1 Modification factor for tension reinforcement
Ref IS 456:2000 Fig 4

f_y N/mm^2	f_s N/mm^2	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	MF_t IS 456 Fig 4
415	229.24	**0.2**	**0.21**	1.85

2 Modification factor for compression reinforcement
Ref IS 456:2000 Fig 5

p_c %	MF_c IS 456 Fig 5
0.2	1.06

3 Permissible shear stress in concrete (τc) for beams in limit state design method
Ref IS 456:2000 Table 19

f_{ck} N/mm^2	p_t %	τ_c N/mm^2
30	**0.5**	0.50

4 Permissible shear stress in concrete (τc) for beams in working stress design method
Ref IS 456:2000 Table 23

f_{ck} N/mm^2	p_t %	τ_c N/mm^2
35	**0.5**	0.31

5 Permissible shear stress in concrete ($k\tau_c$) for solid slabs in limit state design method
Ref IS 456:2000 Cl 40.2.1.1, Table 19

f_{ck} N/mm^2	p_t %	D of slab	k	k τ_c N/mm^2
30	**0.5**	**150**	1.30	0.65

6 Permissible shear stress in concrete ($k\tau_c$) for solid slabs in working stress design method
Ref IS 456:2000 Cl B-5.2.1.1, Table 23

f_{ck} N/mm^2	p_t %	D of slab	k	k τ_c N/mm^2
30	**0.5**	**150**	1.30	0.403

7 Permissible compressive & tensile stress in concrete for working stress design method
Ref IS 456:2000 Table 21, Cl B-2.1.1

f_{ck} N/mm^2	σ_{cbc} N/mm^2	σ_{cc} N/mm^2	σ_{ct} N/mm^2
30	10	8	3.6

8 Area of steel calculation by limit state design method
Ref IS 456-2000 Cl G-1.1b For sections without compression reinforcement

f_y N/mm^2	f_{ck} N/mm^2	b mm	D mm	cc mm	cg of bar mm	d mm	M_u kNm	Ast req mm^2	p_t req %
415	**30**	**1000**	**150**	**30**	**8**	112	**10**	255.48	0.23

9 Area of steel calculation by working stress method
For sections without compression reinforcement

f_{ck} N/mm^2	σst N/mm^2	b mm	D mm	cc mm	cg of bar mm	d mm	M_u kNm	Ast req mm^2	p_t req %

30	**230**	**1000**	**150**	**30**	**8**	112	**10**	429.53	0.384

10 Development length of bars by limit state design method
Ref IS 456-2000 Cl 26.2.1, Cl 26.2.1.1

f_{ck} N/mm^2	f_y N/mm^2	bars in	dia mm	τ_{bd} N/mm^2	L_d mm
30	**415**	**tension**	**20**	2.4	752

11 Development length of bars by working stress method of design
Ref IS 456-2000 Cl 26.2.1, Cl B-2.2, Table 22, Cl B-2.1.2, Table 21

f_{ck} N/mm^2	type of steel	σ_{st} / σ_{sc} N/mm^2	bars in	dia mm	τ_{bd} N/mm^2	L_d mm
30	**HYSD**	**230**	**tension**	**20**	1.6	719

12 Minimum reinforcement in either direction of slab
Ref IS 456-2000 Cl 26.5.2.1

type of steel	b mm	D mm	Ast min. mm^2
HYSD	**1000**	**200**	240.00

13 Modulus of elasticity of concrete
Ref IS 456-2000 Cl 6.2.3.1

f_{ck} N/mm^2	E_c N/mm^2
30	27386.13

14 Flexural strength of concrete
Ref IS 456-2000 Cl 6.2.2

f_{ck} N/mm^2	f_{cr} N/mm^2
30	3.83

15 Maximum shear stress in concrete for limit state method of design
Ref IS 456-2000 Table 20 Cl 40.2.3

f_{ck} N/mm^2	$\tau_{c\ max}$ N/mm^2
20	2.8

16 Maximum shear stress in concrete for working stress method of design
Ref IS 456-2000 Table 24 Cl B 5.2.3

f_{ck} N/mm^2	$\tau_{c\ max}$ N/mm^2
20	1.8

17 Design of beam (singly reinf.) subjected to torsion by limit state design method
Ref IS 456-2000 Cl 41.3, Cl 41.4
Given data

f_{ck} N/mm^2	f_y N/mm^2	V_u kN	T_u kNm	M_u kNm	b mm	D mm	clear cover on ten.face mm	clear cover on com.face mm	side cover mm
20	**415**	**100**	**50**	**181**	**350**	**650**	**40**	**40**	**35**

c_g of tension face steel	c_g of comp. face steel	d for tension face steel	d for comp. face steel	stirrup dia assumed	b_1	d_1	x_1	y_1

mm	mm	mm	mm	mm	mm	mm	mm	mm
12.5	10	597.50	600.00	10	255.0	547.5	290.0	580.0

Equivalent shear
Ref IS 456-2000 Cl 41.3.1, Cl 40.2.3 & Table 20

V_e kN	τ_{ve} N/mm^2	$\tau_{c\,max}$ N/mm^2	Result IS 456-2000 Cl 41.3.1
328.57	1.57	2.8	tau_v <tau_cmax,Ok

Longitudinal reinforcement for beams subjected to torsion
Ref IS 456-2000 Cl 41.4.2

M_t Cl 41.4.2 kNm	M_{e1} Cl 41.4.2 kNm	M_{e2} Cl 41.4.2.1 kNm	Longitudinal reinf, mm^2 reinf on ten. face Cl41.4.2	Longitudinal reinf, mm^2 reinf on comp. face Cl41.4.2.1
84.03	265.03	Mt < Mu	1432.90	Not req.

Transverse reinforcement for beams subjected to torsion
Ref IS 456-2000 Cl 41.4.3

f_y N/mm^2	no. of stirrup legs	stirrup dia mm	max. allowable stirrup sp Cl 26.5.1.7	stirrup spacing prov. mm	p_t %	τ_c Table 19 N/mm^2	V_{us}/d req. Cl 41.4.3 kN/cm	V_{us}/d prov. Cl 40.4 a kN/cm	Result Cl 41.4.3
415	2	10	217.5	125	0.68	0.54	4.31	4.54	Ok

18 Check for shear in beams for limit state design method
Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1

f_{ck} N/mm^2	V_u kN	b mm	D of beam mm	clear cover mm	c_g of bar mm	d mm
25	100	300	650	45	12.5	592.5

p_t %	τ_v Cl 40.1 N/mm^2	τ_c Table 19 N/mm^2	$\tau_{c\,max}$ Table 20 N/mm^2	Result
				tau_v > tau_c,design for shear
0.5	0.56	0.49	3.1	tau_v <tau_cmax, Ok

19 Check for shear in beams for working stress design method
Ref IS 456-2000 Cl B 5.1, B 5.2.1, B 5.2.3, Table 23 & Table 24

f_{ck} N/mm^2	V kN	b mm	D of beam mm	clear cover mm	c_g of bar mm	d mm
25	67	300	650	45	12.5	592.5

p_t %	τ_v Cl B- 5.1 N/mm^2	τ_c Table 23 N/mm^2	$\tau_{c\,max}$ Table 24 N/mm^2	Result
				tau_v > tau_c,design for shear
0.5	0.38	0.31	1.9	tau_v <tau_c max, Ok

20 Check for shear in solid slabs for limit state design method
Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1.1

f_{ck} N/mm^2	V_u kN	b mm	D of slab mm	clear cover mm	c_g of bar mm	d mm
20	10.1	1000	125	25	8	92

p_t %	τ_v Cl 40.1 N/mm^2	k τ_c Cl 40.2.1.1 N/mm^2	$\tau_{c\,max}$ Table 20 N/mm^2	Result
				tau_v < k tau_c, Ok
0.5	0.11	0.624	2.8	tau_v <1/2 tau_c max,Ok

21 Check for shear in solid slabs for working stress design method
Ref IS 456-2000 Cl B 5.1, B 5.2.1.1, B 5.2.3.1, Table 23 & Table 24

f_{ck} N/mm^2	V kN	b mm	D of slab mm	clear cover mm	c_g of bar mm	d mm
20	**6.75**	**1000**	**125**	**25**	**8**	92

p_t %	τ_v Cl B 5.1 N/mm^2	k τ_c B 5.2.1.1 N/mm^2	$\tau_{c\,max}$ Table 24 N/mm^2	Result
				tau_v < k tau_c, Ok
0.5	0.07	0.390	1.8	**tau_v <1/2 tau_cmax,Ok**

22 Design of shear reinf. - vertical stirrups by limit state method of design
Ref SP 16-1980 Table 62 & IS 456-2000, Cl 40.4 a

f_y N/mm^2	stirrup dia mm	no. of stirrup legs	stirrup spacing mm	V_{us}/d kN/cm Cl 40.4 a
415	**10**	**2**	**100**	5.671

23 Design of shear reinf. - vertical stirrups by working stress method of design
Ref SP 16-1980 Table 81 & IS 456-2000, Cl B 5.4 a

f_y N/mm^2	stirrup dia mm	no. of stirrup legs	stirrup spacing mm	V_s/d kN/cm Cl B 5.4 a
415	**10**	**2**	**100**	3.613

24 Minimum shear reinforcement in the form of stirrups
Ref IS 456:2000 Cl 26.5.1.6

f_y N/mm^2	b mm	stirrup dia mm	no. of stirrup legs	stirrup spacing mm Cl 26.5.1.6	stirrup spacing prov. mm	Result Min shear Cl 26.5.1.6
415	**350**	**10**	**2**	**405.1**	**210**	**Ok**

25 Max. spacing of shear reinforcement
Ref IS 456:2000 Cl 26.5.1.5

type of stirrup	D of beam mm	clear cover mm	c.g of bar mm	d mm	Max spacing mm Cl 26.5.1.5
vertical	**350**	**40**	**6**	304	**228.00**

26 Minimum and maximum tensile reinforcement in beams
Ref IS 456-2000 Cl 26.5.1.1a and Cl 26.5.1.1b

f_y N/mm^2	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast min. Cl 26.5.1.1a mm^2	Ast max. Cl 26.5.1.1b mm^2
415	**300**	**450**	**40**	**10**	400.00	245.78	5400.0

27 Maximum compression reinforcement in beams
Ref IS 456-2000 Cl 26.5.1.2

b mm	D of beam mm	Ast max. Cl 26.5.1.2 mm^2
250	**350**	3500.0

28 Maximum diameter of bars for slabs

Ref IS 456-2000 Cl 26.5.2.2

D of slab mm	dia of bar mm	Result Cl 26.5.2.2
100	12	Ok

29 $X_{u\,max}$/d values

Ref IS 456-2000 Cl 38.1 & SP 16 Table B

f_y N/mm^2	$X_{u\,max}$ /d Cl 38.1
415	0.479

30 Limiting moment of resistance and reinforcement index for singly reinforced rectangular sections

Ref SP 16 Table C, Table E & IS 456-2000 G-1.1 c

f_{ck} N/mm^2	f_y N/mm^2	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	$M_{u\ lim}$ kN.m	$p_{t\ lim}$ %
20	415	250	500	40	12.5	447.5	138.18	0.96

31 Basic values of l/d ratio for beams and solid slabs in general

Ref IS 456-2000 Cl 23.2.1,Cl 24.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	p_c %	MFt Fig. 4	MFc Fig.5
S.S.B	415	7000	450	0.4	0.45	0.25	1.43	1.08

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
15.56	30.75	Okay

32 l/d ratio for two way slabs of shorter spans (up to 3.5m) and live load up to 3 kN/m^2

Ref IS 456-2000 Cl 24.1 Notes

Type of beam	f_y N/mm^2	span mm	D mm	l/D prov	l/D Cl 24.1	Result
S.S.B	415	3000	150	20.00	28.00	Okay

33 Pitch and diameter of lateral ties

Ref IS 456-2000 Cl 26.5.3.2 c

Size of column		small long.	large long.	pitch	diameter	pitch	dia of tie	Result	
b	D	ϕ	ϕ	Cl 26.5.3.2 c	Cl 26.5.3.2 c	prov.	prov.	pitch prov.	dia of tie prov.
mm	mm	mm	mm	mm	mm	mm	mm		
350	450	16	16	256	6	250	8	Ok	Ok

34 Side face reinforcement

Ref IS 456-2000 Cl 26.5.1.3

b	D of web	side face reinf. req. / face	side face reinf. mm^2 /face prov.			spc b/w bars not to exceed
			no. per face	dia of bar	Ast prov. mm^2	
mm	mm	Cl 26.5.1.3				Cl 26.5.1.3
350	800	140	2	10	157.08	300 mm

35 Strength of shear reinf. - single bent up bar (Limit State Method)

Ref SP 16-1980 Table 63 & IS 456-2000, Cl 40.4 c

f_y N/mm^2	bar dia mm	α bent up angle, ^{o}	V_{us} kN Cl 40.4 c
415	**20**	**45**	80.205

36 Strength of shear reinf. - single bent up bar (Working Stress Method)

Ref SP 16-1980 Table 82 & IS 456-2000, Cl B 5.4 c

f_y N/mm^2	bar dia mm	α bent up angle, ^{o}	V_s kN Cl B 5.4 c
230	**20**	**45**	51.093

37 Determination of x_u/d value

Ref IS 456-2000 Cl G-1.1a. For sections without compression reinforcement

f_{ck} N/mm^2	f_y N/mm^2	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast mm^2
20	**415**	**250**	**500**	**40**	**12.5**	447.5	**255**

x_u/d obatined	$X_{u\ max}$ /d Cl 38.1	Result G.1.1.a
0.114	0.479	**under reinforced**

38 Determination of total loads on the short span and long span due to one loaded panel

Ref IS 456-2000 Cl 24.5 , Fig 7 & SP 24 Cl 23.5

w kN/m^2	lx short span m	ly long span m	load on short beam kN	load on long beam kN
10	**5**	**15**	**62.500**	**312.500**

39 Determination of equivalent uniform load ' w/m ' for calculation of B.M. for beams for solid slabs

Ref IS 456-2000 Cl 24.5 , Fig 7 & SP 24 Cl 23.5

w kN/m^2	lx short span m	ly long span m	load on short beam kN/m	load on long beam kN/m
10	**5**	**15**	**16.667**	**24.074**

40 Determination of creep coefficient of concrete

Ref IS 456-2000 Cl 6.2.5.1

Age at loading	Creep coefficient
1year	**1.1**

41 Permissible bearing stress on full area of concrete (Working stress method)

Ref IS 456-2000 Cl 34.4

f_{ck}	Bearing stress

N/mm^2	N/mm^2
20	**5.00**

42 Permissible bearing stress on full area of concrete (Limit state method)
Ref IS 456-2000 Cl 34.4

f_{ck} N/mm^2	Bearing stress N/mm^2
20	**9.00**

43 Check for short and slender compression members
Ref IS 456-2000 Cl 25.1.2 Table 28 Cl E-3

size of column	
b	D
mm	mm
450	**450**

Check for short or slender column

unsupported	unsupported	Leff/L		effective length		Lex/D	Ley/b	Result	
Lx, Cl 25.1.3	Ly, Cl 25.1.3	El_x	El_y	L_{ex}	L_{ey}			Cl 25.1.2	
m	m			m	m			L_{ex}/D	L_{ey}/b
5	**5**	**1.200**	**1.200**	6.00	6.00	13.33	13.33	>12,slender	>12,slender

44 Check for Deep beam action-continuous beam
Ref IS 456-2000 Cl 29.1

Geometry of the deep beam

Width of the beam	Overall depth of the beam	Length of the beam		
		clear length	c/c length	eff. length
b	D	L_{clear}	$L_{c/c}$	L_{eff} Cl29.2 IS456
mm	mm	mm	mm	mm
500	**4000**	**5000**	**5500**	5500

Check for cont. deep beam action, minimum thick.of beam to prevent buckling w.r.t span and depth

L_{eff} / D	Result Cl 29.1 IS 456:2000	L_{eff} / b	Result	D / b	Result
1.38	**<2.5,okay**	11.00	**<50,okay**	8.00	**<25,okay**

45 Check for Deep beam action-simply supported beam
Ref IS 456-2000 Cl 29.1

Geometry of the deep beam

Width of the beam	Overall depth of the beam	Length of the beam		
		clear length	c/c length	eff. length
b	D	L_{clear}	$L_{c/c}$	L_{eff} Cl29.2 IS456
mm	mm	mm	mm	mm
500	**3000**	**4500**	**5000**	5000

Check for cont. deep beam action, minimum thick.of beam to prevent buckling w.r.t span and depth

L_{eff} / D	Result Cl 29.1 IS 456:2000	L_{eff} / b	Result	D / b	Result
1.67	**<2.0,okay**	10.00	**<50,okay**	6.00	**<25,okay**

46 Permissible shear stress in concrete (τc) for footings (two way action) in limit state design method

Ref IS 456:2000 Cl 31.6.3.1

f_{ck}	Size of pedestal		β_c	k_s	τ_c	Permissible shear stress
	B	D	IS 456-2000	IS 456-2000	IS 456-2000	$k_s\ \tau_c$
N/mm^2			Cl 31.6.3.1	Cl 31.6.3.1	Cl 31.6.3.1	IS 456 Cl 31.6.3.1
	mm	mm			N/mm^2	N/mm^2
25	**450**	**450**	1.000	1.00	1.250	**1.250**

47 Permissible shear stress in concrete ($k_s\tau c$) for footings (two way action) in working stress method

Ref IS 456:2000 Cl 31.6.3.1

f_{ck}	Size of pedestal		β_c	k_s	τ_c	Permissible shear stress
	B	D	IS 456-2000	IS 456-2000	IS 456-2000	$k_s\ \tau_c$
N/mm^2			Cl 31.6.3.1	Cl 31.6.3.1	Cl 31.6.3.1	IS 456 Cl 31.6.3.1
	mm	mm			N/mm^2	N/mm^2
20	**350**	**500**	0.700	1.00	0.716	**0.716**

48 Design check equation for members subjected to combined axial load and biaxial bending

Ref IS 456:2000 Cl 39.6 Limit state design method

f_{ck}	f_y	size of column		design loads & moments			p	Max. uniaxial moments	
		b	D	P_u	M_{ux}	M_{uy}	assumed	M_{ux1}	M_{uy1}
N/mm^2	N/mm^2	mm	mm	kN	kN.m	kN.m	%	kN.m	kN.m
25	**415**	**350**	**450**	**205**	**13.2**	**115.4**	**2.04**	**194.91**	**137.81**

P_{uz} Cl 39.6 kN	P_u/P_{uz} Cl 39.6	α_n Cl 39.6	$(M_{ux}/M_{ux1})^{\alpha n} + (M_{uy}/M_{uy1})^{\alpha n} \leq 1$ IS 456-2000 Cl 39.6	Result Cl 39.6
2735.78	0.075	1.000	**0.91**	**<1 Ok**

49 Design check equation for members subjected to combined axial load and biaxial bending

Ref IS 456:2000 Cl B-4 Cl B-4.1. Design based on Uncracked Section

$[\sigma cc_{,cal}/\sigma cc + \sigma cbc_{,cal}/\sigma cbc] <= 1$

f_{ck}	σ_{cbc}	σ_{cc}	$\sigma_{cbc,cal}$	$\sigma_{cc,cal}$	ratio	Result
N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2		
30	10	8	**6**	**3**	0.98	**< 1,okay**

50 Coefficient of thermal expansion for concrete/^{o}c

Ref IS 456:2000 Cl 6.2.6

Type of aggregate	coefficient of thermal expansion / ^{o}c
sandstone	**0.9 to 1.2 x 10^{-5}**

51 Partial safety factor 'γ_m' for material

Ref IS 456:2000 Cl 36.4.2

Material	γ_m N/mm^2
steel	**1.15**

1 **Minimum percentage of steel for liquid retaining structures (RCC memb.)**
Ref IS 3370 Part II-1965 Cl 7.1

Type of steel	b mm	D mm	Ast min/face mm^2
HYSD	**1000**	**500**	400.00

2 **Permissible concrete stresses-resistance to cracking**
Ref IS 3370 Part II -1965 Table 1

f_{ck} N/mm^2	σ_{at} N/mm^2	σ_{bt} N/mm^2	Max shear N/mm^2
30	1.5	2	2.2

3 **Calculation of stress due to bending tension in concrete , f_{bt}**
For transformed sections without compression reinforcement

Overall depth of member = D
Effective depth of member = d
Area of tension steel = Ast
Depth of neutral axis X = yc = [(b x D^2/2) + (m-1) x Ast x d)] / [b x D + (m-1) Ast]
(from compression face)
yt = (D - yc) (from tension face)
ys = (d - yc)
modular ratio , m = 280/ (3σcbc) Ref IS 456-2000 , B 1.3 d
Bending moment = M
Stress in concrete in bending tension , f_{bt} = M x y_t / I_t
I_t = [(b x y_c^3/3) + (b x y_t^3/3) + (m-1) Ast y_s^2]

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	9.33	**1000**	**600**	**50**	**8**	542	**2010.62**

A_t mm^2	Depth of neutral axis yc mm	Depth of neutral axis yt mm	I_t mm^4	B.M kNm	$f_{bt\ obtained}$ N/mm^2	$\sigma_{bt\ allowable}$ IS 3370 N/mm^2	Result IS 3370 Table 1
6.2E+05	306.57	293.43	1.9E+10	**109.904**	**1.701**	2	**O.k.**

4 **Calculation of stress due to direct tension in concrete , f_{at}**

Overall depth of member = D
Unit width of member = b
Area of tension steel = Ast
Gross area of the member , Ag = b x D
Transformed area , At = (b x D) + (m-1) Ast
modular ratio , m = 280/ (3σcbc) Ref IS 456-2000 , B 1.3 d
Direct tensile force in concrete = T
Stress in concrete in direct tension , f_{at} = T/A_t

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of beam mm	Ast prov. mm^2	At mm^2	T (direct) tension kN	$f_{at\ obtained}$ N/mm^2	$\sigma_{at\ allowable}$ IS 3370 N/mm^2
30	10	9.33	**1000**	**600**	**2010.62**	**616755.2**	**96**	**0.156**	**1.5**

5 Check for interaction ratio for members on liquid retaing face subjected to direct tension and flexural tension in concrete

Ref IS 3370 Part II -1965 Cl 5.3

$[f_{at} / \sigma_{at} + f_{bt} / \sigma_{bt}] <= 1$

f_{ck} N/mm^2	σ_{at} N/mm^2	σ_{bt} N/mm^2	f_{at} N/mm^2	f_{bt} N/mm^2	ratio	Result
30	1.5	2	**0.156**	**1.701**	0.95	**< 1,okay**

6 Calculation of tensile stress due to bending in concrete, f_{bt} (alternate)

For sections without compression reinforcement

Overall depth of member		=	D
Effective depth of member		=	d
Reinforcement ratio		=	ρ
Area of tension steel	Ast	=	ρbD
Depth of neutral axis	x = kD	=	[0.5 D + (m-1) ρ d] / [1+ (m-1) ρ] (from compression face)
Moment of resistance	M_R	=	R b D^2
	R	=	C σ_{bt}
	C	=	$[k^3 + (1-k)^3 + 3 (m-1) \rho (d/D - k)^2] / [3(1-k)]$

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	9.33	**1000**	**410**	**25**	**10**	375	**1528**

ρ	d/D	k	C	B.M kNm	$f_{bt\ obtained}$ N/mm^2	$\sigma_{bt\ allowable}$ IS 3370 N/mm^2	Result IS 3370 Table 1
0.0037	0.91	0.512	0.182	**55**	**1.794**	2	**O.k.**

7 Calculation of thickness required for a structural member for permissible σ_{bt} and assumed ρ

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	$D_{prov.}$ of member mm	clear cover mm	c.g of bar mm	d prov. mm	ρ = Ast/bd assumed	B.M kNm
35	11.5	8.12	**1000**	**500**	**75**	**8**	417	**0.00300**	**81**

d/D	k	C	$\sigma_{bt\ allowable}$ IS 3370 N/mm^2	R =C σ_{bt}	D req. mm	Result
0.83	0.507	0.174	2.2	0.383	**459.75**	**D prov. > D req, ok**

1 Design for area of steel and shear for singly reinforced beam by limit state design method

Calculation of Ast req for beams

Ref IS 456-2000 Cl G-1.1b & G-1.1c For sections without compression reinforcement

f_y N/mm^2	f_{ck} N/mm^2	b mm	D mm	Cc mm	Cg of bar mm	d mm	$M_{u\ lim}$ kN.m	$p_{t\ lim}$ %
415	**20**	**230**	**350**	**25**	**6**	319	**64.60**	0.96

$M_{u\ support}$	Ast req. spt	p_t req.spt	$M_{u\ span}$	Ast span	p_t req.span	check for depth		
kNm	mm^2	%	kNm	mm^2	%	d req mm	d prov mm	Result
20.625	**189.30**	**0.26**	**17.2**	**156.32**	**0.21**	180.25	**319**	**okay**

Reinforcement details provided at support and span of beam

Reinf. details at support				Result	Reinf. details at span				Result
Nos.	dia mm	Ast support mm^2	pt support %		Nos.	dia mm	Ast span mm^2	pt span %	
2	**12**	**226.19**	**0.31**	**okay**	**2**	**12**	**226.19**	**0.31**	**okay**
0	**0**				**0**	**0**			

Check for shear in beams (limit state design method)

Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1

f_{ck} N/mm^2	V_u kN	pt prov. %	τ_v Cl 40.1 N/mm^2	τ_c Table 19 N/mm^2	$\tau_{c\ max}$ Table 20 N/mm^2	Result
						tau_v > tau_c,design for shear
20	**30**	**0.31**	0.41	0.39	2.8	**tau_v <tau_cmax, Ok**

Design for shear reinforcement (vertical stirrups)

Ref IS 456-2000 Cl 40.4a

V_u kN	τ_c b d kN	V_{us} req kN	V_{us}/d req kN/cm	f_y N/mm^2	assuming stirrup dia mm	no. of stirrup legs	stirrup sp assumed mm	V_{us}/d prov. kN/cm Cl 40.4 a	Result Cl 40.4a
30	28.61	1.39	**0.04**	**415**	**8**	**2**	**225**	**1.613**	**Hence ok**

Check for minimum and maximum spacing of stirrup

Min stirrup spacing mm Cl 26.5.1.6	Max stirrup spacing mm Cl 26.5.1.5	stirrup sp prov. mm	Result
394.53	239.25	225	**Hence ok**

Side face reinforcement

Ref IS 456-2000 Cl 26.5.1.3

b	D of web	side face reinf. req. / face	side face reinf. mm^2 /face prov.			spc b/w bars not to exceed
mm	mm	Cl 26.5.1.3	no. per face	dia of bar	Ast prov. mm^2	Cl 26.5.1.3
230	350	**not req**	**2**	**10**	157.08	**230 mm**

Check for span to depth ratio

Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	p_c %	MFt	MFc
Cont.Beam	415	**5000**	319	**0.21**	**0.31**	**0**	2.266	1

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
15.67	58.92	**Okay**

2 Design of beam (singly reinf.) subjected to torsion by limit state design method

Ref IS 456-2000 Cl 41.3, Cl 41.4

f_{ck} N/mm^2	f_y N/mm^2	V_u kN	T_u kNm	M_u kNm	b mm	D mm	clear cover on ten.face mm	clear cover on com.face mm	side cover mm
30	**415**	**110**	**75**	**181**	**300**	**600**	**40**	**40**	**35**

c_g of tension face steel mm	c_g of comp. face steel mm	d for tension face steel mm	d for comp. face steel mm	stirrup dia assumed mm	b_1 mm	d_1 mm	x_1 mm	y_1 mm
10	**10**	550.00	550.00	**12**	210.0	500.0	242.0	532.0

Equivalent shear

Ref IS 456-2000 Cl 41.3.1, Cl 40.2.3 & Table 20

V_e kN	τ_{ve} N/mm^2	$\tau_{c\,max}$ N/mm^2	Result IS 456-2000 Cl 41.3.1
510.00	3.09	3.5	**tau_v <tau_cmax,Ok**

Longitudinal reinforcement for beams subjected to torsion

Ref IS 456-2000 Cl 41.4.2

M_t Cl 41.4.2 kNm	M_{e1} Cl 41.4.2 kNm	M_{e2} Cl 41.4.2.1 kNm	Longitudinal reinf, mm^2 reinf on ten. face Cl41.4.2	reinf on comp. face Cl41.4.2.1
132.35	313.35	Mt < Mu	**1872.84**	**Not req.**

Transverse reinforcement for beams subjected to torsion

Ref IS 456-2000 Cl 41.4.3

f_y N/mm^2	no. of stirrup legs	stirrup dia mm	max. allowable stirrup sp Cl 26.5.1.7	stirrup spacing prov. mm	p_t %	τ_c Table 19 N/mm^2	V_{us}/d req. Cl 41.4.3 kN/cm	V_{us}/d prov. Cl 40.4 a kN/cm	Result Cl 41.4.3
415	**2**	12	**193.5**	**100**	1.14	0.69	**8.02**	**8.17**	**Ok**

3 Design of column subjected to biaxial bending (with reinforcement equally on all the four sides.)

Ref IS 456-2000 & SP 16 charts for compression with bending

f_{ck}	f_y	size of column		design loads & moments			Cc	bar dia.	d'
		b	D	P_u	M_{ux}	M_{uy}		ϕ	
N/mm^2	N/mm^2	mm	mm	kN	kN.m	kN.m	mm	mm	mm
25	**415**	**350**	**450**	**205**	**5**	**105**	**45**	**20**	55.00

Check for short or slender column

unsupported	unsupported	Leff/L		effective length		Lex/D	Ley/b	Result	
Lx, Cl 25.1.3	Ly, Cl 25.1.3	El_x	El_y	L_{ex}	L_{ey}			Cl 25.1.2	
m	m			m	m			L_{ex}/D	L_{ey}/b
3	**3**	**2.000**	**2.000**	6.00	6.00	13.33	17.14	>12,slender	>12,slender

Longitudinal steel percentage assumed for column

Reinf. details at support				p
Nos.	dia	Asc	p prov.	assumed
	mm	mm^2	%	%
4	**25**			
4	**20**	**3220.13**	**2.04**	**2.04**

Additional moments in slender column

d'/D		P_{bx}, SP 16 Table 60			d'/b		P_{by}, SP 16 Table 60		
obtained	considered	k1	k2	P_{bx}	obtained	considered	k_1	k_2	P_{by}
value	value			kN	value	value			kN
0.122	**0.15**	**0.196**	**0.203**	836.97	**0.157**	**0.20**	**0.184**	**0.028**	733.50

P_{uz}	reduction factor, k		additional moments		additional moments	
Cl 39.6	Cl 39.7.1.1		Cl 39.7.1		Cl 39.7.1.1	
kN	kx	ky	Max ,kN.m	May ,kN.m	Max ,kN.m	May ,kN.m
2735.775	1.000	1.000	8.200	10.543	**8.200**	**10.543**

Moments due to minimum eccentricity

minimum eccentricity		moments due to minimum eccentricity	
Cl 25.4			
e_x	e_y	Mex,kN.m	Mey,kN.m
0.021	0.020	**4.31**	**4.10**

Total moments to be considered for column design are:

M_{ux}	M_{uy}	Pu/f_{ck} bD	p/f_{ck}	Chart No 45 SP16		Chart No 46 SP16		M_{ux1}	M_{uy1}
kN.m	kN.m			d'/D	M_{ux1}/f_{ck} b D^2	d'/b	M_{uy1}/f_{ck} b D^2	kN.m	kN.m
13.20	115.54	**0.052**	**0.08**	**0.15**	**0.11**	**0.20**	**0.1**	194.906	137.813

P_u/P_{uz}	α_n	$(M_{ux}/M_{ux1})^{\alpha n} + (M_{uy}/M_{uy1})^{\alpha n} \leq 1$	Result
Cl 39.6	Cl 39.6	IS 456-2000 Cl 39.6	Cl 39.6
0.075	1.000	**0.91**	**<1 Ok**

4 Design for area of steel and shear for doubly reinforced beam by limit state design method

Ref IS 456-2000 Cl G-1.2 For sections with compression reinforcement

f_y	f_{ck}	b	D	clear cover on ten.face	clear cover on com.face	c_g of tension face steel	c_g of comp. face steel	d for tension face steel	d' for comp. face steel
N/mm^2	N/mm^2	mm	mm	mm	mm	mm	mm	mm	mm
415	**20**	**230**	**350**	**25**	**25**	**30**	**10**	295	35

Check for section : **doubly** Ref IS 456-2000 Cl G 1.2

Ref IS 456-2000 Cl G-1.2

$M_{u\ lim}$ SP 16 Table C	$p_{t\ lim}$ SP 16 Table E	Ast_1 req	M_u	M_u - M_{ulim}	d'/d		f_{sc}	Asc req Cl G-1.2	Ast_2 req Cl G-1.2
					obtained value	considered value			
kN.m	%	mm^2	kNm	Cl G 1.2			N/mm^2	mm^2	mm^2
55.24	0.96	648.09	**125**	69.76	**0.119**	**0.20**	**329**	815.48	743.09

Total Ast req on tension face mm^2	Ast prov on tension face		pt prov	Result reg tesion steel	Asc req on compression face mm^2	Ast prov on comp. face		pc prov	Result reg comp. steel
	Nos.	dia mm				Nos.	dia mm		
	3	**20**				**2**	**20**		
	3	**16**	%			**2**	**16**	%	
1391.18	Ast prov-	**1545.66**	2.28	**Prov > req**	**815.48**	Ast prov-	**1030.44**	1.52	**Prov>req**

Check for shear in beams (limit state design method)

Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1

f_{ck}	V_u	pt prov.	τ_v Cl 40.1	τ_c Table 19	$\tau_{c\ max}$ Table 20	Result
N/mm^2	kN	%	N/mm^2	N/mm^2	N/mm^2	**tau_v > tau_c,design for shear**
20	**116**	**2.28**	1.71	0.82	2.8	**tau_v <tau_cmax, Ok**

Design for shear reinforcement (vertical stirrups)

Ref IS 456-2000 Cl 40.4a

V_u	τ_c b d	V_{us} req	V_{us}/d req	f_y	assuming stirrup dia	no. of stirrup	stirrup sp assumed	V_{us}/d prov. kN/cm	Result
kN	kN	kN	kN/cm	N/mm^2	mm	legs	mm	Cl 40.4 a	Cl 40.4a
116	55.64	60.36	**2.05**	**415**	**10**	**2**	**200**	**2.836**	**Hence ok**

Check for minimum and maximum spacing of stirrup

Min stirrup spacing mm Cl 26.5.1.6	Max stirrup spacing mm Cl 26.5.1.5	stirrup sp prov. mm	Result
616.45	221.25	200	**Hence ok**

Side face reinforcement

Ref IS 456-2000 Cl 26.5.1.3

b	D of web	side face reinf. req. / face	side face reinf. mm^2 /face prov.			spc b/w bars not to exceed
			no. per face	dia of bar	Ast prov. mm^2	
mm	mm	Cl 26.5.1.3				Cl 26.5.1.3
230	350	**not req**	**2**	**10**	157.08	**230 mm**

Check for span to depth ratio

Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	p_c %	MFt	MFc
Cont.Beam	415	**5000**	295	2.05	2.28	1.52	0.873	1.35

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
16.95	30.64	**Okay**

5 Design for area of steel and shear for singly reinforced one way slab by limit state design method

Slab Geometry

Lx	Ly	Ly/Lx	Result
m	m		
2.2	**7.5**	3.409	**>2, Hence one way slab**

Grade of concrete, steel, overall depth of slab & limiting resistance of moment of the slab

f_y	f_{ck}	b	D	Cc	Cg of bar	d	$M_{u\ lim}$	$p_{t\ lim}$
N/mm^2	N/mm^2	mm	mm	mm	mm	mm	kN.m	%
415	**25**	**1000**	**160**	**25**	**6**	129	**57.41**	1.19

Load calculation of the slab

Dead Load of the slab	Floor finish of the slab	Live load of the slab	Misc. load of the slab	Total unfactored load of the slab	Partial safety factor γ_f	Design load of the slab
DL	FF	LL	ML	TL	Table 18	w
kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	IS 456-2000	kN/m^2
4	**1**	**30**	**5**	40	**1.5**	**60**

Moment & Shear calculation

Considering '1m' strip of the slab

w	Lx	w Lx^2	$M_{u\ support}$ 'kNm'		$M_{u\ span}$ 'kNm'		V_u 'kN'	
kN/m^2	m	kNm	$C_{oef\text{-}support}$	C w Lx^2	$C_{oef\text{-}span}$	C w Lx^2	Coef-shear	C w Lx
60	2.2	290.4	**0.100**	**29.040**	**0.083**	**24.103**	**0.500**	**66**

Calculation of Ast req for slab

Ref IS 456-2000 Cl G-1.1b & G-1.1c For sections without compression reinforcement

$M_{u\ support}$	Ast req.spt	pt req.spt	$M_{u\ span}$	Ast span	pt req.span	check for depth		
kNm	mm^2	%	kNm	mm^2	%	d req mm	d prov mm	Result
29.04	**684.03**	**0.53**	**24.10**	**557.81**	**0.43**	91.75	**129**	**okay**

Reinforcement details provided at support and span of slab

Reinf. details at support				Result	Reinf. details at span				Result
dia prov.	spacing	Ast support	pt support		dia prov.	spacing	Ast span	pt span	
mm	mm	mm^2	%		mm	mm	mm^2	%	
12	**150**	**753.98**	**0.58**	**okay**	**12**	**150**	**753.98**	**0.58**	**okay**
0	**150**				**0**	**150**			

Check for shear in solid slabs for limit state design method

Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1.1

f_{ck}	V_u	b	D	clear	c_g	d
N/mm^2	kN	mm	of slab mm	cover mm	of bar mm	mm
25	**66**	1000	160	**25**	**6**	129

p_t	τ_v	k τ_c	$\tau_{c\ max}$	Result
	Cl 40.1	Cl 40.2.1.1	Table 20	
%	N/mm^2	N/mm^2	N/mm^2	**tau_v < k tau_c, Ok**
0.58	0.51	0.67	3.1	**tau_v <1/2 tau_c max,Ok**

Check for span to depth ratio

Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y	span	d	$p_{t\ req.}$	$p_{t\ prov.}$	p_c	MFt	MFc
	N/mm^2	mm	mm	%	%	%		
S.S.Slab	415	2200	129	**0.43**	**0.58**	**0**	1.532	1

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
17.05	30.64	**Okay**

6 Design for area of steel and shear for two way slab by limit state design method

Slab Geometry

Lx	Ly	Ly/Lx	Result
m	m		
2.12	**3.02**	1.425	**<2, Hence two way slab**

Grade of concrete, steel, & overall depth of slab

f_y	f_{ck}	b	D
N/mm^2	N/mm^2	mm	mm
415	**30**	**1000**	**150**

Lx-shorter span					
Cc bot	Cg of bot bar	d bot	Cc top	Cg of top bar	d top
mm	mm	mm	mm	mm	mm
25	4	121	**25**	4	121

Ly-longer span					
Cc bot	Cg of bot bar	d bot	Cc top	Cg of top bar	d top
mm	mm	mm	mm	mm	mm
25	12	113	25	12	113

Load calculation of the slab

Dead Load of the slab	Floor finish of the slab	Live load of the slab	Misc. load of the slab	Total unfactored load of the slab	Partial safety factor γ_f	Design load of the slab
DL	FF	LL	ML	TL	Table 18	w
kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2	IS 456-2000	kN/m^2
3.75	**1.25**	**15**	**0**	20	**1.5**	30

Moment & Shear calculation

Moment calculation for '1m' strip of the slab spanning Lx

w	Lx	w Lx^2	- $M_{ux\ cont.\ edge}$ 'kNm'		+ $M_{ux\ mid\text{-}span}$ 'kNm'		V_u 'kN' Table 13 IS 456	
kN/m^2	m	kNm	- α_x	- α_x w L_x^2	+ α_x	+ α_x w L_x^2	Coef-shear	C w Lx
30	2.12	134.83	**0.000**	**0.00**	**0.064**	**8.63**	**0.400**	**25.44**

Calculation of Ast req for slab spanning Lx

Ref IS 456-2000 Cl G-1.1b & G-1.1c

- $M_{ux\ cont.}$	Ast min	pt req.cont.	+ $M_{ux\ span}$	Ast span	pt req.span
kNm	mm^2	%	kNm	mm^2	%
0	**180.00**	0.15	8.63	**202.30**	0.17

Reinforcement details provided at support and span of slab spanning Lx

Reinf. details at support				Result	Reinf. details at span				Result
dia prov.	spacing	Ast cont.	pt cont.		dia prov.	spacing	Ast span	pt span	
mm	mm	mm^2	%		mm	mm	mm^2	%	
8	**250**	**201.06**	0.17	**okay**	**8**	**150**	**335.10**	0.28	**okay**
0	**250**				**0**	**150**			

Moment calculation for '1m' strip of the slab spanning Ly

w	Lx	w Lx^2	- $M_{uycont.\ edge}$ 'kNm'		+ $M_{uy\ mid\text{-}span}$ 'kNm'	
kN/m^2	m	kNm	- α_y	- α_y w L_x^2	+ α_y	+ α_y w L_x^2
30	2.12	134.83	**0.045**	**6.07**	**0.035**	**4.72**

Calculation of Ast req for slab spanning Ly

Ref IS 456-2000 Cl G-1.1b & G-1.1c

- $M_{uy\ cont.}$	Ast min	pt req.cont.	+ $M_{uy\ span}$	Ast min	pt req.span
kNm	mm^2	%	kNm	mm^2	%
6.07	**180.00**	0.16	4.72	**180.00**	0.16

Reinforcement details provided at support and span of slab spanning Ly

Reinf. details at support				Result	Reinf. details at span				Result
dia prov. mm	spacing mm	Ast cont. mm^2	pt cont. %		dia prov. mm	spacing mm	Ast span mm^2	pt span %	
8	**250**	**201.06**	0.18	**okay**	**8**	**250**	**201.06**	0.18	**okay**
0	**250**				**0**	**250**			

Check for shear in solid slabs for limit state design method
Ref IS 456-2000 Cl 40.1, Cl 40.2.3, Table 19, Table 20 & Cl 40.2.1.1

f_{ck} N/mm^2	V_u kN	b mm	D of slab mm	clear cover mm	c_g of bar mm	d mm
30	25.44	1000	150	25	4	121

p_t %	τ_v Cl 40.1 N/mm^2	k τ_c Cl 40.2.1.1 N/mm^2	$\tau_{c\,max}$ Table 20 N/mm^2	Result
				tau_v < k tau_c, Ok
0.28	0.21	0.51	3.5	**tau_v <1/2 tau_c max,Ok**

Check for span to depth ratio
Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\,req.}$ %	$p_{t\,prov.}$ %	p_c %	MFt	MFc
S.S.Slab	415	2120	121	0.17	0.28	**0**	2.904	1

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
17.52	58.08	**Okay**

1 Design for area of steel and shear for singly reinforced beam by working stress design method

Uncracked section design Per IS 3370 Part II

Calculation of Ast req for beams

f_y N/mm^2	f_{ck} N/mm^2	b mm	D mm	Cc bot face mm	Cc top face mm	Cg bot reinf mm	Cg top reinf mm
415	**30**	**500**	**850**	**50**	**35**	**30**	**19**

d bot reinf mm	d top reinf mm	σ_{cbc} N/mm^2	$\sigma_{st\ liq\text{-}face}$ N/mm^2	$\sigma_{st\ away\ face}$ N/mm^2	M resistance kN.m
770	796	10	**150**	**150**	**495.84**

$M_{u\ support}$ kNm	Ast req. sup mm^2	p_t req.spt %	$M_{u\ span}$ kNm	Ast req.spn mm^2	p_t req.span %	check for depth		
						d req mm	d prov mm	Result
128.74	**1236.29**	**0.32**	**124.66**	**1237.53**	**0.32**	392.35	**770**	**okay**

Reinforcement details provided at support and span of beam

Reinf. details at support				Result	Reinf. details at span			
Nos.	dia mm	Ast prov.sup mm^2	pt support %		Nos.	dia mm	Ast prov.spn mm^2	pt span %
4	**16**	**1608.50**	**0.404**	**okay**	**4**	**20**	**2513.27**	**0.653**
4	**16**				**4**	**20**		

Check for shear in beams

Ref IS 456-2000 Cl B 5.1, B 5.2.1, B 5.2.3, Table 23 & Table 24

f_{ck} N/mm^2	V kN	pt prov. at support %	τ_v Cl B- 5.1 N/mm^2	τ_c Table 23 N/mm^2	$\tau_{c\ max}$ Table 24 N/mm^2	Result
						tau_v > tau_c,design for shear
30	**115.43**	**0.404**	0.30	0.28	2.2	**tau_v <tau_cmax, Ok**

Design for shear reinforcement (vertical stirrups)

Ref SP 16-1980 Table 81 & IS 456-2000, Cl B 5.4 a

V kN	τ_c b d kN	V_s req kN	V_s/d req. Cl B 5.4 a kN/cm	assuming stirrup dia mm	no. of stirrup legs	stirrup sp assumed mm	V_s/d prov. kN/cm Cl 40.4 a	Result Cl 40.4a
115.43	107.80	7.63	**0.10**	**8**	**2**	**150**	**1.173**	**Hence ok**

Check for minimum and maximum spacing of stirrup

Min stirrup spacing mm Cl 26.5.1.6	Max stirrup spacing mm Cl 26.5.1.5	stirrup sp prov. mm	Result Cl 26.5.1.6 Cl 26.5.1.5
181.48	300	150	**Hence ok**

Side face reinforcement

Ref IS 456-2000 Cl 26.5.1.3

b mm	D of web mm	side face reinf. req. / face Cl 26.5.1.3	side face reinf. mm^2 /face prov.			spc b/w bars not to exceed Cl 26.5.1.3
			no. per face	dia of bar	Ast prov. mm^2	
500	850	**212.5**	**2**	**12**	226.19	**300 mm**

Check for span to depth ratio

Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	p_c %	MFt	MFc
S.S.B	415	**5000**	770	**0.32**	**0.653**	**0**	2.037	1

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
6.49	40.74	**Okay**

Check for tensile stress due to bending in concrete for support moment

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	500	850	35	19	796	1608.50

A_T transformed	Depth of neutral axis		M.I $_T$ transformed	B.M	$\sigma_{bt\ obtained}$	$\sigma_{bt\ allowable}$ IS 3370	Result
	Comp.face	Ten.face					
mm^2	mm	mm	mm^4	kNm	N/mm^2	N/mm^2	
4.4E+05	436.34	413.66	2.7E+10	128.74	**1.945**	2	**O.k.**

Check for tensile stress due to bending in concrete for span moment

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	b mm	D of beam mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	500	850	50	30	770	2513.27

A_T transformed	Depth of neutral axis		M.I $_T$ transformed	B.M	$\sigma_{bt\ obtained}$	$\sigma_{bt\ allowable}$ IS 3370	Result
	Comp.face	Ten.face					
mm^2	mm	mm	mm^4	kNm	N/mm^2	N/mm^2	
4.5E+05	441.20	408.80	2.8E+10	124.66	**1.822**	2	**O.k.**

2 Design for area of steel and shear for singly reinforced beam by working stress design method

Per IS 456-2000

Calculation of Ast req for beams

f_y N/mm^2	f_{ck} N/mm^2	b mm	D mm	Cc mm	Cg of bar mm	d mm	σ_{cbc} N/mm^2	σ_{st} N/mm^2
415	20	230	350	25	6	319	7	230

$M_{u\ support}$	Ast req. spt	p_t req.spt	$M_{u\ span}$	Ast span	p_t req.span	check for depth		
kNm	mm^2	%	kNm	mm^2	%	d req mm	d prov mm	Result
20.625	311.04	0.42	17.2	259.39	0.35	313.38	319	okay

Reinforcement details provided at support and span of beam

Reinf. details at support				Result	Reinf. details at span			
Nos.	dia mm	Ast support mm^2	pt support %		Nos.	dia mm	Ast span mm^2	pt span %
2	20	628.32	0.86	okay	2	20	628.32	0.86
0	0				0	0		

Check for shear in beams (working stress design method)

Ref IS 456-2000 Cl B 5.1, B 5.2.1, B 5.2.3, Table 23 & Table 24

f_{ck} N/mm^2	V_u kN	pt prov. %	τ_v Cl B- 5.1 N/mm^2	τ_c Table 23 N/mm^2	$\tau_{c\ max}$ Table 24 N/mm^2	Result
						tau_v > tau_c,design for shear
20	30	0.86	0.41	0.37	1.8	tau_v <tau_cmax, Ok

Design for shear reinforcement (vertical stirrups)

Ref SP 16-1980 Table 81 & IS 456-2000, Cl B 5.4 a

V_u kN	τ_c b d kN	V_s req kN	V_s/d req. Cl B 5.4 a kN/cm	f_y N/mm^2	assuming stirrup dia mm	no. of stirrup legs	stirrup sp assumed mm	V_s/d prov. kN/cm Cl 40.4 a
30	27.15	2.85	0.09	415	8	2	225	1.028

Check for minimum and maximum spacing of stirrup

Min stirrup spacing mm Cl 26.5.1.6	Max stirrup spacing mm Cl 26.5.1.5	stirrup sp prov. mm	Result
394.53	239.25	225	Hence ok

Side face reinforcement

Ref IS 456-2000 Cl 26.5.1.3

b mm	D of web mm	side face reinf. req. / face Cl 26.5.1.3	side face reinf. mm^2 /face prov.			spc b/w bars not to exceed Cl 26.5.1.3
			no. per face	dia of bar	Ast prov. mm^2	
230	350	not req	2	10	157.08	230 mm

Check for span to depth ratio

Ref IS 456-2000 Cl 23.2.1

Type of beam	f_y N/mm^2	span mm	d mm	$p_{t\ req.}$ %	$p_{t\ prov.}$ %	p_c %	MFt	MFc
S.S.B	415	5500	319	0.35	0.86	0	1.989	1

l/d prov	l/d Cl 23.2.1	Result Cl 23.2.1
17.24	39.78	Okay

3 Design of one-way slab as uncracked section design

Slab Geometry

Lx m	Ly m	Ly/Lx	Result
2	5	2.500	>2, Hence one way slab

Grade of steel, concrete, & overall depth of slab

f_y N/mm^2	f_{ck} N/mm^2	b mm	D mm
415	30	1000	150

Load calculation of the slab

Dead Load of the slab DL kN/m^2	Floor finish of the slab FF kN/m^2	Live load of the slab LL kN/m^2	Misc. load of the slab ML kN/m^2	Total unfactored load of the slab TL kN/m^2	Partial safety factor γ_f	Design load of the slab w kN/m^2
3.75	0	10	0	13.75	1	13.75

Moment & Shear calculation

Considering '1m' strip of the slab

w	L	wL^2	$M_{support}$ 'kNm'		M_{span} 'kNm'		V 'kN'	
kN/m^2	m	kNm	$C_{oef-support}$	CwL^2	$C_{oef-span}$	CwL^2	Coef-shear	C w L
13.75	2	55	0.100	5.500	0.100	5.500	0.500	13.75

Area of steel calculation at mid-span

f_{ck} N/mm^2	σst N/mm^2	b mm	D mm	cc mm	cg of bar mm	d mm	M_u kNm	T direct tension kN
30	150	1000	150	40	6	104	5.500	10

Ast req bending	Ast ten/face	Total Ast	Minimum Ast req per IS 3370 - II Cl 7.1				Ast req.	pt req.
mm^2	mm^2	mm^2	Type of steel	b mm	D mm	Ast min/face mm^2	mm^2	at mid-span
404.25	33.33	437.58	HYSD	1000	150	342.86	437.58	0.42

Reinf. details at span				Result
$\phi_{prov.}$ mm	spacing mm	Ast span mm^2	pt span %	
12	200	565.49	0.54	okay
0	200			

Check for thickness (concrete tensile stress) using moment @ mid-span

Calculation of stress due to bending tension in concrete, f_{bt}

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of slab mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	9.33	1000	150	40	6	104	565.49

A_t	Depth of neutral axis		I_t	B.M	$f_{bt\ obtained}$	$\sigma_{bt\ allowable}$ IS 3370	Result IS 3370
mm^2	yc mm	yt mm	mm^4	kNm	N/mm^2	N/mm^2	Table 1
1.5E+05	75.88	74.12	2.9E+08	5.500	1.430	2	O.k.

Calculation of stress due to direct tension in concrete, f_{at}

f_{ck}	σ_{cbc} IS 456	m IS 456	b	D of slab	Ast prov.	At	T (direct) tension	$f_{at\ obtained}$

N/mm^2	N/mm^2	Cl B 1.3 d	mm	mm	mm^2	mm^2	kN	N/mm^2
30	10	9.33	1000	150	565.49	154712.4	10	**0.065**

Check for interaction ratio

$[f_{at} / \sigma_{at} + f_{bt} / \sigma_{bt}] <= 1$

Ref IS 3370 Part II -1965 Cl 5.3

f_{ck} N/mm^2	σ_{at} N/mm^2	σ_{bt} N/mm^2	f_{at} N/mm^2	f_{bt} N/mm^2	ratio	Result
30	1.5	2	0.065	1.430	0.76	**< 1,okay**

Area of steel calculation at support/continuous edge

f_{ck} N/mm^2	σst N/mm^2	b mm	D mm	cc mm	cg of bar mm	d mm	M_u kNm	T direct tension kN
30	**150**	1000	150	**40**	6	104	5.500	10

Ast req bending mm^2	Ast ten/face mm^2	Total Ast mm^2	Minimum Ast req per IS 3370 - II Cl 7.1				Ast req. mm^2	pt req. at support
			Type of steel	b mm	D mm	Ast min/face mm^2		
404.25	33.33	437.58	**HYSD**	1000	150	342.86	**437.58**	**0.42**

Reinf. details at support				Result
ϕ prov. mm	spacing mm	Ast support mm^2	pt support %	
12	**200**	**565.49**	**0.54**	**okay**
0	**200**			

Check for thickness (concrete tensile stress) using moment @ support/continuous edge

Calculation of stress due to bending tension in concrete, f_{bt}

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of slab mm	clear cover mm	c.g of bar mm	d mm	Ast prov. mm^2
30	10	9.33	1000	150	40	6	104	565.49

A_t mm^2	Depth of neutral axis		I_t mm^4	B.M kNm	$f_{bt\ obtained}$ N/mm^2	$\sigma_{bt\ allowable}$ IS 3370 N/mm^2	Result IS 3370 Table 1
	yc mm	yt mm					
1.5E+05	75.88	74.12	2.9E+08	5.500	**1.430**	2	**O.k.**

Calculation of stress due to direct tension in concrete, f_{at}

f_{ck} N/mm^2	σ_{cbc} IS 456 N/mm^2	m IS 456 Cl B 1.3 d	b mm	D of slab mm	Ast prov. mm^2	At mm^2	T (direct) tension kN	$f_{at\ obtained}$ N/mm^2
30	10	9.33	1000	150	565.49	154712.4	10	**0.065**

Check for interaction ratio

$[f_{at} / \sigma_{at} + f_{bt} / \sigma_{bt}] <= 1$

Ref IS 3370 Part II -1965 Cl 5.3

f_{ck} N/mm^2	σ_{at} N/mm^2	σ_{bt} N/mm^2	f_{at} N/mm^2	f_{bt} N/mm^2	ratio	Result
30	1.5	2	0.065	1.430	0.76	**< 1,okay**

Check for shear in solid slabs

Ref IS 456-2000 Cl B 5.1, B 5.2.1.1, B 5.2.3.1, Table 23 & Table 24

f_{ck} N/mm^2	V kN	b mm	D of slab mm	clear cover mm	c_g of bar mm	d mm
30	13.75	1000	150	40	6	104

p_t	τ_v	$k\ \tau_c$	$\tau_{c\ max}$	Result
	Cl B 5.1	B 5.2.1.1	Table 24	
%	N/mm^2	N/mm^2	N/mm^2	**tau_v < k tau_c, Ok**
0.54	0.13	0.416	2.2	**tau_v <1/2 tau_cmax,Ok**

σ_{sv}
175

Result
okay

$M_{resistance}$ kN.m
21.37

σ_{sv}
230

Result
okay

Result Cl 40.4a
Hence ok

$\sigma_{at\ allowable}$ IS 3370

N/mm^2
1.5

$\sigma_{at\ allowable}$ IS 3370 N/mm^2
1.5