What is Open Channel Flow?

Worksheet

Manning's equation: v = (1/n)R_h^(2/3)S^(1/2), where v is mean velocity, n is Manning's roughness coefficient, R_h is hydraulic radius, and S is channel slope.

$$v = (1/n)\ R_h^{(2/3)}\ S^{(1/2)}$$

Questions

1. Manning's equation shows velocity increases with

A) slope only
B) roughness only
C) S^(1/2) and 1/n
D) none of these

2. Hydraulic radius defined as

A) A/P
B) P/A
C) A
D) D/2

3. Manning's n is higher for

A) smooth concrete
B) rough earthen channels
C) vegetated banks
D) all same n

4. Doubling channel slope increases velocity by

A) 2
B) 2
C) 4
D) no change

5. Trapezoidal canal: R_h = 1 m, Manning's n = 0.03, slope S = 0.001. Flow velocity?

6. Rectangular canal: width 5 m, depth 1.2 m (n=0.025, S=0.0005). R_h and velocity?

7. Doubling slope (S = 0.001 to 0.002), velocity increases by?

8. Define: Manning's equation for velocity?

9. Define: What is hydraulic radius?

10. Define: Manning's coefficient n depends on

Answer Key

1. C) S^(1/2) and 1/n - v S^(1/2) and v 1/n - steeper and smoother channels have higher velocity.

2. A) A/P - R_h = A/P - area divided by wetted perimeter.

3. C) vegetated banks - Rougher channels (vegetation, rocks) have higher n, reducing velocity.

4. B) 2 - v S^(1/2), so doubling S increases v by 2 1.414.

5. v = (1/n)R_h^(2/3)S^(1/2) v = (1/0.03) 1^(2/3) (0.001)^(1/2) v = 33.33 1 0.0316 = 1.05 m/s

6. A = 5 1.2 = 6 m; P = 5 + 2(1.2) = 7.4 m R_h = A/P = 6/7.4 = 0.81 m v = (1/0.025) 0.81^(2/3) sqrt(0.0005) = 40 0.735 0.0224 = 0.66 m/s

7. v S^(1/2), so v_new/v_old = sqrt(2) 1.414 Velocity increases by ~41%

8. v = (1/n)R_h^(2/3)S^(1/2) - velocity increases with 1/n, R_h, and S.

9. R_h = A/P - cross-sectional area divided by wetted perimeter.

10. Channel surface roughness (concrete 0.012, earthen 0.03-0.05, natural 0.03-0.1).