FOOTING DESIGN (LSM-IS456:2000)

[A] DESIGN INPUT:

(a) Support reactions:

Table-A1 (Governing loads; X, Y & Z are structural global axes):

Design criterion	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)	FOS	% backfill assumed
Unf. reactions from structure analysis										
Soil press. [1,2]	4	915	-30.8	251	7.0	0.0	0.0	0.0	NA	NA
Uplift	11	121	-11.6	-107	-6.6	0.0	0.0	0.0	1.1	80
Sliding	3	106	22.8	-98	-24.8	0.0	0.0	0.0	1.5	100
Overturning [3]	10	137	32.9	-97	-4.8	0.0	0.0	0.0	1.5	100

[1] Permissible loss of contact with soil = 40%

[2] Increase in allowable stresses for governing LC (915): NA

[3] Restoring moment for governing LC (137) = 100%

(b) Dimensions:

(i) Blockwall:

Length, Wl = 0 m; Height, Wh = 0 m

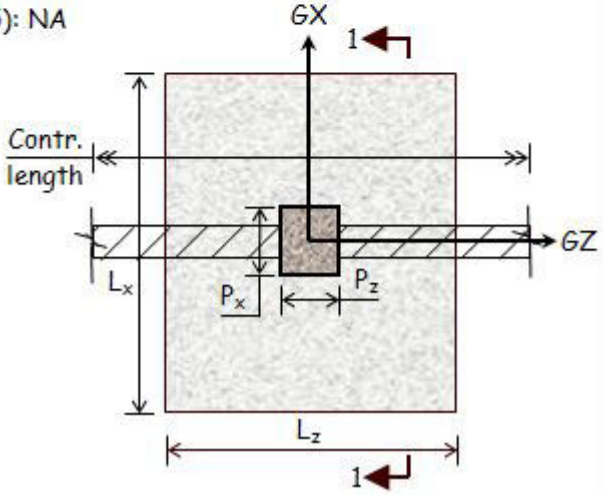
Thk., Wt = 0 m; Density, Wd = 0 kN/cum

(ii) Plinth beam:

Length, Tl = 0 m; Width, Tb = 0 m; Depth, TD = 0 m

(iii) Pedestal size:

Pz = 0.4 m; Px = 0.6 m



FOOTING PLAN

(c) Materials:

fcu = 25 MPa; fy = 500 MPa

Concrete cover, cc = 50 mm

Coeff. of friction bet. conc. and soil, μ = 0.4

(d) Soil data:

Unit wt. of soil, Υs = 18 kN/cum

Net SBC of soil @ ftg. depth = 250 kPa

Depth of water table below ground, Dwt = 1 m

(e) Levels (Ref. section 1-1):

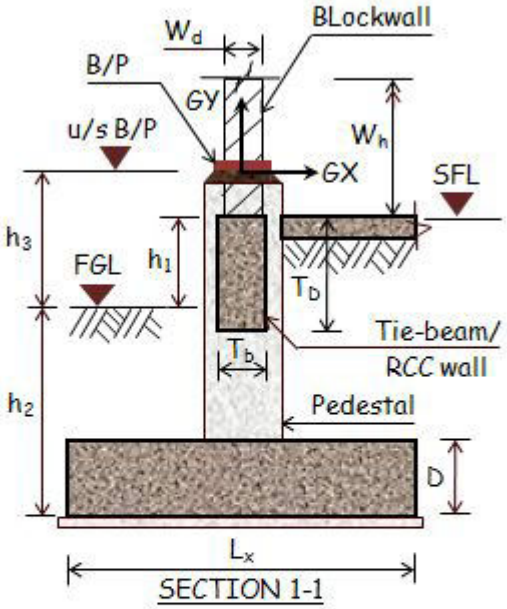
h1 = 0 m; h2 = 2 m; h3 = 0.3 m

(f) Footing size (assumed):

Dim. parallel to GX, Lx = 3 m

Dim. parallel to GZ, Lz = 2.5 m

Dim. parallel to GY, D = 0.5 m



SECTION 1-1

epicenter Consulting Engineers Pvt. Ltd.		Client: -					Element: Edge Footing
		Project: 1016		Doc. No.:	1016-CV-CAL-001		Location/ Grids: A3
		Rev.	Ppd. by	Date	Chd. by	Date	
Project:	-	2	.	.	.	.	Designation: F2
Structure	Pipe Rack	1	.	.	.	.	
Type:	Sub Structure	0	SNR	12/02/20	SHH	12/02/20	Sht. 1 of 6

[B] BASE PRESSURE:

(a) Forces (For governing LC, SBC increase = 0%):

Fx = -30.8/ 1 = -30.8 kN; Fy = 251/ 1 = 251 kN; Fz = 7/ 1 = 7 kN

Mx = 0/ 1 = 0 kNm; My = 0/ 1 = 0 kNm; Mz = 0/ 1 = 0 kNm

Buoyancy force, Fb = 10 Lx.Lz (h2 - Dwt) = 75.00 kN [Water table depth < fdn. depth]

Vol. of soil above the ftg (Vs):

Vs = 0.5 {(h2 - D).(Lz.Lx - Pz.Px)} + 0.5 {(h1 + h2 - D).(Lz.Lx - Pz.Px)}

= 0.5 {(2 - 0.5).(2.5 x 3 - 0.4 x 0.6)} + 0.5 {(0 + 2 - 0.5).(2.5 x 3 - 0.4 x 0.6)} = 10.89 cum

Wt. of soil, Sw = Υs x Vs = 18 x 10.89 = 196.02 kN

Self-wt. of ftg., Fw = 25 Lx.Lz.D = 25 x 3 x 2.5 x 0.5 = 93.75 kN

Self-wt. of pedestal, Pw = 25 Px.Pz (h3 + h2 - D) = 25 x 0.6 x 0.4 x (0.3 + 2 - 0.5) = 10.80 kN

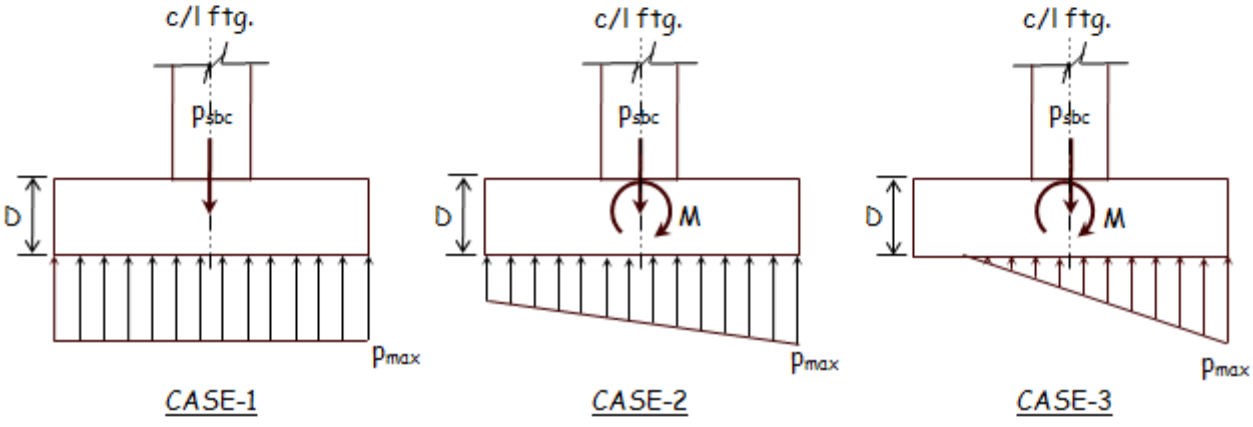
Self-wt. of blockwall, Ww = Wd.Wl.Wh.Wt = 0 x 0 x 0 x 0 = 0 kN

Self-wt. of tie-beam/wall, Wb = 25 Wl.Tb.TD = 25 x 0 x 0 x 0 = 0 kN

Wt. on soil, Psbc = Fy + Sw + Fw + Pw + Ww + Wb - Fb = 476.55 kN

BM @ u/s of ftg. || to GX (Mz,tot) = Mz + Fx (h2 + h3) = 70.89 kNm

BM @ u/s of ftg. || to GZ (Mx,tot) = Mx + Fz (h2 + h3) = 16.08 kNm



(b) Eccentricity:

ex = Mz,tot/ Psbc = 70.89/ 476.55 = 0.149 m < Lx/ 6 [No loss of contact]

ez = Mx,tot/ Psbc = 16.08/ 476.55 = 0.034 m < Lz/ 6 [No loss of contact]

(c) Base pressure (Permissible LOC = 40%):

Ct = {6 (ex/ Lx) + 6 (ez/ Lz)} = {6 x (0.149/ 3) + 6 x (0.034/ 2.5)} = (0.298 + 0.082) = 0.384 < 1

=> pmax = Psbc (1 + Ct)/ (Lz.Lx) = 87.94 kPa

= 476.55(1 + 0.384)/ (2.5 x 3) = 87.94 kPa

Design max. net press., pmax1 = pmax - Υs.h2

=> pmax1 = 87.94 - 18 x 2 = 51.94 kPa < = SBC (= 250), OK

Max. unf. net press. intensity (pmax,npi):

pmax,npi = pmax1 - Fw/ (Lz.Lx)

= 51.94 - 93.75/ (2.5 x 3) = 39.44 kPa

Max. fact. net press. intensity, fpu = 1.5 x pmax,npi = 1.5 x 39.44 = 59.16 kPa

[C] PUNCHING SHEAR [T12-B1 (@ GX); T12-B2 (@ GZ)]:

dx = D - cc - Øx/ 2 = 0.44 m; dz = D - cc - Øx - Øz/ 2 = 0.43 m

davg = (dx + dz)/ 2 = 0.44 m

ßc = 0.4/ 0.6 = 0.67 => ks = Min {(0.5 + 0.67), 1} = 1

Tauc = 0.25 x fck^0.5 = 1.25 MPa => ks.Tauc = 1 x 1.25 = 1.25 MPa

Pxo = Px + davg = 0.6 + 0.44 = 1.04 m

Pzo = Pz + davg = 0.4 + 0.44 = 0.84 m

Case: Pxo < Lx; Pzo < Lz

Area, Ax = {(Lz + Pzo)/ 2}.{(Lx - Pxo)/ 2}

= {(2.5 + 0.84)/ 2}.{(3 - 1.04)/ 2} = 1.64 sqm

Fact. shear stress, Tau,vx = Ax.fpu/ (Pzo.d)

= (1.64 x 59.16)/ (0.84 x 0.44 x 1000) = 0.26 MPa

Area, Az = {(Lx + Pxo)/ 2}.{(Lz - Pzo)/ 2}

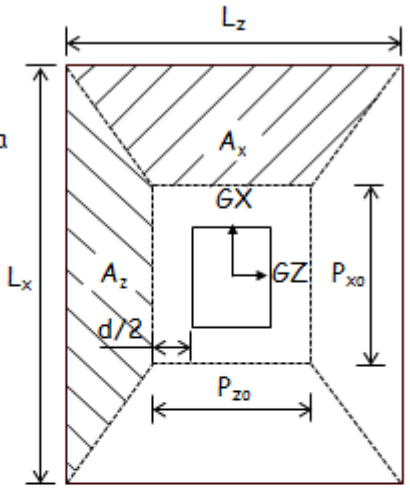
= {(3 + 1.04)/ 2}.{(2.5 - 0.84)/ 2} = 1.68 sqm

Fact. shear stress, Tau,vz = Az.fpu/ (Pxo.d)

= (1.68 x 59.16)/ (1.04 x 0.44 x 1000) = 0.22 MPa

Fact. shear stress, Tau,v = Max {(Tau,vx), (Tau,vz)}

=> Tau,v = Max (0.26, 0.22) = 0.26 MPa < = ks.Tauc (= 1.25), OK



PUNCHING SHEAR

[D] FLEXURE:

(a) Bending @ GZ-axis:

Bending length, Lben = (Lx - Px)/ 2 = (3 - 0.6)/ 2 = 1.2 m

(i) Sagging moment (T12@200 c/c):

Msag = fpu x Lben²/2

= 59.16 x 1.2²/ 2 = 42.59 kNm/ m

As = 113.1 mm² => Pt = 0.15%

Moment of resistance (MRsag):

MRsag = 0.87fy {As/ (s.d)}.[1 - 1.005 {(As/ (s.d)).(fy/ fcu)}].(b.d²)

= [0.87 x 500 x {113.1/ (200 x 440)}] x

[1 - 1.005 x {(113.1/ (200 x 440)) x (500/ 25)}] x (1000 x 440²)

= 106.42 kNm/ m > = Msag (= 42.59), OK

(ii) Hogging moment:

Ct = 0.384 < 1; pmax1 = 51.94 kN/ sqm > = 0

Hence ftg is not subjected to hogging moment

=> Mhog = 0 kN/ m

Since, D = 0.5 m > 0.3 m, provide min top steel @ 1/2 x 0.12% = 0.06%

Provide T12@250 c/c => As = 113.1 mm² => Pt = 0.1%

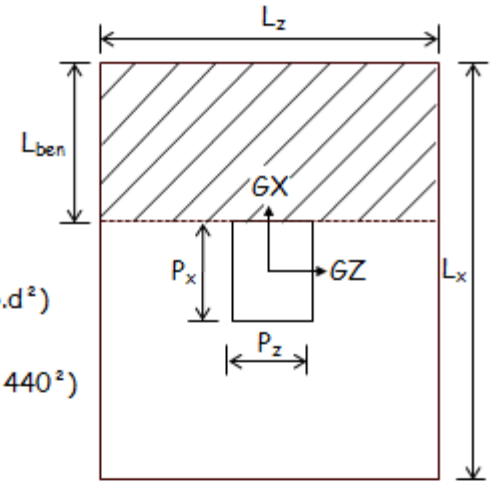
Moment of resistance (MRhog):

MRhog = 0.87fy {As/ (s.d)}.[1 - 1.005 {(As/ (s.d)).(fy/ fcu)}].(b.d²)

= [0.87 x 500 x {113.1/ (250 x 440)}] x

[1 - 1.005 x {(113.1/ (250 x 440)) x (500/ 25)}] x (1000 x 440²)

= 84.8 kNm/ m > = Mhog (= 0), OK



BM @ GZ-AXIS

(b) Bending @ GX-axis:

Bending length, Lben = (Lz - Pz)/ 2 = (2.5 - 0.4)/ 2 = 1.05 m

(i) Sagging moment (T12@200 c/c):

Msag = fpu x Lben²/2

= 59.16 x 1.05²/ 2 = 32.61 kNm/ m

As = 113.1 mm² => Pt = 0.15%

Moment of resistance (MRsag):

MRsag = 0.87fy {As/ (s.d)}.[1 - 1.005 {(As/ (b.d)).(fy/ fcu)}].(b.d²)

= [0.87 x 500 x {113.1/ (200 x 430)}] x

[1 - 1.005 x {(113.1/ (200 x 430)) x (500/ 25)}] x (1000 x 430²)

= 103.47 kNm/ m > = Msag (= 32.61), OK

(ii) Hogging moment:

Ct = 0.384 < 1; pmax1 = 51.94 kN/ sqm > = 0

Hence ftg is not subjected to hogging moment

=> Mhog = 0 kN/ m

Since, D = 0.5 m > 0.3 m, provide min top steel @ 1/2 x 0.12% = 0.06%

Provide T12@250 c/c => As = 113.1 mm² => Pt = 0.1%

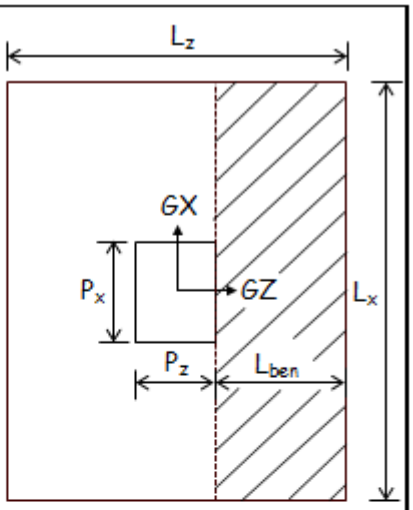
Moment of resistance (MRhog):

MRhog = 0.87fy {As/ (s.d)}.[1 - 1.005 {(As/ (b.d)).(fy/ fcu)}].(b.d²)

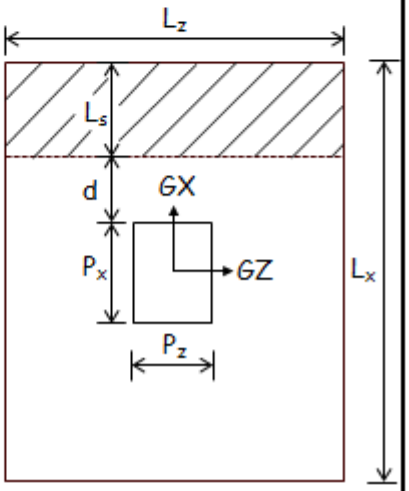
= [0.87 x 500 x {113.1/ (250 x 430)}] x

[1 - 1.005 x {(113.1/ (250 x 430)) x (500/ 25)}] x (1000 x 430²)

= 82.83 kNm/ m > = Mhog (= 0), OK



BM @ GX-AXIS



SHEAR IN GX-DIRN

[E] ONE-WAY SHEAR:

Crit. sec. is at 'd' dist. from ped. face [Cl. 34.2.4 of IS 456:2000]

(a) Shear in GX-direction (T12@200 c/c):

Length, Ls = Lx/ 2 - Px/ 2 - dx = 3/ 2 - 0.6/ 2 - 0.44 = 0.756 m

Shear force @ crit. section (Design max. net press. > 0):

V = fpu x Ls x Lz = 59.16 x 0.756 x 2.5 = 111.81 kN

=> vu = V/ (Lz.dx) = 111.81 x 1000/ (2500 x 440) = 0.1 MPa

pt = 0.15% & Fcu = 25 MPa => Tauc = 0.29 MPa

k = 1 => k.Tauc = 1 x 0.29 = 0.29 MPa [Cl. 40.2.1.1 of IS 456:2000]

vu < = k.Tauc (= 0.29), OK [Cl. 34.2.4 of IS 456:2000]

(b) Shear in GZ-direction (T12@200 c/c):

Length, Ls = Lz/ 2 - Pz/ 2 - dz = 2.5/ 2 - 0.4/ 2 - 0.43 = 0.618 m

Shear force @ crit. section (Design max. net press. > 0):

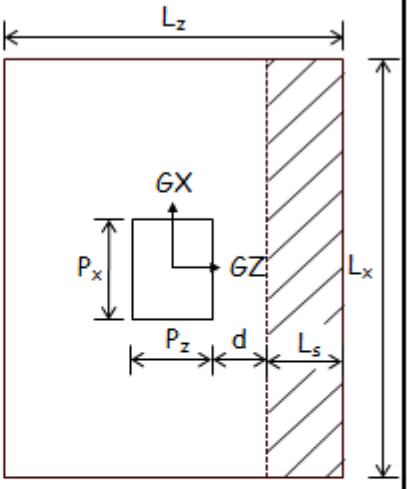
V = fpu x Ls x Lx = 59.16 x 0.618 x 3 = 109.68 kN

=> vu = V/ (Lx.dz) = 109.68 x 1000/ (3000 x 430) = 0.08 MPa

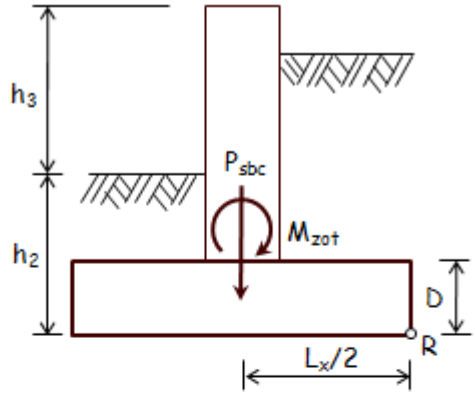
pt = 0.15% & Fcu = 25 MPa => Tauc = 0.29 MPa

k = 1 => k.Tauc = 1 x 0.29 = 0.29 MPa [Cl. 40.2.1.1 of IS 456:2000]

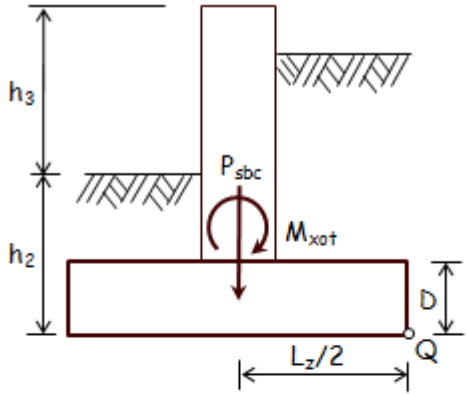
vu < = k.Tauc (= 0.29), OK [Cl. 34.2.4 of IS 456:2000]



SHEAR IN GZ-DIRN



OVERTURNING @ GZ-AXIS



OVERTURNING @ GX-AXIS

[F] CHECK FOR OVERTURNING [MRF = 1]:

(a) Overturning @ Z-axis [Point R is the instantaneous center of rotation]:

Overturning moment, OMz = {Mz + Fx (h2 + h3)} + Fyt. Lx/2

= {0 + 32.9 x (2 + 0.3)} + (96.8 x 3/ 2) = 75.67001 + 145.2 = 220.87 kN.m

Fres = k3.Sw + Fw + Pw + Ww + Wb - Fb

= 1 x 196.02 + 93.75 + 10.8 + 0 + 0 - 75 = 225.57 kN

Restoring moment, RMz = MRF x Fres x Lx/2 = 1 x 225.57 x 3 / 2 = 338.36 kN.m

FOS,oz = RMz/ OMz = 338.36/ 220.88 = 1.53 > = 1.5 (OK)

(b) Overturning @ X-axis [Point Q is the instantaneous center of rotation]:

Overturning moment, OMx = {Mx + Fz (h2 + h3)} + Fyt. Lz/2

= {0 + 4.8 x (2 + 0.3)} + (96.8 x 2.5/ 2) = 11.04 + 121 = 132.04 kN.m

Fres = k3.Sw + Fw + Pw + Ww + Wb - Fb

= 1 x 196.02 + 93.75 + 10.8 + 0 + 0 - 75 = 225.57 kN

Restoring moment, RMx = MRF x Fres x Lz/2 = 1 x 225.57 x 2.5 / 2 = 281.96 kN.m

FOS,ox = RMx/ OMx = 281.96/ 132.06 = 2.14 > = 1.5 (OK)

[G] CHECK FOR UPLIFT

Buoyancy force, Fb = 75.00 kN [Ref. base press. cals. on sheet-2]

Restoring Force, Fu = k1.Sw + Fw + Pw + Ww + Wb

= 0.8 x 196.02 + 93.75 + 10.8 + 0 + 0 = 261.37 kN

FOS,upl = Fu/ (Fb + Fyt) = 261.37/ (75 + 107.4)

=> FOS,upl = 261.37/ 182.4 = 1.43 > = 1.1 (OK)

[H] CHECK FOR SLIDING

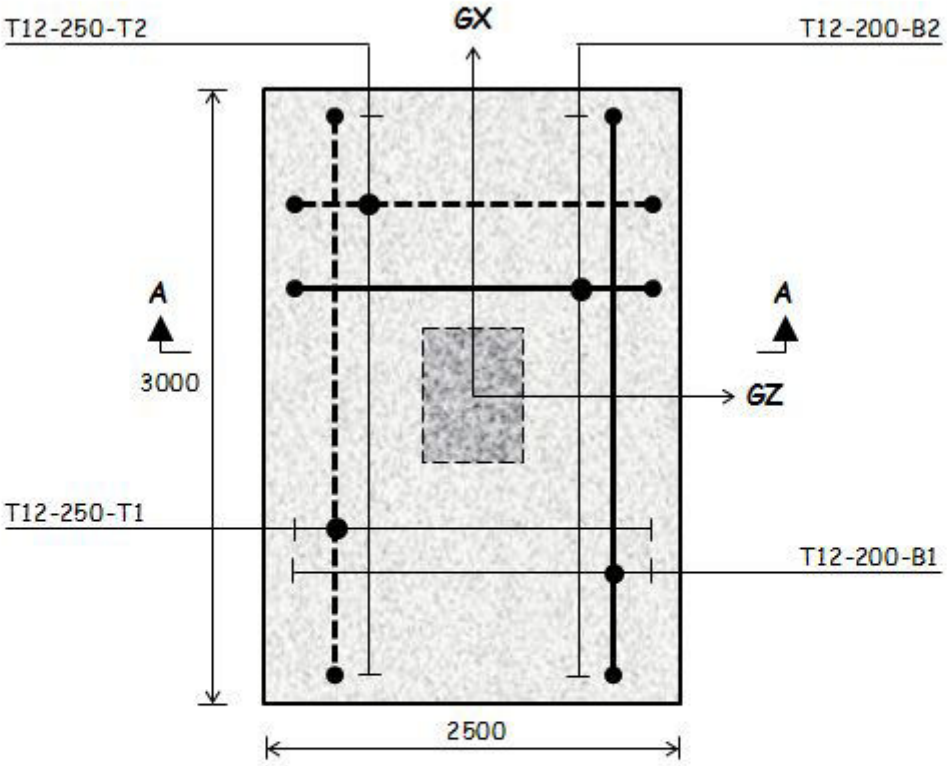
Fx = 22.83 kN; Fz = 24.83 kN => Resultant, R = (Fx² + Fz²) ^ 0.5 = 33.73 kN

Normal reaction, N = Fy + k2.Sw + Fw + Pw + Ww + Wb - Fb

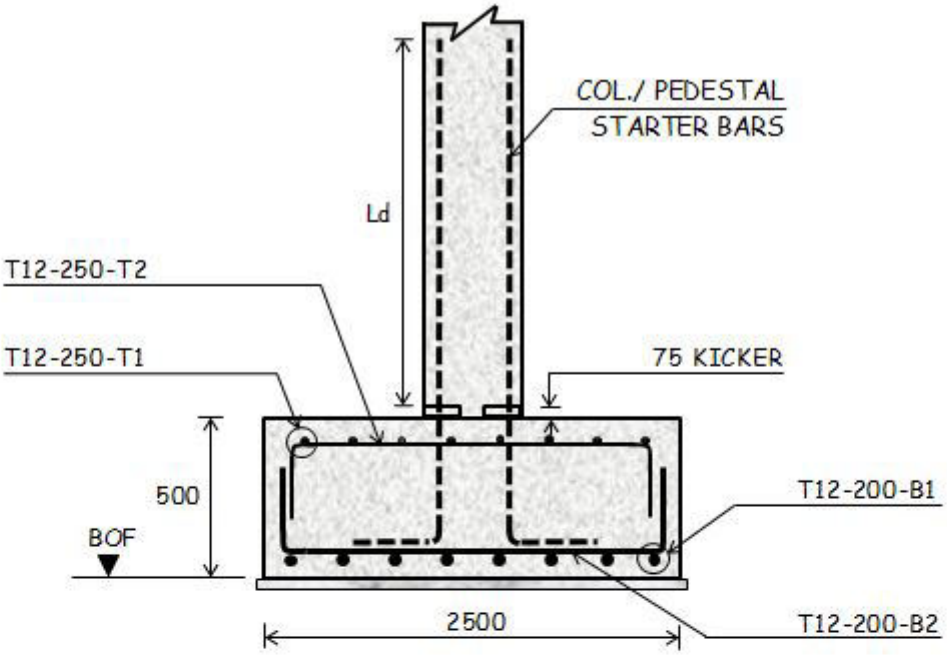
= -98 + 1 x 196.02 + 93.75 + 10.8 + 0 + 0 - 75 = 127.6 kN

Friction, F = 0.4 x 127.6 = 51.04 kN

FOS,sli = F/ R = 51.04/ 33.73 = 1.51 > = 1.5 (OK)



FOOTING PLAN
SCALE: NTS



SECTION A-A
SCALE: NTS

NOTES:

1. ALL DIMENSIONS ARE IN MM
2. FTG. AXES CORRESPOND TO STRUCTURE GLOBAL AXES

epicenter Consulting Engineers Pvt. Ltd.		**Client: -**					Element: Edge Footing
		Project:	1016	Doc. No.:	1016-CV-CAL-001		Location/ Grids: A3
		Rev.	Ppd. by	Date	Chd. by	Date	
Project:	-	2					Designation: F2
Structure:	Pipe Rack	1					
Type:	Sub Structure	0	SNR	12/02/20	SHH	12/02/20	Sht. 6 of 6

Node No.	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kN.m)	My (kN.m)	Mz (kN.m)
3	101	7.196	203.316	-3.065	0	0	0
	106	22.834	-97.966	-24.829	0	0	0
	118	7.014	110.660	8.977	0	0	0
	119	-6.533	83.850	-5.026	0	0	0
	120	6.868	132.992	7.052	0	0	0
	121	39.181	93.607	-6.565	0	0	0
	122	6.629	96.446	-0.676	0	0	0
	136	7.270	-42.928	-1.802	0	0	0
	137	6.645	33.176	-1.992	0	0	0
	138	5.807	16.362	0.466	0	0	0
	141	6.518	-80.122	-6.201	0	0	0
	914	-12.020	-63.607	-1.300	0	0	0
	915	20.402	-98.147	-5.592	0	0	0
	916	11.416	-86.739	-6.419	0	0	0
	917	11.925	233.369	6.902	0	0	0
	918	12.084	244.992	8.954	0	0	0
4	101	-7.196	164.574	3.065	0	0	0
	106	-8.556	278.479	3.849	0	0	0
	118	-7.014	110.660	-8.977	0	0	0
	119	6.533	78.039	5.026	0	0	0
	120	-6.868	111.297	-7.052	0	0	0
	121	-39.181	110.266	6.565	0	0	0
	122	-6.629	94.122	0.676	0	0	0
	136	-7.270	38.666	1.802	0	0	0
	137	-6.645	35.501	1.992	0	0	0
	138	-5.807	18.686	-0.466	0	0	0
	141	-6.518	82.447	6.201	0	0	0
	914	12.020	218.153	1.300	0	0	0
	915	-30.816	250.983	6.990	0	0	0
	916	-11.416	271.710	6.419	0	0	0
	917	-11.925	-77.066	-6.902	0	0	0
	918	-12.084	-73.071	-8.954	0	0	0
10	101	6.215	194.708	-2.647	0	0	0
	106	10.082	266.772	-4.155	0	0	0
	118	6.058	102.052	7.753	0	0	0
	119	-5.642	75.242	-4.341	0	0	0
	120	5.931	124.384	6.091	0	0	0
	121	33.838	84.998	-5.670	0	0	0
	122	5.725	87.838	-0.584	0	0	0
	136	6.279	-51.536	-1.556	0	0	0
	137	32.934	-96.756	-4.829	0	0	0
	138	5.015	7.753	0.403	0	0	0
	141	5.629	-88.731	-5.355	0	0	0
	914	-11.106	-72.216	-1.122	0	0	0
	915	5.739	24.568	-1.720	0	0	0
	916	10.584	-95.348	-5.543	0	0	0
	917	11.023	224.761	5.961	0	0	0
	918	11.161	236.384	7.733	0	0	0
11	101	-6.869	172.927	2.926	0	0	0
	106	-7.684	286.832	3.674	0	0	0
	118	-6.696	119.013	-8.569	0	0	0
	119	6.236	86.392	4.798	0	0	0
	120	-6.556	119.650	-6.732	0	0	0
	121	-11.624	-107.455	-6.589	0	0	0
	122	-6.328	102.475	0.645	0	0	0

Next

136	-6.940	47.019	1.720	0	0	0
137	-6.343	43.854	1.901	0	0	0
138	-6.928	27.039	-0.556	0	0	0
141	-6.222	90.800	5.919	0	0	0
914	11.715	226.505	1.241	0	0	0
915	-24.789	259.335	5.338	0	0	0
916	-11.139	280.062	6.127	0	0	0
917	-37.400	118.619	6.266	0	0	0
918	-11.776	-103.461	-8.547	0	0	0

Previous Default Clear Next

LC	SBC increase (%)	Uplift (FOS)	Sliding (FOS)	Overturning	
				FOS	Restoring moment considered (%)
101	0	1.1	1.5	1.5	100
106	0	1.1	1.5	1.5	100
118	0	1.1	1.5	1.5	100
119	0	1.1	1.5	1.5	100
120	33	1.1	1.5	1.5	80
121	0	1.1	1.5	1.5	100
122	0	1.1	1.5	1.5	100
136	0	1.1	1.5	1.5	100
137	0	1.1	1.5	1.5	100
138	0	1.1	1.5	1.5	100
141	0	1.1	1.5	1.5	100
914	0	1.1	1.5	1.5	100
915	0	1.1	1.5	1.5	100
916	0	1.1	1.5	1.5	100
917	0	1.1	1.5	1.5	100
918	0	1.1	1.5	1.5	100

Exit

DESIGN OPTIONS

IS456:2000

REACTION FORCES APPLIED AT

- (•) Pedestal level
- ( ) Footing level

STRESS INCREASE

- [x] Allow SBC increase as per 'Stress Increase' sheet?

DESIGN FOR

- [x] Fx
- [x] Fy
- [x] Fz
- [x] Mx
- [x] My
- [x] Mz

LOSS OF CONTACT

- ( ) No limitation
- (•) Set max value

Max % value (Teng chart): 40

STABILITY CHECKS

Uplift	(•) Yes	( ) No
Sliding	(•) Yes	( ) No
Overturning	(•) Yes	( ) No

BACKFILL ASSUMED

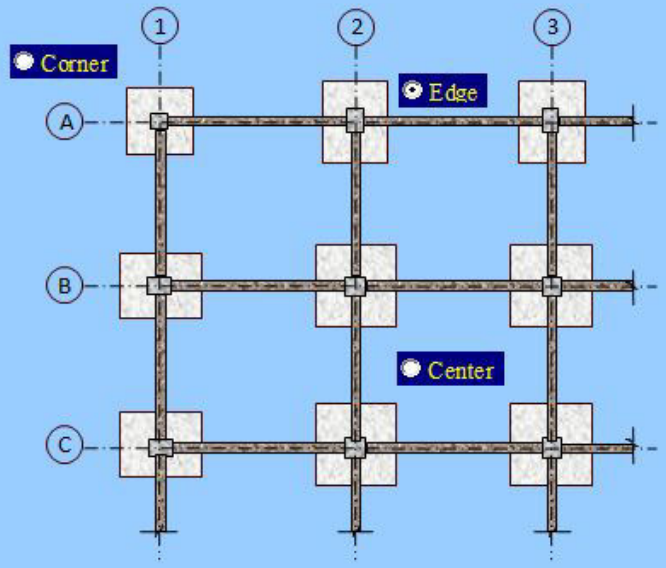
Uplift check (%)	80
Sliding check (%)	100
Overturning check (%)	100

RESET VALUES

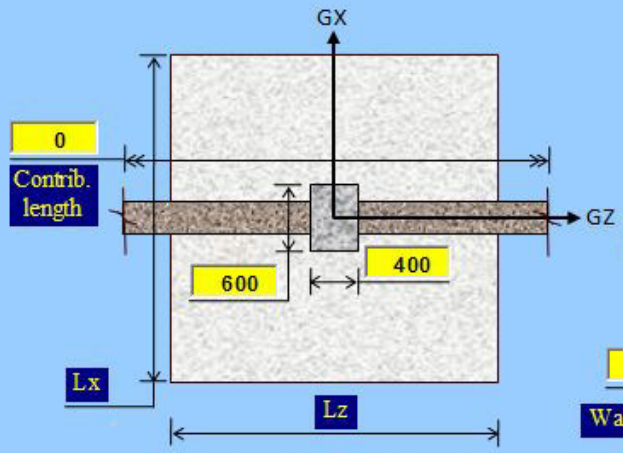
Previous | Default | Clear | Next

Exit

DIMENSIONS

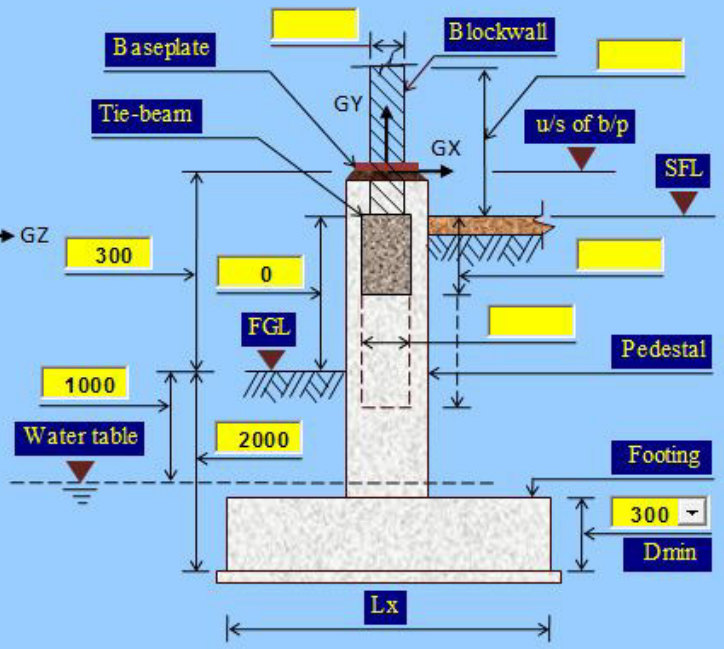


KEY PLAN
(SHOWING FTG. POSITION)



Min plan dim. L(mm)	1000
Max. aspect ratio	2.0
Dmin = Lmax/X; X=	6.0
Dmax = Lmin/Y ; Y=	2.0

FOOTING PLAN
(FTG. AXES CORRESPOND TO STRUCTURE AXES; DIMS. IN MM)



FOOTING C/S
(DIMENSIONS IN MM)

RESET VALUES

Default Clear

Previous

Next

Exit

MATERIALS

CONCRETE

Grade (MPa)	25
Clear cover (mm)	50
Friction coeff. (u/s ftg.)	0.4

UNIT RATES

Concrete (Rs/cu.m)	4200
Re-bar (Rs/kg)	55
Formwork (Rs/sq.ft)	100

REINFORCEMENT

Grade (MPa)	500
Min. bar dia. (mm)	12
Max. bar dia. (mm)	32
Min. bar spg. (mm)	150
Max. bar spg. (mm)	250
Spg. round-off (mm)	25

SOIL

Net SBC (kN/sq.m)	250
Soil density (kN/m3)	18
Repose Angle (deg)	30

BLOCKWALL

Wall density (kN/m3)	

SELECT FOOTING

Calculate for option: Eco

RESET VALUES

Previous | Default | Clear | Finish