DESIGN BASIS REPORT

FOR THE PROPOSED RESIDENTIAL BUILDING AT PADUR ROAD,KUTHAMBAKKAM, CHENNAI-600124.

S.NO.309/1A,1B,1C,1D,1E,1F,3B,418/1A,1B,1C& 1D2 OF KUTHAMBAKKAM VILLAGE POONAMALLEE PANCHAYAT UNION, THIRUVALLUR DISTRICT

Rev	Date	Approval	Prepared by	Checked by	Remarks
R0	12.02.2022	Issued for Approval	KP	SS	

Contents

1. Project Description

The proposed residential building at Padur road, Kuthambakkam, Chennai – 600126, with S.No. 309/aA, 1B, 1C,1D,1E,1F,3B,418/1A, 1B, 1C & 1D2 of Kuthambakkam village, Poonamallee Panchayat Union, Thiruvallur district.

The project consists of 7 Towers with a club house, The towers 3,4, 6 and 7 have a combined basement with stilt and 13 upper floors. Towers 1,2&5 are without basements and has stilt +13 upper floors. The club house has Ground + 2 floors. The campus has a swimming pool and a commercial complex with Ground +4 upper floors.

2. Materials

2.1. Concrete

Concrete used for structural purpose shall be of grade M30/M40 and comply with the relevant provisions of IS: 456 – 2000. Normal coarse aggregates shall be used for all concrete works. Ordinary Portland cement - Grade 43/53 (conforming to IS 8112/12269),Portland Pozzolana Cement (conforming to IS: 1489 (Part 1) shall be used in all structural concrete works.

Structural Elements	Grade of concrete
Foundation	M30
Colum/Walls	M30/M40
Beams	M30/M40
Slabs	M30

2.2. Reinforcement

Steel reinforcement shall be Grade Fe500D. It shall confirm to IS: 1786-2008.Elongation percentage shall be 16%.as per IS-1786-2008

Structural Design Standards

Latest revisions of all applicable codes shall be mentioned below, unless otherwise mentioned:

Design Code Number	Description
IS-875(Part 1) - 1987	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Unit Weights of Buildings Materials and Stored Material

IS-875(Part 2) - 1987	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Imposed Loads
IS-875(Part 3) - 2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Wind Loads
IS-875 (Part 5) - 1987	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Special Loads and Load Combinations
IS:456-2000	Code of Practice for Plain and Reinforced Concrete
IS:432(Part 2) -1982	Specification for Mild Steel and MediumTensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement - Hard Drawn Steel Wire
IS: 1893:part-1-2016	Criteria for Earthquake Resistant Design of Structures Part - 1 General Provisions and Buildings
IS: 800-2007	General construction of steel- code of practice.
IS 1904- 1986	Code of practice for design & construction of foundations in soil general requirements
IS 2950(Part 1)-1981	Code of practice for design & construction of raft Foundations, Part I - Design
IS 6403-1981	Code of Practice for determination of bearing capacity of shallow foundations
IS 13920:2016	Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces

Miscellaneous:

IS: 432(part 2) – 1995	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
IS: 6313(part II) - 2001	Standards for anti-termite treatment
IS:1905 - 1998	Code of Practice for structural use of unreinforced masonry
IS:3067 - 1995	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
SP:6 - 1998	Handbook for structural engineers (all parts)
SP:7 - 2005	National Building Code of India
SP:16 - 1999	Design Aids for reinforced concrete to IS:456-1978
SP:22 - 1982	Explanatory handbook on codes for earthquake engineering (IS:1982-1975 and IS:4326-1976)
SP:24 - 1983	Explanatory handbook on Indian Standard code of Practice for plain and reinforced concrete
SP:34 - 1987	Handbook of concrete reinforcement and detailing (SCIP)

Material :

IS: 269 - 1998	Specification for Ordinary, rapid hardening and low heat Portland cement
IS: 455 - 1995	Specification for Portland blast furnace slag cement.
IS: 1489 - 1991	Specification for Portland pozzolana cement
IS: 4031- 1991	Method of physical tests for Portland cement
IS: 383 - 2016	Specification for coarse and fine aggregates from natural sources for concrete
IS: 516 - 1999	Method of test for strength of concrete
IS: 1199 - 1999	Method of sampling and analysis of concrete
IS: 1566 - 2000	Specification for plain hard drawn steel wire fabric for concrete Reinforcement
IS: 4990 - 1998	Specification for plywood for concrete shuttering works
IS: 2645 - 1999	Specification for integral cement water proofing compounds

Note: Only latest revisions of the codes, unless otherwise mentioned, shall be referred to for the purpose of this tender.

3. Loads

Structures shall be designed for structural stability and integrity to resist safely and effectively all loads and effects of load combinations that may reasonably be expected during the lifetime of the structure. The design loads used for the structures, buildings and foundations shall conform to the requirements of the governing codes and specifications. As a minimum the design loads shall include dead load, super-imposed dead load, live load, wind load and seismic load.

3.1 Dead loads

Dead load shall include weight of all structural and Architectural components. Self-weight of the materials shall be calculated on the basis of unit weights given in IS: 875.

1. Unit weight of Plain concrete : $24.0 kN/m^3$

2. Unit weight of Reinforced concrete : $25.0 kN/m^3$
3. Unit weight of Block masonry : $24.0 kN/m^3$
4. Unit weight of Brick masonry : $20.0 kN/m^3$
5. Unit weight of Aerocon Block masonry : $6.0 kN/m^3$
6. Unit weight of Steel :$78.5 kN/m^3$
7. Floor finish + False ceiling :$1.5 kN/m^2$
8. Partitions Load :$1.5 kN/m^2$
9. Glazing, Louvers Load Per meter high :1.8kN/m
10. Unit Weight of Light Weight Filling :$10 kN/m^3$
11. Unit weight of Sunken filling :$18.8 kN/m^3$
12. Unit weight of Terrace Garden filling load :$18 kN/m^3$

3.2 Live loads

The superimposed loads shall be calculated in accordance with IS: 875(Part-2) based on Occupancy Classification. For multiple occupancies of use in the building shall be referred with the other appropriate comparable occupancy classification as per Table.1 of IS 875(Part-2)

Live loads for the residential tower – 2 kN/sqm

Parking - 2.5 KN/sqm

Driveway - 5 KN/sqm

Podium slab - 15 KN/sqm

3.3 Wind Loads

Basic wind speed shall be considered as per IS: 875 (Part 3) – 2015

Wind Parameters	
Basic wind speed (Vb)	50 m/sec
Probability factor (k1)	K1 = 1.0 (General buildings and structures)
Terrain roughness and height factor (k2)	Terrain category -2 Depends on height
Topography factor (k3)	K3 = 1.0
Importance factor for the cyclonic region(K4)	K4=1.0

Design wind velocity (Vz)	K1 x K2 x K3 x k4xVb
Design Wind Pressure (Pz)	0.6 x Vz^2
Wind directionality factor (K_d)	1.0
Area Averagingfactor (K_a)	1.0
Reduction factor for clad building (K_c)	0.9
Design Wind Pressure (P_d)	Pz x K_d x K_a x K_c

Note:

- Application of wind load and External pressure-wind coefficients considered shall be as adopted as per IS 875 (Part 3) -2015

3.4 Seismic Loads

Seismic loads will be considered as per IS1893 (Part 1):2016 and design shall be carried out as per the same code.

Seismic Parameters	
Seismic Load	IS1893 (Part 1)**:**2016
Zone	III
Zone Factor – Z	0.16
Importance Factor – I	1.2
Response Reduction Factor	5
Fundamental natural period	0.09 h/√d
Soil Type	As per soil report.

Note: Seismic masses are computed based on the following:

- 100% dead load, super-imposed dead loads.
- Suitable percentage of live loads to be considered as per IS: 1893 (Part1) :2016

3.5 ENVIRONMENTAL CONDITIONS

Environment/Exposure – Moderate

Fire protection – Thickness of the structural elements as per relevant codes – 2 hours fire rating

Nominal cover to reinforcement - Not less than 35 mm

Nominal covers for 2 hr. fire resistance

Cover to be adopted:

Footing – 50mm

Column – 40mm

Beams – 35 mm

Slabs – 30mm

3.6 Temperature and shrinkage effect:

Horizontal floor displacement due to differential temperatures and shrinkage is of importance in long concrete buildings. It can be taken care of by either providing expansion joints at an appropriate spacing or designing structural members for the additional moments caused by the temperature and shrinkage effects. Pour strips at suitable locations shall also be considered where required.

3.7 Temperature Loads:

The effect of temperature will be considered wherever applicable (in podium slab) in accordance with relevant Indian Codes. The coefficient for thermal expansion and contraction will be in accordance with IS: 456 for concrete.

3.8 Exceptional Loads:

Loads due to the following catastrophe scenarios are not considered in the design.

Exceptional loads due to terrorist attacks (Explosions) ·
Accidental loads (Falling of aircraft on the building) ·
Accidental collision of vehicle on to the façade of the building ·
Snow load

4. Structural Analysis and Design

The entire structure is analyzed using software ETABS which is internationally accepted.

3D model of structure is prepared. Column and beams are modeled as members, a column is from the foundation level and the support is considered as fixed. Slabs are modeled using elements. Modifiers are provided.

The Structural System comprises Conventional beam slab system supported by RC structural columns/walls for Tower and clubhouse respectively. The Towers in general has the conventional system in typical floor system and transfer girder system for the stilt floor · Floor slabs and beams are considered to act as rigid diaphragm to transfer the lateral forces to the supporting walls· Toilet is sunk by 100 mm . Staircases are provided with mid-landing between the floors as per architectural layout and the walls of staircases and lift are RC walls.

Various loadings are applied and analyzed for various load combinations as per IS -875-(part-5)1897. The results of all load combinations are reviewed and members are designed for maximum forces developed.

Forces and moments from the 3 dimensional analysis output for the worst combination are used for the design of the structure.

Response spectrum method is used for earthquake dynamic analysis.

The super structure members are designed for actual flexure, shear and other forces for the worst load combinations.

4.2 Building response Limits:

Deflection Limits: For Reinforced concrete works: · Limiting values of deflection (Short and Long term) as per clause 35.3 of IS: 456-2000 is followed in the design. · Limiting value for short term deflection is considered as span/250 and for the long term deflection is considered as span/350 or 20mm whichever less as per IS 456 – 2000.

4.3 Load Combinations

Load combinations shall be as per IS 1893:2016 (Part I) using Limit State Design (LSD) approach.

Partial Safety Factors for Loads for Limit States of strength and serviceability shall be as follows;

Load Combinations to be considered for strength and serviceability checks

Load Combination	Limit Sate of Collapse			Limit Sate of Serviceability		
	DL	**LL**	**WL/EL**	**DL**	**LL**	**WL/EL**
DL+LL	1.5	1.5	-	1	1	-
DL+LL+/- WL	1.2	1.2	1.2	1	0.8	0.8
DL+LL+/- EL	1.2	1.2	1.2	1	0.8	0.8
DL+/- WL	1.5 or 0.9*	-	1.5	1	-	1
DL+/- EL	1.5 or 0.9*	-	1.5	1	-	1
DL+LL+/- WL	1.2	1.2	0.6	-	-	-

Note: * This value is to be considered when stability against overturning or stress reversal is critical

Additional Design Load Combinations to be considered ONLY when Clause 6.3.3 is applicable.

Load Combination to account for Design Vertical Earthquake effects					
Load Combination	**DL**	**LL**	**ELx**	**ELz**	**ELy**
DL+/- EL	1.5	-	1	0.3	0.3
DL+/- EL	1.5	-	0.3	1	0.3
DL+LL+/- EL	1.2	1.2	1	0.3	0.3
DL+LL+/- EL	1.2	1.2	0.3	1	0.3
DL+/- EL	0.9	-	1	0.3	0.3
DL+/- EL	0.9	-	0.3	1	0.3

Note: These load combinations should not be considered for serviceability checks.

Where; DL = Dead Load, LL = Live Load, WLx&WLz = Wind Load in X and Z direction,

ELx&ELz = Seismic Load in X and Z **horizontal** direction and

ELy = Seismic Load Y **Vertical** direction.

4.4 Expansion joints

Expansion joints are not provided but temperature stresses are considered in the podium level. Thermal stresses are considered to accommodate temperature and shrinkage effects. Delayed pour strips will be detailed in the raft slab to take care of expansion and contraction due to thermal variation.

4.5 Soil

Foundation design is as per the soil investigation report. The extracts of the same is as below. The isolated footings are provided for columns and raft is provided to resist the uplift forces.

SUB SURFACE CHARACTERISTICS:

The geological formation of the project site consists of the following layers:

0.0m to 4.0m	Dense to Very Dense, Clayey Sand to Silty Sand with Gravels, Lateritic Formation
4.0m to 6.0m/7.5m	Medium Dense to Dense & Very Stiff, Clayey Sand & Sandy Clay at locations
6.0m/7.5m to 15.0m	Very Dense, Silty Sand

FOUNDATION SYSTEM:

FOUNDATION SYSTEM WITHOUT BASEMENT FLOORS:

(IN VICINITY OF BOREHOLE BH-01 & BH-02)/ TOWER-1 & TOWER-2

For the kind of proposed structure isolated column footing located at a depth of 2.5m can be adopted. The recommended allowable bearing pressure for different width of footing is presented in Table 5.1. The bearing pressure is valid even for deeper depth of foundation, if adopted from functional requirement considerations.

In case if the footprint of the footing area exceeds 50% of the footprint of the columns, it is advisable to adopt raft foundation. In case of raft foundation raft can be designed for reaction pressure for super structural load as for such large size of raft the allowable bearing pressure works out more than 2000 kPa. For the analysis of raft the recommended soil spring value is 50000 kN/m^3.

TABLE 5.1 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY (TOWER-1 & 2)					
S.No.	Depth of Foundation below EGL (m)	Size of Footing (m)		Recommended allowable net safe bearing pressure (kPa)	Immediate Settlement (mm)
		Width (B)	Length (L)		
1.0	2.5	1.0m X 1.0m		400	2.1
2.0		2.0m X 2.0m		600	6.4
3.0		3.0m X 3.0m		750	12.0
4.0		4.0m X 4.0m		750	16.0
5.0		5.0m X 5.0m		750	20.0

FOUNDATION SYSTEM WITHOUT BASEMENT FLOORS:

(IN VICINITY OF BOREHOLE BH-9)/ TOWER-5

For the kind of proposed structure isolated column footing located at a depth of 3.5 m can be adopted. The recommended allowable bearing pressure for different width of footing is presented in Table 5.2. The bearing pressure is valid even for deeper depth of foundation, if adopted from functional requirement considerations.

In case if the footprint of the footing area exceeds 50% of the footprint of the columns, it is advisable to adopt raft foundation. In case of raft foundation raft can be designed for reaction pressure for super structural load as for such large size raft the allowable bearing pressure works out more than 2000 kPa. For the analysis of raft the recommended soil spring value is 50000 kN/m3

Typical computation is presented in the Annexure-I

TABLE 5.2 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY (TOWER-5)					
S.No.	Depth of Foundation below EGL (m)	Size of Footing (m)		Recommended allowable net safe bearing pressure (kPa)	Immediate Settlement (mm)
		Width (B)	Length (L)		
1.0	3.5	1.0m X 1.0m		400	2.1
2.0		2.0m X 2.0m		600	6.4
3.0		3.0m X 3.0m		750	12.0
4.0		4.0m X 4.0m		750	16.0
5.0		5.0m X 5.0m		750	20.0

FOUNDATION SYSTEM COMMERCIAL BUILDING:

(IN VICINITY OF BOREHOLE BH-11)

For the kind of proposed structure adopt isolated footing at 2.0m depth without puncturing the very dense, lateritic formation. The lateritic formation acts as a natural geogrid and helps in distributing the stress concentration in the underlying very stiff, clayey strata.

The recommended allowable safe bearing pressure of the underlying clayey layer is 400 kPa. Since the strata under the foundation is over consolidated deposits no consolidation settlements will takes place.

Typical computation is presented in the Annexure-I

FOUNDATION SYSTEM FOR 1 BASEMENT + STILT + 13 UPPER FLOORS:

(IN VICINITY OF BOREHOLE BH-03 to BH-08 & BH-10)

At this location, it is proposed to construct one basement with stilt and 13 upper floors. For the kind of proposed construction either raft foundation or isolated footing with stitch slab are feasible.

In case of raft foundation adopt allowable bearing pressure of 750 kPa. In case of isolated footing the footing can be located at a depth of 6.0m and for different depth of footing the allowable net safe bearing pressure is presented in Table-5.3.

TABLE 5.3 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY WITH SINGLE BASEMENT

S.No.	Depth of Foundation below EGL (m)	Size of Footing (m) Width (B)	Size of Footing (m) Length (L)	Recommended allowable net safe bearing pressure (kPa)	Immediate Settlement (mm)
1.0	6.0	1.0m X 1.0m		400	2.1
2.0		2.0m X 2.0m		600	6.4
3.0		3.0m X 3.0m		750	12.0
4.0		4.0m X 4.0m		750	16.0
5.0		5.0m X 5.0m		750	20.0
6.0	RAFT	10.0m X 10.0m		750	39.9

EXCAVATION:

For the kind of sub soil condition open excavation with 1 Vertical : 4 Horizontal slope stands stable. To prevent surface erosion it is ideal to cover the surface with 1000micron HDPE sheet suitably anchored at top and toe with either sand bags or 100mm thick P.C.C. of M10 grade with minimum 1.0m width.

TABLE 5.1 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY (TOWER-1 & 2)					
S.No.	Depth of Foundation below EGL (m)	Size of Footing (m)		Recommended allowable net safe bearing pressure (kPa)	Immediate Settlement (mm)
		Width (B)	Length (L)		
1.0	2.5	1.0m X 1.0m		400	2.1
2.0		2.0m X 2.0m		600	6.4
3.0		3.0m X 3.0m		750	12.0
4.0		4.0m X 4.0m		750	16.0
5.0		5.0m X 5.0m		750	20.0

FOUNDATION SYSTEM WITHOUT BASEMENT FLOORS:

(IN VICINITY OF BOREHOLE BH-9)/ TOWER-5

For the kind of proposed structure isolated column footing located at a depth of 3.5 m can be adopted. The recommended allowable bearing pressure for different width of footing is presented in Table 5.2. The bearing pressure is valid even for deeper depth of foundation, if adopted from functional requirement considerations.

In case if the footprint of the footing area exceeds 50% of the footprint of the columns, it is advisable to adopt raft foundation. In case of raft foundation raft can be designed for reaction pressure for super structural load as for such large size raft the allowable bearing pressure works out more than 2000 kPa. For the analysis of raft the recommended soil spring value is 50000 kN/m3

Typical computation is presented in the Annexure-I

TABLE 5.2 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY (TOWER-5)					
S.No.	Depth of Foundation below EGL (m)	Size of Footing (m)		Recommended allowable net safe bearing pressure (kPa)	Immediate Settlement (mm)
		Width (B)	Length (L)		
1.0	3.5	1.0m X 1.0m		400	2.1
2.0		2.0m X 2.0m		600	6.4
3.0		3.0m X 3.0m		750	12.0
4.0		4.0m X 4.0m		750	16.0
5.0		5.0m X 5.0m		750	20.0

5. Design Philosphy

The designs of the RCC elements are made using the limit state method with appropriate load factors as per IS 456:2000 and IS 13920:2016

The detailing of the structural elements shall generally confirmed as per IS 13920:2016. Lapping in the columns/vertical elements shall be within the middle third portion of the floor height as per the ductile detailing.

The structural system adopted is as below, based on preliminary analysis and design, which have been elucidated later in this report:

The RC structures are designed as a reinforced concrete framed structure, constructed by mivan technology. RC columns/Walls are adopted as a lateral load resisting element. Transfer girders are proposed to support the structural walls from stilt. The walls are placed such that the codal clauses are met with.

Conventional beam and slab arrangement is suggested for the tower superstructure for economy and ease of construction. Toilets will be sunken to ease piping

Design Life:

The design life of the building is assumed as 50 years. This requirement is applicable only for concrete works and not applicable to replaceable finishing materials, water proofing membrane and thermal insulations (if any). Hence periodic maintenance is required for all replaceable material for longer life.

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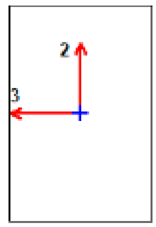
Beam design

IS 456:2000 + IS 13920:2016 Beam Section Design



Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story2	B38	33	BEAM B1	DConS26	2912.5	3100	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
400	600	400	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
5.478	2.0848	8.4003	-12.9657

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
5.478	3.0659	8.5439	0

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	0		568	0	19	568
Bottom (-2 Axis)		8.5439	568	55	16	568

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
141.2716	0	150.8855	132.9377	774.29

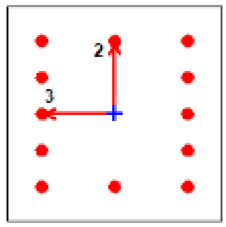
Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.3664	8.2849	300	500	0

Column Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story3	C2	119	ConcCol	DConS26	3400	4000	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
375	375	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
24855.58	27.58	1	413.69	413.69

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
311.7355	-181.1276	-1.3008	6.2347	6.2347	3317	2.36

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.532092	3400	-0.5203	0	6.2347
Minor Bend(M2)	0.737829	3400	8.0488	0	6.2347

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	181.1276	107.4862	73.6414	181.1276	649.88
Minor, V_{u3}	90.5638	108.1651	47.2503	90.5638	416.98

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm^2	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	493.8076	945.2834	1500	0.522
Minor Shear, V_{u3}	0	0	246.9038	945.2834	1500	0.261

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
2.258	0.956

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm^2	A_{sc} cm^2	P_{uz} kN	P_b kN	P_u kN	k Unitless
1406.3	33.2	2774.5083	891.1583	311.7355	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.85	375	4.824	12	No	0
Minor Bending (M_2)	Yes	0.85	375	6.69	12	No	0

DESIGN OF RECTANGULAR FOOTING (Uniform depth)

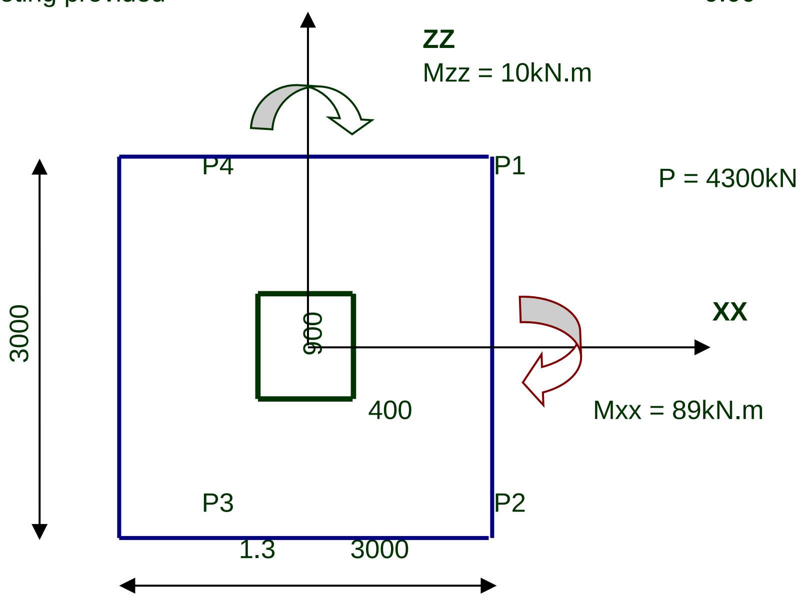
Given data:

Axial load from column (P)	=	4300.00	kN (Unfactor)
Lateral force in XX direction (F_x)	=	181.00	kN (Unfactor)
Lateral force in ZZ direction (F_z)	=	5.80	kN (Unfactor)
Moment in XX direction (M_{xx})	=	89.00	kN.m (Unfactor)
Moment in ZZ direction (Mzz)	=	10.00	kN.m (Unfactor)
Size of column	=	900	x 400 mm
Depth of foundation from FL	=	3.5	m
Safe Bearing Capacity of soil	=	600	kN/m^2
Unit weight of soil	=	18	kN/m^3
Grade of Concrete (Fck)	=	30	N/mm^2
Grade of steel (Fy)	=	500	N/mm^2
Clear cover	=	50	mm
Load factor	=	1.5	
Permissible increase in SBC for seismic		25	%
Safe bearing capacity of soil for seismic load		750	kN/m^2
Mu limit/bd^2	=	66.363	

Solution:

1.Size of footing:

Axial load + self weight of footing & soil	=	4758.1	kN	
Weight of footing	=	225.0	kN	**Breakup of loads only**
Weight of column	=	22.5	kN	
Weight of soil	=	210.6	kN	
Area of footing required	=	6.34	m^2	
Length in longer direction (L_L)	=	3.778	3 m	
Length in shorter direction (Ls)	=	2.115	3 m	
Area of footing provided	=	9.00	m^2	Safe



Moment in XX direction (M_{xx}) = 94.80 kN.m

Moment in ZZ direction (Mzz) = -171.00 kN.m

Net upward pressure ,

P1 = [P/A] + [Mz/Zz] - [Mx/Zx] = 469.61 kN/ m^2

P2 = [P/A] + [Mz/Zz] + [Mx/Zx] = 511.74 kN/ m^2

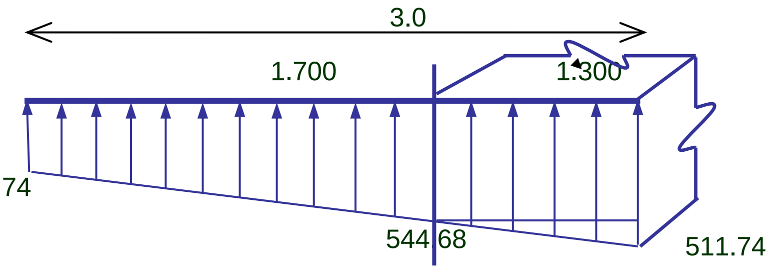
P3 = [P/A] - [Mz/Zz] + [Mx/Zx] = 587.74 kN/ m^2

P4 = [P/A] - [Mz/Zz] - [Mx/Zx] = 545.61 kN/ m^2 Safe

2.Factor Bending moment:

Bending moment in ZZ direction (Mzz):

In shorter direction, cantilever projection = 1.300 m

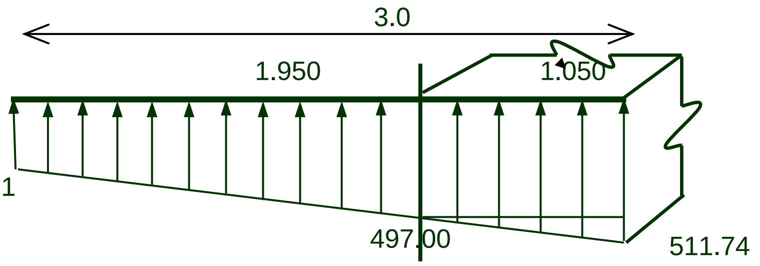


Pressure along shorter direction

Bending moment (Mzz) = 1987.65 KN.m

Bending moment in XX direction (Mxx):

In longer direction, cantilever projection = 1.050 m



Pressure along longer direction

Bending moment (Mxx) = 1257.25 KN.m

3.Depth required for moment :

Depth in longer direction (D_L) = 99.92 mm

Depth in shorter direction (Ds) = 79.47 mm

Overall depth (D) = 1000 mm Safe

Effective depth (d) = 942 mm

4.Reinforcement:

$$\text{Area of steel (Ast)} = \frac{0.5 \times fck}{fy}\left(1- \sqrt{1- \frac{4.6 \times Mu}{fck \times b \times d^2}}\right) b \times d$$

In longer direction (Ast) = 3127.41 mm^2

Required spacing = 192.87 mm

Provide 16 mmØ @ 150 mm c/c

% of reinforcement = 0.142 % (Min 0.1 Safe

In shorter direction (Ast) = 5092.52 mm^2

Required spacing = 118.45 mm

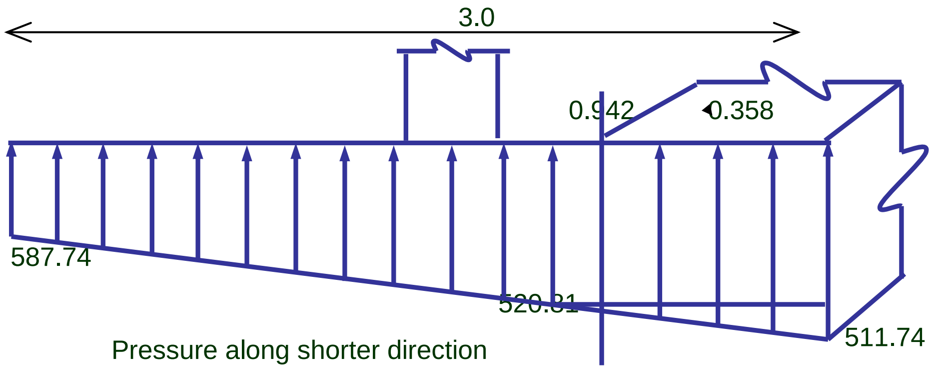
Provide 16 mmØ @ 100 mm c/c

% of reinforcement = 0.213 % (Min 0.1 Safe

5.Check for One-way shear:

In shorter direction,

The critical section for one-way shear is located at a distance of d from the face of the column in longer direction, = 0.358 m

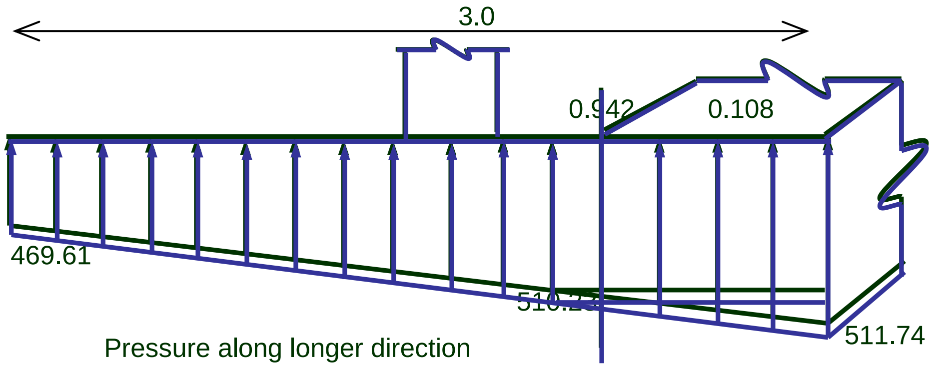


Pressure along shorter direction

Factor shear force (Vu)	=	831.73	KN
Depth at critical section (d)	=	942.00	mm
Eff. transverse shear area (A')	=	2826000	mm^2
Nominal shear stress (ح v)	=	0.294	N/mm^2
% of reinforcement	=	0.213	%
Permissible shear stress (ح c)	=	0.344	N/mm^2 Safe

In longer direction,

The critical section for one-way shear is located at a distance of d from the face of the column in longer direction, = 0.108 m



Pressure along longer direction

Factor shear force (Vu)	=	248.34	KN
Depth at critical section (d)	=	942.00	mm
Eff. transverse shear area (A')	=	2826000	mm^2
Nominal shear stress (ح v)	=	0.088	N/mm^2
% of reinforcement	=	0.142	%
Permissible shear stress (ح c)	=	0.287	N/mm^2 Safe

6.Check for Two-way shear:

The critical section for punching shear is located at a distance of d/2 from the face of the column

Perimeter at the critical section (Bo)	=	6368.0	mm
Eff.depth at critical section	=	942.00	mm

Average pressure	=	520.21	kN/ m^2	
Net shear force (Vu)	=	5093.9	KN	
Punching shear stress (ح v)	=	(Vu/ bo x d)		
	=	0.849	N/mm^2	
The permissible shear stress Ks	=	(0.5 +Bc) <1		
	=	0.9444444		
Max.Per.shear stress (ح cmax)	=	0.25 x √(fck)		
	=	1.369	N/mm^2	
Ks *ح c	=	1.293	N/mm^2	Safe

7.Check for development length:

Development length required	=	725.00	mm
Length of bars from the face of column	=	1250.00	mm

Hence safe, no hooks are required

If unsafe, Length of hooks required	=	0	mm

8.Check for Bearing Pressure:

Length of frustum of pyramid	=	3	m	
Breath of frustum of pyramid	=	3.0	m	
Area of column (A2)	=	0.36	m^2	
Area of base (A1)	=	9.00	m^2	
√A1/A2	=	5.000		
Permissible bearing pressure	=	(0.45*fck*√A1/A2)		
	=	27.00	N/mm^2	
Actual bearing pressure	=	17.92	N/mm^2	Safe

9.Check for S.B.C of soil:

Axial load column (P)	=	4300.00	KN	
Weight of footing	=	225.00	KN	
Soil weight	=	145.15	KN	
Total load on the soil		4670.15	KN	
Pressure on the soil	=	518.906	KN/ m^2	Safe

10.Check for Sliding:

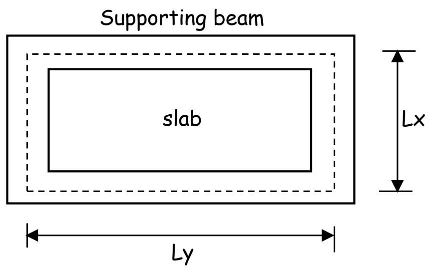
Critical load combination	=	102		
Lateral force in XX direction (F_x)	=	181	kN (Unfactor)	
Lateral force in ZZ direction (F_z)	=	5.80	kN (Unfactor)	
Coefficient of friction	=	0.4		
Resultant sliding force	=	181.09	KN	
Downward force	=	4758.10	KN	
Resisting Force	=	Friction coeff x Downward force		
	=	1903.24	KN	
Factor of safety available	=	Resisting Force / Sliding Force		
	=	10.51	> 1.2	Safe

11.Results:

Size of footing	=	3000 x3000 mm

Depth of footing	=	1000mm
Longer direction (X-X), Provide	=	16mmø @150mm c/c
Shorter direction (Z-Z), Provide	=	16mmø @100mm c/c

	Design of Two way Slab				References
1	**Design Datas**				



	1. Eff. Shorter span between c/c support, Lx	=	4	m	(Eff. Span,As per IS456:2000, clause 22.2 (b))
	2. Eff.Longer span between c/c support, Ly	=	6	m	
	3. Compressive strength of Concrete, Fck	=	30	N/mm^2	
	4. Yield Strength of steel, Fy	=	500	N/mm^2	
	5.Diameter of Reinforcement, (Shoter span)	=	12	mm	
	6.Diameter of Reinforcement, (Longer span)	=	12	mm	
	7. Fire resistance in hours	=	2	hrs	(Nominal cover, As per IS456:2000, Table 16A, clauses 21.4 and 26.4.3 and Fig 1
	8. Nominal cover to the reinforcement, C	=	30	mm	
2	**Assume trial depth of slab**				
	Span/depth, ratio l/d (Basic value)	=	26		(Span/depth ratio,As per IS:456;2000, Clause 23.2.1)
	Assume modification factor, M.F	=	1.5		
	depth of slab	=	(Span/B.V x M.F)		
		=	(4 x 1000) / (26 x 1.5)		
		=	102.56	mm	
	Overall depth required, D	=	(d+cc+1/2 dia of bars)		
		=	102.56 + 30+ 12 /2		
		=	138.56	mm	
		=	**175**	mm	
	Eff. Depth,d	=	**139**	mm	
3	**Load Calculations**				
	Unit weight of Concrete	=	25	KN/m^3	
	Dead load of Slab	=	4.38	KN/m^2	
	Floor finishes	=	1	KN/m^2	
	Partitions	=	0	KN/m^2	
	Extra loads due to filling, surki , etc., if any	=	15	KN/m^2	
	Live Load	=	0	KN/m^2	
	Total Load	=	**20.38**	KN/m^2	
	Design Load	=	**30.57**	KN/m^2	
4	**Calculation of Bending Moment**				
	Edge condition of Slab	=	7 7.Three Edges discontineous (One long Edge Contineous)		Edge conditions,As per IS456:2000, D-1.1and 24.4.1
	Ly/Lx, ratio	=	6 / 4		

= **1.5**
= **The slab is Two way Slab**

S.No	Direction & Sign	Moment Co-efficients	Moment KN.m		
1	X - Negative	0	0	(alpha x * wu *lx^2)	(B.M co-eff frommAnnex D, clause D.1.1, IS:456:2000)
2	X - Positive	0.063	30.81	(alpha x * wu *lx^2)	
3	Y- Negative	0.059	28.86	(alpha y * wu *lx^2)	
4	Y- Positive	0.044	21.52	(alpha y * wu *lx^2)	

M,max = **30.81** KN/m

5 **Effective depth required**

Mu.lim = (0.36 x Fck x (xu.max/d) x (1-0.42(xu.max/d)) x bd^2 (IS:456:2000, Annex G, clause G.1.1.c)
xu.max/d = 0.46
Mu.lim = 4.01 bd^2
d,reqd = $(Mu.lim/Qb)^{1/2}$
= $(30810000 / (4.01 \times 1000))^{1/2}$
= **87.65** mm
87.65 < 139
O.K

6 **Reinforcement Calculations**

S. N	Dn & Sign	Mu/bd^2	pt from SP16	pt, min	pt,provided	Ast, mm^2
1	x -ve	0	0	0.12	0.12	166.8
2	x +ve	1.59	0.39	0.12	0.39	542.1
3	y -ve	1.49	0.364	0.12	0.364	505.96
4	y +ve	1.11	0.267	0.12	0.267	371.13

pt = 100Ast/bd
Ast = (pt/100)xbd

(Minimum reinforcement of slab shall be provide as per IS456:2000, clause 26.5.2.1)

7 **Spacing of reinforcement**

Spacing, mm		Spacing provided, mm	Ast provided, mm^2
Actual	Maximum		
677.7	300	675	167.47
208.52	300	150	753.6
223.42	300	300	376.8
304.58	300	200	565.2

Spacing = (ast x 1000)/Ast

where,
ast= C/s area of bar
Ast=Area of reinforcement provided

max distance of tension reinforcement bars 3d or 300mm which ever is less
As per IS:456:2000, Clause 26.3.3.b

8 **Check for deflection**

lx/d, Actual = 28.78
l/d, Max = B.V x M.F
pt, = 100Ast/bd
= 0.1205

fs = 0.58x fyx(Ast required/Ast provided)

fs = 208.61 N/mm^2

Modification Factor = 3.1 From Fig 4, IS456:2000

l/d, Max = 3.1 X 26

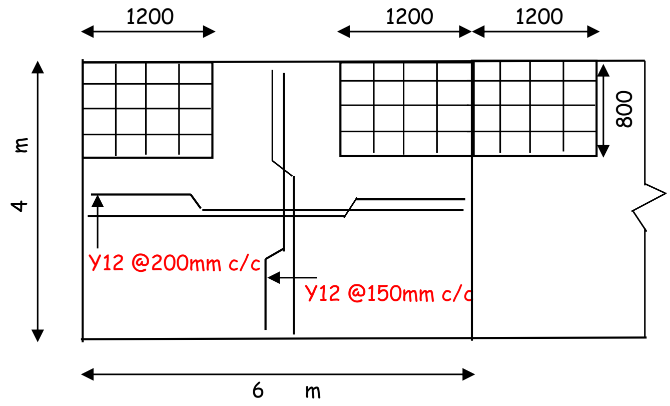
= 80.6

80.6>28.78

O.K

9 **Reinforcement Details**

Direction	Reinforcement
X	**Y12 @150mm c/c**
Y	**Y12 @200mm c/c**



shorter direction		longer direction	
Ast @ support	Ast @ Span	Ast @ support	Ast @ Span
12@675mm	12@150mm	12@300mm	12@200mm

raft Slab

Here the aspect ratio Ly/Lx is less than 2 and hence the slab is designed as a two way slab.

ThreeEdgesDiscontinuousOneLongEdge:

Basic dimensions of slab =

Lx	Ly
11	5

Basic Ly/Lx ratio = 0.455 < 2

Hence designed as two way slab

Clear cover to reinforcement	d'	=	75	mm
Provided overall depth	D	=	450	mm
Effective depth	d	=	367	mm
Diameter of bar	ϕ	=	16	mm
Grade of Concrete	fck	=	30	N/mm²
Grade of Steel	fy	=	500	N/mm²

Load calculation :

Dead load of the slab	DL	=	-15.00	kN/m²
Floor finish (Roof finish)	FF	=	0.0	kN/m²
Live load	LL	=	41	kN/m²
Ceiling Plastering		=	0	kN/m²
Total load	TL	=	26.000	kN/m²

Moment and Area of Steel calculations:

Span	Moment Coefficient		Mu kN.m	Mu/bd² N/mm²	Pt %	Ast reqd mm²	Min Ast mm²	Dia of bar mm	Spacing mm	Ast prov mm²
shorter	$\alpha_{x\ neg}$	-0.041	-195.55	-1.45	-0.317%	-1163	440	16	200	1005
	$\alpha_{x\ pos}$	-0.031	-146.66	-1.09	-0.241%	-883	440	16	200	1005
longer	$\alpha_{y\ neg}$	0	0.00	0.00	0.000%	0	440	16	200	1005
	$\alpha_{y\ pos}$	0.044	205.28	1.52	0.374%	1371	440	16	125	1608

Check for Deflection

The effective depth provided = 367 mm

Fs $= \dfrac{Ast_{reqd} \cdot 0.87 \cdot f_y}{Ast_{prov} \cdot 1.5}$ = 264 N/mm²

Modification factor = **1.38**

$$M.F. = \frac{1}{0.225+0.00322\,F_s - 0.625\,\log_{10}(bd/100Ast)}$$ = **1.38**

Required depth under deflection consideration = 306.14 mm

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CHECK FOR SHEAR

	=	65	
	=	60.66273	
Max shear	=	90.99409	KN/m
Nominal shear stress tv	=	0.24794	N/mm²
Percentage of tension steel	=	0.273926	%
Shear strength of concrete tc (Refer SP: 16 from table 61)	=	0.342	N/mm²
K	=	1	
tc'	=	0.342	N/mm²

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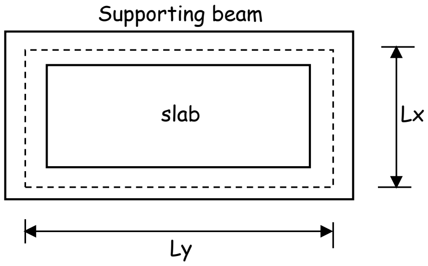
1 Design Datas



(Eff. Span,As per IS456:2000, clause 22.2 (b))

1. Eff. Shorter span between c/c support, Lx	=	4	m
2. Eff.Longer span between c/c support, Ly	=	6	m
3. Compressive strength of Concrete, Fck	=	30	N/mm^2
4. Yield Strength of steel, Fy	=	500	N/mm^2
5.Diameter of Reinforcement, (Shoter span)	=	16	mm
6.Diameter of Reinforcement, (Longer span)	=	12	mm
7. Fire resistance in hours	=	2	hrs
8. Nominal cover to the reinforcement, C	=	30	mm

(Nominal cover, As per IS456:2000, Table 16A, clauses 21.4 and 26.4.3 and Fig 1

2 Assume trial depth of slab

(Span/depth ratio,As per IS:456;2000, Clause 23.2.1)

Span/depth, ratio l/d (Basic value)	=	26	
Assume modification factor, M.F	=	1.5	
depth of slab	=	(Span/B.V x M.F)	
	=	(4 x 1000) / (26 x 1.5)	
	=	102.56	mm
Overall depth required, D	=	(d+cc+1/2 dia of bars)	
	=	102.56 + 30+ 16 /2	
	=	140.56	mm
	=	**275**	mm
Eff. Depth,d	=	**237**	mm

3 Load Calculations

Unit weight of Concrete	=	25	KN/m^3
Dead load of Slab	=	6.88	KN/m^2
Floor finishes	=	1	KN/m^2
Partitions	=	0	KN/m^2
Extra loads due to filling, surki , etc., if any	=	20	KN/m^2
Live Load	=	0	KN/m^2
Total Load	=	**27.88**	KN/m^2
Design Load	=	**41.82**	KN/m^2

4 Calculation of Bending Moment

Edge condition of Slab	=	8 8.Three Edges discontineous (One Short Edge Contineous)	Edge conditions,As per IS456:2000, D-1.1and 24.4.1
Ly/Lx, ratio	=	6 / 4	
	=	**1.5**	

= **The slab is Two way Slab**

S.No	Direction & Sign	Moment Co-efficients	Moment KN.m		
1	X - Negative	0.111	74.27	(alpha x * wu *lx^2)	(B.M co-eff frommAnnex D, clause D.1.1, IS:456:2000)
2	X - Positive	0.083	55.54	(alpha x * wu *lx^2)	
3	Y- Negative	0	0	(alpha y * wu *lx^2)	
4	Y- Positive	0.044	29.44	(alpha y * wu *lx^2)	

M,max = **74.27** KN/m

5 **Effective depth required**

Mu.lim = (0.36 x Fck x (xu.max/d) x (1-0.42(xu.max/d)) x bd^2

(IS:456:2000, Annex G, clause G.1.1.c)

xu.max/d = 0.46

Mu.lim = 4.01 bd^2

d,reqd = $(Mu.lim/Qb)^{1/2}$

= $(74270000 / (4.01 \times 1000))^{1/2}$

= **136.09** mm

136.09 < 237

O.K

6 **Reinforcement Calculations**

S. N	Dn & Sign	Mu/bd^2	pt from SP16	pt, min	pt,provided	Ast, mm^2
1	x -ve	1.32	0.32	0.12	0.32	758.4
2	x +ve	0.99	0.236	0.12	0.236	559.32
3	y -ve	0	0	0.12	0.12	284.4
4	y +ve	0.52	0.122	0.12	0.122	289.14

pt = 100Ast/bd

Ast = (pt/100)xbd

(Minimum reinforcement of slab shall be provide as per IS456:2000, clause 26.5.2.1)

7 **Spacing of reinforcement**

Spacing, mm		Spacing provided, mm	Ast provided, mm^2
Actual	Maximum		
264.98	300	250	803.84
359.29	300	125	1607.68
397.47	300	300	376.8
390.95	300	150	753.6

Spacing = (ast x 1000)/Ast

where,
ast= C/s area of bar
Ast=Area of reinforcement provided

max distance of tension reinforcement bars 3d or 300mm which ever is less
As per IS:456:2000, Clause 26.3.3.b

8 **Check for deflection**

lx/d, Actual = 16.88

l/d, Max = B.V x M.F

pt, = 100Ast/bd

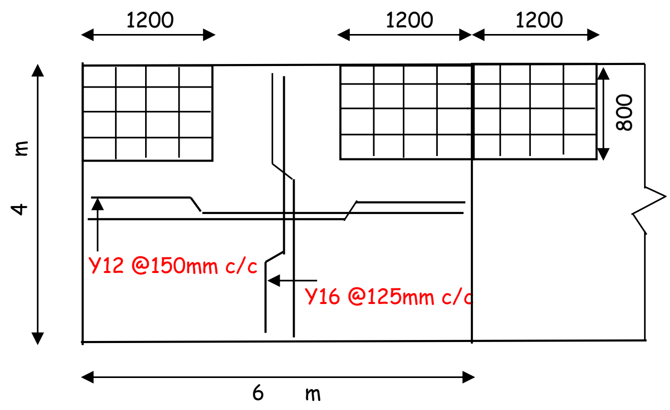
= 0.3392

fs = 0.58x fyx(Ast required/Ast provided)

fs	=	201.78 N/mm^2	
Modification Factor	=	1.72	From Fig 4, IS456:2000
l/d, Max	=	1.72 X 26	
	=	44.72	
		44.72>16.88	
		O.K	

9 Reinforcement Details

Direction	Reinforcement
X	**Y16 @125mm c/c**
Y	**Y12 @150mm c/c**



shorter direction		longer direction	
Ast @ support	Ast @ Span	Ast @ support	Ast @ Span
16@250mm	16@125mm	12@300mm	12@150mm

TITLE	CALCULATION OF CRACK WIDTH FOR 275mm WALL BY IS 456		
CL. NO.	DESIGN CALCULATIONS		REFERENCES

1.0 **Calculation of position of the N.A**

Design moment in the wall	M	=	**80** kNm	
Width of the wall 1m considering	b	=	**1000** mm	
Thickness of the wall	D	=	**275** mm	
Clear cover of beam provided	C_{min}	=	**35** mm	
Effective cover of Beam	d'	=	**43** mm	
Effective Depth of the Beam	d	=	**232** mm	
	d'/d	=	**0.185**	
			Use TABLE 94 of SP16	
Grade of the concrete		=	**M30**	
Elastic Modulus of Steel	E_s	=	200000 N/mm^2	
Elastic Modulus of Concrete	E_c	=	$5000\sqrt{f_{ck}}$	
		=	5000 x sqrt(30)	
		=	27386 N/mm^2	
	$E_{c\,œ}$	=	Ec / 2	
		=	27386.1278752583 / 2	
		=	13693 N/mm^2	
Modular Ratio	m	=	E_s/E_c	
		=	14.606	
Area of compression steel provided	A_{sc}	=	**893** mm^2	
Area of tensile steel provided	A_{st}	=	**1635** mm^2	
Dia of bars used	Φ	=	**16** mm	
Spacing of Bars provided	s_p	=	**125** mm	
% of compression steel	P_c	=	0.385	
% of tensile steel	P_t	=	0.705	
	mP_t	=	14.6059348668044 x 0.704	
		=	10.293	
	$P_c(m-1)/mP_t$	=	0.5	
Neutral Axis Ratio	x/d	=	0.3485	SP 16, Table 94
	x	=	0.3485 x 232	
		=	80.852 mm	

2.0 **Determination of Strain in Concrete**

From Stress in Steel method

TITLE	**CALCULATION OF CRACK WIDTH FOR 275mm WALL BY IS 456**				
CL. NO.	**DESIGN CALCULATIONS**			**REFERENCES**	

$$f_s = \frac{M}{(d - x/3)A_S} = \frac{80 \times 10^6}{205.05 \times 1635} = 238.63 \text{ N/mm}^2$$

Strain in steel = 238.63 / 200000 = 0.00119

Calculation of Crack width at midway between bars at tension face

Strain in steel at this Level

$$\varepsilon_1 = \frac{0.00119 \times (275 - 80.852)}{(232 - 80.852)} = 0.0015$$

Strain in concrete at this Level

$$\varepsilon' = \frac{b(D-x)}{3E_s A_s} \frac{(D-x)}{(d-x)} = 0.0003$$

$$\varepsilon_m = \varepsilon_1 - \varepsilon' = 0.0013$$

$$\alpha_{cr} = \sqrt{(125/2)^2+43^2} - 16/2$$

$$\alpha_{cr} = \sqrt{62.5^2+43^2} - 8 = 67.9 \text{ mm}$$

Crack Width $w = \dfrac{3a_{cr}\varepsilon_m}{1 + 2(a_{cr} - c_{min})/(h-x)} = 0.195$ mm — IS 456, Annex F

Allowable surface crack width= 0.2 mm

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IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story10	P8	3400	16900	3000	160	1

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
0	30	1	0	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	3400	15400	3400	18400	3000	160
Bottom	Leg 1	3400	15400	3400	18400	3000	160

Flexural Design for P and M_3 —Tension Reinforcement

Station Location	Edge Length mm	Rebar Area mm²	Tension Combo	P_u kN	M_{u3} kN-m
Left Top	240	0	DWalS26	637.9604	-69.7758
Right Top	240	0	DWalS26	637.9604	-69.7758
Left Bot	240	0	DWalS26	669.811	-61.8315
Right Bot	240	0	DWalS26	669.811	-61.8315

Flexural Design for P and M_3 —Compression Reinforcement

Station Location	Edge Length mm	Rebar Area mm²	Compression Combo	P_u kN	M_{u3} kN-m
Left Top	240	1012	DWalS2	1167.2257	-128.4968
Right Top	240	652	DWalS2	1167.2257	-128.4968
Left Bot	240	1099	DWalS2	1220.31	-117.0006
Right Bot	240	771	DWalS2	1220.31	-117.0006

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	400	DWalS21	1066.0915	-118.6057	5.2083	144.8485	491.2833
Bottom	Leg 1	400	DWalS21	1119.1758	-103.2414	5.2083	154.266	500.7008

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	DWalS2	1167.2257	-128.4968	2.97	6
Top–Right	Leg 1	0	DWalS2	0	0	0	0
Bottom–Left	Leg 1	0	DWalS2	1220.31	-117.0006	3.03	6
Botttom–Right	Leg 1	0	DWalS2	0	0	0	0

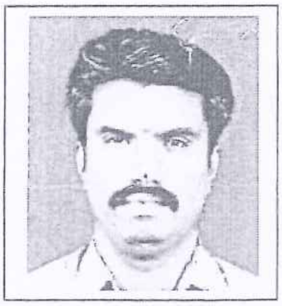
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'Thalamuthu Natarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that **Thiru. MURUGESH. S** 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 **25 years**.

He has been given the Registration No.**SE/GR-I/2022/05/320** on **16.05.2022.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **15.05.2027.**



CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI-600 008

16.5.2022

T. ARIVALAGAN
SUPERINTENDENT
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
EGMORE, CHENNAI-600 008.

S. MURUGESH, M.E., FIE.,
Chartered Engineer F-1279323
Structural Engineer Grade-I
CMDA/SE/GR-I/2022/05/320