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STRUCTURAL DESIGN STABILITY CERTIFICATE

I hereby certify that the Proposed Construction of Stilt + 3 Floors Residential Building at New No: 18, Old No: 33 & 33A, Buddhar Street, Selaiyur, East Tambaram, Chennai – 600059, Comprised in Old S.No: 94/2A3B1C1A1B(part), T.S.No: 19/2 and 20, Block No: 22, Ward – G of Selaiyur Village, Greater Chennai Corporation Limit, that the building will with stand against the Earthquake, (Seismic Zone III as per IS 1893 (Part-I) - 2016) loading stress parameters are within limits of National building code and Bureau of Indian standards code of practice for concrete and loading. 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 the structural design and detailing of reinforcements given in the drawing from foundation to roof slab and beam. For external and internal partition walls 230/115 thick Brick walls are used. The structure is sound and stable.

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DESIGN BASIS REPORT

FOR PROPOSED RESIDENTIAL BUILDING

AT TAMBARAM, CHENNAI.

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1.0 OBJECTIVE

The Design basis covers the basic requirement that will be followed for the design of PROPOSED RESIDENTIAL BUILDING AT TAMBARAM, CHENNAI.

The building is designed for Stilt + 3 Floors. 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 – 1.5 KN/m²
4. Brick work masonry walls 230 thick are proposed to be used (location of walls per Architectural drawings) Unit weight is taken as 20 KN/m^3
5. Weathering course in Terrace finish – 3 KN/m^2

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.	All Floors	=	2 KN/m^2
2.	Staircase	=	3 KN/m^2
3.	Toilets	=	2 KN/m^2
4.	Terrace floors	=	1.5 KN/m^2

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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)

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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 SBC of soil is taken as 300 kN/m^2 at a depth of 2.0 m.

4.1.3 All Concrete elements shall be designed in accordance with IS 456: 2000 Limit State Design.

4.1.4 Appropriate loads and its combinations, as per relevant clauses, for the most unfavorable effects are chosen for design. (Refer Load Combination below).

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5.0 MATERIALS

The self-weight 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 all structural Elements.

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

6.0 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

Footing – 50mm

Beam – 25mm

Slab – 20mm

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DESIGN OF BEAM: 1

Beam size: 230mm x 450mm

Bending moment at support	=	170 kNm
Bending moment at mid span	=	123 kNm
Shear force, Vu	=	119kN
Bending moment at support, Mu	=	170 kNm
R	=	$(170 \times 10^6)/230x405^2$
	=	4.50
Pt/100 = Ast/bd	=	fck/2fy [1-Sq.rt(1-4.598xR/fck)
fck	=	25 N/mm^2
fy	=	500 N/mm^2
Pt	=	1.46%
Ast required	=	1366 mm^2

Provide 2 nos 16Y & 2 no 25Y

Ast provided	=	1384 mm^2

Hence safe

Bending moment at mid span, Mu	=	123 kNm
R	=	$123 \times 10^6 /230 \times 405^2$
	=	3.26
Pt	=	0.916%
Ast required	=	856 mm^2

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Provide 2 nos 16Y & 2 nos 20Y

Ast provided = 1030 mm^2

Hence it is safe.

Shear force, Vu, = 119 kN

τ_v = V_u/bd

= 119 x 10^3 / 230 x 405

= 1.277 N/mm^2

Hence ok.

Shear capacity of concrete:

Pt = 1.39%

τ_c = 0.7

= τ_c* bd

= 0.7 X 230 X 405

= 65205 N (or) 65 kN

Shear to be carried by stirrups

V_u = Vs – τ_c bd

= 119 – 65 kN

= 54 kN

Therefore, provide 2 legged 8Y @ 200 mm C/C at midspan.

Provide 2 legged 8Y @ 100 mm C/C at support.

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DESIGN OF SLAB-1

DESIGN CALCULATIONS

Design of two way Slab

Basic Data

Grade of concrete (fck)		=	M 25	
Grade of steel (fy)		=	Fe 500	
Thickness of slab (D)		=	125	mm
Clear cover (cc)		=	20	mm
Effective thickness of slab (deff)	= 125 - 20 - 8 /2	=	101	mm
Unit weight of concrete		=	25	KN/m^3
Effective Shorter Span (Lx)		=	3.15	m
Effective Longer Span (Ly)		=	3.25	m
Aspect ratio Ly/Lx		=	1.03	**Two way slab**

Edge Condition : **Three Edges Discontinuous (One Long Edge Continuous)**

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	→	0.043	
			1.1	→	0.048	
		for 1.03	αx	=	0.045	
Positive moment Mx :	0.045 x	9.94 x	3.15 ^2	=	**4.40**	KN-m
ax for negative moment			1	→	0.057	
			1.1	→	0.064	
		for 1.03	αx	=	0.059	
Negative moment Mx :	0.059 x	9.94 x	3.15 ^2	=	**5.84**	KN-m

Long Span Direction

For positive moment			αy	=	0.043	
Positive moment My :	0.043 x	9.94 x	3.15 ^2	=	**4.24**	KN-m
For negative moment			αy	=	0.000	
Negative moment My :	0.000 x	9.94 x	3.15 ^2	=	**0.00**	KN-m

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Shear force V_u = 9.94 x 3.2 x 0.5 = **15.65** KN

Check Effective Depth for Bending

Depth required = $(M_x / (0.133x\ fck\ x\ b))^{1/2}$ = 41.91 mm

Depth provided = 125 - 20 - 8 /2 = 101 mm

Hence O.K

Reinforcement calculations

Short Span Direction @ Support

Mu/bd^2 = $\frac{5.84 \times 10 \wedge 6}{1000 \times 101 \times 101}$ = **0.572**

Pt = **0.14** %

Area of steel Ast = 0.00135 x 1000 x 101 = 136.68 mm^2

Minimum area of steel: 0.0012 x 1000 x 125 = 150.00 mm^2

Spacing of Y **8** bars 50.27 x 1000 / 150.00 = 334.933 mm

Ast provided = 335.104 mm^2

Check for Spacing

Minimum of 1) 3d = 303 mm

2) = 300 mm

3) = 334.93 mm

Therefore provide Y **8** @ **150** mm C/C

Short Span Direction @ Mid Span

Mu/bd^2 = $\frac{4.40 \times 10 \wedge 6}{1000 \times 101 \times 101}$ = 0.431

Pt = 0.101 %

Area of steel Ast = 0.00101 x 1000 x 101 = 102.187 mm^2

Minimum area of steel: 0.0012 x 1000 x 125 = 150.00 mm^2

Spacing of Y **8** bars 50.27 x 1000 / 150.00 = 334.933 mm

Ast provided = 335.104 mm^2

Check for Spacing

Minimum of 1) 3d = 303 mm

2) = 300 mm

3) = 334.93 mm

Therefore provide Y **8** @ **150** mm C/C 150

Provided % of Tension Reinforcement (pt) = **0.332** %

Long Span Direction @ Support

Mu/bd^2 = $\frac{0.00 \times 10 \wedge 6}{1000 \times 101 \times 101}$ = 0.000

Pt = 0.000 %

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Area of steel Ast	=	0.00000	x	1000 x	101	=	0	mm^2
Minimum area of steel:		0.0012	x	1000 x	125	=	0.00	mm^2
Spacing of Y	8 bars	50.27	x	1000 /	0.00	=	0	mm
Ast provided						=	335.104	mm^2

Check for Spacing

Minimum of	1)	3d	=	303	mm
	2)		=	300	mm
	3)		=	0.00	mm

Therefore provide Y **8** @ **150** mm C/C

Long Span Direction @ mid Span

$$Mu/bd^2 = \frac{4.24 \times 10 \wedge 6}{1000 \times 101 \times 101} = 0.416$$

Pt = 0.097 %

Area of steel Ast	=	0.00097	x	1000 x	101	=	98.4749	mm^2
Minimum area of steel:		0.0012	x	1000 x	125	=	150.00	mm^2
Spacing of Y	8 bars	50.27	x	1000 /	150.00	=	334.933	mm
Ast provided						=	335.104	mm^2

Check for Spacing

Minimum of	1)	3d	=	303	mm
	2)		=	300	mm
	3)		=	334.93	mm

Therefore provide Y **8** @ **150** mm C/C

Check for Deflection:

Basic Span/depth Ratio	=	20	
% of Tension Reinforcement provided (pt)	=	0.332	%
Service stress of steel (fs) : 0.58fy(Ast_r/Ast_p)	=	88.43	N/mm^2
Modification Factor for Tension Reinforcement (F1)	=	2.00	
Allowable Span/Eff Depth Ratio	=	40	
Actual Span/Eff Depth Ratio = 3.15 x 1000 / 101	=	31.19	

Hence O.K

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DESIGN OF COLUMN - C1

Length of column	D	375	mm
Breadth of column	b	300	mm
Unsupported length (longer direction)	L_x	3000	mm
Unsupported length (shorter direction)	L_y	3000	mm
Eff. Length (longer direction)	L_{ex}	2400	mm
Eff. Length (shorter direction)	L_{ey}	2400	mm
Factored Load	P_u	425	kN
Factored moment (longer direction)	Mux	21	kNm
Factored moment (shorter direction)	Muz	9	kNm
Charac. comp strength of concrete	f_{ck}	25	N/mm^2
Yield stress of steel	f_y	500	N/mm^2
Dia of bar used	Φ	12	mm
Clear cover		40	mm
Effective cover	d'	46	mm
Effective depth	d	329	mm
Check for slenderness			
Longer Direction			
Slenderness ratio	L_{ex}/D	6.40	**short**
Additional moment due to slenderness	M_{ax}	0	kN-m
Shorter Direction			
Slenderness ratio	L_{ey}/b	8.00	**short**
Additional moment due to slenderness	M_{ay}	0	kN-m
Calculation of P_{uz}			
No of bars used		10	
Area of reinforcement	Ast	1130.4	
Provided steel		10 nos Y12	
Percentage of reinforcement	p_t	1.005	%
Area of concrete	Ag	112500	mm^2
Ultimate axial load (without moments)	P_{uz}	1677	kN
Calculation of P_b:			
Longer Direction			
	d'/D	0.123	
Coefficient k_1(from TABLE 60 of SP:1980)	k_{1x}	0.202	From Sp16
Coefficient k_2(from TABLE 60 of SP:1980)	k_{2x}	0.371	
Axial load corresponding to balanced failure	P_{bx}	609	kN
Reduction factor for additional moments	k_x	1.000	
Moment due to slenderness	M_{ax}	**0.00**	kN-m
Shorter Direction			
	d'/b	0.153	
Coefficient k_1(from TABLE 60 of SP:1980)	k_{1y}	0.194	
Coefficient k_2(from TABLE 60 of SP:1980)	k_{2y}	0.297	
Axial load corresponding to balanced failure	P_{by}	580	kN
Reduction factor for additional moments	k_y	1.000	
Moment due to slenderness	M_{ax}	**0.00**	kN-m

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Check for moments due to min. eccentricity			
Longer Direction	e_x	18.50	mm
Minimum eccentricity	M_x	7.86	kN-m
Moment due to min. eccentricity	M_{ux}	21.00	kNm
Moment in longer direction			
Shorter direction	e_y	16.00	mm
Minimum eccentricity	M_y	6.80	kN-m
Moment due to min. eccentricity	M_{uy}	9	kNm
Moment in shorter direction			
Final design moments			
	M_{ux}	**21.00**	kNm
Moment in longer direction	M_{uy}	**9.00**	kNm
Moment in shorter direction			
Check for interaction	d'/D	0.123	
	d'/b	0.153	
	p/f_{ck}	0.040	
p/f_{ck}	$P_u/f_{ck}bD$	0.151	
$P_u/f_{ck}bD$ value	$M_{ux1}/f_{ck}bD^2$	0.090	
$M_{ux1}/f_{ck}bD^2$ value (from SP 16:1980 charts)	M_{ux1}	**94.921875**	kNm
Uniaxial moment capacity (longer direction)	$M_{uy1}/f_{ck}bD^2$	0.090	
$M_{uy1}/f_{ck}bD^2$ value (from SP 16:1980 charts)	M_{uy1}	**75.9375**	kNm
Uniaxial moment capacity (shorter direction)	P_u/P	**0.253**	
P_u/P_{uz} ratio		1.090	
Value of exponent		**0.291**	
Interaction ratio		**safe**	
Percentage reinforcement satisfactory or not			
	b/D	0.8	
b/D ratio		**OK**	
Status of dimensions	A_g	112500	mm^2
Gross area	A_k	70150	mm^2
Area of core	S	75	mm
Spacing of lateral ties	H	230	mm
Larger dimension of the hoop	A_{sh}	93.73	mm^2
Cross sectional area of hoop			

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DESIGN OF FOOTING -F1

Basic Data
Material Data

Grade of Concrete	f_{ck}	=	M25
Yeild Strength of Reinforcement	f_y	=	500 N/mm^2
Unit Weight of Concrete	γ_c	=	25.0 kN/m^3
Unit Weight of Soil	γ_s	=	18.0 kN/m^3
Frictional Factor bet. Soil & Concrete	μ	=	0.35

Soil Data:

Type of soil in foundation			MEDIUM
Net Safe Bearing Capacity	SBC	=	300 kN/m^2

Clear cover to Reinforcement

Clear Cover to Footing Slab	=	50.0 mm
Clear Cover to Pedestal	=	40.0 mm

Basic Dimensions
Size of Pedestal

Length	l	=	0.375 m
Breadth	b	=	0.300 m
Depth of foundation from GL	D	=	2.000 m

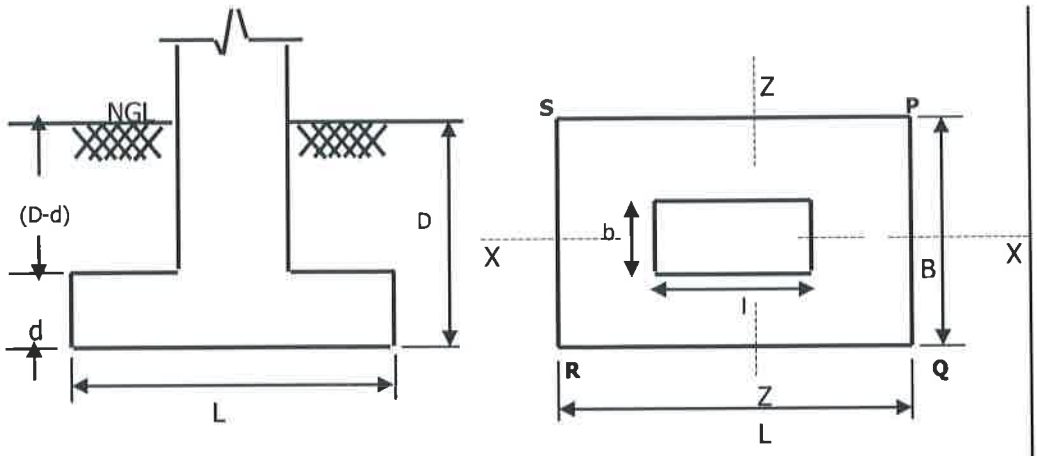
Size of Foundation Pad

Length	L	=	1.425 m
Breadth	B	=	1.425 m
Thickness of Base Slab	d	=	0.375 m

Analysis Results

Loads	V	Mzz	Hx	Mxx	Hz
	kN	kN m	kN	kN m	kN
Dead Load	275.00	10.00	0.00	5.00	0.00
Live Load	0.00	0.00	0.00	0.00	0.00
Wind or Seismic Load	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00

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Load Combination

Load Combination for Design

1) 1.5DL + 1.5LL
2) 1.2DL + 1.2LL + 1.2WL(OR)SL
3) 1.5DL + 1.5WL(OR)SL
4) 0.9DL + 1.5WL(OR)SL

Unfactored Loads

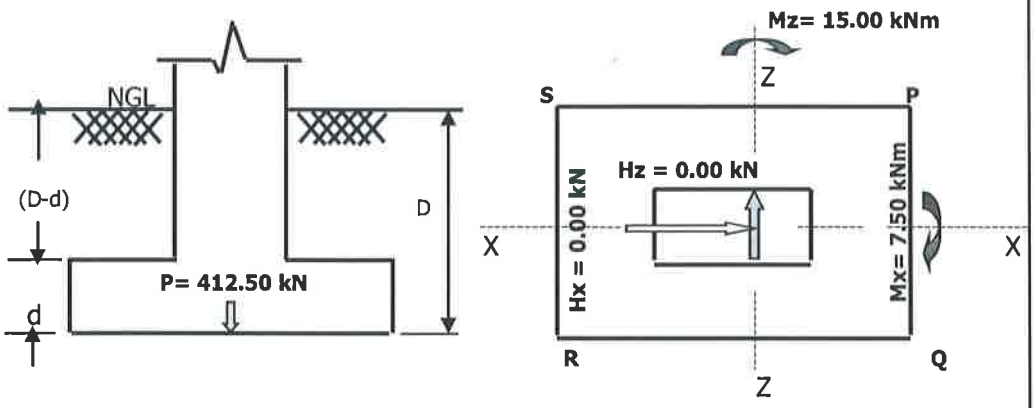
Load Combinaion	V	Mzz	Hx	Mxx	Hz
	kN	kN m	kN	kN m	kN
Case 1) DL + LL	275.00	0.00	0.00	0.00	0.00
Case 2) DL + LL + WL(OR)SL	275.00	10.00	0.00	5.00	0.00
Case 3) DL + WL(OR)SL	275.00	10.00	0.00	5.00	0.00

Factored loads

Load Combinaion	V	Mzz	Hx	Mxx	Hz
	kN	kN m	kN	kN m	kN
Case 1) 1.5DL + 1.5LL	412.50	15.00	0.00	7.50	0.00
Case 2) 1.2DL + 1.2LL + 1.2WL(OR)SL	330.00	12.00	0.00	6.00	0.00
Case 3) 1.5DL + 1.5WL(OR)SL	412.50	15.00	0.00	7.50	0.00
Case 4) 0.9DL + 1.5WL(OR)SL	247.50	9.00	0.00	4.50	0.00

Design of Footing for Case 3

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Calculation of Bearing Pressure under the Footing

eccentricity	e_z	=	M_{xx}/W	=	0.018 m		
			e_z/B	=	0.013		
			B/6	=	0.238	>	0.013
eccentricity	e_x	=	M_{zz}/W	=	0.036 m		
			e_x/L	=	0.026		
			L/6	=	0.238	>	0.026

Hence all the four edges are in contact with Soil

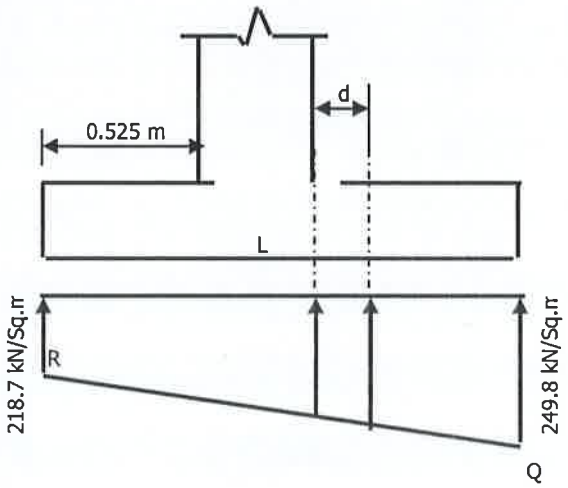
Maximum Soil Pressure at Point Q q_{max} =

= 249.79 kN/m^2

< **450.00** kN/m^2

HENCE SAFE

Design of Foundation Pad along X direction
Bearing Pressure Distribution



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PRESSURE DISTRIBUTION DIAGRAM

Depth of Pad	d	=	375 mm
Therefore, effective depth	d_{eff}	=	320 mm
Pressure at face of Pedestal		=	238.33 kN/m^2
Pressure @ dist "d" from face of pedestal		=	245.32 kN/m^2

Depth required for Bending Moment

Critical section for moment will be at the face of the pedestal.

Overhang distance	x	=	0.525 m
Bending Moment at face of Pedestal		=	**33.9** kNm/m
Depth reqd for the above moment	d_{eff1}	=	101 mm
Provided Depth		=	320 mm
		>	**101 HENCE OK**

Area of Steel Required for Bending

$$\frac{x}{d} = 0.0374$$

Lever Arm Depth Z = 315.02 mm

Reinforcement Required

$$A_{st} = \frac{M_u}{0.87\, f_y Z} = 247.374875 \text{ mm}^2$$

Minimum Area of Steel Required

Minimum reinforcement required: = 450 mm^2

Reinforcement Provided

Spacing of Y 10 bars		=	174.533333 mm
Provide Y **10** at **150** mm c/c		=	**523.6** mm^2
		>	**450.00 HENCE OK**
Percentage of Reinforcement Provided		=	**0.16%**

Check for One Way Shear

Design Shear Strength of Concrete	τ_c	=	0.30 N/mm^2
	K	=	1.00
τ_c for Solid Slab	$\tau_c k$	=	0.30 N/mm^2

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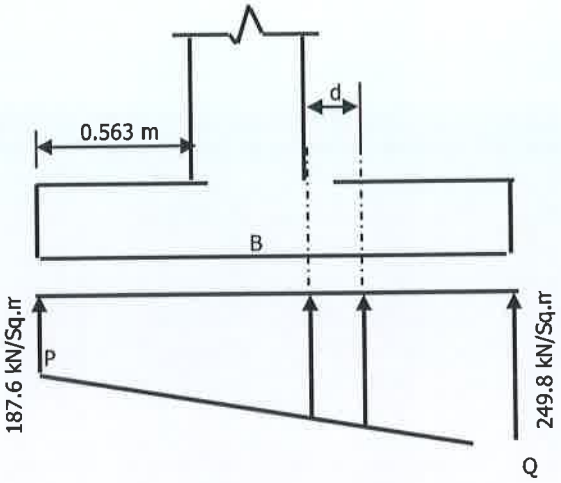
Pressure at dist "d" from face of pedestal		=	245.32 kN/m^2
SF at dist "d" from face of pedestal	V	=	50.75 kN
Depth required for one way shear	d_{eff2}	=	168 mm
Provided Depth		=	320 mm
		>	**168 HENCE OK**

Check for Two Way Shear

Maximum shear stress= 0.25(fck)$^{0.5}$	τ_c	=	1.25 N/mm^2
Vertical load punching the base slab		=	412.50 kN
Preimeter		=	2630 mm
Depth required for two way shear	d_{eff3}	=	125 mm
Provided Depth		=	320 mm
		>	**125 HENCE OK**

Design of Foundation Pad along Z direction

Bearing Pressure Distribution



PRESSURE DISTRIBUTION DIAGRAM

Depth of Pad	d	=	375 mm
Therefore, effective depth	d_{eff}	=	310 mm
Pressure at face of Pedestal		=	226.88 kN/m^2
Pressure at dist "d" from face of pedestal		=	238.77 kN/m^2

Depth required for Bending Moment

Critical section for moment will be at the face of the pedestal.

Overhang distance	y	=	0.563 m
Bending Moment at face of Pedestal		=	**38.31** kNm/m
Depth reqd for the above moment	d_{eff1}	=	107 mm
Provided Depth		=	310 mm
		>	**107 HENCE OK**

Area of Steel Required for Bending

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	$\frac{x}{d}$ =		
	=	0.0452	
Lever Arm Depth	Z =		
	=	304.17	mm
Reinforcement Required	A_{st} =	$\frac{M_u}{0.87 f_y Z}$	
	=	289.54	mm^2

Minimum Area of Steel Required

Minimum reinforcement required:	=	450.00	mm^2

Reinforcement Provided

Spacing of Y 10 bars	=	174.53	mm
Provide Y **10** at **150** mm c/c	=	**523.60**	mm^2
	>	**450.00**	**HENCE OK**
Percentage of Reinforcement Provided	=	**0.17%**	

Check for One Way Shear

Design Shear Strength of Concrete	t_c	=	0.31	N/mm^2
	K	=	1.00	
t_c for Solid Slab	$t_c k$	=	0.31	N/mm^2
Pressure at dist "d" from face of pedestal		=	238.77	kN/m^2
SF at dist "d" from face of pedestal	V	=	61.68	kN
Depth required for one way shear	d_{eff2}	=	201	mm
Provided Depth		=	320	mm
		>	**201**	**HENCE OK**

Check for Two Way Shear

Maximum shear stress= $0.25(fck)^{0.5}$	τ_c	=	1.25	N/mm^2
Vertical load punching the base slab		=	412.50	kN
Preimeter		=	2590	mm
Depth required for two way shear	d_{eff3}	=	127	mm
Provided Depth		=	320	mm
		>	**127**	**HENCE OK**

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