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Discussion of “Neuro-fuzzy GMDH systems based evolutionary algorithms to predict scour pile groups in clear water conditions” by M. Najafzadeh

A.A. Beheshti [a,*], B. Ataie-Ashtiani [b]

[a] Water Resources Eng. Department, Ferdowsi University of Mashhad, P.O.Box 91775-1163, Mashhad, Iran
[b] Civil Engineering Department, Sharif University of Technology, P.O.Box 11155-9313, Tehran, Iran

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ABSTRACT

The author utilized neuro-fuzzy based group method of data handling (NF-GMDH) to predict the local scour depth around pile groups under clear-water conditions. They collected the datasets from literature. To predict the local scour by using NF-GMDH, nine dimensional parameters were considered to define a functional relationship between input and output variables. The results of NF- GMDH networks were compared with that of the empirical equations. However, the collected datasets for pile group scouring, the method of implementing the empirical formula to calculate scour depth, and using the equation of Sheppard et al. (2004) suggested for single pier to predict local scouring around pile groups merits this discussion. Here, we will establish that a part of applied data and also some of the implemented equations were not related to pile group scour. The empirical formulations were not employed correctly too and all the conclusions and results of the paper are disbelieving. Finally, we will discuss on the wide use of various artificial intelligent methods.

1. Experimental data set

The authors used the collected dataset from studies of Ataie-Ashtiani and Beheshti (2006); Ataie-Ashtiani et al. (2010), and Amini et al. (2012), consisting of 321 data. The data reported by Ataie-Ashtiani and Beheshti (2006) include 112 experiments on pile groups of uniform spacing (Sm=Sn) fully obstructing the flow (unsubmerged). The data of Ataie-Ashtiani et al. (2010) was reported for complex piers. Only 3 experiments can be considered as unsubmerged pile groups with uniform spacing, as the pile cap is out of water in these three cases. Amini et al. (2012) reported experimental results of scour measurements around pile groups with varying pile spacing and arrangements. In their study, Amini et al. (2012) conducted some experiments on submerged pile groups (a total of 33 experiments) as well as pile groups of non-uniform spacing (including 32 data). Only 40 experiments were conducted for unsubmerged pile groups with uniform spacing. The number of data reported in the literature used by the author (a sum of 220 from which 65 data related to submerged and non-uniform pile groups) is not consistent with the number (321 data) reported by the author. A part of applied data by the author are related to complex pier scour.

2. Comparison of results with empirical equations

The authors stated that the results are compared with two empirical equations given by Sheppard et al. (2004) and Ataie-Ashtiani and Beheshti (2006). The empirical equations of Sheppard et al. (2004) are presented for local scour prediction around single piles and these could not be used for pile groups. The method of Sheppard et al. (2004) is based on the following equations:

$$\frac{y_s}{D^*}=2.5 f_1\left(\frac{h}{D^*}\right) f_2\left(\frac{V}{V_c}\right) f_3\left(\frac{D^*}{d_{50}}\right)$$

$$f_1\left(\frac{h}{D^*}\right)=\tanh\left[\left(\frac{h}{D^*}\right)^{0.4}\right]$$

$$f_2\left(\frac{V}{V_c}\right)=1-1.75\left[\ln\left(\frac{V}{V_c}\right)\right]^2$$

* Corresponding author.
E-mail addresses: beheshti@ferdowsi.um.ac.ir (A.A. Beheshti), ataie@sharif.ir (B. Ataie-Ashtiani).

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$$f_3\left(\frac{D^*}{d_{50}}\right)=\frac{D^*/d_{50}}{0.4\left(\frac{D^*}{d_{50}}\right)^{1.2}+10.6\left(\frac{D^*}{d_{50}}\right)^{-0.13}}$$

Where y_s is the scour depth, h is the approach water depth, V is the depth averaged velocity, V_c = depth averaged velocity at threshold condition for sediment motion, D^* is the effective structure diameter, and d_{50} is the median sediment grain diameter.

Fig. 10 of the paper is very confusing, as the observed y_s is between about 2 cm and 25 cm, while the predicted values by the method of Ataie-Ashtiani and Beheshti (2006) are almost smaller than 5 cm. The method of Ataie-Ashtiani and Beheshti (2006) was implemented on data of Amini et al. (2012) by Beheshti et al. (2013) [see the Fig. 1 of Beheshti et al. (2013)]. Fig. 1 of this discussion compares the observed y_s of data used by the author on Fig. 10 (i.e. data from Ataie-Ashtiani and Beheshti, 2006; Ataie-Ashtiani et al., 2010; and Amini et al., 2012) and predicted y_s by using the method of Ataie-Ashtiani and Beheshti (2006). Moreover, Fig. 2 of this discussion shows this comparison based on dimensionless scour depth y_s/W_p ($W_p=nD$, n=number of piles normal to the flow, D=pile diameter) by using the methods of Ataie-Ashtiani and Beheshti (2006) [Fig. 2a], Amini et al. (2012) [Fig. 2c], and Eq. (1) of this discussion [Fig. 2b]. Eq. (1) presented in this comment is a correction factor for the scour depth calculated by the method of HEC-18:

$$K_{Smn}=0.8\left[\frac{m^{0.4}}{n^{0.95}(S/D)^{0.55}}\right]+0.4 \tag{1}$$

As seen in Fig. 1, the predicted y_s is between about 2 cm and 25 cm, similar to experimental data. Moreover, Fig. 2 shows that all predicted values limited to ±20% error lines. The results of Fig. 10 of the paper are inconsistent with the results obtained by all the previous studies (e.g. Ataie-Ashtiani and Beheshti, 2006; Zounemat-Kermani et al., 2009; Amini et al., 2012; and Beheshti et al., 2013). We believe that the author was not able to use the empirical methods correctly. Furthermore, it should be noted that the empirical methods are presented for uniform pile spacing, and one cannot take into account the effect of nonuniform pile spacing. In addition, the methods presented by Amini et al. (2012), and Beheshti et al. (2013) were not considered by the author. Finally, we claim that the results obtained from previous empirical equations and from Eq. (1) presented in this comment are more accurate than that of the NF_GMHD-PSO as presented in

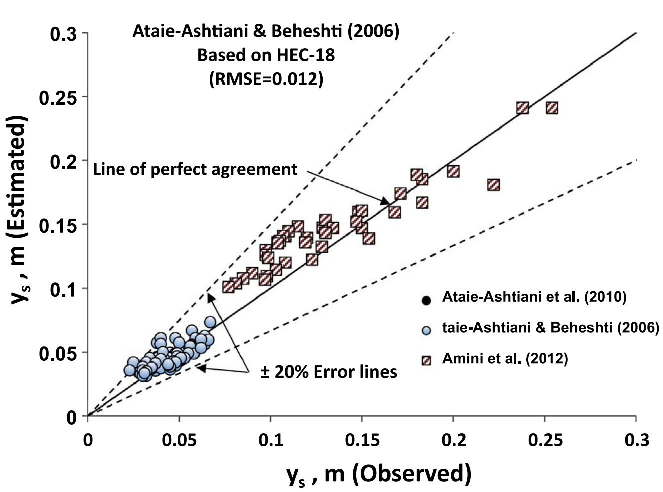

Fig. 1. Comparison of observed and predicted scour depth at unsubmerged pile groups tested by the author using the method presented by Ataie-Ashtiani and Beheshti (2006) based on HEC-18 procedure.

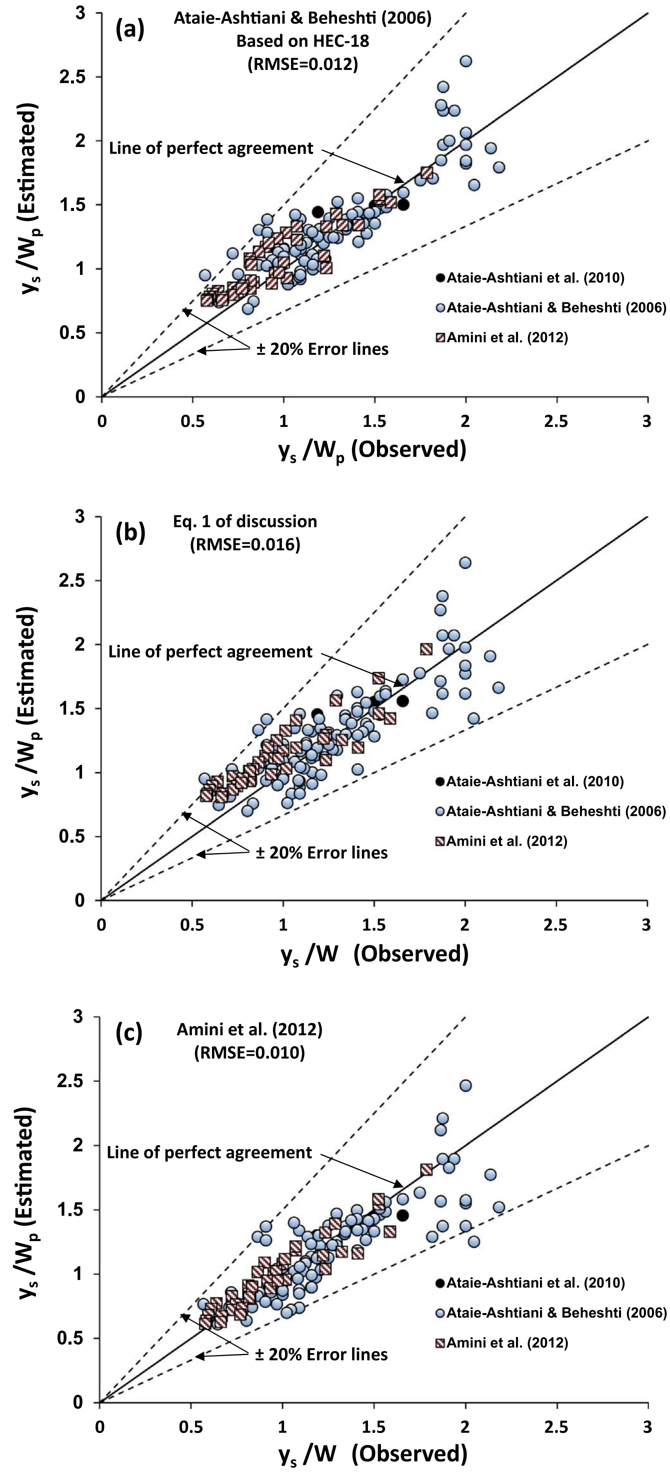

Fig. 2. Comparison of observed and predicted dimensionless scour depth (y_s/W_p) at pile groups tested by the author using: (a) method presented by Ataie-Ashtiani and Beheshti (2006) based on HEC-18 procedure, (b) Eq. (1) of discussion, and (c) Amini et al. (2012).

Figs. 9 and 10 of the paper in training stages and testing stages, respectively. Comparison of RMSEs in Figs. 1 and 2 of the comment and that obtained for NF_GMHD-PSO by the author verify this conclusion.

Herein the discussers aim to complement the analysis by using some new independent data and some existing data that were not considered by the writer. In Fig. 3 we compared the empirical equations of Ataie-Ashtiani and Beheshti (2006); Amini et al. (2012),

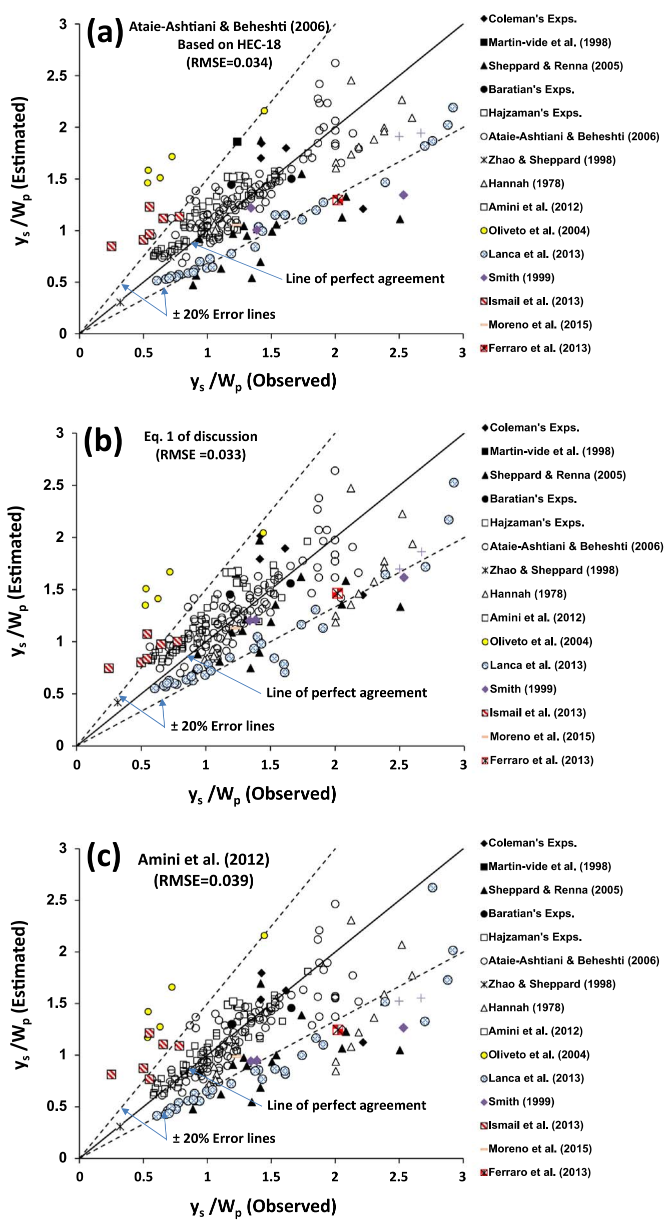

Fig. 3. Comparison of observed and predicted dimensionless scour depth (y_s/W_p) at pile groups reported by different researchers using empirical equations of (a) Ataie-Ashtiani and Beheshti (2006), (b) Eq. (1) of discussion, and (c) Amini et al. (2012).

and Eq. (1) of discussion based on the comprehensive data collected from literature. The root mean square errors (RMSE) are also presented in this figure. In Fig. 3, data for Coleman's experiments are reported by Sheppard and Renna (2005). Data for Baratian's experiments and Hajzaman's experiments are reported by Beheshti et al. (2013). Two data reported by Zhao and Sheppard (1998), 16 data reported by Hannah (1978), one data reported by Martin-Vide et al. (1998), 5 data reported by Oliveto et al. (2004), 3 data reported by Smith (1999), 2 data reported by Nouri Imamzadehei et al. (2013), 6 data reported by Ismail et al. (2013), one data reported by Moreno et al. (2015), and one data reported by Ferraro et al. (2013) are also used for comparison. Recently, Lança et al. (2013) conducted some long duration experiments under steady, clear-water close to the threshold for initiation of sediment motion, to address the effect of time, pile spacing, skew angle and number of pile group columns on the equilibrium scour depth. We used 30 data of this study including the experiments with a skew angle $\theta=0$ and 90° for comparisons in Fig. 3. All together 239 data for pile group scour depth are used in our study. We disagree with the author that his study covers the limitations of previous investigations, i.e. number of input parameters and restricted ranges of input and output parameters. The data used in this discussion is more than data examined by the authors (including the data of this paper and data from other studies). All of the data presented are used to evaluate Eq. (1) presented in this discussion having a RMSE=0.033, which is lower than that of the methods presented by the authors (NF-GMDH-pso-RMSE=0.035, and NF-GMDH-GSA-RMSE=0.036).

The comparison of results obtained by the author and results obtained by previous empirical equations as well as approaches based on neural network and adaptive neuro-fuzzy inference systems (see Zounemat-Kermani et al., 2009) indicate that the advantages of using one method over another are minor. It should be considered that empirical equations were based on the experimental data that was compiled to the publication date of the papers. By inclusion of the recent data and adjustment of the coefficients (as in the Eq. (1) of this discussion), the accuracy of the estimate might further be improved. For more discussion on Figs. 9 and 10 of the paper, it is noteworthy that the comparison of Figs. 9 and 10 of the paper shows the error of NF-GMDH method at training stage is higher than that of the testing stage. Fig. 9 of the paper is confusing as five data group reported in this figure each containing some data points that have the same observed scour depth (y_s) and different predicted scour depths. The inspection of the reported data by previous studies (i.e. Ataie-Ashtiani and Beheshti, 2006; Ataie-Ashtiani et al., 2010; and Amini et al., 2012) do not show such a trend.

In summary, in this discussion, we showed that data, method and results presented by the author are very distrustful, in particular the claim about the advantage of the method used over the other available empirical formulations.

Artificial Intelligence methods are very powerful and valuable tools and their extensive applications for enormous and versatile engineering problems prove their capabilities. However, we believe their wide applications for just the sake of publications and without providing any new insight into the physical problems or improving the methods, is an issue that shall be inspected to prevent producing pseudo-science rather than genuine science.

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