DESIGN OF MULTISTORY RESIDENTIAL BUILDING

Submitted in partial fulfillment of the Degree of
Bachelor of Technology

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WAKNAGHAT

CERTIFICATE

This is to certify that project report entitled "**THE DESIGN OF MULTI STORY BUILDING AT SOLAN** ", submitted by **Chanderkant Agarwal, Akash Aggarwarwal, Pearl Sethi** in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Signature of Student
Name
Date

Signature of Student	Signature of Supervisor
Name	Name
Date	Date

Signature of Student
Name

ACKNOWLEDGEMENTS

I would like to express my gratitude to all the people behind the screen who helped me to transform an idea into a real application.
I would like to express my heart-felt gratitude to my parents without whom I would not have been privileged to achieve and fulfill my dreams. I
am grateful to our principal,
I profoundly thank **Mr. Ashok Kumar Gupta**, Head of the Department of CIVIL Engineering who has been an excellent guide and also a great source of inspiration to my work.
I would like to thank my internal guide **Mr. Mani Mohan** Asst.Professor for his technical guidance, constant encouragement and support in carrying out my project at college. The satisfaction and euphoria that accompany the successful completion of the task would be great but incomplete without the mention of the people who made it possible with their constant guidance and encouragement crowns all the efforts with success. In this context, I would like thank all the other staff members, both teaching and non-teaching, who have extended their timely help and eased my task.

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Contents

SUMMARY

With the advancement of technology, humans are making software to make things simpler and easier. As a result from civil engineering point of view the manual design of buildings lost its importance. It is true that design using software is easy, accurate and time saving.

On the other hand manual design is a cumbersome job and a time consuming Process, but for a beginner manual design helps to understand the basic fundamentals that are involved in designing a building. Once a person gains knowledge in manual design he will know the elements involved in designing and can easily understand the usage of software.

The main objective of the project is to use the knowledge that we have gained during our graduation and learn to deal with practical cases. We wish this project will fulfil our purpose.

List of figures

List of Symbols and acronyms

A = Total area of section

A_b= Equivalent area of helical reinforcement.

A_c= Equivalent area of section

A_h= Area of concrete core.

A_m = Area of steel or iron core.

A_{sc} = Area of longitudinal reinforcement (comp.)

A_{st} = Area of steel (tensile.)

A_l= Area of longitudinal torsional reinforcement.

A_{sv} = Total cross-sectional are of stirrup legs or bent up bars within distance S_v

A_w =Area of web reinforcement.

A_Φ = Area of cross –section of one bars.

a = lever arm.

a_c= Area of concrete.

B =flange width of T-beam.

b = width.

b_r=width of rib.

C =compressive force.

c = compressive stress in concrete.

c'= stress in concrete surrounding compressive steel.

D = depth

d = effective depth

d_c= cover to compressive steel

P_a=active earth pressure.

P_p= passive earth pressure.

P_u= axial load on the member(limit state design).

P = percentage steel.

P'= reinforcement ratio.

P_a=active earth pressure indencity.

P_e=net upward soil pressure.

Q= shear resistance.

q = shear stress due to bending.

q'=shear stress due to torsioN

R= radius.

s= spacing of bars.

s_a= average bond stress.

s_b= local bond stress.

T=tensile force.

T_u= torsional moment.

t= tensile stress in steel.

t_c= compressive stress in compressive steel.

V_u= shear force due to design load.

V_{us}=strength of shear reinforcement.

W= point load.

X= coordinate.

x_u = depth of neutral axis.

Z= distance.

d_t= cover to tensile steel

e = eccentricity.

= compressive steel depth factor (=d_c/d).

F =shear force characteristic load.

F_d= design load

F_r= radial shear force.

f= stress (in general)

f_{ck} = characteristic compressive stress.

F_y = characteristic strength of steel.

H = height.

I = moment of inertia.

I_e=equivalent moment of intertia of stress.

j= lever arm factor.

K_a =coefficient of active earth pressure.

K_p =coefficient of passive earth pressure.

k = neutral axis depth factor (n/d).

L=length.

L_d=devolopment length.

l = effective length of column; length; bond length.

M = bending moment; moment.

M_r=moment of resistance; radial bending moment.

M_t=torsional moment.

M_u= bending moment (limit state design)

M_θ=circumferential bending moment

m = modular ratio.

n = depth of neutral axis.

Chapter 1 Introduction

The population explosion and industrial revolution led to the exodus of people from villages to urban areas. This urbanisation led to a new problem – less space for housing of the people. Because of the demand for land, the land costs got skyrocketed. So, under such conditions, the vertical growth of buildings i.e. constructions of multi-storeyed buildings has become inevitable for residential purpose. For multi-storeyed buildings, the conventional load bearing structures become uneconomical as they require larger sections to resist huge moments and loads. But in a framed structure, the building frame consists of a network of beams and columns which are built monolithically and rigidly with each other at their joints. Because of this rigidity at the joints, there will be reduction in moments and also the structure tends to distribute the loads more uniformly and eliminate the excessive effects of localised loads. Therefore in non-load bearing framed structures, the moments and forces become less which in turn reduces the sections of the members. As the walls don't take any load, they are also of thinner dimensions. So, the lighter structural components and walls reduce the self weight of the whole structure which necessitates a cheaper foundation. Also, the lighter walls which can be easily shifted provide flexibility in space utilisation. In addition to the above mentioned advantages the framed structure is more effective in resisting wind loads and earth quake loads.

It is proposed to construct six story residential building with underground parking at Solan (H.P). In our Project we have designed the architecture drawings with the Auto-cad and 3d sketches with chief architecture. Structure of the building is design by computer application Staad.pro for R.C.C frame including beams and columns , slabs and footing by manual calculation with the use of Latest codes. Other components of the project like elevated water tank, septic tank, Soak pit and rain water harvesting tank is designed as per the requirements of TCP (Town and country planning), Solan district.

1.1 Selection of plot and study

Selection of plot is very important for buildings a house. Site should be in good place where there community but service is convenient but not so closed that becomes a source of inconvenience or noisy. The conventional transportation is important not only because of present need but for retention of property value in future closely related to are transportation, shopping, facilities also necessary. One should observe the road condition whether there is indication of future development or not in case of un developed area.

The factor to be considered while selecting the building site are as follows:-

- Access to park & play ground.
- Agriculture polytonality of the land.
- Availability of public utility services, especially water, electricity & sewage disposal.
- Contour of land in relation the building cost. Cost of land .
- Distance from places of work.
- Ease of drainage.
- Location with respect to school, collage & public buildings.
- Nature of use of adjacent area.
- Wind velocity and direction.

1.2 Survey of the site for proposed building

Reconnaissance survey: the following has been observed during reconnaissance survey of the site.

- Site is located nearly.
- The site is very clear planned without ably dry grass and other throne plats over the entire area.
- No levelling is require since the land is must uniformly level.
- The ground is soft.
- Labour available nearby the site

• Houses are located near by the site.

• Detailed survey: the detailed survey has been done to determine the boundaries of the required areas of the site with the help of theodolite and compass.

RESIDENTIAL BUILDING

Requirement for residential accommodation are different for different classes of people & depends on the income &status of the individual a highly rich family with require a luxurious building, while a poor man we satisfied with a single room house for even poor class family. A standard residential building of bungalow type with has drawing room, dining room office room, guest room, kitchen room, store, pantry, dressing room, bath room, front verandah, stair etc., for other house the number of rooms may be reduced according to the requirements of many available.

1.3 Limitation of built up area

Area of plot up to 200sq.m (240sq.yd) ---- maximum permissable built up area

Ground and first ---- 60% of site area on floor only.

201 to 500sq.m (241to 600sq.yd) ---- 50% of the site area.

501 to 1000sq.m (601 to 1200sq.yd) ---- 40% of the site area

More than 1000sq.m ---- 33% of the site area.

MINIMUM FLOOR AREA & HEIGHT OF ROOMS

FLOOR AREA HIEGHT (m)

LIVING 10sqm (100sqft) (breadth min 2.7 m or 9’) 3.3 (11’)

KITCHEN 6sqm (60sqft) 3.0 (10’)

BATH 2sqm (20sqft) 2.7 (9’)

LATTRINE 1.6sqm (16sqft) 2.7 (9')

BATH & WATER 3.6sqm (36sqft) 2.7 (9')

CLOSET
MIN. HIEGHT OF PLINTH

FOR MAIN BUILDING ------- 0.6 (2')

MIN. HIEGHT OF PLINTH FOR
SERVANT QUARTES ------- 0.3 (1')

MIN. DEPTH OF FOUNDATION ------- 0.9 (3')

THICKNESS OF
WALL 11.5cms to 230cms ------ (9" to13.5")

DAMP PROOF COURSE
2cms to 2.5cms thick full width of (3/4" to1") plinth wall

1.4 Arrangement of rooms

LIVING ROOMS:

This is the area is for general use. Hence the living & drawing room should be planned near the entrance south east aspects. During colder day the sun is towards the south & will receive sunshine which is a welcoming feature. During summer sunshine ti the northern side & entry of sunrays from southern or south – east aspects do not arise.

KITCHEN:

Eastern aspects to admit morning sun to refresh & purity the air.

BED ROOM:

Bed may also be provided with attached toilets, there size depends upon the number of beds, they should be located so as to give privacy & should accommodate beds, chair, cupboard, etc., and they should have north or – west south – west aspect.

BATH & W.C:

Bath and w.c are usually combined in one room & attached to the bed room and should be well finished. This should be filled with bath tub, shower, wash-hand basin, w.c, shelves, towels, racks brackets, etc., all of white glazed tiles. Floor should be mosaic or white glazed files. Instead of providing all bed room with attached bath and W.C separated baths & latrines may also be provided.

STAIR CASE:

This should be located in a easily accessible to all members of the family, when this is intended for visitors it should be in the front, may be on one side of verandah. It meant for family use only, the staircase should be placed the rear. The stairs case should be well ventilated & lighted the middle to make it easy & comfortable to climb. Rises & threads should be uniform through to keep rhythm while climbing or descending.

Some helpful points regarding the orientation of a building are as follows:-

• Long wall of the building should face north south, short wall should face.

• East and west because if the long walls are provided in east facing, the wall.

• Absorb more heat of sun which causes discomfort during night.

• A verandah or balcony can be provided to wards east & west to keep the rooms cool.

• To prevent sun's rays & rain from entering a room through external doors & windows sunshades are required in all directions.

1.5 Orientation

After having selected the site, the next step is proper orientation of building. Orientation means proper placement of rooms in relation to sun, wind, rain, topography and out look and at the same time providing a convenient access both to the street and back yard.

The factors that effect orientation most are as follows.

• Solar heat

• Wind direction

• Humidity

• Intensity of wind site condition

• Lightings and ventilation

SOLAR HEAT:

Solar heat means sun's heat, the building should receive maximum solar radiation in winter and minimum in summer. For evaluation of solar radiation, it is essential to know the duration of sunshine and hourly solar intensity on exposed surfaces.

WIND DIRECTION:

The winds in winter are avoided and are in summer, they are accepted in the house to the maximum extent.

HUMIDITY:

High humidity which is common phenomenon is in coastal areas, causes perspiration, which is very uncomfortable condition from the human body and causes more discomfort.

INTENSITY OF WIND:

Intensity of wind in hilly regions is high and as such window openings of comparatively small size are recommended in such regions.

SITE CONDITIONS:

Location of site in rural areas, suburban areas or urban areas also effects orientation, sometimes to achieve maximum benefits, the building has to be oriented in a particular direction.

LIGHTING:

Good lighting is necessary for all buildings and three primary aims. The first is to promote the work or other activities carried on within the building. The second is to promote the safety of people using the buildings. The third is to create, in conjunction to interest and of well beings.

VENTILATION:

Ventilation may be defined as the system of supplying or removing air by natural or mechanical mean or from any enclosed space to create and maintain comfortable conditions. Operation of building and location to windows helps in providing proper ventilation. A sensation of comfort, reduction in humidity, removal of heat, supply of oxygen is the basic requirements in ventilation apart from reduction of dust.

Chapter 2 Description

The project is carried out in three different phases from the planning phase to the preparation of architectural drawings to preparation of structural drawings.

A. Planning phase
B. Selection of plot and site layout plan

C. Preparation of architectural drawings

D. Preparation of 3-D sketches

E. Design of Structural components:

   i.) Footing

   ii.) Column

   iii.) Staircase

   iv) Plinth Beam

   v.) Slab Beam

   vi.) Slab

F. Design of Elevated water tank

G. Design of septic tank

H. Design of rain water harvesting tank

I. Green concept in project

2.1 Planning phase

The house is the first unit of the society and it is the primary unit of human habitation. The house is built to grant the protection against wind, weathers, and to give insurance against physical insecurity of all kinds. This project is basically designed keeping in view the space requirements for a middle class family. Our project basically consists two towers of G+5 floors with four apartments (3-BHK) on each floor and all are well connected with a central common area for the staircase.

Specification of each apartment (Area 170 sqm)

Three bed-room with attached balcony and toilet.

Living room

Kitchen

Dining area

2.2 Selection of plot and site layout plan

It is proposed to construct seven story residential building. A plot of sqm is selected near the Solan for the construction of the multi-story residential building. Selection of plot is very important for buildings a house. Site should be in good place where there community but service is convenient but not so closed that becomes a source of inconvenience or noisy. The conventional transportation is important not only because of present need but for retention of property value in future closely related to are transportation, shopping, facilities also necessary. One should observe the road condition whether there is indication of future development or not in case of un-developed area.

Location of plot: The proposed site is located at 3.00 km from Solan bus stand on NH-22.

(Google earth image of proposed site)

fig. 1

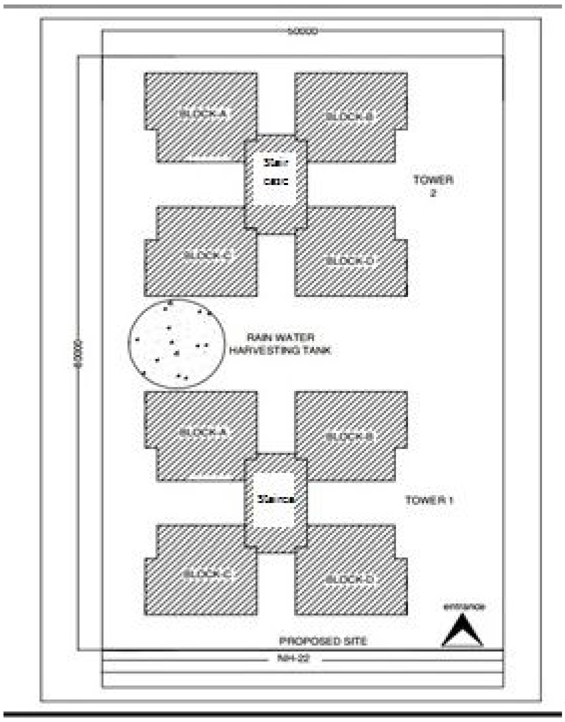

fig. 2 (Site layout plan)

C. Preparation of architectural drawings

Chapter 3 Architectural drawings

All the architectural drawings prepared in this project are as per the norms of the TCP Solan (H.P.) Architectural drawings are prepared using Auto-Cad.

I. Typical floor plan
II. Front elevation
III. Left side view

3.1. Typical floor plan:- It consist of 3-bedroom with attached bathroom, 1 living/dining and 1 kitchen suitable for the needs of a middle class family with a built up area of 170 sqm.

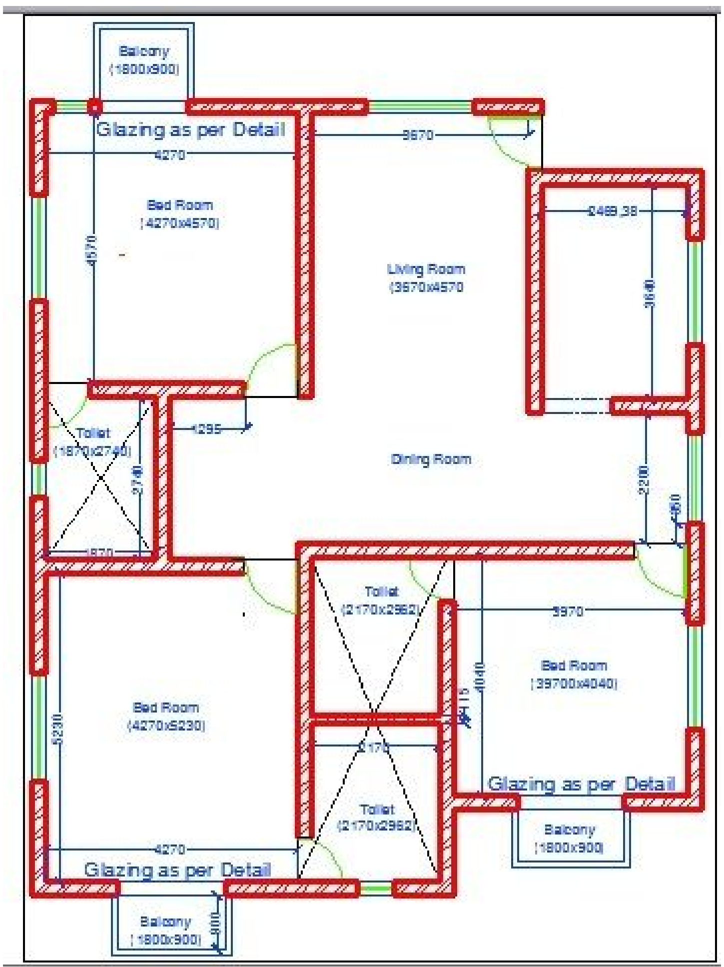

Fig. 3 (Typical floor plan)

3.2. Front Elevation:

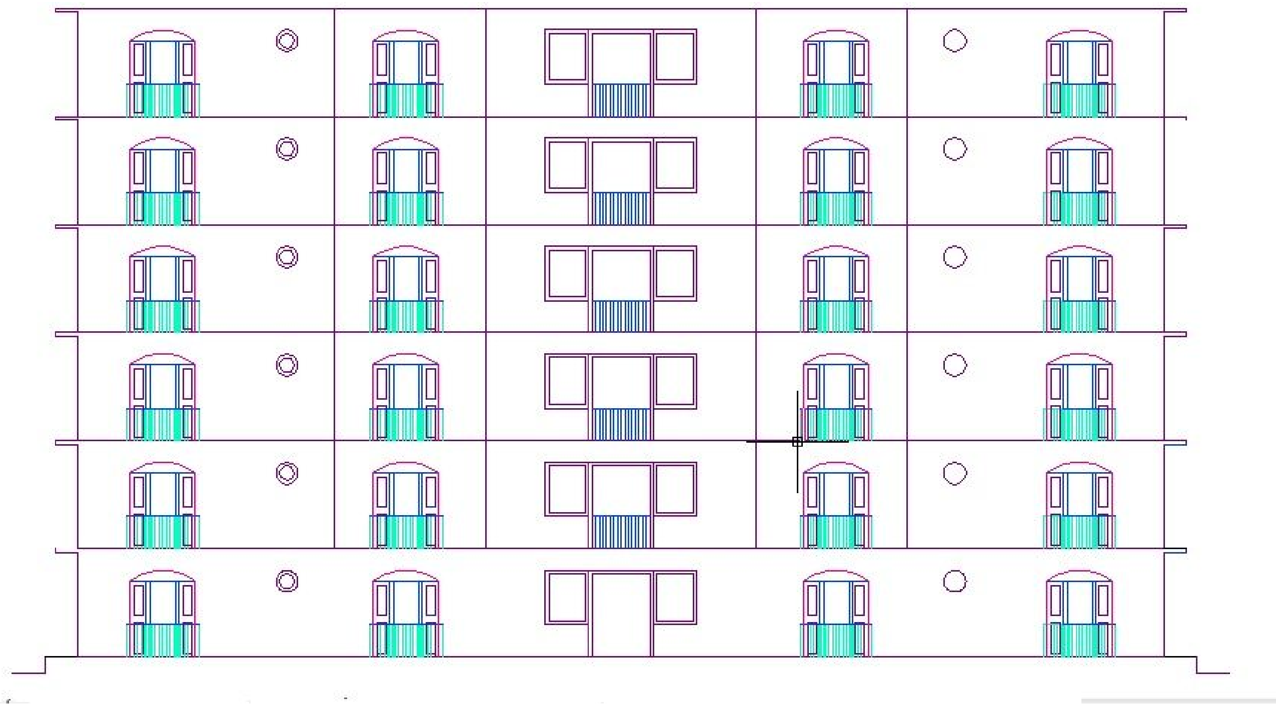

fig. 4

3.3. Left side view:

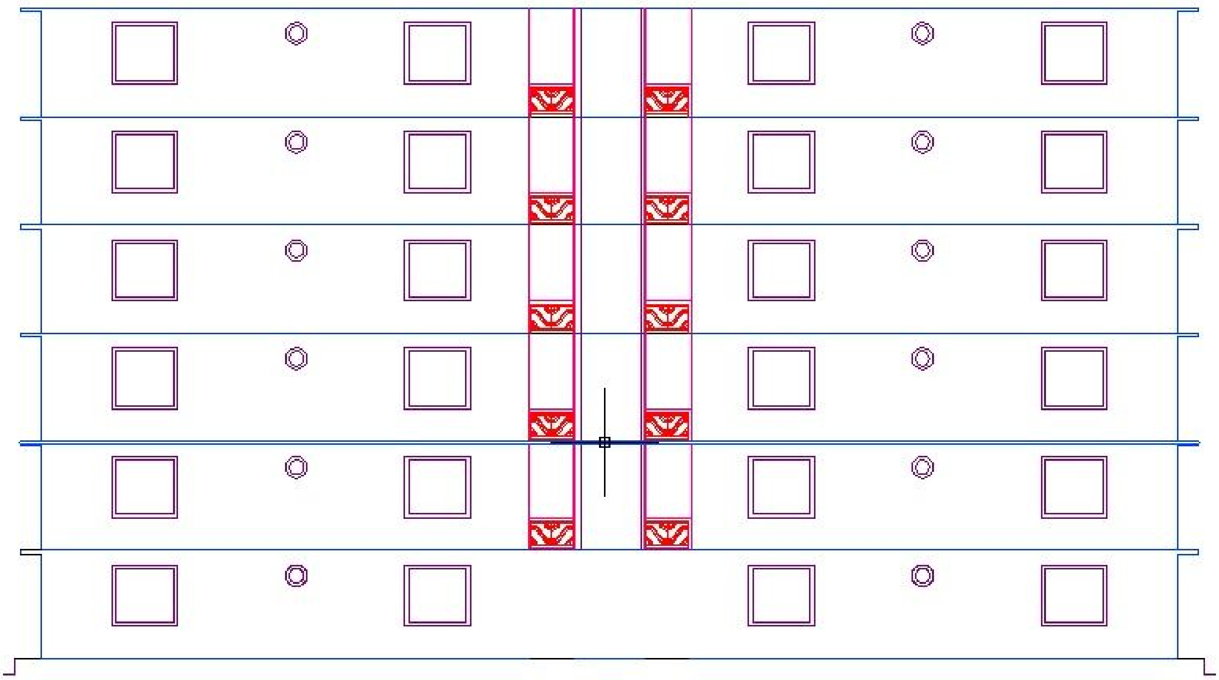

fig. 5

D. Preparation of 3-D sketches

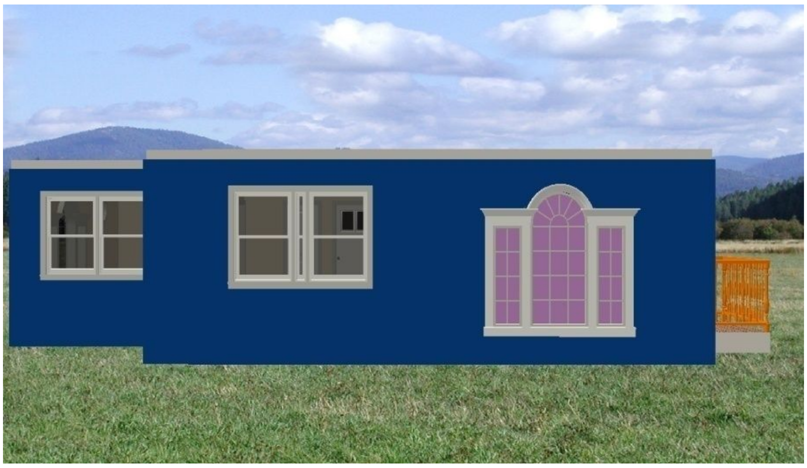

fig. 6

fig. 7

Fig. 8

Chapter 4 Staircase

4.1 Stair-case(Dog legged): The staircase is an important component of a building, and often the only means of access between the various floors in the building. It consists of a *flight* of steps, usually with one or more intermediate *landings* (horizontal slab platforms) provided between the floor levels.

Floor height = 3000m

Width of staircase = 1500m

Tread = 300mm

Riser = 150mm

Number of steps required = 20

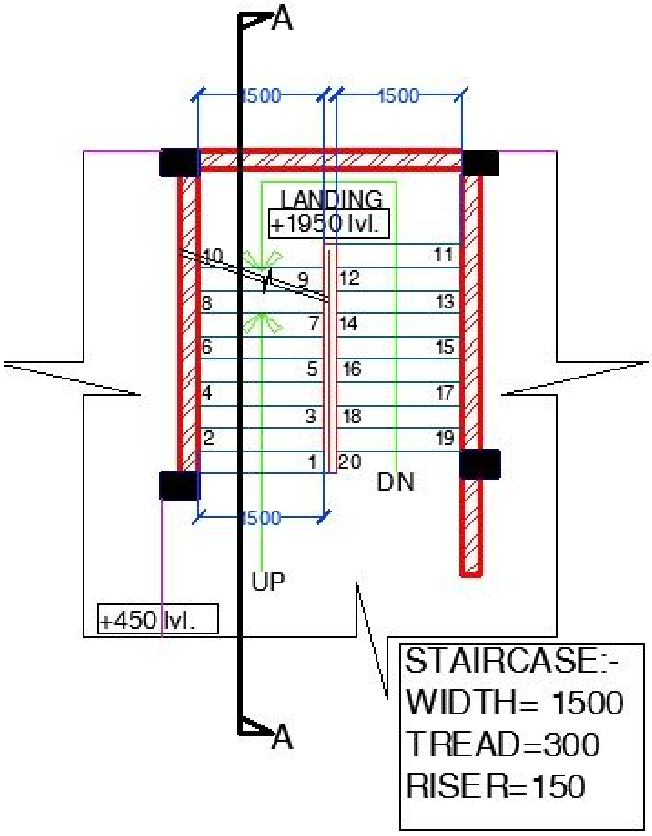

fig 9

Section at A-A

Section at A- A upto fourth floor

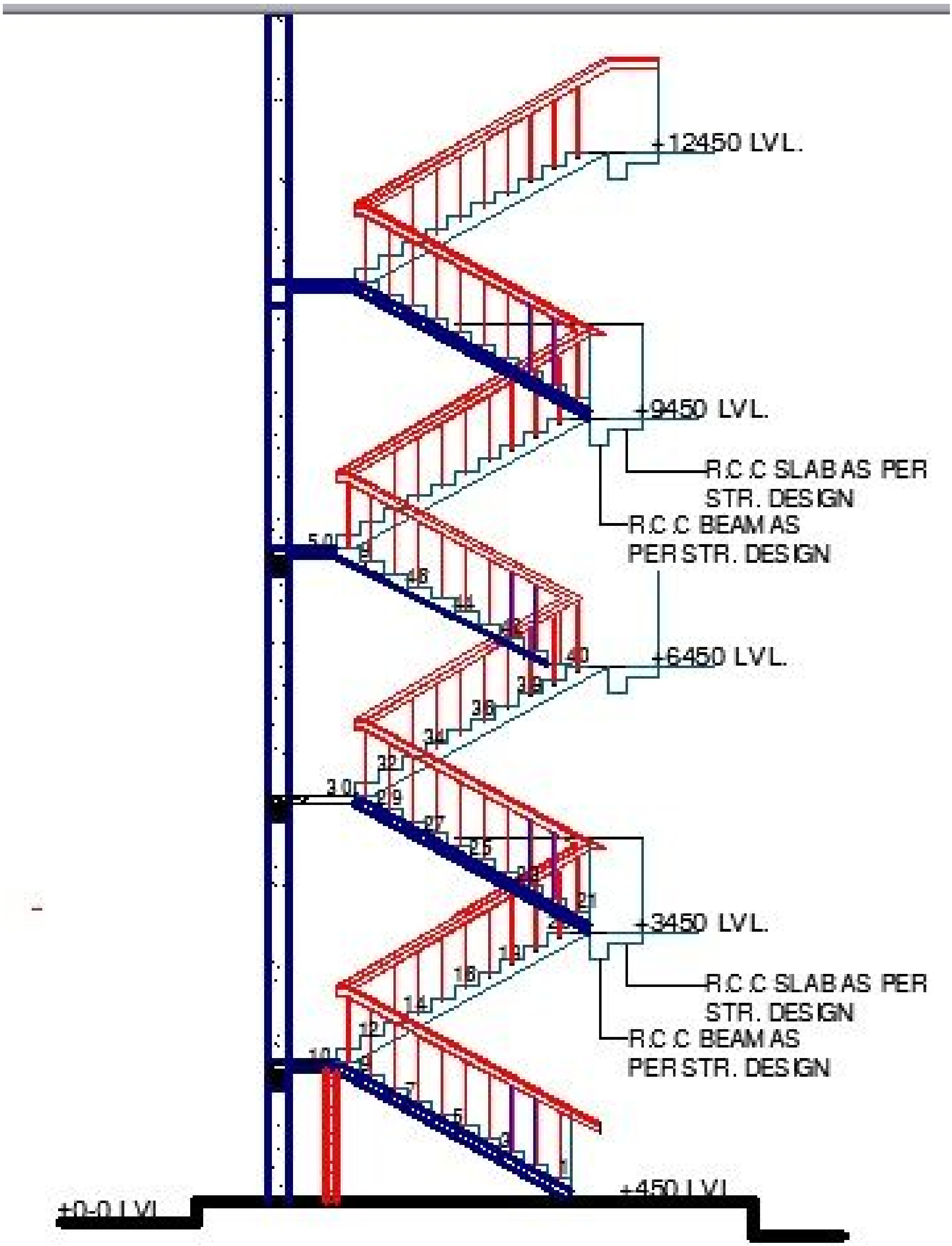
+12450 LVL.
+9450 LVL.
R.C.C SLAB AS PER
STR. DESIGN
R.C.C BEAM AS
PER STR. DESIGN
+6450 LVL.
+3450 LVL.
R.C.C SLAB AS PER
STR. DESIGN
R.C.C BEAM AS
PER STR. DESIGN
+450 LVL
±0-0 LVL

fig 10

4.2 Design of staircase

Given: R = 150 mm, T = 300 mm ⇒$\sqrt{\ ^2 \quad ^2}$ $335.4mm$

Effective span = c/c distance between supports = 3.60 m

• Assume a waist slab thickness ≈ *l*/20 = 3600/20 = 180 mm, say 200 mm

Assuming 20 mm clear cover and 16 φ main bars,

effective depth ***d*** = 200 – 20 – 16/2 = 172 mm.

• *Loads on going* on projected plan area:

(1) self-weight of waist slab @ 25 kN/m^3 × (0.20 × 335.4/300)*m* = 5.60 kN/m^2

(2) self-weight of steps @ 25 kN/m^3 × (0.5 × 0.15) m = 1.88 kN/m^2

(3) finishes (IS-875) = 1.0 kN/m^2

(4) live load (IS-875) = 5.50 kN/m^2

Total load = 14.00 kN/m^2

⇒Factored load = 14.00 × 1.5 = 21.00 kN/m^2

• *Loads on landing*

(1) self-weight of slab @ 25 × 0.23 = 5.75 kN/m^2

(2) finishes @ 0.80 kN/m^2

(3) live loads @ 5.00 kN/m^2

Total = 11.55 kN/m^2

⇒Factored load = 11.55 × 1.5 = 17.33 kN/m^2

Design moment, Considering 1m strip of waist slab

Reaction R_1 = $21.00 \quad 3.45 \quad \frac{4.5 \quad .725}{4.5} \qquad 17.33 \quad 1.05 \quad \frac{0.525}{4.5} \qquad 47.16\ \mathrm{KN/m}$

Max. factored moment occur at the section of zero shear located at

$$\frac{47.}{2\ .\ \ 7} \quad 2.228m\ from \qquad \cancel{s}uppor$$

Mu $\quad 47.16 \quad 2.228 \ - \ 21.17 \quad 2.228^2/2$ = 52.23 KN/m

Main reinforcement

R $\frac{u}{b} = \frac{52.53 \qquad 0}{0 \quad 204} \quad 1.262 \quad p$

Assuming f_{ck} = 20Mpa f_y = 415 Mpa

$$\frac{}{100} \quad \frac{s}{} \quad \frac{fc}{2f} \quad 1 - \sqrt{1} - 4.598 \quad /fc \qquad 0.379 \quad 10^{\ 2}$$

Ast required = $.379 \quad 10^{\ 2} \quad 10^3 \quad 204 \quad 774mm^2/m$

Required spacing of 12-∅ bars = $\frac{3 \quad 0}{774} \quad 146mm$

Provide 12-∅ @140mm c/c.

Distribution steel

A_{st} required = 0.012xbt (for Fe415 bars)

$0.0012 \text{x} 10^3 \quad 230 \quad 276mm^2/m$

Assuming 8-∅ bars, spacing required = $\frac{50.30 \qquad 000}{27} \quad 182mm$

Provide 8-∅ bars @180mm c/c as distributors.

Check for shear (Check at d = 204mm from the support)

$V_u = 47.16 - \quad 21.17 \quad 0.204 \quad 42.8 \quad /m$

$$\frac{42.8 \quad 10^3}{204 \quad 10^3} \quad 0.21 \qquad \ll \qquad 0.42 \quad 1.19 \quad 0.499 \quad p$$

Hence Safe.

Chapter 5 Structutal Design

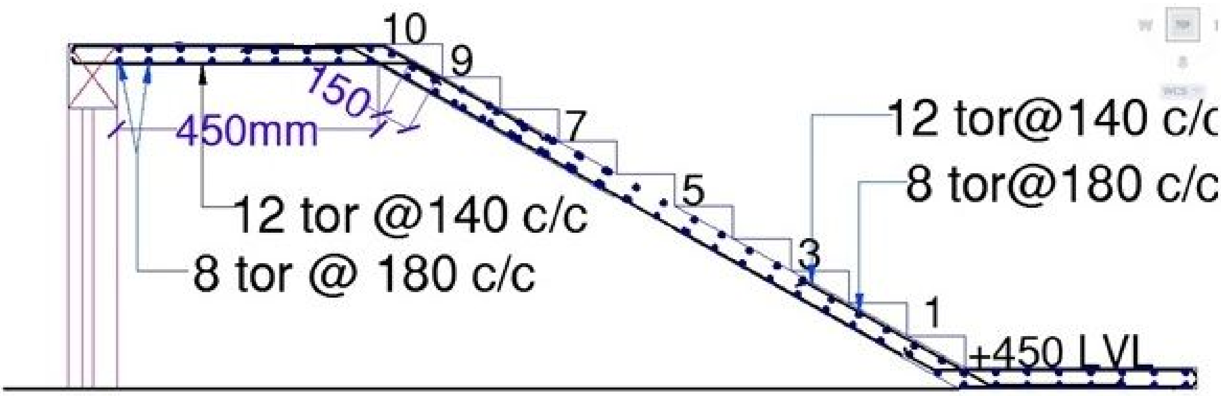

Fig.11 (Reinforcement Detail M-20 Fe415)

5.1 Column

Column is s structural member which resists load and moment by compression. Our project consist of columns of size 230x600mm. All the columns provided here are of same size to save on the cost of form work.

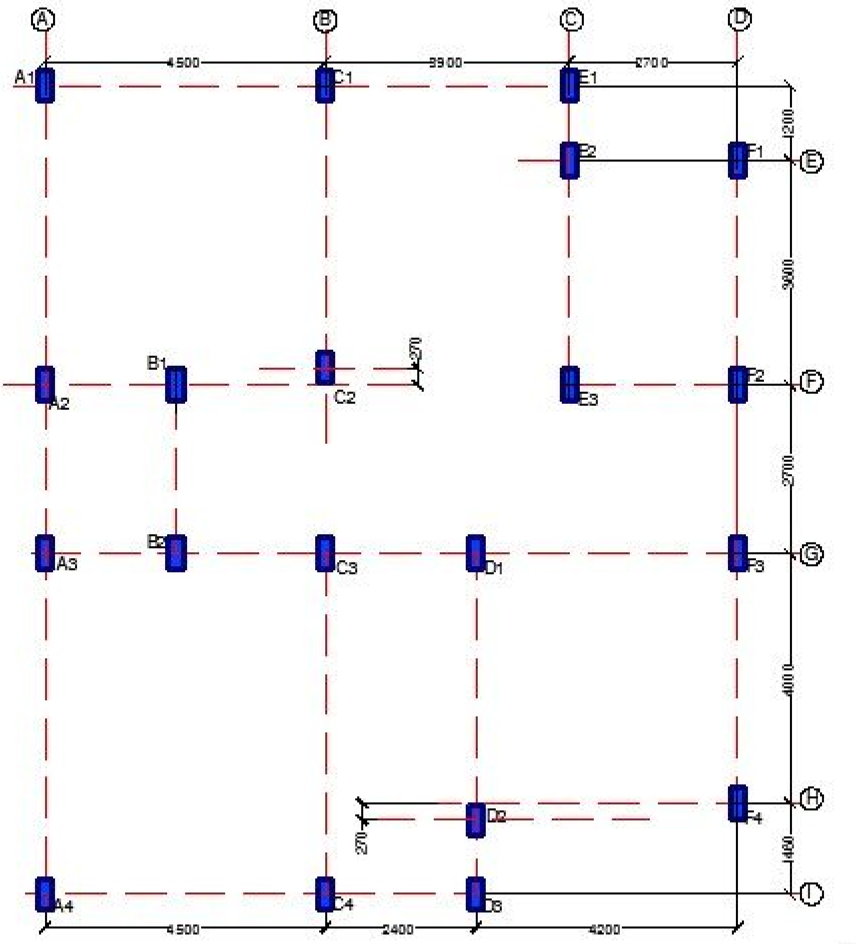

fig.12 (Centre line plan)

SR.NO.	NAME OF COLUMN	SIZE OF COLUMN	LONGITUDINAL REINFORCEMENT						
			FOUNDATION TO GROUND FLOOR	G. FLOOR TO FIRST FLOOR	F. FLOOR TO SECOND FLOOR	SECOND FLOOR TO THIRD FLOOR	THIRD FLOOR TO FORTH FLOOR	FORTH FLOOR TO FIFTH FLOOR	TRANSVERSE REINFORCEMENT
1	A1,A4,D1, F1,F3	230X700	12-25 mm	12-20 mm	12-16 mm	12-16 mm	12-12 mm	12-12 mm	1) 8 mmΦ @100 c/c 2) 8 mmΦ @ 180 c/c
2	A2,A3,B2 C1,C2 C4,D3,E2	230X700	10-25 mm	10-20 mm	10-20 mm	10-20 mm	6-20 mm 4-16 mm	10-16 mm	1) 8 mmΦ @100 c/c 2) 8 mmΦ @ 180 c/c
3	B1,C3, D2,E4, F2	230X700	10-25 mm	6-25 mm 4-20 mm	6-25 mm 4-20mm	10-20 mm	6-20 mm 4-16 mm	10-16 mm	1) 8 mmΦ @100 c/c 2) 8 mmΦ @ 180 c/c
4	E1,F4	230X700	12-20 mm	8-20 mm 4-16 mm	6-20 mm 6-16mm	10-16 mm	10-16 mm	8-12 mm	1) 8 mmΦ @100 c/c 2) 8 mmΦ @ 180 c/c
5	E3	230X700	10-25 mm	8-20 mm 4-16mm	8-20mm 4-16 mm	4-20 mm 8-16 mm	12-16 mm	12-16 mm	1) 8 mmΦ @100 c/c 2) 8 mmΦ @ 180 c/c

fig. 13 (chart showing Column reinforcement)

5.2 Plinth beam:

Here the plinth beam of 300x450 are provided.

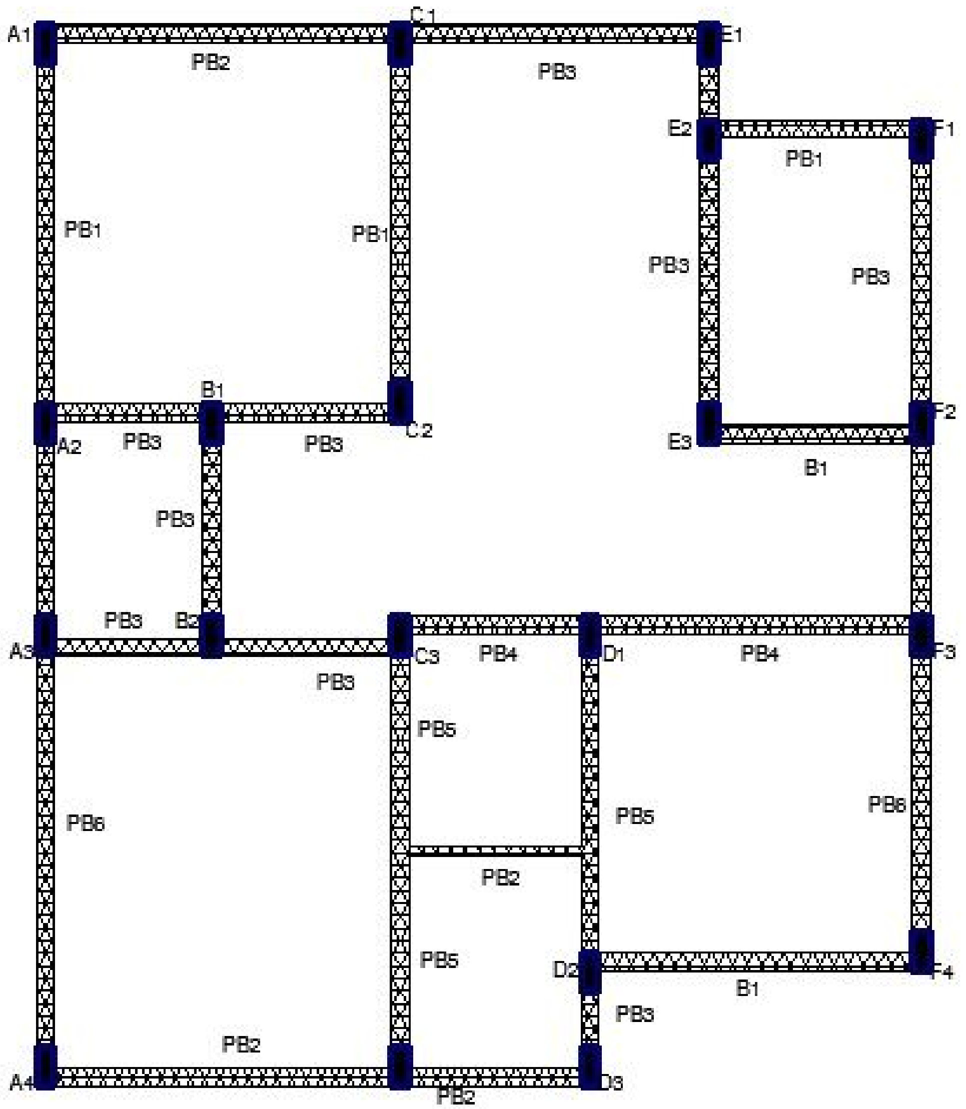

fig 14

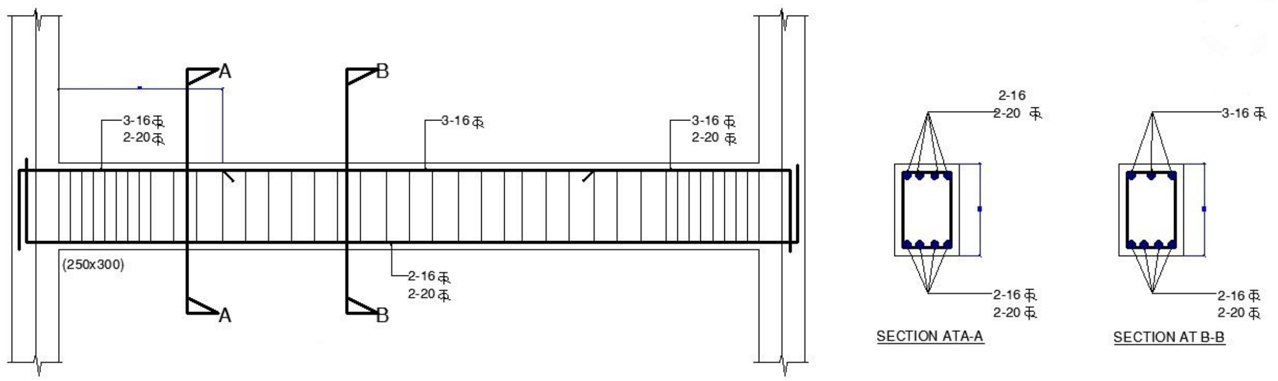

fig 15 Plinth Beam 1

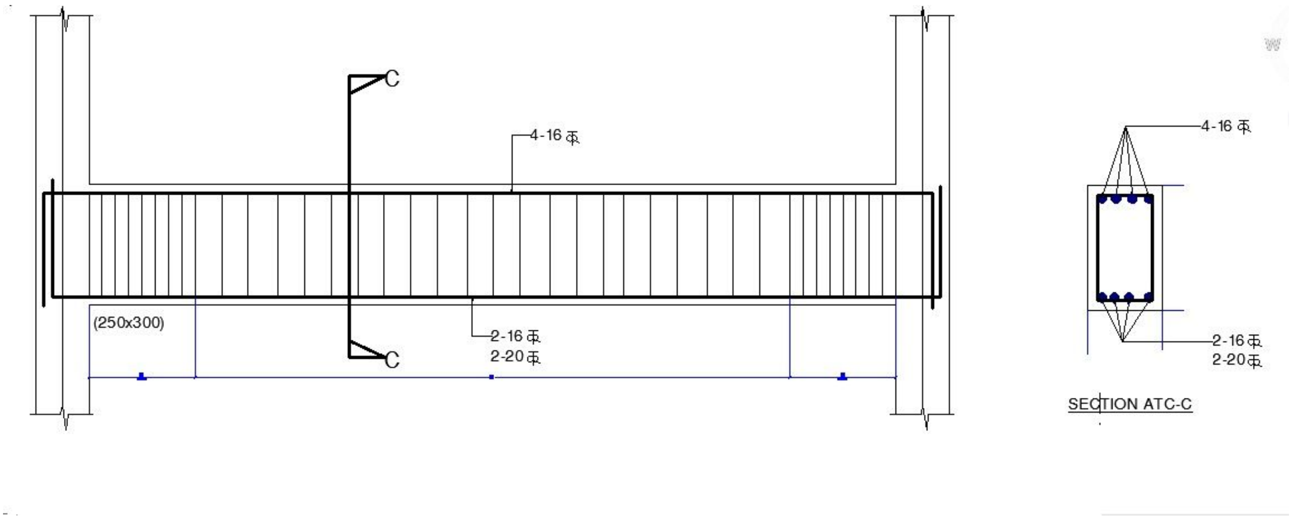

fig 16 Plinth Beam 2

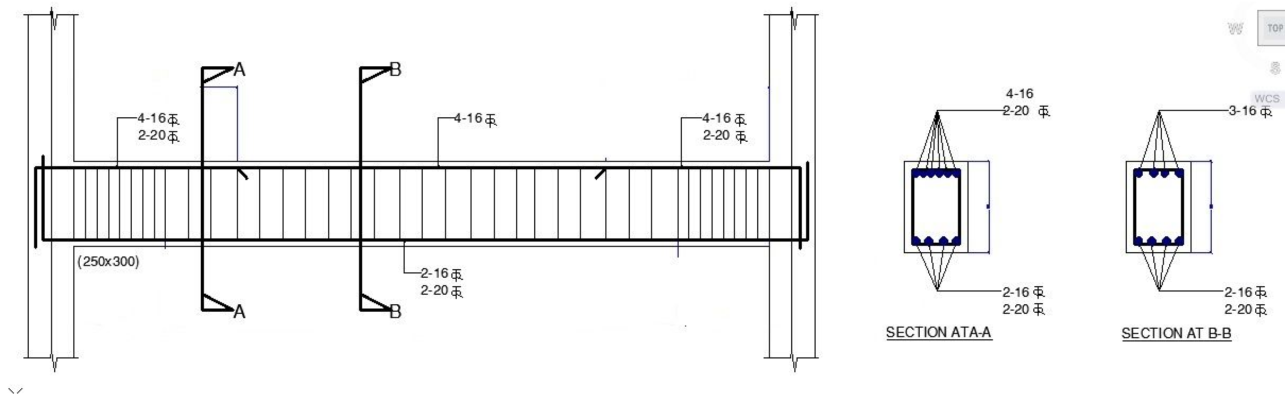

fig 17 Plinth Beam 3

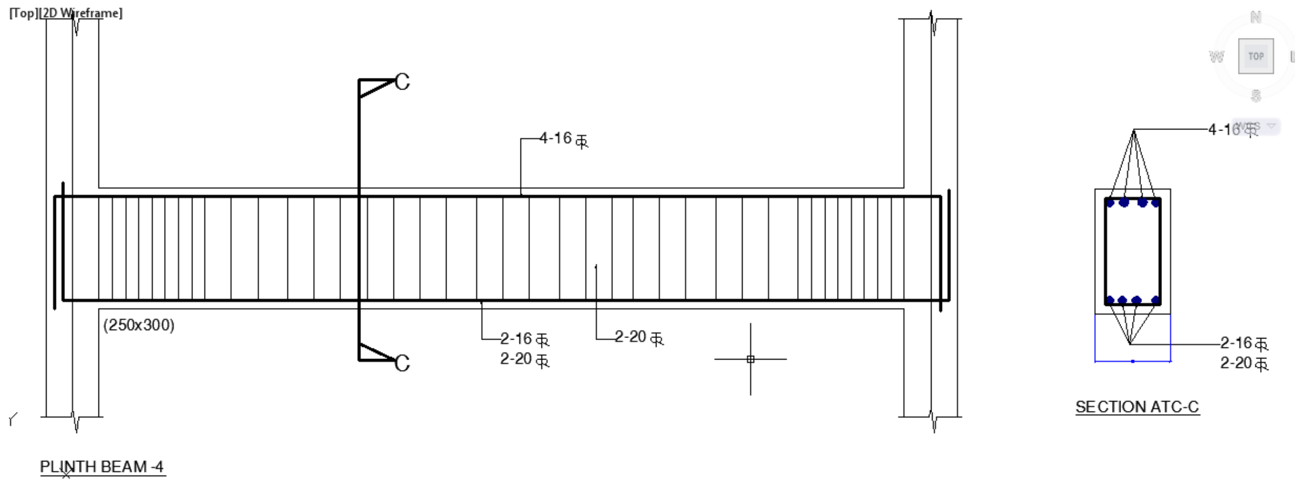

fig 18 Plinth Beam 4

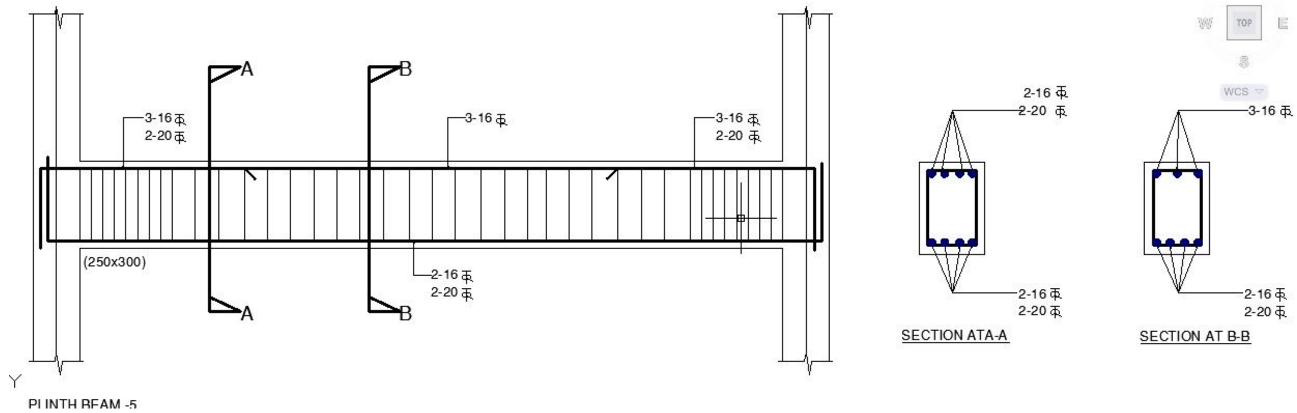

fig 19 Plinth Beam 5

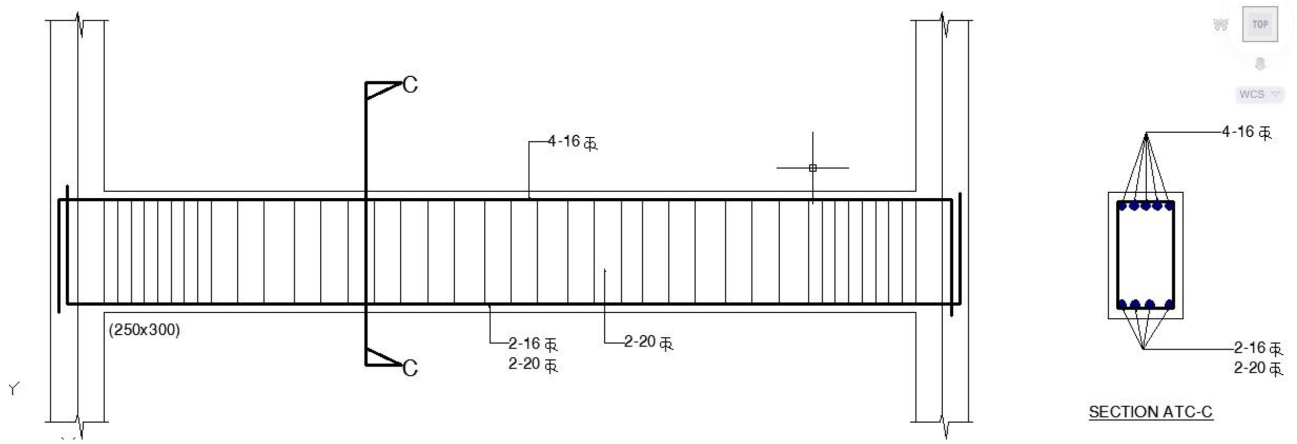

fig 20 Plinth Beam 6

Chapter 6 TANKS

6.1 Design of septic tank

A septic tank is a buried, watertight container used to clarify and partially treat wastewater. The septic tank has been in use in one form or another for over 100 years. The septic tank was originally designed to serve as a settling basin to separate scum and grit from the liquid. The effluent from the tank then was sent to a sewer or the soil for disposal. The clarification function of the tank was known, but the biological processes that partially digested the sewage were discovered by accident. Scientists found that the organic solids in the wastewater decomposed if they stayed in the tank long enough. Therefore, the septic tank is designed to accomplish two tasks: (1) clarification and (2) treatment.

Materials

Typically, septic tanks are made of concrete, polyethylene or fiberglass. Steel and redwood have been used in the past but is no longer accepted by most regulatory agencies. Long term “creep”, resulting in deformation has been a problem with polyethylene tanks. Both polyethylene and fiberglass tanks can easily be moved by a labor crew, whereas concrete tanks are typically moved about by a truck equipped with a crane and boom. Fiberglass tanks are often used in areas inaccessible to concrete tank delivery trucks. Both polyethylene and fiberglass tanks are more prone to “floating” than concrete tanks. Regardless of the material of construction the tank must be watertight and structurally sound.

Structural integrity

The long-term performance of the septic tank will depend on its structural integrity. Or concrete septic tanks, structural integrity is dependent on the method of construction, the placement of the reinforcing steel, and the composition of the concrete mix. For maximum structural integrity, the walls and bottom of the tank should be poured monolithically. Where the walls and the bottom are poured monolithically, the top should be cast in place with the reinforcing steel from the walls extending into the top slab. In some cases, a water seal is placed between the wall and the top.

Size

Tank size and household water usage determine the detention time of the tank.As mentioned above, efficient clarification takes time to complete because fats, oils, greases, and suspended solids travel slowly in water and may require hours to either float to the top or settle to the bottom. A septic tank also accomplishes treatment through the biological activity of anaerobic or facultative bacteria. This type of biodegradation may take many hours to fully work, so treatment efficiency is linked to detention time. Over the years a number of empirical relationships have been developed to estimate the required detention time. The recommended detention time ranges from 36 to 48 hours, but the absolute minimum is 24 hours.

6.2 Design of rain water harvesting tank

Rainwater harvesting (RWH) is a process of collecting and storing rainwater that falls on a catchment surface (typically a roof, although almost any external surface could be suitable) for use, independent from, or supplemental to the mains water supply. This reduces demand on the mains supply, offers some resilience from local supply problems and reduces the amount of energy used for water treatment and transportation. Collection and diversion of surface run-off can also mitigate flood risk and control drainage as part of a sustainable drainage system (SuDS)

Rainwater tanks may be constructed from materials such as plastic (polyethylene), concrete, galvanized steel, as well as fiberglass and stainless steel which are rust and chemical-resistant. Tanks are usually installed above ground, and are usually opaque to prevent the exposure of stored water to sunlight, to decrease algal bloom.

Design of storage tanks

The volume of the storage tank can be determined by the following factors:

Number of persons in the household: The greater the number of persons, the greater the storage capacity required to achieve the same efficiency of fewer people under the same roof area.

Per capita water requirement: This varies from household to household based on habits and also from season to season. Consumption rate has an impact on the storage systems design as well as the duration to which stored rainwater can last.

Average annual rainfall

Period of water scarcity: Apart from the total rainfall, the pattern of rainfall -whether evenly distributed through the year or concentrated in certain periods will determine the storage requirement. The more distributed the pattern, the lesser the size.

Type and size of the catchment:

Type of roofing material determines the selection of the runoff coefficient for designs. Size could be assessed by measuring the area covered by the catchment i.e., the length and horizontal width. Larger the catchment, larger the size of the required cistern (tank).

Dry season demand versus supply approach

In this approach there are three options for determining the volume of storage:

Matching the capacity of the tank to the area of the roof

Matching the capacity of the tank to the quantity of water required by its users

Choosing a tank size that is appropriate in terms of costs, resources and construction methods.

In practice the costs, resources and the construction methods tend to limit the tanks to smaller capacities than would otherwise be justified by roof areas or likely needs of consumers.

6.3 Design of soak pit

A Soak Pit is a covered, porous-walled chamber that allows water to slowly soak into the ground. Pre-settled effluent from septic tank is discharged to the underground chamber from where it infiltrates into the surrounding soil

Design

A layer of sand and fine gravel is spread across the bottom to help disperse the flow. Depth should be between 1.5 and 4m deep, but never less than 1.5m above the ground water table. The Soak Pit is filled with coarse rocks and gravel. The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the waste-water

Maintenance

- the effluent should be clarified or filtered well to prevent excessive build up of solids.
- The Soak Pit should be kept away from high-traffic areas.
- Particles and biomass will clog the pit so need to be cleaned or moved.
- For future access a removable lid should be used to seal the pit.

Advantages

- Can be built and repaired with locally available materials.
- Small land area required.
- Power conservative.
- Can be built and maintained with locally available materials.
- Simple technique for all users.

Disadvantages

- Pre-treatment is required to prevent clogging, although eventual clogging is inevitable.
- Negatively affects soil and groundwater properties

6.4 Design calculations

6.4.1Septic Tank

A septic tank is a key component of the septic system, a small-scale sewage treatment system common in areas with no connection to main sewage pipes provided by local governments.

In the Solan area no connection to the main sewers are provided by the municipal corporation. So construction of a septic tank is must for the disposal of septic waste and sewage.

Given Problem:-No Of Flats = 48 Nos.
Data:-
1.Water supply= 165 lit/pc/day
2.No of persons per Flats = 6 Nos.
3.Sewage generation = 80% of water supply
4.Detention period = 18hours
5.Cleaning period = once in a year
6. L:B = 4:1 & Depth of Storage of water = 1.8m
7.Sludge deposit = 30lit/person/year
8.Min Free Board required = 50cm

Calculation:

Total Waste water coming to septic tank =
48*6*165*80/100=38016 lit/day
Detention period = 18hours
capacity of tank required = 38016/24*18=28512lit
Capacity required for sludge accumulation = 30*6*48 = 8640lit / year
Total capacity required = 28512 + 8640= 37152litre
Plan area of the Septic tank = 37.15/1.8=20.62m2
L:B taken as 4:1, 4B*B= 20.62
B = Sqr. root(20.62/4) = 2.27
B = 2.30m. L = 2.30* 4 = 9.20m.
Total depth of Septic tank = 1.8+0.5= 2.30m

Soak Pit: It is a structure constructed near the septic tank for the removal of overflow waste water in the septic tank. It is made-up of brick masonry with soil strata in the bottom of the tank which helps in the percolation of waste water.

Calculation:

Waste water coming out from septic tank= 38016 lit / day

Percolation rate = 500 lit / m2/ day

(Source: HPPWD Zonal Office Dharamshala)

Volume of filter media =

38016 / 500 = 76.00m^3

Depth taken = 3.00m

Area of soak pit = 76.00/3 = 25.33sqm

- Dia of Soak well required = sqr root(25.33*4 / π) = 5.70m

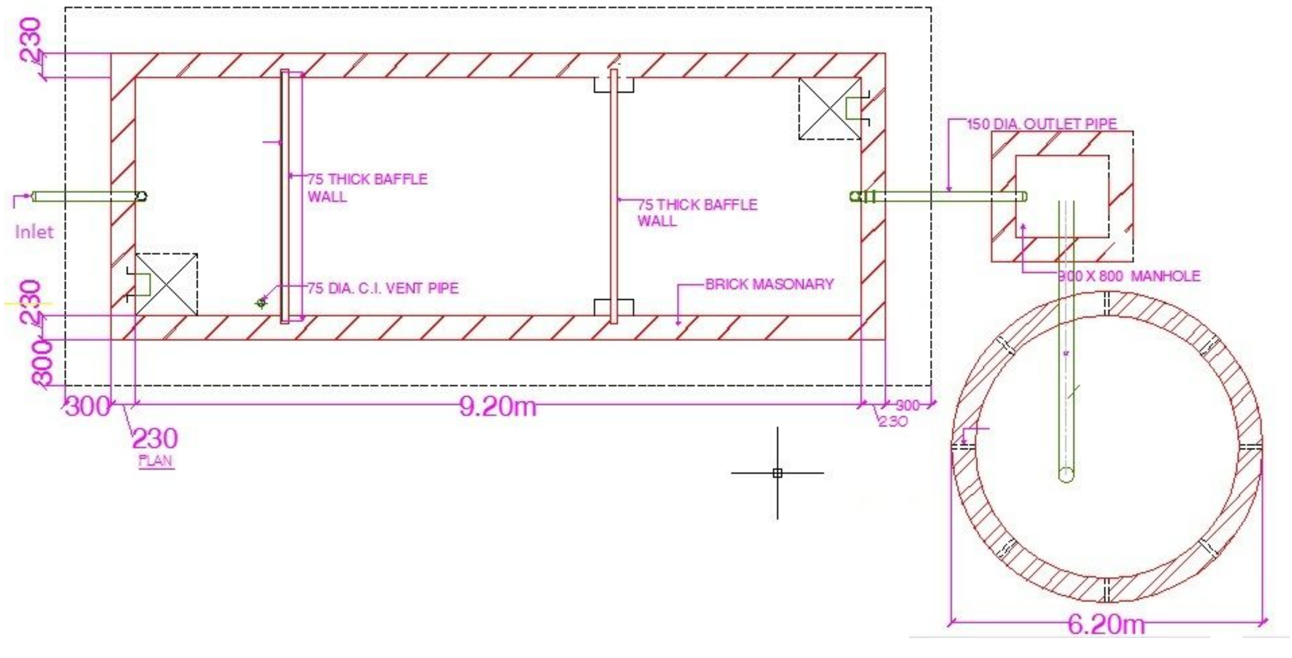

fig 21

6.4.2 Rain Water Harvesting Tank

As per the norms of the TCP (H.P.) all the buildings constructed should have provision for roof rain water harvesting. Rain water harvesting tank is used to store rain water. According to national meteorological department Average annual rainfall in solan is 1424.80 mm.

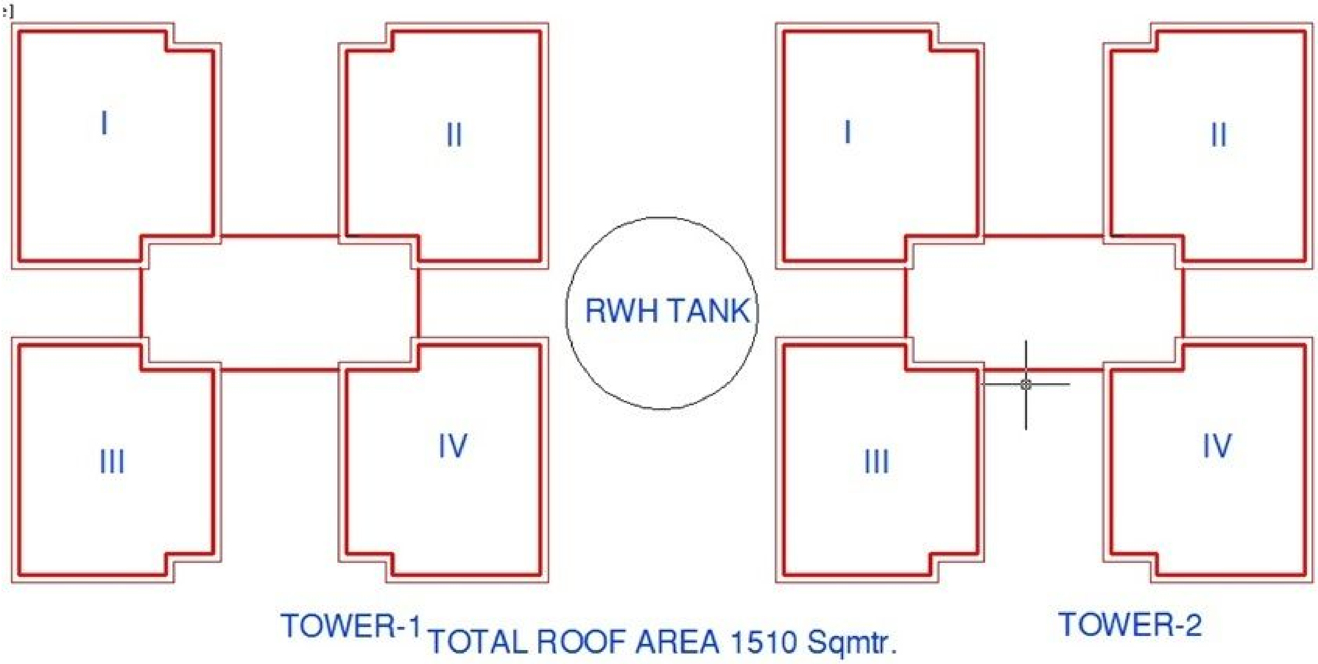

Fig 22. (Layout of rain water harvesting tank)

Calculations for capacity of RWH tank:

Total water collected from the roof in one year = 1.4248x 1510 = 2151.448 cum
After considering the loss
1. Tile roof coefficient = 0.85
2. Constant coefficient for evaporation, wastage = 0.80
Hence Total water collected from the roof after considering the losses
= 2151.45x 0.85x 0.80
= 1462.98 cum

The capacity of recharge tank is designed to retain runoff for at least 15 min of rainfall of the peak intensity.
For solan 32.5 mm/per 15 minutes say 35 mm per 15 minute
In our case the total area is 1510.00 sqm. So recharge shaft/dug well type of str. Is recommended for hard rock strata for the recharge of ground water level.

Surface are of roof top catchment 1510.00 sqm.
Peak rainfall for15 min 35.00 mm
Runoff co-efficient = 0.85
The capacity of tank = 1510x0.035x0.85
= 44.92 cum
= 44920 liters
Assume depth of water in tank = 3.00m
Then diameter of the tank = 4.40m

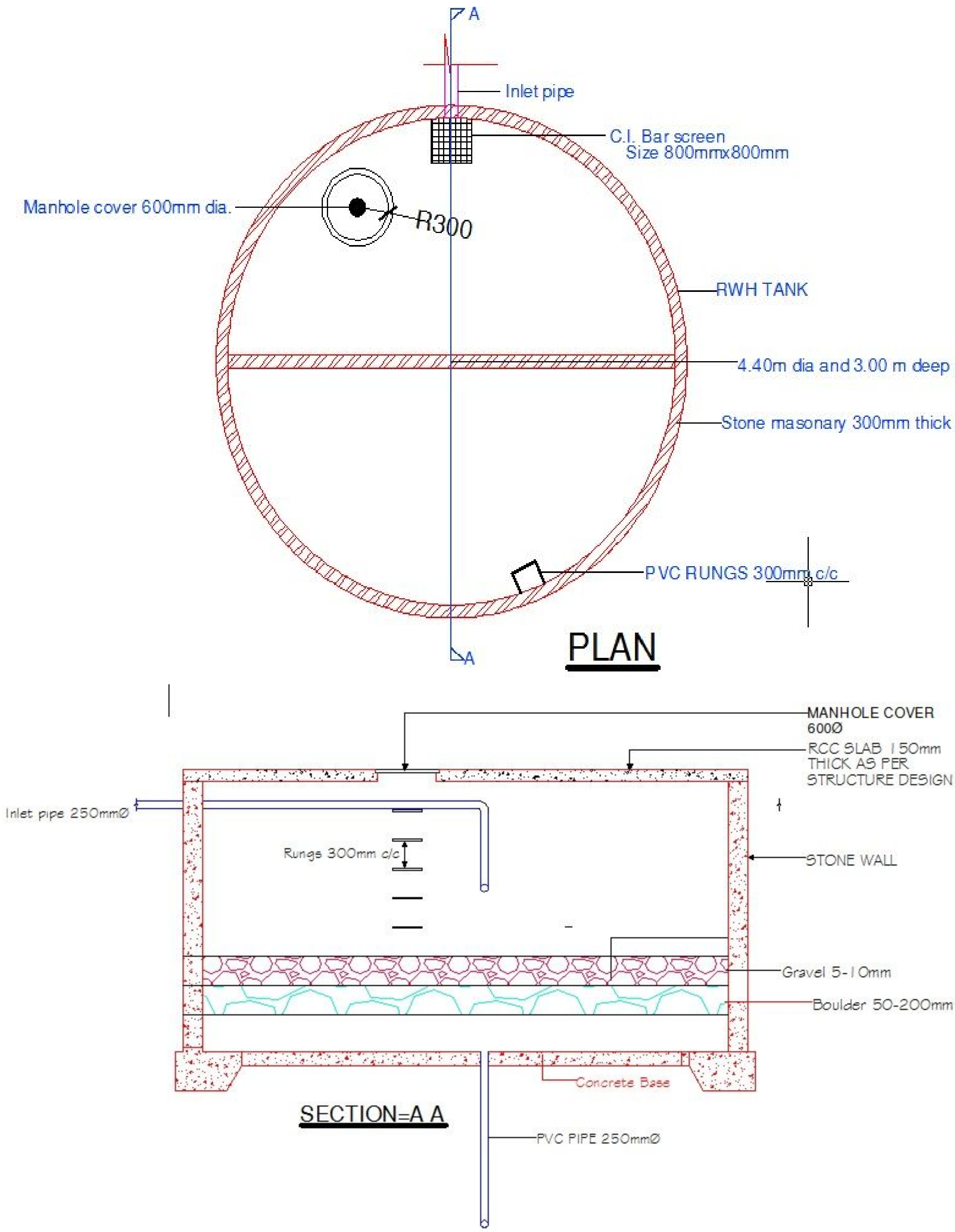

fig 23 rain water harvesting tank

Chapter 7 Elevated tank

7.1 Introduction

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential .The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration

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7.12 OBJECTIVE

1 To make a study about the analysis and design of water tanks.

2. To make a study about the guidelines for the design of liquid retaining structure according to IS Code.

3. To know about the design philosophy for the safe and economical design of water tank.

4. To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations.

5. In the end, the programs are validated with the results of manual

7.2 Sources of water supply :

The various sources of water can be classified into two categories:

Surface sources, such as

1. Ponds and lakes;
2. Streams and rivers;
3. Storage reservoirs; and
4. Oceans, generally not used for water supplies, at present.

Sub-surface sources or underground sources, such as

1. Springs;
2. Infiltration wells ; and
3. Wells and Tube-wells.

7.3 Water Quantity Estimation

The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:

Water consumption rate (Per Capita Demand in litres per day per head)

Population to be served.

Quantity= Per demand x Population

7.4 Water Consumption Rate

It is very difficult to precisely assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption. The various types of water demands, which a city may have, may be broken into following class

	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public including Fire Demand Uses	20-90	45	10
4	Losses and Waste	45-150	62	25

7.5 Fire Fighting Demand:

The per capita fire demand is very less on an average basis but the rate at which the water is required is very large. The rate of fire demand is sometimes treated as a function of population and is worked out from following empirical formulae:

7.6 Factors affecting per capita demand:

	Authority	Formulae (P in thousand)	Q for 1 lakh Population)
1	American Insurance Association	Q (L/min)=4637 ÖP (1-0.01 ÖP)	41760
2	Kuchling's Formula	Q (L/min)=3182 ÖP	31800
3	Freeman's Formula	Q (L/min)= 1136.5(P/5+10)	35050
4	Ministry of Urban Development Manual Formula	Q (kilo liters/d)=100 ÖP for P>50000	31623

- **Size of the city**: Per capita demand for big cities is generally large as compared to that for smaller towns as big cities have sewered houses.
- **Presence of industries.**
- **Climatic conditions.**
- **Habits of economic status.**
- **Quality of water:** If water is aesthetically $ people and their medically safe, the consumption will increase as people will not resort to private

wells, etc.

• **Pressure in the distribution system.**

• **Efficiency of water works administration:** Leaks in water mains and services; and un authorised use of water can be kept to a minimum by surveys.

• **Cost of water.**

• **Policy of metering and charging method:** Water tax is charged in two different

7.7 Fluctuations in Rate of Demand:

Average Daily Per Capita Demand

= Quantity Required in 12 Months/ (365 x Population)

If this average demand is supplied at all the times, it will not be sufficient to meet the fluctuations.

 Seasonal variation: The demand peaks during summer. Firebreak outs are generally more in summer, increasing demand. So, there is seasonal variation .

 Daily variation depends on the activity. People draw out more water on Sundays and Festival days, thus increasing demand on these days.

 Hourly variations are very important as they have a wide range. During active household working hours i.e. from six to ten in the morning and four to eight in the evening, the bulk of the daily requirement is taken. During other hours the requirement is negligible. Moreover, if a fire breaks out, a huge quantity of water is required to be supplied during short duration, necessitating the need for a maximum rate of hourly supply. So, an adequate quantity of water must be available to meet the peak demand. To meet all the fluctuations, the supply pipes, service reservoirs and distribution pipes must be properly proportioned. The water is supplied by pumping directly.

Maximum daily demand

= 1.8 x average daily demand

Maximum hourly demand of maximum day i.e. Peak demand

= 1.5 x average hourly demand

= 1.5 x Maximum daily demand/24

= 1.5 x (1.8 x average daily demand)/24

= 2.7 x average daily demand

= 2.7 x annual average hourly demand

Chapter 8 Design Periods & Population Forecast

This quantity should be worked out with due provision for the estimated requiremthe future. The future period for which a provision is made in the water supply schemknown as the design period. Design period is estimated based on the following:

 Useful life of the component , considering obsolescence, wear, tear, etc.

 Expandability aspect.

 Anticipated rate of growth of population, including industrial, commercial developments & migration-immigration.

 Available resources.

 Performance of the system during initial period.

8.1 Population Forecasting Methods

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discrection and intelligence of the designer.

1. Incremental Increase Method
2. Decreasing Rate of Growth Method
3. Simple Graphical Method

4. Comparative Graphical Method
5. Ratio Method
6. Logistic Curve Method
7. Arithmetic Increase Method
8. Geometric Increase Method.

Chapter 9 Design requirement of concrete (I. S. I)

In water retaining structure a dense impermeable concrete is required therefore,proportion of fine and course aggregates to cement should besuch as to give high quality concrete. Concrete mix weaker than M20 is not used. The minimum quantity of cement in the concrete mix shall be not less than 30 kN/m3.The design of the concrete mix shall be such that the resultant concrete issu efficiently impervious. Efficient compaction preferably by vibration is essential. The permeability of the thoroughly compacted concrete is dependent on water cement ratio. Increase in water cement ratio increases permeability, while concrete with low water cement ratio is difficult to compact.Other causes of leakage in concrete are defects such as segregation and honey combing.All joints should be made water-tight as these are potential sources of leakage. Design of liquid retaining structure is different from ordinary R.C.C,structures as it requires that concrete should not crack and hence tensile stresses in concrete should be within permissible limits. A reinforced concrete member of liquid retaining structure is designed on the usual principles ignoring tensile resistance of concrete in bending. Additionally it should be ensured that tensile stress on the liquid retaining ace of the equivalent concrete section does not exceed the permissible tensile strength of concrete as given in table 1. For calculation purposes the cover is also taken into concrete area. Cracking may be caused due to restraint to shrinkage, expansion and contraction of concrete due to temperature or shrinkage and swelling due to moisture effects. Such restraint may be causes

(i) The interaction between reinforcement and concrete during shrinkage due to drying.
(ii) The boundary conditions.
(iii) The differential conditions prevailing through the large thickness of massive concrete

Use of small size bars placed properly, leads to closer cracks but of smaller width. The risk of cracking due to temperature and shrinkage effects may be minimized by limiting the changes in moisture content and temperature to which the structure as a whole is subjected. The risk ofcracking can also be minimized by reducing the restraint on the free expansion of the structure with long walls or slab founded at or below ground level, restraint can be minimized by the provision of a sliding layer. This can be provided by founding the structure on a flat layer of concrete with interposition of some material to break the bond and facilitate movement.In case length of structure is large it should be subdivided into suitable lengths separated by movement joints, especially where sections are changed the movement joints should be provided.Where structures have to store hot liquids, stresses caused by difference in temperature between inside and outside of the reservoir should be taken into account. The coefficient of expansion due to temperature change is taken as 11 x 10-6 /° C and coefficient of shrinkage may be taken as 450 x 10-6 for initial shrinkage and 200 x 10-6 for drying

9.1 Plain Concrete Structures. Plain concrete member of reinforced concrete liquid retaining structure may be designed against structural failure by allowing tension in plain concrete as per the permissible limits for tension in bending. This will automatically take care of failure due to cracking. However, nominal reinforcement shall be provided, for plain concrete structural members.

9.2. Permissible Stresses in Concrete.

(a) For resistance to cracking. For calculations relating to the resistance of members to cracking, the permissible stresses in tension (direct and due to bending) and shear shall confirm to the values specified in Table 1.The permissible tensile stresses due to bending apply to the face of the member in contact with the liquid. In members less than 225mm. thick and in contact with liquid on one side these permissible stresses in bending apply also to the face remote from the liquid.

(b) For strength calculations. In strength calculations the permissible concrete stresses shall be in accordance with Table 1. Where the calculated shear stress in concrete alone exceeds the permissible value, reinforcement acting in conjunction with diagonal compression in the concrete shall be provided to take the whole of the shear.

9.3 Permissible Stresses in Steel

(a) For resistance to cracking. When steel and concrete are assumed to act together for checking the tensile stress in concrete for avoidance of crack, the tensile stress in steel will be limited by the requirement that the permissible tensile stress in the concrete is not exceeded so the tensile stress in steel shall be equal to the product of modular ratio of steel and concrete, and the corresponding allowable tensile stress in concrete.

(b) For strength calculations.

In strength calculations the permissible stress shall be as follows:

(i) Tensile stress in member in direct tension 1000 kg/cm2

(ii) Tensile stress in member in bending on

liquid retaining face of members or face away from

liquid for members less than 225mm thick 1000 kg/cm2

(iii)On face away from liquid for members 225mm or more

in thickness 1250 kg/cm2

(iv)Tensile stress in shear reinforcement,

For members less than 225mm thickness 1000 kg/cm2

For members 225mm or more in thickness 1250 kg/cm2

(v)Compressive stress in columns subjected to direct load 1250 kg/cm2

9.4 Stresses due to drying Shrinkage or Temperature Change.

(i)Stresses due to drying shrinkage or temperature change may be ignored provided that (a) The permissible stresses specified above in (ii) and (iii) are not otherwise exceeded.(b) Adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use.

(c) Recommendation regarding joints given in article 8.3 and for suitable sliding layer beneath the reservoir are complied with, or the reservoir is to be used only for the storage of water or aqueous liquids at or near ambient temperature and the circumstances are such that the concrete will never dry out.

(ii)Shrinkage stresses may however be required to be calculated in special cases, when a shrinkage co-efficient of 300 x 10-6may be assumed.

(iii) When the shrinkage stresses are allowed, the permissible stresses,tensile stresses to concrete (direct and bending) as given in Table 1 may be increased by 33.33 per cent.

9.5 Floors

(i)Provision of movement joints.

Movement joints should be provided as discussed in article 3.

(ii) Floors of tanks resting on ground.

If the tank is resting directly over ground, floor may be constructed of concrete with nominal percentage of reinforcement provided that it is certain that the ground will carry the load without appreciable subsidence in any part and that the concrete floor is cast in panels with sides not more than 4.5m. with contraction or expansion joints between. In such cases a screed or concrete layer less than 75mm thick shall first be placed on the ground and covered with a sliding layer of bitumen paper or other suitable material to destroy the bond between the screed and floor concrete. In normal circumstances the screed layer shall be of grade not weaker than M 10,where injurious soils or aggressive water are expected, the screed layer shall be of grade not weaker than M 15 and if necessary a sulphate resisting or other special cement should be used.

(iii) Floor of tanks resting on supports

(a) If the tank is supported on walls or other similar supports the floor slab shall be designed as floor in buildings for bending moments due to water load and self weight.

(b)When the floor is rigidly connected to the walls (as is generally the case) the bending moments at the junction between the walls and floors shall be taken into account in the design of floor together with any direct forces transferred to the floor from the walls or from the floor to the wall due to suspension of the floor from the wall.If the walls are non-monolithic with the floor slab, such as in cases, where movement joints have been provided between the floor slabs and walls, the floor shall be designed only for the vertical loads on the floor.

(c) In continuous T-beams and L-beams with ribs on the side remote from the liquid, the tension in concrete on the liquid side at the face of the supports shall not exceed the permissible stresses for controlling cracks in concrete. The width of the slab shall be determined in usual manner for calculation of the resistance to cracking of T-beam, Lbeam sections at supports.

(d)The floor slab may be suitably tied to the walls by rods properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

(e)Sometimes it may be economical to provide the floors of circular tanks, in the shape of dome. In such cases the dome shall be designed for the vertical loads of the liquid over it and the ratio of its rise to its diameter shall be so adjusted that the stresses in the dome are, as far as possible, wholly compressive. The dome shall be supported at its bottom on the ring beam which shall be designed for resultant circumferential tension in addition to vertical loads

9.6 Walls

(i)Provision of joints

(a)Where it is desired to allow the walls to expand or contract separately from the floor, or to prevent moments at the base of the wall owing to fixity to the floor, sliding joints may be employed.

(b)The spacing of vertical movement joints should be as discussed in article 3.3 while the majority of these joints may be of the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements given in article

(ii)Pressure on Walls.

(a) In liquid retaining structures with fixed or floating covers the gas pressure developed above liquid surface shall be added to the liquid pressure.

(b)When the wall of liquid retaining structure is built in ground, or has earth embanked against it, the effect of earth pressure shall be taken into account.
(iii) Walls or Tanks Rectangular or Polygonal in Plan. While designing the walls of rectangular or polygonal concrete tanks, the following points should be borne in mind.

(a) In plane walls, the liquid pressure is resisted by both vertical and horizontal bending moments. An estimate should be made of the proportion of the pressure resisted by bending moments in the vertical and horizontal planes. The direct horizontal tension caused by the direct pull due to water pressure on the end walls, should be added to that resulting from horizontal bending moments. On liquid retaining faces, the tensile stresses due to the combination of direct horizontal tension and bending action shall satisfy the following condition:

(t./t)+ (óc t . /óc t) = 1

t. = calculated direct tensile stress in concrete

t = permissible direct tensile stress in concrete (Table 1)

óc t = calculated tensile stress due to bending in concrete.

ó*c t* = permissible tensile stress due to bending in concrete.

(b)At the vertical edges where the walls of a reservoir are rigidly joined, horizontal reinforcement and haunch bars should be provided to resist the horizontal bending moments even if the walls are designed to withstand the whole load as vertical beams or cantilever without lateral supports.

(c) In the case of rectangular or polygonal tanks, the side walls act as twoway slabs, whereby the wall is continued or restrained in the horizontal direction, fixed or hinged at the bottom and hinged or free at the top. The walls thus act as thin plates subjected triangular loading and with boundary conditions varying between full restraint and free edge. The analysis of moment and forces may be made on the basis of any recognized method.

(iv) Walls of Cylindrical Tanks.

While designing walls of cylindrical tanks the following points should be borne in mind:

(a)Walls of cylindrical tanks are either cast monolithically with the base or are set in grooves and key ways (movement joints). In either case deformation of wall under influence of liquid pressure is restricted at and above the base. Consequently, only part of the triangular hydrostatic load will be carried by ring tension and part of the load at bottom will be supported by cantilever action.

(b)It is difficult to restrict rotation or settlement of the base slab and it is advisable to provide vertical reinforcement as if the walls were fully fixed at the base, in addition to the reinforcement required to resist horizontal ring tension for hinged at base, conditions of walls, unless the appropriate amount of fixity at the base is established by analysis with due consideration to the dimensions of the base slab the type of joint between the wall and slab, and , where applicable, the type of soil supporting the base slab.

9.7 Roofs

(i) Provision of Movement joints.

To avoid the possibility of sympathetic cracking it is important to ensure that movement joints in the roof correspond with those in the walls, if roof and walls are monolithic. It, however, provision is made by means of a sliding joint for movement between the roof and the wall correspondence of joints is not so important.

(ii)Loading

. Field covers of liquid retaining structures should be designed for gravity loads, such as the weight of roof slab, earth cover if any, live loads and mechanical equipment. They should also be designed for upward load if the liquid retaining structure is subjected to internal gas pressure. A superficial load sufficient to ensure safety with the unequal intensity of loading which occurs during the placing of the earth cover should be allowed for in designing roofs. The engineer should specify a loading under these temporary conditions which should not be exceeded. In designing the roof, allowance should be made for the temporary condition of some spans loaded and other spans unloaded, even though in the final state the load may be small and evenly distributed.

(iii)Water tightness.

In case of tanks intended for the storage of water for domesticpurpose, the roof must be made water-tight. This may be achieved by limiting the stresses as for the rest of the tank, or by the use of the covering of the waterproof membrane or by providing slopes to ensure adequate drainage.

(iv) Protection against corrosion. Protection measure shall be provided to the underside of the roof to prevent it from corrosion due to condensation.

9.8 Minimum Reinforcement

(a)The minimum reinforcement in walls, floors and roofs in each of two directions at right angles shall have an area of 0.3 per cent of the concrete section in that direction for sections up to 100mm, thickness. For sections of thickness greater than 100mm, and less than 450mm the minimum reinforcement in each of the two directions shall be linearly reduced from 0.3 percent for 100mm thick section to 0.2 percent for 450mm, thicksections. For sections of thickness greater than 450mm, minimum reinforcement in each of the two directions shall be kept at 0.2 per cent. In concrete sections of thickness225mm or greater, two layers of reinforcement steel shall be placed one near each faceof the section to make up the minimum reinforcement.

(b)In special circumstances floor slabs may be constructed with percentage of reinforcement less than specified above. In no case the percentage of reinforcement in any member be less than 0.15% of gross sectional area of the member.

9.9 Minimum Cover to Reinforcement.

(a)For liquid faces of parts of members either in contact with the liquid (such as inner faces or roof slab) the minimum cover to all reinforcement should be 25mm or the diameter of the main bar whichever is grater. In the presence of the sea water and soils and water of corrosive characters the cover should be increased by 12mm but this additional cover shall not be taken into account for design calculations.

(b)For faces away from liquid and for parts of the structure neither in contact with the liquid on any face, nor enclosing the space above the liquid, the cover shall be as for ordinary concrete member.

9.10 Domes:

A dome may be defined as a thin shell generated by the revolution of a regular curve about one of its axes. The shape of the dome depends on the type of the curve and the direction of the axis of revolution. In spherical and conoidal domes, surface is described by revolving an arc of a circle. The centre of the circle may be on the axis of rotation (spherical dome) or outside the axis (conoidal dome). Both types may or may not have a symmetrical lantern opening through the top. The edge of the shell around its base is usually provided with edge member cast integrally with the shell.

Domes are used in variety of structures, as in the roof of circular areas, in circular tanks, in hangers, exhibition halls, auditoriums, planetorium and bottom of tanks, bins and bunkers. Domes may be constructed of masonry, steel, timber and reinforced concrete. However, reinforced domes are more common nowadays since they can be constructed over large spans

Chapter 10 Design

PER CAPITA DEMAND 2X165X168 = 55440 lit.
Maximum supply 1.8 X 55440 = 99792 lit
DESIGN
Design of an intez tank for a capacity of 100000 lit.

Assuming height of tank floor above G.L 18m

Safe bearing capacity of soil 100kn/m^2

Wind pressure as per IS875 1200N/m^2

For Steel stress,
tensile stress in direct tension =115 N /mm^2

Tensile stress in bending on liquid face=115 N /mm^2 for t < 225 mm

and 125 N / mm^2 for / > 225 mm

Assuming M20 concrete

DIMENSIONS

Let the diameter of the cylinder portion = D = 6m ; R=3m
Let the diameter of the ring beam B = 4m
Height h_0 of the conical dome =1m
Rise h_1 = 0.8m
Rise h_2 = 0.5m

For Bottom Dome
The radius R_2 is given by $0.5(2R_2 – 0.5) = 4$
$R_2 = 4.25m$

$\sin\phi_2 = 2/4.25 = 0.47$

$\phi_2 = 28.072$ $\cos\phi_2 = 0.88$

Capacity of tank $= \pi D^2 h/4 + \pi h_0(D^2 + D_0^2 + DD_0)/4 - \pi h_2^2(3R_2 – h_2) = 60m^3$

$h = 2.72m$
we take H=3m considering free board

For Top Dome
The radius R_2 is given by $0.8(2R_2 – 0.8) = 9$

$R_2 = 6.05m$

$Sin\phi_1 = 3/6.05 = 0.49$
$\phi_1 = 29.86$ $\cos \phi_1 = 0.867$

Design of Top Dome

$R_1 = 6.05$; $Sin\phi_1 = 3/6.05 = 0.49$; $\cos \phi_1 = 0.867$
Let the thickness t_1 =100mm 0.1m
Taking a live load of 1500 N/m²
Total p per sq . m of dome = 0.1 X 25000 +1500 = 4000 N/m²

Meridonal thrust at edges = $T_1 = pR_1/1+ \cos \phi_1$ = 4000X6.05/(1+0.867) = 12961N/m

Meridonal stress = 12961/(100 X 1000) = 0.129 N/mm² (Safe)

Maximum hoop stress occurs at the center and its magnitude is pR_1/t_1X2

= 4000 X 6.05 / (2 X 0.1) = 0.121 N/mm²

Since the stresses are in the safe limits , provide nominal reinforcement @ 0.3%

A_s = 0.3 X 100 X 1000 /100 = 300 mm²
Using 8 mm bars ; $A\phi$ =50 Spacing = 1000 X 50/30 v0 = 160mm c/c in the both direction

Design of top ring beam B_1 : horizontal component of T_1 is given by
T_1 = 12961N/mm² $P_1 = T_1 \cos \phi_1$ = 11237.187 N/m

Total tension tending to rupture the beam = P_1 X D /2 =11237.187 X 3 = 33711.56 N

Permissible stress in high yield strength formed bars (HYSD bars) =150 N/mm²
A_{sh} = 33711.56/150 = 224.74 mm
No. of the 10mm dia bars = 224.74/78.5 = 2.08 » 3
Actual A_{sh} provided = 314 mm² = $\pi 10^2$ X 4 / 4
The area of crosssection of ring beam is given by : 33711.56 / (A + (314 X 12) = 1.2
A = 24324.966
Provide ring beam of 150mm (width) , 165mm (depth) Tie the 10mm dia rings by 6 mm dia @ 200mm c/c

Design of cylindrical wall : In the membrane analysis , the tank wall is assumed to be free at top and bottom . Maximum hoop tension occurs at the base of the wall its magnitude being given by
P = whD/2 = 9800 X 3 X 6 /2 = 88290 N/m height

Area of steel A_{sh} = 88290/150 = 588.6 mm² per meter height
Providing rings on both faces , A_{sh} on each face = 294.3 mm²
Spacing of 10mm dia rings = 1000 X 113 / 294.3 = 383.96 mm
We provide 10mm dia rings @ 300 c/c at bottom .This spacing can be increased at the top
Actual A_{sh} provided 1000 X 78 /300 = 260 mm² on each face

Permitting 1.2 N/mm² stress on composite section 88290/100t + (12 X 588.6) = 1.2

Inclined thrust at topof conical portion = 470223.69/ $\pi(6)\sin\theta$ = 35279.1717 N/m

where θ =45û

t = 66.51 mm

Minimun thickness = 3H + 5 = 14cm = 140 mm

Horizontal component = 35279.17171(cos45û) = 24946.1415 N/m

We provide thickness = 150 mm

A_{sh} = 0.24 X 150 X 1000 / 100 = 360 mm² Area of steel in each face = 180 mm²

Hoop tension in ring beam = 24946.1415 (6/2) = 74838.42 N

Spacing of 8m = 1000 X 50.3 / 180 = 155 mm

Pressure of water at ring level =10000 (3) = 30000N/m

Design of ring beam at bottom of cylindrical wall and top of conical slab:

Hoop tension due to this on the ring beam

From top ΣW =470223.69 N including self weight of beam

30000(6/2) (width of the ring beam) = 18000 N

Taking width as 200mm

Total hoop tension = 18000+74838.42 = 92838.42

Provide 8 mm dia bars @ 160 mm c/c on both face.

Steel required = 92838.42/115 = 807.29 mm^2

Use 6 nos. 12 mm Øbars

$A_c+(m-1)A_{st} = A_c+12(678.58)$

Hence $A_c = \frac{104838.42-12(678.58)}{1.20} = 80576.55mm^2$

Use ring size 400mmX200mm

Design of conical slab:

Wt of side wall and dome = 270223.69N

Wt of conical bottom assuming

250 mm thick $= \frac{\pi(6+4)}{2} (\sqrt{2})$ 250/1000(24000) = 133286.4881N

Wt. of water on dashed part in fig

$$\pi/4((6)^2 - (4)^2)(3.00)(10000) + \pi(1)/12$$
$$= ((6.00)^2 + (4.00)^2 + (6.00)(4.00))(10000) - \pi/4(4.00)^2(1.00)(10000)$$
$$= \underline{471239.26N}$$

Meridian force $N\phi = \frac{471238.264}{\pi(4.00)}\sqrt{2} = 53033.04$ N/m

compressive stress $= \frac{53033.04}{(1000)(250)} = 0.21$ N/mm^2

Hoop tension $N\theta$

Diameter of conical dome at ht 'h'

Above base $= 4.00 + \frac{6.00-4.00}{1.00}(h) = 4.00+2h$

Intensity of water pressure there = (3+1.00-h) (10000) = 40000-10000h

Self Wt. =250/1000 *24000 =6000N/m^2

$N\theta = ((40000-h(10000)) + 6000/\sqrt{2})\frac{(4.00+2h)}{2}\sqrt{2}$

$N\theta$ from $N\varphi/r1 + N\theta/r2 = -P_r$

r1 =infinity $r2 = \frac{(4.70+2h)}{2}$

At h =0 ,$N\theta$ = 125137.08N

h = 0.70 $N\theta$ = 277487.3734N

h = 1.00 $N\theta$ = 145279.22N

maximum Ast $= \frac{277487.37}{115} = 2412.93$mm^2

Axial compression = 902564.22 N = 37238.50 N/m.

Use 16 mm Øbars on each face @ 160 mm c/c.

Checking thickness,

$$A_{eq} = A_c + (m-1)A_{st} = A_c + 12(2513.27)$$

$$\text{Thickness reqd.} = 1/1000\frac{[2412.93 - 12(2513.27)]}{1.20} \sim 210\text{mm}$$

Design as inclined slab of conical Dome:

Total *W* on top of Inclined slab = 500000.37 *N*- Wt. of side wall and done.

= 500000.37-270223.69 = 207263.68N

Vertical load on slab /m = 207263.68/ (π(6+4.00)/2) = 13194.81 N/m

B.M. = 13194.81(1.00)/8 = 1694.35 Nm

A_{st} = 5000(1000)/ 115 (0.853) (210) = 294.44 mm^2

Min^m Steel = 0.30- (0.10/350)(150) = 0.257% *i.e.,* = 642.86 mm^2

Use 12mm@150mm c/c on both sides(hoop)

Design of Bottom dome:

Span of the dome = 4.00 m.

Rise of the dome = 0.80 m.

Radius of the dome from 0.800 (2R - 0.800) =$(4.00/2)^2$

Hence R =3.3816m

Use 8 mm Ø bars @ 80 mm c/c

Angle subtended by the dome =2θ

Sinθ = (4.70/2)/3.3816 =0.695

and θ = 44.02°; Cos θ = 0.71

Take thickness of dome as 200 mm

Loading

D.L. of dome = 0.200 (24000) = 4800 N/m^2

Wt. of water on dome = 10,000 [$\pi/4(4.00)^2(6.00) - \pi/6(0.800)(3 \times 2.00 + 0.800)^2$]

= 700953.69 N

Area of dome surface = 2 n (3.3816) (0.950) = 20.185 m^2

= 2π (3.3816) (0.950) = 20.185 m^2

Load intensity = (1023465.44/20185)+4800 =55504.26N/m^2

Meridian thrust at springing level =$wR/(1+\cos\theta)$ =$\frac{55504.26(3.3816}{1.719}$ =109187.43N/m

Meridian compressive stress = $\frac{109187.43}{1000(200)}$ =0.546N/m^2

Hoop stress = $wR/t[\cos\theta-(1/1+\cos\theta)$

Maximum at θ=0, where

Max hoop stress = 0.469N/mm^2

Stresses are low and provide 0.30 % steel**.**

Use 8mm @120mm c/c on both sides

Design of Circular Girder:

Assume size of girder as 200 x 500 (deep)

Check for Hoop Stress on Ring Beam

From inclined conical slab with $\varphi_0 = 45°$

$N\varphi_0 = 53033.04N$

Horizontal component=$53033.04 \cos\varphi_0 = 37500.022N$

From bottom of Dome $N\varphi_1 = 8162.52$ N/m

with $\varphi_1 = 45°$

Horizontal component = 5771.77 N

Hoop stress as Ring Beam = (37500.02-5771.77)(4.50/2)=14101.44N

Hoop stress (compression) = 14101.44/(1000(400))

$=0.035 N/mm^2$

Total loads on the circular girder are

with a size of 200 x 400 circular girder

Total Wt. 139897.53 N

Provide Six Columns.

At location of Maxm+ V BM. at Center of the Girder *i.e.,* at φ = 0, Torsional moment = 0

From $M_\varphi = \left(\frac{\theta}{\sin\theta}\cos\varphi - 1\right)WR$

$T_\varphi = [(\theta/\sin\theta)\sin\varphi - \theta]WR$

$V_\varphi = WR\varphi$

For the case 2θ = 60°; With 6 Columns

Considering column of diameter 400 mm

φ = 24° on face of column from center of span

φ = 0° at center.

φ= 17.27° from center for T_{max}

Design negative BM on face of column = $[(\pi/6)/0.50)\cos 24°](139897.53)(2.55)^2$

= 133841.23Nm

Maximum +Ve BM at φ =0,

$$B.M. = [(\pi/6)/0.50)\cos 0^o](139897.53)(2.55)^2$$

=952618N.53m

Maxm. Torsion Moment at φ = 17.27° from center

$$T_{max} = [\frac{(\pi/6)}{0.05}\sin 17.27^o - (17.27)\frac{(\pi)]}{180}(139897.53)(2.55)^2$$

= 24591451.21Nm.

At location of- Ve B.M. on face of columns.

$$T_\varphi = [\frac{(\pi/6)}{0.05}\sin 24^o - (24)\frac{(\pi)]}{180}(139897.53)(2.55)^2$$

= 3493601.22 Nm

S.F. at distance d = 360 mm from face of support

Where φ=11.44º

$$V = wR\varphi = (139897.53)(1.55)\frac{(\pi)(11.44)}{180} = 43295.73 \text{ N}$$

S.F on face of column $V = V_e + 1.6(TR/b)$ = 43295.73+1.6 (3493601.22/0.300)

=47577.25N

Shear reinforcement necessary

Design moment at face of column = $M+M_t$

= 133841.23+(343601.22/1.70)(1+500/400)

= 47577.25M

$$A_{st} = \frac{47577.25(1000)}{115(0.853)(450)} = 1077.80 \text{ mm}^2$$

Use 4 Nos. 18 mm *§* at top in one layer

As $M_t < M$, longitudinal reinforcement on flexural compression face not necessary.

For positive B.M.

$$A_{st} = \frac{73625.05(1000)}{115(0.853)(360)} = 1526.47 \text{ mm}^2$$

Use 5 Nos. 20 mm at bottom.

Transverse reinforcement to be not less than

$$A_{sv} = (\tau_{ve} - \tau_c) b.S_v / S_o = [(1.087-0.340)\ 400(S_v)]/125$$

For two legged 12 mm ϕ stirrups. *S* @ 95 mm c/c.

Also $A_{sv} = (T\, S_v / b_1 d_1 \sigma_{sv}) + V\, S_v / 2.5\, d_1 \sigma_{sv}$

$b_1 = 400-2(25+ 12+10) = 306\text{mm}$

$d_1 = 600 -2(25 +12 +10)=506\text{mm}$

$$A_{sv} = [(14769.97\ (1000)S_v)/ (306)\ (506)\ (125)]+[(184389.28\ S_v /2.5\ (506)\ (125)]$$

S = 117 mm c/c. Use S = 95 c/c.

With 2 legged 12 mm ϕ stirrups

Design of Columns – Six columns of 600 mm diameter to be symmetrically place at 60° c/c.

Length of column = 12 + 1 = 13 m. Consider column to have a batter of 1 in 20,

$\alpha = 2.862°$ and $\cos\alpha = 0.999$; $\sin\alpha = 0.050$

Total load:

Load from Top	= 139897.53N
Self wt. of 6 columns	= 529300.00 N
Wt. of Bracing	= 60000.00N
Total	= 729197.53 N

Load on each column due to W = 121532.92 N

Diameter at base = 5.10+(12/10) =6.30m

Wind Loading Considering V_b- 50 m/sec.

$V_z = V_b k_1 k_2 k_3 = 0.90 V_b k_2 k_3$ k_1 taking k as 0.90 for 25 yrs. life.

Taking k_2 and k_3 both as unity.

$p_z = 0.60\, v^2 = 0.60\,(45)^2 = 1215\ \text{N/m}^2$

P1 = [7.5+0.450)(5.0(7.69)(2/3)(1.60)+(7.69+5.10)(1.60)/2]

(1215)(0.70) = 49915N

taking shape factor as 0.70

This acts at a height = 12 +1/2(1.60 + 5 +1.6) = 13829 *N at* 4 m above G.L.

P_2 = Due to column, Bracing and circular Girder

= [(5.50) (0.600) + *Vi* (0.60) (4.0) (6.0)] (1215) (0.70)

+(5.50) (0.300) (1215) (0.70) = 10333.58N at l2m above G.L.

P_3 = On column and Bracing

= [6 (0.600) (4) + (5.80) (0.300)] (1215) (0.70) = 13727 Nat 4 m. above G.L

P_4 = [6(0.600) (4) + (6.20) (0.300)](1215) (0.70) = 13829 *N at* 4 m above G.L.

Cosider column fixed at bottom
Considering PI at mid height of column

Levels	shear	M(Nm)
1-1	49915+10334=60249	49915(4.10+2)+10339(2) =325149.5
2-2	60249+13727=73976	49915(6.10+4)+10334(6) +13724(2) = 667575.50
3-3	73976+13829=87805	49915(14.10)+13727(6) +10334(10)+13829(2) =917181.50

Referring to Fig. For XX axis

∑y2 = 4(D*√3)^2/8 =3/4d^2

For YY axis ∑x2 = 2(D/2)^2 + 4(D/4)^2 =3/4D^2
73976+13829=87805

For bending about *XX* axis, due to wind 73976+13829=87805

V1 = V4 =0

And V2 =V3 =V5 = V6 = 917161.50/(3/4(6.10)^2(sq3/4(6.10)

= ± 86807.12M

For bending about YY axis,

$$V1 = V4 = \frac{917161.50*6.10}{¾(6.10)^2}$$

$V_2 = V_4 = V_5 = V_6 = \pm$ 50118.1 N

Maxm. Thrust in column = 729197.50 + 100236.23 /0.999 = 830446.21N

At point 3-3,

On each column H= 830446.21/6 =138407.70

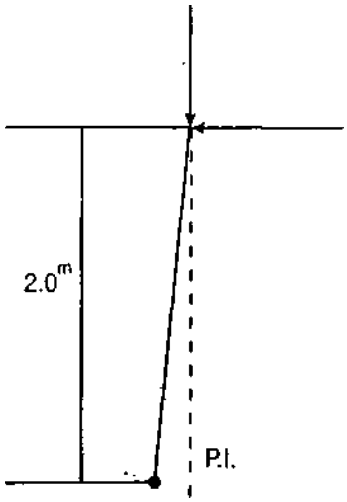
Vertical load at (3) due to WL. = 100236.23 N.

B.M on column = 138407.7(2)-100236.23N

= 176579.17 Nm.

Design of column can be done by limit state method

M - 20 Concrete Fe 415 steel Self wt. of a column = 81530 N



Axial force = 830446.21 N + 8153

M_{yy} = 176579.17Nm. This case 1

Safety factor to be used is 1.20

Case-I:P_u1 105720.80 N

M_{Uy} =23093664 Nm

CaseII : Pu= 108958.938N

Muxx =24705.17 N

With 600φ column

Pu/(fck^{2}d)=0.154 for Case -1 and 0.151 for Case – II

Mu/(fck D^3) = 0,0053 for Case -1 and 0.0057 for Case — II

d/D = (40+8)/0.08

use d /D = 0.10

Min Steel = 0.80 % *i.e.,* p/fck =0.04

Use 2 legged 12 mm stirrups @ 200 c/c

Muxx ~ Muyy = 0.06(20) (600)^3

Hence column is adequate.

Use 8 Nos. 20 mm § bars as longitudinal bars; Ties 10 mm @ 300 c/c.

Design of Bracing:

∑M at Joint above (3) = 20587.64 + 9167(2) = 389.21.64 Nm

Moment in bracing = 38931.64 √2

.

Providing 300 mm x 300 mm section and design as a doubly reinforced beam with equal steel at bottom >p and

Ast = Asc = [(38921.64(1.2 (1000)]/(0.87(415)(260)

=497.54 mm^2

Use 4 Nos. 16 mm both at top and bottom

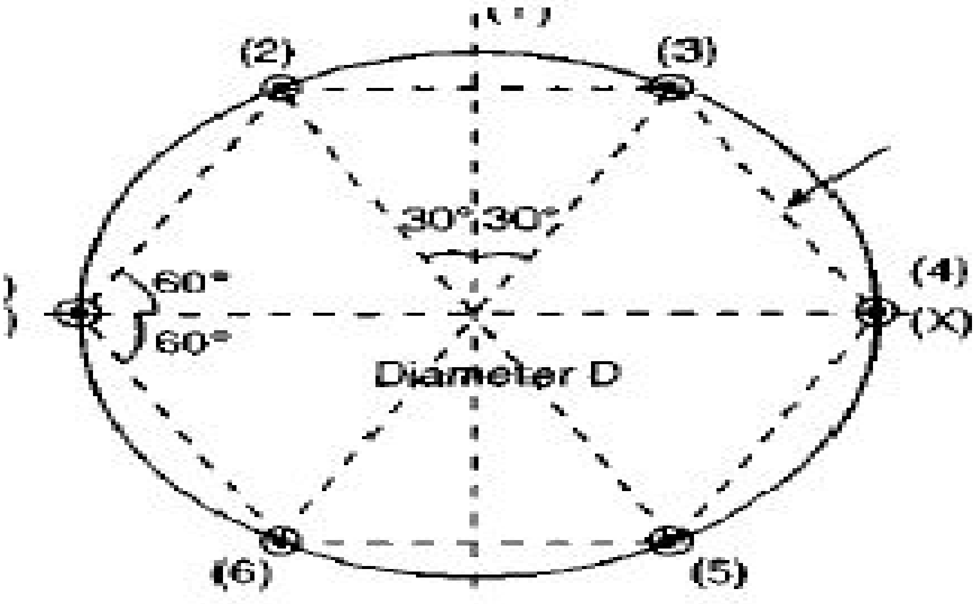
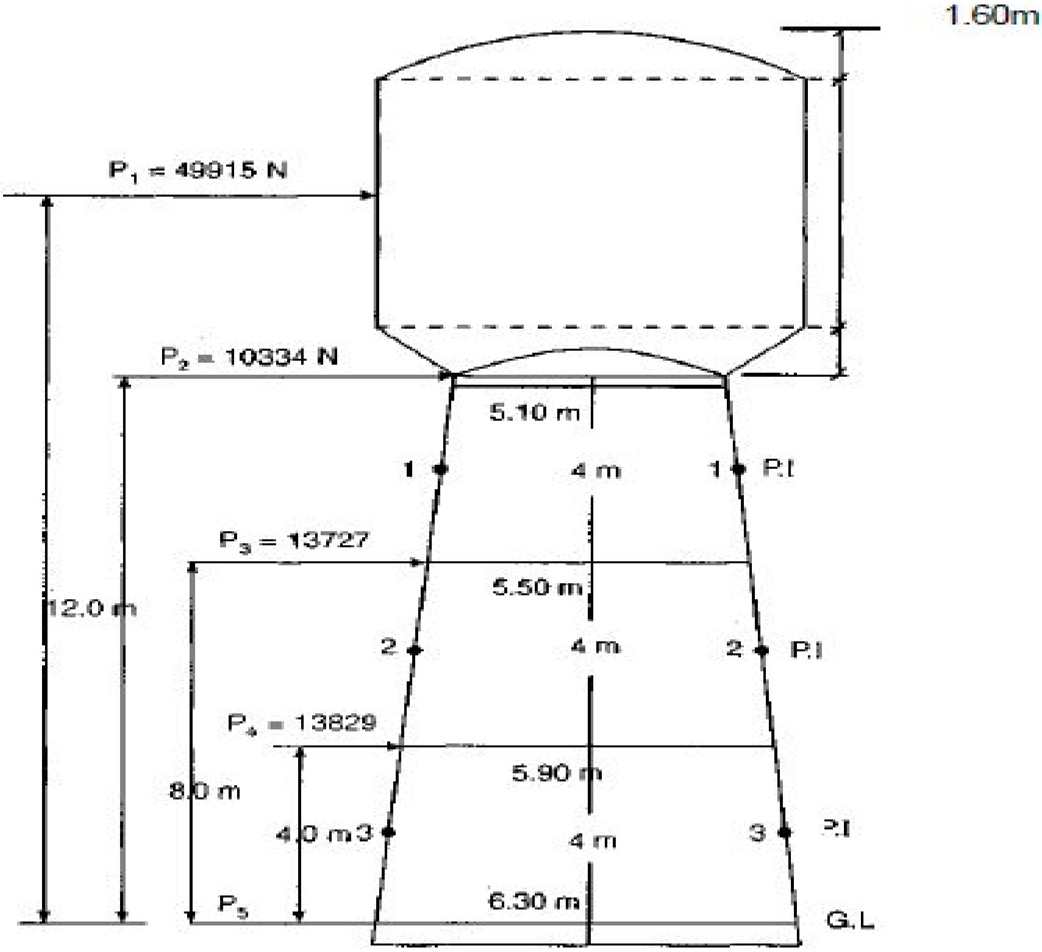


fig 24



=16.10maboveG.L.

fig 25

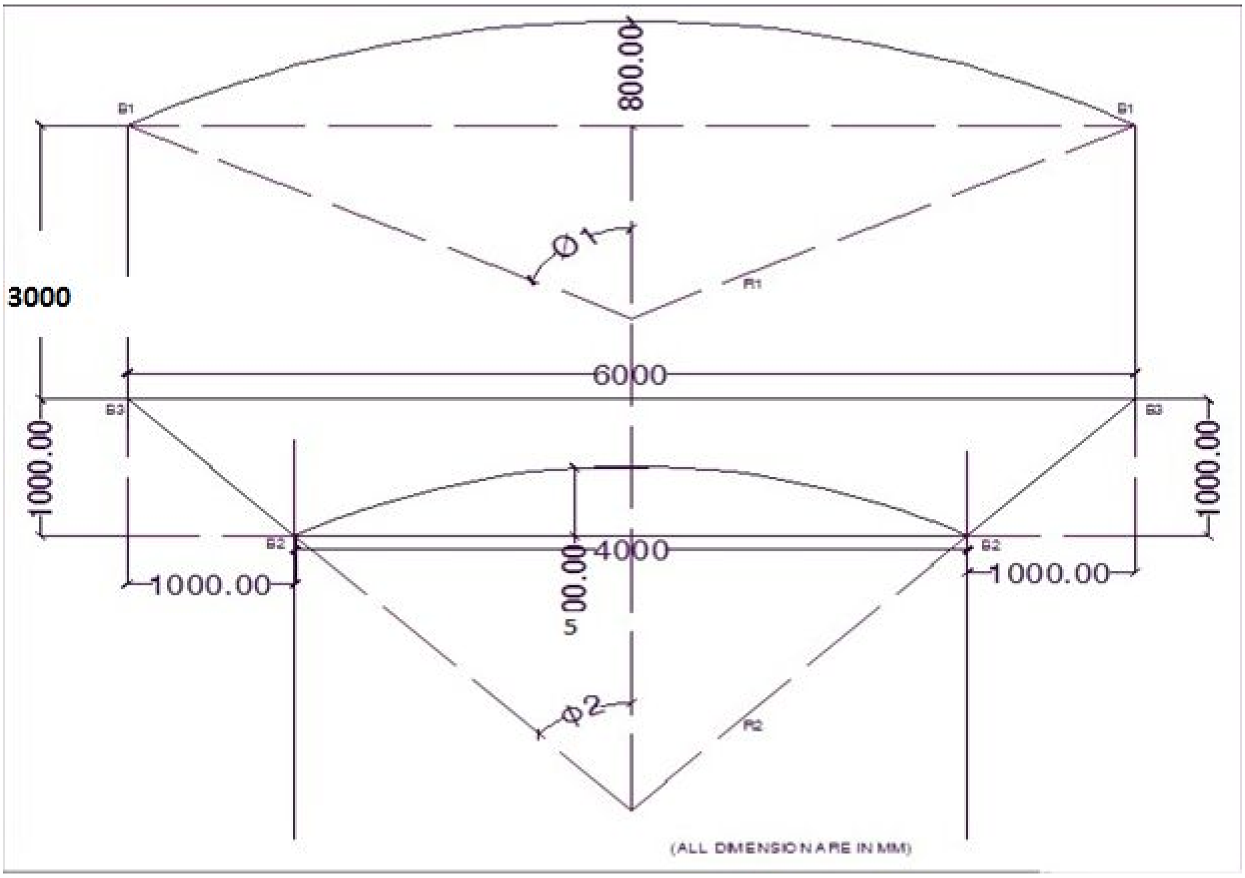

800.00
Ø1
3000
6000
1000.00
1000.00
4000
1000.00
1000.00
φ2
(ALL DIMENSION ARE IN MM)

Fig 26

REINFORCEMENT DETAILS

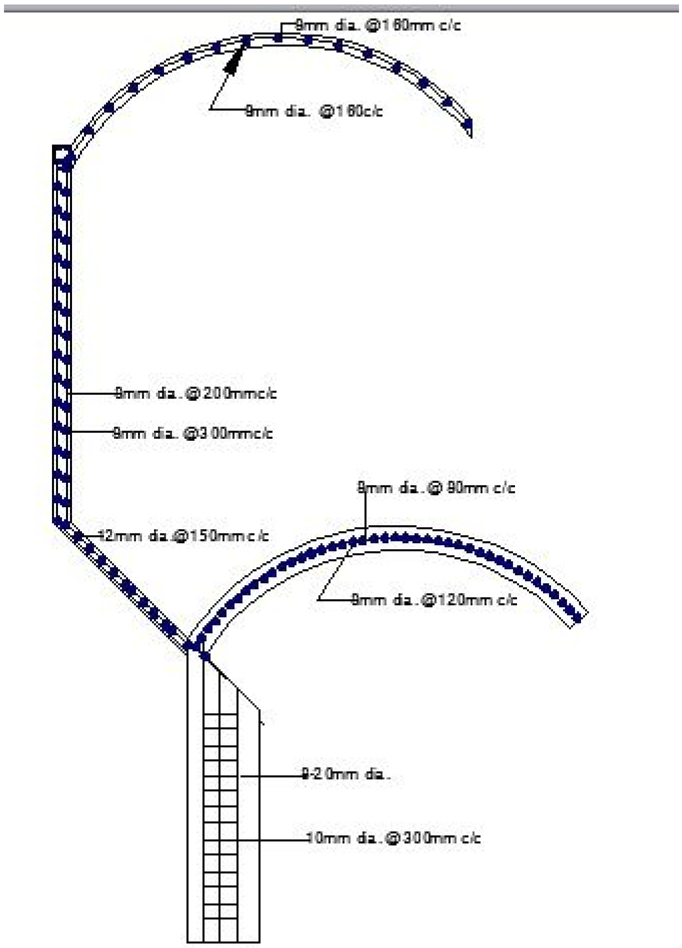
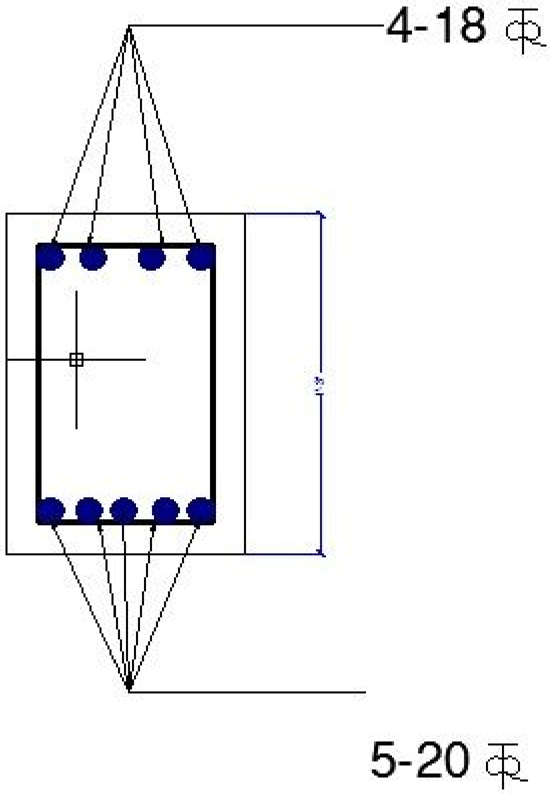


fig 27


4-18 Φ
5-20 Φ

CONCLSION

For building

Staadpro become more and more critical in the analysis of engineering & scientific problems

This facilities for the implementations of more effective & professional engineering software

It should be affordable to promote their wide spread usage amongst civil enggat a global scale

For water tanks

Storage of water in the form of tanks for drinking and washing purposes,swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present day life.

For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks.

Design of water tank is a very tedious method. With out power also we can consume water by gravitational force

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