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Hybrid intelligent model for approximating unconfined compressive strength of cement-based bricks with odd-valued array of peat content (0–29%)

Shahaboddin Shamshirband [a,*], Amirmohammad Tavakkoli [b], Chandra Bhushan Roy [c], Shervin Motamedi [c,d,**], Song KI-IL [e], Roslan Hashim [c,d], Syed Mofachirul Islam [c]

[a] Department of Computer System and Information Technology, Faculty of Computer Science and Information Technology, University of Malaya, 50603, Kuala Lumpur, Malaysia
[b] Department of Information Technology Engineering, Faculty of Technology and Engineering, University of Qom, Qom, Iran
[c] Department of Civil Engineering, Faculty of Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia
[d] Institute of Ocean and Earth Sciences, University of Malaya, 50603, Kuala Lumpur, Malaysia
[e] Department of Civil Engineering, Inha University, 100 Inha-ro, Nam-gu, Incheon 402-751, South Korea

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ABSTRACT

This article presents an innovative approach to estimate the unconfined compressive strength (UCS) of peat-enhanced bricks using a hybrid intelligent system (HIS) resulting from integration of support vector regression (SVR) and Bat meta-heuristic algorithm (hereafter, Bat–SVR). First, peat-enhanced brick specimens were prepared for various compositions of cement, sand, and peat (odd-valued array of peat inclusion in the range of 0–29% from the total specimens' weight). Further, the experimental works were carried out to obtain the UCS of specimens in different curing period. Finally, HIS model was used to predict the UCS of cement–peat–soil mixture. Basically, we used a newly-developed Bat algorithm for tuning the SVR parameters, because the accuracy of SVR estimation highly relies on these parameters. Results from the experimental study were used to train and estimate the UCS of peat-enhanced bricks. In addition, we compared the accuracy of the developed HIS model to other conventional soft computing techniques (i.e., ANFIS and neural network). It was found that the proposed approach outperforms the other conventional prediction models and better estimates the UCS of peat-enhanced bricks.

1. Introduction

Organic in nature, peat soil shows different mechanical properties in comparison to inorganic soil [5, 14]. Peat soil can be found in many geographical locations across the world [9]. High water content in peat soil makes it highly compressible. Also, low mechanical strength and longer consolidation time of peat make it unfit for construction works [15, 39].

In recent years, there has been an increasing trend in utilization of sustainable construction materials in industry [12, 19, 22]. This is because such materials provide better energy efficiency [41]. Peat soil is one such alternative material that reduces production cost and energy usage [18].

Geotechnical engineers consider peat as a problematic soil. Weak geotechnical properties of peat soil due to presence of organic matters may potentially lead to local sinking, slip failures and long-term settlement [14, 20, 24, 36, 42]. Nevertheless, untreated peat soil is unsuitable for construction as it has low bearing capacity and high compressibility [6, 33]. Therefore, it is important to improve the characteristics of peat soil using different binding agents. In this view, previous geotechnical studies such as those conducted by Tremblay et al. [38] and Rotta et al. [35] reported that suitable binders can enhance the material properties of peat soil.

Many studies can be found on improvement of inorganic soil using different binding agents [1, 25, 34]. However, studies on the improvement of unconfined compressive strength (UCS) of peat soil using binding agents are scarce. In one of these rare studies, for example, Wong et al. [40] improved the UCS of peat soil using two types of binder, namely slag (25% of total mixture weight), cement (25% of total mixture weight) and peat (50% of total mixture weight). Their results show that the UCS of the specimen increased from 142.5 kPa to 178.6 kPa. In another study, Huat et al. [16] investigated influence of cement content on peat soil through a series of unconfined compression test (UCT). Their result showed that UCS of the peat–cement mixture increases with increasing cement content.

Soft computing methods are alternatives to the traditional testing techniques in the field of engineering, such as fuzzy logic, artificial

* Correspondence to: S. Shamshirband, Department of Computer System and Information Technology, Faculty of Computer Science and Information technology University of Malaya, 50603, Kuala Lumpur, Malaysia. Tel.: +60146266763.
** Correspondence to: S. Motamedi, Institute of Ocean and Earth Sciences (IOES), University of Malaya, 50603, Kuala Lumpur, Malaysia. Tel.: +60379675271.
E-mail addresses: shahab1396@gmail.com (S. Shamshirband), shervin.motamedi@gmail.com (S. Motamedi).

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neural networks (ANNs) and genetic algorithm (GA) [10, 21, 32, 36]. Researchers use soft computing methods to solve and forecast complex engineering problems [8, 17, 27–30]. However, limited studies have used hybrid techniques to study structural properties of construction material. For example, Güllü [11] estimated the strength of basalts using a hybrid computing approach, which comprised of ANN and Gene Expression programming (GEP). A soft computing technique (ANFIS) was used by Motamedi et al. [27] to estimate the UCS of cockle shell-cement and sand mixture. In a separate work, Motamedi et al. [28] used ANFIS method for predicting the UCS of PFA–cement–sand mixtures and found satisfactory agreement between the results of experiment and simulation. Similarly, Madandoust et al. [23] estimated the compressive strength of concrete using the evolutionary algorithm (EA). Their results showed that the developed GMDH-type neural network, which is a group method for data handling, could accurately estimate compressive strength of concrete.

In the literature review, we found that Bat algorithm (BA) performs better than other counter parts, such as particle swarm optimization (PSO), simulated annealing (SA), and GA [37]. Developed by Yang [42], it is a combination of other meta-heuristics methods. In the subsequent sections, this article elaborates on evaluation of the UCS of enhanced-peat bricks by incorporating BA for setting the SVR parameters. Until now, to the authors' best of knowledge, no similar study has used Bat–SVR combination to explore properties of construction materials.

This study proposes an innovative method for estimating the UCS of peat-enhanced material. First, a set of peat-enhanced bricks was prepared considering that peat content (%) was odd-valued array in the range between 0 and 29% of total weight of samples. Later, a series of UCT tests was conducted to obtain UCS of the samples. Then, the Bat–SVR model was used to estimate the UCS of the mixtures. Input parameters comprised of peat inclusion (%), sand content (%), cement content (%) and curing period (days). The results from the simulation and experiments were subjected to statistical analysis to prove accuracy of the developed prediction model. Further, we conducted a comparative study between the ANFIS, ANN and Bat–SVR model for predicting UCS of the peat-enhanced bricks. The results of this study can be beneficial for future research to determine the UCS of enhanced-peat bricks.

2. Experimental methods and program

This study used an experimental method and a hybrid intelligent system (Bat–SVR) to predict UCS of the peat–cement–sand mixture (Fig. 1). Further, it evaluated the performance of soft computing methods in order to analyze the peat–cement–sand based mixture. Here, we present the experimental setup and later in Section 3, we discuss the proposed Bat–SVR model.

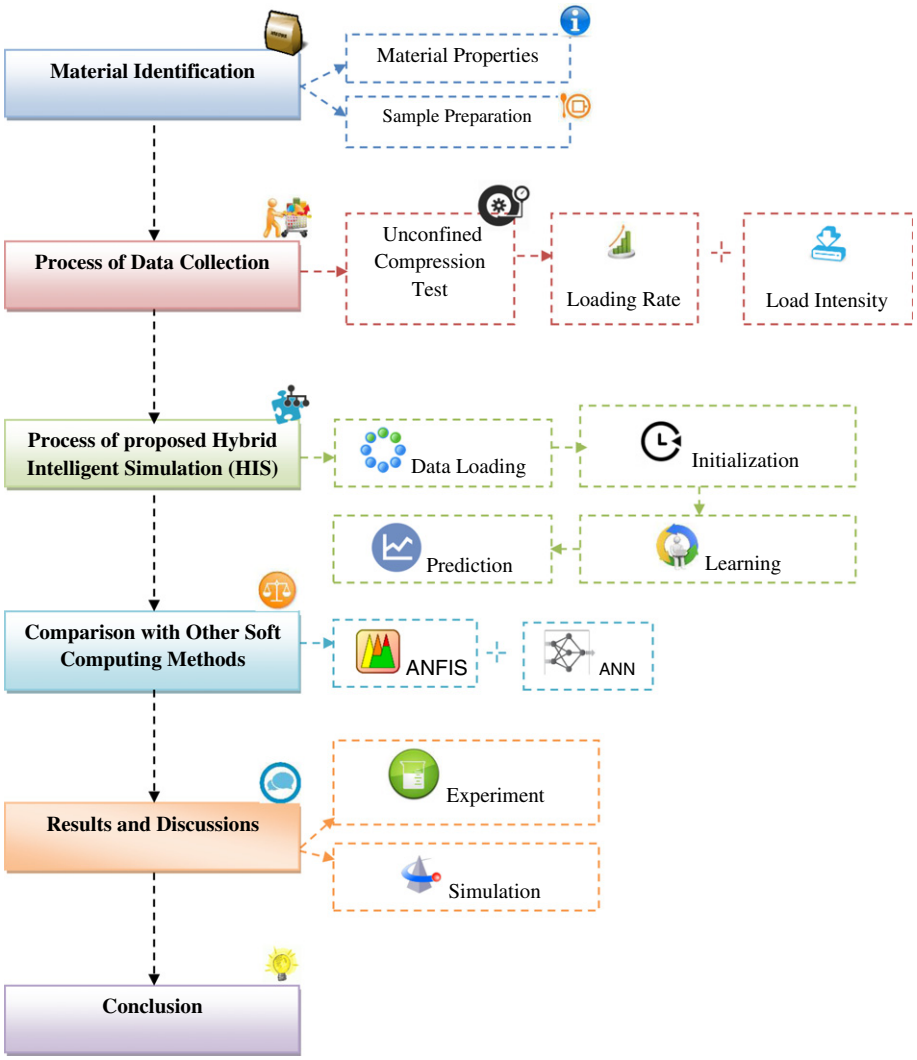

Fig. 1. Flow of research works in this study.