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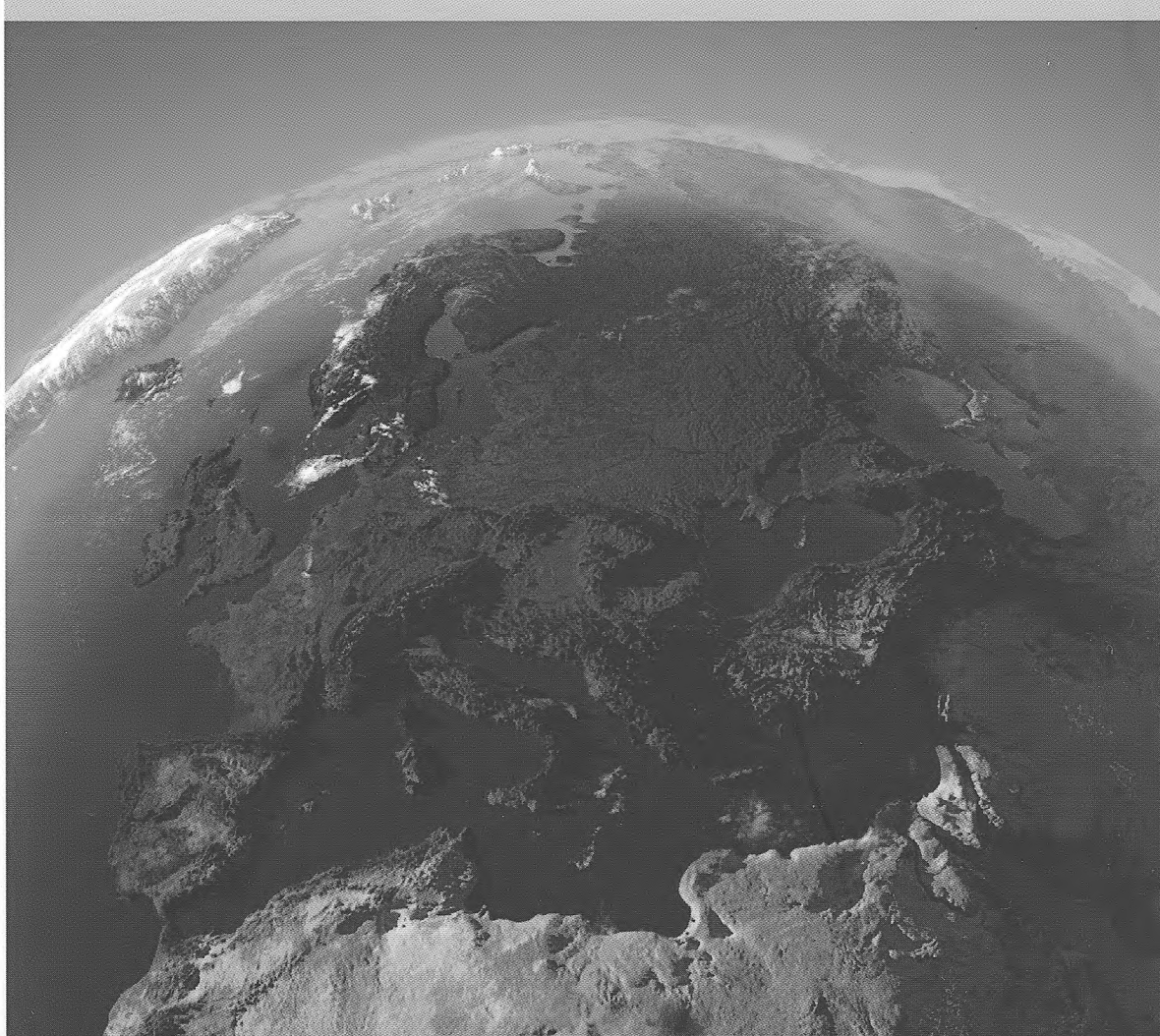

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Impact of the technological factors on strength of the concrete with new generation chemical additive

Abstract: The article provides the results of the surveys of technological factors for the strength of the concrete with new generation chemical additive.

Keywords: strength, superplasticizer, concrete compound, mineral filler, dispergation, cement.

The use of polycarboxylate (PC) superplasticizers (SP) of new generation based on nanotechnology in the global construction practice is constantly increasing [1]. These SP have hyperplasticizing effect and ensure formation of self-sealing concrete compounds and high-strength concretes for the production of monolith and assemble structures.

Practical use of such concretes will ensure successful implementation of the resource supplying tasks in the construction, increasing of concrete and reinforced concrete structures' quality and reliability.

Polycarboxylate SPs are classified as comp-shaped polymers, which molecules consist of the main chain with the suspended side chains, resembling to a comb [2]. PC SP function is based on the combination of electrostatic and space effect, which is reached with the help of side hydrophobic polyether molecule chains preferably adsorbed on cement hydrosulphoaluminate [3]. Due to this the duration of PC SP plasticization effects is 3–4 times higher compared to sulphomelamine and sulpho-naphtaline formaldehydes or lygnosulphonates. This peculiarity enables to obtain self-sealing flowing concrete with the CS (cone slump) flowability > 20 cm. as well as to preserve it within longer time period, positively affects its processing properties, which is particularly important for construction in hot climate conditions.

New SP mechanism involves adsorption of PC molecules on the cement grains surface charging them negatively. The cement particles surface free from SP is enough for the water access and normal cementing hydration. Consequently, dispergation and penetration effects are ensured, which leads to the solidification acceleration and combined with the significant reduction of water requirement ensures the increasing of concrete strength.

In order to obtain self-sealing high-strength concretes the high-grade cements M500 DO are used together with PC SP [4].

As only Portland cement M400 is produced in Uzbekistan, then the issue of obtaining self-sealing concrete with PC SP additive is important.

With this, the problem of mineral filler type and content impact on the concrete strength is poorly studied.

In order to obtain antifloating flowing concrete and high-strength concrete, its components and content should comply with some

requirements. Coarseness of fine filler should be 0.125 mm (30 %) and 0.063 mm (70 %).

Two fractions of coarse filler are used: 5–10 mm. and 10–20 mm. in particular ratio, which ensures the potential minimal cavitation.

Dispersive filler is also desired [1].

Taking into account these requirements to composition design we performed the research of technological factors impact on the strength of self-sealing concrete with PC SP additive with hyper-plastifying and solidification acceleration effects. For experimental researches M400 DO and D2 Portland cement, bank sand, broken stone of the fractions of 5–10 and 10–20 mm., basalt filler with the specific surface of ~2,500 cm^2/t are used. Concrete mix CS flowability is 20–23 cm.

During the researches the impact of the following technological factors on normal solidification of concrete was studied: SP doses, cement type and consumption, sand/broken stone ratio. The following concrete grades were taken as basic B 15, B 22.5 and B 30 with cement consumption 292, 370 and 450 kg/m^3; Water/Cement 0.6, 0.55 and 0.5; sand/broken stone 0.57, 0.52 and 0.55 relatively and the CS flowability of — 4–6 cm.

As it is known, compound flowability and strength are determined by SP doses [2]. Thus, primarily the PC SP dosing impact on selfsealing concrete was determined from flowing concrete with the CS flowability of = 20–23 cm., on M400 DO and D20 Portland cement with water/cement = 0.29 and 0.31 and sand/broken stone 0.63. SP dosing rate was within 0.7 to 1.3 % of cementing agent's weight on conversion to 100 % of substance. The flowability was adjusted by gauged water. The data provided on fig.1 show that the change of concrete strength is extreme with the maximal value in case of 1 % SP dose. Reduction of SP additive to 0.7 % and achieving of the required flowability causes the increasing of water/cement from 0.29 to 0.33 and 0.31 to 0.35 for Portland cement M400 DO and D20, which consequently leads to the strength reduction from 76 and 64 MPa to 60 and 51 MPa or for 13 and 14 % relatively (fig.1, exc. 1,2).

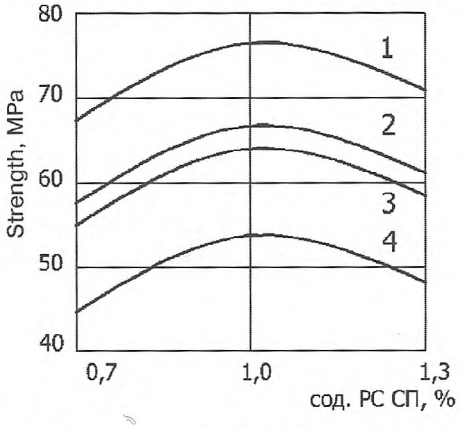

Fig.1 PC SP dosing impact on concrete strength: 1 — concrete on Portland Cement M400 DO; 2 — concrete on Portland Cement M400 DO + 40 % bas. filler; 3 — concrete on Portland Cement M400 D 20; 4 — concrete on Portland Cement M400 D 20 + 30 % bas. filler

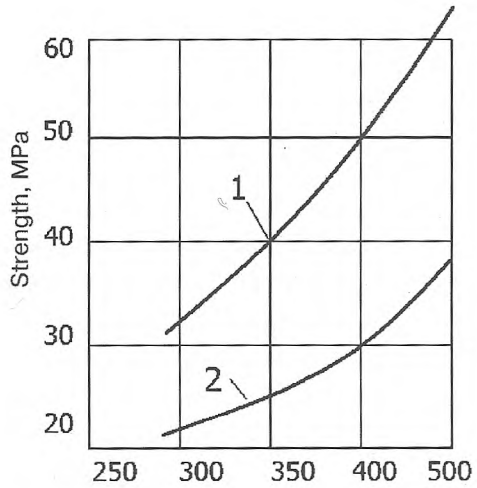

Fig. 2. Impact of cement consumption on the concrete strength with PC SP additive: 1 — concrete on Portland Cement M400 D20 with add. 1 % of PC SP; 2 — the same without additive

When the SP content is increased up to 1.3 %, or 1–2 units, the water requirement is decreased, the concrete strength is reduced for 7 and 8 %, which is probably explained by the thickening of adsorption films of SP water solution around the grains of hydrated cement and some reduction of the cohesion between crystalline hydrate of the cement stone. Lower compression strength values of Portland cement M400 D20 concrete are explained by the increased water requirement caused by the mineral additive (20 % ash) and relatively lower clink content. The behaviour of concrete strength with basalt filler (30 %) is the same as empty concrete, and absolute values of Rc (compression strength) of Portland cement M400 DO concrete and Portland cement M400 D20 concrete are lower for 19 and 25 %. This is explained by the reduction of active clinker.

With this, if Rc of basic concrete of B30 grade on Portland cement M400 DO concrete and Portland cement M400 D20 concrete makes 41 and 38 MPa., then 1 % PC SP exceeds the Rc for 86 and 74 % and with basalt filler the Rc of concrete increases for 46 and 32 % relatively when the cement consumption is reduced for 30 %. In other words, the use of PC SP additive enables to obtain B60 high-strength self-sealing concrete on the typical Portland Cement with DO, and with D20 — increased strength of B40 grade.

The dependence of the impact of cement consumption rate on the concrete strength with PC SP additive is curvilinear (fig. 2) Rc with the cement content of 292, 370 and 450 kg/m^3 is above the standard for 54, 65 and 74 %, which ensures the formation of high-strength concrete.

The highest strength is predetermined by the selection of particular sand/broken stone ratio (fig. 3).

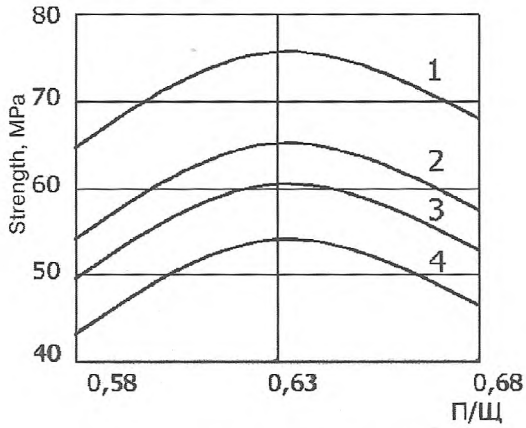

Fig. 3. Dependence of concrete strength from sand/broken stone ratio: 1 — concrete on Portland Cement M400 DO; 2 — concrete on Portland Cement M400 DO + 40 % bas. filler; 3 — concrete on Portland Cement M400 D20; 4 — concrete on Portland Cement M400 D20 + 30 % bas. filler

Dependence of concrete Rc with PC SP additive, and basalt filler is extreme with the maximal value in case of the sand/broken stone ratio of 0.63. The reduction or increasing of sand content in the filler compound increases cavitation which leads to the reduction of concrete Rc.

Due to dispergation effect and penetration effect the PC SP additive (1 %) significantly accelerates the time of concrete solidification under normal conditions. With this the Rc of concrete with PC SP additive in 3, 7 and 14 days of solidification is higher than the standard for 17, 20 and 21 %, which is an important technological effect both for monolith and assemble reinforced concrete structures from the point of view of form reuse and reduction of energy consumption.

Thus, the researches proved the efficiency of practical use of PC SP in concrete technology and ability to obtain low cement-consumable self-sealing concrete compounds, high-strength concrete of B50 and B60 grades on Portland cement M400 DO and increased strength of the grade B40 and B50 on Portland cement M400 D20 with the use of 30 % high-density basalt filler.

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