Middle-East Journal of Scientific Research 13 (11): 1451-1454, 2013
ISSN 1990-9233
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DOI: 10.5829/idosi.mejsr.2013.13.11.1370

Study and Simulation of Hydraulic and Structural Changes Result of Changing of Section from Soil to Concrete

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Abstract: The purpose of this study was to investigate hydraulic and structural variations resulted from sectional changes of soil to concrete canals. In the study of hydraulic regime of water transport canals, other components of flow can be obtained if cross-section and velocity of flow are known and it is possible to analyze water surface profile. Hydraulic calculations are not manually possible or require spending a lot of time and cost. In this study, HEC-RAS model was used for hydraulic and structural simulation in Moghan canal, located in the northwest of Iran. This software has been developed by U.S. Army Engineering Center as a hydraulic analysis system. According to field observations and experience, roughness coefficients were estimated for soil to concrete sections. Hydraulic structures of canal path such as water level control structures, flow control structures and bridges were also simulated in the model. This study demonstrated that, in soil and concrete canals, roughness coefficients were one of the effective parameters on the water surface profile and lead to hydraulic drop of the flow. Also, consecutive hydraulic structures in soil-concrete canal path can create a new water surface profile.

Key words: Soil canal % Concrete canal % Hydraulic structures % HEC-RAS model

INTRODUCTION

Due to water shortage in the world, it is inevitable to utilize water resources in an optimal way. Water resources are limited and water demand is increasingly growing worldwide. Therefore, optimal use of water resources is crucial. This can be done by the correct and optimal design of canals and hydraulic structures and proper programming for water resources management. To model soil and concrete canals and other hydraulic structures, HEC-RAS simulation model has been used in numerous studies.

Johnson *et al*. [1], applied HECARS model in order to predict and determine the limits of humid lands along 10 kilometers of Greybull River in Wyoming, U.S.A. Through water deviation toward a new reservoir and determination of boundary conditions with and without deviation in similar scales, they also predicted that the whole area which undergoes flooding would increase from 167.2 to 149.2 through deviation of 28313 liters of water. These scholars believe that this is a reliable method to determine the quality of deviation effects on humid lands of river bank and it should be more evaluated in order to be used in order to specify the humid lands (touched by water) in similar projects.

The River Engendering Research Division of Soil Conservation and Watershed Management Center in Ala basin in Marvdasht, Fars and Damavand drainage basin, applied HEC-2 model to determine the maximum numbers of water base level in considered direction in two mentioned cases in which the point numbers were manually transferred to specific profiles of the river in topographic plan and the flood affected province was stated in 5 and 25 year return periods. The profile of water level was also plotted for a 25 year return period (Abasi, [2]).

Vahabi [3] used remote sensing methods, Geographic Information Systems, HEC-1 and Mike11 software along with the provided river profiles in Talighan drainage basin for zoning the flood risk. The banned, limited and permitted arias were specified and the conditions were mentioned in the provided zoning map.

Safari [4] proceeded to apply the HEC-RAS model for zoning the flood risk in Neka River located in Mazandaran and concluded that this model is highly efficient to calculate the water level and flood affected provinces.

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In their research, Shahrokhnia and Javan [5] determined the sensitivity of hydraulic structures in Doroodzan irrigation network applying HEC-RAS software. In this investigation, in order to investigate the reliability, the mentioned model was at first calibrated with two sets of measured data, discharge and water level numbers. The Manning's roughness coefficient and structure discharge were used to calibrate the model. The sensitivity of structures was estimated. The discharge variation of basins derived by the changes in chokes setting was investigated as well. A new sensitivity coefficient called sensitivity due to variation of channel roughness was introduced in this research. The results also indicated that HEC-RAS model is suitable for investigation and simulation of hydraulic flows in irrigation network of Doroodzan and it can be used as a sort of accurate tool in analysis of such cases.

In this research, the HEC-RAS model was applied in order to simulate the water level profiles in the main channel of Mugan with its soil bed located in North West of Iran.

MATERIALS AND METHODS

What happens in many hydraulic cases is that the design engineer has to be able to calculate the gradual variations of water depth and other flow characteristics along the channel rather accurately. The effects of basin material of a soil channel and determination of the changes in flow characteristic in upper and lower lands are among such examples.

HEC-RAS software is the advanced version of HEC-2 which has been presented by the U.S. Army Corps of Engineers as a river analysis system. HEC-RAS is a complex software system designed for mutual application in multi-purpose and multi-user networks. This system consists of a Graphical User Interface (GUI), separated hydraulic analysis components, saving capacities and data management, graphical features and reporting.

The present version of HEC-ARS supports the calculation of water level profile for steady and unsteady flows.

The simulation software has been provided in order to calculate the water level profiles in gradually variable states of flows. The system is able to consider a whole network of channels, a branch system or a single interval of the channel the component of steady flow is capable of simulating the water level profiles in sub-critical, super-critic and mixed flows.

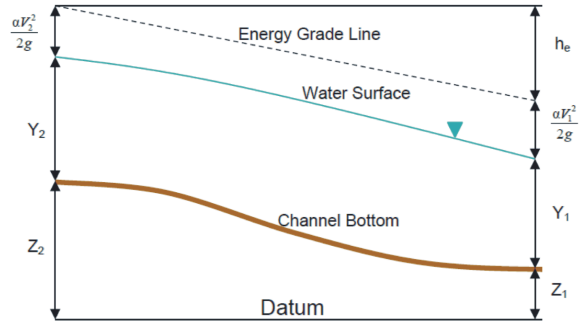

Fig. 1: The energy equation between two spots.

Equation (1) and Figure (1) illustrate the main computing process based on solution of one-dimensional energy equation through standard step by step method (US. Army Grops of Engineers,[6]).

$$Y_1 + Z_1 + a_1 V_1^2 / 2g = Y_2 + Z_2 + a_2 V_2^2 / 2g + h_L \quad (1)$$

Where Y_2,Y_1 is the water level in profile, Z_2,Z_1 is the height of channel bottom from the base level, a_2,a_1 is the weighted speed coefficient, g is the gravitation acceleration and h_L is the friction loss.

Study Area: Moghan Plain, with an area of 350,000 hectares, is situated in northwestern Iran and west of the Caspian Sea. The presence of Aras River and favorable climatic conditions have made this region into an agricultural hub. Implementation of nomads' settlement policy started in 1931 and construction of the irrigation and drainage networks of Moghan started in 1951. With the gradual completion of the network in three consecutive phases and with completion of the diversion dam of Mil and Moghan, about 72,000 hectares of the intact lands of the plain were exploited for cultivation of agricultural products. The irrigation and drainage network of Moghan includes four irrigation areas, called Aslanduz, Shahrak, Parsabad and Bileh-Savar.

This research investigates and analyses the effects of the variation of water level profiles caused by the change in channel basin coverage and the section along the channel and its impacts on regulatory structures (transverse regulators).

RESULTS

In this study, the main part of Moghan canal (from its 55+375 km to 67+375 km) was divided to three intervals:

First Interval: Siphon outlet 1 to siphon inlet 2, from its 55+375 km to 62+415 km.

Second Interval: Siphon outlet 2 to siphon inlet 3, from its 62+723 km to 65+415 km.

Third Interval: Siphon outlet 3 to the current concrete canal, from its 66+200 km to 67+375 km.

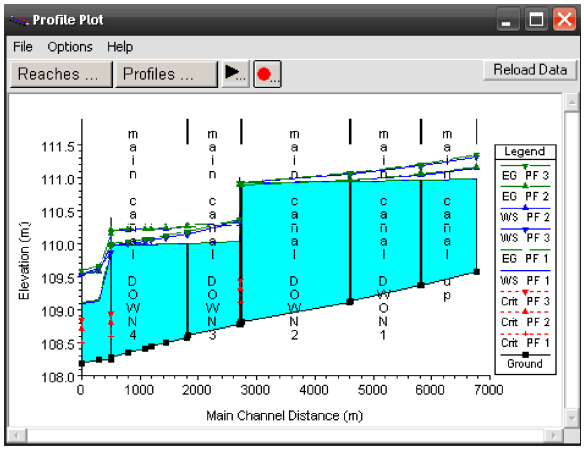

Fig. 2: The longitudinal simulated model of Mugan Concrete channel.

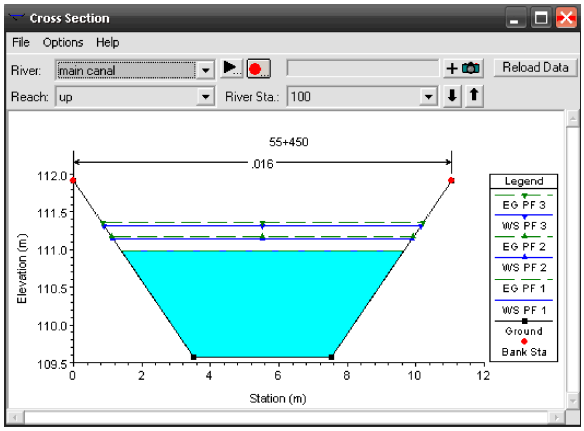

Fig. 3: Demonstrates transverse section of the first interval.

The above-mentioned intervals were of soil and, with increasing main canal capacity, hydraulic regime of flow changes in these intervals. The first interval was modeled in HEC-RAS software; in these intervals, a number of second-class canals along with some hydraulic structures were also modeled in the software. Longitudinal profile of the main canal for the first interval is shown in Figure 2.

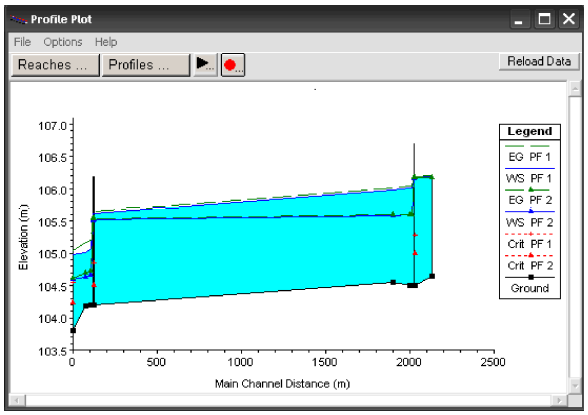

Fig. 4: Structures of water level control.

This simulation was designed for the minimum hydraulic conditions and the maximum flow rate. Figure 3 demonstrates transverse section of the first interval. Moreover, other structures of water level control were modeled, a sample of which is given in Figure 4. The remaining intervals were also modeled in the same way.

DISCUSSION

In this paper, the HEC-RAS hydraulic model was used to simulate soil-concrete canals along with hydraulic structures. The following results were extracted:

- Soil canals lose their optimal form over time, which causes a reduction in water discharge.
- Deformation of bottom slope in soil canals due to improper dredging and sedimentation changes the canal hydraulic regime and, in some cases, reduces canal capacity.
- The concrete canals which have soil canals in their downstream sections increase roughness coefficient and also lead to the increase of energy drop.
- With the increase of roughness coefficient, water level profile is no longer uniform and appears as a gradual variable. Thus, the water level profile changes.
- Hydraulic structures of the main canal path for water transport are among the main factors of generating flow drop and their effects are sometimes greater than those of roughness coefficients.
- Effect of decrease in normal depth of canal to the water discharge capacity of soil canal is considerably more important than canal width, side wall slope and other geometric properties of the canal.

- Due to the sedimentation of suspension materials on the bottom of soil canal and its improper dredging, normal depth of canal decreases and consequently leads to the decrease in canal capacity.
- Walls of left and right banks have more roughness coefficients than the center of the soil canal. This issue becomes more severe in the maximum flow rates.

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