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Application of Improved GMDH Models to Predict Local Scour Depth at Complex Bridge Piers

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Abstract

Scour depth prediction is a vital issue in bridge pier design. Recently, good progress has been made in the development of artificial intelligence (AI) to predict scour depth around hydraulic structures base such as bridge piers. In this study, two hybrid intelligence models based on combination of group method of data handling (GMDH) with harmony search algorithm (HS) and shuffled complex evolution (SCE) have been developed to predict local scour depth around complex bridge piers using 82 laboratory data measured by authors and 615 data points from published literature. The results were compared to conventional GMDH models with two kinds of transfer functions called GMDH1 and GMDH2. Based upon the pile cap location, data points were divided into three categories. The performance of all utilized models was evaluated by statistical criteria of R, RMSE, MAPE, BIAS, and SI. Performances of developed models were evaluated by experimental data points collected in laboratory experiments, together with commonly empirical equations. The results showed that GMDH2SCE was the superior model in terms of all the statistical criteria in training when the pile cap was above the initial bed level and completely buried pile cap. For a partially-buried pile cap, GMDH1SCE offered the best performance. Among empirical equations, HEC-18 produced relatively good performances for different types of complex piers. This study recommends hybrid GMDH models, as powerful tools in complex bridge pier scour depth prediction.

Keywords: Scour Depth Prediction; Complex Bridge Pier; Artificial Intelligence Method; GMDH.

1. Introduction

Physical and economic considerations may lead to complex bridge pier design. Complex piers are commonly constructed of columns and pile caps which are founded on pile groups. Schematic view of complex pier is presented in Figure 1 in which L_c= column length; L_{pc}= pile cap length; b_c= column width; b_{pc}= pile cap width; b_{pg}= pile diameter; S_l= pile spacing in line with flow; S_b= pile spacing normal to the flow; L_u and L_f= extension of the pile cap upstream of and sides of the column, respectively; T= pile cap thickness; Y= pile cap top elevation to the initial bed level. This structure is embedded in the coastal and river environments. The interaction between these structures and their environments may lead to the scour process. Scouring could reduce the stability of these structures and they may collapse. By designing laboratory tests by authors, 82 experimental data points were measured experimentally [1]. Also 615 experimental data sets with the same measured experimental conditions were collected from published literature to evaluate the effects of geometric parameters on complex pier scour depth. Experiments were executed with six complex pier models to quantify the influence of the pile cap upstream extension, pile group arrangement, pile group upstream extension, and pile cap thickness. In these studies, authors tried to find the relationship between the upper limit of the

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