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Computer programming for Water Conveyance structures Design

T. A. KHAN, N. GUL[++], D. KHAN

Agricultural Engineering Department University of Engineering and Technology Peshawar, Pakistan

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Abstract: Irrigation engineers some time feel difficulty for trial solution of the Manning formula to find out various geometric elements of open channels. This paper addresses the development of a Computer model named as " WaterFlow" for hydraulic design of most commonly used cannels section like Parabolic, Trapezoidal and Rectangular cross sections, and also intended as educational tools.

Keywords: Irrigation, Parabolic, Trapezoidal, Rectangular Cross Section.

1. INTRODUCTION

"The irrigation system of Pakistan is one of the largest gravity flow system in the world. Pakistan Indus basin irrigation system (IBIS) comprises three main storages (Tarbela, Mangla, Chashma), sixteen (16) barrages, two (02) head works, two (02) siphons, twelve (12 inter river link) canals (All in Punjab) ,forty four (44) canals systems (23in Punjab + 14 in sindh province + 05 in KPK + 02 in Baluchistan) and in addition with near about 1.4 lacs water courses all over the country. The average canal length is count as 56073 kilo meter, with contribution of 16 lacs Kilometers of water carrying structures from canal outlet to cropping areas, On Farm Water Management (OFWM), 2004-05. It is observed that nearly about 91% of water resources in our country used for irrigating purposes, while the remaining 09% water resources in our country is utilized in equal proportion for household and industries, Farm Water Management (OFWM), 2004-05**.** A worry fact is that the availability of water per capita has substantially decreased with the passage of time that is from "5260 cubic meter", which falls to "1299 cubic meter" in the year 1996-97 and "1101 cubic meter" in the year 2003-04. While this amount of water per capita will reached to "858 cubic meter" by the year 2025. In order to eliminate water stress minimum standard is "1000 cubic meter" per year per capita (Jamal 2011). The irrigation water from source to agriculture field is supplied through watercourse in Pakistan; result into near about 40% water losses, which not only cause of lower efficiency but also source of yield reduction. Merriam (1977) and Kay (1990) pointed out that surface watering system, poor efficiencies are not inherent to the procedure but are result of weak management and design , leading to loss of water, water logging, Stalinization and contaminate surface water resources and ground water resources. However, surface irrigation systems, when properly designed and managed, can attain application efficiencies similar to that of pressurized irrigation systems (James, 1988). Thus, in order to improve performance of surface irrigation systems, there is a need for proper design and management. Mathematical models of surface irrigation can help in better design and management of these systems. In Pakistan water management department, watercourse design mainly carried out manually or using DOS base computer programming name as SuperCal (SC-5).these methods are inefficient, time consuming, and laborious. Development of **WaterFlow,** which is computer programming for design of water course hydraulic structures, is a result of serach to develop a software that help in improvement as well to speed up the design procedure of irrigation / water management structures.

Development of software

Microsoft excel and visual basic application has been used to develop the software, called WaterFlow, consist watercourse design, pipe and pump selection, water storage tank design, watercourse survey calculation sheet, flow measurement sheet and material estimate of hydraulic structures. In this paper I will discuss only watercourse designs.

Here we discus only parabolic, Trapezoidal and Rectangular Section for water carrying from source to field. The input and output data required for design of open channels are shown in **(Table 1)**. Depending on input data, the output can be obtained for different channel sections. Design of open channels is based on

[++]Corresponding Author's email engrnasib@gmail.com

the Manning's equation. Therefore, for a given cross section, velocity and discharge (capacity) are calculated and compared with the required capacity. The design is carried out using a trial and error process, which continued until calculated capacity become equal to required capacity. **(Fig. 1)** shows the flow chart of **WaterFlow**. The input data required for open channel design depends on the chosen cross section, That is Parabolic, Trapezoidal and Rectangular. **(Fig.2)** shows the front page of open channels section design, in WaterFlow programming, the user could click to design either parabolic, Trapezoidal or rectangular section. **(Fig.3)** shows the input and output data for parabolic section lining, are marked as color cells which include station points, Reduced level, Highest field level, discharge, slope and segment number, while output given on the same sheet include "design bed level (dbl)", "flow depth (fd)", "design velocity (dv)", "working head (wh)" and "head losses (hl)". While profile map is appear as on separate sheet. **(Fig.4)** shows the profile map for parabolic section lining, user could review any section of map entering the reduce distance range in profile map page. The procedure is same for design of trapezoidal and Rectangular section.

Table 1 Input and output data for the open channels design.

Section Type	Input	Output
Trapezoidal	Station point, Rd, HFL, Q,n S,and Z	d , v, DBL,WH ,head losses and profile map
Rectangular	Q,n,S and design bed level	d , v, DBL,WH ,head losses and profile map
Parabolic	Q,n,S and PCPS No	d , v, DBL,WH ,head losses and profile map

Where d, v is flow depth and velocity, DBL is design bed level, WH is working head.

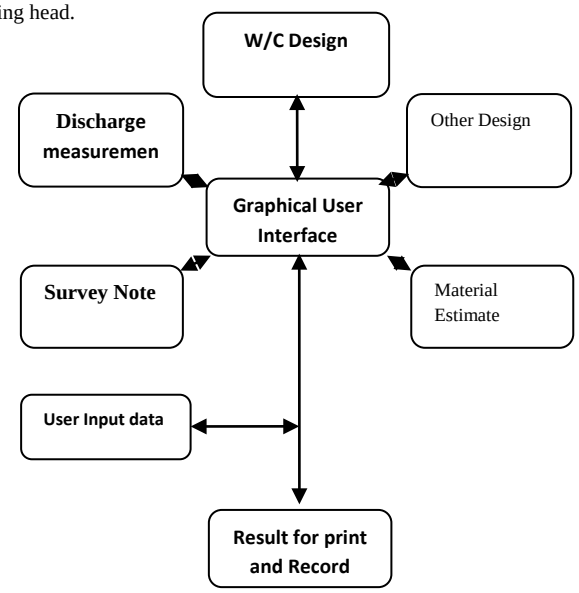


Fig 1. Flow Chart of WaterFlow

2. DESIGN METHODOLOGY

➢ **Parabolic Section:**

The following different steps are used for this design purpose.

a. Input data:

- Required/design capacity = $\boldsymbol{Q}$
- Length wise gradient = $\boldsymbol{S}$
- manning constant = $\boldsymbol{n}$
- PCPS Top width = **T**
- PCS depth = **D**

b. find out C.

$C = T/D$ ---------- 2

c. Find out water depth in watercourse = d

$$\frac{Q*n}{S^{\frac{1}{2}}} = \left(\frac{2*c^2}{3C^{2+8}}\right)^{\frac{2}{3}} * \left(\frac{2}{3} * C\right) * d^{\frac{8}{3}} \text{----------3}$$

d. find out the flow velocity = v

$$v = \frac{1}{n} * S^{\frac{1}{2}} * \left(\frac{2*C^2*d}{3C^2+8}\right)^{\frac{2}{3}} \text{---------- 4}$$

e. Now find water width = **t**

$t = Cd$ ---------- 5

f. determine water cross section area

$A = \frac{2}{3} dt$ ---------- 6

g. Now calculate Discharge = Q_0

$Qo = Av$ ---------- 7

h. match the calculated discharge with the actual discharge = Q

$Q = Qo$

i.. End of Design Steps.

➢ **Rectangular Section**

For rectangular cross section The following steps are used.

a. Input data:

- Required/design capacity = $\boldsymbol{Q}$
- Length wise gradient = **S**
- manning constant = **n**
- width of water course Bottom = **b**

b. let suppose depth in watercourse = $\mathbf{d_0}$

c. determine sectional area = **A**

$\boldsymbol{A = bdo}$ ----------**8**

d. determined wetted perimeter

$\boldsymbol{P = b + 2do}$ ----------9

e. calculate Hydraulic radius "

$\boldsymbol{R = A / P}$ ---------- ----**10**

f. find out velocity "V " from relation No ---**.1**

g similarly find imaginary capacity "Q_0" using relation No 7.

h. match Trial/imaginary capacity Q_0 with actual capacity Q

- if trial discharge Q_0 is less than actual discharge Q then increase Trial depth d_0 steps c & d .
- if imaginary capacity Q_0 s greater than actual capacity Q, Then reduce imaginary depth d_0 steps c & d.

● if imaginary capacity Q_0 is equal to actual flow capacity "Q" Then, imaginary depth d_0 = Actual depth d.

i. End of Design steps.

➢ **Trapezoidal Section:**

In order to design Rectangular Cross section watercourse the following procedure is adopted.

a. Input data:

● Required Capacity = **Q**

● Length wise gradient = **S**

● manning constant = **n**

● Width of watercourse Bottom = **b**

● Side gradient = **z**

b. suppose imaginary flow depth = $\mathbf{d_0}$

c.find sectional area = **A**

A = bdo + Zdo^2 ---------- 11

d.estimate wetted perimeter **P.**

$P = b + 2do(Z^2 + 1)^{(1/2)}$ ------12

e.findout Hydraulic radius **R,** from relation **.10**

f. Find out velocity of flow V from equation **.1**

g. Determine trial discharge Q_0, using equation 7**.**

h. match both capacity that is imaginary/trial Q_0, with real flow capacity Q.

● if imaginary capacity Q_0 is less than real one Q_0 **,** then increase Trial depth d_0 , steps c & d

● If trial/imaginary capacity Q0, is greater than real capacity Q**,** then reduces imaginary depth $\mathbf{d_0}$,steps c & d.

● if imaginary/trial capacity $\mathbf{Q_0}$, is same as to real capacity Q**,** Then, Trial depth d_o = Actual depth d**.**

i. End of design steps.

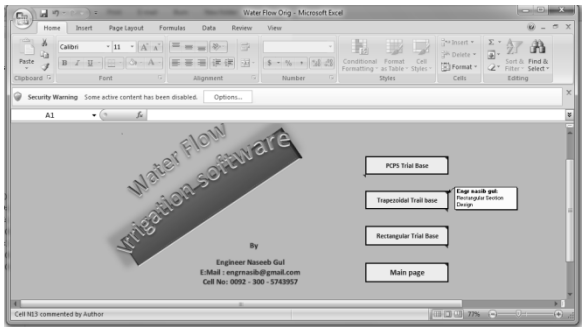
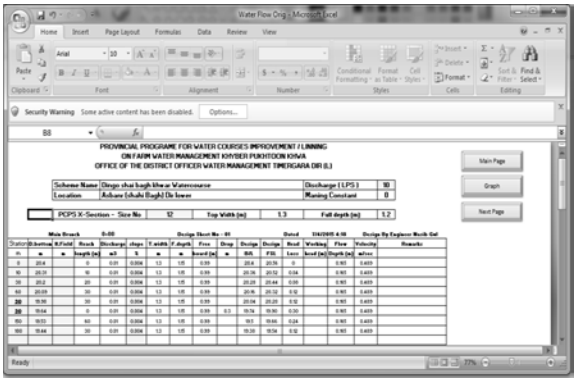


Fig 2: Front page of open channel flow design section



a

Fig 3: input and output data for parabolic section

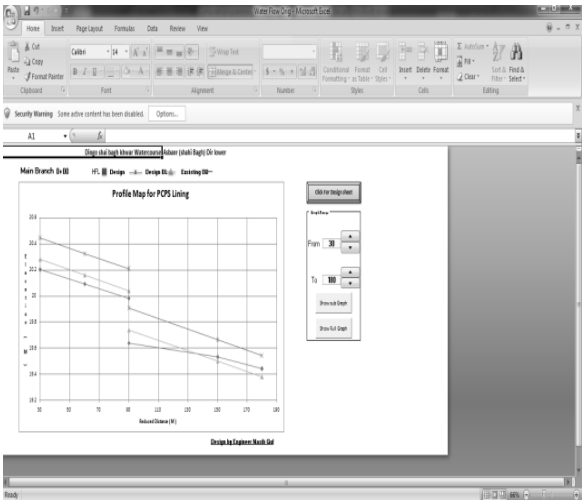


Fig 4: profile map of parabolic section lining

3. RESULT AND DISCUSSION:

The **WaterFlow** computer programming was used to check various hydraulic design parameters, for this purpose various section like parabolic (PCPS), Trapezoidal (earthen) section and Rectangular (Bricks lining plastered) sections were selected locally. For parabolic section with full depth 0.31m and top width 0.46m and up to length of 90m, with discharge of 20 Lps, longitudinal slope 0.004m/m were design with result of design velocity 0.64m/sec and flow depth of 0.13m, similarly the earthen trapezoidal section of the same parabolic water course was design using WaterFlow computer programming, result into design velocity of 0.36m/sec and flow depth of 0.158m, keeping side slope of earthen section 1:1 and manning coefficient n, is 0.035.while for testing Rectangular section through **WaterFlow** computer programming, a rectangular plastered section of length of 100m, with bottom width of 0.15m, slope of .005m/m and manning coefficient of 0.014 and discharge 23Lps, after setting all essential data in computer programming for rectangular section results into design velocity of 0.73m/s and flow depth of 0.21m.

After comparing the result obtained by Water Flow computer programming to that which were taken manually for measurement of flow velocity and flow depth and was found near about similar to that obtained by WaterFlow computer programming. hence WaterFlow gives an accurate result within in few seconds.

4. CONCLUSIONS

The developed computer Program "**WaterFlow**" is user-friendly, and may be used as educational tools. This program is very useful for quick designing in tabular form along with profile maps of parabolic, Rectangular and Trapezoidal Cross sections.

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