TESTING A 550 PORTLAND CEMENT

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Received March 30, 1989
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Abstract

The high initial strength cement was investigated as a possible alternative to steam curing during precasting of concrete elements. A 500 m^2/kg specific surface of cement resulted in high initial strength.

In a summer climate the 550 portland cement is effective without plastificator admixture since the 1 day strength of the plastic concrete is about 30% of the 28 days' strength. With 2 m% plastificator the 1 day strength is about 40% of the 28 days' strength.

If concrete is stored at 40 °C for 24 hours the 12—16 hours' strength is already enough to allow the elements to be removed from the form work. Lower cement content (250—300 kg/m^3) results in higher tensile strength relative tothe compressive strength which is an advantage when from work is removed.

Inceasing the cement content marginally increases the initial strength.

During cold weather the role of grading (fine grinding) is more important.

1. Introduction

In Hungary steam curing is generally used during the precasting of concrete and reinforced concrete elements. The energy crisis initiated an investigation into other methods. The Bekes State Conctruction Company (BSCC) would like to leave steam curing out of its precasting technology. The Department of Building Materials suggested using the existing, but not mass produced, 550 portland cement. Laboratory experiments were set up to investigate the properties of the factory made cement.

2. The experiments

The *cement*, originally clinker from Lábatlan (cement factory in Hungary) was ground to around 500 m^2/kg specific surface (Blaine-method). Table 1 summarizes the properties of cement. The mineral components show that it is an ordinary portland cement. The *aggregate* was a sieved and dried sandy gravel with around 70% quartz content. The maximum diameters were 8, 16 and 32 mm. The grading curves ran between the *A* and *B* limit curves (e.g. $d_{max} = 15$ mm, see Figure 1). The aggregate used did not contain any of the 0.25 mm or smaller grade sand.

Table 1

The Properties of Cement

Physical properties of cement	
Water content, m %	27
Volumetric stability	satisfactory
Density	3.103
Specific surface (Blaine) m^2/kg	507
Setting starts	1 h 50 min
ends	3 h 10 min
Sifted through mass m %	
on a sieve 300	1.8
on a sieve 4900	3.6

Standard strength of cement		
Age day	Strength, MPa	
1	compressive	16.2
	flexure	3.63
3	compressive	28.4
	flexure	5.07
7	compressive	39.9
	flexure	8.47
28	compressive	46.6
	flexure	8.73

Mineral components of cement m%	
C_3S	50.97
C_2S	20.10
C_3A	8.37
C_4AF	10.01
MgO	2.43
free CaO	1.05
SO_3	3.40
ignition losses	2.97

The water-cement was chosen to satisfy the following consistency conditions.

Consistency	Sign	Number of Tamping
plastic	K	35—50
slightly plastic	KK	65—85
soil wet	FN	100—120

During some experiments 2 m% VISCOMENT V water-reducing and 4 m% KALCIDUR 85 ($CaCl_2$) accelerator admixtures were added. Cubes (150 × × 150 × 150 mm^3) were cast. The concrete was mixed in a 50 l capacity force mixer and vibrated at 3000 rev/min. The curing temperature was different.

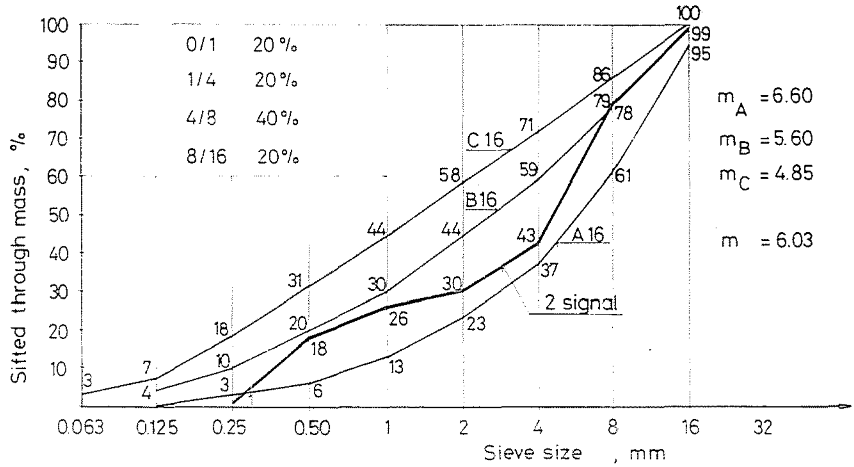

Fig. 1. Grading of a 1st class river aggregate $d_{max} = 16$ mm

3. Experimental results

a) The strength results of concrete cubes made from first class aggregate ($d_{max} =$ and 16 mm) with different cement content and the same water-cement ratio showed little deviation regardless of their 2 m% water-reducing agent content. (See Figure 2.) The lack of fine sand explains this because grading was about the same for all aggregates and thus the surface of the aggregate remained the same. When no plastificator (water-reducing admixture) was added then 0.4 was the lowest water-cement ratio, as Figure 2 indicates.

b) Cement content was increased from 250 kg/m^3 to 400 kg/m^3 and cubes cured at approximately 22 °C. The strength of the cubes which had no plastificator added at 1 day was 3.3 times higher, at 28 days it was 1.8 times higher. When a plastificator was used the 1 day strength (for cubes containing 400 kg/m^3 cement) was 2.9 times higher and 28 days strength was 1.5 times higher. It is concluded that increasing the cement content resulted in much higher early age strength (Figure 3) and only slightly higher final strength. The compared strength of cubes with $d_{max} = 8$ mm aggregate was lower than that of cubes with $d_{max} = 16$ mm.

c) The 1 day strength (550 portland cement, 22 °C temperature, plastic consistenci) of cubes without plastificator was 29,5% of the 28 days strength and 39% for cubes with 2m% plastificator. Thus in a summer (wram) climate without admixtures it is possible to precast elements and the relative strength increases when plastificator is used. At this temperature the $CaCl_2$ (Kalcidur 85) had no significant increasing effect on the early strength but adding water-reducing admixtures could be advantageous.

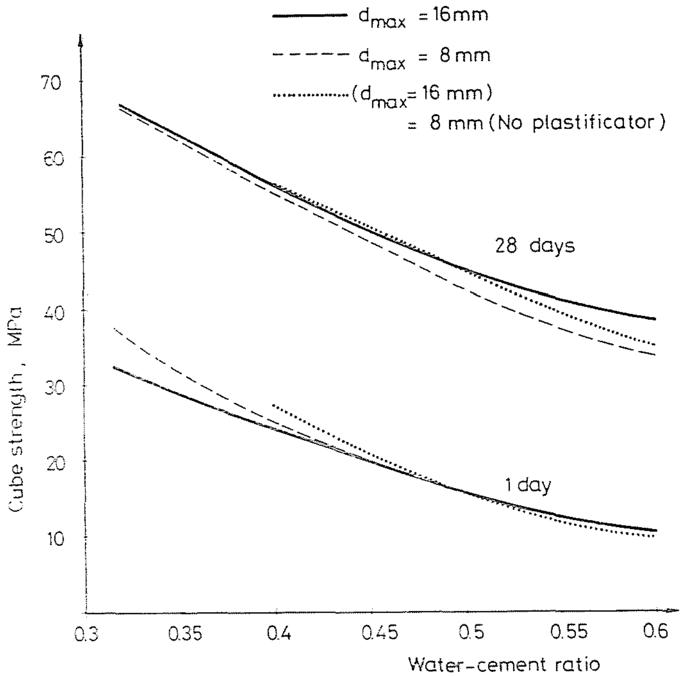

Fig. 2. Strength of concretes containing plastificator admixture related to their water to cement ratio

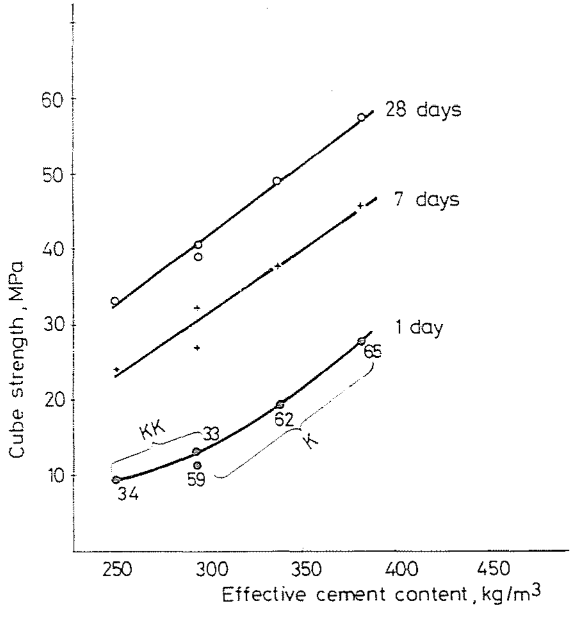

Fig. 3. Strength of concretes without admixtures related to their cement content (22 °C)

d) If cubes with 250 kg/m³ cement content having no admixtures and a slightly plastic (*KK*) consistency are stored at 40 °C the 16 hour strengths are 1.67 or 1.48 times higher compared to the 1 day, 22 °C curing strength. It is assumed that this strength ratio decreases when more cement is added to the mixture. The effect of temperature is also significant. This strength increment was smaller with a plastificator and this coincides with the suggestion that the manifacturers should not use this admixture in undersaturated concretes.

e) Cubes (300 kg/m³ cement without admixtures) were stored at a temperature of 12 °C and the 1 day strength was only 30% of those which were stored at 22 °C, thus the effect of low temperatures was great. The 28 days'-strength was at least as high as for cured at 22 °C. It was concluded that either the water to cement ratio or the cement content had a great effect on compressive strength while the effect of consistency was small. Thus our experimental results are identical with those obtained in the laboratory of the BSCC, that is, the water to cement ratio and temperature were the two most important factors. According to our results the cement content is at least as important and affects the compressive strength. While the cement content increased from 300 kg/m³ to 400 kg/m³ the 1 day strength increased 7 times and the 28 days strength increased 1.5 times. (See Figure 4.) At a temperature of 12 °C adding 4 m% $CaCl_2$ (Kalcidur 85) resulted in an approximately 100% strength increment.

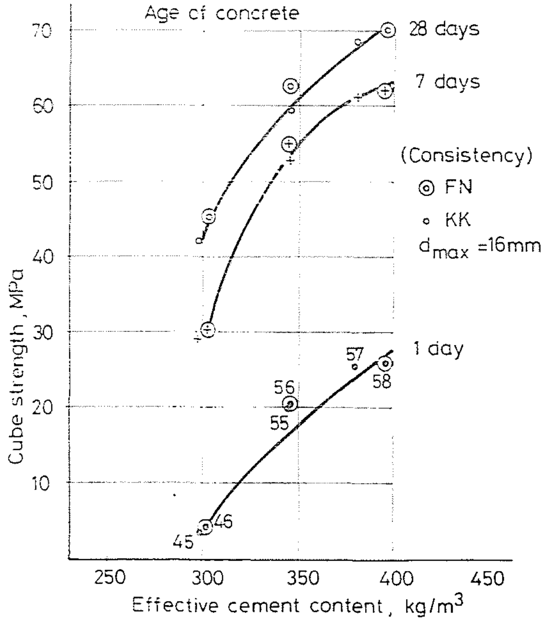

Fig. 4. Strength of concretes without admixtures related to their cement content (12 °C)

f) The high tensile strength is vital during precasting when form work is removed. The flexure strength of a concrete — 300 kg/m^3 cement, 1 day old, plastic (K) consistency — was 32% of its compressive strength and when the cement content was 400—450 kg/m^3 the flexure strength was only 20% of the compressive strength. There was no significant difference in the ratio of flexure to compressive strength of plastic (K) and slightly plastic (KK) concrete but it is assumed that the soil wet consistency would have resulted in even lower values. It is assumed, after previous tests, that 250 kg/m^3 cement content produced the highest ratio of flexure to compressive strength. According to BSCC the elements with 250—300 kg/m^3 cement content were easy to remove with the least loss.

g) Curing was also part of the investigation. Several tests have been completed to evaluate the effects of curing. These tests and the literature indicate that the high initial strength cement and the plastic concrete are less sensitive to the shortcomings of curing compared to other concretes. The development of drying and shrinkage cracks in plastic consistency concretes should be avoided. There is a general rule that only moist curing cannot compensate for the mistakes made previously. It is suggested to keep precast elements, even in open air, in 80—90% relative air moisture content until the end of the first 7 days.

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