DESIGN OF HOSTEL BUILDING

Project Report submitted in partial fulfilment of the requirement for the degree of Bachelor of Technology.

In

Civil Engineering

Under the Supervision of

Dr. Ashish Kumar, **Associate Professor**

By

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To

Jaypee University of Information and Technology

Waknaghat, Solan – 173234, Himachal Pradesh

DECLARATION

We hereby declare that the project work presented in this report entitled "DESIGN OF HOSTEL BUILDING" submitted for the award of the degree of Bachelor of Technology in Civil Engineering to the Department of Civil Engineering, Jaypee University of Information and Technology Wakhnaghat, has been carried out by us. This work is independent and its main content work has not been submitted for degree at any University in India or Abroad.

Abhishek Singh

Shivam Singh Bhadouria

Certificate

This is to certify that project report entitled "DESIGN OF HOSTEL BUILDING", submitted by Abhishek Singh (111705) & Shivam Singh Bhadouria (111668) in partial fulfilment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: 28/1/14

Signature:	Signature:	Signature:
Dr. Ashish Kumar	Dr. Ashok Kumar Gupta	External Examiner
Associate Professor	Professor and Head of Department	
Civil Engineering Department	Civil Engineering Department	

ACKNOWLEDGEMENT

Every project big or small is successful largely due to the effort of a number of wonderful people who have always given their valuable advice or lent a helping hand. I sincerely appreciate the inspiration; support and guidance of all those people who have been instrumental in making this project a success.

At this juncture I feel deeply honoured in expressing my sincere thanks to my guide **Dr. Ashish Kumar, Associate Professor, Jaypee University of Information Technology** for the confidence bestowed in me and providing valuable insights leading to the successful completion of my project.

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Abhishek Singh

Shivam Singh Bhadouria

(4th year, Civil Engineering)

Abstract

This Project includes a Design, Planning & Estimation of Hostel Building for a total no. of 360 students. This included an analysis of the building on the software STAAD-Pro along with the design of the various components of the building. The designing components include Slabs, Beams, Columns, Footing and Staircase.

The project will also include the determination of the amount of water required and therefore providing a suitable water Tank. Estimating the amount of concrete and steel required has also been done.

The hostel is design for Zone II- seismic Zone and a plain terrain Region. The size of one hostel block is 80ftx50ft, with rooms of 16ftx12ft.the . Along with a 4 feet individual balcony for each room and a combined balcony of 4 feet. the passage way provided by is 8ft in length. The hostel will be arranged in a rectangular pattern, each side representing a hostel block. At opposite corners provision of baths and toilets have been provided which are different structural elements.

LIST OF FIGURES

CONTENTS

1. Introduction

A building is a man-made structure with a roof and walls standing more or less permanently in one place. Buildings serve several needs of society – primarily as shelter from weather, security, living space, privacy, to store belongings, and to comfortably live and work. A building as a shelter represents a physical division of the human habitat (a place of comfort and safety) and the outside (a place that at times may be harsh and harmful).

Without any semblance of doubt, reinforced cement concrete construction has been the most revolutionary construction technique of modern times. Combining the high compressive strength of concrete with high tensile strength and elasticity of steel has resulted in a composite material that is strong, durable and economical. Moreover, it is time tested.

1.1 TYPES OF BUILDINGS

1.1.1 Based on Occupancy

1. **Residential buildings**: - The building in which sleeping accommodation is provided for normal residential purposes are called residential buildings.
2. **Educational / institutional buildings**: - The building used for school, college or day care purposes are called education / institutional building.
3. **Assembly Building**: - The buildings which are constructed for the purposes to gathering of the people for their respective purposes i.e. social, religious, civil, political is called assembly buildings.
4. **Business Buildings**: - The buildings used for transaction of business, for the keeping of accounts and records and other similar purposes called business buildings. Mercantile Buildings: - The buildings used for display of merchandise, either wholesale or retail are called Mercantile Buildings.
5. **Industrial buildings**: - The buildings in which products or materials of all kinds and properties are fabricated, assembled or processed are called industrial buildings. Storage buildings: - The buildings used primary for the storage, handling or shattering of goods and wares or merchandise, vehicles and animals are called storage buildings. Hazardous buildings: -The buildings used for storage, handling manufacturing or processing of highly combustible or explosive material are called Hazardous buildings.

1.1.2 Based on type of construction

1. **Building with type 1 construction**: - In these building the design and material used const. are such that all structural components have about 4 hours fire resistance. Buildings with type 2 construction: - In these building the design any type of material used in their construction are such that all structural components have 3 hours fire resistance.
2. **Buildings with type 3 construction**: - In these building the design and types of the materials used in their construction are such that all structural components have 3 hours fire resistance.
3. **Buildings with type 4 construction**: - In these buildings the design and the type of material used in their construction are such that all structural components have 4 hours fire resistance.

1.2 PARTS OF A BUILDING

A building can be divided into two parts: -

1. **Sub structure**: - The part of a building constructed beneath the ground level is known as Sub structure.
2. **Super structure**: - The part of the building constructed above ground level is known as super structure. It is second part of a building. All the activities of the building construction take place after the making of sub-structure. Flooring, wall roofing are the example of super structure of a building.

1.3 COMPONENTS OF A BUILDING

1. **FOUNDATION**: - It is the lowest part of a structure below the ground level which is direct contact with ground and transmitted all the dead, live and other loads to the soil on which the structure rests.
2. **PLINTH**: - The portion of a building and the top of the floor immediately above the ground is known as plinth. The level of the surrounding ground is known as formation level of the ground floor of the building is known as plinth level.
3. **WALLS**: - Walls are provided to enclose or divide the floor space n desired pattern in addition wall provided privacy security and give protection against sun, rain, cold and other undesired effect of the weather.
4. **COLUMN**: - A column may be defined as an isolated load bearing member, the width of which is neither less than its thickness. It carries the axially compressive load.
5. **FLOORS**: - Floors are flat supporting elements of a building. They divided a building into different levels. There by creating more accommodation on a given plot of land. The basic purpose of a floor is to provide a firm and other items like stores, furniture, equipment etc.
6. **DOORS, WINDOWS AND VENTILATORS**: - A door may be defined as a barrier secured in an opening left in a wall to provide usual means of access to a building, room or passage. Windows and ventilators are provided for sun light, fresh air and ventilation purposes.
7. **ROOF**: - It is the uppermost component of a building and its function is to cover the space below it of a room and protect it from rain, snow, sun, wind etc.
8. **BUILDING FINISHES**: - A building is considered incomplete till such time the surface of its components is given appropriate treatment.

   Building finishes include items like plastering, painting, pointing, white / colour washing, varnishes and distempering etc.

1.4 TYPES OF LOADS

1. **DEAD LOAD: -** Dead loads are permanent or stationary loads which are transferred to the structure throughout their life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipment and weighs of different materials.
2. **LIVE LOAD**: - Live loads are those loads which are transient and can change in magnitude. They include all objects found with in a building during its life as well as external environmental effects such as loads due to the sun,earth or weather. Wind and earth quake loads are put into the special category of lateral live loads due to the severity of their action upon a building and their potential to cause failure.

IS: 875 (part-II) deals with the imposed loads on roofs, floors, stairs, balconies, etc., for various occupancies.

2. The Plan of the building

The building to be constructed should have a proper plan, which should be in accordance with Ministry of Urban Development Bye-laws (MoUD Bye-laws) - which state the following.

1. Maximum Ground Coverage -33.33%
2. Maximum Floor Area Ratio - 100%
3. Maximum Height- 26m
4. Minimum Area per person- 4.9 sqmt
5. Minimum Width of Passageway -1.25mt
6. Minimum width of exits- 2 m
7. Minimum width of stairway- 1.25m
8. Minimum Bath & Toilet Conditions -1 for 6 persons.

Therefore the plan for the hostel designed according to the requirements given above.

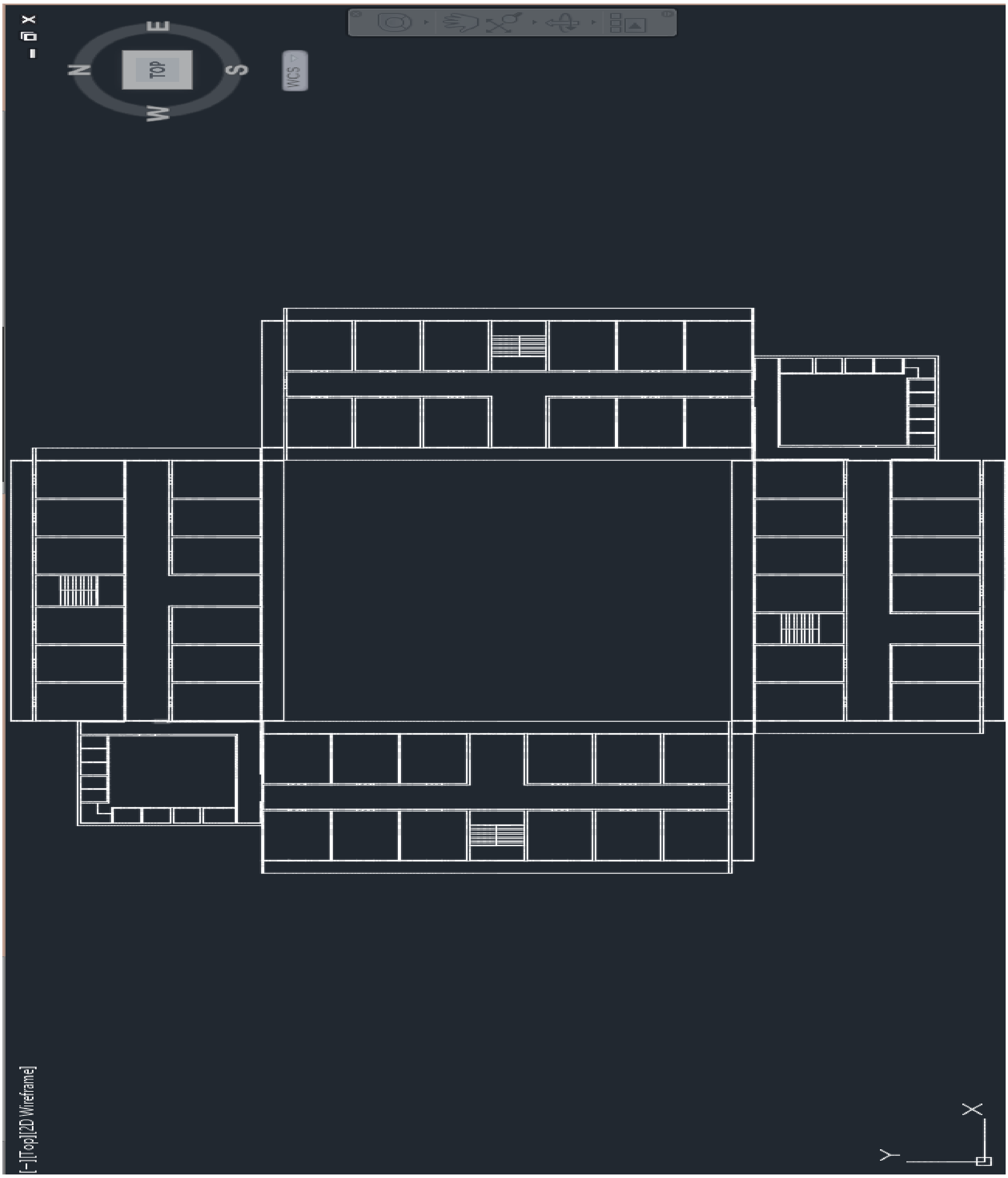


Fig. 1 Plan – 1st Floor

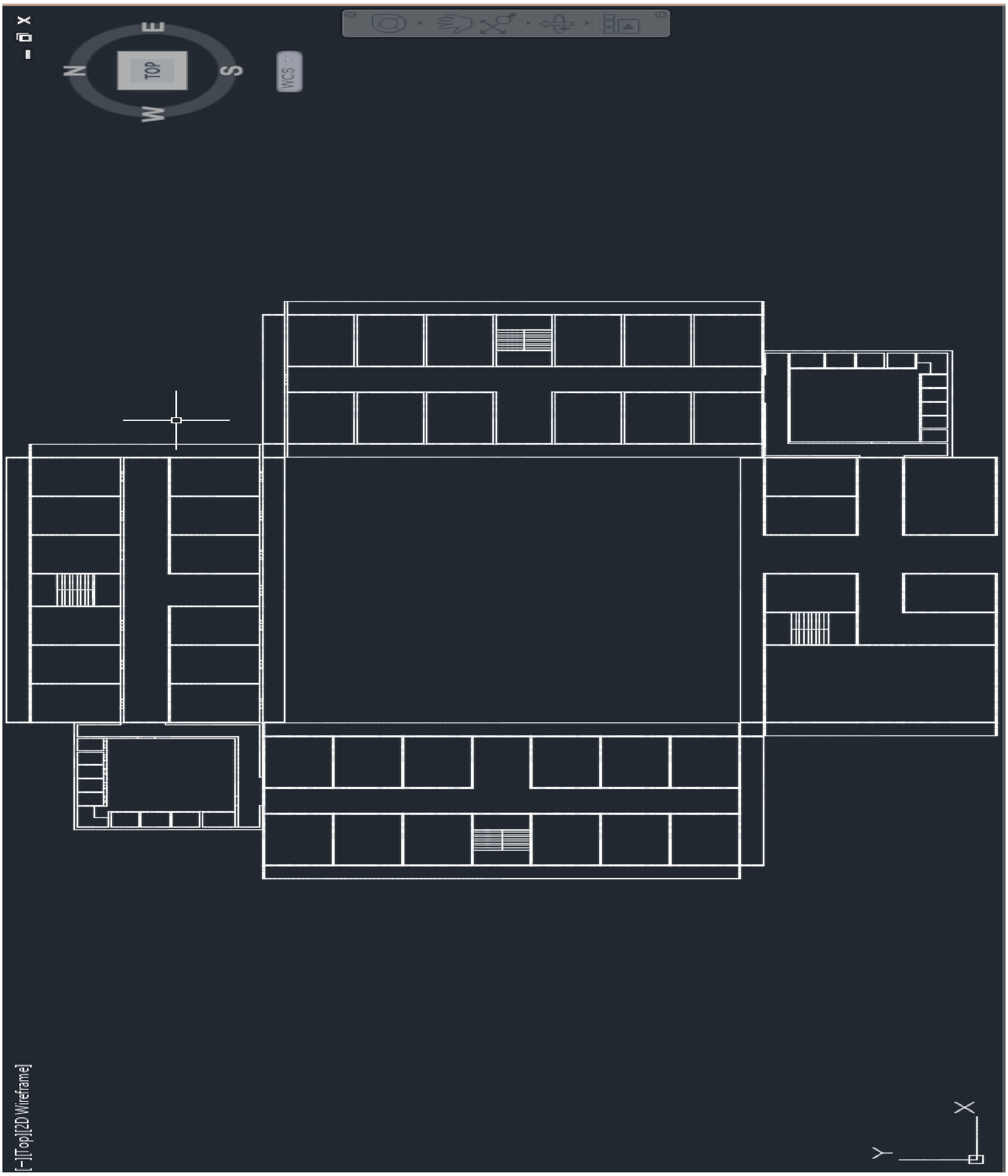


Fig. 2 Plan – Ground Floor

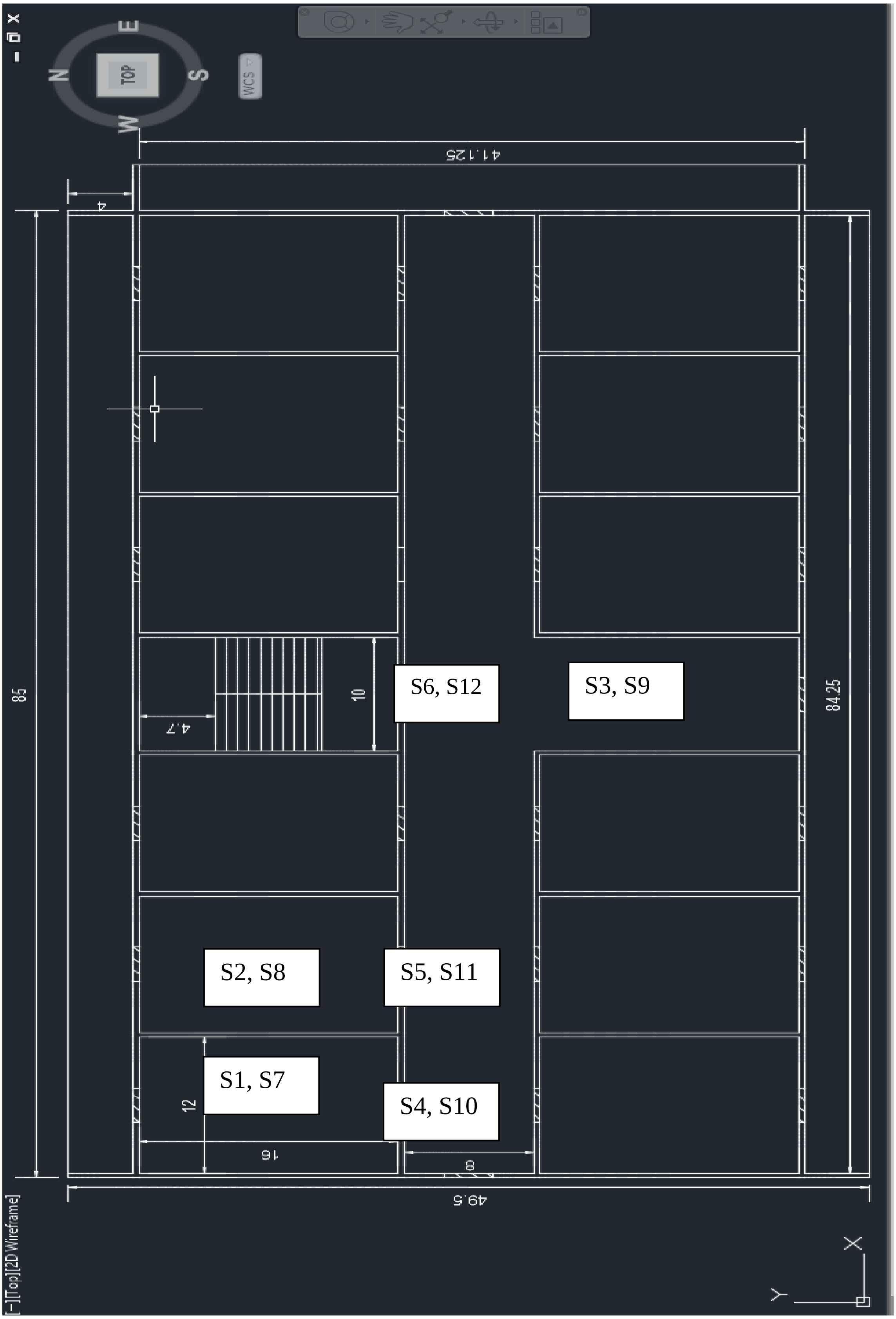


Fig. 3 Detailed Plan of all floors of 3 blocks.

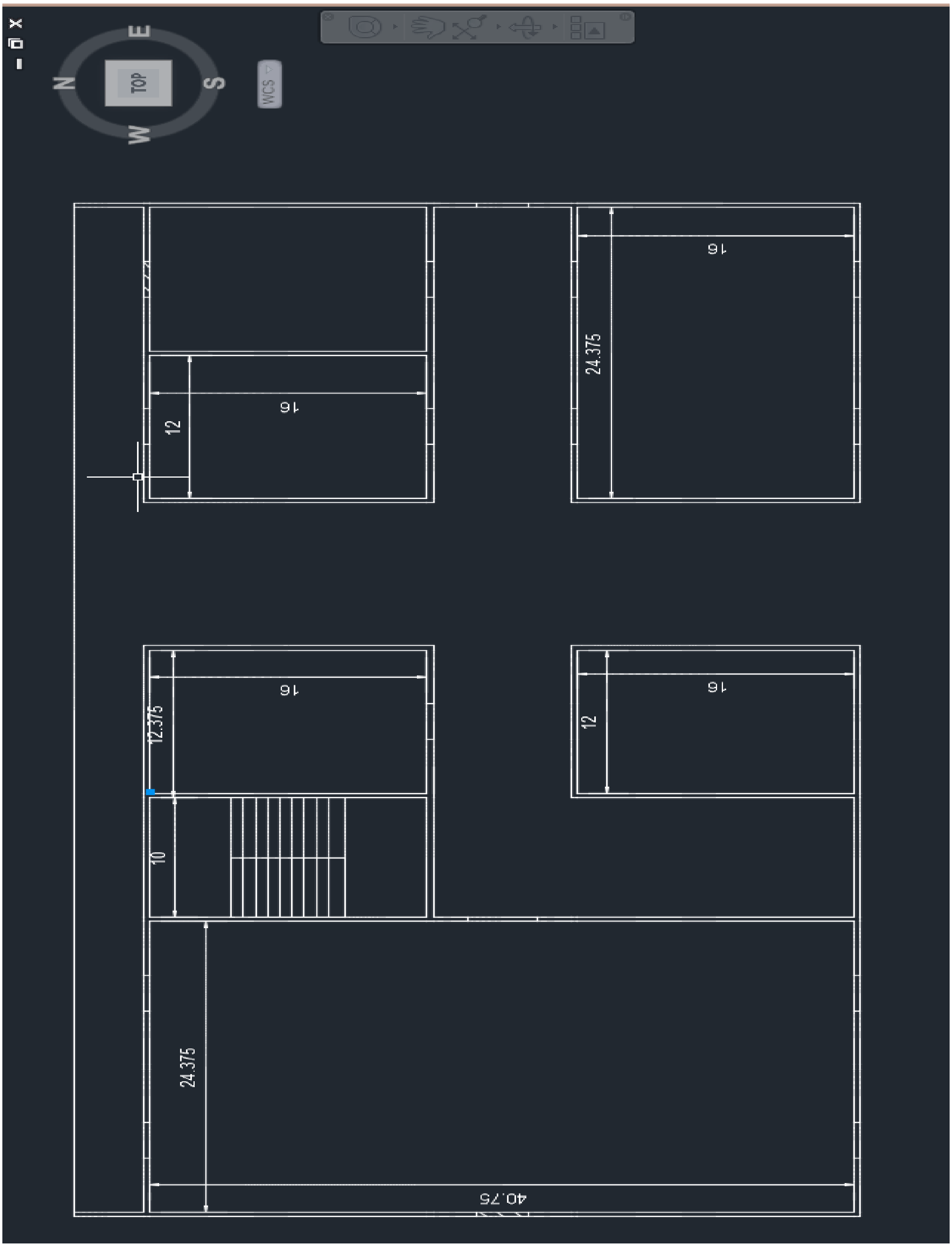


Fig. 4 Detailed Plan of Ground Floor Block 2

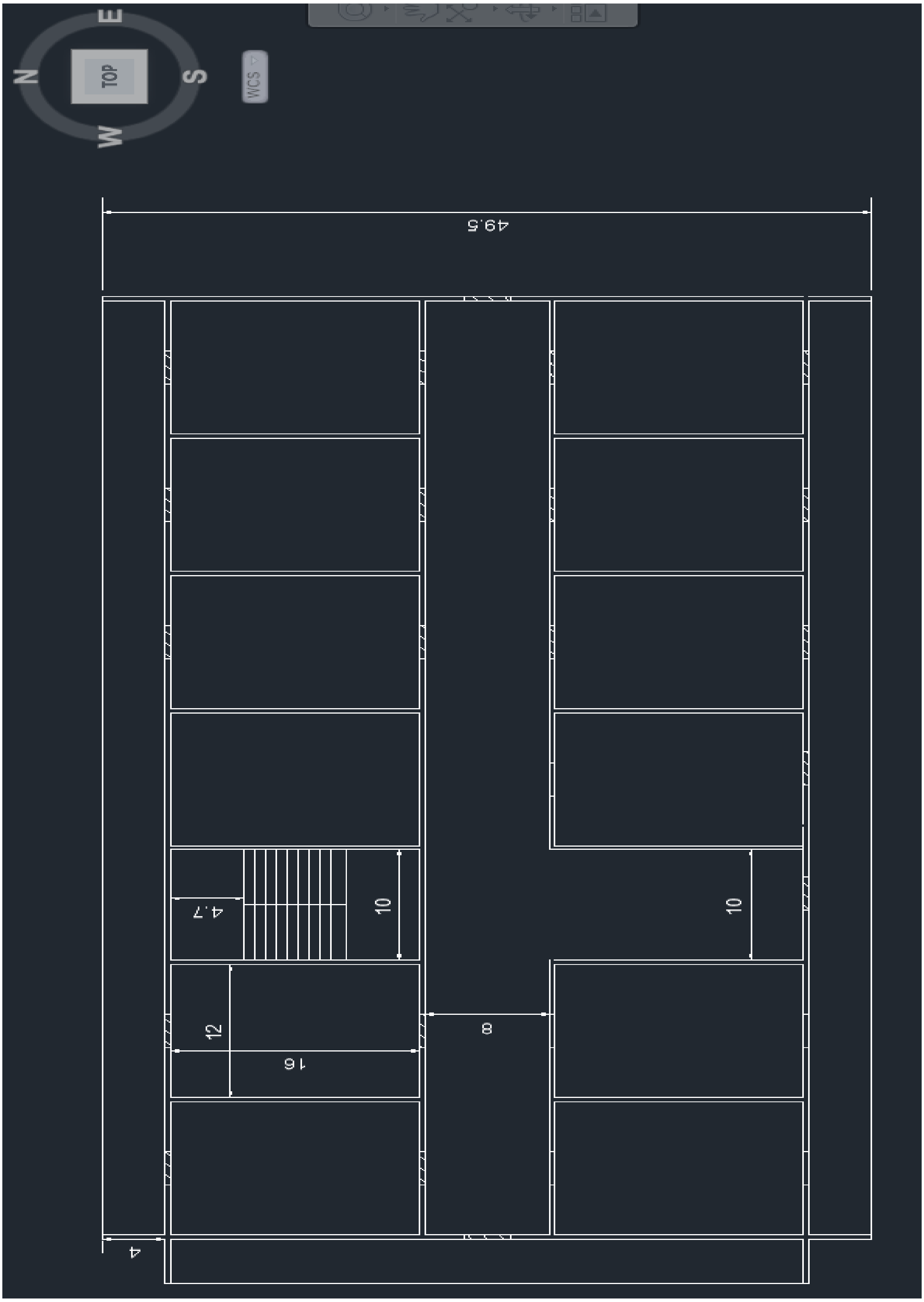


Fig. 5 Detailed plan of Block 2, first floor and above.

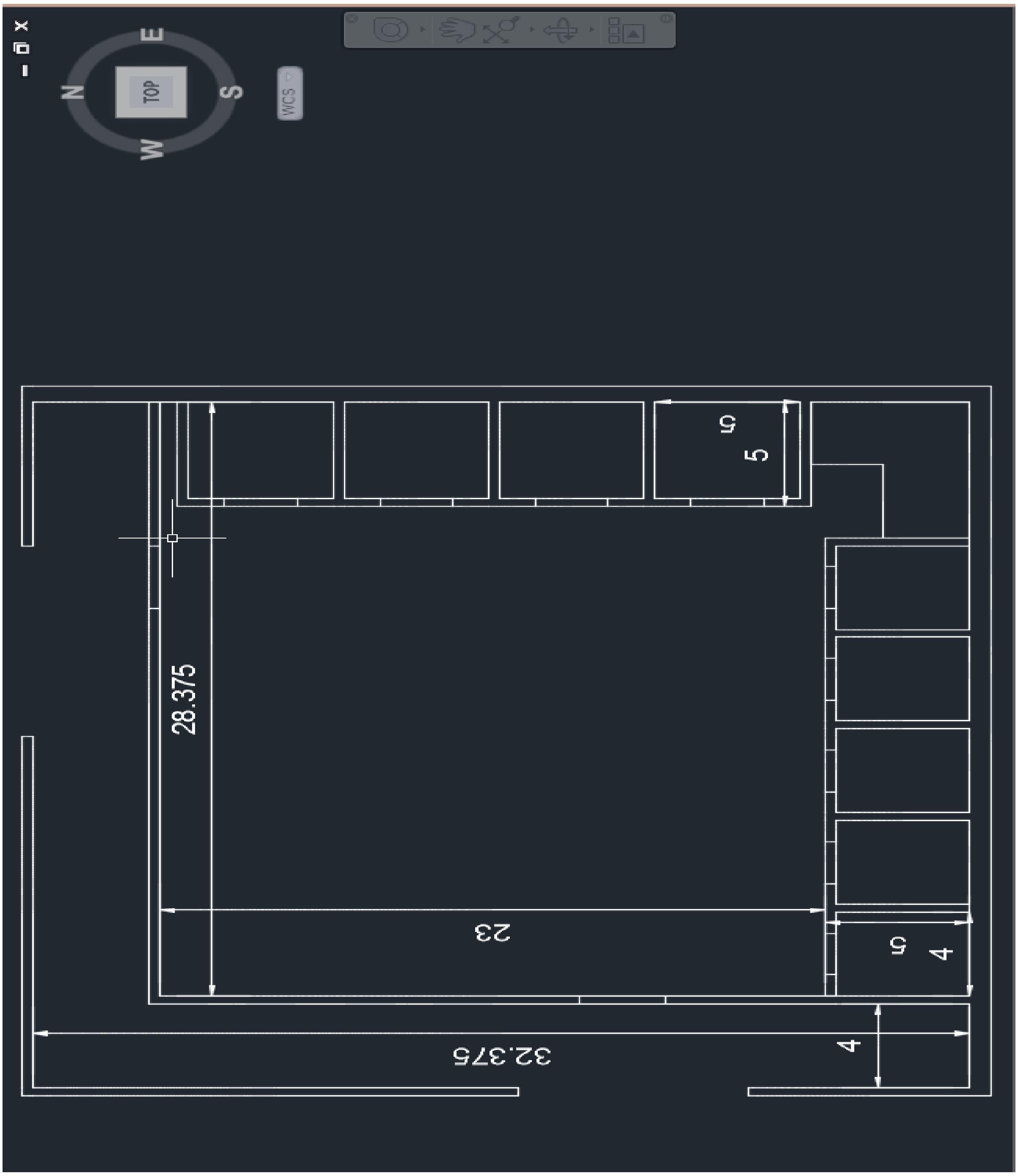


Fig. 6 Detailed Plan of Bath and Toilets.

Therefore the design of the Beams, Columns & slabs will be based upon the above Plan.

3. DESIGN OF SLAB

3.1 GENERAL

A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. It provides a working flat surface or a covering shelter in buildings. It primarily transfers the load by bending in one or two directions. Reinforced concrete slabs are used in floors, roofs and walls of buildings and as the decks of bridges. The floor system of a structure can take many forms such as in situ solid slab, ribbed slab or pre-cast units. Slabs may be supported on monolithic concrete beam, steel beams, walls or directly over the columns.

Concrete slab behave primarily as flexural members and the design is similar to that of beams.

3.2 CLASSIFICATION OF SLABS

1) **Two way slabs:** There are two types of two way slabs
   a) **Two way simply supported slabs: -**The bending moments Mx and My for a rectangular slabs simply supported on all four edges with corners free to lift or the slabs do not having adequate provisions to prevent lifting of corners are obtained using coefficients given in Table 1 (Table 27,IS 456-2000)
   b) **Two way Restrained slabs: -**When the two way slabs are supported on beam or when the corners of the slabs are prevented from lifting the bending moment coefficients are obtained from Table 2 (Table 26, IS456-2000) depending on the type of boundary conditions. These coefficients are obtained using yield line theory. Since, the slabs are restrained; negative moment arises near the supports. We have considered our slabs to be restrained.

We have divided the design of slab on the type of boundary conditions for two way slabs.

2) **One way slabs: -** The slabs spanning in one direction and continuous over supports are called one way continuous slabs. These are idealized as continuous beam of unit width. For slabs of uniform section which support substantially UDL over three or more spans which do not differ by more than 15% of the longest, the B.M and S.F are obtained using the coefficients available in Table 12 and Table 13 of IS 456-2000. For

moments at supports where two unequal spans meet or in case where the slabs are not equally loaded, the average of the two values for the negative moments at supports may be taken. Alternatively, the moments may be obtained by moment distribution or any other methods.

The design of the slabs will be in accordance to Indian Standard Code 456-2000. The Floor Slabs have been divided into 6 different types depending upon the types and number of free edges.

1) S1- One Long Edge Discontinuous (4.8*3.6)
2) S2-Interior Panel (4.8*3.6)
3) S3-Interior Panel (3.6*3)
4) S4- One Short Edge Discontinuous (3.6*2.4)
5) S5- Interior Panel (3.6*2.4)
6) S6- One Long Edge Discontinuous (3*2.4)

Similarly the Roof Slabs have been separated into 6 different slabs.

The Loads acting upon the Structure have been taken & calculated form Indian Standard code 875 part I-1987 and IS 875 part II-1987, taking the values of dead load and Live load applicable on the building respectively.

Thus the values of the loads taken are as follows-

1) Live Load Applicable on the structure
   a) Room Floors – 2kn/m
   b) Baths & toilets- 2kN/m
   c) Balconies- 4kN/m
   d) Roof slab (Access Provided) -1kN/m
2) Dead Load Applicable –
   a. Partition wall -5.73 kN/m
   b. Floor finishes (Rooms) – 1kN/m
   c. Floor Finish (Roof)- 0.5kN/m

Thus the design of Floor and Roof Slabs are as Follows:-

3.3 DESIGN OF SLAB (S1)

1	**Trail depth and effective span**				
	Clear span	length	4.8	m	
		width	3.6	m	
		L/B ratio	1		
		Type of slab	two way		
	From deflection criteria {l/d=26*m}	depth	123.40	mm	
		D	150	mm	
		deff	118	mm	
		Ly	4.918	m	
		Lx	3.718	m	
		α(ly/lx)	1.3		
2	**LOAD ON SLAB**				
		Self Weight	3.75	KN/m^2	
		Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS(RESIDENTIAL)
		floor finish	1	KN/m^2	
		Ultimate Load W	10.125	KN/m^2	IS 875 part 2
		αx(+)	0.044		**The boundary condition of slab in one Long Edge discontinuous (case 3, Table 26) IS 456-2000**
		αy(+)	0.028		
3	**positive moment at mid span**				
		short span	6.16	KN/m^2	
		long span	6.86	KN/m^2	
4	**negative moment at edges**				
		short span	8.21	KN/m^2	as αx(-)=4*αx(+)/3
		long span	9.14	KN/m^2	
5	**Minimum depth required from Maximum BM consideration**				
		d'	52.437	mm	
			design is safe		

KNOWN DATA

M25

FE 500

MONOLITHIC

clear cover 20(mild exposure)

density of conc.=25 kn/m3

dia of main bars =12mm

bc 1 :one Long Edge discontinuous (4.8x3.6)

modification factor=1.2

assuming width of beam=230mm

taking dia of bars as 12 mm

6 area of reinforcement(per m width)

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

short span	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m
long span			
	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m

7 spacing of bars

providing bars of dia		12	mm
	spacing for short span M(+)	300.000	mm/m
	spacing for short span M(-)	300.000	mm/m
	spacing for long span M(+)	300.000	mm/m
	spacing for long span M(-)	300.000	mm/m

check : less than 300mm or 3d whichever is less

300

8 check for cracking

steel should be more than 0.15% of the gross area = 225 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	168.750	mm^2/m
at corner with one edges discontinuous ast=	84.375	mm^2/m

3.4 DESIGN OF SLAB (S2)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	4.8	m		**FE 500**
		width	3.6	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	1			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :Interior Panel (4.8x3.6)
	From deflection criteria {l/d=26*m}	depth	123.40	mm		**modification factor=1.2**
		D	150	mm	**assuming width of beam=230mm**	
		deff	118	mm	**taking dia of bars as**	**12 mm**
		Ly	4.918	m		
		Lx	3.718	m		
		α(ly/lx)	1.3			
2	**LOAD ON SLAB**					
		Self Weight	2	KN/m^2		
		Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS(RESIDENTIAL)	
		floor finish	1	KN/m^2		
		Ultimate Load W	7.5	KN/m^2	(Access provided)	IS 875 part 2
		αx(+)	0.036		**The boundary condition of Interior slab**	
		αy(+)	0.024		**(case 1, Table 26)**	**IS 456-2000**
3	**positive moment at mid span**					
		short span	3.73	KN/m^2		
		long span	4.35	KN/m^2		
4	**negative moment at edges**					
		short span	4.98	KN/m^2	as αx(-)=4*αx(+)/3	
		long span	5.80	KN/m^2		
5	**Minimum depth required from Maximum BM consideration**					
		d'	41.783	mm		

design is safe

6 area of reinforcement(per m width)

short span	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m
long span			
	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m

7 spacing of bars

providing bars of dia	12	mm		
	spacing for short span M(+)	300.000	mm/m	**check : less than 300mm or 3d whichever is less**
	spacing for short span M(-)	300.000	mm/m	
	spacing for long span M(+)	300.000	mm/m	
	spacing for long span M(-)	300.000	mm/m	**300**

8 check for cracking

steel should be more than 0.15% of the gross area = 225 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	168.750	mm^2/m
at corner with one edges discontinuous ast=	84.375	mm^2/m

3.5 DESIGN OF SLAB (S3)

KNOWN DATA

M25
FE 500
MONOLITHIC
clear cover 20(mild exposure)
density of conc.=25 kn/m3
dia of main bars =16mm
bc 1 :Interior Panel (3.6x3)
modification factor=1.2

1 Trail depth and effective span

Clear span	length	3.6	m	
	width	3	m	
	L/B ratio	1		
	Type of slab	two way		
From deflection criteria {l/d=26*m}	depth	104.17	mm	
	D	130	mm	**assuming width of beam=230mm**
	deff	98	mm	**taking dia of bars as 12 mm**
	Ly	3.698	m	
	Lx	3.098	m	
	α(ly/lx)	1.2		

2 LOAD ON SLAB

Self Weight	3.25	KN/m^2	
Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS(RESIDENTIAL)
floor finish	1	KN/m^2	
Ultimate Load W	9.375	KN/m^2	(Access provided) IS 875 part 2
αx(+)	0.032		**The boundary condition of Interior slab**
αy(+)	0.024		**(case 1, Table 26) IS 456-2000**

3 positive moment at mid span

short span	2.88	KN/m^2
long span	3.08	KN/m^2

4 negative moment at edges

short span	3.84	KN/m^2	as αx(-)=4*αx(+)/3
long span	4.10	KN/m^2	

5 Minimum depth required from Maximum BM consideration

d'	35.126	mm

design is safe

6 area of reinforcement(per m width)

short span	ast for + moment	195.000	mm^2/m
	ast for - moment	195.000	mm^2/m
long span			
	ast for + moment	195.000	mm^2/m
	ast for - moment	195.000	mm^2/m

7 spacing of bars

providing bars of dia 12 mm

spacing for short span M(+)	294.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	294.000	mm/m	
spacing for long span M(+)	294.000	mm/m	
spacing for long span M(-)	294.000	mm/m	**294**

8 check for cracking

steel should be more than 0.15% of the gross area = 195 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	146.250	mm^2/m
at corner with one edges discontinuous ast=	73.125	mm^2/m

3.6 DESIGN OF SLAB (S4)

1	**Trail depth and effective span**				KNOWN DATA: **M25**
	Clear span	length	3.6	m	**FE 500**
		width	2.4	m	**MONOLITHIC**
					clear cover 20(mild exposure)
		L/B ratio	2		**density of conc.=25 kn/m3**
		Type of slab	two way		**dia of main bars =12mm**
					bc 1 :one Short Edge discontinuous (3.6x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm	**modification factor=1.2**
		D	110	mm	**assuming width of beam=230mm**
		deff	78	mm	**taking dia of bars as 12 mm**
		Ly	3.678	m	
		Lx	2.478	m	
		α(ly/lx)	1.5		
2	**LOAD ON SLAB**				
		Self Weight	2.75	KN/m^2	
		Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS(RESIDENTIAL)
		floor finish	1	KN/m^2	
		Ultimate Load W	8.625	KN/m^2	(Access provided) IS 875 part 2
		αx(+)	0.051		**The boundary condition of slab in one Short Edge discontinuous (Table 26) IS 456-2000**
		αy(+)	0.028		
3	**positive moment at mid span**				
		short span	2.70	KN/m^2	
		long span	3.27	KN/m^2	
4	**negative moment at edges**				
		short span	3.60	KN/m^2	as αx(-)=4*αx(+)/3
		long span	4.36	KN/m^2	
5	**Minimum depth required from Maximum BM consideration**				
		d'	36.195	mm	

design is safe

6 area of reinforcement(per m width)

short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m
long span			
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m

7 spacing of bars

providing bars of dia	12	mm		
spacing for short span M(+)		234.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)		234.000	mm/m	
spacing for long span M(+)		234.000	mm/m	
spacing for long span M(-)		234.000	mm/m	**234**

8 check for cracking

steel should be more than 0.15% of the gross area = 165 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm^2/m

3.7 DESIGN OF SLAB (S5)

1	**Trail depth and effective span**				KNOWN DATA: **M25**
	Clear span	length	3.6	m	**FE 500**
		width	2.4	m	**MONOLITHIC**
					clear cover 20(mild exposure)
		L/B ratio	2		**density of conc.=25 kn/m3**
		Type of slab	two way		**dia of main bars =12mm**
					bc 1 :Interior Panel (3.6x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm	**modification factor=1.2**
		D	110	mm	**assuming width of beam=230mm**
		deff	78	mm	**taking dia of bars as 12 mm**
		Ly	3.678	m	
		Lx	2.478	m	
		α(ly/lx)	1.5		
2	**LOAD ON SLAB**				
		Self Weight	2.75	KN/m^2	
		Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS (RESIDENTIAL)
		floor finish	1	KN/m^2	
		Ultimate Load W	8.625	KN/m^2	(Access provided) IS 875 part 2
		αx(+)	0.041		**The boundary condition of Interior slab**
		αy(+)	0.024		**case 3 (Table 26) IS 456-2000**
3	**positive moment at mid span**				
		short span	2.17	KN/m^2	
		long span	2.80	KN/m^2	
4	**negative moment at edges**				
		short span	2.90	KN/m^2	as αx(-)=4*αx(+)/3
		long span	3.73	KN/m^2	
5	**Minimum depth required from Maximum BM consideration**				
		d'	33.510	mm	
			design is safe		

6 area of reinforcement(per m width)

			mm^2/m
short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	
long span			mm^2/m
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	

7 spacing of bars

providing bars of dia		12	mm	mm/m	
	spacing for short span M(+)	234.000		mm/m	**check : less than 300mm or 3d whichever is less**
	spacing for short span M(-)	234.000		mm/m	
	spacing for long span M(+)	234.000		mm/m	
	spacing for long span M(-)	234.000			**234**

8 check for cracking

		mm^2/m
steel should be more than 0.15% of the gross area =	165	
	ok	

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers		mm^2/m
at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm2/m

3.8 DESIGN OF SLAB (S6)

1	**Trail depth and effective span**				**KNOWN DATA** — **M25**
	Clear span	length	3	m	**FE 500**
		width	2.4	m	**MONOLITHIC**
					clear cover 20(mild exposure)
		L/B ratio	1		**density of conc.=25 kn/m3**
		Type of slab	two way		**dia of main bars =12mm**
					bc 1 :One Long edge discontinous(3x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm	**modification factor=1.2**
		D	110	mm	**assuming width of beam=230mm**
		deff	78	mm	**taking dia of bars as 12 mm**
		Ly	3.078	m	
		Lx	2.478	m	
		α(ly/lx)	1.2		
2	**LOAD ON SLAB**				
		Self Weight	2.75	KN/m^2	
		Imposed Load	2	KN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF FLOORS(RESIDENTIAL)
		floor finish	1	KN/m^2	
		Ultimate Load W	8.625	KN/m^2	(Access provided) IS 875 part 2
		αx(+)	0.041		**The boundary condition of slab in one Long Edge discontinuous (case 3, Table 26) IS 456-2000**
		αy(+)	0.024		
3	**positive moment at mid span**				
		short span	2.17	KN/m^2	
		long span	1.96	KN/m^2	
4	**negative moment at edges**				
		short span	2.90	KN/m^2	as αx(-)=4*αx(+)/3
		long span	2.61	KN/m^2	
5	**Minimum depth required from Maximum BM consideration**				
		d'	29.508	mm	
			design is safe		

6 area of reinforcement(per m width)

short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m
long span			
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m

7 spacing of bars

providing bars of dia 12 mm

spacing for short span M(+)	234.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	234.000	mm/m	
spacing for long span M(+)	234.000	mm/m	
spacing for long span M(-)	234.000	mm/m	**234**

8 check for cracking

steel should be more than 0.15% of the gross area = 165 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers		
at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm^2/m

3.9 DESIGN OF ROOF SLAB (S7)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	4.8	m		**FE 500**
		width	3.6	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	1			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :one Long Edge discontinuous (4.8x3.6)
	From deflection criteria {l/d=26*m}	depth	123.40	mm		**modification factor=1.2**
		D	150	mm		**assuming width of beam=230mm**
		deff	118	mm	**taking dia of bars as**	**12 mm**
		Ly	4.918	m		
		Lx	3.718	m		
		α(ly/lx)	1.3			
2	**LOAD ON SLAB**					
		Self Weight	3.75	kN/m^2		
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS	
		floor finish	0.5	kN/m^2		
		Ultimate Load W	7.875	kN/m^2	IS 875 part 2	
		αx(+)	0.044		**The boundary condition of slab in one Long Edge discontinuous (case 3, Table 26) IS 456-2000**	
		αy(+)	0.028			
3	**positive moment at mid span**					
		short span	4.79	kN/m^2		
		long span	5.33	kN/m^2		
4	**negative moment at edges**					
		short span	6.39	kN/m^2		
		long span	7.11	kN/m^2	as αx(-)=4*αx(+)/3	
5	**Minimum depth required from Maximum BM consideration**					
		d'	46.245	mm		
			design is safe			

6 area of reinforcement(per m width)

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

short span	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m
long span			
	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m

7 spacing of bars

providing bars of dia 12 mm

check : less than 300mm or 3d whichever is less

spacing for short span M(+)	300.000	mm/m
spacing for short span M(-)	300.000	mm/m
spacing for long span M(+)	300.000	mm/m
spacing for long span M(-)	300.000	mm/m

300

8 check for cracking

steel should be more than 0.15% of the gross area = 225 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	168.750	mm^2/m
at corner with one edges discontinuous ast=	84.375	mm^2/m

3.10 DESIGN OF ROOF SLAB (S8)

1	**Trail depth and effective span**				KNOWN DATA — **M25**
	Clear span	length	4.8	m	**FE 500**
		width	3.6	m	**MONOLITHIC**
					clear cover 20(mild exposure)
		L/B ratio	1		**density of conc.=25 kn/m3**
		Type of slab	two way		**dia of main bars =12mm**
					bc 1 :Interior Panel (4.8x3.6)
	From deflection criteria {l/d=26*m}	depth	123.40	mm	**modification factor=1.2**
		D	150	mm	**assuming width of beam=230mm**
		deff	118	mm	**taking dia of bars as 12 mm**
		Ly	4.918	m	
		Lx	3.718	m	
		α(ly/lx)	1.3		
2	**LOAD ON SLAB**				
		Self Weight	3.75	kN/m^2	
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS
		floor finish	0.5	kN/m^2	
		Ultimate Load W	7.875	kN/m^2	(Access provided) IS 875 part 2
		αx(+)	0.036		**The boundary condition of Interior slab**
		αy(+)	0.024		**(case 1, Table 26) IS 456-2000**
3	**positive moment at mid span**				
		short span	3.92	kN/m^2	
		long span	4.57	kN/m^2	
4	**negative moment at edges**				
		short span	5.23	kN/m^2	as αx(-)=4*αx(+)/3
		long span	6.10	kN/m^2	
5	**Minimum depth required from Maximum BM consideration**				
		d'	42.815	mm	
			design is safe		

6 area of reinforcement(per m width)

short span	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m
long span			
	ast for + moment	225.000	mm^2/m
	ast for - moment	225.000	mm^2/m

7 spacing of bars

providing bars of dia **12** mm

spacing for short span M(+)	300.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	300.000	mm/m	
spacing for long span M(+)	300.000	mm/m	
spacing for long span M(-)	300.000	mm/m	**300**

8 check for cracking

steel should be more than 0.15% of the gross area = 225 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	168.750	mm^2/m
at corner with one edges discontinuous ast=	84.375	mm^2/m

3.11 DESIGN OF ROOF SLAB (S9)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	3.6	m		**FE 500**
		width	3	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	1			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :Interior Panel (3.6x3)
	From deflection criteria {l/d=26*m}	depth	104.17	mm		**modification factor=1.2**
		D	130	mm	**assuming width of beam=230mm**	
		deff	98	mm	**taking dia of bars as**	**12 mm**
		Ly	3.698	m		
		Lx	3.098	m		
		α(ly/lx)	1.2			
2	**LOAD ON SLAB**					
		Self Weight	3.25	kN/m^2		
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS	
		floor finish	0.5	kN/m^2		
		Ultimate Load W	7.125	kN/m^2	(Access provided)	IS 875 part 2
		αx(+)	0.032		**The boundary condition of Interior slab**	
		αy(+)	0.024		**(case 1, Table 26)**	**IS 456-2000**
3	**positive moment at mid span**					
		short span	2.19	kN/m^2		
		long span	2.34	kN/m^2		
4	**negative moment at edges**					
		short span	2.92	kN/m^2	as αx(-)=4*αx(+)/3	
		long span	3.12	kN/m^2		
5	**Minimum depth required from Maximum BM consideration**					
		d'	30.622	mm		
			design is safe			

6 area of reinforcement(per m width)

short span	ast for + moment	195.000	mm^2/m
	ast for - moment	195.000	mm^2/m
long span			
	ast for + moment	195.000	mm^2/m
	ast for - moment	195.000	mm^2/m

7 spacing of bars

providing bars of dia 12 mm

spacing for short span M(+)	294.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	294.000	mm/m	
spacing for long span M(+)	294.000	mm/m	
spacing for long span M(-)	294.000	mm/m	**294**

8 check for cracking

steel should be more than 0.15% of the gross area = 195 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	146.250	mm^2/m
at corner with one edges discontinuous ast=	73.125	mm^2/m

3.12 DESIGN OF ROOF SLAB (S10)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	3.6	m		**FE 500**
		width	2.4	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	2			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :one Short Edge discontinuous (3.6x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm		**modification factor=1.2**
		D	110	mm		**assuming width of beam=230mm**
		deff	78	mm	**taking dia of bars as**	**12 mm**
		Ly	3.678	m		
		Lx	2.478	m		
		α(ly/lx)	1.5			
2	**LOAD ON SLAB**					
		Self-Weight	2.75	kN/m^2		
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS	
		floor finish	0.5	kN/m^2		
		Ultimate Load W	6.375	kN/m^2	(Access provided)	IS 875 part 2
		αx(+)	0.051		**The boundary condition of slab in one Short Edge discontinuous (Table 26) IS 456-2000**	
		αy(+)	0.028			
3	**positive moment at mid span**					
		short span	2.00	kN/m^2		
		long span	2.41	kN/m^2		
4	**negative moment at edges**					
		short span	2.66	kN/m^2	as αx(-)=4*αx(+)/3	
		long span	3.22	kN/m^2		
5	**Minimum depth required from Maximum BM consideration**					
		d'	31.117	mm		

design is safe

6 area of reinforcement(per m width)

short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m
long span			
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m

7 spacing of bars

providing bars of dia		16	mm		
	spacing for short span M(+)		234.000	mm/m	**check : less than 300mm or 3d whichever is less**
	spacing for short span M(-)		234.000	mm/m	
	spacing for long span M(+)		234.000	mm/m	
	spacing for long span M(-)		234.000	mm/m	**234**

8 check for cracking

steel should be more than 0.15% of the gross area = 165 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm^2/m

3.13 DESIGN OF ROOF SLAB (S11)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	3.6	m		**FE 500**
		width	2.4	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	2			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :Interior Panel (3.6x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm		**modification factor=1.2**
		D	110	mm	**assuming width of beam=230mm**	
		deff	78	mm	**taking dia of bars as**	**12 mm**
		Ly	3.678	m		
		Lx	2.478	m		
		α(ly/lx)	1.5			
2	**LOAD ON SLAB**					
		Self Weight	2.75	kN/m^2		
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS	
		floor finish	0.5	kN/m^2		
		Ultimate Load W	6.375	kN/m^2	(Access provided)	IS 875 part 2
		αx(+)	0.041		**The boundary condition of Interior slab**	
		αy(+)	0.024		**case 3 (Table 26)**	**IS 456-2000**
3	**positive moment at mid span**					
		short span	1.60	kN/m^2		
		long span	2.07	kN/m^2		
4	**negative moment at edges**					
		short span	2.14	kN/m^2	as αx(-)=4*αx(+)/3	
		long span	2.76	kN/m^2		
5	**Minimum depth required from Maximum BM consideration**					
		d'	28.809	mm		
			design is safe			

6 area of reinforcement(per m width)

short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m
long span			
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m

7 spacing of bars

providing bars of dia 12 mm

spacing for short span M(+)	234.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	234.000	mm/m	
spacing for long span M(+)	234.000	mm/m	
spacing for long span M(-)	234.000	mm/m	**234**

8 check for cracking

steel should be more than 0.15% of the gross area = 165 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm^2/m

3.14 DESIGN OF ROOF SLAB (S12)

1	**Trail depth and effective span**				KNOWN DATA	**M25**
	Clear span	length	3	m		**FE 500**
		width	2.4	m		**MONOLITHIC**
						clear cover 20(mild exposure)
		L/B ratio	1			**density of conc.=25 kn/m3**
		Type of slab	two way			**dia of main bars =12mm**
						bc 1 :One Long edge discontinous(3x2.4)
	From deflection criteria {l/d=26*m}	depth	84.94	mm		**modification factor=1.2**
		D	110	mm		**assuming width of beam=230mm**
		deff	78	mm	**taking dia of bars as**	**12 mm**
		Ly	3.078	m		
		Lx	2.478	m		
		α(ly/lx)	1.2			
2	**LOAD ON SLAB**					
		Self Weight	2.75	kN/m^2		
		Imposed Load	1	kN/m^2	TABLE 2 IMPOSED LOADS ON VARIOUS TYPES OF ROOFS	
		floor finish	0.5	kN/m^2		
		Ultimate Load W	6.375	kN/m^2	(Access provided)	IS 875 part 2
		αx(+)	0.041		**The boundary condition of slab in one Long Edge discontinuous (case 3, Table 26) IS 456-2000**	
		αy(+)	0.024			
3	**positive moment at mid span**					
		short span	1.60	kN/m^2		
		long span	1.45	kN/m^2		
4	**negative moment at edges**					
		short span	2.14	kN/m^2	as αx(-)=4*αx(+)/3	
		long span	1.93	kN/m^2		
5	**Minimum depth required from Maximum BM consideration**					
		d'	25.369	mm		
			design is safe			

6 area of reinforcement(per m width)

short span	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m
long span			
	ast for + moment	165.000	mm^2/m
	ast for - moment	165.000	mm^2/m

7 spacing of bars

providing bars of dia 16 mm

spacing for short span M(+)	234.000	mm/m	**check : less than 300mm or 3d whichever is less**
spacing for short span M(-)	234.000	mm/m	
spacing for long span M(+)	234.000	mm/m	
spacing for long span M(-)	234.000	mm/m	**234**

8 check for cracking

steel should be more than 0.15% of the gross area = 165 mm^2/m

ok

9 torsional reinforcement at corners

mesh extending 0.2Lx on each side in 4 layers

at corner of two edges discontinuous ast =	123.750	mm^2/m
at corner with one edges discontinuous ast=	61.875	mm^2/m

4. Design of Beam

A beam is a structural element that is capable of withstanding load primarily by resisting bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment.

Beams are traditionally descriptions of building or civil engineering structural elements, but smaller structures such as truck or automobile frames, machine frames, and other mechanical or structural systems contain beam structures that are designed and analyzed in a similar fashion.

4.1 Types of Beams

In engineering, beams are of several types

1. Simply supported - a beam supported on the ends which are free to rotate and have no moment resistance.
2. Fixed - a beam supported on both ends and restrained from rotation.
3. Over hanging - a simple beam extending beyond its support on one end.
4. Double overhanging - a simple beam with both ends extending beyond its supports on both ends.
5. Continuous - a beam extending over more than two supports.
6. Cantilever - a projecting beam fixed only at one end.
7. Trussed - a beam strengthened by adding a cable or rod to form a truss.

The Design of the Beams is done according to norms detailed in IS code 456-2000, Cl-23.

For Simplification, Beams are grouped together according to the Length of the beam and load applicable on the beams.

Therefore for each floor, the different beams have been grouped together as follows:

S. No.	Length (m)	Loading
1	4.8	Having slab on two side
2	4.8	Having slab on one side
3	3.6	Having slab on two sides
4	3.6	Having slab on one side
5	3	Having slab on two side
6	3	Having slab on one side
7	2.5	Having slab on two side
8	2.5	Having slab on one side
9	1.2	Having slab on two side
10	.2	Having slab on one side

The loads taken for the design of beams are as follows

Thus the values of the loads taken are as follows-

1) Live Load Applicable on the structure
   a. Room Floors – 2kn/m
   b. Baths & toilets- 2kN/m
   c. Balconies- 4kN/m
   d. Roof slab (Access Provided) -1kN/m

2) Dead Load Applicable –
   a. Partition wall -5.73kN/m
   b. Floor finishes (Rooms) – 1kN/m
   c. Floor Finish (Roof)- 0.5kN/m
   d. Weight of Slab- 3.75kN/m (From the design of Slab)

4.2 Design and Detailing of Beams

4.2.1 Top floor Beams

Long T Beam (Room-Secondary)

1 Input Data

effective Length		4.92	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	25	mm
tensile steel	20	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		328	mm
effective depth (d)		330	mm
overall depth (D)		380	mm
depth of rib		230	mm
width of rib		250	mm
effective flange width (b_f)		1970	mm

3 Loads

factored	load from slab	7.875	kN/m
slab load transferred to beam		18.2	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		1.4375	kN/m

	Total Load (w)	20.38	kN/m

4 Factored Moment and Shaer forces

	Moment at span	61.7	kNm
	Moment at support	49.3	kNm
	Vu=0.5*w*L	50.1	kN

5 Main Reinforcements

xu,max = 0.48d		158.4	mm
is xu,max>Df		Yes	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	568.0692	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1970 mm

and d= 330 mm

Area of steel at span

Moment at span	4.92	kNm
Area of steel at span	526.35	mm2
No. of bars		2
Detailing		2
no. of bars of dia (mm)		20
Provided Steel mm^2		628

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

Area of steel at support

Moment at support	49.16	kNm
Area of steel at support	419.62	mm2
No. of bars		1
Detailing		1
no. of bars of dia (mm)		25
Provided Steel mm^2		491

provide 2 bars of 20 mm dia giving Ast = 628 mm2 on the tension side

1 hanger bars of 25 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	50.125725	kN
Nominal shear stress τv	0.608	N/mm2

if 1 bars of 20 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 628 mm2

percentage of steel pt 0.76 β 3.048727

τc 0.56 N/mm2

Shear reinforcement Required

Shear carried by bent bars is given by

Vus 160.41 kN

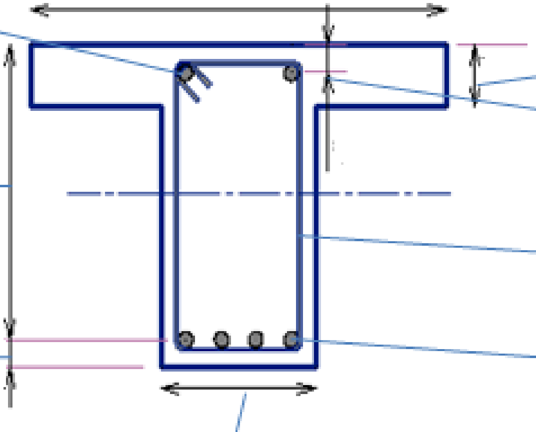
providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

spacing of stirrups sv 363 mm

Detailing

bf= 1970 mm

steel in compress 1 bars
25 mm



Df 150 mm

d'c 50 mm

d 330

8 mm
@ 363 mm

d't 50

Steel in tension 2 bars
20 mm diameter

bw 250 mm

Short T Beam (Room-Secondary)

1 Input Data

effective Length		3.72	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	4.92	m
width of lobby	2.52	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		248	mm
effective depth (d)		250	mm
overall depth (D)		300	mm
depth of rib		150	mm
width of rib		250	mm
effective flange width (b_f)		1770	mm

3 Loads

factored	load from slab 1	7.875	kN/m2
factored	load from slab 2	10.125	kN/m2
slab load transferred to beam		16.0	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.9375	kN/m
	Total Load (w)	17.38	kN/m

4 Factored Moment and Shaer forces

	Moment at span	30.1	kNm
	Moment at support	24.1	kNm
	Vu=0.5*w*L	32.3	kN

5 Main Reinforcements

xu,max = 0.48d		120	mm
is xu,max>Df		No	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	357.4692	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1770 mm

and d= 250 mm

Area of steel at span

Moment at span	3.72	kNm
Area of steel at span	338.55	mm2
No. of bars		2
Detailing		2
no. of bars of dia (mm)		16
Provided Steel mm^2		402

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

Area of steel at support

Moment at support	23.98	kNm

Area of steel at support	269.96	mm2
No. of bars		1
Detailing		1
no. of bars of dia (mm)		20
Provided Steel mm^2		314

provide 2 bars of 16 mm dia giving Ast = 402 mm2 on the tension side

1 hanger bars of 20 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	32.334525	kN
Nominal shear stress τv	0.517	N/mm2

if 1 bars of 16 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 402 mm2

percentage of steel pt 0.64 β 3.608815

τc 0.53 N/mm2

Shear reinforcement Not Required

Shear carried by bent bars is given by

Vus 102.66 kN

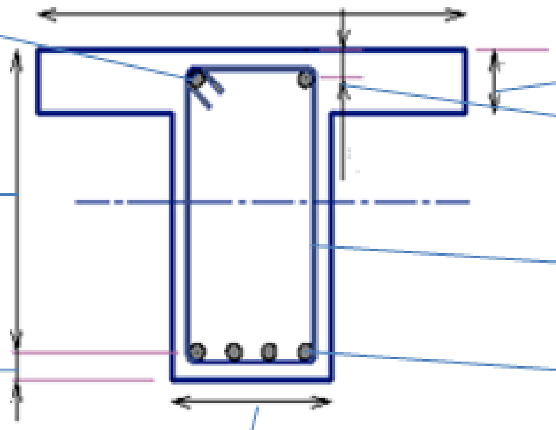
providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

spacing of stirrups sv 363 mm

Detailing

bf= 1770 mm

steel in compress 1 bars
20 mm



Df 150 mm

d'c 50 mm

d 250

8 mm
@ 363 mm

d't 50

Steel in tension 2 bars
16 mm diameter

bw 250 mm

T Beam (Lobby-Secondary)

1 Input Data

effective Length		2.5	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
width of lobby	2.52	m
Dia of bars		
Compression steel	16	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		166.67	mm
effective depth (d)		170	mm
overall depth (D)		220	mm
depth of rib		70	mm
width of rib		250	mm
effective flange width (b_f)		1566.67	mm

3 Loads

factored	load from slab 1	6.375	kN/m2
slab load transferred to beam		8.0	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.4375	kN/m
	Total Load (w)	8.63	kN/m

4 Factored Moment and Shaer forces

	Moment at span	6.7	kNm

	Moment at support	5.4	kNm
	Vu=0.5*w*L	10.8	kN

5 Main Reinforcements

xu,max = 0.48d		81.6	mm
is xu,max>Df		No	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	181.044	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1566.667 mm

and d= 170 mm

Area of steel at span

Moment at span	2.50	kNm
Area of steel at span	110.75	mm2
No. of bars		1
Detailing		2
no. of bars of dia (mm)		16
Provided Steel mm^2		402

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2 f_y}\left[1 - \sqrt{1 - 4.598 M_u / (f_{ck} b d^2)}\right]$$

Area of steel at support

Moment at support	5.38	kNm
Area of steel at support	88.44	mm2

No. of bars		1
Detailing		2
no. of bars of dia (mm)		16
Provided Steel mm^2		402

provide 2 bars of 16 mm dia giving Ast = 402 mm2 on the tension side

2 hanger bars of 16 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	10.78125	kN
Nominal shear stress τv	0.254	N/mm2

if 1 bars of 16 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 402 mm2

percentage of steel pt 0.95 β 2.453994

τc 0.61 N/mm2

Shear reinforcement Not Required

Shear carried by bent bars is given by

Vus 102.66 kN

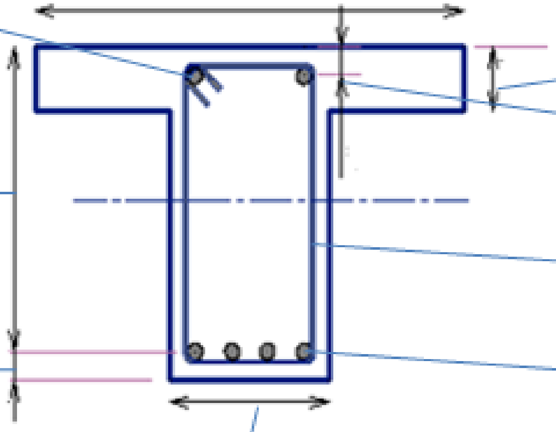
providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

spacing of stirrups sv 363 mm

Detailing

bf= 1566.67 mm

steel in compress 2 bars 16 mm



Df 150 mm

d'c 50 mm

d 170

8 mm

@ 363 mm

d't 50

Steel in tension 2 bars 16 mm diameter

bw 250 mm

Long L Beam (Room)

1 Input Data

effective Length		4.92	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		328	mm
effective depth (d)		330	mm
overall depth (D)		380	mm
depth of rib		230	mm
width of rib		250	mm
effective flange width (b_f)		1970	mm

3 Loads

factored	load from slab	7.875	kN/m
slab load transferred to beam		9.1	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		1.4375	kN/m
	Total Load (w)	11.27	kN/m

4 Factored Moment and Shaer forces

Moment at span	11.4	kNm
Moment at support	22.7	kNm
Vu=0.5*w*L	27.7	kN

5 Effective Flange width

i)	bf	1110	mm
ii)	bf	1860	mm
	using minimum of the two		
hence	bf	1110	mm

6 Torsional Moments at support section

total self weight of rib		6.1	kN/m
total ultimated load on L-beam		44.8	kN
Factored shear force Vu		22.41	kN
Torsional moment Tu		9.64	kN

7 Equivalent Bending Moment and Shear force

	Mt	14.28	kNm
	Mu	22.73	kNm
Equivalent B.M. Mel		37.01	kNm

Equivalent shear force Ve		84.08	kN

8 Main Longitudinal Reinforcement

At the support section (considered as			

rectangular)			
	Mu	37.01	kNm
	Area of steel	339.7	mm2
	no. of bars	2	

provide 2 bars of 20 mm diameter Ast= 628 mm2 at top of support section.

At the center of span section

Mu	11.4	kNm
Area of steel	97.78	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	168.98	mm2
no. of bars	1	

provide 2 bars of 16 mm diameter Ast= 401.92 mm2 on the tension side at centre of span section

9 Shear reinforcement

Equivalent shear force Ve		84.08	kN
Nominal shear stress τv		1.02	N/mm2
percentage steel		0.761	
	τc	0.563	N/mm2
Shear reinforcement		Required	

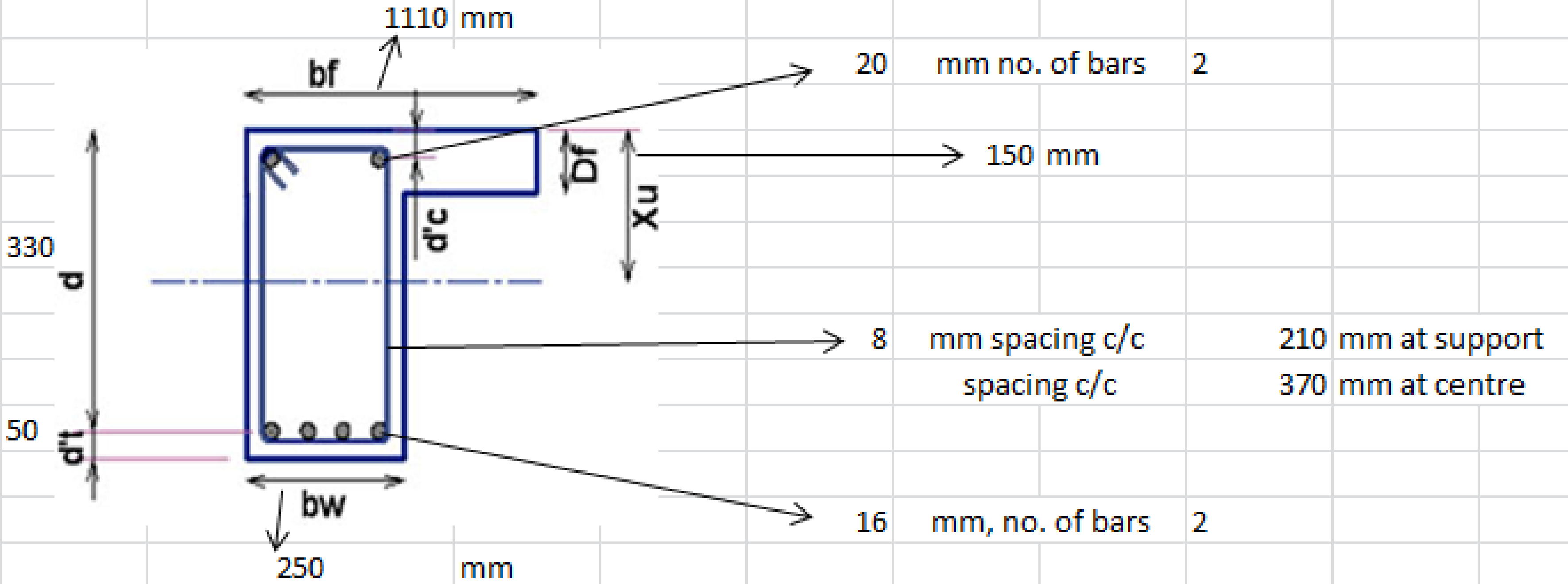
β 3.051

using 8 mm diameter two legged stirrups with side 25mm and bottom covers of 50mm

b1	200	mm
d1	280	mm
spacing sv	210.09	mm
Also sv	318.16	mm
taking spacing	210	mm at support
spacing	370	mm at centre

$$A_{sv} = \frac{T_u s_v}{b_1\, d_1 (0.87\, f_y)} + \frac{V_u\, s_v}{2.5 d_1 (0.87\, f_y)}$$

$$\frac{(\tau_{ve} - \tau_c) b.s_v}{0.87\, f_y}$$



Short L Beam (Room)

1 Input Data

effective Length		3.72	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm 2)
fy		415	(N/mm 2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	4.92	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		248	mm
effective depth (d)		250	mm
overall depth (D)		300	mm
depth of rib		150	mm
width of rib		250	mm
effective flange width (b_f)		1770	mm

3 Loads

factored	load from slab	7.875	kN/m
slab load transferred to beam		7.3	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.9375	kN/m
	Total Load (w)	8.73	kN/m

4 Factored Moment and Shaer forces

Moment at span	5.0	kNm
Moment at support	10.1	kNm
Vu=0.5*w*L	16.2	kN

5 Effective Flange width

i)	bf	1010	mm
ii)	bf	2460	mm
	using minimum of the two		
hence	bf	1010	mm

6 Torsional Moments at support section

total self weight of rib		4.9	kN/m
total ultimated load on L-beam		27.2	kN
Factored shear force Vu		13.62	kN
Torsional moment Tu		5.18	kN

7 Equivalent Bending Moment and Shear force

	Mt	6.70	kNm
	Mu	10.07	kNm
Equivalent B.M. Mel		16.77	kNm

Equivalent shear force Ve		46.75	kN

8 Main Longitudinal Reinforcement

At the support section (considered as			

rectangular)			
	Mu	16.77	kNm
	Area of steel	198.9	mm2
	no. of bars	1	

provide 1 bars of 20 mm diameter Ast= 314 mm2 at top of support section.

At the center of span section

Mu	5.0	kNm
Area of steel	56.84	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	128.01	mm2
no. of bars	1	

provide 2 bars of 16 mm diameter Ast= 401.92 mm2 on the tension side at centre of span section

9 Shear reinforcement

Equivalent shear force Ve		46.75	kN
Nominal shear stress τv		0.75	N/mm2
percentage steel		0.502	
	τc	0.479	N/mm2
Shear reinforcement		Required	

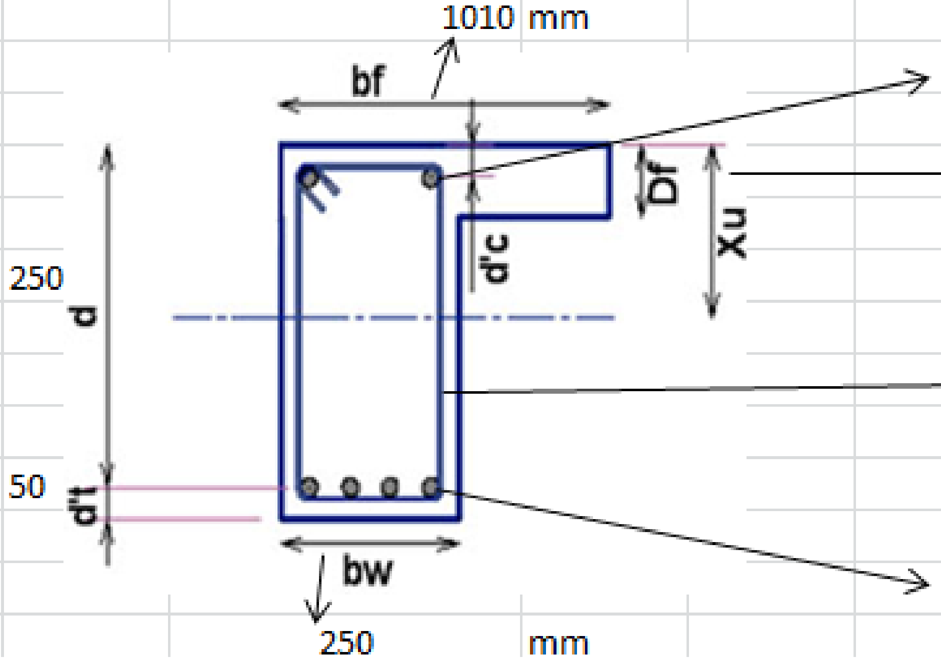
β 4.622

using 8 mm diameter two legged stirrups with side 25mm and bottom covers of 50mm

b1	200	mm	
d1	200	mm	
spacing sv	279.33	mm	
Also sv	540.19	mm	
taking spacing	280	mm	at support
spacing	490	mm	at centre

$$A_{sv} = \frac{T_u s_v}{b_1\, d_1 (0.87\, f_y)} + \frac{V_u\, s_v}{2.5 d_1 (0.87\, f_y)}$$

$$\frac{(\tau_{ve} - \tau_c) b . s_v}{0.87\, f_y}$$



20 mm no. of bars 1

150 mm

8 mm spacing c/c 280 mm at support

spacing c/c 490 mm at centre

16 mm, no. of bars 2

Short L Beam (Lobby)

1 Input Data

effective Length		2.5	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm 2)
fy		415	(N/mm 2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		166.6667	mm
effective depth (d)		170	mm
overall depth (D)		220	mm
depth of rib		70	mm
width of rib		250	mm
effective flange width (b_f)		1566.667	mm

3 Loads

factored	load from slab	6.375	kN/m
slab load transferred to beam		4.0	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.4375	kN/m
	Total Load (w)	4.64	kN/m

4 Factored Moment and Shaer forces

Moment at span	1.2	kNm
Moment at support	2.4	kNm
Vu=0.5*w*L	5.8	kN

5 Effective Flange width

i)	bf	908.3333	mm
ii)	bf	1860	mm
	using minimum of the two		
hence	bf	908.3333	mm

6 Torsional Moments at support section

total self weight of rib		2.7	kN/m
total ultimated load on L-beam		10.0	kN
Factored shear force Vu		4.98	kN
Torsional moment Tu		1.64	kN

7 Equivalent Bending Moment and Shear force

	Mt	1.81	kNm
	Mu	2.42	kNm
Equivalent B.M. Mel		4.23	kNm

Equivalent shear force Ve		15.47	kN

8 Main Longitudinal Reinforcement

At the support section (considered as rectangular)			
	Mu	4.23	kNm
	Area of steel	71.4	mm2
	no. of bars	1	

provide **1** **bars of** **20** **mm diameter Ast=** **314** **mm2 at top of support section.**

At the center of span section

Mu	1.2	kNm
Area of steel	19.88	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	87.05	mm2
no. of bars	1	

provide **2** **bars of** **16** **mm diameter Ast=** **401.92** **mm2 on the tension side at centre of span section**

9 Shear reinforcement

Equivalent shear force Ve		15.47	kN		
Nominal shear stress τv		0.36	N/mm2		
percentage steel		0.739		β	3.143
	τc	0.557	N/mm2		

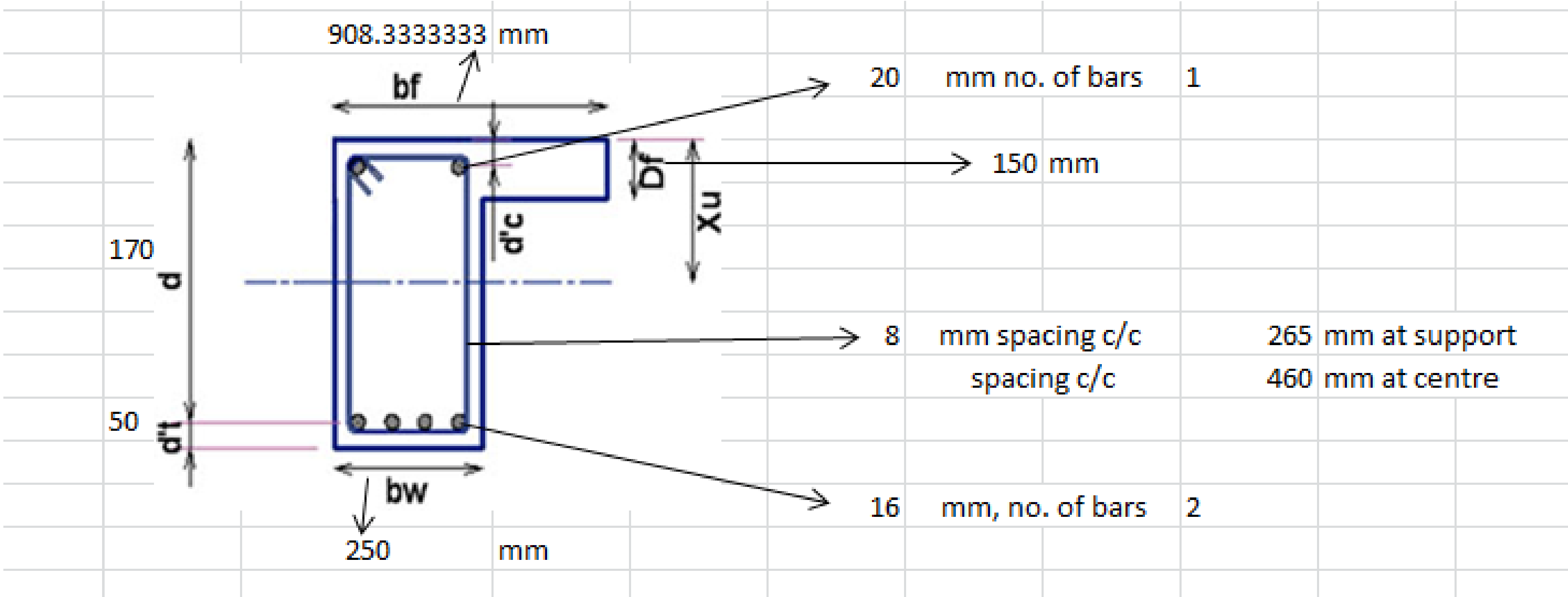
Shear reinforcement	Not Required

using 8 mm diameter two legged stirrups with side 25mm and bottom covers of 50mm

b1	200	mm	
d1	120	mm	
spacing sv	529.10	mm	
Also sv	752.85	mm	
taking spacing	265	mm	at support
spacing	460	mm	at centre

$$A_{sv} = \frac{T_u s_v}{b_1 \, d_1 (0.87 \, f_y)} + \frac{V_u \, s_v}{2.5 d_1 (0.87 \, f_y)}$$

$$\frac{(\tau_{ve} - \tau_c) b . s_v}{0.87 \, f_y}$$



4.2.2 Ground Floor, First Floor and Second Floor Beams

Long T Beam (Room-Secondary)

1 Input Data

effective Length		4.92	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	25	mm
tensile steel	20	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		328	mm
effective depth (d)		330	mm
overall depth (D)		380	mm
depth of rib		230	mm
width of rib		250	mm
effective flange width (b_f)		1970	mm

3 Loads

factored	load from slab	10.125	kN/m
slab load transferred to beam		23.4	kN/m
factored	load from Partition wall	8.595	kN/m
self weight of rib		1.4375	kN/m
	Total Load (w)	34.18	kN/m

4 Factored Moment and Shaer forces

	Moment at span	103.4	kNm
	Moment at support	82.7	kNm
	Vu=0.5*w*L	84.1	kN

5 Main Reinforcements

xu,max = 0.48d		158.4	mm
is xu,max>Df		Yes	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	568.0692	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1970 mm

and d= 330 mm

Area of steel at span

Moment at span	4.92	kNm
Area of steel at span	893.48	mm2
No. of bars		3
Detailing		3
no. of bars of dia (mm)		20
Provided Steel mm^2		943

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

Area of steel at support

Moment at support	82.24	kNm
Area of steel at support	710.52	mm2
No. of bars		2
Detailing		2
no. of bars of dia (mm)		25
Provided Steel mm^2		982

provide 3 bars of 20 mm dia giving Ast = 943 mm2 on the tension side

2 hanger bars of 25 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	84.075525	kN
Nominal shear stress τv	1.019	N/mm2

if 2 bars of 20 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 943 mm2

percentage of steel pt 1.14 β 2.032485

τc 0.65 N/mm2

Shear reinforcement Required

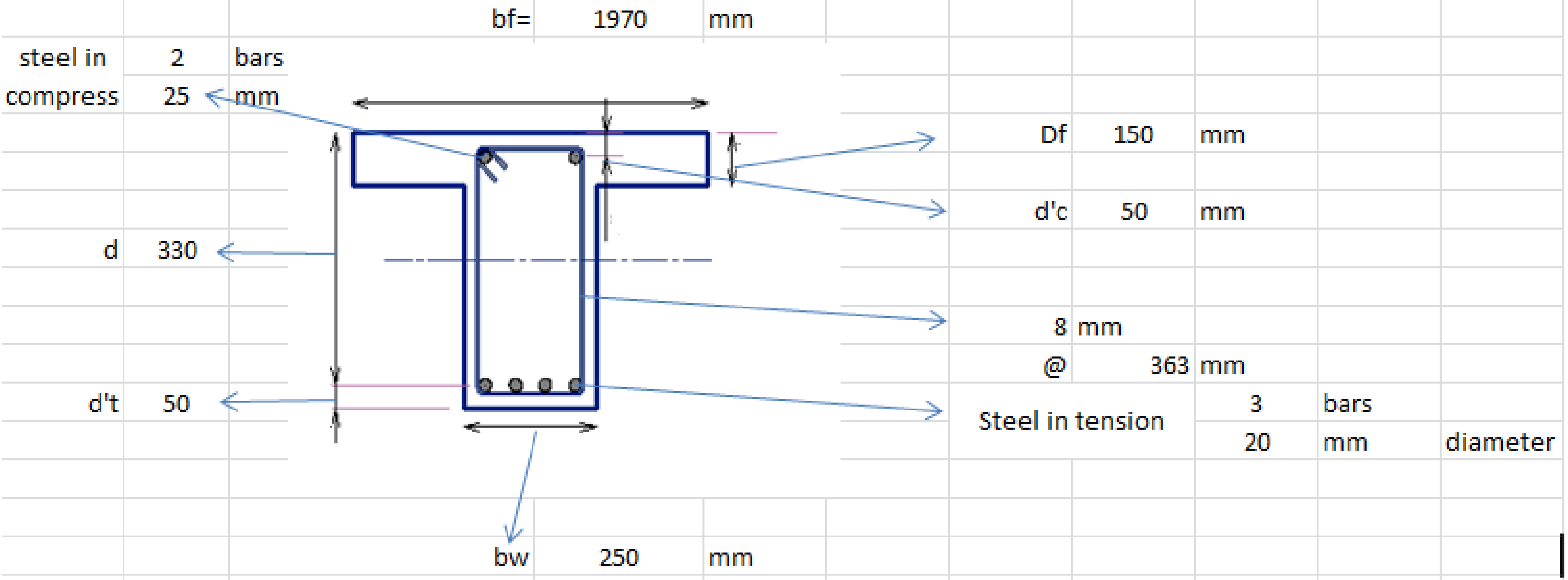
Shear carried by bent bars is given by

Vus 240.61 kN

providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

spacing of stirrups sv 363 mm

Detailing


bf= 1970 mm
steel in compress 2 bars
25 mm
Df 150 mm
d'c 50 mm
d 330
8 mm
@ 363 mm
d't 50
Steel in tension 3 bars
20 mm diameter
bw 250 mm

Short T Beam (Room-Secondary)

1 Input Data

effective Length		3.72	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	4.92	m
width of lobby	2.52	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		248	mm
effective depth (d)		250	mm
overall depth (D)		300	mm
depth of rib		150	mm
width of rib		250	mm
effective flange width (b_f)		1770	mm

3 Loads

factored	load from slab 1	9.375	kN/m2
factored	load from slab 2	10.125	kN/m2
slab load transferred to beam		17.2	kN/m
factored	load from Partition wall	8.595	kN/m
self weight of rib		0.9375	kN/m
	Total Load (w)	27.23	kN/m

4 Factored Moment and Shaer forces

	Moment at span	47.1	kNm
	Moment at support	37.7	kNm
	Vu=0.5*w*L	50.6	kN

5 Main Reinforcements

xu,max = 0.48d		120	mm
is xu,max>Df		No	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	357.4692	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1770 mm

and d= 250 mm

Area of steel at span

Moment at span	3.72	kNm
Area of steel at span	535.29	mm2
No. of bars		3
Detailing		3
no. of bars of dia (mm)		16
Provided Steel mm^2		603

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

Area of steel at support

Moment at support	37.49	kNm

Area of steel at support	425.99	mm2
No. of bars		2
Detailing		2
no. of bars of dia (mm)		20
Provided Steel mm^2		628

provide 3 bars of 16 mm dia giving Ast = 603 mm2 on the tension side

2 hanger bars of 20 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	50.645925	kN
Nominal shear stress τv	0.810	N/mm2

if 2 bars of 16 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 603 mm2

percentage of steel pt 0.97 β 2.405877

τc 0.61 N/mm2

Shear reinforcement Required

Shear carried by bent bars is given by

Vus 153.99 kN

providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

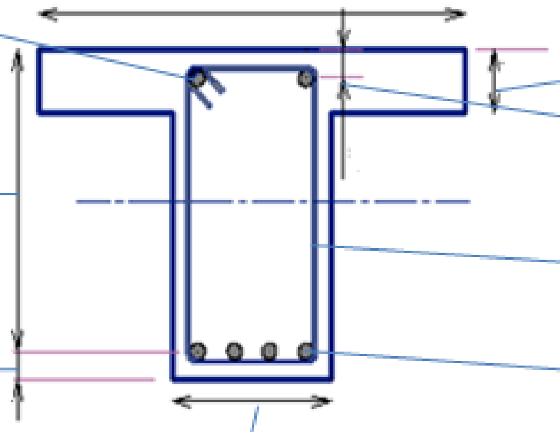
spacing of stirrups sv 363 mm

Detailing

bf= 1770 mm

steel in compression 2 bars

20 mm



Df 150 mm

d'c 50 mm

d 250

8 mm

@ 363 mm

d't 50

Steel in tension 3 bars

16 mm diameter

bw 250 mm

T Beam (Lobby-Secondary)

1 Input Data

effective Length		2.5	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
width of lobby	2.52	m
Dia of bars		
Compression steel	16	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		166.67	mm
effective depth (d)		170	mm
overall depth (D)		220	mm
depth of rib		70	mm
width of rib		250	mm
effective flange width (b_f)		1566.67	mm

3 Loads

factored	load from slab 1	8.625	kN/m2
slab load transferred to beam		10.8	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.4375	kN/m
	Total Load (w)	11.44	kN/m

4 Factored Moment and Shaer forces

	Moment at span	8.9	kNm

	Moment at support	7.1	kNm
	Vu=0.5*w*L	14.3	kN

5 Main Reinforcements

xu,max = 0.48d		81.6	mm
is xu,max>Df		No	
Assuming neutral axis to be located at xu=Df		150	mm

Mur	181.044	kNm
is Mur>Mu	Yes	

Hence the neutral axis is located within the flange (xu<Df)

Hence the T-section is designed as a singly reinforced rectangular section with bf= b 1566.667 mm

and d= 170 mm

Area of steel at span

Moment at span	2.50	kNm
Area of steel at span	147.28	mm2
No. of bars		1
Detailing		2
no. of bars of dia (mm)		16
Provided Steel mm^2		402

$$\frac{(A_{st})_{reqd}}{bd} = \frac{f_{ck}}{2f_y}\left[1-\sqrt{1-4.598M_u/(f_{ck}bd^2)}\right]$$

Area of steel at support

Moment at support	7.13	kNm
Area of steel at support	117.55	mm2

No. of bars		1
Detailing		2
no. of bars of dia (mm)		16
Provided Steel mm^2		402

provide 2 bars of 16 mm dia giving Ast = 402 mm2 on the tension side

2 hanger bars of 16 mm diameter on the compression side

6 Shear reinforcements

Design shear force Vu	14.296875	kN
Nominal shear stress τv	0.336	N/mm2

if 1 bars of 16 mm diameter are bent up near the supports the remaining

bars provide an area Ast = 402 mm2

percentage of steel pt 0.95 β 2.453994

τc 0.61 N/mm2

Shear reinforcement Not Required

Shear carried by bent bars is given by

Vus 102.66 kN

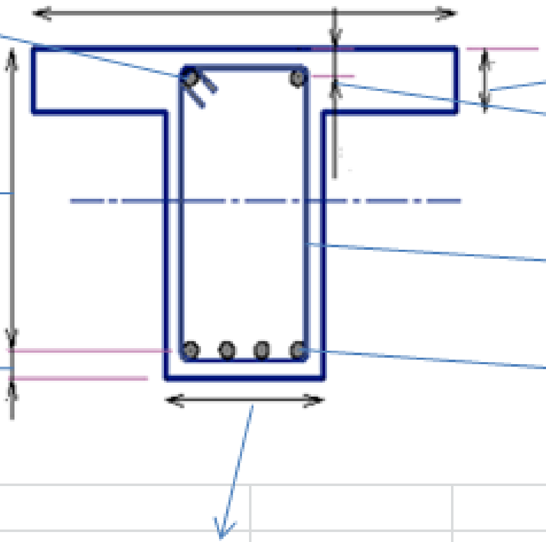
providing nominal shear reinforcements using 8 mm diameter two-legged stirrups.

spacing of stirrups sv 363 mm

Detailing

bf= 1566.67 mm

steel in compression: 2 bars, 16 mm



Df 150 mm

d'c 50 mm

d 170

8 mm @ 363 mm

d't 50

Steel in tension: 2 bars, 16 mm diameter

bw 250 mm

Long L Beam (Room)

1 Input Data

effective Length		4.92	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		328	mm
effective depth (d)		330	mm
overall depth (D)		380	mm
depth of rib		230	mm
width of rib		250	mm
effective flange width (b_f)		1970	mm

3 Loads

factored	load from slab	10.125	kN/m
slab load transferred to beam		11.7	kN/m
factored	load from Partition wall	8.595	kN/m
self weight of rib		1.4375	kN/m
	Total Load (w)	22.46	kN/m

4 Factored Moment and Shaer forces

Moment at span	22.7	kNm
Moment at support	45.3	kNm
Vu=0.5*w*L	55.3	kN

5 Effective Flange width

i)	bf	1110	mm
ii)	bf	1860	mm
	using minimum of the two		
hence	bf	1110	mm

6 Torsional Moments at support section

total self weight of rib		13.5	kN/m
total ultimated load on L-beam		99.9	kN
Factored shear force Vu		49.96	kN
Torsional moment Tu		21.48	kN

7 Equivalent Bending Moment and Shear force

	Mt	31.84	kNm
	Mu	45.31	kNm
Equivalent B.M. Mel		77.16	kNm

Equivalent shear force Ve		187.44	kN

8 Main Longitudinal Reinforcement

At the support section (considered as			

rectangular)			
	Mu	77.16	kNm
	Area of steel	814.5	mm2
	no. of bars	3	

provide 3 bars of 20 mm diameter Ast= 942 mm2 at top of support section.

At the center of span section

Mu	22.7	kNm
Area of steel	200.26	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	168.98	mm2
no. of bars	1	

provide 2 bars of 16 mm diameter Ast= 401.92 mm2 on the tension side at centre of span section

9 Shear reinforcement

Equivalent shear force Ve		187.44	kN
Nominal shear stress τv		2.27	N/mm2
percentage steel		1.142	
	τc	0.653	N/mm2
Shear reinforcement		Required	

β 2.034

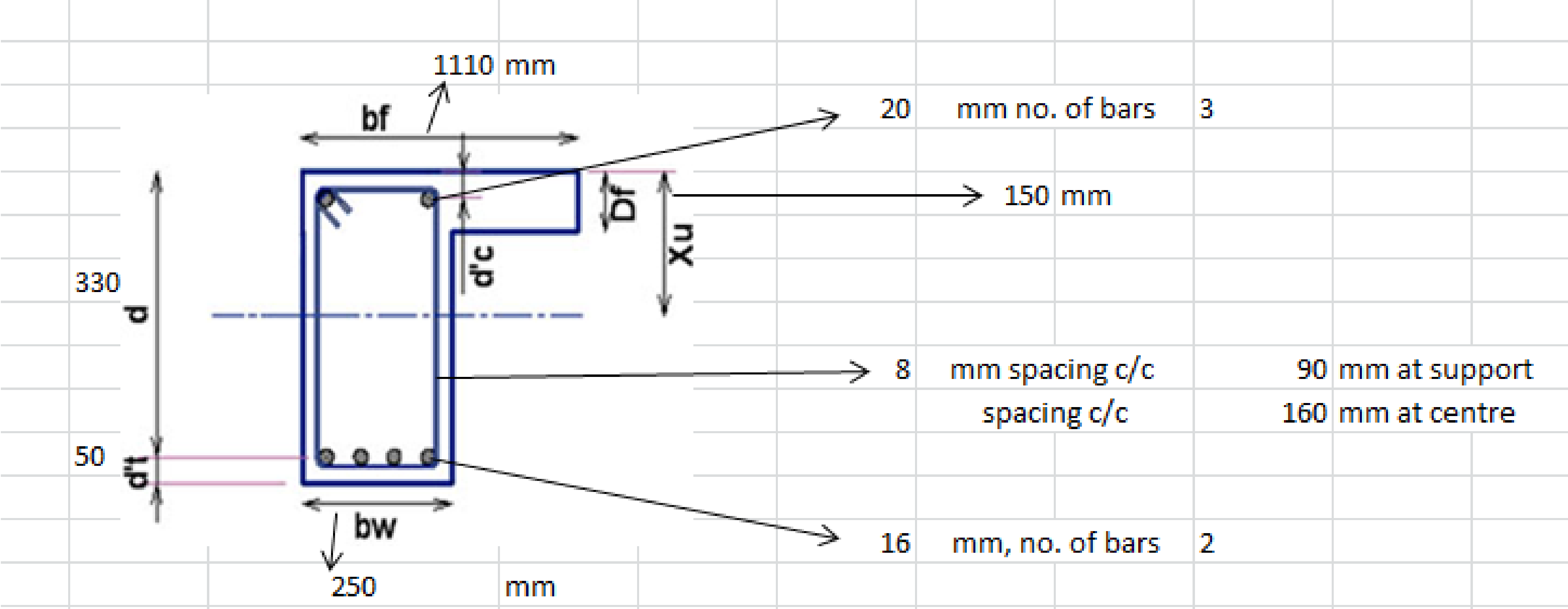
using 8 mm diameter two legged stirrups with side 25mm and bottom covers of 50mm

b1	200	mm
d1	280	mm

$$A_{sv} = \frac{T_u s_v}{b_1 \, d_1 (0.87 \, f_y)} + \frac{V_u \, s_v}{2.5 d_1 (0.87 \, f_y)}$$

spacing sv	94.24	mm	
Also sv	89.61	mm	
taking spacing	90	mm	at support
spacing	160	mm	at centre

$$\frac{(\tau_{ve} - \tau_c) b.s_v}{0.87 f_y}$$



Short L Beam (Room)

1 Input Data

effective Length		3.72	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm2)
fy		415	(N/mm2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	4.92	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		248	mm
effective depth (d)		250	mm
overall depth (D)		300	mm
depth of rib		150	mm
width of rib		250	mm
effective flange width (b_f)		1770	mm

3 Loads

factored	load from slab	10.125	kN/m
slab load transferred to beam		9.4	kN/m
factored	load from Partition wall	8.595	kN/m
self weight of rib		0.9375	kN/m
	Total Load (w)	19.42	kN/m

4 Factored Moment and Shaer forces

Moment at span	11.2	kNm
Moment at support	22.4	kNm
Vu=0.5*w*L	36.1	kN

5 Effective Flange width

i)	bf	1010	mm
ii)	bf	2460	mm
	using minimum of the two		
hence	bf	1010	mm

6 Torsional Moments at support section

total self weight of rib		12.0	kN/m
total ultimated load on L-beam		67.0	kN
Factored shear force Vu		33.50	kN
Torsional moment Tu		12.73	kN

7 Equivalent Bending Moment and Shear force

	Mt	16.47	kNm
	Mu	22.39	kNm
Equivalent B.M. Mel		38.87	kNm

Equivalent shear force Ve		114.98	kN

8 Main Longitudinal Reinforcement

At the support section (considered as			

rectangular)			
	Mu	38.87	kNm
	Area of steel	520.6	mm2
	no. of bars	2	

provide 2 bars of 20 mm diameter Ast= 628 mm2 at top of support section.

At the center of span section

Mu	11.2	kNm
Area of steel	129.63	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	128.01	mm2
no. of bars	1	

provide 2 bars of 16 mm diameter Ast= 401.92 mm2 on the tension side at centre of span section

9 Shear reinforcement

Equivalent shear force Ve		114.98	kN
Nominal shear stress τv		1.84	N/mm2
percentage steel		1.005	
	τc	0.624	N/mm2
Shear reinforcement		Required	

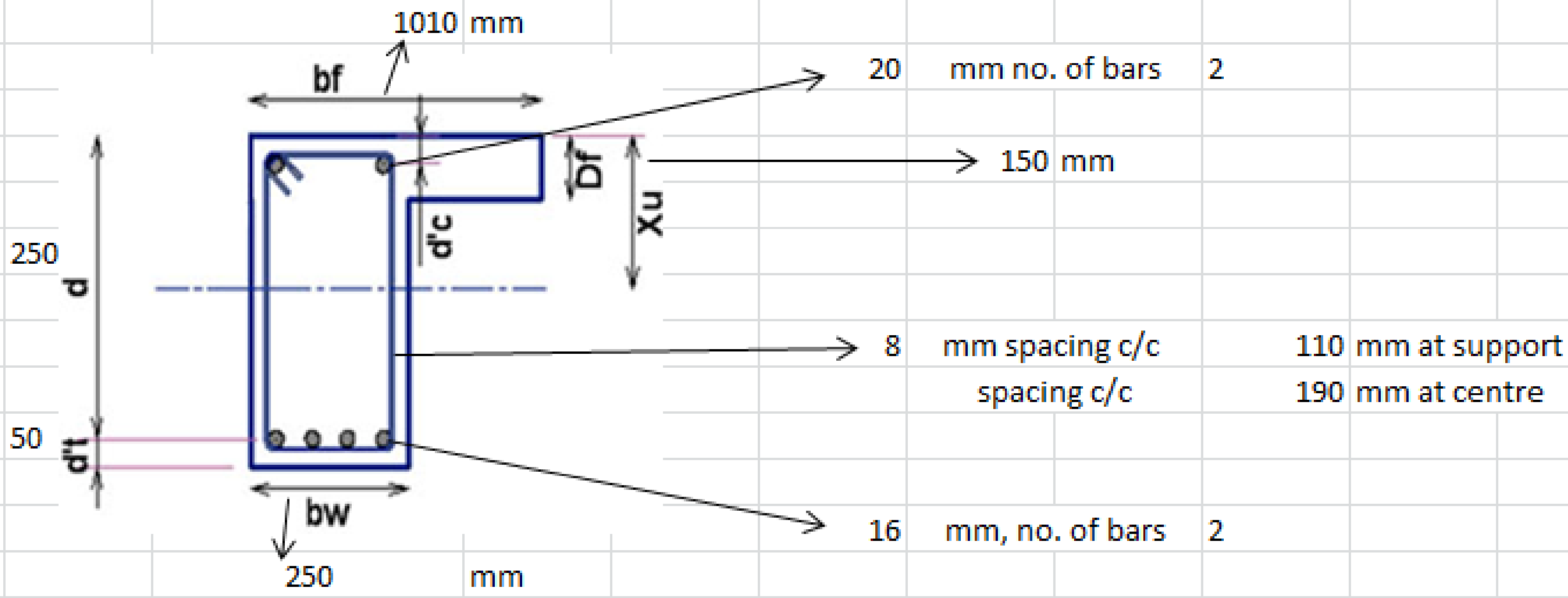
β 2.311

using 8 mm diameter two legged stirrups with side 25mm and bottom covers of 50mm

b1	200	mm	
d1	200	mm	
spacing sv	113.58	mm	
Also sv	119.34	mm	
taking spacing	110	mm	at support
spacing	190	mm	at centre

$$A_{sv} = \frac{T_u s_v}{b_1\, d_1 (0.87\, f_y)} + \frac{V_u\, s_v}{2.5 d_1 (0.87\, f_y)}$$

$$\frac{(\tau_{ve} - \tau_c) b.s_v}{0.87\, f_y}$$



Short L Beam (Lobby)

1 Input Data

effective Length		2.5	m
width (b)		250	mm
thickness of slab		150	mm
fck		20	(N/mm 2)
fy		415	(N/mm 2)
Cover for comp. (d'c)		50	mm
Cover for tension (d't)		50	mm

width of room	3.72	m
Dia of bars		
Compression steel	20	mm
tensile steel	16	mm
Stirrups	8	mm

2 Depth

Effective depth of beam		166.6667	mm
effective depth (d)		170	mm
overall depth (D)		220	mm
depth of rib		70	mm
width of rib		250	mm
effective flange width (b_f)		1566.667	mm

3 Loads

factored	load from slab	8.625	kN/m
slab load transferred to beam		5.4	kN/m
factored	load from Partition wall	0	kN/m
self weight of rib		0.4375	kN/m
	Total Load (w)	6.05	kN/m

4 Factored Moment and Shaer forces

Moment at span	1.6	kNm
Moment at support	3.1	kNm
Vu=0.5*w*L	7.6	kN

5 Effective Flange width

i)	bf	908.3333	mm
ii)	bf	1860	mm
	using minimum of the two		
hence	bf	908.3333	mm

6 Torsional Moments at support section

total self weight of rib		3.6	kN/m
total ultimated load on L-beam		13.5	kN
Factored shear force Vu		6.74	kN
Torsional moment Tu		2.22	kN

7 Equivalent Bending Moment and Shear force

	Mt	2.45	kNm
	Mu	3.15	kNm
Equivalent B.M. Mel		5.60	kNm

Equivalent shear force Ve		20.93	kN

8 Main Longitudinal Reinforcement

At the support section (considered as rectangular)			
	Mu	5.60	kNm
	Area of steel	95.8	mm2
	no. of bars	1	

provide 1 bars of 20 mm diameter Ast= 314 mm2 at top of support section.

At the center of span section

Mu	1.6	kNm
Area of steel	25.99	mm2

checking for minimum reinforcement as per clause 26.5.1.1 of IS:456-200

Ast	87.05	mm2
no. of bars	1	

provide 2 bars of 16 mm diameter Ast= 401.92 mm2 on the tension side at centre of span section

9 Shear reinforcement

Equivalent shear force Ve		20.93	kN
Nominal shear stress τv		0.49	N/mm2
percentage steel		0.739	
	τc	0.557	N/mm2
Shear reinforcement		Not Required	

β 3.143

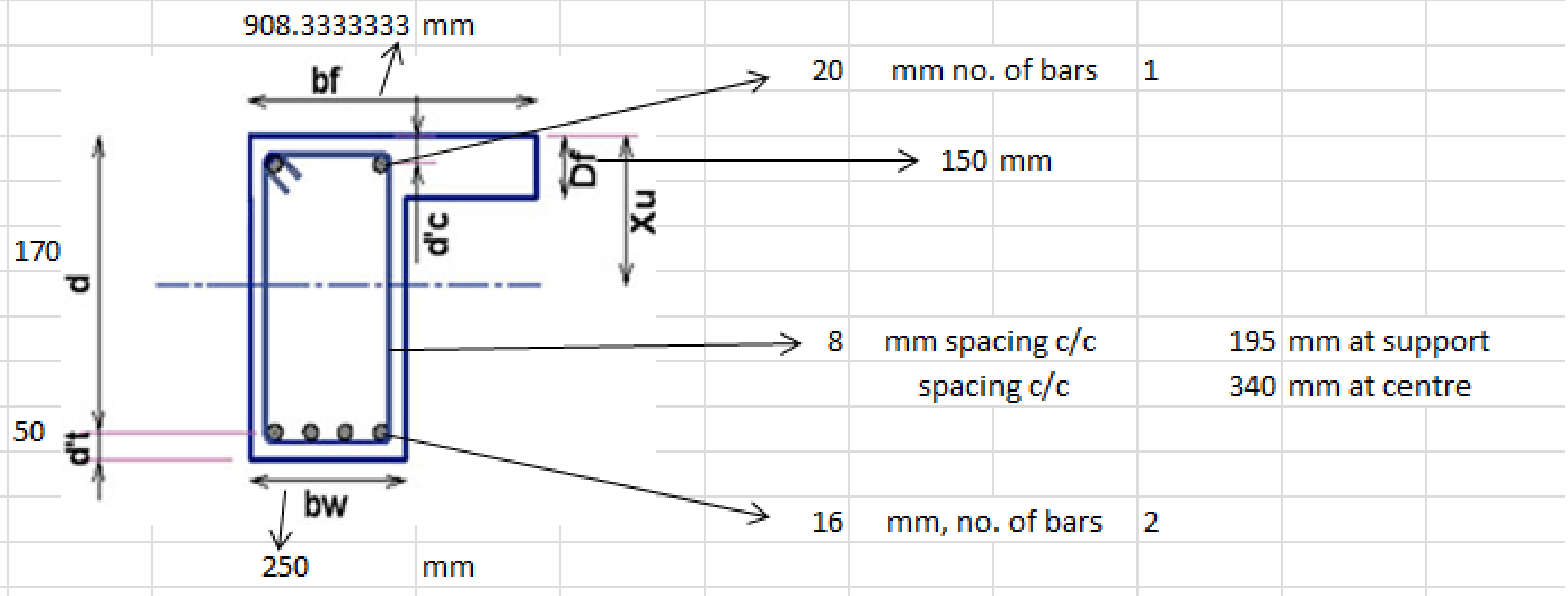
using **8** **mm diameter two legged stirrups with side 25mm and bottom covers of 50mm**

b1	200	mm
d1	120	mm
spacing sv	391.07	mm
Also sv	2258.24	mm
taking spacing	195	mm
spacing	340	mm

taking spacing 195 mm at support; spacing 340 mm at centre

$$A_{sv} = \frac{T_u s_v}{b_1\, d_1 (0.87\, f_y)} + \frac{V_u\, s_v}{2.5 d_1 (0.87\, f_y)}$$

$$\frac{(\tau_{ve} - \tau_c) b.s_v}{0.87\, f_y}$$



5. Design of Columns

Column or pillar in architecture and structural engineering is a structural element that transmits, through compression, the weight of the structure above to other structural elements below. In other words, a column is a compression member. For the purpose of wind or earthquake engineering, columns may be designed to resist lateral forces. Other compression members are often termed "columns" because of the similar stress conditions. Columns are frequently used to support beams or arches on which the upper parts of walls or ceilings rest.

5.1 Types of Columns

1) **Based on shape –** Rectangle, Square, Circular, Polygon
2) **Based on slenderness ratio -** Short column, < 12 , Long column, > 12
3) **Based on type of loading -** Axially loaded column, A column subjected to axial load and uniaxial bending, A column subjected to axial load and biaxial bending
4) **Based on pattern of lateral reinforcement -** Tied columns, Spiral columns
   i) **Minimum eccentricity: Emin** $> l/500 + D/30 > 20$

      Where, l = unsupported length of column in ‘mm’ D = lateral dimensions of column
5) **Types of Reinforcements for columns and their requirements**
   a) **Longitudinal Reinforcement**
      i) Minimum area of cross-section of longitudinal bars must be atleast 0.8% of gross section area of the column.
      ii) Maximum area of cross-section of longitudinal bars must not exceed 6% of the gross cross-section area of the column.
      iii) The bars should not be less than 12mm in diameter.
      iv) Minimum number of longitudinal bars must be four in rectangular column and 6 in circular column. Spacing of longitudinal bars measures along the periphery of a column should not exceed 300mm.

b) **Transverse reinforcement**

i) It may be in the form of lateral ties or spirals.
ii) The diameter of the lateral ties should not be less than 1/4th of the diameter of the largest longitudinal bar and in no case less than 6mm.
iii) The pitch of lateral ties should not exceed Least lateral dimension 16 x diameter of longitudinal bars (small) 300mm

c) Helical Reinforcement

i) The diameter of helical bars should not be less than 1/4th the diameter of largest longitudinal and not less than 6mm
ii) The pitch should not exceed (if helical reinforcement is allowed); 75mm 1/6th of the core diameter of the column
iii) Pitch should not be less than, 25mm 3 x diameter of helical bar Pitch should not exceed (if helical reinforcement is not allowed)
iv) **Least lateral dimension** 16 x diameter of longitudinal bar (smaller) 300mm

The Design of the Columns is done according to norms detailed in IS code 456-2000, Cl-25.

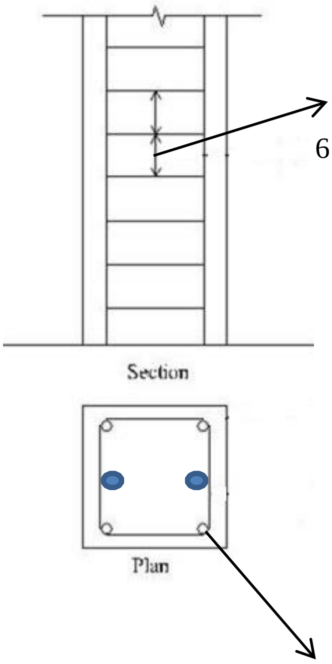
For Simplification, columns are grouped together according to the Length of the columns and load applicable on the columns. Therefore for each floor, the different columns have been grouped together as follows:

Thus the values of the loads taken are as follows-

1) Live Load Applicable on the structure
   a. Room Floors – 2kn/m
   b. Baths & toilets- 2kN/m
   c. Balconies- 4kN/m
   d. Roof slab (Access Provided) -1kN/m
2) Dead Load Applicable –
   a. Partition wall -5.73kN/m
   b. Floor finishes (Rooms) – 1kN/m
   c. Floor Finish (Roof)- 0.5kN/m
   d. Weight of Slab- 3.75kN/m (From the design of Slab)

5.2 Design & Detailing of Columns

Design of Column C1.a-GF



6 mm
at c/c
250

6 bars
dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	862.37	kN
Bending Moment My	6.47	kNm
Bending Moment Mz	0.9	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	7.50	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	1.04	mm	
min eccentricity in z dir	20	mm	
emin/B	0.00	Equal or less	to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	1827.64	mm2		
Min area of Longitudinal reinforcement = 0.8%				
Min area of steel	800	mm2		
Hence As,	1827.64	mm2		
No. of bars required	6			
Provided bars	**6**	**of dia**	**20**	**mm**
provided area of steel	1884	mm2		

4

using stirrups of diameter	6	mm

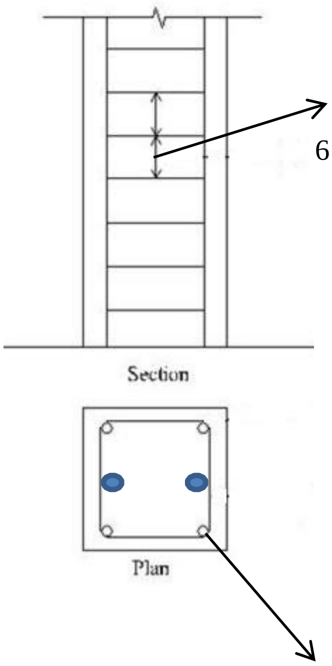
Spacing

i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm

iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of Column C1.b-GF



6 mm at c/c 250

8 bars dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	908.01	kN
Bending Moment My	6.42	kNm
Bending Moment Mz	0.94	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	7.07	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	1.04	mm	
min eccentricity in z dir	20	mm	
emin/B	0.00	Equal or less	to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	2081.15	mm2	
Min area of Longitudinal reinforcement = 0.8%			
Min area of steel	800	mm2	
Hence As,	2081.15	mm2	
No. of bars required	7		
Provided bars	**8**	**of dia**	**20** **mm**
provided area of steel	2512	mm2	

4

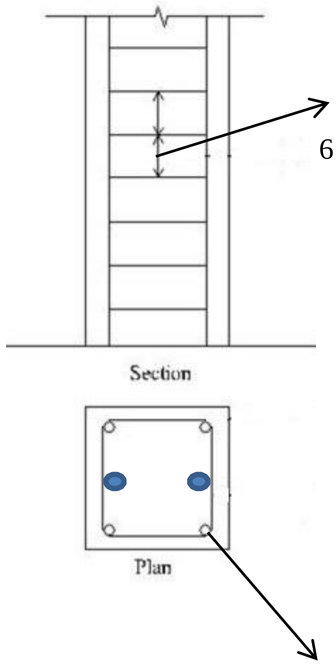
using stirrups of diameter	6	mm

Spacing

i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of Column C1.c-GF



6 mm at c/c 250

4 bars dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	543.57	kN
Bending Moment My	4.71	kNm
Bending Moment Mz	14.9	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	8.66	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	27.41	mm	
min eccentricity in z dir	20	mm	
emin/B	0.08		to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	56.86	mm2		
Min area of Longitudinal reinforcement = 0.8%				
Min area of steel	800	mm2		
Hence As,	800.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**20**	**mm**
provided area of steel	1256	mm2		

4

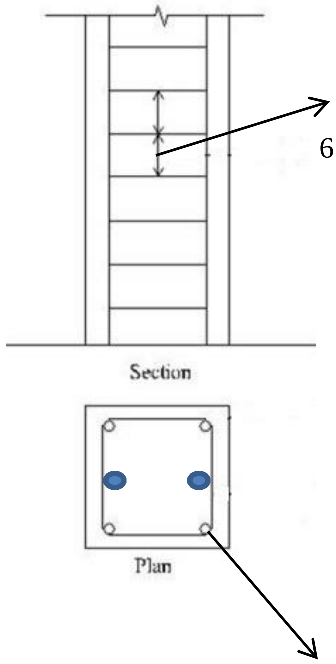
using stirrups of diameter	6	mm

Spacing

i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of Column C1.d-GF



6 mm at c/c 250

4 bars
dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	602.21	kN
Bending Moment My	4.04	kNm
Bending Moment Mz	14.22	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	6.71	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	23.61	mm	
min eccentricity in z dir	20	mm	
emin/B	0.08		to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	382.58	mm2
Min area of Longitudinal reinforcement = 0.8%		
Min area of steel	800	mm2
Hence As,	800.00	mm2

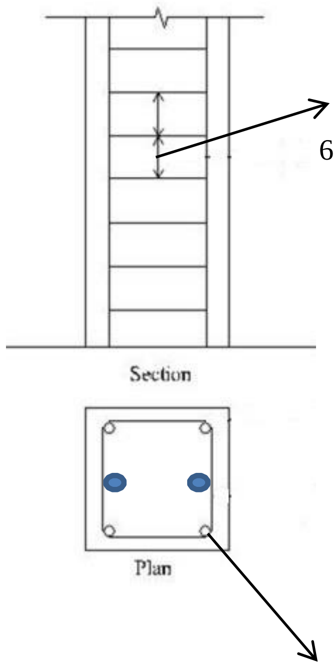
No. of bars required	3			
Provided bars	**4**	**of dia**	**20**	**mm**
provided area of steel	1256	mm2		

4

using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of Column C1.e-IF



6 mm at c/c 250

4 bars dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	606.33	kN
Bending Moment My	9.01	kNm
Bending Moment Mz	1.61	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	14.86	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	2.66	mm	
min eccentricity in z dir	20	mm	
emin/B	0.01		to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	405.46	mm2

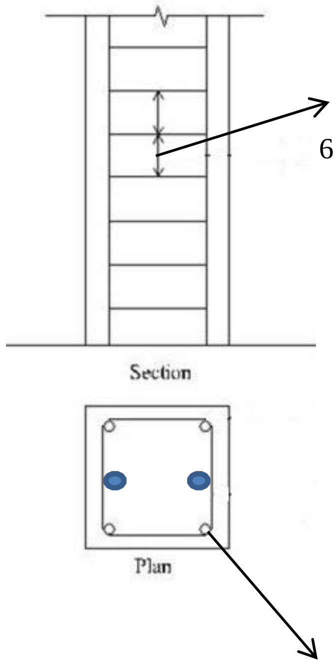
Min area of Longitudinal reinforcement = 0.8%				
Min area of steel	800	mm2		
Hence As,	800.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**20**	**mm**
provided area of steel	1256	mm2		

4

using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of Column C1.f-IF



6 mm at c/c 250

4 bars dia (mm) 20

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	400	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load	652.31	kN
Bending Moment My	9.01	kNm
Bending Moment Mz	1.61	kNm
Diameter of bar	20	mm

2 Eccentricity check

In y-direction

Eccentricity in y direction	13.81	mm	
min eccentricity in y dir	20	mm	
emin/D	0.05	Equal or less	to 0.05

In Z-direction

eccentricity in z direction	2.47	mm	
min eccentricity in z dir	20	mm	
emin/B	0.01		to 0.05

The minimum eccentricity ratio is equal to 0.05 in both directions, and hence the column can be designed as Axially loaded columns

3 Calculation of area of steel

Area of steel required	660.86	mm2		
Min area of Longitudinal reinforcement = 0.8%				
Min area of steel	800	mm2		
Hence As,	800.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**20**	**mm**
provided area of steel	1256	mm2		

4

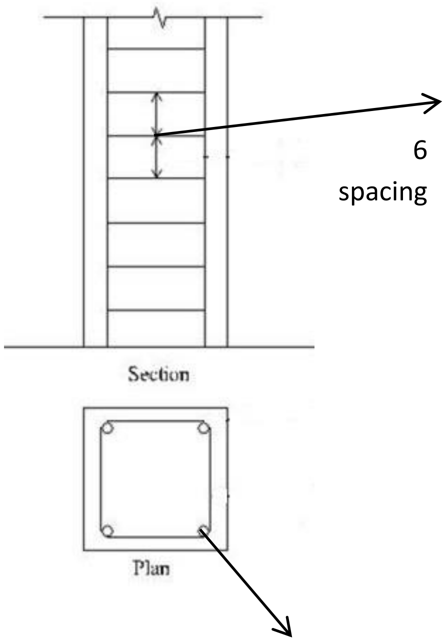
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	320	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.a-IF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	30	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	431.01	kN
Bending Moment M	22	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

effective cover d'	46	mm
d'/D	0.184	mm
pu	0.34	
mu	0.05	
from interaction chart	33	
p/fck	0.02	
percentages steel	0.6	
Area of steel	375	mm2
Min area of steel	500	mm2
Hence As,	500.00	mm2

No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

using stirrups of diameter	6	mm

Spacing

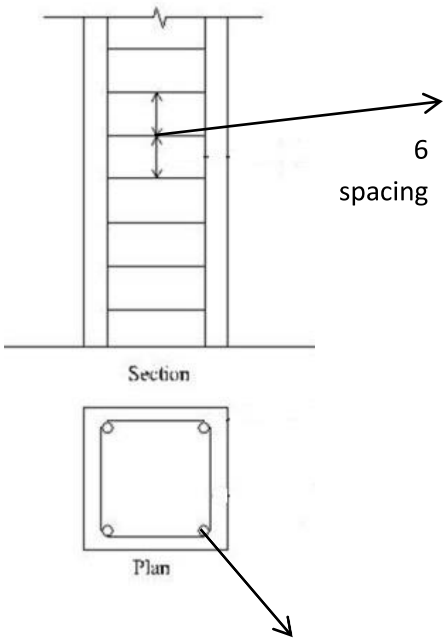
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.b-IF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	30	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	384.11	kN
Bending Moment M	23.6	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.31			
mu	0.05			
from interaction chart	33			
p/fck	0.01			
percentages steel	0.3			
Area of steel	187.5	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

using stirrups of diameter	6	mm

Spacing

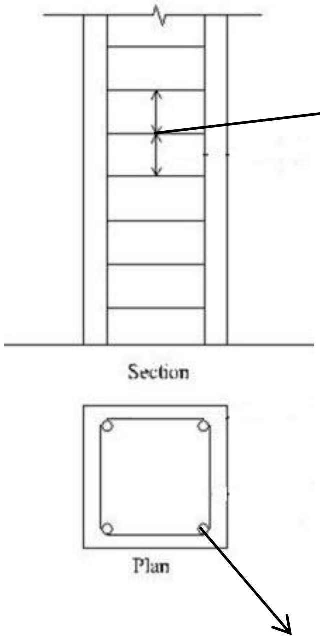
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.c-IIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	352.03	kN
Bending Moment M	9.12	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.42			
mu	0.03			
from interaction chart	33			
p/fck	0.02			
percentages steel	0.4			
Area of steel	250	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

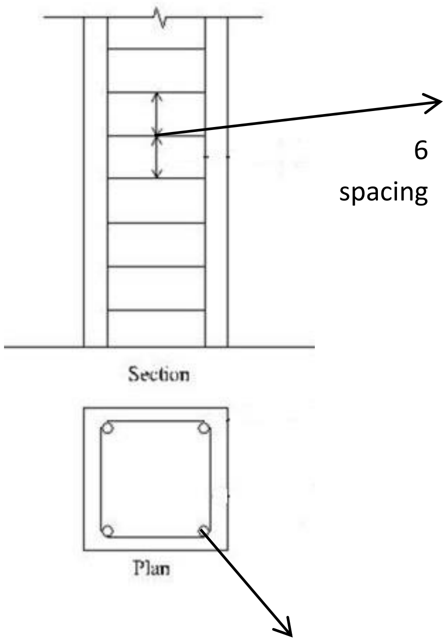
using stirrups of diameter	6	mm

Spacing

i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.d-IIF



1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	398.91	kN
Bending Moment M	9.51	kNm
Diameter of bar	16	mm

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.48			
mu	0.03			
from interaction chart	33			
p/fck	0.04			
percentages steel	0.8			
Area of steel	500	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

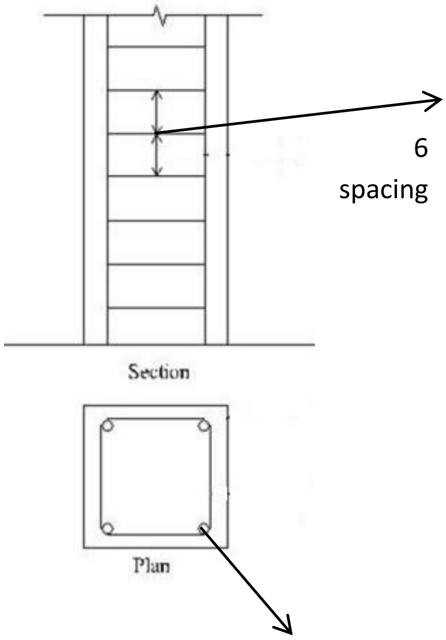
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.e-IIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	258.63	kN
Bending Moment M	21.7	kNm
Diameter of bar	16	mm



2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.31			
mu	0.07			
from interaction chart	33			
p/fck	0.02			
percentages steel	0.4			
Area of steel	250	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

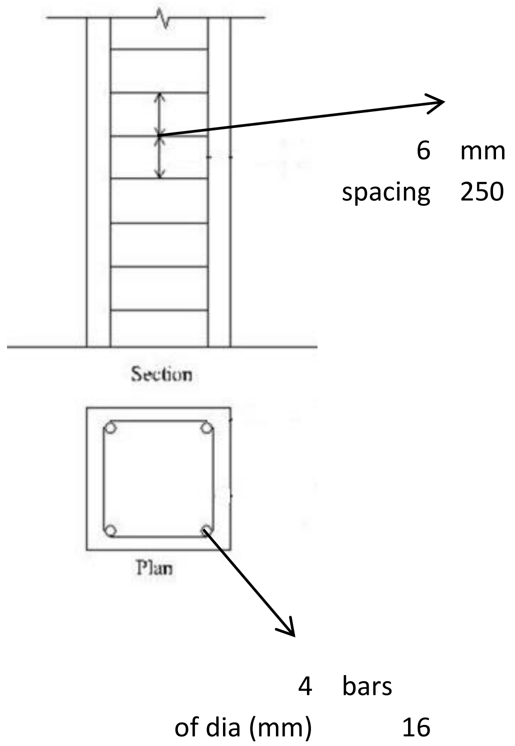
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.f-IIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	222.7	kN
Bending Moment M	23.95	kNm
Diameter of bar	16	mm



2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.27			
mu	0.08			
from interaction chart	33			
p/fck	0.04			
percentages steel	0.8			
Area of steel	500	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

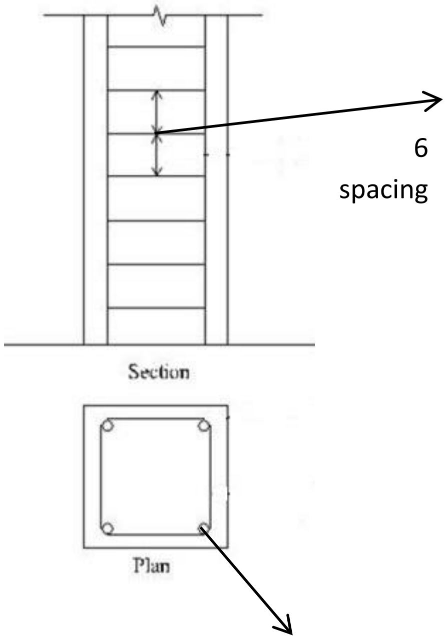
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.g-IIIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	97.63	kN
Bending Moment M	22.4	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

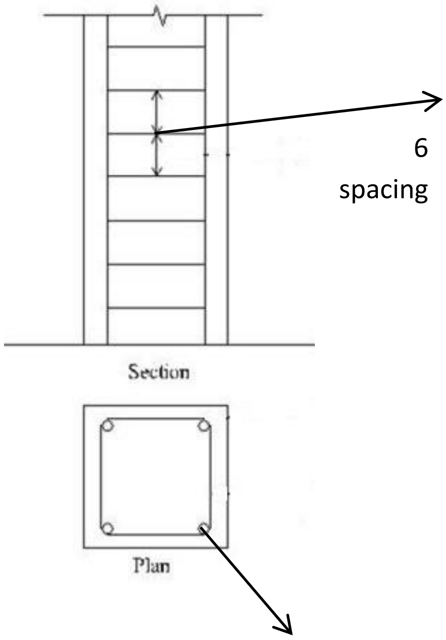
effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.12			
mu	0.07			
from interaction chart	33			
p/fck	0.03			
percentages steel	0.6			
Area of steel	375	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.h-IIIF



6 mm
spacing 250

4 bars
of dia (mm) 16

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	146.98	kN
Bending Moment M	9.5	kNm
Diameter of bar	16	mm

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.18			
mu	0.03			
from interaction chart	33			
p/fck		lies within range<0 , providing		
percentages steel	0	minimum steel		
Area of steel	0	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

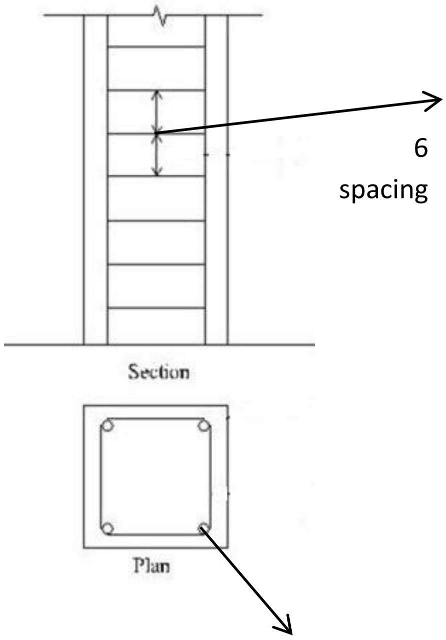
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.i-IIIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	85.66	kN
Bending Moment M	24.36	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.10			
mu	0.08			
from interaction chart	33			
p/fck		0.02		
percentages steel	0.4	minimum steel		
Area of steel	250	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

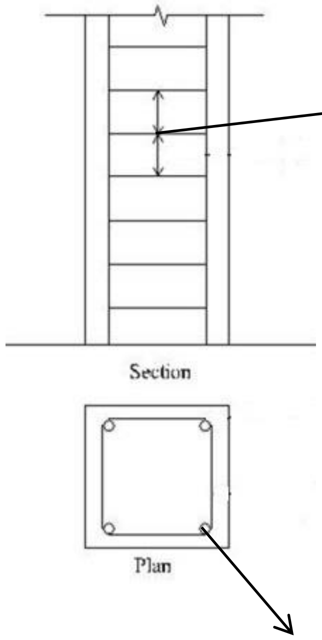
using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

Design of column C2.i-IIIF

1 Input Data

Length of column	3	m
Size of column Breadth	250	mm
D	250	mm
fck	20	N/mm2
fy	415	N/mm2
cover	30	mm
Axial Load P	60.41	kN
Bending Moment M	23.02	kNm
Diameter of bar	16	mm



6 mm
spacing 250

4 bars
of dia (mm) 16

2 Reinforcement Calculation

effective cover d'	46	mm		
d'/D	0.184	mm		
pu	0.07			
mu	0.07			
from interaction chart	33			
p/fck		0.02		
percentages steel	0.4	minimum steel		
Area of steel	250	mm2		
Min area of steel	500	mm2		
Hence As,	500.00	mm2		
No. of bars required	3			
Provided bars	**4**	**of dia**	**16**	**mm**
provided area of steel	803.84	mm2		

3 Spacing of stirrups

using stirrups of diameter	6	mm
Spacing		
i) least lateral dimension	250	mm
ii) 16*dia of main bar	256	mm
iii) 300 mm	300	mm

provide stirrups of dia	**6**	**mm @ spacing**	**250**	**mm**

6. Design of Staircase

Design of Staircase (Dog- Legged)

1 Input Data

vertical distance H	3	m
Length of hall	4.8	m
Breadth of hall	3	m
fck	20	N/mm2
fy	415	N/mm2
Live load	2.5	kN/m2
Diameter of bars	10	mm

2 General Arrangement of stair

Let riser R	150	mm
Tread T	250	mm
width of each flight	1.4	m
Height of each flight	1.5	m
No.of risers	10	in each flight
No. of treads	9	in each flight
Space occupied by treads	2.25	m
taking width of Landing	1.275	m
Space left for passage	1.275	m

3 Computation of design constants

xu,max/d	0.48
Ru	2.762

4 Computation of loading & Bending Moment

Let bearing of th landing slab in the wall (mm)		160
Effective span	3.6	m
let thickness of waist slab	200	mm
Weight of slab w' on slope	5	kN/m2
Dead weight on horizontal area w1	5.831	kN/m2
Dead weight on steps w2	1.875	kN/m2

Total dead weight per meter	7.706	kN/m2
weight of finishing	0.1	kN
Live Load	2.5	kN/m2
Total w	10.306	kN/m
Ultimate Load	15.459	kN/m
Bending Moment Mu	25.11307659	kNm

5 Design of waist slab

depth	95.35	mm

adopting overall depth D	150	mm
depth d	125	mm

6 Computation of reinforcement

Since d provided is more than the required for B.M., we have an under reinforced section for which

Ast	**620.67**	mm2

using 10 mm dia bars having Area 78.5 mm2

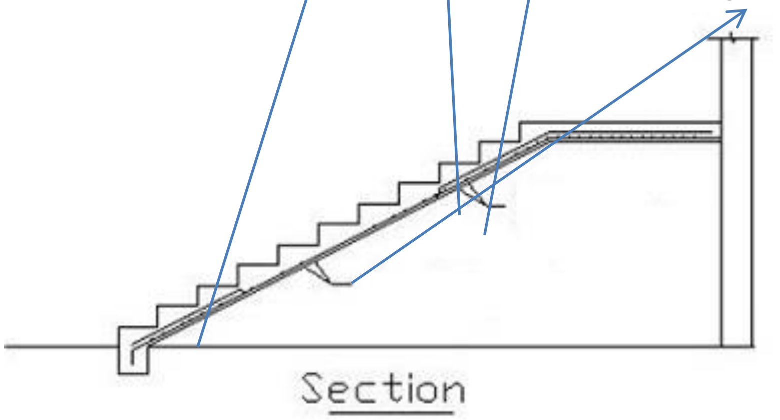
no. of bars required in width	1.4	m
	12	bars
Spacing of bars	**110**	mm
Distribution steel Asd	180	mm2
diamter of bar	8	mm
Spacing of bars of 8mm	**270**	mm

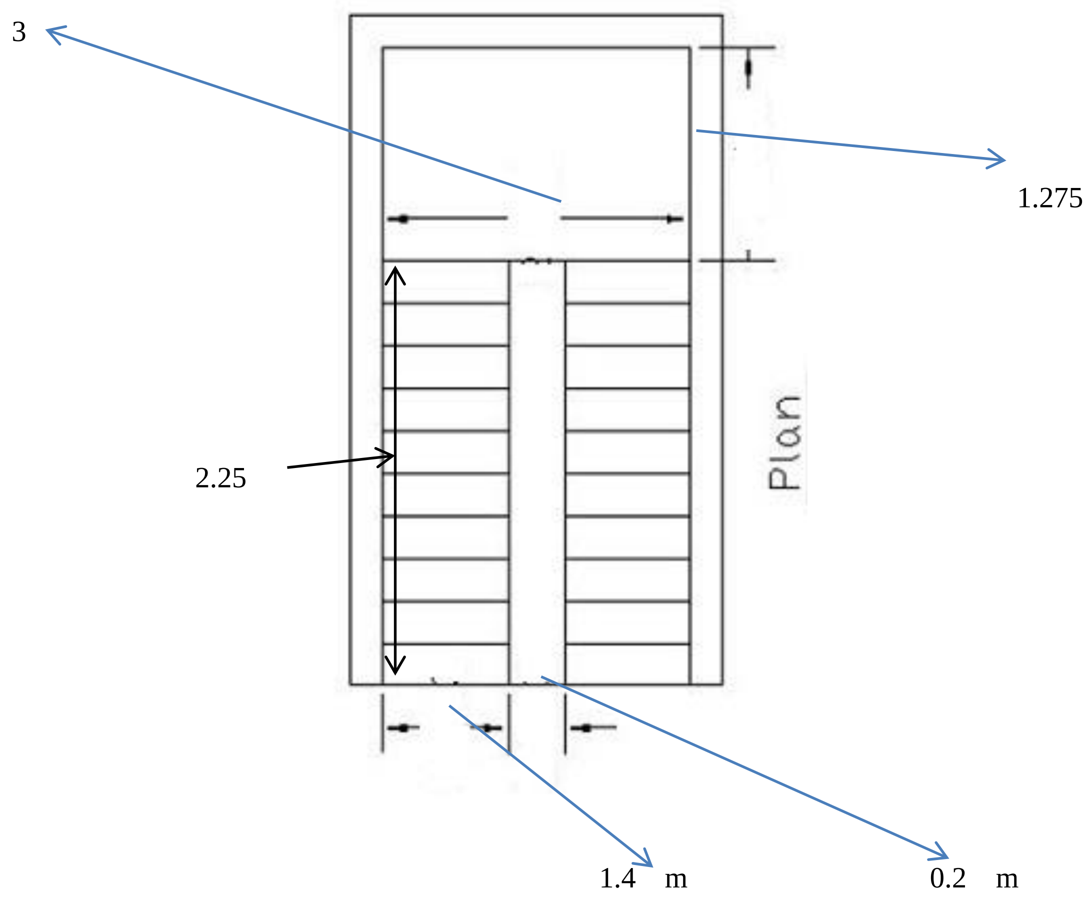
tread 250 mm

Riser 150 mm

8 mm @ 270 mm c/c

10mm @ 110 mm c/c




3
1.275
Plan
2.25
1.4 m
0.2 m

7. Design of Footing

Design of Footing F1

1 Input Data

Length	3	m
cross section of column		
B	250	mm
D	400	mm
Axial Load Pu	1028.671	kN
Moment in x dir	74.35	kNm
fck	20	N/mm2
fy	415	N/mm2
safe bearing capacity	120	kN/m2
dia of bars	16	mm

2 Size of footing

W	1028.671	kN
W'	102.8671	kN
M	74.35	kNm
Area of footing	9.43	m2
taking width B	3.1	m
Length	3.1	m
eccentricity	72.28	mm
P0	107.04	kN/m2

3 Design of footing

Cantilever length	1.497	m
Bending Moment M	371.95	kNm
Mu	557.93	kNm
depth d	899	mm
Taking depth d	900	mm
Depth D	960	mm

effective depth available for the second (inner) layer	884	mm

at the ends	D	480	mm
	d	420	mm

4 **Check for shear**

Two way shear section situated at d/2 from column face all round.

b0	1150	mm
Shear force Fu	1330.66	kN
τv=ks x τc	1.118	N/mm2
d0=Fu/(4*b0*τv)	259	mm

at distance d/2 from column face availabe effective depth = 753.35236 mm

is provided depth > d0 Safe in punching shear

one way shear

critical section at a distance	900	mm	from the column face
cantilever length	0.59727773	m	
shear force Vu	297.291423	kN	

Section will be trapezoidal in shape

width b at the top	2815	mm
effective depth d'	706.693308	mm

For under reinforced section xu/d = 0.4		
xu	282.677323	mm

width of Section at N. A

bn	3096.01	mm
τv	0.136	N/mm2

which is less than the permissible shear stress of 0.384N/mm2 at pt=0.3% corresponding to an under reinforced section

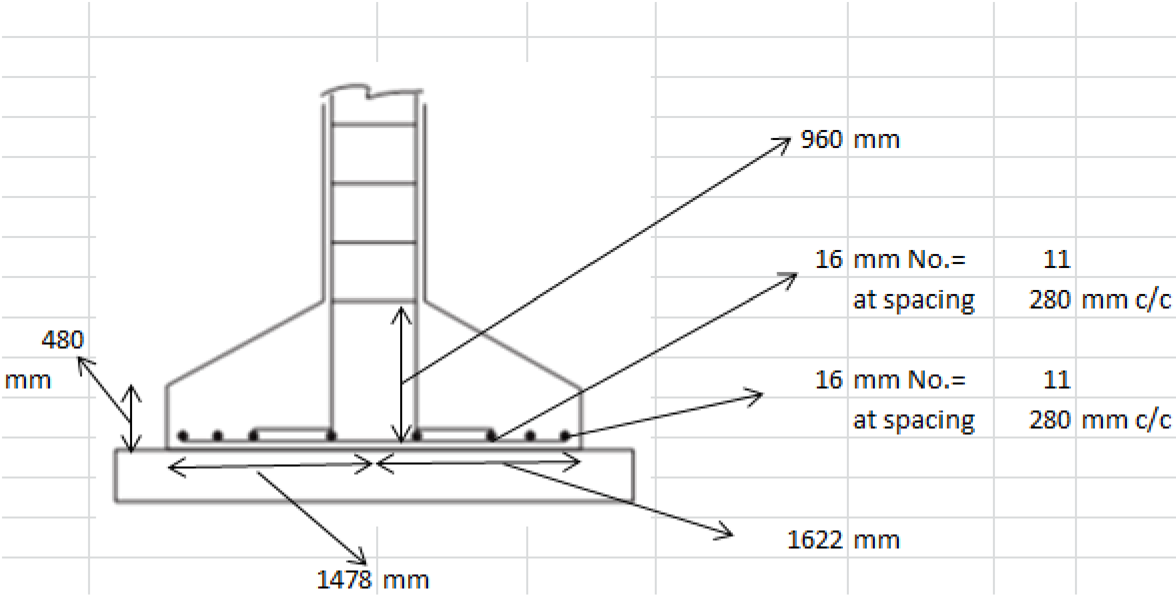
5 Steel reinforcement

For an under reinforced section		
Ast	2140.33361	mm2
using bars of dia	16	mm
number of bars required =		11
spacing	280	mm

using the same reinforcement in the perpendicular dimension.

6 Check for the development length

Ld=47*ϕ	752	mm
using side cover of 60mm available length		1490 mm
provided Ld < La	Yes	



Design of Footing F2

1 Input Data

Length	3	m
cross section of column		
B	250	mm
D	400	mm
Axial Load Pu	1125.84	kN
Moment in x dir	-64.34	kNm
fck	20	N/mm2
fy	415	N/mm2
safe bearing capacity	120	kN/m2
dia of bars	16	mm

2 Size of footing

W	1125.84	kN
W'	112.584	kN
M	-64.34	kNm
Area of footing	10.32	m2
taking width B	3.3	m
Length	3.3	m
eccentricity	-57.14844	mm
P0	103.38	kN/m2

3 Design of footing

Cantilever length	1.468	m

Bending Moment M	367.53	kNm
Mu	551.30	kNm
depth d	894	mm
Taking depth d	900	mm
Depth D	960	mm

effective depth available for the second (inner) layer	884	mm

at the ends	D	480	mm
	d	420	mm

4 **Check for shear**

Two way shear section situated at d/2 from column face all round.

b0	1150	mm
Shear force Fu	1483.67	kN
τv=ks x τc	1.118	N/mm2
d0=Fu/(4*b0*τv)	288	mm

at distance d/2 from column face availabe effective depth = 721.7125 mm

is provided depth > d0 Safe in punching shear

one way shear

critical section at a distance	900	mm	from the column face
cantilever length	0.56785156	m	
shear force Vu	290.595455	kN	

Section will be trapezoidal in shape

width b at the top	2995	mm
effective depth d'	692.568749	mm

For under reinforced section xu/d = 0.4		
xu	277.027499	mm

width of Section at N. A

bn	3304.99	mm
τv	0.127	N/mm2

which is less than the permissible shear stress of 0.384N/mm2 at pt=0.3% corresponding to an under reinforced section

5 **Steel reinforcement**

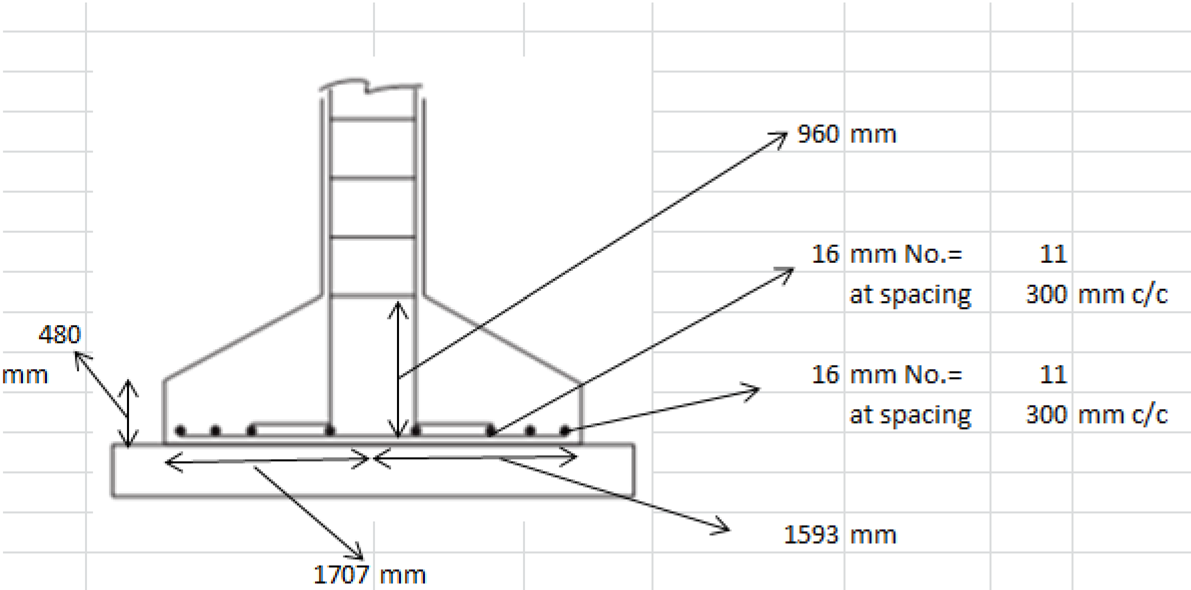
For an under reinforced section		
Ast	2106.77112	mm2

using bars of dia	16	mm
number of bars required =		11
spacing	300	mm

using the same reinforcement in the perpendicular dimension.

6 Check for the development length

Ld=47*ϕ	752	mm
		1590
using side cover of 60mm available length		mm
provided Ld < La	Yes	



Design of Footing F3

1 Input Data

Length	3	m
cross section of column		
B	250	mm
D	400	mm
Axial Load Pu	738.74	kN
Moment in x dir	-37.77	kNm
fck	20	N/mm2
fy	415	N/mm2
safe bearing capacity	120	kN/m2
dia of bars	16	mm

2 Size of footing

W	738.74	kN
W'	73.874	kN
M	-37.77	kNm
Area of footing	6.77	m2
taking width B	2.7	m
Length	2.7	m
eccentricity	-51.127596	mm
P0	101.34	kN/m2

3 Design of footing

Cantilever length	1.174	m
Bending Moment M	188.51	kNm
Mu	282.77	kNm
depth d	640	mm
Taking depth d	650	mm
Depth D	710	mm

effective depth available for the second (inner) layer	634	mm

at the ends	D	355	mm
	d	295	mm

4 **Check for shear**

Two way shear section situated at d/2 from column face all round.

b0	900	mm
Shear force Fu	984.99	kN
τv=ks x τc	1.118	N/mm2
d0=Fu/(4*b0*τv)	245	mm

at distance d/2 from column face availabe effective depth = 523.93725 mm

is provided depth > d0 Safe in punching shear

one way shear

critical section at a distance	650	mm	from the column face
cantilever length	0.5238724	m	
shear force Vu	215.003056	kN	

Section will be trapezoidal in shape

width b at the top	1842.5	mm

effective depth d'	480.974704	mm

For under reinforced section xu/d = 0.4		
xu	192.389881	mm
width of Section at N. A		
bn	2729.58	mm
τv	0.164	N/mm2

which is less than the permissible shear stress of 0.384N/mm2 at pt=0.3% corresponding to an under reinforced section

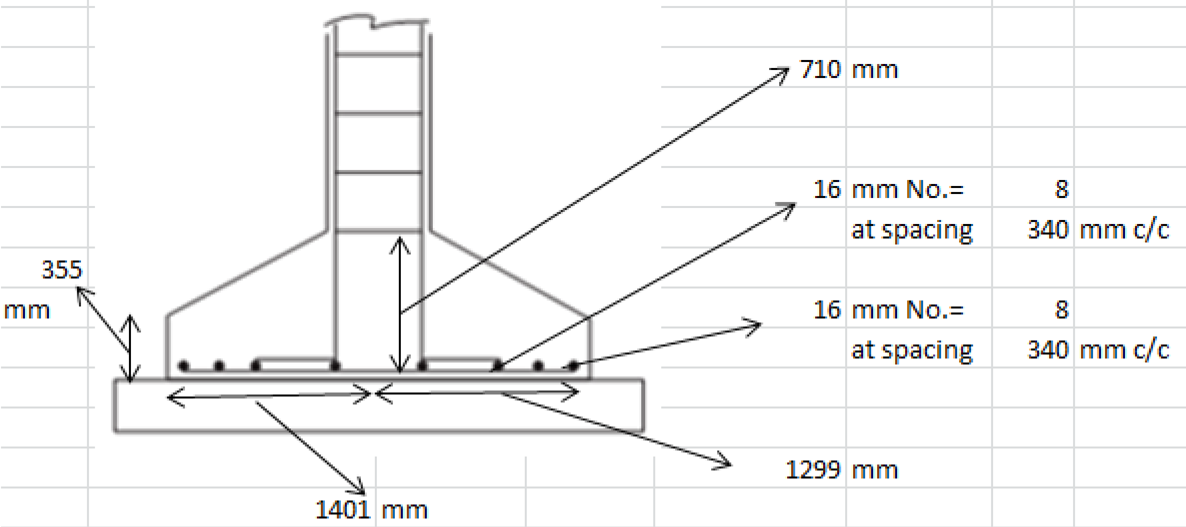
5 Steel reinforcement

For an under reinforced section		
Ast	1488.36997	mm2
using bars of dia	16	mm
number of bars required =		8
spacing	340	mm

using the same reinforcement in the perpendicular dimension.

6 Check for the development length

Ld=47*ϕ	752	mm
using side cover of 60mm available length		1290 mm
provided Ld < La	Yes	



Design of Footing F4

1 Input Data

Length	3	m
cross section of column		
B	250	mm
D	400	mm
Axial Load Pu	641.42	kN
Moment in x dir	47.4	kNm
fck	20	N/mm2
fy	415	N/mm2
safe bearing capacity	120	kN/m2
dia of bars	16	mm

2 Size of footing

W	641.42	kN
W'	64.142	kN
M	47.4	kNm
Area of footing	5.88	m2
taking width B	2.5	m
Length	2.5	m
eccentricity	73.8985376	mm
P0	102.63	kN/m2

3 Design of footing

Cantilever length	1.199	m
Bending Moment M	184.39	kNm
Mu	276.58	kNm
depth d	633	mm
Taking depth d	640	mm
Depth D	700	mm

effective depth available for the second (inner) layer	624	mm

at the ends	D	350	mm
	d	290	mm

4 **Check for shear**

Two way shear section situated at d/2 from column face all round.

b0	890	mm
Shear force Fu	840.19	kN
$\tau v = ks \times \tau c$	1.118	N/mm2
$d0 = Fu/(4*b0*\tau v)$	211	mm

at distance d/2 from column face availabe effective depth = 545.7859 mm

is provided depth > d0 Safe in punching shear

one way shear

critical section at a distance	640	mm	from the column face
cantilever length	0.55889854	m	
shear force Vu	215.09322	kN	

Section will be trapezoidal in shape

width b at the top	1690	mm
effective depth d'	485.614488	mm

For under reinforced section xu/d = 0.4		
xu	194.245795	mm
width of Section at N. A		
bn	2494.33	mm
τv	0.178	N/mm2

which is less than the permissible shear stress of 0.384N/mm2 at pt=0.3% corresponding to an under reinforced section

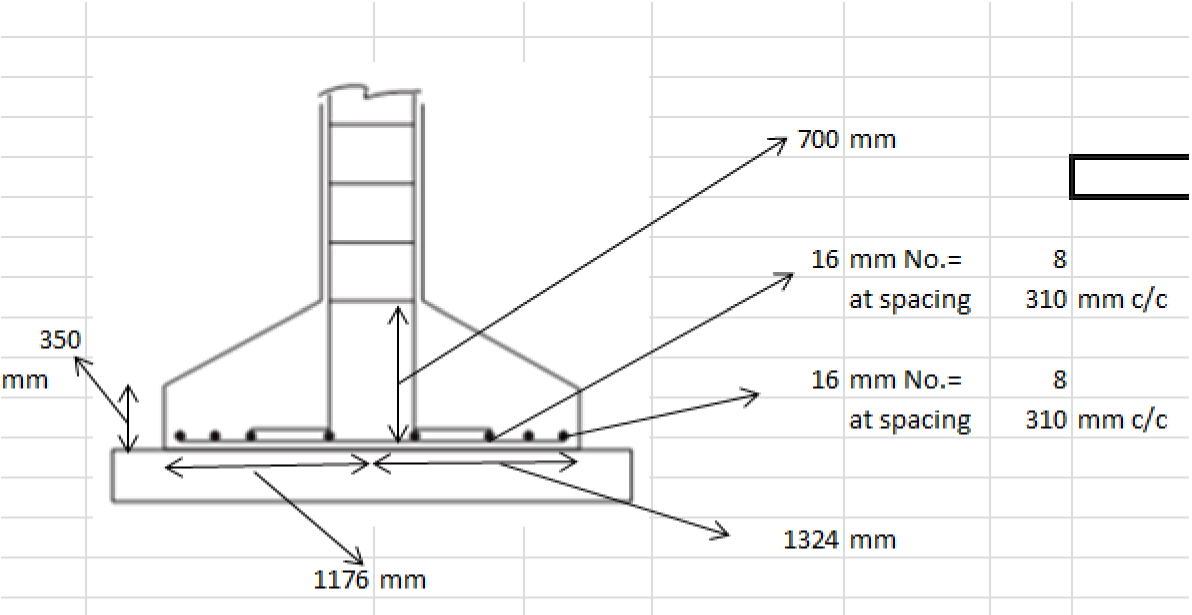
5 Steel reinforcement

For an under reinforced section		
Ast	1482.64791	mm2
using bars of dia	16	mm
number of bars required =		8
spacing	310	mm

using the same reinforcement in the perpendicular dimension.

6 Check for the development length

Ld=47*ϕ	752	mm
using side cover of 60mm available length		1190 mm
provided Ld < La	Yes	


700 mm
16 mm No.= 8
at spacing 310 mm c/c
350
mm
16 mm No.= 8
at spacing 310 mm c/c
1324 mm
1176 mm

8. Elevated Water Tank (Intz Type)

INTRODUCTION

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential .The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength.Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass the risk of cracking can also be minimized by reducing the restraints onfree expansion or contraction of the structure.

WATER DEMAND

Water Quantity Estimation: The quantity of water required for municipal uses for which the water supply scheme hasto be designed requires following data:Water consumption rate (Per Capita Demand in litres per day per head)Population to be served. Quantity= Per demand x Population

Water Consumption Rate: It is very difficult to precisely assess the quantity of water demanded by the public, sincethere are many variable factors affecting water consumption.

Factors affecting per capita demand:

• Size of the city: Per capita demand for big cities is generally large as compared tothat for smaller towns as big cities have sewered houses.

• Presence of industries.

• Climatic conditions.

• Habits of economic status.

• Quality of water: If water is aesthetically $ people and their . Medically safe, the consumption will increase as people will not resort to privatewells, etc.

• Pressure in the distribution system.

• Efficiency of water works administration: Leaks in water mains and services;and un authorised use of water can be kept to a minimum by surveys.

• Cost of water.

• Policy of metering and charging method: Water tax is charged in two different ways on the basis of meter reading and on the basis of certain fixed monthly rate.

WATER TANKS

CLASSIFICATIONS:

Classification based on under three heads:

1. Tanks resting on ground
2. Elevated tanks supported on stagging
3. Underground tanks

. Classification based on shapes

1. Circular tanks
2. Rectangular tanks
3. Spherical tanks
4. Intze tanks
5. Circular tanks with conical bottom

Design of Intz Tank

1) Number of people = 2000
Daily requirement = 1350lpcd
Total water required = 2000*135*2= 540klpcd= 540cu.m
Designing for 350cu.m, with refilling twice a day.

Capacity =350 cu.m
Height of supporting tower=16m
No. of columns=8
Depth of foundation=1 m below GL.

Permissible Stresses:-
M20 Grade Concrete: σ_{ct} =1.2 N/mm^2, σ_{cb} =1.7 N/mm^2 ; m= 13
σ_{cc} =5 N/mm^2, σ_{cbc} =7 N/mm^2
Fe-415 Grade Steel: σ_{st} = 150N/mm^2

2) **Dimensions:-**

Let Inside Diameter of the tank = D

Assuming average depth=0.75D

$(\frac{\pi D2}{4} * 0.75D)$ = 350

Diameter (D) =8.5m
Height of cylindrical portion = 6.2m
Depth of conical dome = 1.7m
Spacing of bracings = 4m
Dia. of supporting tower = 5m

3) **Design of top Dome**

Assume thickness of dome slab =100mm
Live load on dome =1.5 kN/m^2
Self wt. = 2.4 kN/m^2
Finishes = 0.1 kN/m^2
Total load,w = 4 kN/m^2

Central rise, r =1.7m
Radius of dome,R: r(2R-r) =(0.5D)^2
R=6.2m

$\cos\Theta = \cos(36.24) = 0.8$

Meridional Thrust, $T_1 = \frac{wR}{1+\cos\theta} = 13.80$ kN/m

Circumferential force, $T_2 = wR\left[\cos\theta - \frac{1}{1+\cos\theta}\right] = 6.06$ kN/m

Meridian Stress $= \frac{T1}{A} = \frac{13.80*1000}{1000*100} = 0.138$ N/mm^2 < 5N/mm^2

Hoop Stress $= \frac{T2}{A} = \frac{6.06*1000}{1000*100} = 0.0606$N/mm^2 < 5N/mm^2

Stresses are within safe limits, providing nominal reinforcement of 0.3%,

$A_{st} = \frac{0.3*100*1000}{100} = 300$ mm^2

Provide 8mm dia. bars at 160mm c/c on both faces.

4) Design of Top ring beam:

Hoop tension, $F_t = \frac{T1\cos\Theta.D}{2} = 46.92$ kN

$A_{st} = \frac{Ft}{\sigma st} = \frac{46.92*1000}{150} = 313$ mm^2

Provide 4 bars of 12mm dia. ($A_{st} = 452$ mm^2)

If A_c is cross-sectional area of ring beam, $\frac{46.92*1000}{Ac+13*452} = 1.2$

$A_c = 33224$ mm^2

Provide 200mm*200mm size top ring beam, with 4 bars of 12mm dia. as main reinforcement and 6 mm dia. stirrups at 200mm c/c.

Shear force along the edge $= T_1\sin\Theta = 8.21$kN

Shear stress along the edge =0.0821` N/mm^2 – very low

5) Design of cylindrical wall:

Maximum hoop tension at the base of wall, $F_t = \frac{whD}{2}$, where, w =unit wt. of water=10kN/m^3

h=height of water

$F_t = 263.5$ kN/m

Tension reinforcement per metre of height

$A_{st} = \frac{Ft}{\sigma st} = \frac{263.5*1000}{150} = 1757$ mm^2/m height.

Provide 6-20mm dia. bars @180mm c/c on each face.($A_{st} = 1885$mm^2)

A_{st} required at 1.7m below top =482 mm^2
Provide 10-10mm bars @180mm c/c on each face.

Let, t =thickness of side wall at bottom

$\frac{263.5*1000}{1000t+13*1885}$ =1.2

t =195 mm
Adopt 250mm thick wall at bottom gradually reducing to 200mm at top.

Distribution steel:
At bottom, A_{st} =0.2% of cross-sectional area =500mm^2
Provide 6-10mm dia. bars at 200mm c/c.

At top, 0.2% of cross-sectional area =400mm^2
Provide 10mm dia. bars at 250mm c/c.

6) Design of bottom ring beam:

Load due to top dome = T_1sinΘ =8.21kN/m
Load due to top ring beam =0.2*0.2*24 =0.96kN/m
Self wt. of ring beam (assuming 1.2m*0.6m*24kN/m^3) =17.28kN/m
Load due to cylindrical wall = $\frac{0.250+0.2}{2} * 6.2 * 24$ = 33.48kN/m
Total vertical load V=60kN/m

Hoop tension due to vertical loads, $H_v = \frac{VD}{2}$ = 255kN
Hoop tension due to water pressure,$H_w = \frac{whdD}{2}$ = 158.1kN
Total hoop tension = $H_v + H_w$ = 413.1kN
A_{st} = 2754mm^2
Provide 9 bars of 20 mm dia.(A_{st} = 2828mm^2)
Maximum tensile stress =$\frac{548.52*1000}{1200*600+13*2828}$ =0.55 N/mm^2 <1.3 N/mm^2

Provide ring beam 1200mm wide and 600mm deep with 9-20mm dia bars and distribution bars of 10mm dia from cylindrical wall taken round the main bars as stirrups at 180mm c/c spacing.

7) Design of conical dome:

Average dia = $\frac{8.5+5}{2} = 6.75$m

Average depth of water = 6.2+$\frac{1.7}{2} = 7.05\ m$

Weight of water above conical dome

$= \pi \times 6.75 \times 7.05 \times 1.7 \times 10 = 2451.50$ KN

Assuming 600mm thick slab,

Self weight of slab = $\pi \times 2.30 \times 6.75 \times 0.6 \times 24 = 702.33$ KN

Load from top dome, top ring beam, cylindrical wall and bottom ring beam

$= \pi \times 8.5 \times 60$

= 1602.21 KN

Total load at base of conical slab =2451.50+702.33+1602.21= 4756 KN

Load/ unit length, $V_2 = \frac{4756}{\pi \times 6.2} = 244.2$ KN/m

Meridian thrust = T =$V_2 cosec\theta$

$= 244.2 \times$ cosec $45^o = 345.35$ KN

Meridional stress =$\frac{345.35 \times 10^3}{600 \times 1000} = 0.580$ N/ mm^2

Hoop tension in conical dome will be maximum at the top of the conical slab since diameter is maximum at this section.

Hoop tension (H) = (p*cosecθ + q*cosecθ)*D/2

Water pressure, p=10×6.2= 62 KN/ mm^2

Weight of conical dome slab / m^2,

q = 0.6×24=14.4 KN/ mm^2

$\theta = 45^o$, D= 8.5 m

H= (62×cosec45^o + 14.4×cot45^o) 8.5/2

= 433.85 KN

$A_{st} = \frac{433.85 \times 10^3}{150}$ = 2892.33 mm^2

Provide 6-25mm φ bars @ 180mm c/c

$A_{st}(2945.24\ mm^2)$ On both faces of slab

Distribution steel:$\frac{0.2 \times 600 \times 1000}{100} = 1200\ mm^2$

Provide 10mm φ at 130mm c/c on both faces along the meridions.

Max. tensile stress = $\frac{433.85\times10^3}{(600\times1000)+(13\times2945.24)}$

= 0.68<1.3(safe)

8) Design of bottom spherical dome:-

Thickness of dome slab (assume) = 300mm

Diameter at base = 5m

Central rise = 1/5 ×5= 1m

Radius of dome R, (2R-r)r =$(D/2)^2$

R= $\frac{(D/2)^2+r^2}{2r} = \frac{(5/2)^2+1^2}{2}$= 3.625m= 3.7m

Self weight of dome slab

= 2π×3.7×1×0.3×24 = 167.38 KN

Volume of water above the dome

=π×2.5^2× (6.2+1.7) – ($\frac{2\pi*3.7^2*1}{3}$ – $\frac{\pi*2.5^2}{3}$ $(3.7-1)$) = 144.12 m^3

Weight of water = 1441.2 KN

Total load on dome = 167.38+1441.2= 1608.58 KN

Load/ unit area = $\frac{1608.58}{\pi\times2.5^2}$ = 81.92 KN/m^2

Meridional thrust, T=$\frac{wR}{1+cos\theta}$

Cosθ $\frac{2.68}{3.7}$ =0.724

θ = 44.5°

$T_1 = \frac{81.92\times3.7}{1.724}$ = 175.8 KN/m

Meridional stress=$\frac{175.8\times10^3}{300\times1000}$

=0.586(safe)

Circumference force = wR (cosθ- $\frac{1}{1+cos\theta}$)

= 81.92×3.7(0.724-1/1.724)

= 43.63 KN/m

Hoop stress=$\frac{43.63\times10^3}{300\times1000}$=0.145 N/$mm^2$ (safe)

Provide nominal reinforcement of 0.3%,

$A_{st} = \frac{0.3\times300\times1000}{100}$=900$mm^2$

Provide 12mm φ bars @ 120 mm c/c circumferentially and along the meridions.

9) Design of bottom circular Girder

Thrust from conical dome, T_1= 244.2 KN/m

Thrust from spherical dome, T_2= 175.8 KN/m

Net horizontal force on ring beam

$T_1 cos\alpha - T_2 cos\beta$ = (244.2×0.707-175.8×0.713) = 47.3 KN

Hoop compression in beam = $\frac{47.3\times5}{2}$ = 118.25 KN

Assuming the size of girder as 600 mm wide and 1200 mm deep
hoop stress = $\frac{118.25\times10^3}{600\times1200}$ = 0.164 N/mm^2

Vertical load on ring beam = 244.2×0.707+175.8×0.70

= 295.7 KN/m

Self weight of beam = 0.6×1.2×24 = 17.28 KN/m

Total load = 295.7+17.28 = 313KN/m

Total design load on ring girder

W= πDw = π×5×313

= 4916.6KN

The circular girder is supported on 6 columns using the moment coefficient

Maximum –ve BM at support section = 0.0142wR

= 0.0142×4916.6×2.5

= 174.5kN-m

maximum +ve BM at mid span section

$=0.0075wR$

$= 0.0075 \times 4916.6 \times 2.5$

$= 92.2$kN-m

Torsional moment $= 0.0015wR$

$= 0.0015 \times 4916.6 \times 2.5$

$= 18.4$kN-m

Shear force @ support section

$V = \frac{wR \times \frac{\pi}{4}}{2} \quad = \frac{313 \times 2.5 \times \frac{\pi}{4}}{2} = 307.3\text{kN}$

Shear force at section of maximum torsion

$307.3 - \frac{313*3.14*2.5*12.75}{180} = 133.2\text{kN}$

10) Design of support section:

M = 102kN-m

V=307.3kN

$k_b = 0.39$

$j_b = 0.87$, Q=0.897

$d = \sqrt{\frac{174.5*10^6}{0.897*600}} = 570$ mm

Effective depth (d)= 600 mm (taking cover of 50 mm, D= 600+50= 650mm)

$A_{st} = \frac{174.5*10^6}{150*0.897*600} = 2162 \text{ mm}^2$

Providing 7-20mm diameter bars (A_{st}= 2199mm^2)

$\tau_v = \frac{307.3*10^3}{600*600} = 0.85 \text{ N/mm}^2$

$\frac{100Ast}{bd} = \frac{100*2199}{600*600} = 0.61$

$\tau_c = 0.27\text{N/mm}^2$

$\tau_c < \tau_v$, hence shear reinforcement required

Shear taken by concrete $= \frac{0.27*600*600}{1000} = 97.2\text{kN}$

Balance shear =307.3- 97.2=210kN

Using 12mm diameter 4 legged stirrups, spacing

$s_v = \frac{150*4*113*600}{210*10^3}$ = 193 mm ; Adopt 12mm diameter 4 legged stirrups at 190mm c/c near supports.

b) Design of mid span

Maximum positive moment= 92.2kN-m

$A_{st} = \frac{92.2*10^6}{150*0.9*600} = 1138.3mm^2$

But minimum area of reinforcement in the section

$= (\frac{0.3*600*650}{100}) = 1170mm^2$

Providing 6 bars of 16mm diameter at mid span section and 4-legged stirrups of 10mm diameter at 300mm c/c.

c) Design of section subjected to maximum torsion

T= 18.4kN-m D= 650mm

V= 133.2kN b= 600mm

M=0 d= 600mm

$M_t = T*(\frac{1+D/d}{1.7}) = 18.4*(\frac{1+650/600}{1.7}) = 22.6kN\text{-}m$

Therefore $M_{e1} = (M + M_t) = (0 + 22.6) = 22.6kN\text{-}m$

$A_{st} = (\frac{22.6*10^6}{150*0.9*600}) = 279mm^2$

But minimum area of reinforcement

$A_{st} = (\frac{0.3*650*600}{100}) = 1170mm^2$

Provide 6 bars of 16mm diameter ($A_{st} = 1206mm^2$)

Equivalent shear $V_e = (V+1.6(T/b)) = (133.2 + 1.6*18.4/0.6) = 182.3kN$

$\tau_{ve} = (V_e/bd) = 0.506N/mm2$

$\frac{100Ast}{bd} = \frac{100*1206}{600*600} = 0.335$

From Table 1.3B τ_c =0.24N/mm2

Since $\tau_v > \tau_c$, Shear reinforcements are required

Using 12mm diameter 4-legged stirrups with the side covers of 25mm and top and bottom covers of 50mm, spacing

IS456:2000 Clause B-6.4.3 $s_v = \frac{A_{sv}*\sigma_{sv}}{(\tau ve - \tau c)*b} = \frac{4*113*150}{(0.506-0.24)*600}$ = 425mm

Adopt 12mm diameter 4-legged stirrups at 300mm c/c.

11) Design of Column of supporting tower

The supporting tower comprises 6 equally spaced columns on a circle of 5m diameter.

Loads on Columns

Vertical Load on each column: 4916.6/6 = 819.43kN

Self-weight of column of height 16m and diameter 650mm= $\frac{\pi*0.65^2*16*24}{4}$ = 127kN

Self-weight of bracing (3no.s at 4m interval)(size 500mmx500mm) = $\frac{3*0.5*0.5*\pi*5*24}{6}$ = 47kN

Total vertical Load on each column = 819.3 + 127+ 47= 993.3kN

Wind Forces on column

Intensity of wind pressure = 1.5 kN/m^2 . Reduction coefficient for circular shape = 0.7

Wind force on Top Dome and Cylindrical wall = (6.2+1.7/2)*0.7*1.5*8.5 = 62.92kN

Wind force on conical dome = 1.7*6.75*0.7*1.5 = 12.05kN

Wind force on bottom ring beam = 1.2*5*0.7*1.5 = 6.3kN

Wind force on 4 columns = 4*0.65*16*0.7*1.5 = 43.68kN

Wind force on bracings = 0.5*5*3*1.5 = 11.25kN

Total horizontal wind force = 62.92+12.05+6.3+43.68+11.25 = 136.2kN

Assuming contra flexure points at mid height of columns and fixity at base due to raft foundations the moment at the base of the columns is computed as

M = 136.2*2.5*0.5 = 170.25kN-m

M_1= moment at the base of the column due to wind loads

= 62.92*25.6+ 12.05*17.7+ 6.3*16+ 3.75*12+ 3.75*8+ 3.75*4 = 2014.84kN-m

And V = reaction developed at the base of exterior columns

$M_1 = \Sigma M + V/r_1 * (\Sigma r^2)$

$2014.84 = 170.25 + V/2.5 * (2 * 2.5^2 + 2*(2.5/\sqrt{2})^2)$

$V = 245.95kN$

Therefore load on leeward column at base = 993.3+ 245.95 = 1239.2kN

Moment in each column at base = 170.25/6 = 28.375kN-m

Axial Load P = 1239.2kN

Bending Moment M = 28.38kN-m

Eccentricity e = (M/P) = $(28.38*10^6/1239.2*10^3)$ = 23mm

Since eccentricity is small direct stresses are predominant.

Using 8 bars of 32mm diameter and lateral ties of 10mm diameter at 300mm c/c.

A_{sc} = 8*804 = 6432mm2

Equivalent area of composite section $A_e = (\frac{\pi * 650^2}{4} + (1.5 * 13 * 6432)) = 0.45*10^6 mm^2$

Equivalent second Moment of Area of composite section = Ie

$$= \frac{\pi * 325^4}{4} + \left((1.5 * 13) * [(2 * 804 * 275 * 275) + 4 * 804 * (\frac{275}{\sqrt{2}})^2]\right)$$

$$= 13.48*10^9 mm^4$$

Direct compressive stress $\sigma'_{cc} = \frac{1239.2*10^3}{0.45*10^6} = 2.75 N/mm^2$

Bending stress = $\sigma'_{cb} = \frac{28.375*10^6*325}{13.48*10^9} = 0.68 N/mm^2$

IS: 456-200, Clause B-4.1 $\frac{\sigma'_{cc}}{\sigma_{cc}} + \frac{\sigma'_{cb}}{\sigma_{cb}} < 1$

0.5<1

Stress is within safe limits.

12) Design of bracings

Moment in brace = (2*moment in column*$\sqrt{2}$) = 2*28.375* $\sqrt{2}$ = 80.3kN-m

Section of brace = 500mmx500mm

b= 500mm; d= 450mm

Moment of resistance of section M_1= 0.897*500*450^2 = 91kN-m

$A_{st} = \frac{80.3*10^6}{230*0.9*450}$ = 862mm^2

Provide 4 bars of 20mm diameter (A_{st} =1260mm^2) at the top and bottom since wind direction is reversible.

Length of brace L = (2*2.5*sin30^o) = 2.5m

Maximum shear force in brace = Moment in brace / (1/2 *Length of brace)

= 80.3/(0.5*2.5) = 64.24kN

τ_v = 64.24*1000/ (500*450) = 0.286N/mm^2

(100Ast/bd) = $\frac{100*1260}{500*450}$ = 0.56

IS: 456-2000 Clause B-5.4 and Table 23 τ_c = 0.31N/mm^2

Since $\tau_v < \tau_c$, Shear reinforcements are not required.

9. Estimation

Bar Bending Schedule of Columns

Column C1 a GF

Input Data		Length	3	m
		width	0.4	m
		depth	0.25	m
		No. of elements		12

Dia of bars(mm)	20
Number of bars	6

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D²/162 kg
1	A	Straight bars	6	3.98	20	707.56
2	B	stirrups	20	1.076	6	57.387
					total	**764.942**

No. of stirrups= Length/Spacing +1

E	328
A	138
Length of stirrups	1.08

Column C1 b GF

Input Data	Length	3	m
	width	0.4	m
	depth	0.25	m
	No. of elements		12

Dia of bars(mm)	20
Number of bars	8

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D²/162 kg
1	A	Straight bars	8	3.98	20	943.41
2	B	stirrups	20	1.076	6	57.387
					total	**1000.794**

No. of stirrups= Length/Spacing +1

E	328
A	138
Length of stirrups	1.08

Column C1 c GF

Input Data	Length	3	m
	width	0.4	m
	depth	0.25	m
	No. of elements		4

Dia of bars(mm)	20
Number of bars	4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D²/162 kg
1	A	Straight bars	4	3.98	20	157.23
2	B	stirrups	20	1.076	6	19.129
					total	**176.363**

No. of stirrups= Length/Spacing +1

E	328
A	138

Length of stirrups	1.08

Column — C1 d GF

Input Data	Length	3	m	Dia of bars(mm)
	width	0.4	m	20
	depth	0.25	m	Number of bars
	No. of elements		4	4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	4	3.98	20	157.23
2	B	stirrups	20	1.076	6	19.129
					total	**176.363**

No. of stirrups= Length/Spacing +1

E	328
A	138
Length of stirrups	1.08

Column — C1 e IF

Input Data	Length	3	m	Dia of bars(mm)
	width	0.4	m	20
	depth	0.25	m	Number of bars
	No. of elements		12	4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	4	3.98	20	471.70
2	B	stirrups	20	1.076	6	57.387
					total	**529.090**

No. of stirrups= Length/Spacing +1

E	328
A	138
Length of stirrups	1.08

Column — C1 f IF

Input Data	Length	3	m	Dia of bars(mm)
	width	0.4	m	20
	depth	0.25	m	Number of bars
	No. of elements		12	4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg

1	A	Straight bars	4	3.98	20	471.70
2	B	stirrups	20	1.076	6	57.387
					total	**529.090**

No. of stirrups= Length/Spacing +1

E	328
A	138
Length of stirrups	1.08

Column C2 a IF

Input Data		Length	3	m		Dia of bars(mm)
		width	0.25	m		16
		depth	0.25	m		Number of bars
		No. of elements		4		4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	4	3.784	16	95.67
2	B	stirrups	20	0.776	6	13.796
					total	**109.470**

No. of stirrups= Length/Spacing +1

E	178
A	138
Length of stirrups	0.78

Column C2 b IF

Input Data		Length	3	m		Dia of bars(mm)
		width	0.25	m		16
		depth	0.3	m		Number of bars
		No. of elements		4		4

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	4	3.784	16	95.67
2	B	stirrups	20	0.876	6	15.573
					total	**111.248**

No. of stirrups= Length/Spacing +1

E	178
A	188
Length of stirrups	0.88

As all the above columns are similar to the above column , therefore total steel

steel rquired by columns for floor II and III 7119.85936 kg

therefore total steel required by columns 42.069 tons

BBS of Beams of ground floor, Ist Floor and IInd Floor

T Beam **Long**

Input Data	Length	4.8	m	Dia of bars	Number of bars
	width	0.25	m	20	3
	depth	0.38	m	25	2
				stirrups mm	8
				Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	5.008	20	12.37
2	B	Straight bars upper	2	5.286	25	40.78703704
3	C	Bent	2	5.82	20	28.74
4	E	stirrups	10	1.004	8	3.966
					total	**85.859**

E	138
A	268
Length of stirrups	1

No. of stirrups= Length/Spacing +1

T Beam **Short**

Input Data	Length	3.72	m	Dia of bars	Number of bars
	width	0.25	m	16	3
	depth	0.3	m	20	2
				stirrups mm	8
				Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	3.848	20	9.50
2	B	Straight bars upper	2	4.036	20	19.9308642
3	C	Bent	2	4.63	20	22.85
4	E	stirrups	10	0.844	8	3.334
					total	**55.614**

E	138
A	188
Length of stirrups	0.84

No. of stirrups= Length/Spacing +1

T Beam **Lobby**

Input Data	Length	2.5	m	Dia of bars	Number of bars
	width	0.25	m	16	2

depth	0.22	m	16	2
			stirrups mm	8
			Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	2.548	20	6.29
2	B	Straight bars upper	2	2.648	16	8.36899
3	C	Bent	1	3.29	20	8.13
4	E	stirrups	10	0.684	8	2.702
					total	**25.495**

E	138
A	108
Length of stirrups	0.68

No. of stirrups= Length/Spacing +1

L Beam Long

Input Data	Length	4.92	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.38	m	20	3
				stirrups mm	8
				Spacing(mm)	125

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	5.128	20	12.66
2	B	Straight bars upper	3	5.396	20	39.97037
3	C	Bent	1	5.94	20	14.67
4	E	stirrups	40	1.004	8	15.866
					total	**83.164**

E	138
A	268
Length of stirrups	1

No. of stirrups= Length/Spacing +1

L Beam Short

Input Data	Length	3.72	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.3	m	20	2
				stirrups mm	8
				Spacing(mm)	150

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	3.848	20	9.50
2	B	Straight bars upper	2	4.036	20	19.93086
3	C	Bent	1	4.63	20	11.42
4	E	stirrups	30	0.844	8	10.003

total	**50.859**

E	138
A	188
Length of stirrups	0.84

No. of stirrups= Length/Spacing +1

L Beam **Lobby**

Input Data	Length	2.5	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.22	m	20	2
				stirrups mm	8
				Spacing(mm)	150

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D²/162 kg
1	A	Straight bars	1	2.548	20	6.29
2	B	Straight bars upper	2	2.656	20	13.11605
3	C	Bent	1	3.29	20	8.13
4	E	stirrups	20	0.684	8	5.404
					total	**32.944**

E	138
A	108
Length of stirrups	0.68

No. of stirrups= Length/Spacing +1

BBS of Beams of top floor

T Beam **Long**

Input Data	Length	4.8	m	Dia of bars	Number of bars
	width	0.25	m	20	3
	depth	0.38	m	25	2
				stirrups mm	8
				Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D²/162 kg
1	A	Straight bars	1	5.008	20	12.37
2	B	Straight bars upper	2	5.286	25	40.78703704
3	C	Bent	2	5.82	20	28.74
4	E	stirrups	10	1.004	8	3.966
					total	**85.859**

E	138
A	268
Length of stirrups	1

No. of stirrups= Length/Spacing +1

T Beam **Short**

Input Data	Length	3.72	m	Dia of bars	Number of bars
	width	0.25	m	16	3
	depth	0.3	m	20	2
				stirrups mm	8

Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	3.848	20	9.50
2	B	Straight bars upper	2	4.036	20	19.9308642
3	C	Bent	2	4.63	20	22.85
4	E	stirrups	10	0.844	8	3.334
					total	**55.614**

E	138
A	188
Length of stirrups	0.84

No. of stirrups= Length/Spacing +1

T Beam **Lobby**

Input Data					
	Length	2.5	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.22	m	16	2
				stirrups mm	8
				Spacing(mm)	360

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	2.548	20	6.29
2	B	Straight bars upper	2	2.648	16	8.36899
3	C	Bent	1	3.29	20	8.13
4	E	stirrups	10	0.684	8	2.702
					total	**25.495**

E	138
A	108
Length of stirrups	0.68

No. of stirrups= Length/Spacing +1

L Beam **Long**

Input Data					
	Length	4.92	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.38	m	20	2
				stirrups mm	8
				Spacing(mm)	290

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	5.128	20	12.66
2	B	Straight bars upper	2	5.396	20	26.64691
3	C	Bent	1	5.94	20	14.67
4	E	stirrups	20	1.004	8	7.933
					total	**61.908**

E	138

A	268	No. of stirrups= Length/Spacing +1
Length of stirrups	1	

L Beam **Short**

Input Data	Length	3.72	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.3	m	20	2
				stirrups mm	8
				Spacing(mm)	150

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	3.848	20	9.50
2	B	Straight bars upper	2	4.036	20	19.93086
3	C	Bent	1	4.63	20	11.42
4	E	stirrups	30	0.844	8	10.003
					total	**50.859**

E	138	
A	188	No. of stirrups= Length/Spacing +1
Length of stirrups	0.84	

L Beam **Lobby**

Input Data	Length	2.5	m	Dia of bars	Number of bars
	width	0.25	m	16	2
	depth	0.22	m	20	2
				stirrups mm	8
				Spacing(mm)	150

	Bar Mark	Bar Shape	No.	length (m)	Diameter (mm)	Quantity=L*D^2/162 kg
1	A	Straight bars	1	2.548	20	6.29
2	B	Straight bars upper	2	2.656	20	13.11605
3	C	Bent	1	3.29	20	8.13
4	E	stirrups	20	0.684	8	5.404
					total	**32.944**

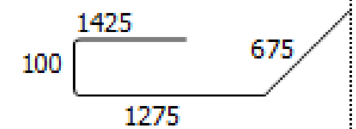
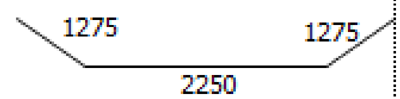
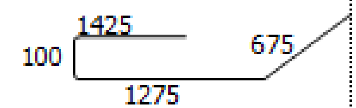
E	138	
A	108	No. of stirrups= Length/Spacing +1
Length of stirrups	0.68	

Total steel required in beams 46.604 tons

Bar bending Schedule of Slabs

Bar Mark	Description of Elements	ø of Bars	Nºof Elmts	Nºof Bars	Total Nº	Cutting length (m)	Code	A	B	C	D	Shape	Weight (Kg)
SLAB S1													
1	MAIN REINFROCEMENT	T12	1	13	13 Nº	5.0374	222	3378	41.4	1618	100	3378 41.4 1618 100	58.124
2	MAIN REINFROCEMENT	T12	1	17	17 Nº	6.5974	222	4399.4	41.4	2098	100	4399.4 41.4 2098 100	99.547
3	MAIN REINFROCEMENT	T12	1	13	13 Nº	5.0374	222	4464	41.4	532	100	4464 41.4 532 100	58.124
4	MAIN REINFROCEMENT	T12	1	17	17 Nº	6.5974	222	5845.4	41.4	652	100	5845.4 41.4 652 100	99.547
5	TORSIONAL BARS	T8	2	3	6 Nº	0.984	100	984				984	2.329
6	TORSIONAL BARS	T8	2	3	6 Nº	0.744	100	744				744	1.761
												ToTal Quantity required in (4.8x3.6m$^{2)}$	319.431
												ToTal Quantity (tons) required in (27x15m^2) in 4 blocks	119.787

Bar Bending Schedule of Staircase

Bar Mark	Description of Elements	ø of Bars	Nº of Elmt	Nº of Bars	Total Nº	Cutting length (m)	Code	A	B	C	D	Shape	Weight (Kg)
STAIRS													
1	MAIN REINFORCEMENT	10	7	13	91	4.8	222	1275	2250	1275			269.23
2	LANDING REINFORCEMENT	10	7	12	84	3.475	304	675	1275	100	1425		179.92
3	DISTRIBUTION REINFORCEMENT	8	7	9	63	1.4	100	1400					34.793
FIRST STAIR													
1	MAIN REINFORCEMENT	10	1	13	13	4.8	213	1275	1275	2250			38.462
2	LANDING REINFORCEMENT	10	1	12	12	3.475	304	675	1275	100	1425		25.703
3	DISTRIBUTION REINFORCEMENT	8	1	9	9	1.4	100	1400					4.9704
												Total quantity Required in 1 starircase	553.08
												Total quantity (tons) Required in 1 starircase	2.2123

Bar Bending Schedule of Footing

Bar Mark	Description of Elements	ø of Bar	Nº of Elmt	Nºof Bars	Total Nº	Cutting length (m)	Code	A	B	C	Shape	Weight (Kg)
						F1						
1	MAIN REINFORCEMENT	16	12	11	132	3.38	200	200	2980	200	200 2980 200	704
2	MAIN REINFORCEMENT	16	12	11	132	3.38	200	200	2980	200	200 2980 200	704
3	STARTER BARS	20	12	6	72	2.4	111	500	1900		500 1900	426.04
4	STIRRUPS	6	12	8	96	1.544	501	328	138	144	138 328	32.89
						F2						
1	MAIN REINFORCEMENT	16	12	11	132	3.46	200	200	3180	80	200 3180 80	720.66
2	MAIN REINFORCEMENT	16	12	11	132	3.46	200	200	3180	80	200 3180 80	720.66
3	STARTER BARS	20	12	8	96	2.4	111	500	1900		500 1900	568.05
4	STIRRUPS	6	12	8	96	1.344	501	328	138	144	328 138	28.63

F3												
1	MAIN REINFORCEMENT	16	8	6	48	2.98	200	200	2580	200	200 2580 200	225.7
2	MAIN REINFORCEMENT	16	8	6	48	2.98	200	200	2580	200	200 2580 200	225.7
3	STARTER BARS	10	8	4	32	2.4	111	500	1900		500 1900	47.337
4	STIRRUPS	6	8	7.6	60.8	1.344	501	328	138	144	138 328	18.132
											Total quantity required for 1 block	4421.8
											Total quantity (tons) required for 4 block	17.687

Therefore Total Quantity of steel required in the 4 blocks = 228 tons

Total cost of steel = Rs. 9.12 lakhs

References

- University Grants commission; Construction of hostels for colleges during the twelfth plan (2012-2017).
- Model Building Bye-laws, Town & country Planning Organization, Ministry of urban development, GOI.
- IS code 456-2000, Plain And Reinforced concrete code of Practice.
- IS code1893-1984, Criteria for Earthquake Resistant Design of Structures
    - Part I- General provisions and buildings.
- IS code 875-1987; Code of Practice for Design Loads (other than Earthquake) for Building and structures.
    - Part 1-Dead Loads –Unit weights of Building Materials and stored Materials.
    - Part II- Imposed Loads