2. CONDUITS FOR TRANSPORTING WATER

HEAD LOSS

- Darcy-weisbach Formula

$$H_L = \frac{fLV^2}{2gD}$$

where, H_L = Head loss in meters.
L = Length of pipe in metres.
d = Diameter of the pipe in metres
V = Mean velocity of flow through the pipe in m/sec.
g = Acceleration due to gravity (m/s².)
f = Friction factor.
= 0.02 for new smooth pipes
= 0.075 for old rough pipes.

$$f = 0.04\left[1+\frac{1}{35d}\right] \rightarrow \text{for old pipes.}$$

$$f = 0.02\left[1+\frac{1}{35d}\right] \rightarrow \text{for new pipes.}$$

$$f = a + \frac{b}{R_e^m}$$

where a, b and m are constants depending upon R_e and δ.
Re = Reynolds number
and δ = Relative roughness.

- For laminar flow ($R_e \le 2000$)

$$f = \frac{64}{R_e} \text{ and } R_e = \frac{VD}{\nu}$$

V = Velocity of water (m/s)
ν = Kinematic viscosity (m²/s)
D = Dia of pipe (m)

- For turbulent flow ($R_e \ge 4000$)

(i) $$\frac{1}{\sqrt{f}} = 2\log_{10} R_e\sqrt{f} - 0.8 \rightarrow \text{for smooth pipe}$$

(ii) $$\frac{1}{\sqrt{f}} = 2\log_{10}\left(\frac{R}{k}\right) + 1.74 \rightarrow \text{for rough pipe}$$

where, R = Radius of pipe = $\frac{D}{2}$

HAZEN-WILLIAM'S FORMULA

$$V = 0.85C_H \cdot R^{0.63} \cdot S^{0.54}$$

where, C_H = Coefficient of hydraulic capacity
R = Hydraulic mean depth of pipes in metres
= $\frac{d}{4}$ for circular pipes flowing full
S = Slope of the energy lines.
V = Flow velocity through the pipe in m/sec.

Pipe material	Value of C_H Depending upon the smoothness of the pipe material
Concrete (regardless of age)	130
Cast Iron	
New	130
5 years old	120
20 years old	100
Welded steel (New)	120
Riveted steel (New)	110
Vitrified clay	110
Brick Sewers	100
Asbestos-Cement	140

MODIFIED HAZEN-WILLIAM'S FORMULA

$$V = \frac{3.83C_R[d^{0.6575}(g.s)^{0.5525}]}{\nu^{0.105}}$$

where, C_R = Dimensionless coefficient of roughness.
d = Pipe diameter.
g = Acceleration due to gravity.
= 9.81 m/s².
s = Friction slope = $\frac{H_L}{L}$.
ν = Viscosity of liquid.

$$V = 143.534C_R \cdot R^{0.6575} \cdot S^{0.5525}$$

where, R = Hydraulic radius or hydraulic mean depth = $\frac{A}{P}$

MANNINGS FORMULA

$$H_L = \frac{n^2 \cdot V^2 \cdot L}{(R)^{4/3}}$$

where, η = Mannings rugosity coefficient.
L = Length of pipe in metres.
V = Flow velocity (m/s).
$R = \frac{A}{P} = \frac{d}{H}$ for circular pipe.

FORCES ACTING ON PRESSURE CONDUITS

(i) Hoop tension or circumferential tension (σ)

$$\sigma = \frac{PD}{2t}$$

where, P = Total internal pressure including the full static water pressure and water hammer pressure
d = Diameter of the pipe in metres
t = Thickness of the pipe in metres.

(ii) Water Hammer Pressure

$$P_{h(maximum)} = \delta_w U_P \cdot V$$

where,
$P_{h(maximum)}$ = Maximum water hammer pressure developed in N/m^2.
U_P = Velocity of the pressure wave generated.
δ_w = Density of water $\left(\gamma_w/g\right)$.
γ_w = Unit wt. of water = 9.81 kN/m^3.
V = Velocity of water in the pipe.

$$U_P = \sqrt{\frac{E_w}{\delta_w}} \cdot \frac{1}{\sqrt{1 + \frac{E_w}{E_P} \cdot \frac{d}{t}}}$$

where, E_w = Modulus of elasticity of water or Bulk modulus of compression of water
E_P = Modulus of elasticity of pipe material.
d = Diameter of pipe
t = Thickness of the pipe shell
δ_w = Density of water.

- $$P_{h(maximum)} = \frac{1433V}{\sqrt{1 + \frac{k \cdot d}{t}}} kN/m^2$$ where, $k = \frac{E_W}{E_P}$
- $$P_h = (P_h)_{maximum} \cdot \left(\frac{T_C}{T}\right)$$ where, T_C = Critical time, T = Actual time of closure.
- $$T_C = \frac{2\delta}{U_P}$$ where, s = Distance of the value from the reservoir.

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