INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY & CREATIVE ENGINEERING (ISSN:2045-8711)
VOL.2 NO.1 JANUARY 2012

Minimizing the Total Cost of Lining and Excavation Including Free Board

Syed Zafar Syed Muzaffar[1], S. L. Atmapoojya[2], D. K. Agrawal[3], M. Aquil[4]
[1] *Assistant Professor, Anjuman College of Engineering,Nagpur- India*
[1]`syedzafar64@yahoo.co.in`
[2] *Principal,S. B. Jain Institute of Technology, Management,Nagpur- India*
[3] *Ex. Dean,Faculty of Engineering & Technology,RSTM & Research, Nagpur University,Nagpur-India.*
[4] *Assistant Professor, M. H. Saboo Siddique College of Engineering, Byculla, Mumbai - 8 - India*

***Abstract* - Lined canal with free board reduces the friction slopes, which enables the canal to be laid on a flatter bed slope. This increases the command area of canal, on other hand, as the lining permits higher average velocities, the canal can be laid on steeper slope to save the cost of earth work in formation. As the lining provide rigid boundary, it ensures protection against bed bank erosion. This paper presents design equation for minimizing the total cost of canal lining and excavation with free board. This can be overcome by using manning equation. It involve lining cost, cost of earth work which varies with the excavation depth, on account of complexities of analysis. The optimal cost equation along with the corresponding section shape coefficient is useful during the planning of canal project. A network of canal represent a major cost item in an irrigation project and economy of the canal network is vital. The maximum economy is achieved by minimizing the cost of lining of canal and excavation with free board. This technique is developed by taking illustration numerical example.**

Keywords:- Round cornered Trapezoidal section, Lined canal, Depth of flow, Discharge, free board Excavation Optimal canal section.

I. INTRODUCTION

Network of canals is used to convey, distribute and apply water to land for irrigation. A canal in a network may be either lined or unlined. It is found that 45 to 50% water is lost due to seepage from the canal system during journey from head work to field. The seepage also enhances water logging of the adjacent area to the canal which causes reduction of crop production. Hence it is require how to control water due to seepage. A section of unlined canal system does not remain in trapezoidal shape for longer time hence need of lining is to made its surface hard which prevent seepage loss. Therefore the lining of canal is one of the measures which overcome this problem. Lined canals are designed for several purpose for uniform flow considering hydraulic efficiency, practicability and economy. Factor to be considered in the design include.

1. The material forming the channel surface, which determines the roughness coefficient.
2. The minimum permissible velocity to avoid deposition of silt or debris.
3. The limiting velocity to avoid erosion of the channel surface.
4. The topography of the channel route, which fixes the channel bed slope.
5. The efficiency of the channel section which indicates how much the section is hydraulically and/ or economically efficient. A maximum hydraulic gradient results in the section of minimum excavation area and the cost hydraulic design.

When an open channel is constructed the excavation and lining constitute a major cost obviously it is desirable to keep the cost minimum by adopting the most economical canal cross section.

Several types of materials are used for canal lining. The choice of material mainly depends on the degree of water tightness required. Though less water tight soil cement lining and boulder lining preferred on account of their low initial cost. Another low lining is composed of polyethylene plastic. Sheets spread over the boundary surface with adequate earth cover. Brick lining and burnt clay tile lining are popular lining as they were providing reasonable water tightness along with strength.

The total area of construction includes the flow area and free board area. The free board area is considered as discharge dependent recommended by USBR. But lining of canal is increase the cost; therefore economic environmental purposes require efficient use of water for irrigation. To get economy purpose in canal construction the section should be minimum which include cost of excavation and cost of lining.

Minimum cost design of canal involve minimizing the sum of depth dependent excavation cost and cost of lining subject to uniform flow condition in the canal, which result in the non linear objective function and non linear equality making the problem hard to solve analytically.

In this paper, an attempt has been made to derive most economical (optimal) canal, section by minimizing the total cost of construction which include lining cost and excavation cost with free board. We can reduce the cost of lining, related to free board and excavation i.e. earthwork cost finally a step by step design procedure with equation, example of cost minimizing is presented. The optimal cost equation of lining and excavation with free board is useful during the planning of a canal project.

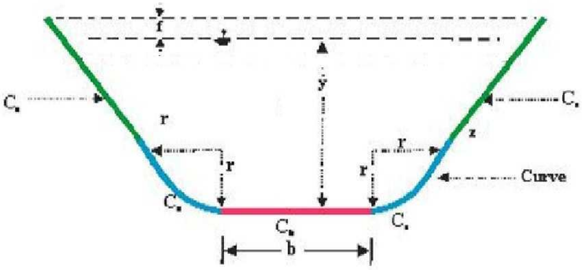

Fig. 1. Trapezoidal Round Cornered section of Lined Canal with excavation and free board

The flow area A for a round cornered section as shown in Fig 1 is given by

$A = by + r^2Z_2 + Zy^2 + 2ryZ_1 – 2r^2Z_1$ …………….(1)

Where

b = bed width of the section

Z = side slope i.e. 1V: ZH

Y = depth of flow

$Z_1 = \surd(1+Z^2) - Z$

$Z_2 = (\pi/180)\tan^{-1}(1/z)$

r = radius of arc

The wetted perimeter P of the section is given by

$P = b+2y\surd(1+Z^2) -2rZ_1+2rZ_2$ ………………… (2)

2. Discharge Dependent Free Board

The total area of Canal section A_t is given by

$A_t = b(y+f) +r^2Z_2+Z(y+f)^2+2r(y+f)\ Z1-2r^2Z_1$ …………… (3)

$dA_t/db = y+f$

$dA_t/dy = b+2Z(y+f) +2rZ_1$

$(dA_t/db)/(dA_t/dy) = (y+f)/b+2Z(y+f) +2rZ_1$

$= (1+f/y)/ (b/y+2Z (1+f/y) +2r/yZ_1)$

$(dA_t/db)/ (dA_t/dy) = (1+m)/ (b/y+2Z (1+m) +2r/yZ_1)$ … (4)

Where m = f/y

$(dAt/db)/ (dA_t/dy) = (dAR^{2/3}/db)/ (dAR^{2/3}/dy)$

$1+m/(b/y+2Z(1+m)+2r/yZ_1)=[3b/y+10\surd(1+Z^2)-14r/yZ_1+$
$10(r/y)Z_2-2Z+4r^2/y^2Z_1-$
$2r^2/y^2Z_2]/[5(b/y)^2+10b/yZ+16z\surd(1+Z^2)$
$-20r/yZZ_1+8r^2/y^2ZZ_1+10r/yb/yZ_2+20r^2/y^2Z_1Z_2+20r/yZZ_2-$
$4r^2/y^2ZZ_2+6b/y\surd(1+Z^2)+12r/yZ_1\surd(1+Z^2)-12(r^2/y^2)\ Z_1^2]$

$(1+m)[5(b/y)^2+10b/yZ+16Z\surd(1+Z^2)-20r/yZZ_1+8r^2/y^2ZZ_1+$
$+10r/yb/yZ_2+20r^2/y^2Z_1Z_2+20(r/y)ZZ_2-$
$4r^2/y^2ZZ_2+6b/y\surd(1+Z^2)\ \ +12r/yZ_1\surd(1+Z^2)\ \ -12r^2/y^2Z_1^2] =$
$(3b/y+10\surd(1+Z^2)-14r/yZ_1$
$+10r/yZ_2-2z+4r^2/y^2z_1-2r^2/y^2Z_2)\ (b/y+2Z (1+m) +2r/yZ$

$5[(1+m)(b/y)^2+(1+m)[10Z+10r/yZ_2+6\surd(1+Z^2)]b/y+(1+m)[1$
$6Z\surd(1+Z^2)-20r/yZZ_1+8r^2/y^2ZZ_1+20r^2/y^2Z_1Z_2+20r/yZZ_2-$
$4r^2/y^2ZZ_2 \qquad +12r/yZ_1\surd(1+Z^2)-$
$12r^2/y^2Z_1^2]=3(b/y)^2+[10\surd(1+Z^2)-14r/yZ_1 \qquad +10r/yZ_2-$
$2Z+4r^2/y^2Z_1-2r^2/y^2Z_2+6Z+6Zm+6r/yZ_1]b/y$
$+[2Z(1+m)+2r/yZ_1][10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-$
$2Z+4r^2/y^2Z_1-2r^2/y^2Z^2]$

$(2+5m)(b/y)^2+[10Z+10r/yZ_2+6\surd(1+Z^2)+10Zm+10r/yZ_2m+$
$6m\surd(1+Z^2)-10\surd(1+Z^2)+14r/yZ_1-10r/yZ_2-4Z-$
$4r^2/y^2Z_1+2r^2/y^2Z_2-6Zm-6r/yZ_1]b/y+(1+m)[16Z\surd(1+Z^2)-$
$20r/yZZ_1 +8r^2/y^2ZZ_1 \qquad +20r^2/y^2Z_1Z_2+20r/yZZ_2-$
$4r^2/y^2ZZ_2+ 12r/yZ_1\surd(1+Z^2)-12r^2/y^2Z-$
$20Z\surd(1+Z^2)+28r/yZZ_1-20r/yZZ_2+4Z^2- 8r^2/y^2ZZ_1$
$+4r^2/y^2ZZ_2]-2r/yZ_1[10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-$
$2Z+4r^2/y^2Z_1-2r^2{}_/y^2Z_2]=0$
$(2+5m)(b/y)^2+[6Z-4\surd(1+Z^2)+8r/yZ_1- 4r^2/y^2Z_1+$
$2(r^2/y^2)Z_2+(4Z+6\surd(1+Z^2)+10(r/y)Z_2)m+[-4Z\surd(1+Z^2)$
$+4Z^2+8r/yZZ_1+20r^2/y^2Z_1Z_2+12r/yZ_1\surd(1+Z^2)-$

$12r^2/y^2Z_1^2](1+m)-2r/yZ_1[10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z+4r^2/y^2Z_1-2r^2/y^2Z_2]=0$

$K_1(b/y)^2+K_2b/y-\{[4Z\surd(1+Z^2)-4Z^2-8r/yZZ_1-20r^2/y^2Z_1Z_2-12(r/y)Z_1\surd(1+Z^2)+12r^2/y^2Z_1^2](1+m)+2r/yZ_2[10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z+4r^2/y^2Z_1-2(r^2/y^2)Z_2]\}=0$

$K_1(b/y)^2+K_2b/y-K_3=0$

This is quadratic equ^n in b/y form

$$\frac{b}{y}=\frac{-K_2+\sqrt{K_2^2+4K_1K_3}}{2K_1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ (5)$$

Where, $K_1 = 2+5m$

$K_2 = 6Z-4\surd(1+Z^2)+8r/yZ_1-4r^2/y^2Z_1+2r^2/y^2Z_2+(4Z+6\surd(1+Z^2)+10r/yZ_2)m$

$K_3 = [4Z\surd(1+Z^2)-4Z^2-8r/yZZ_1-20r^2/y^2Z_1Z_2-12r/yZ_1\surd(1+Z^2)+12r^2/y^2Z_1^2](1+m)+2r/yZ_2[10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z+4r^2/y^2Z_1-2(r^2/y^2)Z_2]$

3. Depth Dependent Free Board

Put $f = K\surd y$

$A_t = b(y+K\surd y)+r^2Z_2+Z(y+K\surd y)^2+2r(y+K\surd y)Z_1-2r^2Z_1$

$dA_t/db = y+K\surd y$

$dA_t/dy=b(1+k/2\surd y)+2Z(y+k\surd y)(1+k/2\surd y)+2r(1+k/2\surd y)Z_1$

$=b(1+K/2\surd y)+2Zy(1+K/\surd y)(1+K/2\surd y)+2r(1+K/2\surd y)Z_1$

$=b(1+K/2\surd y)+2Zy(1+K/2\surd y+K/\surd y+K^2/2y)+2r(1+K/2\surd y)Z$

$dA_t/dy = b(1+K/2\surd y)+2Zy(1+K^2/2y+3K/2\surd y)+2r(1+K/2\surd y)Z_1$

$(dA_t/db)/(dA_t/dy)=(y+K\surd y)/b(1+K/2\surd y)+2Zy(1+K^2/2y+3K/2\surd y)+2r(1+K/2\surd y)Z_1$

$(dA_t/db)/(dA_t/dy)=(1+K/\surd y)/[b/y(1+K/2\surd y)+2Z(1+K^2/2y+3K/2\surd y)+2r/y(1+k/2\surd y)Z_1]$

$(dA_t/db)/(dA_t/dy)=(1+m_1)/[b/y(1+m_1/2)+2Z(1+m_1^2/2+3m_1/2)+2r/y(1+m_1/2)Z1]$ ….. (6)

Equating the above equations

$(dA_t/db)/(dA_t/dy)=(dAR^{2/3}/db)/(dAR^{2/3}/dy)$

$(1+m_1)/[b/y(1+m_1/2)+2Z(1+m_1^2/2+3m_1/2)+2r/y(1+m/2)Z1]=[3b/y+10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z+4r^2Z_1-2r^2Z_2]/5(b/y)^2+10b/yZ+16Z\surd(1+Z^2)-20r/yZZ_1+8(r^2/y^2)ZZ_1+10r/y\,b/yZ_2+20r^2/y^2Z_1Z_2-4r^2/y^2ZZ_2+6b/y\surd(1+Z^2)+12r/yZ_1\surd(1+Z^2)-12(r^2/y^2)Z_1^2+20(r/y)ZZ_2]$

$[(1+m_1)[5(b/y)^2+10b/yZ+16Z\surd(1+Z^2)-20r/yZZ_1+8r^2/y^2ZZ_1+10r/y\,b/yZ_2+20r^2/y^2Z_1Z_2+20(r/y)ZZ_2-4r^2/y^2ZZ_2+6b/y\surd(1+Z^2)+12r/yZ_1\surd(1+Z^2)-12(r^2/y^2)Z_1^2]=[3b/y+10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z+4r^2/y^2Z_1-2r^2/y^2Z_2][b/y(1+m_1/2)+2Z(1+m_1^2/2+3m_1/2)+2r/y(1+m_1/2)Z_1]$

$5(1+m)(b/y)^2+[10Z+6\surd(1+Z^2)+10r/yZ_2](1+m_1)b/y+(1+m_1)[16Z\surd(1+Z^2)-20r/yZZ_1+8r^2/y^2ZZ_1+20r^2/y^2Z_1Z_2+20r/yZZ_2-4r^2/y^2ZZ_2+12r/yZ_1\surd(1+Z^2)-12r^2/y^2Z_1^2]=3(1+m_1/2)(b/y)^2+[10\surd(1+Z^2)+10(r/y)Z_2-14r/yZ_1-2Z+4r^2/y^2Z_1-2r^2/y^2Z_2)(1+(m_1/2))+6Z(1+m_1^2/2+3m_1/2)+6r/y(1+m_1/2)Z_1]b/y+[2Z(1+m_1^2/2+3m_1/2)+2r/y(1+m_1/2)Z_1][10\surd(1+Z^2)14r/yZ_1+10r/yZ_2-2Z-4r^2/y^2Z_1-2r^2/y_1^2Z_2]$

$[(2+7m_1/2)(b/y)^2+[10Z+6\surd(1+Z^2)+10r/yZ_2+10Zm_1+6m_1\surd(1+Z^2)+10m_1r/yZ_2.10\surd(1+Z^2)+14r/yZ_1-10r/yZ_2+2Z-4r^2/y^2Z_1+2r^2/y^2Z_2-5m_1\surd(1+Z^2)+7r/yZ_1m_1-5r/yZ_2m_1+zm_1-2r^2/y^2z_1m_1+r^2/y^2Z_2m_1-6Z-3Zm_1^2-9Zm_1-6r/yZ_1-3r/ym_1Z_1]b/y+(1+m_1)[16Z\surd(1+Z^2)-20r/yZZ_1+8r^2/y^2ZZ_1+20r^2/y^2Z_1Z_2+20r/yZZ_2-4r^2/y^2ZZ_2+12r/yZ_1\surd(1+Z^2)-12r^2/y^2Z_1^2]-[2Z(1+m_1^2/2+3m_1/2)+2r/y(1+m_1/2)Z_1][10\surd(1+Z^2)-14r/yZ_1+10(r/y)Z_2-2Z-4(r^2/y^2)Z_1-2(r^2/y^2)Z_2]=0$

$K_1(b/y)^2+[6z-4\surd(1+Z^2)-8r/yZ_1-4r^2/y^2Z_1+2r^2/y^2Z_2+(2Z+\surd(1+Z^2)+5r/yZ_2+4r/yZ_1-2r^2/y^2Z_1+r^2/y^2Z_2-3zm_1)m1]b/y-K_3=0$

$K_1(b/y)^2+k_2b/y-k_3=0$

$$\frac{b}{y}=\frac{-K_2+\sqrt{K_2^2+4K_1K_3}}{2K_1}$$

Where

$K_1=2+7/2m_1$

$K_2= [6Z-4\surd (1+Z^2) +8r/yZ_1-4r^2/y^2Z_1+2r^2/y^2Z_2+ (2Z+\surd (1+Z^2) +5r/yZ_2+4r/yZ_1-2r^2/y^2Z_1+r^2/y^2Z_2-3zm_1) m_1]$

$K_3=[2Z(1+m_1{}^2/2+3m_1/2)+2r/y(1+m_1/2)Z_1][10\surd(1+Z^2)-14r/yZ_1+10r/yZ_2-2Z-4r^2/y^2Z_1-2r^2/y^2Z_2] - (1+m_1)[16Z\surd(1+Z^2)- 20r/yZZ_1+8r^2/y^2ZZ_1 + 20r^2/y^2ZZ_1 +20r^2/y^2ZZ_1-4r^2/y^2ZZ_2+12r/yZ_1\surd(1+Z^2)-12r^2/y^2Z_1{}^2 +20(r/y)ZZ_2]$

The total Cost per meter Length of Canal can be determined by the following equation.

$C= [bK_1(y+f) +2rK_1(y+f) Z1+K_1{}^2(y+f)^2 Z- 2r^2Z_1 +r^2Z_2]C_e+bC_b+2rZ_2C_c+(2(y+f) \surd(1+Z^2)-2rZ_1)C_s$

Illustrative Example

$Q= 100m^3/sec$, Cost of Excavation Ce = Rs. $80/m^3$
$r/y = 0.7$, Cost of Lining for base C_b = Rs. 180/sqm
$S_0= 1$ in 5000,
Cost of Lining for Curve C_c = Rs. 210/ sqm
$Z= 1.5$, Cost of Lining for sides C_s = Rs. 200/ sqm
$n= 0.014$
$f= 0.75$
$Z_1= 0.30277$
$Z_2= 0.5888$

4. Discharge Dependent Free Board.

Assume $b/y = 0.5$

$[Qn/\surd So]^{3/8} = [100\times0.014/\surd(1/5000)]^{3/8} = 5.6021$

$\Phi_2 = (b/y+2\surd (1+Z^2) -2 r/y Z_1 +2 r/y Z_2)^{1/4} / (b/y+ r^2/y^2 Z_2 +Z+2r/y Z_1-2 r^2 /y^2Z_1)^{5/8}$

$\Phi_2=(0.5+2\times1.8027-2\times0.7\times0.30277+2\times0.7\times0.588)^{1/4}/ (0.5+0.7^2\times0.588+1.5+2\times0.7\times0.30277-2\times0.7^2 \times0.30277)^{5/8}$

$\Phi_2 = 1.4569/1.73522$

$\Phi_2 = 0.8396$

$Y = \Phi_2 (Q_n/\surd S_o)^{3/8}$

$= 0.3896\times5.6021$

$Y = 4.7035$

$m = f/y$

$= 0.75/4.7035$

$m = 0.159$

$K_1= 2+ 5m$

$= 2+ 5\times0.159$

$K_1= 2.797$

$K_2= 6 z - 4 \surd (1+Z^2) +8 r/yZ_1-4 r^2 / y^2Z_1 + 2 r^2/y^2Z_2 + (4Z + 6\surd (1+Z^2) +10 r/y Z_2) m$

$= 6\times1.5 - 4\sqrt{1 + 1.5^2}+8\times0.7\times0.30277 - 4\times0.7^2 \times0.30277 +2\times0.7^2 \times 0.5888 +(4\times1.5+6\times1.80277+10\times0.7\times0.588) \times0.159$

$K_2= 6.796$

$K_3= [4Z\surd (1+Z^2) – 4Z^2 - 8r/yZZ_1- 20 r^2/y^2Z_1Z_2 – 12 r/yZ_1\surd (1+Z^2) + 12 r^2/y^2 Z_1{}^2] (1+m) + 2 r/y Z_2 [10 \surd (1+Z^2) -14 r/y Z_1 + 10 r/y Z_2 – 2Z+4 r^2/y^2 Z1 – 2 r^2/y^2 Z_2]$

$K_3= [4\times 1.5 \times 1.80277 – 4\times1.5^2 - 8\times0.7 \times 1.5 \times 0.30277 – 20 \times0.7^2 \times 0.30277 \times 0.588 -12 \times0.7 \times0.30277 \times1.80277 + 12\times 0.7^2 \times 0.30277^2] (1+0.159)+ (2\times0.7\times0.588) [10\times1.80277 - 14\times0.7\times0.30277+10\times0.7\times0.588 - 2\times1.5 + 4\times0.7^2 \times 0.30277- 2\times0.7^2 \times 0.588]$

$K_3= [10.8166-9-2.5432-1.7446- 4.5849+0.539] (1.159) +0.8243[18.0277-2.9671+4.116-3+0.593-0.577]$

$= -7.553+13.3475$

$K_3= 5.7945$

$$\frac{b}{y} = \frac{-K_2+\sqrt{K_2{}^2+4K_1K_3}}{2K_1}$$

$= (-6.796+\sqrt{6.796 \times 6.796 + 4 \times 2.797 \times 5.7945})/ 2\times2.797$
$= (-6.796+10.5363)/ 5.594$

$b/y= 0.668$

$b = b/y \times y$

$= 0.668\times4.7035$

$b = 3.144$

$r = r/y \times y$

$= 0.7\times4.7035$

$r = 3.292$

$A_t = b(y+f) + r^2 Z_2+ Z(y+f)^2 +2r(y+f) Z_1-2r^2 Z_1$

$=3.144(4.7035+0.75)+3.292^2\times0.588+1.5(4.7035+0.75)^2+2\times3.292(4.7035+0.75)\times0.30277-2\times3.292^2\times0.30277$

$= 17.145+6.3809+44.61+10.8712-6.562$

$A_t = 72.445\ M^2$

$C= [bK_1(y+f)+2rK_1(y+f)\,Z1+K_1^2(y+f)^2Z-2r^2\ Z_1+r^2\ Z_2]C_e +b\ C_b+2r\ Z_2\ C\,C+ (2(y+f)\sqrt{(1+Z^2)} - 2rZ_1)\ C_s$

C = Rs. 8473.938 per met. Length

5. Depth Dependent Free Board

$m_1 = k/\sqrt{y}$

$= 0.7/\sqrt{4.7035}$

$= 0.7/\ 2.16875$

$m_1= 0.32276$

$K_1= 2+7/2\ m_1$

$= 2+7/2\times0.32276$

$K_1= 3.12968$

$K_2= 6Z- 4\sqrt{(1+Z^2)}+8\ r/y\ Z_1 - 4\ r^2/y^2\ Z_1 + 2r^2/y^2Z_2+(2Z+\sqrt{(1+Z^2)}+5\ r/yZ_2 +4\ r/yZ_1- 2\ r^2/y^2\ Z_1+ r^2/y^2\ Z_2 -3Zm_1)\ m_1$

$= 6\times1.5 - 4\times1.8027+8\times0.7\times0.30277-4\times0.7^2\times0.30277+2\times0.7^2\times0.588+(2\times1.5+1.8027+5\times0.7\times0.588+4\times0.7\times0.30277-2\times0.7^2\times0.30277+0.7^2\times0.588-3\times1.5\times0.32276)0.32776$

$= 3.467552+2.01642889$

$K_2= 5.48398$

$K_3= [2Z(1+m_1^2/_2+(3m_1/2))+2\ r/y(1+m_1/2)Z_1]\ \ [10\sqrt{(1+Z^2)}-14r/y\ Z_1+10\ r/y\ Z_2-2Z -4r^2/y^2\ Z_1 -2r^2/y^2Z_2] - (1+m_{1)})[16Z\sqrt{(1+Z^2)} -20r/yZZ_1+8r^2/y^2ZZ_1+20r^2/y^2Z_1Z_2 +20r/yZZ_2-4r^2/y^2ZZ_2+12r/yZ_1\sqrt{(1+Z^2)}-12r^2/y^2Z_1^2]$

$=[2\times1.5(1+0.32276^2/2+3/2\times0.32276)+2\times0.7(1+0.32276/2)\times0.30277]\ [10\times1.8027-\ 14\times0.7\times0.30277 +10\times0.7\times0.588-2\times1.5-4\times0.7^2\times0.30277-2\times0.7^2\times0.588] - (1+0.32276)\ [16\times1.5\times1.802720\times0.7\times1.5\times0.30277+8\times0.7^2\times1.5\times0.30277+20\times0.7^2\times0.30277\times0.588+20\times0.7\times1.5\times0.588- 4\times0.7^2\times1.5\times0.588+12\times0.7\times0.30277\times1.8027-12\times0.7^2\times0.3027]^2$

$=76.5461-72.8795$

$K_3 = 3.666551$

$$\frac{b}{y} = \frac{-K_2+\sqrt{K_2^2+4K_1K_3}}{2K_1}$$

$= - 5.48398+\sqrt{\ }(5.48398x5.48398+4x3.12968x3.66551)/2\quad\times3.12968$

$= - 5.48398+8.716336/6.25936$

$b/y= 0.5164$

$b\ \ =b/y\times y$

$= 0.5164\times4.7035$

$b =2.4288874$

$r =r/y\times y$

$= 0.7\times4.7035$

$r= 3.29245$

$r= 3.29245$

$A_t=b(y+K\sqrt{y}) +r^2Z_2+Z(y+K\sqrt{y})^2+2r(y+K\sqrt{y})Z_1-2r^2Z_1$

$=2.42889(4.7035+0.7\times2.1687)+3.292^2\times0.588+1.5(4.7035+0.7\times2.1687)+2\times3.29245(4.7035+0.7\times2.1687)0.30277-2\times3.292^2\times0.30277$

$A_t=85.3877\ M^2$

$C = [2.4289\ x\ 0.7x\ (4.7035+0.75) +2\ x\ 3.29\ x\ 0.7\ x\ (4.7035+0.75)\ xo.30277+0.7^2\ (4.7035+0.75)^2x0.5-2x3.29^2\qquad x0.30277+3.29^2\ x0.5888]\ x\ 80 +2.4288x180+2x3.292\qquad x0.5888x210+(2(4.7035+0.75)\sqrt{(1+1.5^2)} - 2x3.929\qquad x0.30277)\ x\ 200$

$= [9.272+7.605+7.286 - .554+6.373]80+437.184+813.098+3533.887$

C = Rs. 6703.729 per met Length

CONCLUSION

The condition for the optimal trapezoidal rounded cornered canal section for minimizing the total cost of lining and excavation considering free board has been developed and method based on trial and error numerical technique are suggested. Following conclusions are drawn in the analysis.

1. The discharge dependent free board gives a wider optimal section as compare to the best section for the

same discharge i.e. obtained section with high b/y ratio as well as cost.

2. The depth dependent free board gives a narrow optimal section as compare to the best section i.e. obtained section is with low b/y ratio as well as cost proposed method can be adopted to design the optimal section with consideration of free board.

REFERENCES

[1]. A Das “Optimal Channel Cross Section with Composite roughness” Journal of Irrigation and drainage Division ASCE Vol. 126 No.1. 2000 pp68-71.

[2] Arif A Anwar & Derick Clark “Design of Hydraulically Efficient Power law Channels with free Board “Journal of Irrigation and Drainage engineering @ ASCE/November/December/2005.

[3] Amlan Das “Optimal Design of Channel Having Horizontal Bottom and Parabolic sides” 192 / Journal of Irrigation and Drainage Engineering © ASCE /March/April-2007.

[4] Guo_”Optimal Canal Cross section with free board “Journal of Irrigation and drainage engineering ASCE. Vol.110 No. 8 September 1984.

[5] G.V. Loganathan “Optimal design of parabolic canal” Journal of Irrigation and drainage division ASCE Vol.117 No.5 1995.pp716-735.

[6] Howard H Chang and Zbig Osmolski “Computer Aided Design for Channelization” Journal of Hydraulic Engineering Vol.114 No.11 November 1988 @ ASCE ISSN 0733.

[7] K. Babaeyan-Koopaei’ “Dimensionless Curve for Normal-depthCalculations in Canal Section s” 386/ Journal of Irrigation and Drainage Engineering/ November/December 2001.

[8] Lawrence E. Flynn S.M “Canal Design Optimal cross Section” Drainage Engineering Vol.113 No.3 Aug 87, @ ASCE ISSN 0733.

[9] M.Riyaz and Z. Sen European “Aspect of Design and benefits of Alternative lining systems water 11/12, 17-27, 2005@EW Publications.

[10] P Monadjemi “General formulation of Best Hydraulics Channel Section” Journal of Irrigation and drainage division ASCE Vol. 120 No. 1994.pp27-35.

[11] Prabhata K Swamee Govinda C. Mishra and Bhagur R Chahar, “Minimum Cost Design of Lined Canal Sections”

[12] P N Modi and SM Seth “Design of most Economical Trapezoidal Section of Open Channel” Journal of Irrigation and Power. New Delhi, 1968. PP 271-280.

[13] Prabhata K. Swamee, Govinda C Mishra and Bhagur R Chahar. “Minimum Cost Design of Lined Canal Sections water resources management 14. 1-2-2000. © 2000 Kluwer Academic Publishers. Netherland.

[14] Prabhata K. Swamee “Optimal Irrigation Canal Section” Journal of Irrigation and Drainage engineering Nov/ Dec /1995/467.

[15] Subramanyan K “Open Channel Flow” Tata McGraw Hill Publishing Company Ltd. New Delhi-1986.

[16] S.L. Atmapoojya and R.N Ingle” The Optimal Canal Section with consideration of free board” I E (I) Journal_CV Vol. 83 Feb 2003.

[17] Stone Pitched Lining for Canal of Practice, 1S, 4515-1993.

[18] Subhasish dey’ “choke- free Flow in Circular channel with increase in Bed Elevation” Journal of Irrigation and Drainage Engineering/November/December 1998/317.

[19] Syed Zafar Syed Muzaffar, S.L. Atmapoojya, D.K. Agarwal, M.Aquil “The Optimal Rounded Cornered Canal Section with Consideration of free Board”, International Journal of Engineering Research and Applications(IJERA) 2011, vol. 1 issue 4, pp1317-1322, ISSN:2248-9622.

[20] Syed Zafar Syed Muzaffar, S.L. Atmapoojya, D.K. Agarwal, S.S.Rathore ”Optimal cross section of a Trapezoidal Round Cornered Canal” International J. of Math,Sci & Engineering Applications (IJMSEA) 2011, vol.5 issue 4pp 433-441 ISSN 0973-9424

[21] Syed Zafar Syed Muzaffar, S.L. Atmapoojya, D.K. Agarwal, 2012, vol.2 issue 1, “Minimum Lining Cost of Trapezoidal Round Cornered Section Canal” International Journal of Advances in Engineering & Technology” (IJAET) pp 433-436.

[22] V.L Streeter and E.B Wylie “Fluid Mechanics” McGraw Hills Inc, New York, 1979.

[23] V.T Chow-“Open Channel Hydraulics” The McGraw Hill book Company New York Nu.1959.

[24] V T Chow “Open Channel Hydraulics” The McGraw Hill Book Co, New York, NY 1959.

[25] Yen. B.C (2002)”Open Channel Flow Resistance” J. Hydraul. Eng. 128(1) 20-39.