Planning and Design of An Electrical Substation

P-30

Project Work

Submitted by

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C O N T E N T S

A C K N O W L E D G E M E N T

We express our hearty thanks to our beloved guide Prof. P. Jeyapaul,M.Sc., (Engg.), without whose kind advice and guidance we could not have completed this project successfully.

We also express our sincere thanks to Mr. Joseph V. Thanikkal, B.E., A.M.I.E., for having helped us to have a good start of the project.

We thank the members of faculty of Civil Engineering of Kumaraguru College of Technology for encouraging us.

Last but not the least we express our sincere thanks to Prof. R.M. Lakshmanan, Pricipal, Kumaraguru College of Technology, for providing us all the facilities for the completion of the Project.

SYNOPSIS

The object of this Project Work is to develop independent and creative thinking correlating fundamental and theoritical knowledge we have obtained during our course of study to the practical application in the field.

We have attempted what we have learnt during our course in an easy and understandable manner.

The project is about the planning and design of "An Electrical Substation" which involves with a variety of structural element like coloumns, beams, slabs and foundations.

The procedure followed here is in accordance with the Indian Standard Specifications, by "Working Stress" method.

SUBSTATION IN GENERAL

With rapid expansion of cities and towns in today's India, need of an electrical substation in order to avoid the fall of voltage during the peak time of consumption of power becomes essential at different places. This factor prompted us to design a model Electrical 110KV substation.

An Electrical substation is essential for transforming and distributing the electrical energy. Generally the electrical substations are erected nearer to the centre of gravity of electrical load.

Here the 110KV tapped from the main line is stepped down to 22KV which is the requirement of our college.

PROJECT DETAILS

The present venture is to have an Electrical substation in our college campus, which is situated at Chinnavedampatti about 12Km. from Coimbatore city.

This Electrcial Sub-station consists of the following units :-

1) Control room
2) Administrative building
3) Station yard
4) Quarters
5) Water tank etc.

The Substation is proposed abutting the Thudiyallur road in our college campus covering an area of 3200 Sq.m. We have provided a control room of an area of 200 Sq.m. with cable tranches a duty room and a station engineer room etc. The administrative room is located nearby the control room. A station yard of 450 Sq.m. area has also been provided for the substation.

A staff quarters is also provided in the campus and allotment given respectively. The staff working in the substation is categorised as below :-

1) Sub-station engineers
2) Administrative staffs
3) Technical workers

The allotment of quarters is based on the above category.

SPECIFICATIONS

The specification details of the substation are as follows :-

GENERAL SPECIFICATIONS OF QUARTERS AND OFFICE BUILDING

Foundation:-

Random Rubble in cement Mortar 1:6

Basement :-

Random Rubble in cement Mortar 1:6

Damp Proof Course :-

3mm thick Bitumen over a base plastering of C.M.1:3, 15mm thick.

Super Structure :-

First class country Brick in C.M. 1:6 interior faces plastered over with lime Mortar 1:2 two coats. Exterior faces plastered over with C.M. 1:3, 12mm thick one coat.

Roofing :-

Cement concrete 1:3:6 with 40mm. Broken stone 75mm, thick and plastered over with C.M. 1:3, 15mm thick two coats including a neat flushing coat floated hard and trowelled smooth.

Painting :-

All outside doors, both faces of bathroom doors and all faces of all windows and ventilators to be painted with best enamel paint of approved colour. All other doors to be varnished with varnish of approved quality.

Wall Painting :-

External faces of walls to be painted with water proofing decorative cement paint of approved quality and colour.

GENERAL SPECIFICATIONS OF CONTROL ROOM :-

Foundation And Basement :-

Random Rubble in Cement Mortar 1:6

Super Structure :-

First class country burnt brick in C.M. 1:6

Columns :-

R.C.C. 1:2:4 using 20mm broken stone with Reinforcement as per design.

Roofing :-

R.C.C. 1:2:4 using 20mm broken stone with Reinforcement as per design.

Plastering :-

Both the faces of walls, except the inside of Toilet Room with C.M. 1:3, 12mm thick one coat floated Hard and trowelled smooth. Inside of Toilet room (top 2.2m), with C.M. 1:3, 15mm thick one coat with neat cement flushing coat. Bottom of 1.5m of toilet room to be paved with white glazed tiles over cement plastering 1:3,15mm thick.

Flooring :-

Cement concrete 1:3:6, 150mm thick in control room and 75mm thick in remaining portion using 40mm (nominal size) broken stone and plastered over with C.M. 1:3, 15mm thick one coat with neat cement flushing coat. Floor and walls (Bottom 1.5m) of Battery room to be paved with acid proof white tiles.

Painting :-

Both the faces of doors, windows, ventilators and rolling shutters to be painted with approved quality and shade enamel paint two coats over priming coat.

Wall Finish :-

Exterior faces of walls, parapets, Basements etc., painted with approved quality and shade cement, Decarative paints (Snowcem) two coats.

Interior faces of walls - White washing two coats.

CABLE TRENCH IN CONTROL ROOM :-

Trench is very important one in control room when passes the cables from the station yard to control switch boards. Trench is constructed under the ground level. The advantage of trench is to protect against the effects of moisture and air. Cables are laid in the Trench in the order of three layers which is covered by ordinary slabs. Trench is constructed by Brick Masonry. The size of Trench is 0.6 x 1.2m. The cable is placed at 40cm interval with other layer.

Laying a cable in a Trench :-

The Trench cable laying work consists of the following operations. Carrying a cable reel to the Trench, delivery and distribution of bricks along the Trench, Mounting the cable reel on jacks, Removal of the cable reel sheathing and thorough inspection of the cable, preparing a cable bed of fine soil cable reels out, laying the cable in the trench filling back the trench with soft soil laying the bricks. Filling back the trench and installation of indicators.

After the bricks have been laid, the cable trench is back filled in layers not thicker than 20cm with thoroughly compacting and tamping each soil layer. If the excavation soil contain debris slag, stones etc. use should be made of soil carried from another place. In winter time, the trench should be filled with soil not frosted.

The trench is finally levelled and cleared.

DESIGN OF SLABS

Overall depth of slab = $\frac{\text{Shorter Clear Span}}{35}$

For all cases,

Provide overall depth of slab = 12cm.

Diameter of the bar = 1.2cm = 12mm.

Effective cover = 15mm

Effective depth to the centre of short span steel

$$= 12-(1.5 + \frac{1.2}{2}) = 9.9 \text{ cm}$$

Effective depth to the centre of long span steel

$$= 9.9 - 1.2 = 8.7\text{cm}$$

Effective Span :-

l_x = Shorter Span

clear span + Effective depth of short span steel

(or)

Short Span between centre of bearing

Whichever is less - taken as l_x

l_y = Longer Span

clear span + Effective depth of Long Span Steel

(or)

Long Span between centre of bearings

Whichever is less - taken as l_y

Concrete Mix = M_{150} mix

Permissible stress in steel = 1400 Kg/Cm²
(σ_{st})

Design Constants :-

$$\sigma_{cbc} = 5 \text{ N/mm}^2 = 50 \text{ Kg/Cm}^2$$

$$\sigma_{st} = 140 \text{ N/mm}^2 = 1400 \text{ Kg/Cm}^2$$

σ_{cbc} - Permissible compressive bending stress in concrete.

$$\text{Modular ratio, } m = \frac{2800}{3\ _{cbc}} = \frac{2800}{3 \times 50} = \underline{\underline{18.67}}$$

$$K = \frac{1}{1 + \frac{\sigma_{st}}{m.\sigma_{cbc}}} = \frac{1}{1 + \frac{1400}{18.67 \times 50}} = \underline{\underline{0.4}}$$

$$j = 1 - \frac{K}{3} = 1 - \frac{0.4}{3} = \underline{\underline{0.867}}$$

$$Q = \frac{1}{2} \sigma_{cbc} K.j.$$

$$= \frac{1}{2} \times 50 \times 0.4 \times 0.867 = \underline{\underline{8.67 \text{ Kg/Cm}^2}}$$

Load :-

Live Load, insulation, finishing and weathering coarse = 300 Kg/m²

Dead Load = 0.12 x 2500

= $\underline{\underline{300 \text{ Kg/m}^2}}$

Total load = 300 + 300 = $\underline{\underline{600 \text{ Kg/m}^2}}$

Clear span + Effective depth of Long span steel = 355 + 8.7

= 363.7 cm

Shortspan between centre of bearing = 350 + 20 = 370 cm

Long span between centre of bearing = 355 + 20 = 375 cm

<u>Effective Span</u> :-

l_x = Shorter direction = 359.9 (or) 370 cm (whichever is less)

l_y = Longer direction = 363.7 (or) 375 cm (whichever is less)

l_x = 359.9 cm

l_y = 363.7 cm

$$\frac{l_y}{l_x} = \frac{363.7}{359.9} = 1.01 \not> 2$$

Hence we have to design for two way slab.

For Short Span :-

$$\text{Moment, } M = \text{B.M. Co-efficient for Short Span} \times W (l_x)^2$$

For Long Span :-

$$\text{Moment, } M = \text{B.M. Co-efficient for long Span} \times W (l_x)^2$$

Where,

W = Total Load

l_x = Short span

Office Building :-

Staff Room :-

Clear span = 350 x 355cm

$$\text{Overall depth of slab} = \frac{\text{Shorter clear span}}{35}$$

$$= \frac{350}{35} = 10 \text{ cm}$$

Provide overall depth of slab = 12cm

Diameter of bar = 12mm = 1.2cm

Effective cover = 15mm = 1.5cm

Effective depth to the centre of Short span steel

$$= 12 - (1.5 + \frac{1.2}{2}) = 9.9 \text{ cm}$$

Effective depth to the centre of Long span steel= 9.9-1.2=8.7cm

Clear span + Effective depth of Short span steel = 350+ 9.9

= 359.9 cm

Condition :-

Two adjacent edges are discontinuous.

Description	Short Span		Long Span	
	Mid	Support	Mid	Support
B.M. Co-efficient	0.0355	0.0476	0.035	0.047
Moment, M (Kg - m)	275.89	369.9	272.0	365.27
Effective depth required $= \sqrt{\frac{369.9}{8.67 \times 100}}$ (m)	0.065	0.065	0.065	0.065
Effective depth provided d (cm)	9.9	9.9	8.7	8.7
A_{st} required $= \frac{M}{\sigma_{st} j.d}$ (cm^2)	2.295	3.08	2.58	3.46
Provide 12mm Ø bars				
Spacing (cm)	49.27	36.71	48.83	32.68
Minimum spacing (cm)	29.7	29.7	26.1	26.1
Provided spacing (cm)	25C/C	25C/C	25C/C	25C/C
A_{st} provided ... (cm)	4.52	4.52	4.52	4.52

Edge Strip :-

$$\text{Area, } A_{st} = \frac{0.15}{100} \times b.d$$

For Short Span :-

$$b = \frac{l_x}{8}$$

$$d = \text{Effective depth} = 9.9 \text{ cm}$$

$$A_{st} = \frac{0.15}{100} \times \frac{l_x}{8} \times 9.9$$

$$= \frac{0.15}{100} \times \frac{359.9}{8} \times 9.9$$

$$= 0.668 \text{ cm}^2$$

Provide 8mm Ø bars,

$$\text{No. of bars} = \frac{0.668}{\frac{\pi (0.8)^2}{4}} = 1.32$$

Provide 3 Nos. of 8mm Ø bars for Short span.

For Long Span :-

$$b = \frac{l_y}{8}$$

$$d = 8.7 \text{ cm}$$

$$A_{st} = \frac{0.15}{100} \times \frac{l_y}{8} \times 8.7$$

$$= \frac{0.15}{100} \times \frac{363.7}{8} \times 8.7$$

$$= 0.593 \text{ cm}^2$$

Provide 8mm Ø bars,

$$\text{No. of bars} = \frac{0.593}{\frac{\pi(0.8)^2}{4}} = 1.18$$

Provide 3 Nos. of 8mm Ø bars for Long span.

Corner Mesh :-

(Reinforcement at corners)

At each corner a top mesh and a bottom mesh of reinforcement shall be provided covering a square are

$$\frac{l_x}{5} \times \frac{l_x}{5}$$

In each mesh in each principal direction steel required per metre width $= \frac{3}{4}$ x steel for short span B.M.

$$= \frac{3}{4} \times 4.52$$

$$= 3.39 \text{ cm}^2$$

Provide 8mm Ø bars,

$$\text{No. of bars} = \frac{3.39}{\frac{\pi(0.8)^2}{4}} = 6.7$$

Provide 7 Nos. of 8mm Ø @ corner reinforcement.

One-Way Slab :-

Verandah:- (Office building)

Clear span = 830 x 190 cm

Overall depth = $\frac{190}{35}$

= 5.428 cm

Provide overall depth = 12cm

Dia meter of bar = 12mm

Effective cover = 15mm

Effective depth to the centre of short span steel = $12-(1.5+\frac{1.2}{2})$

= 9.9 cm

Effective depth to the centre of Long span steel = 9.9 - 1.2

= 8.7 cm

Clear span + Effective depth of short span = 190 + 9.9

= 199.9cm

Clearspan + Effective depth of Long span = 830 + 8.7

= 838.7 cm

Short span between centre of bearing = 190 + 20

= 210 cm

Long span between centre of bearing = 830 + 20

= 850 cm

Effective Span :-

Width of support = 20 cm

Clear span = 199.9 - 20 = 179.9 cm

$\frac{1}{12}$ clear span $= \frac{179.9}{12} = 14.99$ cm $\angle$ 20 cm

Hence Safe

For end span :-

Effective span = least of i) clear span $+ \frac{1}{2}$ d

ii) clear span $+ \frac{1}{2}$ b

i) $179.9 + \frac{1}{2}(12) = 185.9$ cm

ii) $179.9 + \frac{1}{2}(20) = 189.9$ cm

Effective span = 185.9 cm

For Interior Span :-

Effective span = clear span = 179.9 cm

Moments :-

$$M_1 = \frac{W_d . l_e^2}{12} + \frac{W_d . l_e^2}{10}$$

$$= \frac{400 \times (1.859)^2}{12} + \frac{200 \times (1.859)^2}{10}$$

= 184.3 Kg-m

$$M_2 = \frac{W_d . l_e^2}{24} + \frac{W_l . l_e^2}{12}$$

$$= \frac{400 \times (1.799)^2}{24} + \frac{200\ (1,799)^2}{12}$$

$$= \underline{\underline{107.88 \text{ Kg-m}}}$$

$$M_3 = \frac{-W_d . l_e^2}{10} - \frac{W_l . l_e^2}{9}$$

$$= \frac{-400 \times (1.859)^2}{10} - \frac{200(1.859)^2}{9}$$

$$= \underline{\underline{-215.0 \text{ Kg-m}}}$$

$$M_4 = \frac{-W_d . l_e^2}{12} - \frac{W_l . l_e^2}{9}$$

$$= \frac{-400 \times (1.799)^2}{12} - \frac{200\ (1.799)^2}{9}$$

$$= \underline{\underline{-179.8 \text{ Kg-m}}}$$

Maximum Positive Moment = $\underline{\underline{184.3 \text{ Kg-m}}}$

Maximum Negative Moment = $\underline{\underline{-215.0 \text{ Kg-m}}}$

<u>Reinforcement</u> :-

Positive $A_{st} = \frac{M}{\sigma_{st}\ j.d}$

$$d_{(required)} = \sqrt{\frac{M}{Qb}} = \sqrt{\frac{184.3 \times 100}{8.67 \times 100}}$$

$$= \underline{\underline{4.61 \text{ cm}}} < 9.9 \text{ cm}$$

Hence Safe

$$\text{Positive } A_{st} = \frac{184.3 \times 100}{0.867 \times 1400 \times 9.9}$$

$$= 1.5337 \text{ cm}^2$$

Spacing of 12mm Ø = 73.7 cm

Minimum spacing = 3 x Effective depth = 3x9.9 = 29.7cm

Provide 12mm Ø @ 25cm C/C as ~~the~~ +ve reinforcement

$$\text{Negative } A_{st} = \frac{215 \times 100}{1400 \times 0.867 \times 9.9} = 1.789 \text{ cm}^2$$

Spacing of 12mm Ø = 63.2 cm

Minimum spacing = 29.7 cm

Provide 12mm Ø @ 25cm C/C Negative reinforcement.

Distribution Steel :-

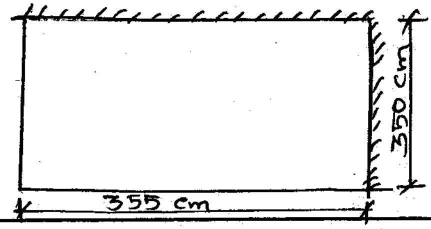
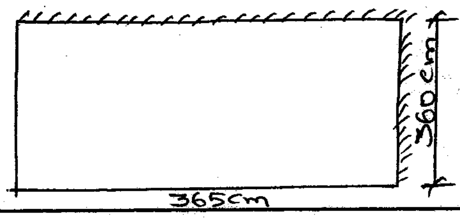
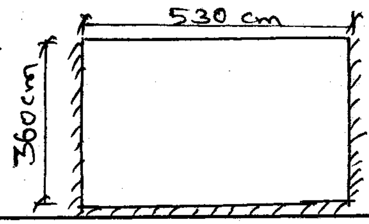
$$A_{st} = \frac{0.15}{100} \times 100 \times 12 = 18 \text{ cm}^2$$

Spacing of 10mm Ø bar = 43,6 cm

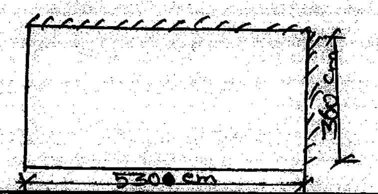
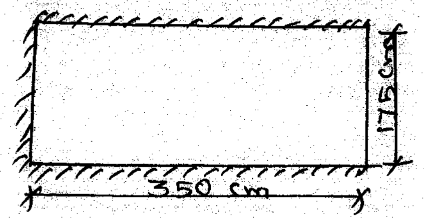
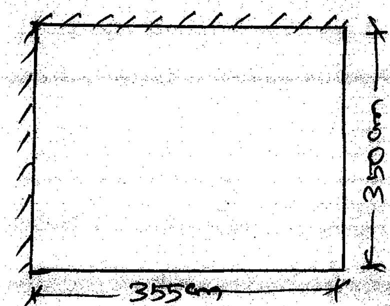
Minimum spacing = 29.7 cm

Provide 10mm Ø @ 25cm C/C as distribution steel.

SLABS FOR OFFICE BUILDING

Sl. No.	Types of Rooms	Dimensions with and conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
1.	Staff Room		12mm Ø bars @ 250mm C/C	12mm Ø bars @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
2.	Store Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos.of 8mmØ bars	3 Nos.of 8mm Ø bars	7 Nos. of 8mm Ø bars
3.	Cashier Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos.of 8mm Ø bars	3 Nos.of 8mm Ø bars	7 Nos. of 8mm Ø bars

Contd...2.

Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details: Middle Strip: Long Span	Middle Strip: Short Span	Edge Strip: Long Span	Edge Strip: Short Span	Torsional Steel/ Layer
4.	Office Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos.of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
5.	Tools Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos.of 8mm Ø bars	3 Nos.of 8mm Ø bars	7 Nos. of 8mm Ø bars
6.	J.E.Room		12mm Ø @ 250mm Ø C/C	12mm Ø @ 250mm C/C	3 Nos.of 8mm Ø bars	3 Nos.of 8mm Ø bars	7 Nos. of 8mm Ø bars

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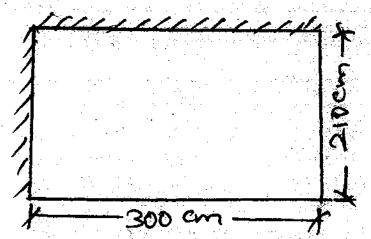
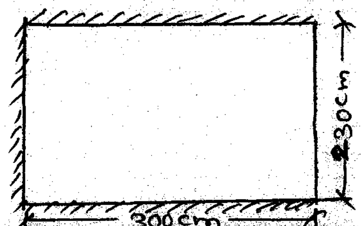
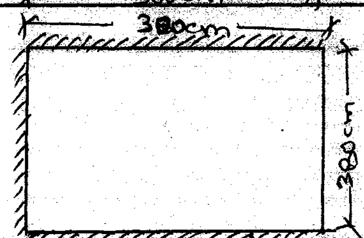
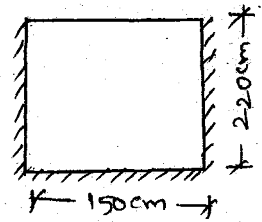
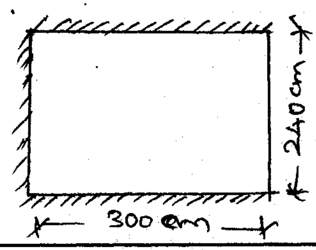
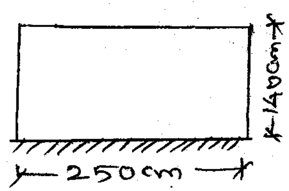
Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
4.	Verandah		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
5.	Office Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
6.	Dining Hall		12mm Ø @ 250mm C/C	12mm Ø@ 250 C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars

Contd..3.

Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
7.	Bathroom & Water Closet		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
8.	Kitchen		12mm Ø @ 250mmC/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
9.	Work area & Fuel		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mmØ bars

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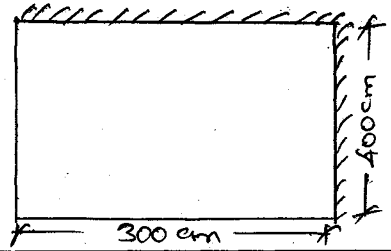
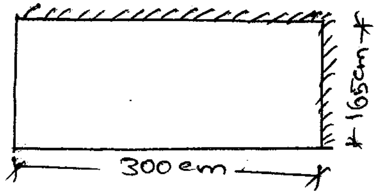
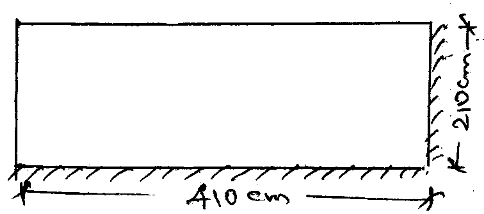
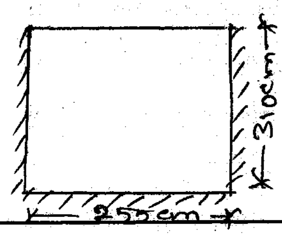
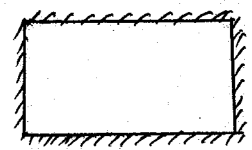
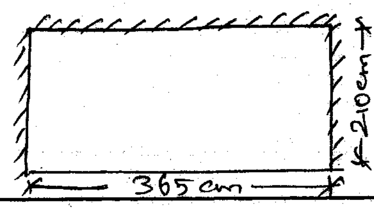
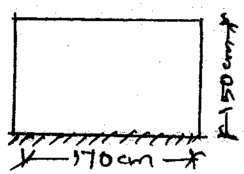
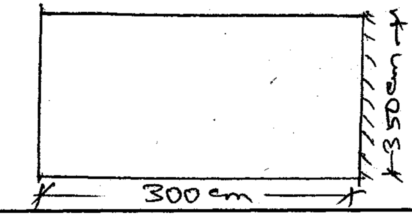
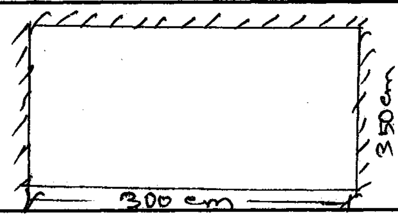
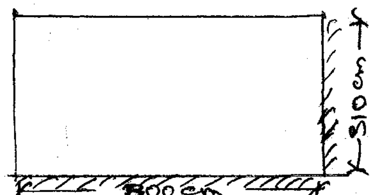
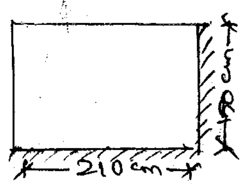
Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
5.	Bed Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
6.	Bathroom & Water Closet		12mm Ø @ 250mmC/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
7.	Dining Hall		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mmØ bars

SLABS FOR STAFF QUARTERS

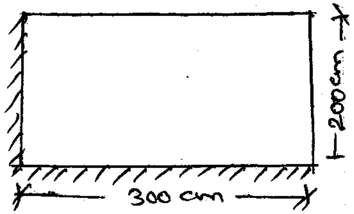
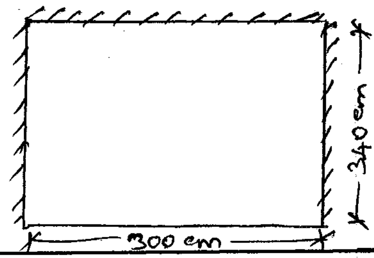
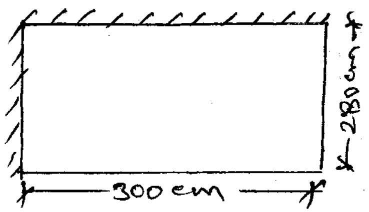
Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional
			Long Span	Short Span	Long Span	Short Span	Steel/ Layer
1.	Kitchen Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
2.	Living Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	—	—	7 Nos. of 8mm Ø bars
3.	Sitout Room		12mm Ø @ 250mm C/C	12mm Ø@ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
4.	Fuel Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars

Contd..2.

<u>SLABS FOR WORKERS QUARTERS</u>

Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
1.	Bed Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
2.	Living Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
3.	Kitchen Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
4.	Toilet Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars

SLABS FOR CONTROL ROOM

Sl. No.	Types of Rooms	Dimensions with end conditions	Reinforcement Details				
			Middle Strip		Edge Strip		Torsional Steel/ Layer
			Long Span	Short Span	Long Span	Short Span	
1.	Verandah		12mm Ø @ 250mm C/C	12mm Ø @ 250mmC/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
2.	Station Engineer Room		12mm Ø @ 250mmC/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mm Ø bars
3.	Urinals Room		12mm Ø @ 250mm C/C	12mm Ø @ 250mm C/C	3 Nos. of 8mm Ø bars	3 Nos. of 8mm Ø bars	7 Nos. of 8mmØ bars

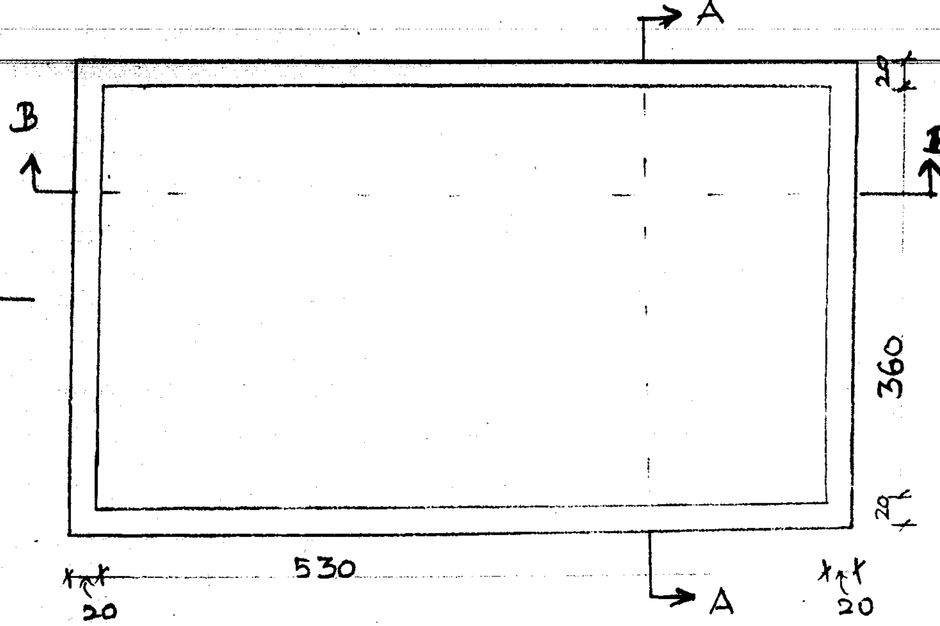
Office Building

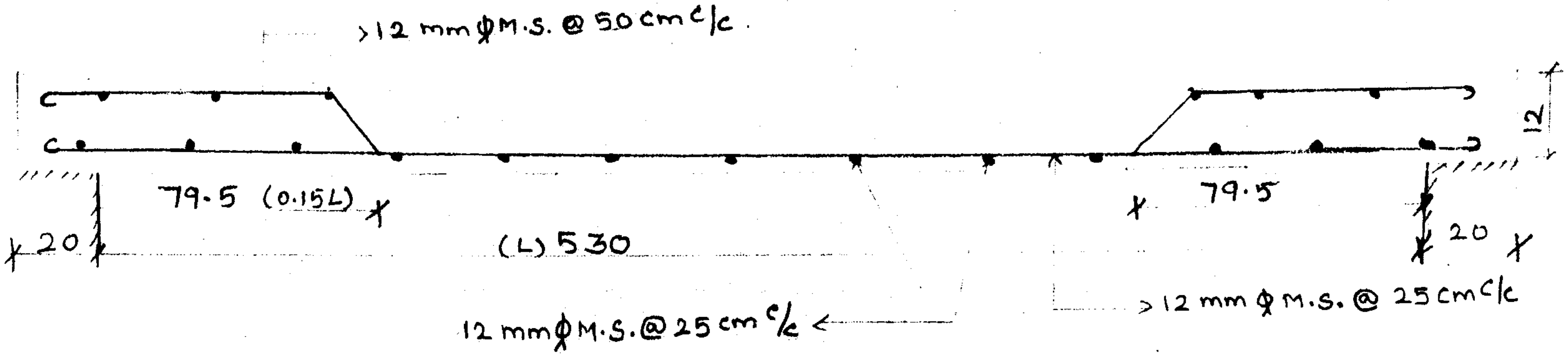
Office Room

Two Way Slab Reinf.

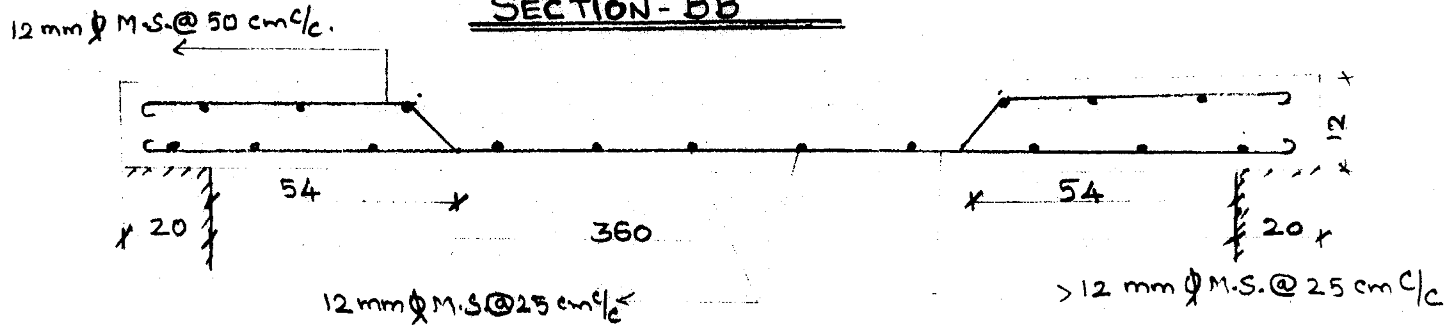
All Dimensions Are in "Cm"

Not To Scale





Section - BB



Section - AA

DESIGN OF BEAM

Length of beam = 9.3m

Centre to centre of beam = 3.0m

Ease M_{150} concret mix and Mild Steel bars

Load Calculations :

Load fron the Slab :-

Dead lead of slab Per metre = 1 x 0.14 x 2500 = 350 Kg/m^2

Assume Live load = 300 Kg/m^2

Finishing load = 100 Kg/m^2

Total load = 750 Kg/m^2

Load from the slab to beam per metre length

= 750 x 3 = 2250 Kg/m^2

Assume size of beam = 400 x 800mm

Self weight of beam per metre = 0.4 x 0.8 x 1 x 25000 = 800 Kg/m

Total load per metre = 3250 + 800 = 3050 Kg/m

Maximum Bending Moment = $M = \frac{W.l^2}{10}$

l = Effective span of beam in metre

W = Uniformly distributed load per metre in metre

$$M = \frac{W.l^2}{10} \quad \frac{3050 \times (9.3)^2 \times 10^3}{10}$$

$$= 2.63 \times 10^6 \text{ Kg-cm}$$

$Q = 8.67\ Kg/cm^2$

$M.R. = Qbd^2$

$2.63 \times 10^6 = 8.67 \times 40 \times d^2$

$d = 87\ cm$

Elective depth of beam is limited to 75 cm

$8.67 \times 40 \times (75)^2 = 1.98 \times 10^6$ Kg-cm $\angle$ Actual B.M.

So beam is designed as doubly reinforced beam

Provide Effective cover of 50mm on both side top and bottom.

Effective depth = 800 - 50 = 750mm

= 75 cm

<u>Area of Reinforcement</u> :-

$$A_{st} = \frac{M}{\sigma_{st} j.d}$$

Where A_t = Area of tensile reinforcement

A_c = Area of compressive reinforcement

M = Bending due to load

σ_{st} = Stress due to bending

d = Effective depth of beam

$$A_{st1} = \frac{M}{\sigma_{st} j.d} = \frac{1.98 \times 10^6}{1400 \times 8.7 \times 75}$$

$= 21.68\ cm^2 \angle 0.04\ bd$

Moment $= M_2 = M - M_1 = 2.63 \times 10^6 - 1.98 \times 10^6$

$= 6.5 \times 10^5$ Kg-cm

$$A_{st2} = \frac{M_2}{\sigma_{st}(d-d')} \quad \frac{6.5 \times 10^5}{1400\ (75-5)} = 6.63\ cm^2$$

Minimum Reinforcement :-

$$A_{st} = \frac{0.85}{f_y}\ bd$$

Where A_{st} = Area of tension reinforcement in cm^2

b = Width of beam in cm

f_y = Characteristic strength of reinforcement in Kg/cm^2

$$= \frac{0.85}{2500} \times 40 \times 75 = 10.2\ cm^2$$

$$A_{st} = A_{st1} + A_{st2} = 21.68 + 6.63 = 28.31\ cm^2$$

25 mm Ø bars

Provide 6 Nos. of 25 mm Ø bars

$$A_{sc} = \frac{M2}{(1.5m-1)\sigma_{sc}\ (d-d')}$$

$$= \frac{6.5 \times 10^5}{(1.5 \times 13-1) \times 1300 \times (75-5)}$$

$$= 6.88\ cm^2$$

Provide 2 Nos. of 25mm Ø bars

Check for Shear :-

$$\text{Shear force} = \frac{W.L.}{2} = \frac{3050 \times 9.3}{2} = 14182\ Kg$$

Nominal shear $\tau_v = \frac{V}{bd}$

Where V = shear force due to working load

b = Width of beam

d = Effective depth of beam

$$\tau_v = \frac{V}{bd} = \frac{14182}{40 \times 75} = 0.47\ Kg/cm^2$$

$$\text{Percentage of steel} = \frac{100\ Ast}{bd} =$$

$$= \frac{100 \times \frac{7 \times \pi \times (25)^2}{4}}{40 \times 75}$$

$$= 1.145\%$$

<u>As per I.S.</u> : 456 - 1978

Permissible shear stress

τ_c = 0.38 N/mm^2 = 3.8 Kg/cm^2

τ_v = 0.47 N/mm^2 = 4.7 Kg/cm2

Shear reinforcements are provided.

Use 2 legged 8mm Ø bars

<u>As per I.S. Code</u> : 456 - 1978

$$S_v = \frac{\sigma_{sv} A_{sv} \cdot d}{V_s}$$

σ_{sv} = Permissible stress in shear reinforcement

A_{sv} = Total cross sectional area of stirrups legs

V_s = Strength of shear reinforcement

$$V_s = V - \sigma_c bd$$

$$= 141.82 \times 10^3 - 0.38 \times 400 \times 750 = 27820N$$

$$= \underline{2782 \text{ Kg}}$$

$$S_v = \frac{\sigma_{sv} A_{sv} d}{V_s} =$$

$$= \frac{1400 \times \frac{2 \times \pi \times (8)^2}{4} \times 75}{2782} = 37.94 \text{ cm}$$

$$= 36 < 45 \text{ cm C/C}$$

<u>Minimum Reinforcement</u> :- (From code)

$$\frac{A_{sv}}{b S_v} = \frac{0.4}{f_y}$$

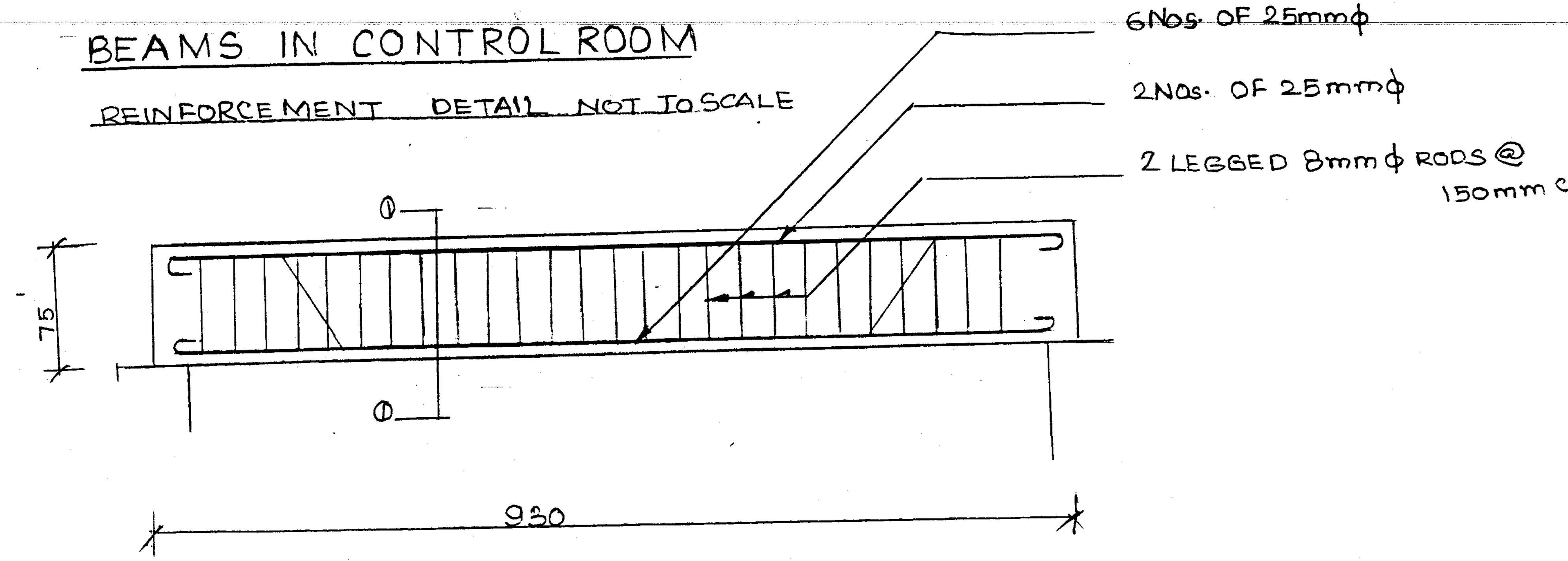
$$S_v = \frac{A_{sv} \times f_y}{0.4 b} = \frac{2 \times \frac{\quad \times 8^2}{4} \times 2500}{0.4 \times 40}$$

$$= 15.1 \text{ cm} \Rightarrow 15 \text{ cm C/C}$$

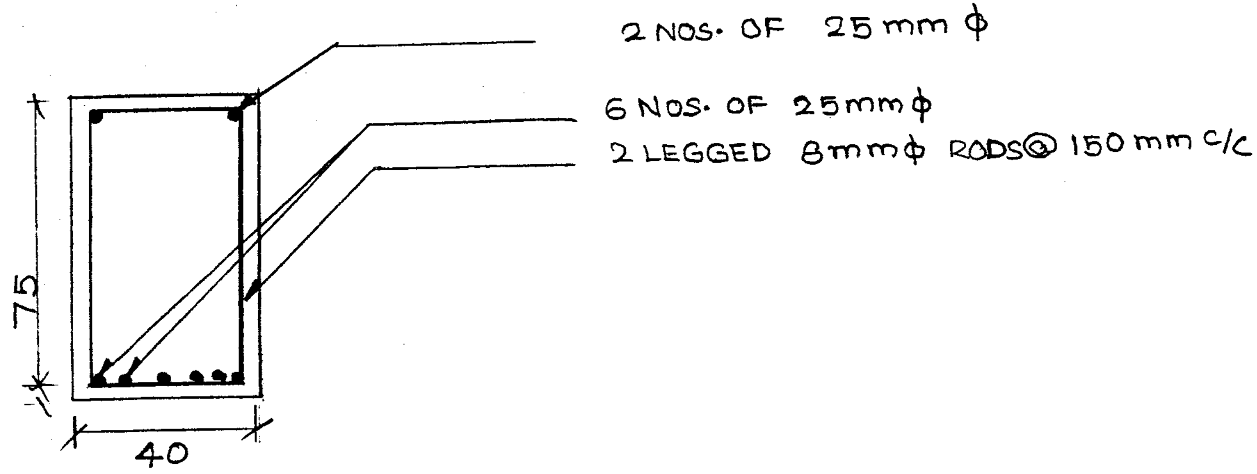
Hence provide 2 legged 8mm Ø strrups at 15cm C/C

BEAMS IN CONTROL ROOM

REINFORCEMENT DETAIL NOT TO SCALE



LONGITUDINAL SECTION



SECTION ①-①

ALL IN CM.

DESIGN OF COLUMNS:-

Working load = 12550 Kg.

Effective length of column = 4.7m

Assume size of column = 300 x 400mm

$$\frac{l_{eff.}}{r_{min.}} = \frac{4700}{300} = 15.6 > 12$$

Hence It is a long column

Reduction co-efficient = C_r. $= 1.25 - \frac{left}{48\ b}$

$$= 1.25 - \frac{4700}{48 \times 300} = \underline{\underline{0.92}}$$

Area of concrete = $(300 \times 400) - A_{st}$

Safe load on long column = Reduction co-efficient x Area of column

$$P = C_r \quad (\sigma_{st}\ A_{st} + \sigma_{sc} + A_c)$$

$$125.5 \times 10^3 = 0.92 \left| 130\ A_{st} + (300 \times 400 - A_{st})\ 4 \right|$$

$$125.5 \times 10^3 = 0.92 \left| 130\ A_{st} + (1.2 \times 105 - A_{st})\ 4 \right|$$

$$A_{st} = 2726\ mm^2$$

Use 20mm Ø bars

Provide 10Nos. of 20mm Ø bars

Lateral Ties :- (From I.S. Code : 456 - 1978)

Use 6mm Ø as transverse reinforcement

(Minimum Spacing of reinforcement)

(i) Least lateral dimensions = 300mm

(ii) 16 times longitudinal dia of bars = 16 x 20 = 320mm

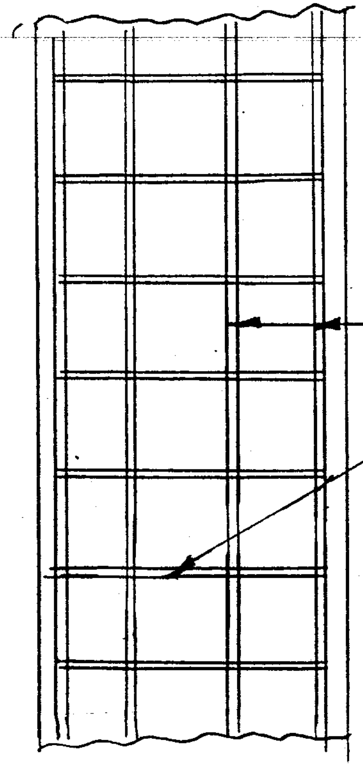
(iii) 48 times transverse dia of bar = 48 x 6 = 288mm

Provides 6mm Ø bars @ 280mm C/C

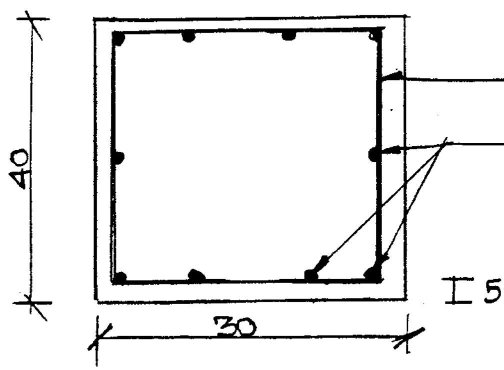
COLUMNS IN CONTROL ROOM NOT TO SCALE

REINFORCEMENT DETAIL

ALL IN CM



LONGITUDINAL SECTION



SECTIONAL PLAN

DESIGN OF FOOTINGS

Total load on column	=	12550 Kg
Add 10% of column load	=	1255 Kg
Total load		13805 Kg

Safe bearing capacity of soil = 20 t/m^2

Area of foundation = $\frac{13.805}{20}$ = 6.9 m^2

Provide the Area of foundation = 2.9 x 2.5m size of footing

Provided Area = 2.9 x 2.5 = 7.25 $m^2 > 6.9$ m^2

Hence safe

Net upward pressure with foundation = $\frac{\text{load}}{\text{Area of footing}}$

= $\frac{12550}{2.9 \times 2.5}$ = 1731 Kg/m^2

Column size 300mm x 400mm size

B.M. section on M_{xx} = $1731 \times 2.9 \times \frac{1.1^2}{2}$ = 3005 Kg-m

B.M. section on M_{yy} = $1731 \times 2.5 \times \frac{1.25^2}{2}$ = 3346 Kg-m

Use M_{150} grade concrete

σ_{cbc} = 50 Kg/cm^2 σ_{st} = 1400 Kg/cm^2

j = 0.87 Q = 8.5 Kg/cm^2

σ_{cbc} permissible compressive stress in concrete

σ_{st} permissible stress in steel

Equating moment of resistance = Maximum bending moment

$8.5 \times 40 \times d^2 = 3005 \times 10^2$

$$d = 29.8 \text{ cm}$$

$$Q\,bd^2 = 334600$$

$$d = \sqrt{\frac{334600}{8.5 \times 30}} = \underline{\underline{36.22 \text{ cm}}}$$

Provide 12mm Ø bars with a clear cover of 40mm Therefore effective cover to the centre of lower layer reinforcement in shorter span $= 40 + \frac{12}{2} = 46\text{mm}$

Effective cover to the centre of top layer of reinforcement

$$= 46 + 12 = 58\text{mm}$$

Overall depth = 362.3 + 58 = 420.3mm

Say 600mm

Effective depth in short span = 600 - 46 = 554mm

Effective depth in long span = 100 - 58 = 542mm

Steel for short span $= \dfrac{M_{xx}}{\sigma_{st}\, jd}$

$$= \frac{30.05 \times 10^6}{140 \times 0.87 \times 554} = 448 \text{ mm}^2$$

<u>Minimum Reinforcement</u> :-

The minimum reinforcement in shorter direction is

$$A_{st} = \frac{0.15}{100} \times b \times d$$

$$= \frac{0.15}{100} \times 2900 \times 554 = \underline{\underline{2410\text{mm}^2}}$$

Steel required for long span

$$A_{st} = \frac{M_{yy}}{\sigma_{st} jd} = \frac{33.46 \times 10^6}{140 \times 0.87 \times 542} = 506.8 mm^2$$

Use 10mm Ø bars

Provide 24 Nos. of 12mm Ø bars

The minimum reinforcement of footing in Longerdirection

$$A_{st} = \frac{0.15}{100} \times bxd.$$

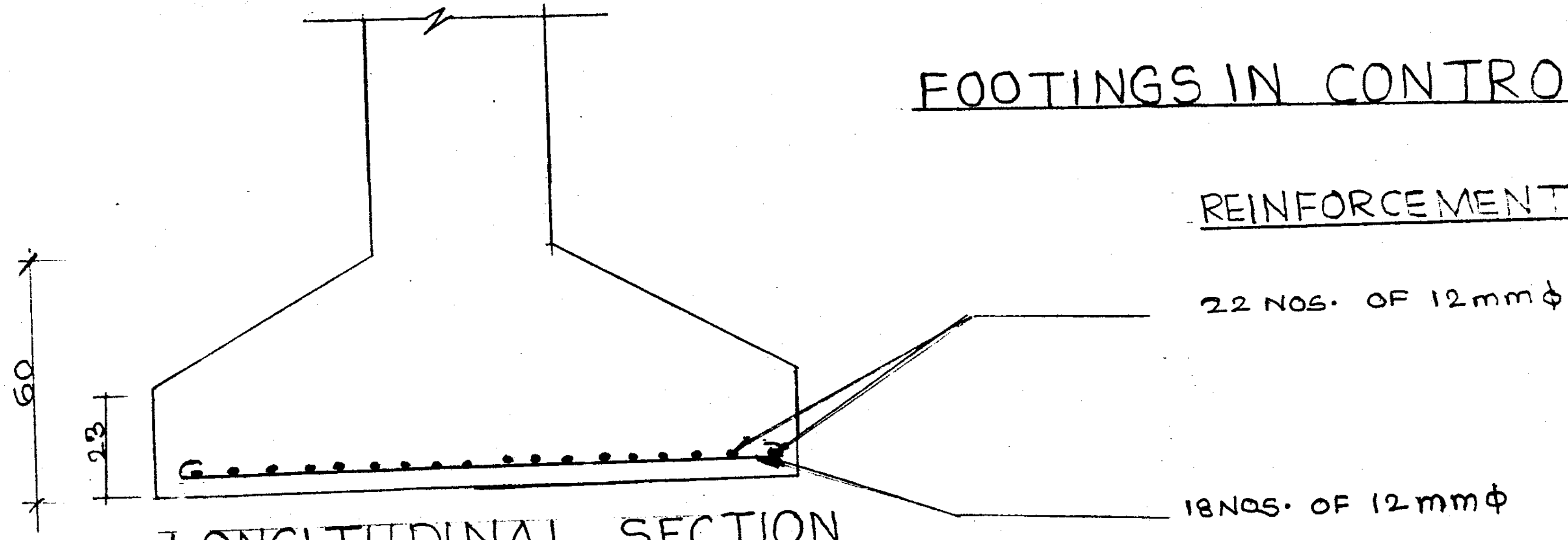
$$= \frac{0.15}{100} \times 2500 \times 542 = 2033 mm^2$$

Use 12mm Ø bars

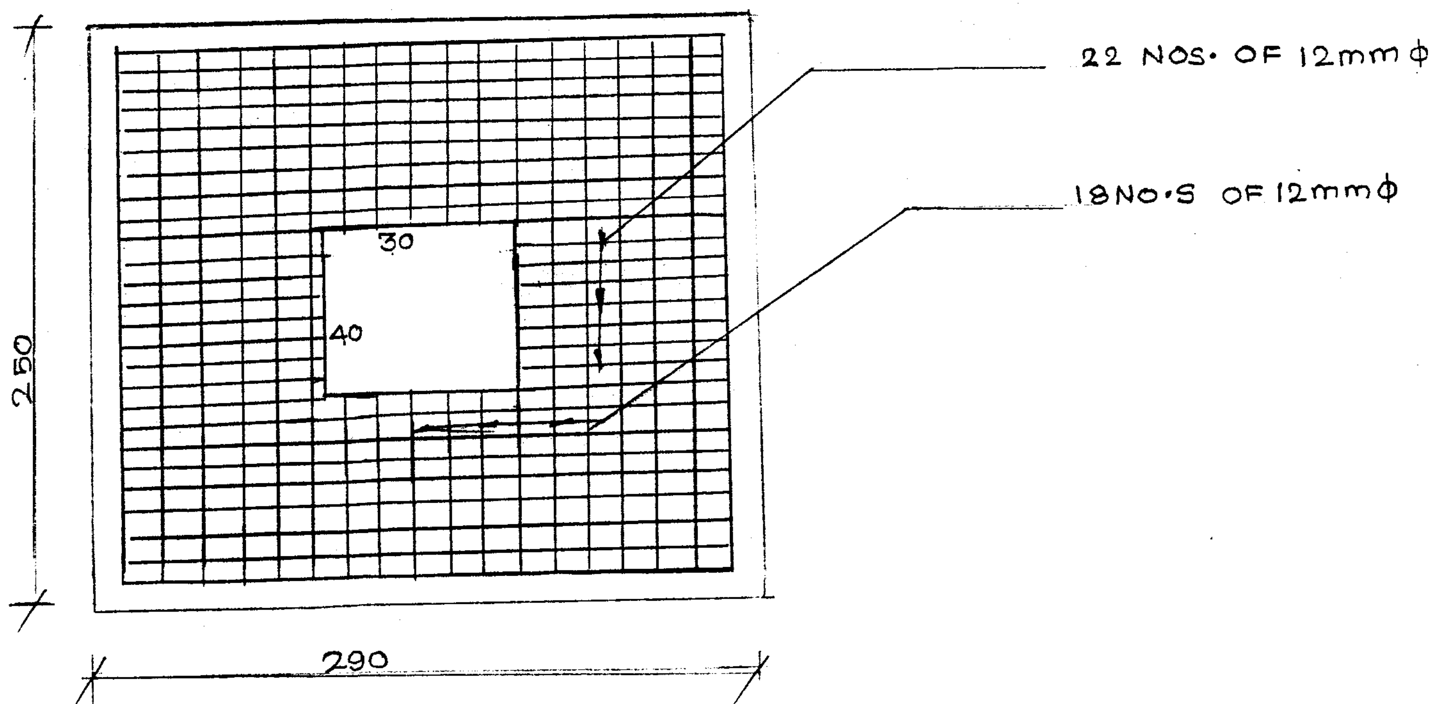
Provide 18 Nos. of 12mm Ø bars

FOOTINGS IN CONTROL ROOM

REINFORCEMENT DETAIL



LONGITUDINAL SECTION



SECTIONAL PLAN NOT TO SCALE

ALL IN CM

DESIGN OF CIRCULAR WATER TANK

Number of persion = 75

Per capita demand = 135 lit/day

Total capacity of water needed = 75 x 135 = 10125

The tank is designed for a capacity of 15,000 litres

Design of Dome :-

Assume thickness of dome slab = 100mm to 150mm

Assume the diameter of the tank = 3m

Height of the tank = 2.2m

Total capacity of the tank $= \frac{\pi 3^2}{4} \times 2.2$

$= 15.550m^3$

Since 15500 15,000 litres

Provide diameter of the tank = 3m

height of the tank = 2.2m

1.5 x 1.5 = 1x (2R - 1)

R = 1.625m

Provide thickness of dome slab = 10cm

Self weight of dome = 0.1 x 2500 x 1 x 1 = 250 Kg/m^2

Total L.L. of dome = 150 Kg/m^2

Total load = 400 Kg/m^2

Meridianal stress $= \frac{WR\ (1-\cos\phi)}{t\ \sin^2\phi}$

$\sin\phi = \frac{1.5}{1.625}$ $\qquad \cos\phi = \frac{0.625}{1.625}$

$\phi = 67°$

$$\text{Meriadinal stress} = \frac{400 \times 1.625 \left(1 - \frac{0.625}{1.625}\right)}{0.1 \times (1.5/1.625)^2}$$

$$= 4694.4 \text{ Kg/m}^2$$

Hoop stress at any angle $\emptyset$ is $f = \frac{WR}{t}\left(\cos\emptyset - \frac{1}{1+\cos\emptyset}\right)$

$$= \frac{4000 \times 1.625}{0.1}\left|\frac{0.625}{1.625} - \frac{1}{1+\cos 67^\circ}\right|$$

$$= 2194.44 \text{ Kg/m}^2$$

Hoop stress is maximum when $\emptyset = 0$

$$f_{max} = \frac{4000 \times 1.625}{0.1}(1 - 7/2)$$

$$= 0.325 \text{ Kg/cm}^2 \angle 16 \text{ Kg/cm}^2$$

(Allowable compressive stress in concrete 8 to 16 Kg/cm^2 in dome safe compressive stress in steel is 1000 Kg/cm^2)

Meridianal and hoop stress are very small hence provide a nominal reinforcement.

Provide a nominal reinforcement = 0.3% of cross sectional area

$$= \frac{0.3}{100} \times 100 \times 10$$

$$= 30 \text{ cm}^2$$

Provide 10mm Ø bars @ 250mm C/C in both direction.

To resist the horizontal component of merdianal stress at the end of rod, ring beam is provided. So the ring beam is subjected to hoop tension.

Design of ring beam :-

Meridianal stress/mm length = 0.046944 x 100 = 4.694 Kg.

Horizontal component of meridianal thrust = 4.694 x $\cos\phi$

$$= 4.694 \times \frac{0.625}{1.625}$$

$$= 1.805 \text{ Kg/cm}$$

Hoop tension $= \frac{P.d}{2} = \frac{1.805 \times 300}{2} = 270.75$ Kg.

$$A_{st} = \frac{2707.5}{100} = 2.707 \text{ cm}^2$$

Provide 6mm Ø No. of bars = 4

Also provide 6mm Ø strrups at 20 cm C/C

To find the size of ring beam - Let A be minimum area of ring beam section

Area required $= A + (m-1) A_{st}$

$$= A + (13-1)\ 4 \times \frac{\pi \times 6^2}{4} = A + 1357.16$$

Allowable tensile stress in concrete = 12 Kg/cm²

$$= 1.2 = \frac{2707.5}{4 + 1357.16}$$

$$A = 8.99 \text{ cm}^2$$

Provide 75mm x 75mm size ring beam

Area provided = 56.25 > 8.99 cm²

Design of cylindrical wall :-

Dome is designed on the membrane theory. The tank wall is assumed to be free at the top.

H = 1.5m D = 3m

Assume thickness wall provided 15cm

$$\frac{H^2}{Dt.} \quad \frac{2.25}{3 \times 0.15} = 5$$

Four this parameter find the maximum hoop tension for cylinderical tanks with fixed at the base and free at the top.

(From I.S. code - table)

Maximum hoop tension = co-efficient x W.H.R.

= 0.469 x 10,000 x 2.2 x1.5

= 1547.7 Kg.

Maximum hoop tension occurs at 0.6H from top

= 0.6 x 2.2 = 1.32m

Maximum negative B.M. = Co-efficient of B.M. x WH^3

= $-0.0222 \times 10{,}000 \times 2.2^3$

= 236.3856 Kg-m

Maximum B.M. occurs at 1 H from top

Maximum positive B.M. = 62.823 Kg-m

Maximum positive B.M. occurs at 0.7H = 0.7 x 2.2 = 1.54m

Maximum shear at the base = Shear co-efficient x WH^2

= $0.213 \times 10{,}000 \times 2{,}2^2$

= 1030.92 Kg.

A_{st} for hoop tension $= \frac{154.77}{100} = 1.55\ cm^2$

Provide 6mm Ø bars @ 300mm C/C on both faces

Minimum distribution steel ; $\left| 0.3 - \frac{0.1 \times (150-100)}{450-100} \right| \times$

$$\frac{1}{100} \times 1000 \times 150$$

$$= 4.29\ cm^2$$

Provide 8mm Ø bars @ 20 cm C/C on both the face throughout the height.

Steel far (Negative) B.M. :-

Tension occurs on the water face)

Provide effective cover = 4cm

$d = 15 - 4 = 11cm$

d required $= \sqrt{\frac{562.5 \times 10^3}{1.411 \times 100}} = 6.312$ cm

Provide an effective cover of 3 cm

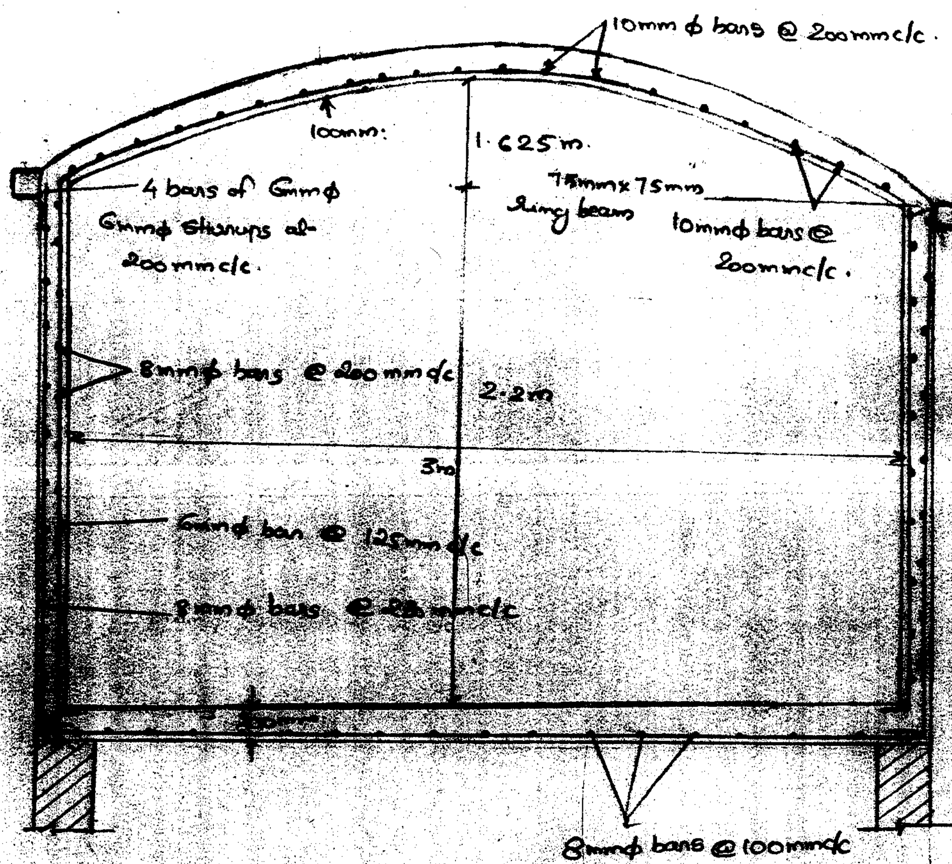
Effective depth available = 20-3 = 17 cm > 6.312cm

Hence the design iscorrect.

A_{st} for Negative radial moment $= \frac{562.5 \times 10^3}{100 \times 8.4 \times 17} = 3.93\ cm^2$

Provide 8mm Ø bars @ 10 cm C/C placed away from the water face.

The tank is supported by a masonry wall.



SECTION OF CIRCULAR WATER TANK.

DESIGN OF SEPTIC TANK

No. of persions	=	75
Quantity of sewage flow	=	150Lit/capita demand
Quantity of water supplied	=	150 x 75
	=	11250 litres/day

Assuming 90% of water supplied became sewage

Quantity of water became sewage	=	11250 x 0.9
	=	10125 lit/day
	=	$10.125m^3$/day

Assuming detentions period as 24 hours

Capacity of the tank	=	$10.125 \times \frac{24}{24}$
	=	$10.125m^3$
Quantity of sludge capacity	=	$0.037m^3$/Capita
Total quantity of sludge capacity	=	0.37 x 75
	=	$2.775m^3$
Quantity of slum storage capacity	=	0.01 x 75
	=	$0.75m^3$
Total capacity of the tank	=	10.125+2.775+0.75+FE

Adding 20% for future expansion

Future expansion	=	$10.125 \times \frac{20}{100}$
	=	$2.025m^3$
Total capacity	=	10.125+2.775+ 0.75+ 2.05
	=	$15.675m^3$

Assuming the depth of tank = 1.5m

$$\text{Area} = \frac{\text{Total Capacity}}{1.5} = \frac{15.675}{1.5} = \quad = 10.45m^2$$

Assuming length L = 3B

B x 3B = 10.45

B^2 = 3.48333

B = 1.8663

B = 2m

Length (L) = 2 x 3 = 6m

Dimension of Septic tank

L = 6m

B = 2m

D = 1.5m

Size of the tank = 6.0 x 2 x (1.5+0.5)

<u>Dispersen trunch</u> :-

Width of trunch = 50cm to 100cm

Depth = 50cm to 100cm

Length 30

Absorbing rate = 100 to 200lit/m^2/day

= 0.1 to 0.2m^3/m^2/day

Minimum clear distance = 1.8m

between successive trunch

Assuming 3 trenches with breadth and depth as 1.0m each

Length of each trunch = 'L'm

Bottom area of trunch = L x $1m^2$

Side area of trunch = 2(Lx1 + 1x1)

= $(3L+2)m^2$

Taking absorbing rate as $o.15m^3/m^2/day$

Total quantity to be absorbed by three units + 3(3L+2)x0.15

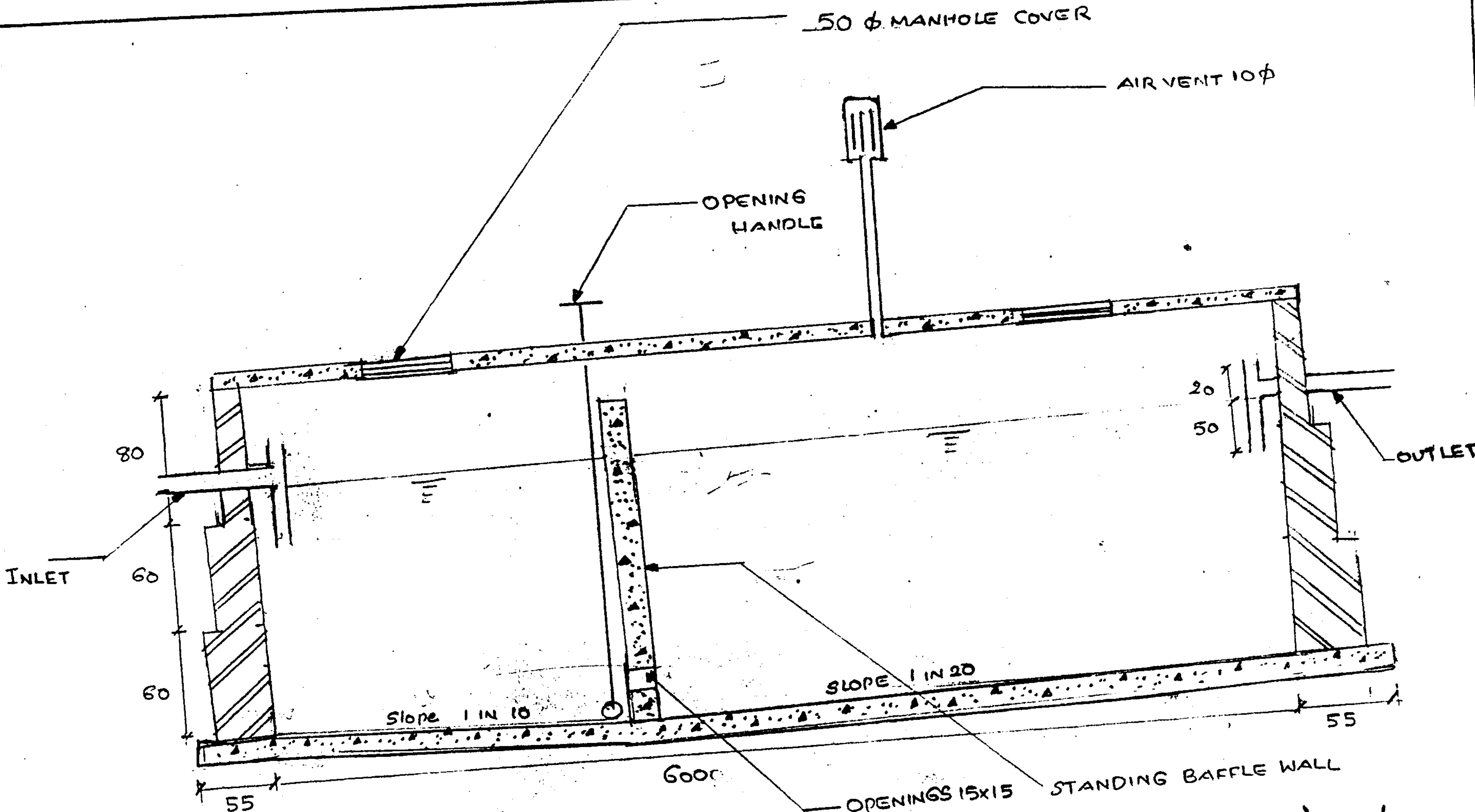
3(3L+2)x0.15 = 15.615

L = 10.94

L = 11m

Length of dispersion trunch = 11m

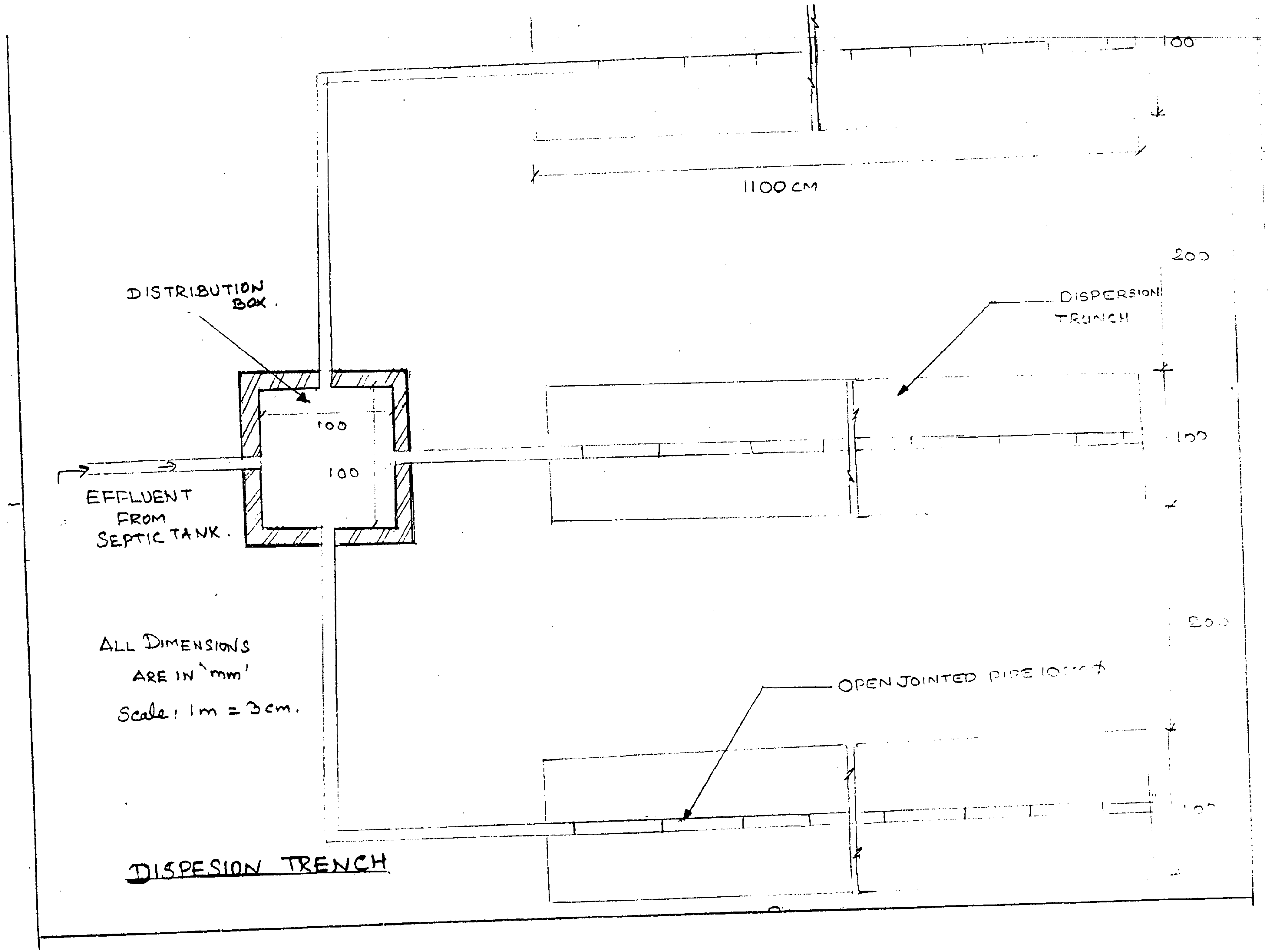
Size of dispersion trunch = 11m x 1.0m x 1.0m



ALL DIMENSIONS ARE IN 'mm'

SCALE : 1 m = 3 cm

CROSS SECTION OF SEPTIC TANK



DISPESION TRENCH

CONCLUSION

The planning and design of 110KV Electrical substation project is planned and structural members are designed.

Detailed drawings of plans etc. are attached. The design parts are shown in detail.

B I B L I O G R A P H Y

1. Concrete Structures — by V.N. VAZIRANI and M.M. RATWANI

2. Design of reinforced Concrete structures — by S. RAMAMRUTHAM

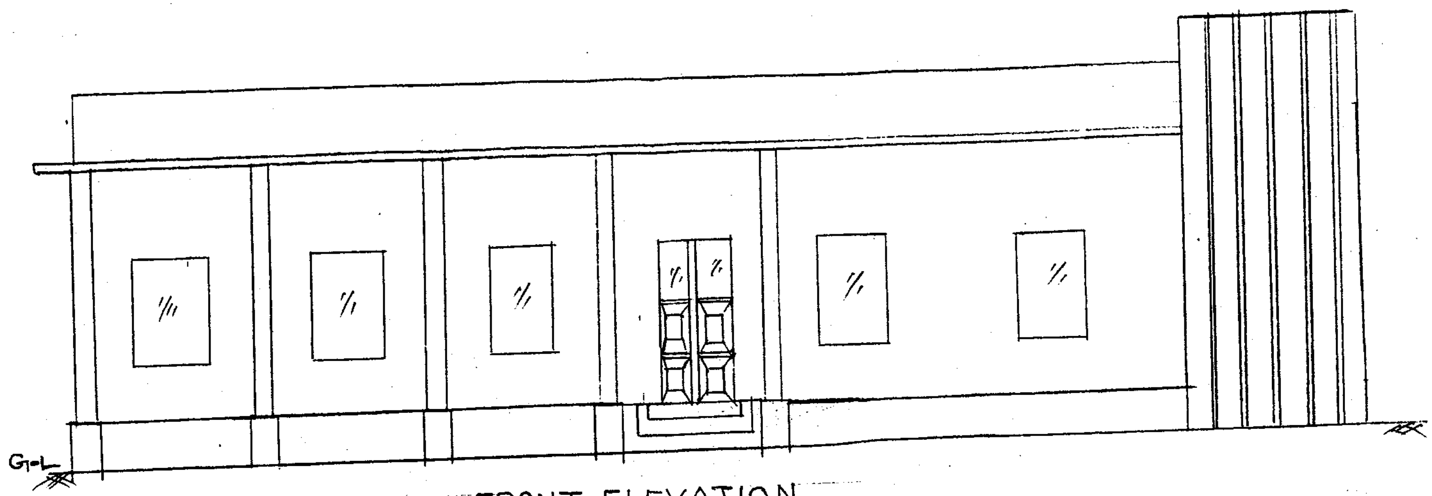
3. Estimation and costing — by B.N. DUTTA

4. National Building Code of India - 1983(ISI)

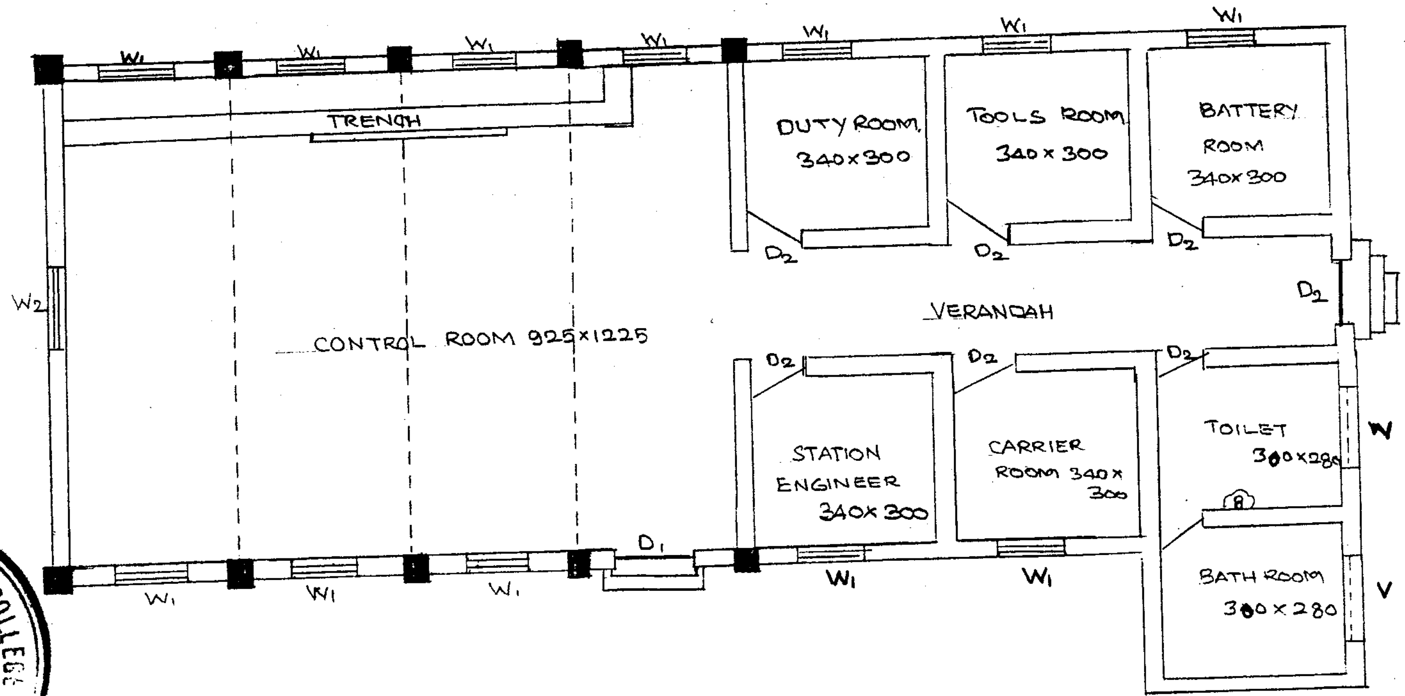
5. ISI Code 456 - 1978

6. Water Supply Engineering — by S.K. GARG

7. Construction of Power transmission lines and substations. — by F. MAGIOIN



FRONT ELEVATION



CONTROL ROOM PLAN

Scale:- 1:100

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