Self-Compacting Concrete mechanically activated on Portland cement with the addition of ground hydrated cement

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Abstract – The paper deals with the influence of ground hydrated cement (GHC) on the change in the strength characteristics of self-compacting concrete. It is found that the addition of hydrated cement binder can accelerate the process of curing concrete in the early stages of hardening, as well as to increase the strength of the vintage age.

Key words – the hydrated cement stone, mechanical activation, self-compacting concrete, strength, and softener.

I. Introduction

Progress in the field of construction contributed to the emergence of high-vibration-free concretes. A distinctive feature is their high mobility in the initial stage of hardening, achieved through the use of super plasticizer Super-PC [1, 2]. Such concrete mixes under its own weight completely fill the space of the formwork, including between the reinforcing bars.

Self – Compacting concrete was first introduced in Japan in 1988 in order to reduce the skilled labor force required for laying of concrete and concrete structures possibility of complex configuration [3, 4].

Using polycarboxylates can receive a self – compacting concrete compressive strength of 40 to 100 MPa. Along with providing high – grade strength is not less important is to increase the early strength of concrete. Increasing the strength of concrete at an early age can accelerate the pace of construction of concrete and reinforced concrete structures and increase the turnover of the formwork of self-compacting concrete.

It is known the use as a hardening accelerator of cement stone and concrete on the basis of its ground of the hydrated cement stone [5, 8]. Acceleration of structure formation of cement stone and concrete based on it is achieved with all kinds of activation [6, 7].

Of interest is to investigate the combined influence of ground hydrated cement and mechanical activation of both the kinetics of curing of self – compacting concrete and the strength in its vintage age.

II. Experimental plan

In studies as the binder was used Portland cement M 500 of Kamenetz-Podolsk cement plant. The experiment was conducted on a 12-point-like 2-factorial D-optimal plan. As an independent prescription factors are taken:

- The content of ground hydrated cement in Portland cement (X_1 = 3±2%);
- Consumption of binder (X_2 = 450±100 kg/m^3).

Plastic coating of concrete was realized by the introduction of its composition, together with the mixing water super plasticizer Super –PC. Plasticizer content was assumed to be 1% by weight of binder. As fillers were used quartz sand with an M_{kr}=2,2 and crushed granite fraction 5…10 mm and 10…20mm.

Concrete mixes were prepared both separately (pre-activation of the binder) and by the conventional technology. Characteristic feature of concrete mixing by separate technology lies in the fact that pre-activated binder slurry was combined later with quartz sand and granite rubble in the ordinary concrete mixer. Activation occurred slurry in a specially designed mixer activator for 90 sec at a speed of rotation of the rotor 2800 rpm/min.

To control the ready-mixed of similar composition, mixing of ingredients was produced in the ordinary concrete mixer. Flow ability of concrete mixtures was determined by Abrams cone and was a plan for each line of 70cm.

The compressive strength of concrete was determined by testing samples of cube with an edge of 10 cm. Concrete mixture was not subjected to vibration. Hardening of the samples occurred in the normal curing chamber at a temperature of 18-20ºC and a relative humidity of not less than 95%. Concrete compressive strength was determined at 2, 7, 14 and 28 days.

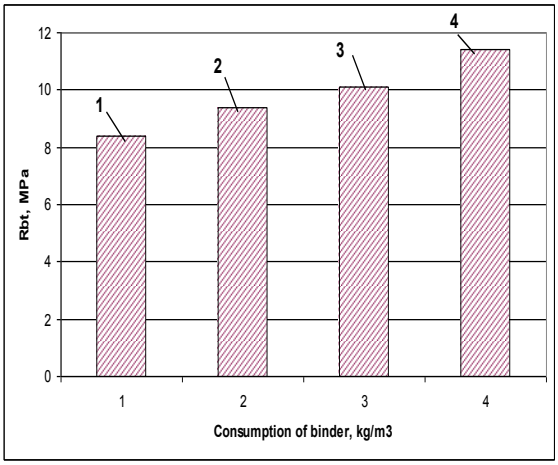

Fig. 1. The influence of factors on the prescription R_{bt} concrete at the age of 2 days (consumption binder 350 kg/m^3). 1 – control: 2- concrete with addition of 5% of ground hydrated cement; 3- concrete on activated binder; 4- concrete on activated binder with addition of 5% of ground hydrated cement

The mathematical treatment of the results of experiments yielded a number of mathematical models describing the combined effect of the studied factors on R_{bt} concrete. Analysis of mathematical models allows us to conclude that each of these independent factors (X_1, X_2) has a significant influence on the strength of concrete as a binder in the mechanically activated and on the strength of the concrete binder which is not subjected to mechanical activation (control). This is confirmed by a graph shown in figure 1.

Introduction to Portland cement of 5% of ground hydrated cement increases the strength of the concrete in 2-day-old on not-activated binder (control) from 8,4 to 9,5 MPa, at 13%. The mechanical activation binder (without addition of hydrated cement ground) increases the strength of concrete as compared with the control from 8,4 to 10,1 MPa, at 20%. The mechanical activation binder with the addition of 5% of ground hydrated cement leads to increase of strength of concrete from 8,4 to 11,4 MPa, at 35%.

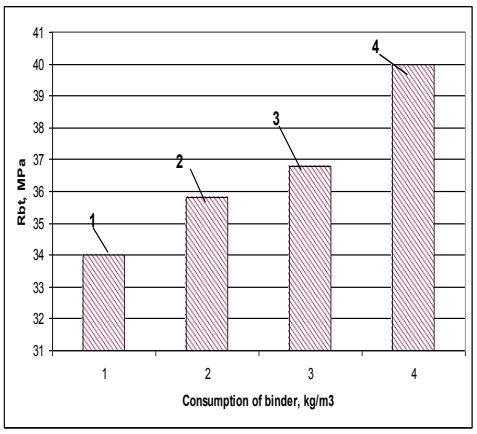

Fig.2 The influence of factors on the prescription R_{bt} concrete at the age of 2 days (consumption binder 350 kg/m^3) 1 – control; 2- concrete with addition of 5% of ground hydrated cement; 3- concrete on activated binder; 4- concrete on activated binder with addition of 5% of ground hydrated cement

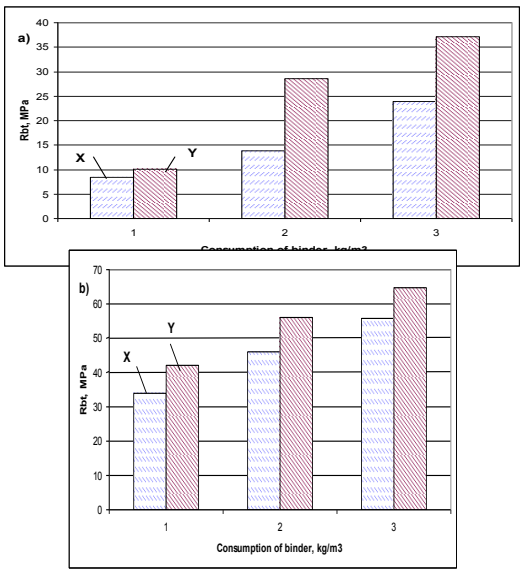

Fig.3 The influence of consumption of binder on change of the compressive strength of concrete: a) – at 2 –day-old; b) – in the vintage age; 1,2,3 – consumption of binder 350, 450 and 550 kg/m^3 respectively; X – control; Y – the mechanical activation with the additional of 5% of ground hydrated cement

A similar effect of ground hydrated cement and mechanical activation is observed for the concrete in the vintage age. Proof of this is a graph shown in figure 2.

As can be seen from figure 2, the mechanical activation Portland cement in the presence of 5% ground hydrated cement increases the compressive strength of self-compacting concrete in the vintage age from 34 (control) to 42 MPa, at 24%.

The similar effect of ground hydrated Portland cement and mechanical activation has been observed on the strength of concrete at a rate of Portland cement from 450 to 550 kg/m^3. This is typical for concrete as 2-day and in the vintage age, figure 3a,b.

It should be noted that the increasing consumption of Portland cement from 350 to 550 kg/m^3 is possible to achieve concrete strength in 2-day-old to 23,9 MPa, which can be attributed to this type of concrete to the quick-setting concrete (according to DSTU B.V. 2.7-91-99.

In vintage age the compressive strength of concrete on mechanical activated binder with the addition of 5% of ground hydrated cement exceeds the strength of samples test on 15%.

Conclusion

Revealed the accelerating effect on the increase of the compressive strength of concrete on mechanical activation of Portland cement with the addition of 5% of ground hydrated cement. Especially it is evident in the early stages of hardening concrete (2 days) – increase of compressive strength of concrete is 35%. By the 28 days of curing the difference in strength of the concrete is reduced and is not more than 12…15%.

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