University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2023), Issue 4 (Winter), 1-12

EXTENDED ABSTRACT

Modeling and Predicting the Rate of Scour Depth below Pipelines Using Kernel-Based Methods for Steady Flows

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Received: 29 November 2021; **Accepted:** 21 Febrruary 2022

Keywords:
Scour depth, Pipelines, Steady flow, Kernel-Based Method, Gaussian process regression (GPR), Support vector machine (SVM).

1. Introduction

Pipelines are used all around the world to transport fluids from one location to another. When these pipelines meet rivers, seas and oceans pipes are laid on the solid bed and it causes changes in the flow pattern around the pipes. In result of these changes, the shear stress of bed under pipelines and turbulence of current will be increased, and scour will occur under pipelines and the scour hole will form and develop. These holes cause damage and failure to the pipe due to the pipe weight. In case of failure of the pipe, irreparable damages will incur to the environment and there will be huge financial costs. Therefore, it is very important to study the scour depth and effective variables to reduce scour and prevent damages. Researchers have conducted experimental and numerical studies on scour phenomenon and have provided relations over the years.

In this research the effect of various factors on this phenomenon in steady current are investigated using Gaussian process regression (GPR) and support vector machine (SVM) and it is compared with the previous presented relations. To this end several laboratory data were used and after defining several non-dimensional parameters the performance of these methods was evaluated. The result of this research demonstrated that these methods are better than experimental relations and have promising outcomes. This study have shown that an SVM model with h/D, D/d, Re and S_0 variables in steady current have the best results. It is worth mentioning that ^{h} and variables in steady current have the most significant effect on the scour below pipelines.

2. Support vector machine and Gaussian process regression

In addition to the importance of gathering reliable information, it is essential to use accurate methods to estimate scour depth. Therefore, in this study, two powerful methods of Gaussian process regression and support vector machine, which are among the soft computational, used to calculate the scour depth and study this phenomenon. How the SVM algorithms work is similar to most intelligent methods, by training and testing. The system is first trained by a portion of the data, then the problem solution for the test data is evaluated. SVM is able to move the problem to a more dimensional space, which is done by kernel methods. According to the circumstances and the problem different type of kernels can be chosen. In this study we used the RBF kernel which gave the best result among others. The Gaussian process can be considered as an infinite dimensional distribution of multivariate Gaussian. The regression process actually provides a possible non-parametric modeling method that is used to solve various engineering problems.

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The data of experiments in a rectangular flume and in a steady current, from two research conducted by Dey and Singh (2008), and Moncada et al. (1999) are used in this study.

3. Modeling and predicting the scour depth

According to the parameters measured in the experiments, non-dimensional parameters are defined and a combination of these criteria is introduced to estimate the scour depth, which can be expressed in the following relation.

$$\frac{S}{D} = f(h/D, D/d, Re, Fr, S_0, e/D) \tag{1}$$

Where S is the equilibrium depth of scour, D is the pipe diameter, h is the height of the flow, d is the diameter of bed material, Re is the Reynolds number, Fr is the Froude number, S_0 is bed longitudinal slope; and e is the initial distance between pipe and bed.

Numerous models were processed by SVM and GPR methods and R, NSE and RMSE coefficient were used to evaluate these models. The best results were obtained from a model with following parameters:

$$SF6 \qquad (h/D, D/d, Re, Fr, S_0) \tag{2}$$

Afterwards the obtained results were compared with results of 3 function presented by the previous researchers, and it is shown that better and more accurate results can be achieved utilizing methods introduced in this study. By selecting the SF6 model as a model that provided the best results, sensitivity analysis has been used to investigate the effect of different parameters in predicting the rate of scour depth under pipelines and to select the most effective parameter.

4. Conclusions

In this research, using experimental data in steady flow showed that the model with input parameters of h/D, D/d, Re and S0 with the values of RMSE=0.084, R=0.877 And NSE=0.767 is selected as the superior model and leads to more accurate results in estimating the scour depth below the pipelines than other models.

By performing sensitivity analysis on the superior model, it was observed that h/D and D/d parameters play an essential role in estimating the scour depth under pipelines under uniform flow. However, they alone cannot provide acceptable results for the study and prediction of that phenomenon. According to the comparison of the results obtained from these models, it can be concluded that the effect of Reynolds number on scour depth is more than the Froude number.

5. References

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