CE412 A
Water Supply & Wastewater Disposal Systems

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Components of Water Supply System

- **1. Water Intake**
  - Types - Refer to Drawings
    - Surface Water
    - Lake / Reservoir
    - River
    - Dams
      - Concrete
      - Earthen
    - Canals
    - Groundwater
  - Specifications to be provided Location, Type and Capacity based on Demand or Yield whichever is lower.

Components of Water Supply System

- **2. Water Transmission/ Conveyance System**
  - ❑ Raw water from source to water treatment plant
    - Both open and close conduits can be used
  - ❑ Treated water to water distribution system from water treatment plant
  - ❑ Specifications to be provided
    - Alignment, type of conduit, shape and size of the conduit.
    - Most economical diameter of the pressure pipe.

Darcy–Weisbach Equation

$$s = \frac{H}{L} = \frac{fv^2}{2g\,D}$$

$$g \rightarrow m/s^2$$

$$v \rightarrow mps$$

$$L \rightarrow m$$

$$d \rightarrow m$$

Manning's Formulae

$$v = \frac{1}{n} r^{2/3} s^{1/2}$$

$$= \frac{0.3968\, d^{2/3}\, s^{1/2}}{n}$$

$$Q = 0.31168 \frac{1}{n} d^{8/3} s^{1/2}$$

v is velocity in m/s; Q is flow or discharge in m^3/s; r is hydraulic radius in m; and d is diameter in m

$n = 0.010 - 0.030$ (Most commonly use value $= 0.013$)

Hazen–Williams Formula

$v = 0.849\, C\ r^{0.63}\ s^{0.54}$

$v = 0.35449\ C\ d^{0.63}\, s^{0.54}$

$Q = 0.27842\, C\ d^{2.63} s^{0.54}$

$For\ c = 100$

$v = 35.449\, (d)^{0.63} (s)^{0.54}$

$v\ is\ velocity\ in \frac{m}{s}; Q\ is\ flow\ in \frac{m3}{s}; r\ is\ hydraulic\ redius\ in\ m;\ d\ is\ diameter\ in\ m;$

$s\ is\ slope\ i.e.\ headloss\ per\ unit\ length; and\ c\ is\ Hazen - Williams\ (Roughness) coefficient\ (100 - 150)$

$Q = 27.842\, d^{2.63}\, (h_f/L)^{0.54}$

$h_f = [\frac{Q}{27.842\ d^{2.63}}]^{1/0.54} L = kQ^{1.85} L;\qquad k = \left[\frac{1}{27.842\ d^{2.63}}\right] for\ given\ diameter\ and\ c = 100$

Equation for Correction in Flow at the end of any iteration in Hardy-Cross Method

The **Hardy Cross method** is an application of continuity of flow and continuity of potential to iteratively solve for flows in a pipe network. In the case of pipe flow, conservation of flow means that the flow in is equal to the flow out at each junction in the pipe.

$$h_f = kQ^{1.85}L$$

$$= k(Q_i + \Delta Q)^{1.85} = k\,(Q_i^{1.85} + 1.85\,Q_i^{1.85-1}\,\Delta Q + \cdots)L$$

$$\sum h_f = \sum kQ^{1.85} + 1.85\,\Delta Q\,\sum Q^{1.85-1} = 0$$

Or

$$\Delta Q = -\frac{\sum kQ^{1.85}}{1.85\sum kQ^{1.85-1}} = -\frac{\sum h_i}{1.85\,\sum h_i\,/Q_i}$$

Pipes in Series:

n *number of pipes with diameter* (di), *Hazen William Coefficient* (Ci) *and Length* (Li) *in series*:
$d_1, c_1, L_1;\ d_2, c_2, L_2; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots d_n, c_n, L_n$

Equivalent Pipe: d_{eq}, c_{eq}, L_{eq}

$$h_{feq} = h_{f1} + h_{f2} + h_{f3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + h_{fn}$$

$$Q_{eq} = Q_1 = Q_2 = Q_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = Q_n$$

$$[\frac{Q_{eq}}{0.27842\ c_{eq}\ d_{eq}^{2.63}}]^{1.85} L_{eq} = [\frac{Q_1}{0.27842\ c_1\ d_1^{2.63}}]^{1.85} L_1 + [\frac{Q_2}{0.27842\ c_2\ d_2^{2.63}}]^{1.85} L_2$$

$$+ \ldots\ldots\ldots\ldots + [\frac{Q_n}{0.27842\ c_n\ d_n^{2.63}}]^{1.85} L_n$$

$$[\frac{1}{c_{eq}\ d_{eq}^{2.63}}]^{1.85} L_{eq} = [\frac{1}{c_1 d_1^{2.63}}]^{1.85} L_1 + [\frac{1}{c_2 d_2^{2.63}}]^{1.85} L_2 + \ldots\ldots\ldots\ldots\ldots + [\frac{1}{c_n d_n^{2.63}}]^{1.85} L_n$$

Pipes in Parallel:

n number id pipes with diameter (di), Hazen William C
$d_1, c_1, L_1;\ d_2, c_2, L_2; \dots\dots\dots\dots\dots\dots\dots\dots d_n, c_n, L_n$

Equivalent Pipe: d_{eq}, c_{eq}, L_{eq}

$$Q_{eq} = Q_1 + Q_2 + \dots\dots\dots\dots\dots\dots + Q_n$$

$$h_{feq} = h_{f1} = h_{f2} = \dots\dots\dots\dots\dots\dots\dots = h_{fn}$$

$$0.27842\, d_{eq}^{2.63} (\frac{h_{feq}}{L_{eq}})^{0.54} = 0.27842\, d_1^{2.63} (\frac{h_{f1}}{L_1})^{0.54} + 0.27842\, d_2^{2.63} (\frac{h_{f2}}{L_2})^{0.54} + \dots\dots\dots\dots\dots\dots + 0.27842\, d_n^{2.63} (\frac{h_{fn}}{L_n})^{0.54}$$

$$h_{feq} = h_{f1} = h_{f2} = h_{f3} = \dots\dots\dots\dots\dots\dots\dots = h_{fn}$$

$$d_{eq}^{2.63} (\frac{1}{L_{eq}})^{0.54} = d_1^{2.63} (\frac{1}{L_1})^{0.54} + d_2^{2.63} (\frac{1}{L_2})^{0.54} + \dots\dots\dots\dots\dots\dots\dots\dots\dots + d_n^{2.63} (\frac{1}{L_n})^{0.54}$$

Population Calculation

- Arithmetic method : dp/dt = constant Formula: $P_n = P_o + n.x$
- Geometric method : dp/dt ∝ P Formula: $P_n = P_o(1+r/100)^n$
- Decreasing growth rate method: dp/dt ∝ (Ps – P)

P_n= prospective or forecasted population after n decades from the present(i.e. the last known census)

P_o= Population at present (i.e. the last known census)

X= arithmetic mean of population increase in known decades

r= assumed growth rate (%) (take geometric mean)

Ps= Saturation population value

Logistic Growth Method

$$P = \frac{Ps}{1+m.\exp(n.t)}$$

$$Ps = \frac{2PoP_1P_2 - P_1^2(Po+P_2)}{P_oP_2 - P_1^2} \qquad m = \frac{Ps - Po}{P_o}$$

$$n = \frac{2.3}{t_1} \log_{10}\frac{P_o(Ps - P_1)}{P_1(Ps - Po)}$$

P_o P_1 P_2 are population values chosen at times t_o t_1 t_2 and the interval between t_o t_1 t_2 remains constant

Fire Demand Formulae

- Kuichling's Formula : $Q = 3182\sqrt{P}$
- Freeman Formula : $Q = 1136[\frac{P}{10} + 10]$
- American Insurance Association : $Q = 4637\sqrt{P}\,[1 - 0.01\sqrt{P}]$

P= Population in thousands

Q= Amount of water required in litres/minute