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CERTIFICATE FOR STRUCTURAL DESIGN SUFFICIENCY AND SAFE & SOUND

With respect to the proposed construction of

Residential Building - Madurai Local Planning Area - Madurai District- Madurai West Taluk - Madurai Corporation – S.Ward No.23 -Block-28-T.S Nos.5,7/5,7/6,7/7,7/8,13/2,13/3-(At ponmeni village old S.No.147/1,2,3,4, 7,8A,8B,9,10)-Site Area of 4876.39 sq.m - proposal of Residential Building (Stilt + 5 floors) for FSI area of 8922.36 sq.m (69 Dwelling units)

we certify that the designs are being done after detailed soil investigation and the design is being done to meet all the structural stability requirements as stipulated in IS456,IS 875 and other relevant codes, and it is structurally safe & sound.

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STRUCTURAL DESIGN STABILITY CERTIFICATE

This is to certify that the PROPOSED NEW CONSTRUCTION OF RESIDENTIAL FLATS IN Old S.NO : 147/1,2,3,4,7,8A,8B,9,10 at PONMENI VILLAGE, MADURAI WEST TALUK, MADURAI (DT). S.WARD NO-23, BLOCK–28, T.S.NO:5,7/5,7/6,7/7,7/8,13/2,13/3, MADURAI CORPORATION.
(MADURAI CORPORATION WARD – 69)

1. IS: 456-2000, code of practice for plain and reinforced concrete, with M25 concrete grade tor RC.C. components.
2. IS: 875-1987, code of practice for design loads for building and structures.
3. IS: 1893-2002, criteria for earthquake resistant design of structures.

The building Designed by me consists of Stilt + FIVE floors + Stair Case Head Room, Lift Machine Room and Water Tank, The R.C.C. building frame of the structure is designed as per the Indian Standard code of practice for concrete and loadings. The loading stress parameters are within limits of practice of National Building Code and other Bureau of Indian standards code.

The Structure will be Constructed as per our structural Design and detailing of reinforcements given in our drawing from foundation to roof slab. Regular Site Inspection will be done to ensure Quality of Work and Materials used.

As per calculations & Detailing the above said building is structurally safe.

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STRUCTURAL DESIGN CALCULATIONS

(LOAD CALCULATIONS)

STRUCTURE:

The proposed Building has been envisaged as R.C Framed Structure with Stilt + Five Upper floors. The Stilt Floor is intended for Car Parking Utility. The upper Floors from 1st to 5th are intended for Residential Utility.

ANALYSIS & DESIGN:

The Structure has been idealized as 3D Frame, with R.C Slab & Beam. All Beams are interconnecting with Columns. The design of all R.C components is done using Limit State Method.

The following codes of the Indian Standards are adopted in the Structural Design:

IS: 456-2000	Plain and Reinforced Concrete-code of Practice (Fourth Revision)
IS: 875-1987	Code of Practice for Design loads (other than Earthquake) for Buildings and Structures.
	Part (1) - Dead Loads-Unit Weights of Building Materials and Stored Materials (second revision)
	Part (2) - Impact Loads (second revision)
	Part (3) - Wind Loads (second revision)
	Part (4) - Snow Loads (second revision)
	Part (5) - Special Loads and Load Combinations.
IS: 1893-2002	Criteria for Earthquake Resistant Design of Structures (Fifth Revision).

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IS: 13920-1993		Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces-Code of Practice.
SP7:1983		National Building Code of India 1983.
SP: 34(S&T)-1987	-	Hand Book on Concrete Reinforcement and Detailing.
SP: 23(S&T)-1982	-	Hand Book on Concrete Mixes.
SP: 16(S&T)-1980	-	Design Aids for Reinforced Concrete to IS: 456-1978.

The concrete grade assumed for all R.C Column is M 25 and others M 25. The Steel grade considered in the design is Fe 500.

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	SHRI BALAJI CONSULTANCY
	- DESIGN OF ISOLATED FOOTING F1

1 MATERIAL PROPERTIES

Unit weight of reinforced concrete	γc	=	25.000 kN/m3
Environmental exposure condition (Table 3 of IS 456)		=	Moderate
Grade of concrete (Table 5 of IS 456)		=	M25
Grade of steel		=	Fe500
Characteristic strength of concrete (Table 2 of IS 456)	fck	=	25.000 N/mm2
Characteristic strength of reinf. steel = Yield stress of reinf. steel (cl. 36.1 of IS 456)	fy	=	500.000 N/mm2

2 DIMENSIONS

Footing plan dimension along X axis	L	=	2.438 m
Footing plan dimension along Z axis	W	=	2.438 m
Thickness of footing	t	=	0.610 m
Column plan dimension along X axis	a	=	0.230 m
Column plan dimension along Z axis	b	=	0.300 m
Depth of footing below NGL	D	=	2.100 m
Eccentricity of the column along X axis	ex	=	0.000 m
Eccentricity of the column along Z axis	ez	=	0.000 m

3 SOIL PROPERTIES

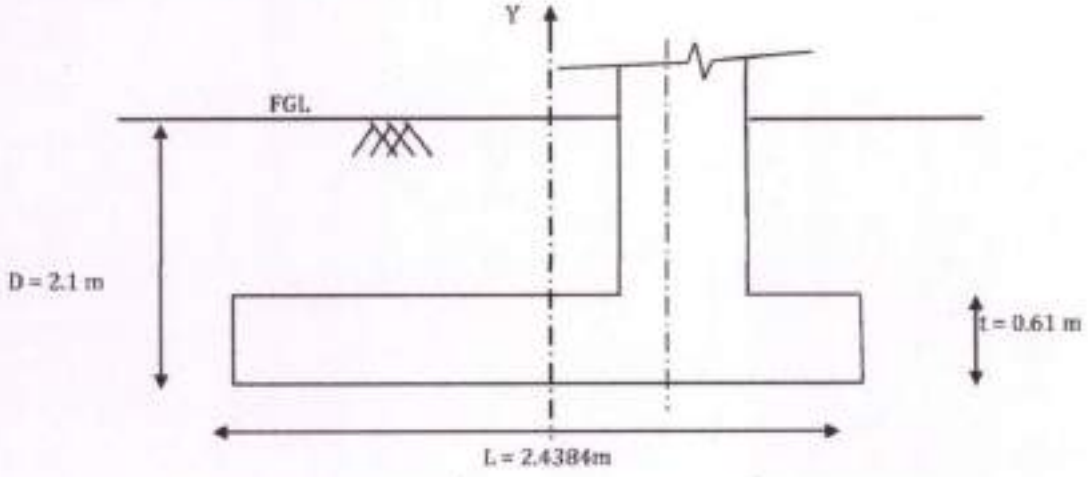
Density of soil	γsoil	=	18.000 kN/m3
Net bearing capacity of soil (from soil report)		=	111.200 kN/m2
Allowable gross SBC		=	111.2 + 18*2.1
		=	149.000 kN/m2
Coefficient of soil friction, μ		=	0.400
Depth of water table from NGL in m		=	NA
Uplift force due to water table		=	0.000 kN

4 DESIGN PARAMETERS

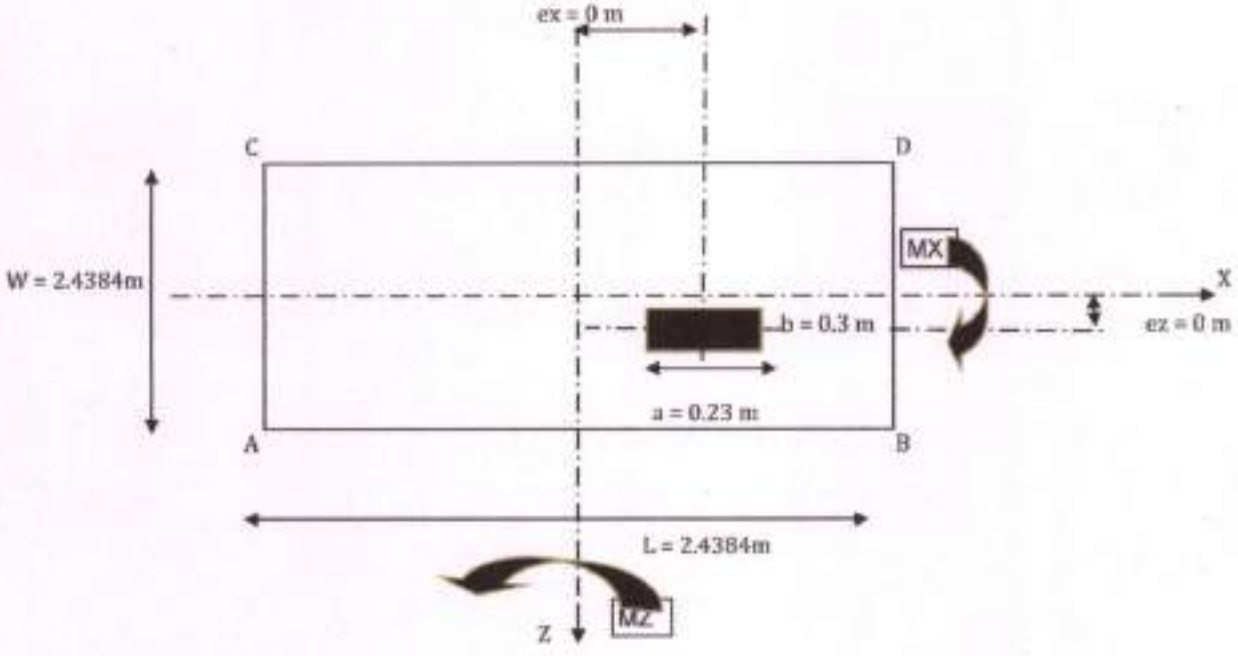
Factor of safety against overturning (Cl. 8.1 of IS:875 (Part 5)	=	1.400
Factor of safety against uplift	=	1.200
Factor of safety against sliding (with 0.9 DL) (Cl. 8.1 of IS:875 (Part 5)	=	1.400
% increase in SBC for load combinations with seismic loads Table 1 of IS:1893 (part1):2002	=	25.000 %
% increase in SBC for load combinations with wind loads Cl.8.1 of IS: 875 (part 5) - 1987	=	25.000 %

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5 ***GEOMETRICAL SKETCH***



Section



Plan

Note :

The above sketch is not to scale. The dimensions are shown only for illustrative purpose.

The sign conventions followed are same as that of STAAD.

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6 *LOADS AT TOP OF FOOTING*

The signs of the STAAD reactions are reversed to transfer it as loads in the appropriate directions.

Horizontal load in X direction at top of footing	=	Fxt
Vertical load in Y direction at top of footing	=	Fyt
Horizontal load in Z direction at top of footing	=	Fzt
Moment about X axis at top of footing	=	Mxt
Moment about Z axis at top of footing	=	Mzt

Table 1 : Loads at top of footing (from the reactions from STAAD)

Load cases	Fxt (kN)	Fyt (kN)	Fzt (kN)	Mxt (kNm)	Mzt (kNm)
DEAD LOAD (DL)	-0.229	-548.193	0.119	0.000	0.000
LIVE LOAD (LL)	0.151	-88.208	0.016	0.000	0.000
WIND LOAD IN +X -CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN +X +CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN -X +CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN -X -CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN +Z +CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN +Z -CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN -Z +CPI	0.000	0.000	0.000	0.000	0.000
WIND LOAD IN -Z -CPI	0.000	0.000	0.000	0.000	0.000
SEISMIC LOAD IN +X direction	0.000	0.000	0.000	0.000	0.000
SEISMIC LOAD IN -X direction	0.000	0.000	0.000	0.000	0.000
SEISMIC LOAD IN +Z direction	0.000	0.000	0.000	0.000	0.000
SEISMIC LOAD IN -Z direction	0.000	0.000	0.000	0.000	0.000
LIVE LOAD ON ROOF (LLR)	0.002	-13.348	0.000	0.000	0.000

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Table 2 : Load combinations (Unfactored - Serviceability load combinations) - as per table 18 of IS 456 : 2000 - Loads at top of footing

Load combinations	Fxt (kN)	Fyt (kN)	Fzt (kN)	Mxt (kNm)	Mzt (kNm)
1.0 DL + a*1.0 LL+a*1.0 LLR	-0.137	-609.127	0.129	0.000	0.000
1.0 DL + 1.0 WL +X +CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL +X -CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL -X +CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL -X -CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL +Z +CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL +Z -CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL -Z +CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 WL -Z -CPI	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z+CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z-CPI	-0.156	-596.940	0.127	0.000	0.000
1.0 DL + 1.0 EL +X	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 EL -X	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 EL +Z	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + 1.0 EL -Z	-0.229	-548.193	0.119	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	-0.199	-565.835	0.122	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	-0.199	-565.835	0.122	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	-0.199	-565.835	0.122	0.000	0.000
1.0 DL +b* 0.8 LL + 0.8 EL -Z	-0.199	-565.835	0.122	0.000	0.000

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Table 3 : Load combinations (Factored - Strength load combinations) - as per table 18 of IS 456 : 2000 - Loads at top of footing

Load combinations	Fxt (kN)	Fyt (kN)	Fzt (kN)	Mxt (kNm)	Mzt (kNm)
1.5 DL + C*1.5 LL + C*1.5 LLR	-0.206	-913.690	0.193	0.000	0.000
1.5 DL + 1.5 WL +X +CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL +X -CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL -X +CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL -X -CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL +Z +CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL +Z -CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL -Z +CPI	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 WL -Z -CPI	-0.344	-822.290	0.179	0.000	0.000
0.9 DL + 1.5 WL +X +CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL +X -CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL -X +CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL -X -CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL +Z +CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL +Z -CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL -Z +CPI	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 WL -Z -CPI	-0.206	-493.374	0.107	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	-0.165	-730.952	0.154	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	-0.165	-730.952	0.154	0.000	0.000
1.5 DL + 1.5 EL +X	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 EL -X	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 EL +Z	-0.344	-822.290	0.179	0.000	0.000
1.5 DL + 1.5 EL -Z	-0.344	-822.290	0.179	0.000	0.000
0.9 DL + 1.5 EL +X	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 EL -X	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 EL +Z	-0.206	-493.374	0.107	0.000	0.000
0.9 DL + 1.5 EL -Z	-0.206	-493.374	0.107	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +X	-0.230	-684.294	0.148	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -X	-0.230	-684.294	0.148	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +Z	-0.230	-684.294	0.148	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -Z	-0.230	-684.294	0.148	0.000	0.000

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7 *LOADS AT BOTTOM OF FOOTING (Load combinations for serviceability check)*

Self weight of footing	SW =	25 * 2.4384 * 2.4384 * 0.61
	=	-90.673 kN
Weight of soil above footing	WS =	18 * (2.4384*2.4384 - 0.23*0.3) *
	=	-157.616 kN
Uplift force due to water table	Fu =	0.000 kN
Horizontal load in X direction at bottom of footing	Fx =	Fxt
Vertical load in Y direction at bottom of footing	P =	Fyt + SW + WS - Fu
Horizontal load in Z direction at bottom of footing	Fz =	Fzt
Moment about X axis at bottom of footing	Mx =	Mxt + Fzt * t + Fy*ez
Moment about Z axis at bottom of footing	Mz =	Mzt - Fxt * t + Fy*ex

Table 4 : Loads at bottom of footing (Unfactored load combinations for pressure & overturning check)

Load Combinations	Fx (kN)	P (kN)	Fz (kN)	Mx (kNm)	Mz (kNm)
1.0 DL + a*1.0 LL+a*1.0 LLR	-0.137	-857.416	0.129	-0.078	-0.084
1.0 DL + 1.0 WL +X +CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL +X -CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL -X +CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL -X -CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL +Z +CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL +Z -CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL -Z +CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 WL -Z -CPI	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z+CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z-CPI	-0.156	-845.229	0.127	-0.077	-0.095
1.0 DL + 1.0 EL +X	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 EL -X	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 EL +Z	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + 1.0 EL -Z	-0.229	-796.482	0.119	-0.073	-0.140
1.0 DL + b*0.8 LL + 0.8 EL +X	-0.199	-814.124	0.122	-0.075	-0.121
1.0 DL + b*0.8 LL + 0.8 EL -X	-0.199	-814.124	0.122	-0.010	-0.121
1.0 DL + b*0.8 LL + 0.8 EL +Z	-0.199	-814.124	0.122	-0.075	-0.121
1.0 DL +b* 0.8 LL + 0.8 EL -Z	-0.199	-814.124	0.122	-0.075	-0.121

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Table 5 : Loads at bottom of footing (Unfactored load combinations) - for sliding check

Load Combinations	Fx s (kN)	P s (kN)	Fz s (kN)	Mx s (kNm)	Mz s (kNm)
0.9 DL + a*1.0 LL +a*1.0 LLR	-0.114	-805.042	0.117	-0.071	-0.070
0.9 DL + 1.0 WL +X +CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL +X -CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL -X +CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL -X -CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL +Z +CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL +Z -CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL -Z +CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 WL -Z -CPI	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	-0.133	-765.581	0.115	-0.070	-0.081
0.9 DL + 1.0 EL +X	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 EL -X	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 EL +Z	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + 1.0 EL -Z	-0.206	-716.834	0.107	-0.065	-0.126
0.9 DL + b*0.8 LL + 0.8 EL +X	-0.176	-734.475	0.110	-0.067	-0.107
0.9 DL + b*0.8 LL + 0.8 EL -X	-0.176	-734.475	0.110	-0.009	-0.107
0.9 DL + b*0.8 LL + 0.8 EL +Z	-0.176	-734.475	0.110	-0.067	-0.107
0.9 DL +b* 0.8 LL + 0.8 EL -Z	-0.176	-734.475	0.110	-0.067	-0.107

8 *CHECK FOR PRESSURE*

Base area	A =	2.4384 * 2.4384
	=	5.946 m2
Section modulus (X axis)	Zx =	2.4384 * 2.4384^2 / 6
		2.416 mm3
Section modulus (Z axis)	Zz =	2.4384 * 2.4384^2 / 6
		2.416 mm3
Pressure at corner A	PA =	-P/A + Mx/ Zx + Mz / Zz
Pressure at corner B	PB =	-P/A + Mx/ Zx - Mz / Zz
Pressure at corner C	PC =	-P/A - Mx/ Zx + Mz / Zz
Pressure at corner D	PD =	-P/A - Mx/ Zx - Mz / Zz

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Table 6 : Pressures at four corners of the footing

Load Combinations	Gross pr. at four corners (kN/m2)			
	PA	PB	PC	PD
1.0 DL + a*1.0 LL+a*1.0 LLR	144.14	144.21	144.20	144.27
1.0 DL + 1.0 WL +X +CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL +X -CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL -X +CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL -X -CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL +Z +CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL +Z -CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL -Z +CPI	133.87	133.98	133.93	134.05
1.0 DL + 1.0 WL -Z -CPI	133.87	133.98	133.93	134.05
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	142.08	142.16	142.15	142.23
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	142.08	142.16	142.15	142.23
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	142.08	142.16	142.15	142.23
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	142.08	142.16	142.15	142.23
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	142.08	142.16	142.15	142.23
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	142.08	142.16	142.15	142.23
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z+CPI	142.08	142.16	142.15	142.23
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z-CPI	142.08	142.16	142.15	142.23
1.0 DL + 1.0 EL +X	133.87	133.98	133.93	134.05
1.0 DL + 1.0 EL -X	133.87	133.98	133.93	134.05
1.0 DL + 1.0 EL +Z	133.87	133.98	133.93	134.05
1.0 DL + 1.0 EL -Z	133.87	133.98	133.93	134.05
1.0 DL + b*0.8 LL + 0.8 EL +X	136.84	136.94	136.90	137.01
1.0 DL + b*0.8 LL + 0.8 EL -X	136.87	136.97	136.88	136.98
1.0 DL + b*0.8 LL + 0.8 EL +Z	136.84	136.94	136.90	137.01
1.0 DL +b* 0.8 LL + 0.8 EL -Z	136.84	136.94	136.90	137.01

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Table 7 : Pmax

Load Combinations	Pmax kN/m2	Net SBC kN/m2	% increase in SBC	Allowable net SBC kN/m2	Overburden pr. kN/m2	Gross SBC kN/m2
1.0 DL + a*1.0 LL+a*1.0 LLR	144.27	111.200	0	111.2	37.8	149
1.0 DL + 1.0 WL +X +CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +X -CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -X +CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -X -CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +Z +CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +Z -CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -Z +CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -Z -CPI	134.05	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z+CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z-CPI	142.23	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL +X	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL -X	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL +Z	134.05	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL -Z	134.05	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL +X	137.01	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL -X	136.98	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL +Z	137.01	111.200	25	139	37.8	176.8
1.0 DL +b* 0.8 LL + 0.8 EL -Z	137.01	111.200	25	139	37.8	176.8

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Table 8 : Pmin

Load Combinations	Pmin kN/m2	Uplift	% loss of contact
1.0 DL + a*1.0 LL+a*1.0 LLR	144.14	No Uplift	0.000
1.0 DL + 1.0 WL +X +CPI	133.87	No Uplift	0.000
1.0 DL + 1.0 WL -X +CPI	133.87	No Uplift	0.000
1.0 DL + 1.0 WL +Z +CPI	133.87	No Uplift	0.000
1.0 DL + 1.0 WL -Z +CPI	133.87	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	142.08	No Uplift	0.000
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	142.08	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	142.08	No Uplift	0.000
1.0 DL + a*0. 8LL+a*0.8 LLR + 0.8 WL -Z+CPI	142.08	No Uplift	0.000
1.0 DL + 1.0 EL +X	133.87	No Uplift	0.000
1.0 DL + 1.0 EL -X	133.87	No Uplift	0.000
1.0 DL + 1.0 EL +Z	133.87	No Uplift	0.000
1.0 DL + 1.0 EL -Z	133.87	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	136.84	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	136.87	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	136.84	No Uplift	0.000
1.0 DL +b* 0.8 LL + 0.8 EL -Z	136.84	No Uplift	0.000

P max Without Wind load	=	**144.27**	kN/m2	
	<	149.00	kN/m2	Hence Safe.
P max With Wind load	=	**142.23**		
	<	186.25	kN/m2	Hence Safe.
% loss of contact	=	**0.0**	%	
	≤	0.0	%	Hence Safe.

The Bearing pressure reached upto 97% of SBC

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9 CHECK FOR OVERTURNING

Table 9 : Factor of safety against overturning

Load Combinations	Moment about X axis (kNm)			Moment about Z axis (kNm)		
	Overturning	Resisting	FOS	Overturning	Resisting	FOS
1.0*1.2 DL + a*1.0*1.4 LL+a*1.0*1.4 LLR	-0.095	-1045.361	Safe	-0.089	-1045.36	Safe
1.0*1.2 DL + 1.0 WL +X +CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL +X -CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL -X +CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL -X -CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL +Z +CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL +Z -CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL -Z +CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 WL -Z -CPI	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + a*0. 8*1.4LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + a*0. 8*1.4LL+a*0.8*1.4 LLR + 0.8 W	-0.094	-1030.503	Safe	-0.105	-1030.5	Safe
1.0*1.2 DL + 1.0 EL +X	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 EL -X	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 EL +Z	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + 1.0 EL -Z	-0.087	-971.0709	Safe	-0.168	-971.071	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	-0.090	-992.5795	Safe	-0.121	-992.579	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	-0.012	-992.5795	Safe	-0.142	-992.579	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	-0.090	-992.5795	Safe	-0.142	-992.579	Safe
1.0*1.2 DL +b* 0.8*1.4 LL + 0.8 EL -Z	-0.104	-992.5795	Safe	-0.142	-992.579	Safe

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10 CHECK FOR SLIDING

Table 10 : Factor of safety against sliding

Load Combinations	Along X axis (kN)			Along Z axis (kN)		
	Sliding force	Resisting force	FOS	Sliding force	Resisting force	FOS
0.9 DL + a*1.0 LL +a*1.0 LLR	-0.114	-322.0167	2817.294	0.117	-322.017	2759.355
0.9 DL + 1.0 WL +X +CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL +X -CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL -X +CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL -X -CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL +Z +CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL +Z -CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL -Z +CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 WL -Z -CPI	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	-0.133	-306.2323	2308.399	0.115	-306.232	2667.993
0.9 DL + 1.0 EL +X	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 EL -X	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 EL +Z	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + 1.0 EL -Z	-0.206	-286.7335	1391.235	0.107	-286.734	2677.250
0.9 DL + b*0.8 LL + 0.8 EL +X	-0.176	-293.7902	1670.211	0.110	-293.79	2663.555
0.9 DL + b*0.8 LL + 0.8 EL -X	-0.176	-293.7902	1670.211	0.110	-293.79	2663.555
0.9 DL + b*0.8 LL + 0.8 EL +Z	-0.176	-293.7902	1670.211	0.110	-293.79	2663.555
0.9 DL +b* 0.8 LL + 0.8 EL -Z	-0.176	-293.7902	1670.211	0.110	-293.79	2663.555

Minimum factor of safety = 1391.23

Allowable factor of safety = 1.400

< 1391.235 Hence Safe

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11 *CHECK FOR UPLIFT*

Table 11 : Factor of safety against uplift

Load combinations	Uplift	Downward load	FS
1.0*1.2 DL + a*1.0*1.4 LL+a*1.0*1.4 LLR	0.000	-857.4156	100
1.0*1.2 DL + 1.0 WL +X +CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL +X -CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL -X +CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL -X -CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL +Z +CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL +Z -CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL -Z +CPI	0.000	-796.482	100
1.0*1.2 DL + 1.0 WL -Z -CPI	0.000	-796.482	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + a*0. 8*1.4LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + a*0. 8*1.4LL+a*0.8*1.4 LLR + 0.8 W	0.000	-845.2289	100
1.0*1.2 DL + 1.0 EL +X	0.000	-796.482	100
1.0*1.2 DL + 1.0 EL -X	0.000	-796.482	100
1.0*1.2 DL + 1.0 EL +Z	0.000	-796.482	100
1.0*1.2 DL + 1.0 EL -Z	0.000	-796.482	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	0.000	-814.1236	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	0.000	-814.1236	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	0.000	-814.1236	100
1.0*1.2 DL +b* 0.8*1.4 LL + 0.8 EL -Z	0.000	-814.1236	100

Minimum factor of safety = 100

Allowable factor of safety = 1.200

< 100.000 Hence Safe

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12 LOADS AT BOTTOM OF FOOTING (Load combinations for strength check)

Table 12 : Loads at bottom of footing (Factored load combinations)

Load Combinations	Fx (kN)	P (kN)	Fz (kN)	Mx (kNm)	Mz (kNm)
1.5 DL + C*1.5 LL + C*1.5 LLR	-0.206	-1286.123	0.193	0.118	0.126
1.5 DL + 1.5 WL +X +CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL +X -CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL -X +CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL -X -CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL +Z +CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL +Z -CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL -Z +CPI	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 WL -Z -CPI	-0.344	-1194.723	0.179	0.109	0.210
0.9 DL + 1.5 WL +X +CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL +X -CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL -X +CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL -X -CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL +Z +CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL +Z -CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL -Z +CPI	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 WL -Z -CPI	-0.206	-865.807	0.107	0.065	0.126
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	-0.165	-1103.385	0.154	0.094	0.100
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	-0.165	-1103.385	0.154	0.094	0.100
1.5 DL + 1.5 EL +X	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 EL -X	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 EL +Z	-0.344	-1194.723	0.179	0.109	0.210
1.5 DL + 1.5 EL -Z	-0.344	-1194.723	0.179	0.109	0.210
0.9 DL + 1.5 EL +X	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 EL -X	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 EL +Z	-0.206	-865.807	0.107	0.065	0.126
0.9 DL + 1.5 EL -Z	-0.206	-865.807	0.107	0.065	0.126
1.2 DL + b*1.2 LL + 1.2 EL +X	-0.230	-1056.727	0.148	0.090	0.140
1.2 DL + b*1.2 LL + 1.2 EL -X	-0.230	-1056.727	0.148	0.090	0.140
1.2 DL + b*1.2 LL + 1.2 EL +Z	-0.230	-1056.727	0.148	0.090	0.140
1.2 DL + b*1.2 LL + 1.2 EL -Z	-0.230	-1056.727	0.148	0.090	0.140

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13 *PRESSURE AT BASE FOR STRENGTH CHECK*

Table 13 : Pressures at four corners of the footing

Load Combinations	Gross pr. at four corners (kN/m2)			
	PA	PB	PC	PD
1.5 DL + C*1.5 LL + C*1.5 LLR	216.41	216.30	216.31	216.21
1.5 DL + 1.5 WL +X +CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL +X -CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL -X +CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL -X -CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL +Z +CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL +Z -CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL -Z +CPI	201.07	200.89	200.98	200.80
1.5 DL + 1.5 WL -Z -CPI	201.07	200.89	200.98	200.80
0.9 DL + 1.5 WL +X +CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL +X -CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL -X +CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL -X -CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL +Z +CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL +Z -CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL -Z +CPI	145.70	145.59	145.64	145.54
0.9 DL + 1.5 WL -Z -CPI	145.70	145.59	145.64	145.54
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	185.65	185.57	185.58	185.49
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	185.65	185.57	185.58	185.49
1.5 DL + 1.5 EL +X	201.07	200.89	200.98	200.80
1.5 DL + 1.5 EL -X	201.07	200.89	200.98	200.80
1.5 DL + 1.5 EL +Z	201.07	200.89	200.98	200.80
1.5 DL + 1.5 EL -Z	201.07	200.89	200.98	200.80
0.9 DL + 1.5 EL +X	145.70	145.59	145.64	145.54
0.9 DL + 1.5 EL -X	145.70	145.59	145.64	145.54
0.9 DL + 1.5 EL +Z	145.70	145.59	145.64	145.54
0.9 DL + 1.5 EL -Z	145.70	145.59	145.64	145.54
1.2 DL + b*1.2 LL + 1.2 EL +X	177.82	177.71	177.75	177.63
1.2 DL + b*1.2 LL + 1.2 EL -X	177.82	177.71	177.75	177.63
1.2 DL + b*1.2 LL + 1.2 EL +Z	177.82	177.71	177.75	177.63
1.2 DL + b*1.2 LL + 1.2 EL -Z	177.82	177.71	177.75	177.63

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14 *REINFORCEMENTS & ONE WAY SHEAR ALONG X AXIS*

Mu= (0.87*fy*Ast*d) * (1 - (fy*Ast)(fck*b*d))

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	12	154.000

Effective depth = 554 mm

Minimum Ast = 1784.909 mm2

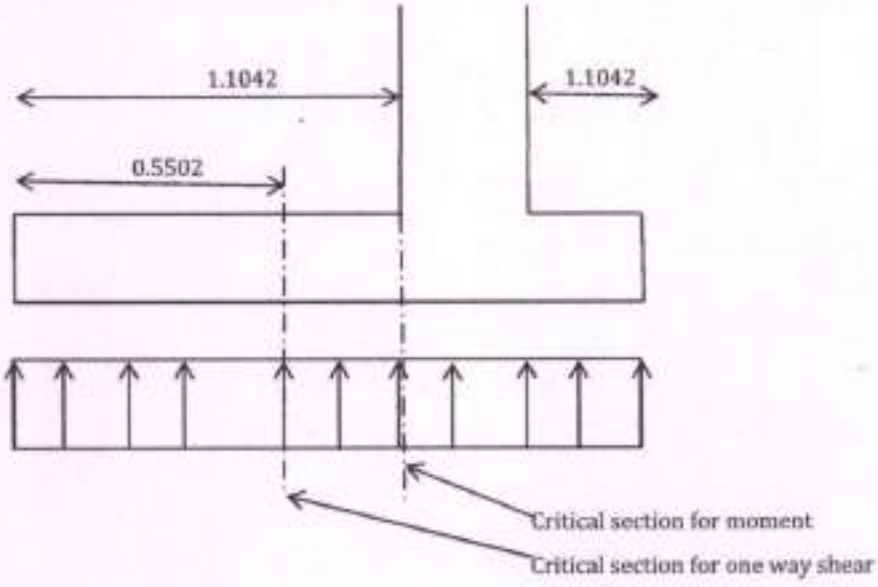
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Table 14 : Pressures at edges, moment and shear

Load Combinations	Edge pressures (kN/m2)		Moment	Ast reqd.	Shear
	PAC	PBD	(kNm)	mm2	kN/m
1.5 DL + C*1.5 LL + C*1.5 LLR	216.360	216.256	228.384	961.375	206.203
1.5 DL + 1.5 WL +X +CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL +X -CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL -X +CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL -X -CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL +Z +CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL +Z -CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL -Z +CPI	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 WL -Z -CPI	201.023	200.849	205.500	863.780	185.605
0.9 DL + 1.5 WL +X +CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL +X -CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL -X +CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL -X -CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL +Z +CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL +Z -CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL -Z +CPI	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 WL -Z -CPI	145.669	145.565	123.300	515.576	111.363
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	185.616	185.533	182.707	766.860	164.962
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	185.616	185.533	182.707	766.860	164.962
1.5 DL + 1.5 EL +X	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 EL -X	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 EL +Z	201.023	200.849	205.500	863.780	185.605
1.5 DL + 1.5 EL -Z	201.023	200.849	205.500	863.780	185.605
0.9 DL + 1.5 EL +X	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 EL -X	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 EL +Z	145.669	145.565	123.300	515.576	111.363
0.9 DL + 1.5 EL -Z	145.669	145.565	123.300	515.576	111.363
1.2 DL + b*1.2 LL + 1.2 EL +X	177.785	177.669	171.027	717.302	154.447
1.2 DL + b*1.2 LL + 1.2 EL -X	177.785	177.669	171.027	717.302	154.447
1.2 DL + b*1.2 LL + 1.2 EL +Z	177.785	177.669	171.027	717.302	154.447
1.2 DL + b*1.2 LL + 1.2 EL -Z	177.785	177.669	171.027	717.302	154.447

Note : The maximum of PAC and PBD is considered for moment calculation.

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Ast required		=	1784.909 mm2	
Spacing of 12mm dia bars required		=	154.505 mm	
Provided spacing		=	154.000 mm	Hence Safe.
Dear shear force		=	206.203 kN/m	
Design shear stress		=	Vu/bd	
		=	0.153 N/mm2	
100Ast/bd		=	0.054	
Allowable shear stress	Tc	=	0.280 N/mm2	
		>	0.153 N/mm2	Hence Safe.

100Ast/bd	Tc
0.15	0.28
0.25	0.36
0.054	0.280

15 ***REINFORCEMENTS & ONE WAY SHEAR ALONG Z AXIS***

Mu= (0.87*fy*Ast*d) * (1 - (fy*Ast)(fck*b*d))

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	12	154.000

Effective depth		=	542 mm
Minimum Ast		=	1784.909 mm2

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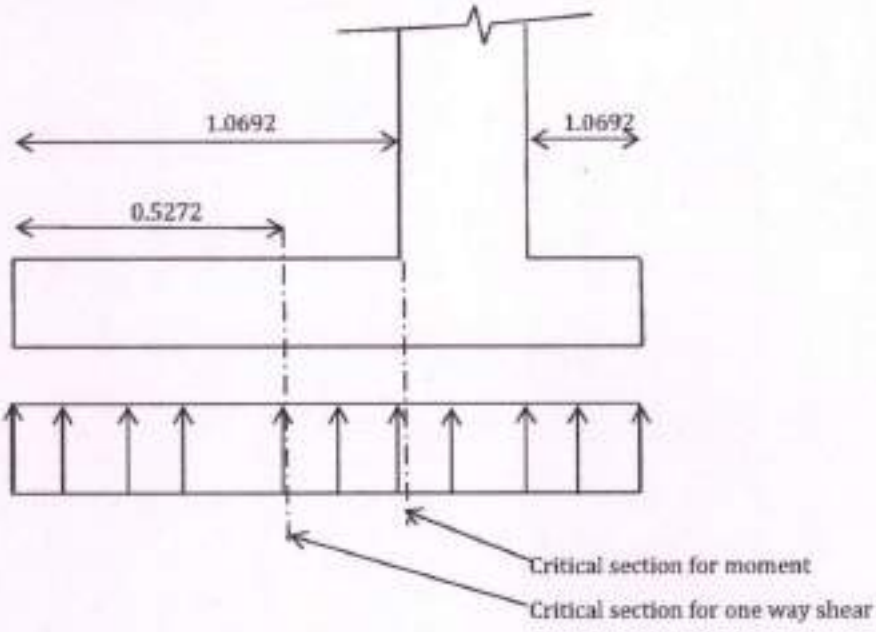
Table 15 : Pressures at edges, moment and shear

Load Combinations	Edge pressures (kN/m2)		Moment	Ast reqd.	Shear
	PAB	PCD	(kNm)	mm2	kN
1.5 DL + C*1.5 LL + C*1.5 LLR	216.357	216.259	214.133	921.068	197.511
1.5 DL + 1.5 WL +X +CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL +X -CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL -X +CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL -X -CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL +Z +CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL +Z -CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL -Z +CPI	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 WL -Z -CPI	200.981	200.891	192.711	827.739	177.752
0.9 DL + 1.5 WL +X +CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL +X -CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL -X +CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL -X -CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL +Z +CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL +Z -CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL -Z +CPI	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 WL -Z -CPI	145.644	145.590	115.627	494.117	106.651
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	185.613	185.535	171.307	734.754	158.009
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	185.613	185.535	171.307	734.754	158.009
1.5 DL + 1.5 EL +X	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 EL -X	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 EL +Z	200.981	200.891	192.711	827.739	177.752
1.5 DL + 1.5 EL -Z	200.981	200.891	192.711	827.739	177.752
0.9 DL + 1.5 EL +X	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 EL -X	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 EL +Z	145.644	145.590	115.627	494.117	106.651
0.9 DL + 1.5 EL -Z	145.644	145.590	115.627	494.117	106.651
1.2 DL + b*1.2 LL + 1.2 EL +X	177.764	177.690	160.371	687.351	147.922
1.2 DL + b*1.2 LL + 1.2 EL -X	177.764	177.690	160.371	687.351	147.922
1.2 DL + b*1.2 LL + 1.2 EL +Z	177.764	177.690	160.371	687.351	147.922
1.2 DL + b*1.2 LL + 1.2 EL -Z	177.764	177.690	160.371	687.351	147.922

Note : The maximum of PAB and PCD is considered for moment calculation.

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	SHRI BALAJI CONSULTANCY
	- DESIGN OF ISOLATED FOOTING F1



Ast required		=	1784.909 mm2	
Spacing of 12mm dia bars required		=	154.505 mm	
Provided spacing		=	154.000 mm	Hence Safe.
Dear shear force		=	197.511 kN/m	
Design shear stress		=	Vu/bd	
		=	0.149 N/mm2	
100Ast/bd		=	0.056	
Allowable shear stress	Tc	=	0.280 N/mm2	
		>	0.149 N/mm2	Hence Safe.

100Ast/bd	Tc
0.15	0.28
0.25	0.36
0.056	0.280

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CHECK FOR TWO WAY SHEAR

16 **Check for punching shear**

Load Combinations	Edge pressures (kN/m2)		s.w of footing + above soil +load	soil pressure at centre (kN/m2)	shear (kN)
	PAB	PCD			
1.5 DL + C*1.5 LL + C*1.5 LLR	216.360	216.259	-1082.34	216.314	-499.919
1.5 DL + 1.5 WL +X +CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL +X -CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL -X +CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL -X -CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL +Z +CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL +Z -CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL -Z +CPI	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 WL -Z -CPI	201.023	200.891	-990.942	200.963	-449.853
0.9 DL + 1.5 WL +X +CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL +X -CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL -X +CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL -X -CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL +Z +CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL +Z -CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL -Z +CPI	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 WL -Z -CPI	145.669	145.590	-662.026	145.633	-269.912
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X+CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X-CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	185.616	185.535	-899.604	185.579	-399.935
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	185.616	185.535	-899.604	185.579	-399.935
1.5 DL + 1.5 EL +X	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 EL -X	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 EL +Z	201.023	200.891	-990.942	200.963	-449.853
1.5 DL + 1.5 EL -Z	201.023	200.891	-990.942	200.963	-449.853
0.9 DL + 1.5 EL +X	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 EL -X	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 EL +Z	145.669	145.590	-662.026	145.633	-269.912
0.9 DL + 1.5 EL -Z	145.669	145.590	-662.026	145.633	-269.912
1.2 DL + b*1.2 LL + 1.2 EL +X	177.785	177.690	-852.946	177.742	-374.38
1.2 DL + b*1.2 LL + 1.2 EL -X	177.785	177.690	-852.946	177.742	-374.38
1.2 DL + b*1.2 LL + 1.2 EL +Z	177.785	177.690	-852.946	177.742	-374.38
1.2 DL + b*1.2 LL + 1.2 EL -Z	177.785	177.690	-852.946	177.742	-374.38

Shear force = 499.919 kN

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Perimeter of the critical section (b0)	=	3252 mm
Effective depth	=	542 mm
Punching shear stress	=	0.284 N/mm2
Ratio of short side to long side of the column βc		
	=	0.766667
Allowable punching shear stress	=	(0.5+βc) * 0.25 * √fck
	=	1.250 N/mm2
	>	0.284 N/mm2

Hence Safe.

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COLUMN NO. 2035 DESIGN RESULTS

M20 Fe500 (Main) Fe500 (Sec.)

LENGTH: 3200.0 mm CROSS SECTION: 457.0 mm X 230.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 551 END JOINT: 1414 UNBRACED LONG(Z)/SHORT(Y)

REQD. STEEL AREA : 1934.02 Sq.mm.

REQD. CONCRETE AREA: 103175.98 Sq.mm.

MAIN REINFORCEMENT : Provide 12 - 16 dia. (2.30%, 2412.74 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 230 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 1653.84 Muz1 : 35.87 Muy1 : 86.77

INTERACTION RATIO: 0.98 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 551

END JOINT: 1414 Puz : 1829.05 Muz : 44.13 Muy : 112.38 IR: 0.79

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BEAM NO. 1 DESIGN RESULTS

M20 Fe500 (Main) Fe500 (Sec.)

LENGTH: 4101.0 mm SIZE: 230.0 mm X 380.0 mm COVER: 25.0 mm

FLANGE WIDTH: 500.0 mm FLANGE DEPTH: 115.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1025.2 mm	2050.5 mm	3075.8 mm	4101.0 mm
TOP REINF.	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	414.50 (Sq. mm)	571.26 (Sq. mm)	398.99 (Sq. mm)	0.00 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1025.2 mm	2050.5 mm	3075.8 mm	4101.0 mm

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TOP	2-12ί	2-12ί	2-12ί	2-12ί	2-12ί
REINF.	1 layer(s)	1 layer(s)	1 layer(s)	1 layer(s)	1 layer(s)
BOTTOM	2-16ί	3-16ί	3-16ί	2-16ί	2-16ί
REINF.	1 layer(s)	1 layer(s)	1 layer(s)	1 layer(s)	1 layer(s)
SHEAR	2 legged 8ί	2 legged 8ί	2 legged 8ί	2 legged 8ί	2 legged 8ί
REINF.	@ 260 mm c/c	@ 260 mm c/c	@ 260 mm c/c	@ 260 mm c/c	@ 260 mm c/c

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	SHRI BALAJI CONSULTANCY
	DESIGN OF TWO WAY SLAB - S1

1 MATERIAL PROPERTIES

Unit weight of reinforced concrete	γ_c	=	25.000 kN/m^3
Environmental exposure condition (Table 3 of IS 456)		=	Mild
Grade of concrete (Table 5 of IS 456)		=	M20
Grade of steel		=	Fe500
Characteristic strength of concrete (Table 2 of IS 456)	f_{ck}	=	20.000 N/mm^2
Characteristic strength of reinf. steel = Yield stress of reinf. steel (cl. 36.1 of IS 456)	f_y	=	500.000 N/mm^2

2 DIMENSIONS

Shorter span	lx	=	3280.000 mm
Longer span	ly	=	4490.000 mm
Span ratio	ly / lx	=	1.369
		≤	2.000
			Hence it is a two way slab.
Thickness of slab		=	115.000 mm
Clear cover to reinforcements (Table 16 of IS 456)		=	15.000 mm
Width of slab considered for design (width of compression face)	= b	=	1000.000 mm

3 REINFORCEMENTS

Zone	Bar dia mm	Spacing mm	A_{st} mm2/m	Eff. Depth d mm
Along short span at bottom	8	200.000	251.327	96
Along long span at bottom	8	200.000	251.327	88
Top bars at short edge	8	200.000	251.327	88
Top bars at long edge	8	200.000	251.327	96

4 DEAD LOAD

Weight of finishes		=	1.150 kN/m^2
Self Weight of slab		=	25 * 0.115
		=	2.875 kN/m^2
Total		=	4.025 kN/m^2

5 LIVE LOAD

Live load on slab (Table 1 of IS 875 Part 2)		=	2.000 kN/m^2

6 FACTORED LOAD COMBINATION

Partial safety factor for DL (Table 18 of IS 456)		=	1.500
Partial safety factor for LL (Table 18 of IS 456)			1.500
Factored Load	= [1.5 DL + 1.5 LL]		9.038 kN/m^2

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7 BENDING MOMENTS

Edge condition : Two adjacent edges discontinuous

As Per Table 26 of IS 456:2000 the moment coefficients are as follows

Ratio of ly/lx	Short span coefficient αx	
	- ve moment at continuous Edge	+ ve moment at midspan
1.300	0.065	0.049
1.400	0.071	0.053
1.369	0.069	0.052

Long span coefficient αy	
- ve moment at continuous Edge	+ ve moment at midspan
0.047	0.035

Negative Bending moment at the short span	$= M_x = \alpha_x \times w \times lx^2$	=	6.722 kNm
Positive Bending moment at the short span	$= M_{+x} = \alpha_{+x} \times w \times lx^2$	=	5.032 kNm
Negative Bending moment at the long span	$= M_y = \alpha_y \times w \times lx^2$	=	4.57 kNm
Positive Bending moment at the long span	$= M_{+y} = \alpha_{+y} \times w \times lx^2$	=	3.403 kNm

8 LIMIT STATE OF COLLAPSE - FLEXURE & SHEAR

Minimum reinforcements (Cl. 26.5.2.1 of IS 456)		=	0.12 %
		=	138 mm^2

A REINFORCEMENTS ALONG SHORT SPAN AT BOTTOM

Positive Bending moment at the short span		=	5.032 kNm
Area of reinf. steel required is calculated as per Annex G of IS 456 :			
Area of tension reinforcement required =	Ast reqd.	=	124.537 mm^2
Spacing of 8 mm dia. bars required		=	403.619 mm
Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller		=	288.000 mm
Hence spacing of 8 mm dia. bars required is the minimum of the above two values		=	288.000 mm
Spacing of 8 mm dia. bars provided		=	200.000 mm
Area of tension reinforcement provided =	Ast prov.	=	251.327 mm^2
		>	138.000 mm^2
			Hence Safe
Moment of resistance is calculated as per Annex G of IS 456 :			
Ratio between depth of neutral axis and effective depth =	x_u / d	=	(0.87 fy Ast)/(0.36 f_{ck} b d)
		=	0.158
Depth of neutral axis =	x_u	=	0.158 * 96
		=	15.168 mm
As per cl. 38.1 of IS 456, the limiting value of xu/d =	$x_{u,max} / d$	=	0.460
		>	0.158
			Hence Safe

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Limiting value of the depth of neutral axis		=	44.160 mm
Moment of resistance Mu =	0.87 fy Ast d (1-(Ast fy / b d fck))	=	9.809 kNm
		>	5.032 kNm
			Hence Safe

Limiting moment of resistance of the section without compression reinforcement

= 0.36 * $x_{u,max}$/d (1-0.42 $x_{u,max}$ /d) * bd^2 fck =	$M_{u,lim}$	=	24.626 kNm
		>	9.809 kNm
			Hence compression reinforcements are not required.

Design stress in compression reinforcement =	f_{sc}	=	500.000 N/mm^2
Depth of compression reinf. from compression face =	d'	=	15 + 8/2
		=	19.000 mm
Area of compression reinforcement = (M_u - $M_{u,lim}$) / (f_{sc} (d-d')) =	A_{sc}	=	0 mm^2
Area of compression reinforcement provided		=	0 mm^2
Additional tension reinforcement required =	A_{st2}	=	0 mm^2
Area of tension reinforcement required for a singly reinforced section for $M_{u,lim}$ =	A_{st1}	=	124.537 mm^2
Total tension reinforcement required = A_{st1} + A_{st2} =	Ast	=	124.537 mm^2

B REINFORCEMENTS ALONG LONG SPAN AT BOTTOM

Positive Bending moment at the long span		=	3.403 kNm
Area of reinf. steel required is calculated as per Annex G of IS 456 :			
Area of tension reinforcement required =	Ast reqd.	=	91.264 mm^2
Spacing of mm dia. bars required		=	550.771 mm
Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller		=	264.000 mm
Hence spacing of mm dia. bars required is the minimum of the above two values		=	264.000 mm
Spacing of mm dia. bars provided		=	200.000 mm
Area of tension reinforcement provided =	Ast prov.	=	251.327 mm^2
		>	138.000 mm^2
			Hence Safe

Moment of resistance is calculated as per Annex G of IS 456 :

Ratio between depth of neutral axis and effective depth =	x_u / d	=	(0.87 fy Ast)/(0.36 f_{ck} b d)
		=	0.173
Depth of neutral axis =	x_u	=	0.173 * 88
		=	15.224 mm
As per cl. 38.1 of IS 456, the limiting value of xu/d =	$x_{u,max}$ / d	=	0.460
		>	0.173
			Hence Safe

Limiting value of the depth of neutral axis		=	40.480 mm
Moment of resistance Mu =	0.87 fy Ast d (1-(Ast fy / b d fck))	=	8.934 kNm

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		>	3.403 kNm
			Hence Safe

Limiting moment of resistance of the section without compression reinforcement

= 0.36 * $x_{u,max}$/d (1-0.42 $x_{u,max}$ /d) * bd^2 fck =	$M_{u,lim}$	=	20.693 kNm
		>	8.934 kNm
			Hence compression reinforcements are not required.
Design stress in compression reinforcement =	f_{sc}	=	500.000 N/mm^2
Depth of compression reinf. from compression face =	d'	=	15 + 8/2
		=	19.000 mm
Area of compression reinforcement = (M_u - $M_{u,lim}$) / (f_{sc} (d-d')) =	A_{sc}	=	0 mm^2
Area of compression reinforcement provided		=	0 mm^2
Additional tension reinforcement required =	A_{st2}	=	0 mm^2
Area of tension reinforcement required for a singly reinforced section for $M_{u,lim}$ =	A_{st1}	=	91.264 mm^2
Total tension reinforcement required = A_{st1} + A_{st2} =	Ast	=	91.264 mm^2

C REINFORCEMENTS AT LONG EDGE AT TOP

Negative Bending moment at the short span		=	6.722 kNm
Area of reinf. steel required is calculated as per Annex G of IS 456 :			
Area of tension reinforcement required =	Ast reqd.	=	168.348 mm^2
Spacing of mm dia. bars required		=	298.581 mm
Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller		=	288.000 mm
Hence spacing of mm dia. bars required is the minimum of the above two values		=	288.000 mm
Spacing of mm dia. bars provided		=	200.000 mm
Area of tension reinforcement provided =	Ast prov.	=	251.327 mm^2
		>	168.348 mm^2
			Hence Safe
Moment of resistance is calculated as per Annex G of IS 456 :			
Ratio between depth of neutral axis and effective depth =	x_u / d	=	(0.87 fy Ast)/(0.36 f_{ck} b d)
		=	0.158
Depth of neutral axis =	x_u	=	0.158 * 96
		=	15.168 mm
As per cl. 38.1 of IS 456, the limiting value of xu/d =	$x_{u,max}$ / d	=	0.460
		>	0.158
			Hence Safe
Limiting value of the depth of neutral axis		=	44.160 mm
Moment of resistance Mu = 0.87 fy Ast d (1-(Ast fy /b d fck))		=	9.809 kNm
		>	6.722 kNm
			Hence Safe

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Limiting moment of resistance of the section without compression reinforcement

= 0.36 * $x_{u,max}$/d (1-0.42 $x_{u,max}$ /d) * bd^2 fck =	$M_{u,lim}$	=	24.626 kNm
		>	9.809 kNm

Hence compression reinforcements are not required.

Design stress in compression reinforcement =	f_{sc}	=	500.000 N/mm^2
Depth of compression reinf. from compression face =	d'	=	15 + 8/2
		=	19.000 mm
Area of compression reinforcement = (M_u - $M_{u,lim}$) / (f_{sc} (d-d')) =	A_{sc}	=	0 mm^2
Area of compression reinforcement provided		=	0 mm^2
Additional tension reinforcement required =	A_{st2}	=	0 mm^2
Area of tension reinforcement required for a singly reinforced section for $M_{u,lim}$	A_{st1}	=	168.348 mm^2
Total tension reinforcement required = A_{st1} + A_{st2} =	Ast	=	168.348 mm^2

D REINFORCEMENTS AT SHORT EDGE AT TOP

Negative Bending moment at the long span		=	4.57 kNm
Area of reinf. steel required is calculated as per Annex G of IS 456 :			
Area of tension reinforcement required =	Ast reqd.	=	123.733 mm^2
Spacing of mm dia. bars required		=	406.242 mm
Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller		=	264.000 mm
Hence spacing of mm dia. bars required is the minimum of the above two values		=	264.000 mm
Spacing of mm dia. bars provided		=	200.000 mm
Area of tension reinforcement provided =	Ast prov.	=	251.327 mm^2
		>	138.000 mm^2

Hence Safe

Moment of resistance is calculated as per Annex G of IS 456 :

Ratio between depth of neutral axis and effective depth =	x_u / d	=	(0.87 fy Ast)/(0.36 f_{ck} b d)
		=	0.173
Depth of neutral axis =	x_u	=	0.173 * 88
		=	15.224 mm
As per cl. 38.1 of IS 456, the limiting value of xu/d =	$x_{u,max}$ / d	=	0.460
		>	0.173

Hence Safe

Limiting value of the depth of neutral axis		=	40.480 mm
Moment of resistance Mu =	0.87 fy Ast d (1-(Ast fy / b d fck))	=	8.934 kNm
			4.570 kNm

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

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$= 0.36 * x_{u,max}/d\ (1-0.42\ x_{u,max}/d) * bd^2\ fck =$	$M_{u,lim}$	=	20.693 kNm
		>	8.934 kNm

Hence compression reinforcements are not required.

Design stress in compression reinforcement =	f_{sc}	=	500.000 N/mm^2
Depth of compression reinf. from compression face =	d'	=	15 + 8/2
		=	19.000 mm
Area of compression reinforcement = $(M_u - M_{u,lim}) / (f_{sc}\ (d-d'))$ =	A_{sc}	=	0 mm^2
Area of compression reinforcement provided		=	0 mm^2
Additional tension reinforcement required =	A_{st2}	=	0 mm^2
Area of tension reinforcement required for a singly reinforced section for $M_{u,lim}$ =	A_{st1}	=	123.733 mm^2
Total tension reinforcement required = $A_{st1} + A_{st2}$ =	Ast	=	123.733 mm^2

E TORSIONAL REINFORCEMENTS

Torsion reinforcements at corners, whose two edges are simply supported (Cl. D.1.8 of IS 456)	=	3/4 * 124.537
	=	93.403 mm^2
Torsion reinforcements at corners, whose one edge is simply supported (Cl. D.1.9 of IS 456)	=	1/2 * 93.403
	=	46.702 mm^2

F CHECK FOR SHEAR

As per Table 3.15 of BS 8110-1 the shear coefficients are as follows

Ratio of ly/lx	Short span coefficient βx	
	continuous edge	discontinuous edge
1.300	0.500	0.330
1.400	0.520	0.340
1.369	0.514	0.337

Long span coefficient βy	
continuous edge	discontinuous edge
0.400	0.260

Shear force at the long continuous edge	$= \beta_{cx} \times W \times lx =$	V_{cx}	=	15.231 kN
Shear force at the long discontinuous edge	$= \beta_{dx} \times W \times lx =$	V_{dx}	=	9.987 kN
Shear force at the short continuous edge	$= \beta_{cy} \times W \times lx =$	V_{cy}	=	11.858 kN
Shear force at the short discontinuous edge	$= \beta_{dy} \times W \times lx =$	V_{dy}	=	7.708 kN

Check for shear near long edge :

Shear force due to design loads	Vu	=	15.231 kN
Effective depth	d	=	96.000 mm
Nominal shear stress (Cl. 40.1 of IS 456)	τ_v	=	Vu / bd
		=	0.159 N/mm^2
Maximum shear stress (Cl. 40.2.3.1of IS 456)	$\tau_{c\,max}$	=	1.400 N/mm^2
		>	0.159 N/mm^2

Hence SAFE

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Area of reinf. provided			=	251.327 mm^2
Percentage of reinf. provided	= 100As/bd =	pt	=	0.262

From table 19 of IS 456,

pt	τ_c
0.250	0.360
0.500	0.480
0.262	0.366

Factor k as per cl. 40.2.1.1 of IS 456	k	=	1.300
Design shear strength of concrete	$\tau_c k$	=	0.475 N/mm^2
		>	0.159 N/mm^2
			Hence SAFE

Check for shear near short edge :

Shear force due to design loads	Vu	=	11.858 kN
Effective depth	d	=	88.000 mm
Nominal shear stress (Cl. 40.1 of IS 456)	τ_v	=	Vu / bd
		=	0.135 N/mm^2
Maximum shear stress (Cl. 40.2.3.1of IS 456)	$\tau_{c\,max}$	=	1.400 N/mm^2
		>	0.135 N/mm^2
			Hence SAFE

Area of reinf. provided		=	251.327 mm^2
Percentage of reinf. provided	= 100As/bd = pt	=	0.286

From table 19 of IS 456,

pt	τ_c
0.250	0.360
0.500	0.480
0.286	0.377

Factor k as per cl. 40.2.1.1 of IS 456	k	=	1.300
Design shear strength of concrete	$\tau_c k$	=	0.490 N/mm^2
		>	0.135 N/mm^2
			Hence SAFE

9 *LIMIT STATE OF SERVICEABILITY - DEFLECTION & CRACKING*

A CHECK FOR DEFLECTION

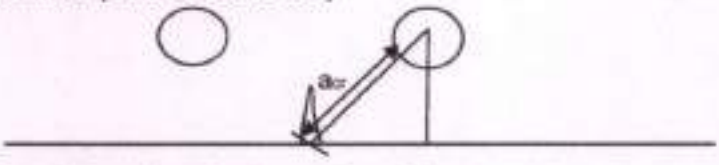
Allowable long term deflection (Cl. 23.2 of IS 456)		=	lx / 350
		=	9.371 mm
Basic allowable span to effective depth ratio (Cl. 23.2.1 of IS 456)		=	26.000 mm
Steel stress at service loads		=	0.58 fy $A_{st,req.}$ / $A_{st,prov.}$
		=	159.235 N/mm^2

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Modification factor for tension reinforcement (Fig. 4 of IS 456)	=	2.000
Modification factor for compression reinforcement (Fig. 4 of IS 456)	=	1.000
Allowable span to effective depth ratio	=	52.000
Actual span to effective depth ratio	=	34.167
	<	52.000
		Hence SAFE

B CHECK FOR CRACK WIDTH AT MIDSPAN

Allowable crack width (Cl. 35.3.2 of IS 456) = 0.3 mm

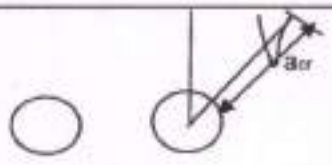


Distance of the point considered to the surface of the nearest longitudinal bar	a_{cr} =	97.789 mm
Minimum cover to the longitudinal bar	C_{min} =	15.000 mm
Overall depth of the member	h =	115.000 mm
Depth of neutral axis	x =	15.168 mm
Effective depth	d =	96.000 mm
Modulus of elasticity of steel reinf.	E_s =	200.000 kN/mm^2
Modulus of elasticity of concrete	E_c =	5000 $\sqrt{f_{ck}}$
	=	22.361 kN/mm^2
Modular ratio	m =	8.944 mm
Maximum moment	M =	5.032 kNm
Section modulus	Z =	$bd^2 / 6$
	=	1536000.000 mm^3
Maximum compressive stress in concrete	fc =	M/z
	=	3.276 N/mm^2
Maximum tensile stress in reinf. Steel	fs =	fc * m
	=	29.302 N/mm^2
Average steel strain at the level considered	=	fs / Es
	=	0.147
Maximum allowable strain	=	0.8 Fy / Es
	=	0.002
Average steel strain at the level considered	ε_m =	0.002
Design surface crack width (Annex F of IS 456)	W_{cr} =	$\frac{3\, a_{cr}\, \varepsilon_m}{1 + 2(a_{cr}-C_{min})/(h-x)}$
	=	0.221 mm
	<	0.300 mm
		Hence Safe

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C CHECK FOR CRACK WIDTH AT SUPPORT OF LONG EDGE

Allowable crack width (Cl. 35.3.2 of IS 456) = 0.3 mm

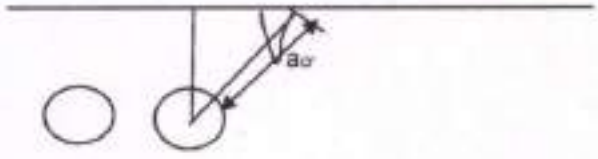


Distance of the point considered to the surface of the nearest longitudinal bar	a_{cr} =	101.789 mm
Minimum cover to the longitudinal bar	C_{min} =	15.000 mm
Overall depth of the member	h =	115.000 mm
Depth of neutral axis	x =	15.168 mm
Effective depth	d =	96.000 mm
Modulus of elasticity of steel reinf.	E_s =	200.000 kN/mm^2
Modulus of elasticity of concrete	E_c =	5000 $\sqrt{f_{ck}}$
	=	22.361 kN/mm^2
Modular ratio	m =	8.944 mm
Maximum moment	M =	6.722 kNm
Section modulus	Z =	bd^2 / 6
	=	1536000.000 mm^3
Maximum compressive stress in concrete	fc =	M/z
	=	4.376 N/mm^2
Maximum tensile stress in reinf. Steel	fs =	fc * m
	=	39.143 N/mm^2
Average steel strain at the level considered	=	fs / Es
	=	0.196
Maximum allowable strain	=	0.8 Fy / Es
	=	0.002
Average steel strain at the level considered	ε_m =	0.002
Design surface crack width (Annex F of IS 456)	W_{cr} =	$\frac{3\, a_{cr}\, \varepsilon_m}{1 + 2(a_{cr}-C_{min})/(h-x)}$
	=	0.223 mm
	<	0.300 mm
		Hence Safe

D CHECK FOR CRACK WIDTH AT SUPPORT OF SHORT EDGE

Allowable crack width (Cl. 35.3.2 of IS 456) 0.3 mm

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Distance of the point considered to the surface of the nearest longitudinal bar	a_{cr} =	101.789 mm
Minimum cover to the longitudinal bar	C_{min} =	15.000 mm
Overall depth of the member	h =	115.000 mm
Depth of neutral axis	x =	15.224 mm
Effective depth	d =	88.000 mm
Modulus of elasticity of steel reinf.	E_s =	200.000 kN/mm^2
Modulus of elasticity of concrete	E_c =	5000 $\sqrt{f_{ck}}$
	=	22.361 kN/mm^2
Modular ratio	m =	8.944 mm
Maximum moment	M =	4.570 kNm
Section modulus	Z =	$bd^2 / 6$
	=	1290666.667 mm^3
Maximum compressive stress in concrete	fc =	M/z
	=	3.541 N/mm^2
Maximum tensile stress in reinf. Steel	fs =	fc * m
	=	31.670 N/mm^2
Average steel strain at the level considered	=	fs / Es
	=	0.158
Maximum allowable strain	=	0.8 Fy / Es
	=	0.002
Average steel strain at the level considered	ε_m =	0.002
Design surface crack width (Annex F of IS 456)	W_{cr} =	$\frac{3\, a_{cr}\, \varepsilon_m}{1 + 2(a_{cr}-C_{min})/(h-x)}$
	=	0.223 mm
	<	0.300 mm
		Hence Safe

10 SLAB REACTIONS

Refer code SP 24-1983 Cl:23.5

On the long span, $wl_x/6*(3-(l_x/l_y)^2)$

Unfactored long beam UDL reaction due to dead load

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Unfactored load = 4.025 kN/m^2

= ***5.427*** kN/m

Unfactored long beam UDL reaction due to live load

Unfactored load = 2.000 kN/m^2

= ***2.697*** kN/m

On the short span, $wl_x/3$

Unfactored long beam UDL reaction due to dead load

Unfactored load = 4.025 kN/m^2

= ***4.401*** kN/m

Unfactored long beam UDL reaction due to live load

Unfactored load = 2.000 kN/m^2

= ***2.187*** kN/m

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MDTCP

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Phone: 0452-2530544, E.mail –ID : dtcpmadurai@gmail.com

PROFESSIONAL REGISTRATION CERTIFICATE

Roc. No.1433/2019/CC **dated :28.04.2022**

This is to certify that **THIRU.R.MANIVANNAN** has enrolled as **STRUCTURAL ENGINEER GRADE-I (SE)** with Madurai District Town and Country Planning (**MDTCP**), who has the qualification of **Degree of Master of Engineering in Civil Engineering (A) Structural Engineering** and experience in the relevant field for **5 years above.**

He has been given the **Registration No.SE. 03/2022 (Gr.I) on 28.04.2022.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide **G.O.(Ms)No.18, MAWS (MA1) Department, Dated: 04.02.2019.**

This Registration is valid upto **27.04.2027**



28 APR 2022

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