

2020

MADE EASY
WORKBOOK



**Detailed Explanations of
Try Yourself Questions**

**Civil Engineering
Irrigation Engineering**



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— Publications

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Water Requirements of Crops



Detailed Explanation of Try Yourself Questions

T1 : Solution

Area to be irrigated under wheat, $A_w =$ Intensity of Irrigation for wheat \times CCA
 $= 0.20 \times 6000 = 1200$ ha

Area to be irrigated under rice, $A_R =$ Intensity of irrigation for Rice \times CCA
 $= 0.1 \times 6000 = 600$ ha

Duty for Wheat and Rice:

Given:

Kor period for wheat = 3 Weeks or 21 days

Depth of Kor watering for wheat = 9 cm

Kor period for rice = 2 weeks or 14 days

Depth of Kor watering for rice = 25 cm

Using relation, $\Delta = 8.64 B/D$

where, $\Delta =$ Kor water depth (in m)

$B =$ days

$D =$ Duty (hectare/cumec)

For Wheat:

$$D_w = \frac{8.64 \times 21}{0.09} = 2016 \text{ ha/cumec}$$

For Rice:

$$D_R = \frac{8.64 \times 14}{0.25} = 483.84 \text{ ha/cumec}$$

Water required at the head of distributary to irrigate,

(i) Wheat:
$$Q_W = \frac{A_W}{D_W} = \frac{1200}{2016} = 0.595 \text{ m}^3/\text{s or cumec}$$

(ii) Rice:
$$Q_R = \frac{A_R}{D_R} = \frac{600}{483.84} = 1.240 \text{ m}^3/\text{s or cumec}$$

The required total outlet discharge is the maximum of the two i.e.

$$Q = 1.240 \text{ cumec}$$

T2 : Solution

$$Q = 10 \text{ cumecs}$$

$$A = 32 \text{ ha}$$

$$t = 4 \text{ hours}$$

Depth of water stored in root zone,

$$y_s = 0.3 \text{ m}$$

Volume of water applied to the field = $0.10 \times 4 \times 60 \times 60 = 144000 \text{ m}^3$

Depth of water applied to the field,

$$y_f = \frac{144000}{32 \times 10^4} = 0.45 \text{ m}$$

\therefore Water application efficiency = $\frac{y_s}{y_f} \times 100 = \frac{0.3}{0.45} \times 100 = 66.67\%$

T3 : Solution

$$Q_R = 0.4 \text{ m}^3/\text{s}$$

$$\text{Time factor} = 0.5$$

$$Q_{kh} = 0.3 \text{ m}^3/\text{s}$$

$$\text{Capacity factor} = 0.8$$

$\therefore Q_{max} = Q_R = 0.4 \text{ m}^3/\text{s}$

\therefore Design discharge = $\frac{0.4}{0.5 \times 0.8} = 1 \text{ m}^3/\text{s}$

T4 : Solution

Crop	Base period (days)	Duty of the water at the field (ha/cumec)	Intensity of irrigation (%)	Area of each crop under irrigation	Water required by crop (cumec)	Volume of water required (in Mm ³)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Wheat	120	1800	20	8000	4.444	46.08
Sugarcane	360	1700	20	8000	4.706	146.37
Cotton	180	1400	10	4000	2.857	44.43
Rice	120	800	15	6000	7.500	77.76
Vegetables	120	700	15	6000	8.571	88.87
			$\Sigma = 80$	$\Sigma = 32000$		$\Sigma = 403.51$

Water required by crop in cumec (Col. 6)

$$= \frac{\text{Area of crop under irrigation}}{\text{Duty of crop at field}}$$

Volume of water required by crop (Col. 7)

$$= \text{Column (6)} \times \text{Column (1)}$$

Hence, total water required at the field = 403.51 Mm³

Canal losses = 25%

$$\therefore \text{Water required at Canal head} = \frac{403.51}{0.75} = 538.013 \text{ Mm}^3$$

Reservoir losses = 15%

$$\therefore \text{Gross reservoir capacity} = \frac{538.013}{0.85} = 633 \text{ Mm}^3$$

$$\therefore \text{Canal capacity} = \frac{(4.706 + 2.857 + 7.500)}{\eta} = \frac{15.063}{0.75} = 20.084 \text{ cumecs}$$

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Design of Unlined and Lined Canals

T1 : Solution

For the more efficient trapezoidal channel, side slopes should be $1:\sqrt{3}$ i.e. $m = \frac{1}{\sqrt{3}}$ and $R = \frac{y}{2}$.

Using, $Q = C\sqrt{RS} \times A$
we have, $Q = 21.5 \text{ m}^3/\text{s}$

$$C = 70 \text{ and } S = \frac{1}{2500}$$

$$\therefore 21.5 = 70 \times \sqrt{R} \cdot \frac{1}{\sqrt{2500}} \times A$$

or, $21.5 = \frac{70}{50} \sqrt{R} \cdot A$

Also, $A = [2\sqrt{1+m^2} - m] y^2 = \left[2\sqrt{1+\frac{1}{3}} - \frac{1}{\sqrt{3}} \right] y^2 = 1.732 y^2$

$$\therefore 21.5 = \frac{70}{50} \cdot \sqrt{\frac{y}{2}} \times 1.732 y^2$$

$$\therefore y = 2.75 \text{ m}$$

Also, $A = 1.732 (2.75)^2 = 13.10 \text{ m}^2$

But, $A = (B + m \cdot y) y = \left(B + \frac{1}{\sqrt{3}} \times 2.75 \right) 2.75$

$$\therefore 13.10 = (B + 0.577 \times 2.75) 2.75$$

$$B = 3.18 \text{ m}$$

The channel dimensions are thus worked out as:

$$B = 3.18 \text{ m and } y = 2.75 \text{ m}$$

Velocity as per Chezy's equation determined above is

$$V = C\sqrt{RS} = 70 \cdot \sqrt{R} \cdot \frac{1}{50}$$

$$= 70 \sqrt{\frac{y}{2}} \cdot \frac{1}{50} = 70 \times \sqrt{\frac{2.75}{2}} \cdot \frac{1}{50} = 1.64 \text{ m/s}$$

With Manning's equation,

$$V = \frac{1}{n} \cdot R^{2/3} \cdot \sqrt{S}$$

$$1.64 = \frac{1}{n} \times \left(\frac{2.75}{2}\right)^{2/3} \cdot \frac{1}{50}$$

$$n = 0.015$$

T2 : Solution

$$Q = 50 \text{ cumec, } f = 1.1$$

$$V = \left[\frac{Qf^2}{140}\right]^{1/6} = \left[\frac{50 \times (1.1)^2}{140}\right]^{1/6} = 0.869 \text{ m/s}$$

$$A = \frac{Q}{V} = \frac{50}{0.869} = 57.54 \text{ m}^2$$

$$R = \frac{5}{2} \cdot \frac{V^2}{f} = 1.716 \text{ m}$$

$$P = 4.75\sqrt{Q} = 4.75\sqrt{50} = 33.59 \text{ m}$$

For a trapezoidal channel with $\frac{1}{2}$ H : 1 V side slopes

$$P = b + \sqrt{5}y$$

∴

$$33.59 = b + \sqrt{5}y \quad \dots(i)$$

and

$$A = \left(b + \frac{y}{2}\right)y$$

∴

$$57.54 = by + \frac{y^2}{2} \quad \dots(ii)$$

From equation (i),

$$b = 33.59 - 2.24y$$

Putting this value of b in equation (ii),

$$57.54 = [33.59 - 2.24y]y + \frac{y^2}{2}$$

$$y^2 - 19.30y + 33.05 = 0$$

∴

$$y = 1.9 \text{ m}$$

and

$$b = 29.35 \text{ m}$$

$$S = \frac{f^{5/3}}{3340Q^{1/6}} = \frac{(1.1)^{5/3}}{3340 \cdot (50)^{1/6}} = \frac{1}{5469}$$

Use a bed slope of 1 in 5469.

T3 : Solution

The channel section is trapezoidal,

$$A = y(B + y\theta + y \cot\theta)$$

and

$$P = B + 2y\theta + 2y \cot\theta$$

For $1\frac{1}{2} : 1$ slope, $\cot\theta = 1.5$ and $\theta = 0.59$ radian

$$\therefore A = y(B + 2.09y)$$

$$\text{and } P = B + 4.18y$$

$$\text{Given, } y = 4.0 \text{ m}$$

$$\therefore A = 4(B + 8.36) = 4B + 33.44$$

$$\text{and } P = B + 4.18 \times 4 = B + 16.72$$

$$\Rightarrow R = \frac{A}{P} = \frac{4B + 33.44}{B + 16.72}$$

$$Q = \frac{1}{n} \cdot AR^{2/3} \cdot S^{1/2}$$

$$\therefore 350 = \frac{1}{0.013} \times (4B + 33.44) \left(\frac{4B + 33.44}{B + 16.72} \right)^{2/3} \frac{1}{\sqrt{6400}}$$

$$\text{or, } 364 = \frac{(4B + 33.44)^{5/3}}{(B + 16.72)^{2/3}} \quad \dots(i)$$

Solving equation (i) by Hit and Trial

(i) Use, $B = 30 \text{ m}$
L.H.S. = 365
R.H.S. = 339

(ii) Use, $B = 32 \text{ m}$
R.H.S. = 359

(iii) Use, $B = 32.5 \text{ m}$
R.H.S. = 364 (OK)

Hence, use $B = 32.5$ and $y = 4.0 \text{ m}$

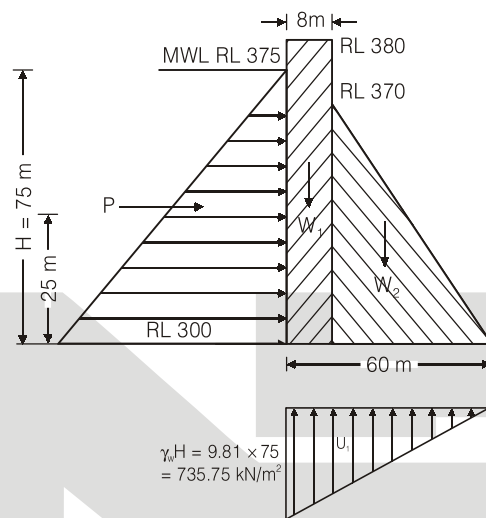
Using free-board of 0.75 m , we get total depth of lined channel = 4.75 m .



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Design & Analysis of Gravity Dam

T1 : Solution



$$\begin{aligned} \text{Unit weight of water} &= 1000 \text{ kg/m}^3 \\ &= 1000 \times 9.81 \text{ N/m}^3 = 9810 \text{ N/m}^3 = 9.81 \text{ kN/m}^3 \end{aligned}$$

$$\begin{aligned} \text{Unit weight of concrete} &= 2400 \times 9.81 \text{ N/m}^3 \\ &= 23544 \text{ N/m}^3 = 23.544 \text{ kN/m}^3 \end{aligned}$$

Consider 1 m length of dam

The various forces and their moments about the toe are then calculated and tabulated in the table

Name of the force	Designation if given	Magnitude in kN	Lever arm in m	Moment about toe
Vertical Forces				
Downward weight of the dam	W_1	$8 \times 80 \times 1 \times 23.54 = 15068.16$	56	(+) 843816.96
	W_2	$\frac{1}{2} \times 52 \times 70 \times 23.54 = 42842.8$	34.67	(+) 1485359.88
		$\Sigma V_1 = 57910.96$		$\Sigma M_1 = 2329176.84$
Uplift pressure	U_1	$-\frac{1}{2} \times 60 \times 735.75 = -22072.5$	40	(-) 882900
		$\Sigma V_2 = -22072.5$		$\Sigma m_2 = -882900$
Horizontal				
Water pressure on U/s face	P	$\frac{1}{2} \times 9.81 \times 75 \times 75 \times 1 = 27591$	25	(-) 689775

Net moment,

$$\Sigma M = 2329176.84 - 882900 - 689775 = 756501.84 \text{ kNm}$$

$$\Sigma V = 57918 - 22072.5 = 35838.46 \text{ kN}$$

Distance of resultant from toe

$$\bar{x} = \frac{\Sigma M}{\Sigma V} = \frac{756501.84}{35838.46} = 21.10 \text{ m}$$

Eccentricity,

$$e = \frac{B}{2} - \bar{x} = 30 - 21.11 = 8.89 \text{ m}$$

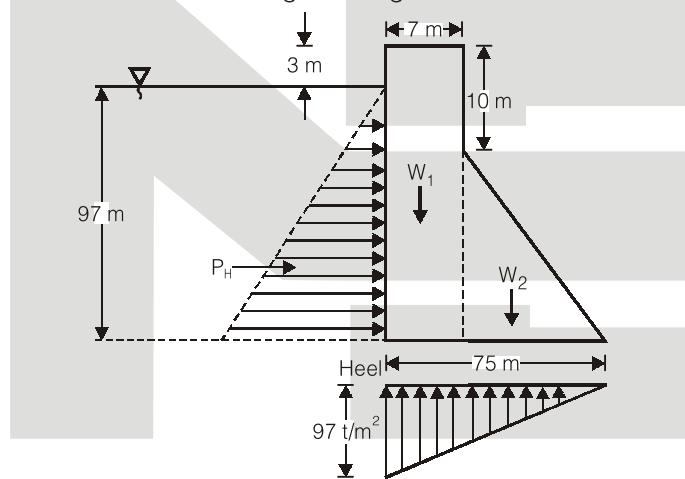
Since,

$$e < \frac{B}{6}$$

∴ Resultant passes through the middle third of the base.

T2 : Solution

Considering the uplift forces and considering unit length of dam all the forces will be calculated.



Given that,

$$\mu = 0.75$$

$$\text{Weight density of concrete} = 2.4 \text{ t/m}^3$$

$$\text{Weight density of water} = 1 \text{ t/m}^3$$

∴

$$W_1 = 7 \times (97 + 3) \times 1 \times 2.4 = 1680 \text{ t}$$

$$W_2 = \frac{1}{2} \times (75 - 7) \times (100 - 10) \times 1 \times 2.4 = 7344 \text{ t}$$

$$U = \frac{1}{2} \times 97 \times 75 \times 1 = 3637.5 \text{ t}$$

⇒

$$\Sigma F_V = W_1 + W_2 - U = 1680 + 7344 - 3637.5 = 5386.5 \text{ t}$$

$$\text{Horizontal force, } P_H = \frac{1}{2} \times 1 \times 97^2 = 4704.5 \text{ t}$$

∴

$$\Sigma F_H = P_H = 4704.5 \text{ t}$$

$$\text{Factor of safety against sliding} = \frac{\mu \Sigma F_V}{\Sigma F_H} = \frac{0.75 \times 5386.5}{4704.5} = 0.859 < 1 \quad (\text{Not safe})$$

Thus, the dam is not safe against sliding due to large magnitudes of uplift forces.



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Conveyance Structures for Canals and Canal Outlets/Modules

T1 : Solution

Non-modular outlet : These are the outlets whose discharge depends on the difference in water levels in the distributing channel and the water course. The discharge of such outlets, therefore, varies with the variation of the water levels in the distributing channel and the water course.

Semi-modular outlet : These are the outlets whose discharge varies with the variation of the water level in the distribution channel but it is independent of the water level in the water course, so long as the minimum working head required for their working is available.

Modular outlet : These are the outlets whose discharge is independent of the water levels in the distributing channel and the water course, within reasonable working limits. In other words modular outlets maintain a constant discharge irrespective of variation of the water levels in the distributing channel and the water course.

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