BACK WATER CURVE

16.9.2 Back Water Curve and Afflux. Consider the flow over a dam as shown in Fig. 16.30. On the upstream side of the dam, the depth of water will be rising. If there had not been any obstruction (such as dam) in the path of flow of water in the channel, the depth of water would have been constant as shown by dotted line parallel to the bed of the channel in Fig. 16.30. Due to obstruction, the water level rises and it has maximum depth from the bed at some section.

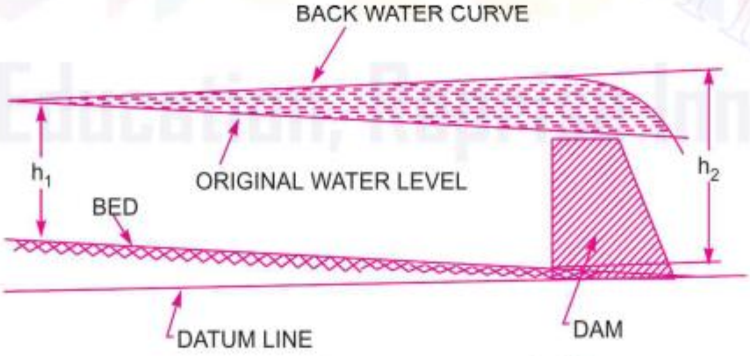

Fig. 16.30 *Back water curve and afflux.*

Let h_1 = depth of water at the point, where the water starts rising up, and

h_2 = maximum height of rising water from bed.

Then $(h_2 - h_1)$ = afflux. Thus *afflux* is defined as the maximum increase in water level due to obstruction in the path of flow of water. The profile of the rising water on the upstream side of the dam is called *back water curve*. The distance along the bed of the channel between the section where water starts rising to the section where water is having maximum height is known as *length of back water curve*.

16.9.3 Expression for the Length of Back Water Curve. Consider the flow of water through a channel in which depth of water is rising as shown in Fig. 16.31. Let the two sections 1-1 and 2-2 are at such a distance that the distance between them represents the length of back water curve.

Let h_1 = depth of flow at section 1-1,

V_1 = velocity of flow at section 1-1,

h_2 = depth of flow at section 2-2,

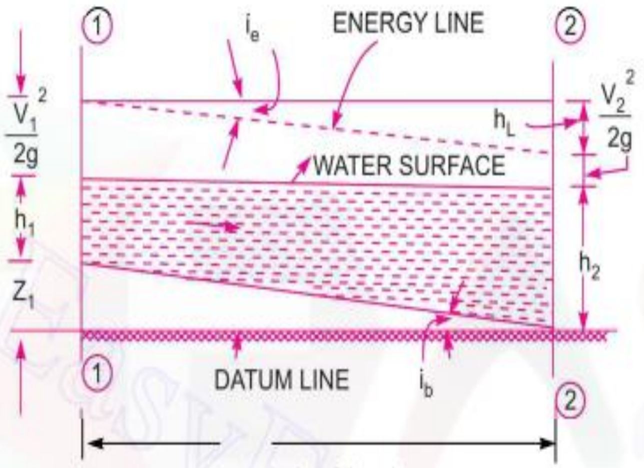

Fig. 16.31 *Length of back water curve.*

V_2 = velocity of flow at section 2-2,

i_b = bed slope,

i_e = energy line slope, and

L = length of back water curve.

Applying Bernoulli's equation at sections 1-1 and 2-2,

$$Z_1 + h_1 + \frac{V_1^2}{2g} = Z_2 + h_2 + \frac{V_2^2}{2g} + h_L \qquad ...(i)$$

where h_L = Loss of energy due to friction = $i_e \times L$

Also taking datum line passing through the bed of the channel at section 2-2. Then $Z_2 = 0$

$\therefore$ Equation (*i*) becomes as $Z_1 + h_1 + \frac{V_1^2}{2g} = h_2 + \frac{V_2^2}{2g} + i_e \times L$

From Fig. 16.31, $Z_1 = i_b \times L$

$$\therefore \quad i_b \times L + h_1 + \frac{V_1^2}{2g} = h_2 + \frac{V_2^2}{2g} + i_e \times L$$

or
$$i_b \times L - i_e \times L = \left(h_2 + \frac{V_2^2}{2g}\right) - \left(h_1 + \frac{V_1^2}{2g}\right)$$

or
$$L\,(i_b - i_e) = E_2 - E_1, \quad \text{where } E_2 = h_2 + \frac{V_2^2}{2g},\ E_1 = h_1 + \frac{V_1^2}{2g}$$

$$\therefore \quad L = \frac{E_2 - E_1}{i_b - i_e}. \qquad ...(16.34)$$

Equation (16.34) is used to calculate the length of back water curve. The value of i_e (slope of energy line) is calculated either by Manning's formula or by Chezy's formula. The mean values of velocity, depth of flow, hydraulic mean depth etc., are used between sections 1-1 and 2-2 for calculating the value of i_e.

Problem 16.45 *Determine the length of the back water curve caused by an afflux of 2.0 m in a rectangular channel of width 40 m and depth 2.5 m. The slope of the bed is given as 1 in 11000. Take Manning's N = 0.03.*

Solution. Given :

Width of channel, $b = 40$ m

Afflux, $(h_2 - h_1) = 2.0$ m

Depth of channel, $h_1 = 2.5$ m

$\therefore$ $h_2 = 2.0 + 2.5 = 4.5$ m

Bed slope, $i_b = \frac{1}{11000} = 0.0000909$

Manning's, $N = 0.03$

Area of flow at section 1, $A_1 = b \times h_1 = 40 \times 2.5 = 100\ \text{m}^2$

Wetted perimeter, $P_1 = b + 2h_1 = 40 + 2 \times 2.5 = 45$ m

$\therefore$ Hydraulic mean depth, $m_1 = \frac{A_1}{P_1} = \frac{100}{45} = 2.22$ m