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Low-shrinkage alcohol cement concrete

Alexsander Shishkin[1,a], Alexsandra Shishkina[2,b], Nikolai Vatin[3,c]

[1,2] Krivoy Rog National University, Ostrovskogo 21, 50005 Krivoy Rog, Ukraine,

[3]St. Petersburg State Politechnical University, 195251 St. Petersburg, Russia

[a] 5691180@mail.ru, [b] shishkina_tbvk@mail.ru, [c] vatin@mail.ru,

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Abstract. The article deals with the results from the analysis of the materials properties based on portland cement, polyalcohol and iron-bearing mineral assemblage. These materials are proved to possess higher compressive strength and lower shrinkage properties first and foremost, and besides they secure appropriate structural properties under a design project as well. On the grounds of the tests carried out it has been suggested to use the mix design of glycerin with portland cement and iron-bearing mineral assemblage with the purpose to obtain the material having the high compressive strength and most nearly lacking the shrinkage properties.

Introduction

While buildings and structures are constructed, renovated or repaired it quite often calls for junctions to be built-up between existing construction objects. Conjunction of both materials - the material of the existing construction structure (concrete or metal) and the material of the new element - is true for all the cases. It's obvious when the processes of formation of the structures - and consequently of the material properties of the existing construction structures - have almost finished by the moment of its repair or application (for pre-cast structures), such processes in the material of the new element has just started to take place. These processes (mainly, in the most widely-used materials) are accompanied by contraction occurrences. Consequently, at the boundary line between «the material of the existing construction structure and the material of the reinforcing element (conjunction with another structure) « shearing stresses emerge which may break (or, in the limiting case, destroy) the contact between the materials specified above. The impacts of these shearing stresses can be compensated only owing to high adhesion strength between the new material and the material of the existing structure. The more the value of the shearing stress caused by contraction of the new material the more the value of the adhesion strength regarding the material of the existing structure should be. Thus in this case the material applied for existing construction structures to be repaired and conjunct has to possess two applicable properties which are the must: high adhesion strength regarding the material of the existing construction structure and low contraction shrinkage. Besides this material should not be aggressive one towards the material of the existing structures.

Nowadays the concrete based on portland cement or especially the materials based on portland cement with polymer mix designs added are used with the aim to reinforce the structures and to build-up the joints between them [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22].

The materials specified herein, especially the ones with polymer mix designs added, either lack adhesion strength regarding the material of the existing construction structures or have considerably high contraction. With the high values of the quality indicators they either lack compressive strength or have high costs having constraints in terms of their application.

The grounds for the study to be conducted have been encouraged by the need to develop the material having high adhesion strength appropriate for basic materials used in construction structures manufacturing, and low contraction shrinkage or even being non-shrinkable at all [23, 24, 25]. Some results of this study are presented below.

The analysis of the well-known materials with the lower contraction shrinkage [26] has revealed that they either have low adhesion strength regarding other construction materials or they consist of sufficiently deficient components, or these materials are of a high cost.

In this respect litharge-glycerin cement [27] generates reasonable interest. It possesses high adhesion strength regarding the majority of construction materials while lacking shrinkage owing to contraction.

This type of the cement has a disadvantage due to binding usage of litharge which is quite costly and environmentally unfriendly.

Having analyzed the properties of glycerin as well as existing surveys on its application in concrete production [28, 29] it has been specified that it can interact not only with litharge [27] but also with the oxides of the other multivalent metals such as calcium, iron, aluminum and etc.

Polyalcohols [30] are able to dissolve caustic alkalis, oxides of calcium, strontium and barium, potassium sulfate, sodium sulfate, copper sulfate and many other salts in large amounts. Like other alcohols they produce glycerates - in most cases crystal and easily variable compounds – when exposed to alkaline metals and oxides of alkaline-earth and heavy metals.

Chemically bonded concretes can be obtained by means of polyalcohols and its derivatives (ethylene glycol, glycerin, ethylene chlorohydrin, mono chlorohydrin and others), and oxides of some metals (lead, calcium and others). Some of them have sufficient strength [30].

Experimental program.

This has developed the grounds for the hypothesis suggesting that the system «glycerin – portland cement» makes it possible for reactions between glycerin and free calcium oxide which is contained in portland cement, to take place with the glycerate formation and water educing by analogy with the reaction of the lead glycerate formation.

The water educed as a result of this process starts to interact with the remaining minerals of portland cement and leads to additional increase in strength of the pre-cast stone.

This hypothesis has been confirmed by the results of the tests carried out. These tests have shown that in the structure formation process of the disperse system «glycerin – portland cement» the pre-cast stone is being formed with the following data: compressive strength from 1.0 to 40 MPa (Fig. 1), adhesion strength to concrete obtained on the basis of portland cement from 0.5 to 15 MPa and contraction shrinkage 0…0.1%.

Results and discussion.

As the result of the tests carried out there have been found out that having applied polyalcohol in the amount of 20% of the mass of portland cement in the system «glycerin – portland cement» it makes feasible to increase setting rate and strength of the cement stone. It can be confirmed by the mechanism of polyalcohol participation in the hydration processes of cement as an active mineral admixture. If the amount of polyalcohol exceeds 20% of the mass of portland cement hydration processes of cement start to retard dramatically up to complete stop. This can be evidently explained by the fact that polyalcohols have certain surface activity, and having the contents stated above in the system either block up the cement particles or involve calcium hydroxide totally into preventing hydrosylicates formation.

The water and glycerin ratio makes considerable impact on the strength of the resulting material at the same time (Fig. 1). The material to be obtained possesses minor strength provided there are equal proportions of water and glycerin. It has ultimate strength provided there is glycerin in the amount of 80% in the water-glycerin ratio. When having such a ratio between water and glycerin (1:4) the resulting material possesses not only ultimate strength but also the lowest value of shrinkage deformations which are most nearly unavailable in this case.

The second set of tests carried out has predetermined wide usage of mineral ad-mixtures [31, 32, 33, 34] to obtain high-standard concrete nowadays. The tests of the second set have been conducted to study density and strength of aerated concrete (foam concrete) [35, 36] according to containing of

the components of the mixed additive consisting of iron-bearing mineral assemblage [37] and polyalcohol. The tests design has been implemented on the grounds of the computer materials sciences by the method of two-factor experiment. The following variables have been taken therein: the value of X1 – alcohol consumption per 1000 cm3 of the cement paste, and X2 – iron-bearing mineral assemblage consumption (iron content in the assemblage equal to 17.3 %) per 1000 cm3 of the cement paste. The strength of aerated concrete has been specified by regular testing of the standard samples.

The tests carried out have defined that the behavior of polyalcohol impact on the strength of aerated concrete can be comparable with the iron-bearing mineral assemblage (Fig. 2). With the content of polyalcohol in the system increasing up to a certain limit the strength of aerated concrete increases as well (Fig. 2). And as soon as this limit is reached the strength of aerated concrete starts to reduce.

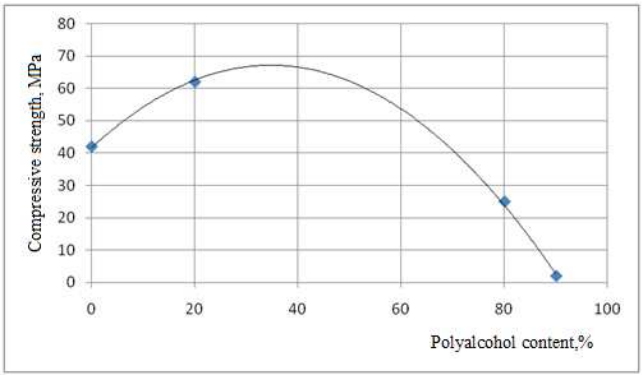

Fig. 1. Impact of glycerin content binding compressive strength in liquid phase (L/C=0.17, L – mix of glycerin and water)

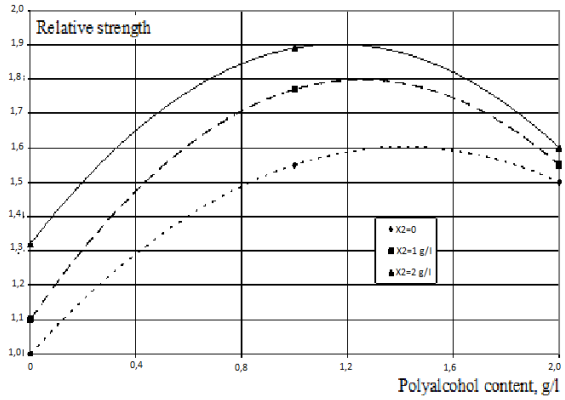

Fig. 2. Iron-bearing mineral assemblage (X2) and polyalcohol impact on the compressive strength of aerated concrete (foam concrete)

Whereas the major increment in strength of aerated concrete takes place when there is a basic (relatively to the tests design) content of polyalcohol and iron-bearing mineral assemblage (polyalcohol content - 1 gr/l, iron-bearing mineral assemblage content – 2 gr/l). On the grounds of the tests carried out the following conclusion can be made: applying iron-bearing mineral assemblage and polyalcohol makes it possible to obtain low-shrinkage concretes both dense and aerated, which possess quite high compressive strength. Whereas the impact of the additives stated above on the strength of aerated concrete appears to be more significant in comparison with the impact on the strength of dense concrete.

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