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# *Recycled Technogenic Raw Materials as an Effective Filler for Modern Construction Composites*

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***Abstract*—Technogenic wastes, which utilization is an urgent issue in developed countries, is quite interesting for the production of fine-ground filler used to produce modern high quality concrete. The amount of technogenic waste (or technogenic raw materials, secondary raw materials) is so big that some sources refer to it as to the technogenic raw materials base for the production of composite concrete.**

***Keywords*—concrete mix, superplasticizer, technogenic raw materials, concrete scrap, crushed brick, ash and slag waste, quartz sand, filler, efficiency, water gain of concrete mix**

## I. INTRODUCTION

Substandard raw materials of concrete plants representing defective products and building demolition waste predetermine their use as fine-dispersion fillers thickening the cement stone in the production of concrete and reinforced concrete, since such raw materials such as polymineral compounds contain particles of granite, limestone, hydrated clinker minerals (non-hydrated clinker), etc. Thus, in Germany, more than 350 organizations are engaged in the processing and recycling of solid waste with a total volume of more than 50 million tons. Up to 50% of such recyclable materials include road reconstruction waste, while about 25% – construction and reconstruction wastes. In general, 94-97% of all waste is recycled to obtain secondary crushed stone of various fractions. A similar technology was introduced in the UK, where the volume of construction waste utilized at multiple enterprises exceeds 30 million tons.

Such fillers differ from silica fume in their structure, chemical activity and composition and require further study of their reactive activity and their role in the formation of early and regulatory (final) strength of concrete. Mineral technogenic fillers, formed during the utilization of concrete scrap, ceramic crushed brick and brick manufacturing defects, were almost not studied [1, 2]. The study of these mineral powders for use in high-quality concrete production is of great interest. It is important to find their water holding capacity, hydraulic activity, influence on basic properties of concrete and concrete mixes, since hundreds of thousands tons of waste in the form of concrete scrap and crushed brick were accumulated in the Chechen Republic in recent years due to dismantling of buildings. Rational utilization of such technogenic materials would have a considerable socio-technical, economic and ecological impact [3, 4].

## II. Methods and Materials

The monolithic concreting of structures made of highly mobile plasticized concrete mixes with P3-P5 workability indicators may cause unacceptable water gain and stratification (sedimentation) [5-7]. The Testing Laboratory of Building materials and Structures of Grozny State Oil Technical University named after academician M.D. Millionshchikov faced such difficulties at the entrance quality control of a concrete mix at the construction site of a multifunctional high-rise complex Akhmat Tower, where highly mobile concrete mixes of the BST B40 P5 brand with a cone flow diameter of 56-62 cm for the device of bored piles under the foundation of a high-rise building were developed (Fig. 1).

Fig. 1. Quality control of high-mobile concrete mixes at the construction site of a multifunctional high-rise complex Akhmat Tower

There are various technological methods preventing strong water gain of highly mobile concrete mixtures with superplasticizers. The most common of such methods implies the addition of fine aggregate into its composition [8]. The addition of up to 15% of fine aggregate into concrete mixes with P3 workability indicator almost completely eliminates the separation of concrete mixes. Some concrete-scientists [9, 10] advise to increase the "weighting capacity" of cement paste by introducing fine silica fume or other high-performance fillers while using concrete mixes P4 and P5. At the same time, for particularly heavy concretes, where the filler-aggregate is 1.5-2.0 times denser than a standard one, such solution only partially prevents the sedimentation.

It is known that the use of mineral various fillers (MF) together with plasticizing additives in concrete mixtures increases their efficiency. Thus, the publications by authors [11, 12] reflect the filled compositions of self-compacting mixtures with the use of various microfillers. The authors of [13, 14] stated the positive effect of fine MF particles from recyclable mortar on water-holding capacity, strength, density and adhesion of concrete mixtures.

Thus, it is assumed that the mineral technogenic filler (MTF) made of concrete scrap and crushed brick, with good water-holding capacity, will be the most suitable in its structure and nature for highly mobile concrete mixtures, thus preventing their sedimentation.

In this regard, within the framework of this study we explored the possibility of stabilizing a cement-water slurry using the following MTF:

- MTF made of concrete scrap;
- MTF made of ceramic crushed brick (CBD);
- MTF made of ash and slag mixtures (ASM);
- MF made of small substandard quartz sands.

The specific surface of the used MTF was in the range of 450-600 $m^2$/kg, which is almost 2 times higher than that of the cement.

The obtained results were compared with special foreign stabilizers – high water-holding additives of Bermocoll cellulose ethers by Akzonobel (Sweden), studied in some papers [15, 16]. Bermocoll-ethyl (hydroxyethyl) cellulose is a non-ionic cellulose ether.

The sedimentation kinetics was studied on cement-water suspensions obtained for Portland cement M500 D0 produced by the State Unitary Enterprise Chechen Cement.

## III. Results

At W/C (Water/Cement ratio) = 1.6, the sedimentation of particles of the dispersed phase in a liquid ends within 0.4-1.0 hours, and the process of sedimentation itself is linear. Repeated test with the replacement of Chechen Cement with Novoros Cement showed that the time of sedimentation and the laws of the process do not depend on the type of cement (Figure 2). In the resulting suspensions, MTF was dosed out from the mass of cement in the amount of 15%.

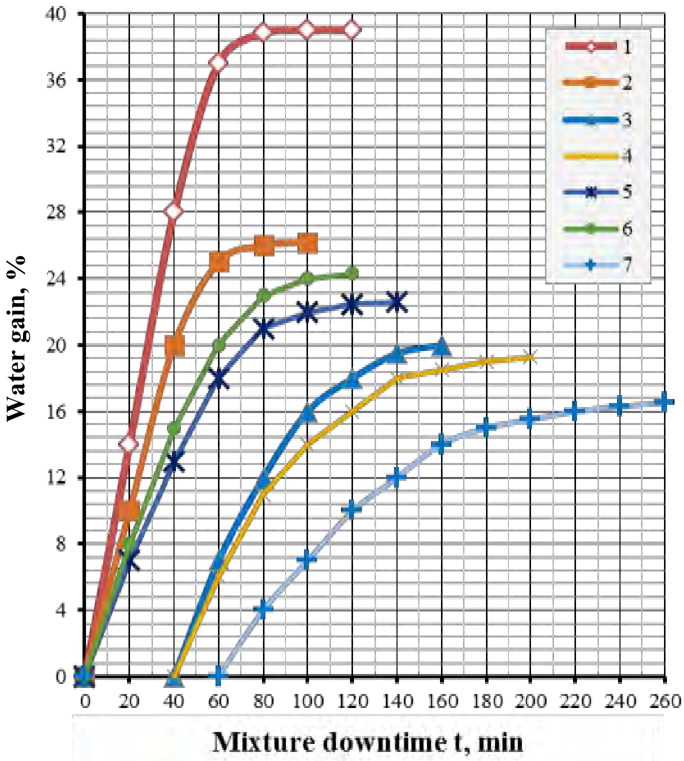


Fig. 2. Kinetics of sedimentation of cement suspensions (W/C = 1.6) with the release of clarified water above the sediment mixture on cement grade M500 D0 produced by Chechencement plant: 1 – additive-free concrete

mix; 2 – the same at W/C = 1.0; 3 – the same with MTF from concrete scrap; 4 – the same with MTF from CBD; 5 – the same with MTF from ash and slag mixtures; 6 – the same with MF from fine quartz sand; 7 – the same with stabilizer Bermocoll = 0.4%

As Figure 2 shows, the amount of clarified water above the sediment of an additive cement gel with W/C = 1.6 is in the range from 36 to 39%, and the volume of sediment is 61-64%.

Sedimentation of suspensions with W/C = 1.0 proceeds more slowly and ends within 1.1-1.3 hours. The addition of MTF to the composition of the cement-water suspension significantly changes its sedimentation performance for the better. Thus, the results of using MTF from concrete scrap and ceramic crushed brick (CDB) are comparable with each other and are close to the values obtained using the Bermocoll stabilizer. The amount of clarified water above the sediment in them does not exceed 18-20%. At the same time, the beginning of water gain is observed after 40 minutes. MTF made of ash-and-slag mixtures (ASM) and quartz sand are noticeably inferior in terms of the water-retaining capacity of MTF made of concrete scrap and CBD. It can be explained by different nature of the used MTF (Table 1).

In the study, we used a centrifuging method, in which samples of fine particles of MTF were maintained in glass flasks with a diameter of 15 mm, tightly closed with filter paper on one side.

Therefore, MTF made of concrete scrap and CBD are the most significant stabilizers for cement slurries (except Bermocoll). These additives reduce the sedimentation effect of particles even with strong dilution of suspensions by the liquid phase (at W/C = 1.6). The use of MTF in conjunction with plasticizing additives, which several times reduce W/C, will have an even greater effect on preventing the sedimentation of concrete mixtures.

TABLE I. WATER-SUPPORTING ABILITY OF THIN-MOLTED TECHNOGENIC FILLERS

| No. | Type of filler | Raw materials for fillers | Amount of bound water (after centrifuging), g/g | Specific surface area Ssp, $m^2$/kg |
|---|---|---|---|---|
| 1 | MTF made of concrete scrap | Concrete scrap | 0.1803 | 560-580 |
| 2 | MTF made of CBD | Ceramic crushed brick | 0.2112 | 580-600 |
| 3 | MTF made of ASM | Ash and slag mixtures | 0.7020 | 550-570 |
| 4 | MF made of small substandard quartz sands | Substandard quartz sand | 0.1688 | 460-480 |

Thus, we estimated the stabilizing function of MTF on concrete mixtures using heavy dense natural granite-diabase aggregates with a density of more than 2.6 g/cm$^3$. The consumption of the constituent components of the concrete mix for the control composition was adopted as follows: local cement – 520 kg, Chervlensky sand – 600 kg, crushed stone – 1200 kg, at W/C ratio = 0.39. Experimental compositions using MTF and chemical additives were made in relation to the control composition.

Concrete mixes were plasticized with the chemical additive Linamiks PK in the amount of 1.1%. Each MTF was dosed out from the mass of cement in the amount of 15%. The resulting mixtures were used to form cylinders with a diameter of 100 mm and a height of 1000 mm in a vertical position in specially made metal forms consisting of two parts – half-molds. To enhance the stratification of the mixture, they were designed with a mark on the draft of the P5 cone (DC more than 20 cm) and sealed on the vibrating plate for 0.5 minutes. Traces of sedimentation of solid particles in the structure of concrete were studied against the difference in the upper and lower layers of the fabricated samples. To this end, cylinders with a diameter and height of 100 mm, that were used to determine the density and strength of concrete in the upper and lower layers of the sample, were sawed on the auxiliary equipment for cutting concrete samples (Table 2).

Table 2 shows that the difference in density of control concrete without a concrete height reaches up to 200kg/m$^3$, which is 8-12%. The use of MTF in concrete mixtures makes it possible to reduce the difference in density to 72 kg/m$^3$ (i.e., about 3% of the density of concrete), and in strength – to 4 MPa. The surface in the upper part of the sample compared to the control composition of the concrete did not have a loose and weak surface layer. The chemical additive Linamix PC in the amount of 1.1% also proved to be quite effective. When it is added to the concrete mix together with MTF, the difference in density decreased to 43 kg/m$^3$ (this is less than 2% of the density of concrete), and in strength – to 1.5-2.0 MPa.

TABLE II. GRADIENTS OF DENSITY OF CONCRETE WITH A STRETCH OF HEAVY CONCRETE MIXTURES

| No. | Additive | | Density, kg/m$^3$ | | Difference in density, kg /m$^3$ | Strength $R^{28}$, MPa | | Difference in strength, MPa |
|---|---|---|---|---|---|---|---|---|
| | mineral | chemical | bottom layer | upper layer | | bottom layer | upper layer | |
| 1 | - | - | 2558 | 2360 | 198 | 47.8 | 40.3 | 7.5 |
| 2 | MTF made of concrete scrap | - | 2470 | 2398 | 72 | 46.9 | 42.8 | 4.1 |
| 3 | The same | Lina mix PC | 2468 | 2425 | 43 | 49.9 | 48.0 | 1.9 |
| 4 | MTF made of CBD | - | 2466 | 2390 | 76 | 44.9 | 41.0 | 3.9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | The same | Lina mix PC | 2450 | 2407 | 43 | 48.8 | 47.3 | 1.5 |
| 6 | MTF made of ASM | - | 2491 | 2399 | 92 | 48.7 | 44.5 | 4.2 |
| 7 | The same | Lina mix PC | 2485 | 2423 | 62 | 50.2 | 47.9 | 2.3 |
| 8 | MF made of small substandar d quartz sands | - | 2498 | 2390 | 108 | 48.9 | 45.0 | 3.9 |
| 9 | The same | Lina mix PC | 2489 | 2435 | 54 | 51.3 | 46.8 | 4.5 |

## IV. CONCLUSIONS

Thus, the possibility of stabilizing cement-water suspensions using mineral components of man-made nature, obtained through recycled industrial waste and dismantling buildings and structures, was proved.

The efficiency of the required stabilization of structural characteristics of concrete mixtures against delamination is improved by the introduction of MTF together with chemical additives-watering agents.

## References

[1] Yu.M. Bazhenov, S.A.Yu. Murtazaev, M.S. Saydumov, Building composites based on concrete scrap and waste stone crushing: scientific publication. Grozny: Grozny Worker Publishing and Printing Complex, 2014, pp. 334.

[2] Magomed S. Saidumov, Madina Sh. Salamanova, Salambek A. Aliev, et al., Cement concrete composites on the basis of by-passed stone and stone milling wastes, Acta Technica CSAV (Ceskoslovensk Akademie Ved), 61, No. 4B/2016, pp.327-336.

[3] S.-A.Y. Murtazaiev, V.S. Lesovik, N.V. Chernysheva, et al., Fine-grained cellular concrete creep analysis technique with consideration forcarbonation, Modern Applied Science, No. 9 (4), pp. 233-245, 2015.

[4] A.A. Volodchenko, V.S. Lesovik, A.N. Volodchenko, L.H. Zagorodnjuk, Improving the efficiency of wall materials for “green” building through the use of aluminosilicate raw materials, International Journal of Applied Engineering Research, No. 10 (24), pp. 45142-45149, 2015.

[5] Yu.I. Koryanova, N.E. Rezantsev, A.S. Shumilova, Materials and constructions used in the construction of high-rise buildings - from traditions to innovations, Alley of Science, Vol. 6, No. 4 (20), pp. 95-99, 2018.

[6] H. Okamura, M. Ouchi, Self-Compacting Concrete, Advanced Concrete Technology, 2003, No. 1, pp. 5-15.

[7] G.V. Nesvetaev, Some questions about the use of additives for concrete, Concrete and reinforced concrete, No. 1, pp. 78-80, 2011.

[8] S.A. Udodov, Re-introduction of a plasticizer as a tool for controlling the mobility of a concrete mix, Journal of Kuban State Technological University, No. 9, pp. 175-185, 2015.

[9] A.V. Usherov-Marshak, T.V. Babaevskaya, The effectiveness of additives is the subject of concrete science and concrete technology, Concrete technology, No. 7-8 (72-73), pp. 53-55, 2012.

[10] Yu.G. Barabanshchikov, M.V. Komarinskiy, Superplasticized technological properties of concrete mixtures, Construction of unique buildings and structures, No. 6 (21), pp. 58-64, 2012.

[11] A.I. Vovk, Additives Based on Domestic Polycarboxylates, Building materials, equipment, technologies of the XXI century, No. 9, pp. 31-33, 2012.

[12] G.V. Nesvetaev, A.N. Davidyuk, Self-compacting concretes: strength and composition design, Building materials, No. 5, pp 54-57, 2009.

[13] A.M. Kudyakov, L.A. Anikanova, H.O. Kopanitsa, Influence of grain composition and type of fillers on the properties of mortars, Building materials, No. 11, pp. 28-29, 2001.

[14] B.A. Usov, L.N. Popov, Dry building mixes on the basis of ground Portland cement to quartz-containing microfillers, Building materials, equipment, technologies of the XXI century, No. 7, pp. 14-15, 2003.

[15] N.N. Shangina, A.P. Leikin, Adsorption-catalytic processes on the surface of the solid phase and their influence on the properties of concrete, Young scientists, graduate students and doctoral students. Petersburg State University of Communication, SPb, pp. 28-34, 1997.

[16] M.Sh. Salamanova, M.S. Saidumov, A.Kh. Alaskhanov, et al., High-quality and high-strength concrete for buildings and structures, Ibausil conference meeting, Vol. 2, pp. 991-996, 2018.