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RAPID HARDENING MODIFIED CONCRETES

In this paper the influence of technological factors on the formation of properties of fine-grained concrete is shown. Rapid hardening concrete, modified with complex chemical admixtures, for prestressed precast hollow core slabs produced by continuous extrusion forming were designed.

Key words: modified concrete, strength, precast hollow core slab, technological factor, complex modifier, heat treatment.

Відображено дослідження впливу технологічних факторів на формування властивостей дрібнозернистого бетону. Розроблено швидкотвердіючий бетон, модифікований комплексними хімічними домішками, для попередньо напружених залізобетонних порожнистих плит, вироблених способом безперервного формування.

Ключові слова: модифікований бетон, міцність, збірні порожнисті плити, технологічний фактор, комплекс модифікаторів, термообробка.

Introduction

Recently the new precast-monolithic building is increasingly implemented in civil residential buildings, which involves using of the maximum amount of precast reinforced concrete constructions. It allows creating relatively inexpensive precast monolithic buildings. They are fast erected, highly demanded on the market of available housing, characterized by high availability and competitiveness, and allow to solve the problem of mass building.

Statement of the problem

Prestressed precast hollow core slabsare the most widely used precast concrete system in the building industry. Usually, they are made by extruded concrete technology. It is widespreadand replaces traditional cassette principle of forming slabs by reducing the cost by 20% [1]. However, there are some problems at continuous formation of hollow core slabs, in particular unforming of the articles in the short term, providing the necessary transmission and branding strength, which lead to high demand of Portland cement and using of energy-consuming heating. Usuaslly, the high-strength concrete of strength class B30 - B50 are used for production of hollow core slabs. Such types of concrete produced on the basis of Portland cement type CEM I-42.5 which is characterized by a high clinker content and high pfig. So the designing of rapid hardening concrete based on Portland cement CEM II/A-S-42.5, CEM II/B-S-32.5 through their modifying by complex chemical admixturewithout loss of building-technical properties is important.

Analysis of recent publications

There are many methods and techniques intended for changing of the concrete structure and creating material with predetermined properties depending on the assigned task. Concrete properties are influenced by technological factors, accepted methods of the concrete mix producing and forming, and technological curing regimes [2]. By changing the raw materials, composition and technological regimes, it is possible to regulate the structure of concrete in the necessary direction. The strength of concrete depends on the quantity and quality of aggregates, grade and quantity of Portland cement, the amount of water, and the presence of admixtures [3, 4].

Heat moisture treatment (HMT) is the most common method for accelerating the concrete hardening in the factory conditions. Increasing of temperature up to 60-100 °C results in acceleration of cement hydration reaction 6-12 times [3, 5]. However, the main disadvantage of heat moisture treatment is high energy consumption, which greatly affects the cost of articles. Currently, the heat treatment consumes about 55 kg of conditional fuel (1600 MJ) per 1 m^3 of precast reinforced concrete.

Increasing of the hardening temperature of concrete may results in shortfall of normative strength at further curing in standard conditions. Coefficients of thermal expansion of water and air are higher than those of aggregates and hydration products. Due to this, water and air pushes apart the solid components at heat moisture treated, creating internal pressure that may exceed the strength of fresh concrete articles, which leads to irreversible damage of concrete structure – reducing of strength, the appearance of micro cracks and capillary channels [5].

Irregularities of temperature distribution in the volume of concrete articles arise during heating and cause thermal expansion of different parts and zones of the articles, thermal tension and deformation. Crush of concrete structure, depending on the degree of temperature influence and destructive processes, compared to concrete of normal hardening is characterized by the deterioration of its main physical and mechanical properties (strength, durability, frost resistance) [4]. Therefore, the unheated and low heated technologies with a significant reduction of energy resources, increased turnover of heating equipment and productivity of technological lines for the production of precast concrete are more effective [6]. Mixing is critical because being in limited quantities water must be well dispersed in the mix. Water reducing admixtures can be used to optimize a mix by reducing cement and water requirements while still retaining adequate workability for proper compaction of the concrete by the machine [1].

Physical and chemical modifying can essentially change the technological properties of concrete mixes due to synergistic combination of presented individual components, allowing to control system parameters on the stage of interaction of cement with water, ensure rapid hardening of the concrete, reduce porosity, increase durability and provide lower cement consumption, which is a prerequisite for the design of modern building materials with improved quality parameters [2, 4].

Admixture as component of concrete composite even of a very insignificant percentage may contribute a lot to its technical properties. The role of admixtures, as the reason of the technological regulation, is increased to adequately growth of their influence on cement hydration and structure formation, properties of fresh concrete and concrete. Complex admixtures have a few reagents of different nature and mechanisms of action, each of which carries the special function. Main forming principle of complex admixture compositions is achieved necessary effects in technological and economic aspects consideration of compatibility with cements [7, 8]. One of the main directions in the chemistry and cements technology development is the creation of rapid-hardening Portland cement binders which allows intensify hardening of concrete strength development. For intensification of binder materials, the hardening accelerators such as inorganic electrolytes are used [7]. Using of complex chemical admixtures of plasticizing and accelerating action allows ensuring the technological properties for the mixtures, obtaining the desired hardening speed of concrete hardening and significantly decrease cost of precast concrete constructions.

Purpose of work - to investigate the influence of technological factors and chemical modifiers of plasticizing and accelerating action on the strength of concrete after heat treatment.

Materials and methods

Portland cements CEM I-42.5, CEM II/A-S-42.5 and CEM II/B-S-32.5 JSC "Ivano-Frankivsk Cement" were used. Natural sand of Yasynytska (modulus fineness M_F = 1.32), Rohatyn (M_F = 1.35) and Zhovkva (M_F = 2.1) quarries, and three coarse aggregates (fractions 2.5-5 mm, 5-10 mm and 10-20 mm) were used for concrete production. To improve efficiency and properties of concretes chemical admixtures such as plasticizer based on lignosulphonate Centrament N3 and complex chemical admixtures of plasticizing and accelerating action of Technocon WP were used.

Technological properties of concrete mixtures and concrete strength were determined in accordance with applicable standards and usual procedures. Concrete cured in normal conditions and at heat moisture treatment by regime (2+10+2) (isothermal temperature was 50°C).

Results and discussion

The adding of aggregates worsens rheological parameters of the mixture and requires significant increase in water-cement ratio to obtain flowability of mixture, which limits the value of maximum strength of concrete. The properties of fine-grained concrete with different ratio of cement:sand (PC:S) were investigated. The results of fine-grained concretes with CEM II/A-S-42.5 and Yasynytska sand were investigated. It was observed that for obtaining the mixtures of equal flowability (flowing is 110-115 mm) with increasing amount of aggregate it is necessary to increase the amount of water.

Thus, when introducing the sand in a ratio of PC:S=1:1, water demand has increased by 12%; when increasing the ratio to 1:3, water demand has increased 1.7 times as much comparing to Portland cement paste. Testing of fine-grained concrete showed that maximum strength of the material is achieved with reducing amounts of aggregate. The best results can be achieved with cement paste for which strength after 28 days is 75 MPa. When using in the cement composition the sand in the ratio 1:1, early strength has reduced 1.2 times, and the strength after 28 days –1.9 times. The results of strength tests of fine-grained concrete in the ratio of 1:3 showed that strength is significantly reduced compared with concrete 1:1. Thus, the concrete strength after 2 days has decreased 7.3 times, and after 28 days - 1.6 times.

The quality of aggregates has significant influence on the concrete strength. The investigation of fine-grained concrete of composition - cement:sand:broken stone = 1:1.2:0.69 (flowing is 110-115 mm) after heat treatment showed that, using Rohatyn sand as fine aggregate, fine-grained concrete based on CEM II/A-S-42.5 is characterized by 42.8% higher strength compared to concrete based on CEM II/B-S-32.5 (fig. 1). Replacement of fine aggregate for Zhovkva sand provides increasing of the strength of fine-grained concrete based on CEM II/A-S-42.5 by 37.9%.

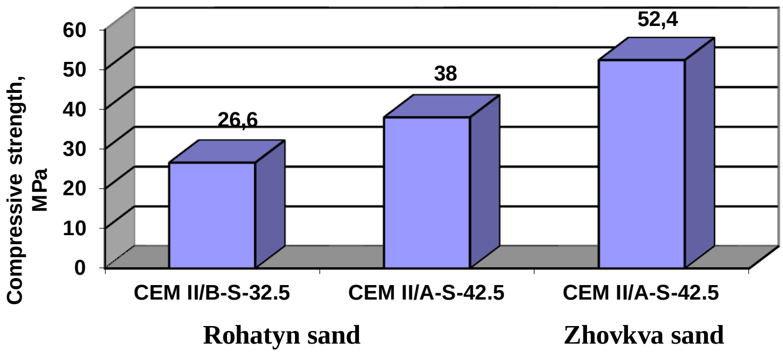

Fig. 1. Results of compressive strength test after heat treatment of fine-grained concretes (PC:S:BS=1:1.2:0.69)

The strength of fine-grained concrete based on CEM I-42.5 and modifying with Centrament N3 after heat treatment is reduced by 9% compared with the control composition (Table 1). At the same time, using of complex admixture Technocon WP provides increasing of concrete strength by 11%.

Table 1

Strength of fine-grained concrete PC:S:BS= 1:1.12:0.63
(F = 110-115 mm)

Type of Portland cement	Type and amount of admixture	Strength after HT, MPa		C_s
		compressive	bending	
CEM I-42.5	-	31.0	2.7	-
	0.5 mass.% Centrament N3	28.9	2.7	0.93
	1.2 mass. % Technocon WP	34.5	2.9	1.11
CEM II/A-S-42.5	-	32.2	2.5	-
	0.5 mass.% Centrament N3	32.4	2.6	1.01
	1.2 mass. % Technocon WP	34.0	2.6	1.06
CEM II/B-S-32.5	-	17.5	2.7	-
	0.5 mass.% Centrament N3	17.8	2.9	1.02
	1.2 mass. % Technocon WP	21.2	2.5	1.21

Strength of fine-grained concrete based on Portland cement CEM II/A-S-42.5 is higher than the strength of concrete based on the CEM I-42.5. Concrete based CEM II/A-S-42.5 without admixtures and with admixture Centrament N3 is characterized by strength 32.2 and 32.4 Mpa respectively. When using 1.2 mass.% Technocon WP, the strength has increased by 5.5% compared to concrete with the admixture Centrament N3.

Fine-grained concrete based on Portland cement CEM II/B-S-32.5 is characterized 1.8 times lower strength compared to concrete based on CEM I-42.5. The admixture Centrament N3 does not provide increasing of strength after heat treatment of fine-grained concrete based on CEM II/B-S-32.5. The strength of fine-grained concrete without admixture and with Centrament N3 is 17.5 and 17.8 MPa respectively, while the strength of concrete with admixture Technocon WP increases by 21%.Therelative strength coefficient C_s characterizes effectiveness of used admixtures. The changing of the relative concrete strength shows that introduction of admixture Centrament N3 has a blocking effect on the kinetics of early strength development of concrete based on the CEM I-42.5 (C_s = 0.93) and no effect on the strength of concrete based on CEM II/A-S-42.5 (C_s = 1.01) and CEM II/B-S-32.5 (C_s = 1.02). Introduction of complex admixture Technocon WP promotes increasing of relative early strength index C_s of concrete on the base of all cement types. So C_s value for Portland Cement CEM I-42.5 is 1.11, CEM II/A-S-42.5 - 1.06 and CEM II/B-S-32.5 – 1.21.

Comparative investigations of chemical modifiers were carried out on heavy concrete nominal composition 1:1.66:0.95:2.53 project class of compressive strength B35 consistency class of fresh concrete G2 (V4). Rohatyn sand, granite gravel fractions 5-10 and 5-20 mm respectively in the ratio (1:2) were used as aggregates. Testing of concrete based on Portland cement CEM I-42.5 showed that the concrete with 0.5 mass.% Centrament N3 is characterized by compressive strength 45.6 MPa, and with the 1.2 mass.% Technocon WP – 47.1 MPa (fig. 2).

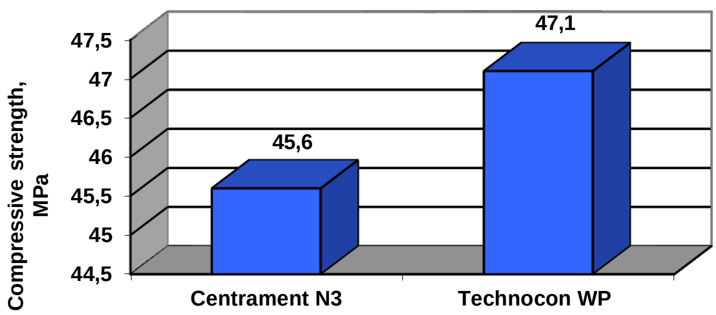

Fig. 2. Compressive strength of concretes after heat treatment

Conclusion

The effective heat treatment technologies with significant reduction of energy resources increase turnover of heating equipment, productivity of technological lines and reduce the cost of production of modern precast concrete. The peculiarity of production of low heating high-strength concrete is the use of complex modifiers which combine the organic component in the form ofsuper plasticizer and the accelerator of the hardening process. Designing of rapid hardening modified concretes with complex admixture of plasticizing and accelerating action provides obtaining of strength 47.1 MPa (class B35) at low heated regime of curing.

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