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Solution:- The Pressure drop Δp is expected to depend upon the gate opening h, the Overall depth d, the velocity V, density ρ and viscosity μ

List the relevent Variables:

$\Delta p, h, d, V, \rho, \mu$

Write down dimensions

$\Delta p \quad ML^{-1}T^{-2}$

$h \quad L$

$d \quad L$

$V \quad LT^{-1}$

$\rho \quad ML^{-1}$

$\mu \quad ML^{-1}\rho^{-1}$

Number of variable $n=6$

Number of independent dimension $m=3$

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Number of non dimensional groups $n-m=3$

Choose m $(=3)$ Scaling variables:

geometric (d); kinematic time-dependent (V)

dynamicl mass dependent (ρ)

Form dimensionless groups by non dimensionalising the remaining variables, Δp, h and μ.

$$\Pi_1 = \Delta p d^a V^b \rho^c$$

$$M^0L^0T^0 = (ML^{-1}T^{-2})(L)^a(LT^{-1})^b(ML^{-3})^c$$

$$= M^{1+c}L^{-1+a+b-3c}T^{-2-b}$$

M: $0 = 1+c \Rightarrow c=-1$

T: $0 = -2-b \Rightarrow b=-2$

L: $0 = -1+a+b-3c \Rightarrow a = 1+3c-b = 0$

$$\Rightarrow \Pi = \Delta p V^{-2} \rho^{-1} = \frac{\Delta p}{\rho V^2}$$

$\Pi_2 = \frac{h}{d}$ (by inspection since h is a length)

$$\Pi_3 = \mu d^a V^b \rho^c$$

$$M^0 L^0 T^0 = (ML^{-1}T^{-1})(L)^a (LT^{-1})^b (ML^{-3})^c$$

$$= M^{1+c} L^{-1+a+b-3c} T^{-1-b}$$

$$M: \quad 0 = 1 + c \quad \Rightarrow c = -1$$

$$T: \quad 0 = -1 - b + 0 \quad \Rightarrow b = -1$$

$$L: \quad 0 = -1 + a + b - 3c \quad \Rightarrow a = 1 + 3c - b = -1$$

$$\Rightarrow \Pi_3 = \mu d^{-1} V^{-1} \rho^{-1} = \frac{\mu}{\rho V d}$$

Recognition of the Reynolds number suggests that we replace Π_3 by

$$\Pi_3' = (\Pi_3)^{-1} = \frac{\rho V d}{\mu}$$

Hence, dimensional analysis yields

$$\Pi_1 = f(\Pi_2, \Pi_3)$$

i.e

$$\frac{\Delta P}{\rho V^2} = f\left(\frac{h}{d}, \frac{\rho V d}{\mu}\right)$$

1(a) Dynamic similarity require that all non- dimensional groups be the same in model and prototype i.e

$$\Pi_1 = \left(\frac{\Delta P}{\rho V^2}\right)_p = \left(\frac{\Delta P}{\rho V^2}\right)_m$$

$$\Pi_2 = \left(\frac{h}{d}\right)_n = \left(\frac{h}{d}\right)_m$$ (automatic of samilar shape i.e geometric Similary

$$\Pi_3' = \left(\frac{\rho V d}{\mu}\right)_p = \left(\frac{\rho V d}{\mu}\right)_m$$

From the last, we have a velocity ratio

$$\frac{V_p}{V_m} = \frac{(\mu/\rho)_p \, d_m}{(\mu/\rho)_m \, d_p}$$

$$= \frac{\frac{0.002}{800}}{1.0 \times 10^{-6}} \times \frac{1}{5}$$

$$= 0.5$$

Hence,

$$V_m = \frac{V_p}{0.5} = \frac{3.0}{0.5} = 6.0 \, m s^{-1}$$

(b) The ratio of quantities of flow is

$$\frac{Q_p}{Q_m} = \frac{(\text{Velocity} \times \text{area})_p}{(\text{Velocity} \times \text{area})_m}$$

$$= \frac{V_p}{V_m}\left[\frac{d_p}{d_m}\right]^2$$

$$= 0.5 \times 5^2 = 12.5$$

(c) Finally, for the drop pressure,

$$\Pi_1 = \left[\frac{\Delta P}{\rho V^2}\right]_p = \left[\frac{\Delta P}{\rho V^2}\right]_m$$

$$\Rightarrow \frac{(\Delta P)_p}{(\Delta P)_m} = \frac{\rho_p}{\rho_m}\left[\frac{V_p}{V_m}\right]^2$$

$$= \frac{800}{1000} \times 0.5^2 = 0.2$$

Hence

$$\Delta P_p = 0.2 \times \Delta P_m = 0.2 \times 60 = 12.0 \text{ kPa}$$

Q No 2

Design a Practical Profile of gravity dam with following data

1. Maximum Depth of Water in the reservoir is (78) $H = 78m$

2. Specific gravity of dam material is $G = 2.4$

3. Allowable compressive strength for the dam masonry is $785 T/m^2$)

4. Height of wawave is Hw 1.2m

5. G and Hw is $\mu = 07$

$CU = 0$

Sol:- ① $H_{limiting} = \dfrac{\sigma_{all}}{\gamma_w (G - CU + 1)}$

$= \dfrac{785 \times 1000}{1000(2.4 - 0 + 1)}$

$H_{limiting} = 230.88 >$ ~~H 78m~~ Hw 78m

So it is low Gravity Dam

② Top width 'a'

Free board = 1.5 hwave = 1.5×1.2

$\boxed{F.B = 1.8m}$

7854 (7) (8)

height of Dam = HD = HW + F.B

$= 78 + 1.8$

$\boxed{HD = 79.8m}$

$a = 14\%$ of HD

$a = 0.14 \times 79.8$

$a = 11.172\,m$

③ Base width (With out offset)

(i). For No sliding Criteria

$$b' = \frac{HW}{\mu G} = \frac{78}{0.7 \times 2.4}$$

$b' = 46.42$

(i). For No tension Criteria

$$b' = \frac{HW}{\sqrt{G}} = \frac{78}{\sqrt{2.4}}$$

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$b' = 50.34\,m$

v Depth of Vertical Portion on U/s Side

$h' = 2a\sqrt{G_2 - C_U}$

$h' = 2 \times 11.172\sqrt{2.4 - 0}$

$h' = 34.40\,m$

⑤ Upstream offset $= \frac{a}{16}$

$= \frac{11.172}{16}$

$= 0.69\,m$

⑥ Depth below the water level to the end of inclined portion in u/s

$= 3.14\,a\sqrt{G_2}$

$= 3.14 \times 11.172\sqrt{2.4}$

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$= 54.02\ m$

⑦ total width of the base of dam

$b = b' + \frac{a}{16}$

$= 50.34 + 0.69$

$\boxed{b = 51.03 m}$

⑧ $\tan Q = \frac{b'}{H} = \frac{50.34}{78} =$

$Q = \tan^{-1} 0.64$

$Q = 32.61°$

⑨ Depth of vertical portion on D/s (from WL on U/s side

$\tan Q = \frac{a}{d'} =$

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Depth of vertical portion D/s

$$\tan Q = \frac{a}{d'} = \frac{11.172}{d'}$$

$$\tan Q = \frac{11.172}{d'}$$

$$0.64d' = 11.172$$

$$d' = \frac{11.172}{0.64}$$

$$d' = 17.45\ m$$

depth of vertical portion

$$d = d' + FB$$

$$= 17.45 + 1.8$$

$$\boxed{d = 19.25\ m}$$

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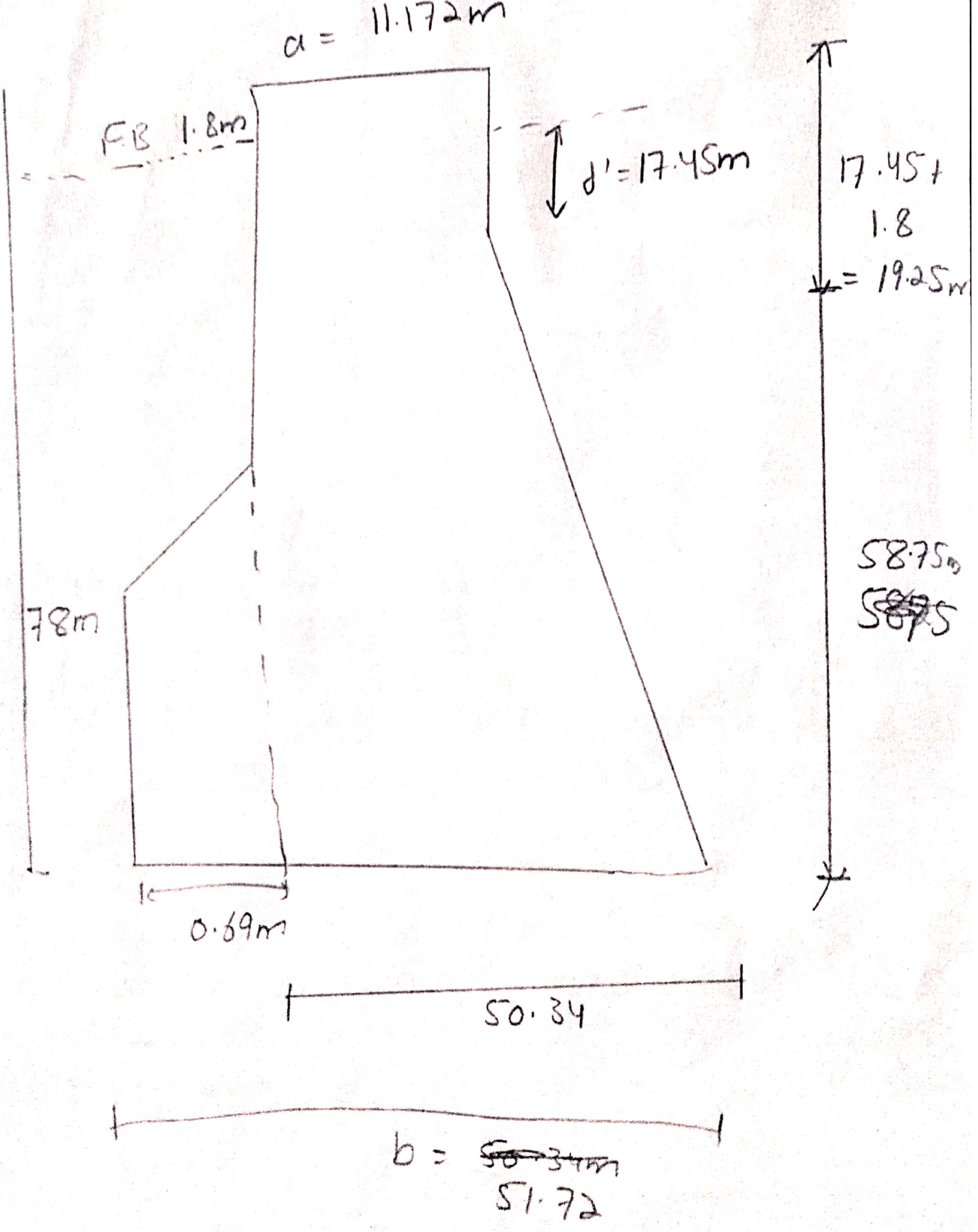
a = 11.172m
FB 1.8m
d' = 17.45m
17.45 + 1.8 = 19.25m
58.75m
5875
78m
0.69m
50.34
b = ~~50.34m~~
51.72

QNo 4:

Ans The dynamic problems of liquid-solid interaction are greatly influenced by the sediment properties. The description of the latter, however is exceedingly complex and one is forced to make many simplifying assumptions. The first of which is is subdivision into cohesive and non-cohesive sediments.

Particle Size, shape and density

Particle size. The most important physical property of a sediment particles is it size.

It has a direct effect on the mobility of particles and range from great boulders, which are rolled only by mountain torrents, to fine clays, Which once stirred uptake days to settle. The size of particles can be determined in a number of ways. The nominal diameter refers to the diameter of a sphere of same volume as the particles, usually measured by the displaced volume of submerged particle. The sieve diameter is minimum length of the square sieve opening through which a particle will fall. The fall diameter is the diameter of an equivalent sphere of specific gravity =2.65 having the same terminal setting velocity in water at 24°C.

Shape :- A part from size, shape effects the transport of sediment but there is no direct quantitative way to measure shape and its effects.

McNown (1951) suggested a shape factor $SF = c/\sqrt{ab}$ where c is the shortest of three perpendicular axes (a, b, c) of the particle. The shape factor is always less than unity, and values of 0.7 are typical for naturally worn particles.

Density:- Density of the particles is important and must be known. A large variation in density effects sediment transport by segregation, eg the armoring effects of heavy minerals on dune crests. The mass density of solid particles describes the solid mass per unit volume. The particles specific weight corresponds.

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to the solid weight per unit volume of solid. The specific weight of solid also equals the product of mass density of a solid particle ρ_s times the gravitational accelerating, thus

$$\gamma_s = \rho_s . g$$

Submerged specific weight of particles

Owning to Archimedes principle, the specific weight of solid particles γ_s submerged in a fluid of specific weight γ, equals to the difference between two specific weights thus.

$$\gamma_s = \gamma_s - \gamma = (\rho_s - \rho) g$$

Where ρ is mass density of fluid.

The relation of specific weight of

fluid at a standard reference temperature defines the specific gravity δ with common reference to water at 4°c, the specific gravity of equal Particles is

$$\delta = \frac{\gamma s}{\gamma} = \frac{P_s}{P} = 2.65$$

The specific gravity is a dimensionless ratio of specific weights, and thus it value remains independent of the system of units.

Fall Velocity

The fall or settling velocity of a particle is assumed to be steady. state motion. It is also a function of size, shape, density and viscosity of fluid

In addition it depends on extent of fluid in which it falls, on the number of particles falling and on the level of turbulence intensity. Turbulent condition occur when settling takes place in flowing fluid and can also occur when a cluster of particles is settling. For grain diameter d greater than 2mm, the fall velocity w can be approximated by the following equation

$$w = 3.32\sqrt{d} \text{ mm/s}$$

Faling under the influences of gravity the particles will reach a constant velocity named the terminal when the drag equal the terminal velocity, ie different of solid and fluid

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$V_s = V = w$, we obtain following equation

$$C_D \frac{\pi d^2}{4} \frac{\rho w^2}{2} = \frac{\pi d^3}{6} g (\rho_s - \rho)$$

$$w^2 = \frac{4}{3} \frac{1}{C_D} g d \left(\frac{\rho_s - \rho}{\rho}\right)$$

Thus the proplem reduces to finding the value of drag coefficient CD, for the particles in question for spherical particles of diameter d in viscous fluid of dynamic viscosity μ the drag coefficient is fairly well defined in laminar flow region for $Re < 0.5$ and approximately up to 1.0, where $Re = \frac{wd}{v}$.

$$F_D = 3\mu dw, \quad \text{and } C_D = \frac{24}{Re}$$

$$C_D = \frac{24}{Re}\left(1 + \frac{3}{16} Re\right)$$

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Goldstein provides a more complete solution for Oseen approximation and gives the drag coefficient

$$CD = \frac{24}{Re}\left(1+\frac{3}{16}Re - \frac{19}{1280}Re^2 + \frac{71}{20480}Re^3\right)$$

for $Re \le 2$

The value of drag coefficient CD, depends strongly on level of free stream turbulance,

Schiller and Nauman 1933) suggest a formula a give good results for Re <800

$$CD = \frac{24}{Re}\left(1+0.150\,Re^{0.687}\right)$$

Olson (1961) suggests that the drag coefficient can be well represented by following for Re<100

$$CD = \frac{24}{Re}\left(1+\frac{3}{16}Re\right)^{1/2}$$

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QNo3 Using any hydraulic model and explain the concept of Dimensional anaylsis and similute.

Ans In fluid dynamics, Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in static pressure or a decrease in fluids potential energy. The principle is named after Daniel Bernoulli who published it in his book Hydrodynamica in ~~173~~ 1738. Although Bernoulli deduced that pressure decreases when the flow speed increases, it was Leonhard Euler who derived Bernoulli's equation. In its usual from in 1752. The Principle is only applicable for

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isentropic flows. When the effects of irreversible processes (like turbulence) and non-adiabatic processes (eg heat radiation) are small and can be neglected

Bernoulli's principle can be applied to various types of fluid flow, resulting in various forms of Bernoulli's equation. there are different forms of Bernoulli's equation for different types of flow.

The simple from of Bernoulli's equation is valid for incompressible flows.

More advanced forms may be applied to compressible flows at higher Mach numbers.

Bernoullis principle can be derived from the principle of conservation of energy.

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Derivation of Bernoulli equation

Derivation through integrating Newton second Law of Motion

The simplest derivation is to first ignore gravity and consider constriction and expansion in pipes that are otherwise straight, as seen in venturi effect. Let the x axis be directed down to axis of pipe.

Flow velocity $v = \frac{dx}{dt}$. Define a parcel of moving through a pipe with cross sectional area A, Length of parcel is dx and the volume of parcel A. dx. If mass density is ρ, mass of parcel is density multiple by its volume $m = \rho A dx$. The change

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Pressure over distance dx is dp and

flow velocity $v = \frac{dx}{dt}$

Apply Newton Second Law of mot

$$m \frac{dv}{dt} = F$$

$$\rho A dx \frac{dv}{dt} = -A dp$$

$$\rho \frac{dv}{dt} = -\frac{dp}{dx}$$

In steady flow the velocity field is constant

$$\frac{dv}{dt} = \frac{dv}{dx} \frac{dx}{dt}$$

$$= \frac{dv}{dx} v$$

$$= \frac{d}{dx} \left(\frac{v^2}{2} \right)$$

with density ρ constant

$$\frac{d}{dx} \left(\rho \frac{v^2}{2} + p \right) = 0$$

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by integrating with respect to x

$$\frac{V^2}{2} + \frac{P}{\rho} = C$$

Where C is constant

In the above derivation, no external work energy is involved. Rather Bernoulli's principle was derived by a simple manipulation of second law.

Application

- An injector on a steam locomotive
- The pitot tube and static port on an aircraft are used to determined the air speed of aircraft