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Date : 02/02/2026

**CERTIFICATE FOR STRUCTURAL DESIGN SUFFICIENCY AND
SAFE & SOUND**

With respect to the proposed construction of Residential unit in

Residential Building – S.No: 21/1A2,21/1B at Thuvariman
Village/Panchayat Thiruparankundram Panchayat Union, Madurai
Local Palanning Authority, Madurai west Taluk, Madurai District.
Site area 4169.77 Sq.m Proposal of residential building
(G+1 Floor) for FSI area of 3350.94 SQ.M (14 Blocks)

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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STABILITY CERTIFICATE

Date : 02/02/2026

The detailed engineering and structure design of the proposed building comprising of G+1 floors at S.No: 21/1A2,21/1B at Thuvariman Village/Panchayat Thiruparankundram Panchayat Union, Madurai Local Palanning Authority, Madurai west Taluk, Madurai District. Site area 4169.77 Sq.m Proposal of residential building (G+1 Floor) for FSI area of 3350.94 SQ.M (14 Blocks) has been done by me/us based on the report of geotechnical investigation (soil test) done by Geomatrix Report No. 366/RB/GMC/2025-26 Dated 13/01/26 and considering the functional requirement of the building.

2.It is certified that among other factors, the proposed building has been designed to resist earthquake. I/We have checked various parameters and found that the proposed building would be safe.

3. I/We further certify that:

(i) The minimum grade of concrete is M20

(ii) The design and analysis has been done using the code of practice for plain and reinforced concrete as per IS 456, design loads as per IS Codes No IS 875 and design of earthquake resistant structure as per IS Code No IS 1893

4.The building will be safe and sound when used for the purpose for which it is designed.

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Encl.: Structural Design Calculation

Stamp and Signature

Date: 02/02/2026

STRUCTURAL DESIGN STABILITY CERTIFICATE

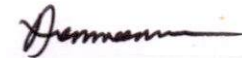
This is to certify that the PROPOSED NEW CONSTRUCTION OF RESIDENTIAL Units in S.No: 21/1A2,21/1B at Thuvariman Village/Panchayat Thiruparankundram Panchayat Union, Madurai Local Palanning Authority, Madurai west Taluk, Madurai District. Site area 4169.77 Sq.m Proposal of residential building (G+1 Floor) for FSI area of 3350.94 SQ.M (14 Blocks). Is designed as per the following IS Codes

1. IS: 456:2000, code of practice for plain and reinforced concrete
2. IS: 875-1987, code of practice for design loads for building and structures.
3. IS: 1893-2016, criteria for earthquake resistant design of structures.

The building Designed by me consists of Ground + 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)

Date : 02/02/2026

STRUCTURE:

The proposed Building has been envisaged as R.C Framed Structure with Ground + First floor. The Ground + First Floor is 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 Building and Structures.

Part (1) – Dead Loads – Unit Weights of Building Materials and Stored Materials (second revision)

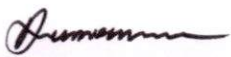
Part (2) – Impact Loads (second revision) Part (3) –

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.
SP:7-1983		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.C members is . The Steel grade considered in the design is Fe500.


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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****1 MATERIAL PROPERTIES**

Unit weight of reinforced concrete	γ_c	=	25.000 kN/m ³
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)	f_{ck}	=	25.000 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	=	2.286 m
Footing plan dimension along Z axis	W	=	2.286 m
Thickness of footing	t	=	0.450 m
Column plan dimension along X axis	a	=	0.230 m
Column plan dimension along Z axis	b	=	0.450 m
Depth of footing below NGL	D	=	2.100 m
Eccentricity of the column along X axis	e_x	=	0.000 m
Eccentricity of the column along Z axis	e_z	=	0.000 m

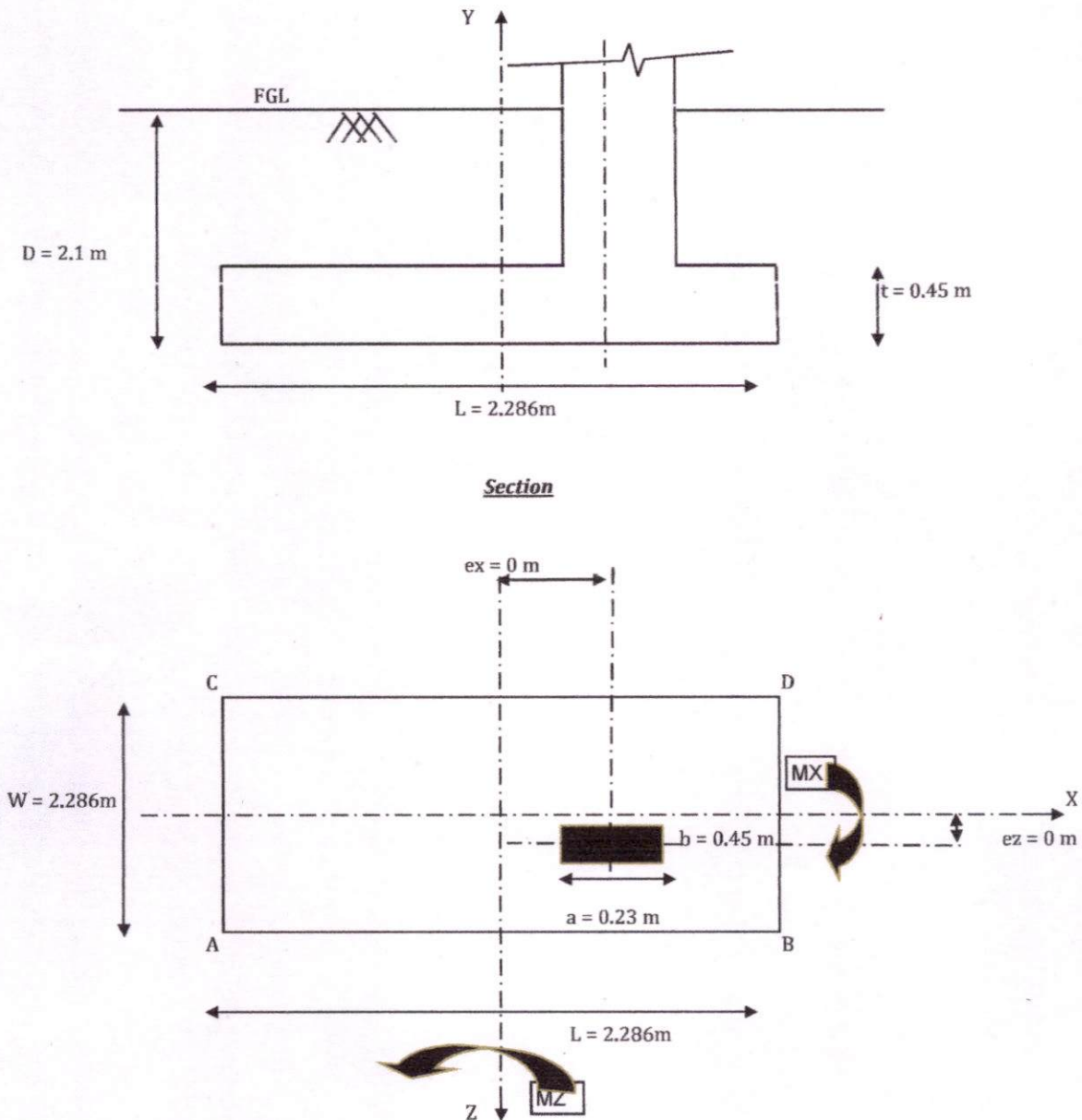
3 SOIL PROPERTIES

Density of soil	γ_{soil}	=	18.000 kN/m ³
Net bearing capacity of soil (from soil report)		=	111.200 kN/m ²
Allowable gross SBC		=	$111.2 + 18 \times 2.1$
		=	149.000 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 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 SKETCHPlan

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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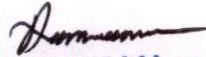
**6 LOADS AT TOP OF FOOTING**

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)	-1.691	-484.984	0.256	0.000	0.000
LIVE LOAD (LL)	-0.029	-64.710	0.038	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	-9.493	0.000	0.000	0.000


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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1**

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

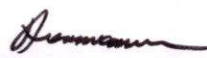
Load combinations	Fxt (kN)	Fyt (kN)	Fzt (kN)	Mxt (kNm)	Mzt (kNm)
1.0 DL + a*1.0 LL+a*1.0 LLR	-1.710	-529.506	0.279	0.000	0.000
1.0 DL + 1.0 WL +X +CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL +X -CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL -X +CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL -X -CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL +Z +CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL +Z -CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL -Z +CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 WL -Z -CPI	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	-1.706	-520.601	0.274	0.000	0.000
1.0 DL + 1.0 EL +X	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 EL -X	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 EL +Z	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + 1.0 EL -Z	-1.691	-484.984	0.256	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	-1.697	-497.926	0.264	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	-1.697	-497.926	0.264	0.000	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	-1.697	-497.926	0.264	0.000	0.000
1.0 DL +b* 0.8 LL + 0.8 EL -Z	-1.697	-497.926	0.264	0.000	0.000

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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1**

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	-2.564	-794.259	0.418	0.000	0.000
1.5 DL + 1.5 WL +X +CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL +X -CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL -X +CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL -X -CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL +Z +CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL +Z -CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL -Z +CPI	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 WL -Z -CPI	-2.537	-727.476	0.384	0.000	0.000
0.9 DL + 1.5 WL +X +CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL +X -CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL -X +CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL -X -CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL +Z +CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL +Z -CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL -Z +CPI	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 WL -Z -CPI	-1.522	-436.486	0.230	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	-2.052	-635.407	0.335	0.000	0.000
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	-2.052	-635.407	0.335	0.000	0.000
1.5 DL + 1.5 EL +X	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 EL -X	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 EL +Z	-2.537	-727.476	0.384	0.000	0.000
1.5 DL + 1.5 EL -Z	-2.537	-727.476	0.384	0.000	0.000
0.9 DL + 1.5 EL +X	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 EL -X	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 EL +Z	-1.522	-436.486	0.230	0.000	0.000
0.9 DL + 1.5 EL -Z	-1.522	-436.486	0.230	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +X	-2.038	-601.394	0.319	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -X	-2.038	-601.394	0.319	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL +Z	-2.038	-601.394	0.319	0.000	0.000
1.2 DL + b*1.2 LL + 1.2 EL -Z	-2.038	-601.394	0.319	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 * 2.286 * 2.286 * 0.45
	=	-58.790 kN
Weight of soil above footing	WS =	18 * (2.286*2.286 - 0.23*0.45) * 1
	=	-152.132 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	-1.710	-740.428	0.279	-0.125	-0.769
1.0 DL + 1.0 WL +X +CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL +X -CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL -X +CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL -X -CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL +Z +CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL +Z -CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL -Z +CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 WL -Z -CPI	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	-1.706	-731.524	0.274	-0.123	-0.768
1.0 DL + 1.0 EL +X	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 EL -X	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 EL +Z	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + 1.0 EL -Z	-1.691	-695.906	0.256	-0.115	-0.761
1.0 DL + b*0.8 LL + 0.8 EL +X	-1.697	-708.848	0.264	-0.119	-0.764
1.0 DL + b*0.8 LL + 0.8 EL -X	-1.697	-708.848	0.264	-0.119	-0.764
1.0 DL + b*0.8 LL + 0.8 EL +Z	-1.697	-708.848	0.264	-0.119	-0.764
1.0 DL + b*0.8 LL + 0.8 EL -Z	-1.697	-708.848	0.264	-0.119	-0.764

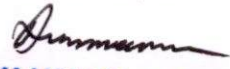
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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****Table 5 : Loads at bottom of footing (Unfactored load combinations) - for sliding check**

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	-1.541	-691.026	0.253	-0.114	-0.693
0.9 DL + 1.0 WL +X +CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL +X -CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL -X +CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL -X -CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL +Z +CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL +Z -CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL -Z +CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 WL -Z -CPI	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	-1.537	-661.933	0.249	-0.112	-0.692
0.9 DL + 1.0 EL +X	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 EL -X	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 EL +Z	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + 1.0 EL -Z	-1.522	-626.316	0.230	-0.104	-0.685
0.9 DL + b*0.8 LL + 0.8 EL +X	-1.528	-639.258	0.238	-0.107	-0.687
0.9 DL + b*0.8 LL + 0.8 EL -X	-1.528	-639.258	0.238	-0.015	-0.687
0.9 DL + b*0.8 LL + 0.8 EL +Z	-1.528	-639.258	0.238	-0.107	-0.687
0.9 DL + b* 0.8 LL + 0.8 EL -Z	-1.528	-639.258	0.238	-0.107	-0.687

8 CHECK FOR PRESSURE

Base area	A =	2.286 * 2.286
	=	5.226 m ²
Section modulus (X axis)	Z _x =	2.286 * 2.286 ² / 6
		1.991 mm ³
Section modulus (Z axis)	Z _z =	2.286 * 2.286 ² / 6
		1.991 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 F1****Table 6 : Pressures at four corners of the footing**

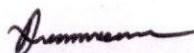
Load Combinations	Gross pr. at four corners (kN/m ²)			
	PA	PB	PC	PD
1.0 DL + a*1.0 LL+a*1.0 LLR	141.24	142.01	141.36	142.14
1.0 DL + 1.0 WL +X +CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL +X -CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL -X +CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL -X -CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL +Z +CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL +Z -CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL -Z +CPI	132.73	133.49	132.84	133.61
1.0 DL + 1.0 WL -Z -CPI	132.73	133.49	132.84	133.61
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	139.54	140.31	139.66	140.43
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	139.54	140.31	139.66	140.43
1.0 DL + 1.0 EL +X	132.73	133.49	132.84	133.61
1.0 DL + 1.0 EL -X	132.73	133.49	132.84	133.61
1.0 DL + 1.0 EL +Z	132.73	133.49	132.84	133.61
1.0 DL + 1.0 EL -Z	132.73	133.49	132.84	133.61
1.0 DL + b*0.8 LL + 0.8 EL +X	135.20	135.97	135.32	136.09
1.0 DL + b*0.8 LL + 0.8 EL -X	135.25	136.02	135.27	136.04
1.0 DL + b*0.8 LL + 0.8 EL +Z	135.20	135.97	135.32	136.09
1.0 DL + b*0.8 LL + 0.8 EL -Z	135.20	135.97	135.32	136.09

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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1**

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	142.14	111.200	0	111.2	37.8	149
1.0 DL + 1.0 WL +X +CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +X -CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -X +CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -X -CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +Z +CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL +Z -CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -Z +CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 WL -Z -CPI	133.61	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X-CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL +a*0.8 LL+a*0.8 LLR + 0.8 WL -X-CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z-CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z-CPI	140.43	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL +X	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL -X	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL +Z	133.61	111.200	25	139	37.8	176.8
1.0 DL + 1.0 EL -Z	133.61	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL +X	136.09	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL -X	136.04	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL +Z	136.09	111.200	25	139	37.8	176.8
1.0 DL + b*0.8 LL + 0.8 EL -Z	136.09	111.200	25	139	37.8	176.8


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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****Table 8 : P_{min}**

Load Combinations	P _{min} kN/m ²	Uplift	% loss of contact
1.0 DL + a*1.0 LL+a*1.0 LLR	141.24	No Uplift	0.000
1.0 DL + 1.0 WL +X +CPI	132.73	No Uplift	0.000
1.0 DL + 1.0 WL -X +CPI	132.73	No Uplift	0.000
1.0 DL + 1.0 WL +Z +CPI	132.73	No Uplift	0.000
1.0 DL + 1.0 WL -Z +CPI	132.73	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +X+CPI	139.54	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -X+CPI	139.54	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL +Z+CPI	139.54	No Uplift	0.000
1.0 DL + a*0.8 LL+a*0.8 LLR + 0.8 WL -Z+CPI	139.54	No Uplift	0.000
1.0 DL + 1.0 EL +X	132.73	No Uplift	0.000
1.0 DL + 1.0 EL -X	132.73	No Uplift	0.000
1.0 DL + 1.0 EL +Z	132.73	No Uplift	0.000
1.0 DL + 1.0 EL -Z	132.73	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +X	135.20	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL -X	135.25	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL +Z	135.20	No Uplift	0.000
1.0 DL + b*0.8 LL + 0.8 EL -Z	135.20	No Uplift	0.000

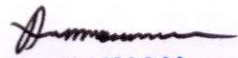
P max Without Wind load	=	142.14 kN/m ²	
	<	149.00 kN/m ²	Hence Safe.
P max With Wind load	=	140.43	
	<	186.25 kN/m ²	Hence Safe.
% loss of contact	=	0.0 %	
	≤	0.0 %	Hence Safe.
The Bearing pressure reached upto		95% of SBC	

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9 **CHECK FOR OVERTURNING**

Table 9 : Factor of safety against overturning

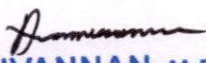
Load Combinations	Moment about X axis (kNm)			Moment about Z axis (kNm)		
	Overturning	Resisting	FOS	Overturning	Resisting	FOS
1.0*1.2 DL + a*1.0*1.4 LL+a*1.0*1.4 LLR	-0.153	-846.3094	Safe	-0.925	-846.309	Safe
1.0*1.2 DL + 1.0 WL +X +CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL +X -CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL -X +CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL -X -CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL +Z +CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL +Z -CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL -Z +CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 WL -Z -CPI	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	-0.150	-836.1317	Safe	-0.923	-836.132	Safe
1.0*1.2 DL + 1.0 EL +X	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 EL -X	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 EL +Z	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + 1.0 EL -Z	-0.138	-795.421	Safe	-0.913	-795.421	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	-0.143	-810.2137	Safe	-0.764	-810.214	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	-0.021	-810.2137	Safe	-0.917	-810.214	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	-0.143	-810.2137	Safe	-0.917	-810.214	Safe
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -Z	-0.166	-810.2137	Safe	-0.917	-810.214	Safe


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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****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	-1.541	-276.4103	179.429	0.253	-276.41	1091.668
0.9 DL + 1.0 WL +X +CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL +X -CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL -X +CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL -X -CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL +Z +CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL +Z -CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL -Z +CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 WL -Z -CPI	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X +CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +X -CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X +CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -X -CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z +CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9DL + a*0.8 LL + a*0.8 LLR + 0.8 WL +Z -CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z +CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + a*0.8 LL + a*0.8 LLR + 0.8 WL -Z -CPI	-1.537	-264.7733	172.291	0.249	-264.773	1064.886
0.9 DL + 1.0 EL +X	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 EL -X	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 EL +Z	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + 1.0 EL -Z	-1.522	-250.5263	164.614	0.230	-250.526	1087.354
0.9 DL + b*0.8 LL + 0.8 EL +X	-1.528	-255.7031	167.378	0.238	-255.703	1074.383
0.9 DL + b*0.8 LL + 0.8 EL -X	-1.528	-255.7031	167.378	0.238	-255.703	1074.383
0.9 DL + b*0.8 LL + 0.8 EL +Z	-1.528	-255.7031	167.378	0.238	-255.703	1074.383
0.9 DL + b*0.8 LL + 0.8 EL -Z	-1.528	-255.7031	167.378	0.238	-255.703	1074.383

Minimum factor of safety = 164.614
Allowable factor of safety = 1.400
< 164.614 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	-740.4282	100
1.0*1.2 DL + 1.0 WL +X +CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL +X -CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL -X +CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL -X -CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL +Z +CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL +Z -CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL -Z +CPI	0.000	-695.9064	100
1.0*1.2 DL + 1.0 WL -Z -CPI	0.000	-695.9064	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-731.5238	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-731.5238	100
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-731.5238	100
1.0*1.2 DL +a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 W	0.000	-731.5238	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	0.000	-731.5238	100
1.0*1.2 DL + a*0.8*1.4 LL+a*0.8*1.4 LLR + 0.8 V	0.000	-731.5238	100
1.0*1.2 DL + a*0.8*1.4LL+a*0.8*1.4 LLR + 0.8 V	0.000	-731.5238	100
1.0*1.2 DL + a*0.8*1.4LL+a*0.8*1.4 LLR + 0.8 V	0.000	-731.5238	100
1.0*1.2 DL + 1.0 EL +X	0.000	-695.9064	100
1.0*1.2 DL + 1.0 EL -X	0.000	-695.9064	100
1.0*1.2 DL + 1.0 EL +Z	0.000	-695.9064	100
1.0*1.2 DL + 1.0 EL -Z	0.000	-695.9064	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +X	0.000	-708.8484	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL -X	0.000	-708.8484	100
1.0*1.2 DL + b*0.8*1.4 LL + 0.8 EL +Z	0.000	-708.8484	100
1.0*1.2 DL +b* 0.8*1.4 LL + 0.8 EL -Z	0.000	-708.8484	100

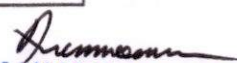
Minimum factor of safety = 100
 Allowable factor of safety = 1.200
 < 100.000 Hence Safe


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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)

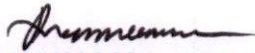
Load Combinations	F _x (kN)	P (kN)	F _z (kN)	M _x (kNm)	M _z (kNm)
1.5 DL + C*1.5 LL + C*1.5 LLR	-2.564	-1110.642	0.418	0.188	1.154
1.5 DL + 1.5 WL +X +CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL +X -CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL -X +CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL -X -CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL +Z +CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL +Z -CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL -Z +CPI	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 WL -Z -CPI	-2.537	-1043.860	0.384	0.173	1.141
0.9 DL + 1.5 WL +X +CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL +X -CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL -X +CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL -X -CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL +Z +CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL +Z -CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL -Z +CPI	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 WL -Z -CPI	-1.522	-752.869	0.230	0.104	0.685
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	-2.052	-951.791	0.335	0.151	0.923
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	-2.052	-951.791	0.335	0.151	0.923
1.5 DL + 1.5 EL +X	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 EL -X	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 EL +Z	-2.537	-1043.860	0.384	0.173	1.141
1.5 DL + 1.5 EL -Z	-2.537	-1043.860	0.384	0.173	1.141
0.9 DL + 1.5 EL +X	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 EL -X	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 EL +Z	-1.522	-752.869	0.230	0.104	0.685
0.9 DL + 1.5 EL -Z	-1.522	-752.869	0.230	0.104	0.685
1.2 DL + b*1.2 LL + 1.2 EL +X	-2.038	-917.777	0.319	0.143	0.917
1.2 DL + b*1.2 LL + 1.2 EL -X	-2.038	-917.777	0.319	0.143	0.917
1.2 DL + b*1.2 LL + 1.2 EL +Z	-2.038	-917.777	0.319	0.143	0.917
1.2 DL + b*1.2 LL + 1.2 EL -Z	-2.038	-917.777	0.319	0.143	0.917


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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	213.20	212.05	213.02	211.86
1.5 DL + 1.5 WL +X +CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL +X -CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL -X +CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL -X -CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL +Z +CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL +Z -CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL -Z +CPI	200.41	199.26	200.24	199.09
1.5 DL + 1.5 WL -Z -CPI	200.41	199.26	200.24	199.09
0.9 DL + 1.5 WL +X +CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL +X -CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL -X +CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL -X -CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL +Z +CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL +Z -CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL -Z +CPI	144.46	143.78	144.36	143.67
0.9 DL + 1.5 WL -Z -CPI	144.46	143.78	144.36	143.67
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	182.67	181.75	182.52	181.59
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	182.67	181.75	182.52	181.59
1.5 DL + 1.5 EL +X	200.41	199.26	200.24	199.09
1.5 DL + 1.5 EL -X	200.41	199.26	200.24	199.09
1.5 DL + 1.5 EL +Z	200.41	199.26	200.24	199.09
1.5 DL + 1.5 EL -Z	200.41	199.26	200.24	199.09
0.9 DL + 1.5 EL +X	144.46	143.78	144.36	143.67
0.9 DL + 1.5 EL -X	144.46	143.78	144.36	143.67
0.9 DL + 1.5 EL +Z	144.46	143.78	144.36	143.67
0.9 DL + 1.5 EL -Z	144.46	143.78	144.36	143.67
1.2 DL + b*1.2 LL + 1.2 EL +X	176.16	175.24	176.01	175.09
1.2 DL + b*1.2 LL + 1.2 EL -X	176.16	175.24	176.01	175.09
1.2 DL + b*1.2 LL + 1.2 EL +Z	176.16	175.24	176.01	175.09
1.2 DL + b*1.2 LL + 1.2 EL -Z	176.16	175.24	176.01	175.09


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SHRI BALAJI CONSULTANCY

- DESIGN OF ISOLATED FOOTING F1

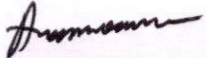
14 **REINFORCEMENTS & ONE WAY SHEAR ALONG X AXIS**

$$Mu = (0.87 \cdot fy \cdot Ast \cdot d) \cdot (1 - (fy \cdot Ast) / (fck \cdot b \cdot d))$$

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	10	145.000

Effective depth = 395 mm

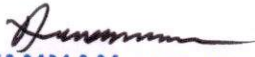
Minimum Ast = 1234.44 mm²

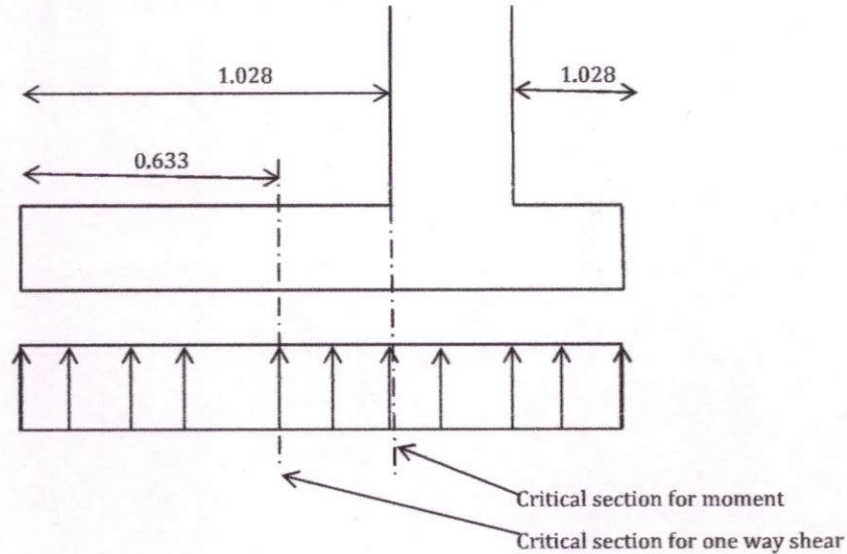

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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****Table 14 : Pressures at edges, moment and shear**

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	213.110	211.951	183.144	1092.300	220.307
1.5 DL + 1.5 WL +X +CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL +X -CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL -X +CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL -X -CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL +Z +CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL +Z -CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL -Z +CPI	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 WL -Z -CPI	200.325	199.178	167.712	998.131	201.810
0.9 DL + 1.5 WL +X +CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL +X -CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL -X +CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL -X -CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL +Z +CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL +Z -CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL -Z +CPI	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 WL -Z -CPI	144.412	143.724	100.627	593.439	121.086
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	182.597	181.669	146.515	869.442	176.245
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	182.597	181.669	146.515	869.442	176.245
1.5 DL + 1.5 EL +X	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 EL -X	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 EL +Z	200.325	199.178	167.712	998.131	201.810
1.5 DL + 1.5 EL -Z	200.325	199.178	167.712	998.131	201.810
0.9 DL + 1.5 EL +X	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 EL -X	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 EL +Z	144.412	143.724	100.627	593.439	121.086
0.9 DL + 1.5 EL -Z	144.412	143.724	100.627	593.439	121.086
1.2 DL + b*1.2 LL + 1.2 EL +X	176.085	175.164	138.655	821.921	166.825
1.2 DL + b*1.2 LL + 1.2 EL -X	176.085	175.164	138.655	821.921	166.825
1.2 DL + b*1.2 LL + 1.2 EL +Z	176.085	175.164	138.655	821.921	166.825
1.2 DL + b*1.2 LL + 1.2 EL -Z	176.085	175.164	138.655	821.921	166.825

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


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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1**

Ast required	=	1234.440 mm ²	
Spacing of 10mm dia bars required	=	145.444 mm	
Provided spacing	=	145.000 mm	Hence Safe.
Dear shear force	=	220.307 kN/m	
Design shear stress	=	V_u/bd	
	=	0.244 N/mm ²	
100Ast/bd	=	0.060	
Allowable shear stress T_c	=	0.280 N/mm ²	
	>	0.244 N/mm ²	Hence Safe.

100Ast/bd	T_c
0.15	0.28
0.25	0.36
0.060	0.280

15 REINFORCEMENTS & ONE WAY SHEAR ALONG Z AXIS

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

Reinforcements	Bar dia (mm)	Spacing (mm)
Along X axis	10	145.000

Effective depth	=	385 mm
Minimum Ast	=	1234.44 mm ²

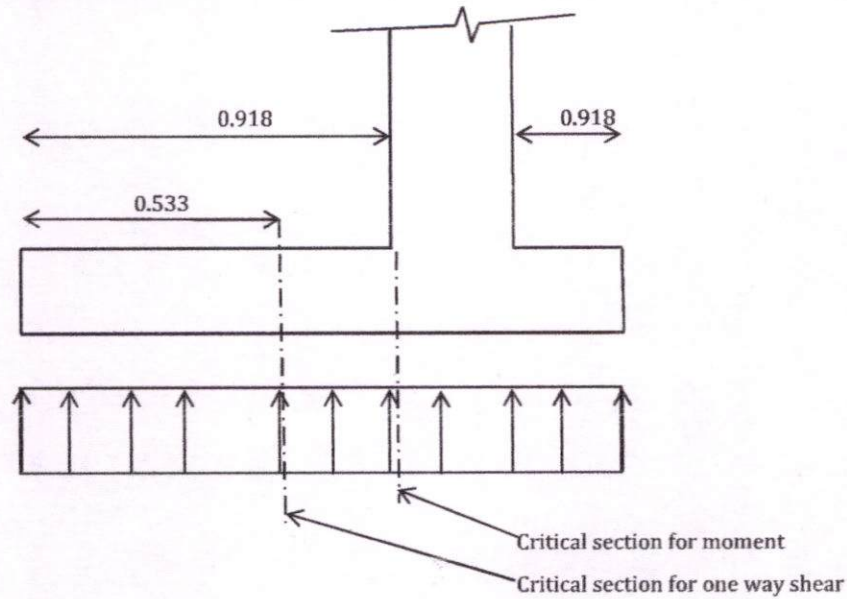

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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1****Table 15 : Pressures at edges, moment and shear**

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	212.625	212.436	146.333	891.837	185.127
1.5 DL + 1.5 WL +X +CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL +X -CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL -X +CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL -X -CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL +Z +CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL +Z -CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL -Z +CPI	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 WL -Z -CPI	199.838	199.665	134.029	815.403	169.561
0.9 DL + 1.5 WL +X +CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL +X -CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL -X +CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL -X -CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL +Z +CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL +Z -CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL -Z +CPI	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 WL -Z -CPI	144.120	144.016	80.418	485.533	101.736
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	182.209	182.058	117.067	710.481	148.101
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	182.209	182.058	117.067	710.481	148.101
1.5 DL + 1.5 EL +X	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 EL -X	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 EL +Z	199.838	199.665	134.029	815.403	169.561
1.5 DL + 1.5 EL -Z	199.838	199.665	134.029	815.403	169.561
0.9 DL + 1.5 EL +X	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 EL -X	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 EL +Z	144.120	144.016	80.418	485.533	101.736
0.9 DL + 1.5 EL -Z	144.120	144.016	80.418	485.533	101.736
1.2 DL + b*1.2 LL + 1.2 EL +X	175.696	175.552	110.800	671.848	140.173
1.2 DL + b*1.2 LL + 1.2 EL -X	175.696	175.552	110.800	671.848	140.173
1.2 DL + b*1.2 LL + 1.2 EL +Z	175.696	175.552	110.800	671.848	140.173
1.2 DL + b*1.2 LL + 1.2 EL -Z	175.696	175.552	110.800	671.848	140.173

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	=	1234.440 mm ²	
Spacing of 10mm dia bars required	=	145.444 mm	
Provided spacing	=	145.000 mm	Hence Safe.
Dear shear force	=	185.127 kN/m	
Design shear stress	=	V_u/bd	
	=	0.210 N/mm ²	
100Ast/bd	=	0.062	
Allowable shear stress	T _c	=	0.280 N/mm ²
		>	0.210 N/mm ² Hence Safe.

100Ast/bd	T _c
0.15	0.28
0.25	0.36
0.062	0.280

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**CHECK FOR TWO WAY SHEAR****16 Check for punching shear**

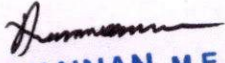
Load Combinations	Edge pressures (kN/m ²)		s.w of footing + above soil +load	soil pressure at centre (kN/m ²)	shear (kN)
	PAB	PCD			
1.5 DL + C*1.5 LL + C*1.5 LLR	213.110	212.436	-936.534	212.807	-436.436
1.5 DL + 1.5 WL +X +CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL +X -CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL -X +CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL -X -CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL +Z +CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL +Z -CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL -Z +CPI	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 WL -Z -CPI	200.325	199.665	-869.752	200.028	-399.685
0.9 DL + 1.5 WL +X +CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL +X -CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL -X +CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL -X -CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL +Z +CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL +Z -CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL -Z +CPI	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 WL -Z -CPI	144.412	144.016	-578.761	144.234	-239.811
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X +CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +X -CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X +CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -X -CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z +CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL +Z -CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z +CPI	182.597	182.058	-777.683	182.354	-349.149
1.2 DL + C*1.2 LL + C*1.2 LLR + 1.2 WL -Z -CPI	182.597	182.058	-777.683	182.354	-349.149
1.5 DL + 1.5 EL +X	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 EL -X	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 EL +Z	200.325	199.665	-869.752	200.028	-399.685
1.5 DL + 1.5 EL -Z	200.325	199.665	-869.752	200.028	-399.685
0.9 DL + 1.5 EL +X	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 EL -X	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 EL +Z	144.412	144.016	-578.761	144.234	-239.811
0.9 DL + 1.5 EL -Z	144.412	144.016	-578.761	144.234	-239.811
1.2 DL + b*1.2 LL + 1.2 EL +X	176.085	175.552	-743.67	175.846	-330.431
1.2 DL + b*1.2 LL + 1.2 EL -X	176.085	175.552	-743.67	175.846	-330.431
1.2 DL + b*1.2 LL + 1.2 EL +Z	176.085	175.552	-743.67	175.846	-330.431
1.2 DL + b*1.2 LL + 1.2 EL -Z	176.085	175.552	-743.67	175.846	-330.431

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**SHRI BALAJI CONSULTANCY****- DESIGN OF ISOLATED FOOTING F1**

Perimeter of the critical section (b ₀)	=	2920 mm
Effective depth	=	385 mm
Punching shear stress	=	0.388 N/mm ²
Ratio of short side to long side of the column β _c	=	0.511111
Allowable punching shear stress	=	$(0.5 + \beta_c) * 0.25 * \sqrt{f_{ck}}$
	=	1.250 N/mm ²
	>	0.388 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	=	3580.000 mm
Longer span	l_y	=	4730.000 mm
Span ratio	l_y / l_x	=	1.321
		$\leq$	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	=	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
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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 DL + 1.5 LL] = w	= 9.038 kN/m ²

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SHRI BALAJI CONSULTANCY

DESIGN OF TWO WAY SLAB - S1

7 BENDING MOMENTS

Edge condition : One long edge continuous

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	
	- ve moment at continuous Edge	+ ve moment at midspan
1.300	0.076	0.057
1.400	0.080	0.060
1.321	0.077	0.058

Long span coefficient α_y	
- ve moment at continuous Edge	+ ve moment at midspan
0.000	0.043

Negative Bending moment at the short span	$= M_x = \alpha_x \times w \times l_x^2$	=	8.902 kNm
Positive Bending moment at the short span	$= M_{+x} = \alpha_{+x} \times w \times l_x^2$	=	6.676 kNm
Negative Bending moment at the long span	$= M_y = \alpha_y \times w \times l_x^2$	=	0 kNm
Positive Bending moment at the long span	$= M_{+y} = \alpha_{+y} \times w \times l_x^2$	=	4.981 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	=	6.676 kNm
Area of reinf. steel required is calculated as per Annex G of IS 456 :		
Area of tension reinforcement required =	Ast reqd.	= 167.141 mm ²
Spacing of 8 mm dia. bars required	=	300.737 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
	>	167.141 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	=	$(0.87 f_y A_{st}) / (0.36 f_{ck} b d)$
		=	0.158
Depth of neutral axis =	x_u	=	0.158×96
		=	15.168 mm
As per cl. 38.1 of IS 456, the limiting value of x_u/d =	$x_{u,max} / d$	=	0.460
		>	0.158

Hence Safe

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SHRI BALAJI CONSULTANCY

DESIGN OF TWO WAY SLAB - S1

$$\begin{aligned}\text{Limiting value of the depth of neutral axis} &= 44.160 \text{ mm} \\ \text{Moment of resistance } M_u &= 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 9.809 \text{ kNm} \\ &> 6.676 \text{ kNm}\end{aligned}$$

Hence Safe

$$\begin{aligned}\text{Limiting moment of resistance of the section without compression reinforcement} \\ = 0.36 * x_{u,max}/d (1 - 0.42 x_{u,max}/d) * b d^2 f_{ck} = M_{u,lim} &= 24.626 \text{ kNm} \\ &> 9.809 \text{ kNm}\end{aligned}$$

Hence compression reinforcements are not required.

$$\begin{aligned}\text{Design stress in compression reinforcement} &= f_{sc} = 500.000 \text{ N/mm}^2 \\ \text{Depth of compression reinf. from compression face} &= d' = 15 + \phi/2 \\ &= 19.000 \text{ mm} \\ \text{Area of compression reinforcement} &= (M_u - M_{u,lim}) / (f_{sc} (d - d')) = A_{sc} = 0 \text{ mm}^2 \\ \text{Area of compression reinforcement provided} &= 0 \text{ mm}^2 \\ \text{Additional tension reinforcement required} &= A_{st2} = 0 \text{ mm}^2 \\ \text{Area of tension reinforcement required for a singly reinforced section for } M_{u,lim} &= A_{st1} = 167.141 \text{ mm}^2 \\ \text{Total tension reinforcement required} &= A_{st1} + A_{st2} = A_{st} = 167.141 \text{ mm}^2\end{aligned}$$

B REINFORCEMENTS ALONG LONG SPAN AT BOTTOM

$$\begin{aligned}\text{Positive Bending moment at the long span} &= 4.981 \text{ kNm} \\ \text{Area of reinf. steel required is calculated as per Annex G of IS 456 :} \\ \text{Area of tension reinforcement required} &= A_{st \text{ reqd.}} = 135.322 \text{ mm}^2 \\ \text{Spacing of mm dia. bars required} &= 371.450 \text{ mm} \\ \text{Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times the effective depth or 300mm which ever is smaller} &= 264.000 \text{ mm} \\ \text{Hence spacing of mm dia. bars required is the minimum of the above two values} &= 264.000 \text{ mm} \\ \text{Spacing of mm dia. bars provided} &= 200.000 \text{ mm} \\ \text{Area of tension reinforcement provided} &= A_{st \text{ prov.}} = 251.327 \text{ mm}^2 \\ &> 138.000 \text{ mm}^2\end{aligned}$$

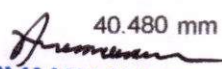
Hence Safe

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

$$\begin{aligned}\text{Ratio between depth of neutral axis and effective depth} &= x_u / d = (0.87 f_y A_{st}) / (0.36 f_{ck} b d) \\ &= 0.173 \\ \text{Depth of neutral axis} &= x_u = 0.173 * 88 \\ &= 15.224 \text{ mm} \\ \text{As per cl. 38.1 of IS 456, the limiting value of } x_u/d &= x_{u,max} / d = 0.460 \\ &> 0.173\end{aligned}$$

Hence Safe

$$\text{Limiting value of the depth of neutral axis} = 40.480 \text{ mm}$$


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

$$\text{Moment of resistance } M_u = 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 8.934 \text{ kNm}$$
$$> 4.981 \text{ kNm}$$

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.

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

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

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

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

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

$$\text{Area of tension reinforcement required for a singly reinforced section for } M_{u,lim} = A_{st1} = 135.322 \text{ mm}^2$$

$$\text{Total tension reinforcement required} = A_{st1} + A_{st2} = A_{st} = 135.322 \text{ mm}^2$$

C REINFORCEMENTS AT LONG EDGE AT TOP

$$\text{Negative Bending moment at the short span} = 8.902 \text{ kNm}$$

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

$$\text{Area of tension reinforcement required} = A_{st \text{ reqd.}} = 226.535 \text{ mm}^2$$

$$\text{Spacing of mm dia. bars required} = 221.889 \text{ mm}$$

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

$$\text{Hence spacing of mm dia. bars required is the minimum of the above two values} = 221.889 \text{ mm}$$

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

$$\text{Area of tension reinforcement provided} = A_{st \text{ prov.}} = 251.327 \text{ mm}^2$$
$$> 226.535 \text{ mm}^2$$

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

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

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

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

$$> 8.902 \text{ kNm}$$

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

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

$$> 9.809 \text{ kNm}$$

Hence compression reinforcements are not required.

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

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

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

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

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

$$\text{Area of tension reinforcement required for a singly reinforced section for } M_{u,lim} = A_{st1} = 226.535 \text{ mm}^2$$

$$\text{Total tension reinforcement required} = A_{st1} + A_{st2} = A_{st} = 226.535 \text{ mm}^2$$

D REINFORCEMENTS AT SHORT EDGE AT TOP

$$\text{Negative Bending moment at the long span} = 0 \text{ kNm}$$

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

$$\text{Area of tension reinforcement required} = A_{st \text{ reqd.}} = 0.000 \text{ mm}^2$$

$$\text{Spacing of mm dia. bars required} = \#DIV/0! \text{ mm}$$

$$\begin{aligned} \text{Maximum spacing allowed as per cl. 26.3.3. of IS 456 is three times} \\ \text{the effective depth or 300mm which ever is smaller} &= 264.000 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{Hence spacing of mm dia. bars required is the minimum of the above} \\ \text{two values} &= \text{NA mm} \end{aligned}$$

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

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

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

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

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

$$\begin{aligned} \text{As per cl. 38.1 of IS 456, the limiting value of } x_u/d &= x_{u,max} / d = 0.460 \\ &> 0.173 \end{aligned}$$

Hence Safe

$$\text{Limiting value of the depth of neutral axis} = 40.480 \text{ mm}$$

$$\begin{aligned} \text{Moment of resistance } M_u &= 0.87 f_y A_{st} d (1 - (A_{st} f_y / b d f_{ck})) = 8.934 \text{ kNm} \\ &> 0.000 \text{ kNm} \end{aligned}$$

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DESIGN OF TWO WAY SLAB - S1

Hence Safe

Limiting moment of resistance of the section without compression reinforcement

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

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

$$> 8.934 \text{ kNm}$$

Hence compression reinforcements are not required.

Design stress in compression reinforcement =

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

Depth of compression reinf. from compression face =

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

$$= 19.000 \text{ mm}$$

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

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

Area of compression reinforcement provided

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

Additional tension reinforcement required =

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

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

$$A_{st1} = 0.000 \text{ mm}^2$$

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

$$A_{st} = 0.000 \text{ mm}^2$$

E TORSIONAL REINFORCEMENTS

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

$$= 3/4 \times 167.141$$

$$= 125.356 \text{ mm}^2$$

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

$$= 1/2 \times 125.356$$

$$= 62.678 \text{ mm}^2$$

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
1.300	0.530	0.350
1.400	0.550	0.360
1.321	0.534	0.352

Long span coefficient β_y	
continuous edge	discontinuous edge
0.000	0.290

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

$$V_{cx} = 17.286 \text{ kN}$$

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

$$V_{dx} = 11.393 \text{ kN}$$

$$\text{Shear force at the short continuous edge} = \beta_{cy} \times W \times l_x =$$

$$V_{cy} = 0 \text{ kN}$$

$$\text{Shear force at the short discontinuous edge} = \beta_{dy} \times W \times l_x =$$

$$V_{dy} = 9.383 \text{ kN}$$

Check for shear near long edge :

Shear force due to design loads

$$V_u = 17.286 \text{ kN}$$

Effective depth

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

Nominal shear stress (Cl. 40.1 of IS 456)

$$T_v = V_u / bd$$

$$= 0.180 \text{ N/mm}^2$$

Maximum shear stress (Cl. 40.2.3.1 of IS 456)

$$T_{c \text{ max}} = 1.400 \text{ N/mm}^2$$

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

$$> 0.180 \text{ N/mm}^2$$

Hence SAFE

Area of reinf. provided

$$= 251.327 \text{ mm}^2$$

Percentage of reinf. provided

$$= 100A_s/bd =$$

pt

$$= 0.262$$

From table 19 of IS 456,

pt	T_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

$$T_c k = 0.475 \text{ N/mm}^2$$

$$> 0.180 \text{ N/mm}^2$$

Hence SAFE*Check for shear near short edge :*

Shear force due to design loads

$$V_u = 9.383 \text{ kN}$$

Effective depth

$$d = 88.000 \text{ mm}$$

Nominal shear stress (Cl. 40.1 of IS 456)

$$T_v = V_u / bd$$

$$= 0.107 \text{ N/mm}^2$$

Maximum shear stress (Cl. 40.2.3.1 of IS 456)

$$T_{c \text{ max}} = 1.400 \text{ N/mm}^2$$

$$> 0.107 \text{ N/mm}^2$$

Hence SAFE

Area of reinf. provided

$$= 251.327 \text{ mm}^2$$

Percentage of reinf. provided

$$= 100A_s/bd =$$

$$= 0.286$$

From table 19 of IS 456,

pt	T_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

$$T_c k = 0.490 \text{ N/mm}^2$$

$$> 0.107 \text{ N/mm}^2$$

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

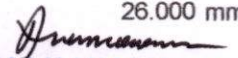
Allowable long term deflection (Cl. 23.2 of IS 456)

$$= l_x / 350$$

$$= 10.229 \text{ mm}$$

Basic allowable span to effective depth ratio (Cl. 23.2.1 of IS 456)

$$= 26.000$$


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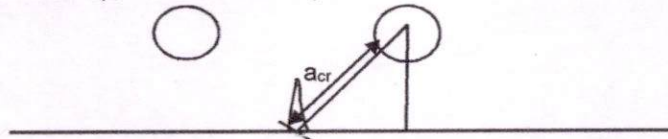
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DESIGN OF TWO WAY SLAB - S1

Steel stress at service loads	$f_s = 0.58 f_y A_{st, reqd.} / A_{st, prov.}$
	$= 192.860 \text{ N/mm}^2$
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	$= 37.292$
	< 52.000
Hence SAFE	

B CHECK FOR CRACK WIDTH AT MIDSPAN

Allowable crack width (Cl. 35.3.2 of IS 456)	$= 0.3 \text{ mm}$
--	--------------------



Distance of the point considered to the surface of the nearest longitudinal bar	$a_{cr} = 97.789 \text{ mm}$
Minimum cover to the longitudinal bar	$C_{min} = 15.000 \text{ mm}$
Overall depth of the member	$h = 115.000 \text{ mm}$
Depth of neutral axis	$x = 15.168 \text{ mm}$
Effective depth	$d = 96.000 \text{ mm}$
Modulus of elasticity of steel reinf.	$E_s = 200.000 \text{ kN/mm}^2$
Modulus of elasticity of concrete	$E_c = 5000 \sqrt{f_{ck}}$
	$= 22.361 \text{ kN/mm}^2$
Modular ratio	$m = 8.944$
Maximum moment	$M = 6.676 \text{ kNm}$
Section modulus	$Z = \frac{bd^2}{6}$
	$= 1536000.000 \text{ mm}^3$
Maximum compressive stress in concrete	$f_c = \frac{M}{Z}$
	$= 4.346 \text{ N/mm}^2$
Maximum tensile stress in reinf. Steel	$f_s = f_c \cdot m$
	$= 38.875 \text{ N/mm}^2$
Average steel strain at the level considered	$= \frac{f_s}{E_s}$
	$= 0.194$
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)	$W_{cr} = \frac{3 a_{cr} \epsilon_m}{1 + 2(a_{cr} - C_{min})/(h - x)}$
	$= 0.221 \text{ mm}$

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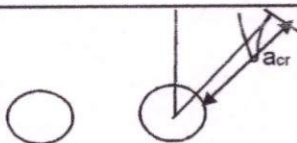
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DESIGN OF TWO WAY SLAB - S1

< 0.300 mm
Hence Safe

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	$M =$	8.902 kNm
Section modulus	$Z =$	$bd^2 / 6$
	$=$	1536000.000 mm ³
Maximum compressive stress in concrete	$f_c =$	M/z
	$=$	5.796 N/mm ²
Maximum tensile stress in reinf. Steel	$f_s =$	$f_c * m$
	$=$	51.837 N/mm ²
Average steel strain at the level considered	$=$	f_s / E_s
	$=$	0.259
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

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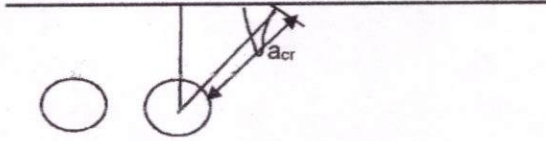


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DESIGN OF TWO WAY SLAB - S1

D CHECK FOR CRACK WIDTH AT SUPPORT OF SHORT 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	$x =$	15.224 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	$M =$	0.000 kNm
Section modulus	$Z =$	$bd^2 / 6$
	$=$	1290666.667 mm ³
Maximum compressive stress in concrete	$f_c =$	M/z
	$=$	0.000 N/mm ²
Maximum tensile stress in reinf. Steel	$f_s =$	$f_c * m$
	$=$	0.000 N/mm ²
Average steel strain at the level considered	$=$	f_s / E_s
	$=$	0.000
Maximum allowable strain	$=$	$0.8 f_y / E_s$
	$=$	0.002
Average steel strain at the level considered	$\epsilon_m =$	0.000
Design surface crack width (Annex F of IS 456)	$W_{cr} =$	$\frac{3 a_{cr} \epsilon_m}{1 + 2(a_{cr} - C_{min})/(h - x)}$
	$=$	0.000 mm
	$<$	0.300 mm
		Hence Safe

10 SLAB REACTIONS

Refer code SP 24-1983 Cl:23.5

On the long span,

$$w l_x / 6 * (3 - (l_x / l_y)^2)$$

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DESIGN OF TWO WAY SLAB - S1

Unfactored long beam UDL reaction due to dead load

$$\begin{aligned}\text{Unfactored load} &= 4.025 \text{ kN/m}^2 \\ &= 5.829 \text{ kN/m}\end{aligned}$$

Unfactored long beam UDL reaction due to live load

$$\begin{aligned}\text{Unfactored load} &= 2.000 \text{ kN/m}^2 \\ &= 2.896 \text{ kN/m}\end{aligned}$$

On the short span, $wl_x/3$

Unfactored long beam UDL reaction due to dead load

$$\begin{aligned}\text{Unfactored load} &= 4.025 \text{ kN/m}^2 \\ &= 4.803 \text{ kN/m}\end{aligned}$$

Unfactored long beam UDL reaction due to live load

$$\begin{aligned}\text{Unfactored load} &= 2.000 \text{ kN/m}^2 \\ &= 2.387 \text{ kN/m}\end{aligned}$$

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BEAM NO. 1735 DESIGN RESULTS

M20 Fe500 (Main) Fe500 (Sec.)

LENGTH: 3162.0 mm SIZE: 230.0 mm X 300.0 mm COVER: 25.0 mm

FLANGE WIDTH: 1000.0 mm FLANGE DEPTH: 115.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	790.5 mm	1581.0 mm	2371.5 mm	3162.0 mm
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TOP	0.00	0.00	0.00	0.00	0.00
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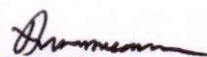
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
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BOTTOM	0.00	308.41	427.81	308.41	0.00
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REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
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SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	790.5 mm	1581.0 mm	2371.5 mm	3162.0 mm
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TOP 2-12í 2-12í 2-12í 2-12í 2-12í

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

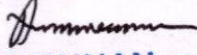
BOTTOM 2-12í 3-12í 4-12í 3-12í 2-12í

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

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

REINF. @ 200 mm c/c @ 200 mm c/c @ 200 mm c/c @ 200 mm c/c @ 200 mm c/c

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