INTRODUCTION

1.0 GENERAL:

Pollution in its broadest sense includes all changes that curtail natural utility and exert deleterious effect on life. The crisis triggered by the rapidly growing population and industrialization with the resultant degradation of the environment causes a grave threat to the quality of life. Degradation of water quality is the unfavorable alteration of the physical, chemical and biological properties of water that prevents domestic, commercial, industrial, agricultural, recreational and other beneficial uses of water. Sewage and sewage effluents are the major sources of water pollution. Sewage is mainly composed of human fecal material, domestic wastes including wash-water and industrial wastes.

The growing environmental pollution needs for decontaminating waste water result in the study of characterization of waste water, especially domestic sewage. In the past, domestic waste water treatment was mainly confined to organic carbon removal. Recently, increasing pollution in the waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants.

Sewage Treatment Plant is a facility designed to receive the waste from domestic, commercial and industrial sources and to remove materials that damage water quality and compromise public health and safety when discharged into water receiving systems. It includes physical, chemical, and biological processes to remove various contaminants depending on its constituents. Using advanced technology it is now possible to re-use sewage effluent for drinking water.

The present study comprises the study on quality of domestic waste water that is discharged from Centurion University of Technology & Management, PKD through the kitchen outlets and bathroom effluents. The study includes characterization tests for pH value, acidity, alkalinity, chloride, residual chlorine, turbidity & DO.

1.1 Objectives of the study:

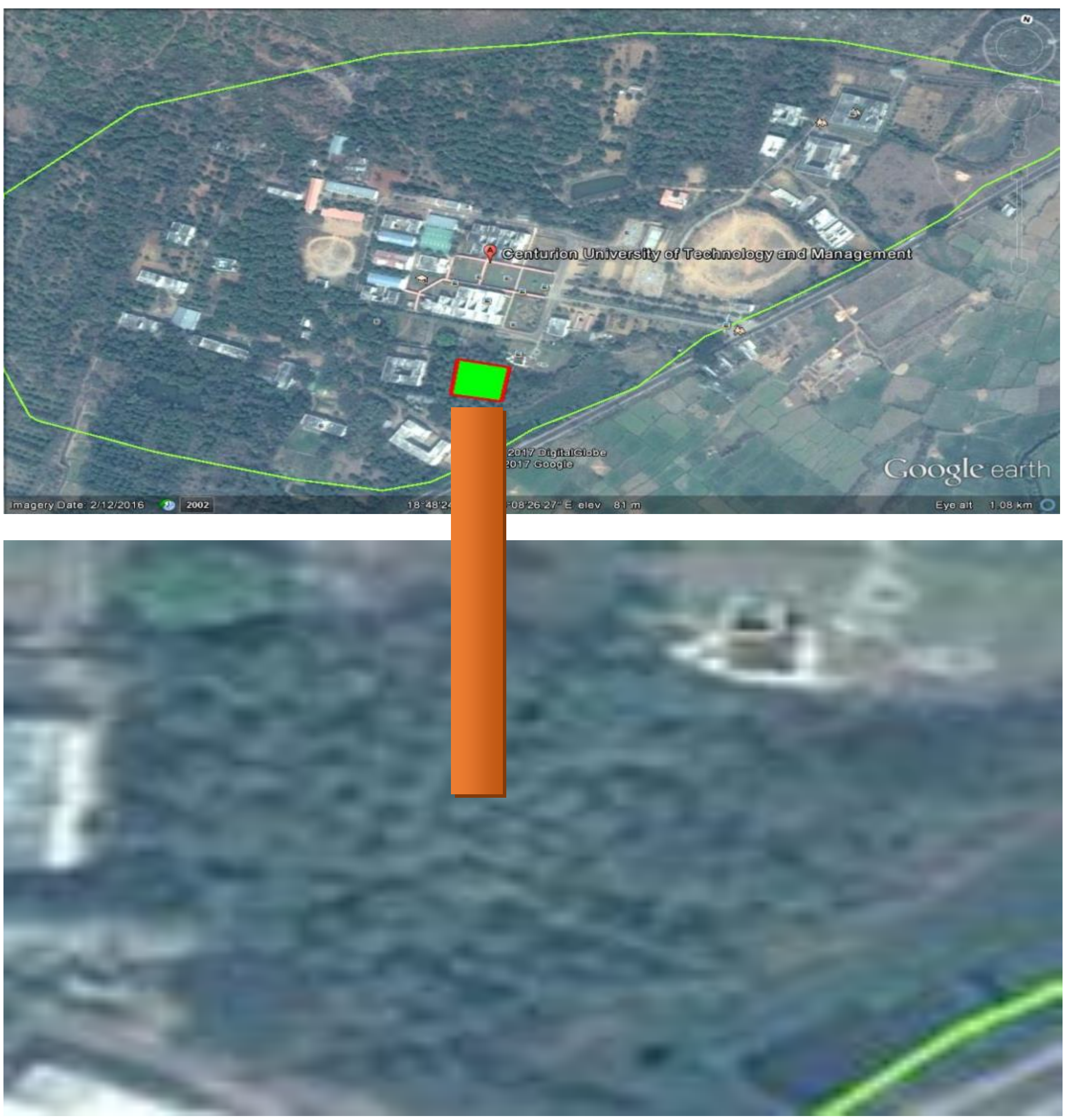
The principal objective of waste water treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. An environmentally-safe fluid waste stream is produced. No danger to human health or unacceptable damage to the natural environment is expected. Sewage includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. Sewage also includes liquid waste from industry and commerce.

The objectives of the study are:

1. Physical, chemical and biological characterization of the domestic waste water from hostels of CUTM, PKD
2. Comparison with the prescribed standard
3. Design of the sewage treatment plant.

1.2 LOCATION:

It is considered to locate a waste water treatment plant at CUTM campus in Allurinagar near Paralakhemundi, Gajapati district. The plant is designed for a population of 1550. Site of treatment plant is in right site of temple and infront of Centurion public school. The site for treatment plant is spread over an area $750m^2$.



1.3 Importance Wastewater Treatment Plant

Wastewater treatment plants do just as they say. They treat the water that goes down our drains before releasing it back into the environment. Wastewater treatment plants have evolved considerably over time. Their first, and most important purpose is to clear the water we use in our homes of solid materials. This process of screening and settlement is known as primary treatment. Although this removes the largest debris items, the wastewater is still full of organic material, which doesn't smell great and, if dumped directly into our water bodies, can contaminate them and consume available oxygen as it decomposes.

1.4 Advantage of Wastewater Treatment:

Through waste water treatment we can save water & use it for agriculture, plantation, vegetation, and gardening. This treated water can be used it for curing of bricks and watering while constructing of new buildings. Treated water can be used for toilets and for domestic need of human beings. The treated water can be stored in tanks and use it during the period of water crisis. By the treatment of polluted there will be decrease in the cost of transportation. A lot of ground water , surface runoff and polluted can be recycled through treatment process and may be use it for the wellbeing of the society.

1.5 Discussion about study area:

Our site is located in Centurion University of Technology and Management which is at Allurinagar near Paralakhemundi. The study area is covering an area about 4 hectares. There are five buildings which are multistoried with proper road alignments. There is a well-planned drainage system to each building and further to the main drain which let out. From each building the waste water is released through pipe line system. Further new buildings are under construction. In our study there is a big waste deposition tank. There are gardens in the study area. A very big forest and hills nearby and very big play ground in our site. A badminton court and a volley ball court exist there.

1.6 Observation of Study:

Waste water samples from the kitchen effluent and the bathroom waste of Hostels & Staff Quarters. The presence study is designed to collect waste water sample from Back side of Hostel -2 pond.

The following physical characteristics were studied:

i. Odour
ii. Taste
iii. Color
iv. Floatables
v. Turbidity

1.3 Literature Review:

Physical characteristic of waste water:

Odour: It depends on the substances which arouse human receptor cells on coming in contact with them. Pure water doesn't produce odour or taste sensations. Thus waste water which contains toxic substances has pungent smell which makes it easy to distinguish. Odour is recognized as a quality factor affecting acceptability of drinking water.

The organic and inorganic substance contributes to taste or odour. The ultimate odour tasting device is the human nose. The odour intensity is done by threshold odour test

Taste: The sense of taste result mainly from chemical stimulation of sensory nerve endings in tongue. Fundamental sensations of taste are, by convention more than by research evidence, salt, sweet, bitter, and sour. The rating involves the following steps: a) dilution series including random blanks is prepared b) initial tasting of about half the sample by taking water into mouth and holding it for several seconds and discharging it without swallowing. c) Forming an initial judgment on the rating scale d) a final rating made for the sample e) rinsing mouth with taste and odour free water f) resting.

Colour: Colour in water results from the presence of natural metallic ions such as Fe or Mg, humus and peat materials, planktons and weeds. It is removed to make water suitable for general and industrial applications. After turbidity is removed the apparent colour and that due to suspended matter is found out.

Tristimulus, Spectroscopic and Platinum cobalt method is used.

Total solids: It refers to matters suspended or dissolved in water and waste water. Solids affect the water or effluent quality adversely in a number of ways. Water with highly dissolved solids are not palatable and may cause physiological reaction in transient consumer.

A limit of 500 mg dissolved solids/L is desirable for drinking waters. Evaporation method is used to separate total solids and their weight is found out.

Floatables: One important criterion for evaluating the possible effect of waste disposal into surface water is the amount of floatable material in the waste. Two general types of floating matters are found

(i) Particulate matters like 'grease balls'

(ii) Liquid component capable of spreading as thin visible film over large areas.

It is important because it accumulates on the surface and may contain pathogenic bacteria and viruses.

Turbidity: Clarity of water is important in producing products destined for human consumption and in many manufacturing uses. It is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. The standard method for determination of turbidity has been based on the Jackson candle turbidimeter and Nephlometer.

Chemical characteristic of waste water:

Chemical characteristics of water state the presence of metals their treatment, the determination of inorganic non-metallic constituents and the determination of organic constituents. Here goes a brief description of all the experiments we have performed.

Biological characteristic of waste water:

Water quality has a key role in deciding the abundance, species composition, stability, productivity and physiological condition of indigenous populations of aquatic communities. Their existence is an expression of the quality of the water. Biological methods used for evaluating water quality include the collection, counting and identification of aquatic organisms. Most microorganisms known to microbiologists can be found in domestic wastewater like Bacteria, Protozoa, Viruses, and Algae.

Planktons, Periphyton, Macro-phyton, Macro-invertebrates, Fish, Amphibians and Aquatic reptiles are the biotic group of interdependent organism. Wastewater contains vast quantities of bacteria and other organisms. Aerobic bacteria break down organic matter in the presence of available oxygen. Anaerobic bacteria disintegrate organic matter which is shut off from free oxygen, such as in the interior of a mass of feces or a dead body. The products of anaerobic decomposition have an extremely nauseating odor. Matter in which this condition exists is said to be septic. A multitude of the bacteria in wastewater are coliform bacteria: those found in the digestive tract of normal humans. It is these comparatively few pathogenic organisms that pose the greatest public health hazard. Waste water which is not properly treated may eventually find its way into a community water source and spread waterborne diseases.

Calculation of Population and Discharge:

Name	**Population**
Hostel-1	243
Hostel-2	192
Hostel-3	192
Hostel-4	240
Hostel-5	152
Girls hostel	275
Staffs	100
Total	1400

10% extra for future Population,

Total Population=10/100x1400=1540

So, Take total Population=1550

Max daily demand per capita=180 lit/day

Amount of water used daily=1550*180=279000 lit/day

REQUIREMENT OF TREATMENT PLANT FOR THE CAMPUS

Before constructing a project we should know why it is necessary to that area. There are certain reasons for constructing a water treatment plant in the campus. Water treatment plant is required in the campus since lot of water is in domestic use by centurion family. In case of water crisis the treatment water can be used for gardening. Centurion campus has a very big garden of about 5 acres which needs lot of water and the water from the treatment plant can be used for gardening. Our campus borrows water from a very far place which is highly expensive. During rainy season a large amount of water wasted by flowing through drainage which can be used by the campus through treatment process. Since there is agricultural B.Sc. in the college the treatment water can be used by the students for plantation. Many new buildings are being constructed inside the campus which needs a large amount of water for curing the bricks and watering the foundation, wall and slab. To certain extent the treated water can meet the demand of construction works. During summer the water supply to the hostel is just time to time and not regular so treatment plant is highly essential to this site. Thousands of gallons of water is used by the students, staff and mess members lot of water is wasted through drains so, constructing a treatment is very important. The drain water is deposited in the tank but of no use after the tank is filled the water is removed and wasted. Since there is a hill nearby our site there comes a large amount of surface runoff water which can be treated for our domestic use. To avoid further future a problem regarding water a waste water treatment plant is definitely required.

BIS 105000 STANDARD FOR GROUND WATER

Sr.no	Characteristic	Requirement.(desirable)	Permissible limit in the absence of an alternative source
1.	Color-Hazen units, maximum	5	25
2.	Odor	Unobjectionable	Unobjectionable
3.	Taste	Agreeable	Agreeable
4.	Turbidity,Ntu,Max	5	10
5.	pH value	6.5 to 8.5	No relaxation

6.	Total Hardness as CaCo3,max mg/l	300	600
7.	Iron as Fe,max mg/l	0.3	1.0
8.	Chlorides as Cl,max mg/l	250	1000
9.	Residual free Chlorine as Cl, min	0.2	- -

Desirable Characteristics:

10.	Dissolved Solids, mg/l, max	500	2000
11.	Calcium as Ca, mg/l,max	75	200
12.	Copper as Cu, mg/l,max	0.05	1.5
13.	Manganese as Mn, mg/l,max	0.10	0.3
14.	Sulphate as So4,mg/l,max	200	400
15.	Nitrate as No3,mg/l,max	45	100
16.	Fluoride as F, mg/l,max	1.5	1.9
17.	Phenolic compounds, mg/lit, max	0.001	0.002
18.	Mercury as Hg, mg/lit max	0.001	No relaxation
19.	Cadmium as Cd, mg/lit , max	0.01	No relaxation
20.	Selenium as Se, mg/lit, max	0.01	No relaxation
21.	Arsenic as As, mg/lit, max	0.01	No relaxation
22.	Cyanide as Cn, mg/lit, max	0.05	No relaxation
23.	Lead as Pb, mg/lit, max	0.05	No relaxation
24.	Zinc as Zn, mg/lit, max	5.0	No relaxation
25.	Anionic detergents, mg/lit, max	0.2	1.0
26.	Chromium as Cr, mg/lit, max	0.05	No relaxation
27.	Polynuclear Hydro carbons	--	--
28.	Mineral oil, mg/lit ,max	0.01	0.03

EXPERIMENTS RELATED TO WASTE WATER QUALITY:

2.0 GENERAL:

Before proceeding to the design of a treatment plant it is essential to access the quality of the waste water coming from our JITM campus. The following are the conventional test to be carried out in establishing the water quality.

2.1 TESTS:

1. Test of hardness of water
2. Test of Dissolved oxygen
3. Test of BOD
4. Test of Ph

The detailed procedure of tests and the result obtained are presented in the subsequent section of this chapters.

Work plan:

Date	1st Phase	2nd Phase	3rd Phase
22/7/17	Sample Collection From H-1&2	Different tests on pH, T.H, D.O, BOD, Turbidity	Calculation, Analysis of Results & comparison with standards
24/7/17	Sample Collection From hostel-3&4	Different tests on pH, T.H, D.O, BOD, Turbidity	Calculation, Analysis of Results & comparison with standards
29/7/17	Sample Collection From H-5,Girls hostel,mess-1	Different tests on pH, T.H, D.O, BOD, Turbidity	Calculation, Analysis of Results & comparison with standards

31/7/17	Sample Collection From Staff quarter-1 & 2,mess-2	Different tests on pH, T.H, D.O, BOD, Turbidity	Calculation, Analysis of Results & comparison with standards

2.1.1 DETERMINATION OF HARDNESS OF WATER

AIM: - To determine the total hardness of supplied water by EDTA method.

Chemical required:-

1. Standard hard water
2. EDTA solution
3. Eurichrome black t indicator (EBT)
4. Buffer solution (NH4Cl and nh4oh)

Theory:-

The hardness of water is generally due to dissolved salt of calcium and magnesium temporarily hardness due to Ca(OH3) etc. and permanent hardness is due to MgCl2,CaCl2,CaSO4,MgSO4 etc.

Total hardness= temp + permanent hardness

Hardness is exposed in terms of CaCO3 equivalent part of CaCO3 equivalent hardness causing ions present per million {106} parts of water is called as ppm. Disodium salt of EDTA is a reagent when treated with hard water consumers all the hardness causing cataions**.**

PROCEDURE:-

- A 10ml of standard hard water (whose hardness is known) was pipette in to a conical flask. One third test tube of buffer solution was added (NH4Cl,NH4OH,PH>9) and 5 drops of EBT indicator was added. The solution was treated against EDTA solution taken in burret.

- At the end point the color changed from wine red to blue. The same procedure was repeated for 3 concurrent readings.
- 10ml of hardness was pipette out to a conical flask.
- One third test tube of buffer solution and drops of EBT indicator was added to it and titrated against EDTA solution taken in the furettetill the color changed from wine red to blue color.

Calculation:

Weight of $CaCO_3$ (x) = 0.2365 gms

Normality of $CaCO_3$ (N_0)=$\frac{\frac{X*1000}{Eq.Wt.of CaCO_3}*1}{v}$

Normality of EDTA (N_2) = N_0V_1/V_2

Concentration of Hardness (N_1) = N_2V_2/V_1

Total Hardness(as mg/lit $CaCO_3$)=$\frac{N_1*w*V}{1000}*1000$

RESULT:

Locations	Total Hardness(ppm)
Hostel-2,4 & Mess-2	265.3
Hostel-5 & Mess-1	432.3
Hostel-3	256.8
Girls hostel(B.Tech)	346.7
Staff quarter-1	271.22
Staff quarter-2	321

2.1.2 DETERMINATION OF DISSOLVED OXYGEN

AIM:- To estimate the amount of dissolved oxygen present in the given water sample by iodometric method.

APPARATUS: - 300 ml air tight B.O.D bottle, burette, pipette and conical flask.

Chemicals and solution:-

1. Standard potassium Dichromate solution

2. Sodium Thiosulphate solution

3. Potassium iodide solution

4. Starch indicator solution

5. Manganous sulphate solution

6. Alkali-iodide-azide reagent

THEORY:-

Dissolved oxygen determination is based on the oxidation of potassium iodide by dissolved. The liberated iodine is titrated against standard sodium thiosulphate solution using starch as final indicator. However dissolved molecular oxygen in water is not capable of reacting with KI so an oxygen carrier is used to bring about the reaction between “KI” and oxygen. Manganese hydroxide is produced by the action of potassium hydroxide and Manganous sulphate.

Sometimes water contains substances like nitrates, sulfites etc. And determination of dissolved oxygen in their presence will give strong results since these ions also liberate iodine form “KI”. Therefore sodium azide is used in alkaline iodide solution to take care any nitrate present in water, does not liberate iodine from “KI”. Sodium azide reacts with nitrate to decompose.

PROCEDURE:-

Standardization of sodium thiosulphate solution:-

1. Take 20 ml of K2Cr2O7 solution in an iodine flask.

2. Add 5ml of HCL or H2So4 and 10 ml “KI” solution and keep it in dark for 3 minutes.

3. Titrate with hypo solution until the color changes to light brown color.

4. Then add starch to it and titrate with hypo until the changes from dark blue to very light green color less.

5. Repeat the experiment 2-3 times and tabulate the readings. The concentration of hypo is calculated.

Estimate of dissolved oxygen:-

1. Collect the tap water 250 ml in a B>O>D bottle avoiding contact with air as for as possible.

2. Immeø tely add 2ml MnSO4 solution and 2ml of Alkali Iodide Azide solution by immersing the tip of the pipette in the water sample.

3. Exclude air bubbles and mix by repeatedly inverting the bottle 2-3 times.

4. If no oxygen is present, the Monogamous ions react with hydroxide ion to form white ppt of $Mn(OH)_2$.If oxygen is present some Mn2 is oxidized to Mn+3 and precipitates as brown colored manganese oxide.

5. After shaking and allowing sufficient time for oxygen to react. The chemical precipitation is allowed to settle for about 15-25 min bearing clear liquid with in the upper portion.

6. Decent the liquid above the precipitate and dissolve the ppt in minimum volume of H2SO4.

7. The contents in the bottle are mixed by inverting until the suspension is completely dissolved and yellow color developed is uniform throughout the bottle.

8. Makeup the solution up to the neck with distilled water.

9. Take 20ml of mixture, titrate with hypo after adding starch.

10. Continue the titration until the color changes from dark blue to light green or colour less.

Calculations:

Weight of potassium Dichromate ($K_2Cr_2O_7$) (X) = 0.1090gms

Normality of $K_2Cr_2O_7$ (N_1) = $\frac{\frac{X*1000}{Eq.Wt.of CaCO_3}*1}{v}$

Normality of hypo (N_2) = N_1V_1/V_2

Dissolved oxygen of sample = $\frac{N_2*Eq.Wt.of O_2*volume of hypo*1000}{volume of sample taken}$

Tabulation:

Dissolved Oxygen Day1

Locations	Dissolved Oxygen (mg/lit)
Hostel-2,4 & Mess-2	4.6
Hostel-5 & Mess-1	1.84
Hostel-3	4.133
Hostel-1	2.3
Girls hostel(B.Tech)	1.38
Staff quarter-1	3.68
Staff quarter-2	2.76

Dissolved Oxygen Day5:-

Locations	Dissolved Oxygen (mg/lit)
Hostel-2,4 & Mess-2	4.14
Hostel-5 & Mess-1	1.38
Hostel-3	3.22
Hostel-1	1.84
Girls hostel(B.Tech)	0.92
Staff quarter-1	2.76
Staff quarter-2	1.84

Calculations:

Difference in DO or Oxygen Demand = $DO_1 - DO_5$

Fraction Ratio = $\frac{volume of sample taken}{volume of BOD bottle}$

Percentage of BOD =$\frac{DO1-DO5}{fraction ratio}$

Locations	BOD (in %) If FR = 0.08	BOD (in %) If FR = 0.02
Hostel-2,4 & Mess-2	5.75	23
Hostel-5 & Mess-1	5.75	23
Hostel-3	11.4125	45.65
Hostel-1	5.75	23
Girls hostel(B.Tech)	5.75	23
Staff quarter-1	11.5	46
Staff quarter-2	11.5	46

2.1.3 DETERMINATION OF pH:

AIM OF THE EXPERIMENT

To prepare buffer solution and to determine its pH by using pH meter.

PROCEDURE

Prepare three acidic buffer solution in three different measuring flasks by mixing CH_3COOH (0.2m) and CH_3COONa (0.2m) solution at different proportion, shake them well.

Standardize the pH meter by using a standard buffer of (pH=7.0) at 25^0C.

Wash the electrode with distilled water and make it dry. Take about 30ml of first buffer in a clean and dry beaker and measure its pH by using pH meter. Similarly measure the pH of other two buffer solutions.

RESULTS

Locations	Ph
Hostel-2,4 & Mess-2	7.72
Hostel-5 & Mess-1	7.02
Hostel-3	7.80
Hostel-1	7.61
Girls hostel(B.Tech)	7.06
Staff quarter-1	7.21
Staff quarter-2	6.52

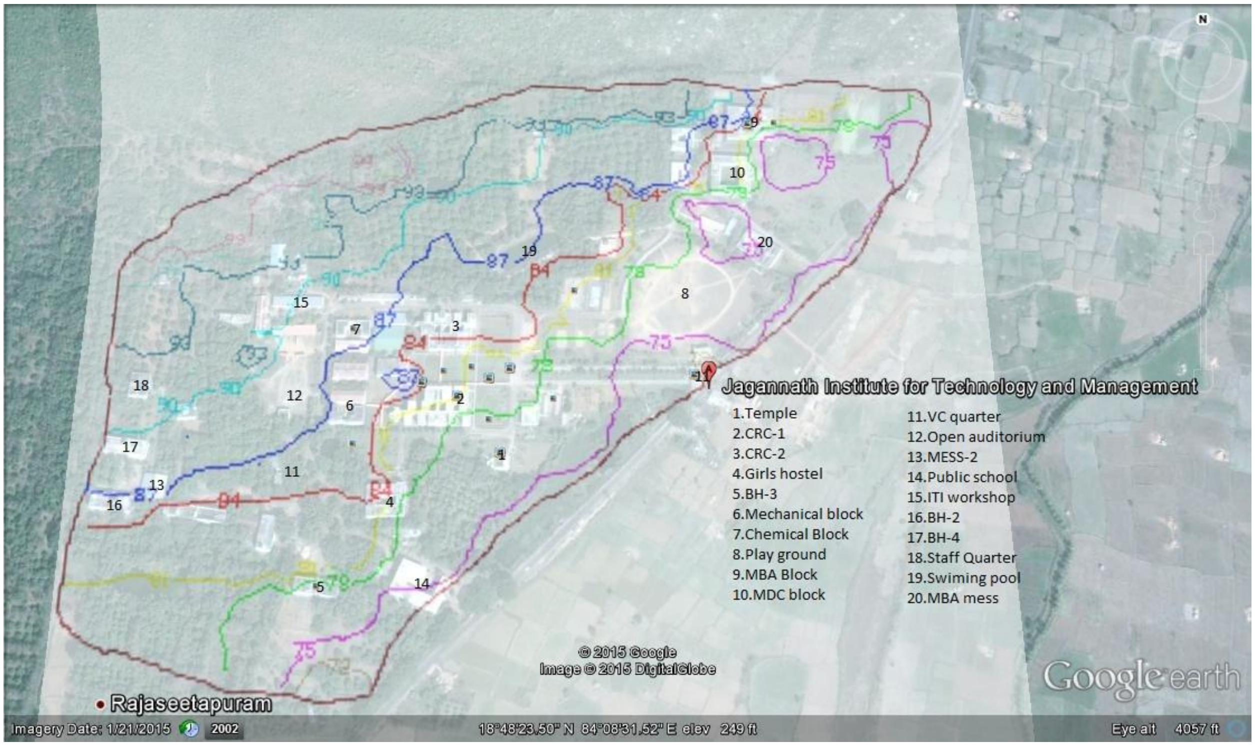
2.6. PROCESS OF WASTE WATER TREATMENT:

1. Waste water as it enters into waste water treatment plant is screened to remove large items from the water. The goal of this step is to remove debris that could damage the treatment facility's equipment.

2. The grit from the waste water is removed by forcing th water through a grit chamber. Forcing the waste water quickly through the chamber prevents organic waste from settling and aerates the mix. Small waste water treatment plants may skip grit removal.
3. The screened waste water is pumped into sedimentation tanks to help further separate the components of waste water. Remove and condense the organic matter, called sludge, which settles to h bottom of the tank.
4. The surface of the waste water is skimmed to remove oil, soap scum and grease. Rakes from the top of tanks remove these components of waste water, known collectively as scum.
5. The scum and sludge is collected into a single sludge processing unit for further treatment. Aerobic digestion process of solid waste, and some facilities use the resulting methane gas as a source of energy.
6. The waste water is filtered through sand to remove excess iron and calcium, some bacteria and remaining solid particles in the water. Filtering the waste water should also reduce the color and make the water more transparent.
7. The waste water is treated with chlorine to kill remaining bacteria. Chlorine is to be added avoid over contamination; most of the chlorine will break down as it kills the bacteria. Sometimes the chlorinated waste water is treated wastewater is treated with chemicals to neutralize any remaining chlorine.
8. The cleaned waste water, called effluent is either reused or disposed.

GENERATION OF CONTOUR MAP:

Generation of contour map by the help of TCX converter and Quick grid from Google earth pro. By help of which we can select the proper site for waste water treatment plant. It helps to know the slope of the ground and placing of the waste water treatment units lie sedimentation, filtration, aeration in proper levels.



Design of Waste Water Treatment Plant

Plant capacity:

Maximum daily demand = 180 lit/day
Average water supply per day = 180 x 1550 =279000 lit = 279cum

Average sewage generated per day = 85% of supplied water

= 0.85*279=223 m^3

Average sewage generated per hour=223/24=9.29 cu.m/hr

Peak factor = 3

Design flow capacity (maximum) = 9.29 x 3=27.85 cu.m/hr

Design of screen chamber:

Peak discharge = 30 m^3/h

Average discharge = 10 m^3/h

Average velocity @ average flow isn't allowed to ex Average spacing between bar 20 mm

The velocity = 0.3*40=12 m/h/ m^2

Cross sectional area required = flow/velocity = 30/12 = 2.5 m^2

Liquid depth required= 1 m

Velocity through screen at the peak flow = 1.6 m/se

Clear area = 2.5/1.6 = 1.3

No. of clear spacing = 1.3/0.02 = 65 Width of channel = (65 x 20) + (67 x 6) = 1702 mm

Width of screen = 1700 mm

Sizing calculation for collection pit:

Retention time required = 8 h

Average design flow = 27.87 m^3/h

Capacity of collection sump = 8 x 27.87=222.96 m^3

Assume liquid depth = 4 m

Area required for collection pits = 222.96/4 = 55.74 m^2

Let it is a rectangle tank

L:B=2.5:1

L=12 m & B=4.7 m

Provide tank size is 12m x 4.7m x 4m

Sizing calculation of Sedimentation Tank:

Quantity Of Water to be Treated in 24 hours = 223000 Litres

= $22.3x10^4$ Litres

Quantity of Water to be Treated during the detention time period of 4 hours

$=\frac{223000}{24}$ x 8

= 37166.6 Litres=38000 Liters

The capacity of Tank required =222.96 cum

Length of tank=13 m

Width of tank=4.3 m

So the depth of tank=$\frac{222.96}{13x4.3}$=3.9m

So Provide a Tank size 13 m x 4.3 m x 3.9 m

Provide a Free Board of 0.5 m

Hence used a Tank Size 13 m x 4.3 m x 4.4 m

Sizing calculation of Slow Sand Filter:

Maximum Daily Demand = 223cu.m

Rate of filtration Per day = (150 x 24) liter/sqm /day

Total Surface Area of Filter required = $\frac{MaximumDailyDemand}{RateOfFiltrationPerDay}$

$= \frac{223x10^3}{150x24}$

= 62

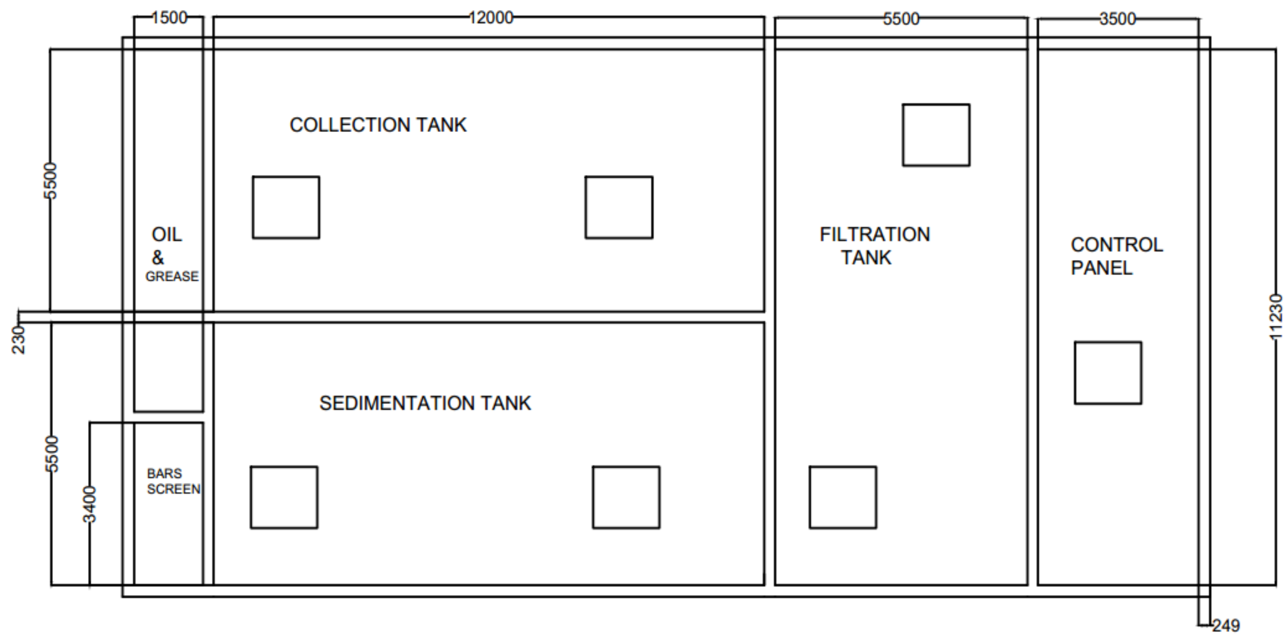
Assume Length, L = 2B

 $2B^2$ = 62

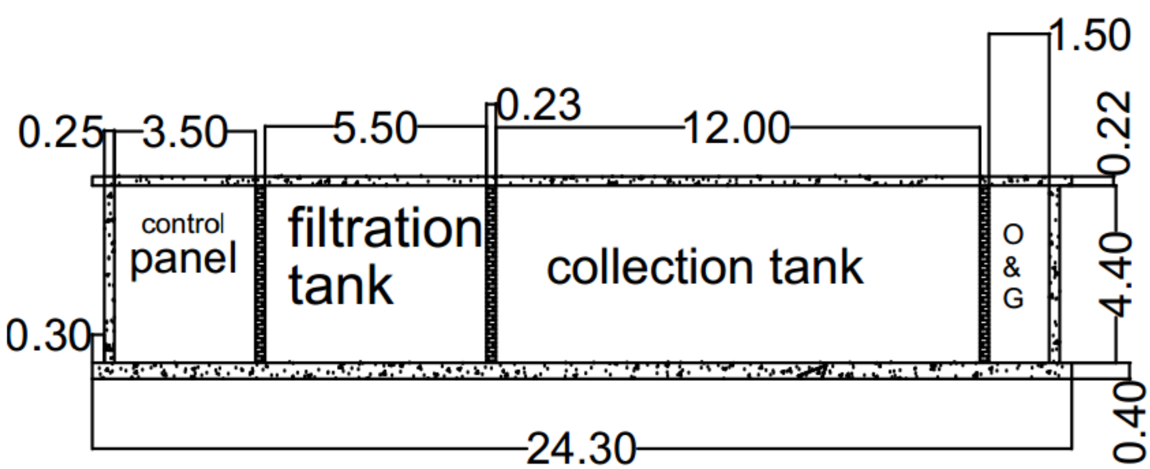
Or, B =5.56 m

& L = 2B = 2x5.56 =11,12m

Auto cad Design:-



(All dimension are in mm)



(All dimension are in meter)

DESIGN OF REINFORCEMENT

Design of top slab

1) Filtration tank:-

$\frac{Ly}{Lx}=\frac{11}{5.5}=2$

Slab is two-way slab.

L.L=0.957kN/m^2

F.F=0.478kN/m^2

Thickness of slab:-

D=5500/25=197mm

Adopt depth (d) =200mm

Overall depth (D) =200mm

Effective Span:-

Lx=5.5+0.22=5.72m

Ly=11+0.22=11.22m

$\frac{Ly}{Lx}=\frac{11.22}{5.72}=1.96$

Loads:-

Per unit area of slab.

Self-weight of the slab=25x0.22=5.5kN/m^2

Live load=0.957kN/m^2

Floor finish=0.478kN/m^2

Total load=6.935kN/ m^2

Factored load, Wu=1.5x6.935=10.40kN/m^2

Design moments and shear forces:-

α_x=0.118

α_y=0.029

$M_{ux}=\alpha x.Wlx^2=0.118x10.40 \text{ x } (5.72)^2=40.15$kN/m

$M_{uy}=\alpha y.Wlx^2=0.029x10.40 \text{ x } (5.72)^2=9.86$kN/m

$Vu=W_u.l/2=10.40x5.72/2=29.74kN$

<u>Reinforcement:-</u>

Along x-direction:-

Mux=0.87fy Ast d$\left[1-\frac{fyAst}{fckbd}\right]$

$40.15x10^6=0.87x415xAstx220\left[1-\frac{415.Ast}{5x1000x220}\right]$

$Ast-1.25x10^{-4}\ Ast^2=505.470$

$Ast=542.22mm^2$

Using 8mm ø bars, spacing of bars

$S=\frac{\pi/4x82}{542.22}x1000=92mm\approx90mm$

Maximum Spacing=3d=3x220=660mm

2)300mm whichever is less.

Hence, provide 8mm ø bars at 90mm c/c.

Along y-direction:-

D=220-8=212mm

$M_{uu}=0.87f_yA_{st}d\left[1-\frac{fyAst}{fckbd}\right]$

9.86x106=0.87x415xAstx212 $\left[1-\frac{415.Ast}{15x1000x212}\right]$

$Ast=131.04mm^2$

Using 8mm ø bars, spacing

$S=\frac{ast}{Ast}x1000=\frac{\pi/4x8x8}{131.04}x1000$

=383.58mm

Maximum Spacing=3d=3*212=636mm

2)300mm

So, provide 8mm ø bars at 300mm c/c.

<u>Reinforcement in edge strip:-</u>

Ast=0.12% of gross area

$=\frac{0.12}{100}x1000x250=300mm^2$

$S=\frac{\pi/4x8x8}{300}x1000=165mm$

5d=5x220=1100mm

2) Control Panel:-

$\frac{ly}{lx}$ =11/3=3.66>2

Slab is one-way slab.

Effective d=3500/25=140mm

D=165mm

Effective Span=Clear span+d=3500+140=3.62m

Loads:-

Per unit area of slab.

Self-weight of the slab=0.165x25=4.125kN/m^2

Live load=0.957kN/m^2

Floor finish=0.478kN/m^2

Total load=5.56kN/m^2

Factored load, Wu=1.5x5.56=8.34kN/m^2

Bearing moments and shear forces:-

B.M=M_u=$W_u l^2/8$=8.34x$(3.62)^2$/8=13.66kN-m

S.F=V_u=$W_u l/2$=8.34x3.62/2=15.09kN

Reinforcement:-

Mu=0.87fyAst d$\left[1-\frac{fyAst}{fckbd}\right]$

13.66x10^6 =0.87x415xAstx140$\left[1-\frac{415.xAst}{15x1000x140}\right]$

Ast=286.30mm^2

Minimum reinforcement=0.12/100x1000x165=198mm^2

Ast>Astmin

10mm ø bars ,spacing of bars should be

S=$\frac{ast}{Ast}$ x1000=$\frac{\pi/4x10x10}{286.30}$ x1000=274.32mm≈275mm

Maximum spacing=3x(140)=420mm

So, provide 10mm ø bars of 275mm c/c bend alternate bars at 0.1L free support.

Distribution reinforcement:-

Astmin=198mm2

Spacing=$\frac{\pi/4x8x8}{198}$ x1000=253.86≈255mm.

5d=5x140=700mm & 450mm.

so, provide 8mm ø bars @ 225mm c/c.

3) <u>Sedimentation tank:-</u>

$\frac{ly}{lx}$ =13/5.3=2.45>2

Slab is one-way slab.

d=5300/28=189.2≈190mm

D=215mm.

Effective span=clear span+d

=5300+190=5.49m

<u>Load:-</u>

self wt of slab=0.215x25=5.375kN/m^2

Factored load=Wu=1.5*6.81=10.215kN/m2

<u>Bearing moments and shear forces:-</u>

B.M=M_u=$W_u l^2/8$=10.215x$(5.49)^2$/8=38.48kN-m

S.F=V_u=W_u.l/2=10.215x5.49/2=28.04kN

Reinforcement:-

Mu=0.87fyAst d$\left[1-\frac{fyAst}{fckbd}\right]$

38.48x10^6 =0.87x415xAstx190$\left[1-\frac{415xAst}{15x1000x190}\right]$

Ast=615.94mm^2

Minimum reinforcement=0.12/100x1000x190=228mm2

Ast>Astmin

10mm ø bars, spacing of bars should be

S=$\frac{ast}{Ast}$ x1000=$\frac{\pi/4x10x10}{615.94}$ x1000=127.51mm≈128mm

So, provide 10mm ø bars of 275mm c/c bend alternate bars at free support.

Distribution reinforcement:-

Ast_{min}=228mm^2

Spacing=$\frac{\pi/4x8x8}{228}$ x1000=220.46≈220mm

so, provide 8mm distribution bars @ 220mm c/c.

4) Collection tank:-

Same as sedimentation tank.

$\frac{ly}{lx}$ =13/5.7=2.28<2.

One way slab.

Depth d=5700/28=203.57≈205mm

D=230mm

Effective span=5700+205=5.90m

Loads:-

Self weight of slab=0.23x25=5.75kN/m^2

Total load=7.185kN/m^2

Factored load=Wu=1.5x7.185=10.77kN/m^2

B.M & S.F:-

B.M=$W_u l^2$/8=10.77x5.9x5.9/8=46.86kN-m

S.F=W_ul/2=10.77*5.9/2=31.77kN

96.86x10^6=0.87x415xAstx205$\left[1-\frac{415xAst}{15x1000x205}\right]$

Ast=698.48mm^2

Ast_{min}=0.12/100x1000x205=246mm^2

Ast_{min}<Ast hence ok

Spacing for reinforcement, provide 10mm ø bars.

S=$\frac{\pi/4*8x8}{698.48}$ x1000=112.44≈115mm

So, provide 10mm ø bars@115mm c/c.

Distribution reinforcement:-

Astmin=246mm2

Spacing=$\frac{\pi/4*8x8}{246}$ x1000=204.3≈205mm

So, provide 8mm ø bass@205c/c.

5) Oil & Grease tank:-

$\frac{ly}{lx}$ =$\frac{7.6}{1.5}$=5.06>2.

One way slab.

Effective span=1500+60=2.1m

Loads:-

Self weight of slab=25x0.85=21.25kN/m.

F.F=0.478kN/m^2

L.L=0.957kN/$m^{2.}$

Total load=22.685kN/m^2

Factored Load=W_u=1.5x22.685=34.02kN/m

B.M. & S.F.:-

B.M=M_u=$\frac{34.02x2.1x2.1}{8}$=18.75kN-m

S.F=V_u=$\frac{34.02x2.1}{2}$=35.71kN

Reinforcement:-

$18.75x10^6$=0.87x415xAstx60$\left[1 - \frac{415.Ast}{15x1000x60}\right]$

Ast=1084.59mm^2

Ast_{min}=0.12/100x1000x60=72mm^2

Ast_{min}<Ast hence (OK).

Spacing=$\frac{\pi/4*10x10}{1084.2}$ x1000=72.44≈75mm

So, provide 10mm ø @bars@73mmc/c.

Distribution reinforcement:-

Ast $_{min}$=72mm^2

Spacing=$\frac{\pi/4*8x8}{72}$ x1000=698.13≈700mm

So, provide 8mm ø & bars @ 700mmc/c.

6) BS TANK:-

$\frac{ly}{lx}$ =$\frac{3.4}{1.5}$=2.26>2.

One way slab

d=1500/25=60mm

D=85mm≈90mm

Effective span=1500+60=2.1m

Loads:-

Self weight of slab=0.9*25=22.5kN/m^2

F.F=0.78kN/m^2

L.L=0.951KN/m^2

Total load =23.93KN/m2

Factored load=23.93x1.5=35.90KN/m2

B.M=Mu =$\frac{35.90x2.1x2.1}{8}$=19.78KN-m

S.F=Vu=$\frac{35.90x2.1}{2}$=37.69KN-m

$19.78*10^6$=0.87*415*Ast*60$\left[1 - \frac{415.Ast}{15x1000x60}\right]$

Ast=1084.5mm2

Astmin=$\frac{0.12}{100}$x1000x60=72mm^2

Spacing=73mm

So, provide 10mm ø @ 73mm c/c

And provide distribution bars of 8mm ø @ 700mm c/c.

Design of sidewalls

1) Filtration tank:-

σ=10x4+(16-10)x4=64KN/m^2

Ka=0.33

Pa=Ka*σ=0.33x64=21.12KN/m^2

Max BM at base=$\frac{1}{2}$x1.5x21.12x4x$\frac{4}{3}$=84.48kN-m

d=230mm & D=250mm

84.48x10^6=0.87x415xAstx230$\left[1-\frac{415Ast}{15x1000x230}\right]$

Ast=744mm^2

Astmin=$\frac{0.12}{100}$x1000x230=276mm^2

Ast>Astmin (OK)

Spacing=$\frac{\pi/4}{744}x10x10x1000$=105mm

So provide 10mm Ø bars @105mm c/c spacing

Direct compression in L/B:-

$\frac{w(H-h)B}{2}$=$\frac{10(4.4-3)5.5}{2}$=72KN-m

Water pressure acting from inside no earth pressure:-

Max. water pressure @ base=wH=10x4=40KN/m^2

B.M @ base = $1.5x40x\,\frac{4x4}{2x3}$=159.99 kN-m

d=230mm & D=250mm

159.99x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=1587.06mm2

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{1587.06}x10x10x1000$=49.48≈50mm

So, Provide 50mmc/c spacing of 10mm ø bars

Direct tension in L/B:-

$\frac{3x10x5.5}{2}$=82.5KN

Min. Ast required =300mm^2

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55≈168mm

So, Provide 168mm c/c spacing of 10mm ø bars

Design of short wall:-

d=230-10=220mm

Bottom 1m acts as cantilever and remaining 3m acts act's as slabs supporting on long walls.

P=WH=10x3=30KN/m^2

Max B.M=1.5$x\ \frac{30x4x4}{12}$=160kN-m

Direct tension from 1m @ end of L/W

=30x1=30KN

Net B.M=160-30x0.105=156.85KN

156.85x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=2893.43mm^2

Astmin==$\frac{0.12}{100}$x1000x250=300mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{2893.43}$x10x10x1000=27.14mm

Provide 10mm ø bars @27.14mm C/C spacing

Design of bottom 1m:-

B.M=$\frac{1}{2}$x1.5x4x$\frac{1}{3}$x10=66. 67KN-m

Astmin=300mm2

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{300}$x10x10x1000=261.7mm

Provide 10mm ø bars @261.7mm C/C spacing

Provide distribution reinforcement of 8mm ø bars

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55≈168mm c/c spacing

Pressure of saturated soil no water pressure from inside:-

Direct compression due to cantilever action of 1m length of L/W=36KN

P=36KN/m2

B.M @ support=$\frac{Wxdxd}{12}$=$1.5x\ \frac{36x4x4}{12}$=48KN-m

B.M @ c.c span=36KN-m

48x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=624.7mm^2

Astmin=300mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{624.87}$x10x10x1000=125mm

Provide 10mm ø bars @125mm C/C spacing

Astmin=300mm2

Provide 8mm ø bars

Spacing=$\frac{\pi/4}{624.87}$x8x8x1000=167.55mm

36x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=458.76 mm^2

Astmin<Ast (OK)

Spacing = 171.2mm @ 10mm ø bars

=167.5 mm @ 8 mmø bars

<u>Bottom one meter:-</u>

B.M=48x$\frac{1}{2}$x3x1.5=8KN-m

8x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=97.47 mm^2

Take Ast=300 mm^2

Main reinforcement =$\frac{\pi/4}{300}$x10x10x1000=261.79mm

Distribution reinforcement=$\frac{\pi/4}{300}$x8x8x1000=167.57mm

<u>Base slab:-</u>

Long wall=2x12.4x0.25x4.4x20=504.38kN

S/W=2x5.5x4.8x0.25x25=330kN

Base slab=13.10x6.6x0.4x25=864.6kN

Wt. of earth on projection=2(13.10+6)x4.4x0.3x16

=806.784kN

Total download wt=504.38+330+864.6+806.784

=2505.764kN

Uplift pressure due to pressure of water at bottom of tank=13.10x6.6x4.8x10=4150.08kN

Frictional resistance required=4150.08-2505.764

=1644.316kN

Pressure of submerged earth and water at a depth of 4.8m=(10x4.8+4.8x6x1/3)=57.50kN/m^2

Total pressure per 1m length of walls=1/2x4.8x57.50=138kN/m^2

As the soil saturated , the angle of friction of submerged soil will be low , assuming coefficient of friction as 0.35=0.35x138=48.3kN/m^2

Total frictional resistance of four sides:-

=2(13.10+6.6)x48.3=1903.02kN

1903.02kN>1644.316kN

Consider 1m of length of slab:-

Upward pressure of water per sq.mt=4.8x10=48kN/m^2

Self wt. of slab=1x1x0.4x25=10kN/m^2

Net upward pressure=48-10=38kN/m^2

Wt. of wall per meter run=0.25x4.4x25=27.5kN.

Wt. of earth on projection=16x5.5=88kN/m^2

Net unbalanced force=38x6.6-2(27.5+88x0.3)=143kN.

Reaction on each wall=143/2=71.5kN.

B.M at edge of cantilever span=$\frac{38x0.3x0.3}{2}$+52.712X$\frac{4.4}{2}\left[\frac{4.4}{3}+0.3\right]$-$\frac{88x0.3x0.3}{2}$

=1.17+204.87-3.96

=202.72kN-m.

Overall depth=400mm,effective depth=350mm

202.72x10^6=0.87x415xAstx350$\left[1-\frac{415.Ast}{15x1000x350}\right]$

7.9x10^{-5} Ast^2-Ast+1604.209=0

Ast=1884.86mm2

Astmin=0.12/100x1000x400=4800mm2

Astmin<Ast (Hence ok.)

Spacing=$A=\frac{\pi/4x10^2}{1884}x1000=41.66mm\simeq 42mm$

B.M at center span=$\frac{38}{2}$x$\left[\frac{6.6}{2}\right]^2$+52.71x$\frac{4.4}{2}$X [$\frac{4.4}{3}$+0.3]-[27.5+71.5]x$\left[\frac{6.6}{2} - 0.3 - \frac{0.25}{2}\right]$-88x0.3x[$\left[\frac{6.6}{2} - 0.15\right]$

=206.91+115.96x1.76-99x[2.875]-26.4x[3.15]

=43.214kN-m.

43.214x10^6=0.87x415xAstx350$\left[1 - \frac{415.Ast}{15x1000x350}\right]$

=7.2x10^{-5}Ast - Ast+341.97=0

Ast=350.83 mm^2

Hence Ast=480m^2

Spacing=$\frac{\pi/4}{480}$x10x10x1000=163.62≃165mm of 10mm ø bars

Provide distribution reinforcement of 8mm,

Spacing=$\frac{\pi/4}{480}$x8^2x1000=104.71 ≃105mm c/c spacing.

2) <u>Control panel</u>

σz=10x4.4+6x4.4=70.4kN/m^2

Ka=$\frac{1-sin30}{1+sin30}$ =0.33

Pa=Ka. σz=0.33x70.4=23.23kN/m^2

Max.B.M at base=$\frac{1}{2}$x1.5x23.23x4.4x$\frac{4.4}{3}$=112.43kN-m

Ast=1029.82 mm^2

Astmin=$\frac{0.12}{100}$x1000x250=276 mm^2

Astmin<Ast hence ok.

Provide 10mm ø bars

Spacing=$\frac{\pi/4x10^2}{1029.82}$x1000=76.26mm ≃77mm

So,provide 77mm of 10mm ø bars.

<u>Direct compression in L/W:-</u>

$\frac{W(H-h)B}{2}$ =$\frac{10(4.4-3.4)x3.5}{2}$=24.5kN-m

<u>Water pressure acting from inside no earth pressure:-</u>

Max.water pressure at base=wh=10x4.4=44kN/m^2

B.M @ base =1.5x44x4.4/2x4.4/3=141.97kN-m

D=230mm, D=250mm

141.97x10^6=0.87fy.Ast.d$\left[1-\frac{fy.Ast}{15x1000x230}\right]$

1.23x$10^{-4}Ast^2$-Ast+1209.82=0

Ast=2402.40 mm^2

Astmin=0.12% of gross area

=0.12/100x1000x250=300 mm^2

Astmin<Ast hence ok.

Provide 10mm ø bars

Spacing=$\frac{\pi/4x10^2}{2402.82}$x1000=32.61mm$\simeq$ 35mmspacing

So, provide 10mm ø bars @ 135mm c/c spacing.

<u>Design of bottom 1m:-</u>

B.M=1.5x1/2X4.4X1/3X10=10.89kN-m

Astmin=300 mm^2

Ast=300mm^2

Provide 10mm ø bars

spacing=$\frac{\pi/4x10^2}{624.87}$x1000=216.7mm

So,provide 10mm ø bars @ 216.7mm

Provide distribution reinforcement of 8mm ø

Spacing= $\frac{\pi/4x8^2}{300}$x1000=167.55mm

So ,provide 10mm ø bars of 125mm c/c spacing

Astmin=300mm^2

Provide 8mm ø bars,

Spacing= $\frac{\pi/4x8^2}{300}$x1000=167.55mm

<u>Pressure of saturated soil,no water pressure from inside</u>:-

Direct compression due to cantilever action of 1m length of L/M=36kN

P=36kN/m^2

B.M@ supports=wl^2/12=1.5x36$(4)^2$/12=72kN-m

B.M@ c/c span=36kN-m

72x10^6=0.87fy.Ast.d$\left[1-\frac{fy.Ast}{15x1000x230}\right]$

Ast=624.87 mm^2

Astmin=300mm^2 hence safe.

Provide 10mm ø bars of reinforcement.

Spacing=$\frac{\pi/4x10^2}{624.87}$x1000=125mm

36x10^6=0.87fy.Ast$\left[1-\frac{fy.Ast}{fck.b.d}\right]$

Ast=458.76 mm^2

Astmin<Ast hence ok.

Spacing=171.2mm 2 10mm ø bars

=167.5mm @ 8mm ø bars

Bottom one meter:-

B.M=1.5x48x1/2x1/3=12kN-m

12x10^6=0.87 fy.Ast.d$\left[1-\frac{fy.Ast}{fck.b.d}\right]$

Ast=97.47 mm^2

Take Ast=300 mm^2

Main reinforcement=$\frac{\pi/4x10^2}{300}$x1000=261.79mm

Distribution reinforcement==$\frac{\pi/4x8^2}{300}$x1000=167.55mm

BASE SLAB:-

L/W=1X12.46X0.23X4.4X25=315.23KN

L/W=1X12.46X0.23X4.4X20=252.19KN

B/W=2X3.5X4.8X0.25X25=210KN

BASE SLAB=13.10X4.6X0.4X25=602.6KN

Wt. of earth on projection=2(13.10+4.6)x4.4x0.31x16=747.648KN

Total download wt=315.23+252.19+210+602.6=2127.668KN

Uplift pressure due to pressure of water @bottom of tank

=13.10X4.6X4.8X10=2892.48KN

Frictional resistance required =2892.48-2127.668=764.82KN

Pressure of submerged earth and water @ depth of 4.8m bottom=10x4.8+4.8x6x1/3=57.50KN/m

Total pressure per 1m length of walls=1/2x4.8x57.50=138KN/m^2

As the soil is saturated the angle of friction in saturated soil is less, so assuming co-efficient of friction as 0.35

=0.35x138=48.3KN/m^2

Total friction resistance for 4 sides=2(13.10+4.6)x48.3

=1709.82KN

1709.82>764.82KN (safe)

Consider one meter length of slab

Upward pressure of water per square meter=4.8x10=48KN/m^2

Self weight of slab =1x1x0.4x25=10KN/m^2

Net upward pressure=48-10=38KN/m^2

Wt. of wall per meter run=025x4.4x25=27.5KN

Wt. of earth on projection=16x3.5=56KN/m^2

Net unbalance force =38x4.6-2(27.5+56x0.3)=86.2KN

Reaction on each wall=8602/2=43.1KN

B.M at edge of cantilever span =38x0.3^2/2+52.712x2.2(4.4/3+0.3)-56(0.3x0.3/2)

=1.71+204.87-2.52=204.06KN.m

d=350mm & D=400mm

$204.06x10^6=0.87x415xAstx350\ (1-\frac{415xAst}{15x1000x350})$

Ast=1900mm2

Astmin=0.12/100x1000x400=480 mm^2

Astmin<Ast (OK)

Spacing=$\frac{\pi/4}{1900}x10x10x1000$=42mm

B.M @ center span=$\frac{38}{2}\left[\frac{4.6}{2}\right]^2+52.71x\frac{4.4}{2}\left[\frac{4.4}{3}+0.3\right]-(27.58+43.1)\left[\frac{4.6}{2}-0.3-\frac{0.25}{2}\right]$

$-56x0.3\left[\frac{4.6}{2}-0.15\right]$

=100.51+204.86-132.375-41.16=131.835KN-m

$131.835x10^6=0.87x415xAstx350\left[1-\frac{415Ast}{15x1000x350}\right]$

Ast=1136.21 mm^2

Ast>Astmin (OK)

Spacing=$\frac{\pi/4}{1900}x10x10x1000$=70mm

So provide 10mm ∅ bars @70mm c/c spacing

Astmin=480 mm^2

Spacing=$\frac{\pi/4}{19001}x8x8x1000$=105mm

So provide distribution reinforcement of 8mm ∅ bars @105mm c/c.

3) <u>Sedimentation & collection tank:-</u>

σz=10x4.4+6x4.4

=70.4KN/m2

Ka=0.33

P=Kaxσz=0.33x70.4=23.23KN/m2

Max. B.M @ base=1.5x$\frac{1}{2}x23.23x4.4x\frac{4.4}{3}$=74.95kN-m

d=230mm & D=250mm

74.95x10^6=0.87xfyxAstxdx1 $- \frac{fyAst}{fckbd}$

Ast=1029.82 mm^2

Astmin=$\frac{0.12}{100}$x1000x250=276 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{1029.82}x10x10x1000$=76.26≈77mm

So,Provide 77mm spacing of 10mm ø bars

Direct compression in L/B:-

$\frac{w(H-h)B}{2}$=$\frac{10(4.4-3)5.5}{2}$=27.5KN-m

Water pressure acting from inside no earth pressure:-

Max. water pressure @ base=wH=10x4.4=44KN/m2

B.M @ base = $1.5x44\,\frac{4.4x4.4}{2x3}$=141.97KN-m

d=230mm & D=250mm

141.97x10^6=0.87Fy x Ast x d$\left[1 - \frac{FyAst}{Fckbd}\right]$

Ast=2402.40 mm^2

Astmin==$\frac{0.12}{100}$x1000x250=300 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{2402.40}x10x10x1000$=32.61≈35mm

So, Provide 35mm c/c spacing of 10mm ø bars

Direct tension in L/B:-

$\frac{3x10x5.5}{2}$=82.5KN

Min. Ast required =300 mm^2

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55≈167mm

So, Provide 168mm c/c spacing of 10mm ø bars

Design of short wall:-

d=230-10=220mm

Bottom 1m acts as cantilever and remaining 3m acts act's as slabs supporting on long walls.

P=wH=10x3=30KN/m^2

Max B.M=1.5$x\,\frac{30x4.4x4.4}{12}$=48.4kN-m

Direct tension from 1m @ end of L/W

=30x1=30kN

Net B.M=48.4-30x0.105=45.25kN

45.25x10^6=0.87fy.Ast.d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=586.12 mm^2

Astmin=0.12/100x1000x250=300 mm^2

Ast>Astmin hence ok.

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{586.12}x10x10x1000$=135mm

So, provide 10mm ø bars @ 135mm c/c.

Design of bottom 1m:-

B.M=1.5x1/2X4.4x1/3x10=10 kN-m

Astmin=300 mm^2

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{300}x8x8x1000$=261.7mm.

So, provide 10mm ø bars @ 261.79mm

Provide distribution reinforcement of 8mm ø bars

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55

So, provide 8mm ø bars of 167.55 c/c spacing.

Pressure of saturated soil, no water pressure from inside:-

Direct compressive due to cantilever action of 1m length of L/M=36kN

P=36kN/m^2

B.M @ supports=1.5xwl^2/12=36x4^2/12=72kN-m

B.M @ c.c span=36kN-m

$72x10^6$=0.87fyxAstxd$\left[1-\frac{fy.Ast}{fck.b.d}\right]$

Ast=624.7mm^2

Astmin=300 mm^2

Astmin<Ast

Provide 10mm ø bars

Spacing=$\frac{\pi/4x10^2}{624.87}$ x1000=125mm

So, provide 10mm ø bars @ 125mm c/c

Astmin=300mm^2

Provide 8mm ø bars

Spacing=$\frac{\pi/4x8^2}{300}$x1000=167.55mm

$36x10^6$=0.87fy.Ast.d$\left[1-\frac{fy.Ast}{fck.b.d}\right]$

Ast=458.76mm^2

Astmin <Ast

Spacing=171.2mm @ 10mm ø bars

=167.5mm @ 8mm ø bars

Bottom one meter:-

B.M=1.5x48x1/2x1/3=12kN-m.

$8x10^6$=0.87fy.Ast.d$\left[1-\frac{fy.Ast}{fck.b.d}\right]$

Ast=97.47 mm^2

Take Ast=300 mm^2

Main reinforcement=$\frac{\pi/4x10^2}{300}$x1000=261.79mm.

Distribution reinforcement=$\frac{\pi/4x8^2}{300}$x1000=167.57mm.

Base slab:-

L/W=1x13.46x0.23x4.4x25=340.53kN

B/W l/w=1X13.46X0.23X4.4X20=272.43KN

b/w S/W=2X5.5X4.8X0.25X20=264KN

Base slab=14.10X6.6X0.4X25=930.60KN

Wt. of earth on projection=2(14.10+6.6)x4.4x0.3x16=874.36kN

Total download wt=340.53+272.43+264+930.60=1807.56kN

Uplift pressure due to pressure of water @ bottom of tank=14.10x6.6x4.4x10

=4094.64KN

Frictional resistance required=4094.64-1807.56=2287.08kN

Pressure of submerged earth and waters @ depth of 4.8m
bottom=(10x4.8+4.8x6x1/3)=57.50kN/m^2

Pressure per 1m length of wall=1/2x4.8x57.50=138kN/m^2

As the soil is saturated ,the angle of friction of soil is low, assume coefficient of soil as 0.35

=0.45x138=62.1kN/m^2

Total frictional resistance required in four sides,

=2(14.10+6.6)x62.10

=2570.94kN

2570.94>2287.08kN (safe)

Consider 1m length of slab, upward pressure of water per sq.mt=4.8x10=48kN/m^2

Self wt. of slab=1x1x0.4x25=10kN/m^2

Net upward pressure =48-10=38kN/m^2

Wt. of wall per meter run=0.25x4.4x25=27.5kN

Wt. of earth on projection=16x5.5-2(27.5+88x0.3)=143kN

Reaction on each wall=143/2=71.5kN

B.M at edge cantilever span= $\frac{38}{2}\left[\frac{4.6}{2}\right]^2 + 52.71x\,\frac{4.4}{2}\left[\frac{4.4}{3} + 0.3\right] - (27.58 + 43.1)\left[\frac{4.6}{2} + 0.3\right]$

$-88\left[\frac{0.3x0.3}{2}\right]$ =202.72kN-m

d=350mm,D=400mm.

$202.72x10^6$=0.87fy.Ast.d$\left[1 - \frac{fy.Ast}{fck.b.d}\right]$

Ast=1884.86mm^2

Astmin=$\frac{0.12}{100}$x1000x400=480mm^2

Astmin <Ast hence ok.

Spacing=$\frac{\frac{\pi}{4}x10^2}{1884.86}$x1000=42mm.

B.M @ center span= $\frac{38}{2}\left[\frac{6.6}{2}\right]^2 + 52.71x\,\frac{4.4}{2}\left[\frac{4.4}{3} + 0.3\right] - (27.58 + 71.5)\left[\frac{6.6}{2} - 0.3 - \frac{0.25}{2}\right]$

-88x0.3$\left[\frac{4.6}{2} - 0.15\right]$ =43.214kN-m.

$43.214x10^6$=0.87fy.Ast.d$\left[1 - \frac{fy.Ast}{fck.b.d}\right]$

Ast=350.83 mm^2

Ast=480m^2

Spacing=$\frac{\pi}{4}x10^2$/480x1000=165mm of 10mm ø bars,

Provide distribution reinforcement of 8mm.

Spacing=$\frac{\pi}{4}x8^2$/480x1000=104.71≃105mm c/c spacing.

4)<u>Oil & Grease:-</u>

σz=10x4.4+6x4.4=70.4KN/m^2

Ka=0.33

P=KaZ=0.33x70.4=23.23KN/m^2

Max. B.M@ base=1.5x1/2x23.23x4.4x$\frac{4.4}{3}$=74.94KN-m

D=250mm & d=230mm

74.95x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=1029.82 mm^2

Astmin==$\frac{0.12}{100}$x1000x250=276 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{1029.82}x10x10x1000$=76.26≈77mm

So, Provide 77mm spacing of 10mm ø bars

Direct compression in L/B:-

$$\frac{w(H-h)B}{2}=\frac{10(4.4-3.4)5.5}{2}=27.5\text{KN-m}$$

Direct compression in L/B:-

$$\frac{w(H-h)B}{2}=\frac{10(4.4-3)5.5}{2}=27.5\text{KN-m}$$

Water pressure acting from inside no earth pressure:-

Max. water pressure @ base=WH=10x4.4=44KN/m^2

B.M @ base = $1.5x44\,\frac{4.4x4.4}{2x3}$=141.97KN-m

d=230mm & D=250mm

141.97x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=2402.40 mm^2

Astmin==$\frac{0.12}{100}$x1000x250=300 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{2402.40}x10x10x1000$=32.61≈35mm

So, Provide 35mmc/c spacing of 10mm ø bars

Direct tension in L/B:-

$\frac{3x10x1.5}{2}$=22.5KN

Min. Ast required =300 mm^2

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55≈168mm

So, Provide 168mmc/c spacing of 10mm ø bars

Design of short wall:-

d=230-10=220mm

Bottom 1m acts as cantilever and remaining 3m acts act's as slabs supporting on long walls.

P=WH=10x3=30KN/m^2

Max B.M=$\frac{30x4.4x4.4}{12}$=48.4KN-m

Direct tension from 1m @ end of L/W

=30x1=30KN

Net B.M=48.4-30x0.105=45.25KN

45.25x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=586.12 mm^2

Astmin==$\frac{0.12}{100}$x1000x250=300 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{586.12}$x10x10x1000=135mm

Provide 10mm ø bars @135mm C/C spacing

Design @bottom 1m:-

B.M=1.5x1/2x4.4x1/3x10=10kN-m

Astmin=300mm2

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{300}$x10x10x1000=261.7mm

Provide 10mm ø bars @261.7mm C/C spacing

Provide distribution reinforcement of 8mm ø bars

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55≈168mm c/c spacing

<u>Pressure of saturated soil no water pressure from inside:-</u>

Direct compression due to cantilever action of 1m length of L/W=36KN

P=36KN/m2

B.M @ support=$\frac{Wd^2}{12}$=$1.5x\frac{36x4x4}{12}$=72KN-m

B.M @ c.c span=36KN-m

72x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=624.7 mm^2

Astmin=300 mm^2

Astmin<Ast (OK)

Provide 10mm ø bars

Spacing=$\frac{\pi/4}{624.87}$x10x10x1000=125mm

Provide 10mm ø bars @125mm C/C spacing

Astmin=300mm2

Provide 8mm ø bars

Spacing=$\frac{\pi/4}{624.87}$x8x8x1000=167.55mm

36x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=458.76 mm^2

Astmin<Ast (OK)

Spacing = 171.2mm @ 10mm ø bars

=167.5 mm @ 8 mm ø bars

Bottom one meter:-

B.M=1.5x48x1/2x3=12kN-m

12x10^6=0.87Fy x Ast x d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=97.47mm2

Take Ast=300mm2

Main reinforcement =$\frac{\pi/4}{300}$x10x10x1000=261.79mm

Distribution reinforcement=$\frac{\pi/4}{300}$x8x8x1000=167.57mm

Base slab:-

L/W=1x9.06x0.23x4.4x25=229.21KN

B/w L/W=1x9.06x0.23x4.4x20=183.37KN

S/w=2x1.5x4.8x0.25x25=90KN

Base slab=8.7x2.6x0.4x25=226.2KN

Wt of earth on projection=2(8.7=2.6)4.4x0.3x16=108.48KN

Total download wt=229.21+183.37+90+226.2=728.78KN

Uplift pressure due to pressure of water @ bottom of tank=9.06x2.6x4.8x10=1130.668KN

Frictional resistance required=1130.688-728.78=401.908KN

Pressure of submerged earth & water@ depth of 4.8m bottom=(10x4.8+4.8x6x1/3)=57.50KN/m^2

Total pressure per 1m length of wall=1/2x4.8x57.50=138KN/m^2

As the soil is saturated the angle of friction of saturated soil is less then angle of frictional as 0.35

=0.35x138=48.3KN/m^2

Total frictional resistance for 4 side=2(9.06+2.6)48.3=1126.35KN

1126.25KN > 401.908KN (safe)

Consider one meter length of slab,

Upward pressure of water per square meter=4.8x10=48KN/m^2

Self weight of slab =1x1x0.4x25=10KN/m^2

Net upward pressure=48-10=38KN/m^2

Wt. of wall per meter run=025x4.4x25=27.5KN

Wt. of earth on projection=16x3.5=56KN/m^2

Net unbalance force =38x2.6-2(27.5+24x0.3)=29.4KN

Reaction on each wall=29.4/2=14.7KN

B.M at edge of cantilever span =$\frac{38x0.3x0.3}{2}$+52.712x2.2$\left[\frac{4.4}{3}+0.3\right]-24\left[\frac{0.3x0.3}{2}\right]$

=1.71+204.87-1.08=205.5KN.m

d=350mm & D=400mm

205.5x10^6=0.87x415xAstx350$\left[1-\frac{415Ast}{15x1000x350}\right]$

Ast=1911.20 mm^2

Astmin=0.12/100x1000x400=480 mm^2

Astmin<Ast (OK)

Spacing=$\frac{\pi/4}{19001}x10x10x1000$=42mm

So provide 10mm ø 42mm spacing

27.58 + 14.7

B.M @ center span=$\frac{38}{2}\left[\frac{4.6}{2}\right]^2+52.71x\frac{4.4}{2}\left[\frac{4.4}{3}+0.3\right]-)\left[\frac{2.6}{2}-0.3-\frac{0.25}{2}\right]$

-24x0.3$\left[\frac{2.6}{2}-0.15\right]$

=157.27KN-m

157.27x10^6=0.87x415xAstx350$\left[1-\frac{415Ast}{15x1000x350}\right]$

Ast=1399.20 mm^2

Ast>Astmin (OK)

Spacing=$\frac{\pi/4}{1399.20}x10x10x1000$=56.13mm

So provide 10mm Ø bars @100mm c/c spacing

Astmin=480 mm^2

Spacing=$\frac{\pi/4}{480}x8x8x1000$=105mm

So provide distribution reinforcement of 8mm ∅ bars @105mm

5)**Bars screen:-**

σz=10x4.4+6x4.4=70.4kN/m^2

Ka=0.33,p=Ka. σz=0.33x70.4=23.23km/m^2

Max. B.M @ base=1.5x$\frac{1}{2}$x23.23x4.4x$\frac{4.4}{3}$

=112.425kN-m

d=230mm,D=250mm

112.425x10^6=0.87fy.Ast.d$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=1029.82 mm^2

Astmin=$\frac{0.12}{100}$x1000x250=276mm^2

Astmin <Ast hence ok.

Provide 10mm ø bars,

Spacing=$\frac{\pi/4}{1029.82}x10x10x1000$=77mm

So, provide 10mm ø bars @ 77mm c/c spacing.

Direct compressive in L/M=$\frac{w(H-h)B}{2}$ =$\frac{10(4.4-3.4)1.5}{2}$=7.5kN

Water pressure acting from outside and no earth pressure:-

Max. water pressure @ base=WH=10x4.4=44kN/m^2

B.M @ base=1.5x44X4.4/2X4.4/3=141.97kN-m

D=230mm, D=250mm.

141.97x10^6=0.87fyxAstxd$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=2402.40 mm^2

Astmin=$\frac{0.12}{100}$x1000x250=300 mm^2

Astmin <Ast hence ok.

Providing 10mm ø bars

Spacing=$\frac{\pi/4}{2402.40}x10x10x1000$=35mm

So, provide 10mm ø bars @ 35mm c/c spacing.

Direct tension in L/W:-

Astmin required=300 mm^2

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55mm

So, provide 8mm ø bars @ 168mm c/c spacing.

Design of shot wall:-

D=230-10=220mm

Bottom 1m acts as cantilever and remaining 3.0m acts as slabs supporting on long walls.

P=WH=10x3=30kN/m^2

Max. B.M=1.5x30(4.4^2)/12=72.6kN-m

Direct tension from 1m @ end of L/W=30x1=30kN

Net B.M=72.6-30(0.015)=72.15 kN-m

$72.15x10^6$=0.87fyxAstxd$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=586.12 mm^2

Astmin=$\frac{0.12}{100}$x1000x250=300 mm^2

Astmin <Ast hence ok.

So, provide 10mm ø bars

Spacing=$\frac{\pi/4}{586.12}x10x10x1000$=135mm

So, provide 10mm ø bars @ 135mm c/c spacing.

Design @ bottom 1m:-

B.M=1.5x$\frac{1}{2}$x4.4x$\frac{1}{3}$x10=10 kN-m

Astmin=300 mm^2

Provide 10mm ø . Bars

Spacing=$\frac{\pi/4}{300}x10x10x1000$=261.7mm

So, provide 10mm ø bars @ 261.7mm spacing.

Provide distribution reinforcement of 8mm ø bars.

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55mm c/c spacing.

<u>Pressure of saturated soil,no water pressure from inside :-</u>

Direct compression due to cantilever action of 1m length Of L/W=36kN

P=36kN/m^2

B.M @ supports=1.5xwl^2/12=36(4 ^{2}/12=72kN-m

B.M @ c.c span=36kN-m

72x10^6=0.87fyxAstxd$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=624.7 mm^2

Astmin=300 mm^2

Astmin <Ast hence ok.

provide 10mm ø bars

Spacing=$\frac{\pi/4}{624.7}x10x10x1000$=125 mm

so, provide 10mm ø bars @ 125mm c/c.

Astmin=300 mm^2

Provide 8mm ø bars

Spacing=$\frac{\pi/4}{300}x8x8x1000$=167.55mm c/c spacing.

36x10^6=0.87fyxAstxd$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=458.76 mm^2

Ast>Astmin

Spacing=171.62 ø 10mm bars.

=167.5mm ø 8mm bars.

<u>Bottom one meter:-</u>

B.M=48x1/2x1/3=8kN-m

$8x10^6$=0.87fyxAstxd$\left[1-\frac{FyAst}{Fckbd}\right]$

Ast=97.47 mm^2

Astmin=300 mm^2

Main reinforcement=$\frac{\pi/4}{300}x10x10x1000$=261.79

Distribution reinforcement=$\frac{\pi/4}{300}x8x8x1000$=167.57mm

BASE SLAB:-

L/W=1X4.86X0.23X4.4X25=122.95KN

L/W=1X4.86X0.23X4.4X20=98.36KN

B/W=2X1.5X4.8X0.25X25=90KN

BASE SLAB=4.5X2.6X0.4X25=117KN

Wt. of earth on projection=2(4.5+2.6)x4.4x0.3x16=299.90KN

Total download wt=122.95+98.36+90+117=728.21KN

Uplift pressure due to pressure of water @bottom of tank

=4.5X2.6X4.8X10=561.6KN

Frictional resistance required =728.21-561.6=166.61KN

Pressure of submerged earth and water @ depth of 4.8m bottom=10x4.8+4.8x6x1/3=57.50KN/m

Total pressure per 1m length of walls=1/2x4.8x57.50=138KN/m^2

As the soil is saturated the angle of friction in saturated soil is less, so assuming co-efficient of friction as 0.35

=0.35x138=48.3KN/m^2

Total friction resistance for 4 sides=2(4.5+2.6)x48.3

=685.86KN

685.86KN >166.61KN (safe)

Consider one meter length of slab

Upward pressure of water per square meter=4.8x10=48KN/m^2

Self weight of slab =1x1x0.4x25=10KN/m^2

Net upward pressure=48-10=38KN/m^2

Wt. of wall per meter run=025x4.4x25=27.5KN

Wt. of earth on projection=16x1.5=24KN/m2

Net unbalance force =38x2.6-2(27.5+24x0.3)=29.4KN

Reaction on each wall=29.4/2=14.7KN

B.M at edge of cantilever span =$\frac{38x0.3x0.3}{2}$+52.712x2.2$\left[\frac{4.4}{3}+0.3\right]$-24($\frac{0.3x0.3}{2}$)

=1.71+204.87-1.81=205.5KN.m

d=350mm & D=400mm

205.5x10^6=0.87x415xAstx350(1-$\frac{415xAst}{15x1000x350}$)

Ast=1911.20 mm^2

Astmin=0.12/100x1000x400=480 mm^2

Astmin<Ast (OK)

Spacing=$\frac{\pi/4}{1900}x10x10x1000$=42mm

B.M @ center span=$\frac{38}{2}\left[\frac{2.6}{2}\right]^2+52.71x\frac{4.4}{2}\left[\frac{4.4}{3}+0.3\right]-\frac{27.58+43.}{}1)\left[\frac{2.6}{2}-0.3-\frac{0.25}{2}\right]$

-24x0.3$\left[\frac{2.6}{2}-0.15\right]$=157.27KN-m

157.27x10^6=0.87x415xAstx350$\left[1-\frac{415Ast}{15x1000x350}\right]$

Ast=1399.20mm^2

Ast>Astmin (OK)

Spacing=$\frac{\pi/4}{1399.20}x10x10x1000$=56.13mm

So provide 10mm ∅ bars @56.16mm c/c spacing

Astmin=480mm^2

Spacing=$\frac{\pi/4}{1399.20}x8x8x1000$=105mm

So provide distribution reinforcement of 8mm ∅ bars @105mm

Reinforcement details:-