GRADING OF WET REGROUND CEMENT

Gy. Balázs, J. Boros, E. Deme, K. Kovács

Building Material Department
Technical University, H-1521, Budapest

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Abstract

Tests show that the specific surface and particle size of wet reground cement can be determined using the "traditional" methods (Blaine-device, Robinson-Köhn Pipette) if the sample is dehydrated after the grinding. Methods have been developed for the determination of the degree of hydration of the cement pulp and for its dehydration. The wet sample was placed into a sintered glass filter lined with filter paper and a suitable amount of isopropyl alcohol was sucked through it. The alcohol retained was removed subsequently under infrared light.

1. Introduction

Literature data and our own experiences show that reground cement hardens faster than the original. When water comes in contact with cement a topo-chemical reaction starts on the surface of the cement particles. The intensity of this reaction depends on the proportion of very fine cement, namely the amount of particles smaller than 30 μm.

It is also known that wet cement grinding requires less energy than the dry procedure. In the literature no procedure was found to determine the particle size distribution of moist reground cement or its specific surface. Our aim was to develop a dehydration procedure for the moist reground cement which stops hydration immediately after grinding and results in dry cement for which traditional tests are applicable.

2. Tests

The tested cement was a Rapid Portland cement (VÁC 450 RPC-MSZ 523).

The water saturated cements were each ground to a different fineness and were dehydrated at once. The fineness and the specific surface were then measured to check the effects of the grinding. The percentage of dehydration was measured using complex thermoanalytical methods.

2.1 *Testing method of grading*

To find particles larger than 0.063 mm the usual dry sieve test [1] was selected out of several methods. For particles smaller than 0.063 mm a settling test [2] was selected.

During the settling test the cement is put into a fluid where, after it a short period of accelerating motion, the cement particles gain a constant speed which depends on their sizes. The Stokes equation describes the speed of settling particles in a gravity field of force. Thus, the settling time is

$$t = \frac{h}{v} = \frac{9h}{2g}\left(\frac{2}{d}\right)^2 \frac{\eta}{\varrho_2 - \varrho_1}, \tag{1}$$

and the settling height is

$$h = tv = \frac{2}{9} gt \left(\frac{d}{2}\right)^2 \frac{\varrho_2 - \varrho_1}{\eta}, \tag{2}$$

where v = settling time,
h = settling height,
t = settling time,
g = gravitational acceleration,
d = equivalent diameter of particle,
ϱ_1 = density of fluid during the test,
ϱc = density of cement,
η = the dynamic viscosity of the fluid during the test.

The testing fluid, isopropyl alcohol, was found to be the best and it did not react with the cement.

There are several devices available today for carrying out settling tests. However, two types, both of which use pipettes, are the most common.

Both methods are based on settling cement in a fluid of a height of h, and taking samples from this suspension at certain time intervals and then determining the amount of floating particles in the sample.

The Andreasen device has a rigid pipette and so the settling height is constant and only the settling time can vary [3, 4]. The disadvantage of this type of device is a long testing time.

The pipette of the Robinson-Köhn device is adjustable and the examined settling height can be freely changed [5]. The solid content of portions taken at intervals from the suspension at a certain height (h) is equal to the amount of fractions with a particle size corresponding to the given settling times. During the tests size limits were chosen to correspond to Hungarian standard sieve sizes.

From the experimental results the particle size distribution and frequency curves were constructed.

2.2 *Test details*

To select the right settling device the grading of the tested cement was determined using both devices described in Chapter 2.1. Since the two test methods produced identical results for the same cement, the Andreasen pipette was not used any longer because of the previously mentioned disadvantage. Thus, for all further tests the Robinson-Köhn device was used.

To study the effects of regrinding, a cement paste containing 30% water was ground in a fast disc mill (Type: DEZAGREGATOR KBFI). After 1, 1.5 and 2 minutes milling time the samples were dehydrated at once. (The heat produced limited the milling time to 2 minutes.)

To effect dehydration after grinding, the samples were put into a glass filter dish and isopropyl alcohol was pumped three times through the samples. The isopropyl alcohol left in the sample after this filtering procedure was evaporated under infra red light.

The effect of short time "fast" dehydratation without milling was also examined. The cement sample was intensively mixed with 30% water for 1.5 minutes and then dehydrated.

For comparison other tests were also carried out by grinding the cement samples in isopropyl alcohol for 1.5 minutes, then drying the cement pulps under infrared light.

To characterise the fineness of the reground particles, the specific surface of the cement sample was determined by using the generally accepted Blaine device — based on the permeability of air. The fineness distribution (grading) of particles was also measured during tests [1, 6]. The results are summarised in Table 1 and shown in Figures 1—4.

3. Discussion

The comparison of grading of the original cement and the sample which was reground in isopropyl alcohol for 1.5 minutes (Figure 1) shows that the reground sample has a greater proportion of smaller particles than the original sample, which shows the effectiveness of grinding. The peak values of the freqency curves of both samples are almost the same which indicates a uniform milling of all grades in the cement.

Figure 2 shows the grading (particle size distribution) of the sample which was mixed intensively with 30% water for 1.5 minutes in comparison to the grading of the original cement.

Figure 2 shows a decreasing amount of 36 μm particles mainly due to a decrease in the amount of particles smaller than 6.3 μm. The peak of the frequency curve for the reground cement moved towards the larger particle sizes.

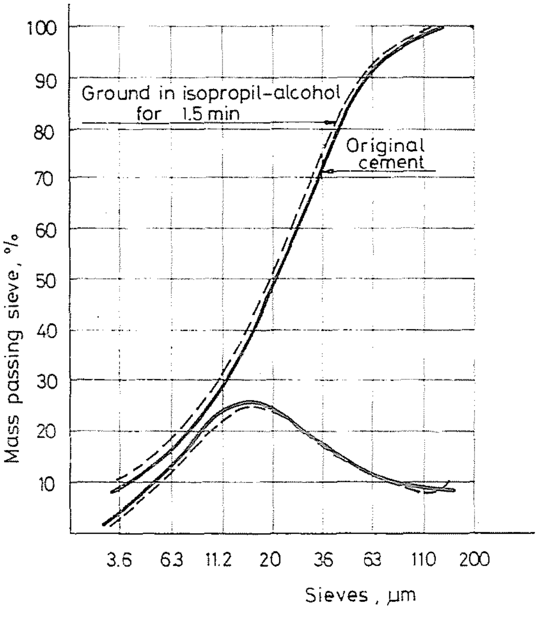

Fig. 1. The effect of grinding for 1.5 minutes grading and frequency curves of the original and ground (in isopropyl alcohol) cement

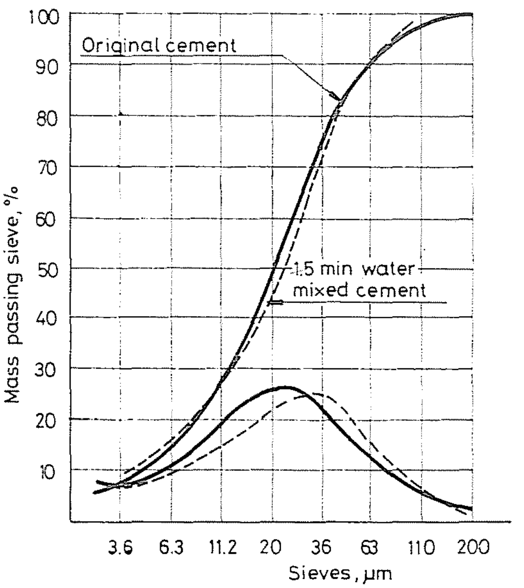

Fig. 2. The effect of hydration for 1.5 minutes grading and frequency curves of the original cement and of the cement mixed with 30% water

This means a 6.6% increment in the amount of particles in the range of 36—63 μm in comparison to the original cement, which means that hydration resulted in an increase of the proportion of particles in this range. Figure 3 shows the effects of increased moist grinding time (1, 1.5 and 2 minutes) on the particle size distribution. This figure clearly indicates the effect of longer grinding time — the amount of particles smaller than 110 μm increases with the time of grinding.

According to the frequency curves the percentage of particles between 36 μm and 110 μm decreased while the percentage of particles with a size of 6.3 μm increased. Thus the wet grinding proved most efficient in the range of 36 μm to 110 μm particle size.

Table 1 shows a significant increment in the specific surface of the cement sample when the grinding time was increased. The data obtained show that the specific surface increased faster during the 1.5 minutes of hydration (with no grinding) than during the grinding in isopropyl-alcohol. These effects are added up during wet grinding.

To support this view, Figure 4 is drawn using data from Table 1. The figure shows the grading of the sample when it was simply mixed with 30% water for 1.5 minutes and when the sample was wet ground with 30% water for 1.5 minutes.

Table 1

Vác 450 Rpc cement. Changing of grading as a result of added water or wet grinding

Sample	Original 450 Rpc	1.5 min. wet mix	1 min. wet ground	1.5 min. wet ground	2 min. wet ground
Specific surface m^2/kg	330	368	428	438	449
GRADING %					
200 μm	99.8	99.6	99.7	99.6	99.6
110 μm	97.2	98.0	97.0	98.0	97.2
63 μm	89.7	90.2	86.8	88.2	89.0
36 μm	73.7	67.6	66.4	69.6	72.0
20 μm	48.9	45.2	44.7	47.5	49.8
11.2 μm	26.6	28.0	27.1	28.8	31.0
6.3 μm	14.3	16.0	15.9	18.7	19.7
3.6 μm	6.6	8.2	9.6	12.1	13.9
FREQUENCY %					
>200 μm	0.2	0.4	0.3	0.4	0.4
200—110 μm	2.6	1.6	2.7	1.6	2.4
110—63 μm	7.5	7.8	10.2	9.8	8.2
63—36 μm	16.0	22.6	20.4	18.6	17.0
36—20 μm	24.8	22.4	21.7	22.1	22.2
20—11.2 μm	22.3	17.2	17.6	18.7	18.8
11.2—6.3 μm	12.3	12.0	11.2	10.1	11.3
6.3—3.6 μm	7.7	7.8	6.3	6.6	7.6
<3.6 μm	6.6	8.2	9.6	12.1	13.9

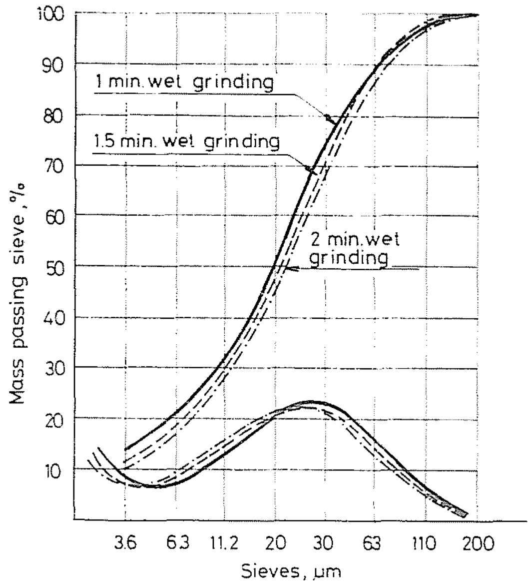

Fig. 3. The effects of the grinding time on the grading and frequency curves

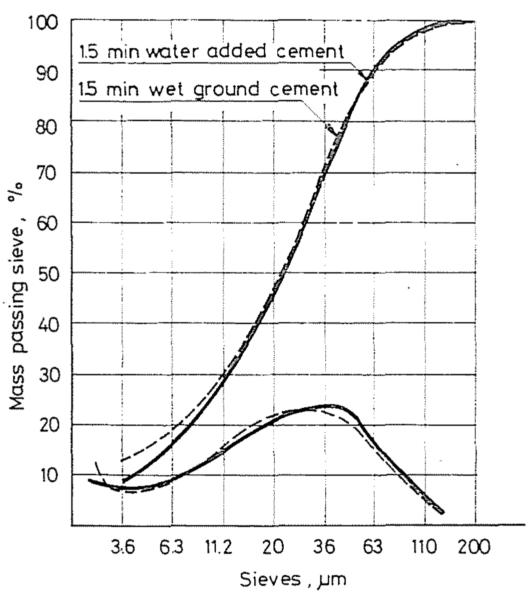

Fig. 4. The combined effects of hydration and grinding for 1.5 minutes of the cement mixed with 30% water on the grading and frequency curves

Comparing each grade it is found that the amount of smaller particles in the ground sample was almost always greater than in the hydrated sample. The frequency curve also indicates this — the maximum of the curve for the ground sample is shifted to smaller particle sizes compared with that of the hydrated sample.

Literature

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Dr. György BALÁZS
Dr. Jánosné BOROS
Dr. Erika DEME
Dr. Károly KOVÁCS
H-1521, Budapest