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Statistical Analysis of *Manning's* Roughness Coefficients in Non-vegetated Canals for Irrigation and Drainage Network of Moghan

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Introduction: Due to sensitiveness of flow to roughness coefficient (RC), selection of this coefficient is important in earth canals designing purposes. Precision selection of this coefficient is necessary for design and operation of earthen canals purposes. Overestimation of the actual amount of this coefficient will cause an underestimation for flow velocity. Accordingly, sedimentation in the earth canals will reduce canals' capacitances. Adversely, underestimation of this coefficient will cause an overestimation for flow velocity and water flux in the earth canals. It will also increase the risk of soil erosion in the channels. This coefficient is expressed by Manning, Chezy and Darcy Weisbach equations. While, hydraulic engineers have selected Manning equation to estimate the flow rate in open channels due to ease of use and acceptable precision in the application of this equation. Water for crop production in Moghan, as one of the most important agricultural centers in Iran, is supplied from Moghan-Meel diversion dam via main canal of irrigation and drainage network with a capacity of 80 m3 s-1 with a length of 116 km. All of the branched 63-channel from the main channel are earthen. Continual sedimentation in the earth canals reduced the capacity of them and re-estimation the capacity of this canals needs to the precise quantities of variables such as roughness coefficient. Because the overestimation of the actual value of the coefficient would reduce the canals' capacity and underestimation of the coefficient increase the risk of erosion in earth canals. The analysis of the correlation among variables, regression, analysis of statistical distribution of variables, analysis of variance of variables and the analysis of the events probabilities for stochastic variables can be made by statistical methods. Therefore, these methods were applied to analysis of roughness coefficient in the earth canals. Also, due to the importance of roughness coefficient and significant sensitivity of the capacity to this coefficient, the current study was conducted to statistically analyze and to evaluate roughness coefficients in non-vegetated canals for irrigation and drainage network of Moghan (in North-west of Iran). The results of the research may be applied in the design, evaluation and utilization of networks, especially in the irrigation and drainage network of Moghan.

Materials and Methods: Experimental area was Moghan plain located at the north-west of Iran with latitude from 39º 22' to 39º 45' N, longitude from 47º 22' to 47º 45' E and sea level of 32.0 m. The annual averages air temperature, relative humidity and pan evaporation are 14.5º C, 72% and 111 mm month-1, respectively. Annual rainfall in this plain is 332 mm. In the network of Moghan, 50 sections were selected to measure water flow velocity (with a flow meter) and canals cross sections (with profilimetery devices). The selected sections were in earth canals located at the farms of Agro-Industrial Company of Moghan, farmers' farms, Pirayvatlu's farms, Iranabad, Hajhazar, Farms of Agricultural Education Center and Agricultural Research Center. A flowmeter (type AOTT) made by Iranian Water Resources Engineering Company was applied to measure flow velocity in different sections of the channel. Resistance coefficient were determined by the following equation according to the dimensions and the velocity of the water flow in the earth canals

$$n = \frac{R^{0.667} S^{0.5}}{V} \qquad (1)$$

Where R is the hydraulic radius (m), V is velocity (m/s) and S is channel slope (m/m).

In this study, the Reynolds number was applied to determine the flow regime in the channel. The partial correlation coefficient was used to determine the effective variables in the roughness coefficient in canals without vegetation. The application of the coefficient of correlation is that the dependent variable (multiple independent variables) and independent stay in the form of fixed values of other independent variables. The software's of SPSS and Minitab were used in statistical analysis.

Results and Discussion: Roughness coefficients averaged 0.06. Results revealed that RC varied from 0.014 to 0.050 (and more than) for 90 to 40% probabilities in non-vegetated canals. Also, flow velocity, hydraulic radius, cross section area, wetted perimeter and roughness coefficient were lognormal in distributions.

Results also showed that flow regimes were turbulent and with increase in Reynolds numbers, roughness

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coefficients decrease. Sensitivity analysis of flow rate to roughness coefficient showed that with increase as 200 and 300 percent in roughness coefficients, flow rates were 0.50 and 0.33 of flow rate from average roughness coefficient. Moreover,

A simple regression model was developed based on effective variables (viz. flow velocity and canal slope) on roughness coefficient by omitting non-effective variables in non-vegetated canals. Developed model was as follows:

$$n = \frac{S^{0.46}}{V^{0.79}} \qquad R^2=0.99 \qquad (2)$$

The variables of the model were previously introduced earlier. The coefficient of determination (R^2) shows that more than 99% variations in RC could be explained by flow velocity and canal slope.

Conclusion: Roughness coefficient in the earth non-vegetated canals was successfully and precisely evaluated for irrigation and drainage network of Moghan (in North-west of Iran) by statistical methods. Roughness coefficients averaged 0.06. The sensitivity of canal discharge to roughness coefficient was significant. It is recommended to select and apply actual values of this coefficient in engineering or computing purposes. By omitting non-effective variables in roughness coefficient in non-vegetated canals, a simple regression model with R^2 of 0.99 was developed based on effective variables. In this study, the role of vegetation in channel for roughness coefficient was not evaluated. Therefore, it is recommended that the effect of different vegetation on roughness coefficient tobe evaluated with models such as hydrodynamic and zero-inertia.

Keywords: Earth canals, Flow resistance coefficient, Hydraulic resistance, Manning