9000 KL CLEAR WATER SUMP DESIGN IN WATER TREATMENT PLANT

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ABSTRACT

Both inherent natural variability and model parameter uncertainty must be considered in the development of robust and reliable designs for drinking water treatment. This study presents an optimization framework for investigating the effects of five variable influent parameters and three uncertain model parameters on the least-cost treatment plant configuration contact, direct, or no sweep conventional filtration that reliably satisfies an effluent particulate matter concentration constraint. Incorporating variability and uncertainty within the decision-making framework generates information for investigating: 1) impact on total cost and treatment reliability; 2) shifts on the least-cost treatment configuration for providing reliable treatment; and 3) the importance of the individual variable and uncertain parameter distributions for reliably satisfying an effluent water quality constraint. Increasing the magnitude of influent variability and model parameter uncertainty results in a greater expected design cost due, generally, to increases in process sizing required to reliably satisfying the effluent concentration constraint. The inclusion of variability and uncertainty can also produce a shift in the locations of the least-cost configuration regions, which are dependent on the expected influent water quality and the magnitude of variability and uncertainty. The additional information provided by incorporating the variable and uncertain parameters illustrates that parameter distributions related to the primary removal mechanism are critical, and that contact and direct filtration are more sensitive to variability and uncertainty than conventional filtration.

Water Sump'', at Jurala dam near 70 MLD WTP

Preamble:

The Government of Telengana had taken up the drinking Water schemes on top priority. The water grid programme is planned with segments by taking various perennial sources. The objective of the scheme is to provide quality drinking water to all the rural and urban people. The Mahaboobnagar Segment 2 (Gadwal) in Mahaboobnagar District (primary grid) is part of the Telangana Water grid program.

The Clear Water Sump cum pump house

General

The present document covers the Design of the 9000 KL Clear water sump. This Design is based on the IS Codes & Standards and Construction materials. The design is carried out with different load combinations. The minimum cover is provided as per IS 3370-2009.

Salient features

Clear Water sump CWS Capacity Type

Size of the CWR

Depth of water Free Board

Depth of Foundation Avg.G.L.

Design Criteria & Specifications :9000 KL.

: Rectangular :60 m

:60 m

:2.8 m(Including height of dead storage):0.6 m

:3.1 m : + 321.800 m

Basic considerations in design of structures are its stability, serviceability, durability, safety and over all economy satisfying to the relevant IS codes of practice & specifications. All the elements of the structure in contact with water are designed as uncracked section.

Codes & Standards -- Code of practice for plain & reinforced concrete

IS 456 - 2000

IS 875 - 1987 -- Design Loads for Buildings and Structures

IS 3370 - (Part I to IV) -- Code of practice for Concrete structures for storage of liquids

Material of Construction

The following materials has been proposed for the construction of the CWR :

Grade of concrete M 30

Grade of steel Fe 500

PCC M 15

Loads

Dead Load [DL]

The weight of all permanent construction including Slab, Beam, Walls and other components are considered.

The unit weight of materials are in accordance with IS: 875 (1987). However following unit weight

has been considered for the design purpose.

Concrete (RCC): 25 kN/m³

water : 21 kN/m³ (bulk density)

: 10 kN/m³

Live Load [LL]

Water Load [WL]

Total depth of water including freeboard is considered for calculating the weight of water and hydrostatic pressure for designing of the structure.

Earth quake Load (EQ)

Jurala dam falls in Seismic ZONE :- II as per the IS-1893:2002, Part1, accordingly design has been checked and the stresses are less than the permissible.

Wind Load

The structure is not checked for wind load as height of the structure is less than 10.0 m.

Design Method

All Structural Elements are designed by Working stress Method.

DESIGN OF RECTANGULAR, CLEAR WATER RESERVOIR

Ground Level = + 321.800 m

MWL = + 322.000 mm

Depth of water in the reservoir = 2.70 m

LWL = + 319.300

Dead storage in the reservoir = 0.100 m

Free board as per site condition = 0.600 m

Total height of water = 2.8 m

Total height of wall (H) 2.7+0.6+0.1 = 3.400 m

Thickness of roof slab Continuous = 0.20 m

No of columns = 225 No's

Size of internal column Width = 0.30 m

Depth = 0.30 m

Length along longer direction - (L) = 60.00 m

Breadth along shorter direction - (B) = 60.00 m

Haunch 500 x 500

External wall

Thickness Wall at bottom = 0.45 m

Thickness Wall at top = 0.30 m

Width of Toe = 1.00 m

Width of Heel = 1.00 m

Foundation thickness = 0.50 m

Foundation thickness for columns = 0.50 m

External wall at Suction Pit portion

Thickness Wall at bottom = 0.750 m

Thickness Wall at Middle = 0.450 m

Thickness Wall at top = 0.300 m

Width of Toe = 2.000 m

Width of Heel = 1.000 m

Thickness of raft under side wall = 0.600 m

Thickness of raft at suction pit wall = 0.750 m

Sump Depth = 1.75 m

Width = 8.80 m

Suction pit

Depth = 1.75 m

Width = 2.60 m

Unit weight of Concrete = 25 kN/m³

Unit weight of water = 10 kN/m³

Unit weight of soil = 21 kN/m³

SBC of soil required = 15 kN/m²

Angle of internal friction $\phi = 30^0$

Ka = (1-sinϕ)/(1+sinϕ) = 0.333

CAPACITY CALCULATIONS

Total volume of water =2.7 x 60 x 60 = 9720 m³

Deductions:

Volume of Columns =225 x0.3 x 0.3 x 2.7 = 54.675 m³

Haunch portion =2 x 120 x 0.5 x 0.5/2 = 30 m³

Partition wall = m³

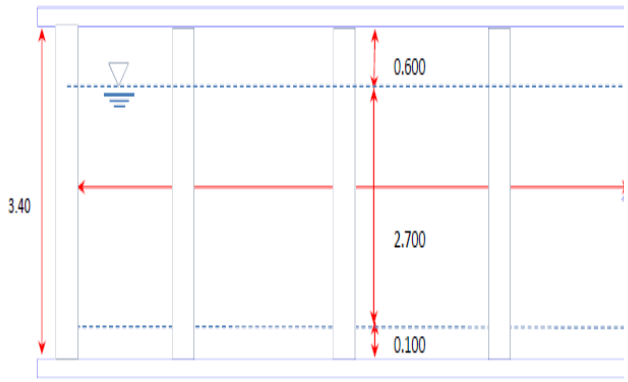
Pipe support portion (Assumption) - for 2 pipes 8.75 m³

Staircase (Assumption) - for 1 dog-legged staircase 10 m³

Total deductions = 103.42 m³

Net Capacity of tank =9720 - 103.423 = 9616.58 m³

Total net capacity of the tank available = 9617 m^3



Design Constants

Grade of steel Fe 500

m = 280/(3*σcbc) k = (m*σcbc)/[(m*σcbc)+σst]

j= 1-k/3 Q= 0.5*k*j*σcbc

σcbc 10 N/mm² m 9.3333 j 0.8607

σst 130 N/mm² k 0.4179 Q 1.7984

σcbc 10 N/mm² m 9.3333 j 0.9038

σst 230 N/mm² k 0.2887 Q 1.3046

Minimum percentage of steel 0.35 %

-- Permissible stresses in Concrete for Water Retaining Structures-(For No Crack Condition)

(As per Table 1 of IS 3370 Direct Tension stress (Part 2) : 2009) ft = 1.5 N/mm²

Tension due to Bending stress fbt = 2 N/mm²

DESIGN OF EXTERNAL WALL OTHER THAN SUMP PORTION

For the 450 mm thick wall:

Case 1. DMeopmthe ncot ndsuied etroe wd afoter rw parteesrs upree sasluornee = 0.5 * γ 2.80 m w* H * H * H/3

= 0.5 x 10 x 2.8^3 / 3

M = 36.59 kN-m

Over all thickness of wall required √(6M/fb) = 331.3 mm Okay

Effective depth of section available = 394 mm

Thickness of wall provided = 450 mm

Cover to the reinforcement = 50 mm

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Area of steel required M/(σst j d) = 830 mm²

Percentage of steel = 0.211 %

Main reinforcement:

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 787.5 mm²

The spacing of bars required at the bottom face = 136.265 mm C/C

Provided spacing of bars = 100 mm C/C

Area of steel provided at the bottom = 1131.00 mm²

Distribution Reinforcement:

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 787.5 mm²

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

DESIGN OF EXTERNAL WALL OTHER THAN SUMP PORTION

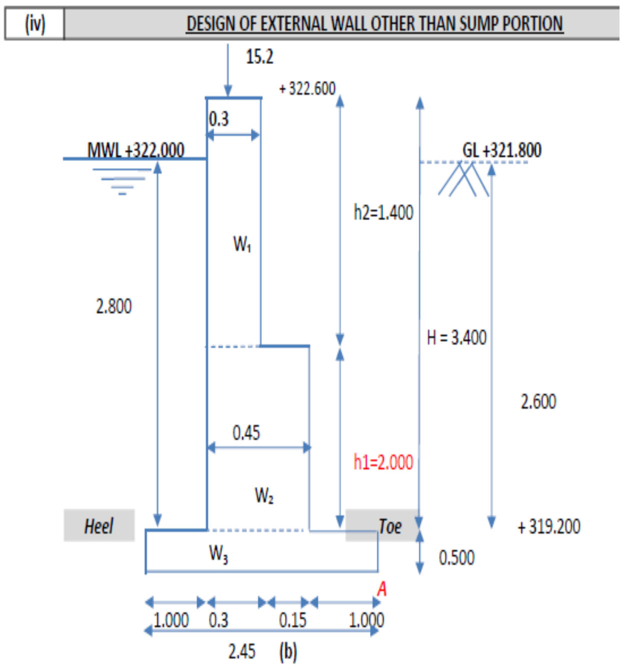


Fig: design of external wall other than sump portion

MWL +322.000 GL +321.800

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The spacing of bars required at the bottom face = 143.619 mm C/C

Provided spacing of bars = 125 mm C/C

Area of steel provided at the bottom = 904.80 mm²

Case 2. Maximum bending moment at bottom of wall due to soil pressure:

Height of soil below ground level h == 0.5 * Ka *2 γ.60 w* h * h * h/3

= 0.5 x 0.333 x 21 x 2.6^3 / 3

M = 20.485 kN-m

Over all thickness of wall required √(6M/fb) = 247.9 mm Okay

Thickness of wall provided = 450.00 mm

Effective thickness of section available = 394 mm

Cover to the reinforcement = 50 mm

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Area of steel required M/(σst j d) = 464.67 mm²

Percentage of steel = 0.2 %

Main reinforcement:

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 787.5 mm²

The spacing of bars required at the bottom face = 143.6 mm C/C

Provided spacing of bars = 100 mm C/C

Area of steel provided at the bottom = 1131.00 mm²

Distribution Reinforcement

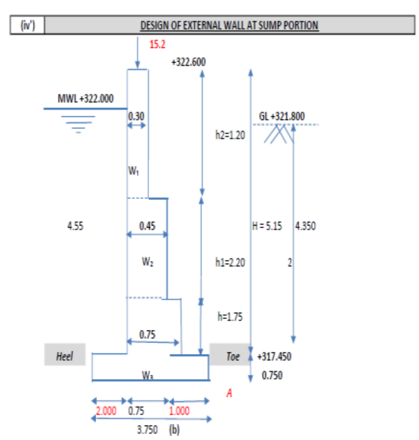

Fig: design of external wall at sump portion

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 787.5 mm²

The spacing of bars required at the bottom face = 143.6 mm C/C

Provided spacing of bars = 125 mm C/C

Area of steel provided at the bottom = 904.80 mm²

For the 300 mm thick wall:

Case 1. HMeoigmhetn otf d0u.3e m to twhaictke rw parllessure alone == 0.5 * γ 1.700 m w* H * H * H/3

= 0.5 x 10 x 1.7^3 / 3

M = 8.188 kN-m

Over all thickness of wall required √(6M/fb) = 156.7 mm Okay

Thickness of wall provided = 300 mm

Effective depth of section available = 244 mm

Cover to the reinforcement = 50 mm

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

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Area of steel required M/(σst j d) = 299.9 mm²

Percentage of steel of steel provided = 0.123 %

Main reinforcement:

Minimum percentage of steel required = 0.35 %

Area of steel required = 525 mm²

The spacing of bars required at the bottom face = 215.4 mm C/C

Provided spacing of bars = 200 mm C/C

Area of steel provided at the bottom = 565.50 mm²

Distribution Reinforcement:

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 525 mm²

The spacing of bars required at the bottom face = 215.400 mm C/C

Provided spacing of bars = 200 mm C/C

Area of steel provided at the bottom = 565.50 mm²

Case 2. Maximum bending moment at bottom of wall due to soil pressure:

Height of soil below ground level h == 0.5 * Ka *0 γ.60 w* h * h * h/3

= 0.5 x 0.333 x 21 x 0.6^3 / 3

M = 0.252 kN-m

Effective depth of section available = 244 mm

Thickness of wall provided = 300.00 mm

Over all thickness of wall required √(6M/fb) = 27.5 mm Okay

Cover to the reinforcement = 50 mm

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Main reinforcement:

Area of steel required M/(σst j d) = 9.23 mm²

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 525 mm²

The spacing of bars required at the bottom face = 215.4 mm C/C

Provided spacing of bars = 200 mm C/C

Area of steel provided at the bottom = 565.50 mm²

Distribution Reinforcement:

Dia of bars proposed to be used = 12 mm

Area of each bar = 113.1 mm²

Minimum percentage of steel required = 0.35 %

Minimum area of steel required = 525 mm²

The spacing of bars required at the bottom face = 215.4 mm C/C

Provided spacing of bars = 200 mm C/C

Total height of the stair case 3.600 m

No. of flights 2

No. of landings 2

Height of flight 2.400 m 1200

Height of bottom flight 1.2 m

Thickness of landing slab 200 mm

Length of landing 1000 mm

Width of landing 900 mm 4

Thickness of the waist slab 200 mm

Total width of the staircase 2100 mm

Riser, R 150 mm Tread, T 300 mm 1200

Cover to the reinforcement 45 mm

2100

Therefore,Length of each flight 4 m

Assuming it to be a simply supported slab,

5.124 (Inclined length)

Load Calculation

Wt. w' on slope = 5 kN/m

Wt. w_1 per horizontal m run = 5.59 kN/m

Wt. of each step = 0.563 kN/m

Wt. w_2 of steps per horizontal meter run 1.877 kN/m

Total dead wt. per m run = 7.467 kN/m

Live load = 1.5 kN/m²

= 1.5 kN/m

Hence, total load w, per horizontal m run 8.967 kN/m

Moment & Shear force calculations

Max. moment obtained = 29.429 kN-m

Max. shear obtained = 22.973 kN

Eff. depth provided = 147 mm

Depth required for uncracked condition √[M/(Qb)]

= 127.9 mm OK

Main R/F

Area of steel required, Ast = M/(σst j d) = 1789.2 mm²

Min. area of steel = 350 mm²

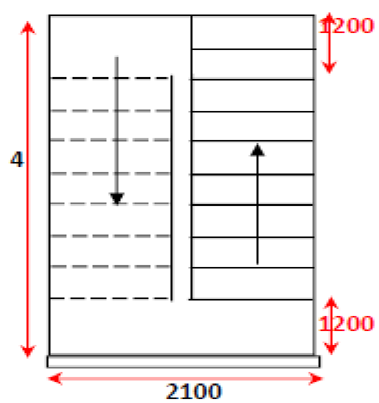
Dia of main reinforcement = 16 mm

Area of single bar, Ab = 201.1 mm²

Spacing of the bars required = 112.4 mm

DESIGN OF DOG-LEGGED STAIR CASE INSIDE THE SUMP

DESIGN OF STAIR CASE



Say 110 mm

Percentage of steel, Pt = 1.244 %

Distribution R/F

Dia of distribution reinforcement = 10 mm

Area of single bar, Ab = 78.5 mm²

Spacing of the bars required = 200 mm

Say 150 mm

Check for Shear

Max. shear force obtained, V = 22.973 kN

Shear stress obtained, τv = 0.156 N/mm²

Value for k = 1.2

τc = 0.445 N/mm²

Permissible shear stress, kτc 0.534 N/mm²

Hence, no shear reinforcement is required.

(ii)Simply Supported beam dimensions Width 0.300 m

Depth 0.450 m

Length 2.1 m

Load on beam, udl, due to the stair case = 8.967 kN/m

Max. moment, wL²/8 = 4.943 kN-m

Max. shear force, wL/2 = 9.415 kN

Cover to the reinforcement = 45 mm

Eff. Depth provided = 397 mm

Overall depth required for uncracked section 6.6 mm OK

Reinforcement details

Area of steel required, Ast = M/(σst j d) = 111.3 mm²

Min. area of steel = 787.5 mm²

Dia of main reinforcement = 16 mm

Area of single bar, Ab = 201.1 mm²

No. of bars required = 3.92

Say 4

Percentage of steel, Pt = 0.596 %

Provide main steel of 16mm dia bars of 4 no.s.

DESIGN OF SIMPLY SUPPORTED BEAM, SB_1

Check for shear

Max. shear obtained = 9.415 kN

Shear stress, τv = V/bd = 0.079 N/mm²

Permissible stress, τc = 0.334 N/mm²

(For Pt = 0.596%) OK

Area of shear reinforcement, Asv = 157.08 mm²

Spacing required = 0.87 fy Asv / (0.4 b) = 569.4 mm

Min. shear spacing 1) 300 mm

2) 0.75 d = 290 mm

Provide 2L-10mm dia stirrups at 200mm spacing.

Provide 2L - 10 mm φ, Vertical Stirrups

CHECK FOR UPLIFT

DATA:-

Unit wt. of concrete = 25 kN/m²

Unit wt. of water = 10 kN/m²

Unit wt. of soil = 21 kN/m²

Ground level = + 321.800 m

Water table at = + 318.650 m

Capacity of CWS = 9617 m³

Length along longer direction-(L) = 60 m

Length along shorter direction-(B) = 60 m

Thickness of roof slab = 0.200 m

Length of roof slab along longer direction-(L) = 60 m

Length of roof slab along shorter direction-(B) = 60 m

Thickness of vertical wall Top = 0.30 m

Bottom 0.45 m

Height of wall = 3.40 m

Thickness of raft = 0.500 m

Length of foundation slab along longer direction-(L) = 62.90 m

Length of foundation slab along shorter direction-(B) = 63.20 m

Depth of soil on raft = 2.60 m

Size of column Width = 0.30 m

Depth = 0.30 m

No of columns = 225 No's

Size of beam Width = 0.300 m

Depth = 0.00 m

Length of beam = 6 x 60.3 + 5 x 60.3 = 663.3 m

Weight of Roof slab = 2 x (60 + 60) x 0.2 x 25 = 1200 KN

Weight of Vertical wall =0.3 x 1.7 x 2 x 60.3 x 25 = 1537.650 KN

=0.45 x 1.7 x 2 x 60.45 x 25 = 2312.213 KN

Weight of foundation =63.2 x 62.9 x 0.5 x 25 = 49691 KN

=60 x 2.45 x 0 x 25 = 0 KN

=60 x 3.75 x 0.25 x 25 = 1406.25 KN

Weight of columns =225 x 0.3 x 0.3 x 3.1 x 25 = 1569.375 KN

Weight of beams =663.3 x 0.3 x 0 x 25 = 0 KN

Weight due to Haunches =0.5 x 0.5 x 0.5 x 4 x 60.45 x 25 = 755.625 KN

Weight of stair case (assumed) = 50 KN

Weight of soil on raft =360 x 2.6 x 21 = 19656 KN

Weight of Head room slab =0.15 x 4 x 4.4 x 25 = 66 KN

Weight of Head room Beam =0.3 x 0.4 x 14.4 x 25 = 22.8 KN

Weight of Head room Column =0.3 x 0.3 x 4.2 x 25 = 66.15 KN

Total Down ward load = 78333.063 KN

Area of raft = 3975.28 m²

Total downward pressure = 19.70504 KN/m²

Uplift pressure = 10 KN/m²

Considering the 100 % uplift pressure

Ratio = 1.971

> 1.200 Check: Structure is safe for uplift pressure

CHECK FOR UPLIFT

Extra depth foundation at side

Extra depth foundation at side

CONCLUSION:

By implementing this project it can be ensured the availability of adequate quantity of drinking water of acceptable quality on long-term basis. The long-term objective of improvement of health of the people in the project area results in the overall development.

The project deserves to be considered on priority to save the people from Fluorosis that is crippling the abilities of the people in the project area. This project would especially cater to the health needs of the women and children who are the most essential target groups for any development to be meaningful and permanent and as well as the socio economic growth of the district.

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