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# Self-Consolidating Concretes with Materials of the Chechen Republic and Neighboring Regions

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**ABSTRACT**

Special aspects of formation of a structure and characteristics of self-consolidating concretes (SCC) with using finely dispersed micro-loadings and aggregates from locally available materials and materials of neighboring regions are disclosed in this article. Results of investigations of SCC for monolithic construction, including high-rise construction, are shown. It is shown that to reach of high operational characteristics of self-consolidating concretes very tough requirements to production materials are imposed. A fineness of a little aggregate is not more 0,125 mm, except that 70% of them have a size 0,063 mm. A coarse aggregate is retified on sizes 10-16 and 16-20 mm. Also, it is allowed using of nonorganic materials with a high specific surface which increase a waterholding capacity of an aggregate (white carbon, kibble spray asbestos, bentonites). It is defined that action of plasticizers of a new type is based on an aggregate of an electrostatic and space effect, which is reached with help of water-repelling polyether chains of a molecule of polycarboxylic ether. By means of that, duration of plasticization effects of polycarboxylates is 3-4 times as compared to sulfate of melanin and naphthalene sulfonate formaldehydes or lignosulfonates. Such capacity allows not just to increase the mobility of the mortar in early terms, but to keep it during of a long period of time, what influences positively on transportation terms of concretes from plants to places of construction. It was discovered, that self-consolidating concrete finds more and more extensive use. It is perspective to use it for production of a prefab reinforced concrete, placement of monolithic extra-strong jointless floorings, air placing, remodeling and enforcement of structure. On the one hand, extension of self-consolidating concretes is limited with expensive additives of polycarboxylates. However, using of this material allows declaring off a vibroflotation that in turn decreases energy consumption and saves time, improving sanitary-hygienic conditions of works labour. A vibration-free technology so much decreases a level of noise nuisance on people and environmental, so that plants of reinforced concrete products can be located in urbanized districts of a city.

**KEYWORDS**
Self-consolidating concretes; micro-loadings; polycarboxylates; superplasticizer; man-triggered materials; aggregates; formation.

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## Introduction

A large-scale implementation of monolith construction in the country requires relevant effective technologies and materials for a building of modern buildings and installations and, primarily, hi-tech concretes and aggregates. One of important components of such approach are modern ways of placing concretes and production of mobile high quality concretes. One of variants of problem solution is using of self-consolidating concretes (SCC), what allows excluding a vibrating process from a

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technology of concrete casting (SCC), even building of high-density reinforcement concretes concrete construction and pick-up fittings of buildings. A self-consolidating concrete aggregate is that does not require an external influence for its impaction and breakdown by a scope of construction and at that it does not disintegrate and keeps a homogeneity.

Not all easily workable mixes belong to SCC (the category P5), and just that from them which have a flow factor (flow) 55 cm and higher. The flow of self-consolidating aggregates is defined with help a standard cone which is using for a definition of fluidity of usual concretes, which upside-down with a big diameter or a foundation. At increasing of a cone the flow, which is flows, bleeds on a horizontal surface in the form of a cake, its diameter services like an index of the flow (Bazhenov, 2009; Minaev et al., 2009).

## Materials and Methods

Approaches to a definition of concrete recipes SCC differ from traditional recipes (ACI 305R-10, 2010; Diederich et al., 2013; EFNARC, 2002; Kollek, 1989; Le et al., 2013; Mouret et al., 2003; Persson, 2001). Firstly, it is a principally other approach to ration and aggregate grading (a chip charge is approximately equal to a sand charge, a bolter of aggregates, as far as possible, must be close to a perfect curve by means of a benefication of several fractions) (Kim et al., 2014; Pujar et al., 2010). Secondly, it is a compulsory attendance of loadings and a plasticizing admix (as rule, it is a superplasticizer on a base of polyester polycarboxylates) (DAfStb-Richtlinie Wasserundurchlässige Bauwerke aus Beton (WU-Richtlinie), 2003; Kaprielov, 2008; Gairabekov et al., 2015; Murtazaev et al., 2015a; 2015b).

An action mechanism of polycarboxylates principally differs from early used superplasticizers on base of melanin or naphthalene formaldehydes compounds. A difference involves that polycarboxylates concentrates on a surface of cement grains and conduct a negative charge to them (Shah et al., 2013; Torrenti et al., 1999; Fix et al., 2004; Lister et al., 2007; ASTM A887-89, 2004). As a result of that cement like-charged grains repels that leads to hydrated cement and also mineral components (figure 1).

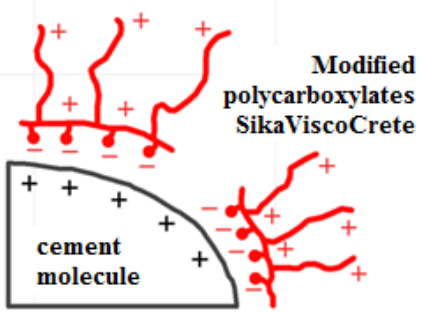


Figure 1. An action mechanism of polycarboxylates of type SikaViskoCrete.

As shown in the report of native and foreign of literature sources (Hillemeier et al., 2006; Bazhenov, 2001; Boldyrew, 1993; Arakawa, 1992), a high cost of SCC-betons in comparison with usual beton, is dependent on an increased cement charge and using high quality components for receiving of betons with high and ultrahigh service characteristics.

However, in passing to self-consolidating aggregates a technology of works is much-simplified, its noisiness is less, labor costs decrease, speed of construction

increases. Thus, in spite of significantly more high cost of these aggregates, general costs on construction even decrease.

## Results and Discussion

For the purpose of a formulation of high-strength self-consolidating concretes with using local materials and materials of neighboring regions in a technological centre of a collective using "Modern constructional materials and technologies" Public University of Petroleum Technologists in Grozny (PUPTG) by name of M.D. Millionschykov experimental investigation were leaded.

In researches quality materials were used like input materials. Seeing that a high quality aggregate is lack in Chechen republic, so it is transferred from a neighboring republic Northern Alania. A sample taking for investigation was performed on GOST30515.97, GOST8269-87 and GOST8735-88.

Aggregates were made with using following components in the laboratory conditions:

1. Portland cement CEM I 42,5 H Chiri-Yurtovskyi cement plant – GOST10178, an activity is 52,2 mPa.
2. Quartzofelsphatic sand Мкр = 2,8 – GOST8736 of Alargysk formation.
3. Quartz sand Мкр = 1,8 Chervlenskyi formation – GOST8736;
4. Ballast of Alargysk formation of a granit diabasic fraction 5…20 mm, a content of mantle parts 12,2% - GOST 8267.
5. Micro-loadings:

– chalky dust, a specific surface area of dust is 920 $m^2$/kg, a true specific gravity is 2500 kg/$m^3$;

– chark of TPP in Grozny, a specific surface area is 780 $m^2$/kg, a true specific gravity is 2200 kg/$m^3$;

– MP-1 mineral and nonactivated powder of Voronezh, a specific surface area of dust is 900 $m^2$/kg, a true specific gravity is 2550 kg/$m^3$;

– cement flue dust of State region power station Nevynomysskyi, a specific surface area of dust is 860 $m^2$/kg, a true specific gravity is 2000 kg/$m^3$.

6. Addition of superplasticizer – SikaViscoCrete 5 New in the form of a ready-mixed matrix.

To produce a self-consolidating concrete it is needed to select aggregates grain-size distribution right, it is needed a continuous aggregates grading of large and small size. For roof-topping of sifting it is used a silica fines of Chervlenskyi formation Мкр = 1,8.

According to data of sifter of aggregates and calculation of full bottoms a graphic of grading (figure 2) on standard sieves on a special program. As it can be seen from a figure, the graphic of grading of used aggregates is posted to an ideal curve so close.

Concrete mixes were made with using of a laboratorial concrete mixing machine of a forced-feed blending with a volume 50 l. The flow was measured which exceeded 55 cm in the most cases. Then after a remixing, mixes were bottled in checked (calibrate) forms of size 10x10x10 cm, which are correspond on requirements GOST 22685. After production of sample materials with tailor-made properties, a consistency of concrete was calculated according to GOST 10181.2.

A maturing of sample materials was happening in normal conditions under temperature (20±3)$^o$C and a relative air humidity (97±3)%) on GOST 18105. Contents of concrete mixes and strength properties of received concretes are presented in tables 1 and 2.

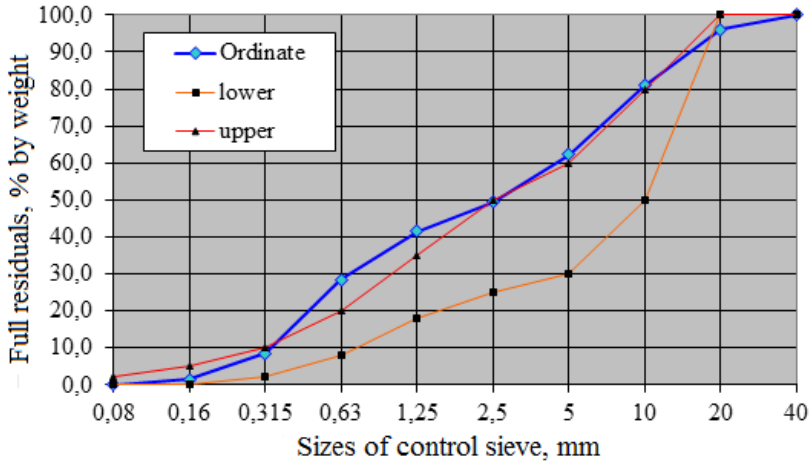


**Figure 2.** A graphic of aggregates grading: ordinate – a curve of aggregates sifting; lower - a lower limit of sifting; upper – an upper limit of sifting

An analyze of investigation results showed that witnessed by superplasticizer SikaViscoCrete 5 New other and less defect structure of cement brick is created, changes of morphology of crystalline hydrates are happening to side of creation of a large quantity of finely-divided phases, which compacted a structure of a cement brick and concrete. In spite of some disagreement of characteristics to requirements an used in this investigation and large aggregate, which, as rule, is applicable to ballast for SCC (flakiness, aggregate maximum size), was used a nonactivated chalky dust. It was succeed in production of self-consolidating concretes of a good quality of a class B60. Concrete mixes of all presented aggregates did not have water gain.

**Table 1.** Compositions of self-consolidating concretes

| Compositions | Components charge, kg/m³ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | V | B 5-20 | B 5-10 | S Мк=2,8 | S Мк=1,8 | Chark 1 | Chark 2 | MP-1 | Chalk dust |
| 1 | 500 | 175 | - | 755 | 420 | 455 | - | - | 100 | - |
| 2 | 480 | 172 | 460 | 220 | 815 | 215 | 80 | - | - | - |
| 3 | 480 | 172 | 450 | 215 | 795 | 205 | - | - | - | 60 |
| 4 | 480 | 178 | 455 | 220 | 835 | 175 | - | - | 100 | - |
| 5 | 500 | 186 | 782 | 414 | 449 | 136 | - | 30 | - | - |

Notice: Chark 1 – Chark TPP Grozny city; Chark 2 – Chark Nevinomysskaya; Composition 4 is made at Novorossiysk PTS M500D20.

**Table 2.** Results of tests of self-consolidating concretes

| Compositions | Quantity of addition | B/C | The concrete's strength, kg/m³ | Compression capacity in the age, day МПа | | | | RK, cm |
|---|---|---|---|---|---|---|---|---|
| | | | | 7 | 14 | 21 | 28 | |
| 1 | SikaVC5N 0,75% | 0,35 | 2440 | 50 | 52,3 | 53,1 | 63,5 | 65 |
| 2 | SikaVC5N 2,0% | 0,36 | 2420 | 56,2 | 60,7 | 59,6 | 56,3 | 57 |
| 3 | SikaVC5N 1,9% | 0,36 | 2450 | 56,7 | 62,5 | 64,0 | 65,5 | 55 |
| 4 | SikaVC5N 3,4% | 0,37 | 2380 | 44,3 | 54,9 | 56,5 | 54,7 | 64 |
| 5 | SikaVC5N 0,6% | 0,37 | 2510 | 56,8 | 65,6 | 65,9 | 68,2 | 65 |

Presented results tell about a significant excess of a concrete strength under compression in comparison with a strength which is waited according to a famous formula of Bolomey's-Scramtaev's.

## Conclusion

Thus, SCC is a new, quite perspective type of cement concretes and for adaptation of technology of their receiving to conditions of Chechen Republic it is necessary to do hard work on learning of various mineral loadings of a natural and man-triggered origin (charks, ground slags and dust, silica fume and others) like micro-loadings with synchronous investigation of all complex of basic constructional-technical capacities of these concretes. Moreover, a development of technology of its production and application in a construction of timbering.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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