Contributor name: Khushbu ghaghada
Book Proposed: Irrigation and water power Engineering
Total Chapters: 23
Total Examples: 251
Codable Examples: 247

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...igation $= \frac{40}{60} \times 29 = 23.2$ millions

Line 3 gives the *total allocation* which is equal to the sum of separable cost and allocated joint cost for each purpose.

Line 4 gives the total allocation in percentage.

14. EXAMPLES FROM COMPETITIVE EXAMINATIONS

Example 6.7. *The Muskingnum method by McCarthy assumes the reach storage in a stream to be given by $S = K[x\,I + (1-x)\,O]$ where K is the storage constant. Also basic routing equation written for discrete time is*

$$\frac{I_1 + I_2}{2} - \frac{O_1 + O_2}{2} t = S_2 - S_1.$$

Derive from these Muskingnum equation and incidently determine the coefficients therein. What is the sum of coefficients ? **(Engg. Services Exam. 1986)**

Solution

Given the reach storage equation as under :

$$S = K\,[x\,I + (1-x)\,O] \quad \text{...(1)}$$

Also, the basic routing equation is

$$\frac{I_1 + I_2}{2} t - \frac{O_1 + O_2}{2} t = S_2 - S_1 \quad \text{...(2)}$$

Substituting the following values of S_1 and S_2 from (1), into (2), we have

$$S_1 = K\,[x\,I_1 + (1-x)\,O_1] \text{ and } S_2 = K\,[x\,I_2 + (1-x)\,O_2]$$

$$\therefore \quad \frac{I_1 + I_2}{2} t - \frac{O_1 + O_2}{2} t = K\,[x\,I_2 + (1-x)\,O_2] - K\,[x\,I_1 + (1-x)\,O_1]$$

or $$\frac{I_1 + I_2}{2} t + K\,[x\,I_1 + (1-x)\,O_1] = \frac{O_1 + O_2}{2} t + K\,[x\,I_2 + (1-x)\,O_2]$$

or $$(I_1 + I_2) + \frac{2K}{t}[x\,I_1 + (1-x)\,O_1] = O_1 + O_2 + \frac{2K}{t}[x\,I_2 + (1-x)\,O_2]$$

or $$I_1 + I_2 + \frac{K x I_1}{0.5\,t} + \frac{K}{0.5\,t}(1-x)\,O_1 = O_1 + O_2 + \frac{x K I_2}{0.5\,t} + \frac{K O_2 (1-x)}{0.5\,t}$$

or $$\left[I_1 + \frac{K x I_1}{0.5\,t}\right] + \left[I_2 - \frac{x K I_2}{0.5\,t}\right] + \left[\frac{K(1-x)}{0.5\,t} O_1 - O_1\right] = \left[O_2 + \frac{K(1-x)}{0.5\,t} O_2\right]$$

or $$O_2\left[\frac{0.5\,t + K(1-x)}{0.5\,t}\right] = I_1\left[\frac{0.5\,t + K x}{0.5\,t}\right] + I_2\left[\frac{0.5\,t - K x}{0.5\,t}\right] + O_1\left[\frac{K(1-x) - (}{0.5\,t}\right.$$

or $$O_2(K - Kx + 0.5t) = I_1(Kx + 0.5t) + I_2(-Kx + 0.5t) + O_1(K - Kx - 0.5t)$$

or $$O_2 = I_1\left[\frac{Kx + 0.5t}{K - Kx + 0.5t}\right] + I_2\left[\frac{-Kx + 0.5t}{K - Kx + 0.5t}\right] + O_1\left[\frac{K - Kx - 0.5t}{K - Kx + 0.5t}\right]$$

or $$O_2 = C_0 I_2 + C_1 I_1 + C_2 O_1$$

Which is the required Muskingnum equation, where

$$C_0 = \frac{-Kx + 0.5t}{K - Kx + 0.5t}, \quad C_1 = \frac{Kx + 0.5t}{K - Kx + 0.5}\quad \text{and} \quad C_2 = \frac{K - Kx - 0.5t}{K - Kx + 0.5t}$$

Sum of the coefficients $C_0 + C_1 + C_2$

$$= \frac{1}{K - Kx + 0.5t}[-Kx + 0.5t + Kx + 0.5t + K - Kx - 0.5t] = 1$$

Example 6.8 – Codable
Example 6.9 – Codable
Example 6.10 – Codable

Chapter 7: Dams I : General
No examples

Chapter 8: Dams II : Gravity Dams
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Example 8.2 – Codable
Example 8.3– Codable
Example 8.4 – Codable
Example 8.5 – Non Codable

Example 8.5. *Considering earthquake forces due to uniform horizontal acceleration $\alpha_h = \alpha$ and uniform vertical acceleration $\alpha_v = \alpha$ in addition to the hydrostatic pressure and uplift pressure, determine the base width of the elementary profile of gravity dam so that resultant passes through the outer third point.*

Solution

Let b = base width of elementary profile dam *ABC*.

The various forces acting on the dam are shown in Fig. 8.33.

(a) *Vertical forces*

1. Force due to self-weight of dam $= W = \frac{1}{2} bHw\rho\ (\downarrow)$
2. Force due to vertical acceleration of earthquake

$$= \alpha W = \frac{\alpha bHw\rho}{2} \uparrow$$

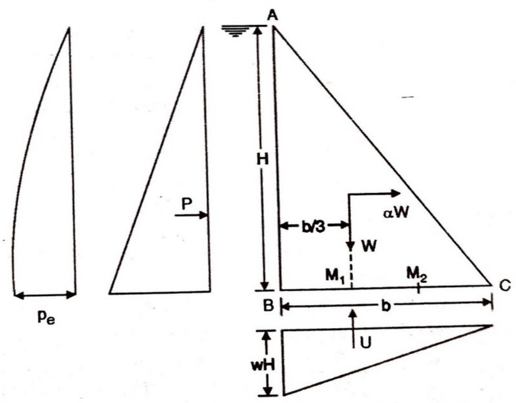

FIG. 8.33.

3. Force due to uplift $= U = \frac{1}{2} b \cdot wH\,(\uparrow)$

Hence $\Sigma V = W - \alpha W - U = \frac{1}{2} bwH\,[(1-\alpha)\rho - 1]$

where w = unit weight of water, ρ = specific weight of concrete

and α = coefficient of earthquake acceleration (both vertical as well as horizontal).

(b) *Horizontal forces*

1. Force due to water pressure $P = \frac{1}{2} wH^2$

2. Force due to hydrodynamic pressure of water at base :

$$C_m = 0.735\left(1 - \frac{\theta}{90^\circ}\right) = 0.735 \text{ (since } \theta = 90^\circ)$$

$$\therefore \quad p_e = C_m\,\alpha\,wH = 0.735\ \alpha\,wH$$

$$P_e = 0.726\ p_e \cdot H$$

$$M_e = 0.299\,p_e\ H^2 = 0.299 \times 0.735\ \alpha\,wH^3 = 0.2198\ \alpha\,w\,H^3.$$

3. *Inertia force* (horizontal) $= \alpha\,W = \frac{1}{2}\,\alpha\,b\,H\,w\,\rho$

If the resultant of all forces has to pass through the outer third point M_2, moment of all these forces at this point must be zero.

$$\therefore \quad \Sigma V \times \frac{b}{3} - \left[\frac{wH^2}{2} \times \frac{H}{3} + 0.2198\ \alpha\,w\,H^3 + \frac{\alpha\,w\,b\,H\,\rho}{2} \times \frac{H}{3}\right] = 0$$

or
$$\frac{b^2\,H\,w}{6}\left[(1-\alpha)\,\rho - 1\right] - \frac{bH^2\,w\,\rho\,\alpha}{6} - \frac{w\,H^3}{6}\left[1 + \alpha\,(1.3186)\right] = 0$$

or
$$b^2\,[(1-\alpha)\,\rho - 1] - bH\rho\alpha - H^2\,[1 + 1.3186\,\alpha] = 0$$

or
$$b = H\,\frac{\rho\alpha \pm \sqrt{\rho^2\alpha^2 + 4(1 + 1.3186\alpha)\left[(1-\alpha)\,\rho - 1\right]}}{2\,[(1-\alpha) - 1]} \qquad \ldots(8.54)$$

which is the required expression.

Putting $\alpha = 0$ when no earthquake acts, the value of b reduces to

$$b = \frac{H}{\sqrt{\rho - 1}}$$

which is the same as Eq. 8.42 when $c = 1$.

Example 8.6 – Non Codable

which is the same as Eq. 8.42 when c = 1.

Example 8.6. *Analysis of Rectangular profile dam*

A rectangular dam has constant width b and height H with reservoir full upto top. Analyse the dam completely.

Solution

Consider a rectangular dam of width b and height H. (Fig. 8.34)

$$W = bH\,\rho\,w; \quad P = \frac{wH}{2}; \quad U = \frac{1}{2}\,cwbH$$

Let the resultant pass through a point M, distant $\bar{x}$ from the toe B. Taking oments about the toe, we have.

$$\Sigma M = W \cdot \frac{b}{2} - \frac{PH}{3} - U \cdot \frac{2b}{3}$$

Also $\Sigma W = W - U.$

$$\therefore \quad \bar{x} = \frac{\Sigma M}{\Sigma W} = \frac{W \frac{b}{2} - \frac{PH}{3} - \frac{U \cdot 2b}{3}}{W - U}$$

Substituting the values of W, P and U, we get.

$$\bar{x} = \frac{bH\rho w \cdot \frac{b}{2} - \frac{wH^3}{6} - \frac{2}{3} b \left(\frac{1}{2} cwbH\right)}{bH\rho w - \frac{1}{2} cwb H}$$

or

$$\bar{x} = \frac{\frac{b}{2} (bH\rho w - \frac{1}{2} cwbH) - \frac{wH^3}{6} - (\frac{1}{2} cwbH) \frac{b}{6}}{bH\rho w - \frac{1}{2} cwbH}$$

$$= \frac{b}{2} - \frac{\frac{wH^3}{6} + \frac{1}{2} cwbH \cdot \frac{b}{6}}{bH\rho w - \frac{1}{2} cwbH}$$

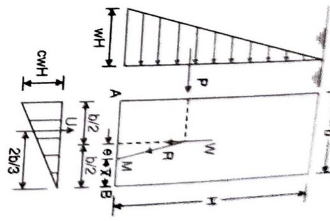

FIG. 8.34. RECTANGULAR PROFILE

Hence $\quad e = \frac{b}{2} - \bar{x} = \frac{\frac{wH^3}{6} + \frac{1}{2} cwbH \cdot \frac{b}{6}}{bH\rho w - \frac{1}{2} cwbH} = \frac{\frac{H^2}{6} + \frac{cb^2}{12}}{b\rho - \frac{1}{2} cb}$

For no tension to develop

$$e = \frac{b}{6} = \frac{\frac{H^2}{6} + \frac{cb^2}{12}}{b\rho - \frac{1}{2} cb}$$

or

$$\frac{b^2}{6} \left(\rho - \frac{c}{2}\right) = \frac{H^2}{6} + \frac{cb^2}{12} \quad \text{or} \quad b^2 (\rho - c) = H^2$$

From which $\quad b = \frac{H}{\sqrt{\rho - c}} \qquad$ If $c = 0$ (no uplift), $\quad b = \frac{H}{\sqrt{\rho}}$

Also, the limiting height is given by, $H_{\text{lim}} = b \sqrt{\rho - c}$

From stability considerations, providing a F.S. of 1.5 against sliding, we have

$$\mu (W - U) = 1.5 \, P$$

or

$$\mu \left(b \, H\rho w - \frac{1}{2} cwbH\right) = \frac{3}{2} \times \frac{wH^2}{2} \quad \text{or} \quad \mu b \left(\rho - \frac{c}{2}\right) = \frac{3}{4} H$$

From which $\quad b = \frac{3}{4} \frac{H}{\mu \left(\rho - \frac{c}{2}\right)}$

If $c = 0$ (i.e. no uplift) $b = \frac{3}{4} \frac{H}{\mu \rho}$

Also, limiting height is, $\quad H_{\text{lim}} = \frac{4}{3} b \, \mu \left(\rho - \frac{c}{2}\right)$

Neglecting uplift, $\quad H_{\text{lim}} = \frac{4}{3} b\mu\rho$

From *crushing point of view*, when $e = b/6$, we get

$$p_n = \frac{2\,(W - U)}{b} = \frac{2}{b} \left(bH\rho w - \frac{1}{2} cwbH\right)$$

$$\sigma_c = p_n = 2\,wH \left(\rho - \frac{1}{2} c\right)$$

$$H_{\text{lim}} = \frac{\sigma_c}{2\,w\,(\rho - \frac{1}{2} c)}$$

If uplift is neglected, $\quad H_{lim.} = \frac{\sigma_c}{2\,w\,\rho}$

Example 8.7 – Non Codable

If uplift is neglected, ... $2w\rho$

Example 8.7. Analysis of trapezoidal dam

A trapezoidal dam with u/s face vertical, has top width a and bottom width b. Analyse the dam completely.

Solution :

Consider a trapezoidal profile with top width a and bottom width b, with upstream face vertical, as shown in Fig. 8.35.

W_1 = weight of rectangular portion
$= aH\rho w$

W_2 = weight of triangular portion
$= \frac{1}{2} bH \,.\, \rho w$

P = Water pressure $= \dfrac{wH^2}{2}$

C = uplift pressure $= \frac{1}{2} cwbH$

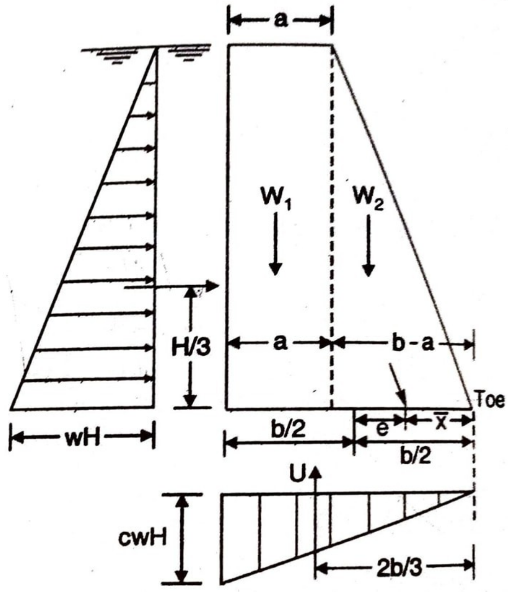

FIG. 8.35

Let the resultant fall at $\bar{x}$ from the toe.

If ΣM is the sum of moments of all the forces about the toe, we have

$$\Sigma M = \bar{x} \,.\, \Sigma W \qquad \text{or} \qquad \bar{x} = \frac{\Sigma M}{\Sigma W}$$

$$\therefore \quad \bar{x} = \frac{aH\rho w\left(b - \dfrac{a}{2}\right) + \dfrac{1}{2} bH\rho w \times \dfrac{2}{3}(b-a) - \dfrac{wH^3}{6} - \dfrac{1}{2} cwb\,H \times \dfrac{2}{3} b}{aH\rho w + \dfrac{1}{2} bH\rho\, w - \dfrac{1}{2} cwbH}$$

$$\text{or} \qquad \bar{x} = \frac{a\,\rho\left(b - \dfrac{a}{2}\right) + \dfrac{1}{3} b\,\rho\,(b-a) - \dfrac{H^2}{6} - \dfrac{1}{3} cb^2}{a\,\rho + \dfrac{1}{2}\rho\, b - \dfrac{1}{2} cb}$$

Eccentricity $e = \dfrac{b}{2} - \bar{x}$ and $p_n = \dfrac{\Sigma W}{b}\left(1 \pm \dfrac{6e}{b}\right)$.

Thus, stress at toe and heel can be found.

Example 8.8. *Rectangular* ...

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Chapter 22: Water Resource Planning
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Chapter 23 : Important Dams of India
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