University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2023), Issue 4 (Winter), 75-89

EXTENDED ABSTRACT

Prediction of the Mechanical Properties of Lightweight Basalt Fiber Reinforced Concrete Containing Silica Fume and Fly Ash with an Adaptive Neuro-fuzzy inference system (AFNIS)

S. Hosein Ghasemzadeh Mousavinejad [a,*], Farzad Johari Majd [b], Ashkan Saradar [a]

[a] *Department of Civil Engineering, Faculty of Engineering, University of Guilan, Rasht, Iran*
[b] *Kadous Institute of Higher Education, Rasht, Iran*

Received: 07 April 2020; **Accepted:** 15 June 2021

Keywords:
Adaptive neuro-fuzzy inference system, Basalt fiber, Fly ash, Lightweight concrete, Mechanical properties, Silica fume.

1. Introduction

Most studies show that some certain fiber can enhance to some extent both mechanical properties as well as ductility of lightweight concrete. On the other hand, due to high industrial potential as well as less damage to the environment, basalt fibers have gradually become an appropriate option to be used in the composite industries and thus is considered as a special competitor to other fibers (Ralegaonkar et al., 2018; Sadrmomtazi et al., 2018). In recent years, there has been a growing interest in the use of the intelligent inference and reasoning methods, including ANFIS and ANN to approximate nonlinear and complex concrete behaviors and predict its properties (Tesfamariam and Najjaran, 2007; Sadrmomtazi et al., 2013). Therefore, this study aimed to investigate mechanical properties of the lightweight structural concrete containing different amounts of basalt fibers (0, 0.1, 0.2, 0.3, 0.4, and 0.5%) as well as pozzolanic materials (silica fume and fly ash). In addition, the modified ANFIS was used as a robust method to predict results to evaluate the experimental results.

2. Laboratory plan

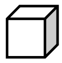
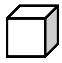
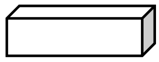
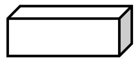
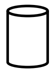
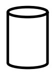
Materials used in this study included Portland cement Type 2, LECA coarse grains with 11% 24-hour water absorption, fine grains of the washed river sand with a density of 2.56 and maximum diameter of 4.75mm, superplasticizer, silica fume and fly ash as a substitute for part of cement weight, and basalt fibers with a length of 12mm.

The mixtures were divided into four different groups in order to achieve the objectives of the study. Group 1: Nonpozzolanic mixtures (OPC), Group 2: Mixtures containing fly ash (FA), Group 3: Mixtures containing silica fume (SF), and Group 4: Mixtures containing both pozzolans (FA+SF). Then, 0, 0.1, 0.2, 0.3, 0.4, and 0.5% of the basalt fibers were added to each of the groups.

After fabrication and curing of the specimens to the intended age, experiments on the specimens were performed according to Table 1.

* Corresponding Author
E-mail addresses: h.mosavi@guilan.ac.ir (S. Hosein Ghasemzadeh Mousavinejad), farzad.johari1985@gmail.com (Farzad Johari Majd), ashkan.saradar@gmail.com (Ashkan Saradar)

Table 1. Experiments

Test	Curing	Sample size (mm)	Sample shape
Compressive strength	7, 28 & 90 days	150 × 150 × 150	
Water absorption	28 & 90 days	150 × 150 × 150	
Flexural strength	28 days	100 × 100 × 350	
Shrinkage	7, 28 & 90 days	70 × 70 × 280	
Indirect tensile strength	28 days	H=300, D=150	
The modulus of elasticity	28 days	H=300, D=150	

3. Results and discussion

The results of the study demonstrated that the presence of basalt fibers had minor effect on compressive strength. On the other hand, the presence of pozzolans such as fly ash and silica fume increased the compressive strength respectively by 11 and 29% in comparison to the non-fiber mixtures. According to Fig. 1 and 2, the presence of basalt fibers in the lightweight concrete increased tensile and flexural strength. Moreover, in the series of OPC, FA, and SF concrete mixtures, tensile strength increased by 52, 50, and 49% and flexural strength by 49, 55, and 62%, respectively. However, the presence of fibers decreased the shrinkage of the lightweight concrete specimens so that adding fibers up to 0.5% vol reduced shrinkage in the mixtures of OPC group by 21, 19, and 20%, respectively at 7, 28, and 90 days. In addition, shrinkage in the mixtures of FA group respectively reduced by 27, 28, and 21% at 7, 28, and 90 days by 25, 26, and 20% for the mixtures of SF group.

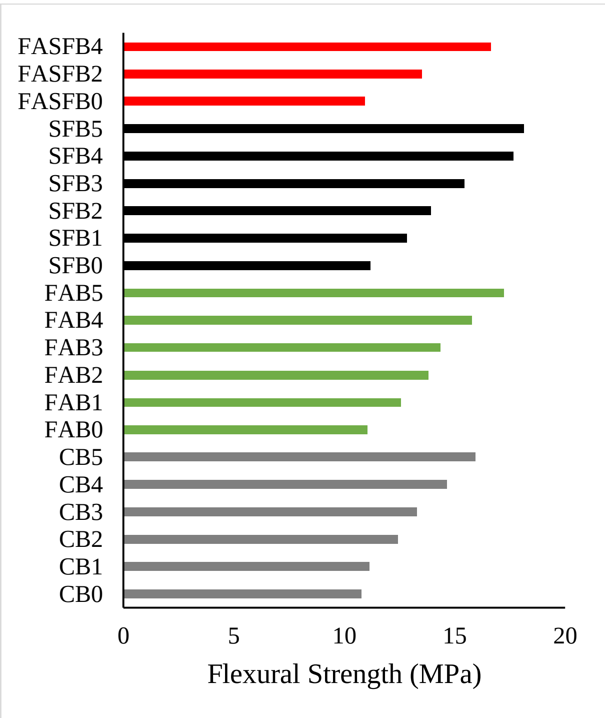


Fig. 1. Results of flexural strength of lightweight concrete mixtures

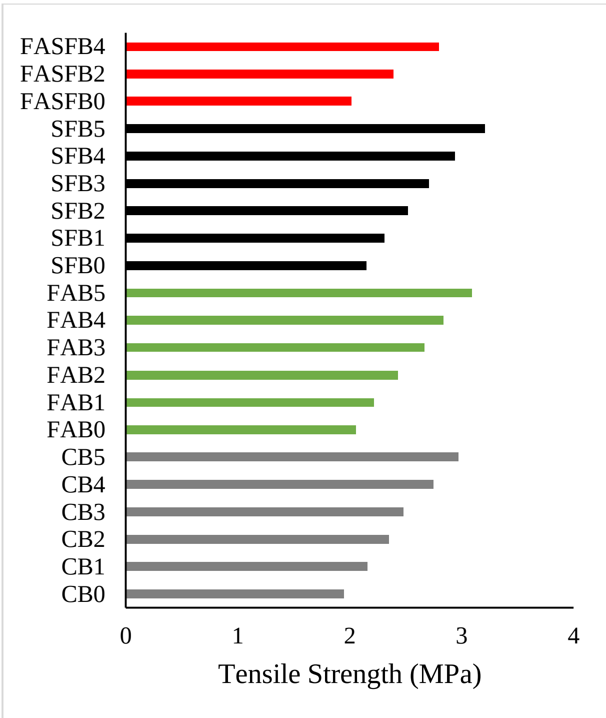


Fig. 2. The tensile strength results of lightweight concrete mixtures

Therefore, a hybrid optimization method with 20 courses was used to achieve the best results from ANFIS model with the epochs in the process of training and data testing. The number of courses for each FIS model was not constant and was determined by trial and error. Fig. 1 depicts a very good correlation between experimental results and the estimated results for compressive strength of the concrete.

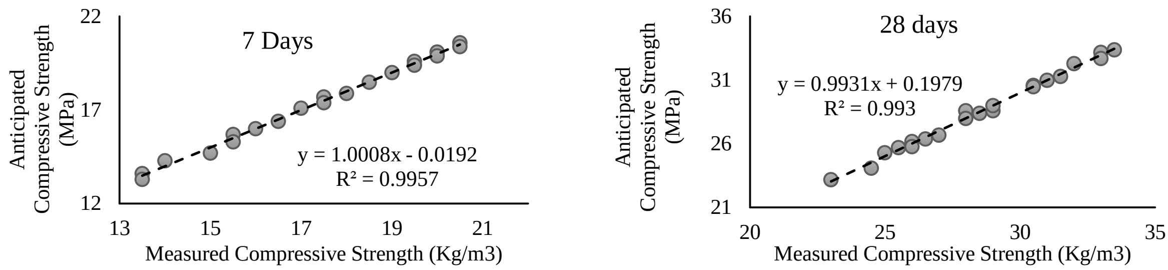


Fig. 3. Prediction of compressive strength (7 and 28 days) of the lightweight concrete with ANFIS against the experimental results

4. Conclusions

The use of pozzolans such as fly ash and silica fume improved compressive strength in comparison to the non-pozzolanic specimens. Moreover, shrinkage reduced by 23% and 29% for mixtures containing silica fume and fly ash, respectively. Addition of the basalt fibers to the lightweight concrete increased the tensile and flexural strength. Although the use of fibers reduced compressive strength, all the developed designs were within the category of lightweight concrete. Evaluation of the results through ANFIS analysis indicated acceptable results, reflecting the high accuracy of the model with less than 2% accuracy compared to the experimental results.

5. References

Ralegaonkar R, Gavali H, Aswath P, Abolmaali S, “Application of chopped basalt fibers in reinforced mortar: A rewiw”, Construction and Building Materials, 2018, 164, 589-602.

Sadrmomtazi A, Sobhani J, Mirgozar MA, “Modeling compressive strength of EPS lightweight concrete using regression, neural network and ANFIS”, Construction and Building Materials, 2013, 42, 205-216.

Sadrmomtazi A, Tahmouresi B, Saradar A, “Effects of silica fume on mechanical strength and microstructure of basalt fiber reinforced cementitious composites (BFRCC)”, Construction and Building Materials, 2018, 162, 321-333.

Tesfamariam S, Najjaran H, “Adaptive network-fuzzy inferencing to estimate concrete strength using mix design”, Journal of Materials in Civil Engineering, 2007, 19 (7), 550-560.