General Theory

Table1.1Minimum Grade of Concrete for different exposure conditions:

Exposure	Minimum Grade of Concrete for RCC
Mild	M20
Moderate	M25
Severe	M30
Very Severe	M35
Extreme	M40

Tensile Strength:

The tensile strength of concrete is very low and hence it is not taken in to account in the design of reinforced concrete.

But it is an important property which affects the extent and width of cracks in the structure. According to IS 456-2000,

the tensile strength of concrete can be calculated from the compressive strength using the following relation

$$f_{cr} = 0.7\sqrt{f_{ck}}N/mm^2$$

Where f_{ck} is the characteristic cube compressive strength of concrete

Modulus of Elasticity:

Modulus of elasticity of concrete is an important property required for computation of deflections of structural concrete members. In the absence of test data the modulus of elasticity fck concrete is related to compressive strength by the following relation as per IS 456-2000

$$E_c = 5000\sqrt{f_{ck}}N/mm^2$$

Where E_C is the short term static modules of elasticity in N/mm^2

Unit weight: The unit weight of concrete depends up on the type of aggregates and amount of voids. The unit weight as specified by the IS 456-2000 for plain concrete and reinforced concrete are 24 KN/m^3 and 25 KN/m^3 respectively.

Design of multi storied residential building

A structure can be defined as a body which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system. The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution. The Design of each part may be designed separately as follows

1. Slab design
2. Beam design
3. Column design
4. Foundation design

These all are designed under limit state method

Limit state method

The object of design based on the limit state concept is to achieve an acceptability that a structure will not become unserviceable in its life time for the use for which it is intended. I.e. it will not reach a limit state. In this limit state method, all relevant states must be considered in design to ensure a degree of safety and serviceability.

Limit state: The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state.

Limit state of collapse:

This is corresponding to the maximum load carrying capacity. Violation of collapse limit state implies failures in the
source that a clearly defined limit state of structural usefulness has been exceeded. However, it does not mean complete collapse.

This limit state corresponds to:

a) Flexural
b) Shear
c) Compression
d) Torsion
e) Limit state of serviceability

DESIGN OF SLABS

Slabs are plane structural members whose thickness is small as compared to its length and breadth. Slabs are most frequently used as roof coverings and floors in various shapes such as square, rectangular, circular, triangular etc., in building. Slabs supports mainly transverse loads and transfers them to the supports by bending action in one or more directions. Beams or walls are the common supports for the slabs.

Types of Slabs: Depending up on the ratio of longer span to short span(l_y/l_x) the slabs are classified in to:

a. One-way slab
b. Two-way slab

One-way slab

Slabs which are supported on all four edges and the ration of longer span to the shorter span (l_y/l_x) are greater than 2 are called as one way slabs. One way slabs bends in one direction .i.e. along the shorter span and hence span and hence it needs main reinforcement in one direction only (along the shorter span) to resist one way bending However minimum reinforcement known as distribution steel is provided along the longer span above the main reinforcement to distribute the load uniformly and to resist temperature and shrinkage stresses.

Two-way slab

When the slabs are supported on all the four edges and the ratio of longer span to the shorter span (l_y/l_x) is less than or equal to 2, the slabs are likely to bend along the two spans and such slabs are called as two-way slabs. The load is transferred in both the direction to the four supporting edges and hence main reinforcement has to be designed in both directions to resist two way bending.

General Design Requirements for slabs as per IS 456:2000

Effective Span:

The effective span of a simply supported slab shall be taken as clear pan plus effective depth of the slab or center to center distance between the supports whichever is less.

The effective span of a cantilever slab shall be taken as its length to the face of the support plus half the effective depth except where it forms the end of a continuous slab where the length to the center of support shall be taken.

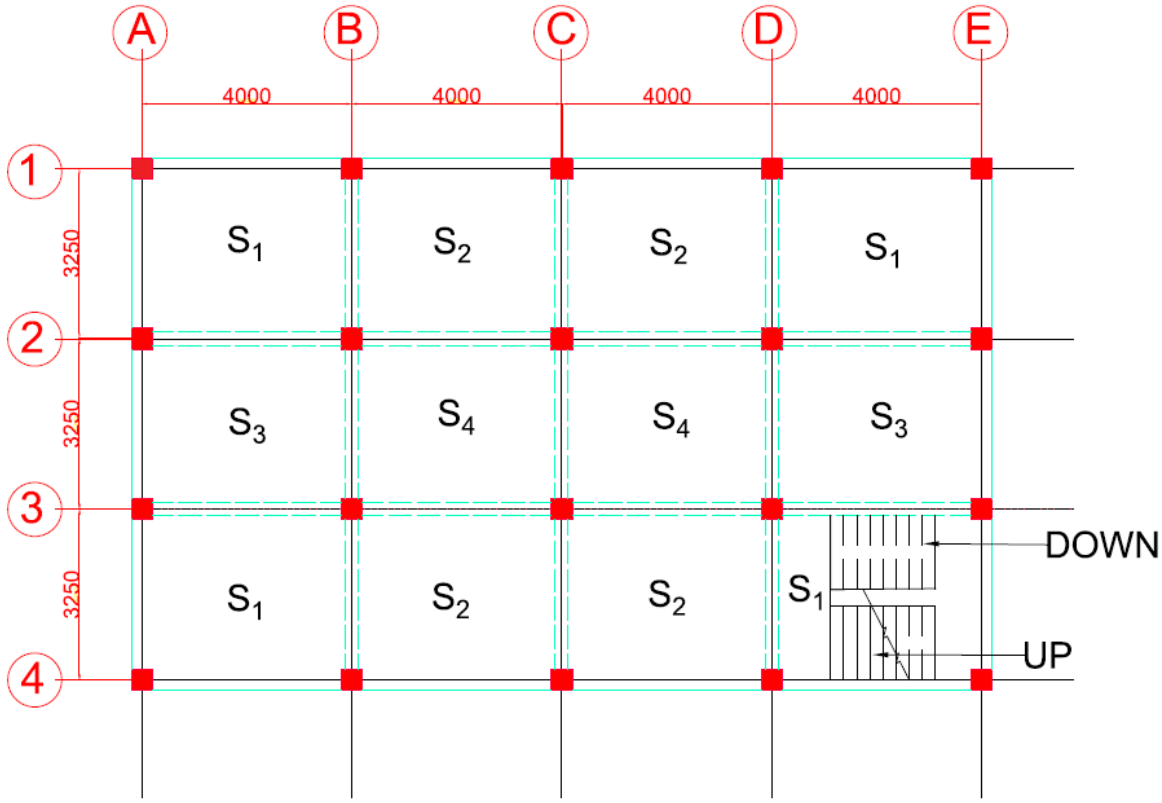
Limiting Stiffness: The stiffness of slabs is governed by the span to depth ratio. As per Clause 23.2 of IS 456 for spans not exceeding 10m, the span to depth ration (Basic values) should not exceed the limits given below
Cantilever – 7
Simply supported – 20
Continuous – 26

Depending upon the type of steel and percentage of steel, the above values have to be modified as per Fig .4 of IS-456
For two way slabs, the shorter span be used for calculating the span to effective depth ration

Minimum Reinforcement: The reinforcement in either direction of span shall not be less than 0.15% of gross cross-sectional area if mild steel is use. However, this value is reduced to 0.12% where high strength deformed bars or welded wire fabrics are used. (Clause 26.5.2.2 of IS -456)

Maximum Reinforcement: The diameter of the bars shall not exceed one eighth of the total thickness of slab (clause 26.5.2.2 of IS-456)

Spacing of Main Reinforcement: The spacing of main reinforcement in slabs shall not be more than three times the effective depth of solid slab or 300 mm whichever is less (Clause 26.3.3 of IS-456).



GROUND FLOOR PLAN

Design of Slab:

Given Data -						
	(i) Length of an individual slab (a) =				4	m
	(ii) Breadth of an individual slab (b) =				3.25	m
	(iii) Live Load =		300	Kg/sqm		
	(iv) Beam Dimension - 250 * 400 mm					
	(v) Column Dimension - 400 * 400					
	(vi) Ceiling Plaster -		6	mm		
	(vii) Reinforcement -		8	mm		
	(viii) Spacing -		200	mm		
	(ix) Grade of concrete - M35		M25	so, fck	25 N/mm^2	
Considerations - (i) One staircase is provided in suitable position						
	(ii) Grade of Steel -		Fe 500	so, fy	500 N/mm^2	

	(iii) Support Width =			125 mm		
	(iv)Density of reinforced concrete(KN/m³) - 25					
	(v) Density of plain cement concrete(KN/m³) - 24					

So, slab(c/c) (Ly) =		4	m	bearing =	125	mm
Slab(c/c) (Lx) =		3.25	m			
Size of column =400 X 400 mm²			length =	0.4	m	
Grade of Concrete = M25			so, fck	25	N/mm²	
Grade of Steel = Fe500			so, fy	500	N/mm2	

clear span(Ly)=		3.75			
clear span(Lx)=		3			
Now, K = (Ly/Lx) =	1.23077	< 2			
So, We design as per two way slab					
Now, depth of slab reqd. (d) =		0.08125	m		
clear cover to be provided =		0.02	m		
So, total depth of slab (D) =		0.10125	m		
So, eff. Length of slab (Ly) =				3.83125	m
So, eff. Length of slab (Lx) =				3	m
	Now, K = (Ly/Lx) =			1.27708	< 2

Step 1: Load analysis:

Load analysis :							
	Total load (W) = Wd + Wd' + LL			[Wd = Dead Load of slab =		2.53125	KN/m²
	=	6.53125	KN/m²	Wd' = Floor finish load =		1	KN/m²

				LL = Live Load =			3	KN/m²
	Factored load = 1.5 X W			for unit width, (b) =			1000	mm

=	9.796875	KN/m²

Step 2: Area of steel required:

$$M_U = 0.87 f_y A_{st} d[1 - \frac{(f_y)A_{st}}{(bd)f_{ck}}]$$

Moment Calculation :								
			Mx = αxWLx2			[As per IS 456:2000 ; page 91 ; Clause D-1.1]		
			My = αyWLx2			[So, WLx² =	88.171875	

Step 3: Spacing of reinforcement:

$S = [a_s * b]/A_{st}$ (Done along with moment calculation)

Step 4: Check for Shear force:

Check for Shear force:				Vu = (W*Lx)/2						
				So, Vu =	14.695313	KN/m				
			Now, computed shear stress =		τv = Vu/bd =	0.180865385				
					Now, τc =	0.2942				
			[As per IS 456:2000 , Table 19 , if minimum percentage of steel is provided]							
				Now, Modification value (k) =					1.3	[Clause

											40.2.1.1]
						Now , τ_c =	k * τ_c =			0.38246	N/mm^2
						Now ,$\tau_{c,max}$ =	3.1	N/mm^2			hence safe from shear
					[As per IS 456:2000 , Table 20 , if minimum percentage of steel is provided]						
					Now, as	$\tau_v < \tau_c < \tau_{c,max}$					
					So, effective Depth of slab (d) =					81.25	mm
					And, provided total depth (D) =					101.25	mm
						Hence OK					

Step 5: Moment calculation:

Moment Calculation:									
	Minimum Ast to be provided =			(0.12*bd)/100 =				97.5	mm^2
	Dia of reinforcement bar to be provided =				8	mm			
	So, as =	50.28571	mm^2						
	Maximum spacing provided can be min of 3d and 300								

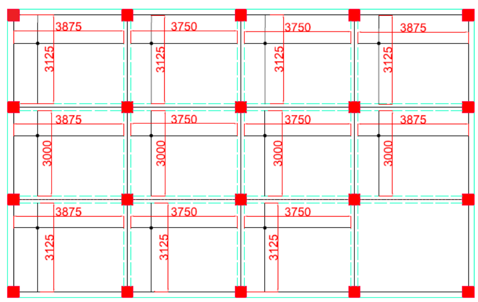
(i)Slabs marked : S1		**[Interior Panels]**					
	Span	Direction	α	M (KNm)	Ast (mm^2)	Spacing	Optimum Spacing
	Mid - Span(+)	x	0.0352	3.10365	89.84411444	559.699593	200
		y	0.024	2.116125	60.81294506	826.891614	200
	Cont. Span(-)	x	0.0462	4.0735406	118.7857806	423.3310927	200
		y	0.032	2.8215	81.50538531	616.961862	200
	Now,						
	So, d(required) =		34.9223	mm			
	Now, d provided =		81.25	mm			
	Hence, we retain D =		101.25	mm	d + 20mm(Cover) = D		

(ii)Slabs marked : S2		**[one short edge discontinuous]**	edge continuous]				
	Span	Direction	α	M (KNm)	A_{st} (mm²)	Spacing	Optimum Spacing
	Mid - Span(+)	x	0.0384	3.3858	98.2188149 2	511.976389 9	200
		y	0.028	2.468812 5	71.1318594 3	706.936592	200
	Cont. Span(-)	x	0.0504	4.443862 5	129.952449 6	386.954724	200
		y	0.037	3.262359 4	94.5504274 3	531.840158 2	200
	Now,						
	So, d(required) =		36.475 2	mm			
	Now, d provided =		81.25	mm			
	Hence, we retain D =		101.25	mm			

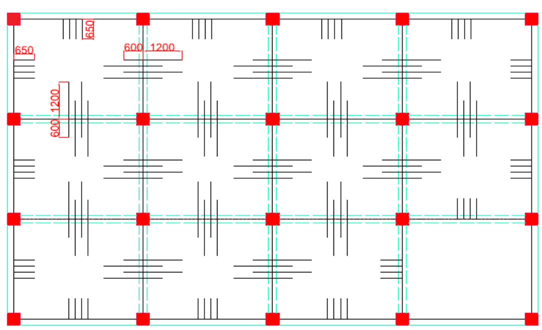
(iii)Slabs marked : S3		**[one long edge discontinuous]**					
	Span	Direction	α	M (KNm)	A_{st} (mm²)	Spacing	Optimum Spacing
	Mid - Span(+)	x	0.043	3.791390 6	110.321411 9	455.811011	200
		y	0.028	2.468812 5	71.1318594 3	706.936592	200
	Cont. Span(-)	x	0.056	4.937625	144.944169 1	346.931612 2	200
		y	0.037	3.262359 4	94.5504274 3	531.840158 2	200
	Now,						
	So, d(required) =		38.448 2	mm			
	Now, d provided =		81.25	mm			

(iv)Slabs marked : S4		**[Two Adjacent Edge Discontinuous]**					
	Span	Direction	α	M (KNm)	A_{st} (mm²)	Spacing	Optimum Spacing
		x	0.0472	4.161712 5	121.438589 2	414.083485 6	200

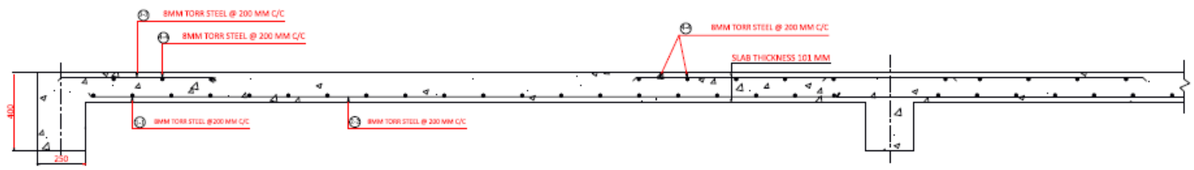
	Mid - Span(+)	y	0.035	3.0860156	89.32189484	562.9718713	200
	Cont. Span(-)	x	0.064	5.643	166.5699839	301.8894108	200
		y	0.047	4.1440781	120.9077327	415.9015569	200
	Now,						
	So, d(required) =		41.1028	mm			
	Now, d provided =		81.25	mm			
	Hence, we retain D =		101.25	mm			



BOTTOM REINFORCEMENT



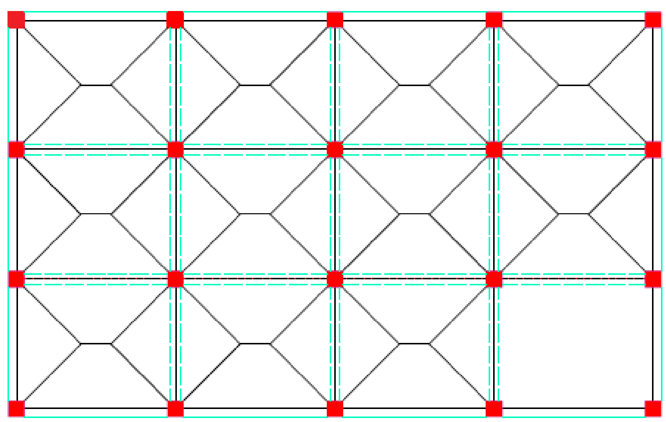
TOP REINFORCEMENT



Typical reinforcement arrangement of slab scale- 1:25

Design of Beam:

Loads on a two-way slab are transferred to all beams on all the sides. So, each beam supports an amount of the load from the slab. The slab is commonly divided into trapezoidal and triangular areas by drawing lines from each corner of the rectangle at 45 degrees.



SLAB REINFORCEMENT

Given data						
Shorter Span	3250	mm	Live Load of Slab	3	kN/m	
			Dead Load of Slab	3.53	kN/m	including Floor finish
Longer Span	4000	mm	Total load of Slab	6.53	kN/m	
Support Width	250	mm	Grade Of Concrete	25	M	

Aspect Ratio	1.230769231		Grade Of Steel	500	Fe	
Floor height	2.6	m	Diameter of Bar	8	mm	
wall thickness	200	mm	Dead Load of Beam	1.5625	kN/m	
			Dead Load of walls	9.88	kN/m	

Step 1:Load Calculation:

Load Calculations		SLABS				BEAM		Total Loads	
	LOADS	Triangular (DL)	Trapezoidal(DL)	Triangular (LL)	Trapezoidal(LL)	DEAD LOAD FROM BEAMS		DL	LL
Spans	3.25	3.82		3.25		11.44		19.09	6.50
	3.25	3.82		3.25		11.44		19.09	6.50
	3.25	3.82		3.25		11.44		19.09	6.50
	4.00		4.47		3.80	11.44		20.39	7.60
	4.00		4.47		3.80	11.44		20.39	7.60
	4.00		4.47		3.80	11.44		20.39	7.60
	4.00		4.47		3.80	11.44		20.39	7.60

Step 2: Bending Moment Calculation:

STEP 2	Bending Moment										Final design Moments	
	For DL	Load	Co efficient of next to end support	Co efficient of interior support	Co efficient of span	Support moment	Interior Support	Span	Span	Support Moment	Interior Support	Span
Shorter Span	3.25	19.09	0.10		0.08	20.16	0.00	16.80	3.25	41.69	0.00	35.50

	3.25	19.09	0.10		0.06	20.16	0.00	12.60	3.25	41.69	0.00	27.49
	3.25	19.09	0.10		0.08	20.16	0.00	16.80	3.25	41.69	0.00	35.50
	4.00	20.39	0.10		0.08	32.62	0.00	27.19	4.00	69.22	0.00	59.03
	4.00	20.39	0.10	0.08	0.06	32.62	27.19	20.39	4.00	69.22	61.06	45.79
	4.00	20.39	0.10	0.08	0.06	32.62	27.19	20.39	4.00	69.22	61.06	45.79
Longer Span	4.00	20.39	0.10		0.08	32.62	0.00	27.19	4.00	69.22	0.00	59.03

	For LL	Load	Co efficient of next to end support	Co efficient of interior support	Co efficient of span	Support moment	Interior Support	Span
	3.25	6.50	0.11		0.10	7.63	0.00	6.87
	3.25	6.50	0.11		0.08	7.63	0.00	5.72
Shorter Span	3.25	6.50	0.11		0.10	7.63	0.00	6.87
	4.00	7.60	0.11		0.10	13.52	0.00	12.17
	4.00	7.60	0.11	0.11	0.08	13.52	13.52	10.14
	4.00	7.60	0.11	0.11	0.08	13.52	13.52	10.14
Longer Span	4.00	7.60	0.11		0.10	13.52	0.00	12.17

Step 3: Shear Force Calculation:

STEP 3	Shear Force											Final design Shear		
	For DL	Load	Co-efficient of end support	Co-efficient of interior support	Co efficient next to end support		End support	Interior Support	Next to end			End support	Interior Support	Next to end
	3.25	19.09	0.40		0.60		24.82	0.00	37.23	Span	3.25	51.49	0.00	74.85
Shorter Span	3.25	19.09			0.55		0.00	0.00	34.12		3.25	0.00	0.00	70.20
	3.25	19.09	0.40		0.60		24.82	0.00	37.23		3.25	51.49	0.00	74.85
	4.00	20.39	0.40		0.60		32.62	0.00	48.94		4.00	69.47	0.00	100.78
	4.00	20.39		0.50	0.55		0.00	40.78	44.86		4.00	0.00	88.55	94.66
	4.00	20.39		0.50	0.55		0.00	40.78	44.86		4.00	0.00	88.55	94.66
Longer Span	4.00	20.39	0.40		0.60		32.62	0.00	48.94		4.00	69.47	0.00	100.78

	For LL	Load	Co eff of end support	Co eff of interior support	Co eff next to end support		End support	Interior Support	Next to end
	3.25	6.50	0.45		0.60		9.51	0.00	12.68
Shorter Span	3.25	6.50			0.60		0.00	0.00	12.68
	3.25	6.50	0.45		0.60		9.51	0.00	12.68
Longer Span	4.00	7.60	0.45		0.60		13.69	0.00	18.25
	4.00	7.60		0.60	0.60		0.00	18.25	18.25

	4.00	7.60		0.60	0.60		0.00	18.25	18.25
	4.00	7.60	0.45		0.60		13.69	0.00	18.25

Step 4: Depth Check:

STEP 4	Depth Check				
Max Moment	69.22	kN-m		0.5*fck*deff*b/fy	6250.00
Depth Req.	141.64	mm		fck*b*d*d	1562500000.00
Depth taken	250.00	deff			
Clear cover	25.00	mm			
Overall Depth	275.00	mm			

Step 5: Area of steel calculations:

STEP 5	Area of Steel Calculations									
SPAN	Effective length	Support moment KN-M	Span moment KN-M	Area of steel required mm2 As per IS 456:2000,Pg:96,G-1.1.b Mu=0.87Fy*Ast*deff(1-Ast*Fy/b*deff*Fck)		Top reinforcement	Bottom reinforcement	Percentage of steel (Pt) at top	Percentage of steel (Pt) at bottom	
SHORTER SPAN	3.25	41.69	35.50	396.10	335.65	4-12Φ	4-12Φ	0.72	0.72	
	3.25	41.69	27.49	396.10	258.21	4-12Φ	3-12Φ	0.72	0.54	
	3.25	41.69	35.50	396.10	335.65	4-12Φ	4-12Φ	0.72	0.72	

SPAN	EFFECTIVE LENGTH	Support moment KN-M	Interior support moment KN-M	Span moment KN-M	Area of steel required mm2 As per IS 456:2000,Pg:96,G-1.1.b Mu=0.87Fy*Ast*deff(1-Ast*Fy/b*deff*Fck)			Top Reinforcement	Bottom reinforcement	Percentage of steel (Pt) at top	Percentage of steel (Pt) at bottom		
LONGER SPAN	4.00	69.22		59.03	673.02	0.00	568.99	4-16Φ	3-16Φ	1.29	0.96		
	4.00	69.22	61.06	45.79	673.02	589.55	436.56	4-16Φ	3-16Φ	1.29	0.96		
	4.00	69.22	61.06	45.79	673.02	589.55	436.56	4-16Φ	3-16Φ	1.29	0.96		
	4.00	69.22		59.03	673.02	0.00	568.99	4-16Φ	3-16Φ	1.29	0.96		

Step 6: Shear Reinforcement:

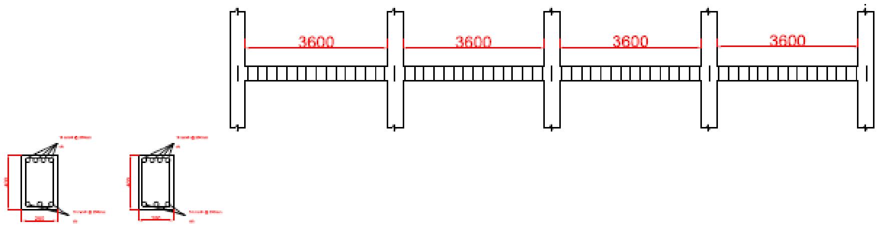
	Shear reinforcement		2 LEGGED STIRRUP OF Φ8MM				
SPAN	EFFECTIVE LENGTH	Shear force at end support KN	Shear force next to end support KN	τv in N/mm2 (V*1000/bd)	τv in N/mm2 (V*1000/bd)	τc in N/mm2 is obtained by interpolation	τc in N/mm2 is obtained by interpolation
SHORTER SPAN	3.25	51.49	74.85	0.82	1.20	0.35	0.35
	3.25	0.00	70.20	0.00	1.12		0.32
	3.25	51.49	74.85	0.82	1.20	0.35	0.35

Design shear force (Vd) V-τcbd	Design shear force (Vd) V-τcbd	Sv in mm from C/C (0.87*fy*Asv*d)/Vd*103	Sv in mm from C/C (0.87*fy*Asv*d)/Vd*103	Spacing provided C/C	
29.36	52.73	370.38	206.25	250.00	
0.00	50.32		216.10	250.00	
29.36	52.73	370.38	206.25	250.00	

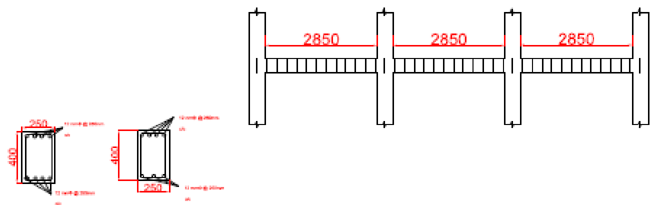
SPAN	EFFECTIVE LENGTH	Shear force at end support KN	Shear force next to end support KN	Shear force at interior support KN	τv in N/mm2 (V*1000/bd)	τv in N/mm2 (V*1000/bd)	τv in N/mm2 (V*1000/bd)
LONGER SPAN	4.00	69.47	100.78	0.00	1.11	1.61	0.00
	4.00	0.00	94.66	88.55	0.00	1.51	1.42
	4.00	0.00	94.66	88.55	0.00	1.51	1.42
	4.00	69.47	100.78	0.00	1.11	1.61	0.00

τc in N/mm2 is obtained by interpolation	τc in N/mm2 is obtained by interpolation	τc in N/mm2 is obtained by interpolation	Design shear force (Vd) V-τcbd	Design shear force (Vd) V-τcbd	Design shear force (Vd) V-τcbd
0.44	0.39		41.78	76.18	0.00
	0.39	0.44	0.00	70.06	60.86
	0.39	0.44	0.00	70.06	60.86
0.44	0.39		41.78	76.18	0.00

Sv in mm from C/C (0.87*fy*Asv*d)/Vd*103	Sv in mm from C/C (0.87*fy*Asv*d)/Vd*103	Sv in mm from C/C (0.87*fy*Asv*d)/Vd*103	SPACING PROVIDED C/C	
260.28	142.75		250.00	
0.00	0.00	178.69	250.00	
0.00	155.21	178.69	250.00	
260.28	142.75		250.00	



BEAM ON X-X DIRECTION



BEAM ON Y-Y DIRECTION

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Design of column:

Considering Exterior column:

Step 1: Load Calculations:

Level	Load Type	Unit weight KN/M3	Height metre	Width metre	Length metre	Load KN
ROOF	Parapet wall	20	1	0.2	1.625	6.5
	Parapet wall	20	1	0.2	2	8
			TOTAL LOAD			14.5

Level	Load Type	Load per m2 KN/M2	Shorter span metre	Longer span metre	Load KN	
3RD FLOOR	D.L on slab	3.53	3.25	4	11.4725	
	L.L on slab	3	3.25	4	9.75	
2ND FLOOR	D.L on slab	3.53	3.25	4	11.4725	
	L.L on slab	3	3.25	4	9.75	
1ST FLOOR	D.L on slab	3.53	3.25	4	11.4725	
	L.L on slab	3	3.25	4	9.75	

Level	Load Type	Load per m KN/M	Shorter span metre	Longer span metre	Load KN	
3RD FLOOR	D.L on beam	11.44	3.25		18.59	
				4	22.88	
	L.L on Beam	3	3.25		4.875	
				4	6	
2nd FLOOR	D.L on beam	11.44	3.25		18.59	
				4	22.88	
	L.L on Beam	3	3.25		4.875	
				4	6	
1ST FLOOR	D.L on beam	11.44	3.25		18.59	
				4	22.88	
	L.L on Beam	3	3.25		4.875	
				4	6	

Level	Load Type	Unit weight KN/M3	Height metre	Width metre	Depth metre	Load KN	
3RD FLOOR		25	3	0.4	0.4	12	
2ND FLOOR		25	3	0.4	0.4	12	
1ST FLOOR	Self-weight of column	25	3	0.4	0.4	12	
		TOTAL LOAD ON COLUMN				271.2025	
		FACTORED LOAD				406.8038	

Step 2: DETERMINATION OF GROSS AREA OF COLUMN

as per IS 456: 2000 Pg:71,Cl:39.3							
Considering .8% area of steel (ASC)							
Axial load	Fck	Fy	Area of steel	Gross area of column Ag	WIDTH mm	Breadth mm	NOTE
406.80375	25	500	0.008	32082.31467	179.1154	179.1154	A column of cross section 300×300 is provided
REMARK	As per IS 13920: 2016 Pg:7, Cl:7.1.1 the minimum size of column should 20db or 300 mm whichever is less where db is diameter of the largest longitudinal reinforcement						

Step 3: Eccentricity Check:

Check for eccentricity								
Unsupported column length	Width mm	Breadth mm	Eccentricity	Minimum Eccentricity(As per IS 456:2000 Pg: 42 Cl:25.4)				
3	300	300	16	20		so size of the column assuming 450mm X 450mm		
	REMARKS		re design			eccentricity	21	> 20

Step 4: Area of steel Calculation:

DETERMINATION OF AREA OF CONCRETE Acc & AREA OF STEEL Ast												
Axial load	Fck	Fy	Width mm	Breadth mm	Gross area of column Ag	Area of Concrete	Area of steel	Reinforcement		provide 20mm bars area of 20mm bars = 314.16 mm2		
406.80375	25	500	450	450	202500	200880	1620	8-20Φ		actual Ast	2513.28	

Step 5: Lateral tie Calculation

CALCULATION FOR LATERAL TIES								Diameter of ties > (1/4)*20 = 5mm	
Dia of lateral Ties	Spacing of lateral ties			REMARK	Spacing provided			using 6mm bars	
	1	2	3						
6	450	320	300	Minimum of 3s is taken = 300	provide Φ6mm @ 300 C/C				

Considering the interior column:

Step 1: Load Calculation:

Load calculation					
Level	Load Type	Load per m2 KN/M2	Shorter span metre	Longer span metre	Load KN
3RD FLOOR	D.L on slab	3.53	3.25	4	45.89
	L.L on slab	3	3.25	4	39
2ND FLOOR	D.L on slab	3.53	3.25	4	45.89
	L.L on slab	3	3.25	4	39
1st FLOOR	D.L on slab	3.53	3.25	4	45.89
	L.L on slab	3	3.25	4	39

Level	Load Type	Load per m KN/M	Shorter span metre	Longer span metre	Load KN
3RD FLOOR	D.L on beam	11.44	3.25	0	37.18
				4	45.76
	L.L on Beam	3	3.25		9.75
				4	12
2nd FLOOR	D.L on beam	11.44	3.25	0	37.18
				4	45.76
	L.L on Beam	3	3.25		9.75
				4	12
1st FLOOR	D.L on beam	11.44	3.25	0	37.18
				4	45.76
	L.L on Beam	3	3.25		9.75
				4	12

Level	Load Type	Unit weight KN/M3	Height metre	Width metre	Depth metre	
3RD FLOOR	Self-weight of column	25	3	0.4	0.4	12
2ND FLOOR		25	3	0.4	0.4	12
1ST FLOOR		25	3	0.4	0.4	12
		TOTAL LOAD ON COLUMN				604.74
		FACTORED LOAD				907.11

Step 2: DETERMINATION OF AREA OF CONCRETE FOR COLUMN

Considering 1% area of steel (ASC)							
Axial load	Fck	Fy	Area of steel	Gross area of column Ag	WIDTH mm	Breadth mm	NOTE
907.11	25	500	0.01	67948.31461	260.669	260.669	A column of cross section 300×300 is provided
REMARK	As per IS 13920: 2016 Pg:7, Cl:7.1.1 the minimum size of column should 20db or 300 mm whichever is less where db is diameter of the largest longitudinal reinforcement						

Step 3: Eccentricity check:

Check for eccentricity										

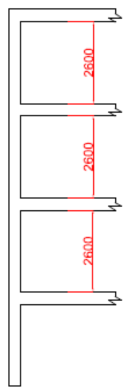
Unsupported column length	Width mm	Breadth mm	Eccentricity	Minimum Eccentricity(As per IS 456:2000 Pg: 42 Cl:25.4)			**so size of the column assuming 450mm X 450mm**			
3	300	300	16	20			eccentricity	21	> 20	
	REMARKS		re design							

Step 4: determination of gross area of Column

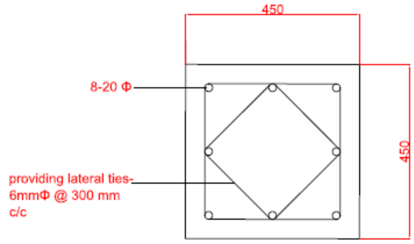
DETERMINATION OF AREA OF CONCRETE Acc & AREA OF STEEL Ast												
										provide 20mm bars		
Axial load	Fck	Fy	Width mm	Breadth mm	Gross area of column Ag	Area of Concrete	Area of steel	Reinforcement		area of 20mm bars = 314.16 mm2		
907.11	25	500	450	450	202500	200475	2025	8-20Φ		actual Ast	2513.28	

Step 5: Calculation for Lateral Ties:

CALCULATION FOR LATERAL TIES								Diameter of ties should be > (1/4)*20 = 5mm			
Diameter of lateral Ties	Spacing of lateral ties			REMARK	Spacing provided			using 8mm bars			
	1	2	3								
6	450	320	300	Minimum of 3s is taken = 300	provide Φ6mm @ 300 C/C						



COLUMN



COLUMN
REINFORCEMENT

<u>Design Of footing:</u>

Step 1: Determination of size of the footing

Determination of Size of footing										
load	605									
Self-weight	60.5		[assuming self-weight of footing = 10% of superimposed Load]							
Total load	665.5									
Design load	665.5		[required area of footing = (total load/ safe bearing capacity)]							
footing area	3.697222		[As we are using square footing, size of footing = square root of(area of footing)]							
size of footing	1.922816									

We provide isolated footing of size 2m×2m

Net upward ultimate soil pressure(p0)	166.375		[p0 = net upward pressure = (total ultimate load / area provided)]

Step 2: Determination of depth of footing based on BM about critical section

Determination of depth of footing on the basis of bending moment							
Bending Moment	149.8935					[Bending Moment = M = p0*(B/8)*(B-b)^2 where B = width of footing provided and b = width of column provided]	
Depth required	197.3896	As per IS 456:2000 Pg:96, Cl:G 1.1.c				Depth required = sqrt(Mu/(.138*Fck*B))	
Depth provided	500					[Due to shear consideration adopting higher effective depth]	

Step 3: Area Of steel:

Area of steel required			Area of one	113.1429		

					12mm bar			
As per IS 456:2000 Pg:96, Cl:1.1.b								
Ast required	585				% of reinforcement = (Ast/Bd)*100]			0.0792
					but minimum % of reinforcement = 0.12%			
No of bars of Φ12mm	6.170455				Hence, % of reinforcement		0.0012	
Ast provided	792							

Step 4: Spacing of Reinforcement:

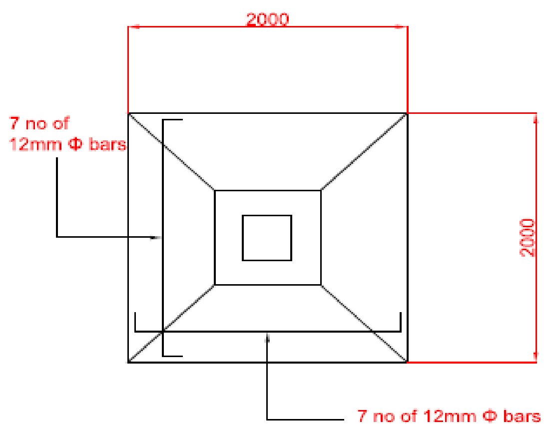
Spacing of Reinforcement					
Spacing required	285.7143				Spacing = width of footing / No of bars provided
Spacing provided	250				

CHECK FOR ONE WAY SHEAR					
Ultimate shear force	205.8891				Shear force = V = p0*B*(0.5(B-b)-d)
					Ultimate shear force = Vu = 1.5*V
Nominal shear stress	0.205889				Nominal shear stress = Tv = (Vu/Bd)
Percentage of steel	0.0012				
Design shear strength of concrete	0.24				Design shear strength of concrete = T' = Tc*k
					k = 1 because depth > 300mm page 72 IS: 456 - 2000
Remark	Safe from one way shear				[As nominal shear stress < design shear strength of concrete]

d = Vu/(B*T')		
428.9355		
d provided = 500mm > 448mm hence safe		

CHECK FOR TWO WAY SHEAR

ultimate shear force	796.1044	Net shear force acting on perimeter = F = p0(B^2 - b0^2) b0 = (b + d)
Perimeter of Critical Section	3.6	ultimate shear force = 1.5*net shear force
Nominal shear stress	0.44228	Nominal shear stress = Fu / (4*b0*d)
Ks calculated	1.5	Ks = 0.5 + 1 as this is a square footing clause 31.6.3.1
Ks as per Is 456: 2000	1	as Ks cannot be greater than 1
Shear strength of concrete	1.25	
REMARK	Safe from two way shear	As nominal shear stress < Ks*shear strength of concrete



FOOTING