

Date 01-12-2025

STABILITY CERTIFICATE

(To be furnished while filing application for registration of building)

The detailed engineering and structure design of the proposed building comprising of **Stilt +4 floors at Villivakkam Village Old S.No:137 / 1(Part), T.S.No:207, Block No: 34, Ward –I** has been done by me/us based on the report of geotechnical investigation (soil test) done by **GEO MINES ENGINEERS PVT LTD** Report No. **262/2023-2024** Dated: **13.09.2023** 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 IS:875 (Part 2) - - 1987 and design of earthquake resistant structure as per IS Code No: 875 (Part 2) - - 1987.

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



S. P. S. INBARAJAN, M.E., (Struct)
Registered Structural Engineer
Grade-I (SE) in CMDA
Reg. No. SE/GR-I/19/02/009 dt. 27.02.2019
Grade-I (RSE) in Greater Chennai Corporation*
Reg. No. RSE 100302019 dt. 30.09.2019
Door No 50, Kirupasankari Street,
West Mambalam, Chennai-600 033.

stamp and Signature

Encl.: Structural Design Calculation

No.50, Kirupasankari Street, West Mambalam, Chennai - 600 033. ☎: 044-2485 4603.
E-Mail : bournace@gmail.com

S.P.S. Inbarajan, M.E. (Structural)
Structural Consultant

BOURNA
CONSULTANTS - ENGINEERS

STRUCTURAL DESIGN STABILITY CERTIFICATE.

I hereby certify that The Proposed Construction Of Office Building At Plot No.1229, Door No. 55, 18th Main Road, Anna Nagar, Chennai-600 040, Comprised In Old S.No: 137/1(Part), T.S.No:207, Block No.34, Ward-1 Of Villivakkam Village. Greater Corporation Of Chennai To Certify That The Building Will Withstand Against The Earthquake, (Seismic Zone III as per IS 1893 (Part I) 2002) loading stress parameters are within limits of National Building Code and Bureau of Indian standards code of practice for concrete and loading. The building consists of Stilt + Four floors upper floors. The R.C.C. building frame of the structure is designed as per the Indian Standard code of practice for concrete and loadings. The structure will be constructed as per our structural design and detailing of reinforcements given in our drawing from foundation to roof slab and beam. For external and internal partition walls 230/115 thick block work walls are used.

For **BOURNA CONSULTANTS ENGINEERS,**



(S.P.S. INBARAJAN.)
Chief Consultant.

S. P. S. INBARAJAN, M.E., (Struct)
Registered Structural Engineer
Grade-I (SE) in CMDA
Reg. No. SE/GR-1/2024/02/009 dt. 27.02.2024
Grade-I (RSE) in Greater Chennai Corporation
Reg. No. RSE 100302024 Dt. 09.10.2024
Door No.50, Kirupasankari Street,
West Mambalam, Chennai-600 033.



**GREATER CHENNAI CORPORATION
TOWN PLANNING DEPARTMENT**

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that Mr. S.P.S. Inbarajan has been enrolled as Registered Structural Engineer Grade- I (RSE) in Greater Chennai Corporation (GCC) who has the qualification of M.E., (Structural Engg.), has been renewed for the period up to 08.10.2029

The Registration No. is RSE100302024 dated 09.10.2024 It is informed herewith to comply with the scope of work, duties and responsibilities as prescribed by the Government of Tamil Nadu in Part – V, “Registration of Professionals”, Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MA&WS (MA1) Dept. dated 04.02.2019. and as amended in G.O.(MS) No.16 MA&WS (MA1) Dept, dated 31.01.2020.

This Registration is valid upto 08.10.2029



RGN No: RSE100302024

Dated : 09.10.2024

AP
9/10/24
Superintending Engineer (TP)
Greater Chennai Corporation. *2/2*

[Signature]
S. P. S. INBARAJAN,
M.E., (Struct) A.M.I.E.,
Structural Consultant
Registered Structural Engineer
Grade-I (RSE) in Greater Chennai Corporation
Reg. No. RSE 100302024 Dt. 09.10.2024
Door No.50, Kirupasankari Street,
West Mambalam, Chennai-600 033.



CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'ThalamuthuNatarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the Thiru. S.P.S. INBARAJAN has enrolled as Registered Structural Engineer Grade-I (SE) with Chennai Metropolitan Development Authority (CMDA) who has the qualification of M.E.,(Structural Engg.) and experience in the relevant field for 30 years.

He has been given the Registration No.SE/GR-I/2024/02/009 on 27.02.2024. He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto 26.02.2029.




(A. MEGANATHAN)
Superintendent


S. P. S. INBARAJAN,
M.E., (Struct) A.M.I.E.,
Structural Consultant
Registered Structural Engineer
Grade-I (SE) in CMDA
Reg. No SE/GR-I/2024/02/009 Dt 27.02.2024
Door No.50, Kirupasankari Street,
West Mambalam, Chennai-600 033.

DESIGN BASIS REPORT

FOR

Mr. G. RADHAKRISHNAN

THE PROPOSED CONSTRUCTION OF OFFICE BUILDING AT PLOT NO.1229, DOOR NO. 55,18TH MAIN ROAD, ANNA NAGAR, CHENNAI-600 040, COMPRISED IN OLD S.NO: 137/1(PART), T.S.NO:207, BLOCK NO.34, WARD-1 OF VILLIVAKKAM VILLAGE WITHIN THE LIMITS OF GREATER CHENNAI CORPORATION.



S. P. S. INBARAJAN, M.E., (Struct)

Registered Structural Engineer

Grade-I (SE) in CMDA

Reg. No. SE/GR-1/2024/02/009 dt. 27.02.2024

Grade-I (RSE) in Greater Chennai Corporation

Reg. No. RSE 100302024 Dt. 09.10.2024

Door No.50, Kirupasankari Street,
West Mambalam, Chennai-600 033.

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Reg. No. RSE 100302024 Dt. 09.10.2024
Door No.50, Kirupasankari Street,
West Mambalam, Chennai-600 033.

1.0 OBJECTIVE

The Design basis covers the basic requirement that will be followed for the design of THE PROPOSED CONSTRUCTION OF OFFICE BUILDING FOR Mr. G. RADHAKRISHNAN AT PLOT NO.1229, DOOR NO. 55, 18TH MAIN ROAD, ANNA NAGAR, CHENNAI-600 040, COMPRISED IN OLD S.NO: 137/1(PART), T.S.NO:207, BLOCK NO.34, WARD-1 OF VILLIVAKKAM VILLAGE WITHIN THE LIMITS OF GREATER CHENNAI CORPORATION.

The building is designed for Stilt + Four Floors. The structure is supported on column in turn resting on Pile Foundation. The Structural system comprises columns, beams, slabs and wall structure.

3-D Analysis of all the building structures will be carried out using STAAD PRO software package and analysis results shall be used for designing the various elements.

2.0 DESIGN LOADS

2.1 Dead Loads

The Dead loads that are envisaged to act permanently are considered as per IS: 875 (Part 1) – 1987 – Dead loads. Indian Standard “Code of Practice for Design Loads (other than earthquake) for Buildings and Structures”.

1. Slab is assumed to be 150mm thick – 3.75 KN/m²
2. Slab is assumed to be 125mm thick – 3.125 KN/m²
3. Floor finish – 1.5KN/m²
4. Brick work masonry walls 230thick are proposed to be used (location of walls per Architectural drawings) Unit weight is taken as 20 KN/m³
5. Weathering course in Terrace finish – 3 KN/m²


S. P. S. INBARAJAN, M.E., (Struct)
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Grade-I (SE) in ClSIPA
Reg. No. SE/GS-1/102/03000 dt. 27.02.2024
Grade-I (RSE) in Greater Chennai Corporation
Reg. No. RSE 1003/2024 dt. 10.10.2024
Door No. 59, Kinnarasankar Street,
West Mambalam, Chennai-600 033.

2.2 Imposed Loads

The imposed loads that are envisaged to act permanently are considered as per **IS : 875 (Part 2) – 1987** . Indian Standard “Code of Practice for Design Loads (other than earthquake) for Buildings and Structures”.

1. Living	=	2 KN/m ²
2. Staircase	=	4 KN/m ²
3. Toilets	=	2 KN/m ²
4. Terrace floors	=	1.5 KN/m ²

2.3 Earthquake Load

The loading due to earthquake is assessed based on the provisions of **IS: 1893-2016**. Structure with ductile detailing is considered as per **IS: 13920-2016**.

CHENNAI falls under Seismic Zone III

Zone factor	=	0.16
Response reduction factor	=	5
Importance factor	=	1.0

Structure with ductile detailing is considered as per **IS: 13920-2016**

2.4 Load Combinations

The various loads shall be combined in accordance with the stipulations in **IS: 875 (Part 5) – 1987**. Whichever combinations produced the most unfavorable effect in the building, foundations or structural member concerned shall be adopted. The various load combinations considered in the analysis are as follows:

1. 1(DL+LL)
2. 1 DL+0.8 LL+ 0.8 SQX +1
3. 1 DL+0.8 LL+ 0.8 SQX -1
4. 1 DL+0.8 LL+ 0.8 SQZ +1
5. 1 DL+0.8 LL+ 0.8 SQZ -1

6. $1.0 (DL+SQX +)$
7. $1.0 (DL+SQX -1)$
8. $1.0 (DL+SQZ +1)$
9. $1.0 (DL+SQZ -1)$
10. $1.5(DL+LL)$
11. $1.5(DL+SQX +1)$
12. $1.5(DL+SQX -1)$
13. $1.5(DL+SQZ +1)$
14. $1.5(DL+SQZ -1)$
15. $1.2(DL+LL+SQX +1)$
16. $1.2(DL+LL+SQX -1)$
17. $1.2(DL+LL+SQZ +1)$
18. $1.2(DL+LL+SQZ -1)$
19. $0.9DL+1.5SQX+1$
20. $0.9DL+1.5SQX -1$
21. $0.9DL+1.5SQZ +1$
22. $0.9DL+1.5SQZ -1$

The above load combinations will be considered and effect of worst combinations

Will be taken for design of various building elements.

3.0 ANALYSIS METHODS

The analysis of the structures is carried out using the STAAD PRO. The entire super-structure is modeled using frame elements as appropriate. Beams and columns are modeled as frame elements. Appropriate loads and its combinations, as per relevant IS code clauses, for most unfavorable effects are chosen for design. Various load cases considered in the analysis are briefed above.

4.0 DESIGN ASSUMPTION

- 4.1.1 The Base of the Foundation is assumed to be FIXED.
- 4.1.2 All Concrete elements shall be designed in accordance with IS 456:2000 Limit State Design.
- 4.1.3 Appropriate loads and its combinations, as per relevant clauses, for the most unfavorable effects are chosen for design. (Refer Load Combination below)

5.0 FOUNDATION DESIGN

Type of Foundation : Pile foundation.

Depth of Foundation : 23m

6.0 MATERIALS

These self-

weights of the various elements are computed based on the unit weight of materials as given below

S.no	Materials	Unit weight KN/m ³
1	Reinforced Cement Concrete	25
2	Solid Block/Brick	20
3	Steel	78.50

Structural concrete shall be of grade M25 for Pile

Structural concrete shall be of grade M20 for Pile cap & Column

Structural concrete shall be of grade M20 for Beam & Slab

Steel reinforcement shall be of Grade Fe500 conforming to IS:1786-2008.

7.0 NOMINAL COVER TO REINFORCEMENT

From Durability requirement, exposure condition is assumed as mild for structural elements above ground level and moderate for structural elements below ground level.

The Clear cover to reinforcement to meet durability requirement shall be as follows:

Column – 40mm

Pile cap – 100mm

Beam – 25mm

Slab – 20mm

DESIGN OF BEAM: 1

Beam size: 230mm x 450mm

Bending moment at support = 140kNm

Bending moment at mid span = 133kNm

Shear force, V_u = 149kN

Bending moment at support, M_u = 140kNm

$$R = (140 \times 10^6) / (230 \times 409^2)$$

$$= 3.64$$

$$P_t / 100 = A_{st} / b d = \frac{f_{ck} / 2 f_y [1 - \sqrt{1 - 4.598 x R / f_{ck}}]}{}$$

$$f_{ck} = 20 \text{ N/mm}^2$$

$$f_y = 500 \text{ N/mm}^2$$

$$P_t = 1.07\%$$

$$A_{st} \text{ required} = 1013 \text{ mm}^2$$

Provide 6nos of 16Y

$$A_{st} \text{ provided} = 1206 \text{ mm}^2$$

Hence safe.

Bending moment at mid span, M_u = 133kNm

$$R = (133 \times 10^6) / (230 \times 409^2)$$

$$= 3.46$$

$$P_t = 1.0\%$$

$$A_{st} \text{ required} = 944 \text{ mm}^2$$

Provide 6nos of 16Y

$$A_{st} \text{ provided} = 1206 \text{ mm}^2$$

Hence it is safe

$$\begin{aligned}\text{Shear force, } V_u &= 149\text{kN} \\ \tau_v &= V_u/bd \\ &= (149 \times 10^3)/230 \times 409 \\ &= 1.58 \text{ N/mm}^2\end{aligned}$$

Hence ok.

Shear capacity of concrete:

$$\begin{aligned}P_t &= 1.0 \% \\ \tau_{cc} &= 0.62 \\ &= \tau_{cc} bd \\ &= 0.62 \times 230 \times 409 \\ &= 58323 \text{ N (or) } 58 \text{ kN}\end{aligned}$$

Shear to be carried by stirrups

$$\begin{aligned}V_u &= V_s - \tau_{cc} bd \\ &= 149 - 58 \text{ kN} \\ &= 91\text{kN}\end{aligned}$$

Therefore, provide 2 legged 10Y @ 150 mm C/C at the supports.

Provide 2 legged 10Y @ 200mm C/C at the midspan.

DESIGN OF BEAM: 2

Beam size: 230mm x 525mm

$$\begin{aligned}\text{Bending moment at support} &= 132\text{kNm} \\ \text{Bending moment at mid span} &= 111\text{kNm} \\ \text{Shear force, } V_u &= 96\text{kN} \\ \text{Bending moment at support, } M_u &= 132\text{kNm} \\ R &= (132 \times 10^6)/230 \times 484^2 \\ &= 2.44\end{aligned}$$

$$P_t/100 = A_{st}/bd = \frac{f_{ck}}{2f_y} [1 - \sqrt{1 - 4.598 \times R/f_{ck}}]$$

$$f_{ck} = 20 \text{ N/mm}^2$$

$$f_y = 500 \text{ N/mm}^2$$

$$P_t = 0.65\%$$

$$A_{st} \text{ required} = 725 \text{ mm}^2$$

Provide 4nos of 16Y

$$A_{st} \text{ provided} = 804 \text{ mm}^2$$

Hence safe.

$$\text{Bending moment at mid span, } M_u = 111 \text{ kNm}$$

$$R = (111 \times 10^6) / (230 \times 484^2)$$

$$= 2.06$$

$$P_t = 0.53\%$$

$$A_{st} \text{ required} = 593 \text{ mm}^2$$

Provide 4 nos of 16Y

$$A_{st} \text{ provided} = 804 \text{ mm}^2$$

Hence it is safe

$$\text{Shear force, } V_u = 96 \text{ kN}$$

$$\tau_v = V_u/bd$$

$$= 96 \times 10^3 / (230 \times 484)$$

$$= 0.86 \text{ N/mm}^2$$

Hence ok.

Shear capacity of concrete:

$$P_t = 0.65\%$$

$$\tau_c = 0.53$$

$$= \tau_c bd$$

$$= 0.53 \times 230 \times 484$$

$$= 58999 \text{ N (or) } 59\text{kN}$$

Shear to be carried by stirrups

$$\begin{aligned} V_u &= V_s - \tau_c b d \\ &= 96 - 59 \text{ kN} \\ &= 37\text{kN} \end{aligned}$$

Therefore, provide 2 legged 8Y @ 100 mm C/C at the supports.

Provide 2 legged 8Y @ 200 mm C/C at the midspan.

Design of Pile Cap :

$$\begin{aligned} \text{Safe load for 600mm Dia pile} &= 1130 \text{ KN} \\ \text{Concrete grade for pile cap} &= \text{M20} \\ \text{Un factored Column load} &= 1442\text{KN} \\ \text{No of piles required} &= 1442/1130 = 1.28 \end{aligned}$$

Provide 2 nos of Pile (600Ø)

$$\begin{aligned} \text{Spacing of Piles} &= 1800\text{mm} \\ &= 1.8\text{m} \end{aligned}$$

$$\begin{aligned} \text{Factored load} &= 1442 \times 1.5 \\ &= 2163 \end{aligned}$$

$$\begin{aligned} \text{Bending moment WL/4} &= 2163 \times 1.8 / 4 \\ &= 973\text{KNM} \end{aligned}$$

$$\begin{aligned} R = MU/bd^2 &= 973 \times 10^6 / 975 \times 875^2 \\ &= 1.3 \end{aligned}$$

$$f_{ck} = 20\text{N/mm}^2$$

$$f_y = 500\text{N/mm}^2$$

$$P_t/100 = A_{st}/bd = f_{ck}/2f_y [1 - \sqrt{1 - 4.598 \times R/20}]$$

$$A_{st} \text{ required} = 2739 \text{ mm}^2$$

Provide 7 nos of 25 Dia bar

$$A_{st} \text{ provided} = 3437 \text{ mm}^2$$

$$A_{st} \text{ required} > A_{st} \text{ provided}$$

Hence it is safe.

DESIGN OF COLUMN C1					
Length of column		D	450	mm	
Breadth of column		b	230	mm	
Unsupported length (longer direction)		L_x	2700	mm	
Unsupported length (shorter direction)		L_y	2700	mm	
Eff. Length (longer direction)		L_{ex}	2160	mm	
Eff. Length (shorter direction)		L_{ey}	2160	mm	
Factored Load		P_u	1051	kN	
Factored moment (longer direction)		M_{ux}	65	kNm	
Factored moment (shorter direction)		M_{uz}	21	kNm	
Charac. comp strength of concrete		f_{ck}	20	N/mm ²	
Yield stress of steel		f_y	500	N/mm ²	
Dia of bar used		Φ	20	mm	
Clear cover			40	mm	
Effective cover		d'	50	mm	
Effective depth		d	400	mm	
Check for slenderness					
Longer Direction					
Slenderness ratio		L_{ex}/D	4.80	short	
Additional moment due to slenderness		M_{ax}	0	kN-m	
Shorter Direction					
Slenderness ratio		L_{ey}/b	9.39	short	
Additional moment due to slenderness		M_{ay}	0	kN-m	
Calculation of P_{uz}					
No of bars used			8		
Area of reinforcement		A_{st}	2512		
Provided steel			8 nos Y20		
Percentage of reinforcement		p_t	2.427	%	
Area of concrete		A_g	103500	mm ²	
Ultimate axial load (without moments)		P_{uz}	1851	kN	
Calculation of P_b :					
Longer Direction					
		d'/D	0.111		
Coefficient k_1 (from TABLE 60 of SP:1980)		k_{1x}	0.204	From Sp16	
Coefficient k_2 (from TABLE 60 of SP:1980)		k_{2x}	0.398		
Axial load corresponding to balanced failure		P_{bx}	523	kN	
Reduction factor for additional moments		k_x	1.000		
Moment due to slenderness		M_{ax}	0.00	kN-m	
Shorter Direction					
		d'/b	0.217		
Coefficient k_1 (from TABLE 60 of SP:1980)		k_{1y}	0.179		
Coefficient k_2 (from TABLE 60 of SP:1980)		k_{2y}	0.143		
Axial load corresponding to balanced failure		P_{by}	406	kN	
Reduction factor for additional moments		k_y	0.554		
Moment due to slenderness		M_{ay}	0.00	kN-m	
Check for moments due to min. eccentricity					
Longer Direction					
Minimum eccentricity		e_x	20.40	mm	

Moment due to min. eccentricity			M_x	21.44	kN-m
Moment in longer direction			M_{ux}	65.00	kNm
Shorter direction					
Minimum eccentricity			e_y	13.07	mm
Moment due to min. eccentricity			M_y	13.73	kN-m
Moment in shorter direction			M_{uy}	21	kNm
Final design moments					
Moment in longer direction			M_{ux}	65.00	kNm
Moment in shorter direction			M_{uy}	21.00	kNm
Check for interaction					
			d'/D	0.111	
			d'/b	0.217	
p/f_{ck}			p/f_{ck}	0.121	
$P_u/f_{ck}bD$ value			$P_u/f_{ck}bD$	0.508	
$M_{ux1}/f_{ck}bD^2$ value (from SP 16:1980 charts)			$M_{ux1}/f_{ck}bD^2$	0.130	
Uniaxial moment capacity (longer direction)			M_{ux1}	121.095	kNm
$M_{uy1}/f_{ck}bD^2$ value (from SP 16:1980 charts)			$M_{uy1}/f_{ck}bD^2$	0.110	
Uniaxial moment capacity (shorter direction)			M_{uy1}	52.371	kNm
P_u/P_{uz} ratio			P_u/P_{uz}	0.568	
Value of exponent				1.614	
Interaction ratio				0.595	
Percentage reinforcement satisfactory or not				safe	
b/D ratio			b/D	0.51111111	
Status of dimensions				OK	
Gross area			A_g	103500	mm ²
Area of core			A_k	60800	mm ²
Spacing of lateral ties			S	57.5	mm
Larger dimension of the hoop			H	230	mm
Cross sectional area of hoop			A_{sh}	66.87	mm ²

DESIGN OF COLUMN C2					
Length of column		D	375	mm	
Breadth of column		b	300	mm	
Unsupported length (longer direction)		L_x	2700	mm	
Unsupported length (shorter direction)		L_y	2700	mm	
Eff. Length (longer direction)		L_{ex}	2160	mm	
Eff. Length (shorter direction)		L_{ey}	2160	mm	
Factored Load		P_u	895	kN	
Factored moment (longer direction)		M_{ux}	41	kNm	
Factored moment (shorter direction)		M_{uz}	11	kNm	
Charac. comp strength of concrete		f_{ck}	20	N/mm ²	
Yield stress of steel		f_y	500	N/mm ²	
Dia of bar used		Φ	16	mm	
Clear cover			40	mm	
Effective cover		d'	48	mm	
Effective depth		d	327	mm	
Check for slenderness					
Longer Direction					
Slenderness ratio		L_{ex}/D	5.76	short	
Additional moment due to slenderness		M_{ax}	0	kN-m	
Shorter Direction					
Slenderness ratio		L_{ey}/b	7.20	short	
Additional moment due to slenderness		M_{ay}	0	kN-m	
Calculation of P_{uz}					
No of bars used			8		
Area of reinforcement		A_{st}	1607.68		
Provided steel			8 nos Y16		
Percentage of reinforcement		p_t	1.429	%	
Area of concrete		A_g	112500	mm ²	
Ultimate axial load (without moments)		P_{uz}	1601	kN	
Calculation of P_b :					
Longer Direction					
		d'/D	0.128		
Coefficient k_1 (from TABLE 60 of SP:1980)		k_{1x}	0.200	From Sp16	
Coefficient k_2 (from TABLE 60 of SP:1980)		k_{2x}	0.358		
Axial load corresponding to balanced failure		P_{bx}	508	kN	
Reduction factor for additional moments		k_x	1.000		
Moment due to slenderness		M_{ax}	0.00	kN-m	
Shorter Direction					
		d'/b	0.160		
Coefficient k_1 (from TABLE 60 of SP:1980)		k_{1y}	0.193		
Coefficient k_2 (from TABLE 60 of SP:1980)		k_{2y}	0.281		
Axial load corresponding to balanced failure		P_{by}	479	kN	
Reduction factor for additional moments		k_y	0.629		
Moment due to slenderness		M_{ay}	0.00	kN-m	
Check for moments due to min. eccentricity					
Longer Direction					
Minimum eccentricity		e_x	17.90	mm	

Moment due to min. eccentricity			M_x	16.02	kN-m
Moment in longer direction			M_{ux}	41.00	kNm
Shorter direction					
Minimum eccentricity			e_y	15.40	mm
Moment due to min. eccentricity			M_y	13.78	kN-m
Moment in shorter direction			M_{uy}	13.783	kNm
Final design moments					
Moment in longer direction			M_{ux}	41.00	kNm
Moment in shorter direction			M_{uy}	13.78	kNm
Check for interaction					
			d'/D	0.128	
			d'/b	0.160	
p/f_{ck}			p/f_{ck}	0.071	
$P_u/f_{ck}bD$ value			$P_u/f_{ck}bD$	0.398	
$M_{ux1}/f_{ck}bD^2$ value (from SP 16:1980 charts)			$M_{ux1}/f_{ck}bD^2$	0.090	
Uniaxial moment capacity (longer direction)			M_{ux1}	75.9375	kNm
$M_{uy1}/f_{ck}bD^2$ value (from SP 16:1980 charts)			$M_{uy1}/f_{ck}bD^2$	0.090	
Uniaxial moment capacity (shorter direction)			M_{uy1}	60.75	kNm
P_u/P_{uz} ratio			P_u/P_{uz}	0.559	
Value of exponent				1.599	
Interaction ratio				0.466	
Percentage reinforcement satisfactory or not				safe	
b/D ratio			b/D	0.8	
Status of dimensions				OK	
Gross area			A_g	112500	mm ²
Area of core			A_k	70150	mm ²
Spacing of lateral ties			S	75	mm
Larger dimension of the hoop			H	230	mm
Cross sectional area of hoop			A_{sh}	74.98	mm ²

DESIGN OF SLAB S1

ROOF LEVEL SLAB

Design of two way Slab

Basic Data

Grade of concrete (fck)	=	M 20
Grade of steel (fy)	=	Fe 500
Thickness of slab (D)	=	125 mm
Clear cover (cc)	=	15 mm
Effective thickness of slab (deff) = 125 - 15 - 8 / 2	=	106 mm
Unit weight of concrete	=	25 KN/m ³
Effective Shorter Span (Lx)	=	3.18 m
Effective Longer Span (Ly)	=	3.467 m
Aspect ratio Ly/Lx	=	1.09 Two way slab
Edge Condition : Two adjacent Edges Discontinuous		

Load Data

Dead Load	=	0.13 x 25	=	3.125	KN/m ²
Floor finish	=		=	1.50	KN/m ²
Imposed Load	=		=	2.00	KN/m ²
Total load	=		=	6.63	KN/m ²
Design load (Wu) = 1.5 x 6.625	=		=	9.94	KN/m ²

Moment and Shear Calculations

Short Span Direction

ax for positive moment	1	→	0.035
	1.1	→	0.04
	for 1.09 αx	=	0.040
Positive moment Mx	0.040 x 9.94 x 3.18 ^2	=	3.97 KN-m
ax for negative moment	1	→	0.047
	1.1	→	0.053
	for 1.09 αx	=	0.052
Negative moment Mx	0.052 x 9.94 x 3.18 ^2	=	5.27 KN-m

Long Span Direction

For positive moment	αy	=	0.035
Positive moment My	0.035 x 9.94 x 3.18 ^2	=	3.52 KN-m
For negative moment	αy	=	0.047
Negative moment My	0.047 x 9.94 x 3.18 ^2	=	4.72 KN-m

$$\text{Shear force } V_u = 9.94 \times 3.2 \times 0.5 = 15.80 \text{ KN}$$

Check Effective Depth for Bending

$$\text{Depth required} = (M_x / (0.133 \times f_{ck} \times b))^{1/2} = 44.50 \text{ mm}$$

$$\text{Depth provided} = 125 - 15 - 8 / 2 = 106 \text{ mm}$$

Hence O.K

Reinforcement calculations

Short Span Direction @ Support

$$M_u / b d^2 = \frac{5.27 \times 10^6}{1000 \times 106 \times 106} = 0.469$$

$$P_t = 0.11 \%$$

$$\text{Area of steel } A_{st} = 0.00111 \times 1000 \times 106 = 117.55 \text{ mm}^2$$

$$\text{Minimum area of steel} = 0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2$$

$$\text{Spacing of Y 8 bars} = 50.27 \times 1000 / 150.00 = 334.93 \text{ mm}$$

$$A_{st} \text{ provided} = 335.1 \text{ mm}^2$$

Check for Spacing

$$\text{Minimum of } 1) \ 3d = 318 \text{ mm}$$

$$2) = 300 \text{ mm}$$

$$3) = 334.93 \text{ mm}$$

Therefore provide Y 8 @ 150 mm C/C

Short Span Direction @ Mid Span

$$M_u / b d^2 = \frac{3.97 \times 10^6}{1000 \times 106 \times 106} = 0.353$$

$$P_t = 0.083 \%$$

$$\text{Area of steel } A_{st} = 0.00083 \times 1000 \times 106 = 87.982 \text{ mm}^2$$

$$\text{Minimum area of steel} = 0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2$$

$$\text{Spacing of Y 8 bars} = 50.27 \times 1000 / 150.00 = 334.93 \text{ mm}$$

$$A_{st} \text{ provided} = 335.1 \text{ mm}^2$$

Check for Spacing

$$\text{Minimum of } 1) \ 3d = 318 \text{ mm}$$

$$2) = 300 \text{ mm}$$

$$3) = 334.93 \text{ mm}$$

Therefore provide Y 8 @ 150 mm C/C 100

$$\text{Provided \% of Tension Reinforcement (pt)} = 0.316 \%$$

Long Span Direction @ Support

$$\mu/bd^2 = \frac{4.72 \times 10^6}{1000 \times 106 \times 106} = 0.420$$

$$P_t = 0.099 \%$$

$$\begin{aligned} \text{Area of steel } A_{st} &= 0.00099 \times 1000 \times 106 = 105.09 \text{ mm}^2 \\ \text{Minimum area of steel} &0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2 \\ \text{Spacing of Y 8 bars} &50.27 \times 1000 / 150.00 = 334.93 \text{ mm} \\ \text{Ast provided} &= 335.1 \text{ mm}^2 \end{aligned}$$

Check for Spacing

$$\begin{aligned} \text{Minimum of} \quad &1) \ 3d = 318 \text{ mm} \\ &2) \quad = 300 \text{ mm} \\ &3) \quad = 334.93 \text{ mm} \end{aligned}$$

Therefore provide Y 8 @ 150 mm C/C

Long Span Direction @ mid Span

$$\mu/bd^2 = \frac{3.52 \times 10^6}{1000 \times 106 \times 106} = 0.313$$

$$P_t = 0.073 \%$$

$$\begin{aligned} \text{Area of steel } A_{st} &= 0.00073 \times 1000 \times 106 = 77.742 \text{ mm}^2 \\ \text{Minimum area of steel} &0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2 \\ \text{Spacing of Y 8 bars} &50.27 \times 1000 / 150.00 = 334.93 \text{ mm} \\ \text{Ast provided} &= 335.1 \text{ mm}^2 \end{aligned}$$

Check for Spacing

$$\begin{aligned} \text{Minimum of} \quad &1) \ 3d = 318 \text{ mm} \\ &2) \quad = 300 \text{ mm} \\ &3) \quad = 334.93 \text{ mm} \end{aligned}$$

Therefore provide Y 8 @ 150 mm C/C

Check for Deflection:

$$\begin{aligned} \text{Basic Span/depth Ratio} &= 22 \\ \% \text{ of Tension Reinforcement provided (} P_t \text{)} &= 0.316 \% \\ \text{Service stress of steel (} f_s \text{) : } 0.58f_y(A_{st_r}/A_{st_p}) &= 76.14 \text{ N/mm}^2 \\ \text{Modification Factor for Tension Reinforcement (} F_1 \text{)} &= 2.00 \\ \text{Allowable Span/Eff Depth Ratio} &= 44 \\ \text{Actual Span/Eff Depth Ratio} &= 3.18 \times 1000 / 106 = 30.00 \end{aligned}$$

Hence O.K

DESIGN OF SLAB S2

ROOF LEVEL SLAB

Design of two way Slab

Basic Data

Grade of concrete (fck)	=	M 20
Grade of steel (fy)	=	Fe 500
Thickness of slab (D)	=	125 mm
Clear cover (cc)	=	15 mm
Effective thickness of slab (deff) = 125 - 15 - 8 / 2	=	106 mm
Unit weight of concrete	=	25 KN/m ³
Effective Shorter Span (Lx)	=	3.35 m
Effective Longer Span (Ly)	=	3.467 m
Aspect ratio Ly/Lx	=	1.03 Two way slab
Edge Condition : Two adjacent Edges Discontinuous		

Load Data

Dead Load	=	0.13 x 25	=	3.125	KN/m ²
Floor finish	=		=	1.50	KN/m ²
Imposed Load	=		=	2.00	KN/m ²
Total load	=		=	6.63	KN/m ²
Design load (Wu) = 1.5 x 6.625	=		=	9.94	KN/m ²

Moment and Shear Calculations

Short Span Direction

ax for positive moment	1	→	0.035
	1.1	→	0.04
	for 1.03 αx	=	0.037
Positive moment Mx	0.037 x 9.94 x 3.35 ^2	=	4.10 KN-m
ax for negative moment	1	→	0.047
	1.1	→	0.053
	for 1.03 αx	=	0.049
Negative moment Mx	0.049 x 9.94 x 3.35 ^2	=	5.48 KN-m

Long Span Direction

For positive moment	αy	=	0.035
Positive moment My	0.035 x 9.94 x 3.35 ^2	=	3.90 KN-m
For negative moment	αy	=	0.047
Negative moment My	0.047 x 9.94 x 3.35 ^2	=	5.24 KN-m

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$$\text{Shear force } V_u = 9.94 \times 3.4 \times 0.5 = 16.65 \text{ KN}$$

Check Effective Depth for Bending

$$\text{Depth required} = (M_x / (0.133 \times f_{ck} \times b))^{1/2} = 45.37 \text{ mm}$$

$$\text{Depth provided} = 125 - 15 - 8 / 2 = 106 \text{ mm}$$

Hence O.K

Reinforcement calculations

Short Span Direction @ Support

$$M_u / b d^2 = \frac{5.48 \times 10^6}{1000 \times 106 \times 106} = 0.487$$

$$P_t = 0.12 \%$$

$$\text{Area of steel } A_{st} = 0.00115 \times 1000 \times 106 = 122.33 \text{ mm}^2$$

$$\text{Minimum area of steel} = 0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2$$

$$\text{Spacing of Y 8 bars} = 50.27 \times 1000 / 150.00 = 334.93 \text{ mm}$$

$$A_{st} \text{ provided} = 402.12 \text{ mm}^2$$

Check for Spacing

$$\text{Minimum of } 1) 3d = 318 \text{ mm}$$

$$2) = 300 \text{ mm}$$

$$3) = 334.93 \text{ mm}$$

Therefore provide Y 8 @ 125 mm C/C

Short Span Direction @ Mid Span

$$M_u / b d^2 = \frac{4.10 \times 10^6}{1000 \times 106 \times 106} = 0.365$$

$$P_t = 0.086 \%$$

$$\text{Area of steel } A_{st} = 0.00086 \times 1000 \times 106 = 90.868 \text{ mm}^2$$

$$\text{Minimum area of steel} = 0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2$$

$$\text{Spacing of Y 8 bars} = 50.27 \times 1000 / 150.00 = 334.93 \text{ mm}$$

$$A_{st} \text{ provided} = 402.12 \text{ mm}^2$$

Check for Spacing

$$\text{Minimum of } 1) 3d = 318 \text{ mm}$$

$$2) = 300 \text{ mm}$$

$$3) = 334.93 \text{ mm}$$

Therefore provide Y 8 @ 125 mm C/C 100

$$\text{Provided \% of Tension Reinforcement (pt)} = 0.379 \%$$

Long Span Direction @ Support

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$$\begin{aligned} \mu/bd^2 &= \frac{5.24 \times 10^6}{1000 \times 106 \times 106} = 0.467 \\ p_t &= 0.110 \% \end{aligned}$$

$$\begin{aligned} \text{Area of steel } A_{st} &= 0.00110 \times 1000 \times 106 = 116.96 \text{ mm}^2 \\ \text{Minimum area of steel} &0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2 \\ \text{Spacing of Y 8 bars} &50.27 \times 1000 / 150.00 = 334.93 \text{ mm} \\ \text{Ast provided} &= 335.1 \text{ mm}^2 \end{aligned}$$

Check for Spacing

$$\begin{aligned} \text{Minimum of} \quad &1) \quad 3d = 318 \text{ mm} \\ &2) \quad = 300 \text{ mm} \\ &3) \quad = 334.93 \text{ mm} \end{aligned}$$

Therefore provide Y 8 @ 150 mm C/C

Long Span Direction @ mid Span

$$\begin{aligned} \mu/bd^2 &= \frac{3.90 \times 10^6}{1000 \times 106 \times 106} = 0.347 \\ p_t &= 0.082 \% \end{aligned}$$

$$\begin{aligned} \text{Area of steel } A_{st} &= 0.00082 \times 1000 \times 106 = 86.458 \text{ mm}^2 \\ \text{Minimum area of steel} &0.0012 \times 1000 \times 125 = 150.00 \text{ mm}^2 \\ \text{Spacing of Y 8 bars} &50.27 \times 1000 / 150.00 = 334.93 \text{ mm} \\ \text{Ast provided} &= 335.1 \text{ mm}^2 \end{aligned}$$

Check for Spacing

$$\begin{aligned} \text{Minimum of} \quad &1) \quad 3d = 318 \text{ mm} \\ &2) \quad = 300 \text{ mm} \\ &3) \quad = 334.93 \text{ mm} \end{aligned}$$

Therefore provide Y 8 @ 150 mm C/C

Check for Deflection:

$$\begin{aligned} \text{Basic Span/depth Ratio} &= 22 \\ \% \text{ of Tension Reinforcement provided (} p_t \text{)} &= 0.379 \% \\ \text{Service stress of steel (} f_s \text{) : } 0.58f_y(A_{st_r}/A_{st_p}) &= 65.53 \text{ N/mm}^2 \\ \text{Modification Factor for Tension Reinforcement (} F_1 \text{)} &= 2.00 \\ \text{Allowable Span/Eff Depth Ratio} &= 44 \\ \text{Actual Span/Eff Depth Ratio} &= 3.35 \times 1000 / 106 = 31.60 \end{aligned}$$

Hence O.K

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