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PLANNING, ANALYSIS AND DESIGN OF OCTAGONAL LIBRARY

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ABSTRACT

A library is a collection of sources of information and similar resources, made accessible to the students and staffs community for reference. The focus of this project is to plan, analyze and design an architectural library building to the college. The distinct shape and appearance of an octagon shaped library adds aesthetic appearance to the college campus. This proposed project is to place inside the college campus covering an area of about 1137.13 m^2. The plans for each floor in the library building are drafted by using the AUTOCAD software. The analysis of the structural frames is carried out manually. The design of all the structural elements such as slab, beam, column, footing, staircase, etc., are carried out as per IS codes. Limit state method is adopted for the design of all the structural members in this project. Concrete mix used for the RCC members is M30 grade concrete and Fe500 grade steel. Footing is designed as isolated type.

Keywords: Octagon shape, aesthetic, plans drafted, design, limit state method, beam, column, slab, M30, Fe500, footing-isolated.

CHAPTER 1 INTRODUCTION

1.1 GENERAL

A library is a collection of sources of information and similar resources, made accessible to a defined community for reference or borrowing. It provides physical or digital access to material, and may be a physical building or room, or a virtual space or both. A library's collection can include books, periodicals, newspapers, manuscripts, maps, prints, documents, microform, CDs, cassettes, DVDs, e-books, audiobooks, databases, and other formats. Libraries range in size from a few shelves of books to several million items.

Library plays a vital role in academic and research system and that is why library is considered to be the _heart' of educational / research system. Without a good library any university cannot ensure quality education or research. Considering the importance of library in higher education and research, the Bureau of Indian Standards came out with Indian Standard: 1553-1989 Code of practice relating to primary elements in the design of library building based on the recommendations of a Committee chaired by Dr.S.R.Ranganathan, who is honored as the _Father of Indian Library Science'.

1.2 IMPORTANCE OF ENGINEERING COLLEGE LIBRARIES

Libraries provide support to engineering colleges for achieving the goals and vision of respective engineering colleges through ensuring quality based library and information support services to the students, research scholars and faculty members. Librarians are professionally committed to update the collections continuously in order to reinforce and enrich the knowledge base for assisting the stakeholders of engineering colleges to achieve excellence in academic, research and development, consultancy, continuing engineering education, and interaction with external environment. With the passage of time, the needs of engineering users have been drastically changed. Libraries are the soul of any research or academic institution. They form the most vital forum of education, especially in the field of engineering education. Due to the rapid development taking place in various fields of science and technology, it becomes imperative for the libraries to remain up-dated so that information becomes accessible to its pursuers. The main purpose of engineering libraries is to support the teaching and research programmes of engineering colleges.

1.3 OCTAGONAL BUILDINGS

Octagon house designs have been around for thousands of years and were very popular in the mid-1800s in the United States with thousands of homes built in an 8-sided geometric configuration. In fact, the headquarters of the American Institute of Architects (AIA) in Washington, D.C. is located in a historical building called ―The Octagon‖ that was built in 1801—so the eight-sided design is a well-established architectural style.

1.3.1 OCTAGON SHAPE

A regular octagon is a closed figure with sides of the same length and internal angles of the same size. It has eight lines of reflective symmetry and rotational symmetry of order 8. A regular octagon is represented by the Schläfli symbol {8}. The internal angle at each vertex of a regular octagon is 135°. The central angle is 45°.

1.3.1.1 PROPERTIES

Octagons can either be regular or irregular. Any shape with eight straight, connected sides is an octagon. Generally, octagons are of two types. They are regular and irregular octagons.

Regular octagons have sides that are congruent. That means that all of the sides of the octagon are the same measurement. They also have a congruent angle, which means that the measurement of all the angles is the same too.

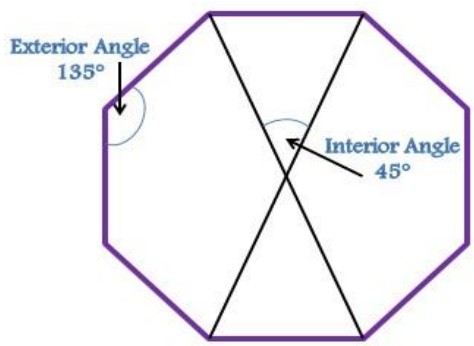


Fig. 1.1 REGULAR OCTAGON

Irregular octagons have sides that are not congruent, which means that they aren't all the same measurement. They also have points that are facing inward and outward. An octagon that has points that are facing inward is a **concave octagon.** An octagon that has points that are facing outward is a **convex octagon.**

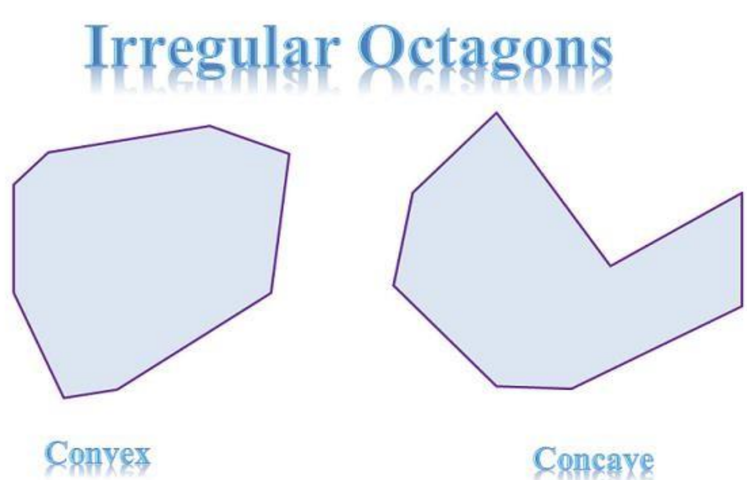


Fig. 1.2 IRREGULAR OCTAGON

1.3.2 EXISTING STRUCTURES

- The headquarters of the **American Institute of Architects (AIA)** in Washington, D.C. is located in a historical building called ―The Octagon‖ that was built in 1801.
- The **Tower of the Winds** in Athens is an octagonal Pentelic marble clock tower in Greece.
- **Intelsat headquarters** in Washington DC built in 1979.
- **The Octagon Chapel** is a Unitarian chapel located in Norwich, England.
- **Fort Edgecomb,** built in 1809 is an octagonal wooden block house located in the town of Edgecomb, Maine, United States.

1.3.3 ADVANTAGES

The octagonal shape is used as a design element in architecture. One of the advantages of an octagonal design is that the shape encloses space more efficiently than its counterpart, the square. An octagon has approximately 20 percent more space than a square with the same perimeter. Because this minimizes the external wall surface area, it decreases heat loss and gain. Additionally, an octagonal structure permits more natural light, aiding in the reduction of electric bills for illumination and heating in the winter and from a livability standpoint, octagonal designs allow for panoramic views and easier orientation on the building site.

Houses were once made in North America in an Octagonal shape because they were believed to be cheaper to build and easier to heat and cool. Few of these houses remain standing today, but we can still appreciate the usefulness of octagons in other areas of life. This new method of designing and constructing octagonal structures creates a structural membrane that is stronger than conventional stick-built designs.

1.4 FACILITY

This project deals with planning, analysis and designing of an octagonal library building to S.I.E.T Campus. Area of the building is 1137.13 sq.m. On the ground floor, the reading room has a capacity of 168 people. On the first floor, the stacks are arranged for about nearly 8 departments including an individual reading section. On the third floor, the separate rooms are provided for conference, internet surfing, book storage, etc,. The full building had natural lighting and proper ventilation facilities.

1.5 SCOPE AND OBJECTIVES

- The College library has a supporting, coordinating and encouraging role. It is an integral part of the college education. Moreover it is the heart of the academic institution with arteries summing into its department and individuals.
- The college libraries thus serves the academic purpose, in addition to it, they co-ordinate several function related to teaching.

- The purpose of this project is to improve the knowledge of students and make them broad minded by reading different books, novels, magazines, etc.
- To plan the octagonal shaped library building for SIET campus as per requirements.
- To design the structural elements of the library building as per IS standards & codes.

CHAPTER 2

REVIEW LITERATURE

2.1 ANDOVER PUBLIC LIBRARY

Fig. 2.1 ANDOVER PUBLIC LIBRARY

- The **Andover Public Library** is located on Church Street in Andover, Maine, United States. Although a private library funded by subscription was founded in the town in 1795, it was not until the establishment of the Andover Public Library Association in 1891 that movement to a publiclyfunded library began.
- It was originally quartered in a room of the Andover Town Hall. The building is one of only two octagonal religious buildings known to have been built anywhere in Maine, and was probably the last building in the state built with inspiration from Orson Squire Fowler's promotion of octagonal buildings in the 19th century. On January 27, 1981, it was added to the National Register of Historic Places.

2.2 ATLANTA PUBLIC LIBRARY

Fig. 2.2 ATLANTA PUBLIC LIBRARY

- The Atlantic Public Library, located at the intersection of Race and Arch Streets, is Atlanta, Illinois' public library. The library was built in 1908 and has operated continuously since then. Architect Paul A. Moratz's design for the building combines the Neoclassical with an octagonal plan, an uncommon mixture of styles. The building's eight sides are all symmetrical except for the front, which is broken by a classical portico with Doric columns and a round arched entrance. The library is topped by a red tile roof.
- Atlanta's public library program began in 1873. When the city built its library building in 1908, they did so through community support rather than receiving a grant from the Carnegie Foundation as most other communities did at the time. A clock tower was added to the property in the 1970s, and the Atlanta Museum formerly operated in the library's basement.

2.3 GOODNOW LIBRARY

Fig. 2.3 GOODNOW LIBRARY

- The **Goodnow Library** is an historic public library building located at 21 Concord Road in Sudbury, Massachusetts.
- It is named for Sudbury-native John Goodnow II, who died in 1851 and left to the town of Sudbury a 3-acre (1.2 ha) site for a library, $2,500 to build it and $20,000 to buy books and to maintain it.
- Construction of the two-story octagon-shaped building began in 1862 and was finished in 1863. In the 1990s it was expanded to its present size, but the original octagon survives as a reading room.

CHAPTER 3

PLANNING

3.1 GENERAL

Planning is the primary and one of the important phases of a building construction. The phase should be carried out with utmost care since, any flaw here may lead bad construction and discomfort to users. All the needs of the users should be considered during planning phase. The total number of persons who are going to accommodate in the building should be taken into due consideration and sample facilities should be provided.

All the planning activities should be done according to AICTE norms. The orientation of columns, size of rooms, location of toilets, dimension of staircase, firefighting and lighting facilities etc, should be taken into account in the planning phases.

3.2 PRINCIPLES OF PLANNING

1. Aspect
2. Prospect
3. Roominess
4. Grouping
5. Circulation
6. Privacy
7. Elegance
8. Furniture requirement
9. Economy
10. Flexibility
11. Practical consideration

3.3 LIBRARY PLANNING

The College Library is planned according to IS1553:1989. This Indian Code refers to **Design of Library Buildings – Recommendations Relating to Its Primary Elements.**

3.3.1 ACADEMIC LIBRARY

An academic library shall be located centrally with respect to class rooms, research rooms and laboratories. There shall be convenient access from these for the library.

3.3.2 TYPES OF ACADEMIC LIBRARY

a) University Library (UL),

b) Departmental Library (DL),

c) College Library (CL), and

d) School Library (SL).

3.3.3 ROOMS REQUIRED FOR COLLEGE LIBRARY

Essential rooms required to be provided for college libraries are given in Table 1. The size of the rooms shall depend upon the actual requirements in each case. The general requirements for sizes are however given in Table 1.

Table 3.1 Rooms Required for Different Types of Libraries

S NO.	ROOMS	COLLEGE LIBRARY
1.	Stack room	R
2.	Catalogue room	R
3.	General reading room	R
4.	Periodicals reading room	R
5.	Group study room	R
6.	Seminar room	R
7.	Conference room	R
8.	Librarian room	R
9.	Committee room	R
10.	Technical staff room	_
11.	Administrative staff room	_
12.	Display space at entrance	_
13.	Night watchman‘s room	_
14.	Exhibition room	_
15.	Computer cell room	R
16.	Audio visual room	R
17.	Store room	_
18.	Document reproduction room	_

R Required

_ provided if necessary

3.3.4 READING ROOM

The average area per reader in the reading room should be 2‘33 m^2, min. The size of the reading table is 2.4 m x 0.6 m. The center-to-center, distance between two consecutive rows of reading room tables is l-8 m with seating arrangement on one side of the table only.

Table 3.2 Sizes of the rooms in library

S.No	For use of	Area m^2
1.	Librarian and deputy Librarian	30
2.	Classifier, Cataloguer, accession Librarian and Maintenance Librarian	9 per person
3.	Secretary to the librarian	9
4.	Visitor‘s room	15
5.	Administrative and professional Staff	5 per person
6.	Group discussion room	2 per person
7.	Conference room	2 per person
8.	Seminar room	2 per person
9.	Committee room	2 per person
10.	Cubicles	7 per person

Thus planning phase of the library building is carried out by following the specifications given in the code. Most of the rooms are planned as per the code and the requirements. The ground floor, first floor, second floor plans are drafted using AUTOCAD software. The height of each floor is 3.5 m.

GROUND FLOOR PLAN FIRST FLOOR PLAN

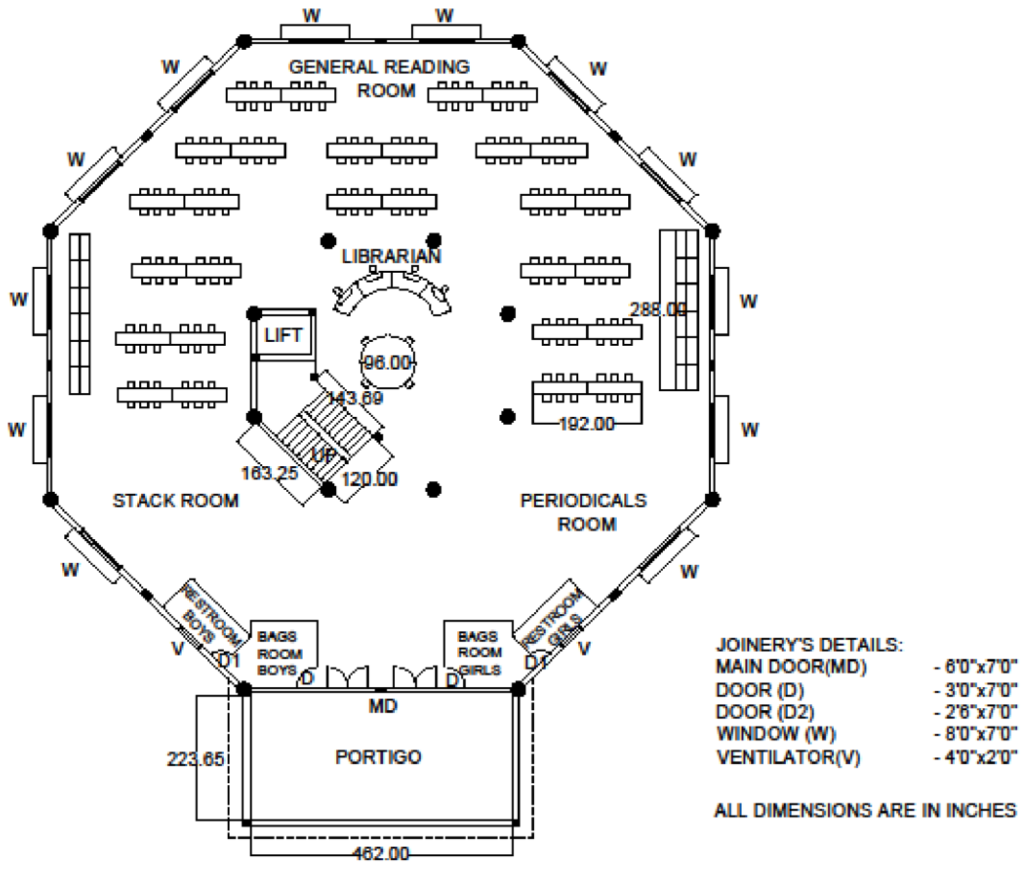


FIG. 3.1 GROUND FLOOR PLAN

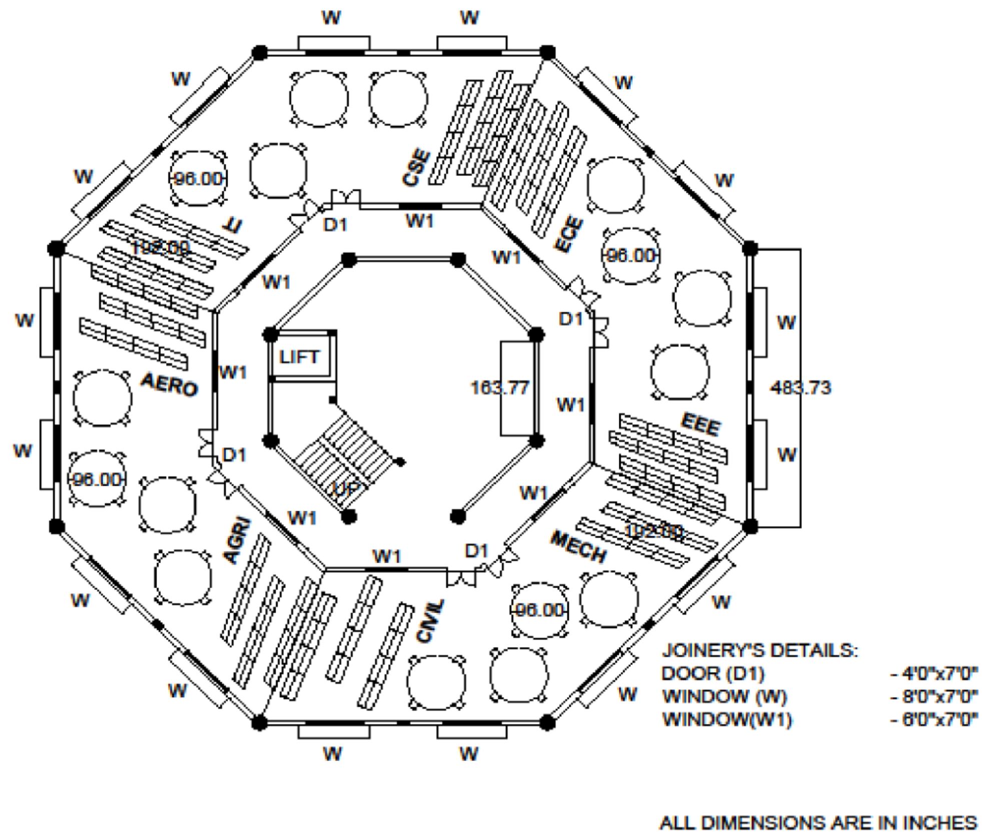
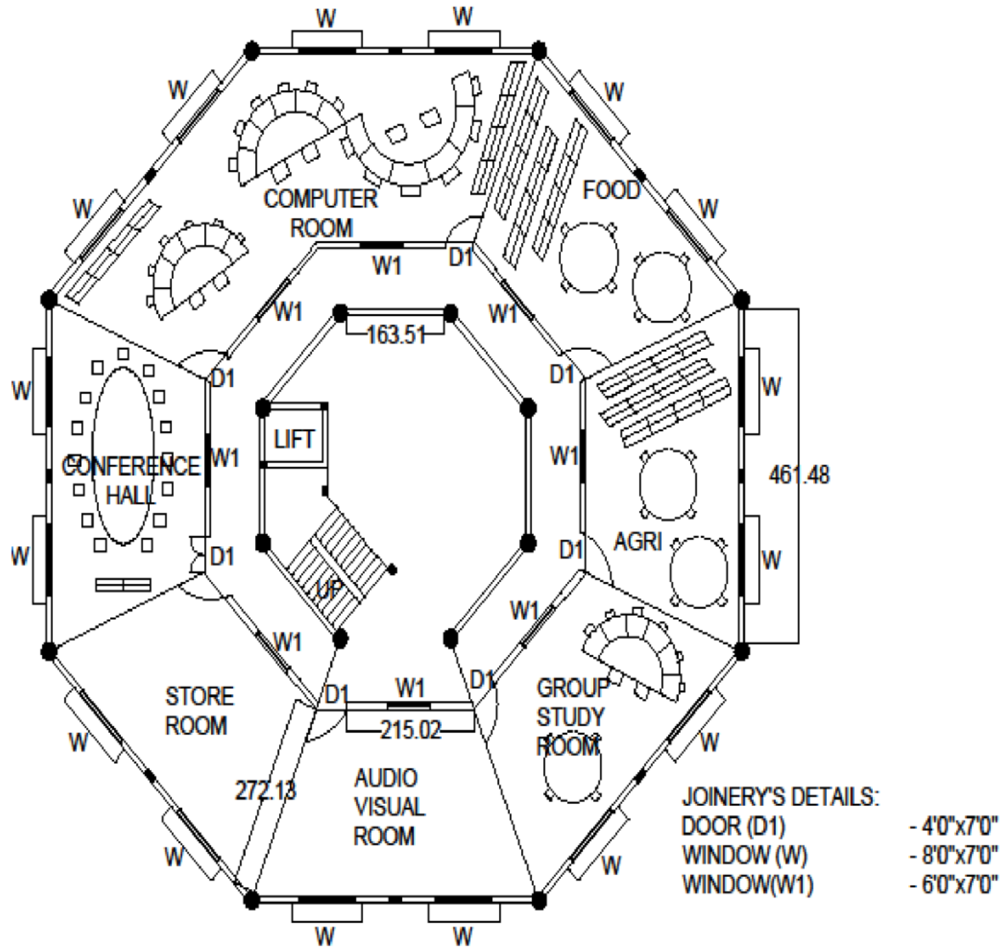


FIG. 3.2 FIRST FLOOR PLAN

SECOND FLOOR PLAN



ALL DIMENSIONS ARE IN INCHES

FIG. 3.3 SECOND FLOOR PLAN

CHAPTER 4

DESIGN

The design of the structural elements of the library building is carried out as per IS 456:2000. The loads are taken from the code IS875. The development of reliable design and construction procedures has paved the way for extensive use of reinforced concrete for a variety of structures all over the world.

Reinforced concrete members are allowed to be designed according to existing codes of practice by one of the following two methods (IS 456:2000 clause 18)

- The method of theoretical calculation using accepted procedures of calculations.
- The method of experimental investigation.

The design of the structural elements is carried out by the _Limit State Method‘. At present most of the national codes follow the limit state design procedure. The latest Indian Standard Code IS 456:2000 incorporated the limit state design as the primary method of design.

The structural elements of the library building are designed as per the code are as follows:

- Slab
- Beam
- Column
- Footing
- Staircase

4.1 DESIGN OF SLAB

4.1.1 GENERAL

In reinforced concrete construction slab are used to provide flat useful surface . A reinforced concrete slab is a broad , flat plate usually horizontal , top and bottom surfaces parallel or nearly so . It may be supported by reinforced concrete beam (is usually cast monolithically with such beam), by masonry or reinforced concrete wall , by structural steel members directly by columns, or continuously by the ground .

4.1.2 TYPES OF SLAB

1. Based on number of supports ✓ Cantilever slab
    - ✓ Simply supported slab
    - ✓ Continuous slab
2. Based on direction of slab ✓ One way slab
    - ✓ Two way slab
3. Based on soundness of the cross section
    - ✓ Solid slab
    - ✓ Hollow slab
    - ✓ Ribbed slab

4.1.2.1 ONE WAY SLAB

When the ratio of the longer span to the shorter span exceeds two, then it is referred to be one way slab. Since the one way slab supported continuously on two opposite sides the load can be easily transferred to one direction only.

4.1.2.2 TWO WAY SLAB

When the ratio of the longer span to the shorter span is less than two, then it is referred to be two way slab. In a two way slab the bending takes place in the shorter span and the bending carried out in longer span will be much shorter than the shorter span. Since the slab is supported in all the four edges, the ratio of the longer span to the shorter span will be small. In two way slab the main reinforcements are provided mutually in the perpendicular directions.

4.1.3 DESIGN OF TWO WAY SLAB

4.1.3.1 DETAILS:

Size = 6m x 6.1m

Wall thickness = 300 mm

Concrete = M_{30}

Steel = Fe500

Partial Safety Factor = 1.5

4.1.3.2 SPAN RATIO OF SLAB:

lx = 6 m ; ly = 6.1 m

Span ratio $= \frac{ly}{lx} = \frac{6.1}{6} = 1.02 <$ 2mm

Since the ratio of long to short span is less than 2, the slab is designed as two way slab.

4.1.3.3 DEPTH OF SLAB:

$\frac{\text{Span}}{\text{depth}}$ ratio = 35 x 0.8

d $= \frac{\text{span}}{35 \text{ x } 0.8}$

$= \frac{6000}{35X0.8} = 195.7$ mm ~ 200 mm

Provide Effective depth = d = 200 mm

D = 200 + 20 = 220 mm Provide Overall depth = D = 200

mm

4.1.3.4 EFFECTIVE SPAN: l = min of {clear span + effective

depth {c/c of supports l = min of {5.75 +

0.2

{6.00

l = 5.95 m

4.1.3.5 LOAD CALCULATION:

Dead load = 0.2 x 25

= 5kN/m^2

Live load = 6 kN/m^2

Floor finish = 1 kN/m^2

Service load W = 12 kN/m^2

Factored load W_u = 1.5 x W

= 1.5 x 12

Factored load W_u =18 kN/m^2

4.1.3.5 DESIGN MOMENTS AND SHEAR FORCES:

From IS: 456 Code (Table 7.2), moment coefficients for (l_y/l_x) = 1.02

$\alpha_x = 0.062$; $\alpha_y = 0.062$

Along X direction:

$M_{ux} = \alpha x * wu * lx^2$

$M_{ux} = 0.062 * 18 * 5.95^2$

$M_{ux} = 39.51$kNm

Along Y direction:

$$M_{uy} = \alpha y * wu * lx^2$$

$$M_{uy} = 0.062 * 18 * 5.95^2$$

$$M_{uy} = 39.51 \text{ kNm}$$

Maximum bending moment of slab = 39.51 kNm

Shear force, $V_u = 0.5\ W_u\ l_x$

$= 0.5 \times 18 \times 5.95 = 53.55$ kN

4.1.3.6 CHECK FOR DEPTH:

$$\text{Effective depth } d = \frac{\sqrt{Mu}}{\sqrt{0.138\ b\ fck}}$$

$$= \frac{\sqrt{39.51*(10^6)}}{\sqrt{0.138*1000*30}}$$

d = 97.7 mm < 200mm

d required < d provided

97.77 < 200

Hence safe

4.1.3.7 AREA OF REINFORCEMENT CALCULATION:

For shorter span,

From IS 456 ANNEX G

$$M_u = 0.87\ f_y\ A_{st}\ d\left(1 - \frac{Ast*fy}{b*d*fck}\right)$$

$$39.51 \times 10^6 = 0.87 \times 500 \times A_{st} \times 200\left(1 - \frac{Ast*\ 500}{1000*200*30}\right)$$

$$A_{st} = 453 mm^2$$

Adopt 10 mm dia bars,

$$\text{Spacing} = \frac{\frac{\pi}{4}(10^2)}{453} \times 1000 = 169 \text{ mm}$$

Take maximum spacing of 165 mm c/c

Provide 10 mm diameter bars @ 165 mm c/c (A_{st} = 476 mm^2)

For longer span,

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

$$39.51 \times 10^6 = 0.87\, fy\, A_{st}\, d\left(1 - \frac{Ast \times 500}{1000 \times 190 \times 30}\right)$$

Ast = 500mm^2

Adopt 10 mm dia bars,

$$\text{Spacing} = \frac{\frac{\pi}{4}(10^2)}{500} \times 1000 = 157 \text{ mm}$$

Take maximum spacing of 165 mm c/c

Provide 10 mm diameter bars @ 150 mm c/c (A_{st} = 523 mm^2)

4.1.3.8 CHECK FOR SHEAR:

$$\text{Shear force} = \frac{Wu\, lx}{2} = \frac{18 \times 5.95}{2}$$

Vu = 53.55kN

$$\tau_v = \frac{Vu}{bd} = \frac{53.55 \times 1000}{1000 \times 200} = 0.27 \text{N/mm}^2$$

$$P_t = (100 \times A_{st}) / bd = 100 \times \frac{476}{1000 \times 200} = 0.24$$

As per IS 456-2000 Table 19,

k = 1.16; τ_c = 0.362 N/mm^2 k x τ_c = 1.16 x

0.362 = 0.42

$\tau v < \tau c$

Hence it is safe.

4.1.3.9 CHECK FOR DEFLECTION:

$$f_s = 0.58x\ fy\ x\ \frac{453}{476}$$

$$f_s = 0.58x\ 500\ x\ \frac{453}{476} = 270$$

Modification factor $k_t = 1.6$

$$\left[\frac{l}{d}\right]_{basic} = 20$$

$$\left[\frac{l}{d}\right]_{max} = \left[\frac{l}{d}\right]_{basic} x\ k_t\ x\ k_c$$

$$= 20\ x\ 1.6\ x\ 1 = 32$$

$$\left[\frac{l}{d}\right]_{actual} = \frac{6200}{200} = 31$$

31 < 32

Hence safe in deflection

4.1.3.10 CHECK FOR CRACK CONTROL:

(i) Min reinforcement = 0.12 % bD

$= 0.0012 \times 1000 \times 220 = 264\ mm^2$

(ii) Spacing of main reinforcement not> 3d

= 3 x 200 = 600 mm

(iii) Diameter of reinforcement < (D/8)

< (220/8) < 27.5 mm

Hence ok

4.1.3.11 TORSION REINFORCEMENT AT CORNERS:

Area of torsion steel at each of the corners in 4 layers is computed as

$= 0.75 \times 476 = 357 \text{ mm}^2$

Length over which torsion steel is provided

= (1/5) short span

= (1/5) x 6000 = 1200 mm

Provide 8 mm dia bars @ 120 mm c/c ($A_{st} = 419 \text{ mm}^2$) for a length of 1200 mm @ all 4 corners in 4 layers.

4.1.3.12 REINFORCEMENT IN EDGE STRIPS:

$A_{st} = 0.12 \text{ \% } bD$

$= 0.0012 \times 1000 \times 220 = 264 \text{ mm}^2$

Provide 10 mm dia bars @ 260 mm c/c ($A_{sr} = 302 \text{ mm}^2$)

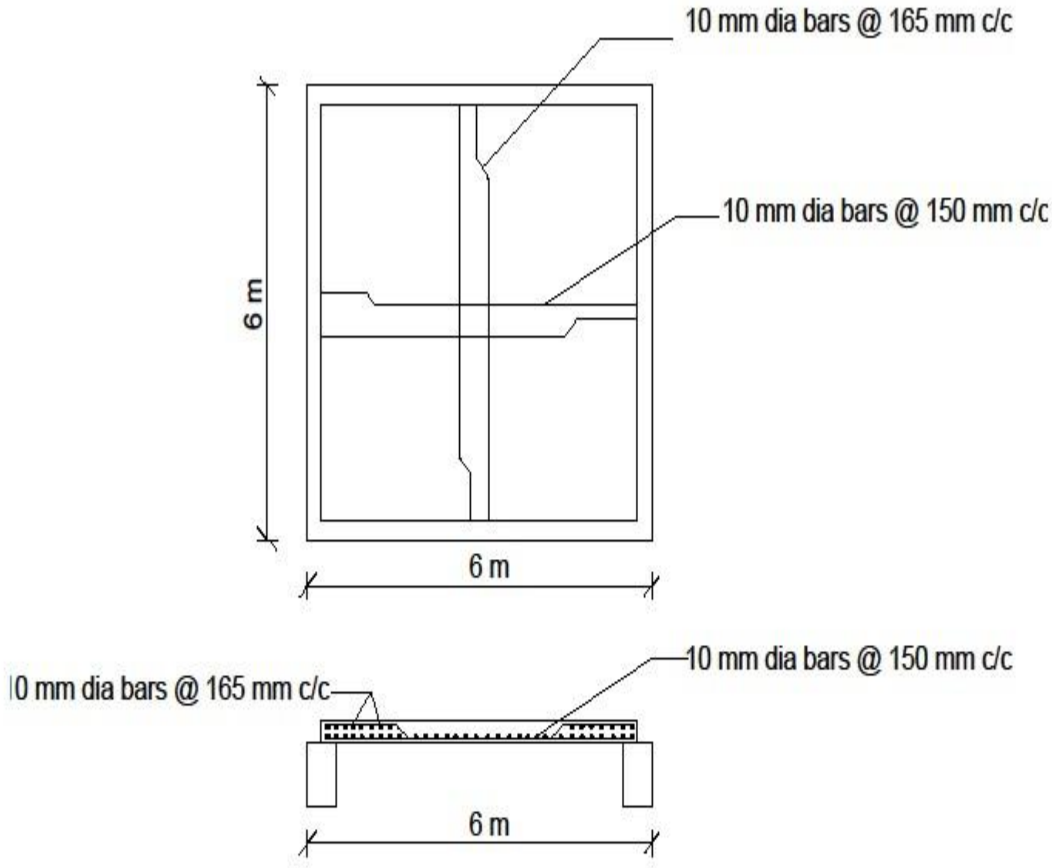


FIG.4.1.3 SLAB REINFORCEMENT DETAILS

4.2 DESIGN OF BEAM

4.2.1 GENERAL

A beam is a horizontal member (or) a tension member which is subjected to bending moment due to transverse load. Beams generally carry vertical gravitation force but are also used to carry horizontal loads (i.e., loads due to earthquake (or) wind.)

4.2.2 CLASSIFICATION OF BEAMS

- Based on shape
  - ✓ Rectangular beam
  - ✓ Flanged beam
- Based on type of supports
  - ✓ Simply supported

- ✓ Continuously supported
- ✓ Cantilever supports Based on reinforcement
- ✓ Singly reinforced section
- ✓ Doubly reinforced section

4.2.2.1 T-BEAM

Normally concrete placed below the N.A does not resist any bending moment but serves to the tensile steel. And the portion of the concrete above the N.A carries only little compression, as the intensity of the compressive force is very small magnitude. So the section of the T-beam should be such that it should have greater width at the top in compression to the width below the neutral axis.

This type of section is known as T-section.

4.2.2.2 CONTINUOUS BEAM

A beam which has more than two supports is known as continuous beam, and it is a statically indeterminate structure. For a critical bending moment at a particular section the whole structure has to be analyzed with the imposed loads on critical position. When a load is removed from a particular span it will alter the bending moment to the whole structure.

4.2.3 DESIGN OF RECTANGULAR BEAM:

4.2.3.1 DETAILS:

Width of beam b	= 300 mm
Span l	= 5.753m
Concrete	= M_{30}
Steel	= Fe500
Partial Safety Factor	= 1.5

4.2.3.2 EFFECTIVE DEPTH:

$$d = \frac{\text{Span}}{10} = \frac{5753}{10} = 575.3 \text{ mm}$$

Provide effective depth d = 600 mm

Overall depth D = d + 50 = 600 + 50 = 650 mm

4.2.3.3 EFFECTIVE SPAN:

l = min of {clear span + effective depth

{c/c of supports

l = min of {5.753 + 0.6

{5.753 + 0.3

l = 6.053 m

4.2.3.4 LOAD CALCULATION:

Self-weight = 0.3 x 0.65 x1 x 25

= 4.875kN/m

Live load = 6 kN/m^2

Dead load = 10 kN/m^2

Service load W = 20.875 kN/m^2 Factored load W_u = 1.5 x W

= 1.5 x 20.875

Factored load W_u =31.31 kN/m^2

4.2.3.5 MOMENTS AND SHEAR FORCES:

$$M_u = \frac{Wu\ l^2}{8} = \frac{31.31 * 6.053^2}{8} = 143.395 \text{ kN m}$$

$$V_u = \frac{Wu\ l}{2} = \frac{31.31 \text{ x } 6.053}{2} = 94.76 \text{ kN}$$

4.2.3.6 CHECK FOR DEPTH: Effective depth d = $\sqrt{0.133 \text{ b fck}}$

$$\sqrt{Mu}$$

$$= \frac{\sqrt{143.395*(10^6)}}{\sqrt{0.133*300*30}}$$

d = 346.12 mm < 600mm d

required < d provided

346.12 < 600 , Hence safe

4.2.3.7 MAIN REINFORCEMENTS:

$M_{u,\,lim} = 0.133\, f_{ck}\, b\, d^2$ for Fe500

$= 0.133 \times 30 \times 300 \times 600^2 = 430.92$ kN m

Mu < Mu, lim

Design the beam as singly reinforced beam.

Section is under reinforced and hence steel controls the design.

From IS 456 ANNEX G

$$M_u = 0.87\, f_y\, A_{st}\, d\left(1 - \frac{Ast*fy}{b*d*fck}\right)$$

$$143.395x10^6 = 0.87 \times 500 \times A_{st} \times 600\left(1 - \frac{Ast*500}{300*600*30}\right)$$

$A_{st} = 581mm^2$

$A_{st\,min} = (0.85\, b\, d)/f_y$

$= (0.85 \times 300 \times 600) / 500 = 306\ mm^2$

Ast prov. = greater of Ast ; Ast min

= 581 mm2

Adopt 16 mm dia bars,

No of bars $= \frac{581}{\frac{\pi}{4}(16^2)} \times 1000 = 2.8 \sim 3$ nos.

Provide 3 nos. 10 mm diameter bars ($A_{st} = 476\ mm^2$) and 2 hanger bars of 10 mm diameter.

4.2.3.8 CHECK FOR SHEAR STRESS:

$$\tau_v = \frac{Vu}{bd}$$

$$= \frac{94.76x1000}{300 \text{ x } 600} = 0.53\text{N/mm}^2$$

P_t = (100 x A_{st}) / bd

$$= 100 \text{ x } \frac{603}{300x\ 600} = 0.335$$

As per IS 456-2000 Table 19,

τ_c = 0.4142 N/mm^2; $\tau_{c,\,max}$ = 3.5 N / mm^2 $\tau v > \tau c$ & $\tau v < \tau c$, max

Shear reinforcement is required.

$V_{us} = (V_u - \tau_c \text{ b d})$

= (94.76 x 1000) – (0.4142 x 300 x 600) = 20.2 kN

Assume 6 mm dia stirrups

$$S_v = \frac{0.87 \text{ fy Asv d}}{\text{Vus}}$$

$$= \frac{0.87 * 500 * \frac{\pi}{4} * 6^2 * 600}{20.2 * 1000} = 365.3 \text{ mm}$$

S_v < 0.75d

< 0.75 x 600 = 350mm (< 450 mm)

Hence ok

Provide 6 mm dia stirrups @ 350 mm c/c of shear supports.

4.1.3.9 CHECK FOR DEFLECTION:

$$f_s = 0.58x \text{ fy x } \frac{581}{603}$$

$$f_s = 0.58x\ 500 \text{ x } \frac{581}{603} = 280$$

Modification factor $k_t = 1.5$

$\left[\frac{l}{d}\right]_{basic} = 20$

$\left[\frac{l}{d}\right]_{max} = \left[\frac{l}{d}\right]_{basic} \times k_t \times k_c$

$= 20 \times 1.5 \times 1 = 30$

$\left[\frac{l}{d}\right]_{actual} = \frac{6200}{200} = 10 < 32$

Hence safe in deflection.

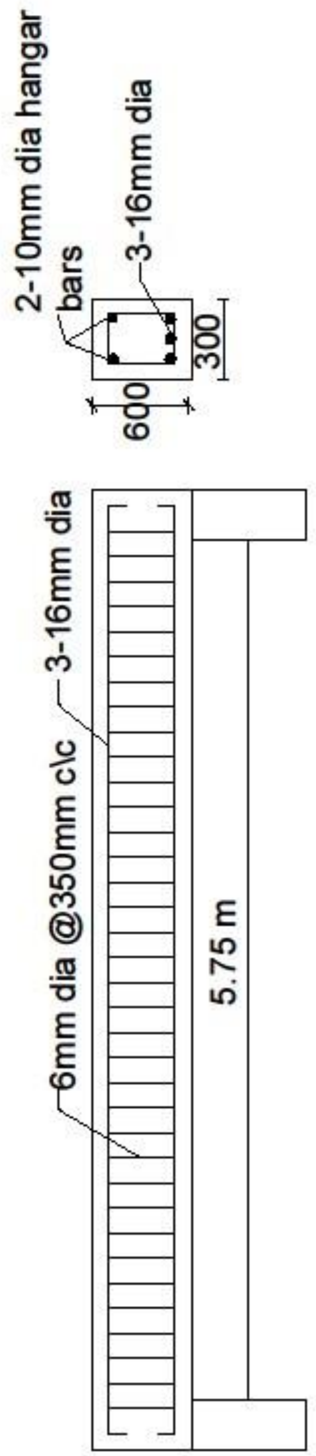


FIG.4.2.3 BEAM REINFORCEMENT DETAILS

4.3 DESIGN OF COLUMN

4.3.1 GENERAL

A column forms a very important component of a structure. Columns support beams which in turn support walls and slabs. It should be realized that the failure of a column results in the collapse of the structure. The design of a column should therefore receive great importance. A column is defined as a compression member, the effective length of which exceeds three times their least lateral dimension are classified as pedestrals.

4.3.2 TYPES OF COLUMNS

- Classification based on types of loading
  - ✓ Axial loaded column
  - ✓ Column with uniaxial eccentric loading
  - ✓ Column with biaxial bending
- Classification based on slenderness ratio
  - ✓ Short column
  - ✓ Long (or) slender column
- Classification based on type of reinforcement
  - ✓ Tied column
  - ✓ Spiral column
  - ✓ Composite column
- Classification based on side sway
  - ✓ Braced column
  - ✓ Unbraced column
- Classification based on materials used in cross section
  - ✓ Composite column
  - ✓ Concrete filled steel tubes

4.3.2.1 SHORT COLUMN:

When the slenderness ratio in the compression member is less than 12, then it is considered as short column.

$$L_{ex}/D \text{ (or) } L_{ey}/b<12$$

4.3.2.2 LONG OR SLENDER COLUMN:

When the slenderness ratio in the compression member is greater than 12, then it is considered as long column.

$$L_{ex}/D \text{ (or) } L_{ey}/b > 12$$

4.3.3 LOADS ON COLUMNS

There are three types of loads on columns as given below

1. Live loads on the floor supported by column
2. Dead weight of floor and beams
3. Self-weight of column

4.3.4 DESIGN OF CIRCULAR COLUMN

4.3.4.1 DETAILS:

Length of column L = 4 m

Diameter of column D = 600 mm

Concrete = M_{30}

Steel = Fe500

Partial Safety Factor = 1.5

4.3.4.2 LOAD CALCULATION:

Self-weight = 0.6 x 1 x 25

= 15kN/m

Live load = 6 kN/m^2

Dead load = 2700 kN/m^2

Service load W = 2721 kN/m^2

Factored load P_u = 1.5 x W

= 1.5 x 2721

Factored load P_u =4081.5 kN/m^2

4.3.4.3 EFFECTIVE SPAN:

l_{eff} = 0.8 x L = 0.8 x 4 = 3.2 m

4.3.4.4 SLENDERNESS RATIO:

Slenderness ratio = (L / D)

= (3200 / 600)

= 5.33 < 12

Hence the column is designed as short column

4.3.4.5 MINIMUM ECCENTRICITY:

$$e = \frac{L}{500} + \frac{D}{30}$$

$$= \frac{4000}{500} + \frac{600}{30}$$

e = 28 mm

emin < 0.05D

< 0.05 x 600

e_{min} < 30 mm

28 < 30 mm

Hence ok

4.3.4.6 MAIN REINFORCEMENT:

According to clause 39.4 of IS 456: 2000,

$P_u = 1.05\,[0.4\, f_{ck}\, A_c + (0.67\, f_y - 0.4\, f_{ck})\, A_{sc}]$

$\frac{4081.5 \times 1000}{1.05} = [0.4 \times 30 \times \pi / 4 \times 600^2 + (0.67 \times 500 - 0.4 \times 30)A_{sc}]$

$A_{sc} = 1289.79\ mm^2$

Asc min = 0.8 % of cross section

$= 0.008 \times \pi \times 600^2 / 4$

$= 2262\ mm^2$

Provide 22 mm dia bars

No. of bars = $\frac{2262}{\frac{\pi}{4} \times 22^2}$

$=$ 5.9 ~ 6 nos.

Provide 6 nos. of 22 mm dia bars ($A_{sc} = 2280.8\ mm^2$)

4.3.4.7 HELICAL REINFORCEMENT:

Adopting clear cover 0f 50 mm over spirals

Core diameter = [600 – (2 x 50)]

= 500 mm

Area of core A_c = $[(\pi \times 500^2 / 4) - 2280.8]$

$= 194068.74\ mm^2$

Volume of core / m Vc = $194068.74 \times 1000\ mm^3$

Gross area of section $A_g = (\pi \times 600^2) / 4$

$= 282743.34\ mm^2$

Using 8 mm diameter helical spirals at a pitch _p _mm, the volume of helical spiral per meter length is computed as:

$V_{us} = [\pi\,(600 - 100 - 8)\ 50 \times 1000 / p]\ mm^3/ m$

$= (76969 \times 1000)/p\ mm^3 / m$

According to code clause 39.4.1 of IS 456,

$$(V_{us} / V_c) < 0.36 [(A_g / A_c) – 1] (f_{ck} / f_y)$$

$$\frac{76969 \text{ x } 1000}{(282743.34 \text{ x } 1000)p} < 0.36 [(282743.34 / 194068.74) – 1] (f_{ck} / f_y)$$

0.272 / p = 0.0097 p = 28 mm

According to clause 26.5.3.2 (d) of IS 456 code, the pitch should comply with the following specifications:

p < [75mm

[(core diameter)/6 =500/6 = 83.33mm

p > [25mm

[3 (diameter of helical reinforcement)

= 3 x 8

= 24 mm

Hence provide 8mm dia spirals @ a pitch of 25mm

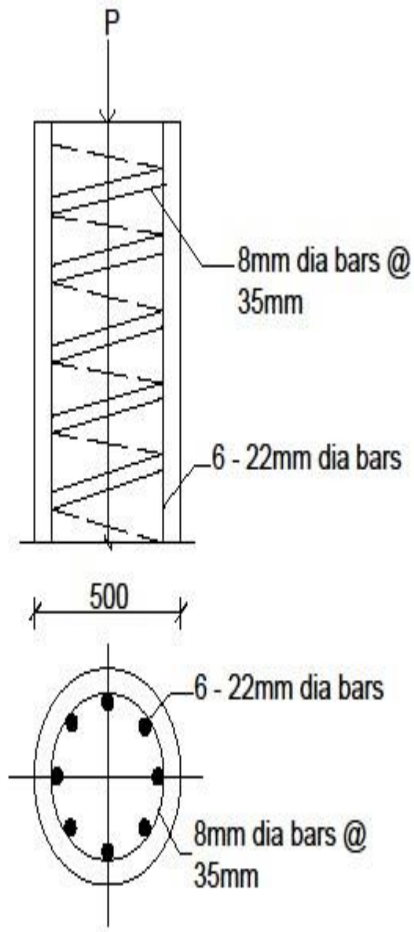


FIG.4.3.4 COLUMN REINFORCEMENT DETAILS

4.4 DESIGN OF FOOTING

4.4.1 GENERAL

Footing are structural elements that transmit column or wall loads to the underlying soil below the structure. Footing are designed to transmit these loads to the soil without exceeding its safe bearing capacity , to prevent excessive settlement to a tolerable limit, to minimize differential settlement, and to prevent sliding and overturning. The main purpose of the footing is to transfer the applied load over the larger area at a uniform rate to the soil.

4.4.2 TYPES OF FOOTINGS

1) Isolated footing

2) Combined footing

3) Strap footing

4) Strip/ continuous footing

5) Mat/raft footing

4.4.2.1 ISOLATED FOOTING

Isolated footing is circular square or rectangular slab of uniform thickness. Sometimes, it is stepped to spread the load over a large area. When separate footings (or) individual footings are provided for each column then they are called isolated footing (or) isolated bases (or) independent footings.

4.4.2.2 COMBINED FOOTING

Combined footing supports two columns. It is used when two columns are so close to each other that their individual footings would overlap. A combined footing is also provided when the property line is so close to one column that spread footing would be eccentricity loaded when kept entirely within the property line. Trapezoidal footing is provided when the load one the column is larger than the other column.

4.4.2.3 STRAP FOOTING

Strap footing consists of two isolated footing connected with structural strap or a lever. The strap connects the footing such that they behave as one unit The strap simply acts as connecting beam. A strap footing is more economical than the combined footing.

4.4.2.4 STRIP FOOTING

A strip footing is another type of spread footing which is provided for a load bearing wall. A strip footing overlap or really touch each other.

4.4.2.5 MAT FOOTING

It is a large slab supporting no of columns walls under entire structure or a large part of a structure. Mat foundation are useful in reducing the differential settlement on non-homogeneous soils or where is large variation in the loads on individual columns.

4.4.3 DESIGN OF RECTANGULAR FOOTING 4.4.3.1 DIMENSIONS:

Size of footing =300x600mm

Load carried by the column P_u =2438.35 kN

Assume self-weight of footing as 10% of column load

Self –weight of footing $= \frac{10}{100} \times 243.835$

Total load = 2682.18kN

Safe bearing capacity of soil = 150 kN /m^2

4.4.3.2 SIZE OF FOOTING:

Area of footing $= \frac{\text{Total load}}{\text{Safe bearing capacity}}$

$= \frac{2682.18}{150}$

$=17.8 \approx 18 m^2$

Assuming l =1.5B

B = 3.5m l = 5.5m

Provide a footing size=3.5m x5.5m

Net upward pressure $p_o = \frac{2438.35}{3.5x5.5}$

=126.66kN/m^2

4.4.3.3 DESIGN OF SECTION:

Bending moment about xx section = $\frac{\quad}{\quad} (L-l)^2$

$M^1 = \frac{\quad}{\quad} (5.5-0.6)^2$

=1330.48kNm

M_{u1} =1.5x1330.48

= 1995.75kNm

Bending moment about yy section

$$M^2 = \frac{P_O}{L}(B-b)^2$$

$$= \frac{}{}(3.5-0.3)^2$$

=891.68kNm

M_{u2} =1.5x891.68

= 1337.52 kNm

$M_{u2}<M_{u1}$

4.4.3.4 DEPTH OF FOOTING:

$$d=\sqrt{\frac{}{}}$$

$$=\sqrt{\frac{1995.75x10^6}{0.138x30x10000}}$$

=850.35 ~ 850 mm

Effective cover=50mm

Overall depth = 900mm

4.4.3.5 AREA OF REINFORCEMENT:

$$M_{u1} = 0.87 f_y A_{st} d\left(1-\frac{A_{st}f_y}{bdf_{ck}}\right)$$

$$=0.87x500xA_{st}x850\left(1-\frac{A_{st}\ x\ 500}{1000x850x30}\right)$$

A_{st} =8107mm^2

Provide 30mm dia bars

No of bars $= \frac{8107}{\frac{\pi}{4}x30^2}$

$=11.47 \approx 12$ bars.

Provide 12 bars @30mm dia

$M_{u2} = 0.87A_{st2}$

$1337.52x10^6=306892.5A_{st2}\ (1-2.44x10^{-6})$

$A_{st} = 4958.27mm2$

Use 30mm dia bars

No of bars $= \frac{4958.27}{3.14x30^2}$

=8bars

Provide 8 bars @ 30mm dia

4.4.3.6 CHEAK FOR SHEAR:

One way shear

Shear force V $= P_O B \left(\frac{L}{2} - \frac{l}{2} - d\right)$

$= 126.66x3.5\left(\frac{5.5}{2} - \frac{0.6}{2} - 0.85\right)$

= 709.29kN

Ultimate shear = 1.5x709.29

= 1063.93kN

Max shear stress $= \frac{Vu}{bd} = \frac{1063.93\ x\ 1000}{3500x850}$

$\tau_v = 0.0036\ N/mm^2$

$A_{st} = \frac{3.14x30x1000}{80}$

$A_{st} = 8834.6mm^2$

Permissible shear stress $= \frac{100A_{st}}{bd}$

$$= \frac{100x8834.6}{3500x850}$$

=0.29 τ_c for 0.29

=0.3792 N / mm^2

$\tau_v < \tau_c$

Max shear stress $= \frac{v_u}{bd} = \frac{1063.93}{3500x850}$

$\tau_v =$ 0.0036

$A_{st} = \frac{3.14x30x1000}{80}$

A_{st} = 8834.6mm2

Permissible shear stress $= \frac{100A_{st}}{bd} = \frac{100x8834.6}{3500x850} = 0.29$

τ_c for 0.29 =0.3792

Hence safe

4.4.3.7 CHECK FOR TWO WAY SHEAR:

Maximum shear force at critical area

$= 126.33[3.5^2 - 1.2^2] = 1369.19$kN

Ultimate shear = 1.5x1369.19

=2053.79kN

Shear stress $= \frac{v_o}{bd} = \frac{2053.79}{4800x850}$

τ_v = 0.50N/mm^2

$\tau_c = 0.25\sqrt{fck} = 0.25\sqrt{30} =$ 1.11N/mm^2

$\tau_v < \tau_c$

Hence safe.

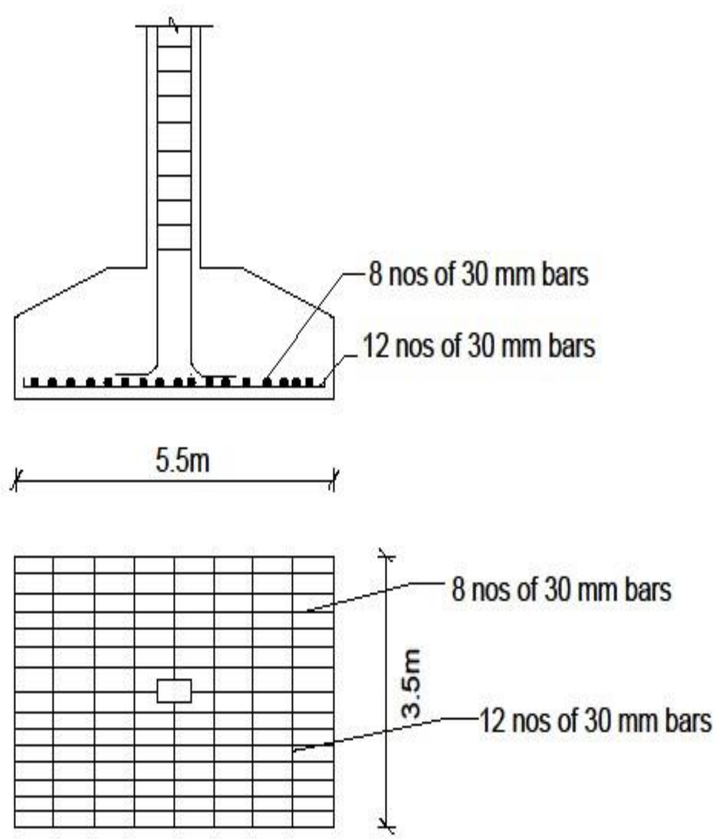


Fig. 4.4.3 FOOTING REINFORCEMENT DETAILS

4.5 DESIGN OF STAIRCASE

4.5.1 GENERAL

Staircase is structured form provided in building to facilitate easy vertical movement of persons from one floor to another. Staircase of different types and shapes are provided depending upon

1. Availability of spaces
2. Purpose of providing
3. Aesthetic appearance required

4.5.2 COMPONENTS OF FLIGHT OF STAIRS

1. Treads of the steps
2. Rise of the steps

4.5.3 TYPES OF STAIRCASE

1. Dog legged stairs
2. Circular stairs
3. Spiral stairs
4. Slab less stairs
5. Free landing stairs
6. Open well stairs
7. Straight stairs
8. Quartered turn stairs
9. Half turn stairs

4.5.4 COMPONENTS OF STAIRCASE

- ✓ Tread
- ✓ Riser
- ✓ Landing
- ✓ Flight

4.5.5 TERMS

Some of the common terms used in design of staircase are,

4.5.5.1 TREAD

Horizontal upper portion of the step on which the foot is to be placed for ascending and descending.

4.5.5.2 RISER

Vertical portion of a step which provides support to the tread.

4.5.5.3 LANDING

A flat platform provided between two flights.

4.5.5.4 SOFFIT

The under surface of a stair – slab

4.5.5.5 FLIGHT

A series of steps without any intermediate platforms, landing, etc. Normally two flights are separated by landing.

4.5.6 DESIGN OF DOG LEGGED STAIR CASE 4.5.6.1 DETAILS:

Height of floor = 3500 mm

Width of landing = 1200 mm

Concrete = M_{30}

Steel = Fe500

4.5.6.2 DIMENSIONS:

Height of each flight = (3500 / 2) = 1750 mm

Assuming, Riser = 150mm

Tread = 300mm

No. of step = $\frac{\text{height}}{\text{rise of 1 step}}$

$= \frac{1.75}{0.15}$ = 11.6 ~ 12 steps

No. of treads = no. of risers 1

= 12 1 = 11

Length of one flight = 11 x 300 = 3300 mm

4.5.6.3 EFFECTIVE SPAN: l = 3300 + 150 + 1200 = 4650 mm

4.5.6.4 LOAD CALCULATION

Assume waist slab of thickness 200 mm

Due to slab along slope = 0.20 x 1 x 24 = 4.8 kN/m^2

Equivalent load on stair = $\frac{W}{T}\left(\sqrt{R^2 + T^2}\right)$

$= \frac{4.8}{0.3}\left(\sqrt{0.15^2 + 0.3^2}\right)$

$= 5.4\ kN/m^2$

Dead weight of step = $\frac{R}{2}$ x 25

$= \frac{0.15}{2}$ x 25

$= 1.875\ kN/m^2$

Live load $= 6\ kN/m^2$

Floor finish $= 0.1\ kN/m^2$

Total load $=13.375\ kN/m^2$

4.5.6.5 MAXIMUM MOMENT:

Consider 1m width slab,

W_u = 1.5 x 13.375 = 20.06 kN/m

Length of waist slab = 3.3 + 1.2 $+ \frac{0.15}{2} = 4.5$ 8 m

$M_u = \frac{W_u l^2}{8} = \frac{20.06 \text{ x } 4.58^2}{8}$ = 52.60 kNm

4.5.6.6 CHECK FOR DEPTH:

Mu = 0.138 x f ck bd2

$d = \sqrt{\frac{52.6 \text{ X } 10^6}{0.138 \text{ X } 30 \text{ X } 1000}}$

d = 112.1 < 150 mm

Hence safe

Provide d = 135; D = 150 mm

4.5.6.7 MAIN REINFORCEMENT:

$$M_u = 0.87\, f_y\, A_{st}\, d \left(1 - \frac{A_{st} \times fy}{fck\ b\ d}\right)$$

$$52.6 \times 10^6 = 0.87 \times 500 \times A_{st} \times 135\left(1 - \frac{A_{st} \times 500}{30 \times 1000 \times 135}\right)$$

$$A_{st} = 1026\ mm^2$$

Adopt 16 mm bars,

$$\text{Spacing} = \frac{\frac{\pi}{4} \times 1000 \times 16^2}{1026} = 196\ \text{mm}$$

Provide 16 mm dia bars @ 190 mm c/c

Distribution of steel = 0.12 % bD

= 0.012 x 1000 x 150 = 180

Adopt 8mm bars

$$\text{Spacing} = \frac{\frac{\pi}{4} \times 1000 \times 8^2}{180} = 279.2\ \text{mm}$$

Provide 8mm bars @ 250 mm c/c

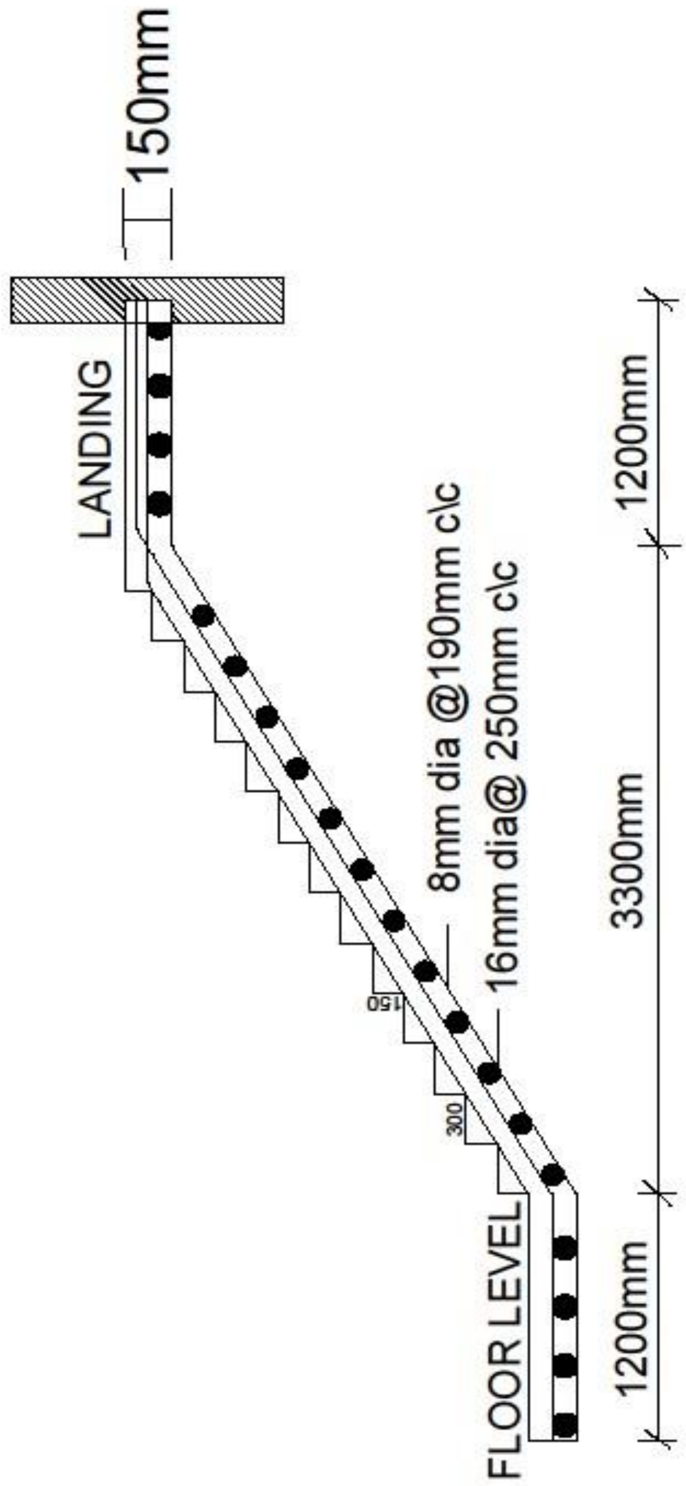


FIG. 4.5.6 STAIRCASE REINFORCEMENT DETAILS

CHAPTER 5

CONCLUSION

The concept of planning with an elegant manner is important for civil Engineering career. We have done this project from the knowledge of theoretical studies and mainly based on the guidelines obtained from the IS 456:2000 and IS 1553:1989 code books. An octagonal Library with a built-up area 1137.13 m^2 was planned as per planning regulation specified in IS 1553:1989. The size of the structure is so large, so that the quantity and quality of the concrete and steel material required is obviously high with our project. The structural drawings were plotted for the design values obtained with the help of AUTOCAD software. This project deals with planning, analysis and designing of an octagonal library building to S.I.E.T Campus. The full building had natural lighting and proper ventilation facilities.

REFERENCES

CODE BOOK REFERENCE

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- ✓ ―Design of Reinforced concrete structures‖ by N. Krishna Raju, CBS Publishers and Distributors, Pvt.Ltd, New Delhi.
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- ✓ ―Reinforced concrete Design‖ by S. Unnikrishna pillai/Devdas Menon, Tata McGraw Hill Education Pvt. Ltd.

SOFTWARE USED

- ✓ AUTOCAD