Solutions to Hydraulics and Hydrology Problems

Civil Engineering Licensure Exam – Mock Quiz (Day 21)

March 2, 2025

Problem Solutions

1. **Problem 1:** A pipeline carries water at a velocity of 3 m/s with a pressure of 120 kPa at one section. If at another section the velocity increases to 5 m/s, determine the pressure at this second section using Bernoulli's equation.

   Solution: Using Bernoulli's equation:

   $$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

   Rearranging:

   $$P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2)$$

   Given $P_1 = 120$ kPa, $v_1 = 3$ m/s, $v_2 = 5$ m/s, and $\rho = 1000$ kg/m^3:

   $$P_2 = 120{,}000 + \frac{1}{2} \times 1000 \times (3^2 - 5^2)$$

   $$= 120{,}000 - 8000 = 112{,}000Pa = 112kPa$$

   Video Solution: `https://www.youtube.com/watch?v=DW4rItB20h4`

2. **Problem 2:** A trapezoidal channel has a bottom width of 4 m and side slopes of 2:1 (H:V). If the flow depth is 1.5 m, determine the hydraulic radius.

   Solution: The hydraulic radius R is:

   $$R = \frac{A}{P}$$

   where A is the cross-sectional area, and P is the wetted perimeter. First, calculate the top width:

$$T = b + 2 \times sideslope \times depth = 4 + 2 \times 2 \times 1.5 = 10m$$

Then, the area:

$$A = \frac{1}{2}(b + T) \times depth = \frac{1}{2}(4 + 10) \times 1.5 = 10.5m^2$$

Wetted perimeter:

$$P = b + 2 \times \sqrt{(sideslope \times depth)^2 + depth^2}$$

$$= 4 + 2 \times \sqrt{(2 \times 1.5)^2 + 1.5^2} = 10.708m$$

Finally:

$$R = \frac{10.5}{10.708} = 0.98m$$

Video Solution: `https://www.youtube.com/watch?v=WFStRMx1HeU`

3. **Problem 3:** A watershed with an area of 5 km^2 receives a storm with an intensity of 40 mm/hr. Using a runoff coefficient of 0.75, compute the peak runoff using the Rational Method.

   Solution: The Rational Method formula:

   $$Q = 0.0028 \times C \times I \times A$$

   where $C = 0.75$, $I = 40$ mm/hr, and $A = 500$ hectares.

   $$Q = 0.0028 \times 0.75 \times 40 \times 500 = 42m^3/s$$

   Video Solution: `https://www.youtube.com/watch?v=AhYI4SqZWOg`

4. **Problem 4:** A 3 m wide rectangular channel has a discharge of 10 m^3/s. Compute the critical depth.

   Solution: The critical depth y_c for a rectangular channel:

   $$y_c = \left(\frac{Q^2}{g \times b^2}\right)^{1/3}$$

   where $Q = 10$ m^3/s, $g = 9.81$ m/s^2, and $b = 3$ m.

   $$y_c = \left(\frac{100}{88.29}\right)^{1/3} = (1.133)^{1/3} = 1.04m$$

   Video Solution: `https://www.youtube.com/watch?v=LMHj7JkxbHc`

5. **Problem 5:** A groundwater well extracts water from an unconfined aquifer with a hydraulic conductivity of 8 m/day. If the water table drop over a distance of 500 m is 2 m, determine the Darcy velocity.

   Solution: Using Darcy's Law:

$$v = K \times i$$

   where $K = 8$ m/day and $i = \frac{\Delta h}{L} = \frac{2}{500} = 0.004$.

$$v = 8 \times 0.004 = 0.032 m/day$$

   Video Solution: `https://www.youtube.com/watch?v=FGWfGavDnmE`