Examples of chapter 1

**EXAMPLE -1**

1 .A rectangular channel is to be dug in the rocky portion of a soil. Find its most economical cross-section if its to convey 12 m3/s of water with an average velocity of 3 m/s. Take chezy constant C=50

**Given**

Q=12 m3/s

V=3 m/s

C=50

**Solution**

The geometric relations for optimum discharge through a rectangular channel are

$$B=2Y and R=\frac{Y}{2}$$

 **Then** $area A=B×Y=2Y^{2}$

 When B,Y and R are base width, depth of flow and hydraulic radius respectively

 Now $Q=A×V or 12=2Y^{2}×3$

 From this equation solve for depth of flow

 $Y=1.414m$

 Therefore base width of flow $B=2Y=2×1.414=2.828m$

 Hydraulic radius,$R=\frac{Y}{2}=\frac{1.414}{2}=0.707m$

Also $V=C\sqrt{RS}$ chezy formula

 $S=\frac{V^{2}}{RC^{2}}=\frac{3^{2}}{0.707×50^{2}}=\frac{1}{196}$

Hence $B=2.828,Y=1.414,S=\frac{1}{196}$

*Most economical trapezoidal channel section*

 $T=B+2mY$

 $A=BY+mY^{2} …………… B=\frac{A}{Y}-mY$

 $P=B+2Y\sqrt{1+m^{2}}$

 $P=\frac{A}{Y}-mY+2Y\sqrt{1+m^{2}}$

But for most economic section
$$\frac{∂P}{∂Y}=0$$

$$\frac{∂P}{∂Y}=\frac{∂}{∂Y}\left(\frac{A}{Y}-mY+2Y\sqrt{1+m^{2}}\right)=0$$

$$A=\left(2\sqrt{1+m^{2}}-m\right)Y^{2} but A=\left(B+mY\right)Y$$

 $\left(B+mY\right)Y=\left(2\sqrt{1+m^{2}}-m\right)Y^{2} $

 $B=2Y(\sqrt{1+m^{2}}-m)$

 $R=\frac{A}{p}=\frac{(B+mY)Y}{(B+2Y\sqrt{1+m^{2}}}$

 $R=\frac{(2\sqrt{1+m^{2}}-m)Y^{2}}{2Y\sqrt{1+m^{2}}-2mY+2Y\sqrt{1+m^{2}}}$

 $R=\frac{Y}{2}$

**EXAMPLE-2**

An irrigation channel of trapezoidal section has side slope, m=2 and carries a discharge of 15m3/s on a longitudinal slope of 1 in 5000. The channel is to be lined for which the value of friction coefficient in Manning’s formula is n=0.012. Find the dimension of the most economic section of the channel.

 **GIVEN**

Side slope m=2

Discharge Q=15m3/s

Longitudinal slope S=1:5000

Manning´s coefficient n=0.012

 **SOLUTION**

 $A=\left(B+2Y\right)Y$

 $P=B+2\sqrt{\left(2Y\right)^{2}+Y^{2}}=B+2\sqrt{5}Y$

 $B=\frac{A}{Y}-2Y $

 $P=\frac{A}{Y}-2Y+2\sqrt{5}Y$

 $\frac{∂P}{∂Y}=-\frac{A}{Y^{2}}-2+2\sqrt{5}=0$

 $A=2.47Y^{2}$

 $P=B+2\sqrt{5}Y but B=\frac{A}{Y}-2Y $

 $=\frac{2.47Y^{2}}{Y}-2Y+2\sqrt{5}Y=4.94Y$

 $Q=\frac{A}{n}R^{^{2}/\_{3}}S^{^{1}/\_{2}}$

 $15^{m^{3}}/\_{s}=\frac{2.47Y^{2}}{0.012}×(0.5Y)^{^{2}/\_{3}}×(\frac{1}{5000})^{^{1}/\_{2}}$

 $Y=2.198m$

 $B=\frac{A}{Y}-2Y=1.04m $

**ACTIVITY1.3**

What do you mean by most economical section of an open channel? How is it determined?

What are the conditions for the rectangular channel of best section?

Show that the hydraulic mean depth of a trapezoidal

**ACTIVITY1.4**

What is specific energy and specific energy curve?

What do you understand by critical depth of an open channel when the flow in it is not uniform?

**Examples**

1. For constant specific energy of $^{1.8NM}/\_{s}$, calculate the maximum discharge that may occur in a rectangular channel 5m width.

**Given**

$$specific energy=^{1.8NM}/\_{s}$$

 $width of channel=5m$

**Solution**

For constant specific energy discharge is maximum

 $Y\_{c}=\frac{2}{3}E\_{c}=\frac{2}{3}×^{1.8NM}/\_{s}=1.2m$

 $Y\_{c}=(\frac{q^{2}}{g})^{^{1}/\_{3}} ,q^{2}=Y\_{c}^{3}×g$

 $q^{2}=(1.2m)^{3}×9.81^{m}/\_{s^{2}}=16.95^{^{m^{3}}/\_{s}}/\_{m}$

 $q=^{4.12m^{2}}/\_{s}$

 $Q=B×q=5m×4.12^{m^{2}}/\_{s}=20.59^{m^{3}}/\_{s}$

2. Most efficient rectangular channel, which is laid on a bottom slope of 0.0064, is to carry 20m3/s of water. Determine the width of the channel when the flow is in critical condition. Take n=0.015.

**Given**

$$Discharge Q=20^{m^{3}}/\_{s}$$

$$Bottom slope=0.0064$$

$$Manning coefficient=0.015$$

**Solution**

$$For most effcient rectangular channel B=2Y,Y=\frac{B}{2}$$

$$ Q=\frac{A}{n}R^{^{2}/\_{3}}S^{^{1}/\_{2}}$$

$$A=B×Y=B×\frac{B}{2}=\frac{B^{2}}{2}$$

 $R=\frac{Y}{2}=\frac{B}{4} $

 $Q=\frac{B^{2}}{2n}×(\frac{B}{4})^{^{2}/\_{3}}×S^{^{1}/\_{2}}$

 $20=\frac{B^{^{8}/\_{3}}}{5.04×0.015}×0.0064^{^{1}/\_{2}}$

 $B=16.9om$

**Examples**

A 3∙6m wide rectangular channel conveys $9.0^{m^{3}}/\_{s}$ of water with a velocity of $6^{m}/\_{s}$.

1. Is there a condition for hydraulic jump occur? If so calculate the height, length and strength of the jump.
2. What is loss of energy?

**Given**

$$width of channel B=3.6m$$

 $Discharge=^{9.0m^{3}}/\_{s}$
 $Velcity before jump=^{6m}/\_{s}$

**Solution**

1. $depth of water before jump=Y\_{1}=\frac{Q}{B×V\_{1}}=\frac{9^{m^{3}}/\_{s}}{3.6m×^{6m}/\_{s}}=0.4167m$

$$Discharge per unit width q=\frac{Q}{B}=\frac{9^{m^{3}}/\_{s}}{3.6m}=2.5^{m^{2}}/\_{s}$$

 $critical depth Y\_{c}=(\frac{q^{2}}{g})^{^{1}/\_{3}}=(\frac{2.5^{2}}{9.81})^{^{1}/\_{3}}=0.86m$

 $since Y\_{1}<Y\_{c }a jump would occur$

$$Fr\_{1}=\frac{V\_{1}}{\sqrt{g×Y\_{1}}}=\frac{6}{\sqrt{9.81×0.4167}}=2.967$$

$$Depth of the jump down stream of the jump $$

$$Y\_{2}=\frac{Y\_{1}}{2}\left[\sqrt{1+8Fr\_{1}^{2}}-1\right]$$

$$Y\_{2}=\frac{0.4167}{2}\left[\sqrt{1+8×2.967^{2}}-1\right]=1.5525m$$

$$height of the jump H\_{j}=Y\_{2}-Y\_{1}=1.5525m-0.4167m=1.1358m$$

$$Length of the jump L\_{j}=6\left(Y\_{2}-Y\_{1}\right)=6\left(1.1358m\right)=6.8148m$$

$$strength of jump=\frac{Y\_{2}}{Y\_{1}}=\frac{1.5525m}{0.4167m}=3.726$$

1. Loss of energy for rectangular channel$∆E=\frac{(Y\_{2}-Y\_{1})^{3}}{4Y\_{1}Y\_{2}}$

 $∆E=\frac{(1.5525m-0.4167m)^{3}}{(4×1.5525m×0.4167m)}=0.57m$

**Exercises**

1. A rectangular channel which is laid on a bottom slope of 0.0064 is to carry 20m3/s of water. Determine the width of the channel when the flow is in critical condition. Take C=66

2.An irrigation canal of trapezoidal section having side slope 2 in 3 is to carry a flow of 10m3/s on a longitudinal slope of 1 in 5000. The canal is lined for which the value of frictional coefficient in Manning’s formula is n=0.012. Find the dimension of the most economical section

3. Determine the side slope of the most hydraulically efficient triangular section. . Show that the head loss in a hydraulic jump formed in a rectangular channel may be expressed as

 ΔE= (V1 –V2)3/ [2g (V1 +V2)]

4. A rectangular channel there occurs a jump corresponding to Froude number (F=2.5). Determine the critical depth and head loss in terms of the initial depth y1.

5. A trapezoidal channel having bottom width 10m and side slope 2:1(H:V) carries a discharge of 100m3/s. Find the depth conjugate to the initial depth of 1m before the jump. Also determine the loss of energy in the jump.