DESIGN OF MULTI-STOREYED LIBRARY BUILDING

Submitted in partial fulfillment of the Degree of

Bachelor of Technology

May – 2014

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Under Supervision Of

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WAKNAGHAT

CERTIFICATE

This is to certify that the work titled "Design of Multi-storey library building" submitted by Vinay Sharma, Aryan Kansal & Umang Agarwal in complete fulfilment of the project for the award of degree of B.Tech Civil Engineering of Jaypee University of Information technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other university or institute for the award of this or any other degree or diploma.

Dr. Ashish Rohila Date: 15/05/2014

Associate Professor

Department of Civil Engineering

CANDIDATE’S DECLARATION

We hereby declare that the work presented in the project entitled “**Design of Multi-Storeyed Library Building**” submitted towards the completion of the project in eight semester at Jaypee University of Information Technology, Waknaghat, is an authentic record of our original work carried out under guidance of Dr. Ashish Kumar Rohila , Associate Professor, Department of Civil Engineering, JUIT.

We have not submitted the matter embodied in this project for the award of any other degree.

Aryan Kansal (101685)

Vinay Sharma (101661)

Umang Agarwal (101608)

Place : Waknaghat

Date : /05/2014

ACKNOWLEDGMENT

We would like to express our deepest appreciation to our project guide Associate Prof. **Dr. Ashish Rohila** (Department of Civil Engineering) for his guidance for the duration of this project. His efforts and his guidelines were always an opportunity for us to learn and played an important role in the completion of this project.

We would also specially like to thank Associate Prof. Dr. Veeresh Gali, Project Co-ordinator who was always present for comments and suggestions.

ABSTRACT

The purpose of project is to the design the library building using the Indian standard code IS: 456-2000 and IS: 1553-1989. The report includes a study of planning and design of Library Building.

A requirement of library building in an engineering institution is taken as a subject. Planning and designing of building is done according to IS codes. We are designing a building using green building recommendations according to the IGBC (Indian Green Building Council).

Structural design is done according to LSD (Limit State Method) and loads are taken from the IS codes. Structural and RCC design is done using STAAD.Pro. in addition sample manual calculation are also done in order to check the results obtained from STAAD. Pro. Software.

The architectural design and other engineering drawings are made with the help of CHIEF ARCHITECT software and AutoCAD. Exterior design of the building is also done in Chief Architect and location of various components of the building is shown with the help of AutoCAD.

We have calculated area by surveying the JUIT library and collected data from various institutions for number of books in the library. Furniture dimensions are taken from the IS:1553-1989.

RCC design is done with limit state method confirming to IS codes: 456-2000. The design results are given by STAAD.Pro are compared with the results obtained manually. Ultimately the various dimensions of sections are obtained. After the RCC design, Green building concept has been applied.

OBJECTIVE

The broad objective of project is to design the multi-storeyed Library Building for an educational institution. The various data like seating capacity, number of books, number of computers etc. are taken as average from three similar engineering institutions. The structural elements of building will be designed as per IS Codes .The planning of library will be done by AutoCAD and exterior design will be made in Chief Architect. We will design it by using software STAAD.Pro and also design it manually. All the imposed loads will also taken from IS Code. We will get command over designing softwares like STAAD.Pro and Chief Architect.

In addition to above engineering skills we try to attempt Green Building Concept and taking considerations while planning.

LIST OF SYMBOLS

F_{ck} - compressive strength of concrete

F_y - strength of steel

M_x - moment in x direction

M_y - moment in y direction

M_z - moment in z direction

τ_c - permissible shear stress

Ast - area of steel

N - no. of bars

d’ - cover for reinforcement

kWh - kilowatthour

E_{sc} - Strain in concrete at the level of stee

Mu - Ultimate Moment

P - percentage of steel

ϕ - Diameter of steel bar

S - spacing of reinforcement bars

A - area

b - breadth of beam

b_{ef} - effective width of slab

b_f - effective width of flange

k - breadth of web of rib

D - Overall depth of beam or slab

D_f - Thickness of Flange

DL - Dead Load

d - Depth of Compression reinforcement

E_C - Modulus of elasticity of concrete

Sv - spacing of shear reinforcement

q - bearing pressure

σ_{st} - permissible stress in steel in tension

σ_{sv} - permissible tensile stress in shear reinforcement

m - modular ratio

T - torsional moment

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1. INTRODUCTION

1.1 WHAT IS LIBRARY?

- A new library is far more than a place for books, it is now a place to learn, a place to meet, a place to explore and ultimately a place to be.
- The library is evolving from warehousing the information to being a river of information and a center for collaboration and interaction.

1.2 SOFTWARE AND IS CODES USED

- AutoCAD 2013
- Chief Architect
- STAAD Pro
- IS: 1553-1989
- IS: 456-2000

1.3 DESIGN PHASES

There are three phases of our project:

- Architectural
- Structural
- Cost Estimation

1.4 WHAT IS GREEN BUILDING CONCEPT?

Green building (also known as green construction or sustainable building) refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the design team, the architects, the engineers, and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

2. PLANNING

2.1 INTRODUCTION

- Open, Flexible Floor Plan. To facilitate the arrangement of the library's activities and to allow for any potential future rearrangement to accommodate new or expanded services, the library has been designed free of interior load-bearing walls and closely placed columns. While the simplest and most functional design shape for a library is in the form of a rectangle so we have taken an area of 30m * 60m.
- Appealing Building Environment. In both its interior and exterior appearance, the library should project an inviting and attractive atmosphere, should be well lighted and should be properly heated and cooled during the changes of seasons.
- Potential for Future Building Expansion. For a completely new facility, planning should occur during design development for a future expansion of 20% to 30% to serve community library needs beyond the next twenty years. Preliminary planning now results in a more successful design and functional features in a future expanded building. So we are providing additional space of area.

2.2 DESIGN REQUIREMENTS

- Since this area is of prime importance, substantial discussion and detailed layout will be required during the design process. Discuss with library staff and consulting librarian. It is important that the public service area or the desk, the check-in work area, and the book return function efficiently together.
- While the desk must be located near the entrance, it is not desirable to immediately confront the user with its presence. Adequate space should be provided around the desk to allow for both the traffic entering and exiting the building as well as those standing at the desk or in line for services

required. Staff should be able to move from behind the desk into the public service area without traveling a long distance around the desk.

- The return and registration stations are best oriented to patrons entering the library and the check-out stations to those leaving the library. Persons queuing at the desk should not conflict with traffic through this area.

- The Circulation Desk must be conveniently accessible from the check-in/shelving area and planned for minimal staffing of one and maximum of five. The desk should desirably be located conveniently to the enclosed workroom and should be placed eight to ten feet from any wall. The desk area should contain some wall shelving for reserves, an electric clock outlet, data outlets for PCs, telephone outlets and electrical service to the desk for computer consoled equipment and cash registers.

- The Circulation Desk may be secured as part of the library furnishings from a library furniture manufacturer and be of modular (movable, organisable) design or may be designated by the architect as part of the building's special millwork contract. The desk is to be designed with the input of the library staff so that all the necessary requirements for drawers, shelves, files and utility connections are met.

- The desk should be at a standard 37" counter height with each workstation 60" in length with a minimum 28" width. A desk lay-out to minimize steps from workstation to workstation is essential. Right angles and modular components are more desirable for efficiency and organization than curved or free forms. One station, possibly the information/registration station, minimum of 60" in length and 28" wide, needs to be at a maximum 34" high level for access by persons with disabilities.

- The desk should be constructed of very durable material. For example, it should have a granite or synthetic material (resin / polyester or resin / acrylic) top. Wood and plastic laminates quickly show wear and require refinishing or replacement. Provide bull nosed, rounded corners on all edges.

- Staff and public at the desk must be protected against excessive heat and glare from lights. Recessed "can" lights must <u>not</u> be used.

- Good sight lines into adjacent public collection and seating areas must be provided for and there should be easy access from behind the desk to the public areas.
- The entrance to the public restrooms can be easily supervised from the Circulation Desk.
- An electronic book security system will be specified and would require installation of gates with mechanical counters at this point of public entrance and exit from the building. There should be direct access from the staff side of the desk to the security gates .Counter space behind the circulation service desk is desirable with cabinet.

2.3 CALCULATIONS

We have surveyed different libraries of 3 Engineering Institutions, the Institutions are

1. NIT Hamirpur.

2. PEC University of Technology, Chandigarh.

3. Jaypee University Of Information Technology , Waknaghat.

Information Collected

- **NIT Hamirpur**

Total Number of Students = 3000

Library Capacity = 150

Number of Books = 72395

Average Number of books per student = 25

Seating capacity/No. of students =0.05

- **PECUOT Chandigarh**

Total Number of Students = 2500

Library Capacity = 250

Number of Books = 119015

Average Number of book per student = 47

Seating capacity/No. of students =0.1

- **Jaypee University of Information Technology , Waknaghat**

Total Number Of Students= 2200

Seating Capacity Of Library=500

Number of books =32219

Average number of books per student = 33

Seating capacity/No. of students =0.22

NEW LIBRARY

For Engineering University

Average of number of books per student (data taken from 3 different institutions) (25+47+33)/3 = 35

Ratio of number of seats/total students to be provided in library = (0.1+0.05+0.22)/3 = 0.13 (Average of Ratio of 3 institutions)

We are taking this ratio as 0.24 because of excess load on library due to changing Examination pattern (for e.g. weekly tests, assignments)

Total strength of students = 3000

Seating capacity = 3000*0.20 = 600

Number of books = 35 * 720 = 25200

As we are designing library for future prospectus of 20 years

Design seating capacity of library = 1.25 *600= 750

Design book capacity of library = 1.50*25200 =37800

Collection Space

Number of Books = 40000

Length of Rack = 2m

Breadth of Rack = 0.45m

Height of Rack = 2.20 m

Calculation no. of Books to be accommodated in Rack

Length of Rack = 2m

No. of Shelves = 5

Assumed Thickness of Books = 0.05m (5 cm)

Shelves on both sides

No. of Books in 1 Rack = (2*5*2)/0.05 = 400

Taking Occupancy Factor = 0.7

Total number of books in 1 rack = 0.7 *400 = 280

Provision for Number of Racks (Future Consideration) = Total No. of Books/No. of Books in 1 Rack = 40000/280 = 143

Racks to be accommodated in PRESENT = (25200/280) = 90

Gangways

Gangways are not only essential for efficient functioning of the library but also to allow easy access/passage to firemen to various parts of a
room/building . The minimum clear width of gangways shall be as follows:
a) Longitudinal gangway not less than 1 m,
b) Cross gangway not less than 1.35 m, and
c) End gangway (between the end wall and nearest row of racks/reading table) not less than 1.325 m.

All gangways shall be maintained clear without any obstruction whatsoever, at all times. No books, records or furniture or any other article shall be placed in a gangway.

Book Rack Area

Center to Center distance between Rack = 1.80 m

Length of Rack = 2 m

Area covered by 1 rack =(2m * 1.80m) = 3.6 m^2

Area covered by 90 Racks = (90*3.6) = 324 m^2

Area covered by 143 Racks= (143*3.6) = 514.8 m^2

Periodical Section Area

Periodicals require two types of shelving—display shelving for current issues and storage shelving for back issues.

Number of Periodicals in our Library = 48

Area Covered by periodical Section = 30 m^2

Reading Room Area

Design Seating Capacity of Library = 750

Area Required per student = 2.33 m^2

Total Reading Room Area = 2.33 m^2 * 750 =1747.5 m^2

So taking Reading room area = 2000m^2

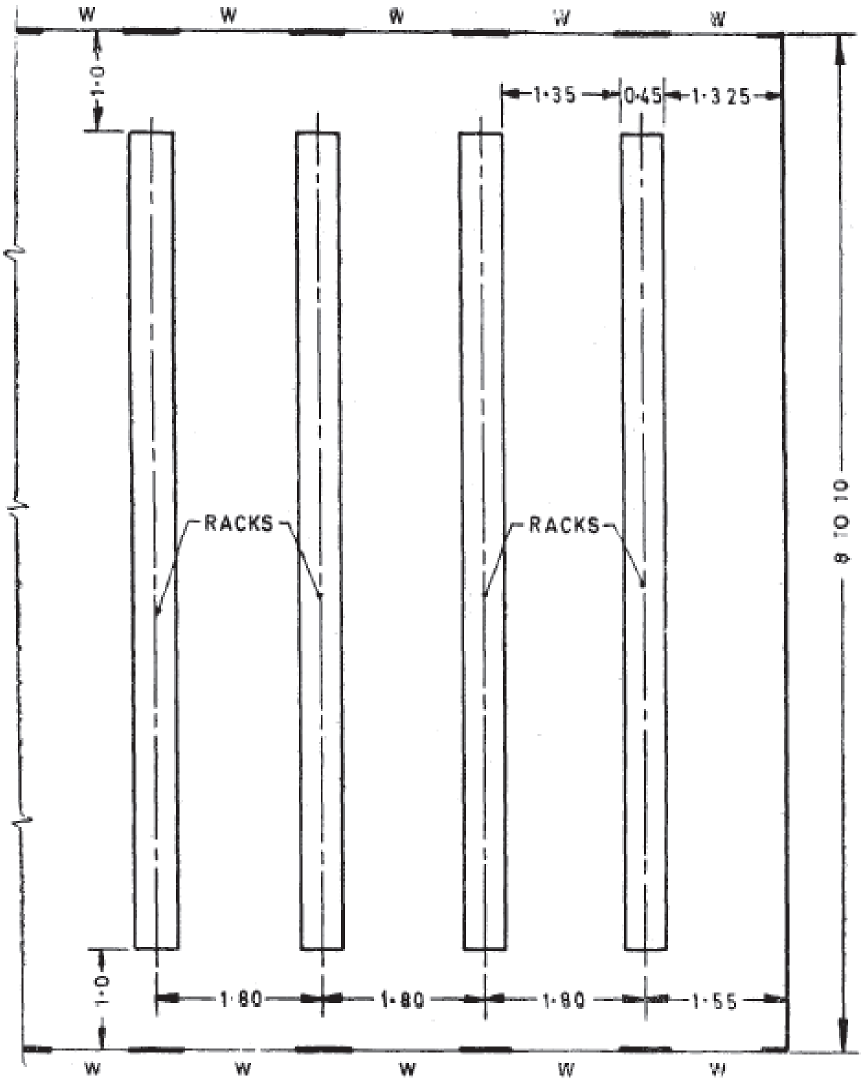
Calculation of area of different rooms

Librarian Room Area = 30 m^2

Secretary to Librarian Room Area = 9 m^2

Conference Room Area = 2 m^2 per student

Conference Room Area = (2*40) = 80 m

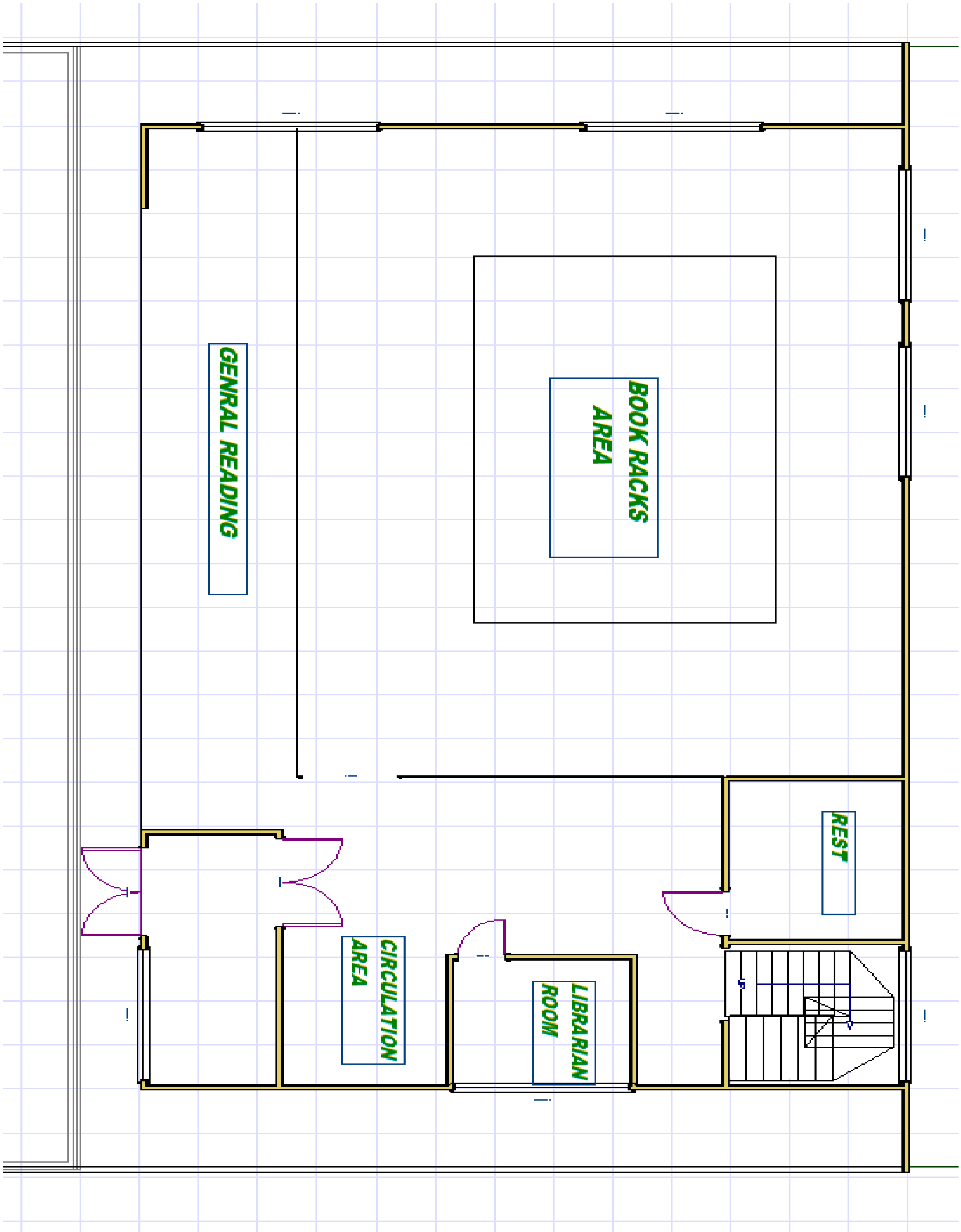


W = Windows.

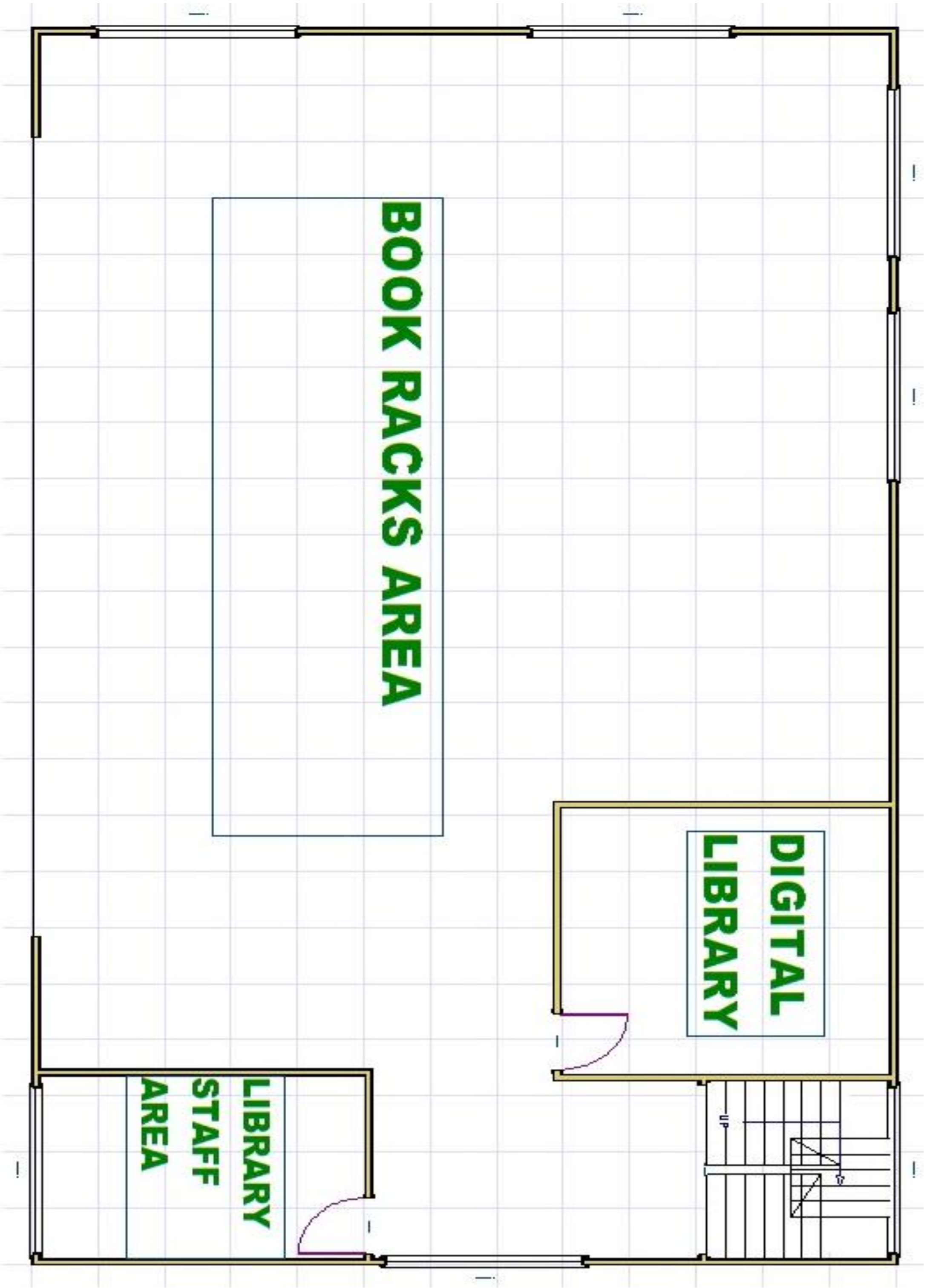
All dimensions in metres.

FIG. 1 PART LAYOUT OF STACK ROOM (ILLUSTRATIVE)

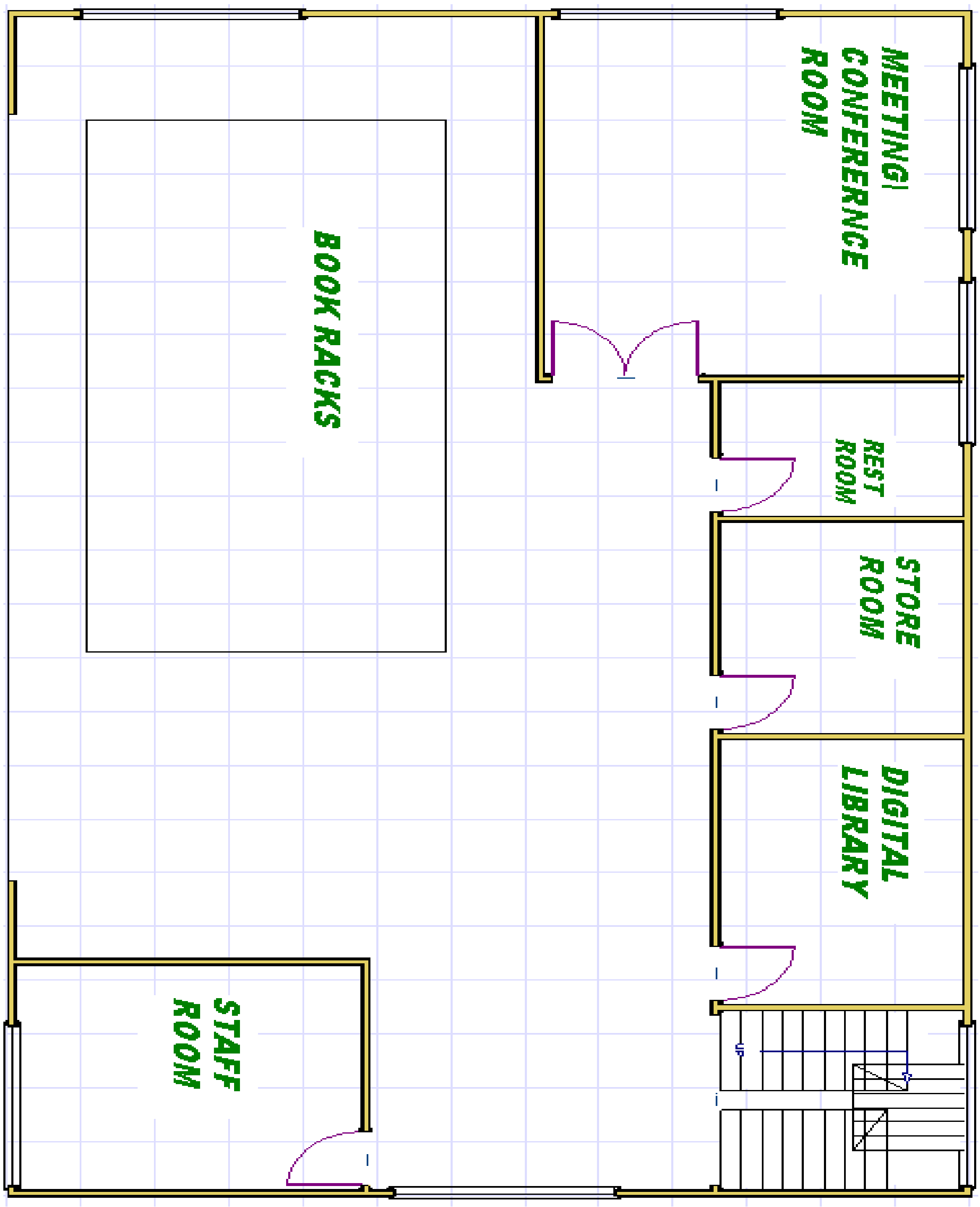
2.4 DRAWINGS



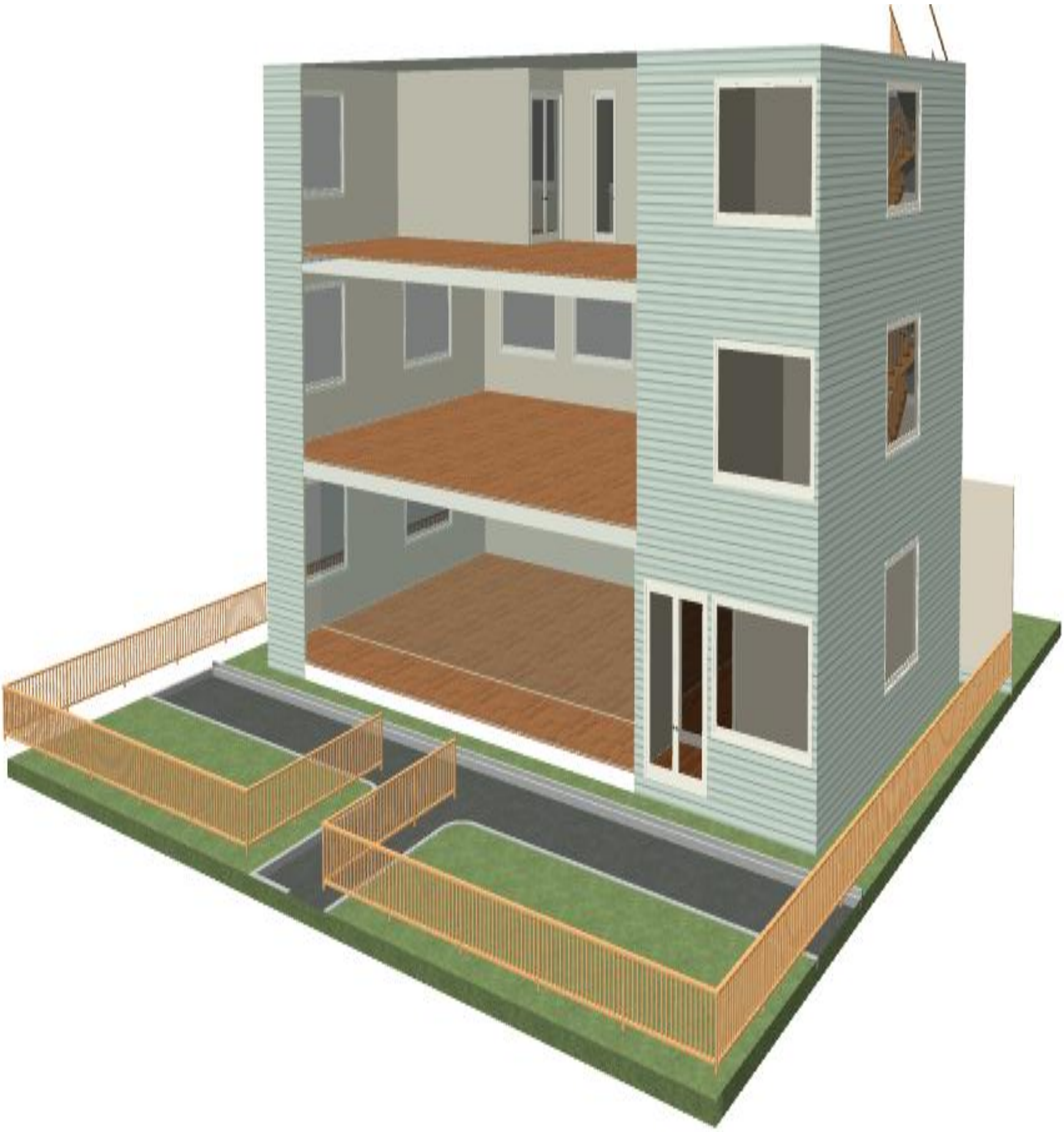
GROUND FLOOR



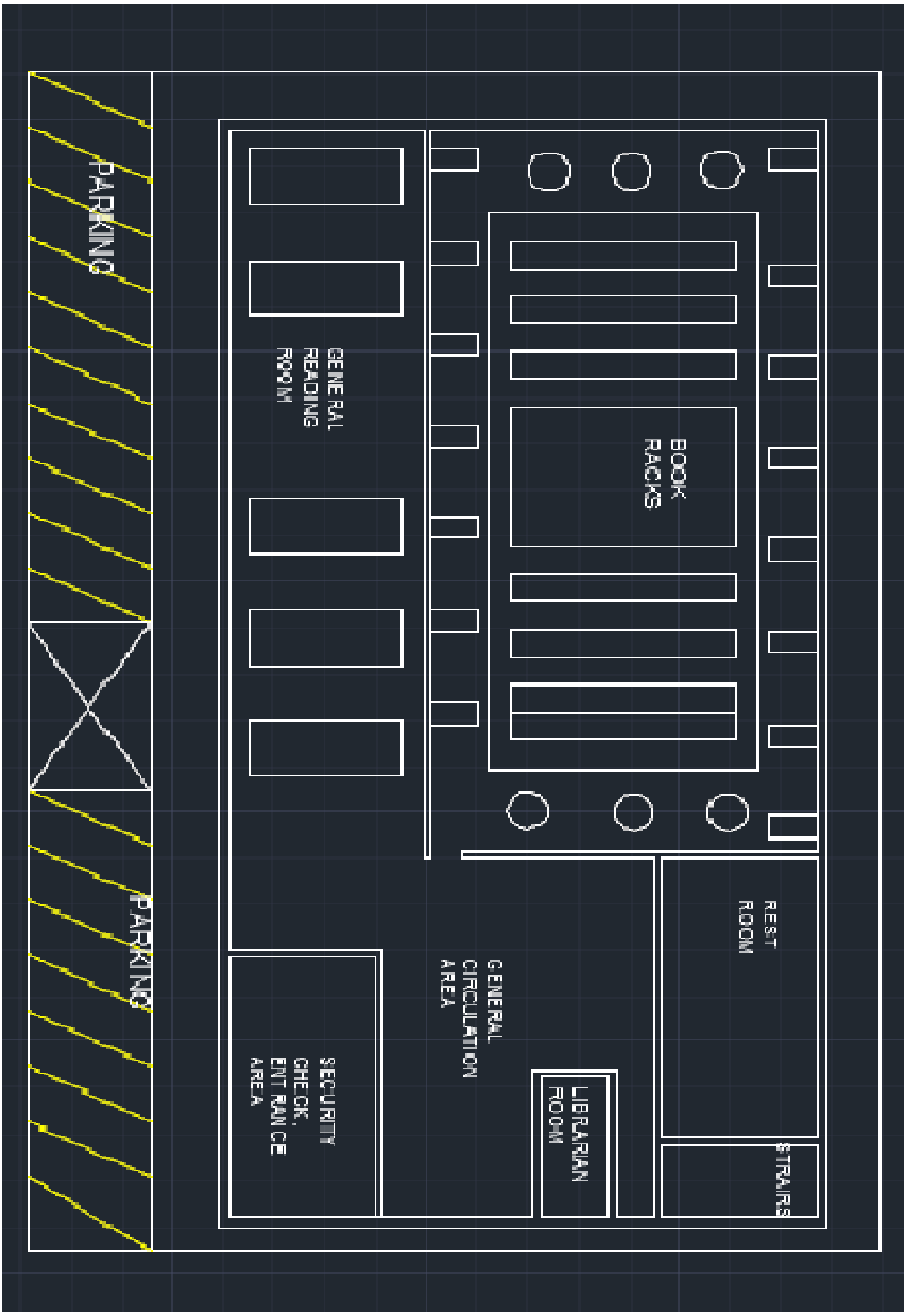
FIRST FLOOR



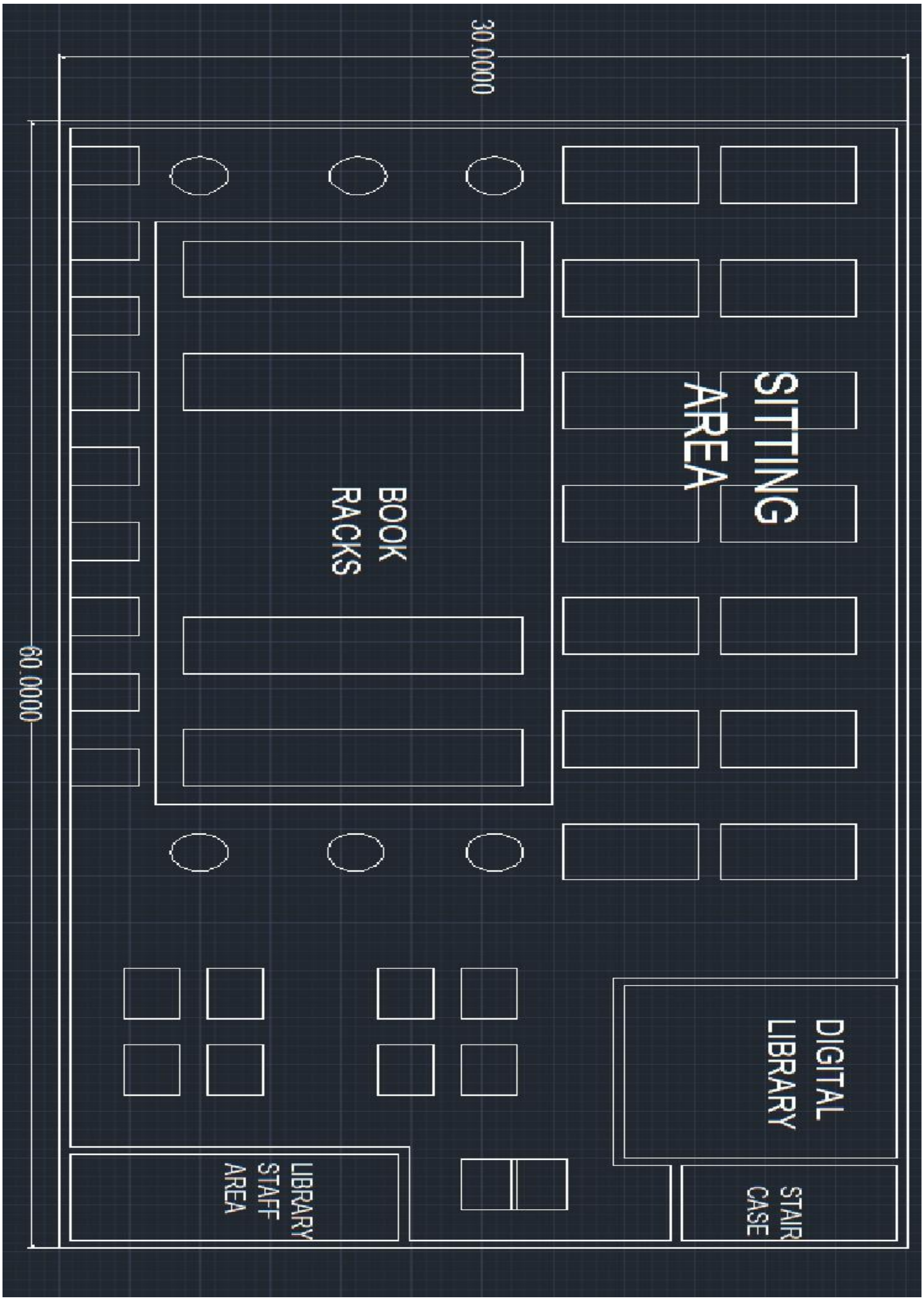
SECOND FLOOR



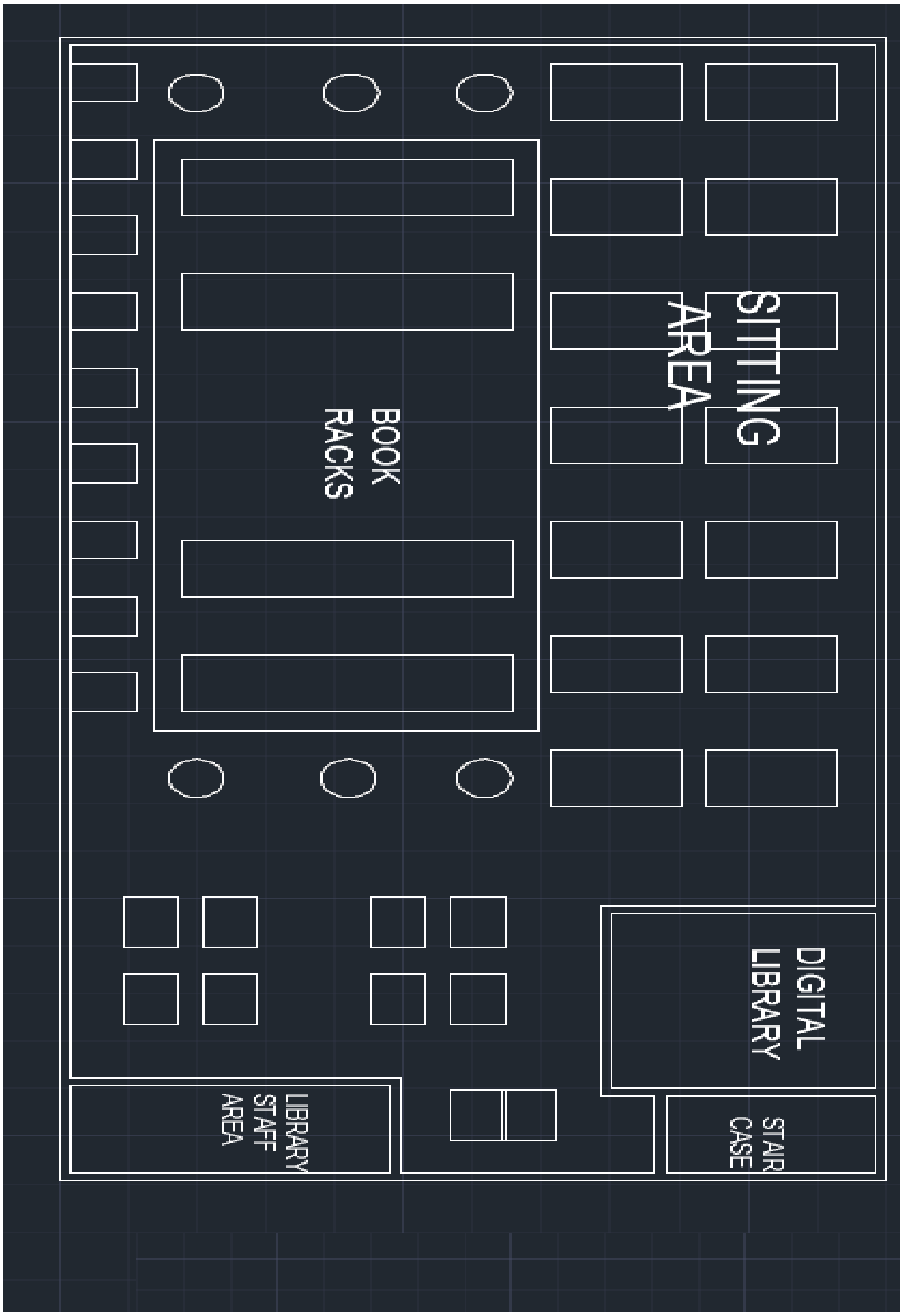
3D VIEW



GROUND FLOOR


30.0000
60.0000
SITTING AREA
BOOK RACKS
DIGITAL LIBRARY
LIBRARY STAFF AREA
STAIR CASE

FIRST FLOOR



SECOND FLOOR

3. DESIGNING

1.1 INTRODUCTION

STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems.

An older version called Staad-III for windows is used by Iowa State University for educational purposes for civil and structural engineers.

The commercial version STAAD.Pro is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes.

It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric nonlinear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

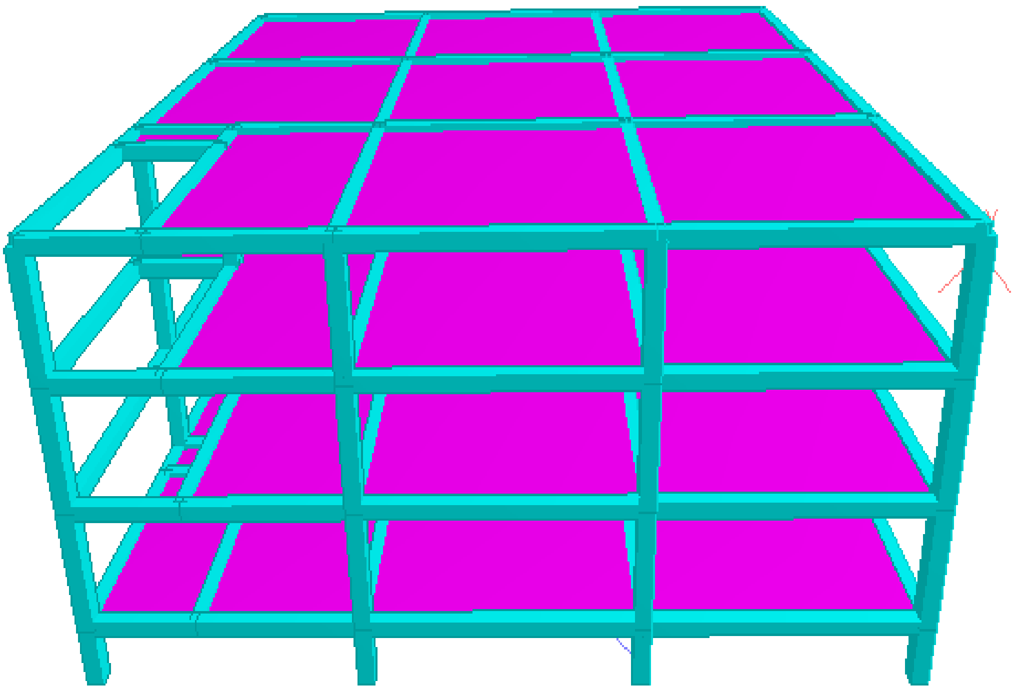
Additionally STAAD.Pro has added direct links to applications such as RAM Connection and STAAD.Foundation to provide engineers working with those applications which handle design post processing not handled by STAAD.Pro itself. Another form of integration supported by STAAD.Pro is the analysis schema of the CIM steel Integration Standard, version 2 commonly known as CIS/2 and used by a number modeling and analysis applications.

1.2 DESIGN CONSIDERATIONS

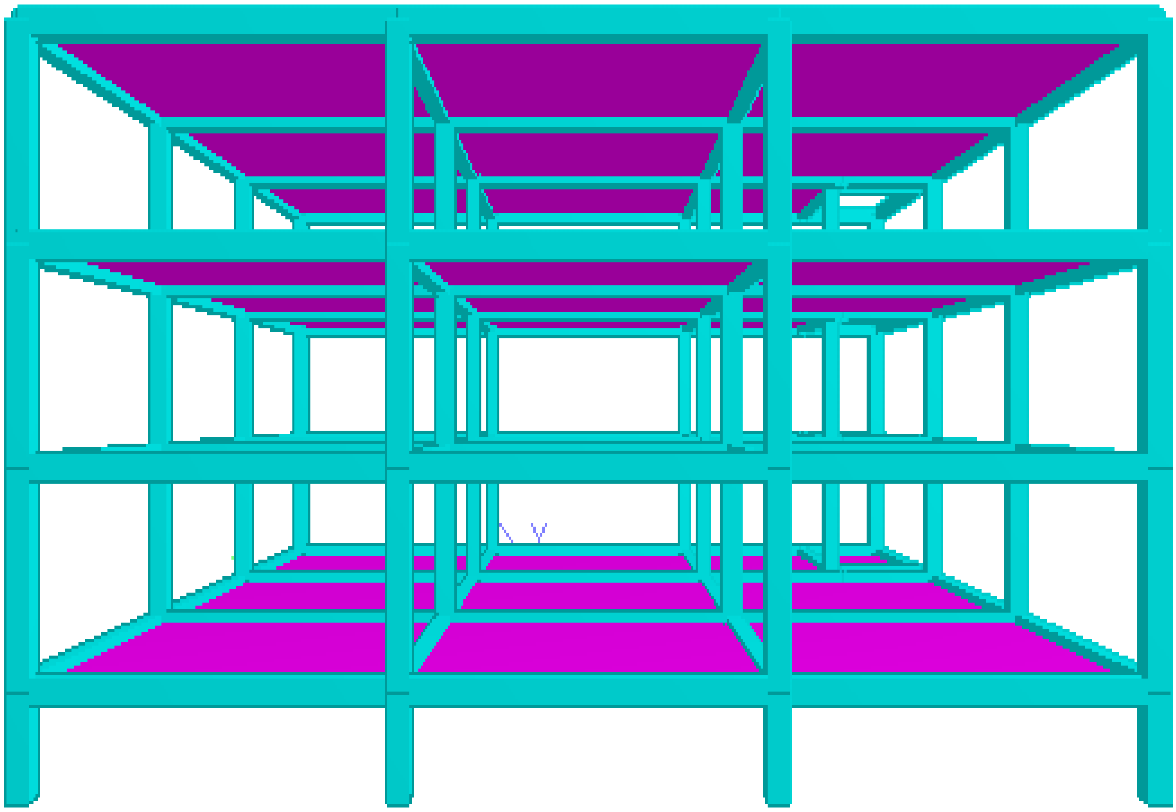
- Maximum Length of building should not be more than 45m due to expansion joints(IS 456 2000)
- Frame type structure is provided.
- Maximum length of span = 10m
- Height of each floor = 4m
- Depth of footing = 2m

- Support - all fixed.
- Total no. of columns – 32
- Total no. of beams – 144
- Live Load value = 5kN/m^2
- Dimensions of frame – 30*30
- No. of frames – 2
- No. of floors - 3

1.3 DRAWINGS



FRAME 1



FRAME 2

3.4 DESIGN RESULTS FROM STAAD.PRO

Support Reactions

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
20	1	7.46	1258.01	8.23	4.55	0.06	-3.95
	2	45.50	484.31	47.21	29.43	0.10	-24.61
	3	79.43	2613.48	83.16	50.97	0.23	-42.84
21	1	-0.61	787.33	8.01	3.82	0.03	0.64
	2	-1.88	993.57	84.72	45.52	0.09	4.01
	3	-3.73	2671.34	139.10	74.01	0.19	6.98
22	1	-0.15	1374.45	-0.60	-1.00	0.03	0.29
	2	-5.13	2041.68	-4.78	-4.17	0.06	7.78
	3	-7.92	5124.19	-8.08	-7.76	0.13	12.11
23	1	-0.37	1375.65	0.16	-0.25	0.02	0.35
	2	-6.73	2036.04	5.74	6.28	0.05	8.70
	3	-10.65	5117.53	8.84	9.04	0.11	13.57
24	1	-0.65	792.55	-8.28	-4.98	0.02	0.40
	2	-1.80	989.24	-84.19	-43.63	0.01	3.21
	3	-3.68	2672.68	-138.71	-72.91	0.05	5.40
25	1	8.35	1259.63	-7.79	-4.63	0.14	-5.10
	2	45.51	483.28	-46.27	-27.13	0.08	-25.51
	3	80.79	2614.36	-81.08	-47.63	0.33	-45.91
26	1	8.10	791.92	0.73	0.25	0.03	-4.40
	2	83.42	987.36	1.17	1.73	0.09	-41.34
	3	137.27	2668.92	2.85	2.97	0.17	-68.61
27	1	8.04	791.97	-0.46	-0.61	0.02	-4.31
	2	83.60	986.62	-0.56	0.50	0.01	-41.30
	3	137.47	2667.88	-1.53	-0.16	0.04	-68.42
28	1	-0.55	749.89	7.63	3.45	-0.15	0.29
	2	-6.87	906.40	76.38	39.70	-0.14	6.64
	3	-11.14	2484.43	126.02	64.72	-0.44	10.39

29	1	-5.42	1280.19	-0.01	-0.96	-0.12	3.14
	2	-49.50	1775.09	5.87	0.76	-0.12	30.46
	3	-82.38	4582.92	8.79	-0.30	-0.36	50.39
30	1	0.31	1374.88	-0.14	-0.63	0.03	-0.36
	2	3.65	2030.13	3.90	4.27	0.06	-1.68
	3	5.94	5107.53	5.63	5.45	0.12	-3.06
31	1	0.09	792.87	-8.44	-5.23	0.03	0.06
	2	0.04	989.59	-84.95	-44.82	0.09	1.85
	3	0.20	2673.68	-140.07	-75.07	0.17	2.86
33	1	-8.75	1109.52	7.95	3.60	0.15	6.67
	2	-45.11	382.52	29.20	17.61	0.08	29.96
	3	-80.78	2238.05	55.72	31.80	0.34	54.94

35	1	2.83	412.39	3.22	7.69	0.25	-0.83
	2	5.90	894.49	-8.87	-1.45	0.51	0.39
	3	13.10	1960.32	-8.48	9.35	1.15	-0.67
36	1	-1.30	578.02	-1.44	-1.76	0.22	1.35
	2	-17.72	538.66	22.88	12.83	0.55	10.67
	3	-28.54	1675.01	32.17	16.60	1.17	18.02
37	1	-8.13	789.81	0.06	-0.71	0.02	4.37
	2	-85.26	993.29	-0.56	-0.65	0.03	47.61
	3	-140.09	2674.65	-0.76	-2.04	0.07	77.98

DESIGN OF END BEAM

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 10000.0 mm SIZE: 250.0 mm X 500.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	2500.0 mm	5000.0 mm	7500.0 mm	10000.0 mm
TOP REINF.	2817.67 (Sq. mm)	0.00 (Sq. mm)	314.85 (Sq. mm)	0.00 (Sq. mm)	3210.57 (Sq. mm)
BOTTOM REINF.	1255.51 (Sq. mm)	468.20 (Sq. mm)	1965.41 (Sq. mm)	278.86 (Sq. mm)	1656.41 (Sq. mm)

```
                     SUMMARY OF PROVIDED REINF. AREA
--------------------------------------------------------------------------
SECTION      0.0 mm     2500.0 mm     5000.0 mm     7500.0 mm    10000.0 mm
--------------------------------------------------------------------------
 TOP       4-32í         2-32í         2-32í         2-32í         4-32í
REINF.   2 layer(s)    1 layer(s)    1 layer(s)    1 layer(s)    2 layer(s)

BOTTOM     4-20í         2-20í         7-20í         2-20í         6-20í
REINF.   1 layer(s)    1 layer(s)    2 layer(s)    1 layer(s)    2 layer(s)

SHEAR    2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í
REINF.   @ 150 mm c/c  @ 150 mm c/c  @ 150 mm c/c  @ 150 mm c/c  @ 150 mm c/c
--------------------------------------------------------------------------
```

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 715.0 mm AWAY FROM START SUPPORT

V_Y = 198.16 M_X = -0.12 LD= 3

Provide 2 Legged 8í @ 150 mm c/c

SHEAR DESIGN RESULTS AT 715.0 mm AWAY FROM END SUPPORT

V_Y = -212.58 M_X = -0.12 LD= 3

Provide 2 Legged 8í @ 140 mm c/c

DESIGN OF INTERMEDIATE BEAM

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 10000.0 mm SIZE: 250.0 mm X 500.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	2500.0 mm	5000.0 mm	7500.0 mm	10000.0 mm
TOP REINF.	3122.28 (Sq. mm)	0.00 (Sq. mm)	220.01 (Sq. mm)	0.00 (Sq. mm)	3140.56 (Sq. mm)
BOTTOM REINF.	1564.68 (Sq. mm)	255.72 (Sq. mm)	1857.57 (Sq. mm)	247.19 (Sq. mm)	1583.31 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	2500.0 mm	5000.0 mm	7500.0 mm	10000.0 mm
TOP REINF.	4-32í 2 layer(s)	2-32í 1 layer(s)	2-32í 1 layer(s)	2-32í 1 layer(s)	4-32í 2 layer(s)
BOTTOM REINF.	5-20í 2 layer(s)	2-20í 1 layer(s)	6-20í 2 layer(s)	2-20í 1 layer(s)	6-20í 2 layer(s)
SHEAR REINF.	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 715.0 mm AWAY FROM START SUPPORT

V_Y = 203.65 M_X = -0.16 LD= 3

Provide 2 Legged 8í @ 150 mm c/c

SHEAR DESIGN RESULTS AT 715.0 mm AWAY FROM END SUPPORT

V_Y = -207.10 M_X =   -0.16 LD=   3

Provide 2 Legged 8í @ 150 mm c/c

DESIGN OF COLUMN

2ND FLOOR COLUMN

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 4000.0 mm   CROSS SECTION: 500.0 mm X 500.0 mm   COVER: 40.0 mm

GUIDING LOAD CASE: 3   COLUMN TYPE: SHORT COLUMN

REQD. STEEL AREA   : 857.27 Sq.mm.

REQD. CONCRETE AREA: 107159.23 Sq.mm.

MAIN REINFORCEMENT: Provide   8 - 12 dia. (0.36%,   904.78 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 190 mm c/c

1ST FLOOR COLUMN

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 4000.0 mm   CROSS SECTION: 500.0 mm X 500.0 mm   COVER: 40.0 mm

GUIDING LOAD CASE: 3   COLUMN TYPE: SHORT COLUMN

REQD. STEEL AREA   :   1700.08 Sq.mm.

REQD. CONCRETE AREA: 212509

.69 Sq.mm.

MAIN REINFORCEMENT: Provide 16 - 12 dia. (0.72%,   1809.56 Sq.mm

(Equally distributed)

TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 190 mm c/c

GROUND FLOOR COLUMN

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 4000.0 mm CROSS SECTION: 500.0 mm X 500.0 mm COVER: 40.0 mm

GUIDING LOAD CASE: 3 COLUMN TYPE: SHORT COLUMN

REQD. STEEL AREA : 5347.77 Sq.mm.

REQD. CONCRETE AREA: 244652.23 Sq.mm.

MAIN REINFORCEMENT: Provide 28 - 16 dia. (2.25%, 5629.73 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 255 mm c/c

BELOW GROUND FLOOR COLUMN

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

LENGTH: 2000.0 mm CROSS SECTION: 500.0 mm X 500.0 mm COVER: 40.0 mm

GUIDING LOAD CASE: 3 COLUMN TYPE: SHORT COLUMN

REQD. STEEL AREA : 8374.71 Sq.mm.

REQD. CONCRETE AREA: 241625.30 Sq.mm.

MAIN REINFORCEMENT : Provide 28 - 20 dia. (3.52%, 8796.46 Sq.mm.) (Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

DESIGN OF SLAB

Concrete - M25

Steel - Fe415 (Main) & Fe415 (Sec.)

Dimension: 10.0*10.0 mType: Two way slab

```
ELEMENT DESIGN SUMMARY
----------------------

ELEMENT     LONG. REINF      MOM-X /LOAD     TRANS. REINF      MOM-Y /LOAD
             (SQ.MM/ME)     (KN-M/M)          (SQ.MM/ME)       (KN-M/M)

  250 TOP :       156.           0.00 /     0         156.          0.00 /     0
     BOTT:       156.        -0.27 /     3         156.         -0.28 /     3
```

3.5 MANUAL DESIGN RESULTS

ISOLATED FOOTING

Load (kN)	3416
Ultimate load (kN)	5124
Soil bearing capacity qa (kN/m^3)	220
Plan area of footing A	15.52727273
Breadth	3.940466055
	4
Plan area	16
	16
Q	213.5
Therefore, qa>q hence OK	
Shear length	1.75
M k kN –m	326.921875

Mu kN –m	490.3828125
$M_u=M_{lim}$	
$M_u=0.138f_{ck}bd^2$	
D	377.0145165
	400
Two Way Shear	
ks=0.5+βc	
τa = ks+τc	but < 1
ks = 0.5 + β	
β=short side of column/long side	
B	1
Ks	1.5>1
Therefore, ks=1	
τ_c =.25sqrtfck	
τ_c	1.25
Total shear force=	(4*4)-((0.5+d/2)*(0.5+d/2))*q
τ=	((4*4)-((0.5+d/2)*(0.5+d/2))*q)/(4*(.5+d/2)*d)
τ=τa	
From above eq	
d mm	550

d	605
adopting 16 dia bars	
d'	16
D	679
take overall depth	700
dimensions of footing	5*5*.8
Mu(kNm)	491
Mu= .87fyAstd(1-(Ast*fy)/fck*b*d)	
d1	626
from above eq	
Ast	2300 mm^2
d2	642
A_{st2}	2100mm^2

SINGLY REINFORCED BEAM

SPAN(L ,m)	10	
BREADTH(mm),b	500	
DEPTH(mm),D	500	
COVER(mm)	40	

EFFECTIVE DEPTH (mm) d	460	
Fck (mPa)	30	
Fy (mPa)	415	
DEAD LOAD(KN/m)	6.25	
LIVE LOAD(KN/m^2)	10.68	
TOTAL LOAD	16.93	
FACTORED LOAD	25.395	
MAX.BENDING MOMENT ,Mu(KNm)	317.4375	
MAX. SHEAR FORCE ,Vu(KN)	126.975	
RESISTING MOMENT ,Mr(KNm)	438.012	
FACTORED MOMENT ,Mu(KNm)	317.4375	
Mu<Mr therefore design the beam as singly r/f beam.		
Xulim(mm)	220.8	cl. 38.1

Ast (mm^2)	3297.819377	
use 25 dia bars		
n (NO. OF BARS)	6.706718783	
n'(NO.OF BARS IN COMPRESSION) use 22 dia bars	0	
DESIGN OF SHEAR REINFORCEMENT		
% STEEL	1.319127751	
τ_c	0.73	
MAX SHEAR FORCE Vu	126.975	
τ_v	0.552065217	

since τv<τc no need for shear r/f		
provide minimum shear r/f	2 legged 8mm dia bars	
Asv(mm^2)	100.48	
Sv(mm)	181.39152	clause 26.5.1.6
provide minimum as specified value of Sv above.		

DOUBLY REINFORCED BEAM

SPAN(L ,m)	10	
BREADTH(mm),b	500	
DEPTH(mm),D	500	
COVER(mm)	40	
EFFECTIVE DEPTH (mm) d	460	
F_{ck} (mPa)	30	
F_y (mPa)	415	
DEAD LOAD(KN/m)	6.25	
LIVE LOAD(KN/m^2)	21.36	
TOTAL LOAD	27.61	
FACTORED LOAD	41.415	
MAX.BENDING MOMENT, Mu(kNm)	517.6875	
RESISTING MOMENT, Mr(kNm)	438.012	
FACTORED MOMENT, Mu(kNm)	517.6875	
Mu>Mr therefore design the beam as doubly r/f beam.		
Mu1=Mr		
Xulim(mm)	220.8	
Ast1	3297.819377	

d'(mm)	40	
Mu_2 (kNm)	79.6755	
Esc = 0.0028		
Fsc = 0.85Fy		
Fsc	352.75	
Asc (area of steel in compression,mm^2)	537.7847525	
Ast2(mm^2)	525.4218846	
Total Ast(mm^2)	3823.241261	
use 25 dia bars		
n(NO. OF BARS)	7.792593654	
n'(NO.OF BARS IN COMPRESSION) use 22 dia bars	1.712690294	
Shear Design		
% STEEL	1.662278809	
τ_c	0.8	
MAX SHEAR FORCE Vu	207.075	
τ_v	0.900326087	
since $\tau v > \tau c$ design for shear r/f		
provide shear r/f	2 legged 8mm dia bars	
Vus	23.075	
Asv(mm^2)	100.48	
Sv(mm)	723.2077937	clause 40.4
Sv min(mm)	181.39152	clause 26.5.1.6

provide minimum as specified value of Sv above.		

AXIALLY LOADED COLUMN

Factored load (Pu kN)	5300	
Size of column	600*600	
Length	600	
Breadth	600	
Pu=.4fckAc+.67fyAst		Ac=area of concrete
		Ast=area of steel
Ac=(600*600-Ast)		
Ast (mm^2)	6342.1	
check for min. steel (mm^2)	2880	
Here Ast>Astmin.		
hence ok		
provide 25mm dia bars		
d (mm)	25	
no of bars	13.00944	
	8	

ECECTERICALLY LOADED COLUMN

Factored load(Pu)	6317
Mux	203.42
Muy	203.42

d'	60
Ex	32.20199
Ey	32.20199
Dimensions of column	
B	500
D	500
d'/D	0.12
$Pu/f_{ck}bd$	0.842267
$Mu/f_{ck}bd2$	0.054245
$Mu/f_{ck}bd2$	0.054245
from SP-16	
p/f_{ck} (FROM APPENDIX)	0.06
Ap	1.8
Ast	4500
dia of bars	25
N	9.230769
	10
Total no. of bars to be provided	10
Lateral Ties	
d' (mm)	

	6
Spacing of lateral ties	
Least of the following	
According to IS Code	
Least Lateral Dimension (s) mm	500
spacing (s) mm	400
spacing (s) mm	288
Using 6mm dia bars at 280mm C/C	

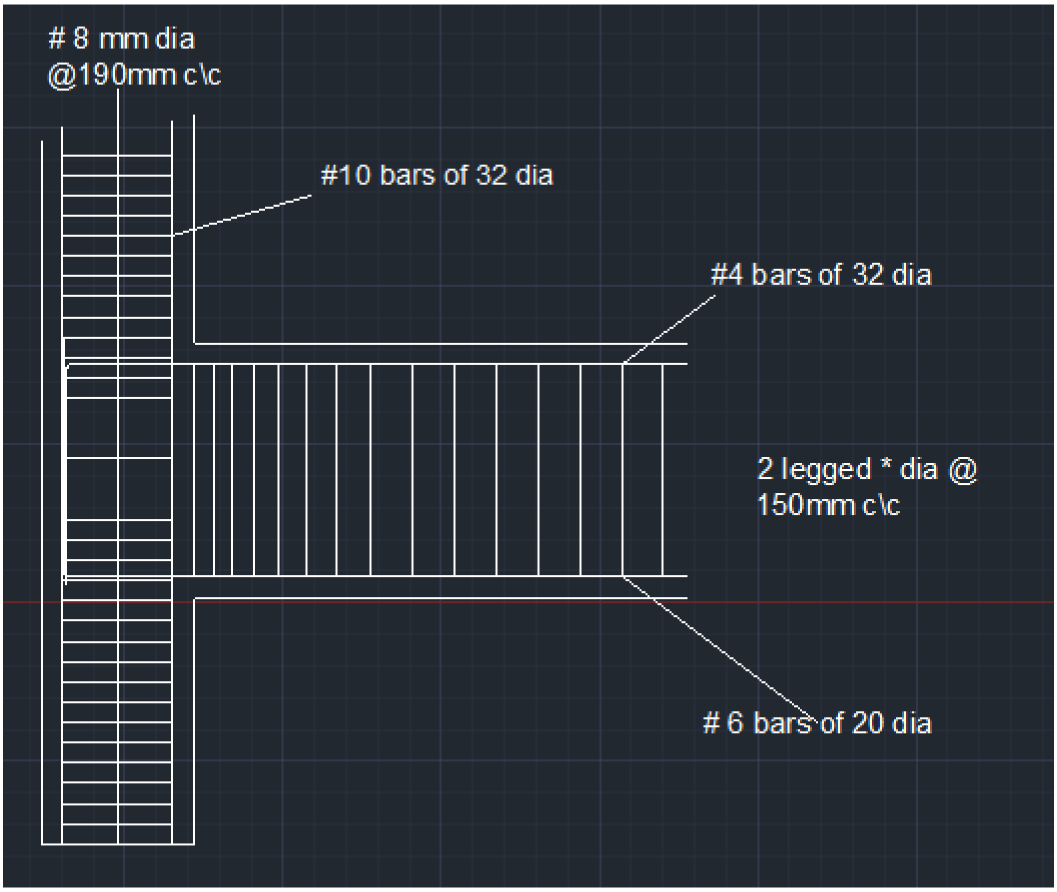
SLAB

Ly	10000	mm		
Lx	10000	mm		
Shorter Span to Depth Ratio(Cl 23.2.1 note a)	26			
Depth	385	mm		
Effective Cover (Cl 26.4.2, Table 16)	20	mm		
Total depth (D)	405			
Factored loads				
Dead Load of Slab	10.125	kN/m		
Load of floor finish	1	kN/m		
Live Load	5	kN/m		
Total load	16.125	kN/ m		
Factored Load	**24.1875**	kN/ m		
MAXIMUM Bending Moments				

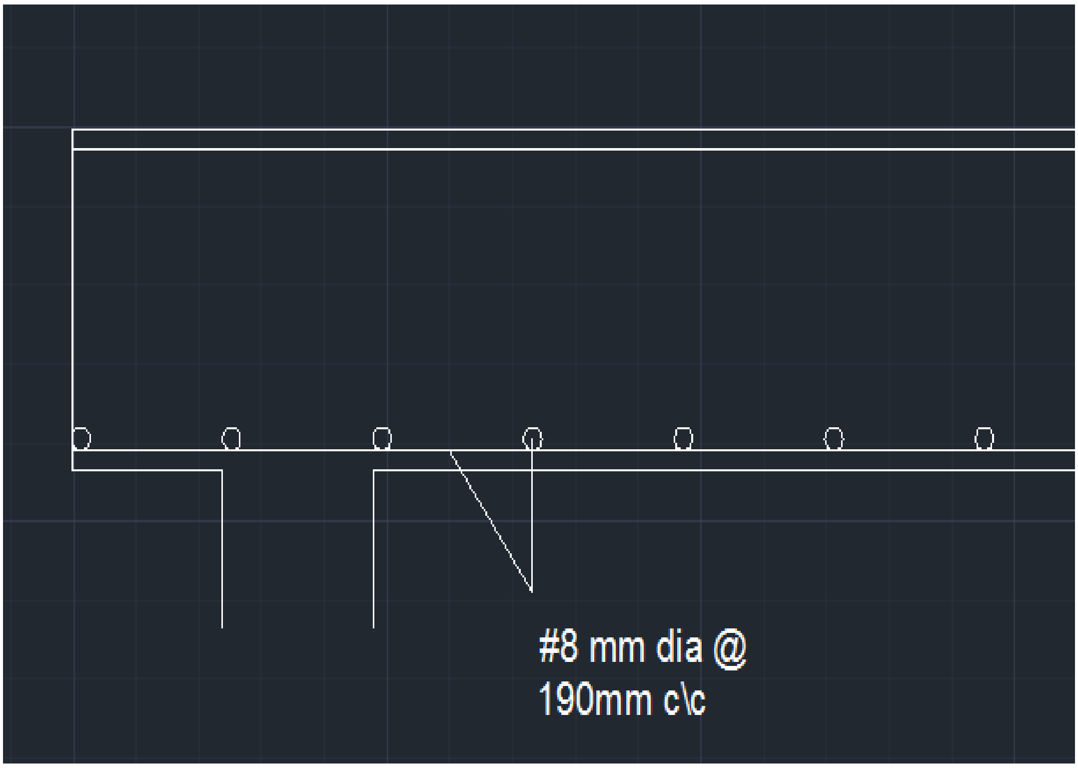
	Short Span		**Long Span**	
	Coeff	Moment(kN-m)	coeff	Moment(kN-m)
Negative Moment At continuous	0.075	181.40625	0.047	113.68125

edge(Annex D, D-2.1)				
Positive Moment At continuous edge(Annex D, D-2.1)	0.056	135.45	0.035	135.45
MAXIMUM Positive Bending Moment	135.45			
MAXIMMUM Negative bending Moment	181.4063			
MAXIMUM Bending Moments	**181.4063**			
Check for depth	229.3066	mm	OK	
Check For Shear				
Shear Force	120.9375	kN		
τv(Cl. 40.1)	0.314123	kN/ mm^2		
τc(Table 19)	0.32	kN/ mm^2	OK	
Positive Steel Area(Annex G, G-1.1(b))	**1019.221**		OK	Spacing= 198
Negative Steel Area	**1388.122**	mm^2	OK	Spacing=145
Torsion				
Minimum Reinforcement Required	486	mm^2		
Distance from the centre of support upto which torsional steel must be provided	2000	mm		
Ast of Torsional Steel	764.4157	mm^2		

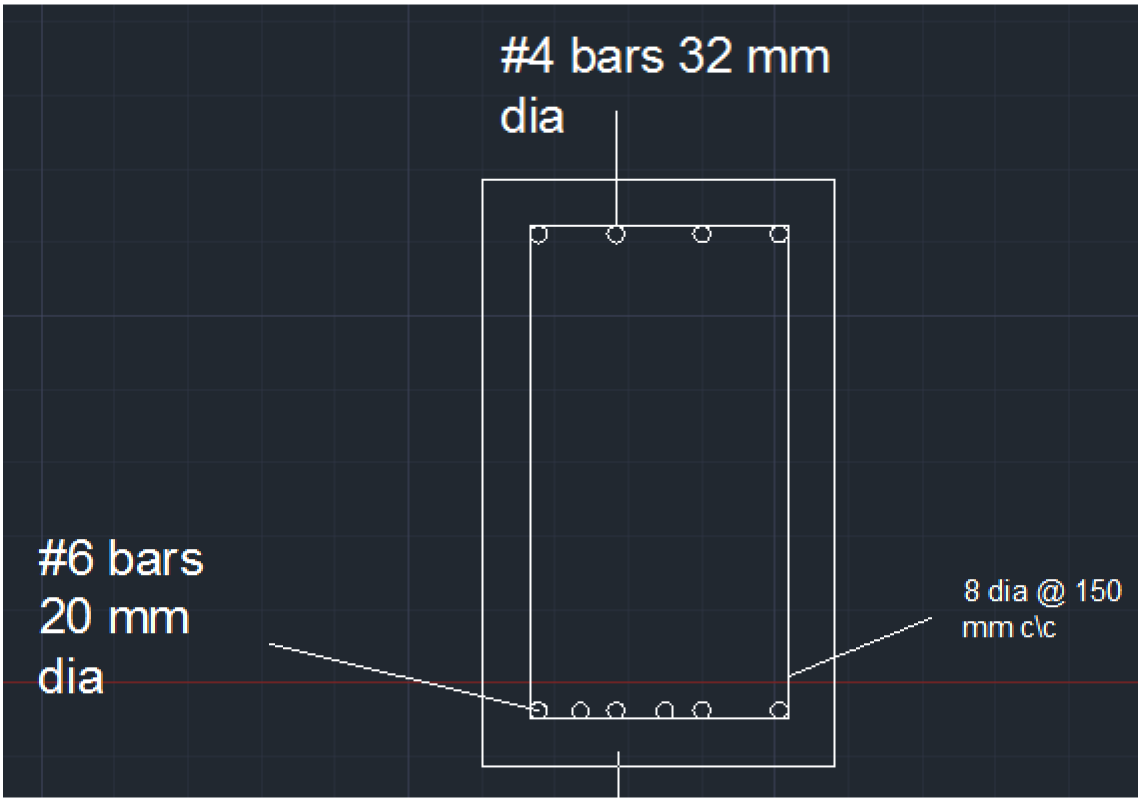
3.6 REINFORCEMENT DETAILING



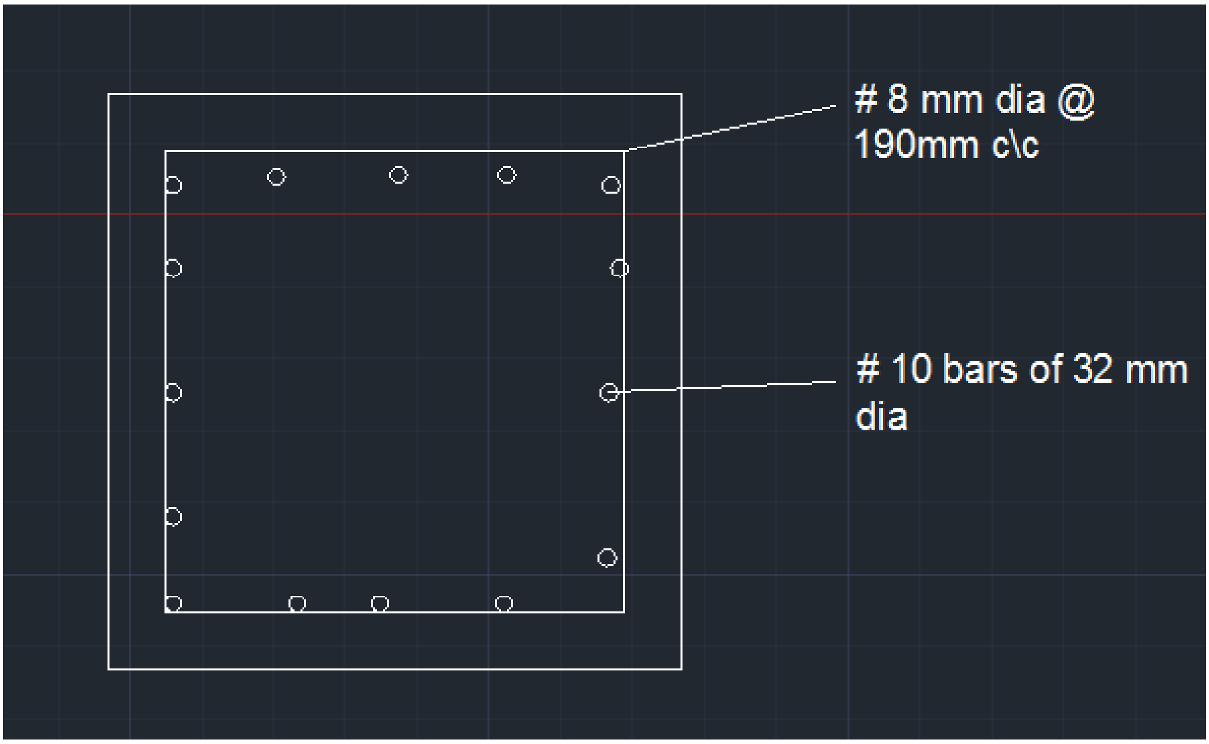
BEAM AND COLUMN



SLAB


#4 bars 32 mm
dia
#6 bars
20 mm
dia
8 dia @ 150
mm c\c

Beam


8 mm dia @
190mm c\c
10 bars of 32 mm
dia

Column

4. Estimation

4.1 ESTIMATION OF STRUCTURAL COSTS

	L(m)	B(m)	H (m)	No.	V(m3)	R M rate	L Rate	Amount
Excavation								
(i) Footing	5.25	5.25	2	32	1764		200	352800
(ii) Boundary Wall	110	0.5	1	1	55		150	8250
Concrete								
(i) Footing	2.5	2.5	0.7	32	140	3000	445	420000
(ii) Column	13.5	0.5	0.5	32	108	3000	720	401760
(iii) Beam	10	0.25	0.5	144	180	3000	564	641520
(iv) Slab	30	30	0.25	6	1350	3000	564	4811400
Steel		A(m2)				W of steel (Tonne)	Rate	
(i) Footing								
(a) main	4.4	0.0023		32	0.32384	3.12	42000	131040
(b) Sec	4.4	0.0021		32	0.29568	2.83	42000	118860
(ii) Column								
(a) 2rd floor	4	0.002		32	0.256	1.99	42000	83580
(b) 1st floor	4	0.002		32	0.256	1.99	42000	83580
(c) Ground F	4	0.0054		32	0.6912	5.4	42000	226800
	2.5	0.0084		32	0.672	5.24	42000	220080
(d) below G. L.	2	0.0007		96	0.1344	1.1	42000	46200
	10.5	0.0054		144	8.1648	55.88	42000	2346960
(e) Secn. r/f	1.5	0.0033		144	0.7128	5.46	42000	229320
(iii) Beam								
(a) main	10.5	.00156		54	0.88452	7.2	42000	302400
(b)shear	10.5	.00156		54	0.88452	7.2	42000	302400
(iv) slab								
							total	10726950

(a) main r/f **(b) sec r/f**								

L = Length in m

B = Breadth in m

H = Height in m

V = Volume in m^3

R M rate = raw material rate

L rate = Labour rate

4.2 ESTIMATION OF BRICK WORK AND FINISHING COSTS

	Area	Deduction	Number	Rate	Price
(i) Brick					
(a) External	1580	225	162000	7	1134000
(b) Internal	1416	110	75500	6	453000
(ii) Plastering	5992	670	5322	257	1367754
(iii) Windows	225	0	18	5000	90000
(iv) Doors					
(a)interior	110	0	9	3000	27000
(b)exterior	20	0	3	6000	18000
(iiv) painting					

(a) exterior	1580	225		333.6	527100
(b) interior	4394	110		90	385560
				TOTAL	4002414

Total cost excluding flooring and furnishing = 1 07 26 950 + 40 02 414

= 1 47 29 364

= 1.48 Cr (approx.)

4. GREEN BUILDING

Defining Green

A green building is one whose construction and lifetime of operation assure the healthiest possible environment while representing the most efficient and least disruptive use of land, water, energy and resources. The optimum design solution is one that effectively emulates all of the natural systems and conditions of the pre-developed site – after development is complete.

Cost Consideration of Green Building

By blending the right mix of green technologies that cost less with green technologies that cost the same or slightly more, it is possible to have a very green building project that costs the same as a conventional one. Often the key to a cost effective green building and site design lies within the interrelationships and associated cost and performance trade-offs that exist between different building systems. For example, the use of high performance windows and window frames increases the first cost of the building envelope, however the resulting reduction in the size and cost of the buildings heating and cooling system more than offsets the added cost of the better glazing system. The result is a building that has a comparable or perhaps even a lower first cost, a higher comfort level, lower energy use, and lower energy bills and operating cost for the life of the building.

Decision to Build Green

It is critical to make the decision to build a green building early in the design process in order to maximize the green potential, minimize redesign, and assure the overall success and economic viability of the green elements of the building project. Making a commitment to build green and establishing firm environmental objectives for the project must be done as early as possible because opportunities for incorporating green technologies and design solutions become less and less available and increasingly costly to implement as the project design and construction process progresses. Ideally, the decision to build green should be made before the site is selected, as many of the green criteria are affected by site characteristics and some sites are inappropriate for certain green projects.

Integrated Design Process

Building a green building is not just a matter of assembling a collection of the latest green technologies or materials. Rather, it is a process in which every element of the design is first optimized and then the impact and interrelationship of various different elements and systems within the building and site are re-evaluated, integrated, and optimized as part of a whole building solution. For example, interrelationships between the building site, site features, the path of the sun, and the location and orientation of the building and elements such as windows and external shading devices have a significant impact on the quality and effectiveness of natural day lighting. These elements also affect direct solar loads and overall energy performance for the life of the building. Without considering these issues early in the design process, the design is not fully optimized and the result is likely to be a very inefficient building. This same emphasis on integrated and optimized design is inherent in nearly every aspect of the building from site planning and use of on-site storm water management strategies to envelope design and detailing and provisions for natural ventilation of the building. This integrated design process mandates that all of the design professionals work cooperatively towards common goals from day one.

FUNDAMENTAL PRINCIPLES OF GREEN BUILDING AND SUSTAINABLE SITE DESIGN

Key Strategies and Technologies:

- Make more efficient use of space in existing occupied buildings, renovate and re-use existing vacant buildings, sites, and associated infrastructure and consider re-development of brownfield sites. Design buildings and renovations to maximize future flexibility and reuse thereby expanding useful life.
- When new development is unavoidable, steer clear of sites that play a key role in the local or regional ecosystem. Identify and protect valuable greenfield and wetland sites from development.
- Recognize that allowing higher density development in urban areas helps to preserve green space and reduce urban sprawl. Invest time and energy in seeking variances and regulatory reform where needed.
- Evaluate each site in terms of the location and orientation of buildings and improvements in order to optimize the use of passive solar energy, natural day lighting, and natural breezes and ventilation.
- Make best use of existing mass transit systems and make buildings and sites pedestrian and bike friendly, including provisions for safe storage of bicycles. Develop programs and incentives that promote car-pooling including preferred parking for commuters who carpool. Consider making provisions for re-fuelling or recharging alternative fuel vehicles.

- Help reduce the urban heat island effect by reducing the building and site development footprint, maximizing the use of pervious surfaces, and using light colored roofs, paving, and walkways. Provide natural shading of buildings and paved areas with trees and other landscape features.

- Reduce impervious areas by carefully evaluating parking and roadway design. Pursue variances or waivers where local ordinances may unintentionally result in the over-design of roadways or parking.

- Optimize the use of on-site storm water treatment and ground water recharge. Minimize the boundaries of the construction area, avoid needless compaction of existing topsoil, and provide effective sedimentation and silt control during all phases of site development and construction.

- Use landscape design to preserve and restore the region's natural habitat and heritage while emphasizing the use of indigenous, hardy, drought resistant trees, shrubs, plants and turf.

- Help reduce night-time light pollution by avoiding over-illumination of the site and use low cut-off exterior lighting fixtures which direct light downward, not upward and outward.

ENERGY AND ENVIRONMENT

Key Principles:

Minimize adverse impacts on the environment (air, water, land, natural resources) through optimized building siting, optimized building design, material selection, and aggressive use of energy conservation measures. Resulting building performance should exceed minimum International Energy Code (IEC) compliance level by 30 to 40% or more. Maximize the use of renewable energy and other low impact energy sources.

Key Strategies and Technologies:

- Optimize passive solar orientation, building massing and use of external shading devices such that the design of the building minimizes undesirable solar gains during the summer months while maximizing desirable solar gains during winter months.

- Optimize building orientation, massing, shape, design, and interior colors and finishes in order to maximize the use of controlled natural day lighting which significantly reduces artificial lighting energy use thereby reducing the buildings internal cooling load and energy use. Consider the use of light shelf technology.

- Use high performance low-e glazing, which can result in significant year round energy savings. Consider insulated double glazing, triple glazing or double pane glazing with a suspended low-e film. Selective coatings offer optimal light transmittance while providing minimal solar gain and minimal heat transmission. Window frames, sashes and curtain wall systems should also be designed for optimum energy performance including the use of multiple thermal breaks to help reduce energy use.

- Optimize the value of exterior insulation and the overall thermal performance of the exterior envelope assembly. Consider advanced/high performance envelope building systems such as structural insulated panel systems (SIPS) and insulated concrete form systems (ICF's) that can be applied to light commercial and institutional buildings. SIPS and ICF's and other thermally "decoupled" envelope systems will offer the highest energy performance.

- Use energy efficient T-8 and T-5 bulbs, high efficiency electronic ballasts, and lighting controls. Consider using indirect ambient lighting with workstation based direct task lighting to improve light quality, reduce glare and improve overall energy performance in general office areas. Incorporate sensors and controls and design circuits so that lighting along perimeter zones and offices can be switched off independently from other interior lights when daylighting is sufficient in perimeter areas.

- Use state-of-the art, high efficiency, heating, ventilation and air conditioning (HVAC) and plumbing equipment, chillers, boilers, and water heaters, etc. Use variable speed drives on fan and pump motors. Use heat recovery ventilators and geothermal heat pump technology for up to 40% energy savings.

- Avoid the use of HCFC and Halon based refrigeration, cooling and fire suppression systems. Optimize the use of natural ventilation and where practical use evaporative cooling, waste heat and/or solar regenerated desiccant dehumidification or absorption cooling. Identify and use sources of waste energy.

- Use Energy Star certified energy efficient appliances, office equipment, lighting and HVAC systems.

- Consider on-site small-scale wind, solar, and/or fuel cell based energy generation and co-generation .Purchase environmentally preferable "green" power from certified renewable and sustainable sources.

ROOF TOP SOLAR POWER PLANT (GRID INTERACTIVE)

Pilot Scheme of MNRE for Large Scale Grid Connected Roof Top Solar Power Generation

Objectives of the scheme

Acute power shortages in India are making most of the commercial and office establishments to have diesel generator backup. By setting up the grid interactive solar power plants on the rooftops would help in reducing the consumption of diesel during the day time in the areas where grid power is intermittent. If the grid power is continuous, the solar power generated will be utilized along with the grid power and the proportionate amount of grid power usage will get reduced. During minimum load periods (e.g. during weekends), the excess power generated from solar systems could be fed to grid. The consumer can be compensated for the exported power as per policy by the State. Connectivity of these projects to the grid also has to be in accordance with the prevailing CEA guidelines or policy by the State regulators/ DISCOMs.

Project size:

Under this scheme, project size between 100 kW to 500 kW is allowed. The minimum size of project size can also be arrived through adding roofs of different buildings available in same campus.

Submission of Proposals from interested beneficiaries:

Interested beneficiaries may apply for the projects where adequate shadow free roof area (@1000-1200 sq. meters /100kW) is available.

Priority will be given to the projects which would have approved funds to meet the system cost.

Financial support

30% subsidy on the system cost arrived at the conclusion of bids by SECI to the developer to whom the project has been allocated. The system cost also includes annual maintenance charges for 2 years. The manner of disbursal of subsidy is as follows:

-20% after successful installation and commissioning of the system

-5% after one year of successful operation of the project

-Balance 5% after two years of successful operation of the project.

ROOFTOP SOLAR POWER GENERATOR (COST CALCULATION)

Estimation of solar energy reaching the earth's surface is essential for solar potential assessment. Solar radiation data based on satellites provide higher spatial and temporal coverage of regions compared to surface based measurements. Solar potential of the Indian hill state of Himachal Pradesh has been assessed using reliable satellite based global horizontal insolation (GHI) datasets validated based on its complex terrain. Solar maps representing regional and temporal resource availability in the state have been generated using geographical information systems (GIS). Spatial analyses show that the state receives annual average GHI above 4.5 kWh/m^2/day and a total of 99530395 million kWh (or million units, MU). The regional availability of GHI in Himachal Pradesh is influenced by its eclectic topography, seasons as well as microclimate. The lower and middle elevation zone (<3500 m) with tropical to wet-temperate climate receives higher GHI (>5 kWh/m^2/day) for a major part of the year compared to the higher elevation zone (>3500 m) with dry-temperate to alpine climate (4–4.5 $kWh/m^2/day$). Results show that Himachal Pradesh receives an average insolation of 5.86 ± 1.02–5.99 ± 0.91 $kWh/m^2/day$ in the warm summer months; 5.69 ± 0.65–5.89 ± 0.65 $kWh/m^2/day$ in the wet monsoon months; 3.73 ± 0.91–3.94 ± 0.78 $kWh/m^2/day$ in the colder winter months.

Cost of Solar Power Plant Located at roof of the library building

Total roof area for solar panel =1000 m^2

Watt of power Panel that can be installed on roof = 60 kilowatts/1000 m^2

Average Energy incident on Land of Himachal Pradesh (height < 3500m) =

4 $kWh/m^2/day$

Per Hour consumption of electricity units of Library Building = 30 kWh

Total units consumed in 24 hr cycle of day = 25*24 = 600 kW (peak day)

As sun light is only sufficient for 6 hr in a day

Power generated in a day= 60*6= 360 kWh

Cost of Panel per kW (battery installed) = Rs. 130000

Cost of 60 kW Power Plant = Rs. 7800000

Subsidy amount @ 30% of Project cost received from MNRE =Rs 2340000

Subsidy from State Government = Rs 1365000

Net Cost of Roof top Solar power plant = COST - SUBSIDY = Rs 4095000

7. CONCLUSIONS

At the end, the library building was designed successfully according to the IS 456:2000. The section chosen for slab, beam and columns are adequate to support the loading imposed on the building. The adequacy of the section has been checked and verified by STAAD.Pro simulation and hand calculation.

We also gave adequate importance to green building concept while designing our library so that the environmental impacts of the building can be minimised. Although it increases the overall cost of the structure considerably, green building concepts make it sustainable, more energy efficient and hence environmentally more acceptable.

During the project duration, we faced a lot of upside-downs, but with the good team coordination and generous guidance from our project guide, these hurdles became very easy to jump-off.

While working on this project, we were able to:

1. Learn various techniques and tricks in order to analyze and design a steel structure on software STAAD.Pro.
2. Learn various software's like Chief Architect and AutoCAD
3. We learn various design procedures and concepts of designing of RCC structures mentioned in IS 456:2000.
4. Also, we can now easily calculate overall cost of the rcc structure.
5. Not to mention, working in a team was also an experience from which we learned working as a team and coordinating among teammates.

APPENDIX

Charts for eccentrically loaded column for fe415

Chart 31 COMPRESSION WITH BENDING–Rectangular Section–Reinforcement Distributed Equally on Two Sides

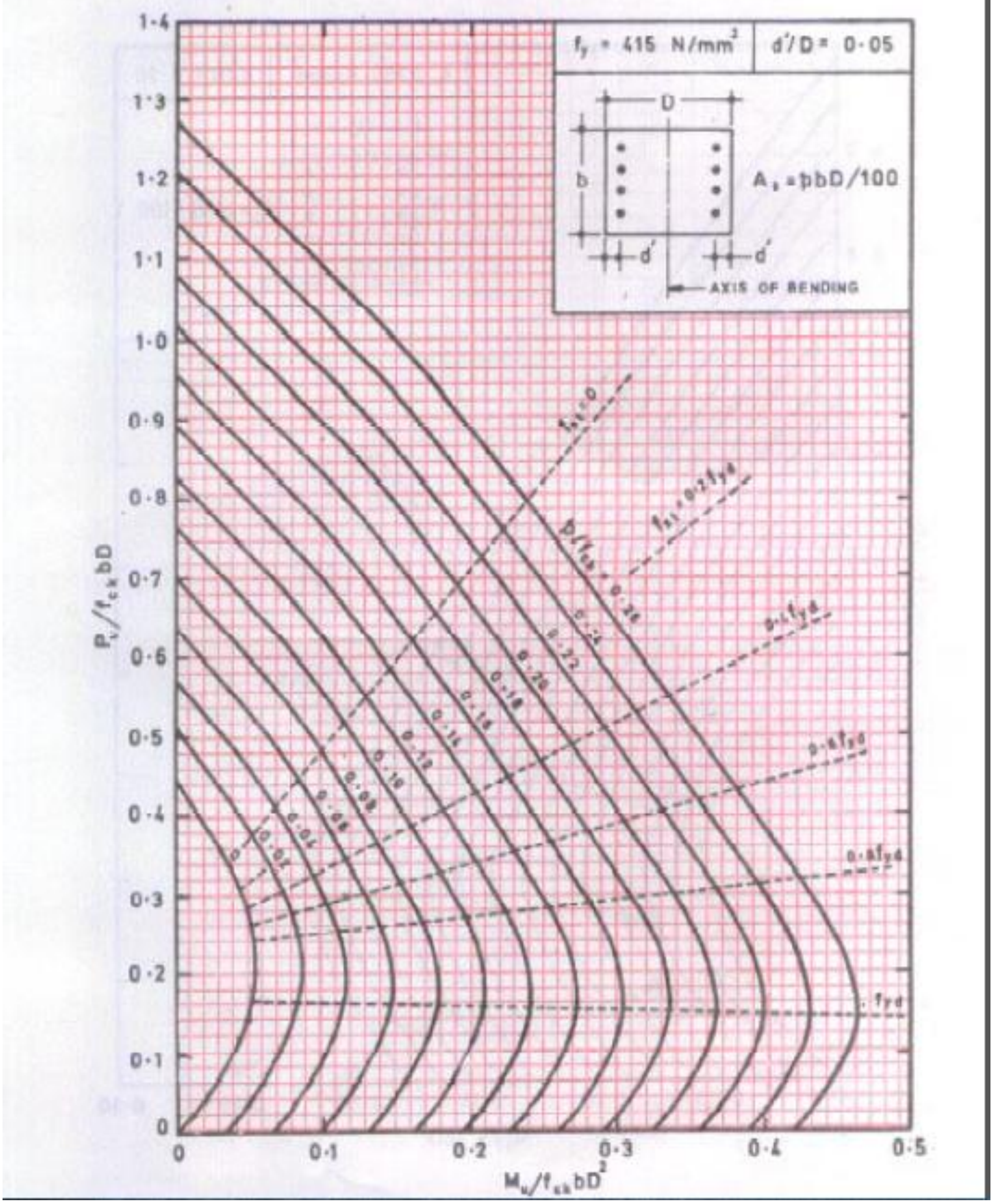


Chart 43 COMPRESSION WITH BENDING–Rectangular Section –Reinforcement Distributed Equally on Four Sides

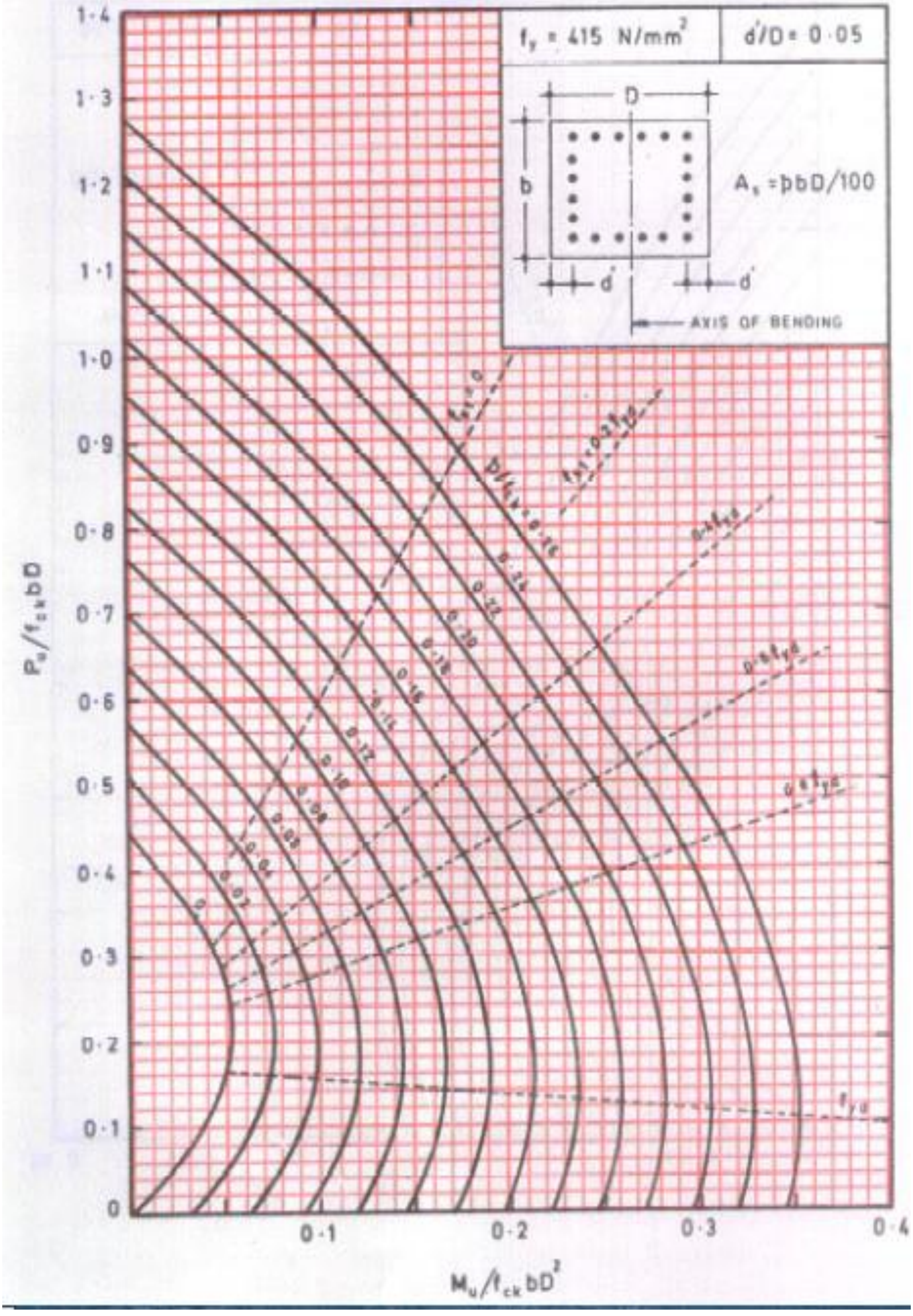


Chart 32 COMPRESSION WITH BENDING–Rectangular Section–Reinforcement Distributed Equally on Two Sides

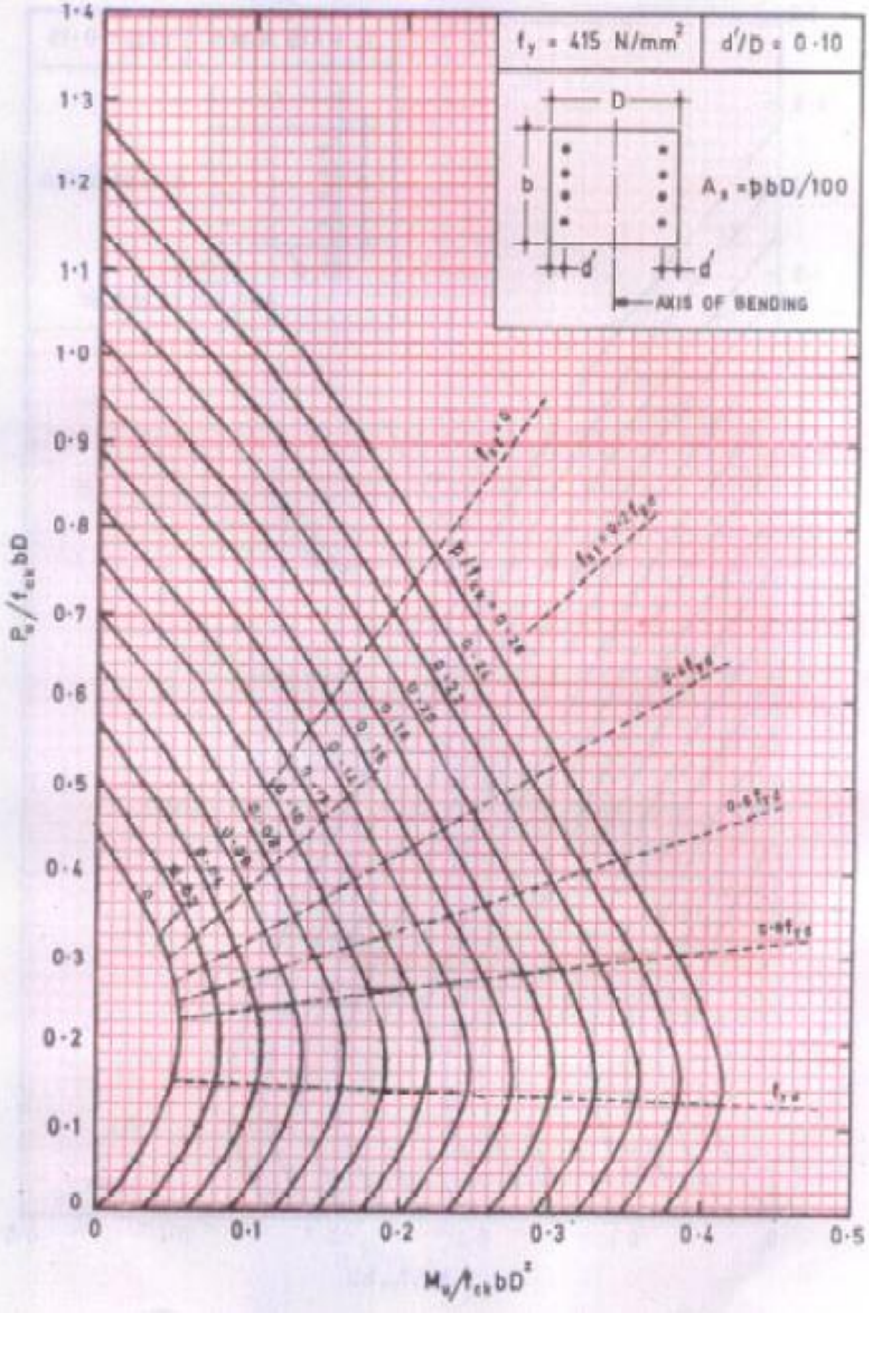


Chart 33 COMPRESSION WITH BENDING–Rectangular Section–Reinforcement Distributed Equally on Two Sides

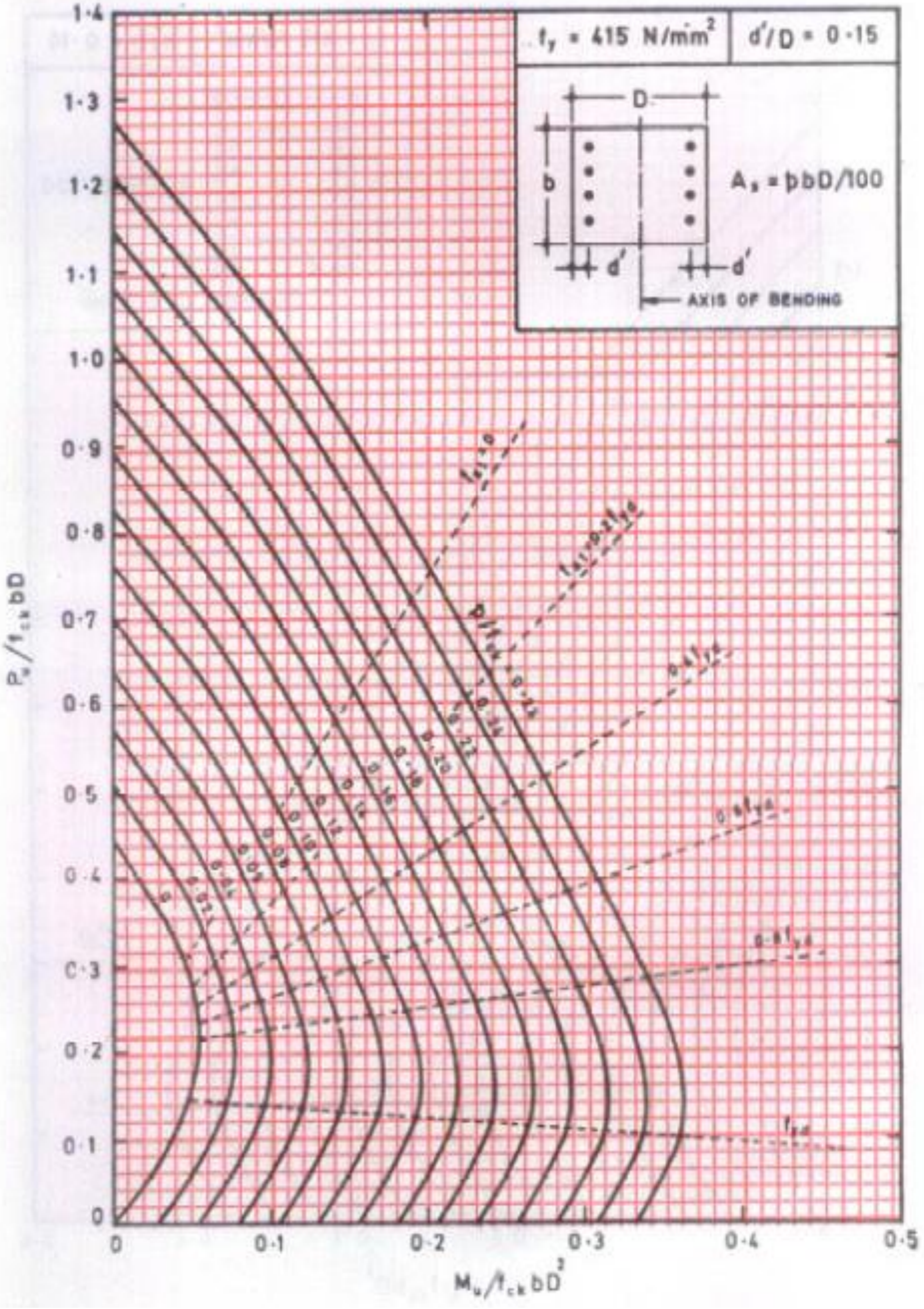


Chart 44 COMPRESSION WITH BENDING–Rectangular Section–Reinforcement Distributed Equally on Four Sides

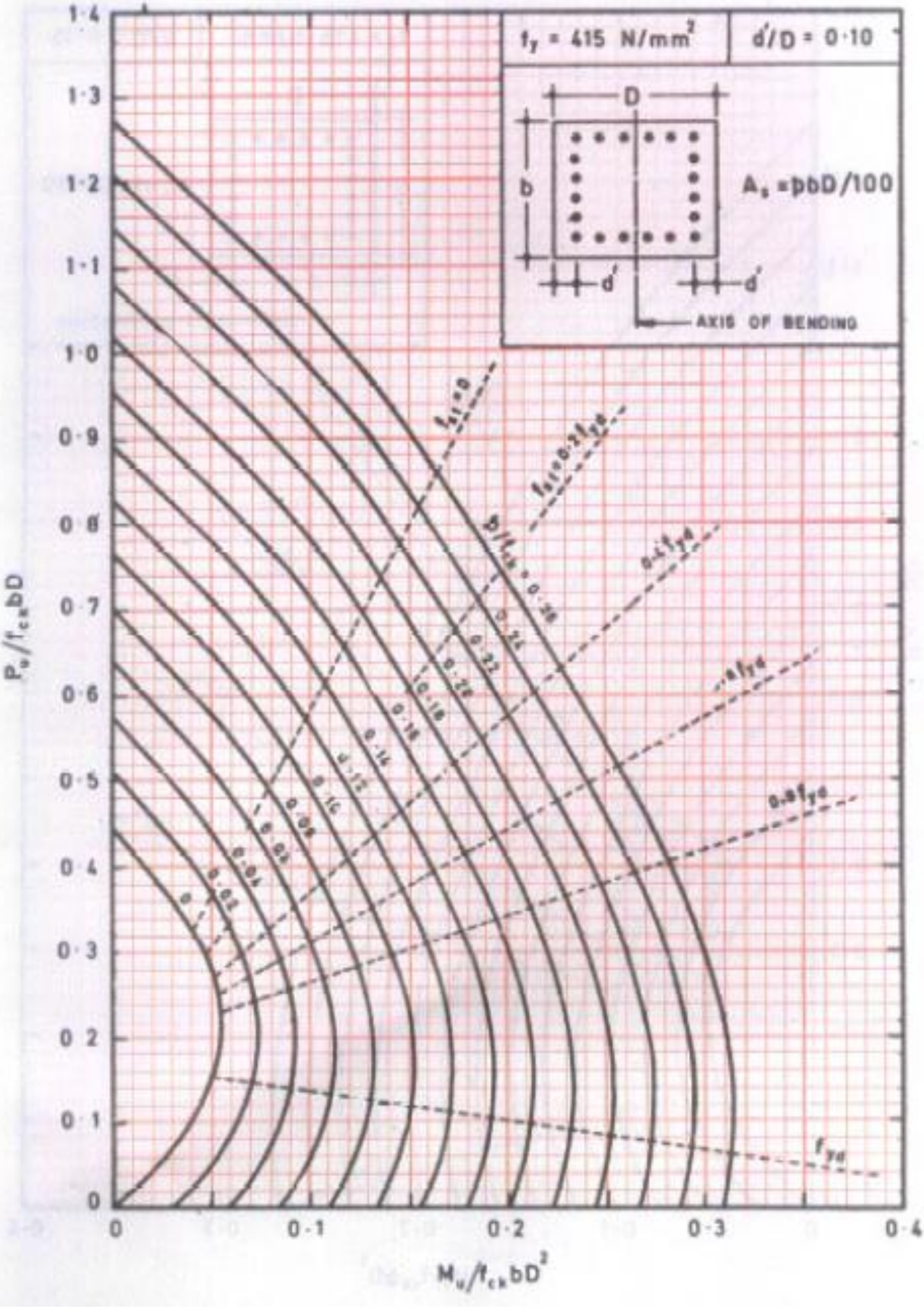
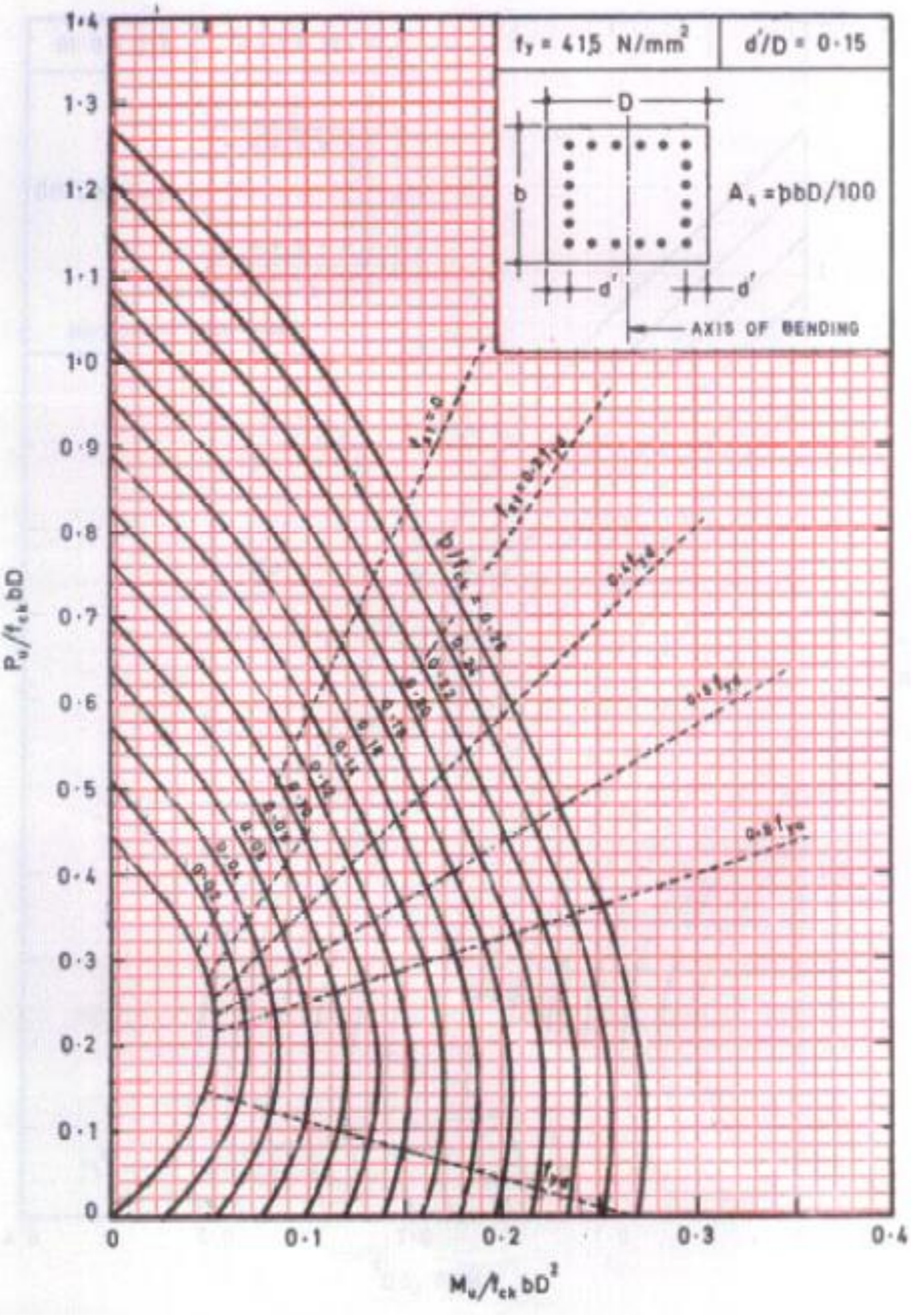


Chart 45 COMPRESSION WITH BENDING–Rectangular Section–Reinforcement Distributed Equally on Four Sides



REFERENCES

IS: 456-2000 (Indian Standard For Plain And Reinforced Concrete)

IS: 1553-1989 (Indian Standard For Design Of Library Building)

IS: 1893-2002 Part 1 (Indian Standard For Earthquake resistant Design Of Structure)

Estimation And Costing In Civil Engineering Theory And Practice By B.N.Dutta publisher: UBS Publishers' Distributors (p) ltd.-New Delhi

Reinforced Concrete Design By Pillai And Menon Published By Mc Graw Hill Education

Websites:

www.mnre.com

www.halifaxcentrallibrary.ca/building-design/

www.igbc.in (Site of Indian Green Building Council)