WATER DISTRIBUTION NETWORKS

CE 370

Components of Water Supply System

Water Source

Pump

Water Transmission System

Water Treatment Plant

Water Distribution System

City
Water Transportation System

Types of transportation systems:

Various types of conduits can be used for transporting water. The selection depends on factors such as: topography, head availability, construction practices, economic considerations, and water quality. The types of transportation systems include:

- Open channels.
- Pipelines
- Tunnels

Open channels.

- Designed to convey water under conditions of atmospheric pressure
- May be covered or open and may be of variety of shapes
- Choice of open channel depends on the topography that will permit gravity flow with minimal excavation or fill
- If the soil is pervious, the channel should be lined to prevent seepage
- The potential of pollution hazard and evaporation losses should be considered
Open Channel

Water Transportation System

Pipelines:

- Usually built where topographic conditions preclude the use of channels
- May be laid above or below ground or partly buried
- Pressure conduits (pipelines) are built of concrete, steel, cast iron, or plastic
- Pipelines transportation system require gate valves, check valves, air-release valves, drains, surge control equipment, expansion joints, insulation joints, manholes, and pumping stations
- The potential of pollution hazard and evaporation losses should be considered
Pipeline
Water Transportation System

➢ Tunnels:

- Where it is not practicle to lay a pipeline on the surface or provide an open channel, a tunnel is selected
- Tunnels are well suited to mountain areas
- They may be operated under pressure or act as an open channel

Hydraulic considerations

➢ Pressure conduits:

- The hydraulic analysis for pressure conduits is carried out using Hazen-Williams equation:
  \[ V = 1.318 \times C \times R^{0.63} \times S^{0.54} \]
  Where:
  - \( V \) = velocity of flow, fps
  - \( C \) = a coefficient, which is a function of the material and age of the conduit
  - \( R \) = hydraulic radius (flow area divided by the wetted perimeter), ft
  - \( S \) = slope of energy grade line, ft/ft
  - The values of \( C \) for Hazen-Williams equation is given in next table.
TABLE 6.1 SOME VALUES OF THE HAZEN-WILLIAMS COEFFICIENT

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>C</th>
<th>Pipe Material</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>New cast iron</td>
<td>130</td>
<td>New welded steel</td>
<td>120</td>
</tr>
<tr>
<td>5-yr-old cast iron</td>
<td>120</td>
<td>Asbestos cement</td>
<td>140</td>
</tr>
<tr>
<td>20-yr-old cast iron</td>
<td>100</td>
<td>Plastic</td>
<td>150</td>
</tr>
<tr>
<td>Average concrete</td>
<td>130</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hydraulic considerations

Open channel:

- The hydraulic analysis for open channel flow is carried out using the Manning equation:

\[ V = \frac{1.49}{n} R^{0.66} S^{0.5} \]

Where:
- \( V \) = velocity of flow, fps
- \( n \) = coefficient of roughness
- \( R \) = hydraulic radius (flow area divided by the wetted perimeter), ft
- \( S \) = slope of energy grade line, ft/ft

The values of \( n \) for Manning equation is given in next table.

<table>
<thead>
<tr>
<th>Material</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>0.013</td>
</tr>
<tr>
<td>Cast-iron pipe</td>
<td>0.015</td>
</tr>
<tr>
<td>Vitrified clay</td>
<td>0.014</td>
</tr>
<tr>
<td>Brick</td>
<td>0.016</td>
</tr>
<tr>
<td>Corrugated metal pipe</td>
<td>0.022</td>
</tr>
<tr>
<td>Bituminous concrete</td>
<td>0.015</td>
</tr>
<tr>
<td>Uniform, firm sodded earth</td>
<td>0.025</td>
</tr>
</tbody>
</table>
Hydraulic considerations

Head loss:

- The head loss as a result of friction can be computed using Darcy-Weisbach equation:

\[ h_L = \frac{fLV^2}{2Dg} \]

Where:
- \( h_L \) = head loss, ft
- \( L \) = pipe length, ft
- \( D \) = pipe diameter, ft
- \( f \) = friction factor
- \( V \) = flow velocity, fps
Hydraulic considerations

Energy equation:

- Consider the figure below which shows the element of fluid moving from Section 1 to Section 2.
- Energy = Pressure energy + Kinetic energy + Potential energy
- Total energy at Section 1 = \( \frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 \)
- Total energy at Section 2 = \( \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 \)
- As there has been no addition or loss of energy between Sections 1 and 2,
  \[ \frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 = E \]
  This is Bernoulli's Equation.
96 Hydraulics and Hydrology

Figure 4.5 Energy equation parameters as related to water flow in a pipe.
Design of Transportation System

The design of the transportation system involves a determination of:

- Hydraulic adequacy
- Structural adequacy
- Economic efficiency

Locating the Aqueduct

- The location is mainly based on engineering and economic considerations
- Finding the most practical and economical route between the water source and the region to be served is a challenging issue
  - Open channel require suitable topography
  - Pressure conduits require pumping
Design of Transportation System

Dimensions of Aqueduct

- The size will be determined on the basis of hydraulic, economic, and construction considerations.

- Hydraulic factors that control the design are:
  - Available head
  - Limiting velocities
    - Minimum velocity is 2.5 fps (prevent silt deposition)
    - Maximum velocity between 10-20 fps (reduce pipe erosion)
\[ H_L = \frac{fL V^2}{D} \frac{V}{g} \]

\[ V = \frac{Q}{A} = \frac{2.5 \times 10^4 \times 1.55}{\pi \times 4 \times 10^{-4}} = 3.09 \text{ ft/psi} \]

\[ H_L = 0.0182 \times \frac{5280 \times 10^3}{4} \times \frac{(3.09)^2}{64.4} \]

5. \[ H_f = (330 - 100) - 35.6 \]
\[ = 150 - 35.6 \approx 115.6 \text{ ft-lb} \]

the energy imparted by the pump to the water.

6. The power requirement may be computed as

\[ P = \frac{QH_f}{\eta} \]
\[ = 25 \times 1.55 \times 62.4 \times 165.6 = 400,000 \text{ ft-lb/sec} \]

7. For 80% efficiency, the power requirement is

\[ \frac{400,000}{0.80} = 500,000 \text{ ft-lb/sec} \]

8. \[ 5.00 \times 10^4 \times 3.766 \times 10^{-7} = 18.8 \times 10^{-2} \text{ kW-h/sec} \]

The number of kilowatt-hours per 30-day month is then

\[ 18.8 \times 10^{-2} \times 30 \times 864 \times 10^3 = 485,000 \text{ kW-h/month} \]

9. The monthly power cost is therefore \[ 485,000 \times 0.01 = 4,850.00 \]