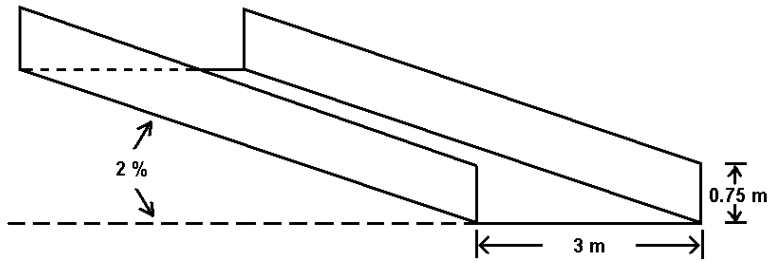
TOPIC

Fluids – Section X – Question 6

QUESTION

A rectangular open channel (see figure below) is used to handle storm water run-off. The channel is 3 m wide and 0.75 m deep and is lined with concrete. The channel is oriented on a 2% grade and the concrete has a Manning roughness coefficient of 0.014. The maximum volumetric flow rate of water (in m^3/s) that the channel can handle is closest to:

(A) 6.4
(B) 8.4
(C) 10.1
(D) 14.3



HINTS

- Maximum flow occurs when the channel is full
- Open channel flow is represented by Manning's equation
- Hydraulic radius is flow area over wetted perimeter
- Volumetric flow rate is velocity times cross sectional area.

SOLUTION

This situation is described by Manning's equation as

$$v = \frac{1}{n} R^{2/3} S^{1/2}$$

where

S is the slope of the channel (m/m),
n is the roughness coefficient,
v is the fluid velocity in m/s, and
R is the hydraulic radius defined in terms of the flow area A and the wetted perimeter Pas

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

For flow in a rectangular channel of width W and liquid height h, the area and wetted perimeter are

$$A = Wh$$
$$P = W + 2h$$

The maximum flow will occur when the channel is full (when h = 0.75 m). Thus

$$A = (3)(0.75)$$
$$= 2.25m^2$$
$$P = 3 + 2(0.75)$$
$$= 4.5m$$
$$R = \frac{2.25}{4.5}$$
$$= 0.5m$$

The velocity of water in the channel is then given by Manning's equation

$$v = \frac{1}{0.014}(0.5)^{2/3}(0.02)^{1/2}$$
$$\rightleftarrows = 6.36\text{m/s}$$

The maximum flow rate is then the velocity times the flow area

$$Q = (6.36\text{m/s})(2.25m^2)$$
$$= 14.3m^3/\text{s}$$

ANSWER

(D)

CONTRIBUTOR

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