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Usability of Fuzzy Logic Modeling for Prediction of Fresh Properties of Self-Compacting Concrete

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The aim of this study is to investigate the usability of fuzzy logic modelling for prediction of fresh properties of self-compacting concrete. In the modelling process, the percentage of fly ash and the percentage of granulated blast furnace slag, as replacement of cement, the percentage of micronized calcite, as replacement of total aggregate, were used as inputs. The slump flow diameter and time and also the V-funnel time were used as outputs. Results show that fuzzy logic modelling may be a useful approach to predict fresh properties of self-compacting concrete, containing fly ash, granulated blast furnace slag and micronized calcite.

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1. Introduction

Concrete is one of the most widely used construction materials. Concrete engineers work continuously to improve the technological properties of the concretes. Nowadays, interdisciplinary studies on concretes have become more and more popular. Joint studies of physicists and civil engineers, to develop concrete for radiation shielding applications, can be given as a very important and specific example [1–3]. As a result of the studies performed by civil engineers, many special concrete types have emerged. One of the most popular special concrete types is the self-compacting concrete (SCC). Self-compacting concrete has little resistance to flow, and thus, it can be placed and compacted under its own weight, with no vibration effort [4].

Industrial byproducts, such as fly ash, slag, and granulated blast furnace slag, are being used as supplementary cementing materials, to reduce the environmental pollution. Besides, industrial byproduct materials are important for reducing the cost of SCC [4, 5].

Nowadays, artificial intelligence methods are much more popular in engineering sciences [6, 7]. Fuzzy logic (FL) concept, an artificial intelligence method, was introduced by Zadeh [8]. FL modelling provides good solutions for controlling of the ambiguous, time-varying, complex and ill-defined systems, encountered in the daily life [9].

Recently, fuzzy logic has been extensively used in the fields of civil engineering applications and there are many studies available in the literature, in which different properties of concrete are modeled using fuzzy logic [10, 11].

In this study, it was aimed to investigate the usability of FL modeling for prediction of fresh properties of SCCs.

2. Fuzzy logic modeling, details and findings

Mamdani-type FL models were developed for prediction of fresh properties of SCCs, containing fly ash (FA) and granulated blast furnace slag (GBFS), as replacement of cement, and micronized calcite (MC), as replacement of total aggregate.

Experimentally obtained results (results of the study are given in Ref. 4) of fresh state properties of SCCs were used to develop FL models. The fresh state properties of SCCs, used as output parameters for developing the models in this study, were slump flow diameter (SFD), slump flow time to spreading to 500 mm diameter (T500) and V-funnel flow time (VFT).

Two models were developed in MATLAB FL toolbox. One of the models was developed using GBFS (20%, 40% and 60%) and MC (5% and 10%) as inputs, while the other model was developed by using FA (20%, 40% and 60%) and MC (5% and 10%) as inputs. General structures of the models are given in Fig. 1.

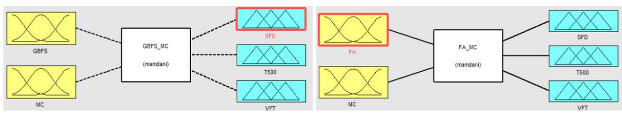

Fig. 1. General structure of the developed FL models.

Fresh state parameters of SCCs, as functions of inputs, according to the rules, formed in the developed FL models, are given in Fig. 2.

To obtain crisp output values (fresh state properties) of the models, defuzzification was performed by centroid of area method. As the last step of the modelling process, crisp results of the model were obtained from the defuzzification interface of FL toolbox. Findings of experimental and FL models are given in Tables I and II.

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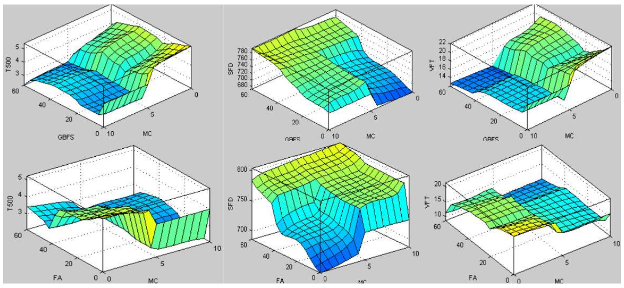

Fig. 2. SFD, T500 and VFT parameters of SCCs as functions of GBFS, FA and MC.

TABLE I

Experimental and FL modeling results of SCCs containing GBFS and MC.

Input parameters		Experimental and FL modeling results					
GBFS	MC	SFD	SFD-FL	T500	T500-FL	VFT	VFT-FL
0	0	653	675	5.95	5.45	24	22.3
20	0	719	702	4.40	4.24	17.6	16.9
20	5	747	752	2.96	2.82	13.6	13.5
20	10	735	732	2.98	3.01	14.33	15.2
40	0	743	742	4.40	4.91	18,9	20.2
40	5	767	762	3.10	3.09	13.3	13.1
40	10	787	784	3.20	3.42	13.6	13.7
60	0	773	776	3.96	3.85	13.3	13.4
60	5	798	797	2.52	2.55	11.74	12.1
60	10	793	793	2.18	2.28	12.85	12.6
		$R^2 = 0.9531$		$R^2 = 0.9467$		$R^2 = 0.9557$	

TABLE II

Experimental and FL modeling results of SCCs containing FA and MC.

Input parameters		Experimental and FL modeling results					
FA	MC	SFD	SFD-FL	T500	T500-FL	VFT	VFT-FL
0	0	653	686	5.95	5.22	24	21.4
20	0	753	721	3.80	4.42	14.28	14.3
20	5	765	767	2.50	2.48	14.6	15
20	10	788	789	2.06	2.11	12.65	12.6
40	0	757	758	2.30	2.32	16	18.2
40	5	780	777	2.50	2.67	14	13.9
40	10	793	792	3.00	3	13.41	13.4
60	0	787	785	3.50	3.43	11.75	11.2
60	5	794	799	2.43	2.41	8.54	8.72
60	10	811	806	2.24	2.2	9.23	9.84
		$R^2 = 0.8838$		$R^2 = 0.9283$		$R^2 = 0.9301$	

3. Conclusions

In this paper, two FL models were developed by using FL Toolbox in MATLAB. Fresh state properties of SCCs containing GBFS, FA and MC were predicted by these models. When the values of the coefficient of determination R^2 are evaluated, it can be concluded that FL modeling may be used to predict the fresh state properties of SCCs, such as slump flow diameter, slump flow time to spread of 500 mm in diameter and V-funnel flow time.

References

[1] Ş. Kılınçarslan, B. Akyol, *Acta Phys. Pol. A* **130**, 441 (2016).

[2] İ. Akkurt, K. Günoğlu, C. Başyiğit, Ş. Kılınçarslan, A. Akkaş, *Acta Phys. Pol. A* **123**, 341 (2013).

[3] İ. Akkurt, C. Başyiğit, A. Akkaş, Ş. Kılınçarslan, B. Mavi, K. Günoğlu, *Acta Phys. Pol. A* **121**, 138 (2012).

[4] A. Beycioğlu, H.Y. Aruntaş, *Construct. Build. Mater.* **73**, 626 (2014).

[5] V. Fugaru, S. Bercea, C. Postolache, S. Manea, A. Moanta, I. Petre, M. Gheorghe, *Acta Phys. Pol. A* **127**, 1427 (2015).

[6] C. Başyiğit, İ. Akkurt, Ş. Kılınçarslan, A. Beycioğlu, *Neural Comput. Applicat.* **19**, 507 (2010).

[7] A. Beycioğlu, M. Emiroğlu, S. Subaşı, Y. Koçak, *Comput. Concrete* **15**, 89 (2015).

[8] L.A. Zadeh, *Informat. Control* **8**, 338 (1965).

[9] U.N. Baykan, M. Erdal, L.O. Ugur, *Romanian J. Mater.* **47**, 54 (2017).

[10] A. Beycioğlu, C. Başyiğit, *Acta Phys. Pol. A* **128**, B-424 (2015).

[11] İ. Akkurt, C. Başyiğit, Ş. Kılınçarslan, A. Beycioğlu, *J. Franklin Instit.* **347**, 1589 (2010).