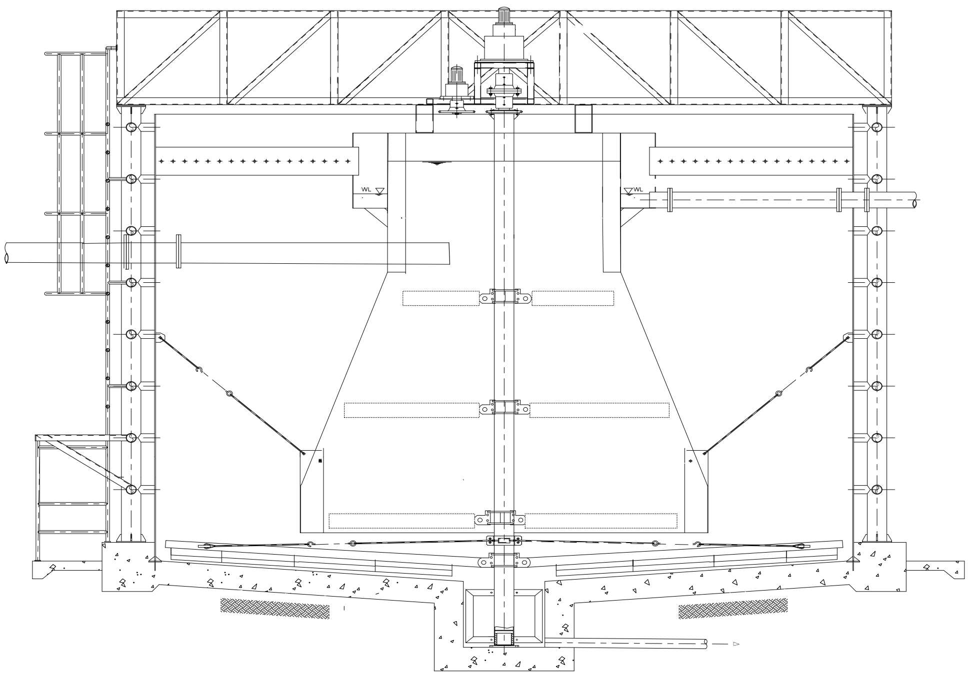
การออกแบบถัง Solid Contact Clarifier Tank

(Sludge Recirculation)

สำหรับน้ำประปาขนาด 150 ลูกบาศก์เมตรต่อชั่วโมง



SOLID CONTACT CLARIFIER

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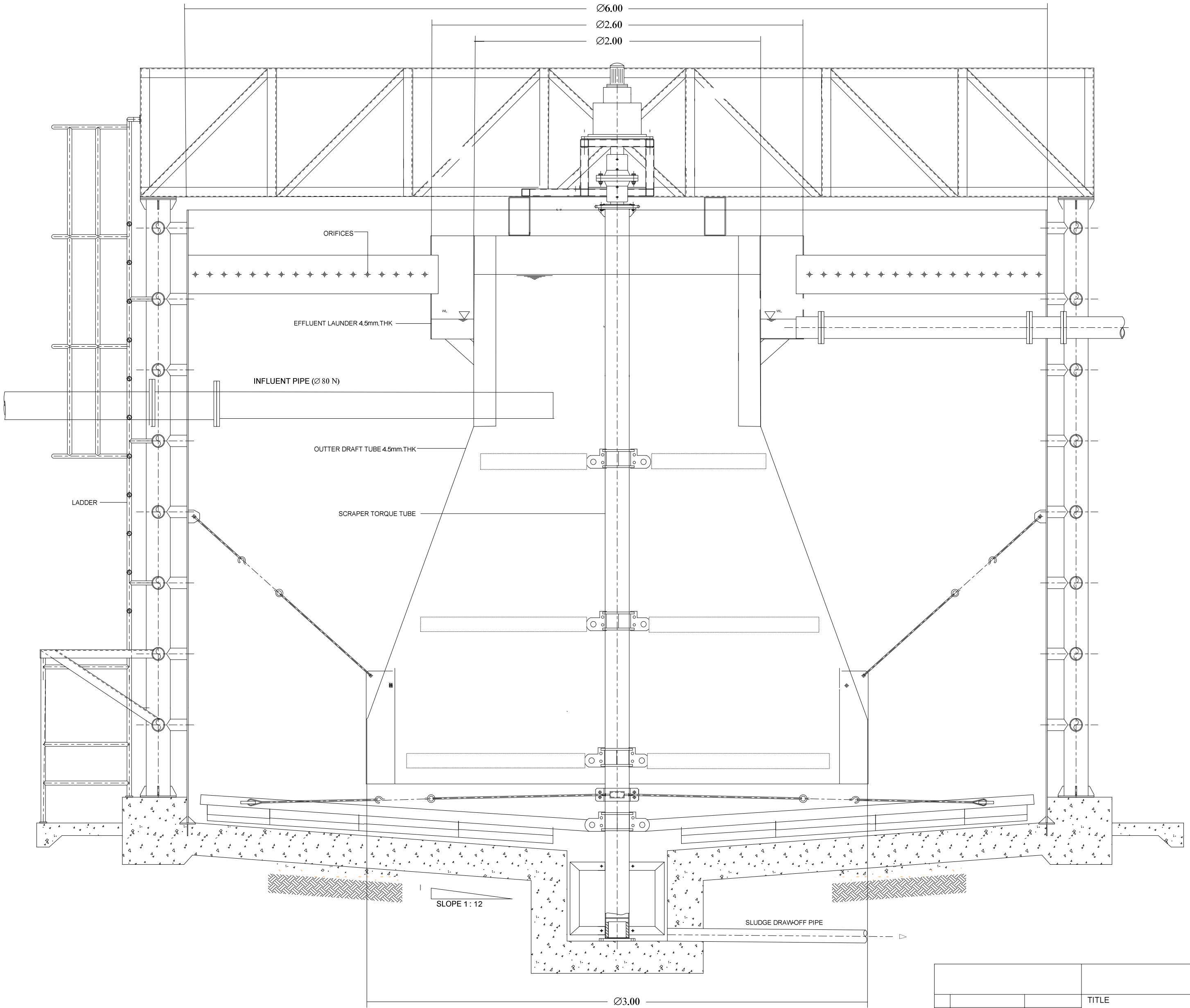


SOLID CONTACT CLARIFIER

DATE	TITLE
	DRAWING No.

DESIGN CALIFIER TANK

(SLUDGE BLANKET CLARIFIER TYPE : VERTICAL SLUDGE BLANKET)

1. Flow Rate

Q = 150 m^3/hr

2. Raw Water Quality input

1	Turbidity	=	NTU
2	pH	=	
3	Alkalinity	=	mg/l as $CaCO_3$
4	Temperature	=	^{o}C
5	Fe		mg/l
6	Mn		mg/l
7	Total Hardness		mg/l as $CaCO_3$

3. Design Criteria

3.1. Kawamura

3.1.1	Flocculation Time	=	approximate = 20 min	
3.1.2	Settling Time	=	1 - 2 hr	
3.1.3	Surface Loading	=	2 - 3 m/hr	
3.1.4	Weir Loading	=	7.3 - 15 m^3/hr	
3.1.5	Upflow Velocity	=	< 10 mm/min	
3.1.6	Slurry Circulation rate	=	up to 3 - 5 time the raw water inflow rate	
3.1.7	G	=	30 - 50 s^{-1}	
3.1.8	MAXIMUM MIXER TIP SPEE		0.9 m/s	(Baffled Channel)
		=	0.9 m/s	(Horizontal Shaft with Paddles)
		=	1.8 - 2.7 m/s	(Vertical Shaft with Paddles)

Equation $\boxed{mixer\ tip\ speed \quad = \quad \pi DN}$

3.1.9	Free Board is approxim	=	0.6 m	
3.1.10	Water Depth	=	4 - 5 m.	
3.1.11	Length and Width ratio	=	6 : 1 (minimum 4 : 1)	(Rectangular Basin)
3.1.12	Width and Water Deptł	=	3 : 1 (maximum 6 : 1)	(Rectangular Basin)
3.1.13	Blade area/Rapid Mixing Tank area = 0.1 - 0.2 %			(page 121)
3.1.14	Blade : Diameter Blade/Diameter Mixing Tank = 0.2 - 0.4			(page 121)
3.1.15	Shaft rpm	=	8 - 12	

3.2. Q'Sim

3.2.1	Detention Time	=	2 Hr
3.2.2	Surface Loading	=	2 - 4 m/hr
3.2.3	Weir Loading	=	7.1 m^3/m.hr

3.3. Sheet Master Degree of Environmental Engineering

3.3.1	Weir Loading	=	7.1 m^3/m.hr
3.3.2	Surface Koading		
	- Q < 0.35 m^3/min	=	0.5 - 1.0 m/hr

- $Q > 0.35\ m^3/min$ = 1.25 - 1.85 m/hr

3.3.3 Water Depth = 3 - 5 m.

3.3.4 Paddle radius = 65 - 75% of radius for Flocculator

3.3.5 Detention Time = 1 - 3 Hr

3.3.6 Diameter Tank < 45 m

3.3.7 Paddle at bottom tank high bottom = 15 - 30 cm

3.3.8 Paddle Velocity = 2 - 3 rpm

3.3.9 Effective Paddle Area = 10 % Sweep area of the fllocculator

3.4. Water Work Engineering Book

3.4.1 Flocculation

2.4.1.1 Detention Time = 20 - 60 min

2.4.1.2 Velocity Gradie = 15 - 60 S^{-1}

2.4.1.3 GT = $1x10^4$ - $15x10^4$

2.4.1.4 Periperal Velocity of Paddle = 0.3 - 0.6 m/s

2.4.1.5 Shaft rotation speed = 1.5 - 5 rpm

3.4.2 Sedimetation (Coagulation)

2.4.2.1 Detention Time = 2 - 8 hr

2.4.2.2 Surface Loadin = 20 - 40 m^3/m^2.day

2.4.2.3 Weir Loading = 200 - 300 m^3/m.day

3.4.3 Sedimentation (Softening)

2.4.3.1 Detention Time = 1 - 6 Hr

2.4.3.2 Surface Loadin = 40 - 60 m^3/m^2.day

2.4.3.3 Weir Loading = 250 - 350 m^3/m.day

3.5 Clarifier Design (Water Poluttion Control Federation 1985)

3.5.1 Detention Time Flocculator central well = 20 - 30 min

3.5.2 Weir Loading (outlet) = 100 to 150 m^3/m^2.day

3.5.3 Radial inner feed well = 10 to 13% of the tank radius

3.5.4 velocity gradient = 30 - 50 S^{-1}

4 GiveContact Time in Hopper inside (Flocculation Zone) = 30 min

5 Flow Rate = 150 m^3/hr

6 Volume in Hopper inside = $Q \ x \ t$

= 75 m^3

7 Give Detention Time in Hopper outside (Sedimentation Zone = 2 Hr

8 Volume in Hopper outside = $Q \ x \ t$

= 300 m^3

9 Calculation Diameter Hopper inside

Give D_1 = 3 m

Surface Area = $\frac{\pi D^2}{4}$ m^2

$\therefore$ A_1 = 7.06858 m^2

10 Theory Volume of Conical Basin = $\frac{d}{3}\left(A_1 + A_2 + \sqrt{A_1 \ x \ A_2}\right)$

Give Water Depth = 5 m

Volume Hopper inside = 75 m^3

Then 45 = 7.06858 + A_2 + 2.658681 $\sqrt{A_2}$

0 = -37.9314 + A_2 + 2.658681 $\sqrt{A_2}$

$\therefore$ $(A_2)^{1/2}$ = 4.97134

A_2 = 24.7142 m^2

Theory Surface Area = $\frac{\pi D^2}{4}$

$\therefore$ $D_2{}^2$ = 31.4671

D_2 = 5.60956 ≈ 6 m.

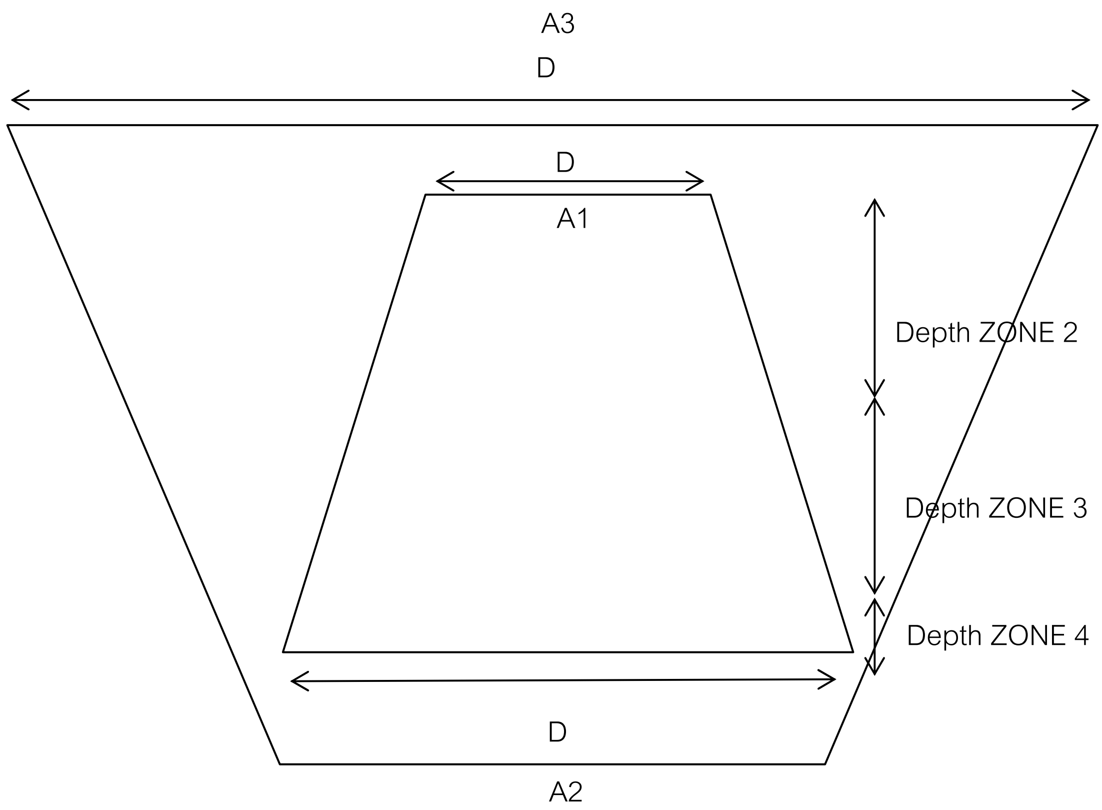
Then D_1 = 3 m.

D_2 = 6 m.

Water Depth = 5 m.

	Free Board from Design Criteria	=	0.6	m	(Kawamura)
∴	Solid Contact Clarifier Tank Height	=	5.6	m	

ZONE2



158.7942

11 Actual Volume in Hopper inside

Theory Volume of Conical Basin = $\frac{d}{3}\left(A_1 + A_2 + \sqrt{A_1 \, x \, A_2}\right)$

A_1 = $\frac{\pi D^2}{4}$ = 7.068583 m^2

A_2 = $\frac{\pi D^2}{4}$ = 28.27433 m^2

Calculate Acture Volume in Hopper inside

Volume in Hopper inside = $\frac{d}{3}\left(A_1 + A_2 + \sqrt{A_1 \, x \, A_2}\right)$

= 82.46681 m^3

12 Acture Contact Time $t = \frac{V}{Q}$ = $\frac{82.46681}{150}$ = 0.549779 Hr.

= 32.98672 min.

13 Calculate Diameter in Hopper Outside (Sedimentation Zone)

Volume in Hopper Outside (Sedimentation Zone) = 300 m^3

A_2 = $\frac{\pi D^2}{4}$ = 28.27433 m^2

Calculate A_3

Theory Volume of Conical Basin = $\frac{d}{3}\left(A_2 + A_3 + \sqrt{A_2 \, x \, A_3}\right)$

229.4801 = 28.27433 + A_3 + 5.317362 $\sqrt{A_3}$

0 = -201.206 + A_3 + 5.317362 $\sqrt{A_3}$

$\therefore$ $(A_3)^{1/2}$ = 11.77303 m^2

A_3 = 138.6043 m^2

$$\frac{\pi D_3^{\ 2}}{4} = 138.6043 \quad m^3$$

$$D_3 = 13.28177 \quad m$$

Acture Volume in Hopper outside

$$A_2 = \frac{\pi D_2^{\ 2}}{4} = 28.27433 \quad m^2$$

$$A_3 = \frac{\pi D_3^{\ 2}}{4} = 138.5485 \quad m^2$$

14 Calculate Acture Volume in Hopper outside + Outside = $\frac{d}{3}\left(A_2 + A_3 + \sqrt{A_2 \, x \, A_3}\right)$

Volume in Hopper outside + Outside = 382.3529 m^3

Conclusion

- Volume in Hopper inside = 82.46681 m^3
- Volume in Hopper outside = 299.8861 m^3

15 Detention Time in Hopper outside $t = \frac{V}{Q}$

t = 1.999 Hr.

16 Calculate Paddle

16.1 At Depth level = 1.5 m.

∴ Slope = 3.333 m.

Then 3.333333 = 1.5 / X_1

∴ X_1 = 0.45 m.

∴ Diameter Paddle = 3.9 m.

∴ Sweep Area = $\frac{\pi D^2}{4}$ = 11.94591 m^2

∴ Paddle Area = 10 % of Sweep area(Bhole,A.G, Personal Communication)

= 1.195 m^2

Assume There are *paddle.* 4 paddles

Length of each paddle = 65 - 75 % of Radius of Flocculation selection 70 %

- At depth level 1.5 m. Diameter of Flocculator = 3.9 m.

∴ Radius = 1.95 m.

∴ Length of each paddle = 1.365 m.

∴ Height of each paddle = $\frac{Area}{Length\ x\ 4}$ = 0.218789 m.

16.2 At Depth level = 3.5 m.

∴ Slope = 3.333 m.

Then 3.333333 = 3.5 / X_2

∴ X_2 = 1.05 m.

∴ Diameter Paddle = 5.1 m.

∴ Sweep Area = $\frac{\pi D^2}{4}$ = 20.42821 m^2

∴ Paddle Area = 10 % of Sweep area(Bhole,A.G, Personal Communication)

= 2.043 m^2

Assume There are *paddle.* 4 paddles

Length of each paddle = 65 - 75 % of Radius of Flocculation selection 70 %

- At depth level 3.5 m. Diameter of Flocculator = 5.1 m.

∴ Radius = 2.55 m.

∴ Length of each paddle = 1.785 m.

∴ Height of each paddle = $\frac{Area}{Length\ x\ 4}$ = 0.286109 m.

16.3 At Depth level = 4.7 m.

∴ Slope = 3.333 m.

Then 3.333333 = 4.7 / X_3

∴ X_3 = 1.41 m.

∴ Diameter Paddle = 5.8 m.

∴ Sweep Area = $\frac{\pi D^2}{4}$ = 26.60332 m^2

∴ Paddle Area = 10 % of Sweep area(Bhole,A.G, Personal Communication)

= 2.66 m^2

Assume There are *paddle.* 4 paddles

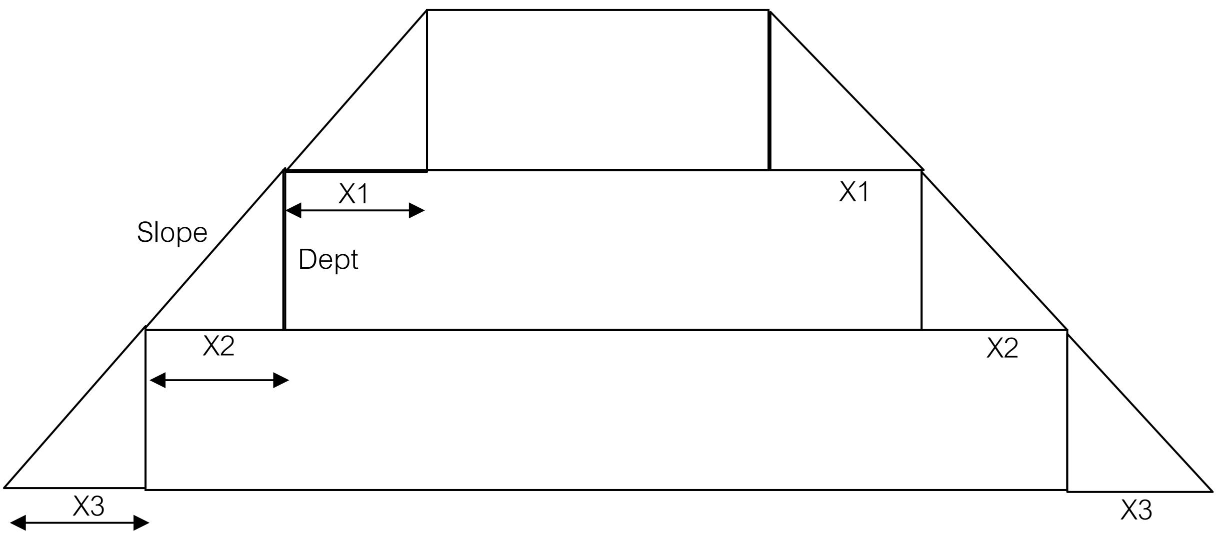
Length of each paddle = 65 - 75 % of Radius of Flocculation selection 70 %

- At depth level 4.7 m. Diameter of Flocculator = 5.82 m.

∴ Radius = 2.91 m.

∴ Length of each paddle = 2.037 m.

∴ Height of each paddle = $\frac{Area}{Length\ x}$ 4 = 0.326501 m.


X1
X1
Slope
Dept
X2
X2
X3
X3

17 Power Requirement

Give Shaft rotation speed = 3 rpm (Design criteria = 2 - 3 rpm.)

17.1 At depth level = 1.5 m.

Radius of Paddle = 1.365 m.

The rotation speed of paddle = $2\pi rN$

= 0.428827 m/s

Design Criteria $\leq$ 0.9 m/s (Horizontal Shaft with Paddles)

17.2 At depth level = 3.5 m.

Radius of Paddle = 1.785 m.

The rotation speed of paddle = $2\pi rN$

= 0.560774 m/s

Design Criteria $\leq$ 0.9 m/s (Horizontal Shaft with Paddles)

17.3 At depth level = 4.7 m.

Radius of Paddle = 2.037 m.

The rotation speed of paddle = $2\pi rN$

= 0.639942 m/s

Design Criteria $\leq$ 0.9 m/s (Horizontal Shaft with Paddles)

18 Calculation Relative of Paddle with respect to water

$V = 0.75V_{paddle}$ m/s

18.1 At depth level = 1.5 m. V_{paddle} = 0.428827 m/s

V = 0.321621 m/s

18.2 At depth level = 3.5 m. V_{paddle} = 0.560774 m/s

V = 0.420581 m/s

18.3 At depth level = 4.7 m. V_{paddle} = 0.639942 m/s

V = 0.479957 m/s

19 Calculation Power requirement

Theory $$P = \frac{1}{2} C_D \Sigma A_p \alpha (\Sigma v)^3$$

Where :

P	=	Power requirement of Mixing (watt) or N.m/s		
C_D	=	Coefficient of drang of Paddle	=	1.8
A_p	=	Area of Paddle (m^2)		
α	=	mass fluid density (kg/m^3)	=	1,000 kg/m^3
v	=	Relative velocity of Paddle with respect to water (m/s)		

Then

P = 437.27 watt or N.m/s

Efficiency Motor at 60 % = 728.78 watt or N.m/s

(From 1 HP = 0.7457 Kilowatt)

Then P = 0.97730575 HP ≈ 1 HP

20 Calculation Velocity Gradient (G)

Theory $$G = \sqrt{\frac{P}{\mu V}}$$

Where :

G = mean velocity gradient (sec^{-1})

P = power requirement for mixing (watt) or N.m/s

μ = dynamic viscosity ($N.s/m^2$) 0.001 $N.s/m^2$

V = volume of the tank (m^3)

$$G = \sqrt{\frac{728.7769012}{0.001 \times 82.46680716}} \quad sec^{-1}$$

$$G = 94.00646 \ sec^{-1}$$

21 Outlet Clarifier Tank

Weir Loading = 7.3 - 15 m^3/m.hr

From Diameter D_3 = 13.28177137 m.

Minus outlet hole 2 side = 1 m.

$\therefore$ *Length of weir* = 12.28177137 m.

Theory

$$Length\ of\ weir = \frac{Q\,(m^3/hr)}{Weir\ Loading\,(m^3/m.hr)}$$

Weir Loading = 12.21322198 m^3/m.hr OK.

Give Diameter of Orifice = 1 in. = 0.0254 m.

Give 1 m. of outlet weir have orifice = 25 pores/side

$\therefore$ 2 side = 50 pores

Length of Orifice = 1.27 m./ 1 m. weir

$\therefore$ 1 side = 0.635 m./ 1 m. weir

Then Free Space of weir = 0.365 m./ 1 m. weir

∴ Space between orifice to orifice = 0.0146 m.

= 1.46 cm.

Give 1 m. of outlet weir have orifice = 25 pores/side

∴ 2 side = 50 pores

Then total orifice = 614 pores

Then sum area of orifice = 0.31 m^2

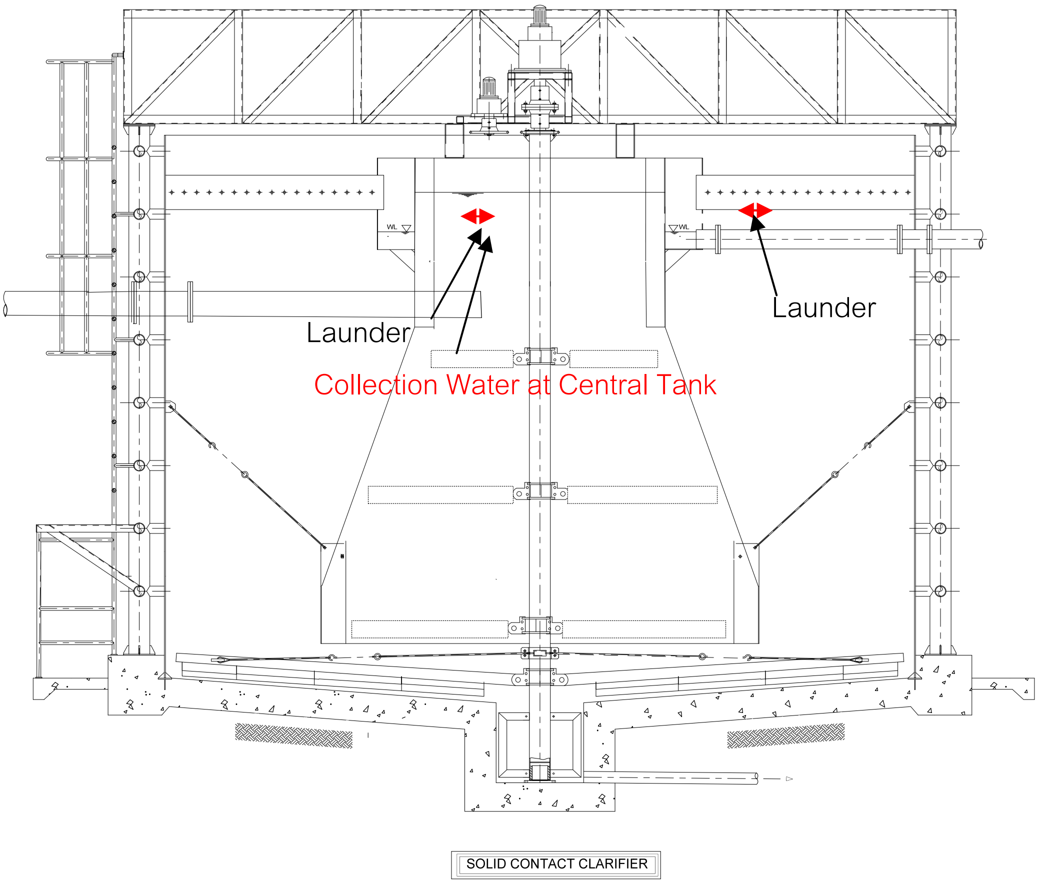
22 Flow Rate pass through 1 orifice = 0.244 m^3/hr

Each of orifice area = $\frac{\pi D^2}{4}$

∴ Each of orifice area = 0.0005067 m^2

Theory $Q = Av$

∴ Velocity pass through each orifice = 0.133906 m/s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Collection Water at Central Tank
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23 Inlet Structure

From Static Mixer Design criteria velocity pass through static mixer = 1 - 2 m/s

Select velocity = 1.5 m/s

Theory $Q = Av$

Area $= \frac{Q}{v}$ m^2

$= 0.027778$ m^2

Circular pipe area $= \frac{\pi D^2}{4}$

$D^2 = 0.035368$

$D = 0.188063$ m.

$= 7.404063$ in. $\approx$ 7 in.

24 Calculation Surface Loading (Sedimentation Zone)

Surface Area at Sedimentation Zone $= \frac{\pi D_{outside}^2}{4} - \frac{\pi D_{inside+2xLaunderswidth}^2}{4}$

$D_{outside} = 13.28177$ m.

$D_{inside+(2xLaunders\ width)} = 4$ m.

$\therefore$ Surface Area at Sedimentation Zone $= 125.9821$ m^2

$\therefore$ Surface Loading $= \frac{Q}{A}$

$= 1.190645$ m/hr.

Design Criteria 1.3 - 1.9 m/hr upflow (radial upflow type)

Text Book (Chularrongkron University < 4.2 m/hr.

Water Works Engineering 0.8333 - 1.6666 m/hr