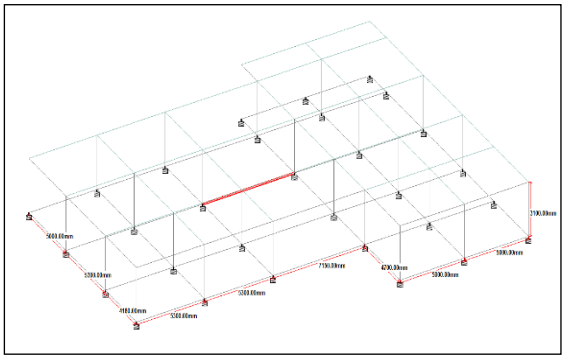

Figure 1. Critical Beam Identification Diagram

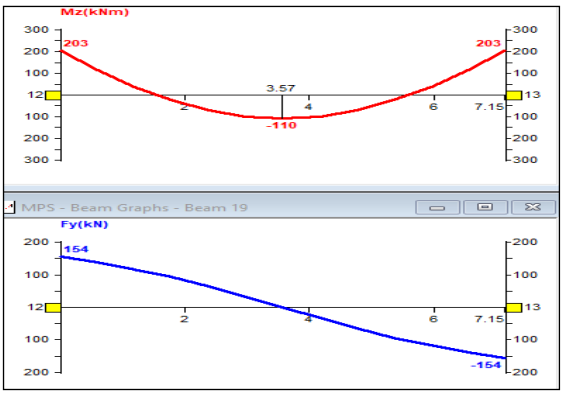

Figure 2. Bending Moment & Shear Force Diagram

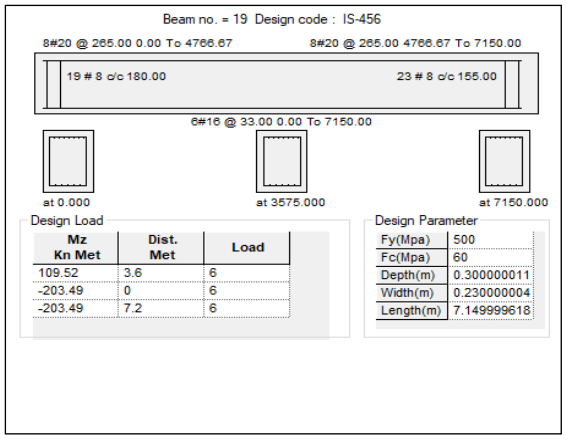

Figure 3. Beam Reinforcement Diagram

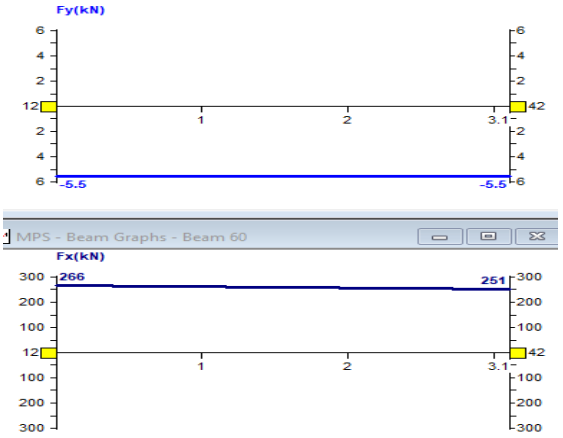

Figure 5. Shear & Axial Force Diagram

4.2 Column Analysis & Design

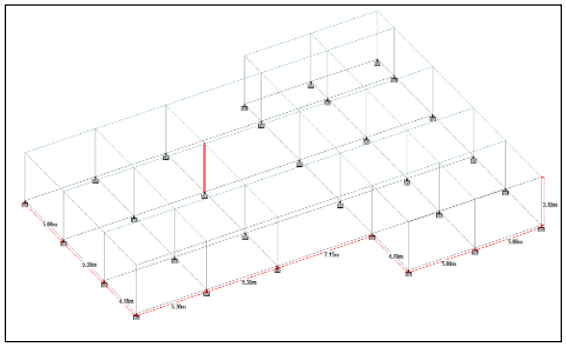

Figure 4 . Critical Column Identification Diagram

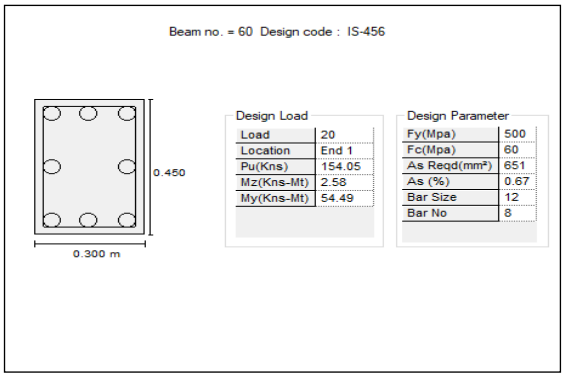

Figure 6. Column Reinforcement Diagram

********** CONCRETE TAKE OFF **********
(FOR BEAMS, COLUMNS AND PLATES DESIGNED ABOVE)

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THE REINFORCING STEEL QUANTITY REPRESENTS THE STEEL MATERIAL USAGE IN DESIGNED ABOVE BEAMS AND COLUMNS.
THE QUANTITY REPORT EXCLUDES REINFORCING STEEL IN PLATES.
TOTAL VOLUME OF CONCRETE = 45.5 CU. METER

BAR DIA (in mm)	WEIGHT (in New)
8	13483
10	9695
12	18763
16	2586
20	1153

*** TOTAL= 45680

5. CONCLUSION

This project has given me a good technical and practical exposure. The project's services and quality management aspects became visible through my hands-on experience. The software application made the project completion rapid. Our academic work, together with this training, will provide us with full engineering knowledge. The additional accuracy for dimension evaluation and analysis benefits from our project work. The application software that we use shows robust features in analyzing structural parameters for potential future research.

REFERENCE

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