Transmission of Water

1. Types of Conduits

Depending upon topography and available materials, conduits are designed to carry the water in open channel or under pressure. They may follow the hydraulic grade line as;

1. Canals dug through the ground
2. Flumes elevated above the ground
3. Grade aqueducts laid in balanced cut and cover at the ground surface
4. Grade tunnels penetrating hills

Or they may depart from the hydraulic gradient as;

5. Pressure aqueducts laid in balanced cut and cover at the ground surface
6. Pressure tunnels dipping beneath valleys or hills
7. Pipelines or force mains of fabricated materials following the ground surface, if necessary over hill and through dale, sometimes rising even above the hydraulic grade line
8. inverted siphons or depressed pipes

2. Hydraulics of Conduits

The hydraulic design of supply conduits chiefly with the estimation of frictional resistances to flow and with the pressures that are maintained in the conduit.

The most nearly rational relationship between the velocity of flow and the head loss in a conduit, is Darcy-Weisbach equation;

\[ h_L = f \cdot \frac{L}{D} \left( \frac{V^2}{2g} \right) \]

- \( h_L \): the head loss
- \( L \): length of the pipe
- \( D \): diameter of the pipe
- \( V \): the mean velocity of flow
- \( g \): the gravity constant (9.81 m/sec\(^2\))
- \( f \): dimensionless friction factor

Because of difficulties or inconveniences inherent in the use of this formula, engineers more commonly make use of so-called exponential equations which relate loss of head to flow.

The Hazen-Williams formula;

\[ V = 0.85CR^{0.63}J^{0.54} \]
\[ Q = 0.279CD^{2.63}J^{0.54} \]

- \( D \): diameter of the pipe
- \( V \): the mean velocity of flow
- \( Q \): discharge
- \( R \): hydraulic radius
- \( J \): hydraulic gradient or headloss
- \( C \): Hazen-Williams coefficient (Table 1)

**Table 1. Hazen-Williams Coefficient (C)**
3. **Appurtenances for Conduits**

   1. **Gates**
   
   In pressure conduits, gate valves are generally placed at the major summits;
   
   - Because these define the sections of line that can be drained by gravity
   
   - Because the pressure is least at these points, making for cheaper valves and easier operation

   2. **Blowoff Valves**
   
   In pressure conduits, small, gated take-offs are provided at low points in the line. The gates are known as blowoff or scour valves

   3. **Air Valves**
   
   Cast-iron and other rigid pipes and pressure conduits require air valves at all high points for the purpose of automatically removing;
   
   - Air that is displaced during the filling of the line
   
   - Air that is released from the flowing water if the pressure fluctuates appreciably and if the summit lies close to the hydraulic gradient.

   4. **Manholes**
   
   To serve as access opening, manholes are spaced 300 m to 600 m apart on large conduits. They are helpful during the construction of the line and for its inspection and repair.

   5. **Insulation Joints**
   
   Use of insulation joints is naturally confined to metallic pipes. Although their primary purpose is to introduce resistance to the flow of stray electric currents along the pipeline.

   6. **Expansion Joints**

   7. **Anchorages**
   
   Anchorages are employed for;

   - To resist the tendency of pipes to pull apart at bends and other points of unbalanced pressure when the resistance of their joints to longitudinal (shearing) stresses is exceeded.
   
   - To resist the tendency of pipes to pull apart when they are laid on steep gradients and the resistance of their joints to longitudinal (shearing) stresses is inadequate.

   8. **Other appurtenances**

### Table: Type of Pipe

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos-cement</td>
<td>140</td>
</tr>
<tr>
<td>Cast iron</td>
<td>100 – 140</td>
</tr>
<tr>
<td>Cement-Mortar Lined Ductile Iron Pipe</td>
<td>120</td>
</tr>
<tr>
<td>Concrete</td>
<td>100 – 140</td>
</tr>
<tr>
<td>Copper</td>
<td>130 – 140</td>
</tr>
<tr>
<td>Steel</td>
<td>90 – 110</td>
</tr>
<tr>
<td>Galvanized iron</td>
<td>120</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>140</td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC)</td>
<td>130</td>
</tr>
<tr>
<td>Fibre-reinforced Plastic (FRP)</td>
<td>150</td>
</tr>
</tbody>
</table>
Example:
A water transmission pipeline will be designed for a town as shown in the figure with elevations. The town’s population is 10000 and max daily draft is 200 lt/capita/day. Calculate the pipe diameter using Hazen-Williams equation. (Neglect all minor losses; C = 100)

Solution:
Max daily draft = 200 lt/capita/day

\[ Q_{\text{max}} = \frac{200 \times 10000}{24 \times 60 \times 60} = \frac{2000000}{24 \times 60 \times 60} = 23.2 \text{lt/sec} = 0.023 \text{m}^3/\text{sec} \]
If we assume a pipe diameter which is equal to 150 mm;
\[ Q = 0.279CD^{2.63}J^{0.54} \]
\[ D = 150\text{mm} = 0.15\text{m} \]
\[ 0.023 = 0.279 \times 100 \times 0.15^{2.63} 	imes J^{0.54} \]
\[ 0.121 = J^{0.54} \]
\[ 0.121^{1/0.54} = J^{0.54/0.54} \]
\[ J = 0.02\text{m/m} = 20\text{m/km} \]

20>10 so we have to increase pipe diameter!

If we assume a pipe diameter which is equal to 200 mm;
\[ Q = 0.279CD^{2.63}J^{0.54} \]
\[ D = 200\text{mm} = 0.2\text{m} \]
\[ 0.023 = 0.279 \times 100 \times 0.2^{2.63} \times J^{0.54} \]
\[ 0.056 = J^{0.54} \]
\[ 0.056^{1/0.54} = J^{0.54/0.54} \]
\[ J = 0.005\text{m/m} = 5\text{m/km} \]

5<10 it’s O.K.

**Exercise:**
A water transmission pipeline will be designed for a town as shown in the figure with elevations. The town’s population is 20000 and average daily draft is 100 lt/capita/day. Calculate the pipe diameter using Hazen-Williams equation. (Neglect all minor losses; C = 110)