Design of Raw Water Treatment Plant at Arakkonam Taluk

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Abstract—Water is one of the main factors that contribute human to live. Rain occurs more or less, in right or wrong period causing draught or flood. Therefore, it is necessary to treat water to use when it is shortage. Water treatment plant is one the structure to treat the water. The main aim of this project is to design the water treatment plant for the population of 7600 near the Sitheri Lake with latitude of 13^{0}5'4.84" N and a Longitude of 79^{0}40'36.76" E which is located at Arakkonam taluk, Vellore district, Tamil Nadu. The respective lake site has been analyzed using satellite image and further data about the lake and its site is collected from Public Works Department (PWD) and Municipality. The objectives, scope, general definitions about clariflocculator, rapid gravity filter and underground tank (sump) along with the literature review and methodology for references and significance for water treatment processes are discussed.The complete project comprises the design of water treatment plant units such as clarifloccuator in which the clarifier with a diameter of 11.80 m and the flocculator with a diameter of 6.28 m, Rapid gravity filter with a dimension of 10.5 x 8 m^2 per bed and an underground water tank of dimension 1.7 x 1.4 x 2 m.

Index Terms—Inlet bay, Clariflocculator, Rapid sand filter, Undder ground water tank.

I. INTRODUCTION

Depending on water source (surface water/ground water), water contains various impurities in the form of suspension as well as dissolved matter. Normally inorganic particles, colloids and biological debris such as microorganisms and algae are in suspension and dissolved impurities consist of highly soluble salts, such as carbonates, sulphates and silica etc.Water treatment is collectively, the industrial- scale processes that make water more acceptable for an end- use, which may be drinking, industry, or medicine. Water treatment is unlike (portable water purification sterilization) that campers and other people wilderness areas practice. Water treatment should remove existing water contaminants or so reduce their concentration that their water becomes fit for its desired end- use, which may be safely returning used water to the environment. The process involved in treating water for drinking purpose to provide a safe source of water supply may be solids separation using physical processes such as settling and filtration, and chemical processes such as disinfection and coagulation. For supplying water which is safe and non-harmful to human life, so we are designing the water treatment plant with inlet bay, clariflocculator, rapid sand filter, sump and overhead tank.

II. METHODOLOGY

It starts with literature survey which guides to proceed the project in a proper manner.For designing the water treatment plant, data's are collected and planning are made for perfect design calculation. After knowing all the data's, detailing is given through which a set of conclusion is obtained.

III. MATH

WATER DEMAND

Rate of water supply =25 lit/day (as per Bureau of Indian Standard and World Health Organization)
No. of days =7 (for every week)
Future population =7600 persons
Amount of water supply = (rate of water supply) x (No.of days) x (future population)
=25 x 7 x 7600
∴ Amount of water supply = 1.5MLD
Hence the water treatment plant is designed for 1.5MLD.

INLET SHAFT

Water velocity in the inlet shaft is assumed to be 0.35 m/s.
1.2 x 1.5 MLD = 62.5 x 1.2
= 0.0208 m^3/c.
Area of the shaft = Q/V
= 0.049 m.
Adopt 0.05m or 50 mm (ID) pipe.
The shaft has bell mouth with 0.07 m diameter.
Flow in launder = Q/2 = 0.0104m^3/s
Velocity of the launder = 0.2 m/s (assumed)
Area requirement = 0.0104 /0.2
= 0.052 m^2
Width of the launder = 1.5 m (assumed)
Height of water (SWD) = 0.052 /1.5
= 0.104 m.
Free board launder = 0.3 m (assumed)
Depth of launder = 0.104 +0.3
= 0.404 ≈ 0.4 m

DISTRIBUTION CHAMBER

To distribute the collected water, a distribution chamber is necessary to divide the flow equally. Assuming side water depth (SWD) as 1.0 m with a detention period of 10s,the volume of the chamber is calculated as follows
0.810 x 10 = 8.1 m^3.
The size of the chamber works out to be 3m x 3m.

FLASH MIXER

There will be 2 flash mixers each consisting of three parts
Inlet chamber, Flash mixer chamber,Outlet chamber

a) size of the chamber
Based on the inlet water, the size of chamber can be calculated by assuming the detention period of 30seconds and also by adopting the depth diameter ratio 1.5.
Flow per unit = 0.75 MLD = 0.0086 m^3/s
Volume of flash
Mixing chamber = 31.25/30 = 1.04 m^3.
Adopt depth to diameter ratio as 1.5 (between 1 to 3)
d = 0.95m
SWD = 2.5 m

b) Inlet and Outlet chamber
They shall be of size 1m x 1m. The depth of inlet chamber will be same as that of flash mixer 2.5 m water depth.

c) Power requirement

The amount of power required for the effective functioning of the water treatment plant is to be computed along with the normal temperature of 25^0 c for a detention period of 60 seconds so that the particles can settle down in the specified duration.

$P = (300)^2 (0.89 \times 10^{-3}) (1.04)$

$= 83$ watts

$= 0.083$ Kw say 0.1 Kw

d) Outlet pipe

Let velocity in the outlet pipe be 1.5 m/s (normally it is between 0.8 to 1.8m/s)

For 20% overload

$0.810 \times 1.2 = 1.5(\pi d^2/4)$

$d = 0.87$ m

Adopt a pipe of diameter 900 mm.

CLARIFLOCCULATOR

The unit combines two units, a flocculator and a clarifier, hence the name "Clariflocculator". Clariflocculator shall have two concentric tanks with inner tank serving as flocculation basin and outer tank serving as clarifier.

No.of units = 2

Using M20 grade of concrete $f_{ck} = 20$ N/mm^2

Using Fe415 grade of steel $f_y = 415$ N/mm^2

i) Central shaft

Let the velocity of water in the central shaft of each unit be 1.2 m/s, so for 20% overload the computations are proceeded.

Diameter of the shaft $= \sqrt{(4Q/v.\pi)} = 0.105$m.

Ports for water outlet have of be provided at the top portion of the shaft

Velocity through ports = 1.0 m/s

Total area of opening of ports = 0.0104m^2.

Total no. of ports =4(2 rows of 2 ports)

Area of each port =0.0026 m^2.

c/c spacing of ports $= 1.2 \times \pi/8 = 0.47$ c/c

ii) Flocculator

Flocculator is where the process of flocculation occurs wherein colloids come out of suspension in the form of floc; either spontaneously or due to the addition of clarifying agent. Assuming outer diameter of central shaft to be 345 mm with a detention period of 30 minutes.

Design parameters

Detention time	= 30 minutes
Velocity gradient	= 40 sec^{-1}
SWD (side water depth)	= 2 m
Paddle tip velocity	= 0.4 m/s
Water velocity	= 0.1 m/s
Water temperature	= 25^0c

Design calculations

Volume of flocculator =187.2 m^3

Outer diameter of central shaft =345 mm (assumed)

Area of flocculator =volume/SWD

=93.6 m^2.

D_F is diameter of flocculator, then

$93.600 = \pi/4 [(D_F)^2 - (1.2)^2]$

$\pi/4\, D_F^2 = \pi/4\, (1.2)^2 + 77.625$

$\pi/4\, D_F^2 = 274.505$

$D_F = 6.28$ m.

$A_P = 2P/ C_D(V-v)\, \rho$

$= 11.00$ m^2.

4 drive units required, area of blades =11.00/4=2.75m^2

Width of each blade = 2.75/(3 x 4)
4 blades, 3m height each) =0.229 m.
Value not possible, hence, $P = C_D A_P \rho(V-v)^3/2$
4 blades per arm and 4 arms per rive unit then total no. of blades for 4 drive units is 4 x 4 x 4 =64
Each blade height = 2.5 m
Width = 0.1m
Area, a_p = 0.25 m^2
Total area of blades, A_p = 64 x 0.25 =16 m^2.
Distance from inlet = 4.25 m

V = 2πrn/60
P = $C_D\rho/2\ \ a_p\,[2\pi r_n/60 - 0.25(2\pi r_n)]^3$
266.5 = 309.132 n^3
n = 1rpm
Total area of blades = 60 x (2.5 x 0.1)= 16 m^2.
Cross sectional area of the floculator
=(10.98-1.2)(4) =39.10m^2

iii) Clarifier

Clarifier are the settling tanks built with mechanical means for continuous removal of solid being deposited by sedimentation. It is generally used to remove solid particulates or suspended solids from liquid for clarification and (or) thickening.

Design data:
Detention time = 30 minutes.
Surface overflow rate = 0.54 m^3/m^2.d
Weir loading = 0.5 m^3/m.d.
Side water depth = 1.5 m

Design details:
Volume of tank = 31.25 x 0.5= 15.62 m^3
Area of the clarifier =15.62 /1.5= 10.41 m^2

If Dc is the diameter of the clarifier and 0.2 m thickness of the partition wall between the flocculator and clarifier then outer diameter of the flocculator. = 10.98 + 0.2
= 11.18 m
10.41 = $\pi/4\ ((D_c)^2 - (11.18)^2)$
Dc = 11.75 m
Say 11.8 m.

Design of **V** notch:
The formula for v notch,$q = 8/13(C_d)\ (2g)^{(1/2)}\ (\tan \Theta/2)\ h^{(5/2}$ Total number of V notches
Q/q = $(0.104 \times 1.2) / (2.565 \times 10^{-3})$
= 48.6.

Design of orifices:
C_d = 0.6
a = area of orifice
q = $C_d\ (a)\ (2gh)^{(1/2)}$
= $(0.6)\ ((\pi\ (0.08)^2/4)\ (2 \times 9.81 \times\ 0.04)^{(1/2)}$
= 2.672×10^{-3} m/s
No of orifices = Q/q
= $(0.104 \times 1.2) / (2.672 \times 10^{-3})$
= 46.7

But to achieve more uniform flow along the weir, provide orifices at 0.3 m c/c
No. of orifices = 11.80 x π /0.3
= 123

iv) Peripheral launders

Let velocity of flow in the launder is 0.6 m/s and width of launder be 0.8 m.
For 20 % overload
0.104 x 1.2 / 2 = 0.6 (0.8h)

h = 0.13 m

Provide free board = 0.3 m

RAPID GRAVITY FILTER:

Flow = 1.5 MLD

Rate of filtration = 0.075 m^3/m^2.h

No of beds = 2

Flow per bed = 0.15 MLD

Area of bed = 6.25/0.075

= 83.34 m^2.

Ratio L/ W = 10.5/8 = 1.313

This is the range of 1.11 to 1.66

a) Sand

Provide depth of sand as 3cm, its effective size 0.5mm and uniformity coefficient 1.5

d_{10} size = 0.50 mm

d_{60} size = 0.75 mm

b) Gravel

Depth of gravel = 0.45 m

Size of gravel at top = 2 to 5 mm

Size of gravel at bottom= 50 mm

c) Depth of water

Depth of water above sand surface = 0.03 m

Free board = 0.5 m

Total depth of filter box=1.73 m

d) Under drain system

Provide 2 sections per filter bed

Area of filter per bed =10.5 x 4

Under drain section = 42 m^2

If twin orifice are provided per c/s of lateral at an angle of 30^0 to vertical then,

Spacing of orifice = 1.65/11 = 150 mm c/c

Size of manifold = 250 mm diameter

Spacing of laterals = 10.5/2.5= 420 mm c/c

e) Backwashing of filter

Rate of backwash = 9 lit/m^2. Minute

Rate of air wash = 12 lit/m^2.

f) Inlet pipe for each filter bed

Inlet flow per bed = 150 m^3/ day

For 20 % overload (Q) =180 m^3/ day = 0.00208 m^3/ s

For velocity of flow of 1.0 m/s

Diameter of pipe (d) = 60 mm

g) Filter water outlet pipe per section of filter bed

Outlet flow per section = 75 m^3/ day

For 20 % overload (Q) =90 m^3/ day = 0.00104 m^3/ s

For velocity of flow of 1.2 m/s

Diameter of pipe (d) = 40 mm

h) Filter water outlet pipe per bed

For 20 % overload (Q) =0.00208 m^3/ s

For velocity of flow of 1.2 m/s

Diameter of pipe (d) = 50 mm

i) pure water pipe for all the 2 beds

Total flow = 1500 m^3/ d

Q = 0.0208 m^3/ s

For velocity 1.2 m/s d = 200 mm

IV. CONCLUSION

The water treatment plant has been designed by using Limit State Method.

During this design project we learned various methodology and basic design concept from which we designed clariflocculator of internal and external diameter of 6.28 m and 11.80 m respectively, Rapid Sand Filter with a dimension of 10.5 x 8 m per bed and an underground water tank of dimension 1.7 x 1.4 x 2 m.

A conclusion section is usually required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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REFERENCES

[1] Bureau of Indian Standards(BIS)
[2] Dr.Anand Bhole, "Design of water treatment plant"
[3] IS 3370 part(i,ii,iii,iv):1965
[4] IS 456:2000, "Indian standard code of practice for plain and reinforced concrete"
[5] Islamic university of Gaza, Water treatment EENV4331,Lecture 4:sedimentation Dr.Fahid Rahah
[6] IWTC8 2004, Alexandria(Eighth International Water Technology Conference) PRILIMINARY DESIGN OF WATER TREATMENT UNIT
[7] SP 16, "Design Aids For Reinforced Concrete"
[8] S.Chand, "RCC Elements"
[9] S.K.Garg, "Water Supply Engineering"
[10] Spectral analysis of pressure variation during combined air and water backwash of rapid gravity filters. David Hall, Caroline S.B.Fitzpatrick() December 1999,vol.33(17):3666-3672
[11] WEF Manual of Practice No.FD-8 Second Edition prepared by clarifier Design Task Force of the Water Environment Federation
[12] WHO 1993,Guidelines for drinking –water quality :*Volume 1*