An Analytical Approach as Well as Soft Computing for Desiging a Channel-a Case Study on Buckingham Canal

V. Chakkravarthy, K. Sri Vamsee, D. Satish Chandra

Abstract--- Today the increased world population and therefore the growth demand has forced the us to investigate better water canal networks distributing much more water while at least keeping its quality. Canal design formulas are explicitly obtained for different cross-sections considering minimum area but optimal design of canal sections considering seepage, evaporation losses and soil erosion. By collecting the present parameters and estimating the water requirement,we have redesigned the existing Buckingham canal for the future use as the canal is not meeting the needs of crop water requirement and for the increased population for drinking.The design is done by the Kennedy's method of design and Lacye's method of design.The comparison of design parameters values of Kennedy's method of design and Lacye's method of design.A program is designed to calculate the design parameters easily for both the methods of design using c programming language.

Index Terms: Canal Design, kennedy'smethod, Lacye's method.

I. INTRODUCTION

Canals are used to move water from a source, whether a stream, reservoir, or holding tank. The canal may be a few feet wide and less than a foot deep, or very wide, and several feet in depth. Flow gates, sluice gates, or valves control the flow of water from the source, to the point of use. When the water reaches the point of use, it may be pumped into the field using drip or spray equipment, or it may be released directly into the field and to the water tanks for domestic use.

A. Canals

A canalis defined as an artificial channel constructed on the ground to carry water from a river or another canal or a reservoir to the fields. Usually, canals have a trapezoidal crosssection. Canals can be classified in many ways.Based on the nature of source of supply, a canal can be either a permanent or aninundation canal. A permanent canalhas a continuous source of water supply.Such canalsarealso calledperennial canals. Aninundation canaldraws its supplies from a river only during the high stages of the river. Such canals do not have any headworks for diversion of river water to the canal, but are provided with a canal head regulator.Based on the nature of source of supply, a canal can be either a permanent or aninundation canal. A permanent canalhas a continuous source of water supply. Such canals are also called perennial canals.

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II. RESEARCH SINIFICANCE

To know the design parameters of a channel and estimate the water requirement of domestic and irrigation purpose.Design the channel by considering soil erosion and minor losses in a channel.To develop a software for easy computation of design parameters and design of channel in kennedy's method and lacye's design of a channel.

III. STUDY AREA

Guntur channel is a Major Irrigation Scheme having 27000 Acres of Aycutduring 1967, it was contemplated to suffice the left over patches of lands between NSP ayacut and KW Delta by a new channel. And hence, the existence of Guntur channel came in the picture with a carrying capacity of 600 Cusecs to utilize 4.00 TMC of water. The channel takes off from Right bank of river Krishna upstream side of Prakasam barrage in Guntur district. The cannel runs in a strata of black cotton soils mixed with fine sandy texture having predominantly slippery in nature at side slopes.

B. Salient Features

Location:

Guntur channel is under Major Irrigation in Guntur district. The channel takes off from Right bank of river Krishna upstream side of Prakasam barrage in Guntur district.

Ayacut: Guntur District: 27,000 Acres

Population: As of 2011census, the Mandal had a population of 99,428. The total population constitute, 49,662 males and 49,766 females.

Fig. 1shows the study area of the Guntur District.

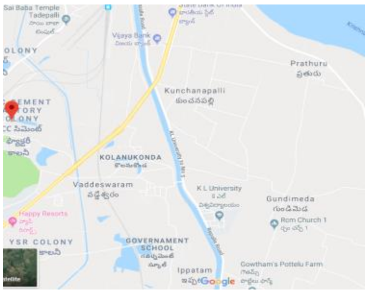

Fig.1: Study Area

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IV. METHODOLOGY

Fig. 2 shows the methodology for the entire project.

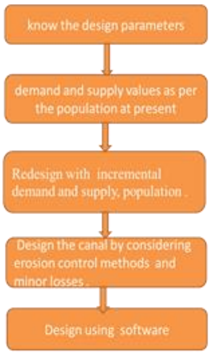

Fig.2: Flow Chart

A. Design Parameters of the Existing Channel:

Table I informs about the hydralic particulars of Guntur Channel.

Table I: Hydralic Particulars

Hydraulic particulars of Guntur Channel

S.No.	Details of Reach From (K.M)	Details of Reach To (K.M)	Bed Width (m)	FSD (m)	Bed fall	Surface fall	N	Designed Velocity (m/s)	Discharge (C/s)
1	0.000	6.300	15.00	2.30	3" per Mile	3" per Mile	0.0225	0.45	600
2	6.300	22.150	14.10	2.30	3" per Mile	3" per Mile	0.0225	0.45	501
3	22.150	29.100	12.80	2.30	3" per Mile	3" per Mile	0.0225	0.44	501
4	29.100	33.500	9.60	2.10	Level	3" per Mile	0.0225	0.41	331
5	33.500	37.000	7.80	2.10	Level	3" per Mile	0.0225	0.38	232
6	37.000	44.800	7.20	1.80	Level	3" per Mile	0.0225	0.34	152
7	44.800	47.000	5.50	1.50	Level	3" per Mile	0.0225	0.30	99

Table II informs about the detailed hydralic particulars of Guntur Channel

Table II: Detailed Hydraulic Particulars

HYDRAULIC PARTICULARS OF GUNTUR CHANNEL

S.No	Reach From	Reach To	Bed Level From	Bed Level To	F.S.L From	F.S.L To	T.B.L From	T.B.L To	Bed Width Starting	Bed Width Ending	F.S.D.	Bed Fall	n Value	Designed Velocity	Discharge Cumecs
Reach 1	0.000	6.317	14.785	14.490	17.070	16.775	17.970	17.675	15.240	15.240	2.286	1 in 21120	0.0225	0.45	16.99
Reach 2	6.317	22.531	14.490	13.720	16.775	16.020	17.675	16.916	14.200	14.173	2.286	1 in 21120	0.0225	0.45	14.18
Reach 3	22.531	29.773	13.730	13.375	16.020	15.660	16.920	16.575	12.800	12.802	2.286	1 in 21120	0.0225	0.44	14.18
Reach 4	29.773	33.500	13.375	13.375	15.660	15.660	16.560	16.575	9.600	9.601	2.100	1 in 21120	0.0225	0.41	9.37
Reach 5	33.500	37.000	13.375	13.375	15.47	15.47	16.37	16.37	7.8	7.8	2.100	1 in 21120	0.0225	0.38	6.57
Reach 6	37.000	44.800	13.375	13.375	15.17	15.17	16.07	16.07	7.2	7.2	1.800	1 in 21120	0.0225	0.34	4.30
Reach 7	44.800	47.000	13.375	13.375	14.87	14.87	15.77	15.77	5.5	5.5	1.500	1 in 21120	0.0225	0.30	2.80

V. ESTIMATING THE DISCHARGE:

A. Population Forecasting

Design of water supply and sanitation scheme is based on the projected population of aparticular city, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Changes in the population of the city over the years occur, and the system should be designedtaking into account of the population at the end of the design period.The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city. Now estimating the population for the next 50years by all the three methods and consider the value which is highest among the three values.

1) Arithmetical Increase Method:

Population after nth decade will be

Pn= P + n*C

Where, Pn is the population after ‘n’ decades and ‘P’ is present population.

Pn= P + n*C

C=5decades, p= 99,428, P_n = 2070

P_n=99,428+(18428)*5

P_n=1, 91,568.

2) Geometrical Increase Method:

The population at the end of nth decade ‘Pn’ can be estimated as:

Pn = P (1+ IG/100) n (2)

Where, IG = geometric mean (%)

P = Present population

N = no. of decades.

Pn = 2070, IG =18428/99428, p= 99428.

Pn= 99428(1+0.229)^5

p_{2070}=278784.1753.

3) Incremental Increase Method:

Population after nth decade is calculate

Pn = P+ n*X + {n (n+1)/2}.Y

Where, Pn = Population after nth decade

X = Average increase

Y = Incremental increase

p_{2070}=99428+(18428*5)+{5(5+1)/2)18428}.

p_{2070}= 99428+92140+{(30/2)*18428}

p_{2070}=4, 67,988.

Incremental increase method got the highest value of population so we consider the 4, 67,988 is the population to be expected in the Tadepalli Mandal. From the standards we know that each and every person requires 135liters per day for their domestic use.

467988*135=63178380 litres of water required per day.

B. Crop Water Requirement

Crop water requirement is defined as "the depth of water needed to meet the water loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields

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under non restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment.

Our study area paddy is the major crop and vegetables and pulses are the second crops. The soil in our study area requires 1200-1400mm of water for 1st kharif season.Rabhi needs 900mm of water in worst cases.

Calculation:

1 Acer = 4046.856sq meters

Quantity of water(1 acer) = Area * delta+losses (Evaporation).

Quantity of water (1 acer)= 4046.856*1.2

Hence, 48, 56,000litres of water required per acre in kharif season.Quantity of water(1 acer)= 4046.856*0.9

Hence36, 42,000litres of water required per acre in rabhi season.

Total water required= irrigation + domestic + 2% extra (losses).

Total water required =300(8498000)+ 4, 45,50000+51879000.

Total water required = 2645829000liters per day

Converting it in to cusecs = 30.62cumecs.

Therefore the discharge required for 2070 year will be 30.62$meter^3$/second.

VI. DESIGN AND ANALYSIS

A. Introduction to Kennedy's Design

Mr. R.G. Kennedy, Executive Engineer in Punjab, PWD was in-charge of this canal system in 1895. The canal was not silt cleared for a long period. He recognized that the canal has attained stable stage and hence he pleaded that the velocity of flow has also attained critical stage. He studied nearly 20 sites on the stable reach of this canal system and finally developed a theory which is known after his name. Sediment in flowing canals is kept in suspension solely by the vertical components of the constant eddies which can always be observed over the full width of any stream, boiling up gently to the surface. (The reason for the production of eddies is the roughness of the bed). In order to obtain an expression for thesilt supporting power of the stream, it may be safely assumed that the quantity of silt supported is proportional to the width of the bed, all other conditions remaining the same.

B. Manual design in Kennedy's method

Design of a channel using Kennedy's Method from the data that we have collected from the irrigation department.

We know that,

Discharge (Q)=16.99 m^3/sec

Modification factor (m)=1.1

Surface and soil properties-Rugosity coefficient (n)=0.0225

Side slopes = 0.5:1

Bed fall (s) = 1 in 21120

Step 1: Assume depth (D) = 2.5 meters

Step 2: Calculating the Initial velocity(v_o)=0.55x$D^{0.64}$m

v_o= 0.55x$(2.5)^{0.64}$x1.1

=1.08075m/sec

Step 3: Calculating Sectional area (A)=$\frac{Q}{v_o}$

A=$\frac{16.99}{1.0875}$=15.63017$meter^2$

Step 4: Determining the width of a channel

A=BD+ $\frac{D^2}{2}$

15.63017=Bx2.5+ $\frac{(2.5)^2}{2}$

2.5B=12.505

B=5.002 meters.

Step 5: Calculating the Wetted perimeter (P)=B+D$\sqrt{5}$

P=5.002+2.5$\sqrt{5}$

P=10.59216 meters.

Step 6: Then Hydraulic mean depth of a channel (R)=$\frac{A}{P}$

R= $\frac{15.63017}{10.56216}$

=1.475meters.

Step 7: Kutters equation (C) =$\frac{\frac{1}{n}+[23+\frac{0.00155}{5}]}{1+[23+\frac{0.00155}{5}]}$

$$C=\frac{[\frac{1}{0.0225}+\left[23+\frac{0.00155}{\frac{1}{21120}}\right]]}{[1+(23+\frac{0.00155}{\frac{1}{21120}})\frac{0.225}{\sqrt{1.475}}]}$$

C =$\frac{100.176}{2.0326}$=49.287084

Step8:We get the Final velocity (V) =C*$\sqrt{RS}$

=49.2870$\sqrt{1.475x\frac{1}{21120}}$

The velocity of the channel is = 0.48 m/sec

Approximately =0.5meter/second.

Hence the velocity obtained is equalent to the designed velocity.

C. Introduction to Lacye's Design

Taking lead from the Kennedy theory Mr. Gerald Lacey undertook detailed study to evolve more scientific method of designing irrigation channels on alluvial soils. He presented revised version of his study in 1939 which is popularly known as Lacey's theory. In this theory, Lacey described in detail concept of regime conditions and rugosity coefficient.

i. Channel should flow uniformly in "incoherent unlimited alluvium" of same character as that transported by the water.
ii. Silt grade and silt charge should be constant;
iii. Discharge should be constant.

D. Design of Channel by Lacey's method:

Step 1: Silt factor for the soil is calculated by (f)=1.76$\sqrt{m_A}$ ($\sqrt{m_A}$)=0.002mm

(f)=1.76$\sqrt{m_A}$=0.07870

Step 2: The Velocity of flow in the channel is (v)=$(\frac{Qf^2}{140})^{\frac{1}{6}}$

Q=16.99 m^3/sec f=0.0787

V=$(\frac{(16.992X0.07870)^{\frac{1}{6}}}{140})$

V =0.30063 meter/second.

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Step 3: Now, calculating the area of the channel (A)=$\frac{Q}{v}$=$\frac{16.99}{0.30063}$

Area = 56.5135$meter^2$

Step 4: Now calculating the Wetted perimeter of channel (p)=4.75$\sqrt{Q}$

4.75$\sqrt{19.66}$=19.57meters.

Step 5: Hydraulic mean depth (R)=$\frac{5}{2}\frac{v^2}{f}$

= $\frac{5}{2}$x$\frac{(0.5081)^2}{0.07870}$

= $\frac{1.29082}{0.1574}$

=2.858 meters.

Step 6: Determining the width and depth of the channel by

A=BD+$\frac{D^2}{2}$ (1)

P=B+D$\sqrt{5}$ (2)

From 1&2 equations, we get

56.515 = BD+$\frac{D^2}{2}$

19.57 = B+$D\sqrt{5}$

2(56.515)= 2BD+D^2

D^2 +2BD-120.52032=0

56.5135 =3B$\frac{D^2}{2}$

Width of channel is =18.58meters.

P=B+D$\sqrt{5}$

Depth of channel is =3meters

Step 7: Finally, Determining the slope of the channel by

Slope(S)=$\frac{f^{\frac{5}{3}}}{3340Q^{\frac{1}{6}}}$=$\frac{0.014452996}{5907.639666}$

S=0.00002698 or 1 in 26980

The bed slope to be provided for the water to flow is =2.698x10^{-6} or 0.000002698.

VII. REDESIGNING CANAL

The existing canal is not meeting the requirement as the canal is in CRD A region.so redesigning the canal by both the methods of design by estimating the increment in population and crop water requirement in tadepalli Mandal.

A. Design of a Channel Using Kennedy's Method:

We know that,

Discharge (Q)=30.62 m^3/sec

Modification factor (m)=1.1

Surface and soil properties-Rugosity

Coefficient (n)= 0.0225

Side slopes= 0.5:1

Bed fall (s)=1 in 21120

Step 1: Assume depth (D)=3 meters

Step 2: Calculating the Initial velocity (v_o)=0.55x$D^{0.64}$ m

v_o=0.55x$(3)^{0.64}$x1.1

=0.55x1.7975x1.1

=1.222117m/sec

Step 3: Calculating Sectional area (A)=$\frac{Q}{v_o}$

A=$\frac{16.99}{1.0875}$= 25.05488$meter^2$

Step 4: Determining the width of a channel

A= BD+ $\frac{D^2}{2}$

25.05488 = B x3 + $\frac{(3)^2}{2}$

25.05488 = 2.5B+3.125

2.5B=20.554

Hence the width of the channel is B= 6.8516 meters.

Step 5: Calculating the Wetted perimeter (P)=B+D$\sqrt{5}$

P= 6.8516+3$\sqrt{5}$

P=6.8516+6.7082

P=13.559 meters.

Step 6: Then Hydraulic mean depth of a channel (R)=$\frac{A}{P}$

R= $\frac{25.05488}{13.559}$

=1.847meters.

Step 7: Kutter's equation (C) =$\frac{\frac{1}{n}+[23+\frac{0.00155}{5}]}{1+\left[23+\frac{0.00155}{5}\right]n/\sqrt{R}}$

C= $\frac{[\frac{1}{0.0225}+\left|23+\frac{0.00155}{\frac{1}{21120}}\right|]}{[1+(23+\frac{0.00155}{\frac{1}{21120}})\frac{0.225}{\sqrt{1.475}}]}$

C=$\frac{44.44+[55.736]}{1+(55.736)x0.0185}$

=$\frac{4.44+(55.736)}{2.0325}$

=$\frac{100.176}{2.0326}$

Kutter's constant © =52.107

Step 8: We get the Final velocity (V)=c $\sqrt{RS}$

V=52.107 $\sqrt{1.475x\frac{1}{21120}}$

=0.48 7305m/sec

Approximately =0.5meter/second.

Hence the velocity obtained is approximately equal t to the designed velocity.

B. Redesign of Channel By Lacey's method:

Step 1: Silt factor for the soil is calculated by (f)=1.76$\sqrt{m_A}$ ($\sqrt{m_A}$)=0.002mm

(f)=1.76$\sqrt{m_A}$=0.07870

Step 2: The Velocity of flow in the channel is (v)=$(\frac{Qf^2}{140})^{\frac{1}{6}}$

Q=30.62m^3/sec f=0.07870

V= $(\frac{(30.62X0.07870)^{\frac{1}{6}}}{140})$

V =0.5081 meter/second.

Step 3: Now, calculating the area of the channel (A)=$\frac{Q}{v}$=$\frac{30.62}{0.508130}$

Area = 60.26016$meter^2$

Step 4: Now calculating the Wetted perimeter of channel (p)=4.75$\sqrt{Q}$

4.75$\sqrt{30.62}$=26.2842meters.

Step 5: Hydraulic mean depth (R)=$\frac{5}{2}\frac{v^2}{f}$

= $\frac{5}{2}$x$\frac{(0.5081)^2}{0.07870}$

= $\frac{1.29082}{0.1574}$

= 8.2145meters.

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Step 6: Determining the width and depth of the channel by

$A=BD+\frac{D^2}{2}$ --------------1

$P=B+D\sqrt{5}$ --------------2

From 1&2 equations,we get

$60.260161=BD+\frac{D^2}{2}$

$26.2842=B+D\sqrt{5}$

$2(60.26016)=2BD+D^2$

D^2 +2BD-120.52032=0

$60.26016=3B\frac{D^2}{2}$

Width of channel is =18.58meters.

$P=B+D\sqrt{5}$

Depth of channel is =3meters.

Step 7: Finally, Determining the slope of the channel by

$Slope(S)=\frac{f^{\frac{5}{3}}}{3340Q^{\frac{1}{6}}}=\frac{0.014452996}{5907.639666}=0.0000246327.$

VIII. RESULTS AND CONCLUSIONS

Table III informs about the details of design parameters

Table III: Details of design parameters

S. No.	Design Parameters	Kenneyd's Design Value	Lacey's Design Value
1	Area	45.0544 Sq meter	60.28061 sq meter
2	Wetted perimeter	15.859 meters	26.2812 meters
3	Breadth	6.8 meters	10.5 meters
4	Depth	5 metres	7 meters
5	N value	0.0225	0.0225
6	Velocity	0.48 m/sec	0.5081m/sec
7	Bed fall	1 in 21120	1in 2463

APPENDIX-A

Design Using the C Programming For Kennedys Method:

```
#include<stdio.h>
#include<stdlib.h>
#include<conio.h>
#include<math.h>
#include <graphics.h>
int main()
{
intgd = DETECT, gm,
points[]={237,150,275,200,400,200,437,150,237,150};
        initgraph(&gd, &gm, "C:\\TC\\BGI");
        double d,s,q,v,a,b,p,c,e,v1,r,m=1.1,n=0.0225;
        s=0.0000473484;
        printf("s is %lf",s);
printf("\n Enter the assumed value of depth of channel in meters");
        scanf("%lf",&d);
        printf("\n Enter the dischrge in cumes");
        scanf("%lf",&q);
v=0.55*pow(d,0.64)*m;
        printf("\n Initial velocity is %lf",v);
        a=q/v;
        printf("\n Area of channel is %lf ",a);
        b=((a-((d*d)/2))/(d));
        printf("\n Width of the channel is %lf",b);
        p=b+d*sqrt(5);
        printf("\n The wetted perimeter is %lf",p);
        r=a/p;
        printf("\n Hydraulic radius is %lf",r);
        e=(0.00155/s)+23;
        c=(e+(1/n))/(((e)*(n/sqrt(r))+1));
printf("\n Value of c is %lf",c);
        v1=c*(sqrt(r*s));
        printf("\n Velocity of water in channel is %lf",v1);
        printf("\n the width,depth and velocity of channel are %lf,%lf,%lf",b,d,v1);
line(100, 100, 200, 100);
line(200,100,275,200);
line(275,200,400,200);
line(400,200,475,100);
line(475,100,575,100);
line(100,100,75,125);
line(575,100,600,125);
line(237,135,437,135);
setfillstyle(LINE_FILL, BLUE);
fillpoly(5,points);
outtextxy(325, 205, "base");
outtextxy(250, 135, "water level");
outtextxy(220, 140, "A");
outtextxy(275, 205, "B");
outtextxy(400, 205, "C");
outtextxy(445, 150, "D");
outtextxy(460,120, "canal embankment");
outtextxy(425, 175, "water depth");
outtextxy(320, 120, "top line");
getch();
closegraph();
        return 0;
}
```

APPENDIX-B

Design Using the C Programming For Kennedys Method:

```
#include<stdio.h>
#include<stdlib.h>
#include<conio.h>
#include<math.h>


#include <graphics.h>
int main()
{
intgd = DETECT, gm,
points[]={237,150,275,200,400,200,437,150,237,150};
initgraph(&gd, &gm, "C:\\TC\\BGI");
  double f=0.07870,q,a,e,v,p,r,b,d,s;
printf("\nenter the discharge value :");
scanf("%lf",&q);
printf("\nthe silt factor of a channel is :%lf",f);
  e=(q*f*f)/140;
  v=pow(e,0.1667);
```


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```
    printf("\nthe velocity in the channel is :%lf",v);
      a=q/v;
    printf("\nthe area of channel is :%lf",a);
      p=4.75*(sqrt(q));
    printf("\nthe wetted perimeter of a channel is :%lf",p);
      r=(5*v*v)/(2*f);
    printf("\nthehydrolic mean depth of the channel :%lf",r);
    printf("\nenter the width of channel :");
    scanf("%lf",&b);
      d=(p-b)/(sqrt(5));
    printf("\nthe depth of the channel is : %lf",d);
      s=(pow(f,1.667))/(3340*(pow(q,0.1667)));
    printf("the slope of the channel is :%lf",s);
    printf("\nthe velocity : %lfm3/s ;wetted perimeter : %lf
meters; hydraulic radius : %lf meters ; depth is : %lf meters;
bed slope of channel : %lf\n",v,p,r,d,s);
    line(100, 100, 200, 100);
    line(200,100,275,200);
    line(275,200,400,200);
    line(400,200,475,100);
    line(475,100,575,100);
    line(100,100,75,125);
    line(575,100,600,125);
    line(237,135,437,135);
    setfillstyle(LINE_FILL, BLUE);
    fillpoly(5,points);
    outtextxy(325, 205, "base");
    outtextxy(250, 135, "water level");
    outtextxy(220, 140, "A");
    outtextxy(275, 205, "B");
    outtextxy(400, 205, "C");
    outtextxy(445, 150, "D");
    outtextxy(460,120, "canal embankment");
    outtextxy(425, 175, "water depth");
    outtextxy(320, 120, "top line");
    getch();
    closegraph();
          return 0;
    }
```

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