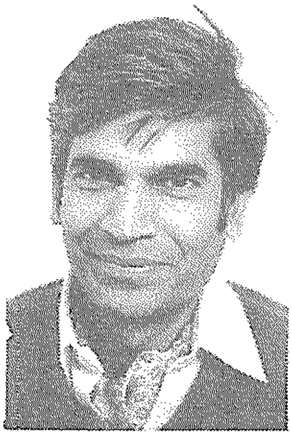

INFLUENCE OF POLYMER DISPERSIONS ON THE CEMENT MORTARS

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Polymer dispersions were made in the laboratory with anionic and nonionic tensides. These were mixed in the mortar and the properties like air content, density, mechanical strength and water absorption were measured. It is observed that the dispersions with nonionic tensides entrain more air than the one with anionic tensides. Filmforming dispersions are more hydrophobe. Dispersions made both with styrene and methylmethacrylate monomer with anionic tensides improve the above mentioned properties of cement mortar.

Keywords: polymer dispersion, tenside, monomer, anionic, nonionic, methylmethacrylate, styrene, stabilizer, acrylic acid, air content, film forming, soft and hard microparticles.

INTRODUCTION

Concrete and polymer are two complex systems and it is difficult to deal with two complex systems at the same time. While mixing the polymer dispersions to the concrete, one must know the exact composition of the polymer dispersion in order to comment on the mechanism of its effect. Only commercial polymers were used in the field of polymer and concrete as cited by Chandra /1/. With the use of commercial polymers, it is not possible to have clear information about their constitution. We know that even small changes in the polymer dispersion can dramatically change their character and its role in concrete.

Anionic, nonionic, and cationic dispersions were made in the laboratory. These dispersions were mixed in cement mortar and air content was measured varying the water to cement ratios. 4x4x16 cms prisms were made with these dispersions and their mechanical strength and water absorption were tested.

MATERIALS AND METHODS

Polymer dispersions were made by emulsion polymerization. Reagents used were monomer, tenside (emulgator), water and water soluble initiator. Tensides used were anionic, nonionic, and cationic. These charged tensides protect the particles from falling with the repulsive charges. Nonionic tenside protects the particles from sterical effect.

Monomers

Two monomer systems were used here.

1. methylmethacrylate (MMA) + butylacrylate (BA)
2. styrene (St.) + 2 ethylhexacrylate (2-EHA)

Pure MMA and styrene produce hard microparticles. Addition of BA and 2-EHA produces dispersions with soft microparticles. Functional monomer used was acrylic acid (AS). This stabilizes the polymer dispersions as well as gives better affinity on concrete surface.

Tensides

Anionic, nonionic, and cationic tensides were used.

Anionic:	Berol 482	sodium lauryl sulfate
	Berol 733	potassium salt of phosphated alkylfenol-etenoxide
Nonionic:	Berol 281	alkylfenoletenoxide HLB = 16.0
	Berol 057	primary alcohol
Cationic:	Berol 594	1-hydroxyletetyl - 2-alkylimidazolin

Basic composition

Water	490 ml
Monomer	210 g
Ammonium per sulfate	1 g
Sodium di sulfite	1 g
Tenside	1.5-4% of monomer

This composition gives theoretically 30% concentration of dispersion (dry weight).

Dispersions were made in a glass pot attached with stirrer, condenser, tube for nitrogen inlet, thermocouple and one opening for inlet of above mentioned reagents. The apparatus is shown in Fig. 1. Thermocouple was connected to a writer which registers the temperature of the reaction pot. Reaction pot is put in a water bath, which is heated by an electrical heater. Temperature in the bath is regulated by contact thermometer. Polymerization was stopped when no drops of monomer were seen falling from the condenser. pH of the emulsion was adjusted to 9 by the addition of ammonia.

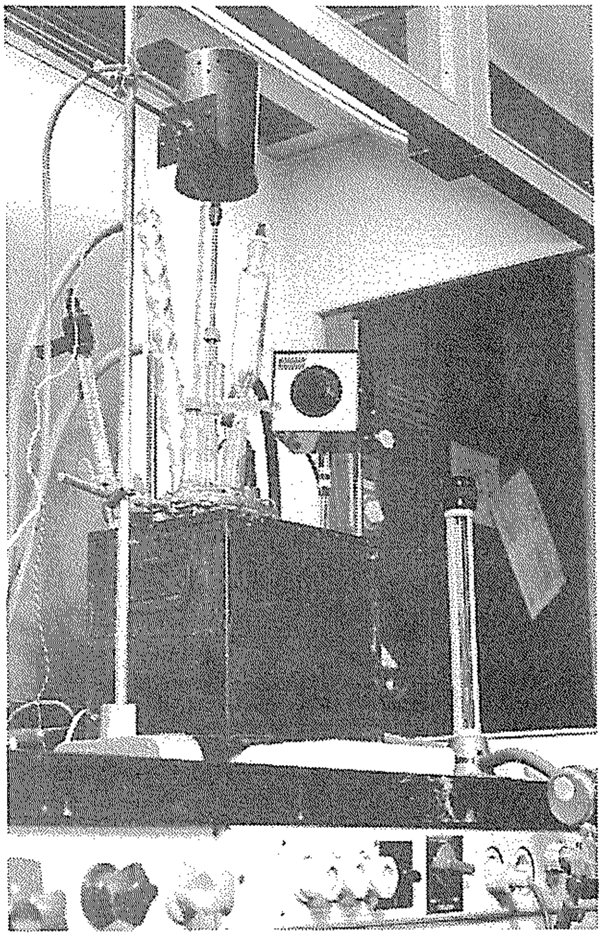


Fig. 1. Polymerization apparatus.

Air eintrainment

1:3 cement mortar was made with 1% polymer dispersion (solid weight), calculated to the weight of cement. Cement used was standard Portland cement supplied by Cementa AB, Slite, Sweden. The cement mortar was made according to ANSI/ASTM 305-65. Fresh density was calculated with different water/cement ratios. Air content was calculated from these fresh densities. The results are shown in Figs. 2-6.

Mechanical strength

Mechanical strengths were tested on 4x4x16 cms prisms made from 1:3 cement mortar with 0.50 water/cement ratio. Compressive and flexural strengths were tested after 28 days curing under water. The results are shown in tables I-V.

Water absorption

Water absorption was tested on the 4x4x16 cms prisms made in the same way as for mechanical strengths testing. After 28 days water curing the specimens were dried at 105^{o}C. Water absorption by capillary action was measured by putting the specimens in a glass trough with their surfaces touching the water surface. Increase in weight of the specimens was measured. The results are produced in Figs. 2-6.

RESULTS AND DISCUSSION

The results are reported in five series.

Series I: This shows the influence of nonionic and anionic dispersions on the properties of mortar specimens (Table I) as stable dispersions with cationic tensides could not be made. This deals with MMA+BA monomer system.

Series II: This shows the influence of acrylic acid addition with respect to tensides in the dispersions and their effect on the properties of mortar specimens (Table II).

Series III: This shows the influence of different amount of tenside in the St+2EHA system with the same tenside (Table III).

Series IV: This shows the influence of acrylic acid in St+2EHA system with the same amount and type of tenside (Table IV).

Series V: This shows the influence of BA and 2EHA addition on the hardness of the microparticles in the dispersion and their effect on the properties of cement mortar (Table V).

Series I

This shows the influence of nonionic and anionic dispersions on the mortar specimens. MB1 and MB2 are made with 4% tenside, as with lower amount stable dispersions could not be made. Both are with nonionic tenside but different types. MB1 entrained more air than MB2. The strengths were in accordance with the air entrained. No appreciable difference in water absorption could be noticed.

MB3 and MB4 were made with the same amount of anionic tenside but different type. It is seen that the air entrained was the same in both cases but the strength obtained with B 482 tenside (MB3) was much higher than with B 733 (MB4). One reason can be that the air entrained by B 733 addition was not stable and inhomogeneous structure of concrete was formed. Water absorption curve (Fig. 2b) also shows that in case of MB4 water absorption was higher.

Increasing the amount of tenside to 5% (MB5) gave more air in the mortar in comparison to MB4 with the 2% of the same tenside. Water absorption of the specimens with MB5 dispersion was also higher.

Minimum air was obtained in the mortar with the dispersion MBA1. This is without any tenside. The strengths obtained were highest in this case, whereas no substantial difference in water absorption could be noticed.

Table I. Influence of nonionic and anionic dispersions on the properties of mortar specimens in MMA+BA system.

		MB1	MB2	MB3	MB4	MB5	MBA1
Monomer		MMA 50 BA 50	MMA 50 BA 50	MMA 50 BA 50	MMA 50 BA 50	MMA 50 BA 50	MMA 45 BA 50
Acrylic acid, %		-	-	-	-	-	5
Tenside		B 057 N	B 281 N	B 482 A	B 733 A	B 733 A	-
Percent tenside		4	4	2	2	5	
Strength MPa	Compr.	20.3	31.2	42.1	29.0	25.6	43.7
	Flex.	3.7	6.2	6.8	5.7	6.7	7.4

N - nonionic tenside
A - anionic tenside

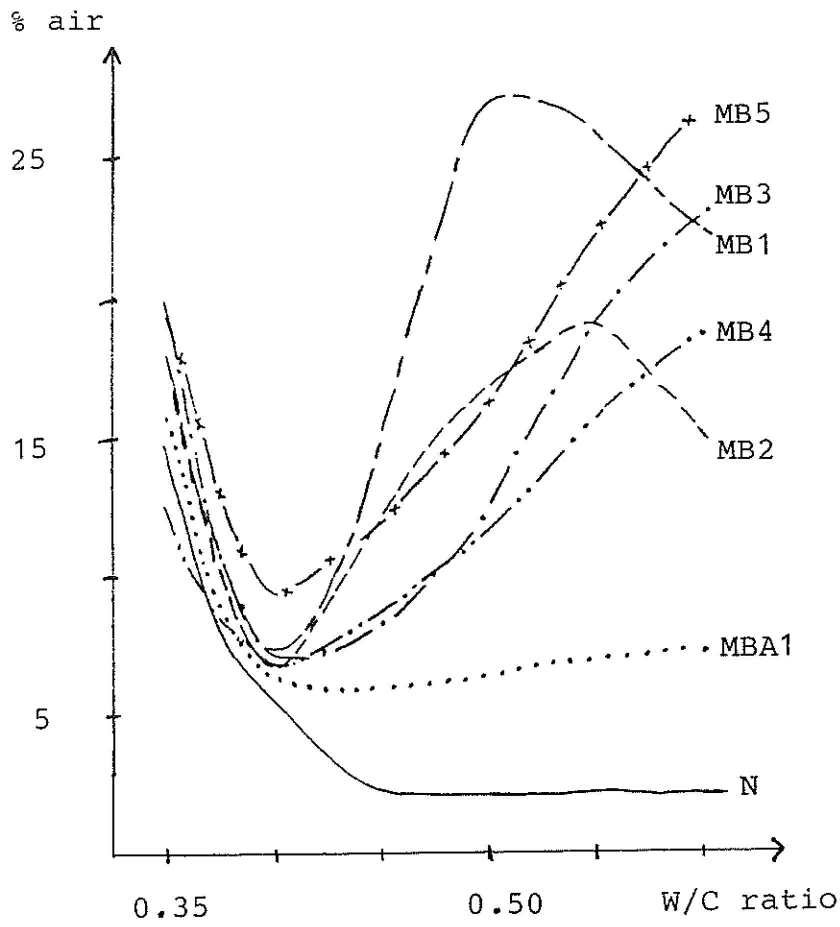


Fig. 2a. The air content vs. the water/cement ratio.

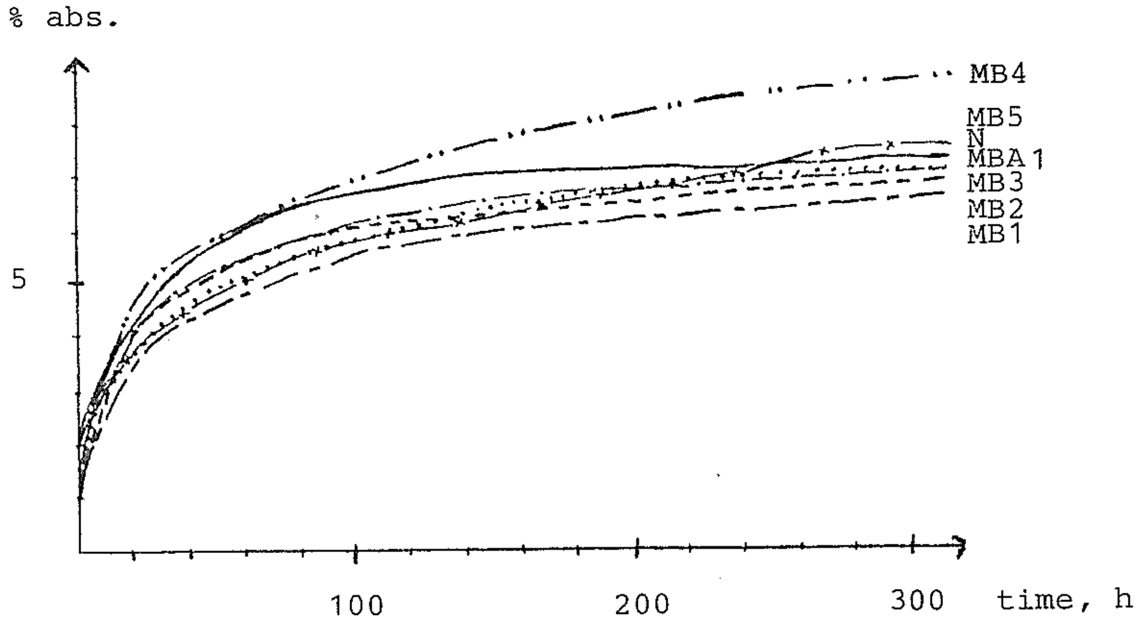


Fig. 2b. The water absorption vs. time.

Series II

Mortar with acrylic acid in the dispersion (MBA2) having the same tenside has entrained more air than without it (MB2) (Fig. 3a). It has also given lower strengths and higher water absorption (Fig. 3b). Comparing MBA2 and MBA3 it is seen that a decrease in the amount of tenside by 1%, decreases the amount of air entrained. Its strength has also been increased accordingly. Its water absorption has been reduced (Fig. 3b) in comparison to MBA2, but is still higher than MB2.

This shows that acrylic acid stabilizes the dispersion, so more tensides are released, and these entrain more air (MBA2). With the addition of acrylic acid less tensides give better result. Water absorption in the presence of acrylic acid is higher. This may be due to its hydrophilic character.

Table II. Influence of acrylic acid addition with respect to tensides in the dispersions and its effect on the mortar specimen.

		MB2	MBA2	MBA3
Monomer		MMA 50 BA 50	MMA 48 BA 50	MMA 48 BA 50
Acrylic acid, %		-	2	2
Tenside		B 281	B 281	B 281
Percent tenside		4	4	3
Strength MPa	Compressive	31.2	19.0	39.2
	Flexural	6.2	3.4	6.9

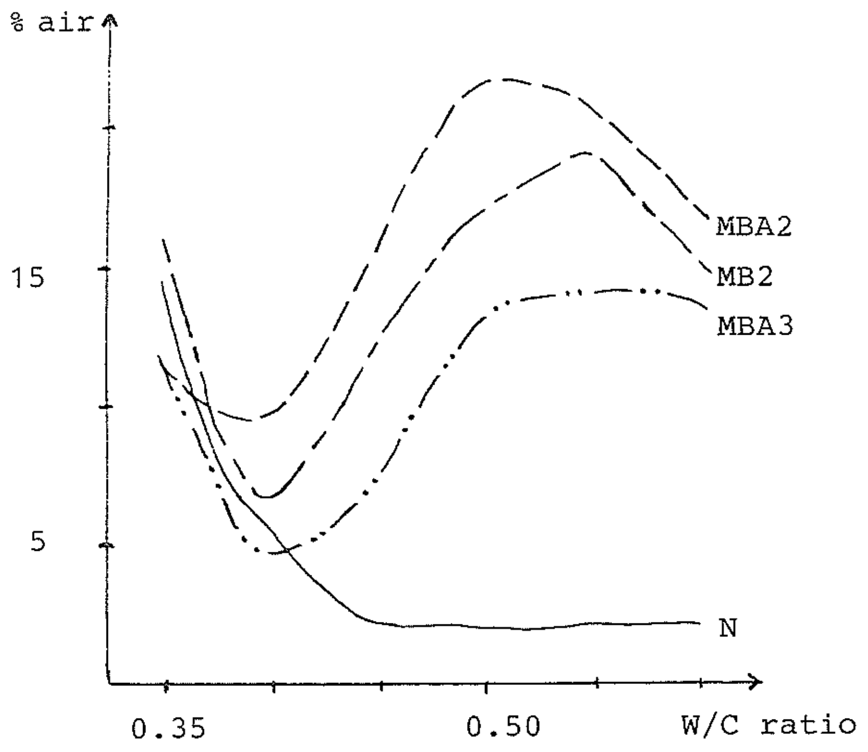


Fig. 3a. The air content vs. the water/cement ratio.

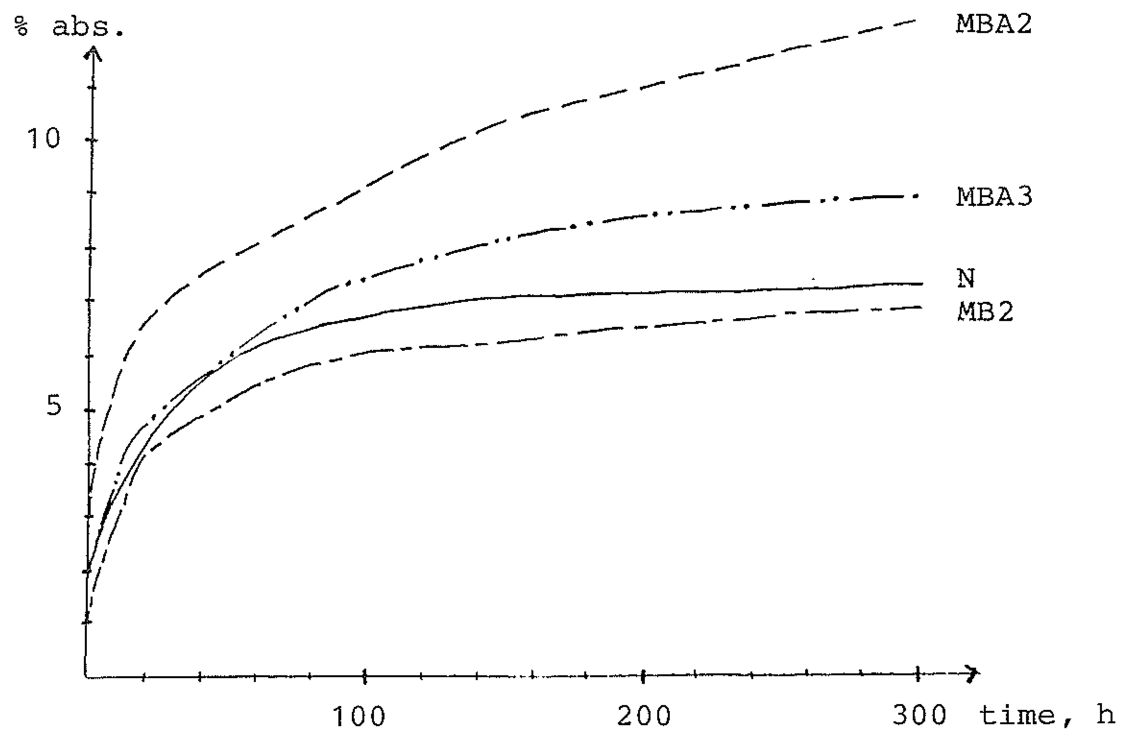


Fig. 3b. The water absorption vs. time.

Series III

In St+2EHA system different amount of tensides has entrained different amount of air (SE1, SE2, SE3). Lowest amount of air and highest strength noticed amongst them were in SE2 with 2% tenside (Fig. 4a). Water absorption noticed was very slow in the beginning but increased later on. There is not much difference between the air entrained by SE1 and SE3 and also not in their water absorption.

This shows that an increase in the amount of tensides gives more air and less strength. But comparing SE1 and SE3 it can be said that after reaching a certain value, it does not affect much, because when the amount of air entrained is much, it bursts out. So in this way maybe the amount of air calculated in the mortar is different than what is actually present in the mortar prisms.

Table III. Influence of different amount of tenside in the St+2EHA system.

		SE1	SE2	SE3
Monomer		St 50 2EHA 50	St 50 2EHA 50	St 50 2EHA 50
Acrylic acid, %		-	-	-
Tenside		B 733	B 733	B 733
Percent tenside		2	3	5
Strength MPa	Compressive	29.0	23.8	25.3
	Flexural	5.5	4.7	4.1

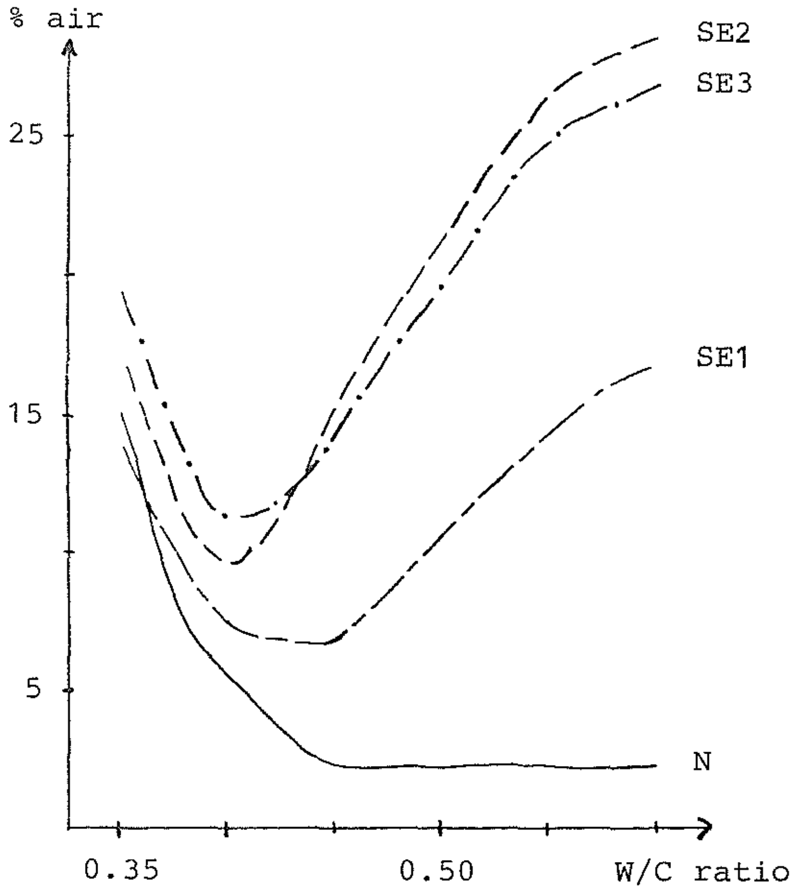
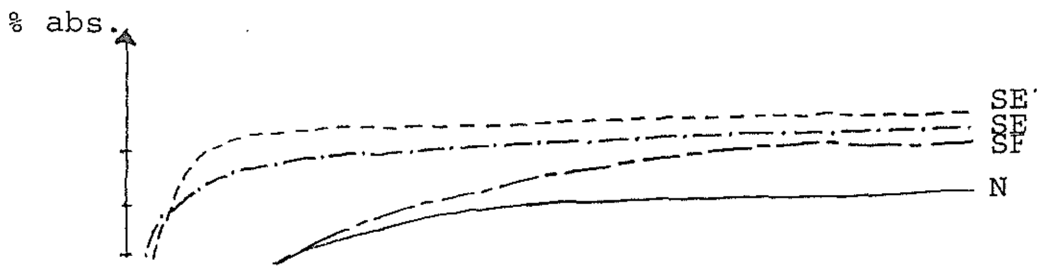


Fig. 4a. The air content vs. the water/cement ratio.



Series IV

Acrylic acid addition in the dispersion gave more air in the mortar, SEA1 (Fig. 5a) but not substantial differences in the strength could be noticed. Water absorption in the case of SE4 (without acrylic acid) was very slow in the beginning in comparison to SEA1 (with acrylic acid).

This shows that in this case also acrylic acid addition in the dispersion has increased its air entraining property and its hydrophobic character is reduced.

Table IV. Influence of acrylic acid in St+2EHA system with the same amount and type of tenside.

		SE4	SEA1
Monomer		St 75 2EHA 25	St 48 2EHA 50
Acrylic acid, %		-	2
Tenside		B 733	B 733
Percent tenside		2	2
Strength MPa	Compressive	39.5	37.0
	Flexural	6.8	6.5

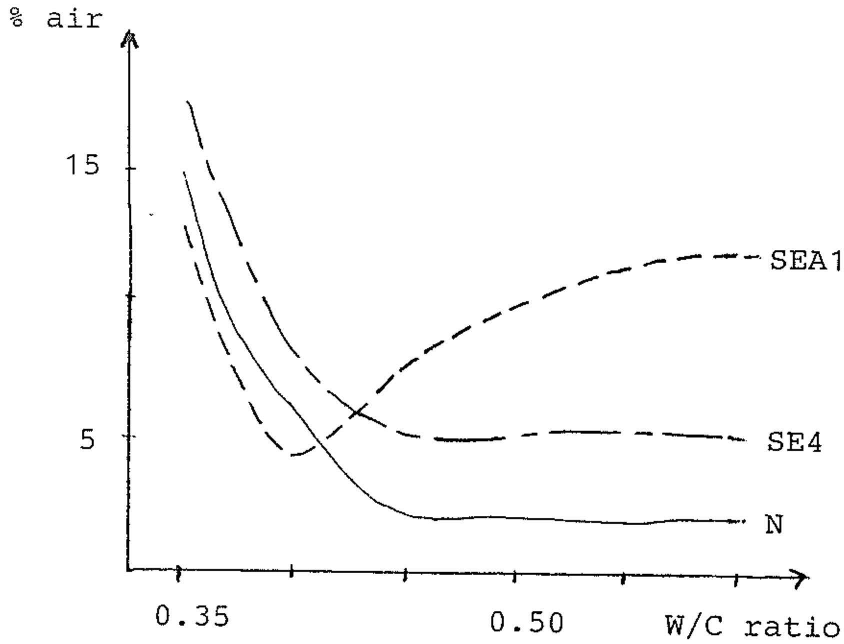


Fig. 5a. The air content vs. the water/cement ratio.

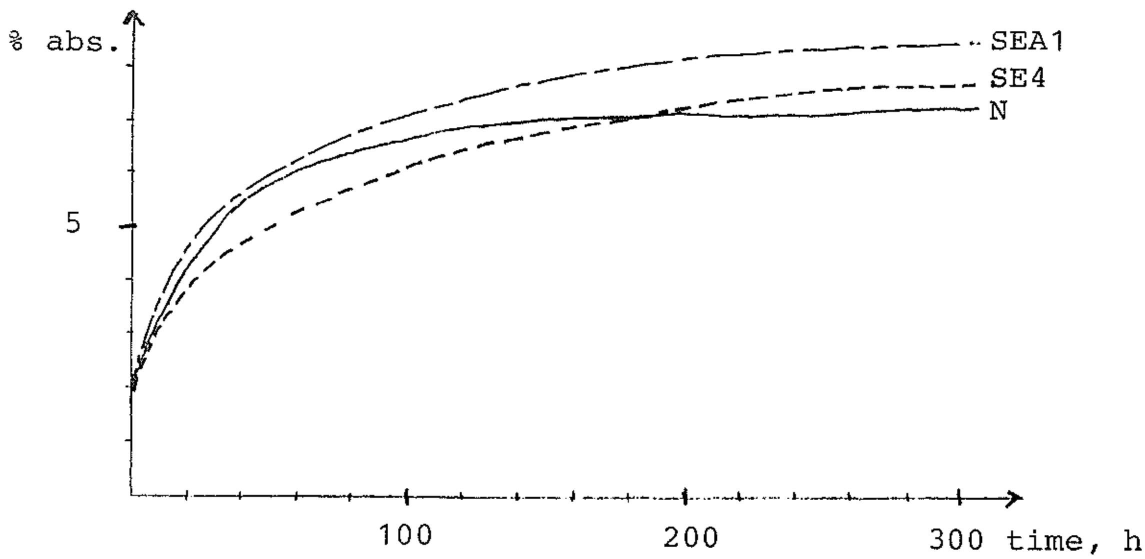


Fig. 5b. The water absorption vs. time.

Series V

Addition of BA and 2EHA has influenced the hardness of the microparticles in the dispersion. Comparing MBA4 and MBA 5 it is seen that the amount of air entrained (Fig. 6a) is the same, but the strength of MBA5 is much higher than with MBA4. MBA5 is a dispersion with soft microparticles and has filmforming ability. This might have provided more stable air and better adhesion. In St+2EHA system lowering the amount of 2EHA to 25% instead of 50% (as before)(Table V) has lowered down its air entraining character (Fig. 6a) and has increased the strength of mortar specimens. MBA5 has shown the lowest water absorption (Fig. 6b). This may be due to its filmforming ability. MBA4 has hard microparticles and has no filmforming ability.

This shows that styrene system in comparison to MMA-system had less air entraining character and gave higher strength to the mortar prisms. Soft microparticles having filmforming ability increased the hydrophobic character.

Table V. Influence of BA and 2EHA addition in the dispersion and their effect on the properties of cement mortar specimens.

		MBA4	MBA5	SEA2
Monomer		MMA 73 BA 25	MMA 48 BA 50	St 73 2EHA 25
Acrylic acid, %		2	2	2
Tenside		B 733	B 733	B 733
Percent tenside		1.5	1.5	1.5
Strength MPa	Compressive	19.0	31.0	42.5
	Flexural	4.3	5.7	7.7

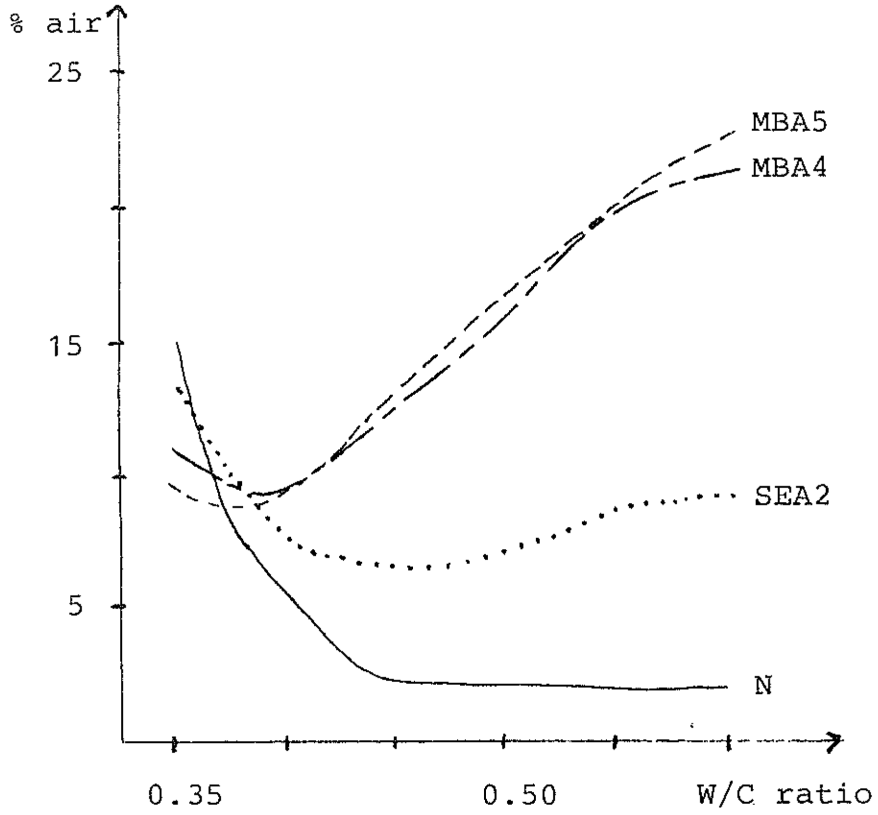


Fig. 6a. The air content vs. the water/cement ratio.

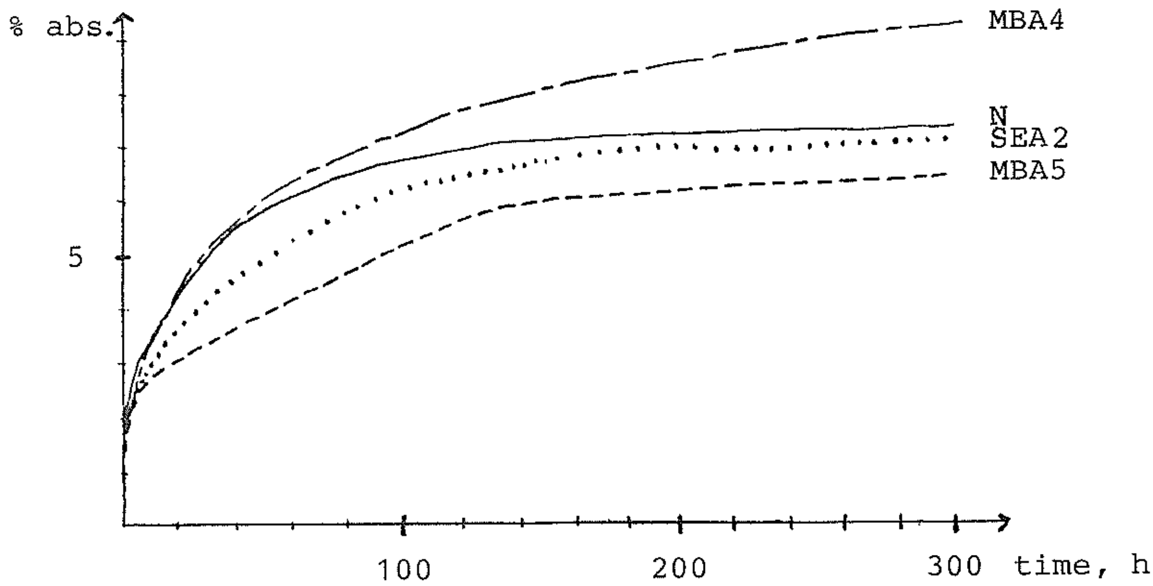


Fig. 6b. The water absorption vs. time.

CONCLUSIONS

1. Dispersions with nonionic tensides gave more air than with anionic tensides.

2. Dispersions without tensides have given less air (6.4%) and imparted better strength to the concrete.

3. It is possible to make dispersions with acrylic acid using less amount of tensides. Acrylic acid works as stabilizer as well as air entraining agent.

4. Acrylic acid when used in MMA system can be less hydrophobe than when used with styrene.

5. Dispersions with soft microparticles having filmforming ability gave more hydrophobicity than with the hard microparticles having no filmforming ability.

Results obtained show that both MMA and styrene system can improve the durability property of concrete if the amount of air they entrain can be controlled. Tensides should be selected in accordance with the monomer used. Work is in progress.

REFERENCES

1 S. Chandra, Structure Stabilization of Mortar and Concrete with Polymer Addition, Division of Building Materials, Chalmers University of Technology, Internal report 82:1, Göteborg, 1982.