Evaluation of Harmony Search Optimization to Predict Local Scour Depth around Complex Bridge Piers

H. Ghodsi a, M. J. Khanjani a*, A. A. Beheshti b

a Department of Civil Engineering, Shahid Bahonar University of Kerman - 76169-133, Kerman, Iran.

b Department of Water Resources Engineering, Ferdowsi University of Mashhad - 9177948974, Mashhad, Iran.

Received 01 January 2018; Accepted 21 February 2018

Abstract

One of the main causes of bridge collapse may be flood flow scour near piers. Several experimental and local field investigations were carried out to study scour depth. However, existing empirical equations do not commonly provide accurate scour prediction due to the complexity of the scour process. Physical and economic considerations often lead to bridge foundation constructs which included a pier column based on a pile cap supported by an array of piles. Piers with this configuration are referred to as complex piers. A few studies have been done on complex bridge pier scour depth estimation. Such efforts may be classified into theoretical and empirical equations. This paper investigates local scour around complex bridge piers by using harmony search algorithm under clear water conditions. Statistical indices such as the coefficient of determination (R2), root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and bias were used to evaluate the performance of these methods. By designing laboratory tests, 82 experimental data points were measured by authors. Also 615 experimental data sets with the same measured experimental conditions were collected from published literature and used for optimization. The results show that the developed HS model can predict scour depth better than other equations according to statistical indices.

Keywords: Complex Bridge Piers; Local Scour; Empirical Formula; Laboratory Data; Scour Depth Estimation; Harmony Search (HS).

1. Introduction

The flow pattern around a bridge pier may be significantly changed, when a stream is partially obstructed by that. The pier produces an adverse pressure gradient, just upstream to the obstruction. Besides, pier upstream boundary layers may undergo three dimensional separations. The shear stress distribution around the pier drastically changes due to the formation of a horseshoe vortex, which makes a scour hole around the pier, which, in turn, changes the flow pattern and shear stress [1].

Local scour depth estimation around the bridge pier is a vital issue in the design of bridge piers. Various design methods and formula have been developed for estimating local scour depth in the vicinity of bridge piers. Scour depth studies started in the late 50s. Raudkivi [2] described the effects of flow and sediment parameters on the local scour around piers and discussed the functional trends of local scour based on laboratory data. Melville [3] investigated the effective parameters on the pier and abutment scour and presented empirical relations, called K-factors. Ettema et al. [4] discussed the generality of skew factors on scour geometry.

While a substantial amount of knowledge has been accumulated about the scour and flow structures around single piers over the past decade or so, comparatively little knowledge is available about the scour and flow field around pile groups and complex piers. Salim and Jones [5] studied the scour around submerged and un-submerged pile groups and...