Liquefaction Potential Assessment Using Fuzzy c-Means Clustering - Artificial Neural Network Hybrid Method (FCM-ANN)

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There are various empirical and intelligent methods to evaluate the liquefaction potential. Although the artificial neural network (ANN) method is one of the most powerful methods that is introduced in liquefaction assessment recently, a new hybrid intelligent system of fuzzy c-means clustering and artificial neural network (FCM-ANN) is examined in this article to overcome the complexity of soil behavior. Fuzzy c-means clustering method refines the patterns used for training neural network, and the entry of inappropriate patterns in training will be prevented. This clustering is performed on the standard penetration test measurements $(N_1)_{60cs}$ and cyclic stress ratio (CSR). In this article, a database of 600 field studies of liquefaction in past earthquakes is used that contains 274 liquefied and 326 non-liquefied cases. The distribution of these 600 studies is presented in Figure (1).

In order to compare the two methods of ANN and FCM-ANN, one ANN and four FCM-ANN models are analyzed (Table 1). All models in these two methods are similar in configuration but different in tolerance semblance values and the number of clusters. Figure (2) presents the results of the various models to assess the

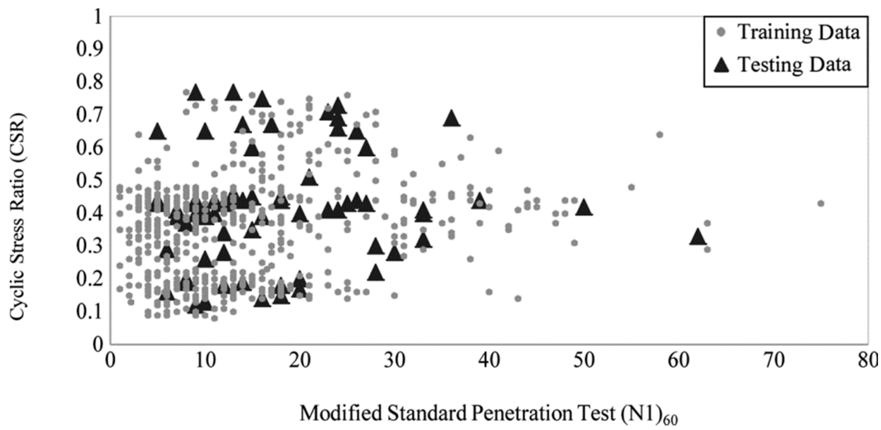

Figure 1. Training and testing data based on standard penetration test modified to fines and cyclic stress ratio.

Table 1. Models used in this article to compare the two methods of ANN and FCM-ANN

	Model	Input Parameters	Number of Input Parameters	Number of Hidden Neurons	Number of Epoch	Learning Rate	Transfer Function	Tolerance Semblance	Number of Clusters
ANN	M1	z,σv.,σ'v.,CSR,mw , (N1)60,FC,amax	8	7	30000	0.01	tgh(x)	-	-
ANN-FCM	M100	z,σv.,σ'v.,CSR,mw , (N1)60,FC,amax	8	7	30000	0.01	tgh(x)	90	40
	M10	z,σv.,σ'v.,CSR,mw , (N1)60,FC,amax	8	7	30000	0.01	tgh(x)	80	40
	M11	z,σv.,σ'v.,CSR,mw , (N1)60,FC,amax	8	7	30000	0.01	tgh(x)	70	40
	M12	z,σv.,σ'v.,CSR,mw , (N1)60,FC,amax	8	7	30000	0.01	tgh(x)	60	40

liquefaction potential in terms of successful liquefaction prediction. As seen in Figure (2), M100 and M10 models reached 100 percent successful prediction. This is while the M1 achieved about 82 percent. Thus an 18% improvement is observed by using new method to evaluate liquefaction potential.

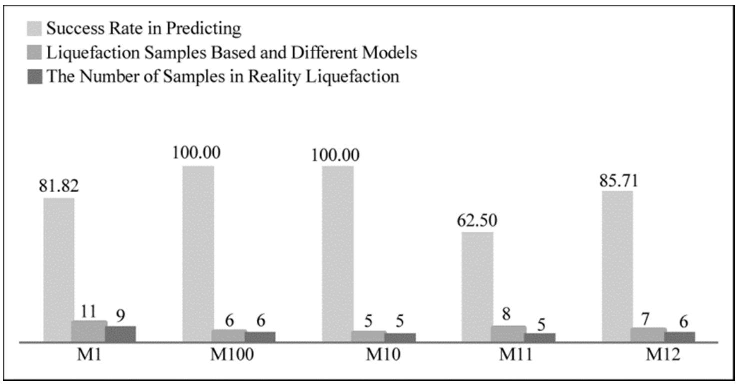

Figure 2. The results of the different models in the evaluation of liquefaction potential.

Besides, an advanced software system for the analysis of ANN and FCM-ANN methods was designed by the authors in Language C# with Microsoft Visual Studio 2012 and the SQL Server 2012 database entitled PILA (Professional Intelligent Liquefaction Assessment).

Keywords: Liquefaction Potential; Fuzzy C-Means Clustering; Artificial Neural Network; Standard Penetration Test