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LOBODA KATERYNA, ZAGORUYKO TAMARA, ZAICHENKO MYKOLA
Donbas National Academy of Civil Engineering and Architecture**HIGH-PERFORMANCE CONCRETE WITH RESTRAINED SHRINKAGE**

Abstract. To prevent restrained shrinkage of high-performance concrete used complex modifiers are used such as: high water-reducing superplasticizer; an expanding component of calcium oxide; an expanding agent that reduces the surface tension of water. This complex increases the effectiveness of each product (the so-called synergistic effect), which partially or completely eliminates shrinkage. It reduces the risk of rapid moisture evaporation of due to climatic conditions hardening. To quantify restrained shrinkage technique «ring test» is used, according to ASTM C1581-04 Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage.

Key words: high-performance concrete, restrained shrinkage, modifier, restrained admixtures.

During the last years High-Performance Concretes have become more and more commonly used. High-Performance Concrete (HPC) is a material that exhibits adequate workability, high strength, low permeability, superior dimensional stability, and long-term durability [5]. However concrete mixtures with low water-binder ratios, incorporating highly-active pozzolans such as silica fume have been observed to undergo significant shrinkage cracking, especially if adequate curing is not provided [4, 8]. Due to the chemical shrinkage that occurs as the cement hydrates, empty pores are created within the cement paste, leading to reduction in its internal relative humidity and a measurable shrinkage that can cause early-age cracking. The empty pores created during self-desiccation not only induce shrinkage stresses but also influence the kinetics of the hydration process, limiting the final degree of hydration, and thus strength, that can be achieved relative to that obtainable under saturated curing conditions [6, 9].

Several methods are available to limit shrinkage: expanding and non-shrinking cements, surface treatments, shrinkage reducing admixtures (SRA) and expansive admixtures [10]. The technology of shrinkage-compensating concrete is based on the use of special products, such as calcium sulpho-aluminates or calcium oxide, which react with water and produce a restrained expansion in reinforced concrete structures. This technology has been invented many years ago, but its use has been very limited in practice due to the difficulty in adopting continuous water curing absolutely needed at the early ages after setting [3, 8]. The experimental data of many researchers' showed that the expansive agent was more effective for water immersed samples. However, from a practical point of view, this technology can be adopted only in some special constructions such as concrete floors or slab foundations.

The synergistic effect in the combined use of SRA and a CaO-based expansive agent in the absence of wet curing have been invented by Mario Collepardi scientific group. On the other hand, this synergistic effect should be much stronger if adequate internal water curing can be provided. So, the partial replacement of normal weight fine aggregate with presoaked LWA (light weight aggregate) will effectively reduce the shrinkage of high-performance concrete that will result in a significant decrease in restrained shrinkage cracking [1, 2].

Standard tests, such as the restrained ring test (ASTM C1581), can be used to quantify how likely it is that a mixture will crack due to the stresses developed under constant temperature conditions [7]. To demonstrate this approach, a plain and three internally cured mortar mixtures were tested and the results of these tests are discussed. The restrained ring test is performed by casting an annulus of a cementitious mixture (paste, mortar, or concrete) around a steel ring. Residual tensile stress develops in the sample as it attempts to shrink but is restrained by the ring. A crack results if the stress that develops due to restraint (called «residual stress» sometimes) exceeds the developing tensile strength. The standard suggests that the relative

cracking potential of mixtures can be quantified by comparing the amount of time required to crack the samples [3]. Shorter measured cracking times indicate a relatively higher cracking potential, whereas longer cracking times indicate a lower cracking potential. While ASTM C1581-0418 describes a material behavior in terms of the age of cracking.

This project purpose is to investigate the influence of the combined effect of expansive and shrinkage reducing admixtures on the free and restrained shrinkage of internally cured High-Performance Concrete.

The main tasks of the project are:

- to develop the mix composition of HPC to satisfy all performance criteria for concrete in both fresh and hardened states;
- to determine the setting time of cement paste samples with addition of Shrinkage Reducing Admixture (propylene glycol ether based);
- to evaluate the influence of Shrinkage Reducing Admixture on the rheological properties of HPC mixtures and long-term behavior of concrete;
- to investigate the effect of Shrinkage-Reducing Admixture on the free and restrained shrinkage of concrete;
- to evaluate the influence of combined effect of Expansive Admixture (calcium oxide based) and Shrinkage Reducing Admixture on the free and restrained shrinkage of High-Performance Concrete without wet curing;
- to evaluate the influence of combined effect of Expansive Admixture and Shrinkage Reducing Admixture on the free and restrained shrinkage of internally cured High-Performance Concrete (with partial replacement of normal weight fine aggregate by presoaked LWA).

Expected results from carrying out of the project are the following:

- the formulations of High Performance Concrete incorporated Expansive and Shrinkage Reducing Admixtures as well as internal curing agent;
- new experimental data on the influence of combined effect of Expansive Admixture and Shrinkage Reducing Admixture on the free and restrained shrinkage of internally cured High-Performance Concrete (with partial replacement of normal weight fine aggregate by presoaked LWA).

USE OF RESULTS

The results of the research will be used in the teaching and learning process for training Masters of Science on the specialties «Industrial and Civil Engineering» and «Technologies of Building Structures, Products and Materials» in teaching courses «Modified Concretes of New Generation», «Technology of Concrete and Reinforced Structures», «Modern Technologies of Building Materials and Products».

The results of the research will be proposed for the ready-mixed concrete producers and precast concrete works of the Donetsk region.

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ВЫСОКОКАЧЕСТВЕННЫЕ БЕТОНЫ С КОМПЕНСИРОВАННОЙ УСАДКОЙ
ГОУ ВПО «Донбасская национальная академия строительства и архитектуры»

Аннотация. Для предотвращения стесненной усадки высококачественных бетонов используется комплекс модификаторов, в частности: суперпластификатор с высоким водоредуцирующим эффектом; расширяющийся компонент на основе оксидов кальция; расширяющая добавка, снижающая поверхностное напряжения воды. Данный комплекс усиливает синергетический эффект каждого продукта, что исключает частично или полностью усадку. Снижается риск быстрого испарения влаги, обусловленный климатическими условиями твердения. Для количественной оценки стесненной усадки бетона использована методика «ring test», согласно ASTM C1581-04 Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage.

Ключевые слова: высококачественный бетон, компенсированная усадка, расширяющие добавки, модификаторы.

К. С. ЛОБОДА, Т. І. ЗАГОРУЙКО, М. М. ЗАЙЧЕНКО
ВИСОКОЯКІСНІ БЕТОНИ З КОМПЕНСОВАНОЮ УСАДКОЮ
ДОУ ВПО «Донбаська національна академія будівництва і архітектури»

Анотація. Для запобігання обмеженої усадки високоякісних бетонів використовується комплекс модифікаторів, зокрема: суперпластифікатор з високим водоредукующим ефектом; розширювальний компонент на основі оксидів кальцію; розширювальна добавка, яка знижує поверхнєве напруження води. Даний комплекс підсилює ефективність кожного продукту (так званий синергетичний ефект), що виключає частково або повністю усадку. Знижується ризик швидкого випаровування вологи, обумовлений кліматичними умовами твердіння. Для кількісної оцінки обмеженої усадки бетону використана методика «ring test», згідно ASTM C1581-04 Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage.

Ключові слова: високоякісний бетон, компенсована усадка, розширювальна добавка, модифікатор.

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