Norwegian University of Science and Technology
Department of Structural Engineering

REPORT

Title **Foam Index measurements on combinations of Air Entraining Agents, Superplasticicers and Fly ash/cement/filler powder mixes**	Report no.: Date: 11th of August 2015
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Abstract:

A series of Foam Index measurements were made with 7 different AEAs (abietic acids/resins/tall oil/tensides), 1 copolymer SuperPlaticizer, 2 different Fly Ashes, 1 blended (80/20 OPC/FA) cement, 2 different OPC and 2 inert fillers (limestone and quartz).

Foam Index = FI = required dosage of AEA to produce stable foam of a particular binder in a w/p = 2.5 slurry where AEA is added dropwise to a container that is shaken and the foam observed repeatedly until stable foam is obtained.

The objective was to investigate the efficiency of the different AEAs with varying Fly Ash binders and the effect of mixing sequence of AEA and SP on the problems encounterd with air entrainment with Fly Ash with variable carbon content.

The results show: that the ranking of the FI of the seven AEAs are the same for different OPC/FA binders (with different carbon content); the more carbon the higher the FI, that “tensides” are more robust than “resins”, and that FI in pure OPC binders are very low and not very different for the 7 AEAs.

When adding SP before AEA the negative effect of carbon on foaming is reduced for most AEAs, presumably due to adsorption of SP before AEA is introduced in the mix, whereas the FI of some (presumably non-adsorbing) AEAs is not affected by SP addition. For those AEA/FA combinations where the FI is affected by SP, adding SP with the AEA and adding SP after the AEA reduces the efficiency of the AEA. Replacing blended cement with limestone filler and quartz filler seems to affect FI in terms of the specific surface of the filler added: the more surface that is taken away the more efficient becomes the AEA. Foaming with pure water

(The report is translated and edited from the Batchelor report in Norwegian by the 3 latter authors and will be published in Nordic Concrete Research in a further edited edition)

Indexing terms

Concrete, durability, frost, frost/salt, fly ash, air entraining and super plasticizing admixtures, adsorption, surfactants, air entrainment

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BACHELOR THESIS:

FOAM INDEX TEST

Interaction AEA- - SP – flyash/cement/filler and stability of air entrainment

AUTHORS:

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Date:

13.05.15

SAMMENDRAG

Tittel:	FOAM INDEX	Dato: 13.05.15
	Påvirkning mellom Flyveaske, L-stoff og SP	
Deltaker(e)/	Henrik Nordahl-Pedersen Hawar Omer Rasol Øyvind Olsen Lødemel	
Veileder(e):	Guri Krigsvoll og Stefan Jacobsen	
Evt. oppdragsgiver:	Høgskolen i Gjøvik	
Stikkord/nøkkel ord (3-5 stk)	Foam Index, Flyveaske, Luftinnførende, Superplastiserende, Porestruktur	
Antall sider/ord:92/8228	Antall vedlegg:30	Tilgjengelighet (åpen/konfidensiell): åpen

Kort beskrivelse av master/bacheloroppgaven:

Med denne oppgaven ønsket vi å se på hvordan Foam Index tester kan brukes som substitutt for å anslå dosering av L-stoff for å få en god porestruktur i herdet betong. Foam Index test kan være en rask og enkel metode for å se på hvordan ulike tilsetningsstoffer reagerer med sement og flyveaske for å få en god og stabil porestruktur i betongen. Det ble sett på 7 ulike luftinnførende- og 1 superplastiserende tilsetningstoffer med ulike kombinasjoner og rekkefølge av dosering. Med dette ønsket vi å finne de riktige doseringene av luftinnførende tilsetningsstoffer og om de superplastiserende hadde påvirkninger på disse.

Resultatene fra laboratorieforsøkene har vist seg at L-stoffene fungerer dårligere ved høyere karboninnhold i flyveasken som gjengitt i teorien. Det viste seg at SP hadde minst påvirkning på L-stoffene når det ble tilsatt først.

ABSTRACT

Title:	FOAM INDEX TEST Interaction between Fly Ash, AEA and SP		Date: 13.05.15
Participants/	Henrik Nordahl-Pedersen Hawar Omer Rasol Øyvind Olsen Lødemel		
Supervisor(s)	Guri Krigsvoll and Stefan Jacobsen		
Employer:	University of Gjøvik		
Keywords (3-5)	Foam Index, Fly ash, AEA, Superplasticizer, pore structure		
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Short description of the bachelor thesis:

The Foam Index (FI) test measures the dosage of AEA (Air Entraining Agent) to obtain stable foam on top of a slurry, indicating the stability of air entrainment in concrete, particularly when using fly ash with variable carbon content. This work investigates how various AEAs combined with SP can be used with varying fly ashes, cements and fillers In brief the air entrainment stability depends strongly on both type of AEA, combination with Superplasticizer (SP) and binder powder: SP before AEA was found to reduce the negative effect of carbon in the fly ash in several cases, whereas SP after AEA in most cases has a negative effect of air entrainment. Negative effects are more severe for tall oil/resin type air entrainers than for synthetic tensides.

Results from laboratory experiments have shown that AEA is less effective at higher carbon content in the fly ash as depicted in theory. It appeared that SP had the least effect on the AEA when added first.

(*Stefan Jacobsen: This is a translated, edited, and shortened version of the original report)*

Preface

This bachelor's thesis was prepared in the spring of 2015 at Gjøvik University College and is part of a 3-year bachelor's degree. This report is written by Henrik Nordahl-Pedersen, Hawar Omer Rasol and Øyvind Olsen Lødemel. The Thesis deals with Foam Index testing of various AEA`s in various fly ashes. It may be difficult to estimate the necessary dosage of AEA to obtain a specific air void system in concrete with fly ash and Foam Index test can be a simplified and inexpensive method to estimate this dose. Our Foam Index tests was conducted in the structural engineering laboratory at NTNU, Trondheim.

Our supervisor at Gjøvik was Guri Krigsvoll, and with help by her we came in touch with Professor Stefan Jacobsen, at NTNU who gave us this task.

We will give a big thanks to Stefan Jacobsen and Guri Krigsvoll for good supervision and guidance associated with this task. Part of the task was to test American materials for PhD student Lori Tunstall at Princeton University (working under the supervision of Professor George W Scherer) who will use our results for further work. We want to thank her for having sent us the American materials.

In connection with the completion of our tests, we will give a big thanks to Engineer Ove Loraas for facilitation and assistance to the testing laboratory. In this regard, we would also like to thank Pål Brokka Rikke for help in finding the correct frequency on the shaker using accelerometer, amplifier, computer equipment etc.

To conduct foam index tests we need materials such as cement and additives. Norcem AS and Mapei AS delivered the Norwegian materials. We therefore thank Tor-Magnus Zachariassen from Norcem AS for sending us cements and fly ashes. In addition, we thank him for testing of carbon content and fineness in the three different fly ashes that we used in our tests. Mapei AS delivered the Norwegian additives. Thanks to Dr Nodar Al-Manasir to assist us with these materials and thanks for advice during our meeting in the lab at the university. The laboratory use and support at NTNU was financed by the BIA DACS project funded by the Research Council of Norway, Kvaerner (project leader) and also with participation of Mapei, Norbetong and Norcem. Finally, we thank each other for good cooperation and we wish each other good luck in future.

1. Introduction

In cold and harsh environments, concrete structures exposed to freezing and thawing and deicing salts can suffer deterioration by scaling and cracking unless properly made. To prevent this, it is desirable to get the right volume of air pores in the concrete (4-6%), consisting of very small and evenly distributed air bubbles throughout the concrete. The disadvantage of fly ash is that it may contain too much carbon because of incomplete combustion in the power plant-(high Loss on Ignition –LOI), and the quality of fly ash can thus be quite variable. It has been found that it is difficult to estimate the dosage of the air entraining agents due to this varying quality of the fly ash. It has also been proposed that some air entraining agents adsorb on carbon in the fly ash. (Tunstall, Prud`homme & Scherer 2015). The FI-test may therefore be a good test to find the correct dosages of additives in relation to various fly ashes since it is simple and inexpensive to perform. Normally AEA is used in combination with water-reducing admixtures, usually super plasticizer (SP) admixtures to retain workability of concrete with low mass ratio (w/b, w/c). Combinations of AEA and SP, effect of carbon in the fly ash, the effect of combination of different binders / fillers with different types of AEA and effect of various orders of dosage of SP / AEA are probably important factors in practical problems with air entraining of concrete at the construction site possibly destroying the desired air pore structure. (Jacobsen, Ollendorff et al. 2012)

This study therefore uses the relatively rapid FI-Test, which has been shown to correlate quantitatively to air entraining in concrete (Gebler & Klieger 1983;Dodson 1990; Vestgarden 2006; Harris, N. et al. 2008; Harris, N. J. et al. 2008), to estimate air-entraining effects and -stability of various AEA`s with different cements and fly ashes (dosage, carbon content) and combination with superplasticizer. We also have looked at the importance of dosage of AEA and superplasticizers and effect of two different types of filler (quartz and limestone) on FI. (FI - Foam Index).

2. Background

2.1 Frost damage

Frost damage in concrete can occur in countries with cold climates, where the concrete is exposed to freezing and thawing while highly saturated and/or with wet surface. Experience has shown that the maximum damage occurs when the concrete surface is cowered with liquid (water or salt solution) during freezing and thawing, and the surface scaling attack is most severe when the concentration of deicer is around 3 %. Examples of exposed structures are bridges, roadsides and sidewalks, which come into direct contact with rain, splash, snow and de-icer salt.

There has been done a lot of research to find a solution to get a frost resistant concrete. A normal concrete contains 120-180[l /m^3] of pores. The air void size distribution/structure expressed as specific surface and spacing factor, and the degree of saturation affect the possibility for frost damage. Also pore size of the fine (gel/capillary) porosity is important. Water in pores having a diameter of 100nm will freeze at -3°C, while water in pores with a diameter of 10nm will freeze at lower temperature than -25°C.

When water comes in contact with concrete, such small pores fill quickly but if the concrete subsequently freezes only water in pores above a certain size will freeze. Freezing of pore water can give the concrete high tensile stresses unless it is protected by air voids. The effect of deicers on damaged surfaces is different from internal frost damage, but for both deicer frost damage and for internal frost damage air voids protects the concrete from deterioration.

2.2 Foam Index (FI)

The test was developed by Dodson (Dodson 1990) in 1980 in the United States. Later, many changes have been made regarding the way to conduct the test. Originally it was used for cement and AEA and then for quality control of pozzolans for concrete. Foam Index (FI) expresses the amount of air entraining agent (typically a few micro liters AEA / g binder powder) that must be added to achieve stable foam on top of a dilute mixture of binder (cement, fly ash) and water after shaking.

The Foam Index test was used to examine the effect of air-entraining agents for Portland cement. The results for a specific type AEA showed that Foam Index increased by cement fineness (that means that more AEA is needed to obtain stable foam, the more finely ground the cement, everything else kept constant) while FI decreased with increased alkali content in the cement. According to Harris (Harris, N. J. et al. 2008), the test is important to find a proper dosage of air entraining agents on a specific type of binding agent. There is no aggregate in the Foam Index test, only a slurry of w/b in the order 2 – 2.5.

In (Külaots, Hurt & Suuberg 2002) tests showed the amount of a type of AEA that must be added to the mixture to adsorb onto the particular fly ash so that the surface is saturated and there is still sufficient AEA in the liquid to create air voids.

Foam Index test may be a useful tool for determining proper dosage of AEA in concrete. Several researchers have worked on various FI procedures and it would be advantageous for the concrete industry with a standardized test, in order to compare results from tests at different laboratories. Here we explore the possibility of further developing it for studies of air entraining effect of various admixture-binder combinations for concrete.

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2.3 Fly Ash

Fly ash is a mineral by-product resulting from the production of electricity and heat by coal-fired power and cogeneration plants. Fly ash is thus an industrial by-product, which can replace a portion of cement. This provides both economic and environmental benefits such as reduction of CO_2 emissions. Due to this the authorities strongly encourages the use of fly ash. Norcem Standard Cement FA contains 20% fly ash. It is desirable to replace the cement with 30-35% fly ash in the future. We have therefore chosen to use 70/30 cement / fly ash in our tests.

In addition fly ash is mainly used in order to reduce heat development during curing, improve durability and other long term properties. This results in reduced risk of cracks in concrete structures. It also has been found that fly ash improves the workability of the concrete by replacing a portion of the cement.

Fly ash contains some carbon, often measured as loss on ignition (LOI). The variation in carbon content depends on various factors that can lead to variable need for AEA as discussed above. This was also found in previously performed FI-tests, among others, of Gebler and Klieger.(Gebler & Klieger 1983; Gebler & Klieger 1985b, 1985a).

2.4 Adsorption

The addition of fly ash in concrete have influence on air entraining because AEA adsorbs on the fly ash.(Pedersen, Jensen & Dam-Johansen 2005) According to them adsorption occurs due to residual coal substance in fly ash, which together with the inorganic / mineral part of the fly ash has a non-polar surface. This provides an opportunity for interaction and thus the adsorption of the hydrophobic portion of the admixture. The adsorption takes place as a competing mechanism that leads to a lower concentration of free air entraining agents in the fresh concrete. Recently Tunstall et al (Tunstall, Scherer, Prud'homme (2015)) quantified this with measurements of Critical Micell Concentration (CMC) as function of AEA and solution.

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2.5 Air Entraining Agents (AEA)

According to Norwegian Standards (NS 2001) frost-resistant concrete shall be produced by adding air entraining admixtures. Use of AEA should supply / convert the large bubbles into small spherical bubbles that evenly distribute throughout the paste portion.

Air entraining agents are aqueous solutions of organic materials which cause a controlled amount of air in the form of tiny air bubbles. Air entraining agents are described in NS EN 934-2 as "Admixtures which allow a controlled amount of small evenly distributed air bubbles to be incorporated within the composition remain after curing."

The addition of air entraining agents, leads to binding of many evenly distributed and small air bubbles in the cement paste which gives the following effects:

- Significant increased resistance to freezing and thawing, this is the main reason for AEA to be used.

- The small and round air bubbles act as "bearings" in the system and improve workability.

- Lower strength. The AEA creates more air voids, where an increase in the amount of air voids results in a decrease of strength. For each percent additional air caused by AEA, we must expect a 5% reduction of strength unless adjustments to the composition are made.

Based on the last point, one can understand why it is desirable to use water-reducing (superplasticizers) admixtures in combination with air entraining agents.

Various substances that can be used as air-entraining agents are:

- Wood rosin (vinsol resin)

- Polyethylene oxides (tensides)

- Fatty acid salts (from tall oil or coconut oil)

- Other types as alkyl aryl sulfonates

These substances work as a soap, which has a foaming effect in water. Conventional soaps will not provide the desired bubbles, which remain stable in the concrete or mixing process.

S. Chatterji (Chatterji 2003) explains that the air-entraining agents can be classified into two general types. One type reacts with calcium hydroxide solution of cement paste to trap insoluble calcium salt. This type comprises vinsol resins, sodium adipate, sodium oleate, etc. He said that with this type of AEA surface tension does not decrease. However, the new CMC measurements by Tunstall et al (2015) show a drop in surface tension for these types as well, though depending on the solution. The function of hydrophobic calcium salts are to be hydrophobic and collect in the contact area water-air-cement grains, hence entraining air by stabilizing the air void system, see also Dodson 1990, Mehta & Monteiro 1993, Rixom 1999 etc. These are expected to adsorb on carbon. The second type is synthetic detergents (tensides). These consist of chains of aliphatic and / or aromatic hydrocarbons with a water-soluble group SO_4, SO_3 or OH etc. attached at one end. All tensides reduce surface tension by preferentially accumulating at the air-water interface. This lowering of the surface tension is the main reason for both air entraining and stability of the air void system. These are believed not to be adsorbing on carbon.

Common for all AEA`s (Vollset 2010) is that they are surface active substances, surfactants, which "settle down" on the cement particles between water and air bubbles. The admixtures orient themselves so that one end faces towards the water (hydrophilic end), while the other end is hydrophobic (afraid of water) and creates stability in the air void system. The air entraining agent orients itself in between water and air, while "settling down" on cement surfaces in which the hydrophobic ends of chain draws air pores and preventing these to form larger bubbles.

This does not mean that all bubbles are of the desired size and there is no guarantee for obtaining the best possible air-pore structure in the fresh concrete.

2.6 Superplasticizing admixture (SP)

Superplasticizing admixture has a better effect than plasticizing admixtures. Obtained water reduction by use of plastisizing admixture is up to 8%, while superplasticizers give a reduction of 12-40% according to NS. A superplasticizer does not have a retarding effect and has a short duration of action. It can be dosed drop wise without giving a poor effect, but unfortunately SP is expensive. The highest water reduction occurs when SPs are added as late as possible in the mixture. Superplasticizers reduce the tendency of flocculation of cement particles. Also the thickness of the adsorbed water film is reduced so that improved workability is obtained.

Superplasticizing admixtures are organic poly-electrolytes, which belong to the category polymeric dispersing agents. Some of these are synthetic, while others are from natural products and can be classified into the following categories:

• sulfonated melamine

• sulfonated naphthalene

• modified lignosulfonates

• polycarboxylate (Co-Polymer)

The new generations of Co-Polymer superplasticizing admixtures are very efficient compared to the other 3 and these new admixtures behave in two ways; some attach themselves to the surface of the cement grains while the rest scatters in the liquid. This causes the cement grains to physically separate from each other simultaneously achieving a longer opening time and increased water reduction.

Today it is desirable to use combinations of SP and AEA for the production of self-compacting concrete (SKB). Duie tpo this and the above discussion of carcon in fly ash it is important to know more about interactions between superplasticizing admixtures and air entraining agents (AEA). In addition it is important to investigate the use of the FI test for this purpose.

3. Execution of FI-test

The same equipment and "standard" procedure for the FI test as used earlier at NTNUs lab was applied, see [Vestgarden 2006, Ollendorff 2011, Jacobsen, Ollendorff et al 2012] . 7 AEAs were investigated to see the effect they have on various binders alone and in combination with SP. In addition, we looked at the effect of dosage sequences between AEA and SP. Only one type of SP was used in all tests. Estimates of minimum and maximum recommended dosage of AEA and SP are given in table 1 in µl / g for the FI test based on recommended concrete dosages from the datasheets in Appendix C.

3.1 Materials

3.1.1 Air Entraining Agent (AEA)

It is not clear how much active ingredient the AEAs contain or whether the ones from the US (AEA1-AEA4) were diluted like the Norwegian AEA 5-AEA7. Based on the recommended dosages of the datasheets for all 7 AEAs to obtain 4-6 % air in concrete we have in our tests added water to the US AEAs (AEA1 – AEA4) so these 4AEAs are diluted 1: 9 so we can compare the AEAs in the best possible way with the Norwegian AEA (L5-L7). The US AEAs had recommended dosage in the data sheets for 4 – 6 % air in concrete that is approximately 10 times higher for the Norwegian AEAs. (The producer of the Norwegian AEA states that their product is diluted 1:9 (1 part AEA:9 parts of water)).

Table 1 below shows recommended dosages based on the datasheets for concentrated AEAs. For the 3 Norwegian AEAs we have assumed 300 kg/m^3 of concrete since the Norwegian and US recommendations used different units for dosage in concrete, and then we corrected for 1:9 dilution of the product.

AEA	Description		Minimum recommended dosage (µl/g)	Maximum recommended dosage (µl/g)
AEA1 – Sika Air	Saponified Rosin	Resipal 55K K-abietate SR	0,32 µl/g	1,95 µl/g
AEA2 – Sika AEA-15	Saponified Tall Oil	Dresinate TX-60W Na soap of tall oil STO	0,16 µl/g	0,65 µl/g
AEA3 – Sika AER	Neutralized Vinsol Resin	Vinsol Resin flakes Carboxylates NVR	0,32 µl/g	0,97 µl/g
AEA4 – Sika Multi Air	Olefin sulfonate	Ninol 40-CO Alkanolamide SOS	0,1 µl/g	1,95 µl/g
AEA5 – Mapeair 25 1:9	Based on synthetic tensides and tall oil derivatives		0,1316 µl/g	1,316 µl/g
AEA6 – Mapeair 50 1:9	Based on Tall Oil		0,1316 µl/g	1,316 µl/g
AEA7 – Mapeair L 1:9	Based on Tensides		0,1316 µl/g	1,316 µl/g

Table 1: The recommended dosage AEA / g cement and description of AEA from the data sheets

3.1.2 Superplasticizers (SP)

In tests with SP before AEA and SP with AEA, we have chosen to add between 30-40% of the maximum recommended SP dosage. This corresponds to about 4 µl / g.

SP	Description	Minimum recommended dosage (µl/g)	Maximum recommended dosage (µl/g)
SP – Dynamon SX - 130	akrylpolymerer	3 µl/g	12 µl/g

Table 2: The recommended dosage and description of the SP from the data sheet.

3.1.3 Cement, fly ash and filler

Binder	Density (g/cm^3)	Carbon content (%)	L.O.I (%)	Blaine (m^2/kg)	PSD
Norcem Standard OPC(NO)	3,15 g/cm^3	0 %	2,35 %	396 m^2/kg	-
Norcem Standard FA	2,99 g/cm^3	0,35 %	1,21 %	461 m^2/kg	Appendix E
US OPC OPC(US)	-	-	-	-	-
Norcem Fly Ash FA(NO)	-	1,74 %	2,27 %	334 m^2/kg	Appendix E
US Fly Ash FA(US)	-	2,06 %	1,91 %	428 m^2/kg	Appendix E
Limestone	2,73 g/cm^3	0 %	37,66 %	362 m^2/kg	-
Quartz (90 %)	2,58 g/cm^3	-	-	-	-

Table 3: Description of cement, fly ash and filler

3.2 Equipment:

Equipment is shown in Photos 1 – 4:

-Griffin flask shaker

- Arm for Griffin flask shaker which provides amplitude of 2 cm.
- 70ml container (see Table 4)
- Weight
- 2 pcs. Finnpipette F1 10-100 µl
- Computer with accelerometer for frequency measurements
- Laptop for data entry
- Stopwatch
- Rubber bands to attach the container lid
- Protective equipment
- Various containers for storage and measurement of materials.

Photo 1: Griffin Flask Shaker

Photo 2: Weight, binder, water and Finnpippette F1

In Photo 2 the left and middle photos show weighing of powder (cement, flyash, filler) and water and the picture on the right shows the pipettes used to measure drop sizes.

Photo 3: All equipment

Photo 3 shows all the equipment used for the tests. At far left the computer with accelerometer and logger for measuring the frequency of the shaker is shown. Photo 4 shows a close-up of the container of the shaker with cement.

Description	
Container	Cylindershaped, plastic
Volume	70ml
Inner diameter	40mm
Inner height	55,7mm
Filled volume fraction (%)	40 %
Filled height	22,3mm
paste (slurry) volume	28ml
	20µl
Drop volume	10 %
AEA concentration	2µl
AEA concentration per drop	

Table 4: Description of container and filling

Photo 4: Container with cement

3.3 Stable Foam

Many observations have been made with different sizes of containers and the quantity of slurry. The results from Harris (Harris, N. J. et al. 2008) showed that at the end point of the test (which is called stable foam) a typical foam thickness of about 4-5 mm at the top of the mixture was observed as shown in Figure 1.

They observed the time needed to obtain stable foam after each shaking at 15, 30 and 45 seconds. They claimed that stable foam at 15 seconds also remained stable for 45 seconds. Therefore, they concluded that it is not necessary to wait 45 seconds if the foam was stable after 15 seconds.

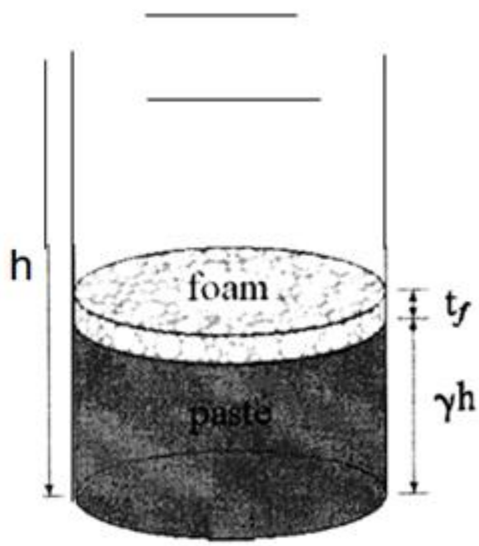

Figure 1: Stable Foam

$$\frac{A}{P} = \frac{Ac \times tf}{Ac \times \gamma h} = \frac{tf}{\gamma h}$$

A : volum av skummet i overflaten ved stabilskum

P: volum av pasta i beholderen

tf: tykkelsen av stabilskum på toppen

γh: γ er fyllingsforhold , og h er høyden av beholderen.

Ac : er overflate arealet av blandningen i beholderen

Formula 1: From figure 1

We have chosen to use the description from Harris about stable foam. We are looking at stable foam when the entire surface is covered with bubbles of approximately 5mm. If the bubbles dissolve and there comes a dark liquid within 45 seconds, we consider that the foam is unstable

Photo 5: The 2 photos to the left show stable foam, while the one to the right is unstable

At left-hand photo in Photo 5 there is a layer of foam of approximately 5 mm which differs from the cement paste. This is stable foam. The middle photo shows stable foam as described above. The photo to the right shows unstable foam and we see that the fluid emerges in the centre.

3.4 Frequency selection

Harris (Harris, N. J. et al. 2008) did several tests to estimate a standardized frequency for the foam index test. Their results show that between frequencies of 3 to 5 Hz they get a more stable index compared to when using frequency below 3 Hz. They recommend a standardized frequency of 4 Hz by hand shaking with amplitude of 0.2 meters in a time interval of 10 seconds. They also claimed that it is likely that other frequencies will be more effective for other containers, loads of materials, viscosity of the cement paste and choice of air-entraining agents. This is especially true when mechanical agitation is used.

We decided to measure frequency accurately for the first time with our shaker. Figure 2 shows the effect of frequency during the Foam Index test in some of our experiments without the use of SP. The tests were made with different frequencies and were done 3 times for 5 and 7.5 Hz and 5 times for 10 Hz. The curves in Figure 2 show average values of Foam Index (FI) as function of AEA dosage. Materials were Standard cement 70%, Norw Fly ash 30% and Mapeair 25 1:9.

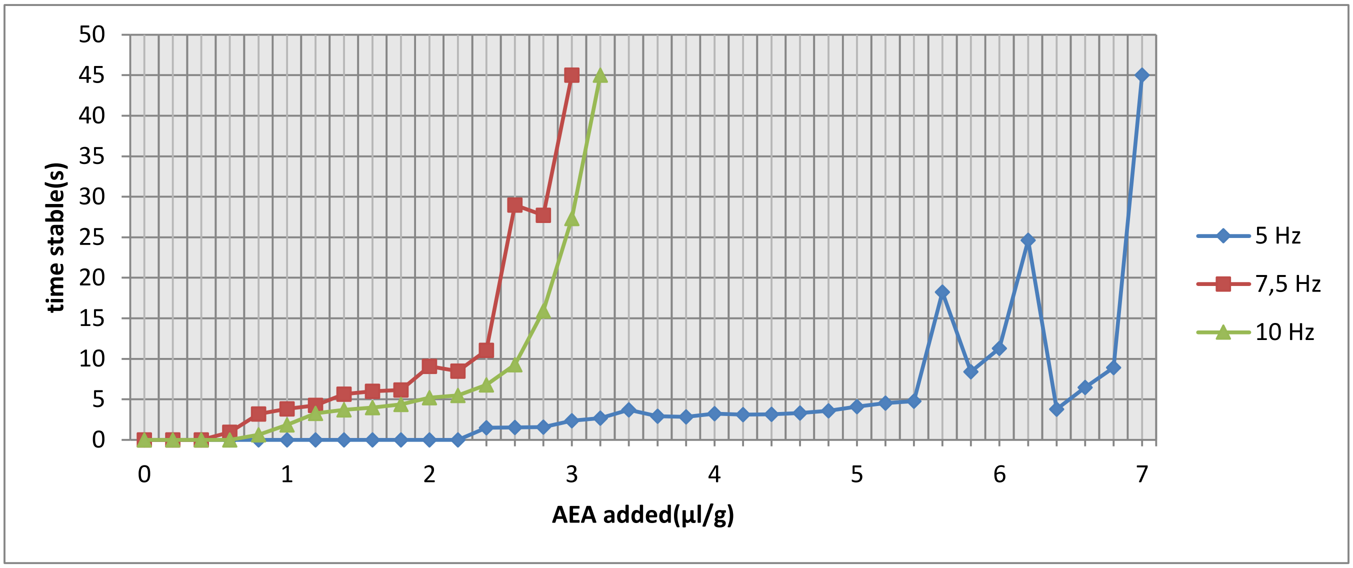

Figure 2: Effect of Frequency on AEA (without SP) for 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used in this test.

Figure 3 shows the number of shakes for the different frequencies until it reaches stable foam as function of AEA dosage. Table 5 sums up the results including FI.

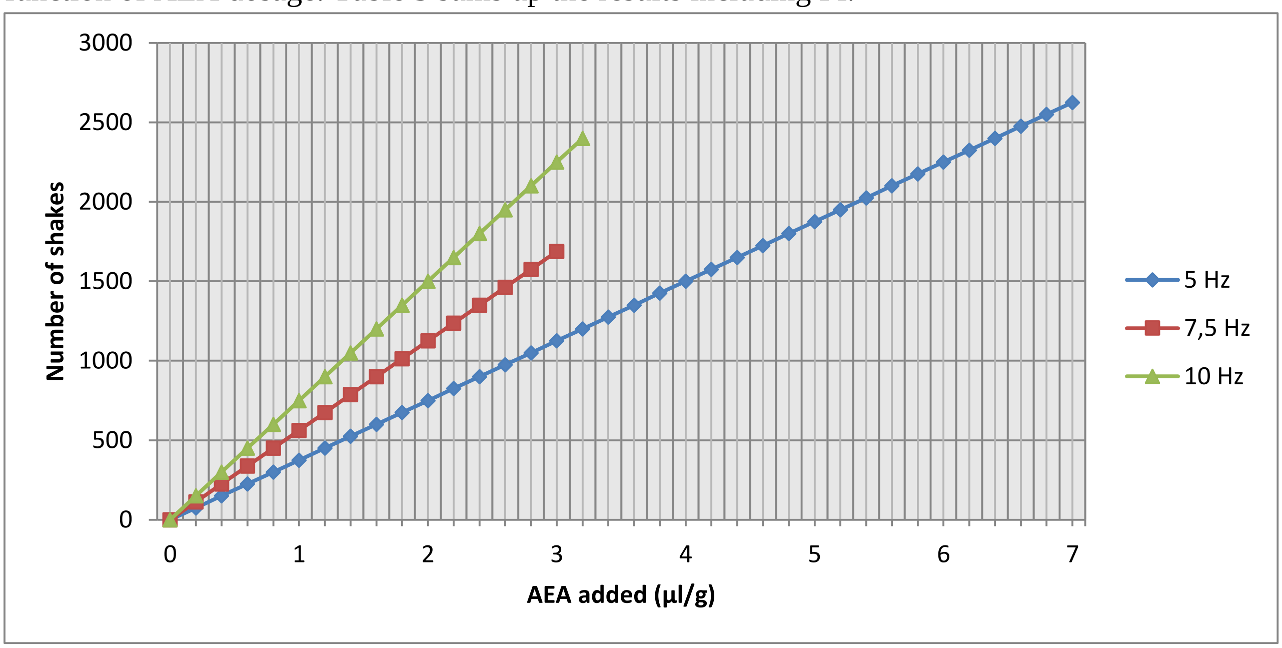

Figure 3: Effect of frequency on number of shakes to reach stable foam for the results in figure 2 70/30 OPC/FA from Norcem, Mapeair 25 1:9 (no SP)

Frequency	Binder	AEA	FI Standard µl/g (without SP)	Number of Shakes	Number of drops AEA
5Hz	OPC(NO) 70% + FA(NO)30%	AEA5	7,0 µl/g	2625	35
7,5Hz	OPC(NO) 70% + FA(NO)30%	AEA5	3,0 µl/g	1687,5	15
10Hz	OPC(NO) 70% + FA(NO)30%	AEA5	3,2 µl/g	2400	16

Table 5: Shows results from Figures 1 and 2 when it comes to FI-test and the number of shakes.

As we can see from Table 5, Figure 2 and 3 the low frequency 5 Hz requires much more AEA to foam than 7.5 and 10 Hz and there is little difference between 7.5 Hz and 10 Hz. The reason(s) for this may be that at 5 Hz shaking the cement grains sank to the bottom of the container, and were therefore unable to properly mix the materials and/or less energy was supplied to produce foam.

According to Harris' tests there is a tendency of the same effect, and it may therefore indicate that 7.5-10 Hz is the best for our FI method. We therefore decided on the basis of this to use a frequency of 10 Hz with amplitude of 2cm in our tests.

3.5 Test procedure

Based on various foam index tests in the literature and previous experiences at NTNU, we used the following procedures.

3.5.1 AEA (without SP):

1. Add 10g binder (cement and / or fly ash) and 25 ml of distilled water in a container with a volume of 70 ml. Shake it for 1 minute with Griffin flask shaker, an amplitude of 2 cm and frequency of 10 Hz.
2. Add one 20µl drop of air entraining agent.
3. Shake again for 15 seconds on the same frequency.
4. Observe for stable foam. If it bursts or breaks before 45 seconds after stop of shaking it is not stable foam and the clock is stopped and time noted.
5. Repeat from step 3-4 to get stable foam that lasts 45 seconds or more.

3.5.2 SP after AEA:

1. Use sample and results from AEA (without SP).
2. Add a drop of superplasticizer of 20µl immediately after stop of test on sample with only AEA
3. Shake it for 15 seconds.
4. Observe if the foam bursts or remains stable and take time before foam breaks or bursts.
5. Repeat point 2-4 until the foam cracks before 45 seconds.

3.5.3 SP before AEA:

1. Add 10g binder (cement and / or fly ash) and 25 ml of distilled water in a container with a volume of 70 ml. Shake it for 1 minute with a Griffin flask shaker, an amplitude of 2 cm and frequency of 10 Hz.
2. Add 40µl superplasticizing admixture
3. Shake it again for 15 seconds on the same frequency.
4. Add a drop of air entraining agent of 20µl.
5. Shake it again for 15 seconds on the same frequency.
6. Observe for stable foam. If it bursts before 45 seconds it is not stable, the clock is stopped and the time noted.
7. Repeat from point 6-4 to get stable foam for 45 seconds or more.

3.5.4 SP with AEA:

1. Add 10g binder (cement and / or fly ash) and 25 ml of distilled water in a container with a volume of 70 ml. Shake it for 1 minute with a Griffin flask shaker, an amplitude of 2 cm and frequency of 10 Hz.

2. Add 40µl superplasticizing admixture (approx. 40% of the maximum recommended dosage in data sheet). Adding at the same time as many drops of air entraining agent as from the result for stable foam on the SP before AEA test (= FI).

3. Shakes it for 15 seconds on the same frequency

4. Observe if the foam remains stable for 45 seconds or bursts before that (note time).

5. Repeat the same procedure with adding 40% recommended maximum dosage based on the data sheets for both AEA and SP.

3.5.5 AEA and water

A series of measurements of foaming with only AEA and water was conducted by filling the container with the same volume of water as in the FI test = 25 cm^3 water + (10g/3,14g/cm^3)= 28,2 cm^3 = 28,2 g water. The AEA dosage was given pr "imaginary" 10 g mass of cement = pr 28,2 g water, hence μl AEA/(2,82 g water) as presented in table 7.

3.6 Deviations

During the tests there can be some deviations. For example drop sizes from the pipettes can vary from 20 ± 0.2 μl according to the equipment supplier. Furthermore, it may under some circumstances be difficult to judge visually whether the foam is stable or not.

In Figure 4 we have completed 5 tests on the same material to assess the accuracy of the results. Figure 5 shows average and standard deviation based on the same result. It is seen that the scatter in results is big for the dosages where the foam starts to propagate and small/negligible before and after the foam propagation as expected from the nature of the foam. Apparently there is some sort of nick-point for each test after which the foam propagates rapidly for these test conditions.

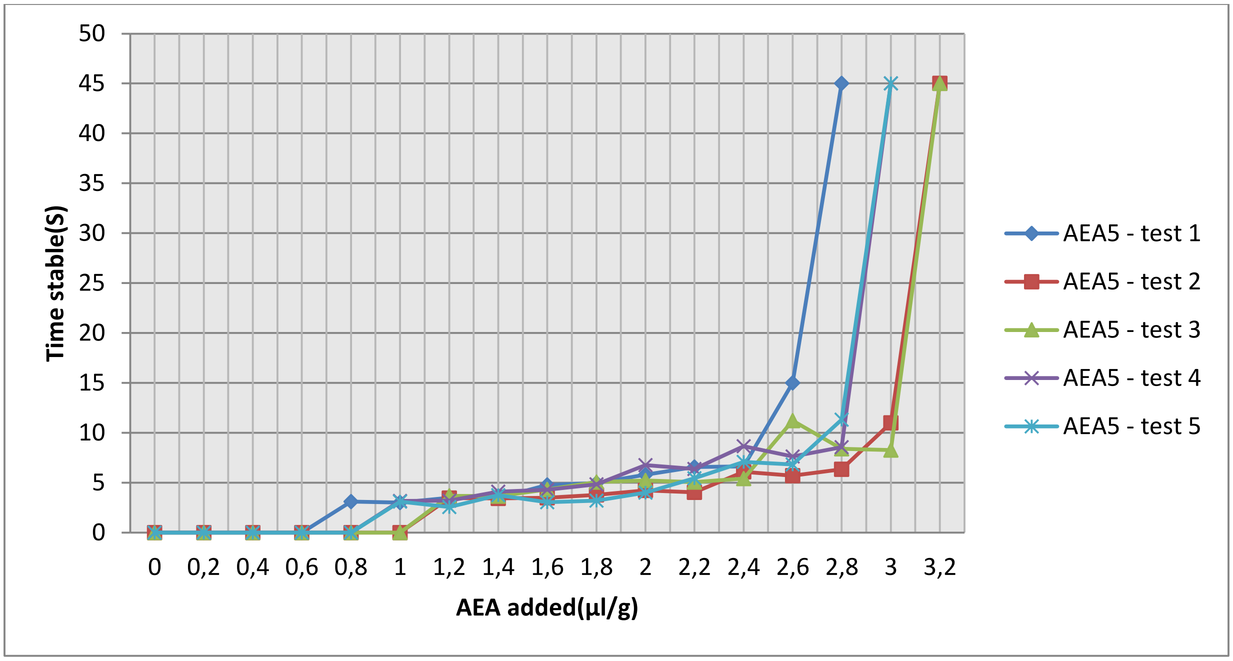

Figure 4: AEA (without SP): Shows 5 tests of 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used.

We have used the results from Figure 4 to calculate an average value and standard deviation. In Figure 5 we have plotted this average value with ± standard deviation.

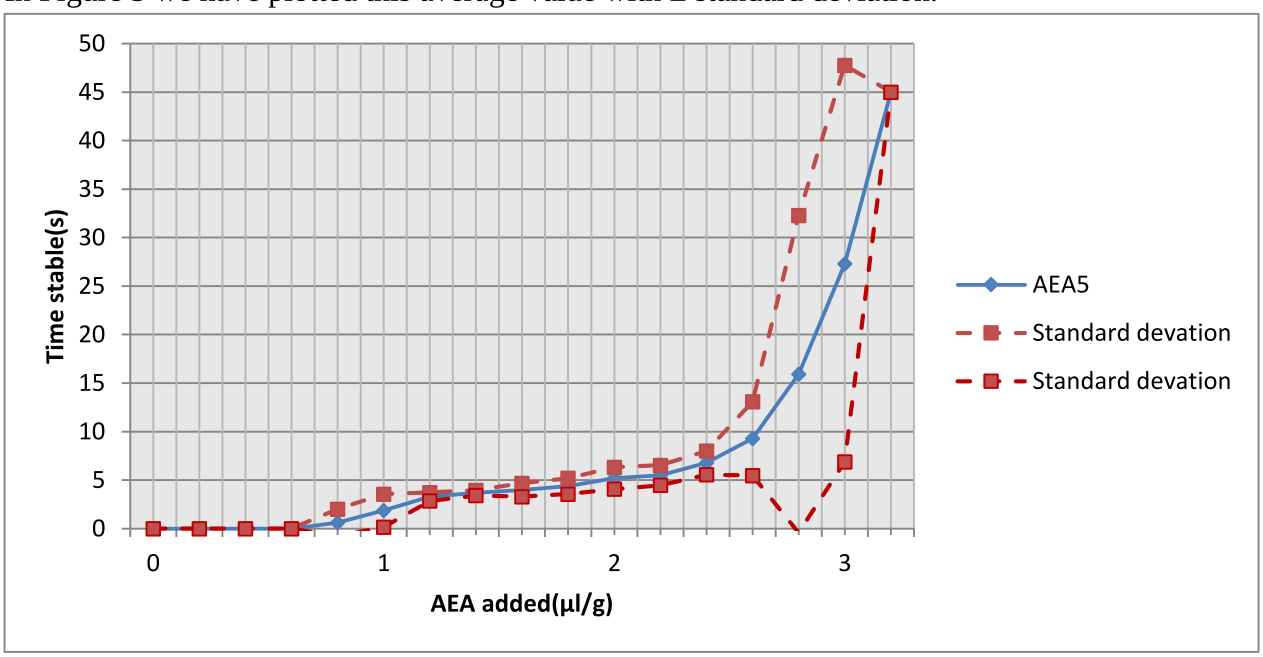

Figure 5: AEA(without SP): Shows average value of 5 tests and standard deviation for 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used.

4. Results and dicussion

AEA (without SP) compared with SP before AEA

Figure 6 compares the results of AEA (without SP) and SP before AEA. AEA (without SP) are shown as solid lines and SP before AEA are the dotted lines. The powders are Norcem Standard (blue and red line) and Norcem Standard 70% + FA (NO) 30% (Purple and green line) AEA used was Mapeair 25 1: 9. 5 tests were conducted with Norcem Standard 70 % + 30 % FA (NO). Norcem Standard was tested just once for combinations of AEA and SP.

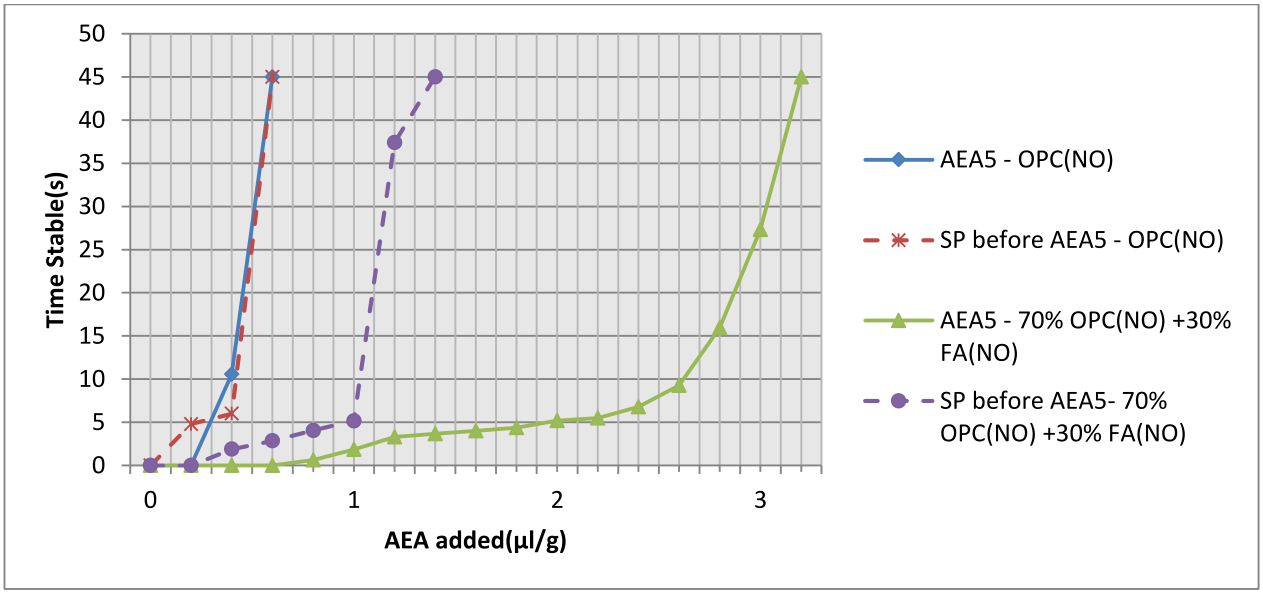

Figure 6: Effect of AEA (without SP) and SP before AEA on OPC and 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used.

Figure 7 compares the results from AEA (without SP) and SP before AEA for several AEA`s with 70/30 OPC / FA mixture (same OPC / FA mixture as in Figure 6). Pure AEA tests (without SP) are shown as solid lines, and tests of SP before AEA are the dotted lines. The cement material used is Norcem Standard cement 70% + Norwegian fly ash 30%.

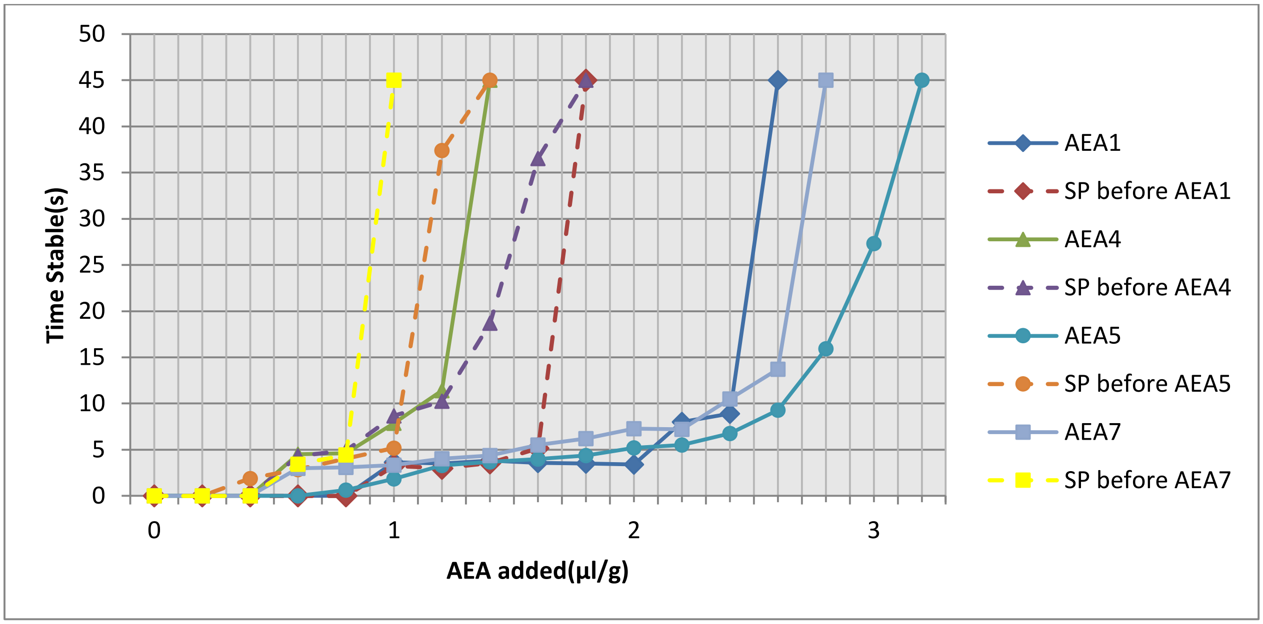

Figure 7: Effect of AEA (without SP) and SP before AEA for 70/30 OPC/FA from Norcem

Figure 8 compares the results of AEA (without SP) and SP before AEA. AEA (without SP) are shown as a solid line, and SP before AEA are the dotted lines. The materials used are American OPC cement 70% + American fly ash 30%, American AEAs and the same (Norwegian SP).

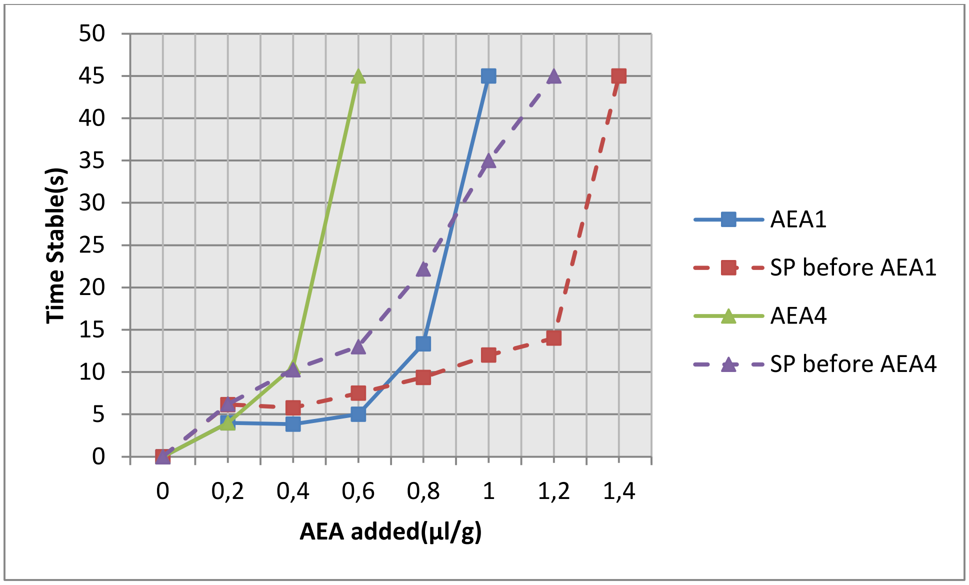

Figure 8: Effect of AEA (without SP) and SP before AEA for 70/30 OPC/FA from US for 2 types of AEA.

As we can see from Figure 6, there is no effect of adding SP before AEA compared to without SP on the Norwegian Portland cement without fly ash (OPC (NO)). With Norwegian cement / fly ash (70/30), on the other hand, the Foam Index is much lower if we add SP before AEA compared to without SP. This suggests that there is a mechanisms (reaction, adsorption) between Fly ash and SP, which makes it easier for AEA to create foam when added after SP.

In Figure 7, we also see that SP added before AEA gives a positive effect on the Foam Index also for other types of AEA (both Norwegian and US) when used with the same Fly Ash binder as in Figure 6. There is one exception though: Sika Multi Air which foams slightly more effectively without SP. This could be within the scatter and could indicate that the foaming of this AEA (which has a very low Foam Index when used without SP and hence seems to be very efficient with this 70/30 OPC/Fly Ash binder) also is unaffected by SP under these conditions.

Figure 8 shows that there is probably no effect of SP on Foaming for the two US AEAs 1 and 4 when used with US 70/30 OPC/FA . The Foam Index is in all cases very low. The US fly ash had lower carbon content than the “Norwegian” Fly Ash seen as lower LOI (see table 3 and appendix).

Procedure		3.5.1	3.5.3	3.5.4	3.5.2
Materials/binder	AEA	AEA (without SP) µl/g	SP before AEA(SP/AEA) µl/g	SP with AEA (SP/AEA/(time stable)) µl/g	SP after AEA* (SP) µl/g
OPC(NO)	AEA5	0,6	4/0,6	4/0,6(4,5sec)	4
OPC(NO)	AEA6	0,6	4/1	4/1(3,5sec)	2
OPC(NO) 70% + FA(NO)30%	AEA1	2,6	4/1,8	4/1,8(6,59sec)	2
OPC(NO) 70% + FA(NO)30%	AEA4	1,4	4/1,8	4/1,8(26,5sec)	2
OPC(NO) 70% + FA(NO)30%	AEA5	3,2	4/1,2	4/1,2(4,41sec)	2
OPC(NO) 70% + FA(NO)30%	AEA7	2,8	4/1	4/1(5,31sec)	4
OPC(US) 70% + FA(US)30%	AEA1	1	4/1,4	4/1,4(11sec)	2
OPC(US) 70% + FA(US)30%	AEA4	0,6	4/1,2	4/1,2(45sec)	2

Table 6: Shows Foam Index results for different combinations and dosage sequence (dosage to "kill" foam)

In Table 6 we see that adding SP simultaneously with AEA (procedure 3.5.4) does not provide the same positive effect as when adding SP before AEA (procedure 3.5.3). SP simultaneously with AEA shows that the time for stable foam ranges from 3.5 to 26.5 seconds except AEA4 combined with the US cement and Fly Ash, which then retains stable foam for 45 seconds. It was also easily seen during tests that there was much movement in the foam. The foam dissolved, but could be formed again shortly after. Possibly both admixtures adsorb on the cement grains simultaneously and therefore interfere with each other, reducing their effects.

When we added SP after AEA (procedure 3.5.2), the results show that the foam dissolved before 45 sec with 2-4 µl/g dosage. It appears that the SP then in some way can affect the surfactant-/foaming properties of the AEA negatively.

All AEAs in NO(70/30), US(70/30) and NO(100) without SP

Figure 9 shows the effect of all the air-entraining agents (standard FI procedure without SP) on Norcem Standard cement 70% + Norwegian fly ash 30%.

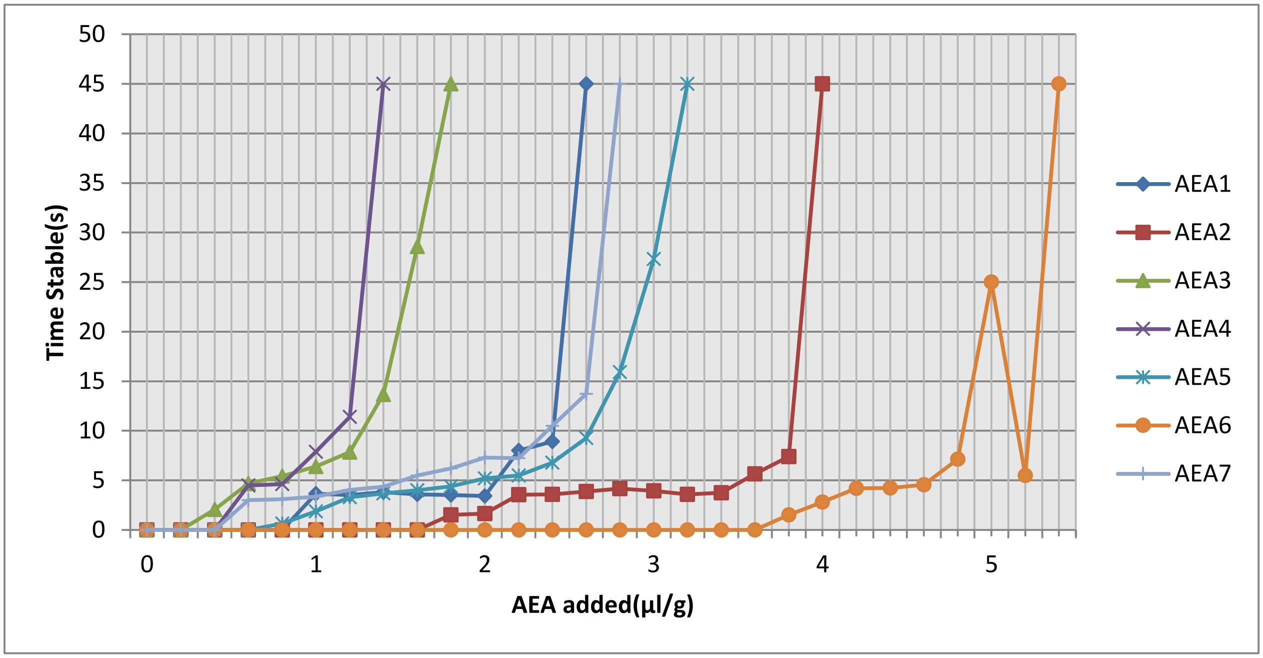

Figure 9: AEA (without SP) on 70/30 OPC/FA from Norcem.

Figure 10 shows the effect of all air entraining agents against American OPC cement 70% + American fly ash 30%.

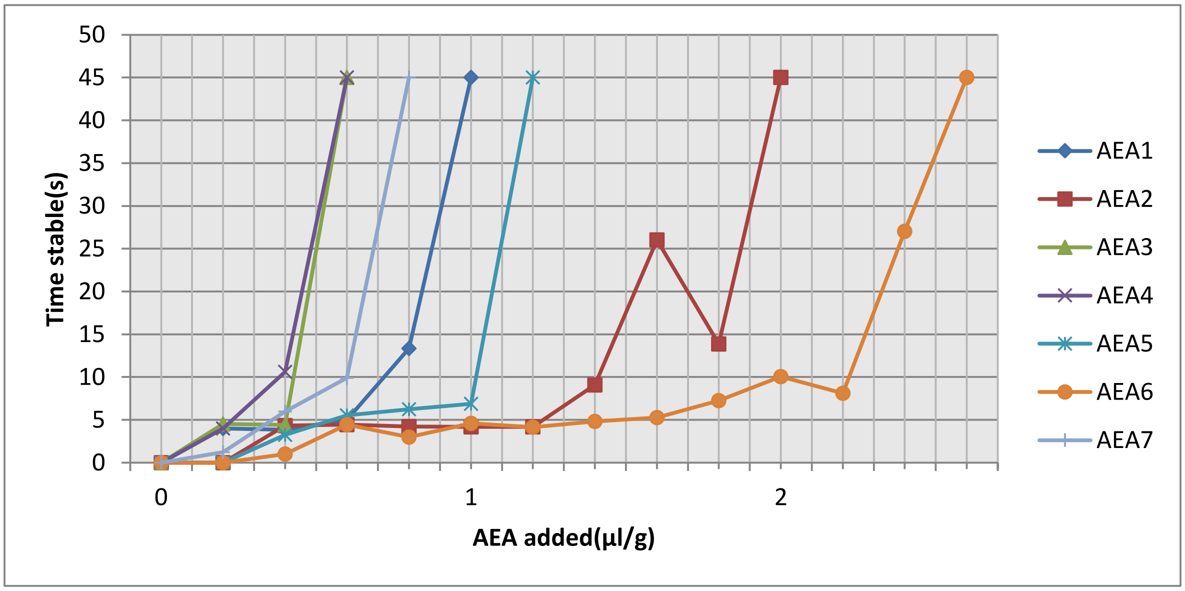

Figure 10: AEA(without SP) for 70/30 OPC/FA from US.

Figure 11 shows the effect of all the air-entraining agents against Norcem Standard cement.

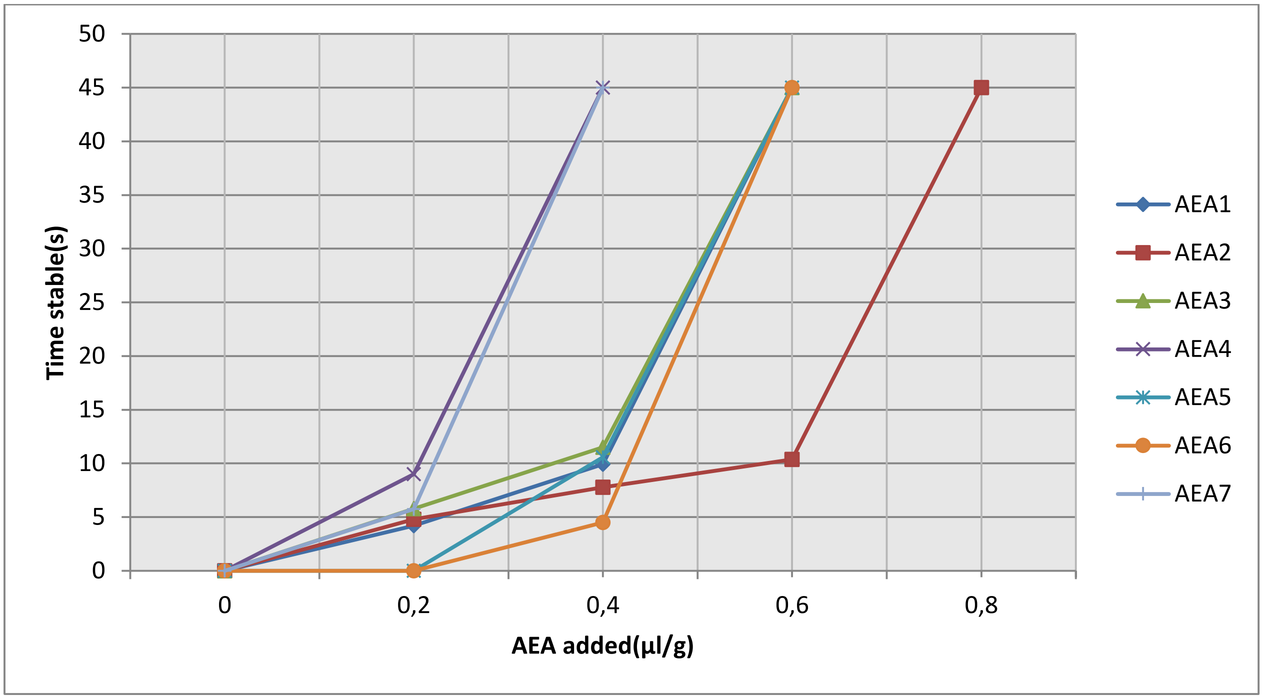

Figure 11: AEA (without SP) for OPC from Norcem.

It is seen from Figures 9 and 10 that the Norwegian70/30 binder requires more air entraining agent than the US binder (about twice). This may indicate that the Norwegian fly ash adsorbs more AEA relative to the US because of the carbon in the fly ash. The ranking of efficiency of the 7 AEAs is the same in Fig 9 and 10. AEA 3 and 4 are the most efficient and AEA 2 and 6 the least efficient ones. When the same 7 AEAs are used with pure Portland cement it is probably not possible to tell any difference between them due to the low FI values.

It seems that Tunstall's conjecture that Sika Air is adsorbing and Sika Multi Air is non-adsorbing AEA is right .

We also note that air-entraining agents based on tensides have the lowest FI, especially Sika Multi Air which gives the best results in all 3 figures. Sika AER is second best, while Mapeair L takes 3 and 4 place.

Based on the recommended dosage from the data sheets, we see that the Norwegian 70/30 binders are far above the maximum recommended dosage. With the US 70/30 binders the AEAs are within recommended dosage, except Sika AEA-15 and Mapeair 50. For Norwegian Portland cement (OPC(NO)), the AEAs are also within the recommended dosage, except Sika AEA-15.

Quartz, Limestone and NO (70/30) Cement/Fly Ash

Figure 12 shows the effect on AEA dosage (without SP) when replacing some of the Norwegian OPC/FA 70/30 with limestone filler. The binder used contained 56% Norcem standard cement, 24% Norwegian fly ash and 20% limestone (70/30 Norcem standard / Norwegian fly ash). The air entraining agent that was used in this test was AEA5 = Mapeair 25 1:9.

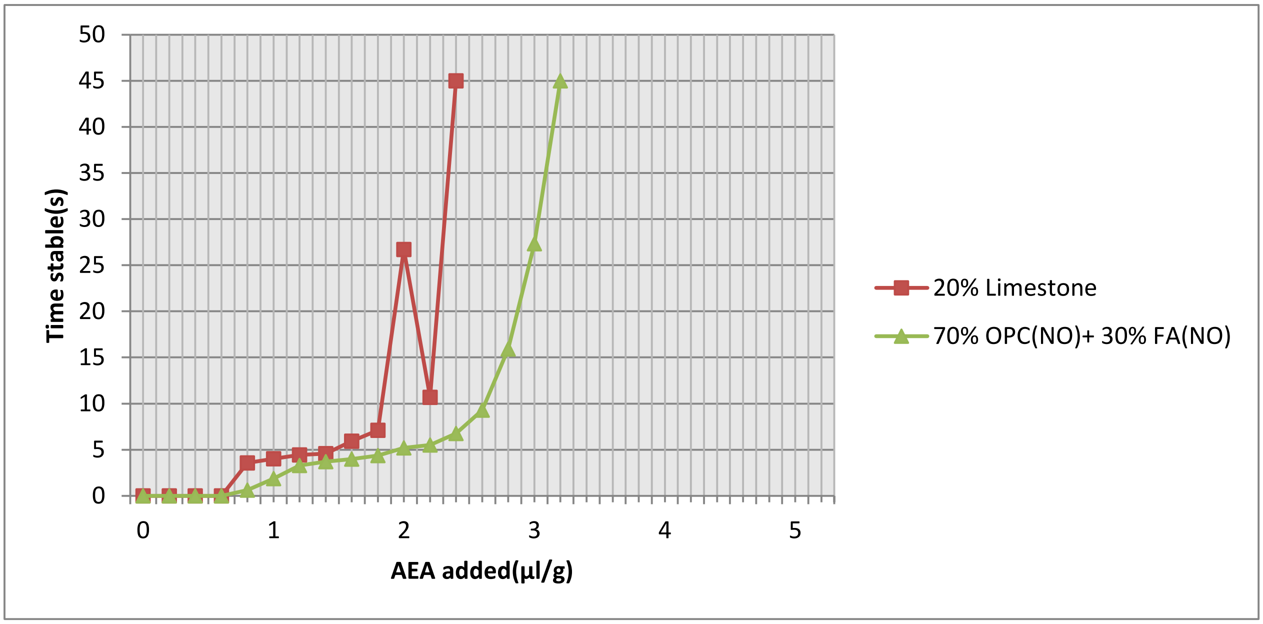

Figure 12: AEA (without SP) of 70/30 OPC/FA and 56/24/20 OPC/FA/LS from Norcem. Mapeair 25 1:9 was used.

Figure 13 shows the effect on necessary dosage of a different AEA (AEA6 Mapeair 50 1:9) (without SP) when we replace some of Norwegian OPC/FA 70/30 with quartz or limestone filler. The binders we used contained 56% Norcem standard cement, 24% Norwegian fly ash and 20% quartz or limestone. These were compared with the average value of 3 tests on Norcem standard cement 70% + Norwegian fly ash 30%.

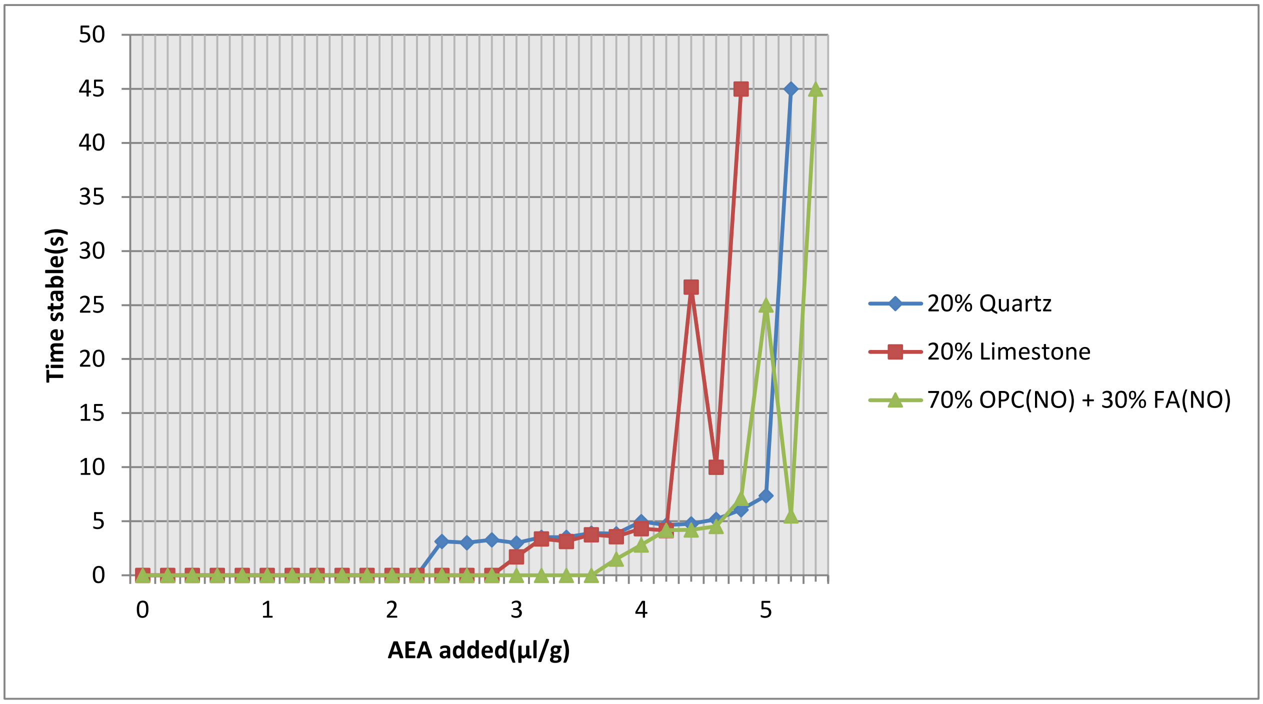

Figure 13: AEA (without SP) of 70/30 OPC/FA, 56/24/20 OPC/FA/LS and 56/24/20 OPC/FA/Q from Norcem. Mapeair 50 1:9 was used.

By replacing some of the cement / fly ash with limestone the results show that the index decreases with 0.6 µl / g. Replacement of quartz gives a slight reduction of FI of 0.2 µl / g. The reason why the FI decreases is pressumably because the carbon content and surface area are both reduced somewhat in the binder so that AEA adsorption is reduced.

The actual quartz filler used has a much greater fineness than the limestone filler and hence adorbes more than limestone. In the mixture with limestone, we also see that there is a big scatter before the foam becomes stable.

Fly Ash

Figure 14 shows the difference between the properties of the different fly ash in terms of Foam Index (=minimum quantity AEA to obtain stable foam).

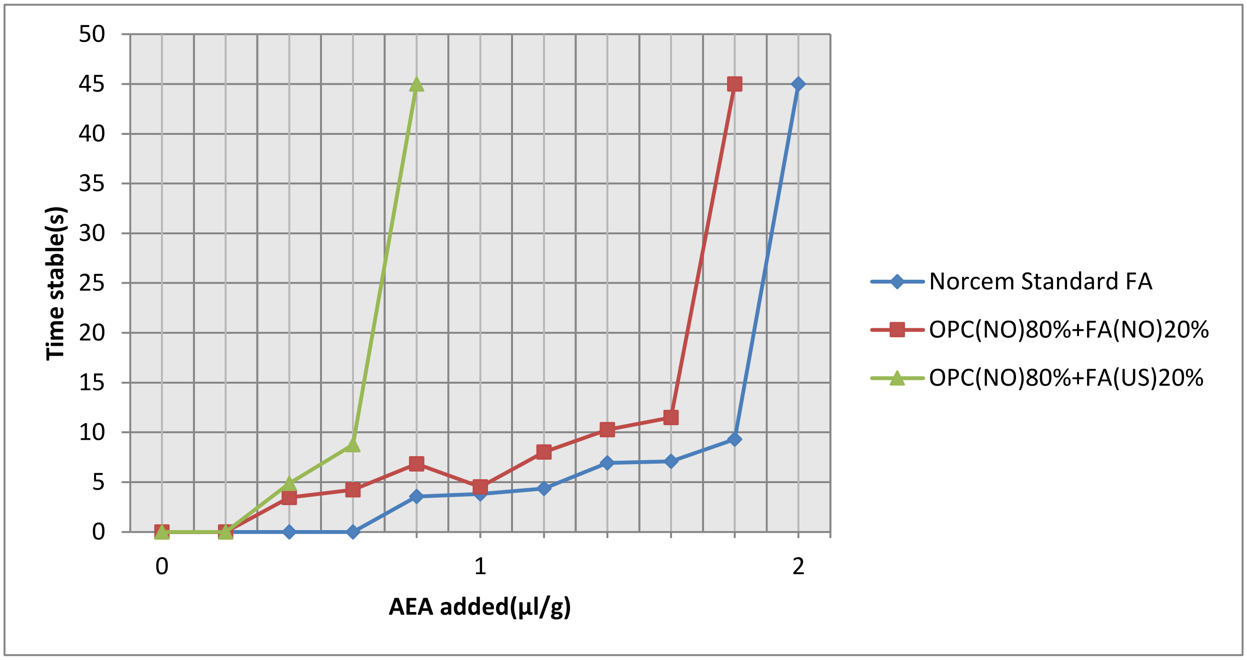

Figure 14: AEA(without SP). Mapeair 25 1:9 was used.

We see in Figure 14 that the US fly ash needs much less air entraining agents compared to Norcem Standard FA and the Norwegian fly ash. The reason is pressumably the different carbon contents in the fly ash giving diffent LOI (see tabelø 3 and appendix). The figure also indicates that the fly ash in Norcem Standard FA has the similar characteristics as the Norwegian pure fly ash. The low FI of the US Fly Ash is in line with the previous results.

Other observations:

Based on all the figures in this report, it seems that if we achieve stable foam at 15 seconds it will mainly be stable for 45 seconds (some exceptions). This is in line with Harris findings on selection of frequency and suggests that our choice of frequency makes sense and that there are certain similarities in the results regardless of the test procedure.

Overview of all observations – summary table

Table 7 sums up all FI measurements

Procedure		3.5.1	3.5.3	3.5.4	3.5.2
Material/binder	AEA	AEA(without SP) µl/g	SP before AEA (SP/AEA) µl/g	SP with AEA (SP/AEA, time stable) µl/g	SP after AEA (SP) µl/g
OPC(NO)	AEA1	0,6	-	-	-
OPC(NO)	AEA2	0,8	-	-	-
OPC(NO)	AEA3	0,6	-	-	-
OPC(NO)	AEA4	0,4	-	-	-
OPC(NO)	AEA5	0,6	4/0,6	4/0,6(4,5sek)[1]	4
OPC(NO)	AEA6	0,6	4/1	4/1(3,5sek)	2
OPC(NO)	AEA7	0,4	-	-	4
OPC(NO) 70% + FA(NO)30%	AEA1	2,6	4/1,8	4/1,8(6,59sek)	2
OPC(NO) 70% + FA(NO)30%	AEA2	4	-	-	2
OPC(NO) 70% + FA(NO)30%	AEA3	1,8	-	-	2
OPC(NO) 70% + FA(NO)30%	AEA4	1,4	4/1,8	4/1,8(26,5sek)	2
OPC(NO) 70% + FA(NO)30%	AEA5	3,2[3]	4/1,2[4]	4/1,2(4,41sek)	2
OPC(NO) 70% + FA(NO)30%	AEA6	5,4	-	-	4
OPC(NO) 70% + FA(NO)30%	AEA7	2,8	4/1	4/1(5,31sek)	4
OPC(US) 70% + FA(US)30%	AEA1	1	4/1,4	4/1,4(11sek)	2
OPC(US) 70% + FA(US)30%	AEA2	2	-	-	2
OPC(US) 70% + FA(US)30%	AEA3	0,6	-	-	2
OPC(US) 70% + FA(US)30%	AEA4	0,6	4/1,2	4/1,2(45sek)[5]	2
OPC(US) 70% + FA(US)30%	AEA5	1,4	-	-	2
OPC(US) 70% + FA(US)30%	AEA6	2,6	-	-	2
OPC(US) 70% + FA(US)30%	AEA7	0,8	-	-	2
OPC(NO)56%+FA(NO)24%+Kalkstein20%	AEA5	2,4			
OPC(NO)56%+FA(NO)24%+Kalkstein20%	AEA6	4,8			
OPC(NO)56%+FA(NO)24%+Kvarts20%	AEA6	5,2			
Norcem Standard FA	AEA5	2			
OPC(NO)80% + FA(NO)20%	AEA5	1,8			
OPC(NO)80% + FA(US)20%	AEA5	0,8			
Water[2]	AEA1	-			
Water	AEA2	-			
Water	AEA3	1,2			
Water	AEA4	0,4			
Water	AEA5	3,2			
Water	AEA6	-			
Water	AEA7	1			

Table 7: All results from Foam Index testing.

[1] Time stable
[2] See 3.5.5: = µl AEA/(g water x 2,82)
[3] Average value of 5 tests
[4] Average value of 5 tests
[5] Obtained stable foam

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Appendix

Appendix A – Foam Index - Diagrams

Appendix B – Chosen Photos

Appendix C – Calculations

Appendix D – Data sheets

Appendix E – Test report from Norcem

Appendix A – Foam Index - Diagrams

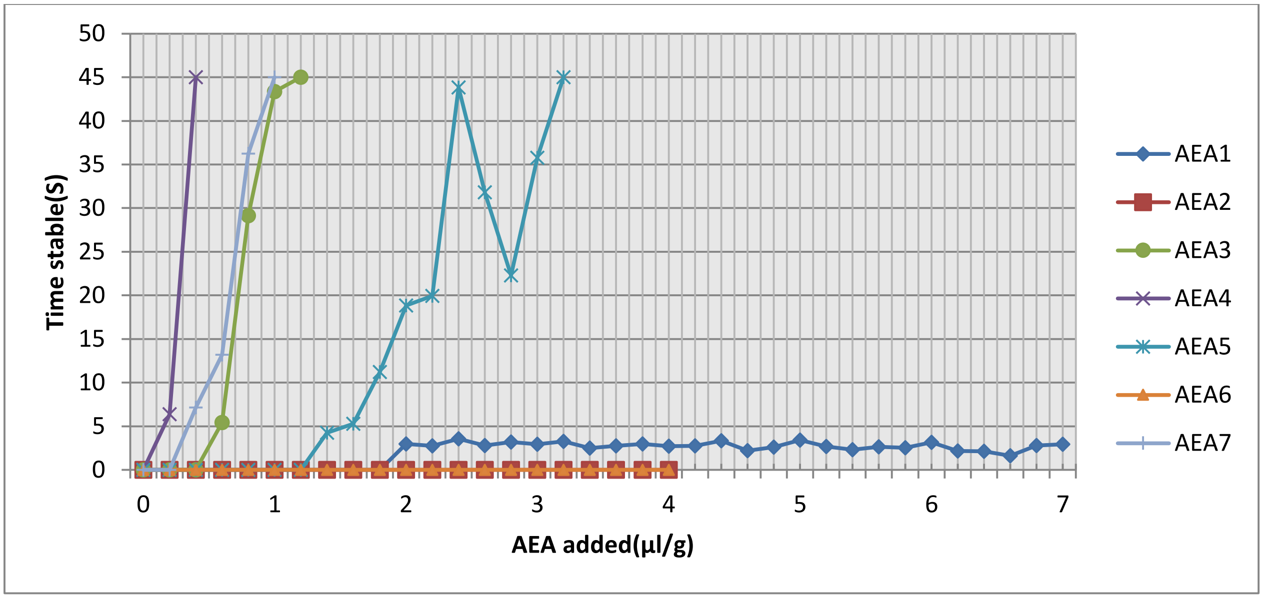


Figure 15: Shows the effect of AEA (without SP) on deionized water.

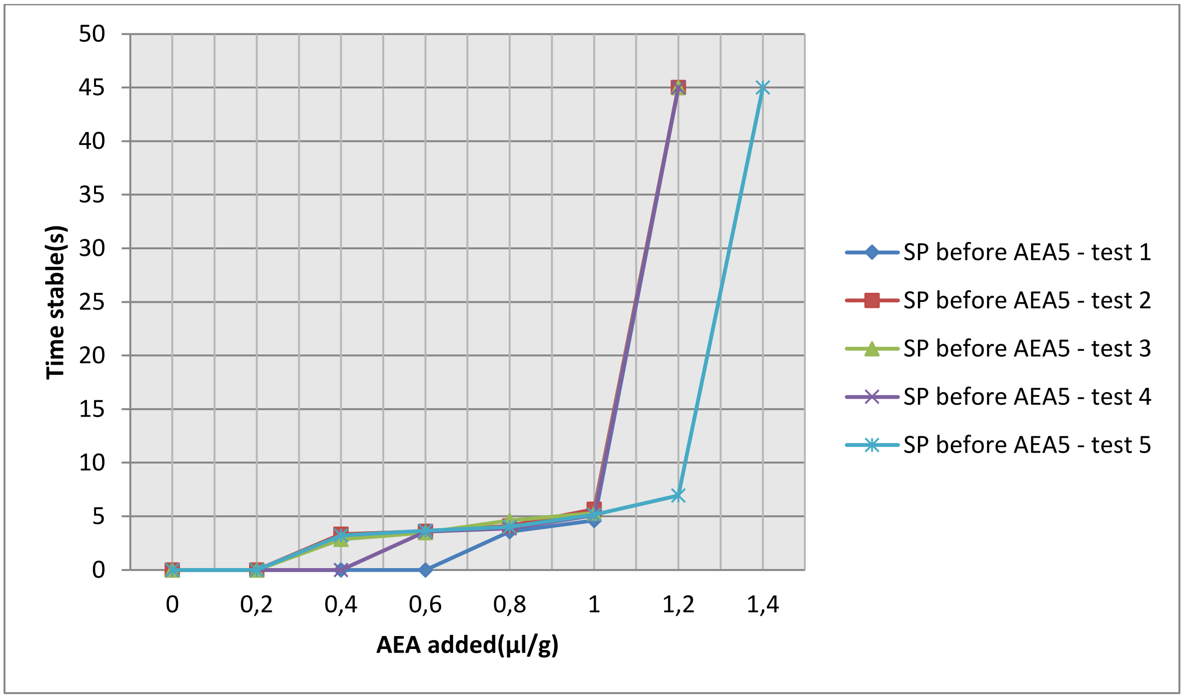


Figure 16: SP before AEA: Shows 5 tests of 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used.

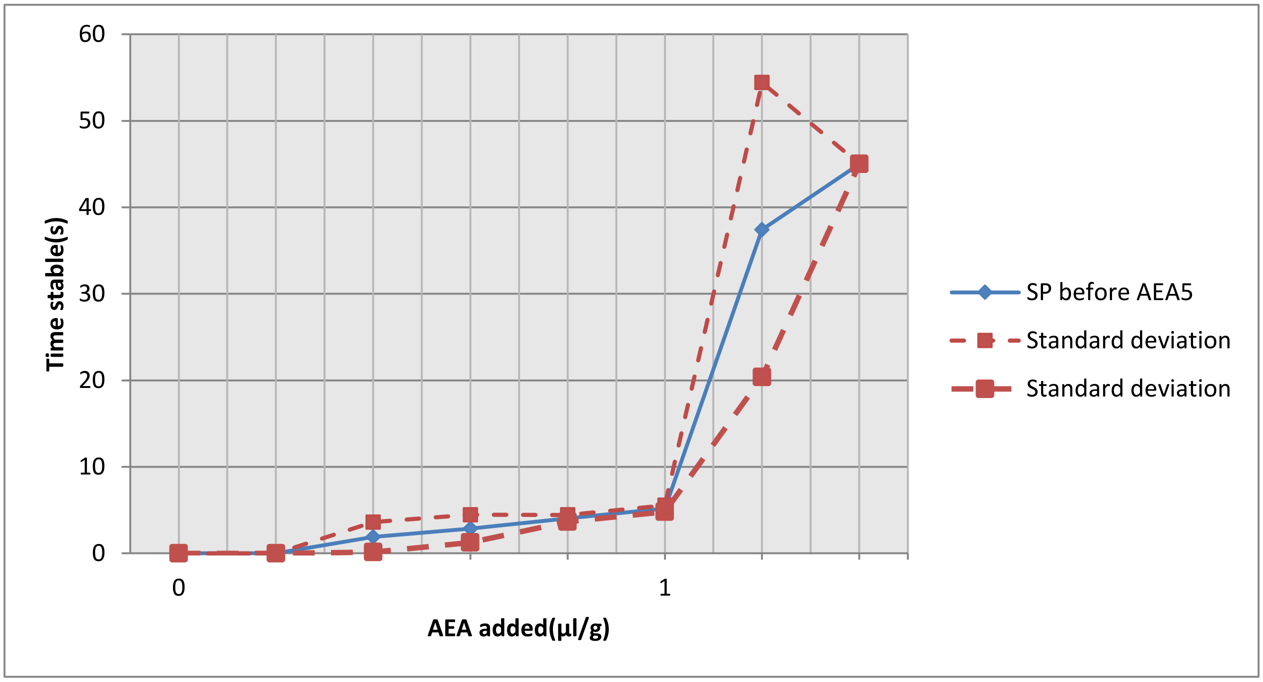


Figure 17: SP before AEA: Shows average value of 5 tests and standard deviation for 70/30 OPC/FA from Norcem. Mapeair 25 1:9 was used.

Appendix B – Chosen Photos

Mapeair 25 1:9 – 70/30 OPC (NO)/FA (NO)

Photo 6: AEA (without SP) -AEA5

Photo 7: SP before AEA – AEA5

Mapeair L 1:9 – 70/30 OPC (NO)/FA(NO) and water

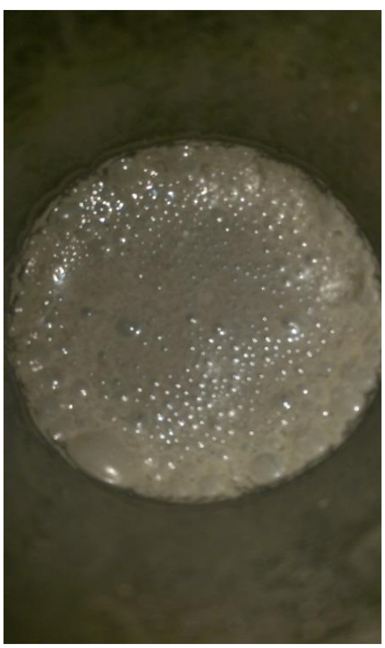


Photo 8: AEA(without SP)- AEA 7

Photo 9: SP before AEA - AEA7

Photo 10: AEA(without SP) - Water - AEA7

Sika Multi Air – 70/30 OPC (US)/FA (US)

Photo 11: AEA(without SP)-AEA4

Photo 12: SP before AEA – AEA4

Photo 13: SP with AEA – AEA4

Appendix C - Calculations

Sika Air minimum recommended dosage $32\ ml/100kg$

$$\frac{kg}{kg} = \frac{32\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}000320\ \frac{kg}{kg}$$

$$Masspercent: 0{,}000320\frac{kg}{kg} \times 100\% = \mathbf{0{,}032}\%$$

$$\frac{g}{g} = \frac{0{,}000320\frac{kg}{kg} \times 1000g}{1000g} = 0{,}000320\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}000320\frac{g}{g} \times 10g = 0{,}0032\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0032\frac{g}{10g} \times 1000\mu l = 3{,}2\frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{3{,}2\frac{\mu l}{10g}}{10g} = 0{,}32\frac{\mu l}{g}$$

Dilluted 1:9

$$3{,}2\frac{\mu l}{10g} \times 10 = \mathbf{32}\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1{:}\,9$$

$$0{,}32\frac{\mu l}{g} \times 10 = \mathbf{3{,}2}\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1{:}\,9$$

Sika Air maximum recommended dosage $\mathbf{195 ml/100kg}$

$$\frac{kg}{kg} = \frac{195\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}001950\ \frac{kg}{kg}$$

$$Masspercent: 0{,}00195\frac{kg}{kg} \times 100\% = \mathbf{0{,}195}\%$$

$$\frac{g}{g} = \frac{0{,}00195\frac{kg}{kg} \times 1000g}{1000g} = 0{,}00195\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}00195\frac{g}{g} \times 10g = 0{,}0195\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0195\frac{g}{10g} \times 1000\mu l = 19{,}5\frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{19{,}5\frac{\mu l}{10g}}{10g} = 1{,}95\frac{\mu l}{g}$$

Dilluted 1:9

$$19{,}5\frac{\mu l}{g} \times 10 = \mathbf{195\frac{\mu l}{10g}}\ Dilluted\ 1:9$$

$$1{,}95\frac{\mu l}{g} \times 10 = \mathbf{19{,}5\frac{\mu l}{g}}\ Dilluted\ 1:9$$

Sika AEA - 15 minimum recommended dosage 16ml/$100kg$

$$\frac{kg}{kg} = \frac{16\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}000160\ \frac{kg}{kg}$$

$$Masspercent: 0{,}000160 \frac{kg}{kg} \times 100\% = \mathbf{0{,}016}\%$$

$$\frac{g}{g} = \frac{0{,}000160 \frac{kg}{kg} \times 1000g}{1000g} = 0{,}000160\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}000160 \times 10g = 0{,}0016 \frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0016 \frac{g}{10g} \times 1000\mu l = 1{,}6 \frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{1{,}6 \frac{\mu l}{10g}}{10g} = 0{,}16 \frac{\mu l}{g}$$

Dilluted 1:9

$$1{,}6 \frac{\mu l}{10g} \times 10 = \mathbf{16} \frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1{:}9$$

$$0{,}16 \frac{\mu l}{g} \times 10 = \mathbf{1{,}6} \frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1{:}9$$

Sika AEA - 15 maximum recommended dosage 65ml/$\mathbf{100}\boldsymbol{kg}$

$$\frac{kg}{kg} = \frac{65\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}00065\ \frac{kg}{kg}$$

$$Masspercent: 0{,}00065\frac{kg}{kg} \times 100\% = \mathbf{0{,}065}\%$$

$$\frac{g}{g} = \frac{0{,}00065\frac{kg}{kg} \times 1000g}{1000g} = 0{,}00065\frac{g}{g}$$

$$\frac{g}{10g} = 0{,}00065 \times 10g = 0{,}0065\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0065\frac{g}{10g} \times 1000\mu l = 6{,}5\frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{6{,}5\frac{\mu l}{10g}}{10g} = 0{,}65\frac{\mu l}{g}$$

Dillution 1:9

$$6{,}5\frac{\mu l}{10g} \times 10 = \mathbf{65}\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1:9$$

$$0{,}65\frac{\mu l}{g} \times 10 = \mathbf{6{,}5}\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1:9$$

Sika AER minimum recommended dosage $\mathbf{32}\boldsymbol{ml}/\mathbf{100}\boldsymbol{kg}$

$$\frac{kg}{kg} = \frac{32\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}000320\ \frac{kg}{kg}$$

$$Masspercent: 0{,}000320 \frac{kg}{kg} \times 100\% = \mathbf{0{,}032}\%$$

$$\frac{g}{g} = \frac{0{,}000320 \frac{kg}{kg} \times 1000g}{1000g} = 0{,}000320\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}000320 \times 10g = 0{,}0032 \frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0032 \frac{g}{10g} \times 1000\mu l = 3{,}2 \frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{3{,}2 \frac{\mu l}{10g}}{10g} = 0{,}32 \frac{\mu l}{g}$$

Dillution 1:9

$$3{,}2 \frac{\mu l}{10g} \times 10 = \mathbf{32} \frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1:9$$

$$0{,}32 \frac{\mu l}{g} \times 10 = \mathbf{3{,}2} \frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1:9$$

Sika AER maximum recommended dosage 97 $\boldsymbol{ml/100kg}$

$$\frac{kg}{kg} = \frac{97\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}00097\ \frac{kg}{kg}$$

$$Masspercent: 0{,}00097 \frac{kg}{kg} \times 100\% = \mathbf{0{,}097}\%$$

$$\frac{g}{g} = \frac{0{,}00097 \frac{kg}{kg} \times 1000g}{1000g} = 0{,}00097\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}00097 \times 10g = 0{,}0097 \frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0097 \frac{g}{10g} \times 1000\mu l = 9{,}7 \frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{9{,}7 \frac{\mu l}{10g}}{10g} = 0{,}97 \frac{\mu l}{g}$$

Dillution 1:9

$$9{,}7 \frac{\mu l}{10g} \times 10 = \mathbf{97} \frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1:9$$

$$0{,}97 \frac{\mu l}{g} \times 10 = \mathbf{9{,}7} \frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1:9$$

Sika Multi Air minimum recommended dosage 10 $\boldsymbol{ml/100kg}$

$$\frac{kg}{kg} = \frac{10\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}000100\ \frac{kg}{kg}$$

$$Masspercent: 0{,}000100 \frac{kg}{kg} \times 100\% = \mathbf{0{,}010}\%$$

$$\frac{g}{g} = \frac{0{,}000100 \frac{kg}{kg} \times 1000g}{1000g} = 0{,}000100\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}000100 \times 10g = 0{,}0010 \frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0010 \frac{g}{10g} \times 1000\mu l = 1 \frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{1 \frac{\mu l}{10g}}{10g} = 0{,}10 \frac{\mu l}{g}$$

Dillution 1:9

$$1 \frac{\mu l}{10g} \times 10 = \mathbf{10} \frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1:9$$

$$0{,}1 \frac{\mu l}{g} \times 10 = \mathbf{1} \frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1:9$$

Sika Multi Air maximum recommended dosage $\mathbf{195}\boldsymbol{ml}/\mathbf{100}\boldsymbol{kg}$

$$\frac{kg}{kg} = \frac{195\ (\frac{ml}{100kg})}{1000g \times 100kg} = 0{,}001950\ \frac{kg}{kg}$$

$$Masspercent: 0{,}00195\frac{kg}{kg} \times 100\% = \mathbf{0{,}195}\%$$

$$\frac{g}{g} = \frac{0{,}00195\frac{kg}{kg} \times 1000g}{1000g} = 0{,}00195\ \frac{g}{g}$$

$$\frac{g}{10g} = 0{,}00195 \times 10g = 0{,}0195\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}0195\frac{g}{10g} \times 1000\mu l = 19{,}5\frac{\mu l}{10g}$$

$$\frac{\mu l}{g} = \frac{19{,}5\frac{\mu l}{10g}}{10g} = 1{,}95\frac{\mu l}{g}$$

Dillution 1:9

$$19{,}5\frac{\mu l}{10g} \times 10 = \mathbf{195}\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ Dilluted\ 1:9$$

$$1{,}95\frac{\mu l}{g} \times 10 = \mathbf{19{,}5}\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ Dilluted\ 1:9$$

Mapeair 25, -50 og –L dillution 1:9. Minimum dosage $\mathbf{0,5\frac{l}{m^3}}$ $\boldsymbol{cement}$.

Assuming a cement weight of 380 $\frac{kg}{m^3}$. According to Standard NS-EN 197-1 table 5.7 does the concrete with a durability class cement content to be 330$\frac{kg}{m^3}$. Together with Professor Stefan Jacobsen did we assume cement content to be 380$\frac{kg}{m^3}$.

$$\frac{kg}{kg} = \frac{0,5\frac{l}{m^3}}{380\frac{kg}{m^3}} = 0,001316\frac{kg}{kg}$$

Massepercent % $\quad 0,001316\frac{kg}{kg} \times 100\ \% = \mathbf{0,1316}\ \%$

$$\frac{g}{10g} = \frac{0,001316\frac{kg}{kg} \times 10g \times 1000g}{1000g} = 0,01316\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0,01316\frac{g}{10g} \times 1000\mu l = \mathbf{13,2}\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}\ dilluted\ 1:9$$

$$\frac{\mu l}{g} = \frac{13,2\frac{\mu l}{10g}}{10g} = \mathbf{1,32}\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}\ dilluted\ 1:9$$

Mapeair 25, -50 og –L dillution 1:9. Maximum dosage $\mathbf{5,0\frac{l}{m^3}\,sement.}$

$$\frac{kg}{kg} = \frac{5{,}0\,\frac{l}{m^3}}{380\,\frac{kg}{m^3}} = 0{,}01316\,\frac{kg}{kg}$$

Masspercent % $\quad 0{,}01316\,\frac{kg}{kg} \times 100\% = \mathbf{1,316}\%$

$$\frac{g}{10g} = \frac{0{,}01316\,\frac{kg}{kg} \times 10g \times 1000g}{1000g} = 0{,}1316\,\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}1316\,\frac{g}{10g} \times 1000\mu l = \mathbf{131,6\,\frac{\mu l}{10g}}\ Dilluted\ 1{:}\,9$$

$$\frac{\mu l}{g} = \frac{131{,}6\,\frac{\mu l}{10g}}{10g} = \mathbf{13,16\,\frac{\mu l}{g}}\ Dilluted\ 1{:}\,9$$

Dynamon SX – 130. Minimum recommended dosage.

$\mathbf{0,3}\ \%\ \boldsymbol{of\ cementweight.}$

Cementweight = 10g

$$0{,}3\ \% \times 10g = 0{,}03\,\frac{g}{10g}$$

$$\frac{\mu l}{10g} = 0{,}03\,\frac{g}{10g} \times 1000\mu l = \mathbf{32,7}\,\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}$$

$$\frac{\mu l}{g} = \frac{32{,}7\,\frac{\mu l}{10g}}{10} = \mathbf{3,27}\,\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}$$

Dynamon SX – 130. Maximum recommended dosage.

$\mathbf{1,2}\ \%\ \boldsymbol{of\ cement\ weight}$

Cementweight = 10g

$$1{,}2\ \% \times 10g = 0{,}12\,\frac{g}{10g}$$

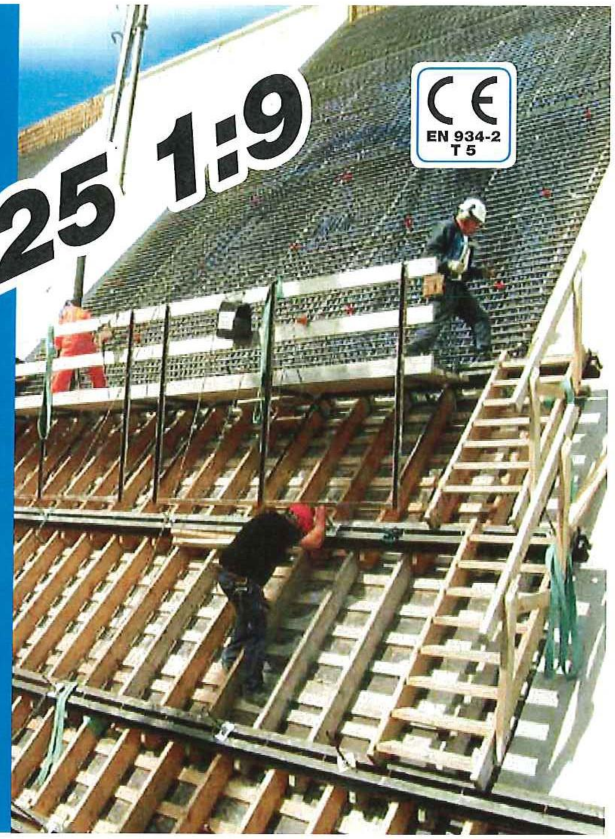
$$\frac{\mu l}{10g} = 0{,}12\,\frac{g}{10g} \times 1000\mu l = \mathbf{120}\,\frac{\mu \boldsymbol{l}}{\mathbf{10}\boldsymbol{g}}$$

$$\frac{\mu l}{g} = \frac{120\,\frac{\mu l}{10g}}{10} = \mathbf{12}\,\frac{\mu \boldsymbol{l}}{\boldsymbol{g}}$$

Appendix D – Data sheet

MAPEI

Mapeair 25 1:9



Air entraining admixture

AREA OF USE

Mapeair® 25 1:9 is a surface active agent which promotes the formation of small air bubbles and is used to improve the frost resistance of concrete and mortar.
Mapeair® 25 1:9 also gives improved workability and reduces the risk of segregation. The product is usually used in combination with Mapei's plasticising or superplasticising admixtures.
Mapeair® 25 1:9 is based on synthetic tensides and tall oil derivatives.

TECHNICAL CHARACTERISTICS

Concrete always contains a certain amount of air (1 - 3 %). In order to meet the usual requirements of 4 - 6 % air in fresh concrete, **Mapeair® 25 1:9** is added, which produces smaller and more evenly distributed air bubbles, which leads to improved freeze-thaw resistance.

Air introduced during mixing is transformed into small evenly distributed pores in the presence of **Mapeair® 25 1:9**. These entrained air bubbles also improve the workability and reduce the amount of water required. Increased air content generally leads to a decrease in compressive strength. A general guide is that 1 % of air reduces the compressive strength by 5 %. This is partly compensated for by the reduced need for water and by adding plasticising and/or superplasticizing admixtures.

Mapeair® 25 1:9 will also improve stability during transportation by reducing the risk of segregation for concrete containing a low volume of fine particles and actively preventing bleeding (transportation of water to the surface of fresh concrete).

WORKING INSTRUCTIONS

Mapeair® 25 1:9 is delivered ready for use and can be added directly into the mixer. To obtain an even distribution of air from batch to batch, it is important that **Mapeair® 25 1:9** is added at the same stage of the mixing procedure each time.

The dosage required to give the desired air content varies with aggregates, cement type and quantity present. Other additives may also have an influence.
It is important that the addition of **Mapeair® 25 1:9** is determined by test mixing and that the air content in the fresh concrete is regularly checked.

DOSAGE

0.5 - 5.0 litres of **Mapeair® 25 1:9** pr. m³ of concrete.

ATTENTION

Variations in other components in the concrete can greatly influence the formation of air bubbles in concrete. In some cases duration of transport and the type of transportation equipment used can produce variations in air content.
If the mixing time has been too short the total measured air content may increase from production to delivery, whereas in most cases a reduction of air content is observed. Normally this reduction is the result of the release of larger, undesirable air bubbles.

Mapeair 25 1:9

Hence, the producer must base his calculations on experience with the particular constituents used.

PACKAGING
Mapeair® 25 1:9 is available in 1000 liter IBC tanks and in tank.

STORAGE
The product must be stored at temperatures between +8 and +35°C, and will retain its properties for at least one year when stored unopened in original packaging. If the product is exposed to direct sunlight, colour variation may occur, but this will not affect the technical properties of the product.

SAFETY INSTRUCTIONS FOR PREPARATION AND USE
Mapeair® 25 1:9 is not considered dangerous according to European regulations regarding classification of chemicals. It is recommended to wear gloves and goggles and to take usual precautions for handling of chemicals.

For further and complete information about safe use of the product, please refer to the latest version of the safety data sheet.

PRODUCT FOR PROFESSIONAL USE

WARNING
Although the technical details and recommendations contained in this product data sheet correspond to the best of our knowledge and experience, all the above - information must, in every case, be taken as merely indicative and subject to confirmation after long-term practical application: for this reason, anyone who intends to use the product must ensure beforehand that it is suitable for the envisaged application: in every case, the user alone is fully responsible for any consequences deriving from the use of the product.

Please refer to the current version of the technical data sheet, available from our web site www.mapei.com

All relevant references for the product are available upon request and from www.mapei.com

TECHNICAL DATA (typical values)	
PRODUCT IDENTITY	
Type:	liquid
Colour:	transparent
Viscosity:	low viscosity < 20 mPa*S
Solid content, (%):	0.42 + 0.04
Density, (g/cm³):	1.00 ± 0.02
pH:	8.5 ± 1
Chloride content, (%):	≤ 0.05
Alkali content (Na_2O-equivalent), (%):	≤ 0.2
CHARACTERISTICS OF CONCRETE CONTAINING MAPEAIR 25 1:9:	
Volume of air in concrete mixture EN 12350-7:	6 % at dosage 0.05 % weight of cement (reference 2.2 %)
Spacing factor in hardened concrete, EN 480-11 (mm):	0.190 (requirement < 0.200)
Specific surface, EN 480-11, (mm²/mm³):	25.2 (requirement > 25)
Frost resistance (scaling) – EN 12390-9 (kg/m²):	0.05 (best classification < 0.1 : excellent)

04.12.2013 GB

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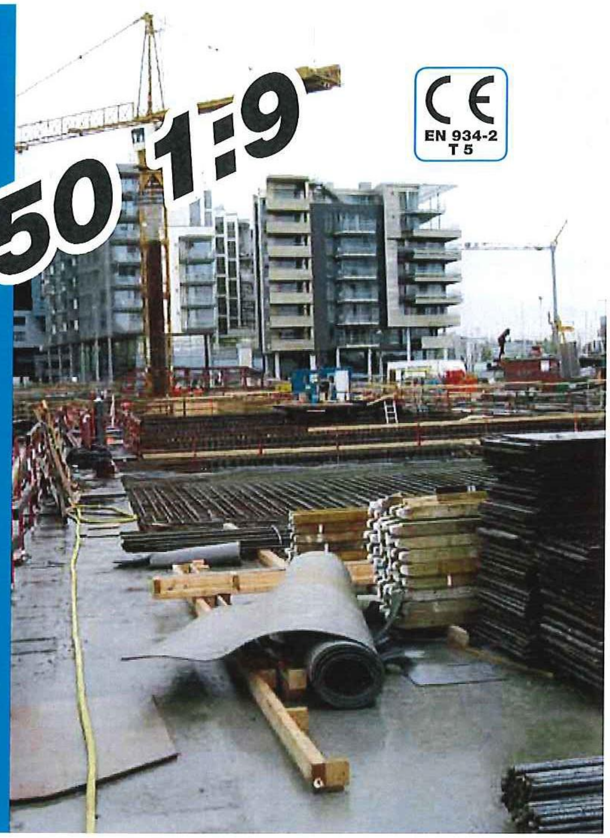
Mapeair 50 1:9



CE
EN 934-2
T 5

Air entraining admixture

AREA OF USE
Mapeair® 50 1:9 is a surface active agent which promotes the formation of small air bubbles and is used to improve the frost resistance of concrete and mortar.
Mapeair® 50 1:9 also gives improved workability and reduces the risk or segregation. The product is usually used in combination with Mapei's plasticising or superplasticising admixtures.
Mapeair® 50 1:9 is based on synthetic tensides and tall oil derivatives.

TECHNICAL CHARACTERISTICS
Concrete always contains a certain amount of air (1 - 3 %). In order to meet the usual requirements of 4 - 6 % air in fresh concrete, **Mapeair® 50 1:9** is added, which produces smaller and more evenly distributed air bubbles, which leads to improved freeze-thaw resistance.

Air introduced during mixing is transformed into small evenly distributed pores in the presence of **Mapeair® 50 1:9**. These entrained air bubbles also improve the workability and reduce the amount of water required. Increased air content leads generally to a decrease in compressive strength. A general guide is that 1 % of air reduces the compressive strength by 5 %. This is partly compensated for by the reduced need for water and by adding plastic ising and/or superplasticizing admixtures.

Mapeair® 50 1:9 will also improve stability during transportation by reducing the risk of segregation for concrete containing a low volume of fine particles and actively preventing bleeding (transportation of water to the surface of fresh concrete).

WORKING INSTRUCTIONS
Mapeair® 50 1:9 is delivered ready for use and can be added directly into the mixer. To obtain an even distribution of air from batch to batch, it is important that **Mapeair® 50 1:9** is added at the same stage of the mixing procedure each time.

The dosage required to give the desired air content varies with aggregates, cement type and quantity present. Other additives may also have an influence.
It is important that the addition of **Mapeair® 50 1:9** is determined by trial mixing and that the air content in the fresh concrete is checked regularly.

DOSAGE
0.5 - 5.0 litres of **Mapeair® 50 1:9** pr. m³ of concrete.

ATTENTION
Variations in other components in the concrete can greatly influence the formation of air bubbles in concrete. In some cases duration of transport and transportation equipment used can produce variations in air content.
If the mixing time has been too short the total measured air content may increase from production to delivery, whereas in most cases a reduction of air content is observed. Normally this reduction is the result of the release of larger, undesirable air bubbles.

Mapeair 50 1:9

The producer must therefore base his calculations on experience with the particular constituents used.

PACKAGING
Mapeair® 50 1:9 is available in 1000 liter IBC tanks and in tank.

STORAGE
The product must be stored at temperatures between +8 and +35°C, and will retain its properties for at least one year if stored unopened in its original packaging. If the product is exposed to direct sunlight, colour variation may occur, but this will not affect the technical properties of the product.

SAFETY INSTRUCTIONS FOR PREPARATION AND USE
Mapeair® 50 1:9 is not considered dangerous according to European regulations regarding classification of chemicals. It is recommended to wear gloves and goggles and to take usual precautions for handling of chemicals.

For further and complete information about safe use of our product, please refer to our latest version of the Safety Data Sheet.

PRODUCT FOR PROFESSIONAL USE

WARNING
Although the technical details and recommendations contained in this product data sheet correspond to the best of our knowledge and experience, all the above - information must, in every case, be taken as merely indicative and subject to confirmation after long-term practical application: for this reason, anyone who intends to use the product must ensure beforehand that it is suitable for the envisaged application: in every case, the user alone is fully responsible for any consequences deriving from the use of the product.

Please refer to the current version of the technical data sheet, available from our web site www.mapei.com

All relevant references for the product are available upon request and from www.mapei.com

TECHNICAL DATA (typical values)	
PRODUCT IDENTITY	
Type:	liquid
Colour:	transparent
Viscosity:	low viscosity < 20 mPa*S
Solid content, (%):	1.1 ± 0.1
Density, (g/cm³):	1.00 ± 0.02
pH:	10.5 ± 1
Chloride content, (%):	≤ 0.05
Alkali content (Na_2O-equivalent), (%):	≤ 0.2
CHARACTERISTICS OF CONCRETE CONTAINING MAPEAIR 50 1:9:	
Volume of air in concrete mixture EN 12350-7:	6 % at dosage 0.05 % weight of cement (reference 2.2 %)
Spacing factor in hardened concrete, EN 480-11 (mm):	0.152 (requirement < 0.200)
Specific surface, EN 480-11, (mm²/mm³):	36.1 (requirement > 25)
Frost resistance (scaling) – EN 12390-9 (kg/m²):	0.05 (best classification < 0.1 : excellent)

26.11.2013 GB

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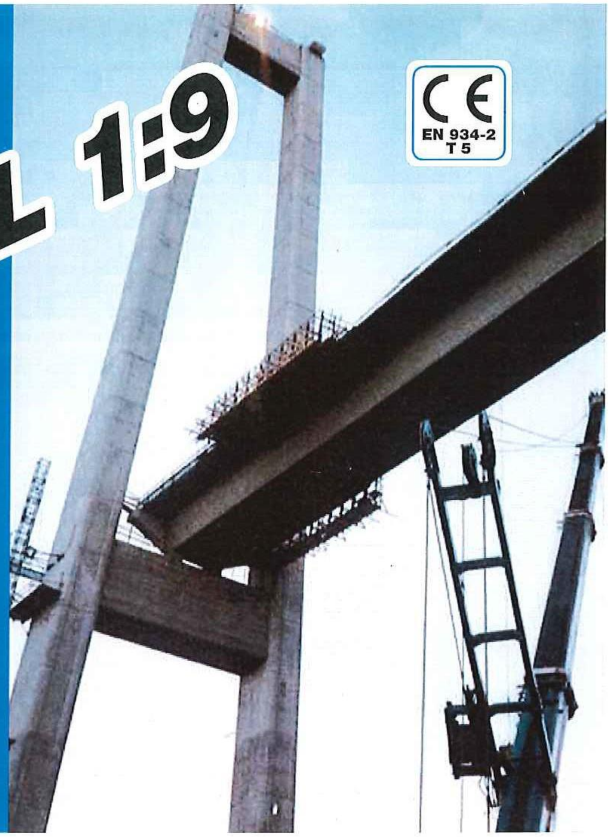
Mapeair L 1:9



Air entraining agent

AREA OF USE

Mapeair® L 1:9 is a surface-active agent which promotes the formation of small air bubbles and is used to improve the frost resistance of concrete and mortar. **Mapeair® L 1:9** also has a slight water reducing effect and reduces the risk of segregation. The product is normally used in combination with Mapei's plasticizing and superplasticizing admixtures.

TECHNICAL CHARACTERISTICS

Concrete always contains a certain amount of air (1 - 3 %). In order to meet the usual requirements of 4 - 6 % air in fresh concrete, **Mapeair® L 1:9** is added, which produces smaller and more evenly distributed air bubbles, which leads to improved freeze-thaw resistance.

Air introduced during mixing is transformed into small evenly distributed pores in the presence of **Mapeair® L 1:9**. The measured pore volume and spacing factor in hardened concrete is given in the technical data. These entrained air bubbles also improve the workability and reduce the amount of water required. Increased air content leads generally to a decrease in compressive strength. A general guide is that 1 % of air reduces the compressive strength by 5 %. This is partly compensated for by the reduced need for water and by adding plastic ising and/or superplasticizing admixtures.

Mapeair® L 1:9 will also improve stability during transportation by reducing the risk of segregation for concrete containing a low volume of fine particles and actively preventing bleeding (transportation of water to the surface of fresh concrete).

WORKING INSTRUCTIONS

Mapeair® L is delivered ready for use and can be added directly into the mixer. To obtain an even distribution of air from batch to batch, it is important that **Mapeair® L 1:9** is added at the same stage of the mixing procedure each time.

The dosage required to give the desired air content varies with aggregates, cement type and quantity present. Other additives may also have an influence. It is important that the addition of **Mapeair® L 1:9** is determined by trial mixing and that the air content in the fresh concrete is checked regularly.

DOSAGE

0.5 - 5.0 litres of **Mapeair® L 1:9** pr. m^3 of concrete.

Mapeair L 1:9

ATTENTION
Variations in other components in the concrete can greatly influence the formation of air bubbles in concrete. In some cases duration of transport and transportation equipment used can produce variations in air content.

If the mixing time has been too short the total measured air content may increase from production to delivery, whereas in most cases a reduction of air content is observed. Normally this reduction is the result of the release of larger, undesirable air bubbles. The producer must therefore base his calculations on experience with the particular constituents used.

PACKAGING
Mapeair® L 1:9 is available in 1000 liter IBC tanks and in tank.

STORAGE
The product must be stored at temperatures between +8 and +35°C, and will retain its properties for at least one year if stored unopened in its original packaging. If the product is exposed to direct sunlight, colour variation may occur, but this will not affect the technical properties of the product.

SAFETY INSTRUCTIONS FOR PREPARATION AND USE
Mapeair® L 1:9 is not considered dangerous according to European regulations regarding classification of chemicals. It is recommended to wear gloves and goggles and to take usual precautions for handling of chemicals.

For further and complete information about safe use of our product, please refer to our latest version of the Safety Data Sheet.

PRODUCT FOR PROFESSIONAL USE

WARNING
Although the technical details and recommendations contained in this product data sheet correspond to the best of our knowledge and experience, all the above - information must, in every case, be taken as merely indicative and subject to confirmation after long-term practical application: for this reason, anyone who intends to use the product must ensure beforehand that it is suitable for the envisaged application: in every case, the user alone is fully responsible for any consequences deriving from the use of the product.

Please refer to the current version of the technical data sheet, available from our web site www.mapei.com

All relevant references for the product are available upon request and from www.mapei.com

Mapeair L 1:9

TECHNICAL DATA (typical values)	
PRODUCT IDENTITY	
Type:	liquid
Colour:	transparent red
Viscosity:	low viscosity < 10 mPa*S
Solid content, (%):	0.35 ± 0..3
Density, (g/cm³):	1.00 ± 0.02
pH:	7.0 ± 1
Chloride content, (%):	≤ 0.05
Alkali content (Na_2O-equivalent), (%):	≤ 0.3
CHARACTERISTICS OF CONCRETE CONTAINING MAPEAIR® L:	
Volume of air in concrete mixture EN 12350-7:	6 % at dosage 0.05 % weight of cement (reference 2.2 %)
Spacing factor in hardened concrete, EN 480-11 (mm):	0.190 (requirement < 0.200)
Specific surface, EN 480-11, (mm²/mm³):	28.6 (requirement > 25)
Frost resistance (scaling) – EN 12390-9 (kg/m²):	0.05 (best classification < 0.1 : excellent)

25.11.2013 GB

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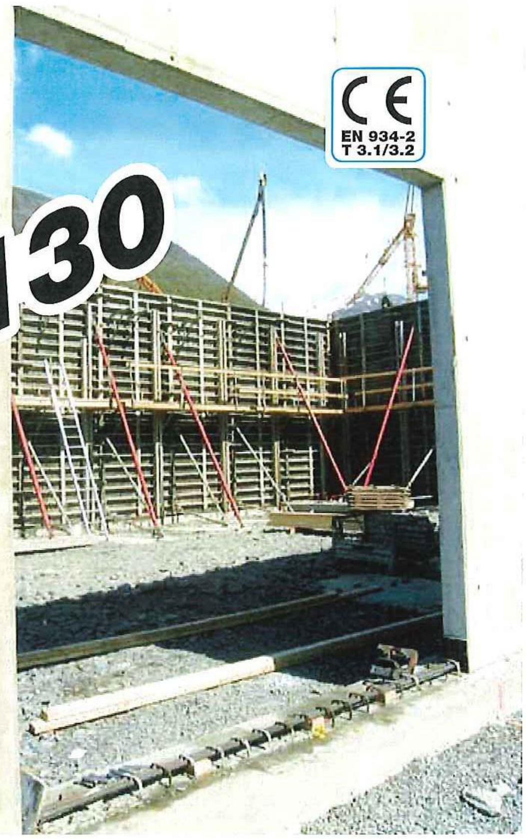
Dynamon SX-130



Superplasticizing admixture

BESKRIVELSE

PRODUCT DESCRIPTION

Dynamon SX-130 is a very efficient liquid superplasticising admixture, based on modified acrylic polymers.
The product belongs to the **Dynamon System** based on the DPP (Design Performance Polymers) technology, a new chemical process that can model the admixture's properties in relation to specific performances required for concrete. The process is developed by means of a complete design and production of monomers (an exclusive Mapei know-how).

AREAS OF APPLICATION

Dynamon SX-130 is a superplasticizing admixture used to improve workability and/or reduce the amount of mixing water.

Dynamon SX-130 is a **Dynamon** version with a higher share of active polymers. At a normal dosage of 0.3 - 1.2 % by weight of cement you will achieve considerable higher water reduction compared to other **Dynamon** products. The product is recommendable if you have a relatively big mixer and/or an accurate dosing system.

All **Dynamon** products are significantly different from conventional sulphonated melamine based and sulphonated naphthalene based superplasticizers, and also from first generation acrylic based polymers in terms of their superior water-reduction.

Over-dosing can cause concrete separation. We always recommend test productions production,using the actual parameters.

Dynamon SX-130 can give higher early strength than other superplasticizers, even at low temperatures.
The dosage required to achieve a particular workability will be considerably lower for **Dynamon SX-130** than for previous superplasticizers. In contrast to conventional melamine or naphthalene based admixtures, **Dynamon SX-130** produces the maximum effect regardless of when it is added, but the time of addition can influence the mixing time.
If at least 80 % of the mixing water is added before **Dynamon SX-130** the required mixing time will generally be shortest. It is nevertheless important to perform tests using the actual mixing equipment.

TECHNICAL PROPERTIES

Dynamon SX-130 is an aqueous solution of active acrylic copolymers which effectively disperse the cement grains.

<u>This effect can be used in three ways:</u>

1. To reduce the amount of mixing water, and simultaneonely maintain the concrete workability. Lower w/c ratio gives increased strength, reduced permeability and improved durability.
2. To increase workability compared to concrete with the same w/c ratio. The strength remains the same but ease of placement is improved.

3. To reduce both water and cement without altering the mechanical strength. Through this method it is possible to reduce costs (less cement), shrinkage (less water) and also the risk of temperature gradients due to the lower heat of hydration.
This last effect is particularly important for concrete containing a high percentage of cement.

COMPATIBILITY WITH OTHER PRODUCTS
Dynamon SX-130 can be combined with other Mapei admixtures, e.g. **Mapefast** accelerating additives and **Mapetard** retarding admixtures.
The product is also compatible with **Mapeair** air entraining admixtures for production of frost resistant concrete (the selection of air entraining admixtures depends upon the other components e.g. cement type and aggregate).

DOSAGE
To achieve the desired results (strength, durability, workability, cement reduction) add **Dynamon SX-130** in dosages between 0.3 and 1.2 % of the cement weight. Increased dosages will increase the open time (the time the concrete is workable).

PACKAGING
Dynamon SX-130 is available in 25 liter cans, 200 liter drums, 1000 liter IBC tanks and in tank.

STORAGE
The product must be stored at a temperature of between +8 and +35°C, and will retain its properties for at least one year if stored unopened in its original packaging. If the product is exposed to direct sunlight, colour variation may occur, but this will not affect the technical properties of the product.

SAFETY INSTRUCTIONS FOR PREPARATION AND USE
Dynamon SX-130 is not considered dangerous according to the European regulation regarding the classification of admixtures. It is recommended to wear gloves and goggles and to take the usual precautions taken for the handling of chemicals.

For further and complete information about the safe use of our product please refer to our latest version of the Material Safety Data Sheet.

PRODUCT FOR PROFESSIONAL USE

WARNING
Although the technical details and recommendations contained in this product data sheet correspond to the best of our knowledge and experience, all the above - information must, in every case, be taken as merely indicative and subject to confirmation after long-term practical application: for this reason, anyone who intends to use the product must ensure beforehand that it is suitable for the envisaged application: in every case, the user alone is fully responsible for any consequences deriving from the use of the product.

Please refer to the current version of the technical data sheet, available from our web site www.mapei.com

All relevant references for the product are available upon request and from www.mapei.com

Dynamon SX-130

TECHNICAL DATA (typical values)

PRODUCT IDENTITY	
Appearance:	liquid
Colour:	yellowish brown
Viscosity (Brookfield Viscometer DV-1, LV1, 100rpm at 20±2°C)	easy flowing; < 30 mPa*S
Solids content, %:	30.0 ± 1.5
Density, g/cm³:	1.09 ± 0.02
pH-value:	6.5 ± 1
Chlorides, %:	< 0.05
Alkali content (equiv. Na_2O) %:	< 2.5

CONCRETE PROPERTIES

As a water-reducing admixture (same workability)	Reference	Dynamon SX-130
Cement kg/m³ (type CEM I):	350	350
Admixture dosage (% by weight of cement):	0	0.6
Water to cement ratio:	0.59	0.43
Water reduction (%):	-	27
Workability, mm:		
- slump, 5 min	220	230
- slump, 30 min	200	200
Compressive strength (N/mm² cubes):		
- 1 day	18	25
- 7 day	38	58
- 28 days	50	73

02.09.2013 GB

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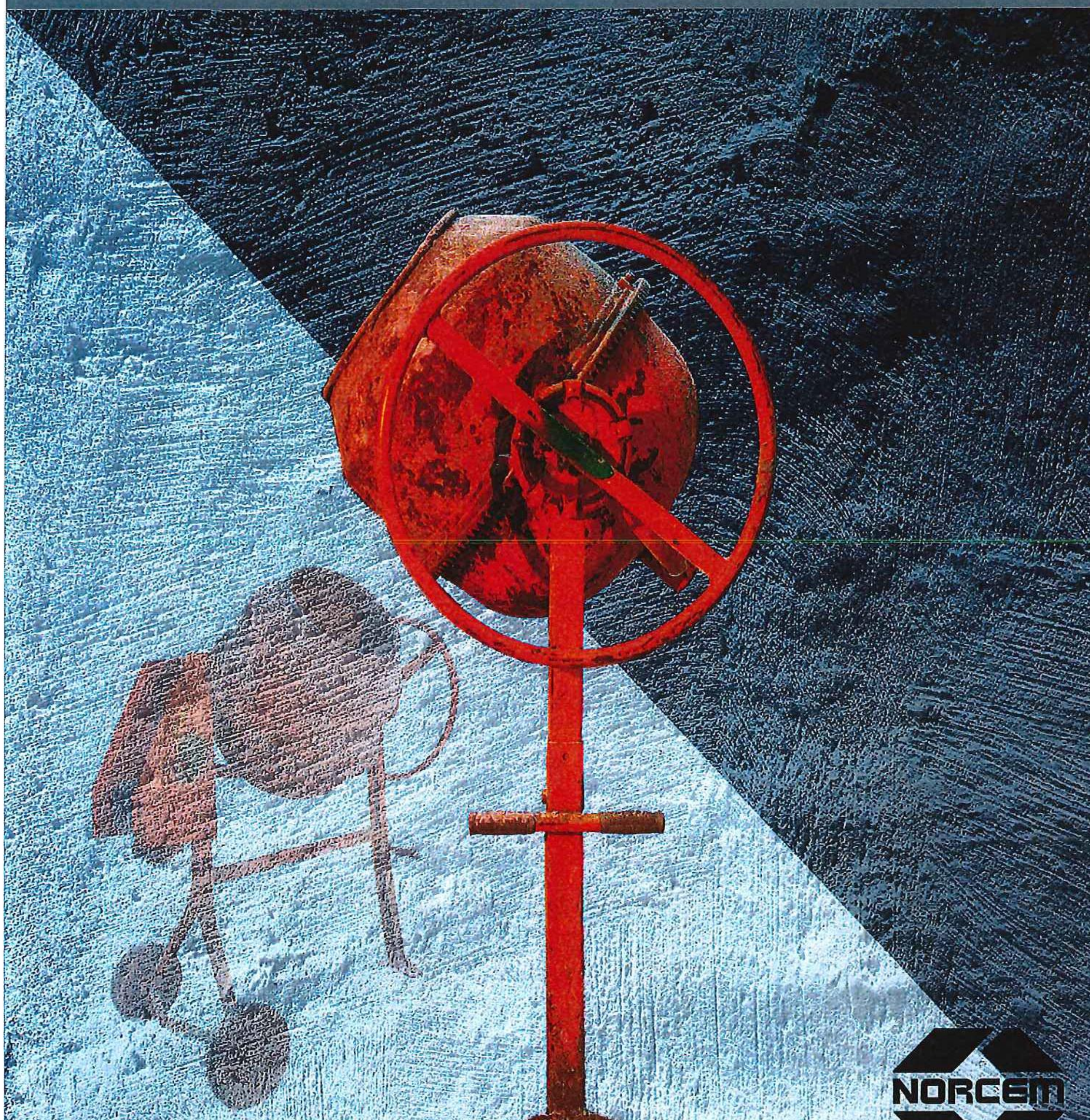
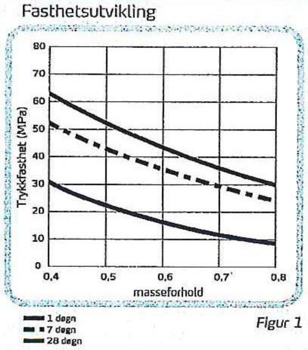
PRODUKTINFORMASJON

Standardsement

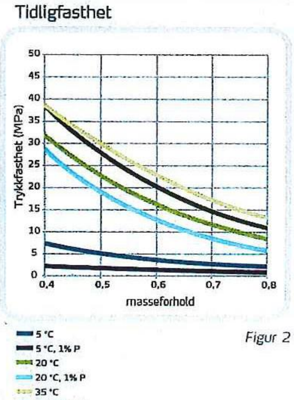


Fasthetsutvikling



Figur 1

Tidligfasthet



Figur 2

Fasthetsutvikling

Fasthetsutvikling er en sentral egenskap for planlegging, styring og utførelse av alle betongarbeider. Fasthetsutvillingen er avhengig av sementtype, tilslag, masseforhold, herdeforhold (temperatur, tid og fuktighet), og eventuell bruk av tilsetningsmaterialer eller -stoffer. I figur 1 er vist et eksempel på trykkfasthetsutviklingen som funksjon av masseforhold og alder ved 20°C vannlagring for betong med Norcem Standardsement.

Tidligfasthet

Tidligfasheten i betong er avhengig av temperatur og eventuell dosering av tilsetningsstoff med retarderende effekt. I figur 2 er vist trykkfasthet for betong etter 1 døgn med forskjellig masseforhold med og uten 1% plastiserende tilsetningsstoff (P-stoff) med Standardsement. Prøvene er lagret ved 95% luftfuktighet ved varierende temperatur.

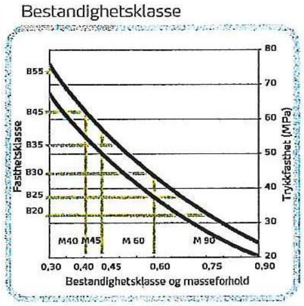
Fasthetsklasse - masseforhold

Med normal, god styring av betongproduksjonen, er det behov for en overhøyde på ca 7 MPa ved de ulike fasthetsklassene for å produsere med tilstrekkelig sikkerhet mot undermålere. Standardsement gir følgende retningsgivende verdier for minste og største masseforhold i ulike fast-hetsklasser for betong uten luftinnføring.

Fasthets-klasse	B20	B25	B30	B35	B45
Minste - største masse-forhold	0,68 - 0,76	0,57 - 0,68	0,51 - 0,57	0,42 - 0,51	0,35 - 0,42

Norcem Standardsement er tilpasset norske forhold og kan benyttes til betong i alle eksponerings-, bestandighets- og fasthetsklasser. Standardsementen har en fasthetsprofil som er tilpasset minimum sementbehov for konstruksjoner i bestandighetsklasse M60. Sementen har relativt høy tidligfasthet, moderat sluttfasthet, moderat varmeutvikling, god støpelighet og veldokumenterte bestandighetsegenskaper.

Bestandighetsklasse



Figur 3

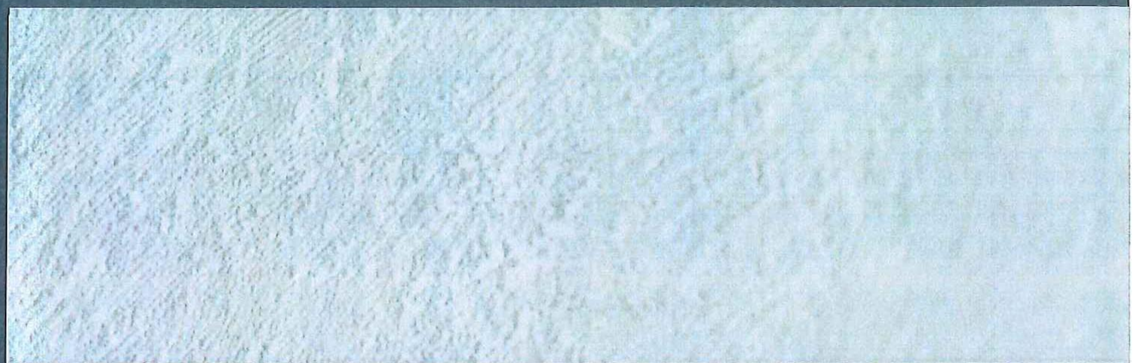
Bestandighetsklasse

NS-EN 206-1 klassifiserer betongens miljøpåvirkninger i eksponeringsklasser. I nasjonalt tillegg til denne standarden er de ulike eksponeringsklassene gruppert i seks bestandighetsklasser med krav til betongens maksimale masseforhold (se tabell 3). Tabell 2 viser anbefalte kombinasjoner av bestandighets- og fasthetsklasser. Retningsgivende verdier for største masseforhold i de ulike fasthetsklassene er gitt i tabell 1. I figur 3 er vist sammenhengen mellom bestandighetsklasse og fasthetsklasse i et variasjonsbelte forårsaket av ulike produksjonsforutsetninger. Figuren gjelder for betong med Standardsement uten luftinnføring.

Anbefalte kombinasjoner	
Bestandighetsklasse M90	Fasthetsklasse B20 el høyere
Bestandighetsklasse M60	Fasthetsklasse B25 el høyere
Bestandighetsklasse M45	Fasthetsklasse B35 el høyere
Bestandighetsklasse M40	Fasthetsklasse B45 el høyere

Valg av bestandighetsklasse (nasjonale krav)						
Eksponeringsklasse	**M90**	**M60**	**M45**	**MF45***	**M40**	**MF40***
X0	•	•	•	•	•	•
XC1, XC2, XC3, XC4, XF1		•	•	•	•	•
XD1, XS1, XA1, XA2, XA4			•	•	•	•
XF2, XF3, XF4				•		•
XD2, XD3, XS2, XS3, XA3					•	•
XSA	**Betongsammensetning og beskyttelsestiltak fastsettes særskilt. Betongsammensetningen skal minst tilfredsstille kravene til M40.**					
Største masseforhold v/(c + Ekp)	**0,90**	**0,60**	**0,45**	**0,45**	**0,40**	**0,40**

** Minst 4% luft*



Deklarerte data

Norcem Standardsement tilfredsstiller kravene til Portlandsement

EN 197-1-CEM I 42,5R

Kjemiske data		
Egenskap	**Deklarerte data**	**Krav iflg NS-EN 197-1**
Finhet (Blaine)	370 m^2/kg i) / 380m^2/kg ii)	
Trikalsiumaluminat C_3A	7 %	
Alkali (ekv Na_2O, NB21)	1,3% i) / 1,3% ii)	Deklarert verdi iht NB21
Mineralske tilsetninger	4%	≤ 5%
Glødetap	2,5%	≤ 5%
Uløselig rest	1%	≤ 5%
Sulfat (SO_3)	3-4%	≤ 4%
Klorid	< 0,085%	≤ 0,1%
Vannløselig Cr^{6+}	< 2 ppm	≤ 2 ppm *)
Spesifikk vekt	3,15 kg/dm^3	

i) Brevik-produsert
ii) Kjøpsvik-produsert

**) I henhold til Forskrift om vannløselige kromater i sement- og betongrelaterte materialer*

Fysikalske data		
Egenskap	**Deklarerte data**	**Krav iflg NS-EN 197-1**
Trykkfasthet 1 døgn	21 MPa	
Trykkfasthet 2 døgn	32 MPa	≥ 20 MPa
Trykkfaasthet 7 døgn	42 MPa	
Trykkfasthet 28 døgn	52 MPa	≥ 42,5 MPa ≤ 62,5 MPa
Begynnende bindetid	130 min i) / 125 min ii)	≥ 60 min
Ekspansjon	1 mm	≤ 10 mm

i) Brevik-produsert
ii) Kjøpsvik-produsert

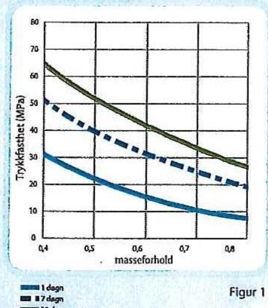
NORCEM

www.norcem.no

PRODUKTINFORMASJON

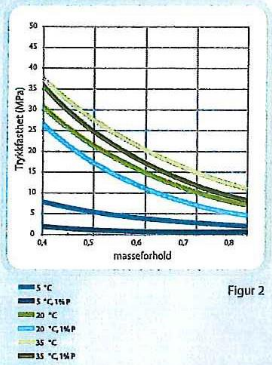
Standard sement FA

Fasthetsutvikling



Figur 1

Tidligfasthet



Figur 2

Fasthetsutvikling

Fasthetsutvikling er en sentral egenskap for planlegging, styring og utførelse av alle betongarbeider. Fasthetsutviklingen er avhengig av sementtype, tilslag, masseforhold, herdeforhold (temperatur, tid og fuktighet) og eventuell bruk av tilsetningsmaterialer eller -stoffer. I figur 1 er vist eksempel på trykkfasthetsutviklingen som funksjon av masseforhold og alder ved 20°C vannlagring for betong med Norcem Standardsement FA.

Tidligfasthet

Tidligfastheten i betong er meget avhengig av temperatur og eventuell dosering av tilsetningsstoff med retarderende effekt. I figur 2 er vist trykkfasthet etter 1 døgn med forskjellige masseforhold med og uten 1% plastiserende tilsetningsstoff (P-stoff) med Standardsement FA. Prøvene er lagret ved 95% luftfuktighet ved varierende temperatur.

Motstand mot alkalireaksjoner

Norsk Betongforenings publikasjon nr. 21 fastsetter retningslinjer for produksjon av bestandig betong med alkalireaktivt tilslag. Publikasjonen fastlegger at for betong med Standardsement FA kan det benyttes alkalireaktivt tilslag dersom betongens totale alkali-innhold ikke overstiger visse verdier.

For betong der Standardsement FA blandes med andre sementtyper, gjelder andre grenser. For grenseverdier - se www.betong.net under Publikasjoner, og Vedlegg C til publikasjon 21.

Fasthetsklasse – masseforhold

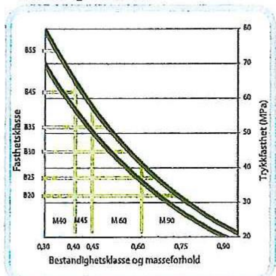
Med normalt god styring av betongproduksjonen er det behov for en overhøyde på ca 7 MPa ved de ulike fasthetsklassene for å produsere med tilstrekkelig sikkerhet mot undermålere. Standardsement FA gir følgende retningsgivende verdier for minste og største masseforhold i ulike fasthetsklasser for betong uten luftinnføring.

Fasthetsklasse	B20	B25	B30	B35	B45
Minste - Største masseforhold	0.65 - 0.72	0.57 - 0.65	0.51 - 0.57	0.44 - 0.51	0.35 - 0.44

Tabell 1

Norcem Standardsement FA er tilpasset norske forhold og kan benyttes til betong i alle eksponerings-, bestandighets- og fasthetsklasser. Standard FA gir bestandig betong også i kombinasjon med alkalireaktivt tilslag. Fasthetsprofilen er tilpasset minimum sementbehov for konstruksjoner utendørs i bestandighetsklasse M60.

Bestandighetsklasse



Figur 3

Bestandighetsklasse

NS-EN 206-1 klassifiserer betongens miljøpåvirkninger i eksponeringsklasser. I nasjonalt tillegg til denne standarden er de ulike eksponeringsklassene gruppert i seks bestandighetsklasser med krav til betongens største masseforhold (se tabell 3). Tabell 2 viser anbefalte kombinasjoner av bestandighets- og fasthetsklasser. Retningsgivende verdier for største masseforhold i de ulike fasthetsklassene er gitt i tabell 1. I figur 3 er vist sammenhengen mellom bestandighetsklasse og fasthetsklasse, i et variasjonsbelte forårsaket av ulike produksjonsforutsetninger. Figuren gjelder for betong uten luftinnføring med Norcem Standardsement FA. I bestandighetsklasse M60 anbefaler vi generelt fasthetsklasse B25.

Anbefalte kombinasjoner

Bestandighetsklasse M90	Fasthetsklasse B20 eller høyere
Bestandighetsklasse M60	Fasthetsklasse B25 eller høyere
Bestandighetsklasse M45	Fasthetsklasse B35 eller høyere
Bestandighetsklasse M40	Fasthetsklasse B45 eller høyere

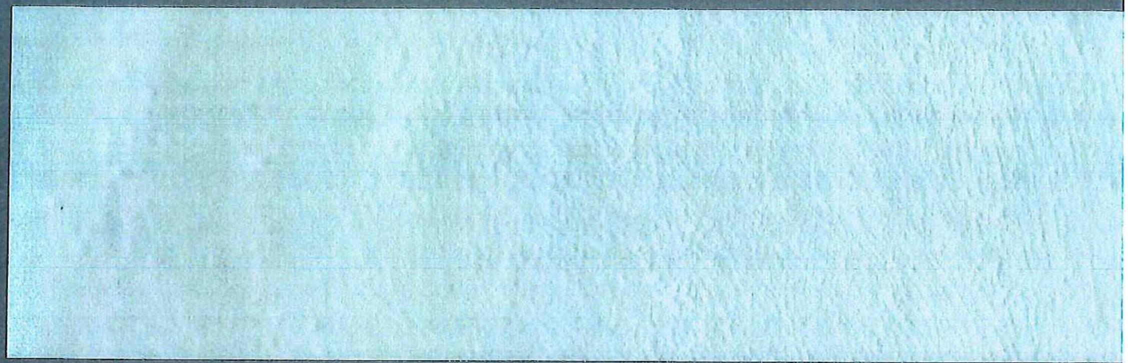
Tabell 2

Valg av bestandighetsklasse (nasjonale krav)

Eksponeringsklasse	M90	M60	M45	MF45*	M40	MF40*
X0	•	•	•	•	•	•
XCl, XC2, XC3, XC4, XF1		•	•	•	•	•
XD1, XS1, XA1, XA2, XA4			•	•	•	•
XF2, XF3, XF4				•		•
XD2, XD3, XS2, XS3, XA3					•	•
XSA	Betongsammensetning og beskyttelsestiltak fastsettes særskilt. Betongsammensetningen skal minst tilfredsstille kravene til M40.					
Største masseforhold v/(c+ kp)	0,90	0,60	0,45	0,45	0,40	0,40

*Minst 4% luft

Tabell 3



Deklarerte verdier

Norcem Standardsement FA tilfredsstiller kravene til Portlandflygeaskesement

EN 197-1 -CEM II/A-V 42,5 R   B = Brevik   K = Kjøpsvik

Kjemiske data

Egenskap	Deklarerte verdier	Krav ifølge NS-EN 197-1
Finhet (Blaine)	450 m²/kg	
Alkali (ekv Na_2O) - Brevik	1,4 %	Deklarert iht NB21
Alkali (ekv Na_2O) - Kjøpsvik	1,5%	Deklarert iht NB21
Flygeaskeinnhold	20,0 %	6-20%
Glødetap	2,0 %	-
Sulfat (SO_3)	3-4 %	≤ 4 %
Klorid	< 0,07%	≤ 0,1%
Vannløselig Cr^{6+}	< 2 ppm	≤ 2 ppm
Spesifikk vekt (kg/dm³)	2,99	

Fysikalske data

Egenskap	Retningsgivende verdier	Krav ifølge NS-EN 197-1
Trykkfasthet 1 døgn	21 MPa	
Trykkfasthet 2 døgn	31 MPa	≥ 20 MPa
Trykkfasthet 7 døgn	40 MPa	
Trykkfasthet 28 døgn	52 MPa	≥ 42,5 MPa ≤ 62,5 MPa
Begynnende bindetid (min)	130 (B) / 120 (K)	≥ 60 min
Ekspansjon	1 mm	≤ 10 mm

*Karakteristiske verdier

NORCEM

www.norcem.no

Product Data Sheet
Edition 09.25.2009
Identification no. 147-540
Sika Air

Sika® Air

Air Entraining Admixture

Construction

Description	Sika Air admixture is an aqueous solution of organic materials. Sika Air meets the requirements of ASTM C-260 for air entraining admixtures.
Applications	Sika Air is recommended for use whenever air entrained concrete is desired. Ready-mix, precast and block producers can achieve predictable and uniform entrained air contents in concrete, even where harsh lean mixes are used or fly-ash is added to the concrete.
Advantages	**Durability:** ▪ Air entrainment is recognized as the most effective prevention against concrete scaling in exposed environments. Air entrained concrete delivers particular benefits in the form of increased concrete durability. This is important in colder climates where frost and freeze-thaw cycles can cause scaling and damage to the concrete surface. ▪ Air entraining agents help to prevent scaling by creating microscopic air voids that water trapped in the concrete can expand into when the concrete freezes, thus preventing cracks caused by the natural expansion. Entrained air voids in the concrete will also increase durability in harsh environments where concrete is exposed to deicing salts, marine salts and sulfates. **Workability and Placeability:** ▪ Workability and placeability are also improved by the lubricating action of the microscopic bubbles in the concrete. Concrete will flow better, and bleeding and shrinkage will be reduced because less water is needed to obtain the desired workability.

How to Use

Dosage

Dosage rates for Sika Air will typically fall between 0.5 and 3 fl. oz. per 100 lbs. (32 - 195 ml/100 kg) of cementitious to entrain between 4 and 6 percent air. Higher air contents may be obtained by increasing the dosage rate.

Dosage rates will vary depending on the air content required for a particular project. Typically air contents will be specified in the range of 4 to 8 percent by volume.

Other factors that may affect the amount of air entrained into the concrete including total cementitious content, type of pozzolanic materials, sand gradation, salt/clay in aggregates, temperature and water content. The use of fly ash, particularly high LOI fly ash, can result in a higher dosage of air entrainment. Sika recommends that trial mixes be performed whenever material or any other changes are made that may affect the amount of entrained air.

In mixes requiring a lower or higher amount dosage rate, please contact your local regional Sika office or Sika technical service department at 1-800-933-7452 for further information.

Construction

Mixing	Measure the required quantity per batch manually or with automatic dispenser equipment. Add Sika Air to mixing water or sand. Do not mix with dry cement. When Sika Air is used in combination with other admixtures, care must be taken to dispense each admixture separately into the mix. **Combination with Other Admixtures:** Combination with other admixtures, particularly water reducers and retarders, may increase the amount of entrained air in the mix. Air contents should be checked with an air-meter after batching and dosage adjustments made at the concrete plant.
Packaging	Sika Air is available in 55 gallon drum (208 liter), 275 gallon totes (1040 liters) drums and bulk delivery.
Storage and Shelf life	Sika Air should be stored at above 40°F (5°C). If frozen, thaw and agitate thoroughly to return to normal state. Shelf life when stored in dry warehouse conditions between 50°F and 80°F (10°C - 27°C) is one year.

Typical Data

Appearance	Dark Amber liquid.
Specific Gravity	Approx. 1.0
CAUTION: IRRITANT	Contains Aqueous Solution (CAS:Mixture). May cause eye/skin/respiratory irritaton. May be harmful if swallowed.
Handling and Storage	Avoid direct contact. Wear personal protective equipment (chemical resistant goggles/gloves/clothing) to prevent direct contact with skin and eyes. Use only in well ventilated areas. Wash thoroughly with soap and water after use. Remove contaminated clothing and launder before reuse.
First Aid	**Eyes:** Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin:** Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation:** Remove person to fresh air. **Ingestion:** Do not induce vomiting. Dilute with water. Contact physician. **In all cases contact a physician immediately if symptoms persist.**
Safety	Tested and Certified by WQA according to NSF/ANSI 61 Section 5 for materials safety.
Clean Up	Use personal protective equipment (chemical resistant goggles/gloves/clothing). Without direct contact, remove spilled or excess product and place in suitable sealed container. Dispose of excess product and container in accordance with applicable environmental regulations.

KEEP CONTAINER TIGHTLY CLOSED • KEEP OUT OF REACH OF CHILDREN • NOT FOR INTERNAL CONSUMPTION • FOR INDUSTRIAL USE ONLY

Sika Corporation
201 Polito Avenue
Lyndhurst, NJ 07071
Phone: (201) 933-8800
Fax: (201) 933-6225
www.sikaconstruction.com

Sika Canada Inc.
601, Delmar Avenue
Pointe-Claire, QC H9R 4A9
Phone: (514) 697-2610
Fax: (514) 697-3087
www.sika.ca

1-800-933-SIKA

Regional Information and Sales Centers. For the location of your nearest Sika representative, contact your regional center.

U.S.:
North East Region: Fairless Hills, PA, Phone: (215) 295 -6600
North Central Region: Marion, OH, Phone: (800) 851-1545
South East Region: Conyers, GA, Phone: (770) 760-1300
South Central Region: Mesquite, TX, Phone: (972) 289-6480
Western Region: Santa Fe Springs, CA, Phone: (562) 903-3650

Canada: **Ontario:** Mississauga, ON, Phone: (905) 795-3177, **Alberta:** Edmonton, AB, Phone: (780) 486-6111

Quality Certification Numbers: Lyndhurst: FM 69711 (ISO 9000), FM 70421 (QS 9000), Marion: FM 69715, Kansas City: FM 69107, Santa Fe Springs: FM 69408

Construction

Product Data Sheet
Edition 09.25.2009
Identification no. 106
Sika AEA-15

Sika® AEA-15

Air Entraining Admixture

Description	Sika AEA-15 admixture is a liquid solution of concentrated organic materials. Sika AEA-15 meets the requirements of ASTM C-260 for air entraining admixtures.
Applications	Sika AEA-15 can be used whenever air entrained concrete is desired. Ready-mix, precast and block producers can all achieve optimum entrained air contents, even where harsh mixes are used or fly-ash is added to the mix.
Advantages	**Durability:** ▪ Air entrainment is recognized as the most effective prevention against concrete scaling in exposed environments. Air entrained concrete delivers particular benefits in the form of increased concrete durability. This is important in colder climates where frost and freeze-thaw cycles can cause scaling and damage to the concrete surface. ▪ Air entraining agents help to prevent scaling by creating microscopic air voids, allowing water trapped in the concrete to expand when the concrete freezes, thus preventing cracks caused by natural expansion. Entrained air voids in the concrete will also increase durability in harsh environments where concrete is exposed to deicing salts, marine salts and sulfates. **Workability and Placeability:** ▪ Workability and placeability are also improved by the lubricating action of the microscopic bubbles in the concrete. Concrete flows better, and bleeding and shrinkage is reduced because less water is needed to obtain the desired workability.

How to Use

Dosage

Dosage rates for Sika AEA-15 will typically fall between 0.25 and 1 fl. oz. /100 lbs. (16 - 65 ml/100 kg) of cement to entrain between 4 and 6 percent air. Higher air contents may be obtained by increasing the dosage rate.

Dosage rates will vary depending on the air content required for a particular project. Typically air contents will be specified in the range of 4 to 8 percent by volume. Dosage rates outside the recommended range may be used where specialized materials such as microsilica are specified, extreme ambient conditions are encountered or unusual project conditions require special consideration. In this case please contact your local regional Sika office or Sika technical service department at 1-800-933-7452 for further information. Other factors that may affect the amount of air entrained into the concrete include, but are not limited to: total cementitious content, type of pozzolanic materials, sand gradation, temperature and water content. Sika recommends that trial mixes be performed whenever material or any other changes are made that may affect the amount of entrained air.

Construction

Mixing

Measure the required quantity per batch manually or with automatic dispenser equipment. Add Sika AEA-15 to mixing water or sand. Do not mix with dry cement. When used in combination with other admixtures, care must be taken to dispense each admixture separately into the mix.

Combination with Other Admixtures:
Combination with other admixtures, particularly water reducers and retarders, may increase the amount of entrained air in the mix. Air contents should be checked with an air-meter after batching and dosage adjustments made at the concrete plant.

Packaging

Sika AEA-15 is available in 55 gallon drum (208 liter), 275 gallon totes (1040 liters) drums and bulk delivery.

Storage and Shelf life

Sika AEA-15 should be stored at above 40°F (5°C). If frozen, thaw and agitate thoroughly to return to normal state.

Shelf life when stored in dry warehouse conditions between 50°F and 80°F (10°C - 27°C) is one year minimum.

Typical Data

Appearance

Dark Brown liquid.

Specific Gravity

Approx. 1.0

CAUTION: IRRITANT

Contains Aqueous Solution (CAS:Mixture) May cause eye/skin/respiratory irritation. May be harmful if swallowed.

Handling and Storage

Avoid direct contact. Wear personal protective equipment (chemical resistant goggles/gloves/clothing) to prevent direct contact with skin and eyes. Use only in well ventilated areas. Wash thoroughly with soap and water after use. Remove contaminated clothing and launder before reuse.

First Aid

Eyes: Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin:** Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation:** Remove person to fresh air. **Ingestion:** Do not induce vomiting. Dilute with water. Contact a physician. **In all cases, contact a physician immediately if symptoms persist.**

Clean Up

Use personal protective equipment (chemical resistant goggles/gloves/clothing). Without direct contact, remove spilled or excess product and place in suitable sealed container. Dispose of excess product and container in accordance with applicable environmental regulations.

KEEP CONTAINER TIGHTLY CLOSED • KEEP OUT OF REACH OF CHILDREN • NOT FOR INTERNAL CONSUMPTION • FOR INDUSTRIAL USE ONLY

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Regional Information and Sales Centers. For the location of your nearest Sika representative, contact your regional center.

U.S. : **North East Region:** Fairless Hills, PA, Phone: (215) 295 -6600 **North Central Region:** Marion, OH, Phone: (800) 851-1545
South East Region: Conyers, GA, Phone: (770) 760-1300 **South Central Region:** Mesquite, TX, Phone: (972) 289-6480
Western Region: Santa Fe Springs, CA, Phone: (562) 903-3650

Canada: **Ontario:** Mississauga, ON, Phone: (905) 795-3177, **Alberta:** Edmonton, AB, Phone: (780) 486-6111

Quality Certification Numbers: Lyndhurst: FM 69711 (ISO 9000), FM 70421 (QS 9000), Marion: FM 69715, Kansas City: FM 69107, Santa Fe Springs: FM 69408

Product Data Sheet
Edition 09.25.2009
Identification no. 104
Sika AER

Construction

Sika® AER
Air Entraining Admixture

Description	Sika AER admixture is a concentrated liquid solution of neutralized vinsol resin. Sika AER meets the requirements of ASTM C-260 for Air Entraining Admixtures.
Applications	Sika AER can be used whenever air entrained concrete is desired. Ready-mix, precast and block producers can achieve optimum entrained air contents, even where harsh mixes are used or fly-ash is added to the mix. Sika AER is an effective and economical means to improve the paste quality of lean concrete mixes.
Advantages	**Durability:** Air entrainment is recognized as the most effective prevention against concrete scaling in exposed environments. Air entrained concrete delivers particular benefits in the form of increased concrete durability. This is important in colder climates where frost and freeze-thaw cycles can cause scaling and damage to the concrete surface. Air entraining agents help to prevent scaling by creating millions of microscopic air voids that water trapped in the concrete can expand into when the concrete freezes, thus preventing cracks caused by the natural expansion. Entrained air voids in the concrete will also increase durability in harsh environments where concrete is exposed to deicing salts, marine salts and sulfates. **Workability and Placeability:** Workability and placeability are also improved by the lubricating action of the microscopic bubbles in the concrete. The concrete flows better, bleeding and shrinkage is reduced because lower water content is needed for desired workability.

How to Use

Dosage	Dosage rates for Sika AER will typically fall between 0.5 and 1.5 fl. oz./100 lbs. (32 - 97 ml/100 kg) of cementitious to entrain between 4 and 6 percent air. Higher air contents may be obtained by increasing the dosage rate. Dosage rates will vary depending on the air content required for a particular project. Typically air contents will be specified in the range of 4 to 8 percent by volume. Other factors that may affect the amount of air entrained into the concrete include, but are not limited to total cementitious content, type of pozzolanic materials, sand gradation, temperature and water content. Sika recommends that trial mixes be tested whenever material or any other changes are made that may affect the amount of entrained air.

Sika®

Construction

Mixing	Measure the required quantity per batch manually or with automatic dispenser equipment. Add Sika AER to mixing water or sand. Do not mix with dry cement. When used in combination with other admixtures, care must be taken to dispense each admixture separately into the mix. **Combination with Other Admixtures:** Combination with other admixtures, particularly water reducers and retarders, will tend to increase the amount of entrained air in the mix. Air contents should be checked with an air-meter after batching and dosage adjustments made at the concrete plant.
Packaging	Sika AER is supplied in 55 gallon (208 liter) drums and bulk delivery.
Storage and Shelf Life	Sika AER should be stored at above 40°F (5°C). If frozen, thaw and agitate thoroughly to return to its normal state before use. Shelf life when stored in dry warehouse conditions between 50°F and 80°F (10°C - 27°C) is one year.

Typical Data

Appearance	Dark Brown Yellow liquid.
Specific Gravity	Approx. 1.0

Caution	Skin and eye irritant; avoid contact. The use of NIOSH approved respirator, safety goggles and rubber gloves is recommended. Avoid breathing product. Use with adequate ventilation. Remove contaminated clothing.
Handling and Storage	Avoid direct contact. Wear personal protective equipment (chemical resistant goggles/gloves/clothing) to prevent direct contact with skin and eyes. Use only in well ventilated areas. Wash thoroughly with soap and water after use. Remove contaminated clothing and launder before reuse.
First Aid	**Eyes:** Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin:** Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation:** Remove person to fresh air. **Ingestion:** Do not induce vomiting. Dilute with water. Contact a physician. **In all cases, contact a physician immediately if symptoms persist.**
Clean Up	Use personal protective equipment (chemical resistant goggles/gloves/clothing). Without direct contact, remove spilled or excess product and place in suitable sealed container. Dispose of excess product and container in accordance with applicable environmental regulations.

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1-800-933-SIKA

ISO 9001
QS 14001

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Quality Certification Numbers: Lyndhurst: FM 69711 (ISO 9000), FM 70421 (QS 9000), Marion: FM 69715, Kansas City: FM 69107, Santa Fe Springs: FM 69408

Product Data Sheet
Edition 5.3.2011
Sika Multi Air 25

Sika® Multi Air 25

Multi Component Synthetic Air Entrainer

Description

Sika Multi Air 25 is a multi component synthetic air entrainer. Sika Multi Air 25 meets the requirements of ASTM C-260 for air entraining admixtures.

Applications

Sika Multi Air 25 is recommended for use whenever air entrained concrete is desired. Sika Multi Air 25 is very effective in specialized applications such as low slump, harsh, lean mixes or in mixes utilizing fly-ash.

Benefits

Air entrainment is recognized as the most effective prevention against concrete damage caused by repetitive freeze-thaw cycles. Air entraining agents help to prevent scaling by creating microscopic air voids that water trapped in the concrete can expand into when the concrete freezes. This prevents cracking caused by the natural expansion of ice. Entrained air voids in the concrete will also increase durability in harsh environments where concrete is exposed to deicing salts, marine salts and sulfates. Besides that Air entraining agents also improve workability and placeability of a concrete mixture and reduce bleeding.

How to Use

Dosage

The amount of Sika Multi Air 25 will vary depending on the mix design and air content required for a particular project. Dosage rates needed to entrain between 4 and 6 percent will typically fall between 0.5 and 1.5 fl. oz. per 100 lbs. (10 - 195 ml/100 kg) of cementitious materials. In special applications such as paving, dry cast applications or mixes utilizing flyash, the dosage may increase above the recommended dosage range. In cases such as this, actual testing is recommended to determine proper dosage range. If required, higher air content may be obtained by increasing the dosage rate. Combination with other admixtures, particularly water reducers, accelerators and retarders, may decrease or increase the effectiveness of Sika Multi Air 25, therefore random air content tests with an air-meter after batching should be performed to provide desired consistency. In mixes requiring a lower or higher amount dosage rate, it is always recommended to contact your local regional office or technical service department at 1-800-933-7452.

Mixing

Measure the required quantity per batch manually or with automatic dispenser equipment. Add Sika Multi Air 25 to mixing water or sand. Do not mix with dry cement. When used in combination with other admixtures, care must be taken to dispense each admixture separately into the mix.

Combination with other Admixtures: Combination with other admixtures, may affect the amount of entrained air in the mix. If multiple admixtures are used, actual air content should be verified as per applicable ASTM standards to ensure desired level of air entrainment is achieved.

Construction

Construction

Packaging	Sika Multi Air 25 is available in 55 gallon drum (208 liter), 275 gallon totes (1040 liters) drums and bulk delivery.
Storage and Shelf Life	Sika Multi Air 25 should be stored at above 40°F (5°C). If frozen, thaw and agitate thoroughly to return to normal state. Shelf life when stored in original packaging in dry warehouse conditions between 50°F and 80°F (10°C - 27°C) is 1 year.

Typical Data

Appearance	Yellow, clear liquid
Specific Gravity	1.010
Caution	**IRRITANT.** Contains Sodium C14-16 Olefin Sulfonate for Bioterge 40 (CAS:68439-57-6) and Amides, coco, N,N-bis (hydroxyethyl) (CAS: 68603-42-9). May cause eye/skin/respiratory irritation. May be harmful if swallowed.
Handling and Storage	Avoid direct contact. Wear personal protective equipment (chemical resistant goggles/gloves/clothing) to prevent direct contact with skin and eyes. Use only in well ventilated areas. Open doors and windows during use. Use a properly fitted NIOSH respirator if ventilation is poor. Wash thoroughly with soap and water after use. Remove contaminated clothing and launder before reuse.
First Aid	**Eyes** – Hold eyelids apart and flush thoroughly with water for 15 minutes. **Skin** – Remove contaminated clothing. Wash skin thoroughly for 15 minutes with soap and water. **Inhalation** – Remove to fresh air. **Ingestion** – Do not induce vomiting. Dilute with water. Contact physician. **In all cases contact a physician immediately if symptoms persist.**
Clean Up	Use personal protective equipment (chemical resistant gloves/ goggles/clothing). Without direct contact, sweep up spilled or excess product and place in suitable sealed container. Dispose of excess product and container in accordance with applicable local, state, and federal regulations.

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1-800-933-SIKA

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Quality Certification Numbers: Lyndhurst: FM 69711 (ISO 9000), FM 70421 (QS 9000), Marion: FM 69715, Kansas City: FM 69107, Santa Fe Springs: FM 69408

Appendix E – Test/Quality Report

NORCEM
HEIDELBERGCEMENT Group

REPORT ON QUALITY TEST

Sample marked: Norcem A.S. Standard Cement CEM I 42.5 R.
Uttatt bulkbilstasjon 23.02.15

Our Ref.: BZ-2015-0001 **Your ref.: 20/15**

CHEMICAL ANALYSIS

Loss on ignition	(L.O.I.)	2.35	%
Free Lime		1.62	%
Limestone		2.3	%
Tot. Chloride		0.051	%
Water soluble Chromium (Cr^{6+})		0.000	mg/kg
Insoluble Residue		0.620	%
Sulphur Trioxide	(SO_3)	3.07	%
Silica	(SiO_2)	20.02	%
Alumina	(Al_2O_3)	5.00	%
Ferric Oxide	(Fe_2O_3)	3.39	%
Lime	(CaO)	61.98	%
Magnesia	(MgO)	2.25	%
Phosphorus Pentoxide	(P2O5)	0.16	%
Potassium Oxide	(K_2O)	0.98	%
Sodium Oxide	(Na_2O)	0.46	%
Alkali	(Na_2O Eq.)	1.11	%

PHYSICAL TEST EN 196

FINENESS		
Particle analysis	+90 mic.	0.0 %
" "	+64 mic.	1.2 %
" "	-24 mic.	74.7 %
" "	-30 mic.	83.1 %
Specific Surface;	Blaine	396 m^2/kg
STANDARD CONSISTENCY		
Temperate climate	20°C	28.9 %
Le Chatelier expansion		1.0 mm
SETTING TIME		
Initial		163 min.
COMPRESSIVE STRENGTH		
1 day		22.3 MPa
2 days		34.1 MPa
7 days		47.0 MPa
28 days		MPa

Norcem A.S Brevik, Cement and Concrete Laboratory, 16.03.2015

kcs.

Laboratory Manager

NORCEM A.S

Address:
Setreveien 2
P.O.Box 38
N-3991 Brevik

Phone: +47 35 57 20 00
Telefax: +47 35 57 04 00

Ent.no:
NO 934 949 145 VAT
Bank account:
6003 06 12488

Head Office:
Lilleakerveien 2b
P.O.Box 143 Lilleaker
0216 Oslo

NORCEM
HEIDELBERGCEMENT Group

REPORT ON QUALITY TEST

Sample marked: Norcem A.S. Standard FA Cement
Uttak og forsendelse av materialer til NTNU

Our Ref.: AZ-2015-0070 **Your ref.: 20/15**

CHEMICAL ANALYSIS

Loss on ignition	(L.O.I.)		%
Free Lime		1.90	%
Fly Ash		17.7	%
Tot. Chloride			%
Water soluble Chromium (Cr^{6+})			mg/kg
Insoluble Residue		-	%
Sulphur Trioxide	(SO_3)	3.28	%
Silica	(SiO_2)	28.27	%
Alumina	(Al_2O_3)	8.27	%
Ferric Oxide	(Fe_2O_3)	3.52	%
Lime	(CaO)	52.02	%
Magnesia	(MgO)	2.12	%
Phosphorus Pentoxide	(P_2O_5)	0.24	%
Potassium Oxide	(K_2O)	1.21	%
Sodium Oxide	(Na_2O)	0.57	%
Alkali	(Na_2O Eq.)	1.37	%

PHYSICAL TEST EN 196

FINENESS

Particle analysis	+90 mic.	0.0 %
" "	+64 mic.	0.6 %
" "	-24 mic.	79.9 %
" "	-30 mic.	87.3 %
Specific Surface;	Blaine	461 m^2/kg

STANDARD CONSISTENCY

Temperate climate 20°C	23.9 %
Le Chatelier expansion	mm

SETTING TIME

Initial	166 min.

COMPRESSIVE STRENGTH

1 day	23.9 MPa
2 days	MPa
7 days	MPa
28 days	MPa

Norcem A.S Brevik, Cement and Concrete Laboratory, 16.03.2015

kcs.

for Kirsti [signature]
Laboratory Manager

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NORCEM
HEIDELBERGCEMENTGroup

REPORT ON QUALITY TEST

In commission from: P 653
Sample marked: 1 pall med sekket kalkmel (ca 1000kg) uttatt 08.05.06
Our ref.: HW1-06 Your ref: 66/06-P653

CHEMICAL ANALYSIS

Loss on ignition	v/1000°C	(L.O.I)	37.66 %
Silica		(SiO_2)	12.87 %
Alumina		(Al_2O_3)	2.68 %
Ferric Oxide		(Fe_2O_3)	2.04 %
Lime		(CaO)	79.80 %
Magnesia		(MgO)	1.84 %
Potassium Oxide		(K_2O)	0.62 %
Sodium Oxide		(Na_2O)	0.49 %

Specific weight 2.73 g/cm^3
Blaine 362 m^2/kg

Malvern			
<24my	<30my	>64my	>90my
57.2	64.3	12.2	5.6

Norcem A.S Brevik, Cement and Concrete Laboratory, May 22th 2005

po.
Po

Kirsti Coch Sæter
Laboratory Manager

NORCEM A.S
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Ent.no: NO 934 949 145 VAT Bank account: 6003 06 12488
Head Office: Lilleakerveien 2b P.O.Box 143 Lilleaker 0216 Oslo

Norcem Standard FA

NORCEM
HEIDELBERGCEMENTGroup

REPORT ON QUALITY TEST

Costumer:	Tor Magnus Zakkariassen	Your ref.:	62-15
Date received:	04.05.2015	Our ref.:	PN-2015-0012
Sample Marked:	Test av FA/Sement for studenter ved NTNU Norcem Standard FA		

Parameter		Results		Method
CHEMICAL COMPOSITION				
Chemical Parameters				
Loss On Ignition	LOI	1.21	%	EN196-2
Sulfur Trioxide-IR	SO3	3.22	%	PD1752
XRF Analysis				
Silica Oxide	SiO2	26.52	%	EN196-2
Aluminum Oxide	Al2O3	8.33	%	EN196-2
Ferric Oxide	Fe2O3	3.53	%	EN196-2
Calsium Oxide	CaO	52.55	%	EN196-2
Potassium Oxide	K2O	1.20	%	EN196-2
Sodium Oxide	Na2O	0.57	%	EN196-2
Magnesium Oxide	MgO	2.15	%	EN196-2
Titanium Dioxide	TiO2	0.42	%	EN196-2
Phosphorous Pentoxide	P2O5	0.24	%	EN196-2
Manganic Oxide	Mn2O3	0.06	%	EN196-2
Sodium Oxide Equivalent	Na2O Eq.	1.36	%	EN196-2
TECHNICAL PARAMETERS				
Fineness				
Specific surface, Blaine		461	m2/kg	EN196-6

Particle Size Distribution See enclosure

Norcem A.S Brevik, Cement and Concrete Laboratory, 13.05.2015

Laboratory Manager

NORCEM AS

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Telefax: +47-35-57 04 00
Ent.no.: NO 934 949145 VAT
Bank Account: 6003 06 12488
Head Office: Lilleakerveien 2b, P.O. Box 143 Lilleaker, 0216 Oslo

MASTERSIZER 2000

Result Analysis Report

Sample Name:
PN-2015-0012 - Average

Sample Source & type:
Factory = Brevik

Sample bulk lot ref:

SOP Name:
Cement

Measured by:
LLABX0

Result Source:

Measured:
12. mai 2015 10:22:45

Analysed:
12. mai 2015 10:22:46

Particle Name:
Cement18

Particle RI:
1.680

Percentage below 24.00 µm : 79.75%

Accessory Name:
Hydro 2000SM (A)

Absorption:
0.1

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
1.000 %

Sensitivity:
Enhanced

Obscuration:
13.49 %

Result Emulation:
Off

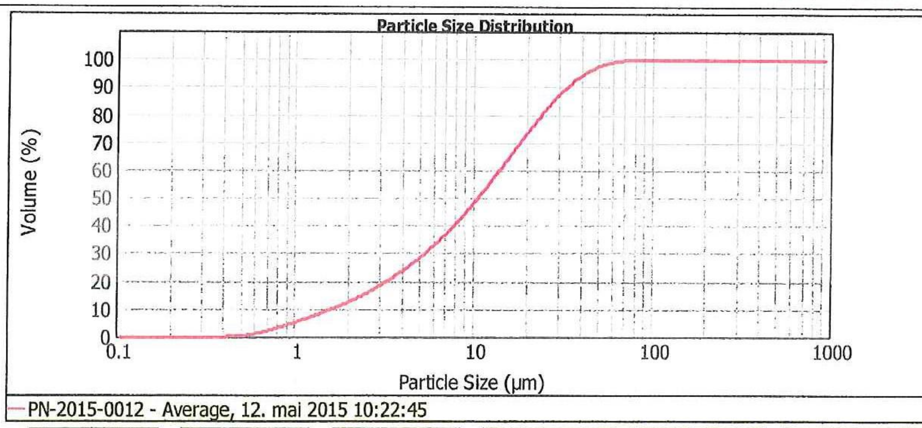
Percentage below 30.00 µm : 86.96% Percentage above 64.00 µm : 0.74% Percentage above 90.00 µm : 0.02%

Specific Surface Area:
1.36 m²/g

Surface Weighted Mean D[3,2]:
4.396 um

Vol. Weighted Mean D[4,3]:
14.757 um

d(0.1): 1.629 um **d(0.2):** 3.314 m **d(0.5):** 10.804 um **d(0.9):** 33.516 um



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.022	0.00	1.000	5.08	5.000	28.15	22.440	77.36	80.000	99.90	399.052	100.00
0.025	0.00	1.002	5.10	5.024	28.26	24.000	79.75	89.337	99.97	447.744	100.00
0.028	0.00	1.125	6.19	6.000	32.47	25.000	81.17	90.000	99.98	500.000	100.00
0.032	0.00	1.262	7.32	6.325	33.81	25.179	81.41	96.000	100.00	563.677	100.00
0.036	0.00	1.416	8.49	7.096	36.89	28.251	85.16	100.000	100.00	632.456	100.00
0.040	0.00	1.500	9.10	7.962	40.18	30.000	86.96	112.468	100.00	709.627	100.00
0.050	0.00	1.783	11.04	8.000	40.32	32.000	88.78	125.000	100.00	796.214	100.00
0.100	0.00	2.000	12.44	8.934	43.70	35.566	91.45	128.000	100.00	893.367	100.00
0.200	0.00	2.244	13.96	10.000	47.37	39.905	93.91	141.589	100.00	1002.374	100.00
0.224	0.00	2.518	15.59	11.247	51.40	40.000	93.95	158.866	100.00	1124.683	100.00
0.399	0.00	2.825	17.35	12.000	53.72	45.000	95.95	178.250	100.00	1261.915	100.00
0.448	0.06	3.000	18.31	12.619	55.55	48.000	96.84	200.000	100.00	1415.892	100.00
0.502	0.25	3.170	19.23	14.159	59.85	50.238	97.39	224.404	100.00	1588.656	100.00
0.564	0.71	3.557	21.26	15.000	62.05	56.368	98.47	250.000	100.00	1782.502	100.00
0.710	2.14	3.991	23.43	16.000	64.53	63.000	99.19	282.508	100.00	2000.000	100.00
0.796	3.06	4.000	23.48	17.825	68.69	64.000	99.26	316.979	100.00		
0.893	4.05	4.477	25.76	20.000	73.09	70.963	99.65	355.658	100.00		

Operator notes:

Malvern Instruments Ltd.
Malvern, UK
Tel := +[44] (0) 1684-892456 Fax +[44] (0) 1684-892789

Mastersizer 2000 E Ver. 5.60
Serial Number : MAL1049689

File name: Cement_Mal.mea
Record Number: 137
13.05.2015 13:51:23

Norcem Fly Ash

NORCEM
HEIDELBERGCEMENTGroup

REPORT ON QUALITY TEST

Costumer:	Tor Magnus Zakkariassen	Your ref.:	62-15
Date received:	04.05.2015	Our ref.:	PN-2015-0014
Sample Marked:	Test av FA/Sement for studenter ved NTNU Flyveaske Norcem		

Parameter		Results		Method
CHEMICAL COMPOSITION				
Chemical Parameters				
Loss On Ignition	LOI	2.27	%	EN196-2
Sulfur Trioxide-IR	SO3	0.44	%	PD1752
XRF Analysis				
Silica Oxide	SiO2	53.73	%	EN196-2
Aluminum Oxide	Al2O3	22.74	%	EN196-2
Ferric Oxide	Fe2O3	6.95	%	EN196-2
Calsium Oxide	CaO	5.73	%	EN196-2
Potassium Oxide	K2O	1.72	%	EN196-2
Sodium Oxide	Na2O	0.91	%	EN196-2
Magnesium Oxide	MgO	2.56	%	EN196-2
Titanium Dioxide	TiO2	0.88	%	EN196-2
Phosphorous Pentoxide	P2O5	0.58	%	EN196-2
Manganic Oxide	Mn2O3	0.10	%	EN196-2
Sodium Oxide Equivalent	Na2O Eq.	2.04	%	EN196-2
TECHNICAL PARAMETERS				
Fineness				
Specific surface, Blaine		334	m2/kg	EN196-6

Particle Size Distribution See enclosure

Norcem A.S Brevik, Cement and Concrete Laboratory, 13.05.2015

Laboratory Manager

NORCEM AS

Adress: Setreveien 2, P.O. Box 38, N-3991 Brevik	Phone: +47-35-57 20 00 Telefax: +47-35-57 04 00 Ent.no.: NO 934 949145 VAT Bank Account: 6003 06 12488		Head Office: Lilleakerveien 2b, P.O. Box 143 Lilleaker, 0216 Oslo

MASTERSIZER 2000

Result Analysis Report

Sample Name:
PN-2015-0014 - Average

Sample Source & type:
Factory = Brevik

Sample bulk lot ref:

SOP Name:
Cement

Measured by:
LLABX0

Result Source:

Measured:
12. mai 2015 10:32:31

Analysed:
12. mai 2015 10:32:32

Particle Name:
Cement18

Particle RI:
1.680

Accessory Name:
Hydro 2000SM (A)

Absorption:
0.1

Analysis model:
General purpose

Size range:
0.100 to 1000.000 um

Weighted Residual:
0.461 %

Sensitivity:
Enhanced

Obscuration:
12.23 %

Result Emulation:
Off

Percentage below 24.00 µm : 54.10%

Percentage below 30.00 µm : 59.41% Percentage above 64.00 µm : 21.25% Percentage above 90.00 µm : 13.72%

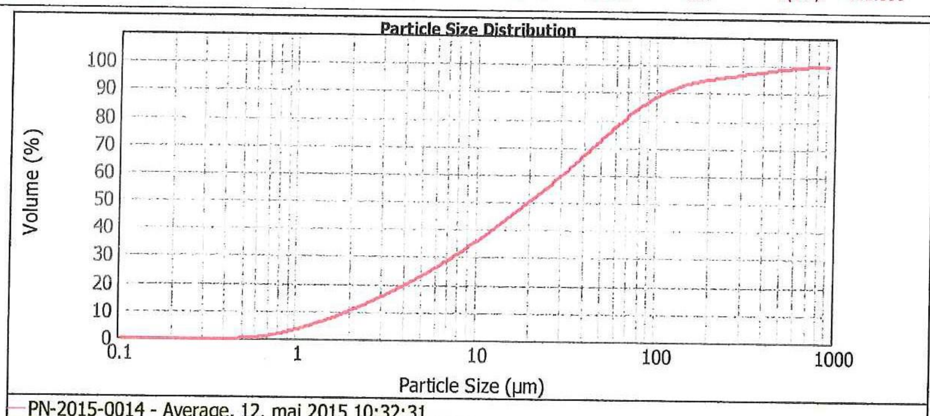
Specific Surface Area:
1.03 m²/g

Surface Weighted Mean D[3,2]:
5.821 um

Vol. Weighted Mean D[4,3]:
52.602 um

d(0.1): 1.960 um d(0.2): 4.176 m d(0.5): 20.052 um d(0.9): 112.898 um

---



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.022	0.00	1.000	3.35	5.000	22.77	22.440	52.55	80.000	83.90	399.052	97.69
0.025	0.00	1.002	3.37	5.024	22.84	24.000	54.10	89.337	86.14	447.744	98.15
0.028	0.00	1.125	4.33	6.000	25.76	25.000	55.05	90.000	86.28	500.000	98.56
0.032	0.00	1.262	5.36	6.325	26.66	25.179	55.22	96.000	87.46	563.677	98.96
0.036	0.00	1.416	6.48	7.096	28.69	28.251	57.95	100.000	88.15	632.456	99.29
0.040	0.00	1.500	7.06	7.962	30.81	30.000	59.41	112.468	89.95	709.627	99.57
0.050	0.00	1.783	8.92	8.000	30.89	32.000	61.00	125.000	91.29	796.214	99.78
0.100	0.00	2.000	10.23	8.934	33.00	35.566	63.64	128.000	91.56	893.367	99.94
0.200	0.00	2.244	11.61	10.000	35.21	39.905	66.59	141.589	92.56	1002.374	100.00
0.224	0.00	2.518	13.05	11.247	37.58	40.000	66.65	158.866	93.48	1124.683	100.00
0.399	0.00	2.825	14.54	12.000	38.92	45.000	69.71	178.250	94.22	1261.915	100.00
0.448	0.00	3.000	15.33	12.619	39.96	48.000	71.40	200.000	94.82	1415.892	100.00
0.502	0.02	3.170	16.08	14.159	42.39	50.238	72.58	224.404	95.33	1588.656	100.00
0.564	0.23	3.557	17.67	15.000	43.63	56.368	75.56	250.000	95.78	1782.502	100.00
0.710	1.10	3.991	19.33	16.000	45.02	63.000	78.37	282.508	96.27	2000.000	100.00
0.796	1.74	4.000	19.36	17.825	47.38	64.000	78.75	316.979	96.74		
0.893	2.50	4.477	21.05	20.000	49.94	70.963	81.23	355.656	97.22		

Operator notes:

Malvern Instruments Ltd.
Malvern, UK
Tel := +[44] (0) 1684-892456 Fax +[44] (0) 1684-892789

Mastersizer 2000 E Ver. 5.60
Serial Number : MAL1049689

File name: Cement_Mai.mea
Record Number: 145
13.05.2015 13:09:50

Fly Ash USA

NORCEM
HEIDELBERGCEMENT Group

REPORT ON QUALITY TEST

Costumer:	Tor Magnus Zakkariassen		Your ref.:	62-15
Date received:	04.05.2015		Our ref.:	PN-2015-0013
Sample Marked:	Test av FA/Sement for studenter ved NTNU Flyveaske USA			

Parameter		Results		Method
CHEMICAL COMPOSITION				
Chemical Parameters				
Loss On Ignition	LOI	1.91	%	EN196-2
Sulfur Trioxide-IR	SO3	0.51	%	PD1752
XRF Analysis				
Silica Oxide	SiO2	57.79	%	EN196-2
Aluminum Oxide	Al2O3	26.22	%	EN196-2
Ferric Oxide	Fe2O3	5.61	%	EN196-2
Calsium Oxide	CaO	1.21	%	EN196-2
Potassium Oxide	K2O	2.38	%	EN196-2
Sodium Oxide	Na2O	0.85	%	EN196-2
Magnesium Oxide	MgO	1.26	%	EN196-2
Titanium Dioxide	TiO2	1.28	%	EN196-2
Phosphorous Pentoxide	P2O5	0.16	%	EN196-2
Manganic Oxide	Mn2O3	0.04	%	EN196-2
Sodium Oxide Equivalent	Na2O Eq.	2.42	%	EN196-2
TECHNICAL PARAMETERS				
Fineness				
Specific surface, Blaine		428	m2/kg	EN196-6

Particle Size Distribution See enclosure

Norcem A.S Brevik, Cement and Concrete Laboratory, 13.05.2015

Laboratory Manager

NORCEM AS

Adress: Setreveien 2, P.O. Box 38, N-3991 Brevik
Phone: +47-35-57 20 00
Telefax: +47-35-57 04 00
Ent.no.: NO 934 949145 VAT
Bank Account: 6003 06 12488
Head Office: Lilleakerveien 2b, P.O. Box 143 Lilleaker, 0216 Oslo

MASTERSIZER 2000

Result Analysis Report

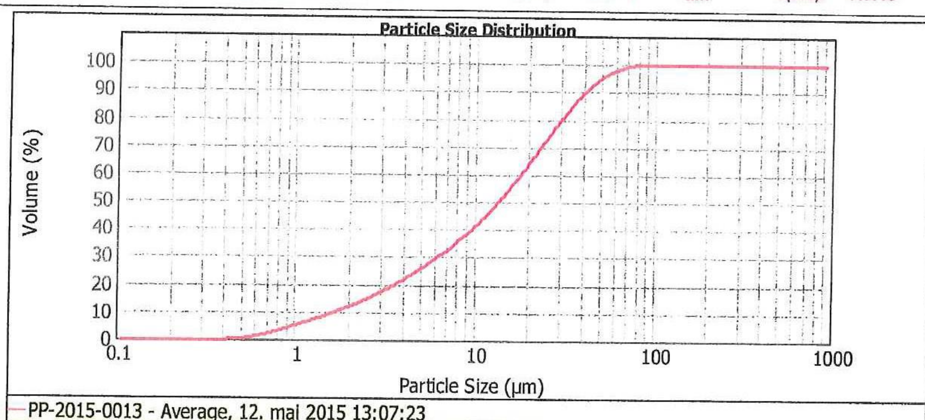
Sample Name: PP-2015-0013 - Average	**SOP Name:** Cement	**Measured:** 12. mai 2015 13:07:23
Sample Source & type: Factory = Brevik	**Measured by:** LLABX0	**Analysed:** 12. mai 2015 13:07:24
Sample bulk lot ref:	**Result Source:**	

Particle Name: Cement18	**Accessory Name:** Hydro 2000SM (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.680	**Absorption:** 0.1	**Size range:** 0.100 to 1000.000 um	**Obscuration:** 14.86 %
Percentage below 24.00 µm : 70.74%		**Weighted Residual:** 1.296 %	**Result Emulation:** Off

Percentage below 30.00 µm : 79.47% Percentage above 64.00 µm : 1.70% Percentage above 90.00 µm : 0.07%

Specific Surface Area: 1.28 m²/g	**Surface Weighted Mean D[3,2]:** 4.671 um	**Vol. Weighted Mean D[4,3]:** 18.079 um

d(0.1): 1.677 um d(0.2): 3.602 m d(0.5): 13.713 um d(0.9): 41.115 um



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.022	0.00	1.000	5.15	5.000	25.65	22.440	68.07	80.000	99.71	399.052	100.00
0.025	0.00	1.002	5.17	5.024	25.74	24.000	70.74	89.337	99.92	447.744	100.00
0.028	0.00	1.125	6.20	6.000	29.15	25.000	72.37	90.000	99.93	500.000	100.00
0.032	0.00	1.262	7.25	6.325	30.22	25.179	72.65	96.000	99.99	563.677	100.00
0.036	0.00	1.416	8.32	7.096	32.63	28.251	77.17	100.000	100.00	632.456	100.00
0.040	0.00	1.500	8.88	7.962	35.19	30.000	79.47	112.468	100.00	709.627	100.00
0.050	0.00	1.783	10.64	8.000	35.30	32.000	81.86	125.000	100.00	796.214	100.00
0.100	0.00	2.000	11.92	8.934	37.92	35.566	85.54	128.000	100.00	893.367	100.00
0.200	0.00	2.244	13.29	10.000	40.78	39.905	89.14	141.589	100.00	1002.374	100.00
0.224	0.00	2.518	14.76	11.247	43.99	40.000	89.21	158.866	100.00	1124.683	100.00
0.399	0.00	2.825	16.33	12.000	45.87	45.000	92.36	178.250	100.00	1261.915	100.00
0.448	0.06	3.000	17.20	12.619	47.39	48.000	93.85	200.000	100.00	1415.892	100.00
0.502	0.36	3.170	18.01	14.159	51.04	50.238	94.78	224.404	100.00	1588.656	100.00
0.564	0.84	3.557	19.80	15.000	52.98	56.368	96.75	250.000	100.00	1782.502	100.00
0.710	2.30	3.991	21.68	16.000	55.22	63.000	98.14	282.508	100.00	2000.000	100.00
0.796	3.20	4.000	21.72	17.825	59.15	64.000	98.30	316.979	100.00		
0.893	4.17	4.477	23.66	20.000	63.54	70.963	99.13	355.656	100.00		

Operator notes:

HEADWATERS RESOURCES

Adding Value to Energy ™

ASTM C618-05 / AASHTO M 295 Testing of
Brayton Point Fly Ash

Sample Type:	**3200-ton**	**Report Date:**	**11/16/2010**
Sample Date:	**9/27 - 9/30/10**	**MTRF ID**	**2434BP**
Sample ID:			

Chemical Analysis			**ASTM / AASHTO Limits Class F**	**Class C**	**ASTM Test Method**
Silicon Dioxide (SiO2)	57.71	%			
Aluminum Oxide (Al2O3)	25.86	%			
Iron Oxide (Fe2O3)	5.99	%			
Sum of Constituents	89.56	%	70.0% min	50.0% min	D4326
Sulfur Trioxide (SO3)	0.31	%	5.0% max	5.0% max	D4326
Calcium Oxide (CaO)	1.78	%			D4326
Moisture	0.06	%	3.0% max	3.0% max	C311
Loss on Ignition	2.40	%	6.0% max	6.0% max	C311
(AASHTO M 295 req.)			5.0% max	5.0% max	
Available Alkalies, as Na2O	1.01	%			C311
(AASHTO M 295 req.)			1.5% max	1.5% max	
Physical Analysis					
Fineness, % retained on #325	15.98	%	34% max	34% max	C311, C430
Strength Activity Index - 7 or 28 day requirement					C311, C109
7 day, % of control	93	%	75% min	75% min	
28 day, % of control	101	%	75% min	75% min	
Water Requirement, % control	99	%	105% max	105% max	
Autoclave Soundness	0.08	%	0.8% max	0.8% max	C311, C151
True Particle Density	2.34				

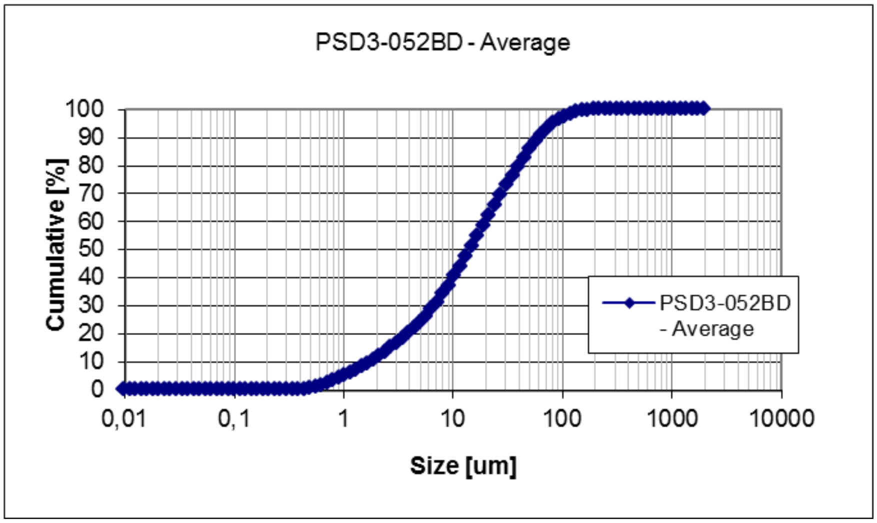
Headwaters Resources certifies that pursuant to ASTM C618-05 protocol for testing, the test data listed herein was generated by applicable ASTM methods and meets the requirements of ASTM C618-05 for Class F fly ash.

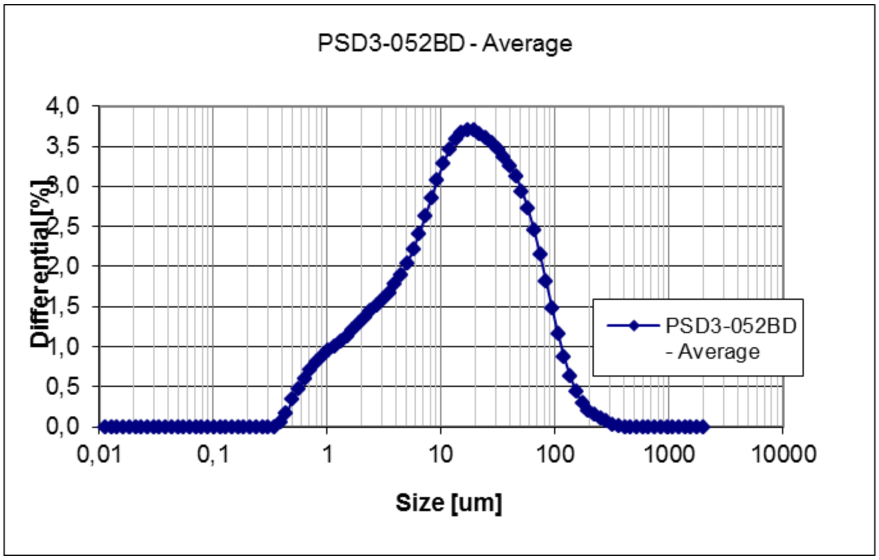
Bobby Bergman
MTRF Manager

AASHTO R18

Materials Testing & Research Facility
2650 Old State Highway 113
Taylorsville, Georgia 30178
P: 770.684.0102
F: 770.684.5114
www.headwaters.com

Date/time Wednesday, January 05, 2011 2:48:11 PM		**File Name**	Y:\PSD\PSD3-DATA\PSD3-052\PSD3-052B.mea				
Sample Name	PSD3-052BD - Average	**Source**	MA2-194L-FlyAsh L.C.			**SSA (m^2/g**	0,45
						density g/	2,7
Dispersant Name	Propan-2-ol	***Refractive index***		1,39			
Particle Name	Fly Ash	***Index:***	***Refractive***	1,57	***Absorption***	0,1	
Obscuration Low	1 ***High***		20				
Statistic	**d(0.1)** 1,791	**d(0.5)**	14,596	**d(0.9)** 63,366		**span**	4,22





Carbon content on:

Norcem Standard FA,

Norcem Fly Ash and

American Fly Ash

E-post 147 av 166 (Besvart)

Tilbake Forrige Neste Svar Svar til alle Videresend

Fra: "Zachariassen, Tor Magnus (Brevik) NOR" Ny kontakt

Til: Hawar Omer Rasol

Tittel: SV: SV: SV: SV: materiale fra NTNU via studentene fra Gjøvik

Dato: 13-05-2015 16:20

Karbon

PN12-15 (STDFA Norcem) = **0,35**

PN13-15 (FA fra USA) = **2,06**

PN14-15 (FA fra Norcem) = **1.74**

E-post 148 av 166 Tilbake Forrige Neste Svar Svar til alle Videresend Slett Flytt

Fra: "Zachariassen, Tor Magnus (Brevik) NOR" Ny kontakt
Til: Hawar Omer Rasol
Tittel: SV: SV: SV: SV: SV: materiale fra NTNU via studentene fra Gjøvik
Dato: 13-05-2015 17:27

Hei.

Bare å mase, men jeg går straks kjem og da er jeg ikke på mail.

Så vidt jeg vet ble det bruk en leco http://www.leco.com/products/analytical-sciences/carbon-sulfur-analyzers/230-series (Usikker på om det er denne typen)

Vi har dessverre ingen mulighet til å få tatt den analysen igjen før neste uke.

Tor-Magnus