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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 – Thiruparankundram Panchayat Union-
Thuvariman Panchayat /Village S.No.22/5A, 5B,6,7A,7B-Site area of
8376.90 sq.m - proposal residential Group Housing Building – Block 1
to 15 (Ground Floor + 1 Floor) – FSI area of 6473.87 sq.m (37 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 IS 456,IS 875 and other relevant
codes, and it is structurally safe & sound.


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STRUCTURAL DESIGN STABILITY CERTIFICATE

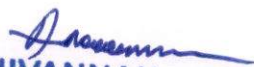
This is to certify that the PROPOSED NEW CONSTRUCTION OF RESIDENTIAL GROUP HOUSING BUILDING IN S.NO: 22/5A,5B,6,7A,7B, AT THUVARIMAN VILLAGE/ PANCHAYAT, THIRUPARANKUNDRAM PANCHAYAT UNION, MADURAI WEST TALUK, MADURAI (DT). (37 DWELLING UNITS)

1. IS: 456-2000, code of practice for plain and reinforced concrete, with M25 concrete grade for R.C.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 Gound Floor + First floor + Stair Case Head 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 Residential Group Housing Building R.C Framed Structure with Ground + One Upper floor. The Ground Floor and upper Floors 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 20 and others M 20. The Steel grade considered in the design is Fe 500.


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	DESIGN OF ISOLATED FOOTING

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

Footing plan dimension along X axis	L	=	1.753 m
Footing plan dimension along Z axis	W	=	1.753 m
Thickness of footing	t	=	0.380 m
Column plan dimension along X axis	a	=	0.230 m
Column plan dimension along Z axis	b	=	0.230 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

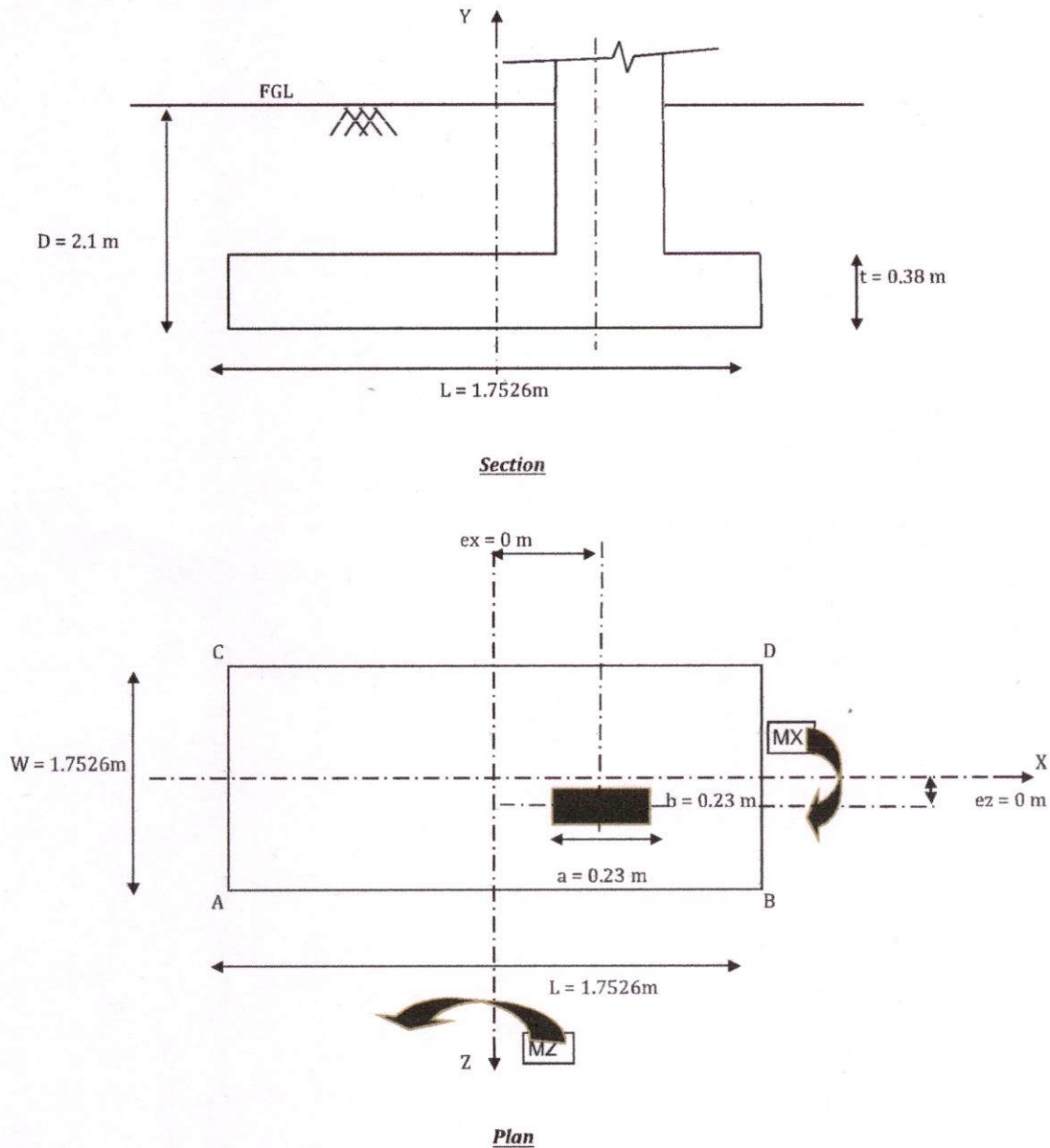
3 SOIL PROPERTIES

Density of soil	γ_{soil}	=	18.000 kN/m ³
Net bearing capacity of soil (from soil report)		=	114.200 kN/m ²
Allowable gross SBC		=	114.2 + 18*2.1
		=	152.000 kN/m ²
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		=	25.000 %
Table 1 of IS:1893 (part1):2002			
% increase in SBC for load combinations with wind loads		=	25.000 %
Cl.8.1 of IS: 875 (part 5) - 1987			


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5 **GEOMETRICAL SKETCH**

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)	0.000	-335.000	0.000	0.000	0.000
LIVE LOAD (LL)	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 -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)	0.000	0.000	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	F _{xt} (kN)	F _{yt} (kN)	F _{zt} (kN)	M _{xt} (kNm)	M _{zt} (kNm)
1.0 DL + a*1.0 LL+a*1.0 LLR	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL +X +CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL +X -CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL -X +CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL -X -CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL +Z +CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL +Z -CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL -Z +CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 WL -Z -CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 EL +X	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 EL -X	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 EL +Z	0.000	-335.000	0.000	0.000	0.000
1.0 DL + 1.0 EL -Z	0.000	-335.000	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	0.000	-335.000	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	0.000	-335.000	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	0.000	-335.000	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -Z	0.000	-335.000	0.000	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	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL +X +CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL +X -CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL -X +CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL -X -CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL +Z +CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL +Z -CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL -Z +CPI	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 WL -Z -CPI	0.000	-502.500	0.000	0.000	0.000
0.9 DL + 1.5 WL +X +CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL +X -CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL -X +CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL -X -CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL +Z +CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL +Z -CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL -Z +CPI	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 WL -Z -CPI	0.000	-301.500	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	0.000	-402.000	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	0.000	-402.000	0.000	0.000	0.000
1.5 DL + 1.5 EL +X	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 EL -X	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 EL +Z	0.000	-502.500	0.000	0.000	0.000
1.5 DL + 1.5 EL -Z	0.000	-502.500	0.000	0.000	0.000
0.9 DL + 1.5 EL +X	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 EL -X	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 EL +Z	0.000	-301.500	0.000	0.000	0.000
0.9 DL + 1.5 EL -Z	0.000	-301.500	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +X	0.000	-402.000	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -X	0.000	-402.000	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +Z	0.000	-402.000	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -Z	0.000	-402.000	0.000	0.000	0.000


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

Self weight of footing	SW =	$25 * 1.7526 * 1.7526 * 0.38$
	=	-29.180 kN
Weight of soil above footing	WS =	$18 * (1.7526 * 1.7526 - 0.23 * 0.23)$
	=	-93.459 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	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL +X +CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL +X -CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL -X +CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL -X -CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL +Z +CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL +Z -CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL -Z +CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 WL -Z -CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 EL +X	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 EL -X	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 EL +Z	0.000	-457.639	0.000	0.000	0.000
1.0 DL + 1.0 EL -Z	0.000	-457.639	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	0.000	-457.639	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	0.000	-457.639	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	0.000	-457.639	0.000	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -Z	0.000	-457.639	0.000	0.000	0.000

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

Load Combinations	F_x s (kN)	P s (kN)	F_z s (kN)	M_x s (kNm)	M_z s (kNm)
0.9 DL + a*1.0 LL + a*1.0 LLR	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL +X +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL +X -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL -X +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL -X -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL +Z +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL +Z -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL -Z +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 WL -Z -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 EL +X	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 EL -X	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 EL +Z	0.000	-411.875	0.000	0.000	0.000
0.9 DL + 1.0 EL -Z	0.000	-411.875	0.000	0.000	0.000
0.9 DL + b*0.8 LL + 0.8 EL +X	0.000	-411.875	0.000	0.000	0.000
0.9 DL + b*0.8 LL + 0.8 EL -X	0.000	-411.875	0.000	0.000	0.000
0.9 DL + b*0.8 LL + 0.8 EL +Z	0.000	-411.875	0.000	0.000	0.000
0.9 DL + b*0.8 LL + 0.8 EL -Z	0.000	-411.875	0.000	0.000	0.000

8 CHECK FOR PRESSURE

Base area	$A =$	$1.7526 * 1.7526$
	$=$	3.072 m^2
Section modulus (X axis)	$Z_x =$	$1.7526 * 1.7526^2 / 6$
		0.897 mm^3
Section modulus (Z axis)	$Z_z =$	$1.7526 * 1.7526^2 / 6$
		0.897 mm^3
Pressure at corner A	$P_A =$	$-P/A + M_x/Z_x + M_z/Z_z$
Pressure at corner B	$P_B =$	$-P/A + M_x/Z_x - M_z/Z_z$
Pressure at corner C	$P_C =$	$-P/A - M_x/Z_x + M_z/Z_z$
Pressure at corner D	$P_D =$	$-P/A - M_x/Z_x - M_z/Z_z$


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**SHRI BALAJI CONSULTANCY****DESIGN OF ISOLATED FOOTING***Table 6 : Pressures at four corners of the footing*

Load Combinations	Gross pr. at four corners (kN/m ²)			
	PA	PB	PC	PD
1.0 DL + a*1.0 LL+a*1.0 LLR	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL +X +CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL +X -CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL -X +CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL -X -CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL +Z +CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL +Z -CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL -Z +CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 WL -Z -CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	148.99	148.99	148.99	148.99
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	148.99	148.99	148.99	148.99
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	148.99	148.99	148.99	148.99
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	148.99	148.99	148.99	148.99
1.0 DL + 1.0 EL +X	148.99	148.99	148.99	148.99
1.0 DL + 1.0 EL -X	148.99	148.99	148.99	148.99
1.0 DL + 1.0 EL +Z	148.99	148.99	148.99	148.99
1.0 DL + 1.0 EL -Z	148.99	148.99	148.99	148.99
1.0 DL + b*0.8 LL + 0.8 EL +X	148.99	148.99	148.99	148.99
1.0 DL + b*0.8 LL + 0.8 EL -X	148.99	148.99	148.99	148.99
1.0 DL + b*0.8 LL + 0.8 EL +Z	148.99	148.99	148.99	148.99
1.0 DL +b* 0.8 LL + 0.8 EL -Z	148.99	148.99	148.99	148.99

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	SHRI BALAJI CONSULTANCY
	DESIGN OF ISOLATED FOOTING

Table 7 : Pmax

Load Combinations	Pmax kN/m ²	Net SBC kN/m ²	% increase in SBC	Allowable net SBC kN/m ²	Overburd en pr. kN/m ²	Gross SBC kN/m ²
1.0 DL + a*1.0 LL+a*1.0 LLR	148.99	114.200	0	114.2	37.8	152
1.0 DL + 1.0 WL +X +CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL +X -CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL -X +CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL -X -CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL +Z +CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL +Z -CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL -Z +CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 WL -Z -CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 EL +X	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 EL -X	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 EL +Z	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + 1.0 EL -Z	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + b*0.8 LL + 0.8 EL +X	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + b*0.8 LL + 0.8 EL -X	148.99	114.200	25	142.75	37.8	180.55
1.0 DL + b*0.8 LL + 0.8 EL +Z	148.99	114.200	25	142.75	37.8	180.55
1.0 DL +b* 0.8 LL + 0.8 EL -Z	148.99	114.200	25	142.75	37.8	180.55


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Table 8 : Pmin

Load Combinations	Pmin kN/m ²	Uplift	% loss of contact
1.0 DL + a*1.0 LL+a*1.0 LLR	148.99	No Uplift	0.000
1.0 DL + 1.0 WL +X +CPI	148.99	No Uplift	0.000
1.0 DL + 1.0 WL -X +CPI	148.99	No Uplift	0.000
1.0 DL + 1.0 WL +Z +CPI	148.99	No Uplift	0.000
1.0 DL + 1.0 WL -Z +CPI	148.99	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	148.99	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	148.99	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	148.99	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	148.99	No Uplift	0.000
1.0 DL + 1.0 EL +X	148.99	No Uplift	0.000
1.0 DL + 1.0 EL -X	148.99	No Uplift	0.000
1.0 DL + 1.0 EL +Z	148.99	No Uplift	0.000
1.0 DL + 1.0 EL -Z	148.99	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	148.99	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	148.99	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	148.99	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL -Z	148.99	No Uplift	0.000

P max Without Wind load = 148.99 kN/m²
< 152.00 kN/m² Hence Safe.

P max With Wind load = 148.99
< 190.00 kN/m² Hence Safe.

% loss of contact = 0.0 %
≤ 0.0 % Hence Safe.

The Bearing pressure reached upto 98% of SBC


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**SHRI BALAJI CONSULTANCY****DESIGN OF ISOLATED FOOTING****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	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL +X +CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL +X -CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL -X +CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL -X -CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL +Z +CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL +Z -CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL -Z +CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 WL -Z -CPI	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 EL +X	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 EL -X	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 EL +Z	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + 1.0 EL -Z	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	0.000	-401.0294	Safe	0.000	-401.029	Safe
1.0*1.2 DL +b* 0.8*1.4 LL + 0.8 EL -Z	0.000	-401.0294	Safe	0.000	-401.029	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	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL +X +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL +X -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL -X +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL -X -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL +Z +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL +Z -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL -Z +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 WL -Z -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 EL +X	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 EL -X	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 EL +Z	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + 1.0 EL -Z	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + b*0.8 LL + 0.8 EL +X	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + b*0.8 LL + 0.8 EL -X	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + b*0.8 LL + 0.8 EL +Z	0.000	-164.7502	100.000	0.000	-164.75	100.000
0.9 DL + b*0.8 LL + 0.8 EL -Z	0.000	-164.7502	100.000	0.000	-164.75	100.000

Minimum factor of safety = 100
Allowable factor of safety = 1.400
< 100.000 Hence Safe


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**SHRI BALAJI CONSULTANCY**

DESIGN OF ISOLATED FOOTING

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	-457.6394	100
1.0*1.2 DL + 1.0 WL +X +CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL +X -CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL -X +CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL -X -CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL +Z +CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL +Z -CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL -Z +CPI	0.000	-457.6394	100
1.0*1.2 DL + 1.0 WL -Z -CPI	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-457.6394	100
1.0*1.2 DL + 1.0 EL +X	0.000	-457.6394	100
1.0*1.2 DL + 1.0 EL -X	0.000	-457.6394	100
1.0*1.2 DL + 1.0 EL +Z	0.000	-457.6394	100
1.0*1.2 DL + 1.0 EL -Z	0.000	-457.6394	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	0.000	-457.6394	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	0.000	-457.6394	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	0.000	-457.6394	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -Z	0.000	-457.6394	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)

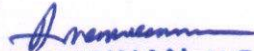
Load Combinations	F _x (kN)	P (kN)	F _z (kN)	M _x (kNm)	M _z (kNm)
1.5 DL + C*1.5 LL + C*1.5 LLR	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL +X +CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL +X -CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL -X +CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL -X -CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL +Z +CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL +Z -CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL -Z +CPI	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 WL -Z -CPI	0.000	-686.459	0.000	0.000	0.000
0.9 DL + 1.5 WL +X +CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL +X -CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL -X +CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL -X -CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL +Z +CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL +Z -CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL -Z +CPI	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 WL -Z -CPI	0.000	-485.459	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	0.000	-585.959	0.000	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	0.000	-585.959	0.000	0.000	0.000
1.5 DL + 1.5 EL +X	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 EL -X	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 EL +Z	0.000	-686.459	0.000	0.000	0.000
1.5 DL + 1.5 EL -Z	0.000	-686.459	0.000	0.000	0.000
0.9 DL + 1.5 EL +X	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 EL -X	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 EL +Z	0.000	-485.459	0.000	0.000	0.000
0.9 DL + 1.5 EL -Z	0.000	-485.459	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +X	0.000	-585.959	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -X	0.000	-585.959	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +Z	0.000	-585.959	0.000	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -Z	0.000	-585.959	0.000	0.000	0.000


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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/m ²)			
	PA	PB	PC	PD
1.5 DL + C*1.5 LL + C*1.5 LLR	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL +X +CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL +X -CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL -X +CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL -X -CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL +Z +CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL +Z -CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL -Z +CPI	223.49	223.49	223.49	223.49
1.5 DL + 1.5 WL -Z -CPI	223.49	223.49	223.49	223.49
0.9 DL + 1.5 WL +X +CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL +X -CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL -X +CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL -X -CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL +Z +CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL +Z -CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL -Z +CPI	158.05	158.05	158.05	158.05
0.9 DL + 1.5 WL -Z -CPI	158.05	158.05	158.05	158.05
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	190.77	190.77	190.77	190.77
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	190.77	190.77	190.77	190.77
1.5 DL + 1.5 EL +X	223.49	223.49	223.49	223.49
1.5 DL + 1.5 EL -X	223.49	223.49	223.49	223.49
1.5 DL + 1.5 EL +Z	223.49	223.49	223.49	223.49
1.5 DL + 1.5 EL -Z	223.49	223.49	223.49	223.49
0.9 DL + 1.5 EL +X	158.05	158.05	158.05	158.05
0.9 DL + 1.5 EL -X	158.05	158.05	158.05	158.05
0.9 DL + 1.5 EL +Z	158.05	158.05	158.05	158.05
0.9 DL + 1.5 EL -Z	158.05	158.05	158.05	158.05
1.2 DL + b*1.2 LL + 1.2 EL +X	190.77	190.77	190.77	190.77
1.2 DL + b*1.2 LL + 1.2 EL -X	190.77	190.77	190.77	190.77
1.2 DL + b*1.2 LL + 1.2 EL +Z	190.77	190.77	190.77	190.77
1.2 DL + b*1.2 LL + 1.2 EL -Z	190.77	190.77	190.77	190.77


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	SHRI BALAJI CONSULTANCY
	DESIGN OF ISOLATED FOOTING

14 **REINFORCEMENTS & ONE WAY SHEAR ALONG X AXIS**

$$\text{Mu} = (0.87 \cdot f_y \cdot A_{st} \cdot d) \cdot (1 - (f_y \cdot A_{st}) / (f_{ck} \cdot b \cdot d))$$

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	10	172.000

Effective depth = 325 mm

Minimum Ast = 799.1856 mm²


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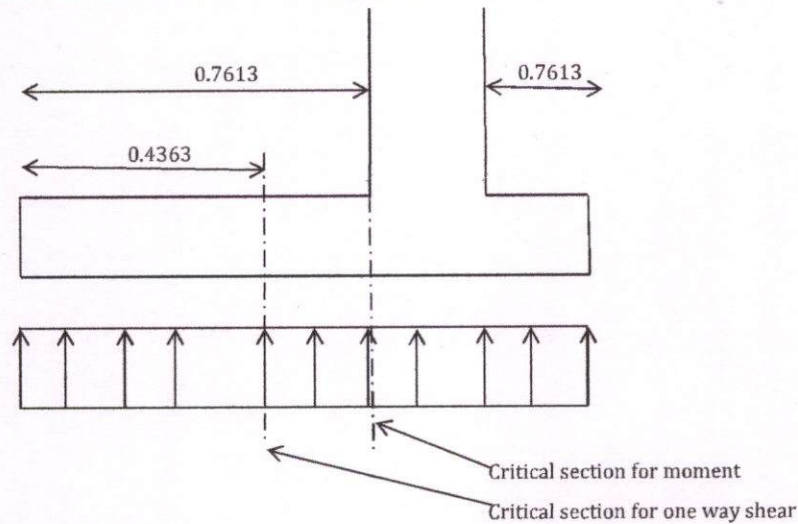
**SHRI BALAJI CONSULTANCY****DESIGN OF ISOLATED FOOTING**

Table 14 : Pressures at edges, moment and shear

Load Combinations	Edge pressures (kN/m ²)		Moment (kNm)	Ast reqd. mm ²	Shear kN/m
	PAC	PBD			
1.5 DL + C*1.5 LL + C*1.5 LLR	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL +X +CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL +X -CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL -X +CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL -X -CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL +Z +CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL +Z -CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL -Z +CPI	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 WL -Z -CPI	223.485	223.485	83.087	603.705	125.095
0.9 DL + 1.5 WL +X +CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL +X -CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL -X +CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL -X -CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL +Z +CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL +Z -CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL -Z +CPI	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 WL -Z -CPI	158.047	158.047	49.852	358.259	75.057
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	190.766	190.766	66.470	480.292	100.076
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	190.766	190.766	66.470	480.292	100.076
1.5 DL + 1.5 EL +X	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 EL -X	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 EL +Z	223.485	223.485	83.087	603.705	125.095
1.5 DL + 1.5 EL -Z	223.485	223.485	83.087	603.705	125.095
0.9 DL + 1.5 EL +X	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 EL -X	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 EL +Z	158.047	158.047	49.852	358.259	75.057
0.9 DL + 1.5 EL -Z	158.047	158.047	49.852	358.259	75.057
1.2 DL + b*1.2 LL + 1.2 EL +X	190.766	190.766	66.470	480.292	100.076
1.2 DL + b*1.2 LL + 1.2 EL -X	190.766	190.766	66.470	480.292	100.076
1.2 DL + b*1.2 LL + 1.2 EL +Z	190.766	190.766	66.470	480.292	100.076
1.2 DL + b*1.2 LL + 1.2 EL -Z	190.766	190.766	66.470	480.292	100.076

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


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Ast required	=	799.186	mm ²	
Spacing of 10mm dia bars required	=	172.236	mm	
Provided spacing	=	172.000	mm	Hence Safe.
Dear shear force	=	125.095	kN/m	
Design shear stress	=	Vu/bd		
	=	0.220	N/mm ²	
100Ast/bd	=	0.080		
Allowable shear stress Tc	=	0.280	N/mm ²	
	>	0.220	N/mm ²	Hence Safe.

100Ast/bd	Tc
0.15	0.28
0.25	0.36
0.080	0.280

15 REINFORCEMENTS & ONE WAY SHEAR ALONG Z AXIS

$$\mu_u = (0.87 \cdot f_y \cdot A_{st} \cdot d) \cdot (1 - (f_y \cdot A_{st}) / (f_{ck} \cdot b \cdot d))$$

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	10	172.000

Effective depth	=	315 mm
Minimum Ast	=	799.1856 mm ²


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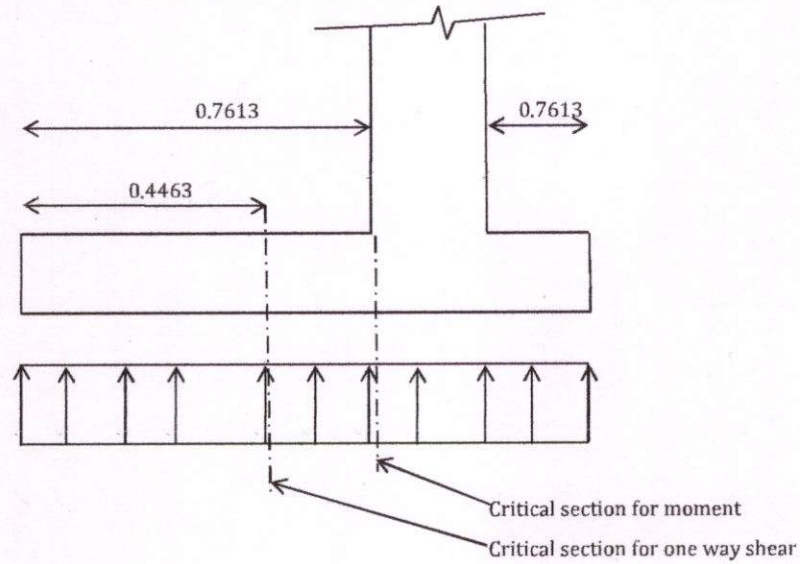
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Table 15 : Pressures at edges, moment and shear

Load Combinations	Edge pressures (kN/m ²)		Moment (kNm)	Ast reqd. mm ²	Shear kN
	PAB	PCD			
1.5 DL + C*1.5 LL + C*1.5 LLR	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL +X +CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL +X -CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL -X +CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL -X -CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL +Z +CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL +Z -CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL -Z +CPI	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 WL -Z -CPI	223.485	223.485	83.087	623.999	127.962
0.9 DL + 1.5 WL +X +CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL +X -CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL -X +CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL -X -CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL +Z +CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL +Z -CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL -Z +CPI	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 WL -Z -CPI	158.047	158.047	49.852	370.020	76.777
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	190.766	190.766	66.470	496.245	102.369
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	190.766	190.766	66.470	496.245	102.369
1.5 DL + 1.5 EL +X	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 EL -X	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 EL +Z	223.485	223.485	83.087	623.999	127.962
1.5 DL + 1.5 EL -Z	223.485	223.485	83.087	623.999	127.962
0.9 DL + 1.5 EL +X	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 EL -X	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 EL +Z	158.047	158.047	49.852	370.020	76.777
0.9 DL + 1.5 EL -Z	158.047	158.047	49.852	370.020	76.777
1.2 DL + b*1.2 LL + 1.2 EL +X	190.766	190.766	66.470	496.245	102.369
1.2 DL + b*1.2 LL + 1.2 EL -X	190.766	190.766	66.470	496.245	102.369
1.2 DL + b*1.2 LL + 1.2 EL +Z	190.766	190.766	66.470	496.245	102.369
1.2 DL + b*1.2 LL + 1.2 EL -Z	190.766	190.766	66.470	496.245	102.369

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


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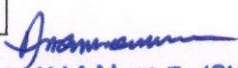
Ast required	=	799.186	mm ²	
Spacing of 10mm dia bars required	=	172.236	mm	
Provided spacing	=	172.000	mm	Hence Safe.
Dear shear force	=	127.962	kN/m	
Design shear stress	=	Vu/bd		
	=	0.232	N/mm ²	
100Ast/bd	=	0.083		
Allowable shear stress	Tc	=	0.280	N/mm ²
		>	0.232	N/mm ² Hence Safe.

100Ast/bd	Tc
0.15	0.28
0.25	0.36
0.083	0.280


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**SHRI BALAJI CONSULTANCY****DESIGN OF ISOLATED FOOTING****CHECK FOR TWO WAY SHEAR****16 Check for punching shear**

Load Combinations	Edge pressures (kN/m ²)		s.w of footing + above soil + load	soil pressure at centre (kN/m ²)	shear (kN)
	PAB	PCD			
1.5 DL + C*1.5 LL + C*1.5 LLR	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL +X +CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL +X -CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL -X +CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL -X -CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL +Z +CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL +Z -CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL -Z +CPI	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 WL -Z -CPI	223.485	223.485	-582.409	223.485	-284.222
0.9 DL + 1.5 WL +X +CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL +X -CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL -X +CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL -X -CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL +Z +CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL +Z -CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL -Z +CPI	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 WL -Z -CPI	158.047	158.047	-381.409	158.047	-170.533
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	190.766	190.766	-481.909	190.766	-227.378
1.5 DL + 1.5 EL +X	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 EL -X	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 EL +Z	223.485	223.485	-582.409	223.485	-284.222
1.5 DL + 1.5 EL -Z	223.485	223.485	-582.409	223.485	-284.222
0.9 DL + 1.5 EL +X	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 EL -X	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 EL +Z	158.047	158.047	-381.409	158.047	-170.533
0.9 DL + 1.5 EL -Z	158.047	158.047	-381.409	158.047	-170.533
1.2 DL + b*1.2 LL + 1.2 EL +X	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + b*1.2 LL + 1.2 EL -X	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + b*1.2 LL + 1.2 EL +Z	190.766	190.766	-481.909	190.766	-227.378
1.2 DL + b*1.2 LL + 1.2 EL -Z	190.766	190.766	-481.909	190.766	-227.378


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	SHRI BALAJI CONSULTANCY
	DESIGN OF ISOLATED FOOTING

Perimeter of the critical section (b0)	=	2200 mm
Effective depth	=	315 mm
Punching shear stress	=	0.410 N/mm ²
Ratio of short side to long side of the column β_c	=	1
Allowable punching shear stress	=	$(0.5 + \beta_c) * 0.25 * \sqrt{f_{ck}}$
	=	1.118 N/mm ²
	>	0.410 N/mm ²

Hence Safe.



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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	l_x	=	3277.000 mm
Longer span	l_y	=	3810.000 mm
Span ratio	l_y / l_x	=	1.163
		$\leq$	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} mm ² /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	=	2.250 kN/m ²
Self Weight of slab	=	25 * 0.115
	=	2.875 kN/m ²
Total	=	5.125 kN/m ²

5 LIVE LOAD

Live load on slab (Table 1 of IS 875 Part 2)	=	1.500 kN/m ²
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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	=	$[1.5 \text{ DL} + 1.5 \text{ LL}] = w = 9.938 \text{ kN/m}^2$


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SHRI BALAJI CONSULTANCY

DESIGN OF TWO WAY SLAB - S1

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 l_y/l_x	Short span coefficient α_x		Long span coefficient α_y	
	- ve moment at continuous Edge	+ ve moment at midspan	- ve moment at continuous Edge	+ ve moment at midspan
1.100	0.053	0.040	0.047	0.035
1.200	0.060	0.045		
1.163	0.057	0.043		

$$\begin{aligned}
 \text{Negative Bending moment at the short span} &= M_x = \alpha_x \times w \times l_x^2 = 6.124 \text{ kNm} \\
 \text{Positive Bending moment at the short span} &= M_{+x} = \alpha_{+x} \times w \times l_x^2 = 4.603 \text{ kNm} \\
 \text{Negative Bending moment at the long span} &= M_y = \alpha_y \times w \times l_x^2 = 5.016 \text{ kNm} \\
 \text{Positive Bending moment at the long span} &= M_{+y} = \alpha_{+y} \times w \times l_x^2 = 3.735 \text{ kNm}
 \end{aligned}$$

8 LIMIT STATE OF COLLAPSE - FLEXURE & SHEAR

$$\begin{aligned}
 \text{Minimum reinforcements (Cl. 26.5.2.1 of IS 456)} &= 0.12 \% \\
 &= 138 \text{ mm}^2
 \end{aligned}$$

A REINFORCEMENTS ALONG SHORT SPAN AT BOTTOM

$$\text{Positive Bending moment at the short span} = 4.603 \text{ kNm}$$

Area of reinf. steel required is calculated as per Annex G of IS 456 :

$$\text{Area of tension reinforcement required} = A_{st \text{ reqd.}} = 113.585 \text{ mm}^2$$

$$\text{Spacing of 8 mm dia. bars required} = 442.536 \text{ mm}$$

$$\text{Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller} = 288.000 \text{ mm}$$

$$\text{Hence spacing of 8 mm dia. bars required is the minimum of the above two values} = 288.000 \text{ mm}$$

$$\text{Spacing of 8 mm dia. bars provided} = 200.000 \text{ mm}$$

$$\begin{aligned}
 \text{Area of tension reinforcement provided} &= A_{st \text{ prov.}} = 251.327 \text{ mm}^2 \\
 &> 138.000 \text{ mm}^2
 \end{aligned}$$

Hence Safe

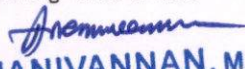
Moment of resistance is calculated as per Annex G of IS 456 :

$$\begin{aligned}
 \text{Ratio between depth of neutral axis and effective depth} &= x_u / d = (0.87 f_y A_{st}) / (0.36 f_{ck} b d) \\
 &= 0.158
 \end{aligned}$$

$$\begin{aligned}
 \text{Depth of neutral axis} &= x_u = 0.158 \times 96 \\
 &= 15.168 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 \text{As per cl. 38.1 of IS 456, the limiting value of } x_u/d &= x_{u, \text{max}} / d = 0.460 \\
 &> 0.158
 \end{aligned}$$

Hence Safe


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	SHRI BALAJI CONSULTANCY
	DESIGN OF TWO WAY SLAB - S1

Limiting value of the depth of neutral axis	=	44.160 mm
Moment of resistance $M_u = 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck}))$	=	9.809 kNm
	>	4.603 kNm

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

$= 0.36 * x_{u,max} / d (1 - 0.42 x_{u,max} / d) * b d^2 f_{ck} =$	$M_{u,lim} =$	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 $M_{u,lim} =$	$A_{st1} =$	113.585 mm ²
Total tension reinforcement required = $A_{st1} + A_{st2} =$	$A_{st} =$	113.585 mm ²

B REINFORCEMENTS ALONG LONG SPAN AT BOTTOM

Positive Bending moment at the long span	=	3.735 kNm
<i>Area of reinf. steel required is calculated as per Annex G of IS 456 :</i>		
Area of tension reinforcement required =	$A_{st} \text{ reqd.} =$	100.436 mm ²
Spacing of mm dia. bars required	=	500.471 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 =	$A_{st} \text{ prov.} =$	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 =	$x_u / d =$	$(0.87 f_y A_{st}) / (0.36 f_{ck} b d)$
	=	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 $x_u / d =$	$x_{u,max} / d =$	0.460
	>	0.173

Hence Safe

Limiting value of the depth of neutral axis	=	40.480 mm
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	SHRI BALAJI CONSULTANCY
	DESIGN OF TWO WAY SLAB - S1

Moment of resistance $M_u = 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 8.934 \text{ kNm}$


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**SHRI BALAJI CONSULTANCY****DESIGN OF TWO WAY SLAB - S1**

$$> 3.735 \text{ kNm}$$

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

$$= 0.36 * x_{u,max}/d (1 - 0.42 x_{u,max}/d) * b d^2 f_{ck} = M_{u,lim} = 20.693 \text{ kNm}$$

$$> 8.934 \text{ kNm}$$

Hence compression reinforcements are not required.

$$\text{Design stress in compression reinforcement} = f_{sc} = 500.000 \text{ N/mm}^2$$

$$\text{Depth of compression reinf. from compression face} = d' = 15 + 8/2 = 19.000 \text{ mm}$$

$$\text{Area of compression reinforcement} = (M_u - M_{u,lim}) / (f_{sc} (d - d')) = A_{sc} = 0 \text{ mm}^2$$

$$\text{Area of compression reinforcement provided} = 0 \text{ mm}^2$$

$$\text{Additional tension reinforcement required} = A_{st2} = 0 \text{ mm}^2$$

$$\text{Area of tension reinforcement required for a singly reinforced section for } M_{u,lim} = A_{st1} = 100.436 \text{ mm}^2$$

$$\text{Total tension reinforcement required} = A_{st1} + A_{st2} = A_{st} = 100.436 \text{ mm}^2$$

C REINFORCEMENTS AT LONG EDGE AT TOP

$$\text{Negative Bending moment at the short span} = 6.124 \text{ kNm}$$

Area of reinf. steel required is calculated as per Annex G of IS 456 :

$$\text{Area of tension reinforcement required} = A_{st \text{ reqd.}} = 152.721 \text{ mm}^2$$

$$\text{Spacing of mm dia. bars required} = 329.132 \text{ mm}$$

$$\text{Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller} = 288.000 \text{ mm}$$

$$\text{Hence spacing of mm dia. bars required is the minimum of the above two values} = 288.000 \text{ mm}$$

$$\text{Spacing of mm dia. bars provided} = 200.000 \text{ mm}$$

$$\text{Area of tension reinforcement provided} = A_{st \text{ prov.}} = 251.327 \text{ mm}^2$$
$$> 152.721 \text{ mm}^2$$

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

$$\text{Ratio between depth of neutral axis and effective depth} = x_u / d = (0.87 f_y A_{st}) / (0.36 f_{ck} b d) = 0.158$$

$$\text{Depth of neutral axis} = x_u = 0.158 * 96 = 15.168 \text{ mm}$$

$$\text{As per cl. 38.1 of IS 456, the limiting value of } x_u/d = x_{u,max} / d = 0.460$$
$$> 0.158$$

Hence Safe

$$\text{Limiting value of the depth of neutral axis} = 44.160 \text{ mm}$$

$$\text{Moment of resistance } M_u = 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 9.809 \text{ kNm}$$

$$> 6.124 \text{ kNm}$$

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SHRI BALAJI CONSULTANCY

DESIGN OF TWO WAY SLAB - S1

Hence Safe

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**SHRI BALAJI CONSULTANCY****DESIGN OF TWO WAY SLAB - S1**

Limiting moment of resistance of the section without compression reinforcement

$$= 0.36 * x_{u,max}/d (1 - 0.42 x_{u,max}/d) * b d^2 f_{ck} = M_{u,lim} = 24.626 \text{ kNm}$$
$$> 9.809 \text{ kNm}$$

Hence compression reinforcements are not required.

Design stress in compression reinforcement = $f_{sc} = 500.000 \text{ N/mm}^2$

Depth of compression reinf. from compression face = $d' = 15 + 8/2 = 19.000 \text{ mm}$

Area of compression reinforcement = $(M_u - M_{u,lim}) / (f_{sc} (d - d')) = A_{sc} = 0 \text{ mm}^2$

Area of compression reinforcement provided = 0 mm^2

Additional tension reinforcement required = $A_{st2} = 0 \text{ mm}^2$

Area of tension reinforcement required for a singly reinforced section for $M_{u,lim}$ $A_{st1} = 152.721 \text{ mm}^2$

Total tension reinforcement required = $A_{st1} + A_{st2} = A_{st} = 152.721 \text{ mm}^2$

D REINFORCEMENTS AT SHORT EDGE AT TOP

Negative Bending moment at the long span = 5.016 kNm

Area of reinf. steel required is calculated as per Annex G of IS 456 :

Area of tension reinforcement required = $A_{st \text{ reqd.}} = 136.313 \text{ mm}^2$

Spacing of mm dia. bars required = 368.750 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 = $A_{st \text{ prov.}} = 251.327 \text{ mm}^2$

$$> 138.000 \text{ mm}^2$$

Hence Safe

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

Ratio between depth of neutral axis and effective depth = $x_u / d = (0.87 f_y A_{st}) / (0.36 f_{ck} b d) = 0.173$

Depth of neutral axis = $x_u = 0.173 * 88 = 15.224 \text{ mm}$

As per cl. 38.1 of IS 456, the limiting value of $x_u/d = x_{u,max} / d = 0.460$

$$> 0.173$$

Hence Safe

Limiting value of the depth of neutral axis = 40.480 mm

Moment of resistance $M_u = 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 8.934 \text{ kNm}$

$$> 5.016 \text{ kNm}$$

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

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SHRI BALAJI CONSULTANCY

DESIGN OF TWO WAY SLAB - S1

$$= 0.36 \times x_{u,max}/d (1 - 0.42 x_{u,max}/d) \times b d^2 f_{ck} =$$

$$M_{u,lim} = 20.693 \text{ kNm}$$

$$> 8.934 \text{ kNm}$$

Hence compression reinforcements are not required.

$$\text{Design stress in compression reinforcement} =$$

$$f_{sc} = 500.000 \text{ N/mm}^2$$

$$\text{Depth of compression reinf. from compression face} =$$

$$d' = 15 + 8/2$$

$$= 19.000 \text{ mm}$$

$$\text{Area of compression reinforcement} = (M_u - M_{u,lim}) / (f_{sc} (d - d')) = A_{sc}$$

$$= 0 \text{ mm}^2$$

$$\text{Area of compression reinforcement provided} =$$

$$= 0 \text{ mm}^2$$

$$\text{Additional tension reinforcement required} =$$

$$A_{st2} = 0 \text{ mm}^2$$

$$\text{Area of tension reinforcement required for a singly reinforced section for } M_{u,lim} =$$

$$A_{st1} = 136.313 \text{ mm}^2$$

$$\text{Total tension reinforcement required} = A_{st1} + A_{st2} =$$

$$A_{st} = 136.313 \text{ mm}^2$$

E TORSIONAL REINFORCEMENTS

Torsion reinforcements at corners, whose two edges are simply supported (Cl. D.1.8 of IS 456)

$$= 3/4 \times 113.585$$

$$= 85.189 \text{ mm}^2$$

Torsion reinforcements at corners, whose one edge is simply supported (Cl. D.1.9 of IS 456)

$$= 1/2 \times 85.189$$

$$= 42.595 \text{ mm}^2$$

F CHECK FOR SHEAR

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

Ratio of l_y/l_x	Short span coefficient β_x	
	continuous edge	discontinuous edge
1.100	0.440	0.290
1.200	0.470	0.310
1.163	0.459	0.303

Long span coefficient β_y	
continuous edge	discontinuous edge
0.400	0.260

$$\text{Shear force at the long continuous edge} = \beta_{cx} \times W \times l_x = V_{cx} = 14.941 \text{ kN}$$

$$\text{Shear force at the long discontinuous edge} = \beta_{dx} \times W \times l_x = V_{dx} = 9.852 \text{ kN}$$

$$\text{Shear force at the short continuous edge} = \beta_{cy} \times W \times l_y = V_{cy} = 13.027 \text{ kN}$$

$$\text{Shear force at the short discontinuous edge} = \beta_{dy} \times W \times l_y = V_{dy} = 8.467 \text{ kN}$$

Check for shear near long edge :

$$\text{Shear force due to design loads} V_u = 14.941 \text{ kN}$$

$$\text{Effective depth} d = 96.000 \text{ mm}$$

$$\text{Nominal shear stress (Cl. 40.1 of IS 456)} T_v = V_u / b d = 0.156 \text{ N/mm}^2$$

$$\text{Maximum shear stress (Cl. 40.2.3.1 of IS 456)} T_{c \text{ max}} = 1.400 \text{ N/mm}^2$$

$$> 0.156 \text{ N/mm}^2$$

Hence SAFE

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**SHRI BALAJI CONSULTANCY****DESIGN OF TWO WAY SLAB - S1**

Area of reinf. provided = 251.327 mm²
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 $\tau_{ck} = 0.475 \text{ N/mm}^2$
 $> 0.156 \text{ N/mm}^2$
Hence SAFE

Check for shear near short edge :

Shear force due to design loads $V_u = 13.027 \text{ kN}$
Effective depth $d = 88.000 \text{ mm}$
Nominal shear stress (Cl. 40.1 of IS 456) $\tau_v = V_u / bd = 0.148 \text{ N/mm}^2$
Maximum shear stress (Cl. 40.2.3.1 of IS 456) $\tau_{c \text{ max}} = 1.400 \text{ N/mm}^2$
 $> 0.148 \text{ N/mm}^2$
Hence SAFE

Area of reinf. provided = 251.327 mm²
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 $\tau_{ck} = 0.490 \text{ N/mm}^2$
 $> 0.148 \text{ N/mm}^2$
Hence SAFE

9 LIMIT STATE OF SERVICEABILITY - DEFLECTION & CRACKING**A CHECK FOR DEFLECTION**

Allowable long term deflection (Cl. 23.2 of IS 456) = $l_x / 350$
= 9.363 mm
Basic allowable span to effective depth ratio (Cl. 23.2.1 of IS 456) = 26.000 mm
Steel stress at service loads $f_s = 0.58 f_y A_{st, reqd.} / A_{st, prov.}$
= 159.235 N/mm²


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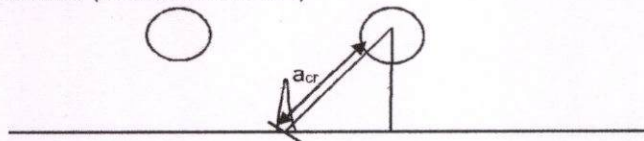
DESIGN OF TWO WAY SLAB - S1

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	=	34.135
	<	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	$M =$	4.603 kNm
Section modulus	$Z =$	$\frac{bd^2}{6}$
	=	1536000.000 mm ³
Maximum compressive stress in concrete	$f_c =$	M/Z
	=	2.997 N/mm ²
Maximum tensile stress in reinf. Steel	$f_s =$	$f_c * m$
	=	26.804 N/mm ²
Average steel strain at the level considered	=	f_s / E_s
	=	0.134
Maximum allowable strain	=	$0.8 f_y / E_s$
	=	0.002
Average steel strain at the level considered	$\epsilon_m =$	0.002
Design surface crack width (Annex F of IS 456)	$W_{cr} =$	$\frac{3 a_{cr} \epsilon_m}{1 + 2(a_{cr} - C_{min})/(h - x)}$
	=	0.221 mm
	<	0.300 mm

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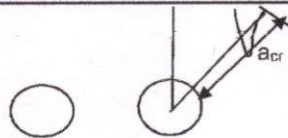


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DESIGN OF TWO WAY SLAB - S1

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
Maximum moment	$M =$	6.124 kNm
Section modulus	$Z =$	$bd^2 / 6$
	$=$	1536000.000 mm ³
Maximum compressive stress in concrete	$f_c =$	M/z
	$=$	3.987 N/mm ²
Maximum tensile stress in reinf. Steel	$f_s =$	$f_c * m$
	$=$	35.661 N/mm ²
Average steel strain at the level considered	$=$	f_s / E_s
	$=$	0.178
Maximum allowable strain	$=$	$0.8 f_y / E_s$
	$=$	0.002
Average steel strain at the level considered	$\epsilon_m =$	0.002
Design surface crack width (Annex F of IS 456)	$W_{cr} =$	$\frac{3 a_{cr} \epsilon_m}{1 + 2(a_{cr} - C_{min})/(h - x)}$
	$=$	0.223 mm
	$<$	0.300 mm
Hence Safe		

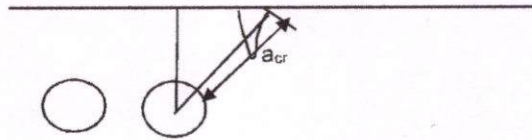
D CHECK FOR CRACK WIDTH AT SUPPORT OF SHORT EDGE


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DESIGN OF TWO WAY SLAB - S1



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	$M =$	5.016 kNm
Section modulus	$Z =$	$bd^2 / 6$
	$=$	1290666.667 mm ³
Maximum compressive stress in concrete	$f_c =$	M/z
	$=$	3.886 N/mm ²
Maximum tensile stress in reinf. Steel	$f_s =$	$f_c * m$
	$=$	34.761 N/mm ²
Average steel strain at the level considered	$=$	f_s / E_s
	$=$	0.174
Maximum allowable strain	$=$	$0.8 F_y / E_s$
	$=$	0.002
Average steel strain at the level considered	$\epsilon_m =$	0.002
Design surface crack width (Annex F of IS 456)	$W_{cr} =$	$\frac{3 a_{cr} \epsilon_m}{1 + 2(a_{cr} - C_{min})/(h - x)}$
	$=$	0.223 mm
	$<$	0.300 mm
		Hence Safe

10 SLAB REACTIONS

Refer code SP 24-1983 Cl:23.5

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

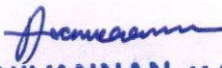
Unfactored long beam UDL reaction due to dead load

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**SHRI BALAJI CONSULTANCY****DESIGN OF TWO WAY SLAB - S1**

Unfactored load	=	5.125 kN/m ²
	=	6.327 kN/m
Unfactored long beam UDL reaction due to live load		
Unfactored load	=	1.500 kN/m ²
	=	1.852 kN/m
<i>On the short span, $wl_x/3$</i>		
Unfactored long beam UDL reaction due to dead load		
Unfactored load	=	5.125 kN/m ²
	=	5.598 kN/m
Unfactored long beam UDL reaction due to live load		
Unfactored load	=	1.500 kN/m ²
	=	1.639 kN/m


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BEAM NO. 2 DESIGN RESULTS

M20 Fe500 (Main) Fe500 (Sec.)

LENGTH: 4533.0 mm SIZE: 230.0 mm X 457.0 mm COVER: 25.0 mm

STAAD SPACE

-- PAGE NO. 6

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1133.2 mm	2266.5 mm	3399.8 mm	4533.0 mm
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TOP	0.00	69.42	333.45	69.42	0.00
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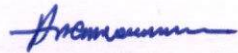
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
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BOTTOM	0.00	793.52	1039.45	793.52	0.00
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REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
--------	----------	----------	----------	----------	----------

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1133.2 mm	2266.5 mm	3399.8 mm	4533.0 mm
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TOP 2-12í 3-12í 3-12í 3-12í 2-12í

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

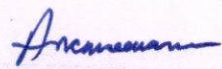
BOTTOM 2-12í 8-12í 10-12í 8-12í 2-12í

REINF. 1 layer(s) 2 layer(s) 2 layer(s) 2 layer(s) 1 layer(s)

SHEAR 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í 2 legged 8í

REINF. @ 300 mm c/c @ 300 mm c/c @ 300 mm c/c @ 300 mm c/c @ 300 mm c/c

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COLUMN NO. 6 DESIGN RESULTS

M20 Fe500 (Main) Fe500 (Sec.)

LENGTH: 4000.0 mm CROSS SECTION: 457.0 mm X 230.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 251 END JOINT: 7 UNBRACED LONG(Z)/SHORT(Y)

REQD. STEEL AREA : 283.52 Sq.mm.

REQD. CONCRETE AREA: 104826.48 Sq.mm.

MAIN REINFORCEMENT : Provide 8 - 12 dia. (0.86%, 904.78 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 1049.76 Muz1 : 29.76 Muy1 : 63.52

INTERACTION RATIO: 0.61 (as per Cl. 39.6, IS456:2000)

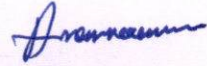
SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)


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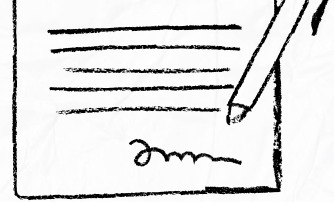
WORST LOAD CASE: 251

END JOINT: 7 Puz: 1277.14 Muz: 42.13 Muy: 100.30 IR: 0.44

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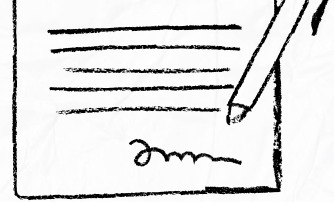
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