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Investigation of Scour Depths Around the Side Weir with GEP

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Abstract: *Side weirs are structures used to reduce excess flow in a channel or to take the needed flow from any channel. Side weirs are built in necessary places so that excess water entering the canal does not overflow and damage the environment. Dimensionless parameters* V_1/V_c, L/b, $(h_1\text{-}p)/h_1$, d_{50}/p, *which affect the* H_d/p *equilibrium scour depth, were obtained.* R^2 *and RMSE values were obtained by making models with 3 and 4 dimensionless parameters. In the first model, Model-1, all variables* V_1/V_c, L/b, $(h_1\text{-}p)/h_1$, d_{50}/p *were included in the calculations. As a result of the calculations made in Model-1,* R^2=0.86 *and RMSE=0.1452 for the training data,* R^2=0.86 *and RMSE=0.1531 for the test data.*

Keyword: *Side-weir, Scour, GEP, RMSE*

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I.INTRODUCTION

Side weirs are structures used to reduce excess flow in a channel or to extract the required flow from any channel. Side weirs are one of the most frequently used solutions in engineering applications. Side weirs are generally used in irrigation systems, sewage networks and flood protection structures, dams and hydroelectric power plants. In order to prevent excess water entering the canal from overflowing and damaging the environment, side weirs are being built. The side sluices are constructed only on one side or both sides of the channel, on the side of structures such as sedimentation pools.

Side weirs in channels with live-bed have a significant effect on the channel bottom profile and the flow characteristics in the main channel. Both the lateral flow and the secondary flow created by the obstacles and curvatures in the channel cause very important changes in the bottom profile and hydraulic characteristics of the main channel.

With the increase in flow intensity, when the shear stress in the upstream exceeds the critical shear stress value that the base material will resist, sediment material movement starts from the upstream in the flow direction. Although the scour depth is initially high, it decreases over time, forming a parabolic curve in the depth-time graph.

Önen [1] carried out serial experiments on the physical model for rectangular side weirs along the movable bottom channel under subcritical regime conditions. Relative equilibrium scour depth was investigated for clear water scour ($0.5 < V_1/V_c < 1$) and live bed scour ($0.95\text{-}1.0<V_1/V_c<2.5$).

Emiroglu et al. [2] carried out experimental studies on scour depth in θ=90° curved channel under subcritical regime conditions and in cohesionless ground. In the study, they observed that in the case of clear water scouring for V_1/V_c<l, base fluctuation did not occur in the cohesionless soil at the bottom of the channel. They observed that the intensity of the secondary flow increased with the increase in the amount of weir, and the amount of scour depth increased along with it, and it formed at the side weir outlet.

Onen and Agaccıoglu [3] carried out experimental studies to determine the depth of clear water scour around the side weir in an alluvial channel in a rectangular channel. The researchers determined that the depth of scour in the alluvial channel is dependent on the flow rate, side weir length, water depth, and solid grain diameter. It has been determined that the depth of clear water scour increases with time and approaches the equilibrium scour depth asymptotically.

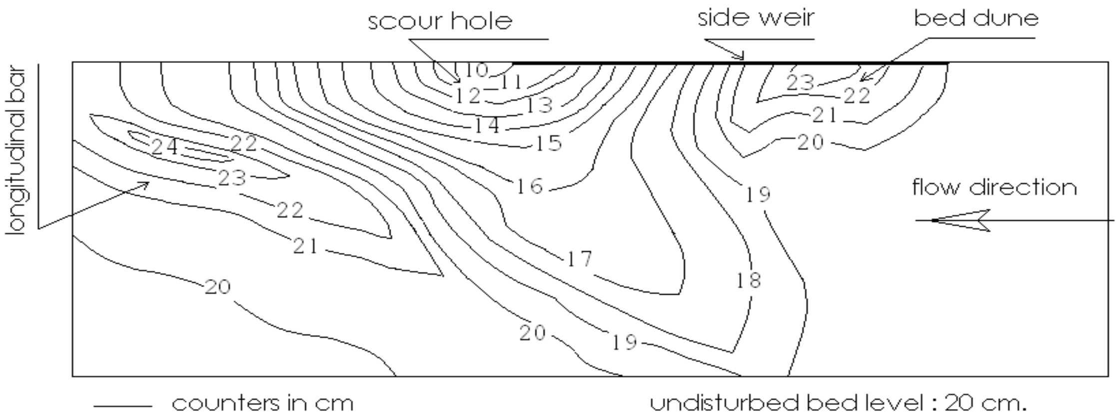
Varol [4] experimentally investigated side weir scour in cohesive soils under subcritical regime flow conditions (Fr=0.33-0.81). In the study, scour and relative equilibrium scour depths were investigated around a rectangular side weir with a length of L=25, 40 and 50 cm and a crest height of p=7, 12 and 17 cm along a sand and clay-bottomed rectangular channel.

Tunc et al. [5] experimentally investigated the local scour depths around the triangular labyrinth side weir for steady flow conditions and free spillway in a rectangular alluvial channel. In the study, a series of experiments were carried out in different conditions to determine the maximum scour depths around the triangular labyrinth side weir. In the experiments, different sizes of scour depths were observed at the upstream and downstream of the weir, and they observed that the maximum scour depth was mostly formed at the downstream end of the triangular labyrinth side weir.

The variation of scour depth can be characterized over time. One of the characteristics of live bed scour is that the scour depth oscillates around the equilibrium depth.

As can be seen from the Figure 1, the maximum scour depth occurs in the countercurrent region. The maximum scour depth and the location of the longitudinal bar depend on the location of the stagnation zone and the countercurrent area. In the experiments, the maximum scour depth location moves towards the downstream of the side weir with the increase of the dimensionless V_1/Vc and $(h_1-p)/h_1$ value [6].

Figure1. Bed topography at a Side-Weir



In this study, the scour depths around the side weir in moving-alluvial rivers were modeled mathematically using genetic programming. In addition, the accuracy of the mathematical models will be determined by comparing the scour depths measured in the physical model with the results of the GEP model.

II. MATERIAL AND METHOD

Experimental studies by agaccioglu and Onen (2005) were carried out in the existing rectangular cross-section 180-degree curved channel in Yıldız Technical University Civil Engineering Department, Hydraulics Department, Hydraulics and Coastal Harbor Laboratory. The existing channel has a total width of 0.90 m and a height of 0.60 m with an aluminum base. The test channel consists of seven sections connected in series to each other. These are respectively; Approach Channel, Curved Channel, Linear Outlet Channel, Side Weir Separation Wall, Collection Channel, Discharge Pool and Movable Level Measuring Trolley.

The experiments were carried out for side weirs with a length of L=25, 40 and 50 cm in a linear channel and a crest height of p=7, 12 and 17 cm from the sand bed. Detailed information about the experimental study can be obtained from the researcher's doctoral thesis.

In the studies of creating a model with the GEP method; There are 235 different data belonging to four independent variables (V_1/V_c, L/b, $(h_1-p)/h_1$, d_{50}/p) and one output data (H_d/p) obtained by measurement from the physical model. 80% of these 235 different data, that is 188 data, were used as training set, and the remaining 20% of 47 data were used as validation data. The test data is used to compare the calculations made by the program.

The GEP approach is an algorithm based on genetic programming (GP) and genetic algorithms (GA). Computer program is developed which is encoded in linear chromosomes in fixed length. The GEP approach is a research model that includes computer program as mathematical expression, decision tree, and logical expression [16]. There is a marked difference between GP and GEP approaches. In GP, individual is non-linear entities, introduced in different dimensions and shapes, as a parse trees; whereas the individuals in the GEP are also nonlinear entities in various dimensions and forms, also known as expression trees [7].

Chromosome and expression tree (ET) are the two main elements of GEP. Chromosomes can be composed of one or more germs that represent a mathematical expression. These genetic mathematical codes are specified in two different lines, the language of gene and expression tree (ET), which is called the Karva Language. GEP genes are consisting of two parts, the head and tail name. The head contains some mathematical operators, variables and constants.

In the creation of the GEP Model, the equation showing the independent variables affecting Scour depth is given below.

$$H_d / p = fonk\ (V_1 / V_c, L / b, (h_1 - p) / h_1, d_{50} / p) \tag{1}$$

The development of approaches GEP involves five steps, and the first step is the selection of the fitness function, f_i. For this problem, an individual program i suitability measured by the following expression:

$$f_i = \sum_{j=1}^{c_i} (M - |C_{(i,j)} - T_j|) \tag{2}$$

where M=selection interval; $C_{(i,\ j)}$ =value returned by the individual chromosome i for fitness case j; and T_j=target value for fitness case j. In the second stage, the terminals T_j set and function f group are selected to produce chromosomes. In the problem, the terminal set explicitly accounts for the independent variables, $H_d/p=f$ (V_1/Vc, L/b, (h_1-p)/h_1, d_{50}/p). Although the selection of the fitness function set is not so clear, a good prediction can be made to include all necessary functions. In this case, the four main operators (+, -, *, /) and some basic mathematical expressions (1/x, $x^{1/2}$, $x^{1/3}$, x^2, x^3) are utilized. Third stage is to structure the chromosome architecture, the head size and the number of genes. The fourth main step is to select the link function. Finally, the fifth big step is to choose the set of genetic operators that cause variations and proportions. Other details of the GEP modeling structure are expressed in the literature. This is a big step, chromosomal architecture, ie the head size and to choose the number of genes. After several attempts, the head size is 8 and the number of genes is 3 to get the best result for GEP models. The Linking function is selected as the multiplication function. Finally, a set of genetic operators have been used as a set of genetic operators.

In model studies, 4-variable and 3-variable variations were created and the results were observed. In the first model Model-1, all variables V/Vc, L/b, (h_1-p)/h_1, d_{50}/p were included in the calculations. V_1/V_c, (h_1-p)/h_1, d_{50}/p in Model-2, V_1/V_c, L/b, (h_1-p)/h_1 in Model-3 were calculated with 3 variables.

As a result of the calculations made in Model-1, R^2=0.864 and RMSE=0.145 for the training data, R^2=0.858 and RMSE=0.153 for the test data.

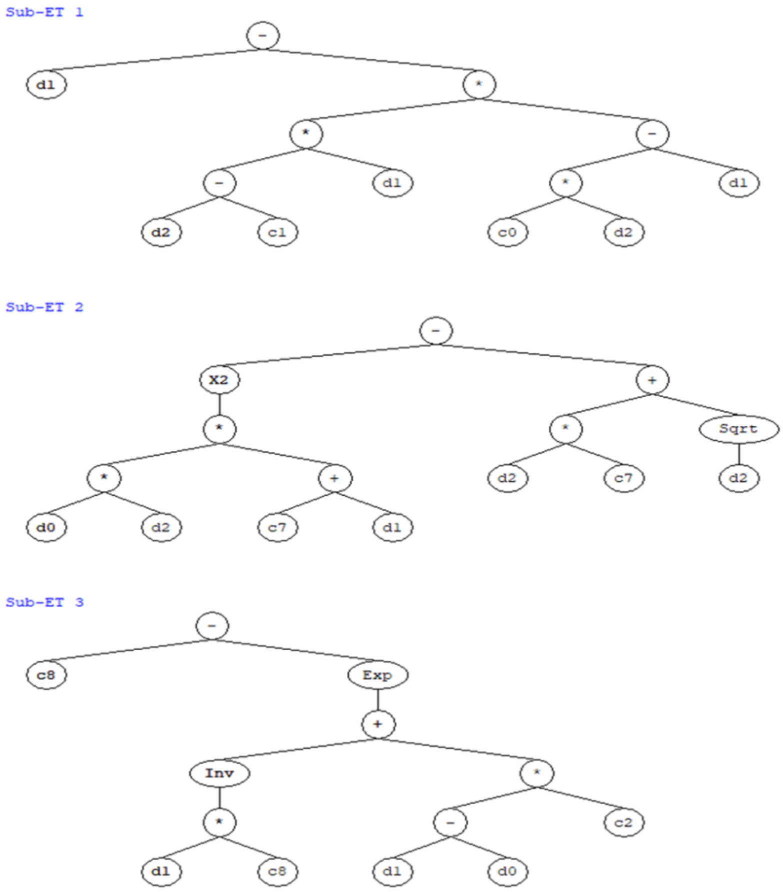
Expression Tree (ET) was obtained for Model-2 obtained by Genetic Expression Programming method. With this expression tree, the GEP formula was obtained. The resulting GEP formula is as follows.

$$\boldsymbol{Hd/p = \left((h_1 - p)/h_1 - \left(((h_1 - p)/h_1 * (d_{50}/p - 5.5)) * ((13.5 * d_{50}/p) - (h_1 - p)/h_1)\right)\right) * \left(((V1/V_c * d_{50}/p) * (10.2 + (h_1 - p)/h_1))^2 - \left((d_{50}/p * 10.2) + \sqrt{d_{50}/p}\right)\right) * \left(2.22 - e^{\left(((h_1-p)/h_1*2.2)^1 + (((h_1-p)/h_1 - V1/V_c)*7.3)\right)}\right)} \tag{3}$$

As a result of the calculations made in Model-2, R^2=0.903 and RMSE=0.123 for the training data, R^2=0.892 and RMSE=0.133 for the test data. When the R^2 and RMSE values obtained for Model-2 are examined, it will be clearly seen that the model is reliable and performs well.

As a result of the calculations made in Model-2, R^2=0.89 and RMSE=0.1303 for the training data, R^2=0.883 and RMSE=0.138 for the test data.

Figure 2. Expression Tree (ET) for Model-2



The number and type of independent variables used in the model differed in each model, with the output data H_d/p remaining constant. In this way, it has been determined how the number and type of variables affect the R^2 and RMSE, which determine the performance of the model.

As a result of the calculations made in Model-2, R^2=0.90 and RMSE=0.1231 for the training data, R^2=0.89 and RMSE=0.1333 for the test data. If the R^2 value of the training data is high and the RMSE value is low, it indicates that the model is working correctly. The partial difference in the R^2 and RMSE values of the test data is due to the number of data used while creating the model, and the closeness of the test and training data reveals that the model performs well.

IV. CONCLUSIONS

The aim of this study is to investigate the local scouring which is one of the main problems encountered in the design and operation phase of hydraulic structures in terms of live-bed and side weir, mathematically modeling and to reveal the usability, accuracy and performance of the models calculated by Genetic Expression Programming method.

In this study, while creating the models, independent dimensionless variables (V_1/Vc), (L/b), ($(h_1-p)/h_1$) and (d_{50}/p) were obtained. Formulations and expression trees of Model 1, Model 2 and Model 3 were obtained. As a result of the study, it was determined that the model showed a good performance by comparing the values calculated in the mathematical modeling with the values measured in the physical model. It has been demonstrated that the scour depths around the side weirs can be determined by using Genetic Expression Programming in alluvial rivers. When the R^2 and RMSE values were examined, the 3 and 4 variable models showed good performance in general. R^2=0.86 and RMSE=0.1452 for 4-variable Model-1 and R^2=0.90 and RMSE=0.1231 values for 3-variable Model-2 were obtained.

For a more widespread and accurate use of GEP modeling in hydraulic engineering, this study can also be applied to cohesive soils, curved channels and different types of weirs.

Conflict of interest

There is no conflict to disclose.

ACKNOWLEDGEMENT

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REFERENCES

[1]. Onen, F., Agaccioglu, H. 2013. Live bed scour at a side- weir intersection located on an alluvial channel. *Irrigation and Drainage*, *62*(4): 488-500.

[2]. Emiroğlu, M. E., Kaya, N.,Öztürk, M. 2007. Investigation of labyrinth side weir flow and scouring at the lateral intake region in a curved channel. *Engineering Science Research Grant Group,* TÜBİTAK Proje No: 104M394.

[3]. Onen, F., Agaçcioglu, H. 2007. Scour at a side-weir intersection located on an alluvial river. *Hydrology Research*, *38*(2):165-176.

[4]. Varol, F. A. 2015. Yan savak akımlarının etkisindeki kohezyonlu taban malzemesinin oyulma probleminin deneysel incelenmesi. Yüksek Lisans Tezi, YTÜ Fen Bilimleri Enstitüsü, İstanbul. 233.

[5]. Tunc, M., Emiroglu, M. E., 2017. Investigation of live-bed scour at labyrinth side weirs. Fırat University *Turkish Journal of Science & Technology,* 13(1): 129-136.

[6]. Agaccioglu H, Onen F. 2005. Clear-water scour at a side-weir intersection along the bend. Irrigation and Drainage 54(5): 553–569.

[7]. Ferreira C 2006, Gene expression programming: mathematical modeling by an artificial intelligence. 2nd Ed., Springer-Verlag, Germany

[8]. Bagatur T, Onen F 2014, A predictive model on air entrainment by plunging water jets using GEP and ANN. *KSCE* Journal of Civil Engineering, 18:304–314.

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