Pergamon 560 ADMIXTURE: CEMENT

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EFFECT OF VARIOUS ADMIXTURES ON THE PARTICLE SIZE DISTRIBUTION OF CEMENT DETERMINED WITH THE AID OF LASER PARTICLE ANALYSER

BY

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ABSTRACT

The paper presents an attempt on the determination of dispersability of cement particles in the presence of various admixtures (Superplasticizers, accelerator, retardars etc.) using a commercially available laser particle size analyser. The change in particle size during hydration after various intervals of time has been determined in this study. This also brings out a quick efficacy evaluation method for various admixtures by observing the reduction in particle size as compared to the size of unhydrated cement particles originally taken for experiment.

This paper describes the results of a number of particle size distribution studies made with seven admixtures alongwith one without admixture for particle sizes distribution and surface areas using a commercially available Indian OPC grade 43 produced by M/S Dalmia Cements.

INTRODUCTION

The preparation of particle size distribution curve by making use of the rate of sedimentation of particles and calculation of particle size based on Stokes Law is considered quite a difficult and time consuming exercise. Odler et al[1] made use of this method to study the effect on hydration of particles of cement in the presence of other materials in the hydrating medium. Recently some workers[2-10] have employed particle size analyzers for determining the various properties of cement.
The laser particle size analyser is an automatic device, based on low power He-Ne visible Laser Transmitter produced collimated beam of rays which illuminates the sample to obtain results on particle size distribution faster. Therefore in the present study of evaluating the efficacy of dispersability of addition of superplasticizers for cement water systems, use of this technique has been made to follow the change in the size of cement parti-

TABLE - 1

AVERAGE PARTICLE SIZE AND SPECIFIC AREA OF CEMENT PARTICLES IN THE PRESENCE OF VARIOUS ADMIXTURES

Description	Diameter of Particles (μm) at finer than										
	10% 150 mts	10% start	Redn (%) mts	50% 150 mts	50% Start	Redn (%)	90% 150 mts	90% Start	Redn (%)	Specific Surface (Sqm./cc) 150 mts	- Start
C+B	4.3	4.9		11.2	13.5		20.5	26.3		0.31	0.26
C+B+Water	1.4	2.1	71.4	4.5	5.7	66.6	9.3	11.6	64.6	0.73	0.58
C+B+SP-I (0.5%)	1.2	1.9	75.5	4.1	5.5	71.9	8.4	10.8	68.0	0.77	0.59
C+B+SP-2 (0.5%)	0.7	1.3	85.7	3.7	5.2	72.6	8.1	10.9	69.2	0.82	0.58
C+B+SP-3 (0.5%)	1.1	2.9	77.5	5.2	7.7	61.4	11.0	17.3	58.1	0.57	0.35
C+B+SP-4 (0.5%)	2.1	2.8	57.1	5.8	7.5	59.2	14.4	19.0	45.2	0.46	0.26
C+B+SP-5 (0.5%)	2.5	3.7	48.9	6.2	9.6	54.0	14.6	21.2	45.6	0.35	0.28
C+B+Ca. Formate (1%)	2.2	3.2	55.1	7.0	9.3	48.1	24.6	26.3	7.6	0.20	0.21
C+B+Sucrose (0.25%)	1.9	2.6	61.2	5.2	6.7	61.5	12.7	14.9	51.7	0.47	0.42

C = Cement B = Benzene SP = Superplasticizer Redn = Reduction in Particle Size cles and the resulting over all surface area of the cement mass at any particular situation during hydration. The superplasticizer being a surfactant, alongwith the water acts on the surface of the particles resulting in influencing the hydration of particles, their dispersion (and later on an agglomeration of the gel mass) and inter-action of the polar groups on the hydrating surface and extending of the non-polar groups in the suspended liquid mass enabling the particles to acquire a free flowing characteristic. The effectiveness of each type of superplasticizer vary depending upon its inherent nature. Therefore with the help of the laser particle size analyser the determination of efficacy of dispersion by superplasticizers has been attempted by finding the particle size distribution curves at various intervals of the period of interaction.

MATERIALS

The commercially available Ordinary Portland Cement grade 43 confirming to BIS 8112/1989 has been used throughout the study.

Admixtures:- SP-I; CNSL Sulfonated formaldehyde condensate (developed at CBRI); SP-2: Lignosulphonate; SP-3:Naphthalene sulfonated formal-dehyde condensate, (commercial product) SP-4 Organic polymer liquid, (Proprietry commercial product) SP-5:synthetic dispersion; (Proprietory commercial product) Calcium formate and Sucrose. Benzene of analytical grade dehydrated over sodium sulphate was used as dispersion medium for carrying out evaluation of the particle size distribution using laser particle size analyser.

Equipment :

A commercially available model 3600 Laser particle size Analyser manufactured by M/s Malvern, U.K. installed at the Institute was used.

Methodology of Experiment:

Small volume cell was used and 20 ml. of benzene was introduced in it and the instrument was set for "Blank" reading of zero. A 10 mg. dry Cement sample was added and readings were noted at 5,10 and 15 minute intervals after addition of cement sample. The contents were continuously kept stirred so that the cement particles do not agglomerate.

The period of 15 minutes was found adequate for uniform mechanical distribution from 3 trial runs carried up to 45 minutes.

The particle size distribution from 15 minutes onwards remained constant within the limits. So in all other measurements the time was kept at 15 minutes. After this period pure distilled water or requisite amount of the given admixture dissolved in water was added. A drop with the help of a micro syringe was added which in case of pure water weighed 3mg and with admixture 4 mg within 0.01 mg limits. This permitted water/cement ratio around 0.3:1 nominal.

RESULTS AND DISCUSSION

The laser particle size analyser has an arrangment to ascertain diameter of a particular percentage of particles in μm at finer than various perccentages 10, 50 or 90% at any given time. The diameter of certain percentages of particles at different intervals of time 5,15,30,45 ....240 minutes determined with the help of this device in the presence of non reacting suspending medium benzene (designated as B in presence of water labelled as B+W and the 0.5% superplasticizers by weight of cement alongwith B+W labled as SP-1 to SP-5 and some retarder and accelerator were also used alongwith B+W+SP.

In table 1 the average diameter of particles in μm which constitute finer than 10,50 and 90 percent of the total particles present in the medium at the start of the experiment and after certain periods of time (in this case 150 minutes) have been given. In this experiment efforts have been made to use moisture free benzene as the suspending medium so that the unhydrated cement particles repersent a true condition of the particles in the medium and can be made a base for comparison of the dispersability results in different conditions obtained in the other experiments. As there does not occur any reaction except the free flowing condition in the benzene medium where as in the other cases the hydrating reaction and adsorption/desorption of the moisture/ superplasticizer etc. also occur.

In the case where the two admixtures CB SP-1 and SP-2 have been used the cement particles appear more fine which becomes quite clear from the comparison of diameter either of the 10,50 or 90% level of particles with the diameter of cement in B+W. In case of SP-1, SP-2 and SP-3, 10% of particles have average diameter finer than 1.2, 0.7 and 1.1 μm respectively in comparison to 1.4 μm with water (B+W) only. The particle size reduction at this level in the above three cases occur to the order of 75.5, 85.7 and 77.5 per cent when compared to the particle size 4.9 μm at the start of the experiment. In the beginning the particle size is expected to be 4.9 μm in all cases but interaction for 150 minutes in different cases the resulting particle size show a reduction of varying order due to formation of hydration product. In case of water only this reduction is 71%. However the finer than 90% particles have the average diameter 8.4, 8.1 and 11.0 μm in comparison to 9.3 μm. The reduction of particles (dispersion) in this case is 68, 69.2 and 58% respectively while with water only it is 64.6%. The quantity of water used is very very small and may exist as moisture in the dispersing medium and the possibility of the partitioning of the medium and aqueous layer as well as the distribution of cement and the superplasticizer in two mediums become quite remote. All the constituents are very well stirred and due to affinity of cement to water, hydration reaction occurs.

The specific surface area determined in the above cases is given in the table 1 as 0.77, 0.82 and 0.57 (sqm/cc) respectively compared to 0.73 (sqm/cc) in case of water (B+W). A comparision of the different distribution curves given in figures 1 & 2 makes evident the effect of various admixtures during hydration.

The results discussed above show that the SP-1 and SP-2 have a better dispersing capacity than the SP-3 and the others.

Similar trend has also been observed with other admixtures

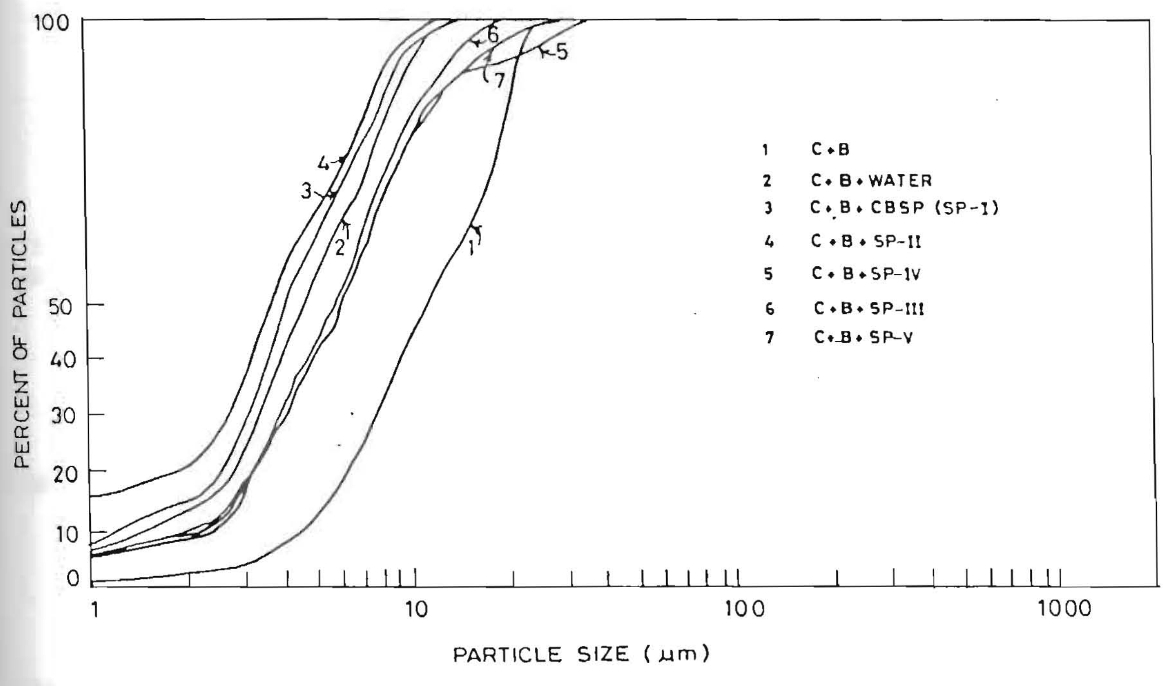

FIG. 1. PARTICLE SIZE DISTRIBUTION CURVES OF CEMENT IN PRESENCE OF SUPERPLASTICIZERS

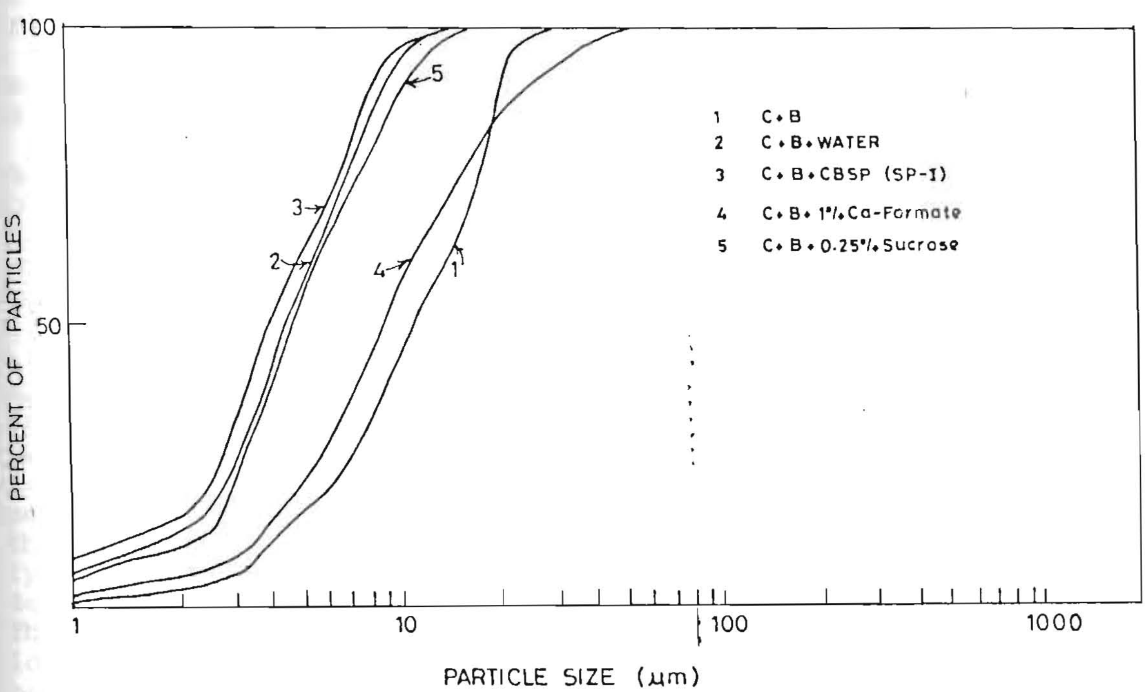

FIG. 2. PARTICLE SIZE DISTRIBUTION CURVES OF CEMENT IN PRESENCE OF SUPERPLASTICIZER WITH OTHER ADDITIVES.

including the 1% calcium formate and 0.25 per cent sucrose solutions where the average diameter at each level i.e. 10%, 50% amd 90% particles, have been observed to be larger as well as the specific surface area to be lesser than that with water (W +B) only. This shows that these admixtures have a low dispersing capacity.

CONCLUSIONS

It is concluded from the above studies that the laser particle size analyzer can be used to evaluate the efficacy of admixtures through their capability of dispersing the cement particles and determination of the particle size distribution and specific surface area. Two superplasticizers out of the five studies show better dispersing capacity depending upon their nature and the method of manufacture.

ACKNOWLEGEMENT

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