Fresh properties of the self-compacting high-performance concrete using recycled concrete aggregate

Mohammed ABED

Civil engineer (MSc), PhD candidate at the Department of Construction Materials and Technologies, Budapest University of Technology and Economics. Main fields of interests: recycled concrete aggregate, non-destructive testing of concrete, high performance concrete, supplementary cementations materials, fire resistance, self-compacting concrete. Member of the Hungarian Group of fib and the Scientific Society of Silicate Industry.

Rita NEMES

Civil engineer (MSc), postgraduate degree in concrete technology, PhD, associate professor at the Department of Construction Materials and Technologies, Budapest University of Technology and Economics. Main fields of interest: concrete technology, ceramics, non-destructive testing of concrete, supplementary cementing materials for concrete, bond in concrete, fibre reinforced concrete, lightweight concrete, shrinkage of concrete, durability measurement, waste materials as aggregates. Member of the Hungarian Group of fib and the Scientific Society of Silicate Industry.

MOHAMMED ABED ▪ Department of Construction Materials and Technologies, Budapest University of Technology and Economics, Hungary ▪ abed.mohammed@epito.bme.hu

RITA NEMES ▪ Department of Construction Materials and Technologies, Budapest University of Technology and Economics, Hungary ▪ nemes.rita@epito.bme.hu

Érkezett: 2018. 10. 06. ▪ Received: 06. 10. 2018. ▪ <https://doi.org/10.14382/epitoanyag-jsbcm.2019.4>

Abstract

The present study is investigating the fresh properties of the self-compacting high-performance concrete (SCHPC) using recycled concrete aggregate and waste powder materials. Twenty-one mixtures with the same water to binder ration have been tested for both slump flow and V-funnel tests. Their results shows that using recycled concrete aggregate (RCA) up to 50% is not affecting the workability of SCHPC if the water absorption of RCA is compensated, however, waste powder materials are affecting the fresh properties negatively and demanded higher dosage of chemical admixture. Their effect differentiates depending on the grading and particles properties of the waste powder material. The workability results of SCHPC using recycled aggregate and waste powder materials are satisfying the workability process of normal SCC, which is specified in the European Guideline for Self-compacting Concrete regulations (EFNARC).

Keywords: self-compacting high-performance concrete – SCHPC, recycled concrete aggregate – RCA, workability process, high range water reducing admixture – HRWRA.

Kulcsszavak: öntömörödő beton, újrachasznosított beton, nagyszilárdságú beton, bedolgozhatóság, frissbeton jellemzők, adalékszerek

1. Introduction

It was revealed that the using of recycled concrete aggregate (RCA) affects the workability of fresh concrete negatively, where recycled aggregate concrete (RAC) has higher slump loss than the natural aggregate (NA) concrete [1-3], which is mainly due to the aggregate itself where the size, texture, shape and water content of aggregate have a high effect on the fresh properties [4-6]. Fresh properties or workability defined in ACI as that property of freshly mixed concrete or mortar that determines the ease with which it can be mixed, placed, consolidated, and finished to a homogenous condition [7]. It is the basic property that characterizes the SCC, and to be SCC it has to flow and consolidate within the formwork without vibration and just under its own weight. Low water to binder (w/b) ratio is required in case of the self-compacting high-performance concrete (SCHPC); to achieve higher durability abilities. Thus chemical admixtures are recommended through the literature to use for enhancing the fresh properties of RAC with saving the hardened properties [5, 8, 9]. It is also recommended in the literature to use RCA with a saturated surface dry condition for enhancing the workability [10], however, using RCA at the partially wet condition or whatever its water content in the field could simulate more precisely the reality and make the study more reliable.

2. Fresh properties testing

Filling ability, passing ability, viscosity, and segregation resistance are the key primary fresh properties of the SCHPC

which must be taken into consideration in the design phase of the SCHPC. Slump flow and V-funnel are the two tests were used in the present study to evaluate the properties SCHPC in addition to the physical observations. They applied in accordance with European Guideline for Self-compacting Concrete EFNARC (2005) [11], which specifies their required specifications, limitation, and classifications.

2.1 Filling ability

EFNARC (2002) [12], defined the filling ability as the ability of fresh concrete to flow into and fill all spaces within the formwork, under its own weight which absolutely fill the framework without using any means of consolidation like the vibrator. Aggregate content, aggregate size, w/b ratio, binder content, binder type and HRWR dosage of concrete are the main factors affecting the filing ability [13, 14]. Where getting better filling ability could be achieved by:

- Using the optimal dosage of high range water reducing admixture (HRWR), which is neither too much to avoid segregations nor less the required to control the rheological parameters and reduce the yield stress and plastic viscosity.
- Using cementing materials enhance the segregation resistance, which improves the filling ability, the cementing materials could be filler materials or supplementary cementitious materials (SCMs), where the waste powder materials could be achieved the properties of the filling materials or SCMs [15].

Wherein case of using RCA the focus on other enhancing parameters should be of high importance. *Table 1* summarizes the slump flow classes, which is related to the flowability and filling ability in unconfined conditions.

Slump flow classes	Mean slump flow diameter (mm)
SF1	550 – 650
SF2	660 – 750
SF3	760 – 850

Table 1 The slump flow classes by EFNARC (2005) [11]
1. táblázat Területi osztályok az EFNARC (2005) szerint [11]

2.2 Segregation resistance

The ability of concrete to remain uniform during and after placement without any loss of stability due to bleeding, mortar separation and coarse aggregate settlement is the segregation resistance [12]. Choosing better grading of aggregates, decreasing the maximum aggregate size, using cementing materials with cement, and decreasing the w/b ratio enhances the segregation resistance [16, 17], where in case of SCHPC the low segregation resistance decrease the durability of concrete [18].

Segregating resistance could be investigated by physical inspection through the test of slump flow and casting of concrete, where the lack of any bleeding or separation is good induction for good resistance of segregation. However, the passing ability which is defined at EFNARC (2002) as the ability of fresh SCHPC to flow through tight openings or spaces confined by steel reinforcing bars, could be achieved as well by limiting the segregation of coarse aggregate.

2.3 Viscosity

The resistance to the flow of concrete once flow has started is the definition of the viscosity of concrete, which could be determined by investigating the efflux time in the V-funnel test [11]. The flow time has to be limited to be from 6 to 12 second by using the V-funnel test to achieve the good viscosity of SCHPC. Where the concrete with a low viscosity will have a very quick initial flow and then stop, while the concrete with a high viscosity may continue to creep forward over an extended time [11, 12].

2.4 Processing window

Processing window is a window created by mainly two coordinates, those coordinates are the slump flow (mm) in the x-axis and V-funnel time (s) in the y-axis, which could help to assess and limits the targeted values based on the upper and lower limits of the slump flow and for the V-funnel time tests. Some modifications have been suggested on the limited ranges EFNARC by a number of researchers who they investigated the fresh properties of SCHPC [16, 17]. However, in the present study the suggested window EFNARC tested for its applicability in case of using RCA in the SCHPC.

3. Experimental method

Twenty-one mixtures of SCHPC have been designed to achieve the properties of SCC at the fresh stage, 500 kg/m³

binder content, and a 0.35 w/b ratio were constant throughout this experimental study. The variables through the present study were the aggregate and the binder type, where the coarse NA have been replaced partially (25% or 50%) by RCA, and the cement has been replaced partially (15% or 30%) by three different waste powder materials. The used cement was a pure Portland cement CEM I 42.5 N, where the waste powder materials were:

- Unprocessed waste fly ash (UWFA) which collected from a coal power station in Hungary (Visonta coal-fired thermal power station) and delivered to the laboratory for use in the testing program without any processing.
- Waste cellular concrete powder (WCCP) which is a waste material collected from a factory for cutting cellular concrete masonry in Hungary.
- Waste perlite powder (WPP) which is amorphous volcanic silicate/alumina rock which originating from raw perlite resulting from cutting the raw perlite rock, where Hungary consider one of the main countries for producing Perlite [19]. *Fig. 1* shows the sieve curves for both cement and waste powder materials.

The NA used in the present study was quartz sand and gravel (0/16 mm size), which have been imported with three nominal grading fractions, sand (0/4 mm), small gravel (4/8 mm), medium gravel (8/16 mm), where divided regarding the fractions to 45%, 30%, and 25% respectively. While the coarse RCA fraction (4/16 mm size) produced by crushing of concrete cubes with average compressive strength between 28 to 33 MPa. The particle grading distribution shown in *Fig. 2*.

Fig. 1. Grading curves of cement and waste materials
1. ábra A cement és a hulladékok szemmegoszlási görbéje

A considerable amount of HRWRA was required to achieve the deformability and resistance to segregation at fresh state. Sika ViscoCrete-5 Neu is a modified polycarboxylates aqueous solution, which has been used as HRWRA in the present study to achieve and ensure the rheological properties of the fresh SCC.

Fig. 2. Grading curves of different types of aggregates
2. ábra A különböző adalékanyagok szemmegoszlási görbéje

Replacement of cement	Series I 0% replacement of coarse aggregate with RA	Series II 25% replacement of coarse aggregate with RA	Series III 50% replacement of coarse aggregate with RA
0%	RA0	RA25	RA50
15% UWFA	F15RA0	F15RA25	F15RA50
30% UWFA	F30RA0	F30RA25	F30RA50
15% WCCP	C15RA0	C15RA25	C15RA50
30% WCCP	C30RA0	C30RA25	C30RA50
15% WPP	P15RA0	P15RA25	P15RA50
30% WPP	P30RA0	P30RA25	P30RA50

Table 2. Mixing series
2. táblázat Keverési sorozatok

Name of mixture	Proportions in kg/m³					Superplasticizer	Water
	CEM I 42.5 N	Waste material	Fine aggregate	Coarse aggregate			
			N. Sand	NA	RCA		
			0/4	4/16			
Series I							
RA0	500	0	783	939	0	1.5	175
RA25	500	0	783	704	230	1.5	175
RA50	500	0	783	470	460	1.5	175
Series II							
F15RA0	425	75	767	920	0	2	175
F15RA25	425	75	767	690	226	2	175
F15RA50	425	75	767	460	251	2	175
Series III							
F30RA0	350	150	751	901	0	3	175
F30RA25	350	150	751	475	221	3	175
F30RA50	350	150	751	451	442	3	175
Series IV							
C15RA0	425	75	766	919	0	1.7	175
C15RA25	425	75	766	690	225	1.7	175
C15RA50	425	75	766	459	451	1.7	175
Series V							
C30RA0	350	150	750	899	0	3.25	175
C30RA25	350	150	750	674	220	3.25	175
C30RA50	350	150	750	451	442	3.25	175
Series VI							
P15RA0	425	75	774	928	0	3	175
P15RA25	425	75	774	697	228	3	175
P15RA50	425	75	774	464	455	3	175
Series VII							
P30RA0	350	150	766	918	0	3.75	175
P30RA25	350	150	766	688	225	3.75	175
P30RA50	350	150	766	459	450	3.75	175

Table 3. Concrete mixing proportioning
3. táblázat A betonkeverékek összetétele

The twenty-one mixtures were allocated through seven series; each series contains three mixtures with the same type of binder and amount of HRWR to investigate the actual effect of each replacement amount of both RCA and waste powder materials on the fresh properties of SCHPC. Table 2 shows the produced mixtures for the present study, while Table 3 shows the chemical compositions for all mixture. Where mainly two replacement amounts of NA have been replaced by RCA (25% and 50%) while the cement has been replaced by two percentages by each of the proposed waste powder materials (15% and 30%).

4. Mixing procedure

Mixing was carried out in accordance with EN 196-1 [20] for a total mixing time of four and a half minutes partitioned in three stages by using an electric concrete mixer. After each stage, the ingredients were manually mixed to achieve the highest homogeneity. The first stage the aggregate and binder powders are mixed, the second stage the water is added, and finally in the third stage the HRWR is added. The samples have been cast in steel molds having different sizes to obtain the standard specimens for each test. The fresh properties have been tested after one minute of finishing the mixing, which means after 4 minutes from adding water. The mixing procedure has a significant effect on both fresh and hardened concrete, in the present study the mixing procedure have been optimized as the first step for the study.

5. Results

5.1 High range water reducer demand

To achieve the European Guideline for Self-compacting Concrete regulations and to study the countless effects of RCA, UWFA, WCCP, and WPP, the adding amount of HRWR have been optimized in the preparation stage. Fig. 4 shows the HRWR demand in case of using the waste powder materials with and without RCA, where using RCA up to 50% does not affect the fresh properties of SCHPC. In RAC mixtures the water absorption capacity of RCA was compensated, which in this case almost the same slump flow (between 67.5 to 69.75 cm) and flow time (between 6 to 12 s) have been recorded by using the same amount of HRWR as shown in Fig. 4 at point (a). However, the water absorption capacity of the adhered mortar in RCA is the main reason which affects the workability of RAC but by compensating the water absorption the negative effect of RCA on workability could be eliminated despite that the effect of the rough surface of RCA will still slightly affects the flow time of RAC.

Where the literature is not discussing the three of the previously mentioned waste powder materials and their effect on the fresh properties of SCHPC, where in this case the demand of HRWR has been optimized in form of a linear relationship for each waste powder material at constant binder content 500 kg/m³. The demand of HRWR increased linearly by increasing the dosage of waste powder materials, due to the absorption capacity and different grading fraction comparing to the cement.

Fig. 4. The HRWR demand by increasing the waste powder materials substitution
4. ábra A cementhelyettesítések hatása a folyósítószer-igényre különböző hulladékpорок esetén

In case of using any of the three waste powder materials the concrete mixtures demanded HRWR with a linear function ($R^2 > 0.83$), however, in case of using the three of the waste powder materials together with the same amounts, the demanded HRWR was in a linear function for the average dosage of the dosages whom using for each alone. The function is:

$$\text{HRWR (kg/m}^3\text{)} = 0.0585x + 1.5,$$

where x is equal to the total substitution of cement by waste powder materials in percentage (%), when the three of the waste powder materials are using together with the same equal amounts. This function has been gotten by optimizing two mixes with the three of waste powder materials together for achieving the requirements of European guideline EFNARC (2005), where the first mix was with replacing 15% of cement by waste powder materials (5% UWFA + 5% WCCP + 5% WPP), while the second by 10% for each. Fig. 5 shows the HRWR demand by increasing the dosage of waste powder materials, in case of using the three of the waste powder materials together with the same dosage of each.

Fig. 5. The HRWR demand by increasing waste powder materials substitution, (in case of using the three of the waste powder materials together with the same dosage of each)

5. ábra A cementhelyettesítések hatása a folyósítószer-igényre a különböző hulladékpорок együttes használatával (mindhárom azonos mennyiségben való alkalmazása esetén)

5.2 Slump flow and V-funnel

Increasing the amount of RCA decreases the slump diameter slightly which agrees with most researchers findings [21-23], as well as the flow time has increased by adding 50% of RCA and that is mainly related to the shape and texture of RCA compared with the NA that have been used. While the RCA has greater surface roughness and relatively big amount fine particles, which were a result of the processes of crushing,

these factors affect the slump diameter and the flow time of the mixtures directly against increasing the amount of the involved RCA.

Fig. 6. Results of slump and V-funnel tests

6. ábra A területés a kifolyási idő vizsgálatának eredményei

Fig. 6 shows the results of slump flow and V-funnel tests for all mixtures and series. It is clear that adding UWFA as a replacement of cement either by 15 or 30% cause decreasing in the slump flow even by using a higher amount of HRWR. This behavior might be due to the big particles and the high-unburned carbon content of the added UWFA, where these two parameters absorb higher amount of water, resulting in less workability [24, 25]. Almost the same behavior has been observed by adding WCCP, which also has relatively big particles size compared to cement, in addition to its ability to absorb a high amount of water. Despite the slump, flow and V-funnel time are not changed significantly by adding WPP; the fresh properties considered as negatively affected when WPP added for both recycled and natural aggregate concrete. Where the required amounts of superplasticizer have been increased considerably, this reduction in workability might be due to the high surface area of WPP and its absorption capacity [26, 27]. The WPP does not affect the V-funnel time because WPP consumes longer time to absorb water due to its special amorphous, as well as its particles are relatively small comparing to UWFA and WCCP.

The effect of RCA was ranged in less than 30 mm concerning flow diameter and 1.5 seconds concerning flow time, which its effect could be neglected and that due to compensating of the water absorption capacity of RCA by adding water for RAC mixtures. However, by increasing the amount of any of the waste powder materials; the flow time increase and that is due to amorphousness and water absorption capability of the waste powder materials if compared with ordinary Portland cement (OPC) especially in case of using UWFA. That does not agree with SCHPC incorporating processed fly ash where the flowability increase in that situation [28]. All of the obtained measures of slump flow and V-funnel tests throughout all series satisfied the European guideline EFNARC (2005) and the suggested determinations of the previous literature.

5.3 Processing window

The workability ranges for all SCHPC mixtures shows the same rang of EFNARC (2002) regulation for normal SCC, which indicate that the EFNARC regulations for SCC are

also appropriate for SCHPC either by using NA or RCA. Where those regulations have been proposed by EFNARC to avoid any segregations or stagnations. Fig. 7 shows that the processing window of SCHPC mixtures, which is the same as the recommended processing window by EFNARC (2002) regulation for SCC.

Fig. 7. Processing window of RASCC

7. ábra Alkalmazhatósági tartomány hulladék adalékanyagok öntömörödő betonok esetén

The visual examination was carried out during mixing and by inspection the periphery of the concrete after measuring the slump flow, where no segregations or agglomerations of aggregate have been observed as well as the amount of HRWR optimized to produce a healthy mixture with appropriate fresh properties.

6. Conclusions

The present study is investigated the fresh properties of the self-compacting high-performance concrete (SCHPC) using recycled concrete aggregate (RCA) and waste powder materials. Where the main conclusions that could be concluded are:

- RCA does not affect the fresh properties of SCHPC significantly if the water absorption of RCA is compensated, whereby adding waste powder materials the effect decrease more,
- Waste powder materials affect the fresh properties of SCHPC negatively in both cases of using either NA or RCA,
- The demand of HRWR increase by increasing the replacement amount of cement by any of the waste powder materials.
- The workability process window of SCHPC using recycled aggregate is satisfying the workability process of normal SCC which is specified in the European Guideline for Self-compacting Concrete regulations (EFNARC),
- Slump flow and V-funnel tests with the physical observations are very important to produce and classify the fresh properties of SCHPC.

6. Acknowledgments

Authors are grateful to the Hungarian Scientific Research Fund (OTKA) for the financial support of the OTKA K 109233 research project. Special thanks to Duna-Dráva Cement Kft., SIKÁ Hungária Kft. for providing the materials used in the experiments.

References

- [1] Debieb, F. – Courard, L. – Kenai, S. – Degeimbre, R. (2009): Roller compacted concrete with contaminated recycled aggregates. *Construction and Building Materials*, Vol. 23, No. 11, pp. 3382-3387. <https://doi.org/10.1016/j.conbuildmat.2009.06.031>
- [2] Hama, S. M. – Hilal, N. N. (2017): Fresh properties of self-compacting concrete with plastic waste as partial replacement of sand. *International Journal of Sustainable Built Environment*, Vol. 6, No. 2, pp. 299-308. <https://doi.org/10.1016/j.ijbsbe.2017.01.001>
- [3] Carro-López, D. – González-Fontebao, B. – Martínez-Abella, F. – González-Taboada, I. – Brito, J. – Varela-Puga, F. (2017): Proportioning, Microstructure and Fresh Properties of Self-compacting Concrete with Recycled Sand. *Procedia Engineering*, Vol. 171, pp. 645-657. <https://doi.org/10.1016/j.proeng.2017.01.401>
- [4] Kou, S. C. – Poon, C. S. (2009): Properties of self-compacting concrete prepared with coarse and fine recycled concrete aggregates. *Cement and Concrete Composites*, Vol. 31, No. 9, pp. 622-627. <https://doi.org/10.1016/j.cemconcomp.2009.06.005>
- [5] Revathi, P. – Selvi, R. S. – Velin, S. S. (2013): Investigations on Fresh and Hardened Properties of Recycled Aggregate Self Compacting Concrete. *Journal of The Institution of Engineers (India): Series A*, Vol. 94, No. 3, pp. 179-185. <https://doi.org/10.1007/s40030-014-0051-5>
- [6] Revathi, P. – Mani, S. (2014): Studies on Fresh and Hardened Properties of Recycled Aggregate Concrete with Quarry Dust. *ACI Materials Journal*, Vol. 111, pp. 283-289. <https://doi.org/10.14359/51686507>
- [7] CT-13: ACI Concrete Terminology - An ACI Standard 2013.
- [8] Kisku, N. – Joshi, H. – Ansari, M. – Panda, S. K. – Nayak, S. – Chandra Dutta, S. (2017): A critical review and assessment for usage of recycled aggregate as sustainable construction material. *Construction and Building Materials*, Vol. 131, pp. 721-740. <https://doi.org/10.1016/j.conbuildmat.2016.11.029>
- [9] Madandoust, R. – Mousavi, S. Y. (2012): Fresh and hardened properties of self-compacting concrete containing metakaolin. *Construction and Building Materials*, Vol. 35, pp. 752-760. <https://doi.org/10.1016/j.conbuildmat.2012.04.109>
- [10] Yong, P. C. – Teo, D. C. L. (2009): Utilisation of Recycled Aggregate as Coarse Aggregate in Concrete. *Journal of Civil Engineering, Science and Technology*, Vol. 1, No. 1
- [11] EFNARC, Specifications and guidelines for self-compacting concrete, English ed. *European federation for specialist construction chemicals & concrete systems*, 2005.
- [12] EFNARC, Specifications and guidelines for self-compacting concrete, English ed. 2002, *European federation for specialist construction chemicals & concrete systems*.
- [13] Puthipad, N. – Ouchi, M. – Rath, S. – Attachaiyawuth, A. (2016): Enhancement in self-compatibility and stability in volume of entrained air in self-compacting concrete with high volume fly ash. *Construction and Building Materials*, Vol. 128, pp. 349-360. <https://doi.org/10.1016/j.conbuildmat.2016.10.087>
- [14] Megat Johari, M. A. – Brooks, J. J. – Kabira, S. – Rivard, P. (2011): Influence of supplementary cementitious materials on engineering properties of high strength concrete. *Construction and Building Materials*, Vol. 25, No. 5, pp. 2639-2648. <https://doi.org/10.1016/j.conbuildmat.2010.12.013>
- [15] Mehmet Karatas, A. G. (2015): Engineering Properties of Self-Compacting Concrete Produced by Polypropylene and Steel Fiber. *Periodica Polytechnica Civil Engineering*, Vol. 59, No. 2, pp. 95-102.
- [16] Güneysi, E. – Gesoglu, M. – Al-Rawi, S. – Mermerdas, K. (2013): Effect of volcanic pumice powder on the fresh properties of self-compacting concretes with and without silica fume. *Materials and Structures*, Vol. 47. <https://doi.org/10.1617/s11527-013-0155-9>
- [17] El Mir, A. – Nehme, S. G. (2017): Assessment of the fresh selfcompacting concrete properties utilizing different types of additives. *Építőanyag, Journal of Silicate Based and Composite Materials*, Vol. 69, No. 3, pp. 83-88. <https://doi.org/10.14382/epitoanyag-jsbcm.2017.14>
- [18] Assaad, J. – Khayat, K. – Daczko, J. (2004): Evaluation of Static Stability of Self-Consolidating Concrete. *ACI Materials Journal*, Vol. 101, pp. 168-176.
- [19] Rashad, A. M. (2016): A synopsis about perlite as building material – A best practice guide for Civil Engineer. *Construction and Building Materials*, Vol. 121, pp. 338-353. <https://doi.org/10.1016/j.conbuildmat.2016.06.001>

- [20] EN 196-1: Methods of testing cement. Determination of strength 2016.
- [21] Omrane, M. – Kenai, S. – Kadri, E-H. – Ait-Mokhtar, A. (2017): Performance and durability of self compacting concrete using recycled concrete aggregates and natural pozzolan. *Journal of Cleaner Production*, Vol. 165, pp. 415-430. <https://doi.org/10.1016/j.jclepro.2017.07.139>
- [22] Safiuddin, M. D. – Salam, M. A. – Jumaat, M. Z. (2011): Effects of recycled concrete aggregate on the fresh properties of self-consolidating concrete. *Archives of Civil and Mechanical Engineering*, 2011. Vol. 11, No. 4, pp. 1023-1041. [https://doi.org/10.1016/S1644-9665\(12\)60093-4](https://doi.org/10.1016/S1644-9665(12)60093-4)
- [23] Silva, Y. F. – Robayo, R. A. – Mathey, P. E. – Delvasto, S. (2016): Properties of self-compacting concrete on fresh and hardened with residue of masonry and recycled concrete. *Construction and Building Materials*, Vol. 124, pp. 639-644. <https://doi.org/10.1016/j.conbuildmat.2016.07.057>
- [24] Snelson, D. G. – Kinuthia, J. M. (2010): Characterisation of an unprocessed landfill ash for application in concrete. *Journal of Environmental Management*, Vol. 91, No. 11, pp. 2117-2125. <https://doi.org/10.1016/j.jenvman.2010.04.015>
- [25] Hamood, A. – Khatib, J. M. – Williams, C. (2017): The effectiveness of using Raw Sewage Sludge (RSS) as a water replacement in cement mortar mixes containing Unprocessed Fly Ash (u-FA). *Construction and Building Materials*, Vol. 147, pp. 27-34. <https://doi.org/10.1016/j.conbuildmat.2017.04.159>
- [26] Karein, S. M. M. – Joshaghani, A. – Ramezani-pour, A. A. – Isapour, S. – Karakouzian, M. (2018): Effects of the mechanical milling method on transport properties of self-compacting concrete containing perlite powder as a supplementary cementitious material. *Construction and Building Materials*, Vol. 172, pp. 677-684. <https://doi.org/10.1016/j.conbuildmat.2018.03.205>
- [27] El Mir, A. – Nehme, S. G. (2017): Utilization of industrial waste perlite powder in self-compacting concrete. *Journal of Cleaner Production*, Vol. 156, pp. 507-517. <https://doi.org/10.1016/j.jclepro.2017.04.103>
- [28] Sabet, F. A. – Libre, N. A. – Shekarchi, M. (2013): Mechanical and durability properties of self consolidating high performance concrete

incorporating natural zeolite, silica fume and fly ash. *Construction and Building Materials*, Vol. 44, pp. 175-184. <https://doi.org/10.1016/j.conbuildmat.2013.02.069>

Nagyszilárdságú öntömörödő beton frissbeton jellemzői hulladék anyagok hasznosításával

Öntömörödő, nagy teljesítőképességű betonok (SCHPC) frissbeton jellemzőit vizsgáltuk újrahasznosított beton adalékanyagként való felhasználásával és különböző hulladékalapú (feldolgozatlan pernye, perlit, pórusbetonpor) cementhelyettesítő, illetve kiegészítő anyagok alkalmazása esetén. Huszonegy keveréket vizsgáltunk, a terület és a kifolyási időt mérve. Eredményeik azt mutatják, hogy a kavicsfrakció 25 és 50%-os helyettesítése újrahasznosított betonüzalékkal (RCA) nem rontja az SCHPC bedolgozhatóságát, ha a betonüzalék vízfelvétele számításba vesszük. A hulladékalapú cementhelyettesítő anyagok viszont negatívan befolyásolják a friss tulajdonságokat, és jelentősen megnő a folyósítószer-igény, de megfelelő keverékek esetén újrahasznosított adalékanyagok és hulladék alapú kiegészítő anyagok együttesen is alkalmazhatók úgy, hogy az öntömörödő betonokra vonatkozó elvárásoknak (EFNARC) megfeleljen.

Kulcsszavak: öntömörödő beton, újrahasznosított beton, nagyszilárdságú beton, bedolgozhatóság, frissbeton jellemzők, adalékszerek

Ref.:

Abed, Mohammed – Nemes, Rita: *Fresh properties of the self-compacting high-performance concrete using recycled concrete aggregate*

Építőanyag – Journal of Silicate Based and Composite Materials, Vol. 71, No. 1 (2019), 18–23. p.

<https://doi.org/10.14382/epitoanyag-jsbcm.2019.4>

European Science Foundation (ESF)

Over four decades of setting science agendas for Europe

Based in Strasbourg, France, ESF was established in 1974 as an independent, non-governmental, non-profit organisation to provide a common platform for its Member Organisations to collaborate internationally on research programmes through its networking, funding and coordination activities. The launch of Science Connect, our new expert services division, marks the next phase of ESF's role, borne out of our deep understanding of the science landscape, funding context and needs of the research community at this critical juncture.

www.esf.org

Science Connect

Your partner in Science

Science Connect's mission is to partner with clients in leading successful projects and in facilitating informed decision-making through a broad range of science-support services including Peer Review, Evaluation, Career Tracking, Programme and Project Management and Administration, the hosting of Expert Boards and Virtual Institutes. Building on ESF's extensive network and experience, Science Connect delivers resources, tools and metrics to support the effective administration of science projects in both the private and public research sector.