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# Effect of adding sequence of air-entraining and water-reducing agents on macro-porosity and air-void stability of concrete. AVA measurements

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TITLE:

**Effect of adding sequence of air-entraining and water-reducing agents on macro-porosity and air-void stability of concrete with AVA measurements**

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Include picture

SUMMARY:
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It is noted that the concrete with FA is highly volatile what dosage of AEA concern, any adding sequence that stood out positively was not found in the work. Especially the spacing factor tend to fluctuate. The concrete without FA showed a better reliability for the frost resistance.
In contrast of earlier findings, the total air void content in this work tended to decrease with an increasing workability.

RESPONSIBLE TEACHER: Stefan Jacobsen

SUPERVISOR(S) Stefan Jacobsen and Andrei Shpak

CARRIED OUT AT:Department of Structural Engineering, Norwegian University of Science and Technology

# Preface

This report is composed at the Department of Structural Engineering at Norwegian University of Science and Technology, spring 2017. This thesis is written and executed by Ole Petter Vimo, as a final project before graduating with an MSc, Master degree in Civil Engineering from the two years study program Civil and Environment Engineering at NTNU, Trondheim.

The work is motivated by the project DACS (Durable Advanced Concrete Solutions) which is taking place as a collaboration with Norbetong, NTNU, Mapei, Multiconsult, Kværner, Statens Vegvesen among others. The purpose of project DACS WP2 is to investigate production and documentation of frost durable concrete. This work is part of WP2 targeted at the air void structure in concrete with Fly Ash (FA) concrete, and its stability over time. The project compromises a field in the concrete technology which is relatively young, but important. This has made the study exciting to work with.

I would like to thank my supervisors, Professor Stefan Jacobsen and PhD candidate Andrei Shpak for the counseling, feedback and critic during the progress of the project. Further thanks to Andrei for seeing through my writing and results before due date.

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Ole Petter Vimo

Trondheim, June 2017

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## Abstract

Frost resistance is an important part of Concrete Technology in Northern countries, especially with increasing interest of Fly Ash as a binder product more knowledge of this topic is desired.

Nowadays concrete is mixed with use of different admixtures, especially with plasticizer and air entraining agents. The sequence of how the admixtures is being introduced is found to have an influence on how the air void and its parameters are being developed.

This work try to study this relation and further how the fly ash do affect this. The following adding sequences are superplasticizer (SP) then air entrained admixture (AEA), AEA then SP and AEA and SP at the same time, this is performed with FA and without FA. With the concrete with FA, 35 % FA was used.

It is noted that the concrete with FA is highly volatile what dosage of AEA concern, any adding sequence that stood out positively was not found in the work. Especially the spacing factor tend to fluctuate. The concrete without FA showed a better reliability for the frost resistance.

In contrast of earlier findings, the total air void content in this work tended to decrease with an increasing workability.

When diluting the AEA used (Mapeair 25) with regularly tap water, it lost effect over time, making the mission to found correct admixture dosages required air void content even more difficult.

Experiment with Air Void Analyzer (AVA) was obtained in this work and time analyzes were performed. The air void content tended to increase over time, reason for this was not found.

# 1. Introduction and Scope

## Introduction

One purpose of using a concrete with a high content of FA is to reduce the CO2 emission. Emission from cement production is contributing notably on the total CO2 emission and can be reduced by use of other binder products (pozzolan) like Fly Ash.

Fly ash is probably the most common pozzolan used in concrete. The reason for this is not limited to a lower carbon dioxide emission, but also because it reduces cost while contributing positively in both fresh and hardened concrete. Fly ash is found to improve the workability of concrete when used as a replacement. The curing reaction may also be retarded for several weeks, making use of FA beneficial where the total temperature rise during curing must be minimized. During curing, the k-factor will not exceed 1 until after several months of curing, making the concrete improve slowly over time. The pozzolanic reaction also produce a finer pore structure due to its production of extra C-S-H, which decreases the permeability. [14]

FA is available in blended cements which contains varying amounts depending on actual type (*NS-EN 196,197).* In Norway ~20 % FA is most common (2016), but a higher FA content in blended cement may come to the market in the future. FA can also be ordered separately.

It is in the interest of entrepreneurs and researchers to understand how the air voids behaves in an FA concrete. Concrete structures exposed to freezing and thawing with or without salt can suffer with deterioration like cracks and scaling unless it possesses a properly entrained micro air void system. At the same time it is important that there is not too much air voids in the concrete, as this will reduce the concrete strength.

FA has several inherent properties that affect the required air entraining admixture (AEA) dosage. There is also an uncertainty when combining admixtures like air entrained admixture (AEA) and superplasticizer (SP) and the resulting air void content. Uncertainties include types of AEA and SP, adding sequences, workability, type and amount of cement and FA etc. This makes air entrainment in concrete very difficult to predict and trial mixing is always needed

AEA belong to a big group of chemical called surfactants. Concrete technologists roughly divide AEA in two group: natural resins and synthetic, which react with SP in different ways [10]. It has been found by research that adding SP first and then AEA in FA concrete can be recommended [14], it is also been found that adding AEA first and then SP is to be recommend [10]. Because of these potentially confusing recommendations from research, it is in interest to find out more about use of FA in concrete and the air void system it gives with different adding sequences of the admixtures.

A master thesis done by Turowski [21] found that a concrete with OPC – FA: 70/30 gave the highest total air voids content when adding the air entrained admixture together with the superplasticizer. Adding it after the superplasticizer will give second highest total air void content. In [21] the same AEA dosages were used in 4 different dosage sequences (only AEA, AEA then SP, SP then AEA and AEA with SP) and the resulting variation in air entrainment was studied. Workability was kept constant (+- 10 mm for a 120 mm slump cone for mortars.

This thesis will conduct a research about the air system in fresh concrete with a relatively high amount of Fly Ash (FA) (35 % of binder) and a control concrete without FA. Different adding sequences will be introduced and studied.

First, the necessary dosage of SP and AEA are found for a slump of 100 mm +-10 mm and an air content between 7 +- 1 % is stable, i.e different approach than Turowski in his master thesis [21], where the AEA dosage was constant and the air content was set to chance. Here in this work constant air void content is targeted by varying the dosage of AEA in the different mixing sequences. In addition the time dependency of the air void stability and quality in fresh mix are measured using 3 different methods: Density measurements, pressure meter and AVA.

The AVA gives results from the total air void content (chord length < 2 mm), air void content with chord length < 1 mm and chord length < 0.35 mm, where it is the latter that is of most interest. From this it can be analyzed if there is any coherence with a given adding sequence and wanted air voids. The AVA results will also be analyzed against the workability.

After the correct AEA and SP content are ensured, the air void system over time is measured with use of AVA. In order to do so, the air void content is measured two times using AVA. The last one is taken 1 hour after the water is introduced. The idea is to try to analyze the air pore system and how stable it is in time with respect to the different adding sequences.

Measurements with AVA will also be done with newly mixed concrete that is outside of the requirements. This will give a good training approach using the AVA, and from this find out how much time that is needed for each operation (extracting of mortar, preparing the AVA, ejecting of the fresh mortar, washing of equipment, etc.) Doing AVA with this concrete will also work as a safety net.

The mortar will be cast in cubes after each of the tests in order to do Image Analysis (IMA) of the hardened specimens. Only concrete that fulfills the given requirements will be cast.

### Scope of this work

- Find correct dosage of admixtures for a required slump (100 mm +- 10 mm) and total air void content of 6 – 8 % (measured by pressure meter). This for all of the given sequences, with and without FA. Density is also measured
- While doing this, AVA measurements are being performed
- After finding the dosage needed to obtain given requirements, the same concrete is again mix in order to do a time analysis with AVA. The air content is also measured by pressure meter, the workability is also measured
- The concrete which hold the required values is cast in cubes.

# 2 Literature study

## 2.1 Frost deterioration

It is several hypotheses for the frost deterioration mechanisms related to the entrained voids. Researchers believe that the magnitude of the pressure, developed by the water as it expands during freezing, depends upon the distance the water must travel to the nearest empty air void [1].

The unfrozen water will also build up a hydrostatic pressure in the paste as the water expands 9 % when it freezes, if the distance to an empty pore is too large or there is lack of pores the hydrostatic pressure from the unfrozen water can exceed the concrete tensile strength and cause cracks. [16]

Deicer salt scaling is also a relevant deterioration mechanism causing damage on bridges and pavements. Salt scaling is a surface damage where small pieces of concrete scales from the surface. This mechanism is due to mismatch of the thermal properties between ice and concrete [16]. As ice has much higher thermal contraction than concrete, this causes a tensile stress on the surface during cooling. Scaling occurs after a long period of freezing and thawing process on a surface covered with salt water. From tests it has been found that it is an intermediate salt content (2 -4%) that will create the greatest tensile stress. This because the two extremes has mechanisms that eases the tensile stress: Pure ice creeps, which causes less tensile stress, and ice with high salt content is too weak to create any tension. A water with intermediate salt content is quite common in Norway as it is used in order to melt the ice on the roads during winter.

Air voids in the concrete lead to a higher thermal contraction of the concrete and will increase the thermal expansion match between the concrete and the ice. [16]

## 2.2 Air voids in concrete

In general the air void system in concrete can be separated in entrained and entrapped voids:

- Entrained voids are small spherical voids that are introduced during mixing. These pores are in the range of 5 – 1000 µm. It is the voids from 5 – 300 µm (which may be referred as micro air voids in this report) that are most beneficial for the freeze/thaw resistance both external and internal. These entrained voids do not have any capillary suction any water due to the size, size of capillary pores are in range of 0.1 – 10 µm. External pressure must be introduced in order to fill them with water. Thus, these pores are empty for the water that is set in motion during freezing, and contribute to ease the hydrostatic pressure that builds up internal during freezing.

- Entrapped voids come from lack of compacting, and is non-spherical voids, which do not contribute with freeze and thaw resistance, but weakened the strength to the concrete. These voids can be seen by the naked eye and are considered to be in the size range ~1 – 10 mm.

The air void properties consists mainly of three parameters: Air content, the spacing factor and the specific surface.

### 2.2.1 Air Content

This is the content of air in the concrete, and is quantified in volume per cent. It is not always that meeting the required total air void content meets the required frost resistance. It is expected that a concrete with equal air content but with different air void spacing, exhibit different frost resistance [13].

### 2.2.2 Specific Surface

The specific surface (α) is defined as the ratio of total surface area of the air bubbles, divided by the total volume of the air bubbles. Higher specific surface indicates smaller air bubbles, which are wanted. A given volume of air distributed among small bubbles will give a closer spacing between them. A concrete with larger air bubbles but the same given air content will possess a higher volume of paste without entrained air voids. [5]

A specific surface of > 25 mm^-1 will generally provide a sufficient spacing factor of 0.2 mm. [2]

### 2.2.3 The Spacing factor

It is generally the spacing factor (L) that is considered to be the most relevant parameter for the freeze/thaw resistance. [2]

The spacing factor is according to Powers, equal to the difference between the radius of the sphere of influence and the radius of the bubble. As illustrated on Figure 1 below, the spacing factor can be seen as the average maximum distance in the binder paste from the periphery of an air bubble.

ASTM C 457 sees it as the average distance the water or expansive force must travel before it contacts an air void. The definition of the spacing factor is based on the assumption that the voids are equal size spheres and evenly distributed through the cement paste, which is considered to be a cube.

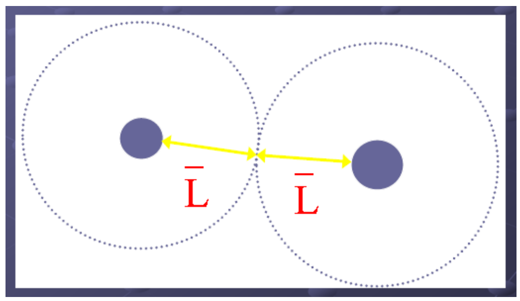



**Figure 1: Spacing factor, L. (The blue sphere is here an air void.)**

A desirable spacing factor varies from country to country, naturally depending on how much freezing and thawing there is that affects the concrete and magnitude of use of salt on the roads. A desirable spacing tend to vary from 0.18 – 0.25 mm. [16]

The spacing factor is more covered in Nist (Appendix J). Also a comprehensive explanation is provided in the paper: *a numerical test of Air Void Spacing Equations.* [13]

### 2.2.4 Mechanisms affecting the air void properties

Careful investigations by a combination of controlled sampling and testing with petrographic analyses has shown that air-void content does not change upon hardening. This implies that a stable and untouched concrete in fresh state should possess the same air void system when cured. However, it is not that simple as there are many mechanisms that can disrupt this. Fagerlund describes three well cited mechanisms in his paper [4].

The first mechanism is the **outside influence**: Like excessive vibration, further addition of water, or pumping operations. [3] Also compression of the concrete due to hydrostatic pressure in the pore system. [12]

According to Fagerlund outside influence will only lead to a decrease of the larger air-bubbles. This will not lead to any dramatic decrease in the frost-resistance, provided that the smallest bubbles stays in their place. The spacing factor is thus believed to be almost uninfluenced by this kind of air loss until the air loss becomes very large. [4]

However, vibrating can cause segregation of the concrete since the mortar moves into the vibrator zone. A research done in 1997 suggested a higher spacing factor on the area that were more affected by vibration than other parts of the concrete [2]. This may indicate that an outside influence can affect the spacing factor and thus the frost resistance.

Second mechanism to Fagerlund is **dissolution of small bubbles in the water**. This mechanism is a physical mechanism that is cause by the over pressure in the bubble.

The pressure in a bubble is:

$$P = P_o + \frac{2\sigma}{r}$$

[1]

Where $P_0$ is a composition of the atmospheric pressure and the hydrostatic pressure in the fresh concrete. The letter **σ** is the surface tension between the air and the liquid meniscus. For air bubbles that is related to AEA, the surface tension can be 25 % lower than a normal air-water tension, depending on type of AEA used [4]. Smaller surface tension reduces the overpressure. When the overpressure becomes large enough the air bubble will dissolve completely. Fagerlund finds the air bubbles that dissolve completely, to have a diameter of the spectra < 45 µm. [4]

The rate of dissolution depends of the air-liquid interface, the thicker and more impermeable the interface the slower the dissolution. This may suggests that more of the small air bubbles will be retained in the cured concrete if the interface is strong.

A small air-volume loss of the micro air voids leads to a considerable change in the specific surface and the spacing factor, an air loss of 0.5 %, caused by dissolution of all pores smaller than 55 µm radius, will lead to a 22 % increase in the spacing factor. [4]

The third mechanism is the **excess of oxygen in the water** as a result when smaller air bubbles burst. This excess oxygen will increase the larger bubbles, and a courser concrete is developed.

This mechanism is according to Fagerlund the most plausible reason that we often see a higher air-content in hardened concrete than in fresh concrete. [4]

## 2.3 Introduction to Air Void Analyzer (AVA)

According to a report made by the U.S Department of Transportation, 107 Billion $ each year is required to maintain the highways in the US. In order to reduce this cost have many agencies looked at ways to increase the design life of pavements to 50 years or more, and bridges to 100 years.

The culture in the industry has been that a concrete of 4 – 8 % air is seen to be satisfactory and mostly the spacing factor and specific surface were set to chance. With new design life requirements, this approach is maybe no longer adequate. To improve the concretes quality, better and more rapid test methods are needed to measure the concretes air voids properties in situ. The one method to do so is AVA. [1]

### 2.3.1 Mechanism of the AVA

The mortar is injected in a blue liquid with a considerably higher viscosity than water. Due to the viscosity the drag force from the liquid is much higher, which means that the terminal velocity (velocity that obtain equilibrium between the gravity and the drag force) can be much smaller to obtain equilibrium. Thus, when the air bubbles leave the blue liquid, the largest bubbles comes first because they have the highest terminal velocity by Stokes law. The blue liquid slows down the initial rise of the bubbles and provides separation of the bubbles so that AVA can more easily separate the bubbles in their sizes during the measurement. The change in buoyance is measured as change in weight and is recorded as a function of time [7]

Due to the risk that the stirrer may potentially be trapped between a large aggregate particle and the glass wall, the AVA equipment does not allow any mortar with an aggregate over 6 mm.

A mortar of 20 ml is there for extracted from a representative area of the concrete by vibrating a wire cage into the concrete. This will trap some of the concrete inside the wire cage without any aggregate over 6 mm.

When the steel stirrer start to stir the mortar, the air in the mortar will be released and will rise to the surface. The air bubbles hit the submerged pan that is attached to a scale on top of the glass column, the scale will gauge the weight loss, which is caused by the buoyance force. The measurement is finished when there is no more change in weight. The software then can calculate the air content, specific surface and the spacing factor.

### 2.3.2 Calculation of air void parameters by AVA

The derivations are taken from the report from the Brite Euram project [5]

### Air content

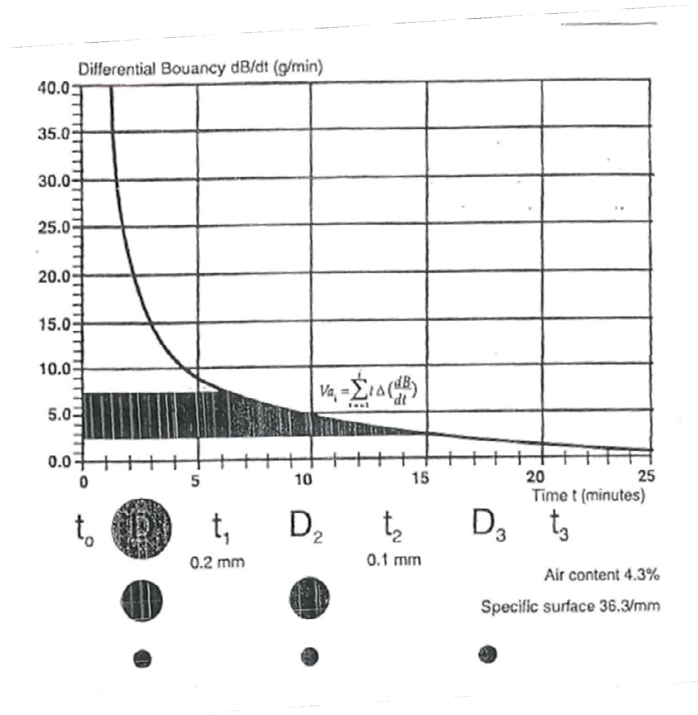



**Figure 2: Differential Buoyancy (g/min) vs. Time (min) Figure from DBT (Danske Beton Teknik) report [5]**

The air content volume is divided in different diameter classes for known time intervals. The diameter classes with the time intervals are illustrated in Figure 2 above. In accordance with the user manual for AVA it does not register the first 10 seconds, in this way it excludes the air bubbles > 2 mm [19]

The total volume of air in these classes are calculated by the formula:

$$Va_1 = \sum_{t=\iota-1}^{i} t\Delta \left(\frac{dB}{dt}\right),$$

[2]

Where Δt is per definition a small defined time interval, and $\frac{dB}{dt}$ is the recorded differential buoyance (g/min) for a specific time interval. The total air content is then calculated by summing each of the classes' air volume:

$$Va = \sum Va_i$$

[3]

## Specific surface and spacing factor

By knowing the total air content we can calculate the specific surface by using the equation:

$$\alpha = \frac{1}{Va} \sum \alpha i \, Va_i$$

[4]

Where $\alpha_i = 6/D_i$

As we see the AVA software uses the diameter of the air bubbles to find the mean specific surface in the concrete by using Stokes law:

$$V = \frac{2}{9} \frac{(\rho_p - \rho_f)}{\mu} g R^2$$

[5]

Where V is the thermal velocity, with $\rho_p$ and $\rho_f$ the mass densities of the sphere and fluid, respectively, $g$ the gravitational acceleration and R is the radius of the sphere.

As we know $\rho_p$ is near 0, which means that V becomes negative, which implies buoyance.

As we see, assuming that a thermal velocity is reach in the riser column, the software can now find the spheres diameter by measuring when the bubble reaches the buoyance pan. From Figure 2 we see that the AVA is dividing the bubbles in different diameter classes from when it reaches the buoyance pan. The largest bubbles will reach first and be in the first time interval and so on. Dividing in small time intervals will give AVA information about the diameter distribution in the concrete, and can obtain a pretty accurate mean specific surface.

From Equation 5 the only unknown is R. This means that the mass density of the sphere, the liquid and the viscosity must be a constant value that AVA has programmed. If the temperature in the blue liquid and the water is not within the 21-25 C range it will have a different viscosity and the calculations will give wrong output.

The air content will not be so sensitive to the viscosity because, it is only the weight change that is measured and the weight change that is caused by the buoyance force from the bubble will be the same regardless of the viscosity of the water or liquid.

When we know the content of mortar, the expected air content and volume of the sample the software can calculate the real air content in the concrete, given that the sample represent the concrete.

$$A = \frac{Mo \frac{Va}{Vo}}{Mo \frac{Va}{Vo} + 100} 100\%$$

[6]

$V_o = V_S - V_a$, where $V_S$ is the volume of the sample (20 ml) and $V_a$ is expected air content.

$M_o = M/(100-A_e)*100$ %, where M is the content of mortar.

When the air content and the specific surface are known it can find the spacing factor L, by directly using Powers:

Powers spacing factor (***$L_{mean}$***):

- For p/A ≤ 4.342

$$L_{mean} = \frac{T_p}{4N}$$

[7]

- For p/A > 4.342

$$L_{mean} = \frac{3}{\alpha}(1.4\,(1 + \frac{p}{A})^{1/3} - 1)$$

[8]

The small sample represents the concrete as a whole, because the spacing factor will not be changed by the largest air voids that are ignored by the AVA.

### 2.3.3 Advantages and disadvantages of AVA

The bullet points below reflects the experiences obtained in the lab and from experiments of the Federal Highway Administration (FHWA, USA).

- The balance, measuring the change in buoyance of the pan, is sensitive and vibrations affect its recording of weight. Because of this, the AVA needs to be placed on a solid table where vibrations are not transferred. This may cause problems if the lab is mobile, and near a road with heavy duty traffic or construction work that causes vibration.

- The machine is sensitive for temperature changes, and requires a temperature from 21 – 25 Celsius, which is a relatively narrow interval. The blue liquid has a specific viscosity so that the bubbles are getting released by a certain velocity, a temperature out of this range will disturb the assumptions that AVA software uses for its calculations [9]. The software will prompt a message if the temperature is not within the temperature interval.
- The mortar has to be without aggregates over 6 mm which is not a standard equivalent aggregate size in Norway, thus the mortar without the aggregates over 6 mm must be extracted. This may affect the fresh concrete, but according to FHWA [2], the rotational frequency of the drill with vibrator used for sampling (about 2600 - 2800 rpm) should not affect the air void system.
- After around one and a half hour (when studying aging effect, see chapter 3.7) the mortar is starting to become stiff, making it difficult to extract the mortar in to the syringe, when following the standard sampling procedure.
- AVA can in situ and rapid assess the frost resistance in the fresh concrete that is planned to be cast within a relatively good confidence limits. This can potentially save money, material and work span.

### 2.3.4 AVA results and reliability

The AVA software gives data about the Air Content, Specific surface and the Spacing factor within three different chord lengths: Chord length < 2 mm, Chord length < 1 mm and Chord length < 0.35 mm. These parameters are calculated to correspond to those that would be obtained from a linear traverse measurements (ASTM C 457), where the mean measured chord length is defined as 2/3 of the mean void diameter. [7]

AVA does not consider air voids with diameter larger than 3 mm (2 mm chord length), thus the AVA will naturally show a smaller air void content then based on the ASTM C 457 method. Consequently, the AVA also tend to show approximately 2 % less air than the pressure meter [1].

According to the Quality Assurance of Concrete report from the Brite Euram project [5] the determination of the specific surface and the spacing factor from AVA turns out to be a reliable method falling well under a given 95 % confidence limit. The report finds that the correlation between output from AVA and the ASTM method is similar with a slope of the regression line at around 1. This is also shown in the report from Crawford [1], where a difference in observed spacing factor between the AVA and ASTM C 457 were on average 0.0024 inches (0.061 mm). For the air content, the slope of the regression line between these two mentioned methods is only in order of 0.7 – 0.8, the AVA show less air content than the method based on ASTM C 457 method (IMA). This trend is unilaterally for all of the reports in the AVA literature.

See attachements in the Brite report [5] for graphs showing regression lines between ASTM C 457 and AVA results, from measurements done by DBT (Danske Beton Teknik).

The report [1] concludes that a determination of the air content obtained by AVA alone is not sufficient, and the pressure meter method is required. However, pressure meter results conducted by Crawford [1] showed that the air content requirements analyzed by the pressure meter failed 18 % of the time, the results from AVA /ASTM showed failure of the air requirements nearly 50 % of the times. This findings indicate that the pressure meter may not be so accurate when assessing the frost resistance.

The AVA was not developed for the purpose of measuring the air content in concrete, because the sample is statistically too small to take proper account of the larger air voids. However, this does not have any notably consequences for the assessment of air voids, because larger air voids do not contribute to the freeze/thaw resistance, neither do they have any significant influence on the spacing factor, as seen from the illustration in Figure 3 below. [12]

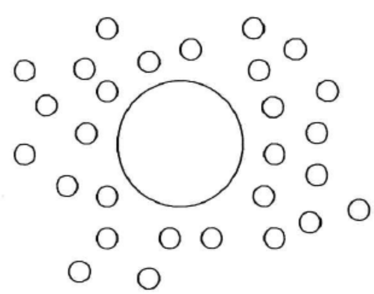


**Figure 3: Simple illustration of the effect larger air void has on the spacing factor. [12]**

The output from the AVA assumes that the thermal velocity for all of the bubbles are reached, in other case Stokes law cannot be used. The reliability also relies on a laminar flow, with no turbulence (low Reynolds number). Where Reynolds number is the ratio of the inertial forces to viscous forces. This ratio depends on the fluid dynamic viscosity, the fluids density, velocity of the object and a characteristic length of the object (diameter of the bubble).

It may be that the high viscosity of the blue liquid used in AVA, ensures laminar flow for the bubbles.

## 2.4 Admixtures

### 2.4.1 Air Entraining Admixtures (AEA)

According to Norwegian Standard, concrete used in structures must have a correct air void content in order to prevent frost and thaw deterioration.

Air is incorporated in the concrete during the mixing process. The hydrophobic/hydrophilic molecular structure of the AEA turns this air in to small well distributed air bubbles that stabilize in the fresh concrete [8]. A good air entraining admixture should ensure a large specific surface and low spacing factor (see Chapter 2.2), without excessive use or a high total air void content.

It is known that for concrete and mortar the entrained air bubbles will improve the workability and thus reduce the amount of water required. Less water will again compensate the loss of strength that is a consequence of the entrained air [8]. In his master thesis, Turowski confirmed the coherence between increasing slump and air void content. [21]

The basic materials used for natural AEA are mostly soaps made from resin (wood resin). Now synthetic AEA and half natural AEA, based on tall oil have also been developed [8]. According to measurements by Eickschen, the natural wood resin based agent's releases their full potential after a short mixing time. Meaning that the air content do not increase when increasing mixing time. The synthetic agents however increases the air content when increasing the mixing time, this was especially notable if the air entraining admixture dosage (kg/m3) was tripled. The synthetic admixture continues activation long after adding. [11]

### 2.4.2 Super plasticizers (SP) and its reaction with Air Entraining Admixture

Super plasticizer (SP) is a water reducing admixture, their negatively charged molecules attaches to the positive charged cement particles and separates them from each other. This mechanism allows having lower w/b ratios, which ensure sufficient strength, and at the same time good workability.

The adding sequence of the admixtures affects the AEA needed in the concrete. Foam index test is a fast method to check the effect from the AEA. The method is based on the idea that adding cement, FA, water, SP and AEA in a small mix, the blend is then stirred for some time. If a foam is covering the surface the AEA is having an effect. From measurements [14] it is shown that after adding a small amount of SP after AEA the foam tends to disappear. A reason can be that SP changes the surface energy on the interfaces the air entraining admixtures molecules work on, causing a de-foaming effect. The foam index has some limitations and it just meant as an indication of the efficient of the AEA, as it does not fully represent how AEA may react in a concrete in reality. [14]

Both of the admixtures are negatively charged, which is believed to cause competing reactions on the positively charged cement particles, causing that the AEA is less available for a foam stabilization [10].

If the charged plasticizer is added after the AEA, it may replace the air entrained agent molecules on the binder particles, and the air entrained admixture molecules will be released in to the pore solution again. When using a synthetic air entrained agent, this mechanism leads to a higher air void content, because it continues to activate in the solution. When using a natural resin based AEA, this mechanism was found to be not present or negligible. [10]

According to Eickschen, stiff concrete lead to an air void system with smaller air voids. Adding plasticizer first however implies that the air voids gets established in a softer concrete, which causes a coarser concrete. In a soft concrete the air bubbles will not split up in the same way as it do in a stiff concrete. [10]

Eickschen recommends a sequence of AEA first and then SP. When adding the plasticizer first the positive charged air bubbles by the AEA may not adhere to the cement particles as they are supposed to do, which causes the danger that air bubbles will escape from the fresh concrete leading to poorer air void establishment in the concrete. [10]

However, according to [14], with ready mixed concrete with FA it has in practice been proven that adding SP before AEA gives a more stable air void content. The FI test showed a positive effect from SP when adding it first. This observation was just for some type of AEAs and not for concrete with pure cement (OPC) [14]. This positive effect is believed to be caused by the SP that occupies the carbon surface, making AEA more efficient since it does not adsorbs on to the carbon surface.

Adding SP after AEA has a negative effect for the foam for all the concretes in the tests, including pure OPC. After adding 0.2 % – 0.4 % SP of binder the foam disappears, the SP separates the particles, revealing more surface to adsorb on for the AEA making it less efficient. [14]

Combination of SP and AEA is a major issue, and more research is needed to find out how these admixtures react to each other in order to find the right AEA dosage. Now that FA as a pozzolan is more and more wanted in construction, it is even more important to know the mechanism around these two admixtures and how it affect the air voids.

## 2.5 Fly Ash and its influence on the air entrained voids

Fly Ash is a product of coal combustion and is formed from the mineral matter in the coal. The properties of Fly Ash do vary a lot depending among others on the coal characteristics and how it is filtered. [16]

*ASTM Designation: C 618* divides FA into two classes: Class F and Class C.

Class F are normally produced from burning anthracite or bituminous coal and is considered as a Pozzolan.

Class C are normally produced from lignite or subbituminous coal and has a lower content of carbon. The retained impurities from burning are also less than the FA in class F. Class C fly ash has both pozzolanic and cementitious properties.

Norway do not use coal burning power stations and import their FA mostly from Denmark, which is considered to be a class C fly ash. [15]

The properties of Fly Ash make it difficult to produce stable air-entrained concrete. According to the report [15] the most important components that affects the air entrainment admixtures are:

- Organic matter content
- Carbon content
- Loss on ignition
- Alkali content

Studies show an almost perfect correlation between increasing organic matter content and a higher AEA dosage needed. It is also a good correlation within an increasing organic matter and an increasing carbon content. [15]

One of the reason that the carbon affects the AEA efficacy could be the adsorption of AEA due to the surface energy from the ash particles, which shields the AEA from interaction with the air bubbles. The larger surface area of the particles the more air entrained agent molecules will be adsorbed. The problem can be solved by simply increasing the AEA content, however, a too high amount of AEA shows to exhibit a low air content retention in cured state [15]. Excess use of AEA may harm the retained air void content in hardened concrete.

Adding SP after AEA will cause a de-flocculation of the binder particles and will expose more carbon surface available for the AEA to adsorb on, which will increase the required AEA dosage. When adding SP first, the SP will possibly adsorb on the carbon the surface leaving less surface for the AEA to adsorb on. It will then reduce the negative effect from the carbon and more AEA in the solution will be used efficient. [14]

# 3. Experiments

## 3.1 Materials

### 3.1.1 Binders

| **Material:** | **Specific weight [kg/dm³]:** | **Carbon [%]:** | **Blaine [m²/kg]** |
|---|---|---|---|
| Norcem Anleggsement | 3.14 | ~ 0 | 360 |
| Norcem Anleggsement FA | 3.02 | 0.79 | 384 |
| Fly Ash (FA) | 2.31 | 3.01 | 334 |
| Silica Fume (SF) Grade 940 | 2.2 | N/A | N/A |

**Table 1: Binder properties**

The cement (CEM1/CEM2) and Fly Ash (FA) is provided by Norcem, Brevik and satisfies the requirements *NS-EN 197-1:2001*. The Silica Fume (SF) is provided by Elkem and is certified to *ISO 9001:2008*. Table 1 shows the most relevant data, see Appendix D-I for data sheets of the materials.

### 3.1.2 Aggregate

The sand mixture consisted of 0/8 mm size particle with a filler content (< 0.125 mm) 7.2 % of the aggregate. A 0/8 mm size particle was used to make it more similar to concrete. A larger particle size was considered as unpractical. A sieve curve from Årdal Sand taken 12.08/16 is provided in Appendix D.

The moisture of the sand was checked frequently (around every third lab day). The sand was taken right from the sand storage in the lab. The moisture was found to be around 3.7 % of the in situ sand weight each time.

### 3.1.3 Air Entraining Agent (AEA)

Air entraining admixture used for this report was **Mapeiair 25** from the manufacture Mapei, which is as mentioned one of the partner in the DACS project.

As we can interpret from Mapei's data sheet, Mapeiair 25 is a blend between synthetic- and nature based, with tall oil derivate as a natural contribution. According to Wikipedia, tall oil is:

"*Tall oil, also called "liquid rosin" or tallol, is a viscous yellow-black odorous liquid obtained as a by-product of the Kraft process of wood pulp manufacture when pulping mainly coniferous trees"* [23]

The Mapeiair 25 was diluted with water on the lab with an AEA-water ratio of 1:9. When stored it was stored in a cooled room at the lab.

The same air content with 1 % AEA of the binder and with 0.5 % AEA of the binder were achieved in some of the mixes, which may indicate that the 1:9 AEA-water did not give the optimal effect. Also two mixes with the sequence AEA-SP when using FA concrete, gave a stable air void content of 6.5 % when using 2 % AEA which is exceeding the recommended quantity from the producer. The same dosage when using newly diluted AEA (fresh AEA) gave a total air void content of around 15 %. A theory that may explain this phenomena is when AEA is diluted with water it starts to lose its chemical effect. When storing it diluted with water over time it will probably lose more and more of its effect, which implies that we get a very volatile AEA effect depending on when we diluted the AEA. This theory is based on observations in Dodsons book, *Concrete Admixtures* [20]. This means in practice that same AEA possess different qualities, depending on the duration of days it has been stored. To reduce this uncertainty and ensure the same effect a new blend of 1:9 AEA-water was mixed for each time. After doing this the effect from the AEA increased considerably as is shown in the result. Because of this, if the theory is correct, the pre blended will possess different properties, depending on how long it has been stored. The fresh AEA is diluted 1:9 with water, right before each mixing, hence has the same effect each time.

In the results this difference will be noted as pre blended AEA and fresh AEA, were pre blended AEA can be AEA that has been stored for everywhere from 0 to around 30 days, depending on when it was diluted last. The separation is mostly used were dosage of AEA is one of the values that is being analyzed.

### 3.1.4 Superplasticizer (SP)

Superplasticizer used in this report was The Dynamom SX-130 from the manufacture Mapei.

The Dynamom SX-130 is based on modified acrylic polymers with higher active polymers than previous products from Mapei and hence requires less dosage. [22]

The quantity for the mixes did not varied too much in order to ensure a slump of 100 mm +- 10 mm, A quantity of 0.6 – 0.8 % showed to be adequate for all of the mixes. To ensure a sufficient distribution of the SP, the mixing with SP were 2 minutes.

## 3.2 Concrete parameters and proportioning

### 3.2.1 Proportioning

To do the proportioning an Excel script made by a professor from Skanska and professor 2 at NTNU was used. This script standardize the proportioning and ensures a seaming free proportioning. It also makes the proportioning easy to interpret for others. For short, this script may be referred in the report as “the Skanska sheet”.

Below there are two examples of proportioned concrete with FA concrete and OPC concrete (concrete without FA) respectively and with SP dosage and AEA dosage of 0.7 % and 0.8 % of binder respectively as an example. Taken directly from the Skanska sheet.

**Proporsjonert betong**

| Materialer | kg/m³ |
|---|---|
| Norcem StandardFA | 0.0 |
| Norcem AnleggFA | 353.0 |
| Norcem Anlegg | 0.0 |
| Elkem Microsilica | 14.2 |
| Norcem Fly Ash - FA (NO) | 105.4 |
| Limestone filler | 0.0 |
| Fritt vann | 189.0 |
| Absorbert vann | 4.5 |
| Årdal 0/8 mm nat. vask. | 0.0 |
| Årdal 0/2 mm nat. vask | 0.0 |
| Årdal 8/16mm | 0.0 |
| Årdal 16/22 mm | 0.0 |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 |
| | 0.0 |
| Mapei Dynamon SX-130 | 3.31 |
| Mapeair 25 1:9 | 3.78 |
| Mapeair L 1:9 | 0.00 |
| Sika Multiair | 0.00 |
| Prop. betongdens. (kg/m³) | 2181 |

**Proporsjonert betong**

| Materialer | kg/m³ |
|---|---|
| Norcem StandardFA | 0.0 |
| Norcem AnleggFA | 0.0 |
| Norcem Anlegg | 480.5 |
| Elkem Microsilica | 14.9 |
| Norcem Fly Ash - FA (NO) | 0.0 |
| Limestone filler | 0.0 |
| Fritt vann | 198.1 |
| Absorbert vann | 4.5 |
| Årdal 0/8 mm nat. vask. | 0.0 |
| Årdal 0/2 mm nat. vask | 0.0 |
| Årdal 8/16mm | 0.0 |
| Årdal 16/22 mm | 0.0 |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 |
| | 0.0 |
| Mapei Dynamon SX-130 | 3.47 |
| Mapeair 25 1:9 | 3.96 |
| Mapeair L 1:9 | 0.00 |
| Sika Multiair | 0.00 |
| Prop. betongdens. (kg/m³) | 2213 |

**Table 2: Proportioned concrete of FA concrete and OPC concrete.**

### 3.2.2 Concrete parameters

| | |
|---|---|
| Matrix volume | 0.4 |
| Target workability | 100 mm +- 10 mm |
| Target air void content | 6% - 8% |
| w/b ratio | 0.4 |
| Expected air content (Input in the Skanska sheet) | 7 % |

**Table 3: Concrete parameters**

The water binder ratio (w/b) is calculated as follows:

$$\frac{w}{b} = \frac{Mtotal\ water}{Mcement + Mflyash + Msilica}$$

[9]

## 3.3 Adding sequences

The adding sequences and binder materials varied with six different mixes:

**<u>FA mortar:</u>**

- SP before AEA
- SP after AEA
- SP and AEA simultaneously
- SP without AEA

**<u>Mortar without FA:</u>**

- SP before AEA
- AEA before SP
- SP and AEA simultaneously

## 3.4 Mixing procedures

**<u>SP before AEA</u>**:

- 1 minute mixing of the dry materials

- 1 minute mixing with the water
- Adding SP and 2 minute mixing
- Adding AEA and 3 minutes mixing
- 2 minute pause
- 1 minute with mixing

**AEA then SP:**

- 1 minute mixing of dry materials
- 1 minute mixing with the water
- AEA and 3 minutes mixing
- Adding SP, 2 minute more mixing
- 2 minute pause
- 1 minute with mixing

**SP simultaneously with AEA:**

- 1 minute mixing of dry materials
- 1 minute mixing with the water
- SP and AEA, 5 minutes mixing
- 2 minute pause
- 1 minute with mixing

**SP without AEA**

- 1 minute mixing of dry materials
- 1 minute mixing with the water
- SP and 5 minutes mixing
- 2 minute pause
- 1 minute with mixing

These adding sequences were made to ensure the exactly same mixing time for all of the adding sequences. The mixing time were controlled using a stop watch.

Adding water first was decided to saturate the sand and prevent adsorbing any of the admixtures. The two minutes pause is inherited from the standard procedure in the lab due to the instant chemical reaction that occur when cement and water react to each other. This is however not so vital for our mixing due to the long mixing time, but since it were done the first times it became part of the procedure.

Before mixing, the paddle and the mixing container were carefully sprayed with water to ensure no adsorption of water on the steel surface.

## 3.5 Equipment

For the mixing process a paddle mixer was used, maximum capacity for the mixer is 10 liters.

**Figure 4: Paddle mixer**

## 3.6 Measurement methods

The measurement process was always the same and the time lap was as follows:

- Slump ~ 12 minutes after adding water
- Density meter ~ 14 minutes after adding water
- Pressure meter ~ 15 minutes after adding water
- AVA ~ 30 minutes after adding water

### 3.6.1 Slump test

For each of the mixes a slump test were performed around 12 minutes after adding water. The *NS-EN 12350:2009: Testing fresh concrete, Part 2: Slump test* [18] was followed in order to ensure correct performance: The cone was filled in two layers. The half of the cone was first filled and then compacted with 25 tamps. Then the rest of the cone was filled and further 25 tamps. The slump tests were done on a dry and clean Plexiglas sheet.

The equipment used for the slump test was:

- Steel cone (Height: 120 mm, Lower diameter: 80 mm, Top diameter: 40 mm, Volume:  0.33 l)
- Steel rod
- Measuring tape
- Plexiglas sheet

**Figure 5: Slump test showing a slump of around 110 mm**

### 3.6.2 Density and Pressure method

Immediately after the slump test (~15 min after adding water), density and air content with the pressure meter were measured.

#### Density method

The density method was proceeded by following the standard *NS-EN 12350:2009: Testing fresh concrete, part 6: Density [18]*

The method was as followed:

1. A container with a known volume (1 l) was filled, with the same method as in pressure method.
2. Put the container on a tared scale.
3. The concrete was then weighted.

The air content difference from the theoretical one (expected) is found by the formula:

$$A = 1 - \frac{\rho_{fresh}}{\rho_{TAvf}}$$

[10]

Where:

- $\rho_{fresh}$ is the measured density (kg/m3)
- $\rho_{TAvf}$ is the theoretically (expected) density based on material data provided by the manufacture and the expected air.

If the real concrete density and the expected air content are the same, then A is 0 and the expected air content is correct. If it is a difference, then the air content by the density method is found by adding the expected air content and the calculated air content difference. This method accuracy relies on that the material particle density are correct.

### Pressure method

This method is done by following *NS-EN 12350:2009: Testing fresh concrete Part 7: Pressure method [18].* The pressure meter is based on the Boyle's law which states that, at a given constant temperature, the product from the volume occupied by an ideal gas (air) and the applied pressure is constant. Thus:

$$p_0V_0 = p_1V_1.$$

[11]

The procedure is as followed:

1. Fill the container in two layers. After the first layer the steel rod is used to compact the concrete with 25 tamps as in the slump test, then the container is filled by the second layer, and again 25 tamps to compact the container. Now the container and the flanges must be thoroughly cleaned.
2. Now cover the container with the pressure lid
3. Open the valves

4. Inject water through the first valve, and seal it, do the same with the other valve
5. Pump air into the chamber.
6. Release some of the pressure until the gauge shows 0
7. Now release the lever and read of the air content

The accuracy of this method is depending on that the container is adequate filled and that the flanges are cleaned, it is crucial that the pressure meter is sealed so no pressure is released.

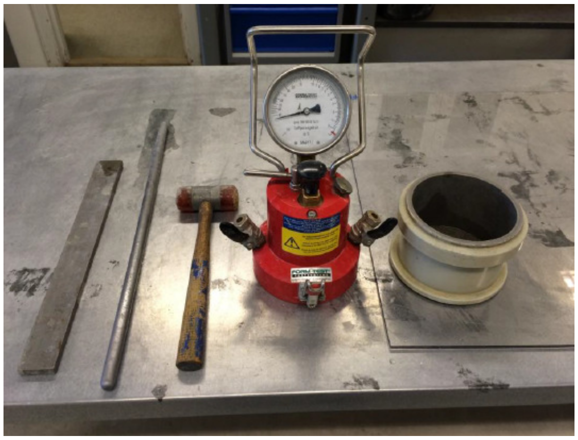


**Figure 6: Picture of the pressure- and density method equipment.**

### 3.6.3 AVA Procedure

The procedure while conducting the tests were according to the instructions in *Germann Instrument manual* [19]. Also an own instruction manual has been made, inspired by the mentioned manual and by own experience. This can be found in Appendix L.

A summary of the procedure is provided below:

1. The water column was filled up with water taken from temperature bath, up to the line, (around 3 cm from the top).

2. The funnel got filled with the blue liquid to the line. And released on the bottom, until the flow of blue liquid stopped.

3. The buoyance pan was placed side wards into the water. The side must be lowered last so the entrapped air escapes trough this hole.

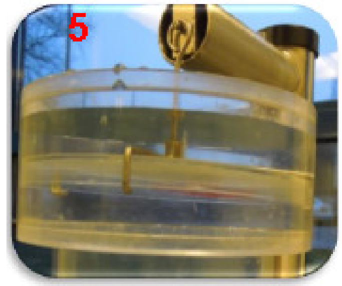



**Figure 7: Buoyance pan**

4. The mortar was now extracted with the drill.

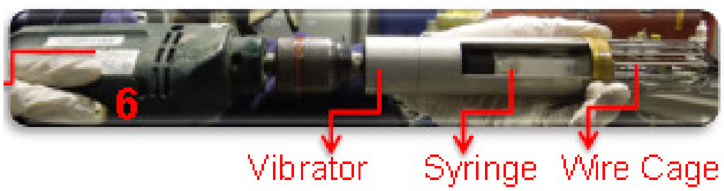



**Figure 8: Picture of the drill, vibrator, syringe and the wire cage.**

A suitable container with a height on at least 120 mm is filled, this to ensure a completely submerged wire cage. Now the drill with the syringe and wire cage mounted on as seen on picture. The wire cage was submerged into the mortar while vibrating, and lasted 3 -4 seconds. When fully submerged further vibration for approximately 3-4 seconds in order to fill up the wire cage. The wire cage was then raised up from the mortar while turning around the drill so the mortar did not fall out from the syringe. The wire cage was released and syringe cleaned.

The plunger is pushed forward to 1 mm before the 20 ml mark (Figure 9.a below), the excess mortar must be wiped off.

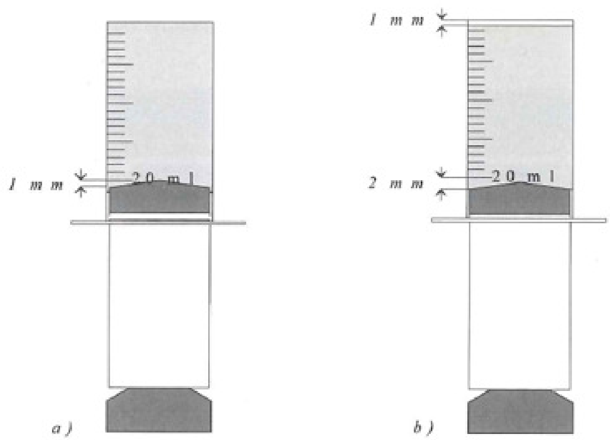



**Figure 9: Illustration of a filled syringe ready for testing. Figure b. illustrates the syringe right before testing.**

Withdraw the plunger 1 mm, so it is a gap between the edge and the mortar surface (Figure 9,b).

The syringe is now placed against the end of the piston (plug) so that the end of the piston fits approximately 1 mm into the syringe. And the plug carefully pulled out until a black marked flushed with the column wall.

5. Now the data is inserted. The data the AVA requires is as follows:

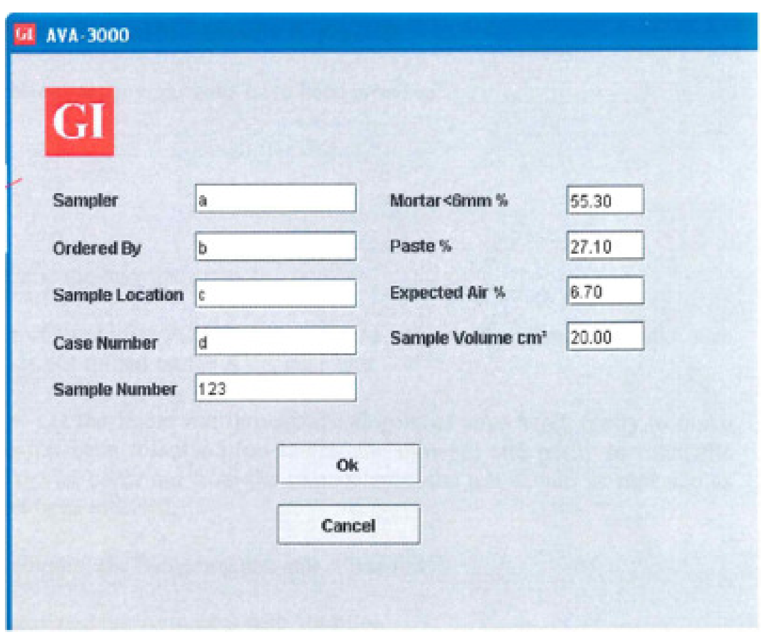



**Figure 10: Germann Instrument software data input window.**

Volume of mortar with aggregate < 6 mm is found from the formula:

$$V_{mortar<6mm} = 1 - V_{agg>6mm} - V_{air}$$

[12]

- $V_{agg>6mm}$ is the volume of the aggregate with a size over 6 mm in the concrete. If knowing the volume aggregate in the concrete and the volume of aggregate > 6 mm in the total volume of aggregate, the volume is found by multiplying these two numbers.
  *Example*: If the aggregate content in the concrete is 50 % of the total volume, and the volume of aggregate > 6 mm in the total aggregate is 50 %. Then: $V_{agg>6mm} = 0.25$

- $V_{air}$ is the air void content found with the pressure meter.

As we see the AVA software also need the paste volume, which is calculated by the formula:

$$V_{paste} = V_{cem} + V_{FA} + V_{SF} + V_{freewater} + V_{SP_{Solid}}$$

[13]

After inserting the data the Ok button is pressed and a new window comes up on the screen, the AVA is now ready to analyze. Before analyzing, the tare button is pressed. On beforehand the buoyance pan must be cleared for the air bubbles that may have been released, stemming from the air gap between the mortar and the edge of the syringe.

After pressing the Start button the metal pin begin to stir the mortar. The mortar is injected in 3 steps during the first seconds to avoid that the stirrer pin gets trapped. The stirrer spins for around 30 seconds.

The AVA software will continue measuring the air bubbles until no weight change is felt by the AVA software or maximum 25 minutes. The results is registered in an Excel sheet.

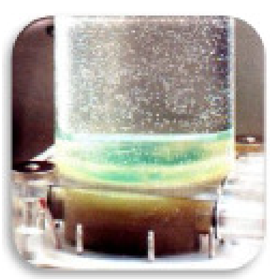


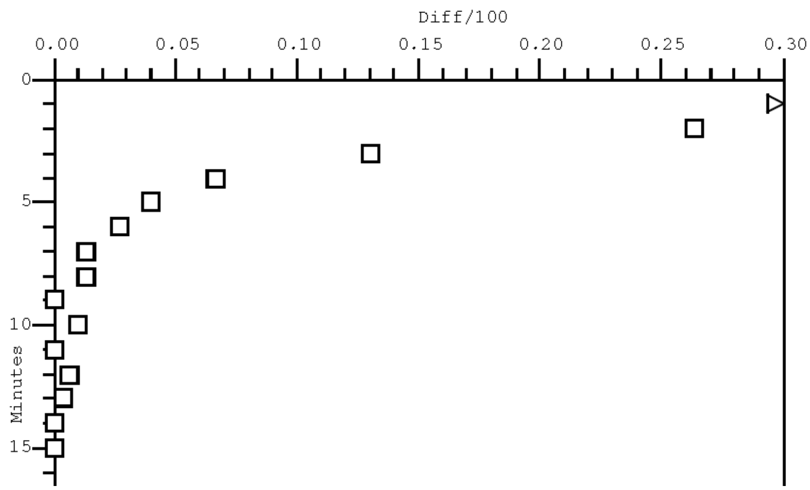
**Figure 11: Air bubbles floating up from the mortar**

When pouring out the sludge, it is checked for slumps. This is done by holding a hand under the riser column when pouring, this is also partly done to catch the stirrer pin.

"If lumps are still present in the sludge after testing at the bottom of the rise column, the injection of the mortar in the riser column should be done by crushing the mortar by pressing the piston in a rotary motion against the mortar while this is being released over the rotating stirrer pin.

The reason for lack of stirring may also be that the mortar is very stiff and the stirrer pin is caught below mortar sample during stirring, however, the important issue is that there are no lumps in the dissolved sample." (An excerpt from page 40 in Appendix H in the AVA – 3000 manual. [19])

### 3.6.4 Output from AVA measurements




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 34.7 | 0.25 | 0.35 | 0.44 | 22.0 |
| 26.3 | 0.55 | 0.62 | 0.66 | 22.1 |
| 13.0 | 0.72 | 0.74 | 0.76 | 22.1 |
| 6.7 | 0.79 | 0.81 | 0.82 | 22.1 |
| 4.0 | 0.84 | 0.85 | 0.85 | 22.1 |
| 2.7 | 0.87 | 0.87 | 0.88 | 22.1 |
| 1.3 | 0.88 | 0.89 | 0.89 | 22.1 |
| 1.3 | 0.90 | 0.90 | 0.90 | 22.1 |
| 0.0 | 0.90 | 0.90 | 0.90 | 22.1 |
| 1.0 | 0.91 | 0.91 | 0.91 | 22.2 |
| 0.0 | 0.91 | 0.91 | 0.91 | 22.2 |
| 0.7 | 0.91 | 0.92 | 0.92 | 22.1 |
| 0.3 | 0.92 | 0.92 | 0.92 | 22.2 |
| 0.0 | 0.92 | 0.92 | 0.92 | 22.2 |
| 0.0 | 0.92 | 0.92 | 0.92 | 22.2 |

**Figure 12: AVA measuring the difference in weight over time**

**Results (adjusted to correlate with ASTM C457)**

| Chord length | : | < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|---|
| Air-% concrete | : | 4.3 % | 4.1 % | 3.3 % |
| Air-% paste | : | 11.4 % | 11.0 % | 8.7 % |
| Air-%putty | : | 10.2 % | 9.9 % | 7.8 % |
| Specific surface | : | 25.7 mm-1 | 26.6 mm-1 | |
| Spacing factor | : | 0.229 mm | 0.225 mm | |

**Figure 13: Results from AVA measurements [19], data for three different chord lengths (2/3 of the void diameter. Where the average chord length is 2/3 of the void diameter. [5]**

Figure 13 shows what the AVA measures. It splits the air void content in three, < 2 mm (the total air void content in the concrete). For < 1 mm is the air void content with a chord length with maximum 1 mm, etc. For air void content with chord length < 0.35 mm AVA do not give spacing factor and specific surface.

## 3.7 Time dependency measurements

During a time dependent analysis, it is crucial for the scientific reliance that the fresh concrete is stored properly.

Two methods of storing were tested:

> Method 1: The concrete was stored in the mixing bucket covered with plastic, and placed in a regular 1 liter container right before testing for further compaction and sampling of the mortar fraction.
>
> Method 2: The concrete was filled in 1 liter containers, compacted and all of the syringes were filled right away. The concrete were then stored in each of the syringes, covered with plastic. This method was introduced after the second lab day because it is more time/work efficient.

The AVA is made for mortar extracted directly from the site, and therefore the storage method must be as similar as possible to achieve representative results.

Because of the small amount of the mortar and restrained storage, method 2 was concluded to not represent the reality in a satisfactory way. Thus, the method was discarded and replaced with method 1.

The cons for method 1 is that after around 1 hour the mortar is starting to harden, making it difficult to extract the sample. Some few times a void on the syringe wall appeared, meaning that the syringe was not completely full of mortar. The uncertainty this will have on the results is unknown.

Also when storing in the mixing bucket the surface exposed is large, compared to the depth of the concrete which may cause the concrete to dry out faster than normal. A smaller container can be more suitable for measurements in the future.

Method 2 has some advantages, it is more time efficient, and less work for one person in the lab. It is also easier to extract the mortar when it is still fresh, ensuring that the syringes are completely filled.

When filling the syringe, regardless of storage method, an electric drill was used. A 1 liter jug was used to compact the mortar. Then the syringe was filled following the instructions from the Germann Instrument manual. Following procedure was executed:

- Vibrating the drill on full speed when descending the wire cage. 4 seconds were used for this purpose
- Then, 4 new seconds with vibrating when the wire cage was fully submerged making sure that the wire cage got filled with the mortar < 6 mm.
- Now, the drill was stopped and the syringe filled with mortar < 6 mm aggregate
- The drill, with the wire cage and the syringe inside, was lifted while turning the drill upwards making sure that the mortar remained in the syringe. The syringe was released from the wire cage

Measurements were conducted two times. The first was conducted around 30 minutes (can deviate some) after adding water, then the concrete was stored for 1 hour (delta 30 minutes) and new tests were performed. It was planned to conduct a second test with pressure meter and slump, but this required more fresh concrete and the paddle mixer hardly managed to mix with 6 liters. Because of this, it was decided that one measurement with the pressure meter was sufficient, also, the work span for one person was already filled.

The AVA measurements were done by following Germann Instruments instructions [19]

# 4. Results

## Terms used in the results

- AEA-SP: AEA then adding SP
- SP-AEA: SP then adding AEA
- SP+AEA: Adding SP and AEA at the same time
- SP w/o AEA: SP without any AEA
- C1: Concrete (CEM1) with 3 % SF of binder, without FA, also referred as OPC
- C2: Concrete (CEM2) with extra FA, total 35% FA of binder and 3 % SF of binder
- Chord length: 2/3 of the air void diameter.
- < x mm: Short for chord length < x mm (due to limited place in the Axis title)
- Micro air void content: Air void content with chord length < 0.35 mm (Used interchangeably)
- Fresh AEA: 1:9 AEA-Water diluted right before mixing
- Pre blended: Stored 1:9 AEA-Water dilution
- Method 1: Fresh concrete stored in mixing bucket (only for time measurements)
- Method 2: Fresh concrete stored in syringes (only for time measurements)

## 4.1 Summary of results from the measurements

| Seq | | # | AEA [%] | SP [%] | Pressure Air [%] | Density [kg/m3] | Slump [mm] | Density Air [%] | AVA measurements Air [%] (Chord < 2 mm) | L[mm] | α [mm^-1] | Air [%] <0.35 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | SP-AEA | | 1.00 | 0.80 | 2.60 | 2342.50 | 110.00 | 1.15 | | | | |
| C1 | SP-AEA | | 0.90 | 0.70 | 10.50 | 2126.20 | 97.00 | 10.92 | | | | |
| C1 | SP-AEA | | 0.70 | 0.70 | 3.10 | 2327.30 | 105.00 | 1.84 | | | | |
| C1 | SP-AEA | | 0.81 | 0.70 | 5.00 | 2301.40 | 105.00 | 3.01 | | | | |
| C1 | SP-AEA | | 0.84 | 0.70 | 8.40 | 2205.50 | 92.00 | 7.34 | | | | |
| C1 | SP-AEA | | 0.84 | 0.65 | 12.00 | 2085.60 | 82.00 | 12.76 | | | | |
| C1 | SP-AEA* | 1 | 0.82 | 0.71 | 6.00 | 2302.40 | 109.00 | 2.96 | 3.50 | 0.33 | 19.20 | 2.20 |
| C1 | SP+AEA | | 0.74 | 0.70 | | 1912.70 | 85.00 | 20.57 | | | | |
| C1 | AEA-SP | 1 | 0.76 | 0.74 | 8.40 | 2238.80 | 107.00 | 5.83 | 6.20 | 0.24 | 20.40 | 3.80 |
| C1 | AEA-SP* | 2 | 0.76 | 0.70 | 9.50 | 2192.30 | 95.00 | 7.94 | 10.60 | 0.20 | 17.20 | 5.30 |
| C2 | AEA-SP | 1 | 0.90 | 0.70 | 3.00 | 2273.00 | 105.00 | 3.57 | 3.30 | 0.58 | 11.50 | 1.20 |
| C2 | AEA-SP | 2 | 1.20 | 0.60 | 4.00 | 2381.00 | 105.00 | -1.37 | 3.60 | 0.73 | 8.80 | 0.80 |
| C2 | AEA-SP | 3 | 1.50 | 0.60 | 4.00 | 2236.00 | 105.00 | 5.26 | 4.50 | 0.34 | 16.60 | 2.50 |
| C2 | AEA-SP | 4 | 2.00 | 0.50 | 6.60 | 2194.50 | 101.00 | 7.16 | 9.00 | 0.17 | 23.60 | 6.10 |
| C2 | AEA-SP | 5 | 2.00 | 0.50 | 6.50 | 2205.20 | 95.00 | 6.67 | 3.60 | 0.85 | 10.90 | 1.30 |
| C2 | AEA-SP* | 6 | 0.76 | 0.60 | 7.50 | 2238.50 | 105.00 | 4.36 | 5.20 | 0.58 | 9.20 | 1.40 |
| C2 | AEA-SP | | 2.00 | 0.55 | 15.00 | 1930.00 | 89.00 | 18.51 | | | | |
| C2 | SP+AEA | | 0.70 | 0.60 | 2.00 | 2289.40 | 105.00 | 2.82 | | | | |
| C2 | SP+AEA | 1 | 1.60 | 0.50 | 6.00 | 2202.70 | 100.00 | 6.78 | 5.70 | 0.48 | 10.70 | 2.10 |
| C2 | SP+AEA | 2 | 1.60 | 0.50 | 8.10 | 2131.00 | 96.00 | 10.06 | 5.70 | 0.37 | 20.40 | 3.00 |
| C2 | SP-AEA | | 0.70 | 0.80 | 3.50 | 2266.20 | 105.00 | 2.92 | | | | |
| C2 | SP-AEA | | 0.80 | 0.50 | 7.00 | 2189.10 | 87.00 | 7.40 | | | | |
| C2 | SP-AEA | | 1.00 | 0.70 | 5.60 | 2260.40 | 85.00 | 3.36 | | | | |
| C2 | SP-AEA | | 1.10 | 0.80 | 2.60 | 2338.40 | 100.00 | -0.22 | | | | |
| C2 | SP-AEA | | 0.80 | 0.70 | 10.10 | 2118.40 | 82.00 | 9.87 | | | | |
| C2 | SP-AEA | | 0.76 | 0.77 | 4.00 | 2289.40 | 105.00 | 2.03 | | | | |
| C2 | SP-AEA | | 0.70 | 0.77 | 3.90 | 2299.80 | 95.00 | 1.55 | | | | |
| C2 | SP-AEA | 1 | 0.80 | 0.80 | | | | | 4.20 | 0.68 | 8.70 | 1.00 |
| C2 | SP-AEA | 2 | 0.80 | 0.70 | 4.40 | 2311.60 | 95.00 | 1.01 | 3.40 | 0.42 | 15.40 | 1.70 |
| C2 | SP-AEA* | 3 | 0.79 | 0.77 | 8.00 | 2202.90 | 98.00 | 6.00 | 4.30 | 0.23 | 25.70 | 3.30 |
| C2 | Only SP | | 0.00 | 0.80 | 2.30 | 2314.00 | 100.00 | 1.69 | | | | |
| C2 | Only SP | | 0.00 | 0.80 | 1.60 | 2337.00 | 105.00 | 0.64 | | | | |

* = Cast

** = Some "too large bubbles" were observed

Shaded cells means mixed with "fresh AEA"
(Diluted 1:9 AEA, right before mixing)

**Table 4: Summary of results for all mixes**

## 4.2 X-Y Plots

### Fresh air void content

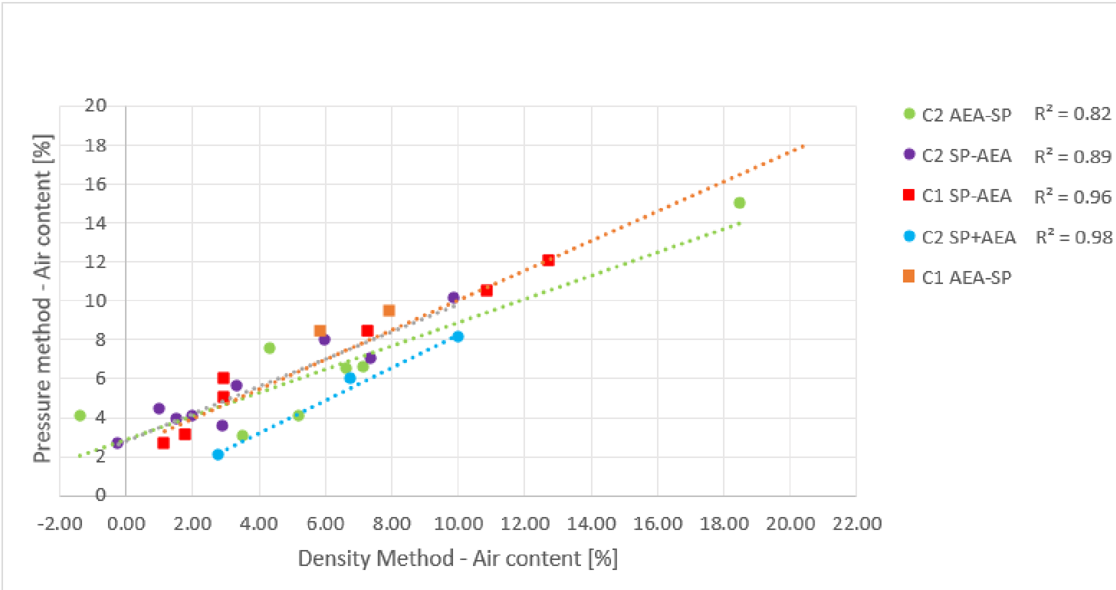



**Figure 14: Density method vs Pressure method**

Figure 14 shows the correlation between the measurements made by the pressure meter and the density meter. As we can see it is a relatively good correlation between these two, indicating that the measurements were taken in a consistent manner.

It is two negative values in the plot. Also Turowski [21] got negative values when using the density method. The reason is believed that the density of the material particles are not correct. These however should be correct as they are recently provided by the producer Norcem, at least they should be correct enough to not give any negative answers. Operative errors can also be a reason.

Figure 15.a shows the correlation between the pressure meter and the total air void measurements done by the AVA.

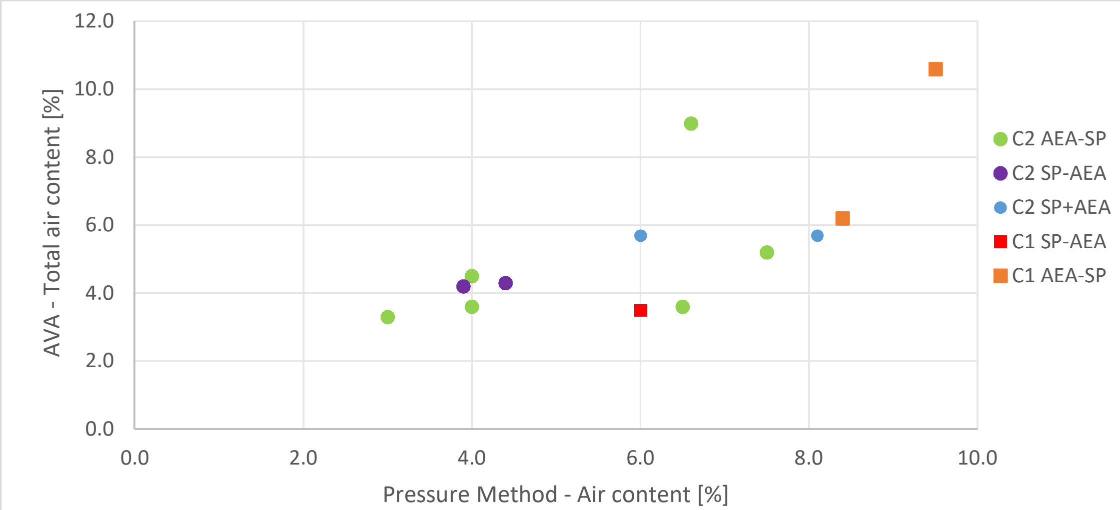



**Figure 15.a: Pressure meter vs. AVA (Total air void content)**

**Note: C2 SP-AEA 1 were not measured with pressure meter and slump cone due to occupied lab.**

Figure 15.a illustrates what was initially expected and in compliance with literature, the AVA show less air content then the pressure meter.

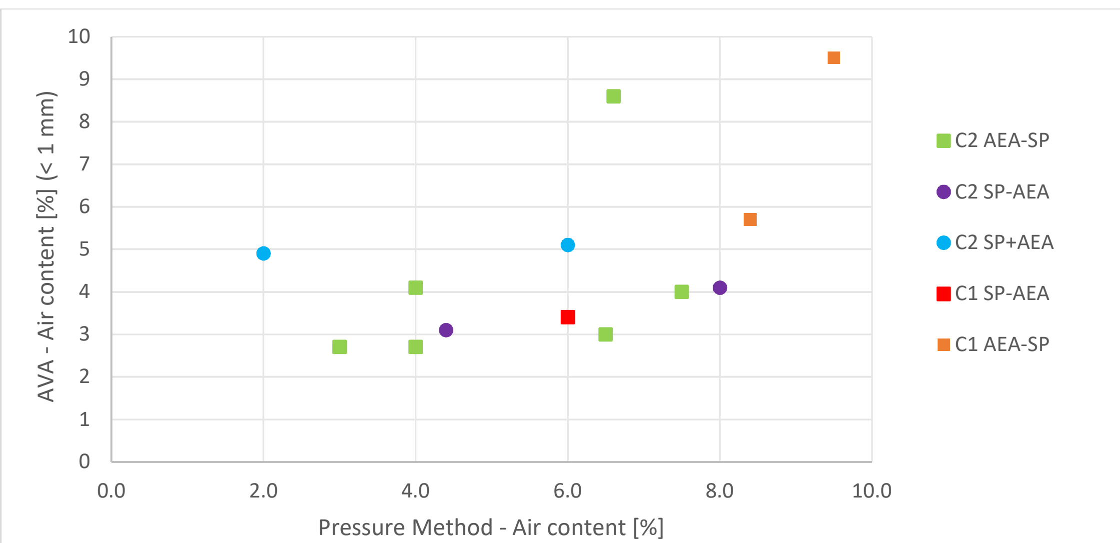



**Figure 15.b: Pressure meter vs. AVA (Air content with chord length < 1 mm)**

As illustrated in Figure 15.b, the pressure meter will naturally show a higher air void content because it consider all of the air void, while AVA only consider the air void content with air bubbles with a maximum diameter of 1.5 mm (chord length < 1 mm).

Figure 15.c shows the correlation between measurements done by pressure meter and AVA only considering the air void content with air bubbles with a maximum chord length of 0.35 mm.

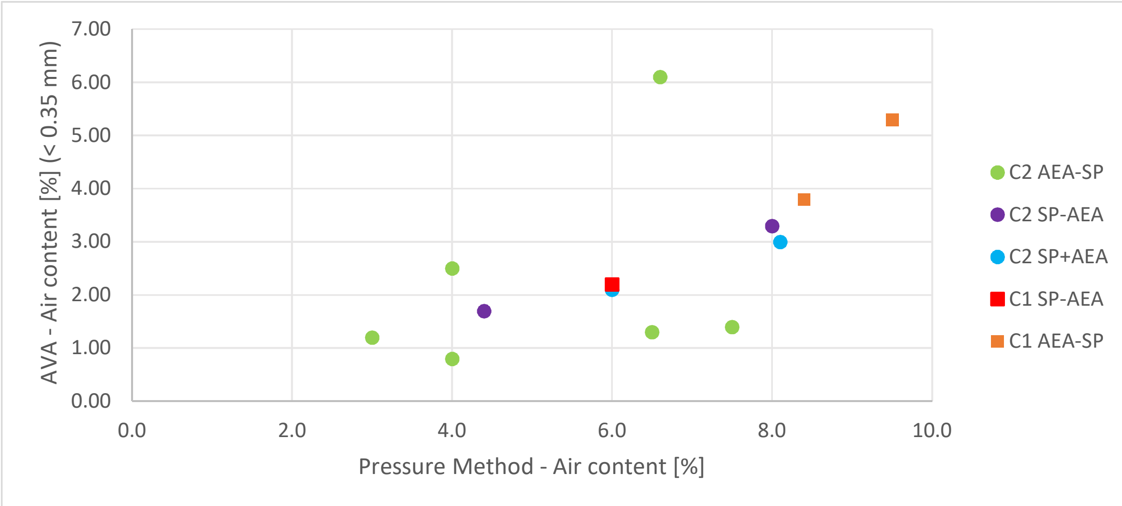



**Figure 15.c: Pressure meter vs. AVA (Chord length < 0.35 mm)**

Figure 16.a, b and c shows the same as the three previous figures, except the AVA measurements are compared with the results taken by the density method.

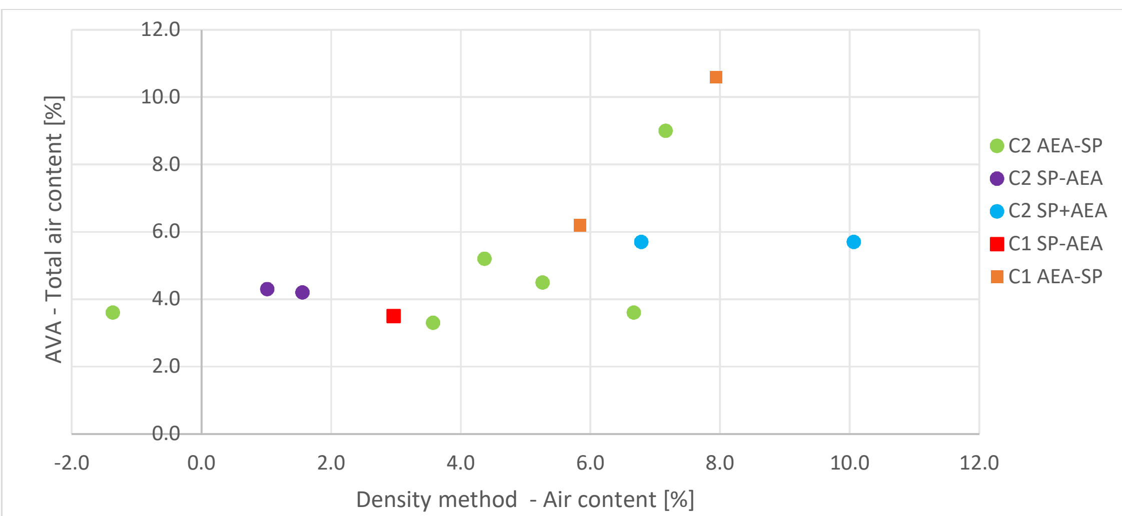



**Figure 16.a: Density method vs AVA (Total air content)**

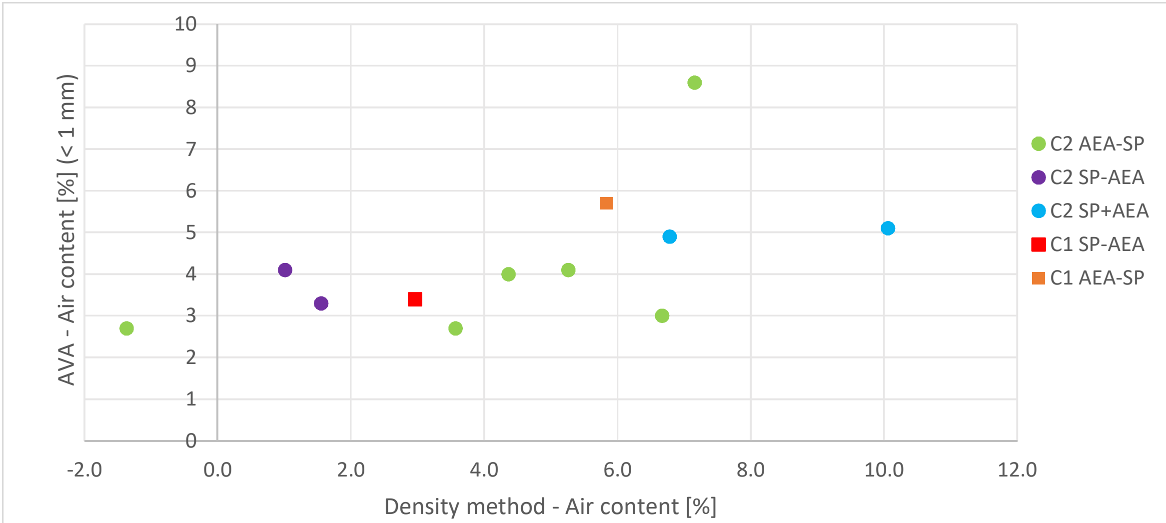



**Figure 16.b: Density method vs AVA (Air content with chord length < 1 mm)**

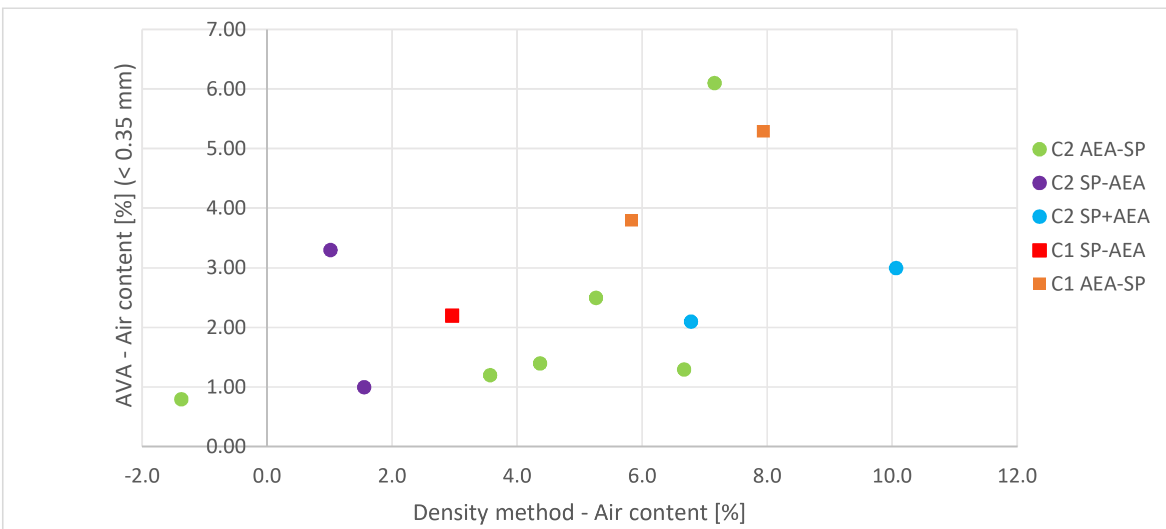



**Figure 16.c: Density method vs AVA (Air content with chord length < 0.35 mm)**

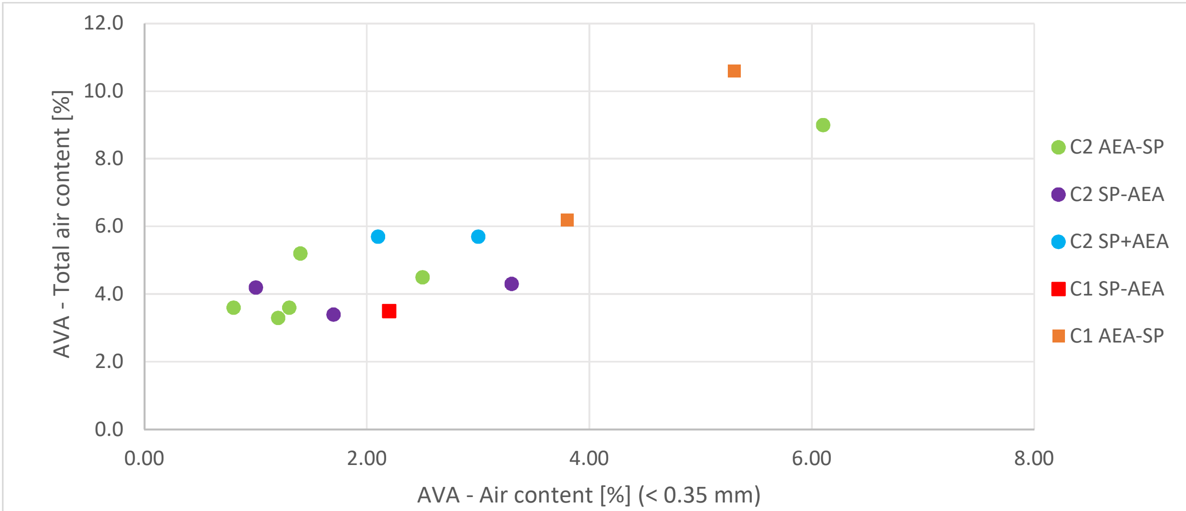



**Figure 16.d: Air content with chord length < 0.35 mm vs. Total air content**

Figure 16.d shows the correlation between the total air void content measured by AVA and the air void content with air void content with a maximum chord length of 0.35 mm.

The two mixes with SP+AEA sequence has the same air void content but have a change in the air void content with chord length < 0.35 mm. SP-AEA and AEA-SP sequences also shows the same trend. Within a specific total air void content the micro air void content (chord length < 0.35) mm can vary notably.

### Admixture dosage vs. Air void content (Pressure meter)

Due to the vastly effect it had to dilute the AEA right before mixing contra using pre blended (stored) AEA these to procedures were split when showing results from admixture dosage vs. air void content.

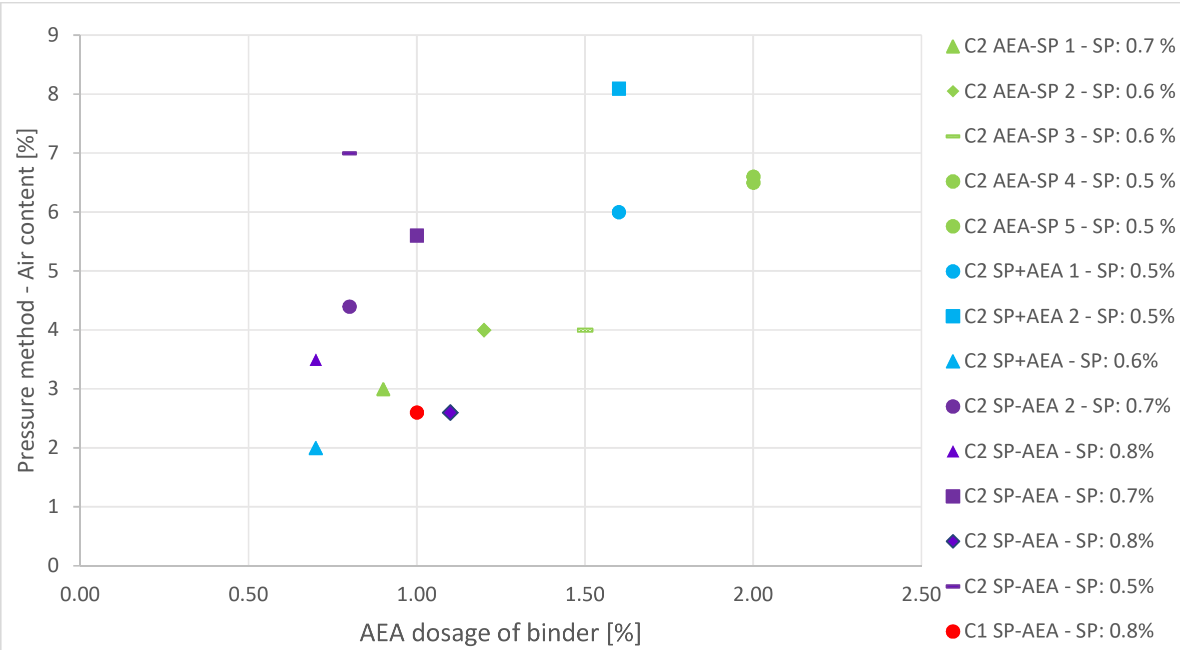



**Figure 17.a: AEA dosage (% of binder) vs. Air content (Pressure meter) (Pre blended AEA)**

Only mixes analyzed with AVA were assigned numbers, because of this some mixes will not have numbers

The maximum recommended limit 5 kg/m$^3$ is reach at around an AEA dosage of 1.05 % of the binder. As mentioned in chapter 3, many of the mixes when using pre blended AEA the recommended limit was exceeded, which indicates little effect on air entrainment from the diluted AEA when stored over time.

As shown in Figure 17.a the SP-AEA plots are more scattered and show weak or no correlation, finding a correct dosage for SP-AEA is therefore difficult since it will change considerably for each time. For example, one mix with AEA dosage of 1 % of binder gives ~6 % air void content while with another mix with a dosage of 1.1 % of binder only has air void content of around 3 %.

The sequences SP+AEA vary between 6 % - 8 % with the same AEA dosage.

AEA-SP shows a relatively good exponential correlation and a more predictable behavior, but requires the highest AEA dosage to obtain 6-8 % air void content. As for the SP-AEA sequence lower AEA dosage is needed to obtain required air void content, however, this sequence as mentioned is highly unpredictable and cannot be completely reliable. This volatility can also be due to the diluted AEA and not due to the sequence. To exclude this uncertainty the AEA can be diluted right before mixing.

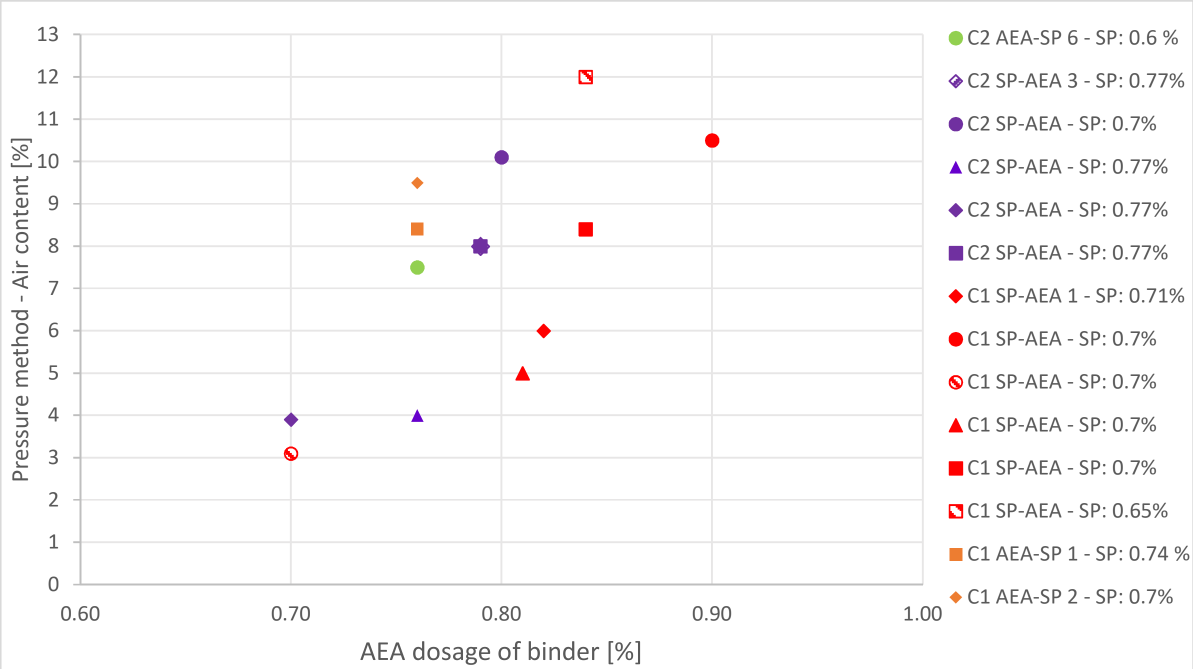



**Figure 17.b: AEA dosage (% of binder) vs. Air content (Pressure meter) (Fresh AEA)**

On Figure 17.b we see that the SP-AEA sequence tend to show more predictable behavior, with an exponential curve.

The AEA-SP sequence without FA gives slightly more air void content than its peer with FA.

The required air void content was found at the first try so no more mixes were conducted with the AEA-SP sequence with FA. From what we can see from both Figure 17.b and 17.c the sequence AEA-SP seem to be more stable than the sequence SP-AEA, for both with FA and without, however, it is too few mixes to conclude with anything.

### Admixture dosage vs. Air void content (AVA)

Admixture dosage vs. Air void content was also performed with use of AVA.

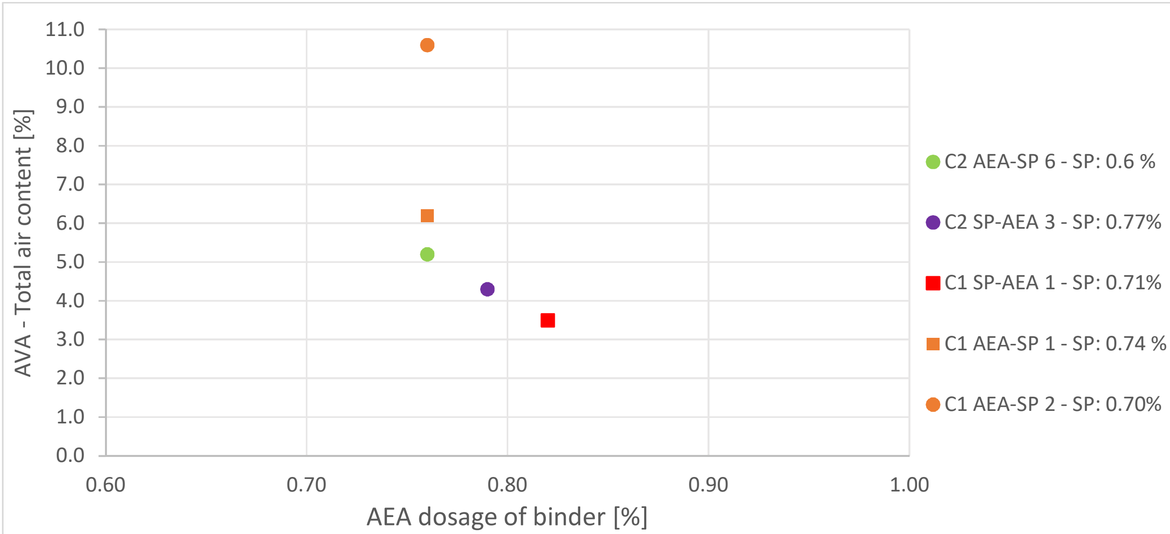



**Figure 17.c: AEA dosage (% of binder) vs. Total air content (Fresh AEA)**

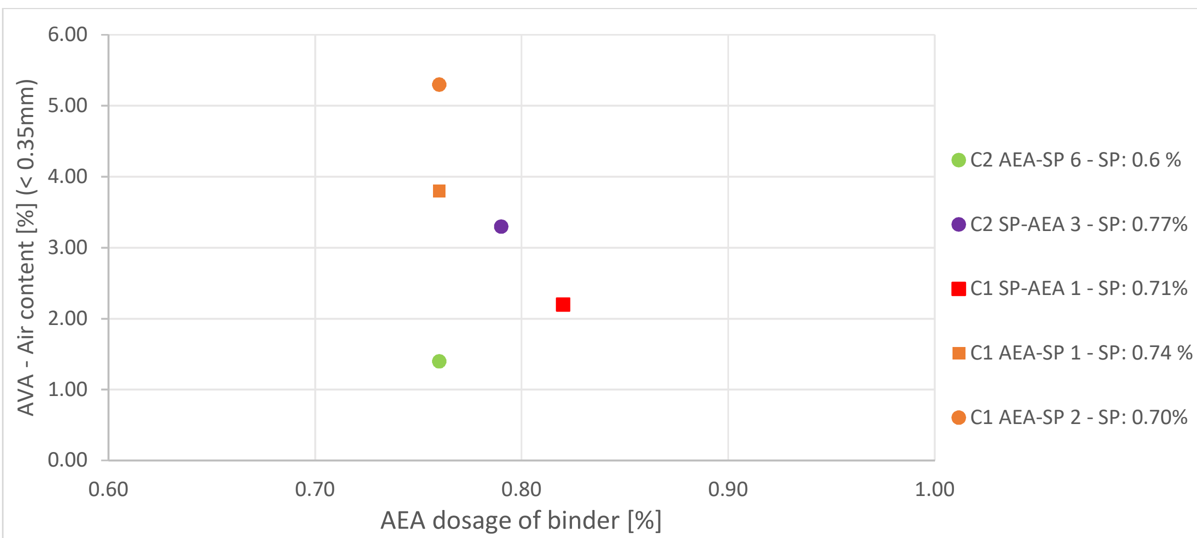



**Figure 17.d: AEA dosage (% of binder) vs. Air content with chord length < 0.35 mm (Fresh AEA)**

Figure 17.d suggests that the AEA-SP sequence without FA gives considerable higher micro air void content than its peer with FA, again it is too few results to conclude with anything.

Interestingly, the latter has the second highest total air void content but possess the smallest micro air void content.

In opposite of the AEA-SP mixes the SP-AEA sequence possess a satisfying micro air void content relative to its total air void content, ~78 % of the total air void content are micro air voids in this mix.

For the AEA-SP mix this accounts for only ~ 25 % of the total air void content, but again it is only one mixes of each sequence so this observation can just be a coincident.

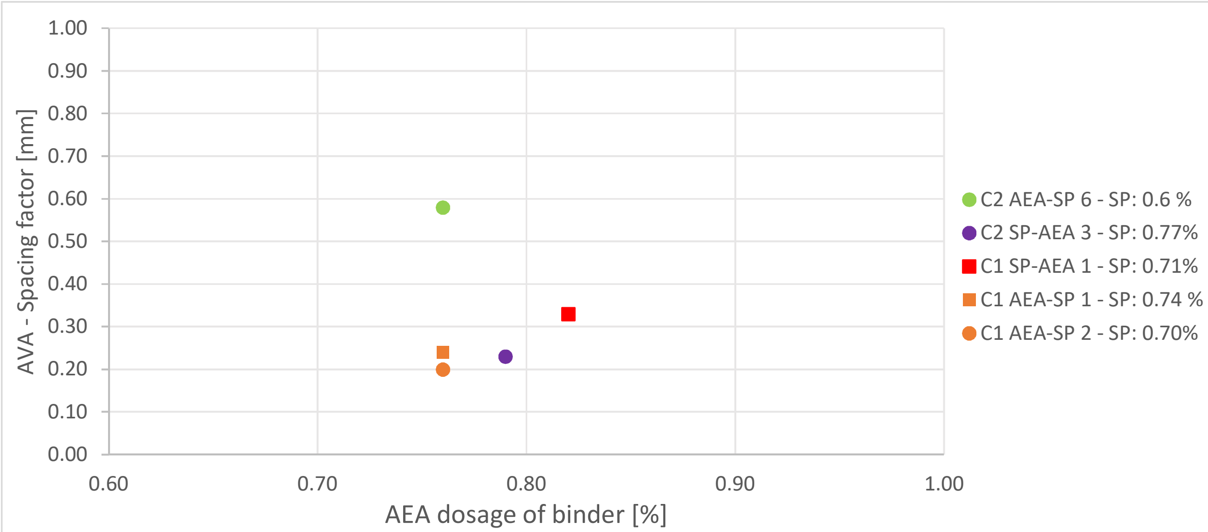



**Figure 17.e: AEA dosage (% of binder) vs. Spacing factor (fresh AEA)**

As shown in Figure 17.e, the spacing factor seems to correlate well with the results in Figure 17.d, with AEA-SP sequence without FA having lowest spacing factor and with FA the sequence the highest.

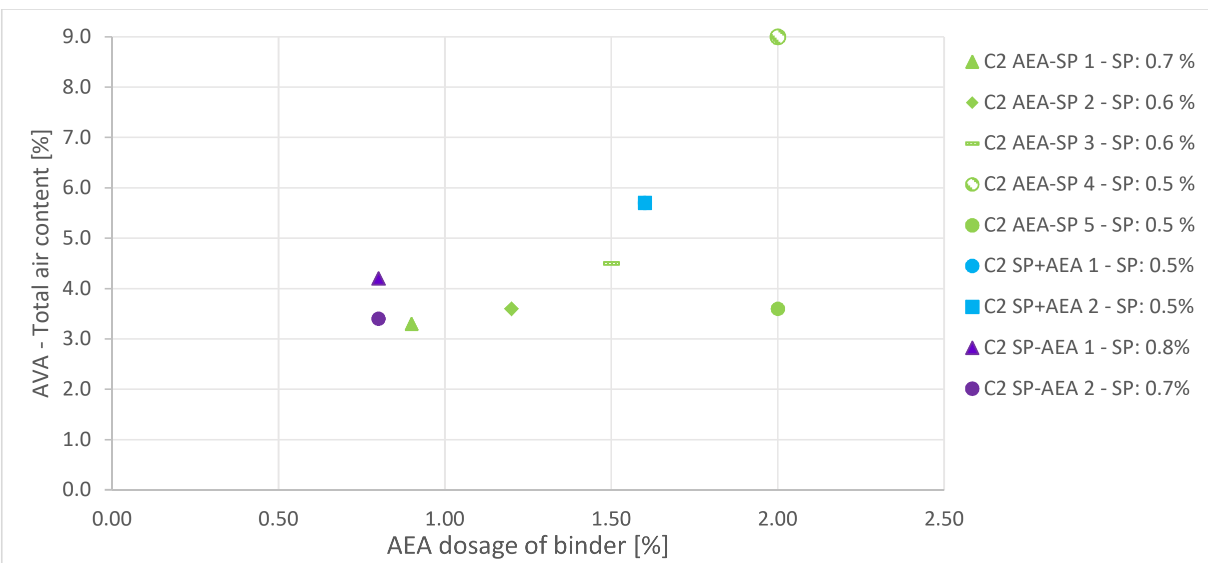



**Figure 17.f: AEA dosage (% of binder) vs. Total air content (pre blended AEA)**

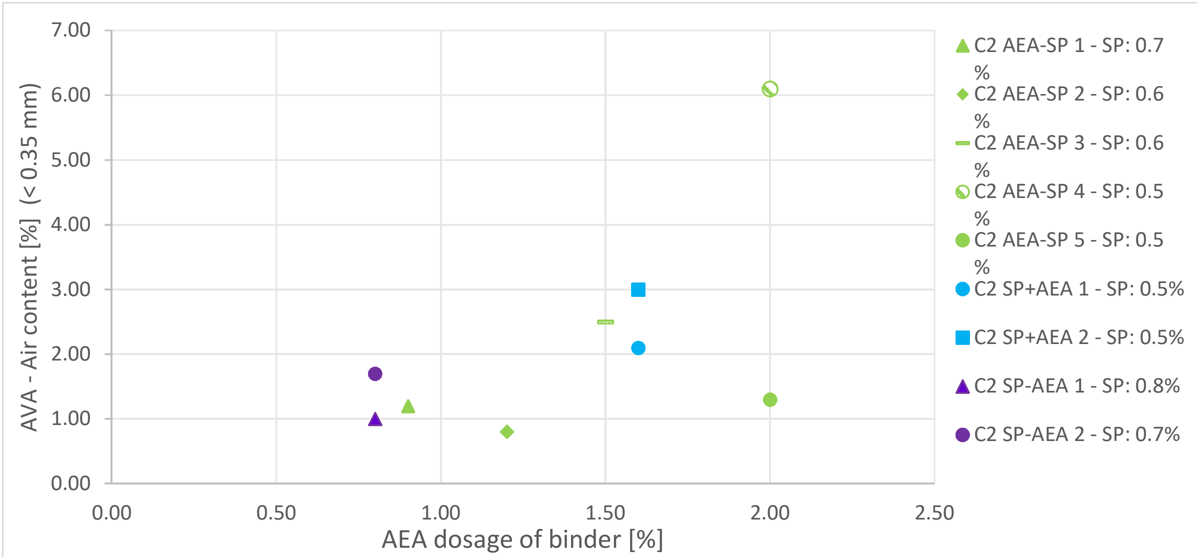



**Figure 17.g: AEA dosage (% of binder) vs. Air content with chord length < 0.35 mm (pre blended AEA)**

The AEA does not give any effect even with a dosage of 2 %. The micro air void content is the same for almost all of the AEA-SP mixes.

The SP-AEA (1) has 26 % higher total air void content but 41 % lower air void content with chord length < 0.35 mm. Since SP-AEA (1) has 14 % higher SP dosage, which can suggests that this is the cause. How this affects the spacing factor is showed on Figure 17.g.

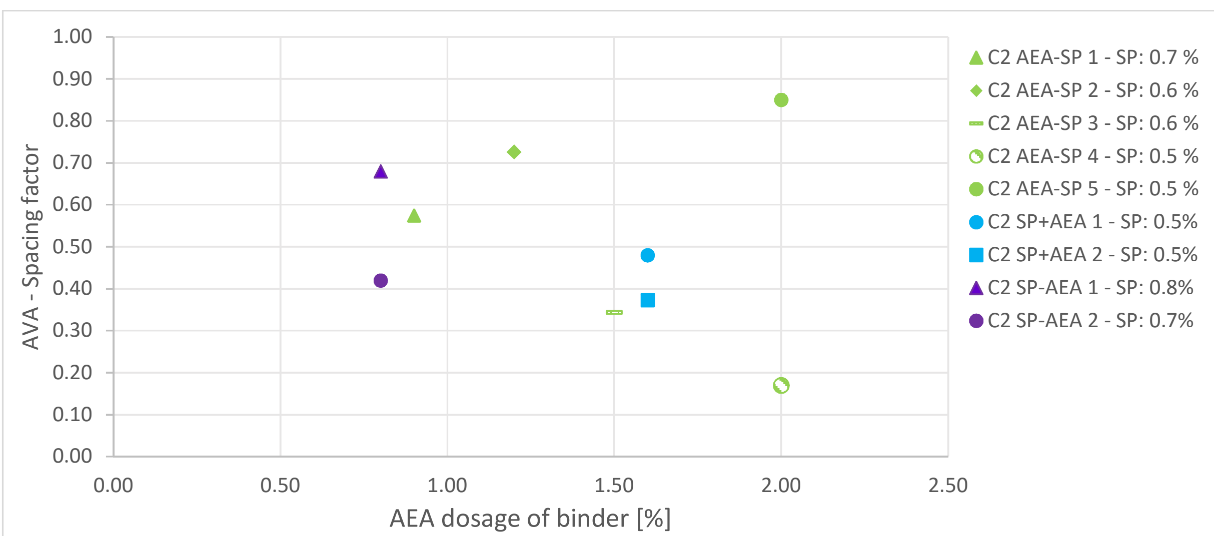



**Figure 17.h: AEA dosage (% of binder) vs. Spacing factor (pre blended AEA)**

As illustrated in Figure 17.h the spacing factor for the SP-AEA (1) is higher than its SP-AEA (2). More tests may be conducted to find out if the SP dosage causing a higher spacing factor as this result suggests.

### Workability vs. Air void properties

For rest of the X-Y plots the AEA used is not divided in use of pre blended AEA and fresh AEA, this because it is believed that this just dictates the amount of AEA needed and not necessary anything else.

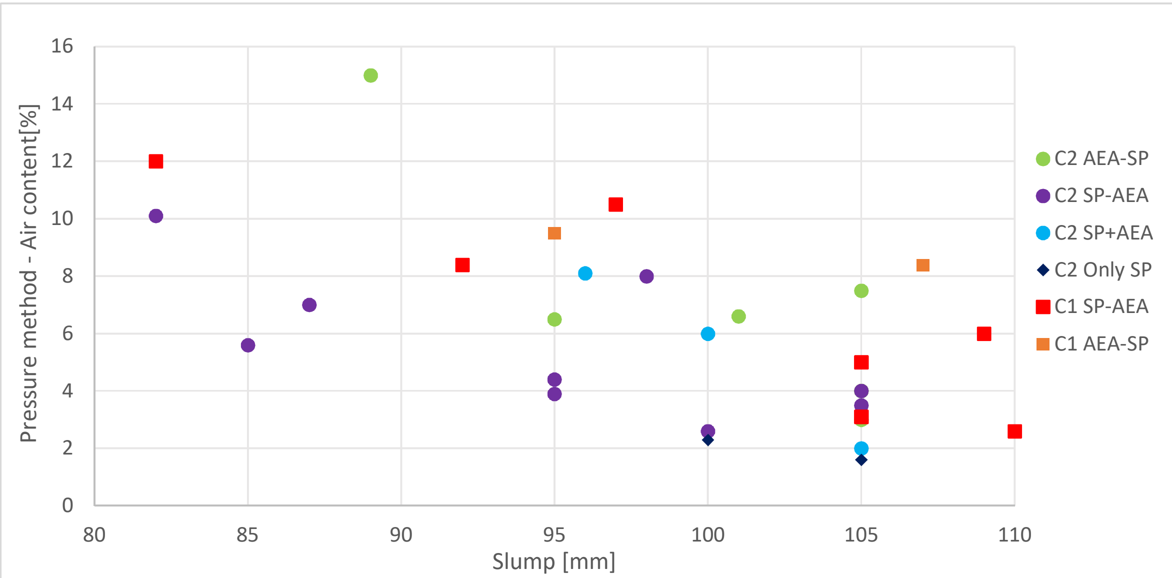



**Figure 18: Slump vs Total air content (Pressure method) for all mixes**

Figure 18 shows the correlation between slump and the air content for all of the mixes, also the two reference mixes without any AEA. It is a clear trend that the air void content decreases with an increasing workability. This trend seems to apply for all of the adding sequences.

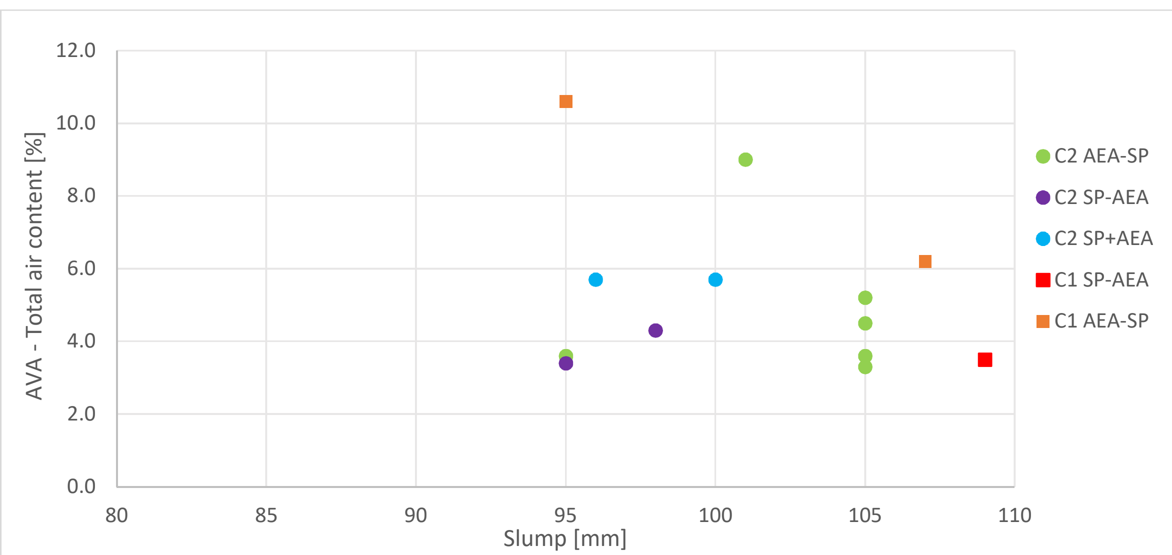



**Figure 19.a: Slump vs. Total air void content**

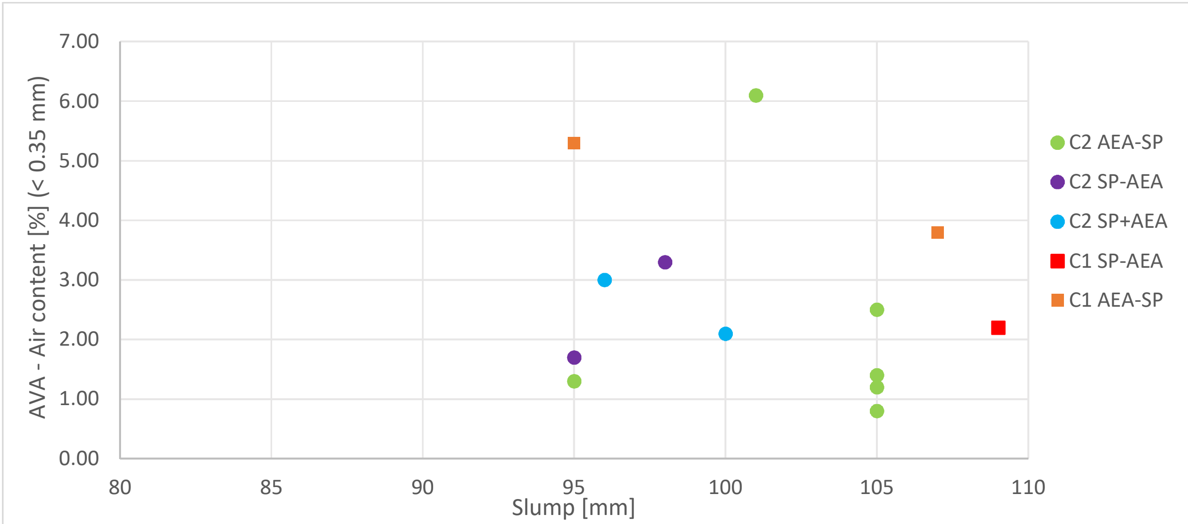



**Figure 19.b: Slump vs. Air void content with chord length < 0.35 mm.**

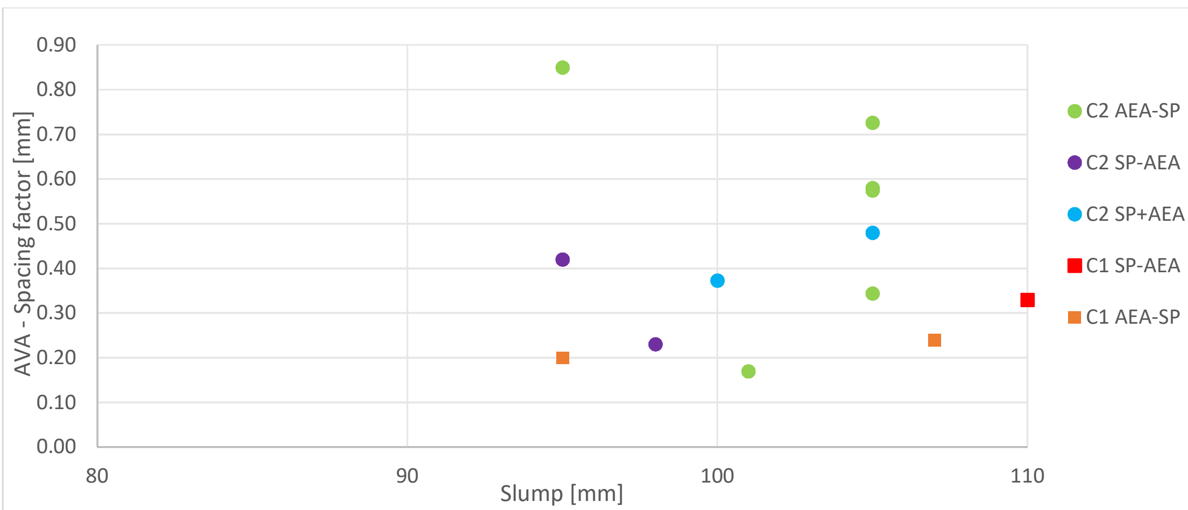



**Figure 19.c: Slump vs. Spacing factor**

Figure 19.c shows that the spacing factor seem to increase slightly with the slump. It is the mixes that have the highest slump that possess the highest spacing factor. However, measurements from the AEA-SP sequence with FA are largely scattered, which may suggests no coherence.

## Spacing factor

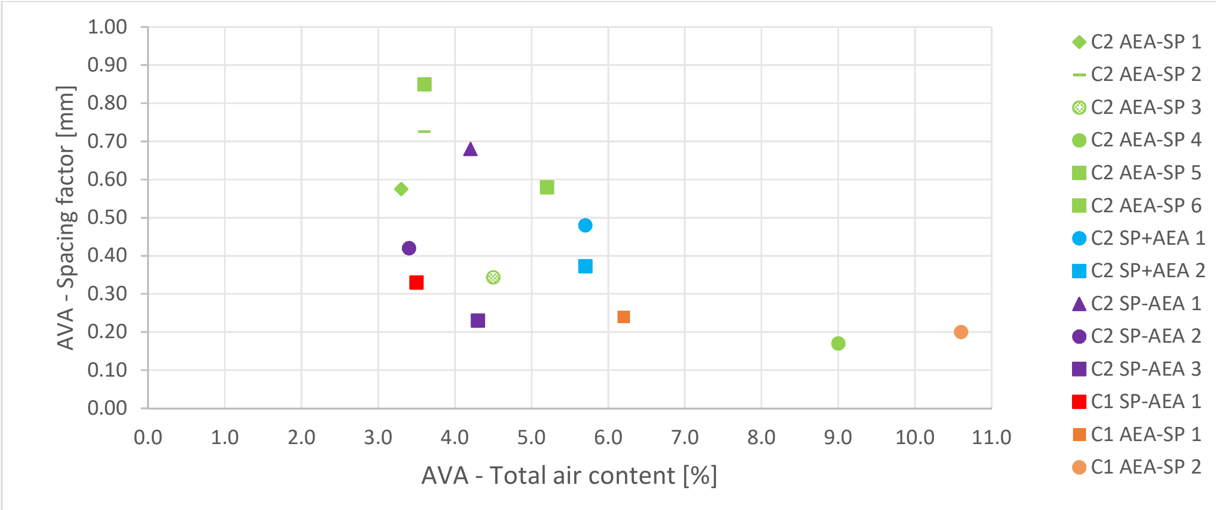



**Figure 20.a: Total air void content vs. Spacing Factor**

As shown in Figure 20.a, the sequence SP-AEA has almost the same air void content (~4%) but the spacing factor for these varies in an interval from 0.2 – 0.7 which is a relative large difference. Also, the sequence AEA-SP shows a spacing factor that vary despite a relatively constant air void content (~3.5 %).

The SP+AEA sequence has a constant air void content and a variation in the spacing factor of 0.1 mm, compared to the mixes with the other adding sequences this is not so large variation, but since our target is in the a narrow range of 0.18 – 0.25 mm this may be seen as a large deviation. These results can also be highly influenced on the dosage and SP and not necessary the adding sequences. Therefore, to do these kind of analysis it may have been better to keep the SP dosage constant, and set the workability to chance.

These plots tend to show the same correlation as was found in the project report [22] with Image Analysis (ASTM C 457), after a total air void content of around 5 % the spacing factor starting to flatten out.

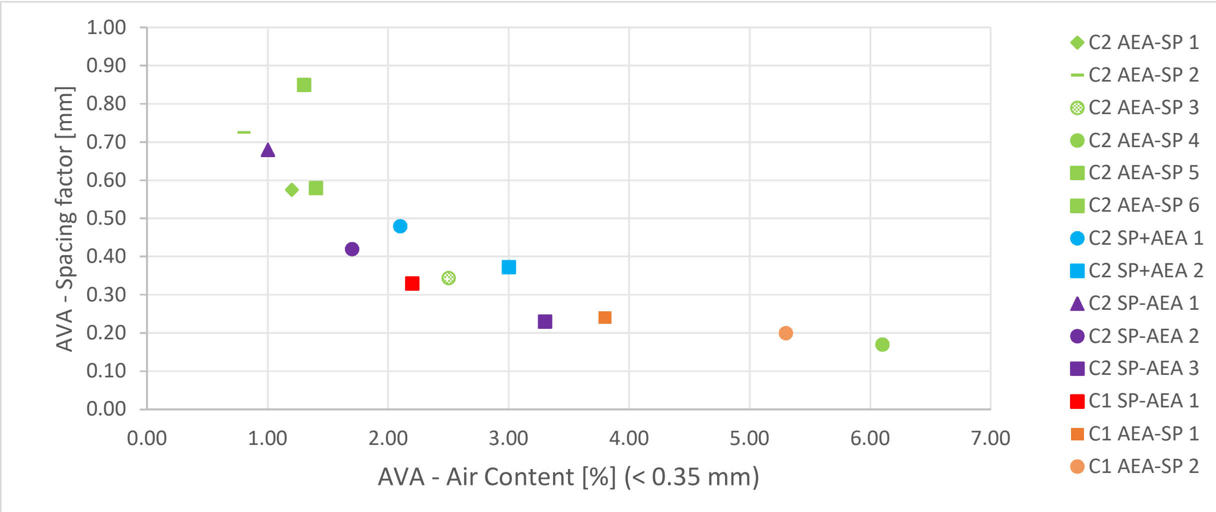



**Figure 20.b: Air content with chord length < 0.35 mm vs. Spacing Factor**

Figure 20.b shows satisfying correlation. A higher air void content that is under a chord length of 0.35 mm the lower the spacing factor becomes. In addition it may be observed that after micro air void content of 3-5 %, the spacing factor tend to fall into frost durable values that satisfies a desirable spacing factor (0.18 – 0.25 mm). This trend applies for all the sequences.

### Specific surface

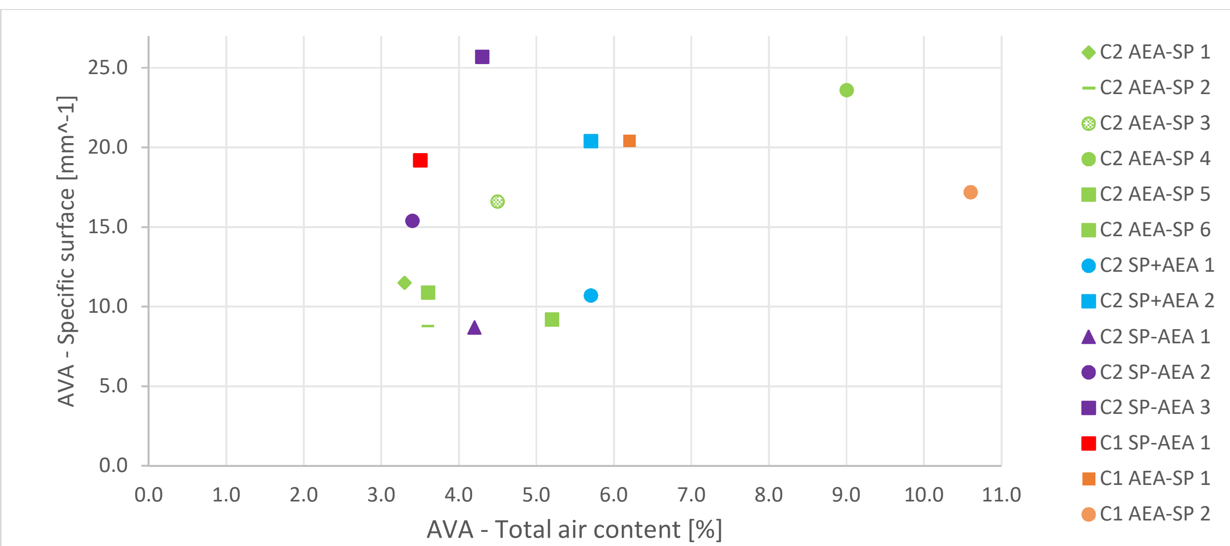



**Figure 21.a: Air content, total air void content vs. Specific surface**

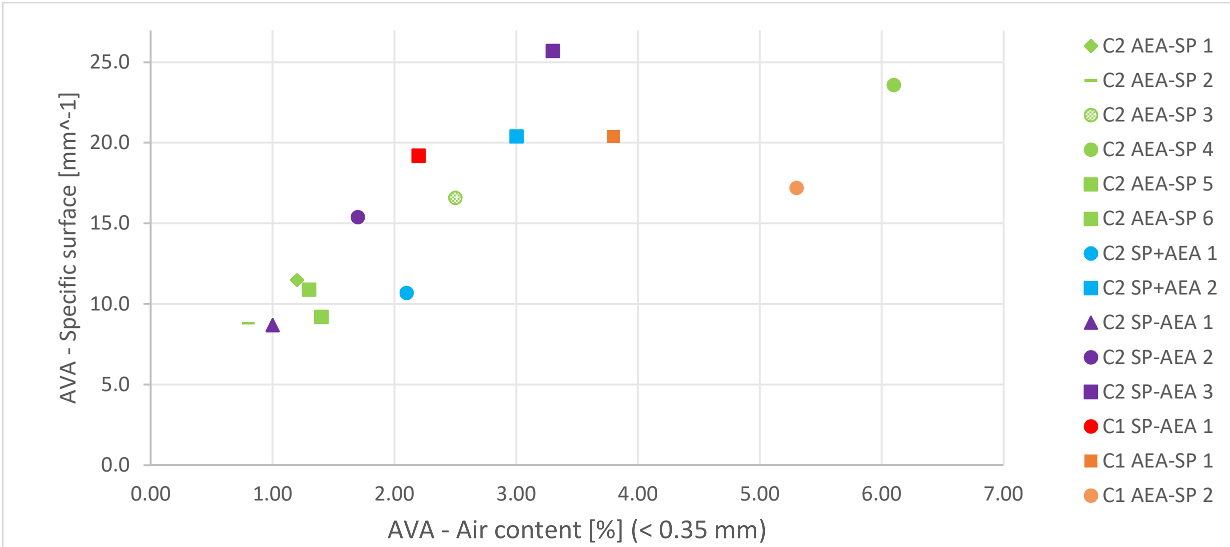



**Figure 21.b: Air content with chord length < 0.35 mm vs. Specific surface**

## Specific surface vs. Spacing factor

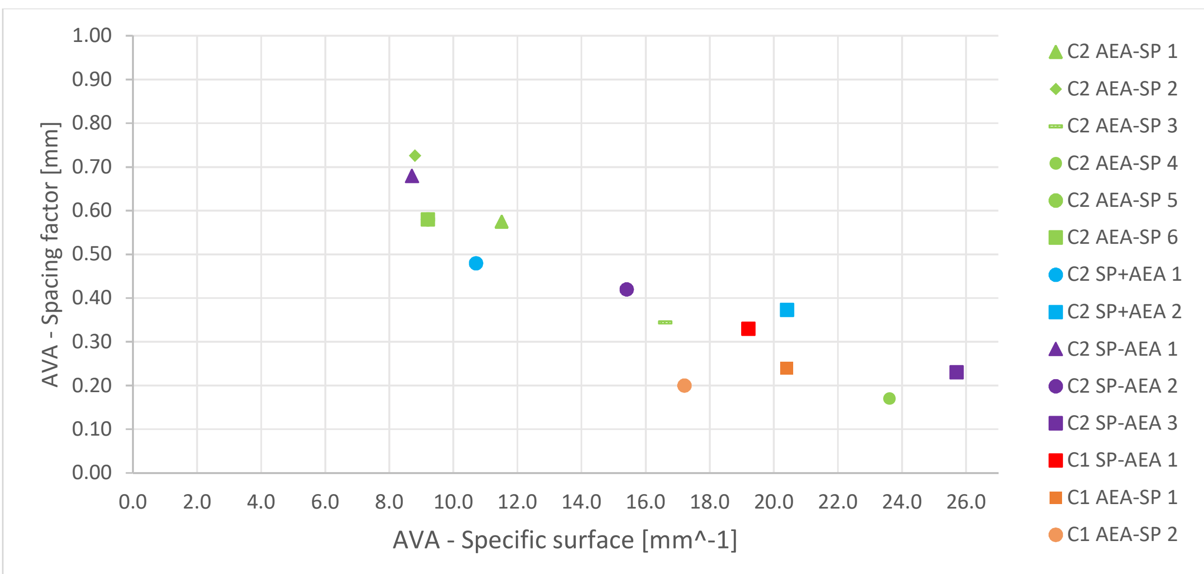



**Figure 22: Specific surface vs. Spacing factor**

Regardless of adding sequence it is an unambiguously correlation between the specific surface and the spacing factor.

### Data for the mixes, in the x-y plots, analyzed with AVA

The data for the mixes analyzed with AVA are presented below.

| | AEA [%] | SP [%] | AEA-type | FA-content |
|---|---|---|---|---|
| C2 AEA-SP 1 | 0.90 | 0.70 | Pre blend | 35 % FA |
| C2 AEA-SP 2 | 1.20 | 0.60 | Pre blend | 35 % FA |
| C2 AEA-SP 3 | 1.50 | 0.60 | Pre blend | 35 % FA |
| C2 AEA-SP 4 | 2.00 | 0.50 | Pre blend | 35 % FA |
| C2 AEA-SP 5 | 2.00 | 0.50 | Pre blend | 35 % FA |
| C2 AEA-SP 6 | 0.76 | 0.60 | Fresh | 35 % FA |
| C2 SP+AEA 1 | 1.60 | 0.50 | Pre blend | 35 % FA |
| C2 SP+AEA 2 | 1.60 | 0.50 | Pre blend | 35 % FA |
| C2 SP-AEA 1 | 0.80 | 0.80 | Pre blend | 35 % FA |
| C2 SP-AEA 2 | 0.80 | 0.70 | Pre blend | 35 % FA |
| C2 SP-AEA 3 | 0.79 | 0.77 | Fresh | 35 % FA |
| C1 SP-AEA 1 | 0.82 | 0.71 | Fresh | 0 % FA |
| C1 AEA-SP 1 | 0.76 | 0.74 | Fresh | 0 % FA |
| C1 AEA-SP 2 | 0.76 | 0.70 | Fresh | 0 % FA |

**Table 5: Explanations for the legends**

## 4.3 Column charts

### 4.3.1 Measurements with pressure meter and density method

The measurements performed by pressure meter and density method are presented below.

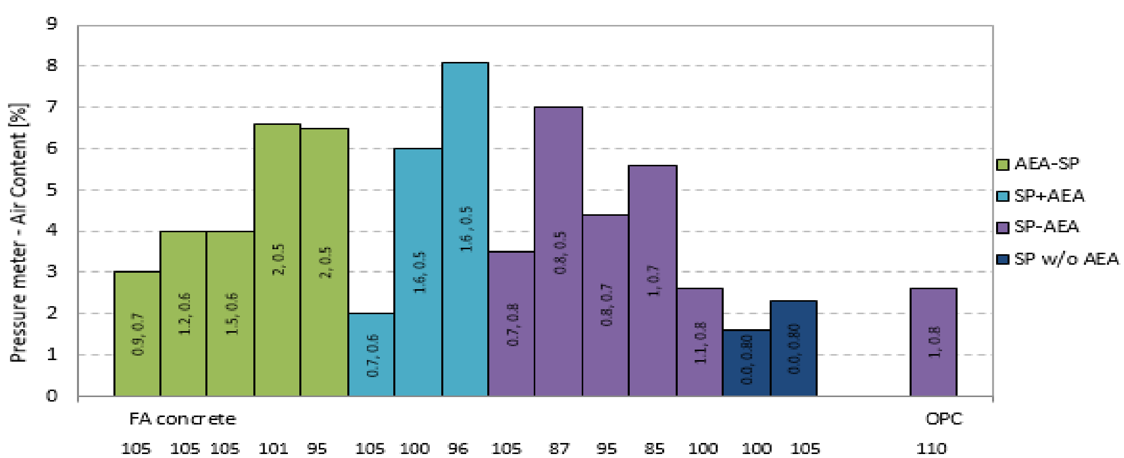



**Figure 23.a: Air content (Pressure meter), pre blended AEA**

**Note: The numbers inside the columns are the AEA and SP dosage respectively, the numbers under the columns are the slump values for the mixes.**

As we see in Figure 23.a, the AEA-SP sequence gives steadily higher total air content with increased AEA dosage, and the reproducibility is good. The AEA+SP sequence also show a steady increase in air void content when increasing the AEA dosage. SP-AEA sequence is shown to be the most unpredictable sequence. With almost the same AEA dosage (0.7 – 0.8 %) we get an air content that vary from 3.5 % to 7 %. This sequence is also sensitive to small changes in AEA dosages.

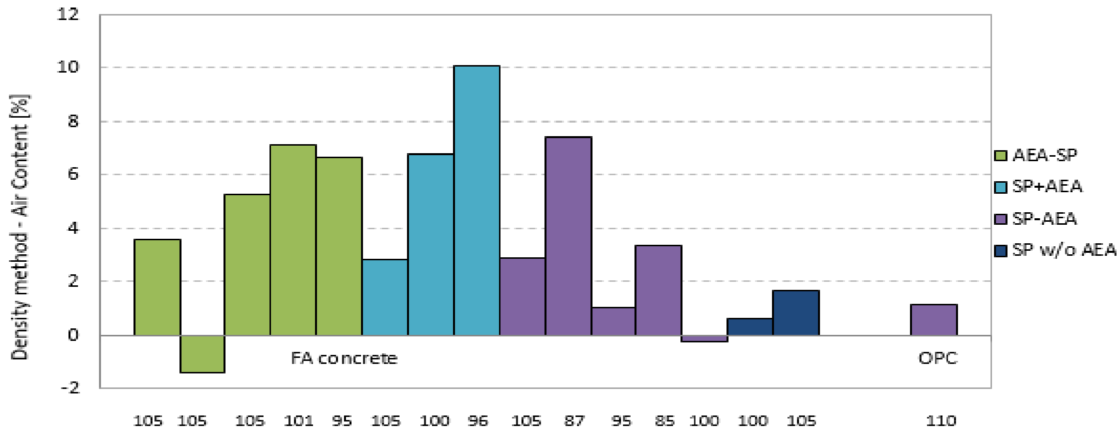



**Figure 23.b: Air content measured with density method, pre blended AEA**

**Note: The mixes done with density meters are set up in the same order as in Figure 23.a.**

The density method shows less realistic values. This can be as mentioned due to the particle density is not correct, or it can be operative errors.

The measurements performed using fresh AEA in the mix are presented below.

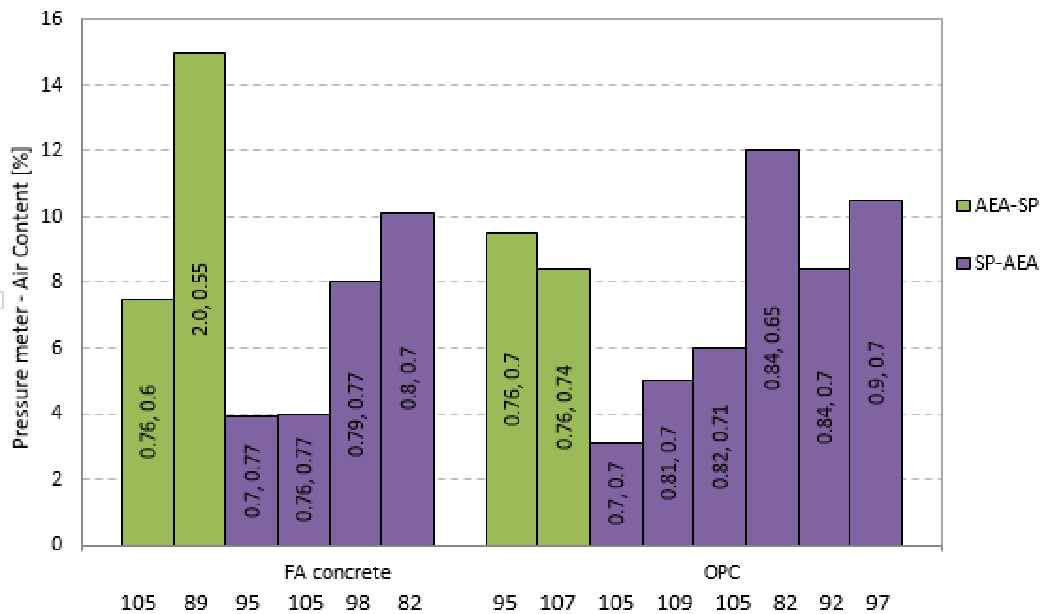



Figure 23.c: Air content (Pressure meter), fresh AEA

**Note: The numbers in the columns are the dosage of AEA and SP respectively. The numbers under are the slump value. Same measurements have also been performed with density method as shown below.**

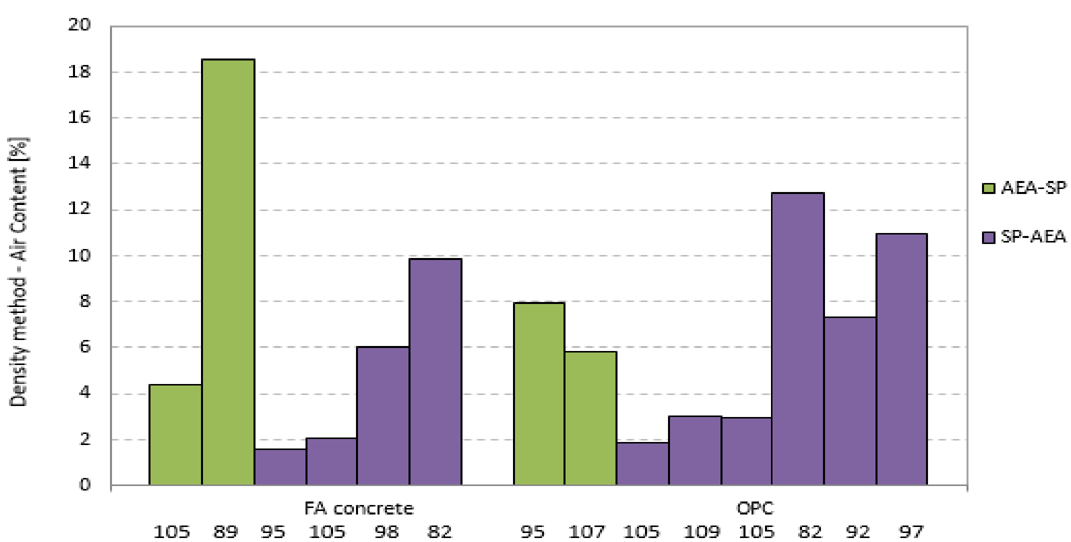



Figure 23.d: Air content measured with density method, fresh AEA

As shown in Figure 23.c, and as mentioned, the effect it has to dilute the AEA right before mixing, is considerably better. For example, 2% dosage gives 15 %, instead of 7 % for so-called pre-blended AEA.

Many mixes done with the sequence SP-AEA illustrate on the Figure 23.c its volatility, and illustrate how difficult it could be to find the required air content for this sequence. It can vary from 8 to 12 %

(50 % increase) with the same AEA dosage. It is also sensitive to small changes in the dosage. For example an AEA dosage change of 0.02 %, doubles the air void content (from 6 % to 12%), hence 2 decimals was found to be necessary. This unpredictable behavior applies for both pre-blended and fresh AEA, and for both with FA and without, for this sequence.

For the AEA-SP sequence with the same AEA-dosage we get a slightly higher air void content with the OPC concrete but this is only 0.9 % and can be a coincident.

Below on Figure 23.e are all of the measurements with the required slump been gathered (100 mm +- mm).Here for both pre blended AEA and fresh AEA.

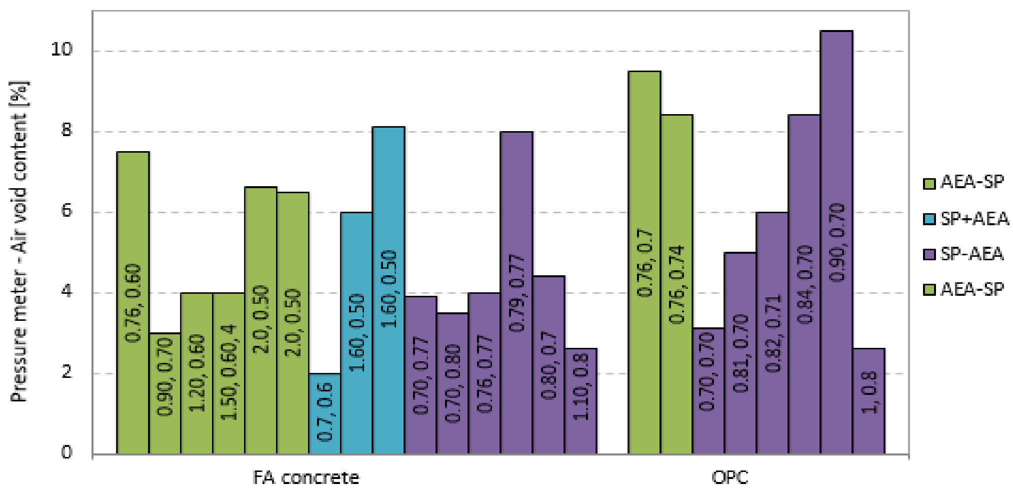



**Figure 23.e: All measurements with constant slump interval 100 mm +- 10 mm**

As shown in Figure 23.e, results suggests that a specific slump interval can both have high and low air void content. It is difficult to see any trend from the column chart. A correlation is easier to see in the x-y plot, as shown in Figure 18. Here again it shows how unstable the SP-AEA sequence is. A change of 0.03 % dosage of fresh AEA with the same SP dosage doubles the total air void content (from 4 to 8 %). As Figure 23.e illustrates, OPC concrete seem to obtain higher total air void content than the concrete without FA.

### 4.3.2 Measurements with AVA

#### Concrete with FA

Measurements performed with AVA are presented below. Main focus was to analyze:

- The total air void content with the air void content with chord length < 0.35 mm, and see how the different adding sequences influence this.

- The air void spacing factor and how it relates to air void content, both total and voids with chord length < 035 mm.

How the AEA was diluted is not believed to have any influence on this, this just dictates the amount of AEA needed to obtain a given total air void content, and not necessary anything else. It is the relationship total air void content to the micro air voids and the spacing factor that is of interest here. Because of this the two dilution procedures are decided not to be separated. A separation can be conducted in order to see if this assumption is incorrect

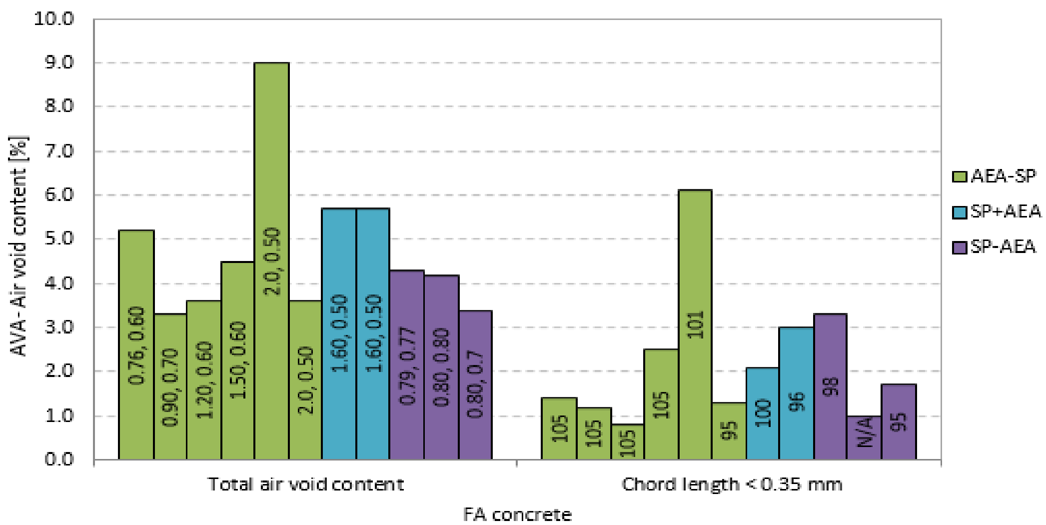



**Figure 24.a: Total air content and air void content with chord length < 0.35 mm for the different adding sequences for all FA concrete.**

**Note: The numbers in the columns are the dosage of AEA and SP respectively. The numbers inside the columns of the micro air are the slump values.**

Figure 24.a illustrates the coherence of the total air void content and the air void content with chord length < 0.35 mm. The air void content with chord length < 1 mm are chosen not to be shown, since these are intermediate values and are not seen as interesting as the two extremes.

As shown in Figure 24.a the air void content with chord length < 0.35 mm is slightly more unstable. This can be due to general statistical reasons: The smaller the numbers that are being measured, the more meaning the flaws from the measures methods have. But it can also be due to the problem with the diluted AEA.

SP+AEA sequence seem to be the most stable for both total air and micro air (on the basis of two measurements), which are in compliance with the air results given from the pressure meter. The micro air void content relative to its total air void content seem to be the highest for this sequence.

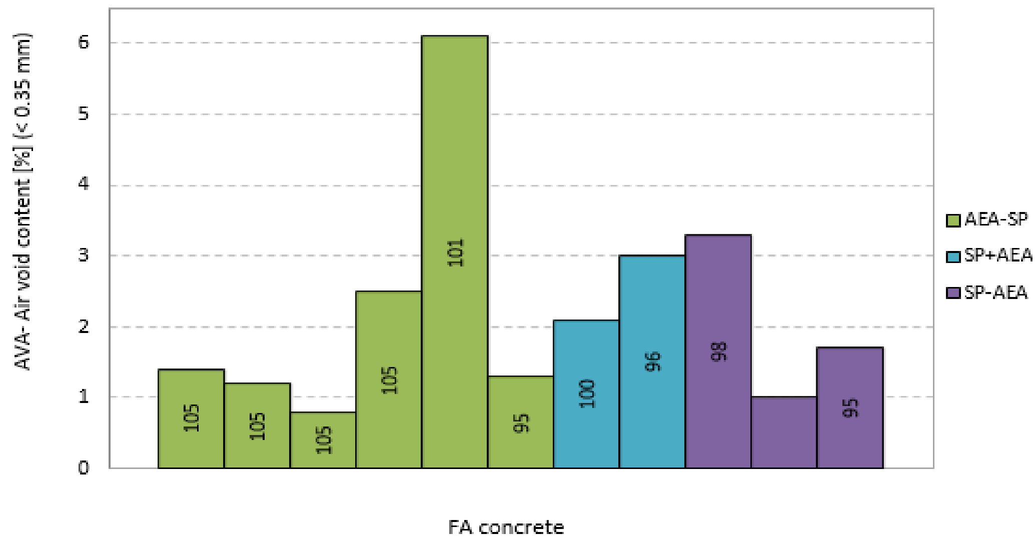



**Figure 24.b: Micro air void content for FA concrete**

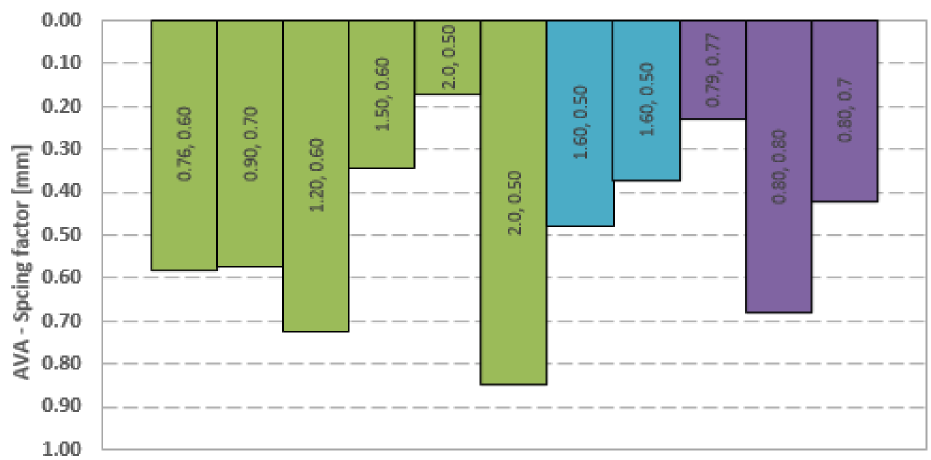



**Figure 24.c: Spacing factor for FA concrete**

**Note: Numbers inside the columns for the micro air void content is the slump values (Figure 2.b), numbers inside the columns for the spacing factor are the dosage of the admixtures (Figure 24.c).**

As shown in Figures 24.b-c it is a clear correlation between the micro air void content and the spacing factor. This is also illustrated in x-y plot Figure 20.a – b.

The total air void content for the AEA-SP sequence is quite stable, but the spacing factor is not, for example does it vary from 0.58 mm to 0.85 mm with mixes with almost the same total air void content, this is almost a change of 50 %. Also for SP-AEA we can observe a change in the spacing factor, with a relative stable total air void content. The SP+AEA sequence there we add the admixtures together seem to have the most stable air void content both total and micro and also the spacing factor, but as mentioned just based on two measurements and any trend cannot be concluded

It is interesting to see that none of the mixes, except the one with 9 % air void content, meets the EN-480-11 requirements of < 0.19 mm spacing factor [8] even with a total air content of ~ 6 %.

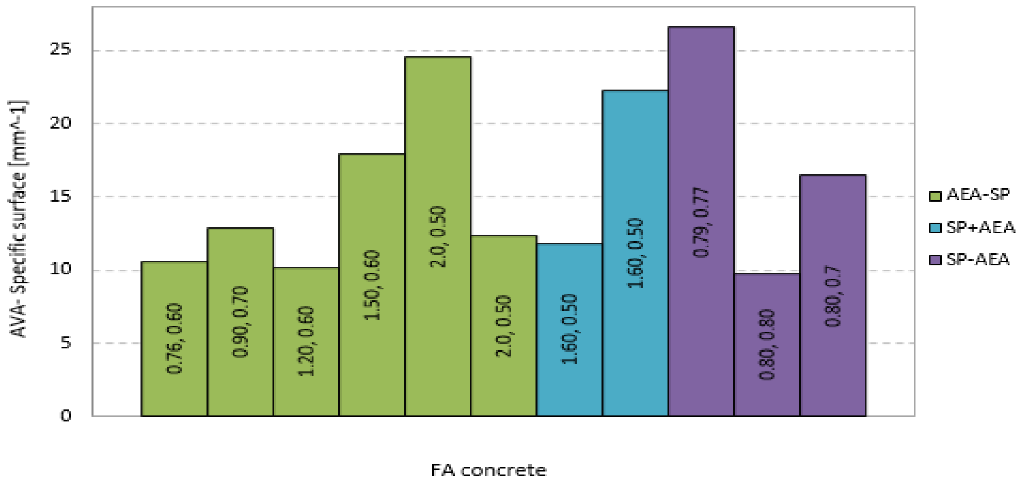



**Figure 24.d: Specific surface, FA concrete**

**Note: The numbers inside the columns are the AEA and SP dosages respectively.**

## Concrete without FA (only fresh AEA)

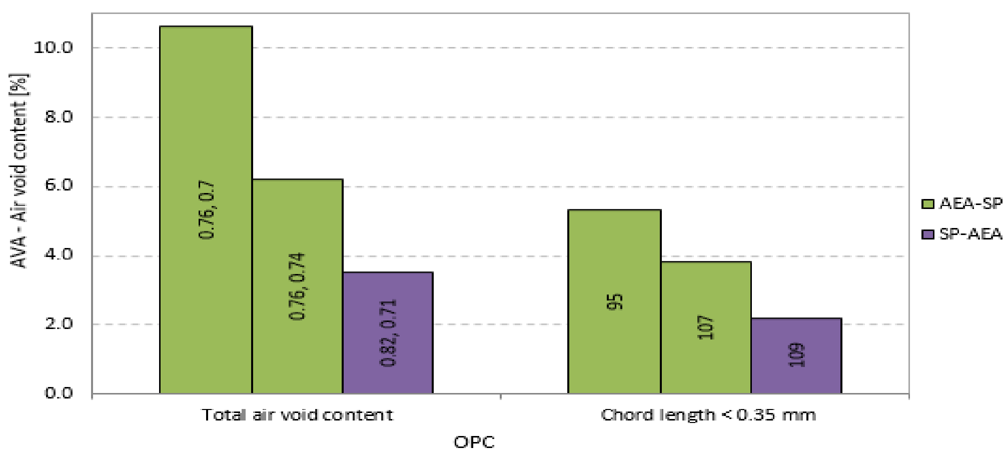



**Figure 24.e: Total air content (Chord < 2 mm) and air void content with chord length < 0.35 mm for the different adding sequences for all the OPC concrete.**

**Note: The numbers inside the columns of the total air void content are the dosage of AEA and SP respectively (also for Figure 24.g). The numbers inside the columns of the micro air are the slump values (also for Figure 24.f).**

The OPC concrete tends to have higher micro air void content relative to its total air void content than the FA concrete.

Micro air void content is presented alone on Figure 24.f, with the spacing factor right below.


Figure 24.f: Air void content with chord length < 0.35 mm, OPC

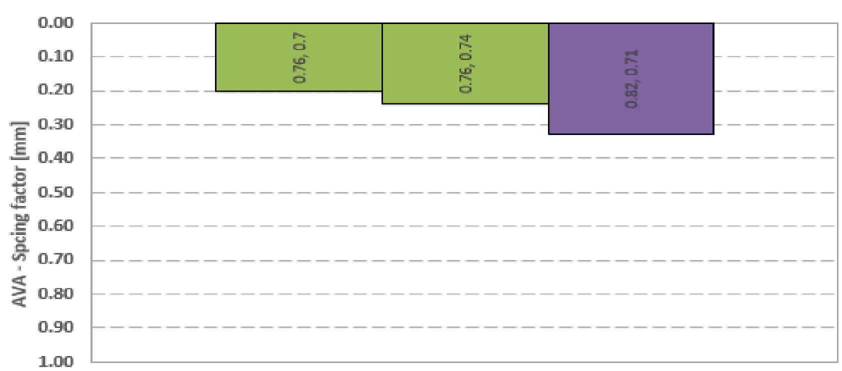



Figure 24.g: Spacing factor for the concrete without FA.

The micro air void content seem to be higher in the concrete without FA than the concrete with FA, and consequently the spacing factor is lower.

The air void content to the two AEA-SP sequence mixes have a relative large deviation in total air void content, whereas the air void content with air void with chord length < 0.35 mm is relative stable. Interestingly the spacing factor show even lower deviation. The two AEA-SP mixes almost possess same spacing factor despite the large deviation in total air void content. This may be due to that the excess total air void content do not achieve a higher micro air voids or any notable decrease in the spacing factor. This observation is in compliance with Figure 20.a-b.

Below are the specific surface presented.


**Figure 24.h: Specific surface measured with AVA**

**Note: The numbers inside the columns are the dosage of AEA and SP respectively.**

Figure 24.g-h indicates that the spacing factor and specific surface are stable for the concrete without FA, which is a considerable difference from the concrete with FA that showed a highly volatile behavior.

### FA concrete vs. Concrete without FA

Chosen concrete with FA and without FA are presented below. This to see if there is any trend indicating any difference in frost resistance properties for concrete with and without FA.

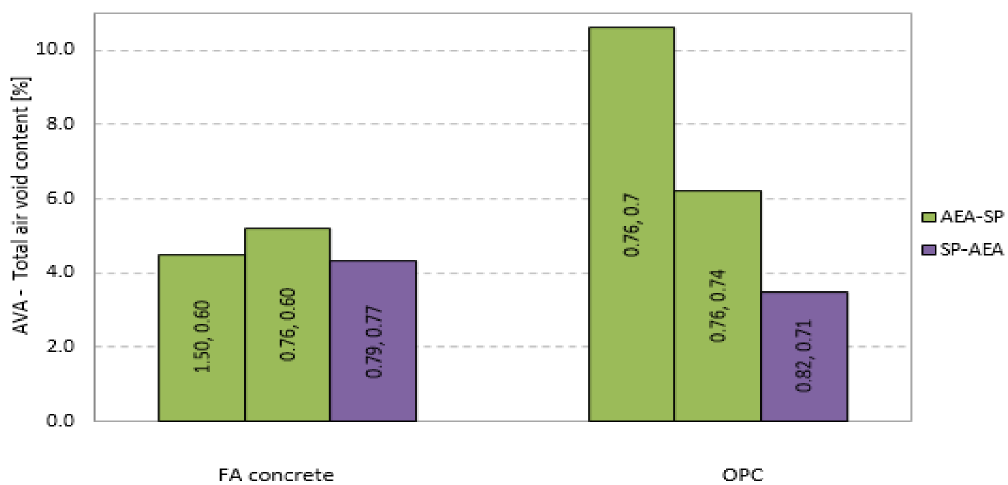



**Figure 25.a: Total air void content for both FA concrete and OPC, measured with AVA**

**Note: The numbers inside the columns of the total air void content are the dosage of AEA and SP respectively. The numbers inside the columns of the micro air are the slump values (Figure 25.a). Here the dilation procedure of AEA is not separated.**

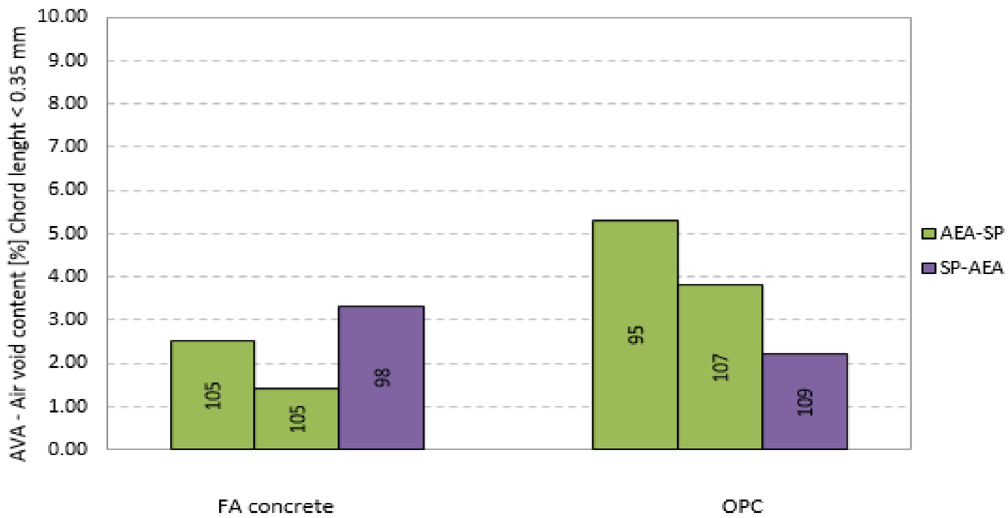



**Figure 25.b: Air void content with chord length < 0.35 mm for both FA concrete and OPC, measured with AVA**

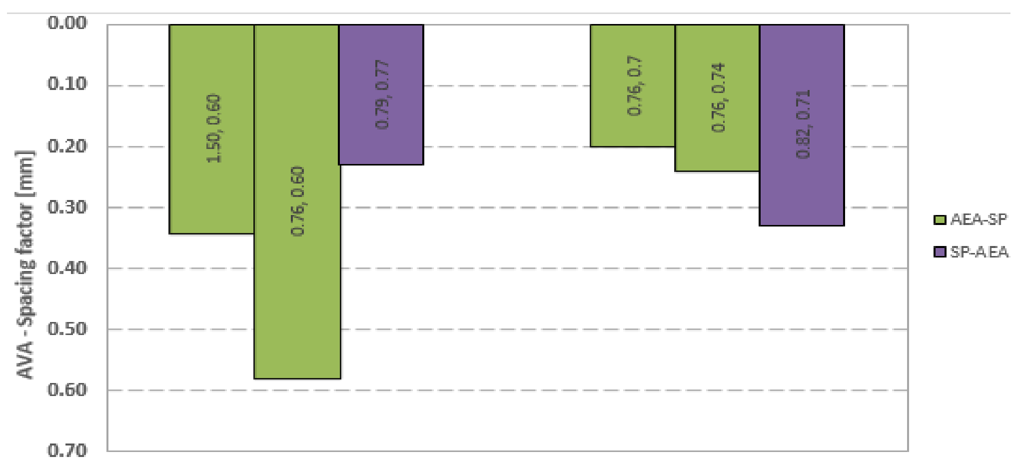



**Figure 25.c: Spacing factor for both FA concrete and OPC, measured with AVA**

As seen in Figure 25.a, for two of the mixes, the total air void content for the AEA-SP sequences with FA concrete and OPC concrete is almost the same, but as shown in Figure 25.c the spacing factor is notably higher for the FA concrete. This suggests that a concrete without FA has better frost resistance relative to its total air void content, a higher total air void content in FA concrete may be required in order to obtain low enough spacing factor.

The adding sequence SP-AEA do not have any large deviation within these two different concretes. The FA concrete has slightly higher total air void content and the spacing factor reflects the same. Unfortunately only one mix without FA was analyzed within this sequence.

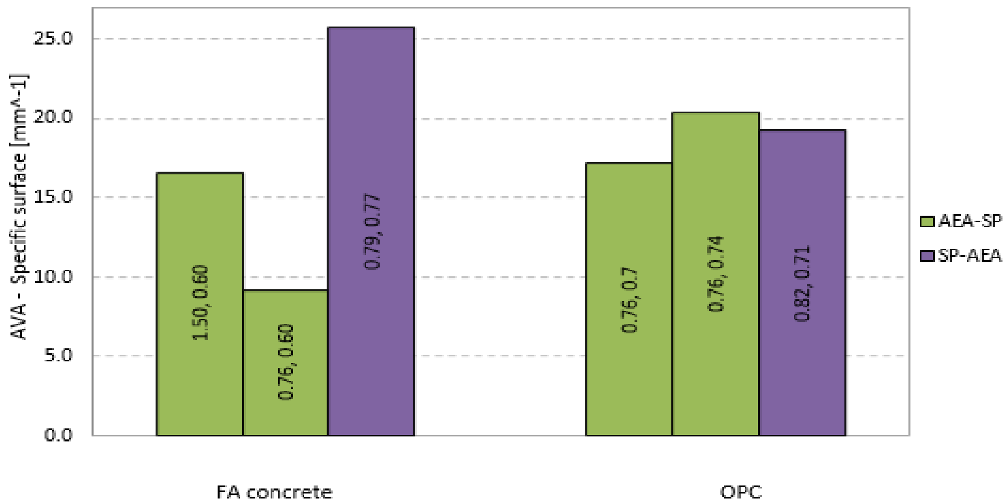



**Figure 25.d: Specific surface for both FA concrete and OPC, measured with AVA**

As shown in Figure 25.d it is clear that the specific surface is considerably more stable with concrete without FA than with FA, this is also reflected in the spacing factor as shown in Figure 25.c, the spacing factor are not only more stable but also lower.

### 4.3.3 Admixture dosages

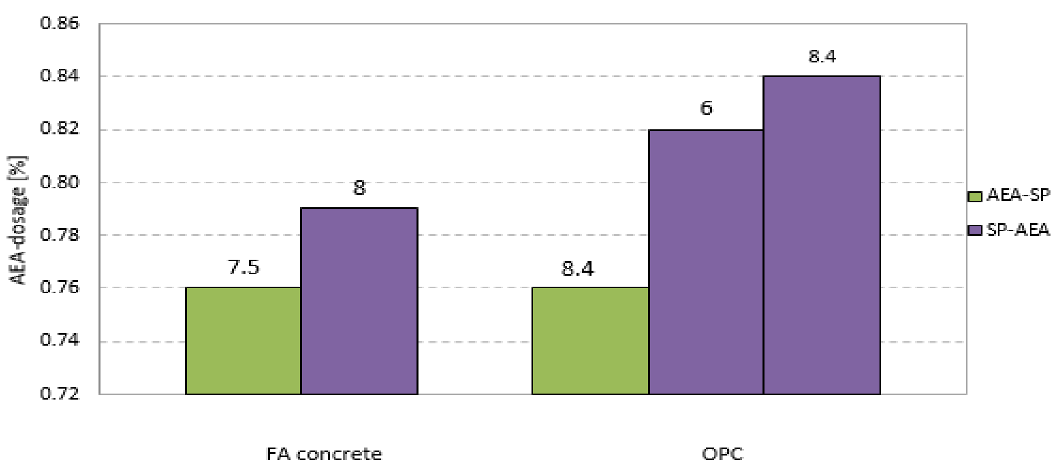



**Figure 26.a: AEA-dosage (% of b), different adding sequences, (6-8% air), fresh AEA**

**Note: The data label over the columns shows the air void content.**

Figure 26.a shows the AEA dosage with different adding sequences within an air void content of 6 % – 8 %. It is obvious that when adding air entrained admixture first tends to give the required air void content with less dosage. This applies both of the concrete. However, more measurements must be proceeded in order to make any conclusion.

Below on Figure 26.b the same measurements shows for the pre-blended AEA.

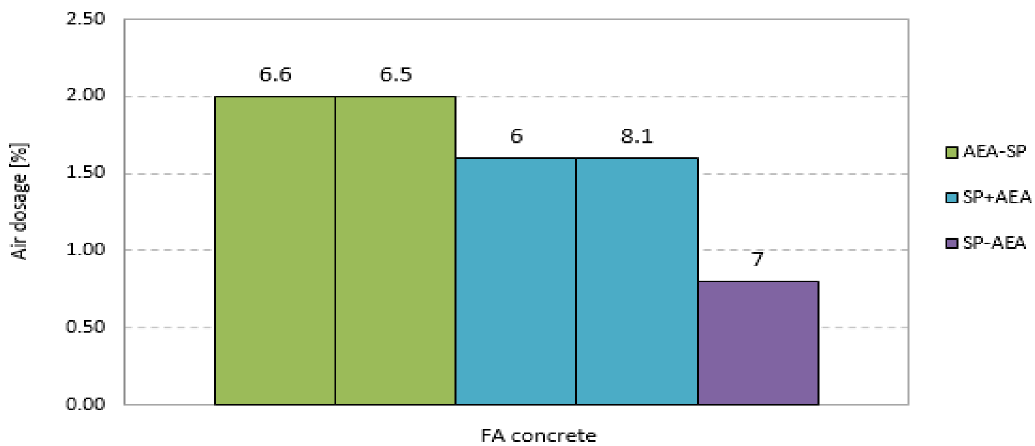



**Figure 26.b: AEA-dosage (% of b), different adding sequences (6-8% air), pre blended AEA**

**Note: The data label over the columns shows the air void content.**

Both the sequence AEA-SP mixes shows a robust air void content within. SP+AEA changes with 2.1 % which may be consider as a relatively volatile behavior as the air content seems to be in general.

## 4.4 Time measurements (AVA measurements)

### 4.4.1 Total air content

In the results that follows, the mixes are chosen not to be separated, details can be find in Appendix C

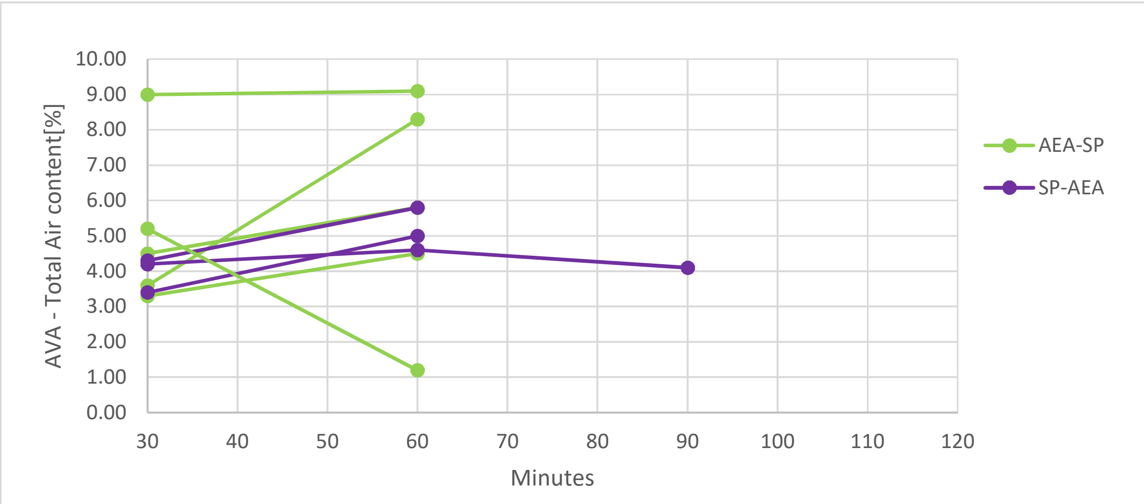



**Figure 27.a: Total air content development over time measured with AVA (Method 1)**

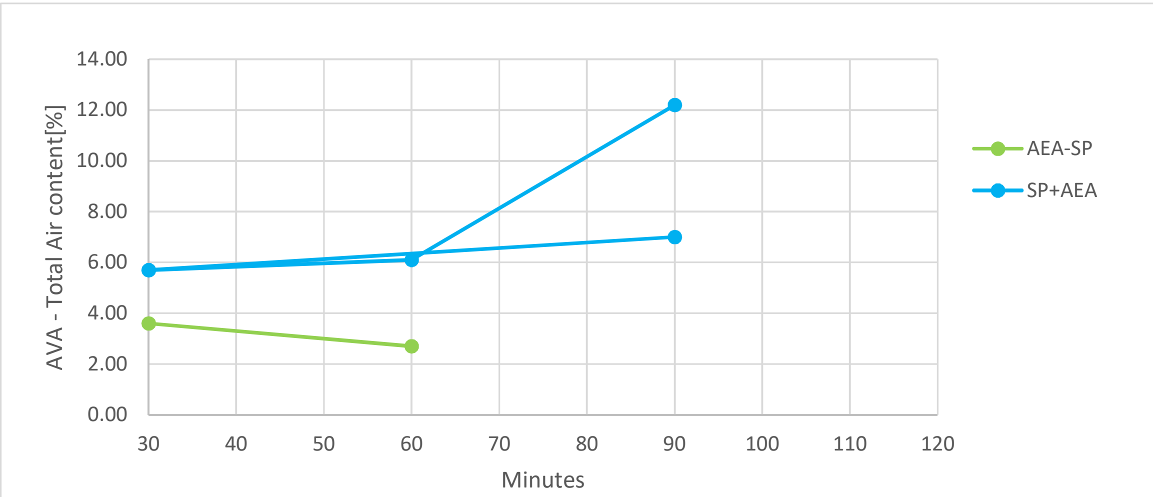



**Figure 27.b: Total air content development over time measured with AVA (Method 2)**

## 4.4.2 Air content, chord length < 1 mm

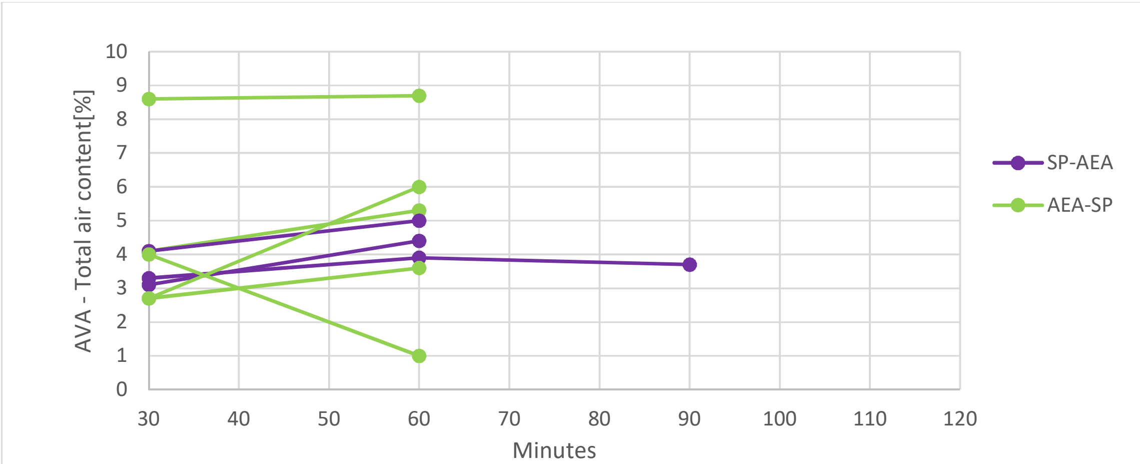



**Figure 27.c: Air content development over time, with chord length < 0.1 mm measured with AVA (Method 1)**

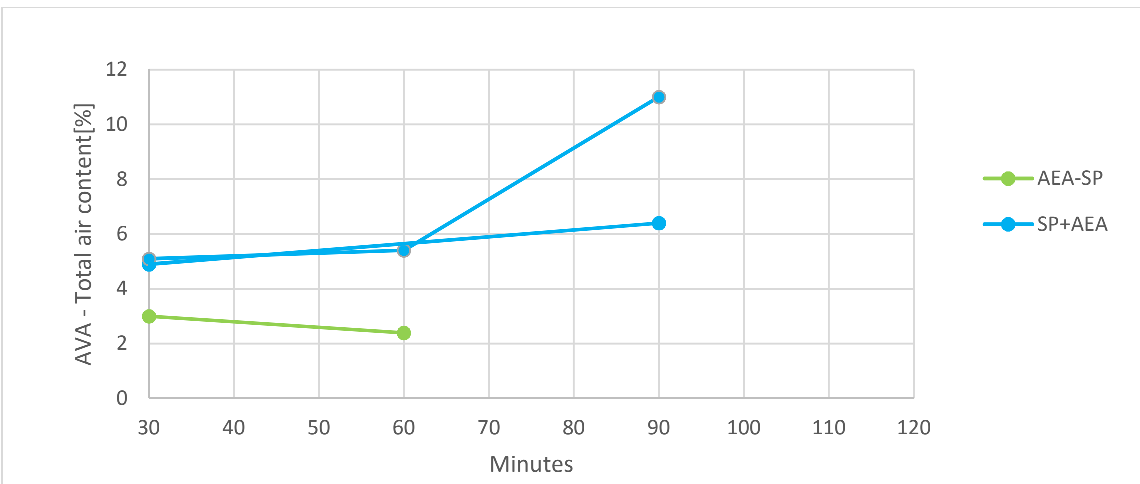



**Figure 27.d: Air content development over time, with chord length < 1 mm measured with AVA (Method 2)**

### 4.4.3 Air content, chord length < 0.35 mm

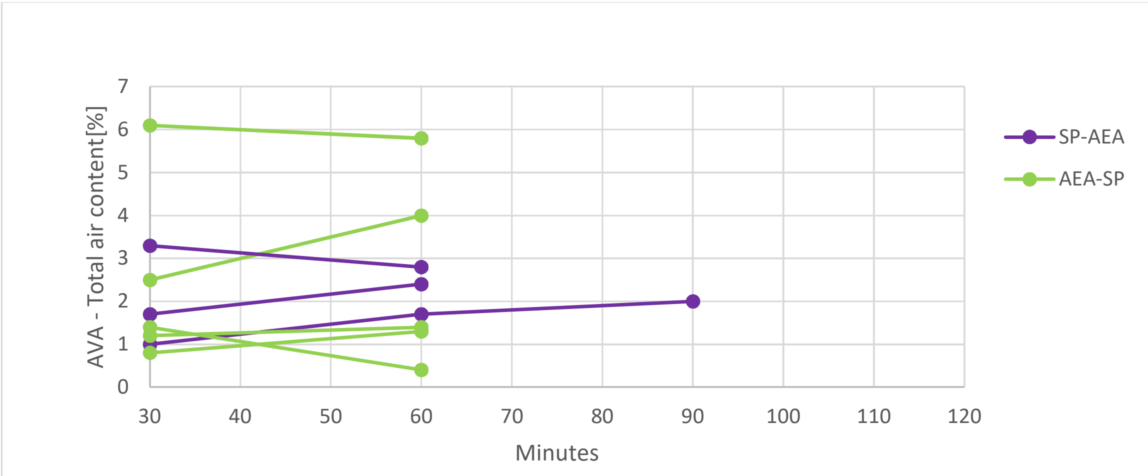



**Figure 27.e: Air content development over time, with chord length < 0.35 mm measured with AVA (Method 1)**

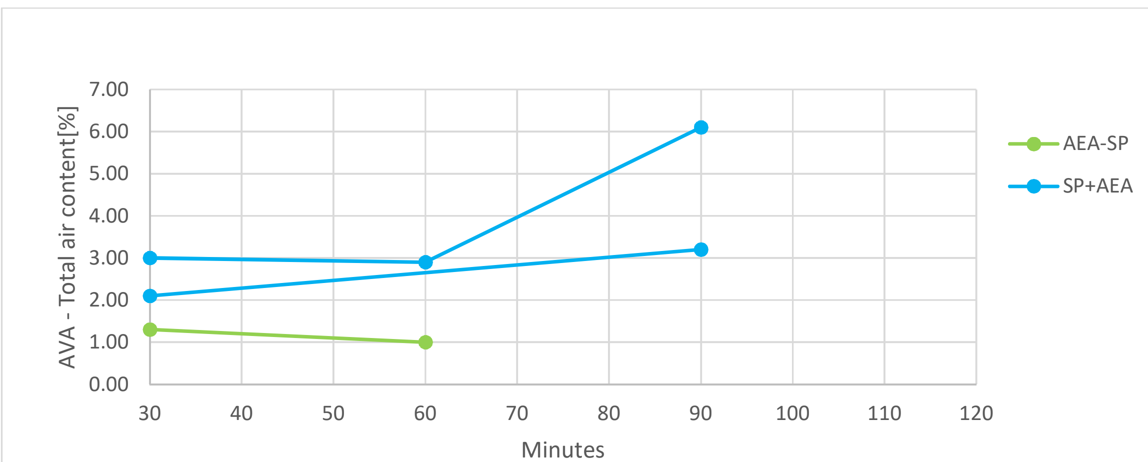



**Figure 27.f: Air content development over time, with chord length < 0.35 mm measured with AVA (Method 2)**

From we see for most of the measurements the air void content tend to increase over time.

### 4.4.4 Spacing factor

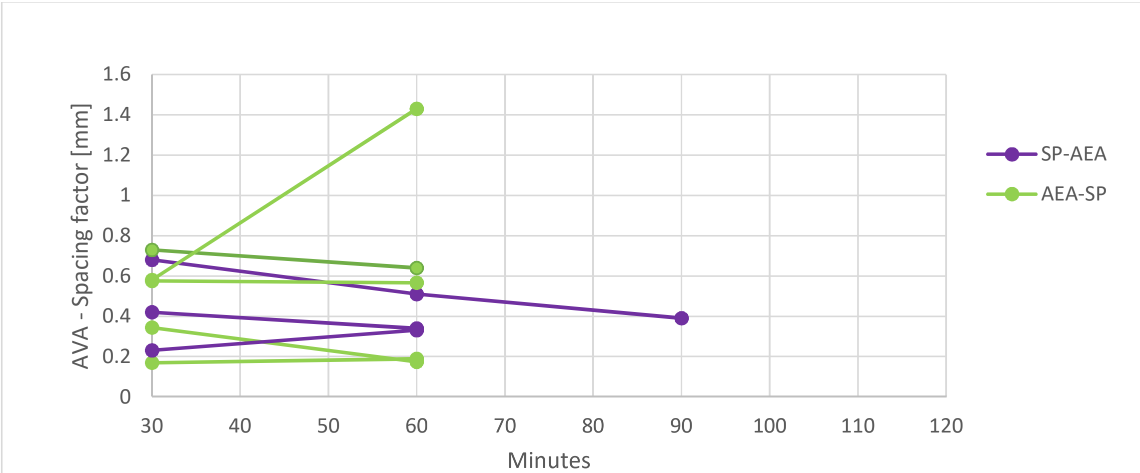



**Figure 28.a: Spacing factor measured over time (Method 1)**

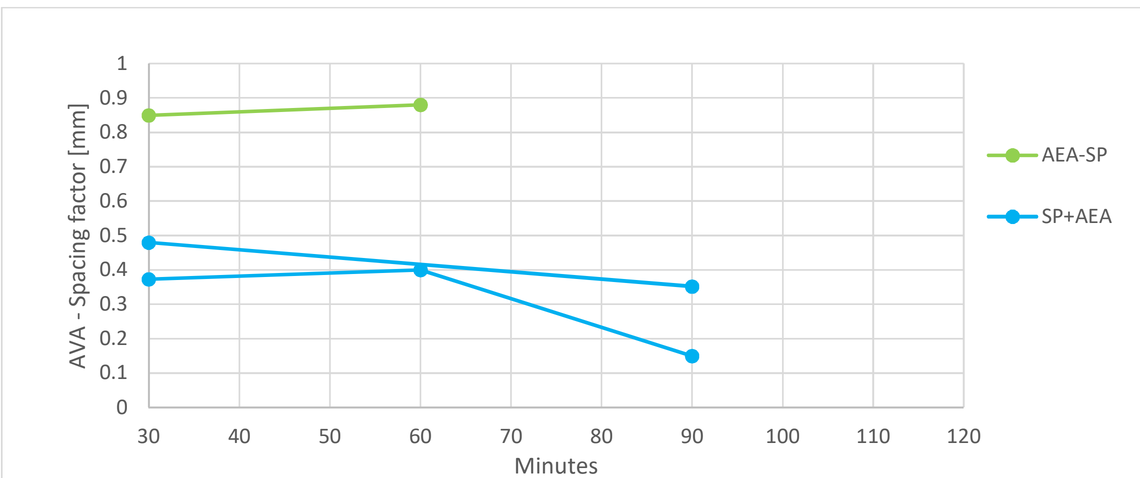



**Figure 28.b: Spacing factor measured over time (Method 2)**

As shown in Figure 28.b the spacing factor tend to decrease with time, in accordance with the air void increase.

### 4.4.5 Specific surface

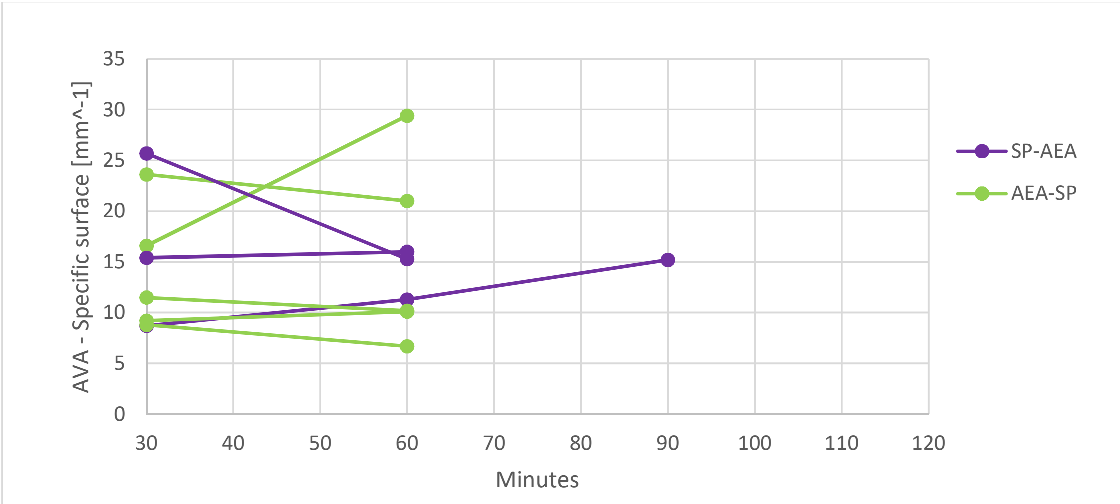



**Figure 29.a: Specific surface measured over time (Method 1)**

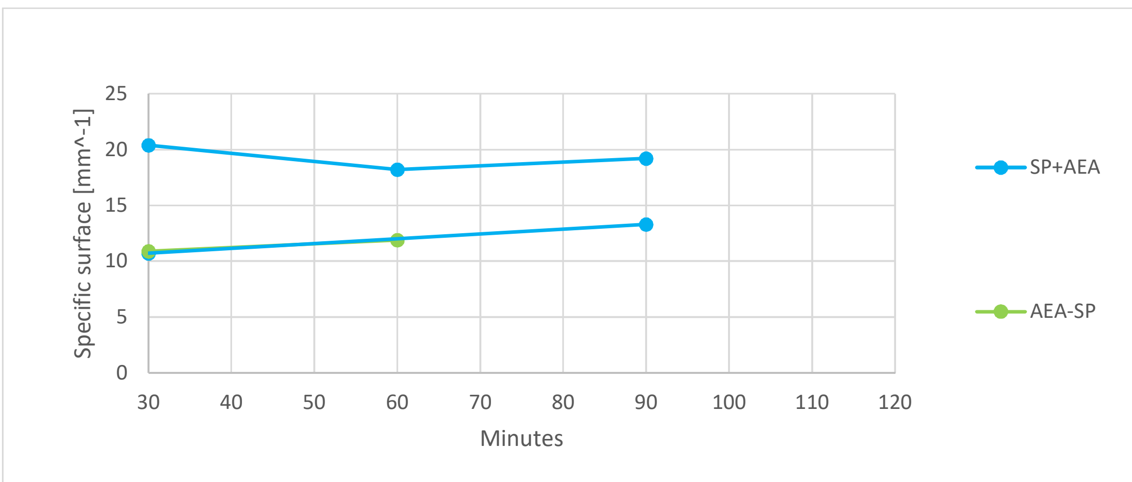



**Figure 29.b: Specific surface measured over time (Method 2)**

As shown in Figure 29.a-b, the specific surface the trend is not as clear as it is with the spacing factor and the air void content.

# 5. Discussion with conclusion

## Pre blended and fresh AEA

As shown it is quite clear that the time duration the AEA has been stored diluted with tap water has a large influence on the effect from the AEA. It may be seen as different AEAs, depending on how long it has been stored. Because of this any conclusion of which of the adding sequences that is most efficient regarding dosage of AEA is not possible for these mixes or neither has any meaning. A conclusion is possible with the mixes where AEA was diluted right before mixing. Results here suggests that the sequence AEA and then SP in most effective in what total air void concerns. However, as Figure 20.a illustrates, a FA concrete with a total air void content between 3 - 6 % have spacing factor values that are not correlating. The spacing in this interval can vary from 0.2 – 0.9, which indicate that despite a relatively high total air void content, the spacing factor and hence frost resistance is not reliable.

It is not any sequence that shows better spacing than others, and if something can be observed, this is not anything certain because of its volatile behavior and nothing to rely on. It is also not enough measurements to conclude with anything of this important matter. More research must be performed to satisfactory conclude with anything. It may be observed that the sequence SP-AEA is the most volatile what total air void concern, the two other sequences tend to have a relatively steady increase in total air content with increasing AEA dosage, while the sequence SP-AEA tend to be quite more unreliable.

The theory from Eichschen [10] about less coarse air voids when air is entrained in in stiff concrete, hence recommending AEA-SP, are not in compliance with these results, especially not anything that is notably obvious. No coherence where seen in the workability results (Figures 18 and 19)

One thing observed from these results, is that FA definitely has an influence on the frost resistance. As shown in results concrete without FA possess higher total air void content, and higher micro air voids with reflecting spacing factor, suggesting that FA has a negative influence. As illustrated, concrete with FA that has the required total air void content will most likely not fulfill the required spacing factor value.

Finding required total air void content was not easy, despite that the same sand, SF, FA, cement and matrix volume were used each time. As initially expected the air is not reliable and it seem to fluctuate for each time. As shown the SP-AEA sequence was especially volatile and a reproducible total air void content between 6 %-8 % was difficult.

Problems with the AEA made it even more difficult, as the AEA dosage had to be changed considerably, and experience made from earlier mixes had to be discarded, meaning which AEA dosage to use to obtain 6-8 % total air void content had to be tried out from scratch. This was not only for the concrete with FA but also without.

As an extra observation and in compliance with theory, the concrete without FA had different requirements what dosage of SP concern, as it required more SP to receive the required slump.

### Air entrained admixture and its reaction with SP and FA

It is useful to reiterate that it is does not seem to be fully consensus from experts which adding sequence to recommend, or if SP inherent de foaming properties enough to inhibit fully effect from the AEA. The research performed in the lab, indicated that the adding sequence SP-AEA seemed to be highly volatile both for FA and without FA. This sequence can give a high air void content in one mix and a very low in the other. It also showed to be very sensitive for small changes in AEA dosage. A concrete should possess a reliable reproducibility and small changes should not cause significant changes in the properties. Changes in SP can also be a reason, it may be that when adding AEA first it develops air voids in exactly the same concrete without the disrupting from the SP, when adding after SP it develop the air voids in a different concrete for each time, depending on SP dosage, as it is highly effective even in small doses.

### Frost resistance properties

The AEA-SP sequence without FA gave the highest total air void content, highest void content with chord length < 0.35 mm and lowest spacing factor. The SP-AEA sequence concrete without FA required the most AEA dosage in order to obtain required as is illustrated in Figure 17.b, a little more than its peer with concrete, but the concrete without FA showed lower and stable spacing factor relative to its total air void content, which is illustrated in Figure 17.e and Figure 25.c.

For two of the SP-AEA sequence mixes it was observed, even with a lower total air void content, that the spacing factor became higher when the SP content was increased and AEA dosage was constant (17.f-h). Suggesting a sensitively for the SP dosage. According to literature adding SP first should occupy the ash surface, making the AEA more efficient in the mix. Higher dosage of SP should suggest that this mechanism was amplified. This mechanism may apply be for the total air void content and not necessary spacing factor. Because it is only two mixes with this trend this can just be a coincident, but it is something that may be investigated further.

### Workability and air void properties

A concrete with a slump of 85 mm and 110 mm when using 120 mm cone, is highly different.

As mentioned, it is believed that air entrainment in stiffer concrete leads to less coarser concrete than in a soft concrete. It is also believed that the air void parameters are harder to comply when the workability is high [10]. The latter may be observed in these results, as illustrated in 19.c. Where the spacing factor tend to vary more in the slump values 100-105, but this can be just to more measurements that were obtained around this slump value.

It is at least clear trend that increasing total air void content correlates with a decreasing slump (Figure 18). This can be because it is easier for a stiffer paste to hold on its air bubbles, than it is for a softer paste.

### Air void properties over time

The air void content and its properties (L, α) seem to improve over time. It is not found any logical explanation for this. The physical process should be that the air bubbles escapes from the mortar over this period of time or that the smaller air bubbles dissolute causing increasing of the larger bubbles which leads to more bubbles that is not registered by the AVA. An explanation can be that for some reason the AVA do register air bubbles more easily when the mortar is stiff. Another reason can be that measurements done in relation with this thesis is not performed accurate enough due to little experience in use of the highly sensitive AVA and the changes in storing methods. However it is reason to believe that this should just affect the reproducibility and accuracy in exact numerical values, and not necessary the trend as a whole. Anyways a time performance with use of AVA where storage method are planned better in order to simulate curing circumstances on real construction sites, and better experience in use of AVA should give a more accurate answer.

### Limitations of this work and further work

Its shows to be harder to obtain wanted air void content than expected. Also the slump was hard to find sometimes, especially with the concrete without FA after being confident to concrete with FA. Also problems with the dilution of AEA, which was understood in the middle of the process made it harder to comply with the initial planned scope. The span of work for one person was also more than what was expected. It is easy to underestimate work needed for mixing and washing, especially with concrete that is drying out fast. And with AVA that is a new and advanced equipment. Because of this the scope deviate some with the scope initially planned.

It may be that it is nothing here that can be used to fully conclude with anything, due to limited mixes that were reproduced.  More research are needed for that, then with reproduced mixes with the exactly the same dosages. Also mixes with constant SP dosage can be tried, in this way one possible variable is taken out. Despite this, I hope that some of the results found here can be useful, and some new experience were made by this thesis.

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# Appendix A

**Proportioned concrete**

Proportioned concrete for all mixes.

| Sequence | | # | AEA [%] | SP [%] | Air (ref) [%] | Density [kg] | Pressure [%] | Density [kg/m3] | CemI [kg] | CemII [kg] | SF [kg] | FA [kg] | Free water [kg] | Abs water [kg] | Sand [kg] | SP [kg] | AEA 1:9 [kg] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | SP-AEA | | 1.00 | 0.80 | 7 | 2213 | 2.6 | 2342.5 | 480.3 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.96 | 4.95 |
| C1 | SP-AEA | | 0.90 | 0.70 | 7 | 2213 | 10.5 | 2126.2 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 4.46 |
| C1 | SP-AEA | | 0.70 | 0.70 | 7 | 2213 | 3.1 | 2327.3 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 3.47 |
| C1 | SP-AEA | | 0.81 | 0.70 | 7 | 2213 | 5.0 | 2301.4 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 4.01 |
| C1 | SP-AEA | | 0.84 | 0.70 | 7 | 2213 | 8.4 | 2205.5 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 4.16 |
| C1 | SP-AEA | | 0.84 | 0.65 | 7 | 2213 | 12.0 | 2085.6 | 480.6 | | 14.9 | | 198.2 | 4.5 | 1514.0 | 3.22 | 4.16 |
| C1 | SP-AEA* | 1 | 0.82 | 0.71 | 7 | 2213 | 6.0 | 2302.4 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.52 | 4.06 |
| C1 | SP+AEA | | 0.74 | 0.70 | 7 | 2213 | N/A | 1912.7 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 3.67 |
| C1 | AEA-SP | 1 | 0.76 | 0.74 | 7 | 2213 | 8.4 | 2238.8 | 480.1 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.67 | 3.76 |
| C1 | AEA-SP* | 2 | 0.76 | 0.70 | 7 | 2213 | 9.5 | 2192.3 | 480.5 | | 14.9 | | 198.1 | 4.5 | 1514.0 | 3.47 | 3.76 |
| C2 | AEA-SP | 1 | 0.90 | 0.70 | 7.5 | 2187 | 3.0 | 2273.0 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.31 | 4.25 |
| C2 | AEA-SP | 2 | 1.20 | 0.60 | 7.5 | 2187 | 4.0 | 2381.0 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.84 | 5.67 |
| C2 | AEA-SP | 3 | 1.50 | 0.60 | 7.5 | 2187 | 4.0 | 2236.0 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.84 | 7.09 |
| C2 | AEA-SP | 4 | 2.00 | 0.50 | 7.5 | 2187 | 6.6 | 2194.5 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.36 | 9.46 |
| C2 | AEA-SP | 5 | 2.00 | 0.50 | 7.5 | 2187 | 6.5 | 2205.2 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.36 | 9.46 |
| C2 | AEA-SP* | 6 | 0.76 | 0.60 | 7 | 2181 | 7.5 | 2238.5 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.84 | 3.59 |
| C2 | AEA-SP | | 2.00 | 0.55 | 7 | 2181 | 15.0 | 1930.0 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.60 | 9.45 |
| C2 | SP+AEA | | 0.70 | 0.60 | 7.5 | 2187 | 2.0 | 2289.4 | | 353.0 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.84 | 3.31 |
| C2 | SP+AEA | 1 | 1.60 | 0.50 | 7.5 | 2187 | 6.0 | 2202.7 | | 353.2 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.36 | 7.56 |
| C2 | SP+AEA | 2 | 1.60 | 0.50 | 7.5 | 2187 | 8.1 | 2131.0 | | 353.2 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 2.36 | 7.56 |
| C2 | SP-AEA | | 0.70 | 0.80 | 7.5 | 2167 | 3.5 | 2266.2 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 3.31 |
| C2 | SP-AEA | | 0.80 | 0.50 | 7.5 | 2187 | 7.0 | 2189.1 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 2.36 |
| C2 | SP-AEA | | 1.00 | 0.70 | 7 | 2181 | 5.6 | 2260.4 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.31 | 4.73 |
| C2 | SP-AEA | | 1.10 | 0.80 | 7 | 2181 | 2.6 | 2338.4 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 5.20 |
| C2 | SP-AEA | | 0.80 | 0.70 | 7 | 2181 | 10.1 | 2118.4 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.31 | 3.78 |
| C2 | SP-AEA | | 0.76 | 0.77 | 7 | 2181 | 4.0 | 2289.4 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.64 | 3.59 |
| C2 | SP-AEA | | 0.70 | 0.77 | 7 | 2181 | 3.9 | 2299.8 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.64 | 3.31 |
| C2 | SP-AEA | 1 | 0.80 | 0.80 | 7 | 2181 | N/A | N/A | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 3.78 |
| C2 | SP-AEA | 2 | 0.80 | 0.70 | 7 | 2181 | 4.4 | 2311.6 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.31 | 3.78 |
| C2 | SP-AEA* | 3 | 0.79 | 0.77 | 7 | 2181 | 8.0 | 2202.9 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.64 | 3.73 |
| C2 | Only SP | | 0.00 | 0.80 | 7.5 | 2181 | 2.3 | 2314.0 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 0.00 |
| C2 | Only SP | | 0.00 | 0.80 | 7.5 | 2181 | 1.6 | 2337.0 | | 352.9 | 14.2 | 105.4 | 189.0 | 4.5 | 1514.0 | 3.78 | 0.00 |

Shaded cells means mixed with "fresh AEA"
(Diluted 1:9 AEA, right before mixing)

# Appendix B

## Volume correction

Volume correction for all mixes

| | | | | | | | Measured | | Volume Correction (Skanska sheet) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sequence | | # | AEA [%] | SP [%] | Air (ref) [%] | Density [kg] | Pressure [%] | Density [kg/m3] | CemI [kg] | CemII [kg] | SF [kg] | FA [kg] | Free water [kg] | Abs water [kg] | Sand [kg] | SP [kg] | AEA 1:9 [kg] |
| C1 | SP-AEA | | 1.00 | 0.80 | 7 | 2213 | 2.6 | 2342.5 | 508.4 | | 15.5 | | 209.6 | 4.8 | 1602.3 | 4.14 | 5.24 |
| C1 | SP-AEA | | 0.90 | 0.70 | 7 | 2213 | 10.5 | 2126.2 | 508.2 | | 15.7 | | 209.6 | 4.9 | 1634.1 | 4.72 | 3.67 |
| C1 | SP-AEA | | 0.70 | 0.70 | 7 | 2213 | 3.1 | 2327.3 | 499.5 | | 15.4 | | 206.0 | 4.7 | 1574.0 | 3.60 | 3.60 |
| C1 | SP-AEA | | 0.81 | 0.70 | 7 | 2213 | 5.0 | 2301.4 | 505.3 | | 15.6 | | 208.4 | 4.8 | 1592.0 | 3.65 | 4.22 |
| C1 | SP-AEA | | 0.84 | 0.70 | 7 | 2213 | 8.4 | 2205.5 | 478.9 | | 14.8 | | 197.5 | 4.5 | 1509.0 | 3.46 | 4.00 |
| C1 | SP-AEA | | 0.84 | 0.65 | 7 | 2213 | 12.0 | 2085.6 | 452.9 | | 14.0 | | 186.8 | 4.3 | 1427.0 | 3.27 | 3.78 |
| C1 | SP-AEA* | 1 | 0.82 | 0.71 | 7 | 2213 | 6.0 | 2302.4 | 500.0 | | 15.5 | | 206.0 | 4.7 | 1575.0 | 3.61 | 4.17 |
| C1 | SP+AEA | | 0.74 | 0.70 | 7 | 2213 | N/A | 1912.7 | | | | | | | | | |
| C1 | AEA-SP | 1 | 0.76 | 0.74 | 7 | 2213 | 8.4 | 2238.8 | 486.1 | | 15.0 | | 200.4 | 4.6 | 1531.6 | 3.51 | 4.06 |
| C1 | AEA-SP* | 2 | 0.76 | 0.70 | 7 | 2213 | 9.5 | 2192.3 | 476.0 | | 14.7 | | 196.3 | 4.5 | 1499.7 | 3.43 | 3.73 |
| C2 | AEA-SP | 1 | 0.90 | 0.70 | 7.5 | 2187 | 3.0 | 2273.0 | | 367.8 | 14.8 | 109.8 | 197.0 | 4.7 | 1577.6 | 3.45 | 4.43 |
| C2 | AEA-SP | 2 | 1.20 | 0.60 | 7.5 | 2187 | 4.0 | 2381.0 | | 362.0 | 14.5 | 108.0 | 194.0 | 4.7 | 1552.0 | 2.99 | 5.81 |
| C2 | AEA-SP | 3 | 1.50 | 0.60 | 7.5 | 2187 | 4.0 | 2236.0 | | 362.2 | 14.5 | 108.0 | 194.0 | 4.7 | 1553.0 | 2.91 | 5.82 |
| C2 | AEA-SP | 4 | 2.00 | 0.50 | 7.5 | 2187 | 6.6 | 2194.5 | | 356.0 | 14.3 | 106.2 | 190.5 | 4.6 | 1525.6 | 2.86 | 5.72 |
| C2 | AEA-SP | 5 | 2.00 | 0.50 | 7.5 | 2187 | 6.5 | 2205.2 | | 357.5 | 14.4 | 106.7 | 191.4 | 4.6 | 1533.0 | 2.87 | 5.74 |
| C2 | AEA-SP* | 6 | 0.76 | 0.60 | 7 | 2181 | 7.5 | 2238.5 | | 362.0 | 14.5 | 108.1 | 194.0 | 4.7 | 1552.3 | 2.91 | 5.82 |
| C2 | AEA-SP | | 2.00 | 0.55 | 7 | 2181 | 15.0 | 1930.0 | | 313.0 | 12.6 | 93.5 | 167.6 | 4.0 | 1342.5 | 2.51 | 5.03 |
| C2 | SP+AEA | | 0.70 | 0.60 | 7.5 | 2187 | 2.0 | 2289.4 | | 370.0 | 14.9 | 110.5 | 198.2 | 4.8 | 1587.2 | 2.97 | 3.47 |
| C2 | SP+AEA | 1 | 1.60 | 0.50 | 7.5 | 2187 | 6.0 | 2202.7 | | 357.0 | 13.9 | 106.5 | 191.0 | 4.6 | 1530.0 | 2.39 | 7.64 |
| C2 | SP+AEA | 2 | 1.60 | 0.50 | 7.5 | 2187 | 8.1 | 2131.0 | | 345.0 | 13.9 | 103.0 | 185.0 | 4.4 | 1480.3 | 2.31 | 7.39 |
| C2 | SP-AEA | | 0.70 | 0.80 | 7.5 | 2167 | 3.5 | 2266.2 | | 366.5 | 14.7 | 109.4 | 196.4 | 4.7 | 1573.0 | 3.93 | 3.44 |
| C2 | SP-AEA | | 0.80 | 0.50 | 7.5 | 2187 | 7.0 | 2189.1 | | 354.0 | 14.2 | 105.7 | 189.5 | 4.6 | 1519.0 | 3.32 | 3.79 |
| C2 | SP-AEA | | 1.00 | 0.70 | 7 | 2181 | 5.6 | 2260.4 | | 366.0 | 14.7 | 109.2 | 196.0 | 4.7 | 1568.5 | 2.94 | 5.88 |
| C2 | SP-AEA | | 1.10 | 0.80 | 7 | 2181 | 2.6 | 2338.4 | | 378.5 | 15.2 | 113.0 | 202.7 | 4.9 | 1623.0 | 3.04 | 6.08 |
| C2 | SP-AEA | | 0.80 | 0.70 | 7 | 2181 | 10.1 | 2118.4 | | 359.0 | 14.4 | 107.0 | 192.2 | 4.6 | 1539.0 | 2.88 | 5.77 |
| C2 | SP-AEA | | 0.76 | 0.77 | 7 | 2181 | 4.0 | 2289.4 | | 370.4 | 14.9 | 110.6 | 198.4 | 4.8 | 1588.3 | 2.98 | 5.95 |
| C2 | SP-AEA | | 0.70 | 0.77 | 7 | 2181 | 3.9 | 2299.8 | | 372.0 | 14.9 | 111.0 | 199.0 | 4.8 | 1595.0 | 2.99 | 5.98 |
| C2 | SP-AEA | 1 | 0.80 | 0.80 | 7 | 2181 | N/A | N/A | | | | | | | | | |
| C2 | SP-AEA | 2 | 0.80 | 0.70 | 7 | 2181 | 4.4 | 2311.6 | | 374.0 | 15.0 | 111.6 | 200.0 | 4.8 | 1603.3 | 3.00 | 6.00 |
| C2 | SP-AEA* | 3 | 0.79 | 0.77 | 7 | 2181 | 8.0 | 2202.9 | | 356.4 | 14.3 | 106.4 | 191.0 | 4.6 | 1528.0 | 2.86 | 5.73 |
| C2 | Only SP | | 0.00 | 0.80 | 7.5 | 2181 | 2.3 | 2314.0 | | 374.4 | 15.0 | 111.6 | 200.0 | 4.8 | 1606.2 | 4.00 | 0.00 |
| C2 | Only SP | | 0.00 | 0.80 | 7.5 | 2181 | 1.6 | 2337.0 | | 378.0 | 15.2 | 113.0 | 202.5 | 4.9 | 1622.0 | 4.05 | 0.00 |

Shaded cells means mixed with "fresh AEA"
(Diluted 1:9 AEA, right before mixing)

# Appendix C

**Time measurements**

Time measurements with AVA

| | | | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min | 30 min | 60 min | 90 min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Chord length < 2 mm | | | | | | | | | Chord length < 1 mmm | | | | | | | | | Chord < 0.35 mm | | |
| Sequence | | # | Air [%] | | | L[mm] | | | α [mm^-1] | | | Air [%] | | | L [mm] | | | α[mm^-1] | | | Air [%] | | |
| C1 | SP-AEA* | 1 | 3.5 | | | 0.33 | | | 19.2 | | | 3.4 | | | 0.33 | | | 19.8 | | | 2.20 | | |
| C1 | AEA-SP | 1 | 6.2 | | | 0.24 | | | 20.4 | | | 5.7 | | | 0.23 | | | 21.9 | | | 3.8 | | |
| C1 | AEA-SP* | 2 | 10.6 | ** | | 0.20 | | | 17.2 | | | 9.5 | | | 0.2 | | | 18.8 | | | 5.3 | | |
| C2 | AEA-SP | 1 | 3.3 | 4.5 | | 0.58 | 0.57 | | 11.5 | 10.2 | | 2.7 | 3.6 | | 0.55 | 0.55 | | 12.9 | 11.5 | | 1.20 | 1.4 | |
| C2 | AEA-SP | 2 | 3.6 | | | 0.73 | | | 8.8 | | | 2.7 | 6 | | 0.71 | 0.67 | | 10.2 | 7.5 | | 0.80 | 1.3 | |
| C2 | AEA-SP | 3 | 4.5 | 5.8 | | 0.34 | 0.17 | | 16.6 | 29.4 | | 4.1 | 5.3 | | 0.33 | 0.17 | | 17.9 | 31.6 | | 2.50 | 4 | |
| C2 | AEA-SP | 4 | 9.0 | 9.1 | | 0.17 | 0.19 | | 23.6 | 21.0 | | 8.6 | 8.7 | | 0.17 | 0.19 | | 24.5 | 21.7 | | 6.10 | 5.8 | |
| C2 | AEA-SP | 5 | 3.6 | 2.7 | | 0.85 | 0.88 | | 10.9 | 11.9 | | 3 | 2.4 | | 0.82 | 0.86 | | 12.3 | 13 | | 1.30 | 1 | |
| C2 | AEA-SP* | 6 | 5.2 | 1.2 | | 0.58 | 1.43 | | 9.2 | 10.1 | | 4 | 1 | | 0.57 | 1.37 | | 10.6 | 11.6 | | 1.40 | 0.4 | |
| C2 | SP+AEA | 1 | 5.7 | | 7.0 | 0.48 | | 0.35 | 10.7 | | 13.3 | 4.9 | | 6.4 | 0.47 | | 0.34 | 11.8 | | 14.1 | 2.1 | | 3.20 |
| C2 | SP+AEA | 2 | 5.7 | 6.1 | 12.2 | 0.37 | 0.40 | 0.15 | 20.4 | 18.2 | 19.2 | 5.1 | 5.4 | 11 | 0.36 | 0.39 | 0.16 | 22.3 | 20.3 | 20.9 | 3.00 | 2.9 | 6.1 |
| C2 | SP-AEA | 1 | 4.2 | 4.6 | 4.1 | 0.68 | 0.51 | 0.39 | 8.7 | 11.3 | 15.2 | 3.3 | 3.9 | 3.7 | 0.68 | 0.49 | 0.384 | 9.8 | 12.6 | 16.3 | 1 | 1.7 | 2 |
| C2 | SP-AEA | 2 | 3.4 | 5.0 | | 0.42 | 0.34 | | 15.4 | 16.0 | | 3.1 | 4.4 | | 0.41 | 0.33 | | 16.5 | 17.6 | | 1.70 | 2.4 | |
| C2 | SP-AEA* | 3 | 4.3 | 5.8 | | 0.23 | 0.33 | | 25.7 | 15.3 | | 4.1 | 5 | | 0.22 | 0.32 | | 26.6 | 17 | | 3.30 | 2.8 | |

Shaded cells means mixed with "fresh AEA"
(Diluted 1:9 AEA, right before mixing)

# Appendix D

**Aardal sand, sieve curve**

**Dato:** 12.08.2016 | **Kunde:** NTNU

**Materiale:** 0/8 mm System 2+ | **Havn:**

**Varenr:** 101718-115 | **Båt:**

**Følgeseddel nr:**

| | | | |
|---|---|---|---|
| Test | NS-EN 933-1 | Laboratorium | NorStone Årdal |
| Identifikasjon av prøven | 0/8 mm 115 | Operatør | Dahle |
| Dato mottatt/uttatt | 10.08.2016 | Dato utført | 11.08.2016 |
| Metod (angi) | ☐ Vasking og sikting | Standard | NS-EN 12620 |
| | x Tørrsikting | Sertifikat: | 1111-CPD-0007 |
| | | Produksjonssted | NorStone Årdal |

Total tørr masse $M_1$ = 867,9 g

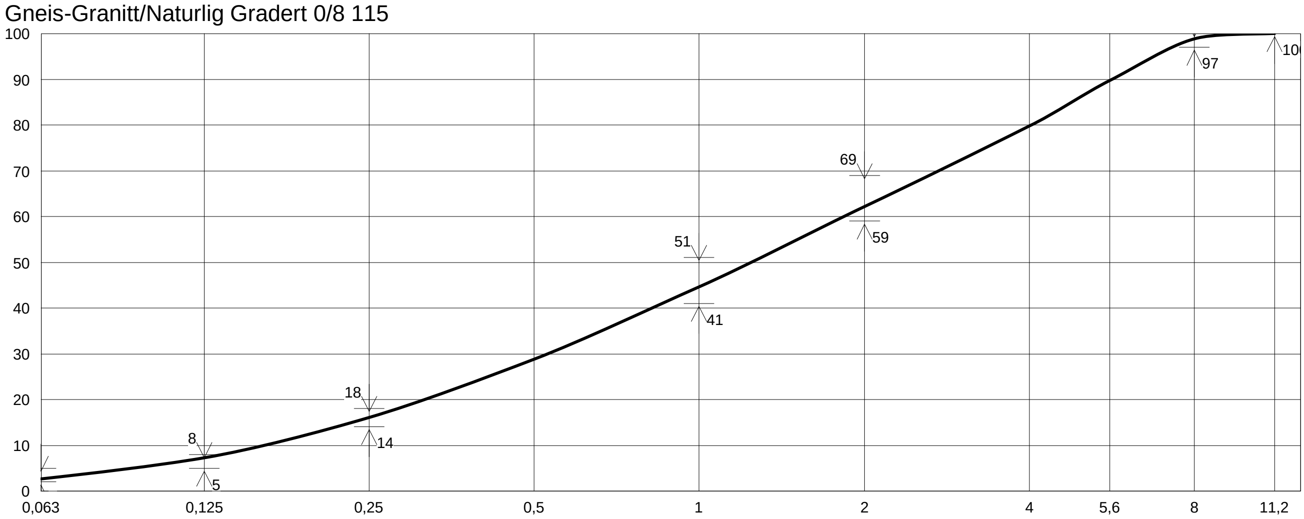
Tørr masse etter vasking $M_2$ = g

Tørr masse av Finstoff fjernet ved vasking $M_1 - M_2$ = g

Vanninnhold (%) NS 1097-5 = 5,7

| | | | Gjennomgang | | | |
|---|---|---|---|---|---|---|
| Sikteåpning (mm) | Masse tilbakehold (g) | Prosentandel (%) | Akkumulert Prosentandel (%) | Idealkurve (%) | Min (%) | Max (%) |
| 11,2 | | | 100,0 | 100,0 | 100,0 | |
| 8 | 9,8 | 1,1 | 98,9 | 99,0 | 97,0 | 100,0 |
| 5,6 | 79,2 | 9,2 | 89,7 | 90,0 | | |
| 4 | 86,4 | 9,9 | 79,8 | 80,0 | | |
| 2 | 153,3 | 17,7 | 62,1 | 64,0 | 59,0 | 69,0 |
| 1 | 151,5 | 17,5 | 44,6 | 46,0 | 41,0 | 51,0 |
| 0,5 | 137,2 | 15,8 | 28,8 | 28,0 | | |
| 0,25 | 110,0 | 12,7 | 16,1 | 16,0 | 14,0 | 18,0 |
| 0,125 | 77,1 | 8,9 | 7,2 | 7,0 | 5,0 | 8,0 |
| 0,063 | 39,5 | 4,5 | 2,7 | 3,0 | 2,0 | 5,0 |
| < 0,063 | 23,2 | 2,7 | | | | |
| Sum | 867,2 | 100.0 | 0,1 | *< 1% Prosentsats materiale tapt* | | |

Gneis-Granitt/Naturlig Gradert 0/8 115




15.08.2016

Dato

Gro S¿b¸

Signatur

NORSTONE
HEIDELBERGCEMENT Group

| | | | |
|---|---|---|---|
| **Dato:** | 12.08.2016 | **Kunde:** | NTNU |
| **Materiale:** | 8/16 mm System 2+ | **Havn:** | |
| **Varenr:** | 101711-160 | **Båt:** | |
| **Følgeseddel nr:** | | | |

| | | | |
|---|---|---|---|
| Test | NS-EN 933-1 | Laboratorium | NorStone Årdal |
| Identifikasjon av prøven | 8/16 mm 160 | Operatør | Dahle |
| Dato mottatt/uttatt | 10.08.2016 | Dato utført | 11.08.2016 |
| Metod (angi) | ☐ Vasking og sikting | Standard | NS-EN 12620 |
| | x Tørrsikting | Sertifikat: | 1111-CPD-0007 |
| | | Produksjonssted | NorStone Årdal |

Total tørr masse $M_1$ = 1422,6 g

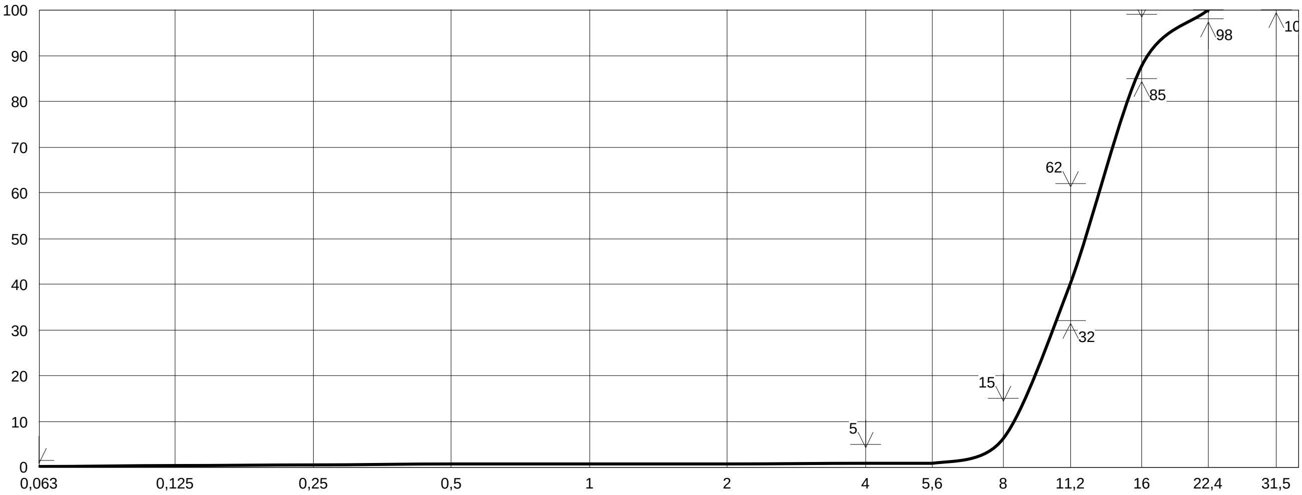
Tørr masse etter vasking $M_2$ = g

Tørr masse av Finstoff fjernet ved vasking $M_1$ - $M_2$ = g

Vanninnhold (%) NS 1097-5 = 1,2

| | | | Gjennomgang | | | |
|---|---|---|---|---|---|---|
| **Sikteåpning** (mm) | **Masse tilbakehold** (g) | **Prosentandel** (%) | **Akkumulert Prosentandel** (%) | **Idealkurve** (%) | **Min** (%) | **Max** (%) |
| 31,5 | | | | | 100,0 | |
| 22,4 | | | 100,0 | 100,0 | 98,0 | 100,0 |
| 16 | 175,2 | 12,3 | 87,7 | 90,8 | 85,0 | 99,0 |
| 11,2 | 672,0 | 47,3 | 40,4 | 46,9 | 32,0 | 62,0 |
| 8 | 486,0 | 34,2 | 6,2 | 8,9 | | 15,0 |
| 5,6 | 75,5 | 5,3 | 0,9 | 2,7 | | |
| 4 | 1,2 | 0,0 | 0,9 | 2,3 | | 5,0 |
| 2 | 1,9 | 0,2 | 0,7 | 2,0 | | |
| 1 | 1,0 | 0,1 | 0,6 | 1,7 | | |
| 0,5 | 1,0 | 0,0 | 0,6 | 1,3 | | |
| 0,25 | 1,8 | 0,1 | 0,5 | 0,9 | | |
| 0,125 | 2,2 | 0,2 | 0,3 | 0,6 | | |
| 0,063 | 1,8 | 0,1 | 0,2 | 0,4 | | 1,5 |
| < 0,063 | 2,4 | 0,2 | | | | |
| Sum | 1422,0 | 100.0 | 0,0 | *< 1% Prosentsats materiale tapt* | | |

Gneis-Granitt/Grovt 8/16 160




| | |
|---|---|
| 15.08.2016 | Gro S¿b¸ |
| Dato | Signatur |

# Appendix E

## Norcem, Anleggsement FA, CEM ||/A-V, Technical data sheet

PRODUCT DATA SHEET

# ANLEGGSEMENT FA

## CEM II/A-V

LAST REVISION JUNE 2015

The cement satisfies the requirements according to NS-EN 197-1:2011 to Portland-fly ash cement CEM II/A-V 42.5 N.

| Properties | | Declared values | Requirements according to NS-EN 197-1:2011 |
|---|---|---|---|
| Fineness (Blaine $m^2/kg$) | | 390 | |
| Specific weight ($kg/dm^3$) | | 3.02 | |
| Soundness (mm) | | 1 | ≤ 10 |
| Initial setting time (min) | | 165 | ≥ 60 |
| Compressive strength (MPa) | 1 day | 15 | |
| | 2 days | 24 | ≥ 10 |
| | 7 days | 37 | |
| | 28 days | 55 | ≥ 42.5 ≤ 62.5 |
| Sulfate (% $SO_3$) | | ≤ 3.5 | ≤ 3.5 |
| Chloride (% $Cl^-$) | | ≤ 0.085 | ≤ 0.10 |
| Water soluble chromium (ppm $Cr^{6}$+) | | ≤ 2 | ≤ 2[1] |
| Alkalies (% $Na_2O_{ekv}$)[2] | | 0.6 | |
| Clinker (%) | | 83 | 80-94 |
| Fly ash (%) | | 17 | 6-20 |

1. According to EU regulation REACH Annex XVII point 47 Chromium VI compounds.
2. Calculated from the clinker part.

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# Appendix F

## Norcem, Anleggsement, CEM | 52.5 N, Technical data sheet

PRODUCT DATA SHEET

# Anleggsement

## CEM I 52.5 N

Last revision June2016

The cement satisfies the requirements according to NS-EN 197-1:2011 for Portland cement CEM I 52.5 N.

| Properties | | Declared values | Requirements according to NS-EN 197-1:2011 |
|---|---|---|---|
| Fineness (Blaine $m^2/kg$) | | 415 | |
| Specific weight ($kg/dm^3$) | | 3.14 | |
| Soundness (mm) | | 1 | ≤ 10 |
| Initial setting time (min) | | 120 | ≥ 45 |
| Compressive strength (MPa) | 1 day | 21 | |
| | 2 days | 33 | ≥ 20 |
| | 7 days | 49 | |
| | 28 days | 63 | ≥ 52.5 |
| Sulfate (% $SO_3$) | | ≤ 4.0 | ≤ 4.0 |
| Cloride (% $Cl^-$) | | ≤ 0. 085 | ≤ 0.10 |
| Water soluble chromium (ppm $Cr^{6+}$) | | ≤ 2 | ≤ 2 [1] |
| Alkalies (% $Na_2O_{eq.}$) | | 0.60 | |
| Clinker (%) | | 96 | 95 -100 |
| Minor additional constituents (%) | | 4 | 0-5 |

1. According to EU regulation REACH Annex XVII point 47 Chromium VI compounds.

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# Appendix G

## Mapei, Mapeiair 25, Technical data sheet

# Mapeair 25


## Luftporedannende tilsetningsstoff

**BRUKSOMRÅDE**
**Mapeair® 25** er et luftporedannende tilsetningsstoff som benyttes til å øke frostbestandigheten til betong og mørtel.
**Mapeair® 25** virker også støpelighetsforbedrende og reduserer separasjonsfaren for betong. Produktet benyttes som regel i kombinasjon med Mapeis plastiserende eller superplastiserende tilsetningsstoffer.
**Mapeair® 25** er formulert på basis av syntetiske tensider og talloljederivater.

**EGENSKAPER**
Betong inneholder alltid noe luft (1 - 3 %). For å oppnå det kravet som vanligvis stilles, 4 - 6 % luft i den ferske betongen, tilsettes **Mapeair® 25**, som gir mindre, bedre og fint fordelte porer, noe som øker betongens bestandighet mot fryse-tine påkjenninger.

**Mapeair® 25** har den egenskap at den under blandingen omdanner den innpiskede luften til små, jevnt fordelte luftporer. Målt luftporevolum og avstandsfaktor i herdnet betong for **Mapeair® 25** er vist under tekniske spesifikasjoner. Disse porene gir også betongen en bedret støpelighet og redusert vannbehov.

Økt luftinnhold medfører generelt en reduksjon i trykkfastheten. En tommelfingerregel er at 1 % luft reduserer trykkfastheten med 5 %. Dette kompenseres delvis med betongens reduserte vannbehov og ved tilsetning av plastiserende og/eller høyplastiserende tilsetningsstoff.
**Mapeair® 25** vil i tillegg forbedre transportstabiliteten ved å redusere separasjonsfaren for betong med lite finstoffer og aktivt motvirke betongs “bleeding” (vanntransport opp til overflaten av den ferske betongen).

**UTFØRELSE**
**Mapeair® 25** leveres ferdig til bruk og skal tilsettes direkte i blanderen. For å oppnå jevn luftinnføring fra blanding til blanding er det viktig at **Mapeair® 25** tilsettes på samme tid hver gang.

Doseringen for å oppnå ønsket luftinnhold varierer med tilslag, sementtype og mengde. Andre tilsetningsstoffer kan også ha innvirkning. Det er viktig at tilsatsen av **Mapeair® 25** bestemmes ut fra prøveblandinger og at luftinnholdet i den ferske betongen kontrolleres jevnlig.

**DOSERING**
0,05 - 0,5 kg **Mapeair® 25** pr. $m^3$ betong.

Siden doseringsmengden for **Mapeair® 25** normalt er liten, vil en uttynning med vann være en fordel.
Bruk 1 del **Mapeair® 25** til 9 eller 19 deler vann.
Slik kan en oppnå sikrere dosering. Produktet lar seg lett blande med vann. Sørg likevel for omrøring før bruk for å sikre et homogent produkt.

**VÆR OPPMERKSOM PÅ**
Variasjoner i de øvrige delmaterialene i betongen kan sterkt påvirke dannelsen av luftporer i betong. I noen tilfeller kan også transportlengde og transportutstyr gi variasjoner i luftmengde. Dersom blandetiden har vært for kort, vil en kunne oppleve at den totale målte luftmengde øker fra produksjon til levering, mens det i de fleste tilfeller registreres en reduksjon i luftmengde. Som regel betyr denne reduksjonen ikke annet enn at større, uønskede luftbobler slipper ut. Betongprodusenten må derfor opparbeide egne erfaringstall med sine aktuelle delmaterialer.

**EMBALLASJE**
**Mapeair® 25** leveres i 25 liters kanner, 200 liters fat, 1000 liter IBC-tanker og i tank.

**LAGRING**
Produktet må oppbevares ved temperaturer mellom +8°C og +35°C. I lukket emballasje bevarer produktet sine egenskaper i minst 12 måneder. Forsiktig omrøring før bruk anbefales. Hvis produktet utsettes for direkte sollys, kan det føre til variasjoner i fargetonen uten at dette påvirker egenskapene til produktet.

**SIKKERHETSINSTRUKSJONER FOR KLARGJØRING OG BRUK**
For instruksjon vedrørende sikker håndtering av våre produkter, vennligst se siste utgave av sikkerhetsdatablad på vår nettside www.mapei.no

PRODUKT FOR PROFESJONELL BRUK

***ADVARSEL***
*Selv om tekniske detaljer og anbefalinger i dette produktdatabladet er i henhold til vår beste kunnskap og erfaring, må all informasjon ovenfor i hvert tilfelle anses som kun indikerende og underlagt bekreftelse etter langvarig praktisk bruk. Derfor må alle som skal bruke dette produktet, på forhånd sørge for at det er egnet til tiltenkt bruksområde. I hvert enkelt tilfelle er brukeren alene ansvarlig for eventuelle konsekvenser som følge av bruk av produktet.*

**Se den aktuelle versjonen av det tekniske databladet som er tilgjengelig på vårt nettsted www.mapei.no**

**JURIDISK MERKNAD**
***Innholdet i dette tekniske databladet kan kopieres til andre prosjektrelaterte dokumenter, men det endelige dokumentet må ikke suppleres eller erstatte betingelsene i det tekniske datablad, som er gjeldende, når MAPEI-produktet benyttes. Se det seneste oppdaterte datablad samt garanti-informasjoner på www.mapei.no.***

***ENHVER ENDRING AV ORDLYDEN ELLER BETINGELSER, SOM ER GITT I ELLER AVLEDET FRA DETTE TEKNISKE DATABLADET, MEDFØRER AT ALLE RELATERTE MAPEI GARANTIER OPPHØRER.***

**Alle relevante referanser for produktet fås på forespørsel og fra www.mapei.no**

Mapeair 25

## TEKNISKE DATA (typiske verdier)

| | |
|---|---|
| **PRODUKTBESKRIVELSE** | |
| **Form:** | væske |
| **Farge:** | lys gulbrun |
| **Viskositet:** | lettflytende; < 10 mPa*S |
| **Tørrstoffinnhold, %:** | 6 |
| **Tyngdetetthet, g/cm³:** | 1,00 ± 0,02 |
| **pH:** | 9,0 ± 1 |
| **Kloridinnhold, %:** | ≤ 0,05 |
| **Alkaliinnhold ($Na_2O$-ekvivalent):** | ≤ 1,0 |
| **BRUKSEGENSKAPER I BETONG:** | |
| **Luftporevolum i betongmasse EN 12350-7:** | 6 % ved dosering 0,05 % av sementvekt (referanse 2,2 %) |
| **Avstandsfaktor i herdnet betong, EN 480-11, (mm):** | 0,190 (krav < 0,200) |
| **Spesifikk overflate, EN 480-11, (mm²/mm³):** | 25,2 (krav > 25) |
| **Frostbestandighet (avskalling) – EN 12390-9, (kg/m²):** | 0,05 (beste klassifisering < 0,1 : excellent) |



6908-12-2016 (NO)

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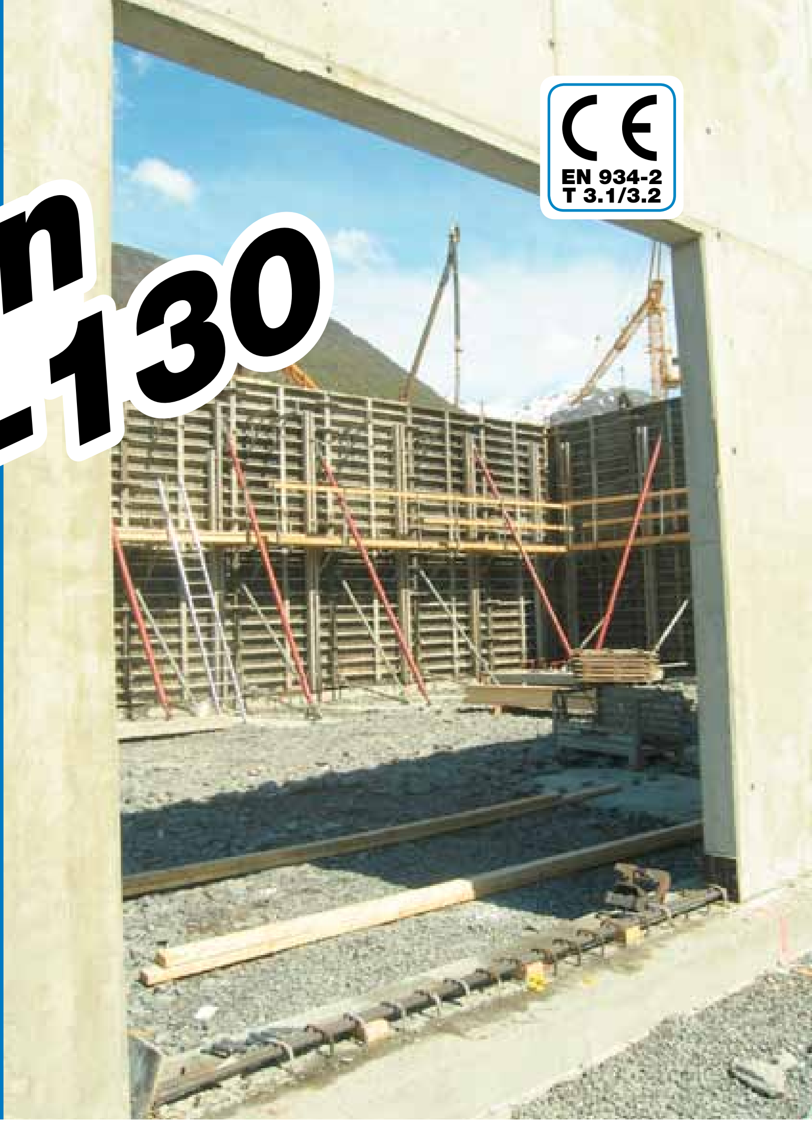
# Appendix H

## Mapei, SX-130 Superplasticizing, Technical data sheet

MAPEI

# Dynamon SX-130



CE
EN 934-2
T 3.1/3.2

## 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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# Appendix I

## Elkem, Microsilica ® Grade 940, Silica fume, Technical data sheet

Elkem AS
Drammensveien 169
Postboks 334, Skøyen
NO-0213 Oslo
Norway
Tel: +47 22 45 01 00
www.elkem.com

Product Data Sheet

# Elkem Microsilica® Grade 940 for fibre cement

Elkem Microsilica® Grade 940 is a dry silica fume available in two main forms: Undensified (U) and Densified (D)

## Description

Elkem Microsilica® Grade 940 is a dry silica fume available in two main forms: Undensified (U) and Densified (D). In use, it acts physically as a filler and chemically as a highly reactive pozzolan. A key ingredient in many construction materials, Elkem Microsilica® is used in fibre cement products as a process aid, to improve ingredient dispersion and to improve hardened properties and overall durability.

## Packing

The product is available in:

- 25 kg paper bags
- Big bags in various designs & sizes
- Bulk road tanker

Please contact our representative for more details.

## Storage & handling

Elkem Microsilica® Grade 940 should be stored in dry conditions and not exposed to moisture.

## Quality assurance & quality control

Elkem Silicon Materials' Management System for development, processing and supply of Elkem Microsilica® is certified to ISO 9001:2008. The chemical and physical properties of Elkem Microsilica® are regularly tested.

Elkem AS
Drammensveien 169
Postboks 334, Skøyen
NO-0213 Oslo
Norway
Tel: +47 22 45 01 00
www.elkem.com

## Chemical and physical properties

| Properties | Unit | Specification |
|---|---|---|
| $SiO_2$ | % | > 90 |
| Retention on 45µm sieve | % | < 1.5* |
| $H_2O$ (when packed) | % | < 1.0 |
| Bulk Density (U) | $kg/m^3$ | 200 – 350 |
| Bulk Density (D) | $kg/m^3$ | 500 – 700 |

*Tested on Undensified.

Test methods are available on request.

# Appendix J

**Nist, Powers spacing factor**

**Next:** Philleo Spacing Equation **Up:** Spacing Equations **Previous:** Spacing Equations

# Powers Spacing Factor

The most widely used paste-void spacing equation is the Powers spacing factor[2]. Contrary to a popular misconception, it does not attempt to estimate the distance between air voids. Rather, it is an attempt to calculate the fraction of paste within some distance of an air void (paste-void proximity). The Powers equation *approximates* the distance from the surface of all the air void surfaces which would encompass some large fraction of the paste. However, the value of this fraction is not quantified.

The second misconception is that the Powers spacing factor represents the maximum distance water must travel to reach the nearest air void in a concrete specimen[3,8,17]. From the previous discussion of the distribution of paste-void and void-void spacings, it should be clear that there is no single theoretical maximum value for the paste-void spacings. One can only quantify percentiles of the distribution to characterize the fraction of paste within some distance to the nearest air void surface. In practice, the maximum paste-void spacing is the size of the sample.

The Powers spacing factor was developed using two idealized systems. For small values of the *p/A* ratio, there is very little paste for each air void. Powers used the ``frosting'' approach of spreading all of the paste in a uniformly thick layer over each air void. The thickness of this ``frosting'' is approximately equal to the ratio of the volume of paste to the total surface area of air voids,

$$\bar{L} = \frac{p}{4\langle R^2 \rangle} = \frac{p}{\alpha A} \qquad : p/A < 4.342 \qquad (5)$$

For large values of the *p/A* ratio, Powers used the cubic lattice approach. The spheres are placed at the vertices of a simple cubic array. The air voids are monosized, each with a specific surface area equal to the bulk value. The cubic lattice spacing is chosen such that the air content equals the bulk value. The resulting Powers spacing factor is the distance from the center of a unit cell to the nearest air void surface,

$$\bar{L} = \frac{3}{\alpha}\left[1.4\left(\frac{p}{A}+1\right)^{1/3} - 1\right] \qquad : p/A \geq 4.342 \qquad (6)$$

The *p/A* value of 4.342 is the point at which these two equations are equal.

The intent was that a large fraction of the paste should be within $\bar{L}$ of an air void surface. An acceptable value of $\bar{L}$ for good freeze-thaw performance was determined from estimating material properties of concrete.

**Next:** Philleo Spacing Equation **Up:** Spacing Equations **Previous:** Spacing Equations

# Appendix L

**AVA procedure**

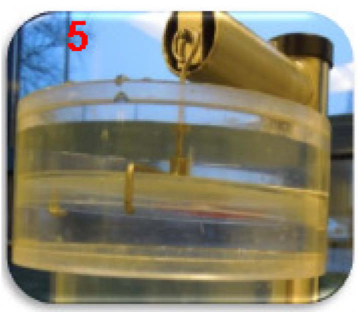
## AVA-Procedure

1. Fill up the column with water taken from temperature bath, up to the line, (around 3 cm from the top). When pouring water, some air bubbles will stick on the column side. Use the brush gently to remove this.

**When the water is filled, place the magnetic steel piece so it rest on the bottom. This can also be done before the water is poured.**

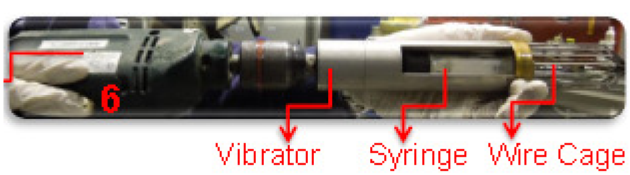
2. Fill the funnel with the blue liquid to the line. Make sure that the funnel is closed. Carefully lower the filled funnel until the tip rest against the bottom. Then release the blue liquid, until the flow of blue liquid stops. Close the funnel by pulling the steel thread axially towards the Plexiglas top part. Carefully lift up the funnel, make sure that the blue liquid don't mix with water. However some mixing is not crucial for the result. This because the blue liquid will sink to the bottom with time anyway. The water surface must now be around 2-3 mm from the edge. If not, add or remove water.

3. Place the buoyance pan side wards into the water, it is a hole on the side of the pan, this side must be lowered last, so the entrapped air escapes trough this hole. If it is some air bubbles left on the pan, try again. This can be a little tedious to do and requires a good "touch" from the user.

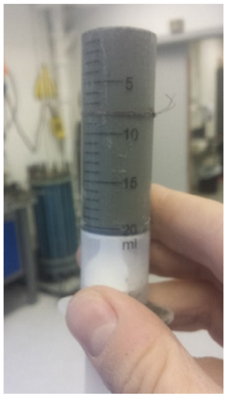



**Buoyance pan**

4. The mortar can now be extracted, with the drill:




Fill up a suitable container with mortar (Height > 120 mm). Now start the drill with the syringe and wire cage mounted on as seen on picture. Lower the wire cage in the mortar while vibrating, this submersion must not be longer the approximately 3 -4 seconds. When fully submerged, continue to vibrate the mortar for approximately 3-4 seconds. The wire cage will be filled up with mortar. After this push down the syringe so it get filled by mortar. Raise the wire cage carefully up from the mortar. Turn around the drill while doing this so the mortar don't fall out from the syringe. Now release the wire cage, clean off the excess mortar surrounding the syringe, release the syringe from the vibrator by rotating the piston 90 degrees out of the keyways in the fork.



**Filled syringe**

The plunger is pushed forward to 1 mm before the 20 ml mark (figure a below), the excess mortar must be wiped off.

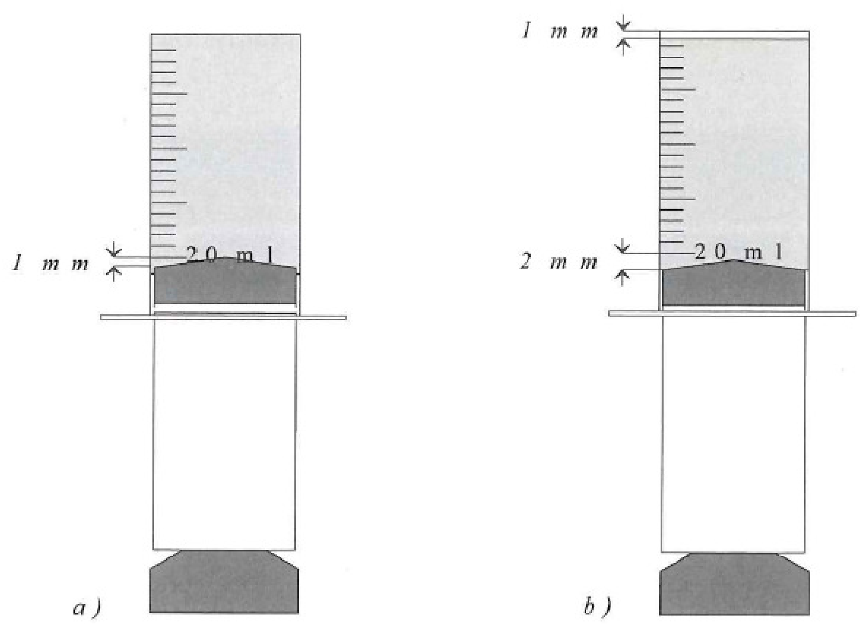



**Fig. 10.** *Mortar sample made ready for testing. The 1 mm of mortar added in a) is due to the shape of the syringe piston. The b) figure illustrates the syringe right before testing.*

Withdraw the plunger 1 mm, so it is a gap between the edge and the mortar surface (figure b).

Smear the syringe with Vaseline.

The syringe is now placed against the end of the piston (plug) so that the end of the piston fits approximately 1 mm into the syringe, se picture below.

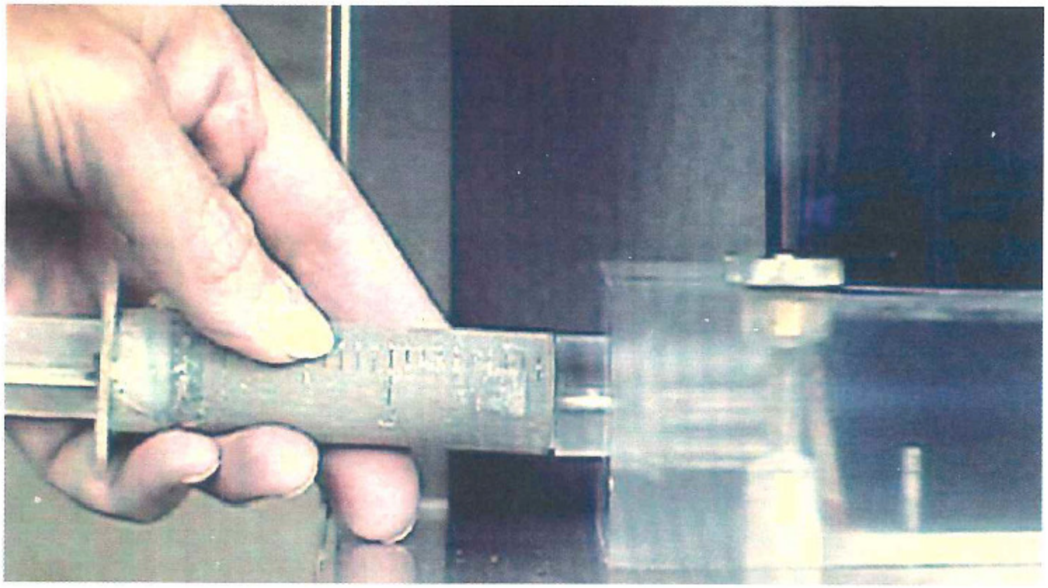
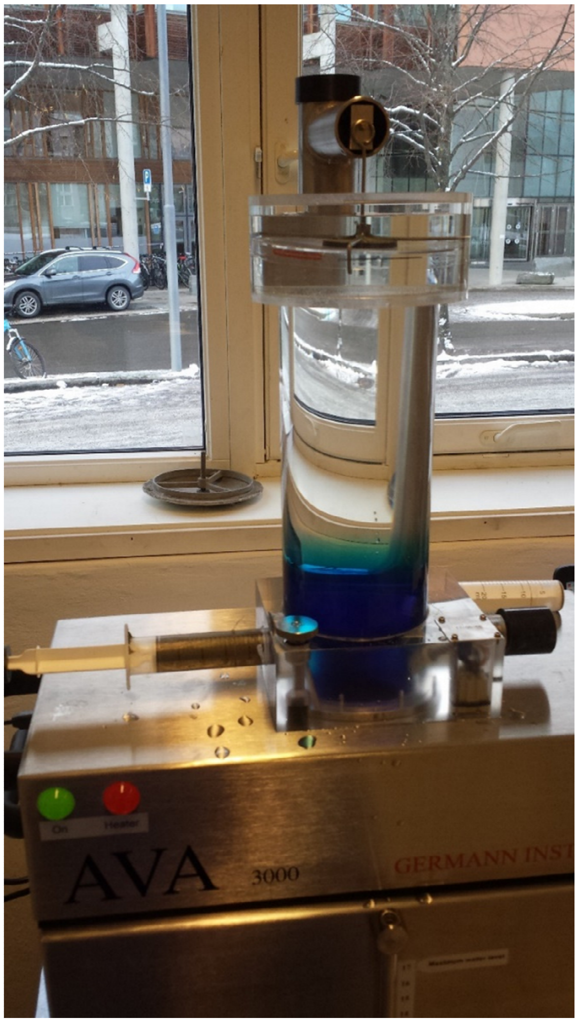


**Fig. 11.** *Positioning the syringe with sample at the end face of the piston*

Press the syringe with a rotary motion until the red line of the syringe approximately flushes with the outer chamber side face. (See page 39 in the AVA manual). In the same time carefully withdraw the piston out. The piston must only be pulled to a certain, marked level. This in order to keep the water inside the column.

*Do not pull the piston totally out!*

*At this time the air that may have been trapped between the syringe and the mortar will rise into the buoyance pan.*




6. Turn on the computer and start the AVA software. If a prompt Java error message shows up, restart the computer and try again.

Now fill in the data needed. A volume of mortar with aggregate < 6 mm must be calculated from the formula:

**1 – (The ratio aggregate over 6 mm in the aggregate*the ratio of total aggregate in the mortar)-Air**

The per cent of aggregate over 6 mm in our sand was 8.67 % and the per cent aggregate in our mortar was 57 %. If air is expected to be 7.5 %. The mortar in per cent with aggregate < 6 mm then becomes:

1 – ((8.67/100)*0.57)-7.5/100 = 87 %

(Germann Instruments manual, Appendix A)

(See Appendix X for the sieve curve provided by Årdal Sand.)

The AVA software also need the paste volume. This is calculated by the formula:

**Volume cement + volume FA + volume free water + volume of the dry part of the SP + volume Silica**

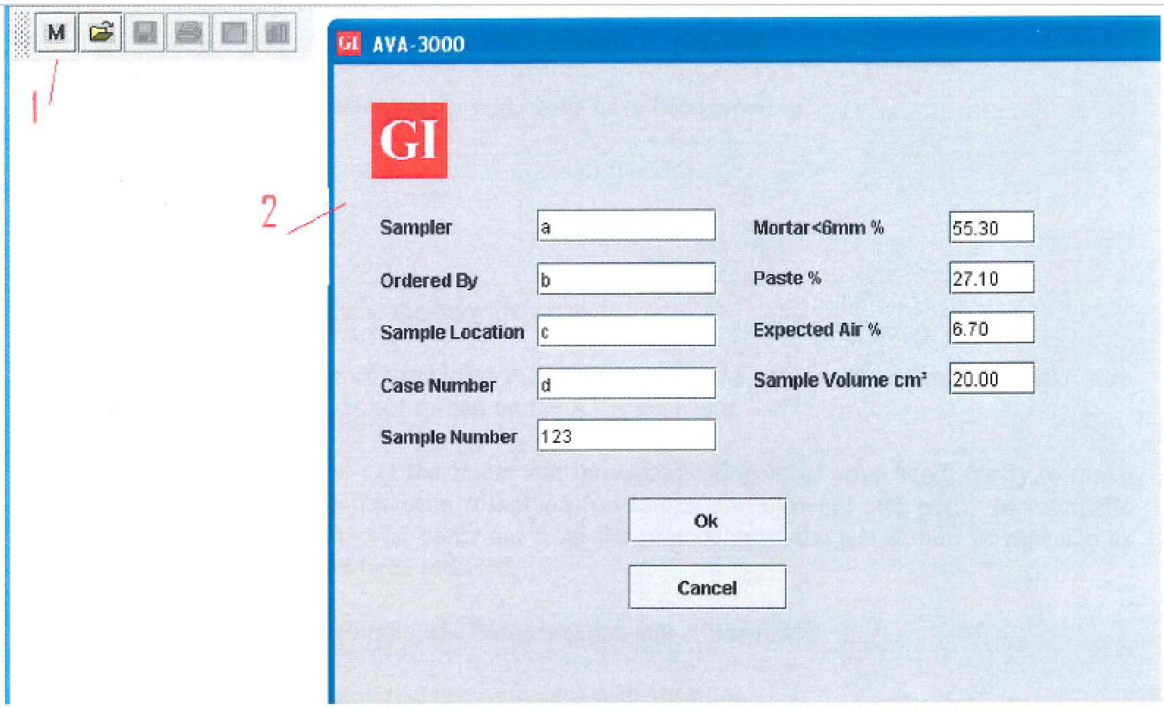



**Fig. 12.** *Press the M–button and type in all input data.*

**Germann Instrument software window**

Press the Ok button.

Now a new window will come up on the screen, and the AVA is ready to analyze. Press the tare button to reset the weight. Before this the buoyance pan may be cleared for the air bubbles that has been released, is so do the process in point 3 again.  After this press the tare button.

Press the Start button to initiate the stirrer and immediately afterwards inject the mortar in 3 steps, during the first seconds. This is to avoid that the stirrer pin gets trapped. The stirrer will now spin for around 30 seconds.

The AVA software will continue measuring the air bubbles until no weight change is felt by the AVA software or maximum 25 minutes. After the AVA is finished, the results will be stored in a folder and can be printed out in pdf-files. The results is registered in an Excel sheet.

When pouring out the sludge from the rise column, it must be checked for slumps. This is done by holding a hand under the riser column when pouring, this is also done to catch the stirrer pin.

“If lumps are still present in the sludge after testing at the bottom of the rise column, the injection of the mortar in the riser column should be done by crushing the mortar by pressing the piston in a rotary motion against the mortar while this is being released over the rotating stirrer pin.”

“Should stirring for 30 seconds not take place, the reason may also be that the mortar is very stiff and the stirrer pin is caught below mortar sample during stirring, however the important issue is that there are no lumps in the dissolved sample.”

From page 40 in Appendix H in the AVA – 3000 manual.

## Cleaning procedure of the AVA

To clean the AVA it has to be released from its platform. When it is loose it can be carried, with the syringe and the plug on its place, to a sink. Here the water can carefully be poured out. The mortar must not be poured out. The mortar has to be placed in a suitable container. **Remember to take out the stirrer rod.**

*The blue liquid is according to Germann Instrument not a hazardous material, and can be poured out with the water.*

When the water and the mortar is out, the cylinder can carefully be washed, flushed adequately in hot water is usually enough. After washed the cylinder must be air dried, in order to prevent rust.

## Mixing procedure

Materials are weighted up, using a printed mixing sheet from Skanska (this is be used to register the results later). The mixing container is sprayed with water in order to prevent absorption of water from the steel walls. Then the dry materials are poured in and mixed for a time duration of 1 minute. Water is then poured in and mixed 1 minute. Then the agents are poured in with some water, procedure for this may vary depending on the adding sequences (see chapter 3) but the rule is a total mixing time for 5 minutes with the AEA, independent on adding sequences. It is also a pause for a 2 minutes and then additional 1 minute mixing. Right after mixing (total 9 minutes) the workability, density, and air content are measured. This measurements methods followed the prescription from Norsk Standard – Fersk Betong.

# Appendix M

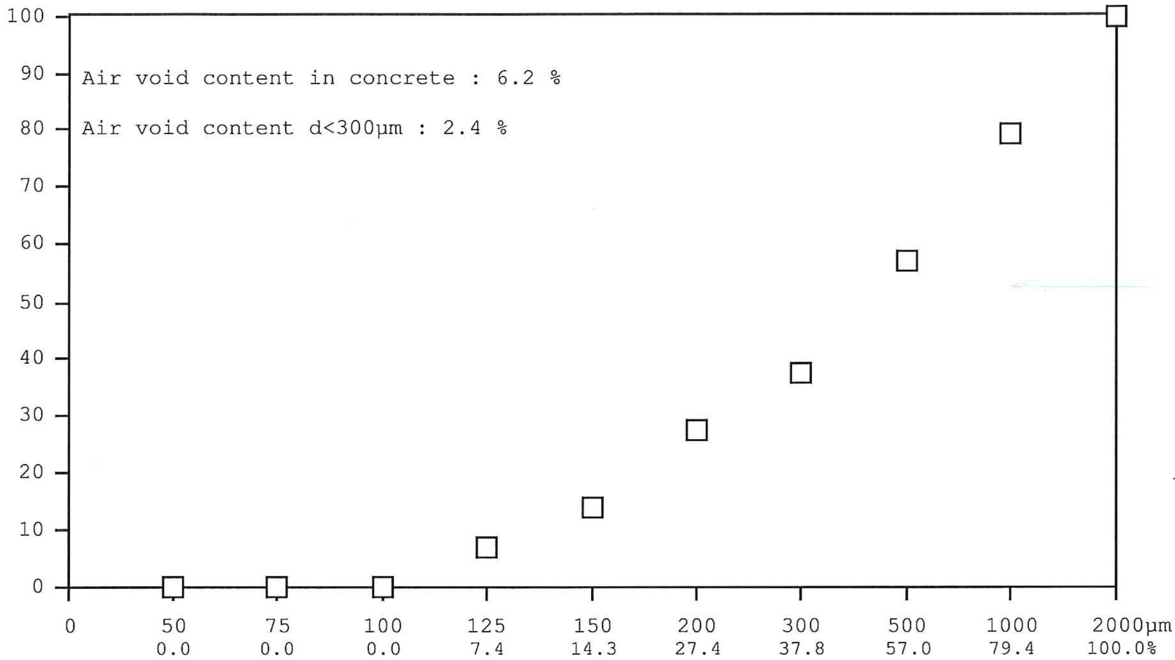
**AVA raw data**

# Air Void Analyzer AVA-3000
## Type Company name

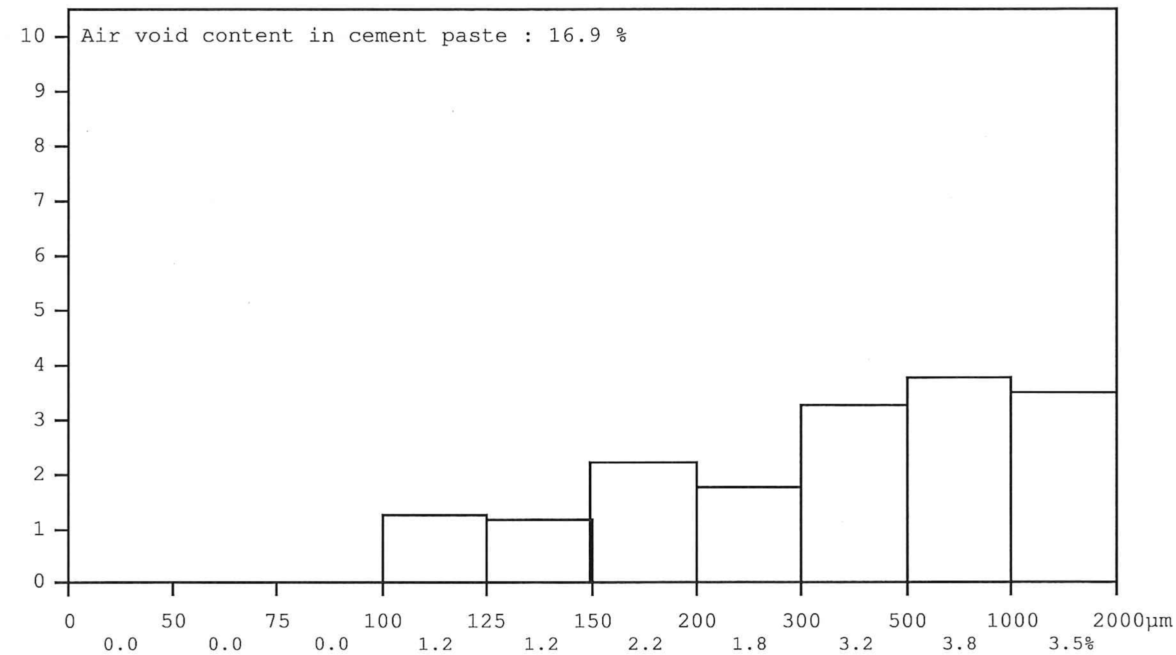
**Measurement of May 23, 2017 9:35 AM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



# Air Void Analyzer AVA-3000

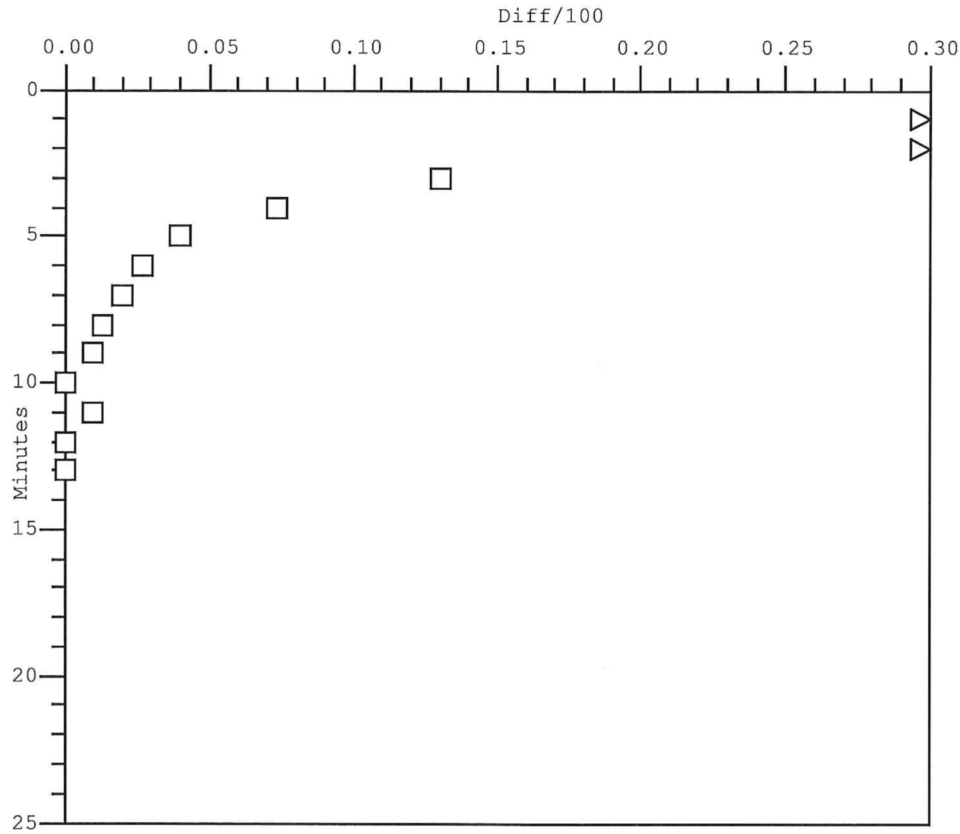
## Type Company name

### Measurement of May 23, 2017 9:35 AM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : o | Mortar<6mm | : 86.0 % |
| Sample location | : n | Expected air | : 8.4 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.01g +30sec.: 0.46g Temp: 23.4°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 69.7 | 0.58 | 0.71 | 0.80 | 23.9 |
| 31.0 | 0.96 | 1.01 | 1.05 | 23.8 |
| 13.0 | 1.11 | 1.14 | 1.16 | 23.8 |
| 7.3 | 1.20 | 1.21 | 1.22 | 23.8 |
| 4.0 | 1.24 | 1.25 | 1.26 | 23.8 |
| 2.7 | 1.27 | 1.28 | 1.28 | 23.8 |
| 2.0 | 1.29 | 1.30 | 1.30 | 23.8 |
| 1.3 | 1.31 | 1.31 | 1.31 | 23.8 |
| 1.0 | 1.32 | 1.32 | 1.32 | 23.8 |
| 0.0 | 1.32 | 1.32 | 1.32 | 23.7 |
| 1.0 | 1.33 | 1.33 | 1.33 | 23.8 |
| 0.0 | 1.33 | 1.33 | 1.33 | 23.7 |
| 0.0 | 1.33 | 1.33 | 1.33 | 23.8 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 6.2 % | 5.7 % | 3.8 % |
| Air-% paste | : 16.9 % | 15.4 % | 10.3 % |
| Air-%putty | : 14.5 % | 13.4 % | 8.8 % |
| Specific surface | : 20.4 mm-1 | 21.9 mm-1 | |
| Spacing factor | : 0.243 mm | 0.235 mm | |

### Comments

> AEA-SP
> Uten FA
> 8.5% med pressure meter
>

Sign.:______________________

AEA-SP 6

# Air Void Analyzer AVA-3000
## Type Company name

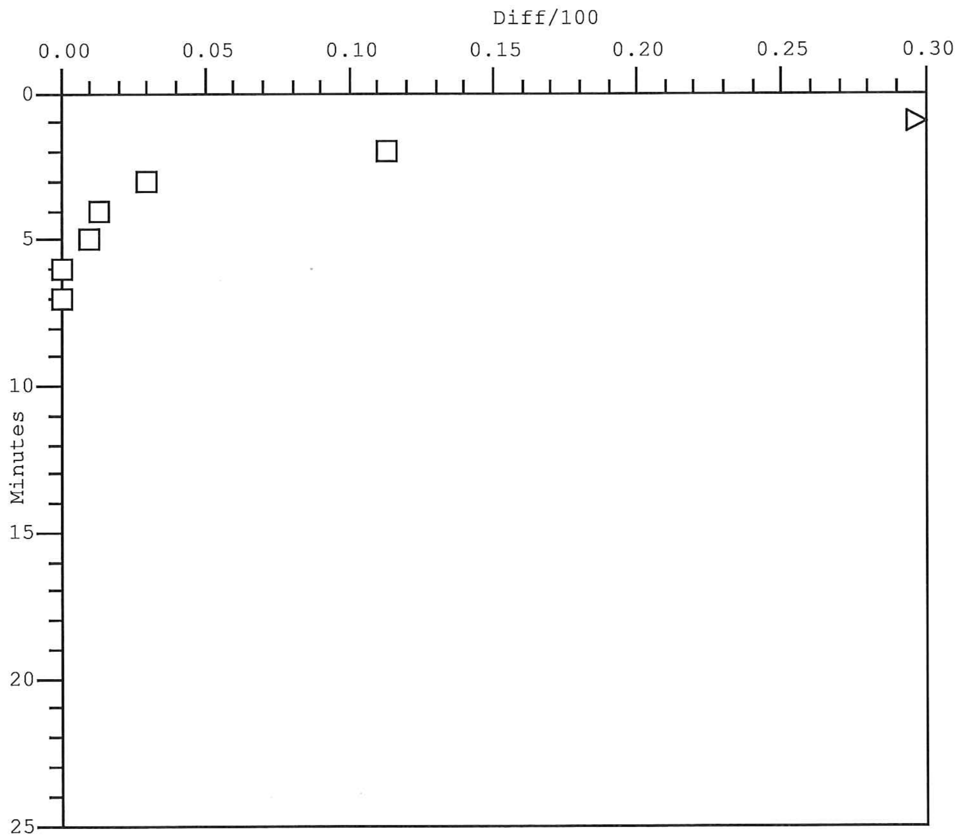
GI

**Measurement of May 2, 2017 1:37 PM**

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 7.5 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g    +5sec.: 0.1g    +30sec.: 0.85g    Temp: 22.8°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 98.3 | 0.92 | 1.00 | 1.03 | 23.6 |
| 11.3 | 1.08 | 1.10 | 1.11 | 23.7 |
| 3.0 | 1.12 | 1.13 | 1.13 | 23.7 |
| 1.3 | 1.14 | 1.14 | 1.14 | 23.7 |
| 1.0 | 1.15 | 1.15 | 1.15 | 23.7 |
| 0.0 | 1.15 | 1.15 | 1.15 | 23.7 |
| 0.0 | 1.15 | 1.15 | 1.15 | 23.7 |

**Results (adjusted to correlate with ASTM C457)**

| | | | | |
|---|---|---|---|---|
| Chord length | : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : | 5.2 % | 4.0 % | 1.4 % |
| Air-% paste | : | 14.0 % | 10.7 % | 3.8 % |
| Air-%putty | : | 12.3 % | 9.7 % | 3.4 % |
| Specific surface | : | 9.2 mm-1 | 10.6 mm-1 | |
| Spacing factor | : | 0.586 mm | 0.571 mm | |

**Comments**

> Cem2
> AEA-SP
> 45 min etter vann
>

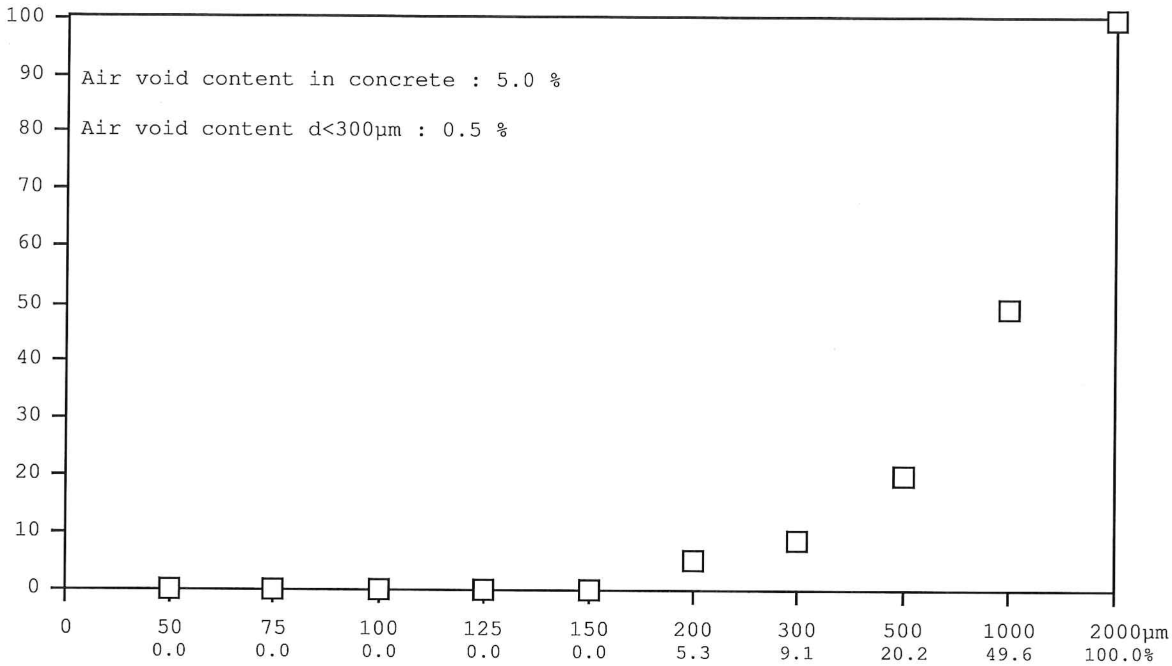
Sign.:____________________

# Air Void Analyzer AVA-3000
## Type Company name

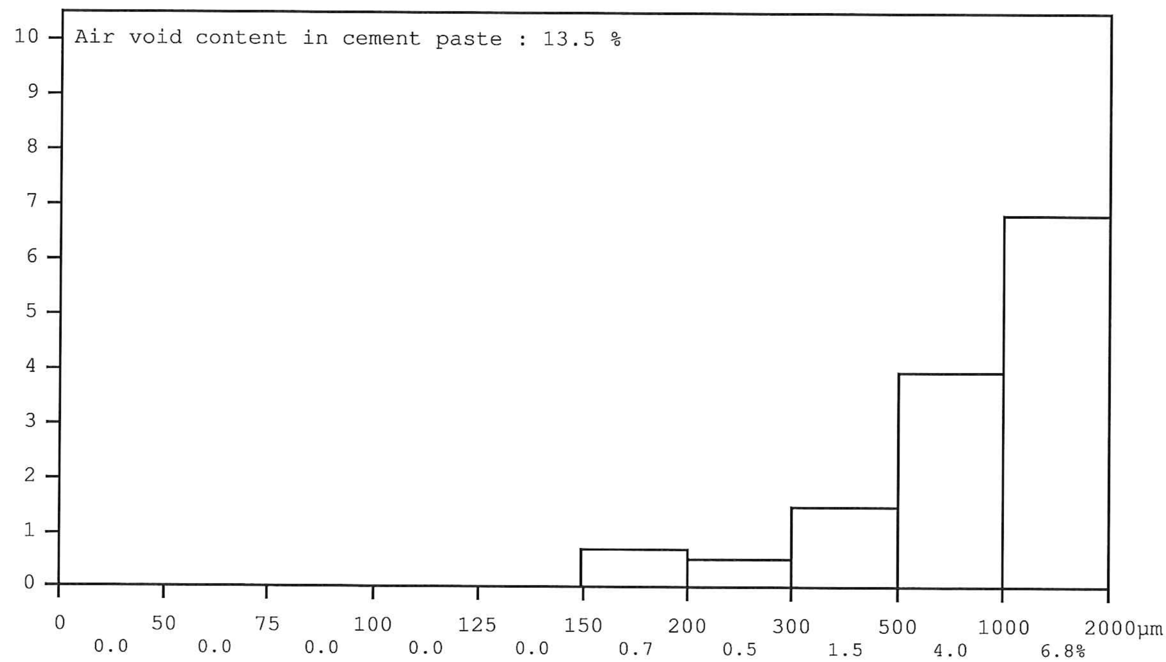
**Measurement of May 2, 2017 1:37 PM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



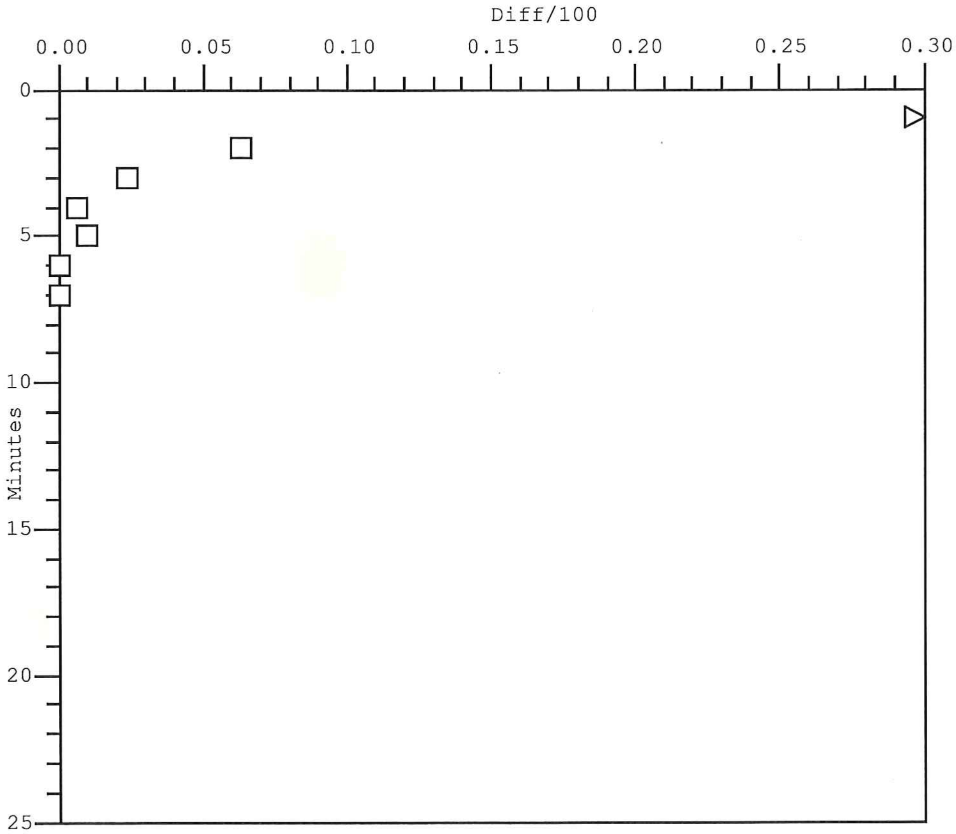
## Air Void Analyzer AVA-3000
## Type Company name

### Measurement of May 2, 2017 2:17 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 36.0 % |
| Sample location | : n | Expected air | : 7.5 % |
| Case number | : 2 | Paste | : 87.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g    +5sec.: 0.08g    +30sec.: 0.46g    Temp: 23.6°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 55.7 | 0.53 | 0.56 | 0.58 | 24.2 |
| 6.3 | 0.61 | 0.62 | 0.63 | 24.0 |
| 2.3 | 0.64 | 0.64 | 0.65 | 24.0 |
| 0.7 | 0.65 | 0.65 | 0.65 | 24.2 |
| 1.0 | 0.66 | 0.66 | 0.66 | 24.3 |
| 0.0 | 0.66 | 0.66 | 0.66 | 24.3 |
| 0.0 | 0.66 | 0.66 | 0.66 | 24.3 |

### Results (adjusted to correlate with ASTM C457)

| | | | |
|---|---|---|---|
| Chord length | : < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : 1.2 % | 1.0 % | 0.4 % |
| Air-% paste | : 1.3 % | 1.0 % | 0.4 % |
| Air-%putty | : 1.3 % | 1.0 % | 0.4 % |
| Specific surface | : 10.1 mm-1 | 11.6 mm-1 | |
| Spacing factor | : 1.436 mm | 1.369 mm | |

NOTE: Air-%Concrete <2mm out of range 3.5-10%

### Comments

> aea-sp
> cem2
> 2 maling
>

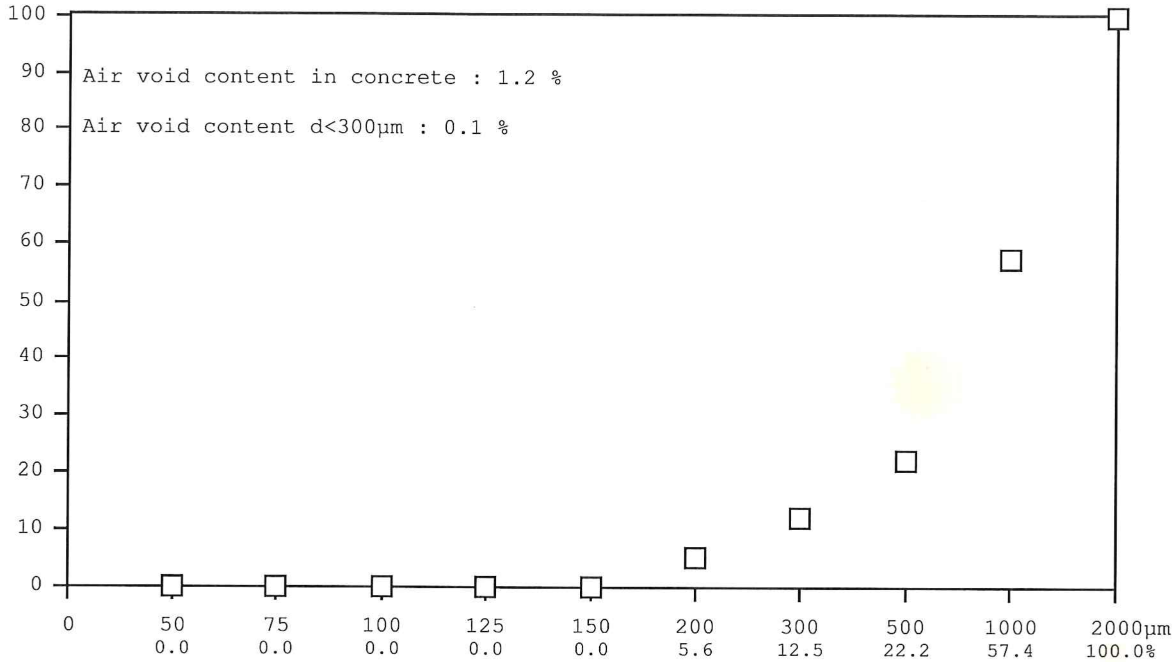
Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

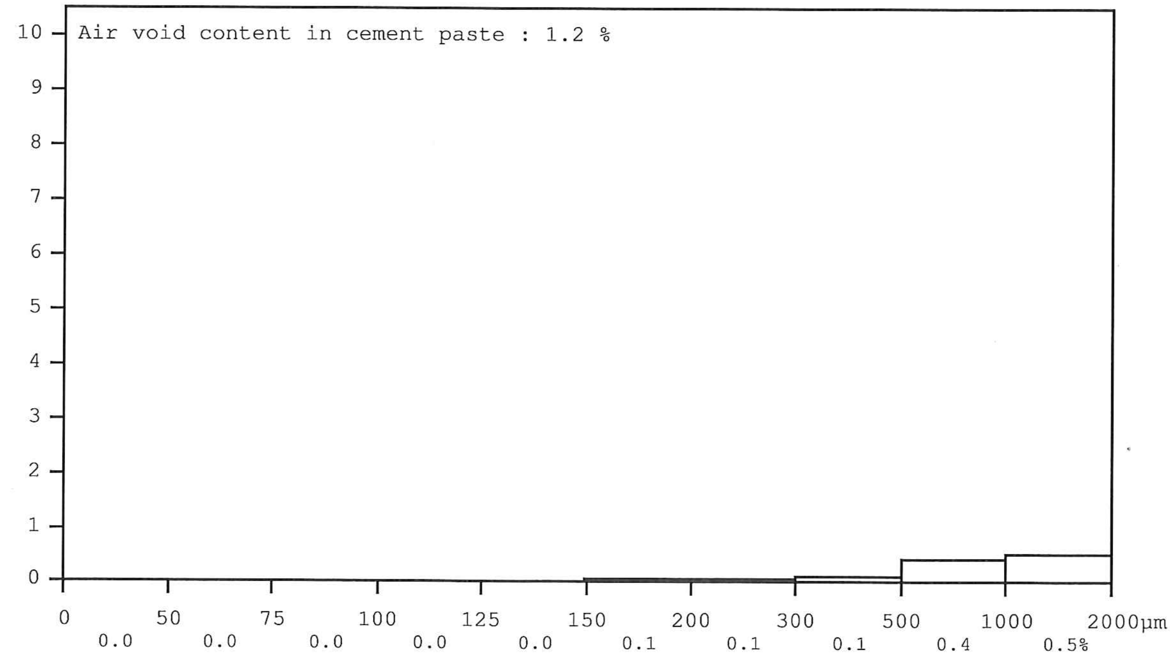
**Measurement of May 2, 2017 2:17 PM**

Case number   :   2
Sample number :   2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP-AEA 3

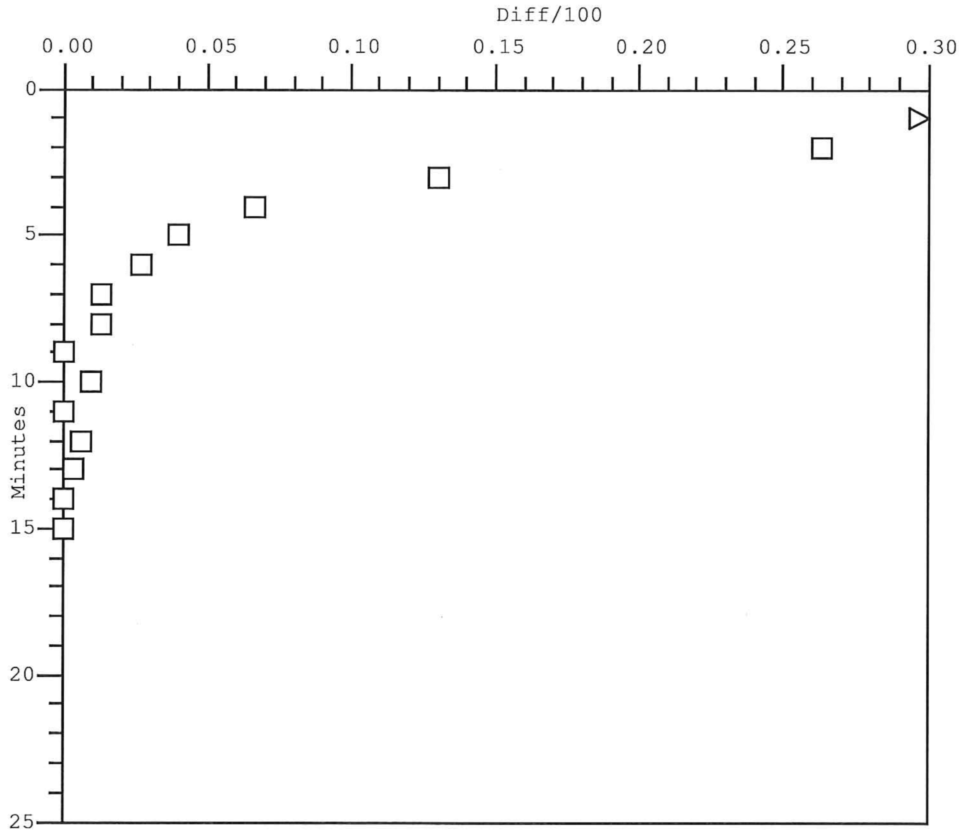
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of May 2, 2017 9:38 AM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 8.0 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.04g +30sec.: 0.17g Temp: 21.4°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 34.7 | 0.25 | 0.35 | 0.44 | 22.0 |
| 26.3 | 0.55 | 0.62 | 0.66 | 22.1 |
| 13.0 | 0.72 | 0.74 | 0.76 | 22.1 |
| 6.7 | 0.79 | 0.81 | 0.82 | 22.1 |
| 4.0 | 0.84 | 0.85 | 0.85 | 22.1 |
| 2.7 | 0.87 | 0.87 | 0.88 | 22.1 |
| 1.3 | 0.88 | 0.89 | 0.89 | 22.1 |
| 1.3 | 0.90 | 0.90 | 0.90 | 22.1 |
| 0.0 | 0.90 | 0.90 | 0.90 | 22.1 |
| 1.0 | 0.91 | 0.91 | 0.91 | 22.2 |
| 0.0 | 0.91 | 0.91 | 0.91 | 22.2 |
| 0.7 | 0.91 | 0.92 | 0.92 | 22.1 |
| 0.3 | 0.92 | 0.92 | 0.92 | 22.2 |
| 0.0 | 0.92 | 0.92 | 0.92 | 22.2 |
| 0.0 | 0.92 | 0.92 | 0.92 | 22.2 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 4.3 % | 4.1 % | 3.3 % |
| Air-% paste | : 11.4 % | 11.0 % | 8.7 % |
| Air-%putty | : 10.2 % | 9.9 % | 7.8 % |
| Specific surface | : 25.7 mm-1 | 26.6 mm-1 | |
| Spacing factor | : 0.229 mm | 0.225 mm | |

### Comments

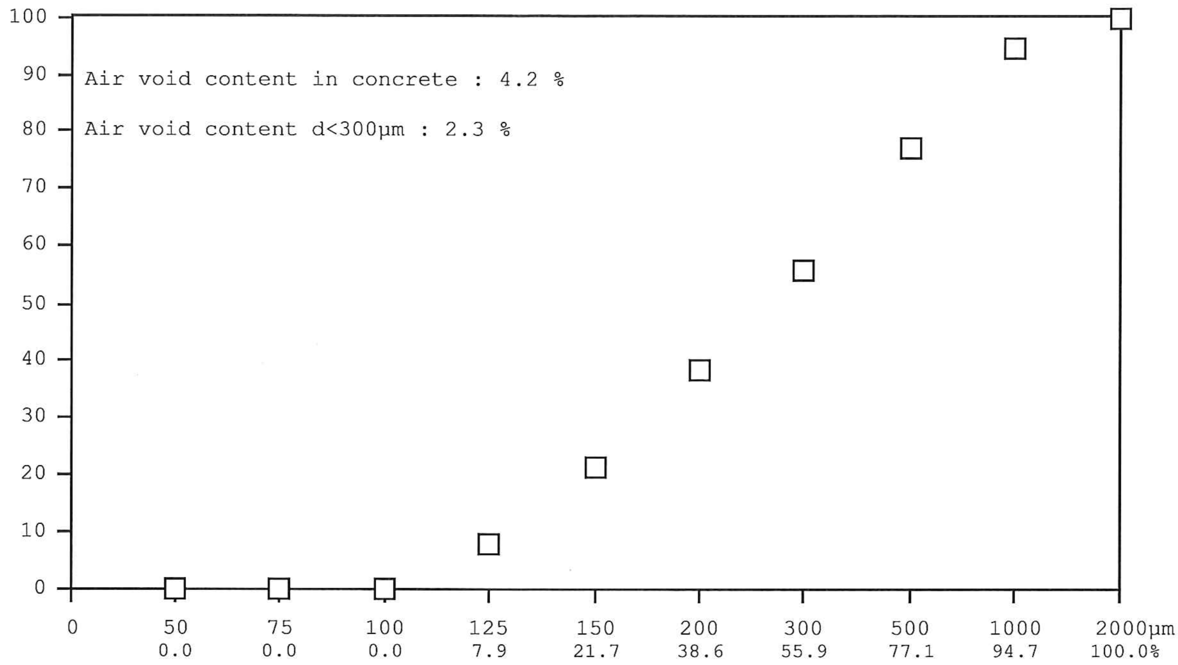
> Cem2
> SP-AEA
>
> Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

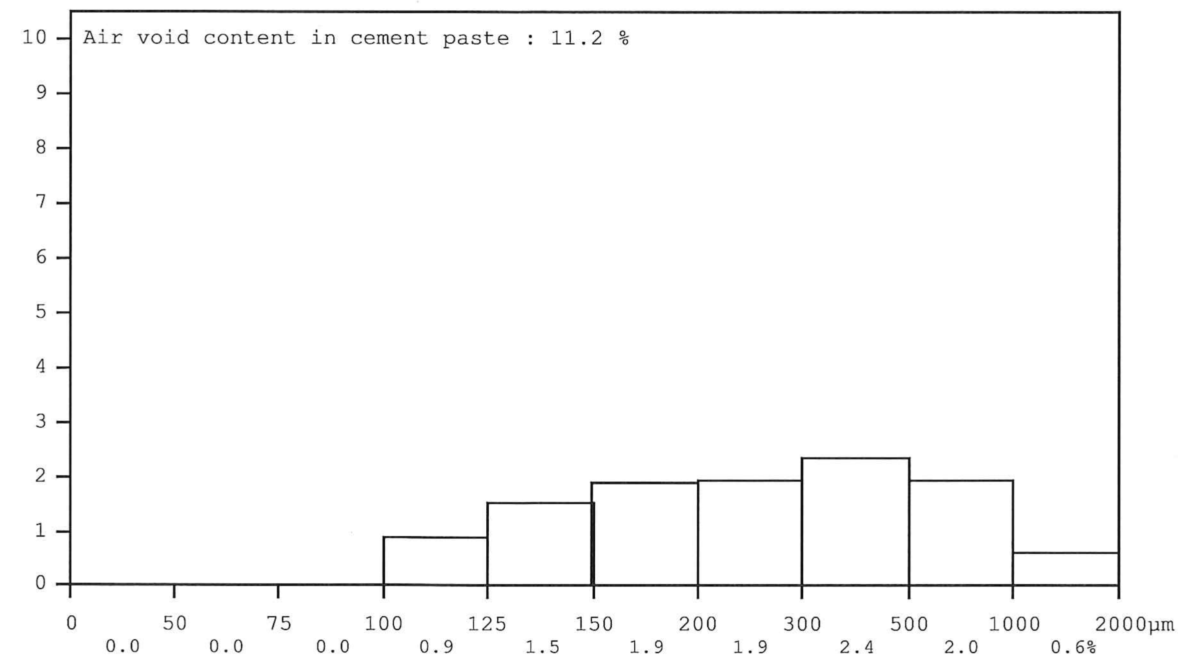
**Measurement of May 2, 2017 9:38 AM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP-AEA 3

# Air Void Analyzer AVA-3000
## Type Company name

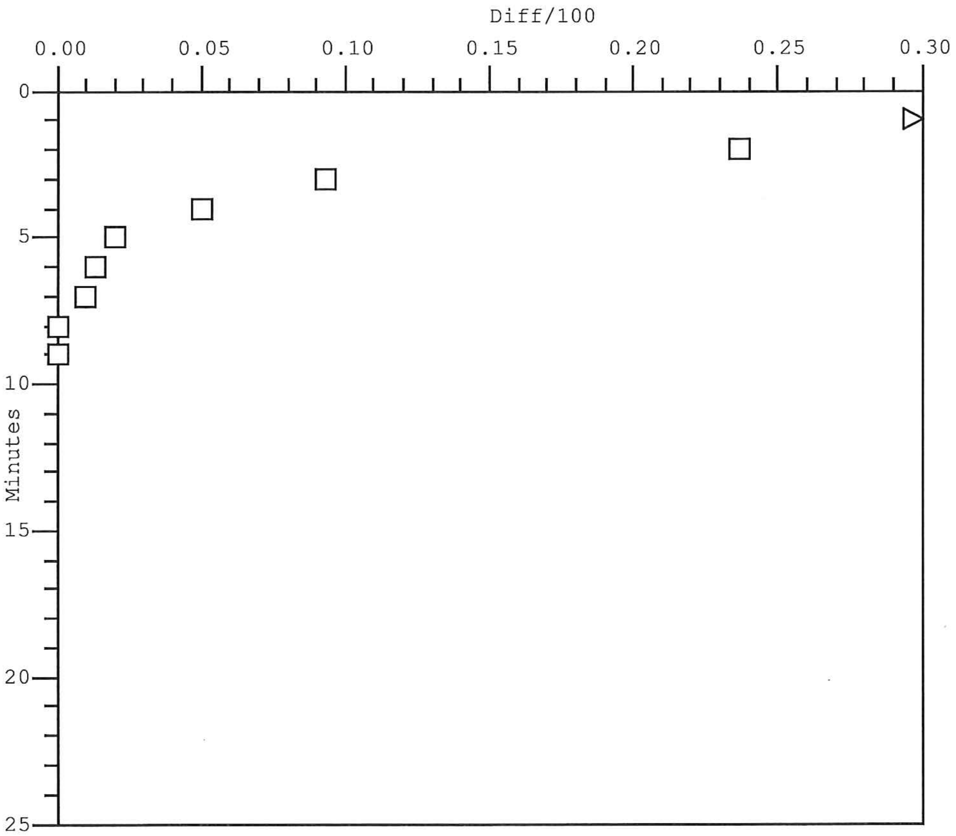
GI

**Measurement of May 2, 2017 10:25 AM**

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 8.0 % |
| Case number | : 2 | Paste | : 36.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.04g +30sec.: 0.61g Temp: 22.5°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 81.7 | 0.72 | 0.83 | 0.90 | 23.4 |
| 23.7 | 1.02 | 1.05 | 1.09 | 23.4 |
| 9.3 | 1.13 | 1.15 | 1.16 | 23.4 |
| 5.0 | 1.19 | 1.20 | 1.20 | 23.4 |
| 2.0 | 1.21 | 1.22 | 1.22 | 23.4 |
| 1.3 | 1.23 | 1.23 | 1.23 | 23.4 |
| 1.0 | 1.24 | 1.24 | 1.24 | 23.4 |
| 0.0 | 1.24 | 1.24 | 1.24 | 23.4 |
| 0.0 | 1.24 | 1.24 | 1.24 | 23.6 |

**Results (adjusted to correlate with ASTM C457)**

| Chord length | < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | 5.8 % | 5.0 % | 2.8 % |
| Air-% paste | 15.7 % | 13.5 % | 7.5 % |
| Air-%putty | 13.6 % | 11.9 % | 6.5 % |
| Specific surface | 15.3 mm-1 | 17.0 mm-1 | |
| Spacing factor | 0.335 mm | 0.321 mm | |

**Comments**

> Cem2
> SP-AEA
> 2. Maaling
>

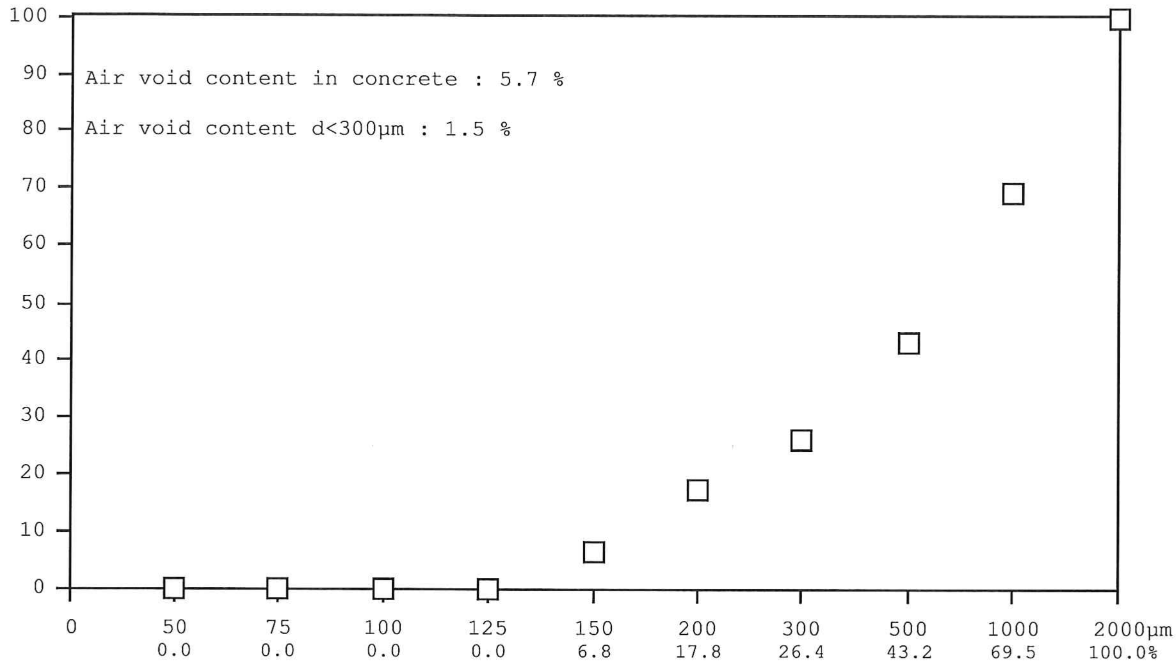
Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

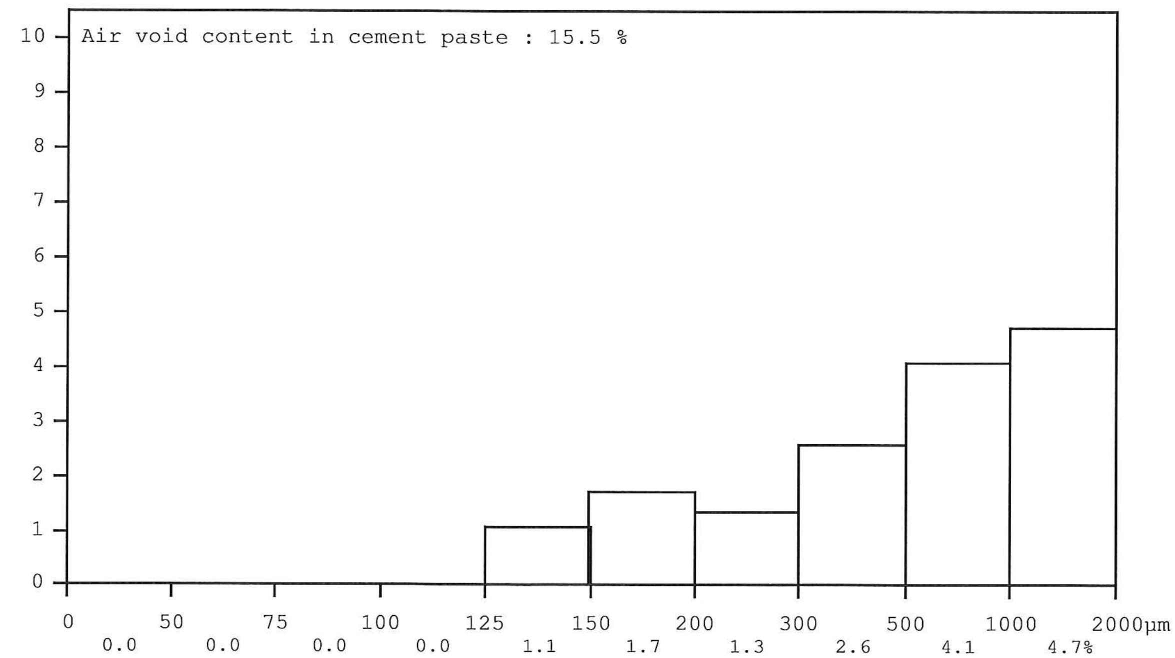
**Measurement of May 2, 2017 10:25 AM**

Case number   :   2
Sample number :   2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP-AEA 1

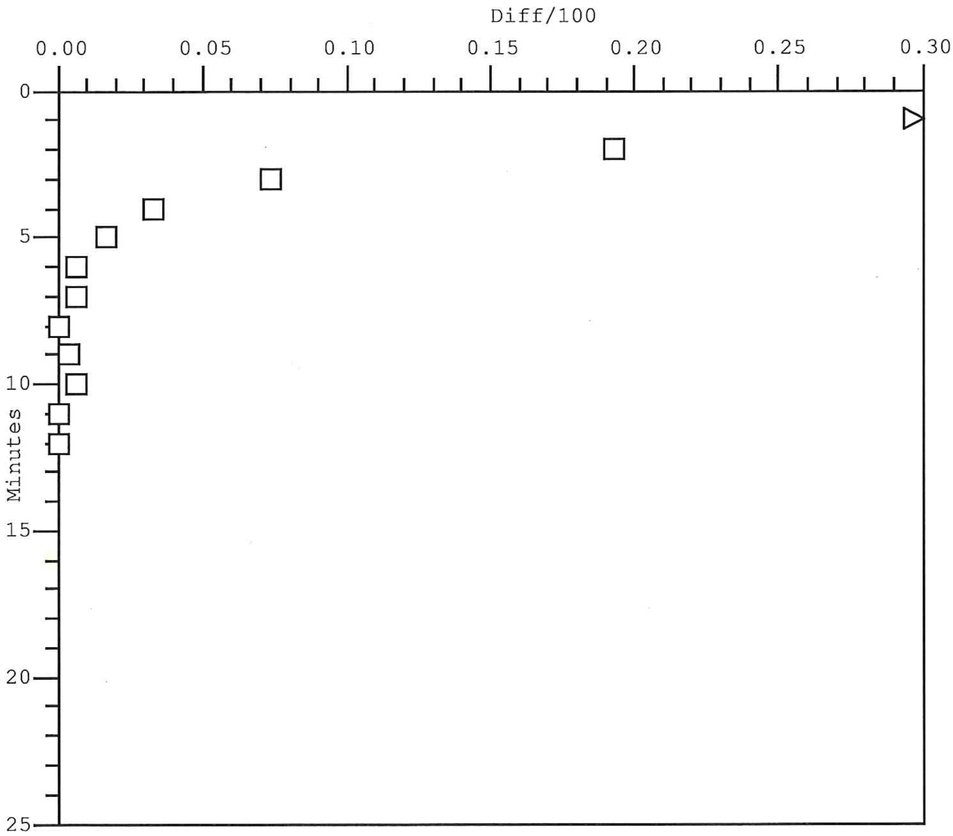
# Air Void Analyzer AVA-3000
## Type Company name

**Measurement of Apr 27, 2017 1:22 PM**

| | | | |
|---|---|---|---|
| Sampler | : ko | | |
| Ordered by | : a | Mortar<6mm | : 89.0 % |
| Sample location | : n | Expected air | : 6.0 % |
| Case number | : 1 | Paste | : 35.87 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.03g +30sec.: 0.21g Temp: 22.9°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 42.0 | 0.33 | 0.43 | 0.50 | 23.4 |
| 19.3 | 0.59 | 0.61 | 0.64 | 23.4 |
| 7.3 | 0.67 | 0.69 | 0.70 | 23.4 |
| 3.3 | 0.71 | 0.72 | 0.73 | 23.4 |
| 1.7 | 0.73 | 0.74 | 0.74 | 23.4 |
| 0.7 | 0.74 | 0.74 | 0.75 | 23.4 |
| 0.7 | 0.75 | 0.75 | 0.75 | 23.4 |
| 0.0 | 0.75 | 0.75 | 0.75 | 23.3 |
| 0.3 | 0.75 | 0.75 | 0.76 | 23.3 |
| 0.7 | 0.76 | 0.76 | 0.76 | 23.3 |
| 0.0 | 0.76 | 0.76 | 0.76 | 23.2 |
| 0.0 | 0.76 | 0.76 | 0.76 | 23.3 |

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 3.5 % | 3.4 % | 2.2 % |
| Air-% paste : | 9.6 % | 9.3 % | 6.1 % |
| Air-%putty : | 8.7 % | 8.5 % | 5.6 % |
| Specific surface : | 19.2 mm-1 | 19.8 mm-1 | |
| Spacing factor : | 0.333 mm | 0.328 mm | |

**Comments**

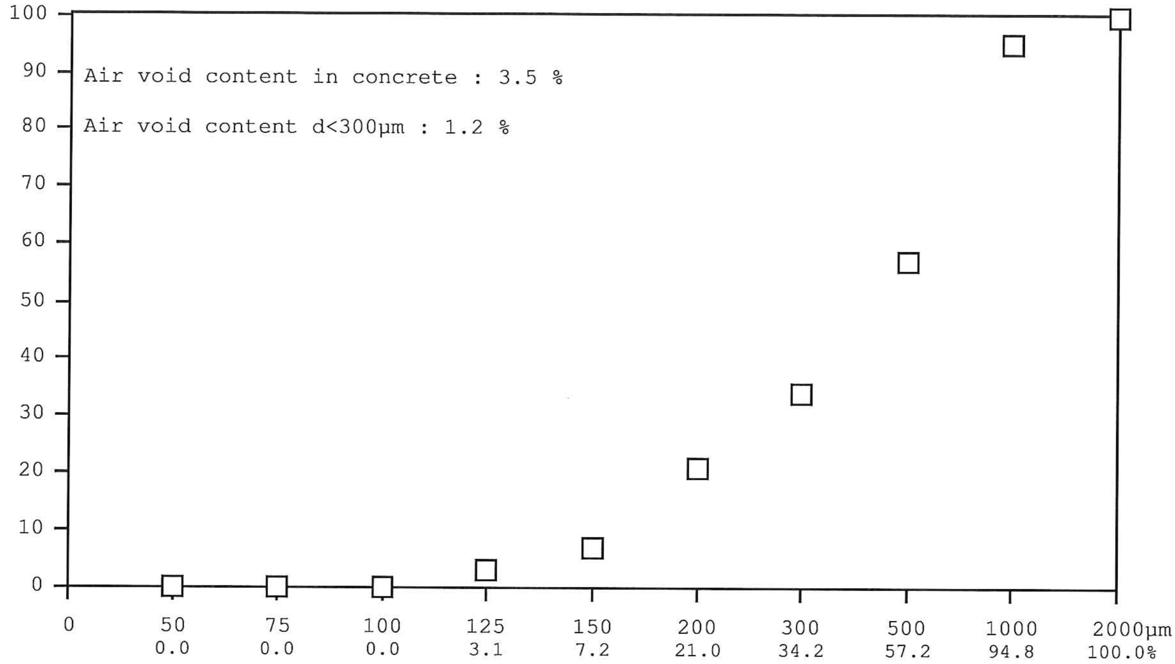
> sp-aea
> cem1
>
> Sign.:________________________

# Air Void Analyzer AVA-3000
## Type Company name

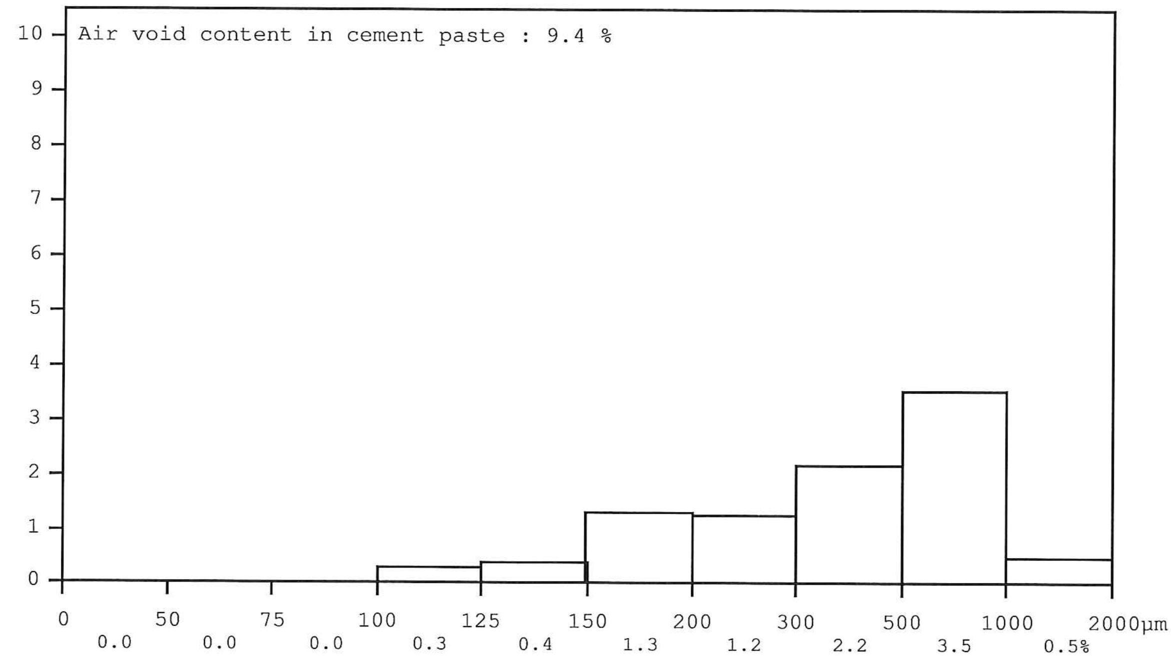
**Measurement of Apr 27, 2017 1:22 PM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SR-AEA 2

# Air Void Analyzer AVA-3000
## Type Company name

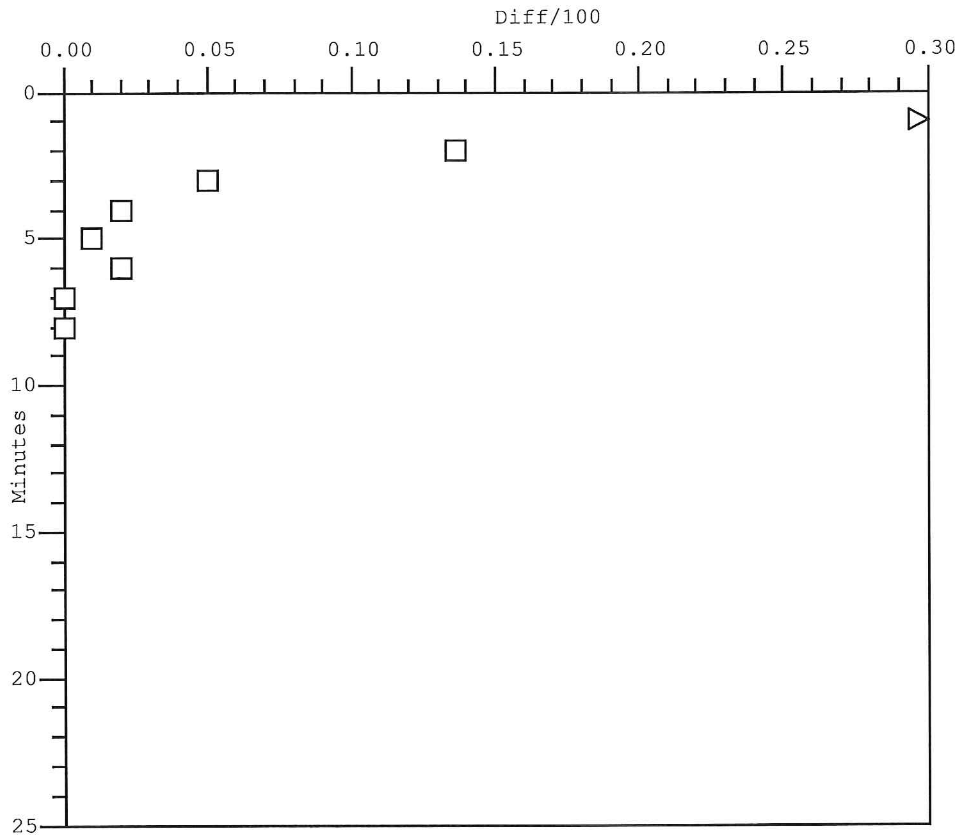
GI

**Measurement of Apr 18, 2017 12:21 PM**

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 4.4 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.05g +30sec.: 0.34g Temp: 23.1°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 53.3 | 0.47 | 0.54 | 0.59 | 23.3 |
| 13.7 | 0.65 | 0.67 | 0.69 | 23.2 |
| 5.0 | 0.71 | 0.72 | 0.73 | 23.3 |
| 2.0 | 0.74 | 0.74 | 0.74 | 23.2 |
| 1.0 | 0.75 | 0.75 | 0.75 | 23.2 |
| 2.0 | 0.77 | 0.77 | 0.77 | 23.2 |
| 0.0 | 0.77 | 0.77 | 0.77 | 23.1 |
| 0.0 | 0.77 | 0.77 | 0.77 | 23.1 |

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 3.4 % | 3.1 % | 1.7 % |
| Air-% paste : | 9.3 % | 8.5 % | 4.6 % |
| Air-%putty : | 8.5 % | 7.8 % | 4.3 % |
| Specific surface : | 15.4 mm-1 | 16.5 mm-1 | |
| Spacing factor : | 0.422 mm | 0.410 mm | |

NOTE: Air-%Concrete <2mm out of range 3.5-10%

**Comments**

> SP F;r AEA
> 0.7 % SP
> 0.8 % AEA
>

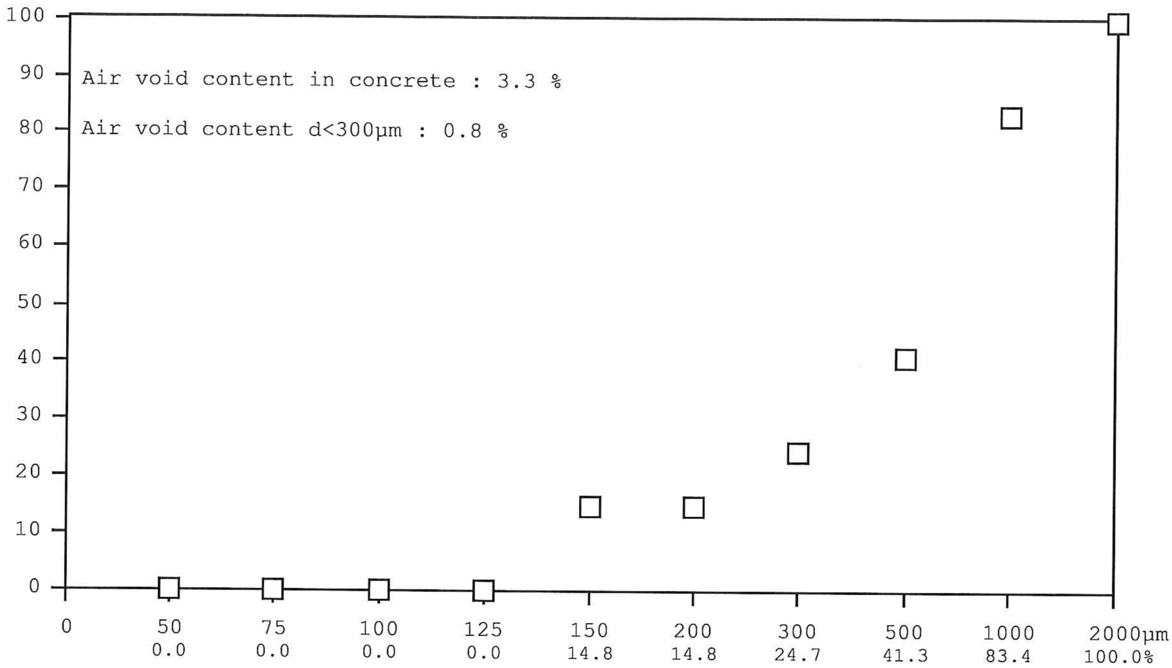
Sign.:______________________

Air Void Analyzer AVA-3000
Type Company name

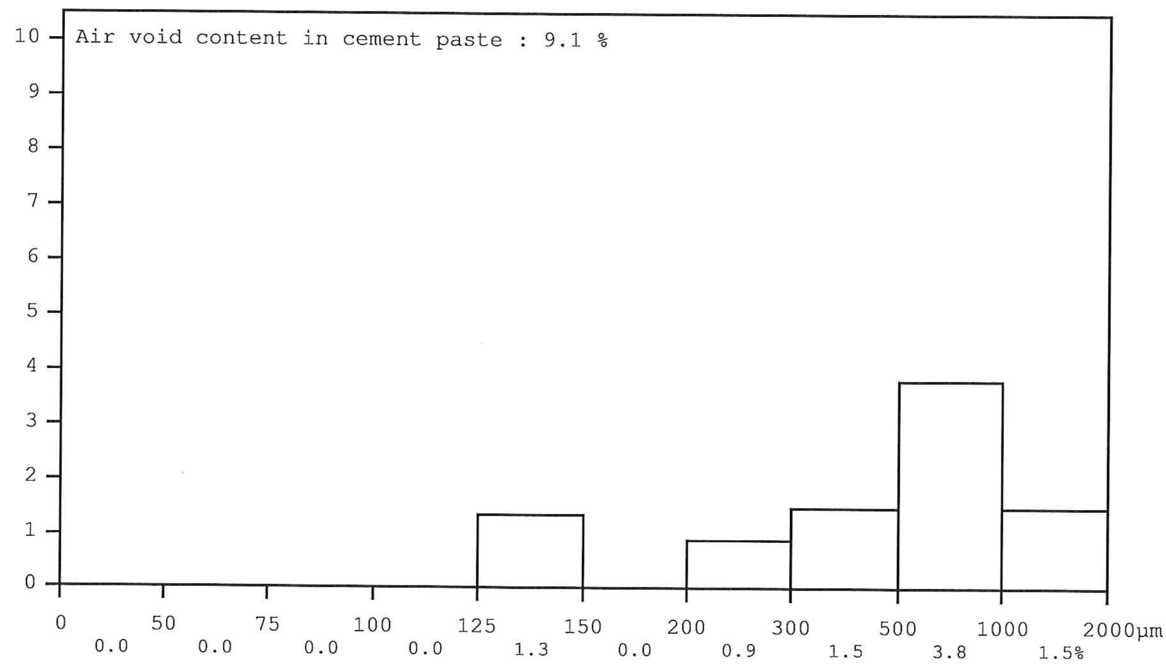
**Measurement of Apr 18, 2017 12:21 PM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP-ACA 2

# Air Void Analyzer AVA-3000
## Type Company name

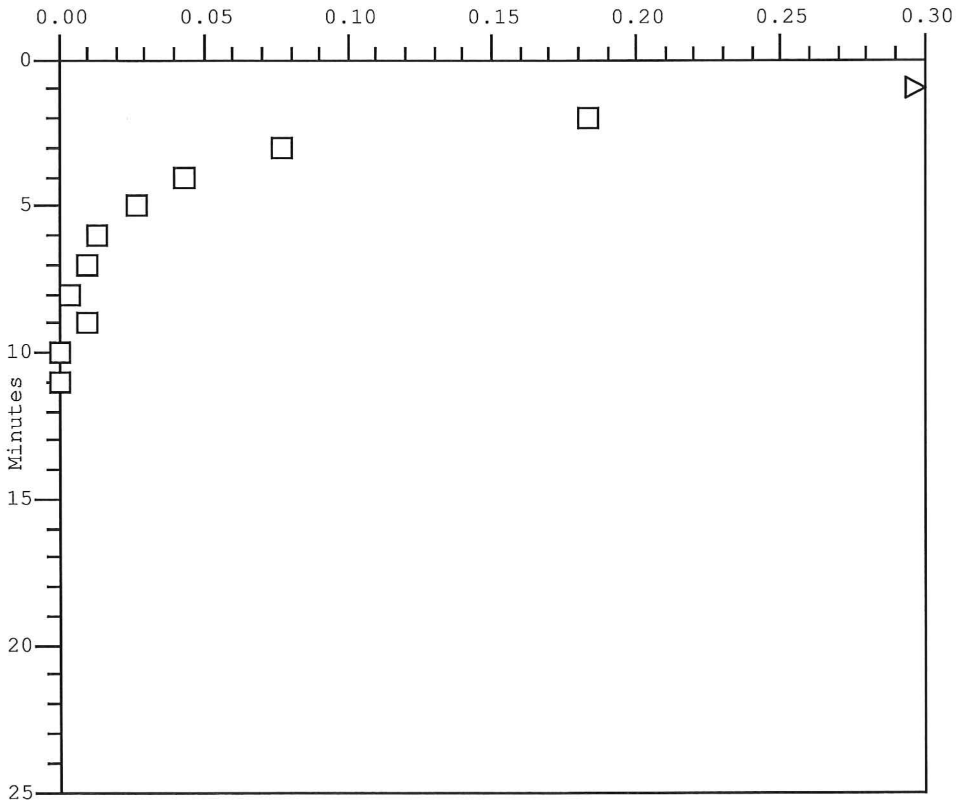
GI

### Measurement of Apr 18, 2017 12:59 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 4.7 % |
| Case number | : 2 | Paste | : 36.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.0g +30sec.: 0.53g Temp: 21.1°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 73.3 | 0.66 | 0.73 | 0.81 | 21.6 |
| 18.3 | 0.89 | 0.92 | 0.94 | 21.6 |
| 7.7 | 0.98 | 0.99 | 1.01 | 21.6 |
| 4.3 | 1.03 | 1.04 | 1.04 | 21.6 |
| 2.7 | 1.06 | 1.06 | 1.07 | 21.6 |
| 1.3 | 1.07 | 1.08 | 1.08 | 21.6 |
| 1.0 | 1.08 | 1.09 | 1.09 | 21.6 |
| 0.3 | 1.09 | 1.09 | 1.09 | 21.6 |
| 1.0 | 1.10 | 1.10 | 1.10 | 21.6 |
| 0.0 | 1.10 | 1.10 | 1.10 | 21.6 |
| 0.0 | 1.10 | 1.10 | 1.10 | 21.6 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 5.0 % | 4.4 % | 2.4 % |
| Air-% paste | : 14.1 % | 12.3 % | 6.7 % |
| Air-%putty | : 12.3 % | 11.0 % | 5.9 % |
| Specific surface | : 16.0 mm-1 | 17.6 mm-1 | |
| Spacing factor | : 0.339 mm | 0.328 mm | |

### Comments

> 40 min etter
>
>
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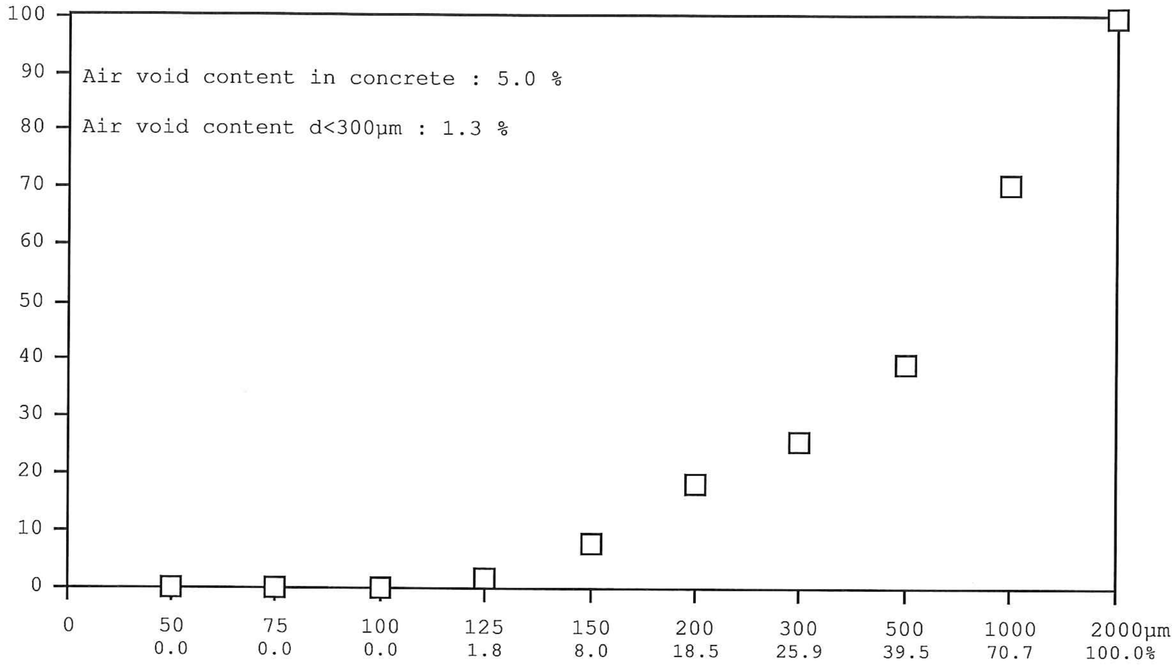
Sign.:______________________

**Air Void Analyzer AVA-3000**
**Type Company name**

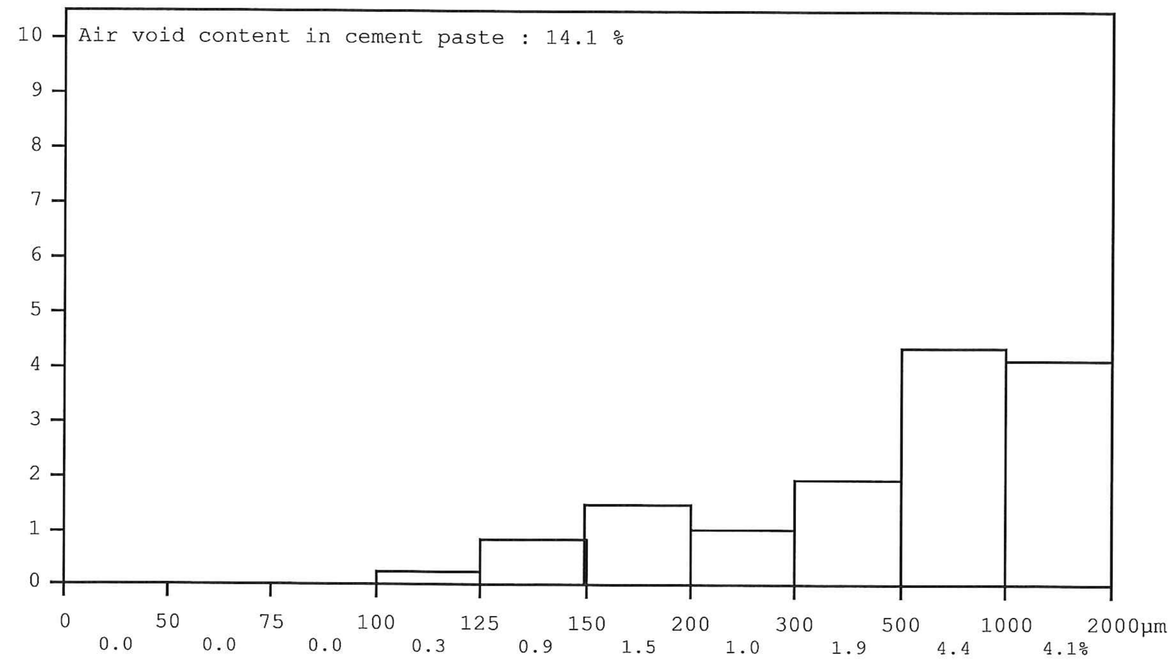
**Measurement of Apr 18, 2017 12:59 PM**

Case number : 2
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP+AEA 2

# Air Void Analyzer AVA-3000
## Type Company name

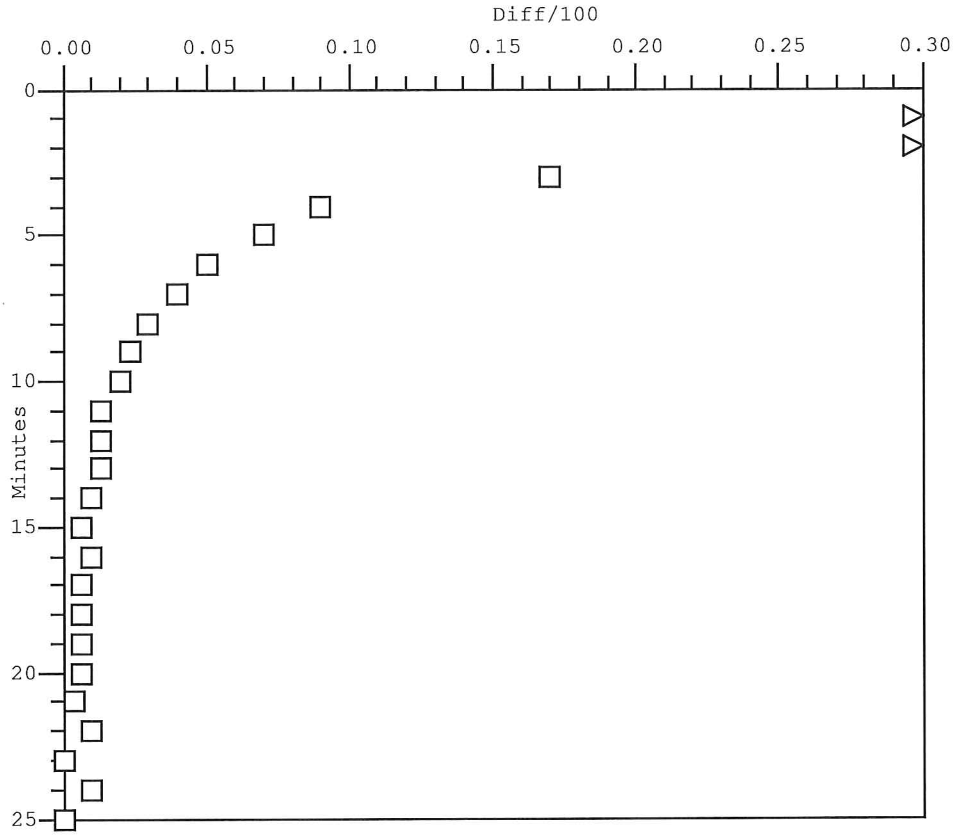
GI

**Measurement of Mar 9, 2017 12:13 PM**

| | | | | |
|---|---|---|---|---|
| Sampler | : o | | | |
| Ordered by | : a | Mortar<6mm | : | 36.0 % |
| Sample location | : n | Expected air | : | 6.0 % |
| Case number | : 2 | Paste | : | 87.0 % |
| Sample number | : 2 | Sample volume | : | 20.0 cm3 |

**Analysis**

Start: 0.0g    +5sec.: 0.1g    +30sec.: 1.23g    Temp: 21.8°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 175.7 | 1.57 | 1.77 | 1.93 | 22.5 |
| 41.3 | 2.11 | 2.17 | 2.23 | 22.5 |
| 17.0 | 2.31 | 2.34 | 2.37 | 22.5 |
| 9.0 | 2.41 | 2.43 | 2.45 | 22.5 |
| 7.0 | 2.48 | 2.50 | 2.52 | 22.6 |
| 5.0 | 2.54 | 2.55 | 2.56 | 22.6 |
| 4.0 | 2.58 | 2.59 | 2.60 | 22.6 |
| 3.0 | 2.61 | 2.62 | 2.63 | 22.7 |
| 2.3 | 2.64 | 2.64 | 2.65 | 22.7 |
| 2.0 | 2.66 | 2.66 | 2.67 | 22.7 |
| 1.3 | 2.67 | 2.68 | 2.68 | 22.7 |
| 1.3 | 2.69 | 2.69 | 2.69 | 22.7 |
| 1.3 | 2.70 | 2.70 | 2.71 | 22.7 |
| 1.0 | 2.71 | 2.71 | 2.72 | 22.7 |
| 0.7 | 2.72 | 2.72 | 2.72 | 22.8 |
| 1.0 | 2.73 | 2.73 | 2.73 | 22.7 |
| 0.7 | 2.73 | 2.74 | 2.74 | 22.7 |
| 0.7 | 2.74 | 2.74 | 2.75 | 22.7 |
| 0.7 | 2.75 | 2.75 | 2.75 | 22.7 |
| 0.7 | 2.75 | 2.76 | 2.76 | 22.7 |
| 0.3 | 2.76 | 2.76 | 2.76 | 22.7 |
| 1.0 | 2.77 | 2.77 | 2.77 | 22.7 |
| 0.0 | 2.77 | 2.77 | 2.77 | 22.7 |
| 1.0 | 2.78 | 2.78 | 2.78 | 22.7 |
| 0.0 | 2.78 | 2.78 | 2.78 | 22.7 |

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 5.7 % | 5.1 % | 3.0 % |
| Air-% paste : | 6.5 % | 5.8 % | 3.4 % |
| Air-%putty : | 6.1 % | 5.5 % | 3.2 % |
| Specific surface : | 20.4 mm-1 | 22.3 mm-1 | |
| Spacing factor : | 0.373 mm | 0.358 mm | |

**Comments**

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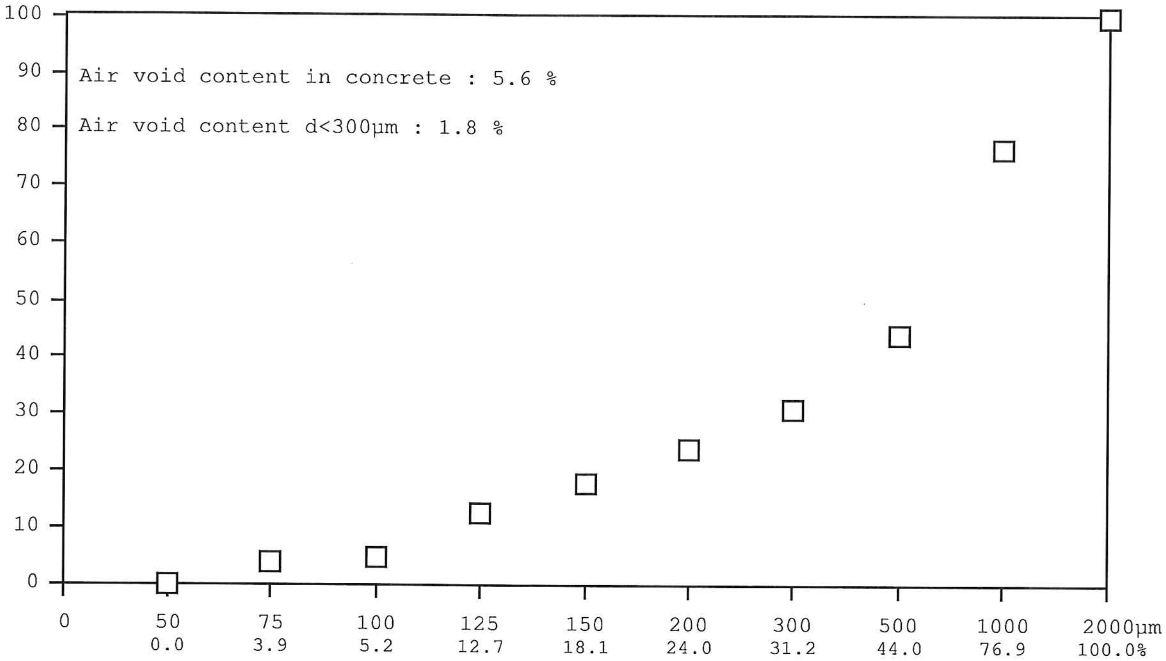
Sign.:________________

# Air Void Analyzer AVA-3000
## Type Company name

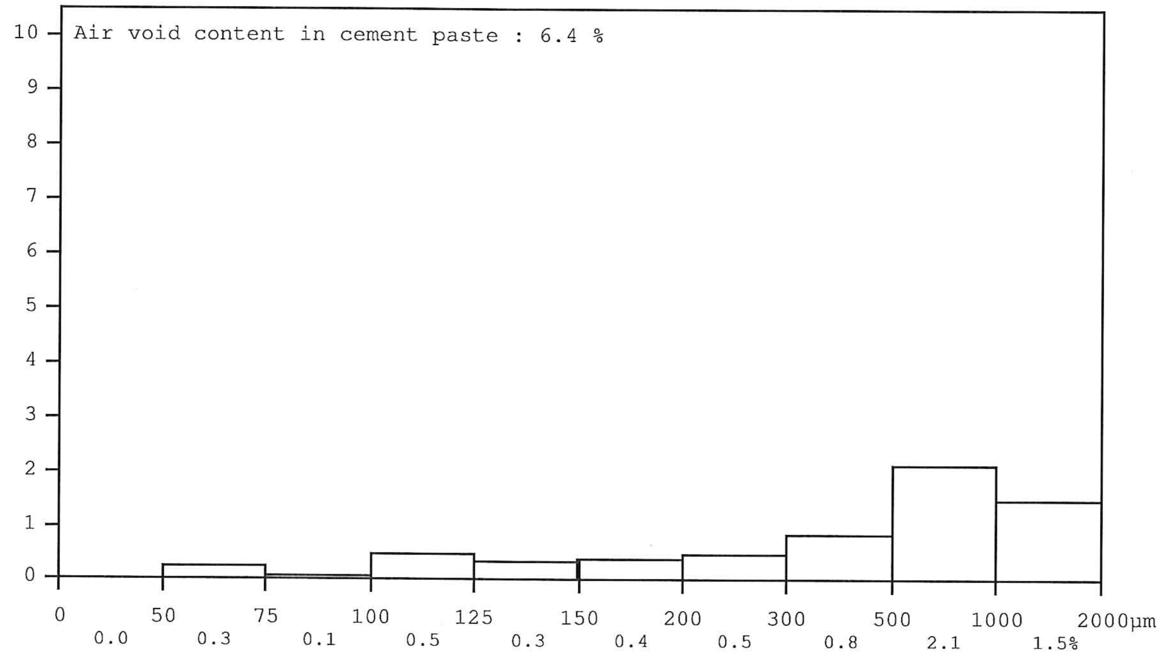
**Measurement of Mar 9, 2017 12:13 PM**

Case number : 2
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP+AEA 2

# Air Void Analyzer AVA-3000
## Type Company name

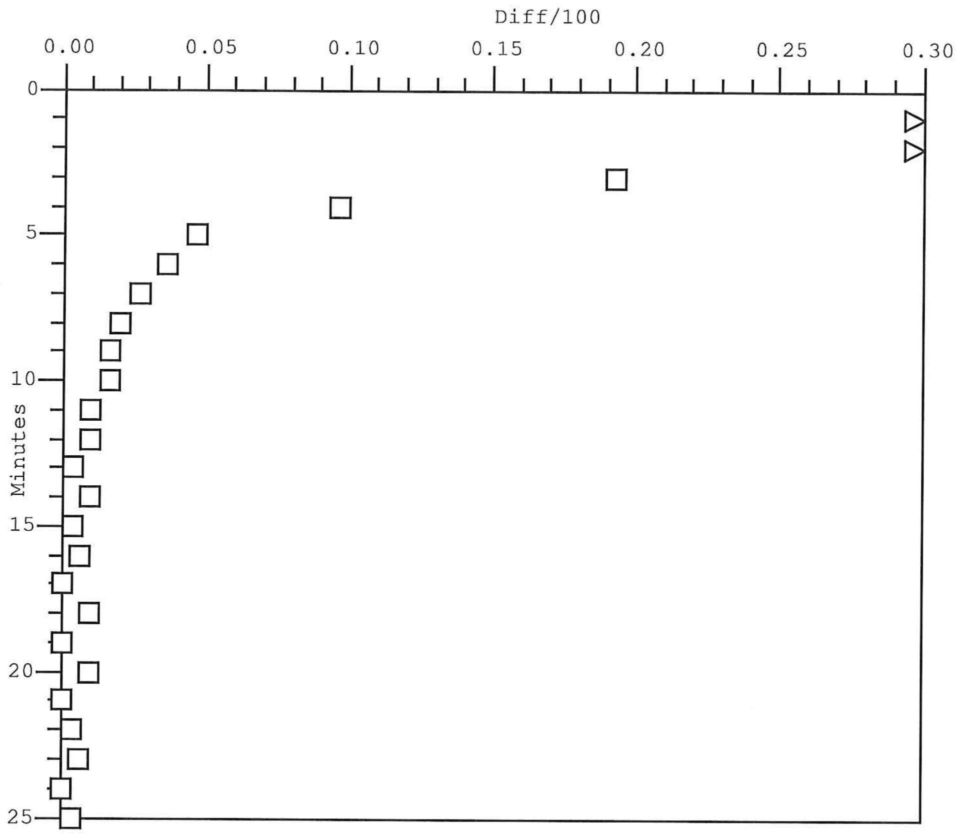
GI

**Measurement of Mar 9, 2017 12:50 PM**

| | | | | |
|---|---|---|---|---|
| Sampler | : o | | | |
| Ordered by | : a | Mortar<6mm | : | 36.0 % |
| Sample location | : n | Expected air | : | 6.0 % |
| Case number | : 2 | Paste | : | 87.0 % |
| Sample number | : 2 | Sample volume | : | 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.16g +30sec.: 1.47g Temp: 22.3°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 201.0 | 1.82 | 2.03 | 2.18 | 23.7 |
| 44.3 | 2.38 | 2.46 | 2.52 | 23.6 |
| 19.3 | 2.61 | 2.65 | 2.68 | 23.7 |
| 9.7 | 2.73 | 2.74 | 2.76 | 23.7 |
| 4.7 | 2.78 | 2.79 | 2.80 | 23.7 |
| 3.7 | 2.82 | 2.83 | 2.83 | 23.7 |
| 2.7 | 2.85 | 2.85 | 2.86 | 23.6 |
| 2.0 | 2.87 | 2.87 | 2.88 | 23.6 |
| 1.7 | 2.89 | 2.89 | 2.89 | 23.6 |
| 1.7 | 2.90 | 2.91 | 2.91 | 23.4 |
| 1.0 | 2.91 | 2.92 | 2.92 | 23.4 |
| 1.0 | 2.92 | 2.93 | 2.93 | 23.4 |
| 0.3 | 2.93 | 2.93 | 2.93 | 23.3 |
| 1.0 | 2.94 | 2.94 | 2.94 | 23.3 |
| 0.3 | 2.94 | 2.94 | 2.95 | 23.3 |
| 0.7 | 2.95 | 2.95 | 2.95 | 23.3 |
| 0.0 | 2.95 | 2.95 | 2.95 | 23.2 |
| 1.0 | 2.96 | 2.96 | 2.96 | 23.2 |
| 0.0 | 2.96 | 2.96 | 2.96 | 23.2 |
| 1.0 | 2.97 | 2.97 | 2.97 | 23.2 |
| 0.0 | 2.97 | 2.97 | 2.97 | 23.2 |
| 0.3 | 2.97 | 2.97 | 2.98 | 23.2 |
| 0.7 | 2.98 | 2.98 | 2.98 | 23.2 |
| 0.0 | 2.98 | 2.98 | 2.98 | 23.2 |
| 0.3 | 2.98 | 2.98 | 2.99 | 23.1 |

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 6.1 % | 5.4 % | 2.9 % |
| Air-% paste : | 7.0 % | 6.1 % | 3.4 % |
| Air-%putty : | 6.6 % | 5.8 % | 3.2 % |
| Specific surface : | 18.2 mm-1 | 20.3 mm-1 | |
| Spacing factor : | 0.406 mm | 0.387 mm | |

**Comments**

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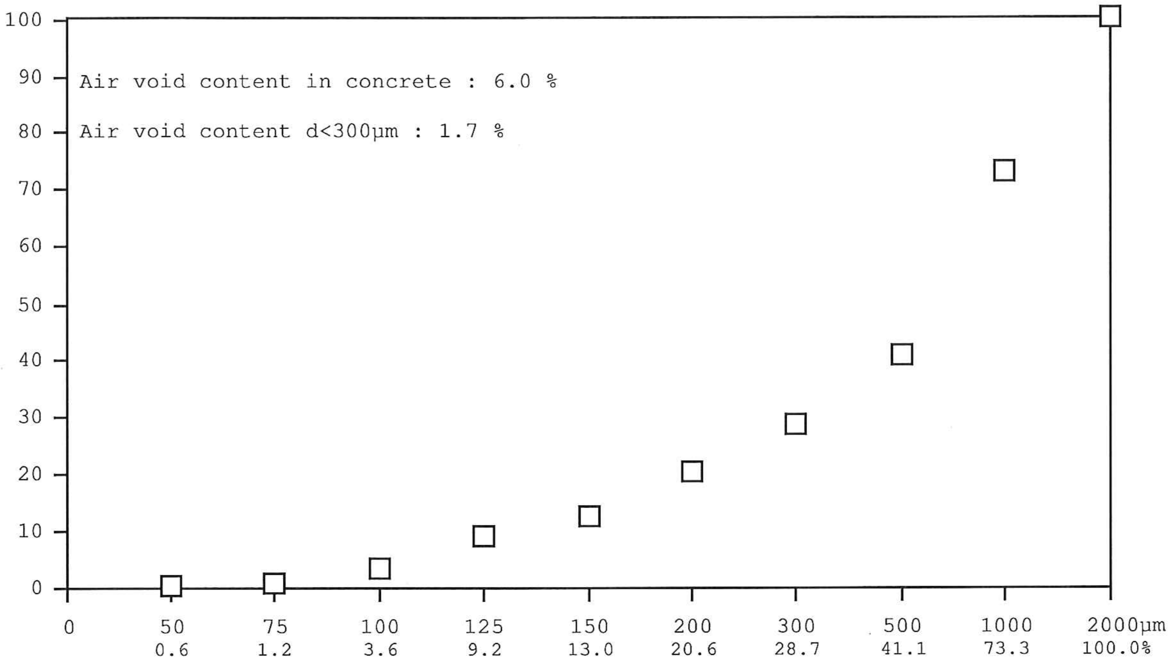
Sign.:________________________

Air Void Analyzer AVA-3000
Type Company name

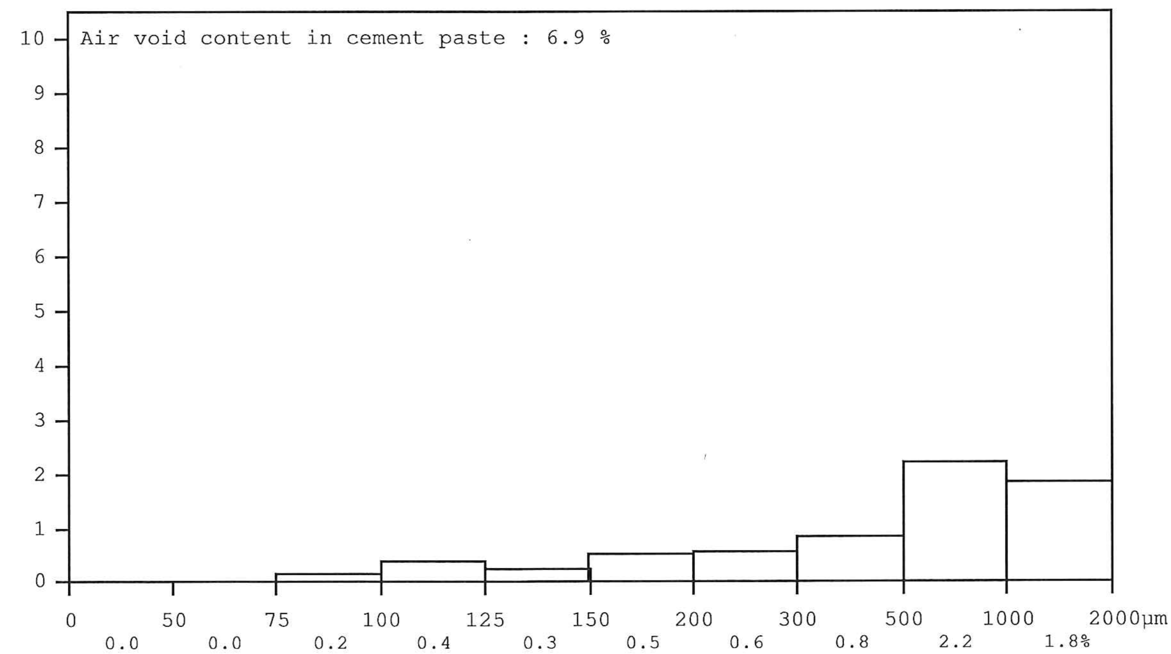
**Measurement of Mar 9, 2017 12:50 PM**

Case number : 2
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



SP+AEA 2

# Air Void Analyzer AVA-3000
## Type Company name

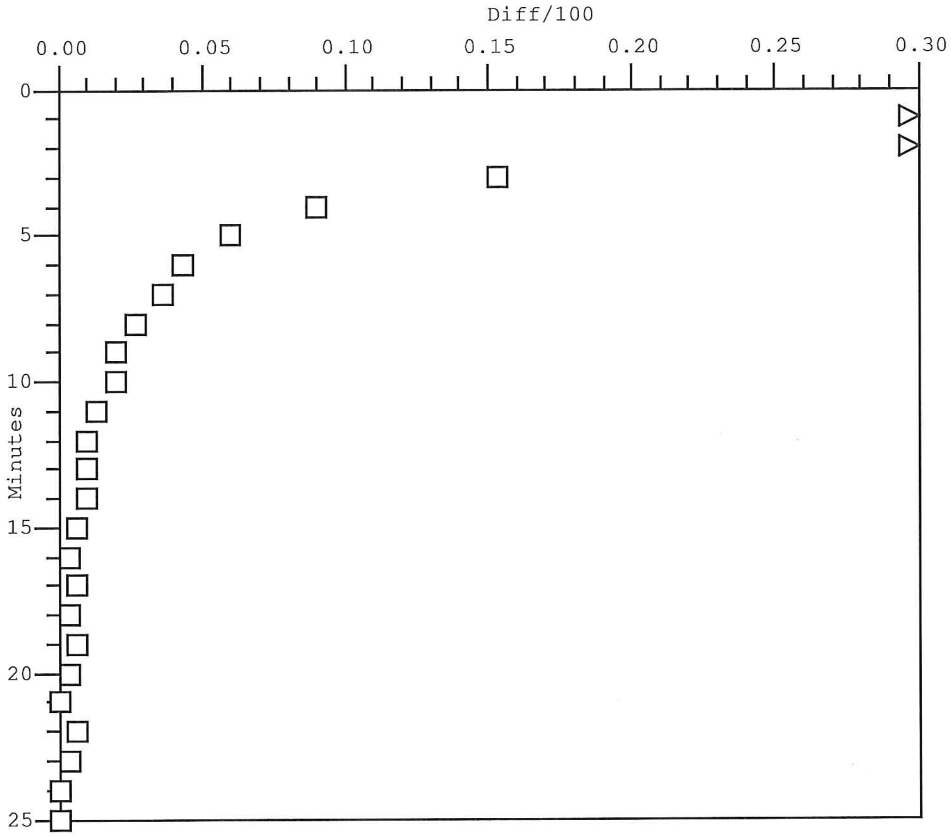
**Measurement of Mar 9, 2017 1:26 PM**

Sampler : o
Ordered by : a
Sample location : n
Case number : 2
Sample number : 3

Mortar<6mm : 87.0 %
Expected air : 6.0 %
Paste : 36.0 %
Sample volume : 20.0 cm3

**Analysis**

Start: 0.0g +5sec.: 0.09g +30sec.: 1.2g Temp: 21.8°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 174.3 | 1.57 | 1.76 | 1.90 | 23.1 |
| 37.3 | 2.06 | 2.12 | 2.17 | 22.9 |
| 15.3 | 2.24 | 2.27 | 2.30 | 22.8 |
| 9.0 | 2.34 | 2.36 | 2.38 | 22.8 |
| 6.0 | 2.41 | 2.42 | 2.43 | 22.8 |
| 4.3 | 2.45 | 2.46 | 2.48 | 22.7 |
| 3.7 | 2.49 | 2.50 | 2.51 | 22.7 |
| 2.7 | 2.52 | 2.53 | 2.53 | 22.6 |
| 2.0 | 2.54 | 2.55 | 2.55 | 22.7 |
| 2.0 | 2.56 | 2.57 | 2.57 | 22.6 |
| 1.3 | 2.58 | 2.58 | 2.58 | 22.6 |
| 1.0 | 2.59 | 2.59 | 2.59 | 22.5 |
| 1.0 | 2.60 | 2.60 | 2.60 | 22.6 |
| 1.0 | 2.61 | 2.61 | 2.61 | 22.6 |
| 0.7 | 2.61 | 2.62 | 2.62 | 22.5 |
| 0.3 | 2.62 | 2.62 | 2.62 | 22.5 |
| 0.7 | 2.62 | 2.63 | 2.63 | 22.5 |
| 0.3 | 2.63 | 2.63 | 2.63 | 22.5 |
| 0.7 | 2.63 | 2.64 | 2.64 | 22.5 |
| 0.3 | 2.64 | 2.64 | 2.64 | 22.3 |
| 0.0 | 2.64 | 2.64 | 2.64 | 22.3 |
| 0.7 | 2.64 | 2.65 | 2.65 | 22.3 |
| 0.3 | 2.65 | 2.65 | 2.65 | 22.3 |
| 0.0 | 2.65 | 2.65 | 2.65 | 22.3 |
| 0.0 | 2.65 | 2.65 | 2.65 | 22.3 |

**Results (adjusted to correlate with ASTM C457)**

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 12.2 % | 11.0 % | 6.1 % |
| Air-% paste | : 36.2 % | 32.4 % | 18.3 % |
| Air-%putty | : 26.6 % | 24.5 % | 13.4 % |
| Specific surface | : 19.2 mm-1 | 20.9 mm-1 | |
| Spacing factor | : 0.154 mm | 0.156 mm | |

NOTE: Air-%Concrete <2mm out of range 3.5-10%

**Comments**

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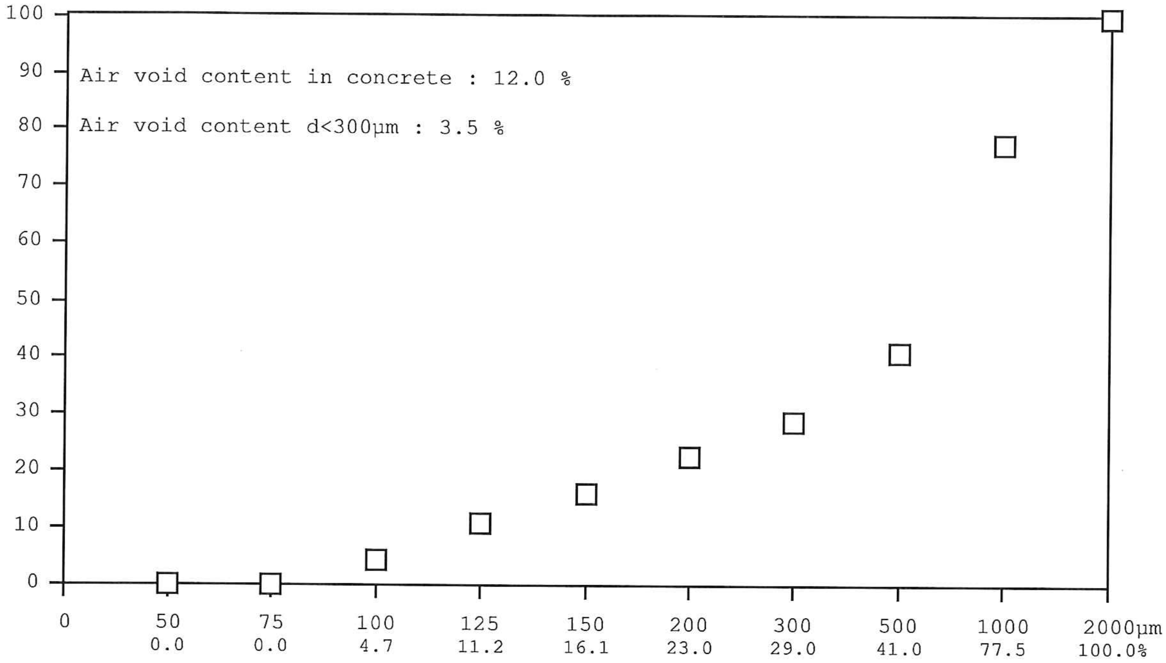
Sign.:______________________

Air Void Analyzer AVA-3000
Type Company name

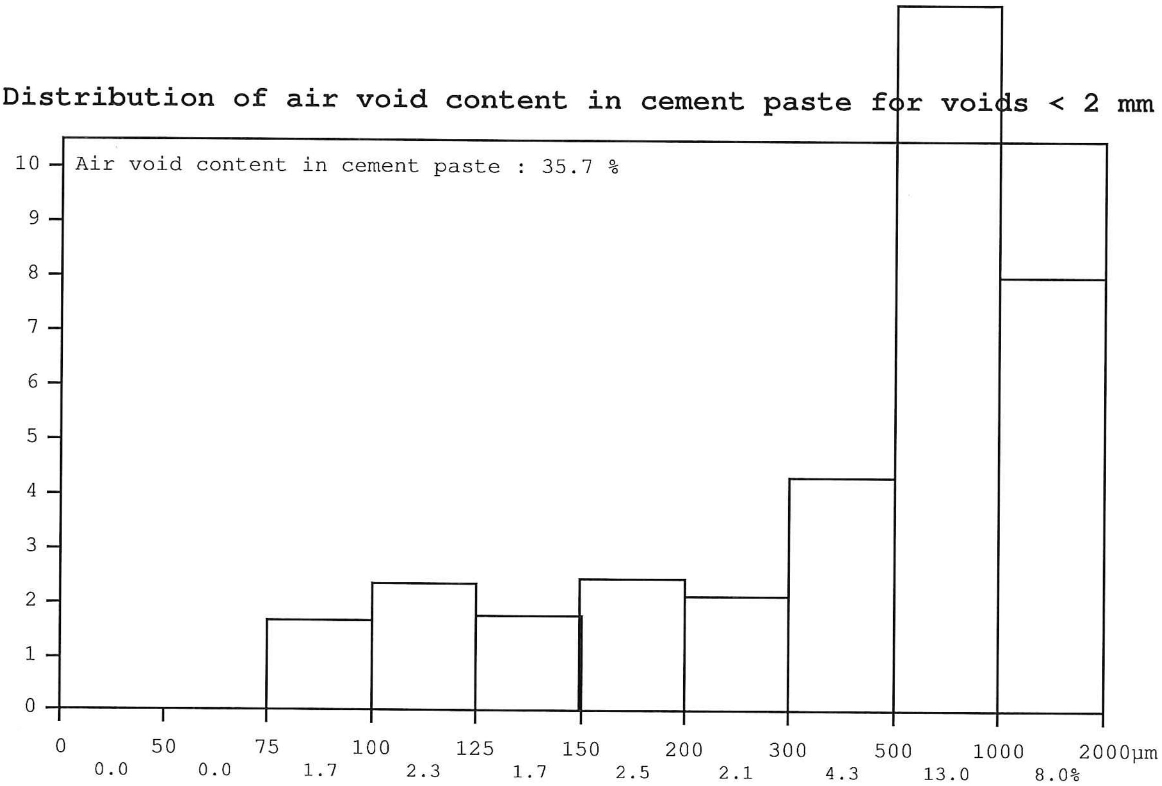
**Measurement of Mar 9, 2017 1:26 PM**

Case number : 2
Sample number : 3

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



(Samtidig)

AEA og SP

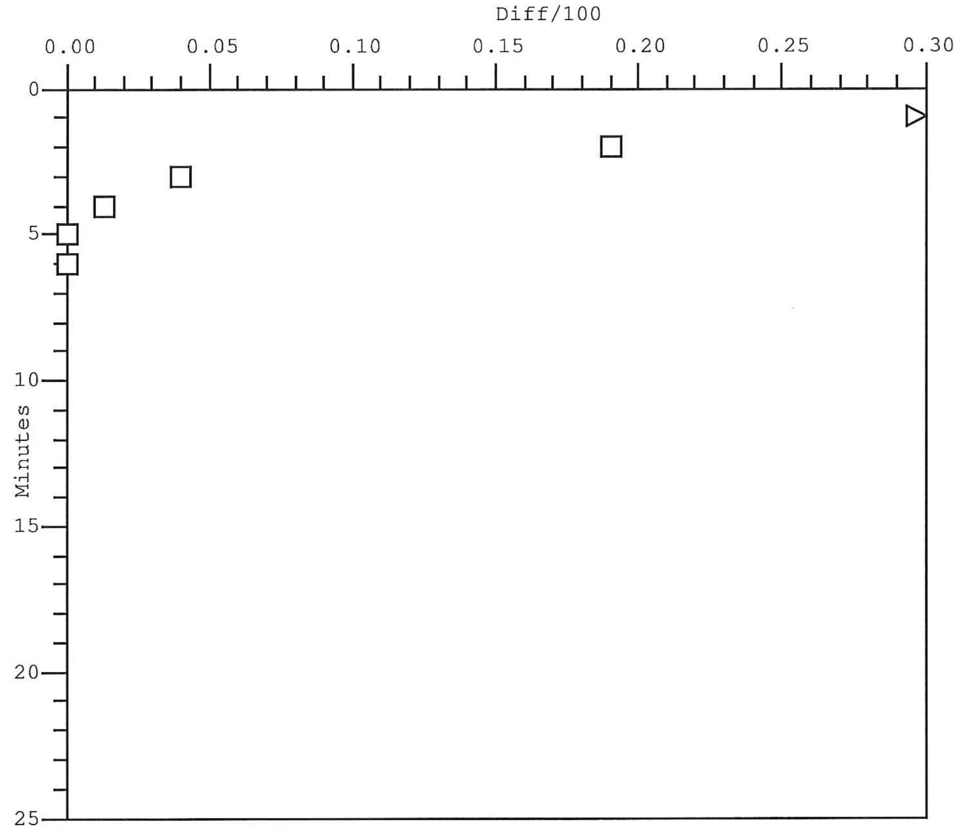
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of Mar 3, 2017 2:14 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 6.0 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.16g +30sec.: 0.76g Temp: 22.9°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 106.7 | 0.96 | 1.08 | 1.16 | 23.1 |
| 19.0 | 1.24 | 1.26 | 1.27 | 23.2 |
| 4.0 | 1.29 | 1.30 | 1.30 | 23.1 |
| 1.3 | 1.31 | 1.31 | 1.31 | 23.2 |
| 0.0 | 1.31 | 1.31 | 1.31 | 23.1 |
| 0.0 | 1.31 | 1.31 | 1.31 | 23.1 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 5.7 % | 4.9 % | 2.1 % |
| Air-% paste | : 15.8 % | 13.5 % | 5.9 % |
| Air-%putty | : 13.6 % | 11.9 % | 5.1 % |
| Specific surface | : 10.7 mm-1 | 11.8 mm-1 | |
| Spacing factor | : 0.481 mm | 0.466 mm | |

### Comments

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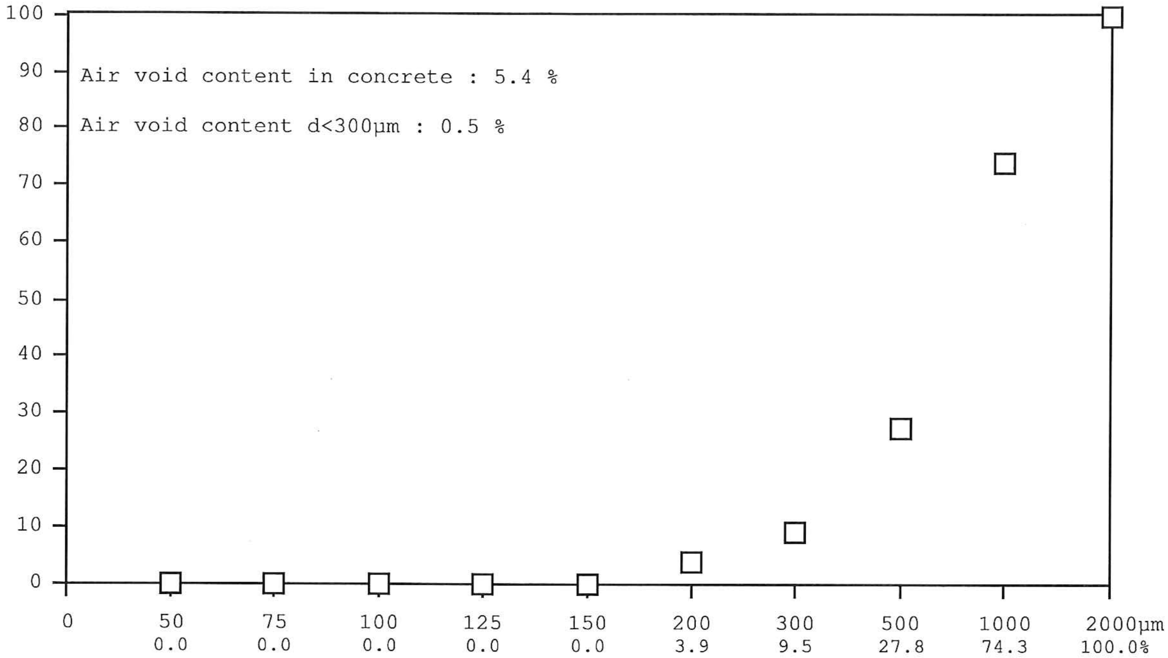
## Air Void Analyzer AVA-3000
## Type Company name

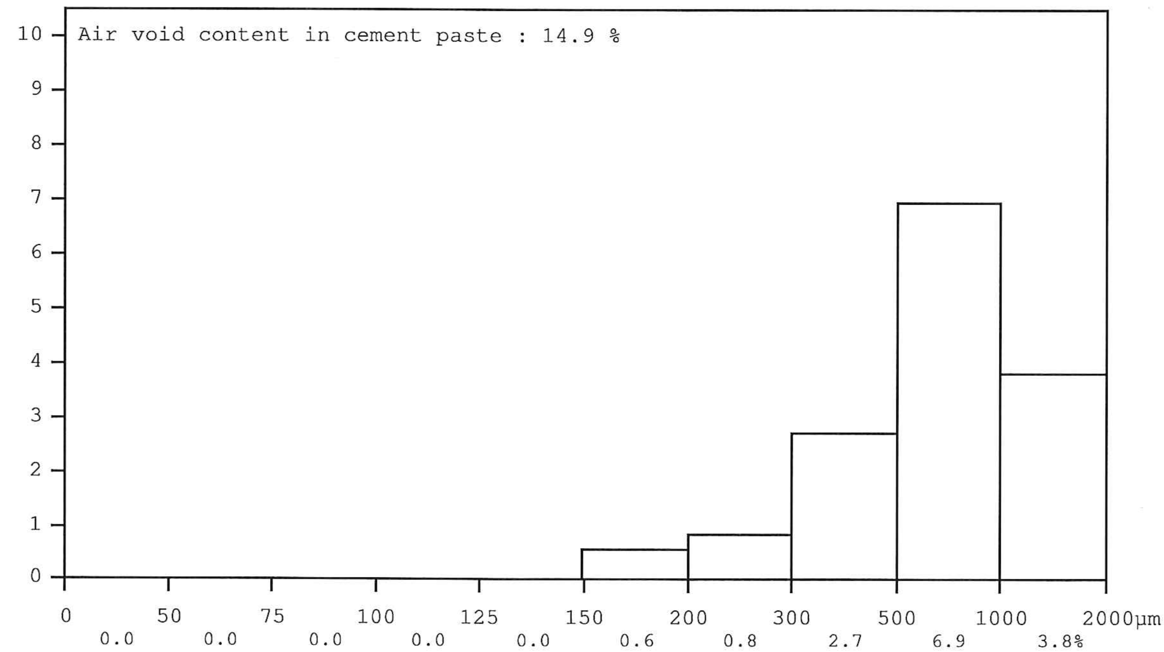
**Measurement of Mar 3, 2017 2:14 PM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AEA og SP 1

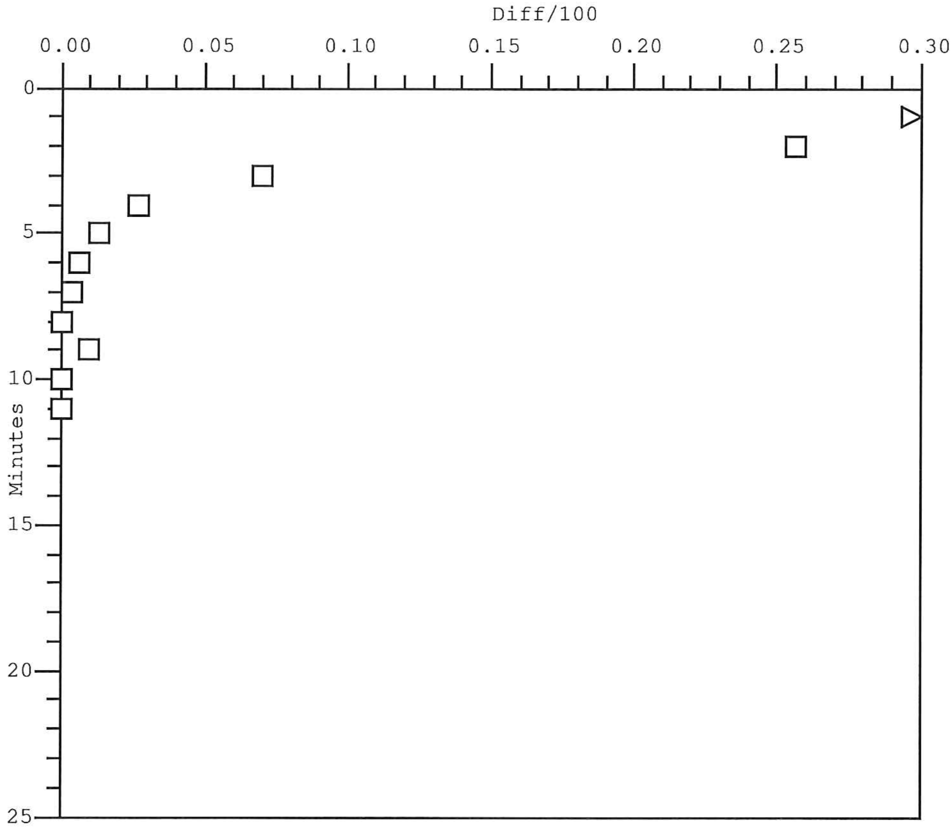
# Air Void Analyzer AVA-3000
## Type Company name

**Measurement of Mar 3, 2017 3:12 PM**

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 6.0 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.01g +30sec.: 0.7000000000000001g Temp: 22.9°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 112.3 | 0.98 | 1.15 | 1.24 | 23.8 |
| 25.7 | 1.35 | 1.39 | 1.40 | 23.7 |
| 7.0 | 1.44 | 1.45 | 1.46 | 23.7 |
| 2.7 | 1.47 | 1.48 | 1.48 | 23.6 |
| 1.3 | 1.49 | 1.49 | 1.49 | 23.6 |
| 0.7 | 1.50 | 1.49 | 1.50 | 23.7 |
| 0.3 | 1.50 | 1.50 | 1.50 | 23.7 |
| 0.0 | 1.50 | 1.50 | 1.50 | 23.7 |
| 1.0 | 1.51 | 1.51 | 1.51 | 23.7 |
| 0.0 | 1.51 | 1.51 | 1.51 | 23.7 |
| 0.0 | 1.51 | 1.51 | 1.51 | 23.7 |

**Results (adjusted to correlate with ASTM C457)**

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 7.0 % | 6.4 % | 3.2 % |
| Air-% paste | : 19.7 % | 18.0 % | 8.8 % |
| Air-%putty | : 16.4 % | 15.2 % | 7.4 % |
| Specific surface | : 13.3 mm-1 | 14.1 mm-1 | |
| Spacing factor | : 0.352 mm | 0.345 mm | |

**Comments**

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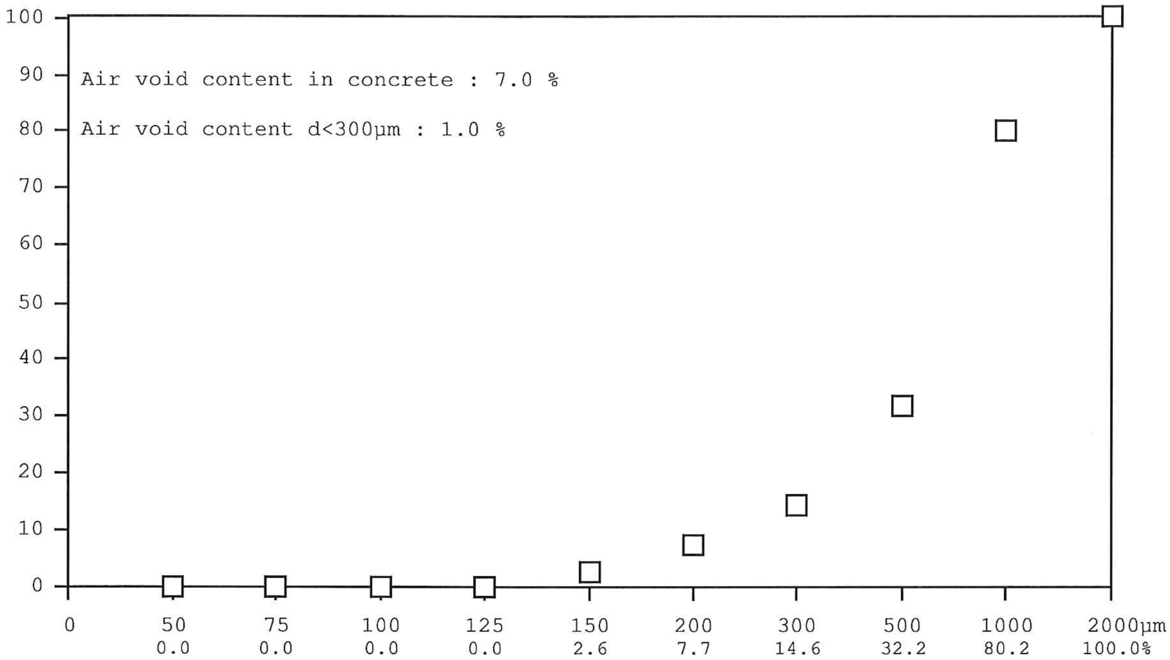
# Air Void Analyzer AVA-3000
## Type Company name

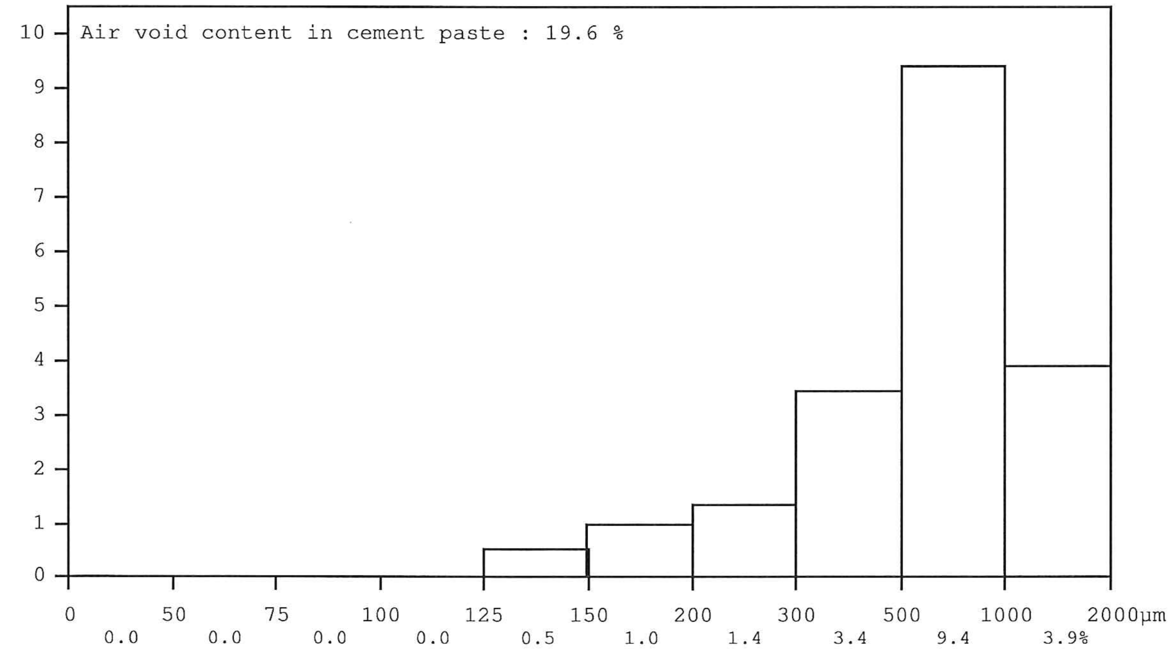
**Measurement of Mar 3, 2017 3:12 PM**

Case number : 1
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AEA-SP 5

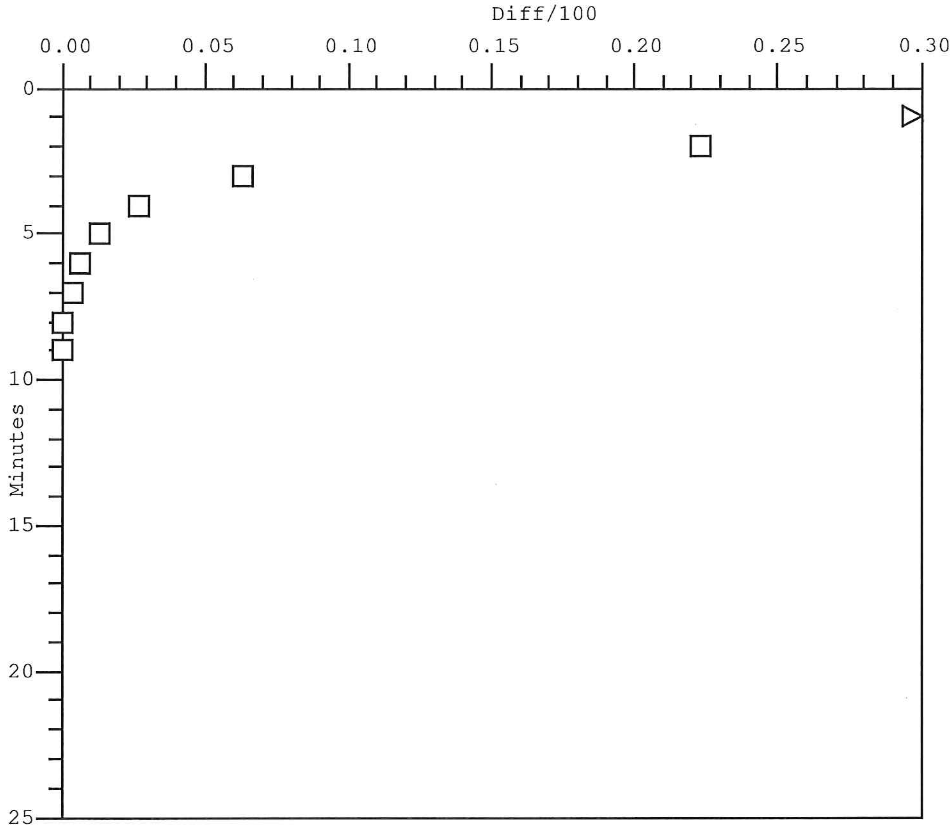
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of Mar 9, 2017 9:59 AM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 36.0 % |
| Sample location | : n | Expected air | : 6.6 % |
| Case number | : 2 | Paste | : 87.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.18g +30sec.: 1.17g Temp: 21.5°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 152.3 | 1.40 | 1.55 | 1.62 | 21.7 |
| 22.3 | 1.72 | 1.75 | 1.77 | 21.8 |
| 6.3 | 1.80 | 1.81 | 1.82 | 21.8 |
| 2.7 | 1.83 | 1.84 | 1.84 | 21.8 |
| 1.3 | 1.85 | 1.85 | 1.85 | 21.7 |
| 0.7 | 1.85 | 1.86 | 1.86 | 21.8 |
| 0.3 | 1.86 | 1.86 | 1.86 | 21.8 |
| 0.0 | 1.86 | 1.86 | 1.86 | 21.8 |
| 0.0 | 1.86 | 1.86 | 1.86 | 21.8 |

### Results (adjusted to correlate with ASTM C457)

| | | | |
|---|---|---|---|
| Chord length | : < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : 3.6 % | 3.0 % | 1.3 % |
| Air-% paste | : 4.0 % | 3.3 % | 1.4 % |
| Air-%putty | : 3.9 % | 3.2 % | 1.3 % |
| Specific surface | : 10.9 mm-1 | 12.3 mm-1 | |
| Spacing factor | : 0.851 mm | 0.818 mm | |

### Comments

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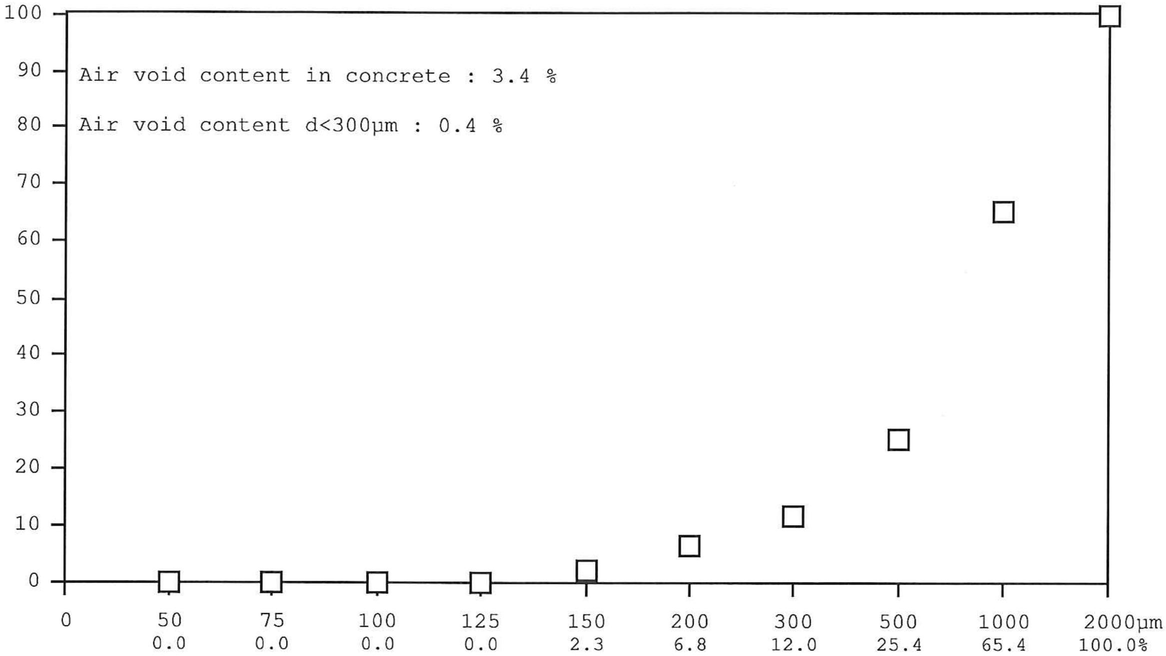
# Air Void Analyzer AVA-3000
## Type Company name

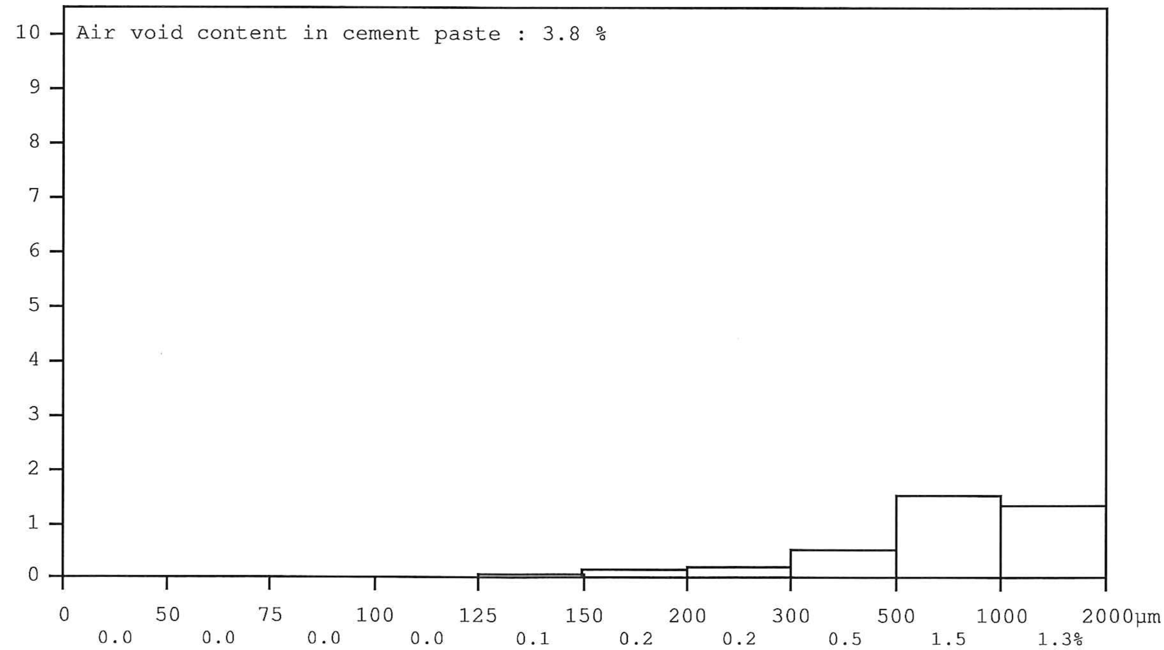
**Measurement of Mar 9, 2017 9:59 AM**

Case number : 2
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



## Air Void Analyzer AVA-3000
## Type Company name

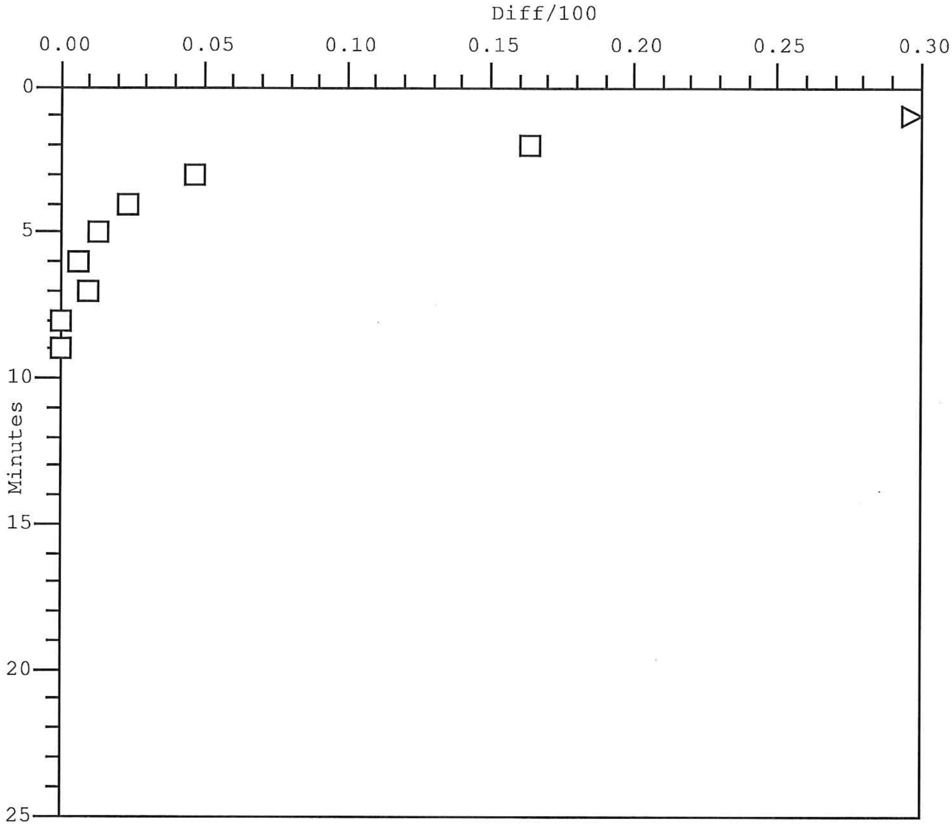
GI

**Measurement of Mar 9, 2017 10:26 AM**

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 36.0 % |
| Sample location | : n | Expected air | : 6.6 % |
| Case number | : 2 | Paste | : 87.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.01g +30sec.: 0.77g Temp: 22.5°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 108.7 | 1.00 | 1.10 | 1.16 | 23.6 |
| 16.3 | 1.23 | 1.25 | 1.27 | 23.6 |
| 4.7 | 1.29 | 1.30 | 1.30 | 23.6 |
| 2.3 | 1.32 | 1.32 | 1.32 | 23.4 |
| 1.3 | 1.33 | 1.33 | 1.34 | 23.4 |
| 0.7 | 1.34 | 1.34 | 1.34 | 23.3 |
| 1.0 | 1.35 | 1.35 | 1.35 | 23.4 |
| 0.0 | 1.35 | 1.35 | 1.35 | 23.4 |
| 0.0 | 1.35 | 1.35 | 1.35 | 23.3 |

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 2.7 % | 2.4 % | 1.0 % |
| Air-% paste : | 3.0 % | 2.6 % | 1.1 % |
| Air-%putty : | 2.9 % | 2.5 % | 1.1 % |
| Specific surface : | 11.9 mm-1 | 13.0 mm-1 | |
| Spacing factor : | 0.881 mm | 0.856 mm | |

NOTE: Air-%Concrete <2mm out of range 3.5-10%

**Comments**

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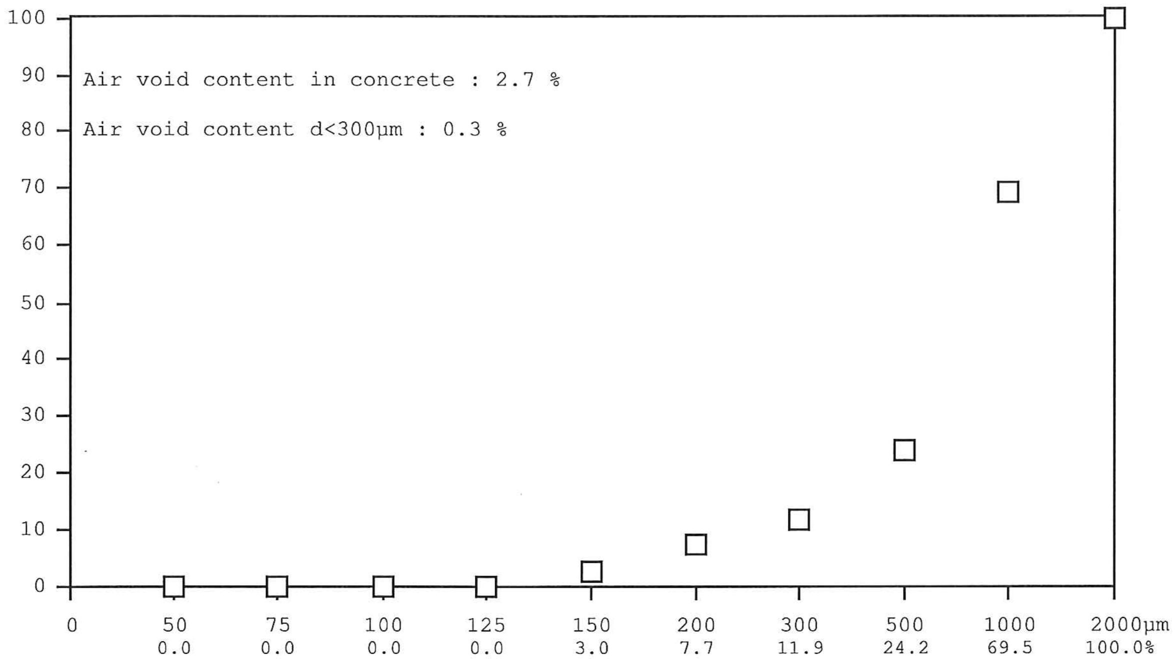
Air Void Analyzer AVA-3000
Type Company name

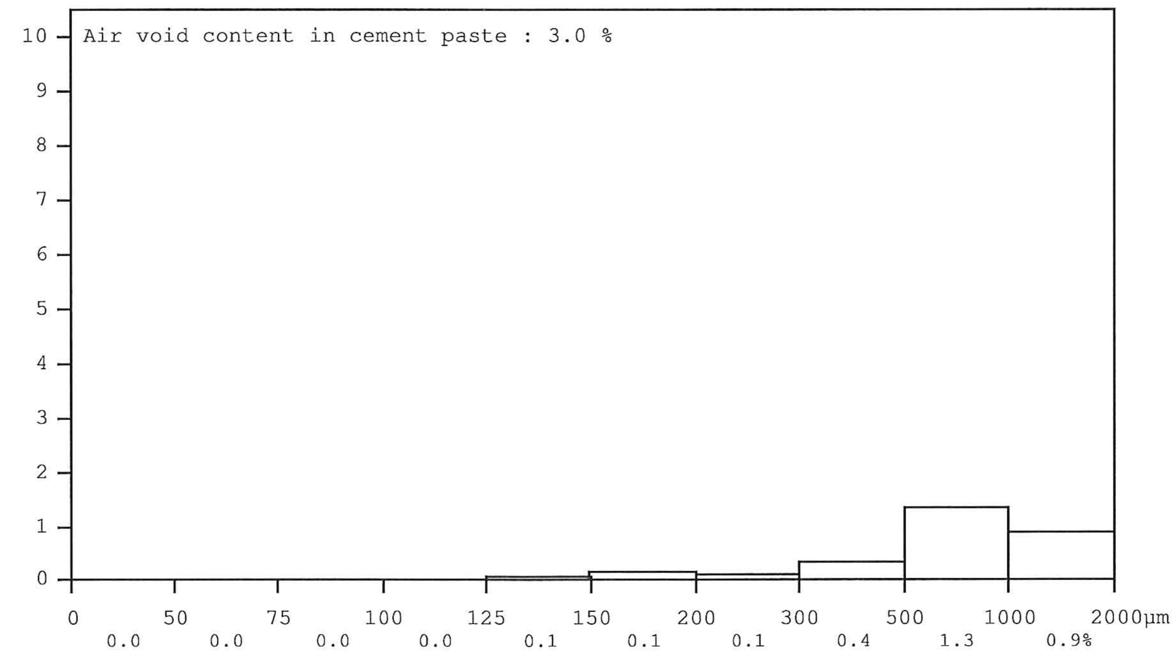
**Measurement of Mar 9, 2017 10:26 AM**

Case number : 2
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AEA-SP 4

# Air Void Analyzer AVA-3000
## Type Company name

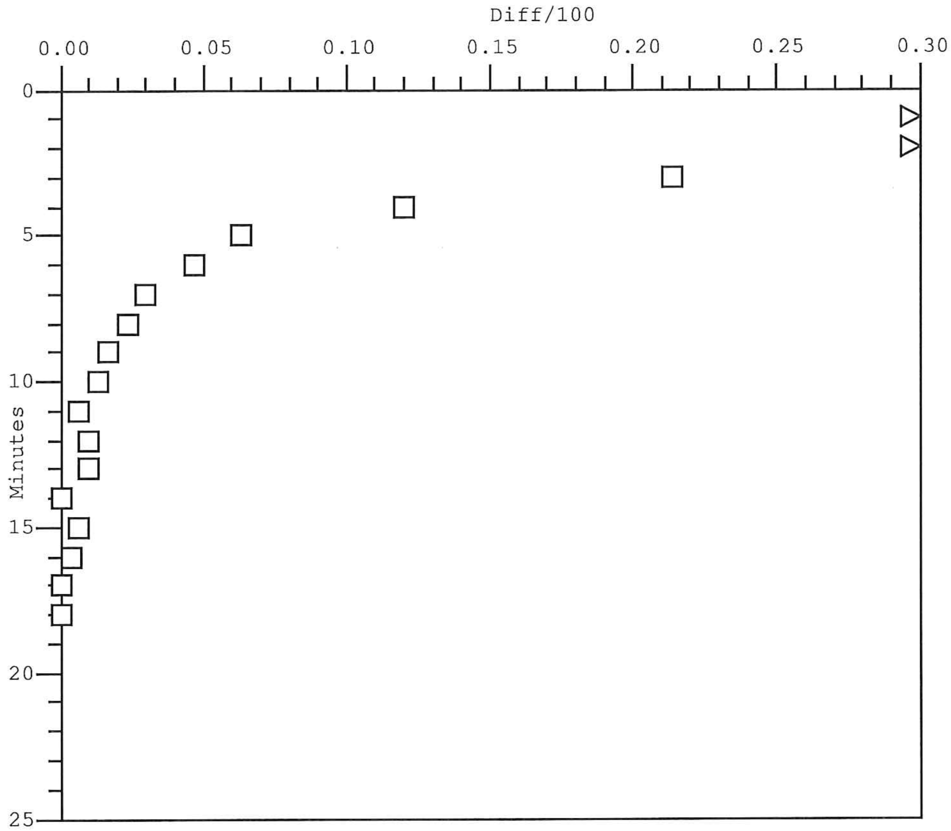
GI

## Measurement of Mar 2, 2017 1:54 PM

| | | | | |
|---|---|---|---|---|
| Sampler | : o | | | |
| Ordered by | : a | Mortar<6mm | : | 87.0 % |
| Sample location | : n | Expected air | : | 6.6 % |
| Case number | : 1 | Paste | : | 36.0 % |
| Sample number | : 3 | Sample volume | : | 20.0 cm3 |

## Analysis

Start: 0.0g  +5sec.: 0.08g  +30sec.: 0.51g  Temp: 23.3°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 93.7 | 0.77 | 0.95 | 1.09 | 23.6 |
| 45.0 | 1.31 | 1.39 | 1.46 | 23.6 |
| 21.3 | 1.56 | 1.60 | 1.64 | 23.6 |
| 12.0 | 1.70 | 1.72 | 1.74 | 23.6 |
| 6.3 | 1.77 | 1.78 | 1.80 | 23.6 |
| 4.7 | 1.82 | 1.83 | 1.84 | 23.6 |
| 3.0 | 1.85 | 1.86 | 1.87 | 23.6 |
| 2.3 | 1.88 | 1.88 | 1.89 | 23.6 |
| 1.7 | 1.90 | 1.90 | 1.90 | 23.6 |
| 1.3 | 1.91 | 1.91 | 1.92 | 23.6 |
| 0.7 | 1.92 | 1.92 | 1.92 | 23.4 |
| 1.0 | 1.93 | 1.93 | 1.93 | 23.6 |
| 1.0 | 1.94 | 1.94 | 1.94 | 23.4 |
| 0.0 | 1.94 | 1.94 | 1.94 | 23.4 |
| 0.7 | 1.94 | 1.95 | 1.95 | 23.4 |
| 0.3 | 1.95 | 1.95 | 1.95 | 23.4 |
| 0.0 | 1.95 | 1.95 | 1.95 | 23.4 |
| 0.0 | 1.95 | 1.95 | 1.95 | 23.4 |

## Results (adjusted to correlate with ASTM C457)

| | | | | |
|---|---|---|---|---|
| Chord length | : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : | 9.0 % | 8.6 % | 6.1 % |
| Air-% paste | : | 25.5 % | 24.3 % | 17.4 % |
| Air-%putty | : | 20.3 % | 19.6 % | 13.9 % |
| Specific surface | : | 23.6 mm-1 | 24.5 mm-1 | |
| Spacing factor | : | 0.170 mm | 0.171 mm | |

## Comments

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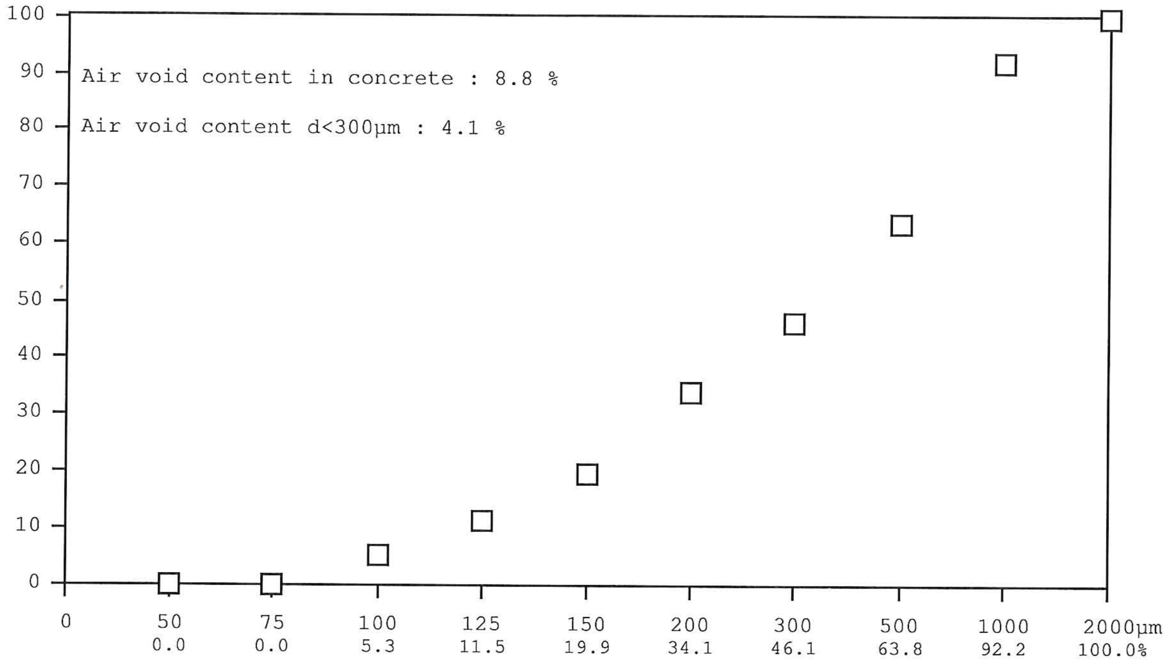
Sign.:____________________

# Air Void Analyzer AVA-3000
## Type Company name

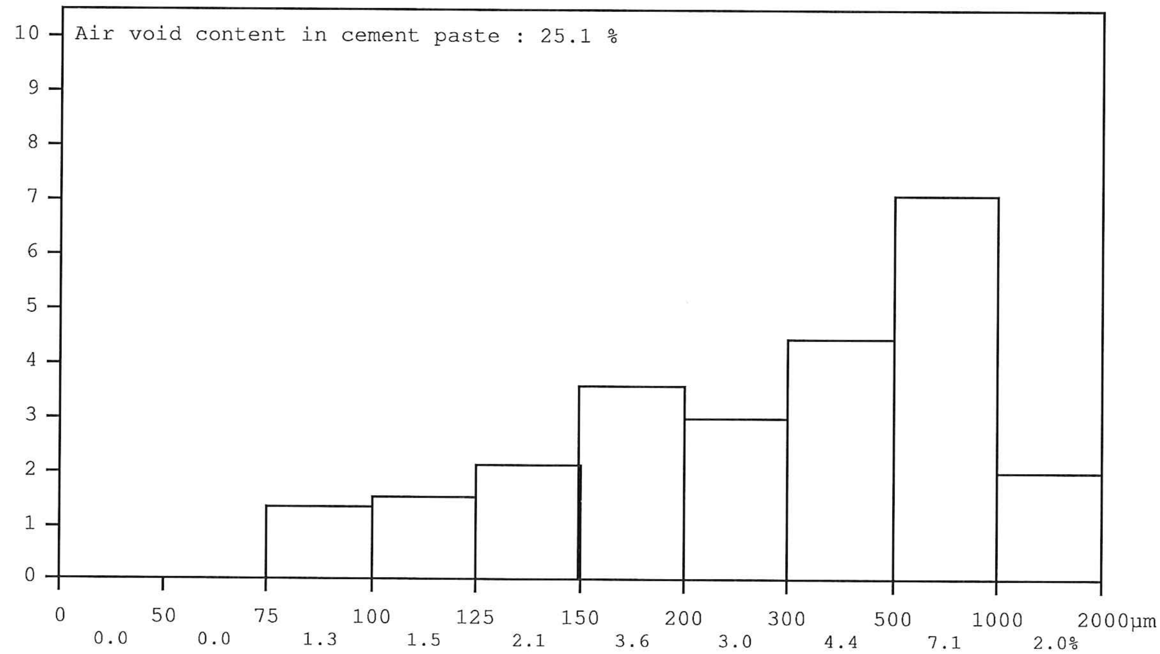
**Measurement of Mar 2, 2017 1:54 PM**

Case number : 1
Sample number : 3

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AfA-SP 4

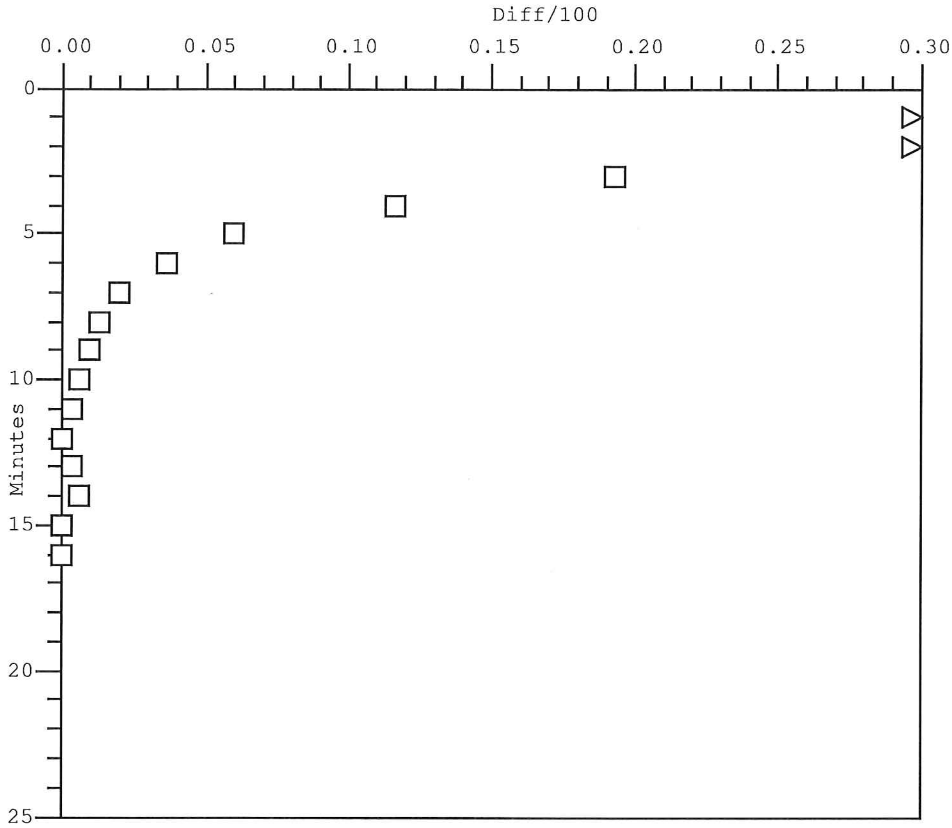
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of Mar 2, 2017 2:24 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 6.6 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 4 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.06g +30sec.: 0.56g Temp: 22.3°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 104.7 | 0.86 | 1.07 | 1.21 | 23.3 |
| 45.3 | 1.43 | 1.50 | 1.57 | 23.3 |
| 19.3 | 1.65 | 1.70 | 1.73 | 23.3 |
| 11.7 | 1.79 | 1.81 | 1.83 | 23.3 |
| 6.0 | 1.86 | 1.87 | 1.88 | 23.2 |
| 3.7 | 1.90 | 1.91 | 1.91 | 23.2 |
| 2.0 | 1.92 | 1.93 | 1.93 | 23.2 |
| 1.3 | 1.94 | 1.94 | 1.94 | 23.1 |
| 1.0 | 1.95 | 1.95 | 1.95 | 22.9 |
| 0.7 | 1.95 | 1.96 | 1.96 | 22.9 |
| 0.3 | 1.96 | 1.96 | 1.96 | 22.9 |
| 0.0 | 1.96 | 1.96 | 1.96 | 22.9 |
| 0.3 | 1.96 | 1.96 | 1.97 | 22.8 |
| 0.7 | 1.97 | 1.97 | 1.97 | 22.8 |
| 0.0 | 1.97 | 1.97 | 1.97 | 22.7 |
| 0.0 | 1.97 | 1.97 | 1.97 | 22.7 |

### Results (adjusted to correlate with ASTM C457)

| | | | | |
|---|---|---|---|---|
| Chord length | : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : | 9.1 % | 8.7 % | 5.8 % |
| Air-% paste | : | 26.0 % | 24.8 % | 16.7 % |
| Air-%putty | : | 20.6 % | 19.9 % | 13.2 % |
| Specific surface | : | 21.0 mm-1 | 21.7 mm-1 | |
| Spacing factor | : | 0.189 mm | 0.190 mm | |

### Comments

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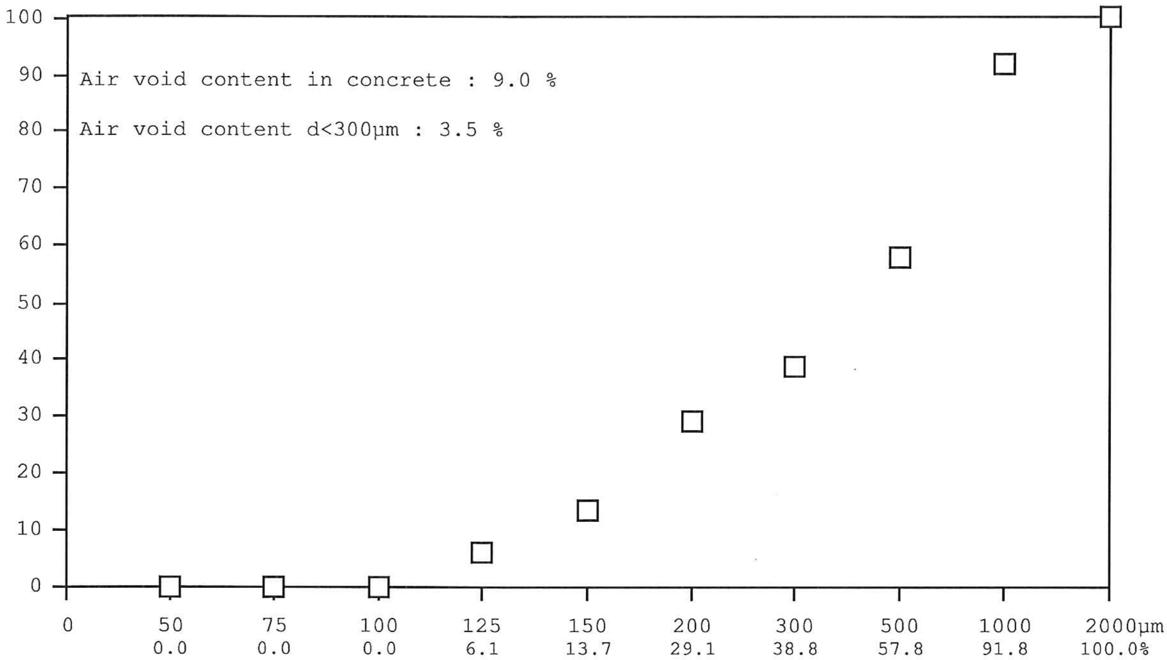
Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

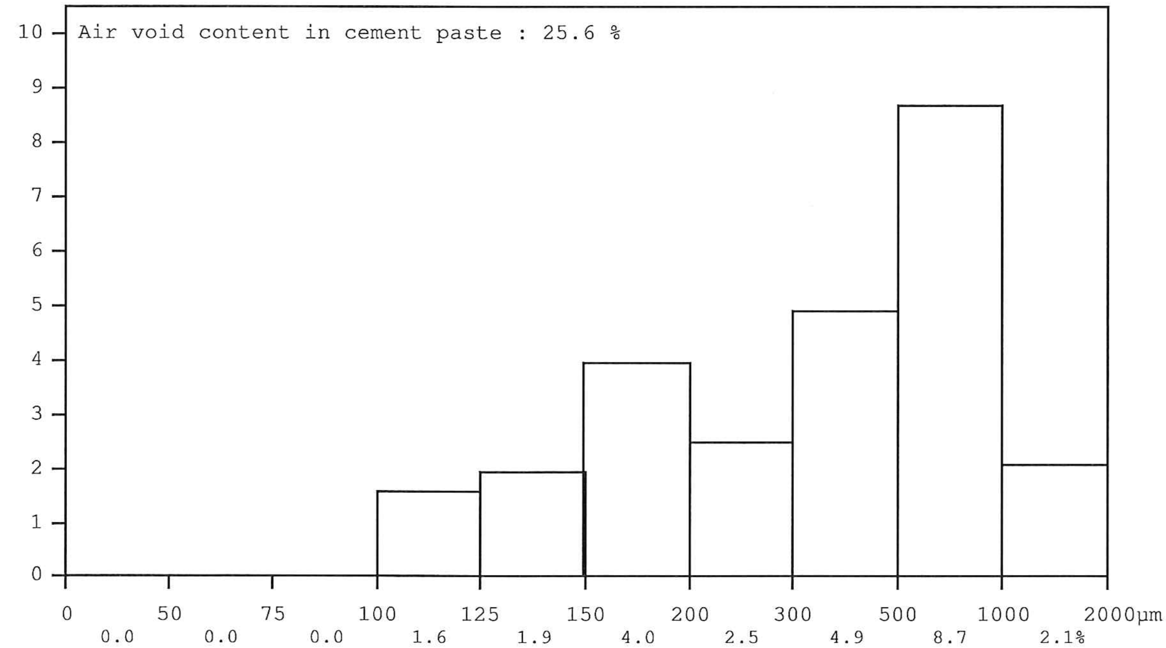
**Measurement of Mar 2, 2017 2:24 PM**

Case number : 1
Sample number : 4

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AfA - SP 3

# Air Void Analyzer AVA-3000
## Type Company name

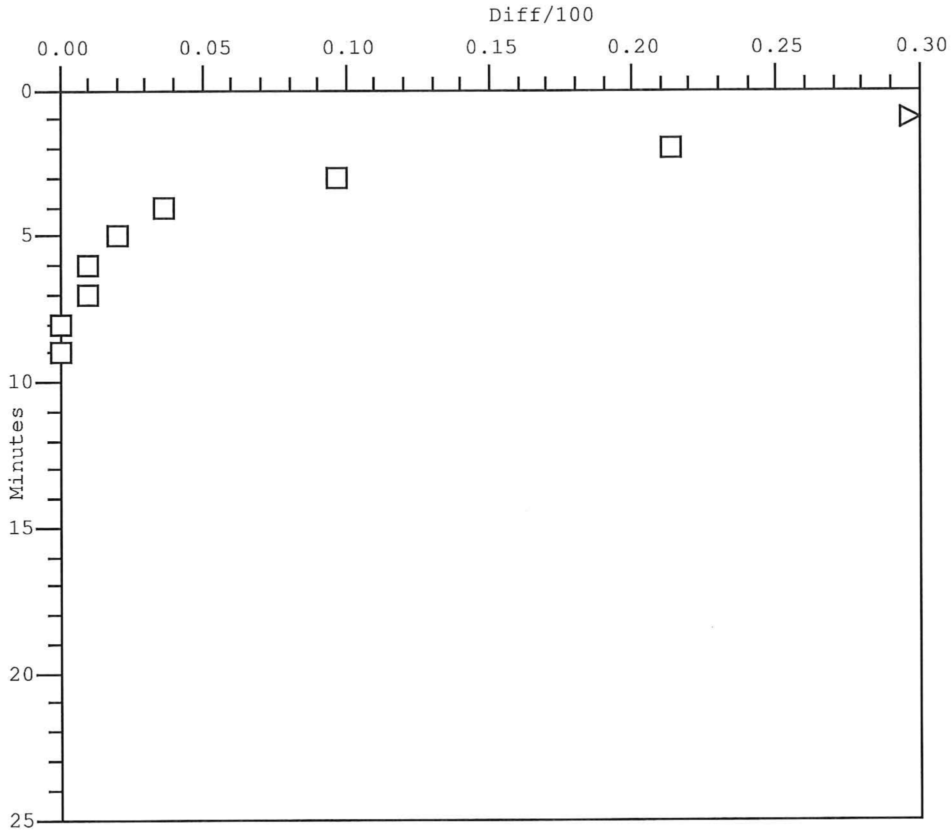
GI

### Measurement of Mar 2, 2017 11:45 AM

| | | | | |
|---|---|---|---|---|
| Sampler | : o | | | |
| Ordered by | : a | Mortar<6mm | : | 87.0 % |
| Sample location | : n | Expected air | : | 4.0 % |
| Case number | : 1 | Paste | : | 36.0 % |
| Sample number | : 1 | Sample volume | : | 20.0 cm3 |

### Analysis

Start: 0.0g    +5sec.: 0.04g    +30sec.: 0.42g    Temp: 22.0°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 63.3 | 0.55 | 0.64 | 0.71 | 22.5 |
| 21.3 | 0.81 | 0.85 | 0.88 | 22.6 |
| 9.7 | 0.93 | 0.94 | 0.96 | 22.6 |
| 3.7 | 0.97 | 0.98 | 0.99 | 22.6 |
| 2.0 | 1.00 | 1.00 | 1.00 | 22.6 |
| 1.0 | 1.01 | 1.01 | 1.01 | 22.6 |
| 1.0 | 1.02 | 1.02 | 1.02 | 22.6 |
| 0.0 | 1.02 | 1.02 | 1.02 | 22.6 |
| 0.0 | 1.02 | 1.02 | 1.02 | 22.6 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 4.5 % | 4.1 % | 2.5 % |
| Air-% paste | : 12.7 % | 11.4 % | 6.9 % |
| Air-%putty | : 11.3 % | 10.3 % | 6.1 % |
| Specific surface | : 16.6 mm-1 | 17.9 mm-1 | |
| Spacing factor | : 0.344 mm | 0.333 mm | |

### Comments

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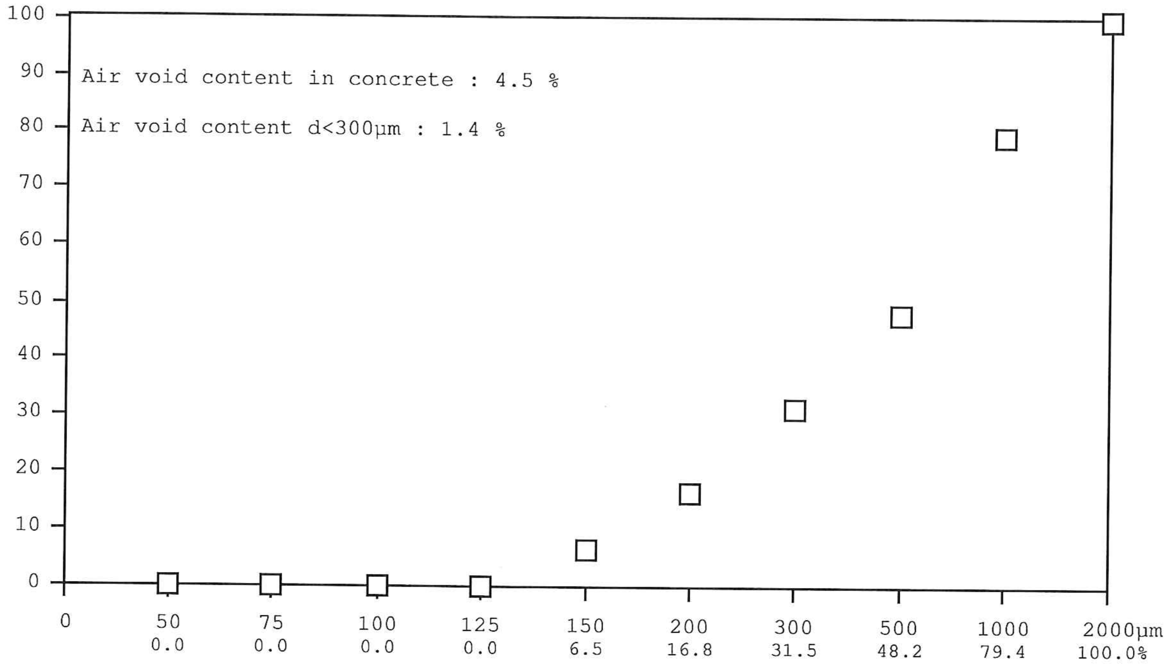
Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

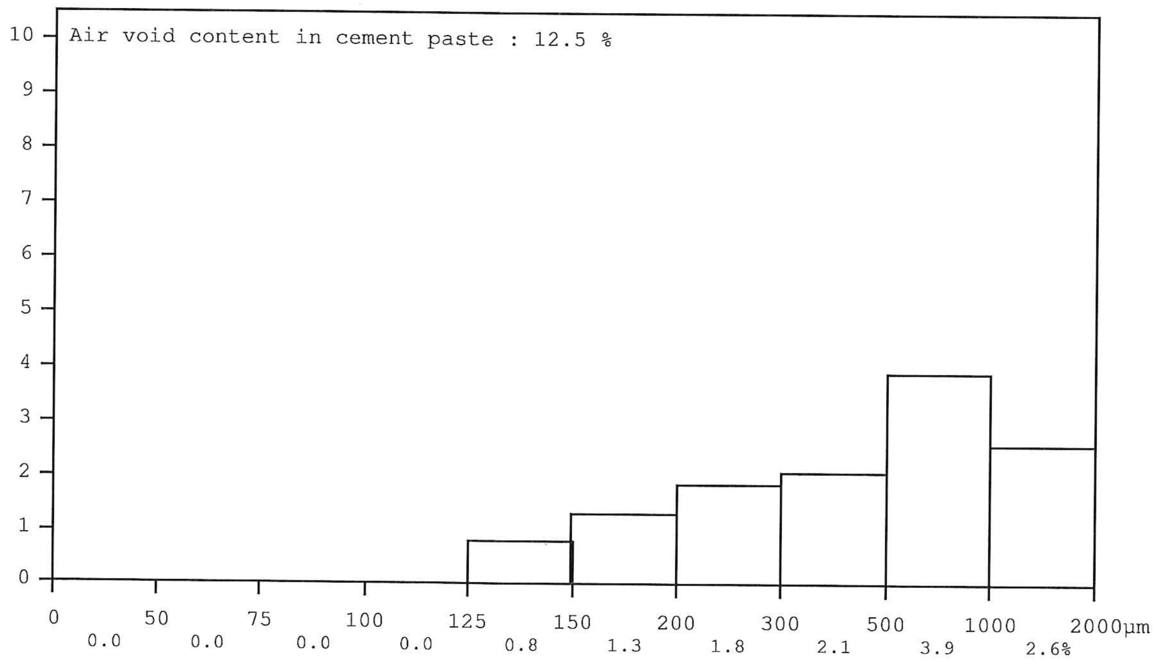
**Measurement of Mar 2, 2017 11:45 AM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AEA-SP 3

# Air Void Analyzer AVA-3000
## Type Company name

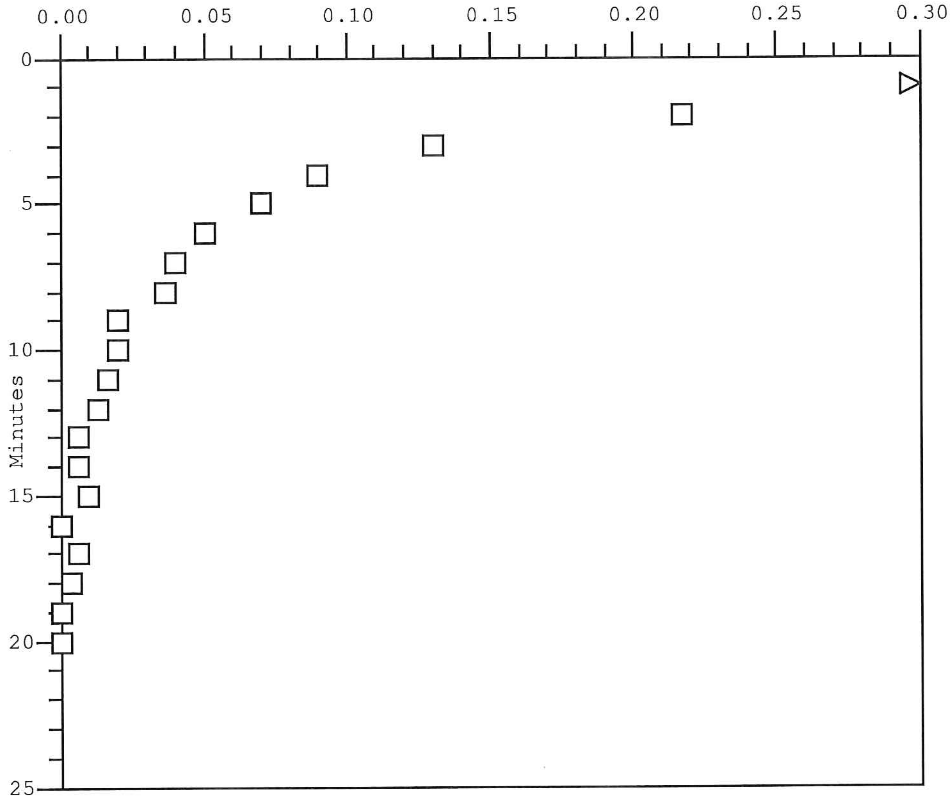
GI

### Measurement of Mar 2, 2017 12:14 PM

| | | | |
|---|---|---|---|
| Sampler | : o | Mortar<6mm | : 87.0 % |
| Ordered by | : a | Expected air | : 4.0 % |
| Sample location | : n | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 1 | | |

### Analysis

Start: 0.0g    +5sec.: 0.13g    +30sec.: 0.4g    Temp: 22.0°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 59.3 | 0.51 | 0.60 | 0.67 | 23.3 |
| 21.7 | 0.77 | 0.81 | 0.85 | 23.2 |
| 13.0 | 0.91 | 0.94 | 0.97 | 23.2 |
| 9.0 | 1.01 | 1.03 | 1.05 | 23.2 |
| 7.0 | 1.09 | 1.10 | 1.11 | 23.2 |
| 5.0 | 1.14 | 1.15 | 1.16 | 23.2 |
| 4.0 | 1.18 | 1.19 | 1.20 | 23.2 |
| 3.7 | 1.22 | 1.23 | 1.23 | 23.2 |
| 2.0 | 1.24 | 1.25 | 1.25 | 23.2 |
| 2.0 | 1.26 | 1.27 | 1.27 | 23.2 |
| 1.7 | 1.28 | 1.28 | 1.29 | 23.2 |
| 1.3 | 1.29 | 1.30 | 1.30 | 23.2 |
| 0.7 | 1.30 | 1.30 | 1.31 | 23.2 |
| 0.7 | 1.31 | 1.31 | 1.31 | 23.2 |
| 1.0 | 1.32 | 1.32 | 1.32 | 22.9 |
| 0.0 | 1.32 | 1.32 | 1.32 | 23.1 |
| 0.7 | 1.32 | 1.33 | 1.33 | 23.1 |
| 0.3 | 1.33 | 1.33 | 1.33 | 23.1 |
| 0.0 | 1.33 | 1.33 | 1.33 | 22.9 |
| 0.0 | 1.33 | 1.33 | 1.33 | 22.9 |

### Results (adjusted to correlate with ASTM C457)

| | | | |
|---|---|---|---|
| Chord length | : < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : 5.8 % | 5.3 % | 4.0 % |
| Air-% paste | : 16.3 % | 15.0 % | 11.4 % |
| Air-%putty | : 14.0 % | 13.1 % | 9.8 % |
| Specific surface | : 29.4 mm-1 | 31.6 mm-1 | |
| Spacing factor | : 0.174 mm | 0.168 mm | |

### Comments

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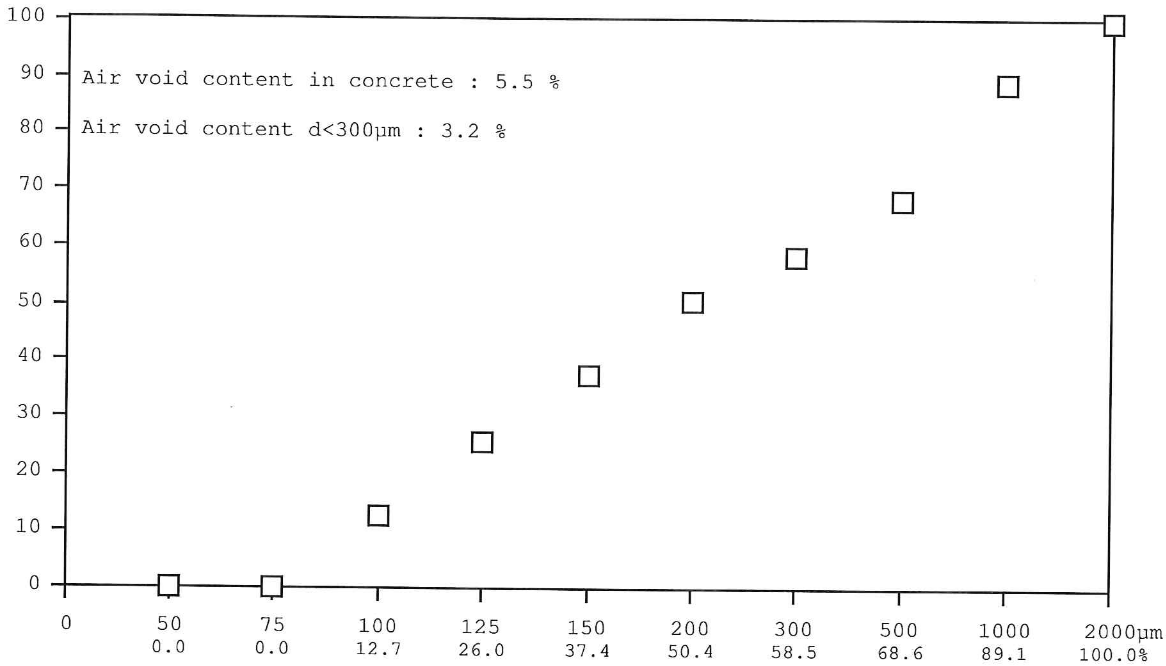
Sign.:____________________

Air Void Analyzer AVA-3000
Type Company name

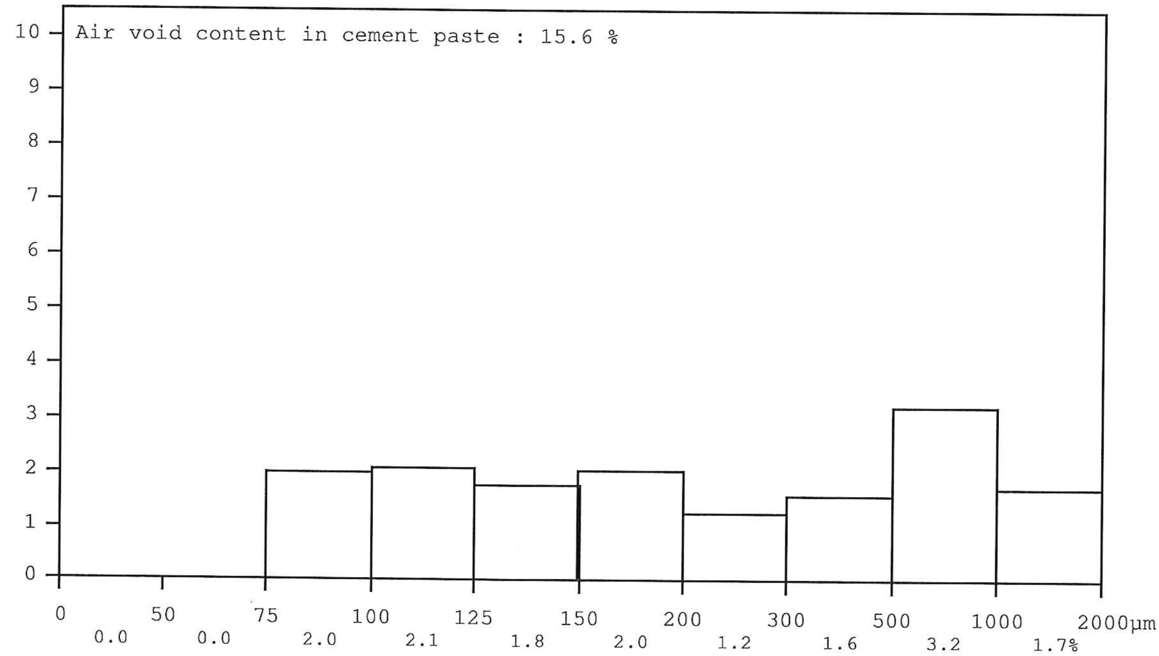
**Measurement of Mar 2, 2017 12:14 PM**

Case number : 1
Sample number : 1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AEA-SP1

# Air Void Analyzer AVA-3000
Type Company name

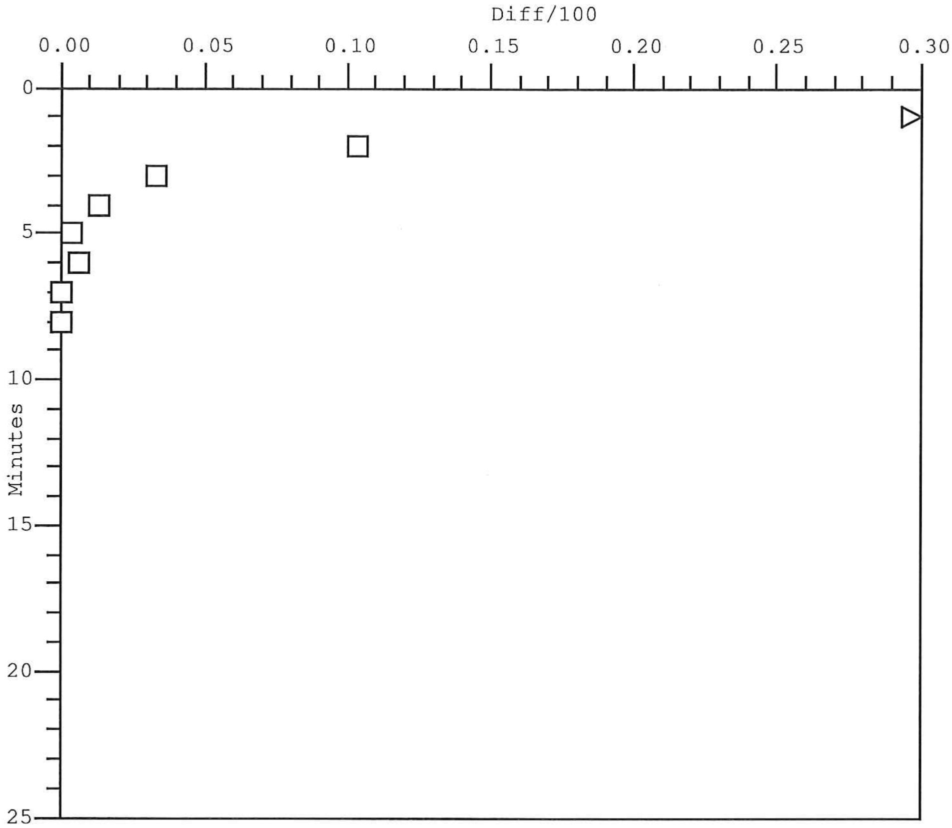
GI

## Measurement of Mar 1, 2017 12:56 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 3.0 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 1 | Sample volume | : 20.0 cm3 |

## Analysis

Start: 0.0g +5sec.: 0.04g +30sec.: 0.46g Temp: 22.0°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 59.0 | 0.54 | 0.60 | 0.63 | 22.3 |
| 10.3 | 0.68 | 0.69 | 0.71 | 22.3 |
| 3.3 | 0.72 | 0.73 | 0.73 | 22.5 |
| 1.3 | 0.74 | 0.74 | 0.74 | 22.5 |
| 0.3 | 0.74 | 0.74 | 0.75 | 22.5 |
| 0.7 | 0.75 | 0.75 | 0.75 | 22.5 |
| 0.0 | 0.75 | 0.75 | 0.75 | 22.3 |
| 0.0 | 0.75 | 0.75 | 0.75 | 22.5 |

## Results (adjusted to correlate with ASTM C457)

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 3.3 % | 2.7 % | 1.2 % |
| Air-% paste : | 9.1 % | 7.6 % | 3.3 % |
| Air-%putty : | 8.4 % | 7.0 % | 3.1 % |
| Specific surface : | 11.5 mm-1 | 12.9 mm-1 | |
| Spacing factor : | 0.575 mm | 0.555 mm | |

NOTE: Air-%Concrete <2mm out of range 3.5-10%

## Comments

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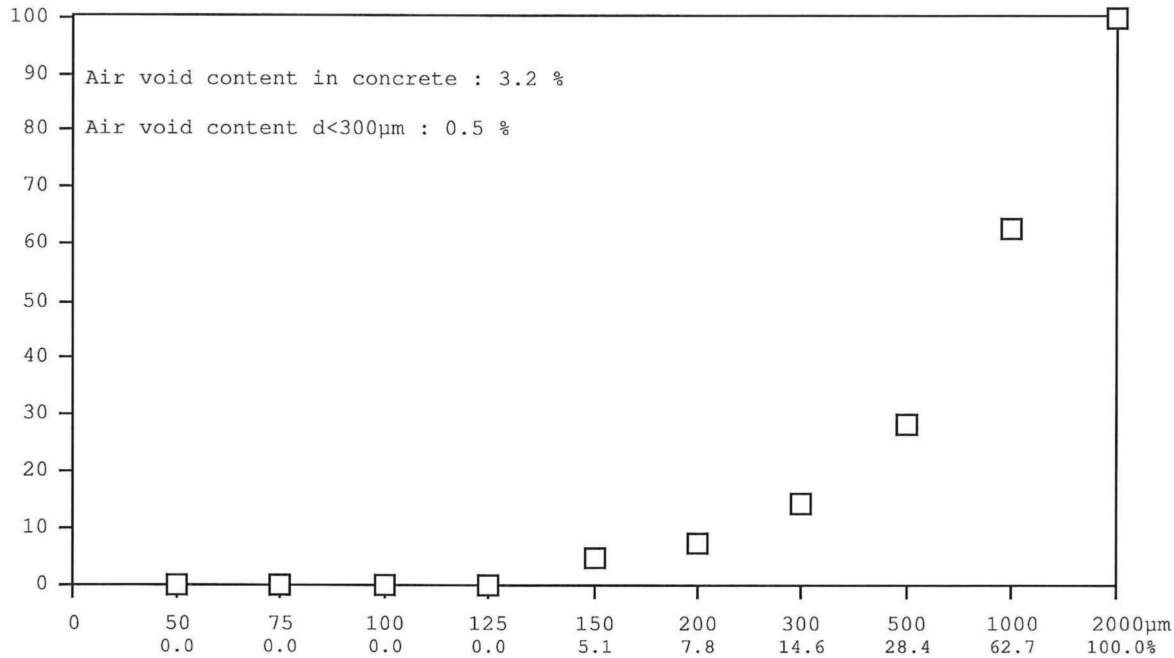
Sign.:____________________

# Air Void Analyzer AVA-3000
## Type Company name

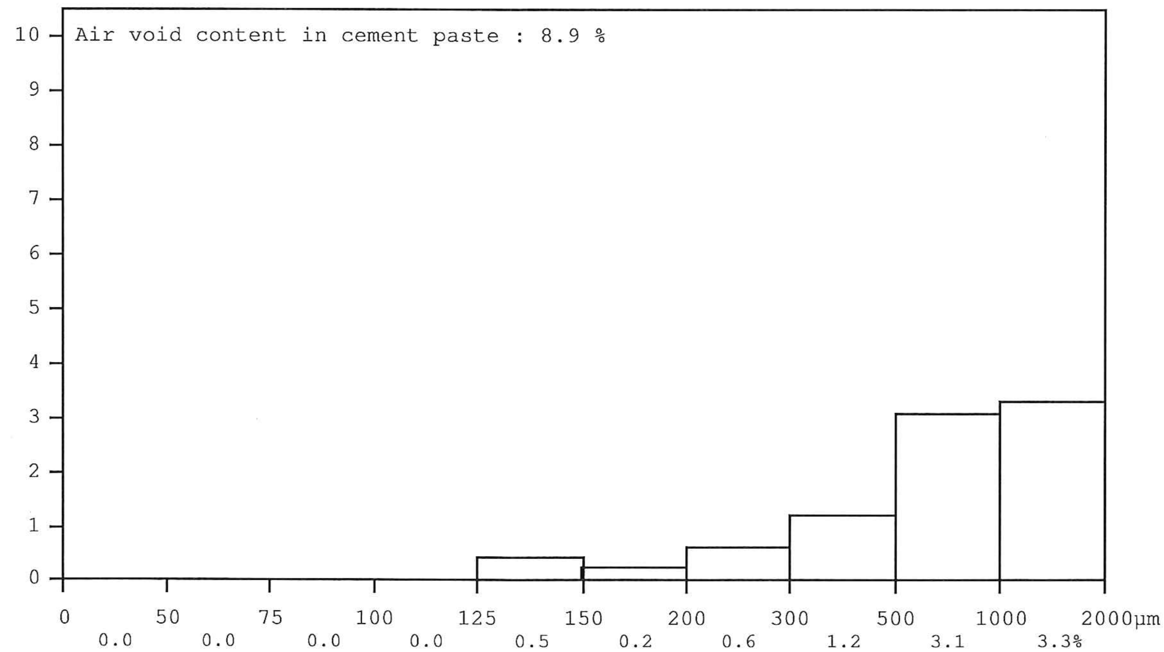
**Measurement of Mar 1, 2017 12:56 PM**

Case number   :   1
Sample number :   1

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AAA - SP 1

# Air Void Analyzer AVA-3000
## Type Company name

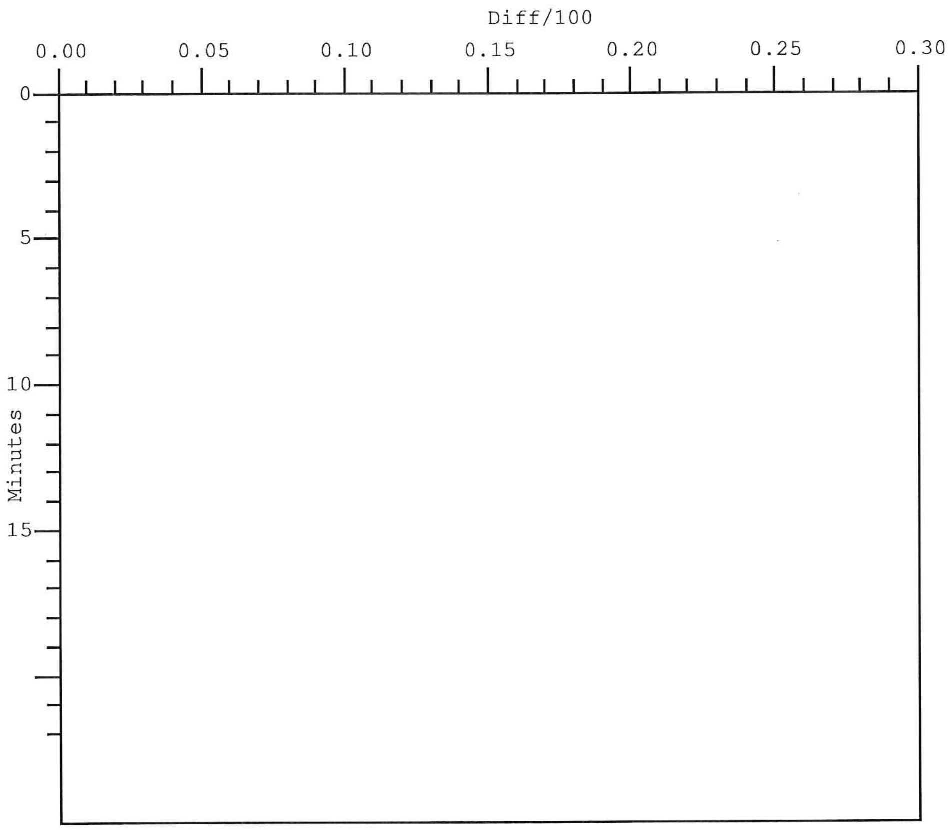
GI

### Measurement of Mar 1, 2017 1:22 PM

| | | | |
|---|---|---|---|
| Sampler | : o | Mortar<6mm | : 87.0 % |
| Ordered by | : a | Expected air | : 3.0 % |
| Sample location | : n | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 2 | | |

### Analysis

Start: 0.0g +5sec.: 0.03g +30sec.: 0.7000000000000001g Temp: 22.3°C




### Results (adjusted to correlate with ASTM C457)

| | | | | |
|---|---|---|---|---|
| Chord length | : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : | 4.5 % | 3.6 % | 1.4 % |
| Air-% paste | : | 12.6 % | 10.1 % | 3.8 % |
| Air-%putty | : | 11.2 % | 9.1 % | 3.4 % |
| Specific surface | : | 10.2 mm-1 | 11.5 mm-1 | |
| Spacing factor | : | 0.566 mm | 0.551 mm | |

### Comments

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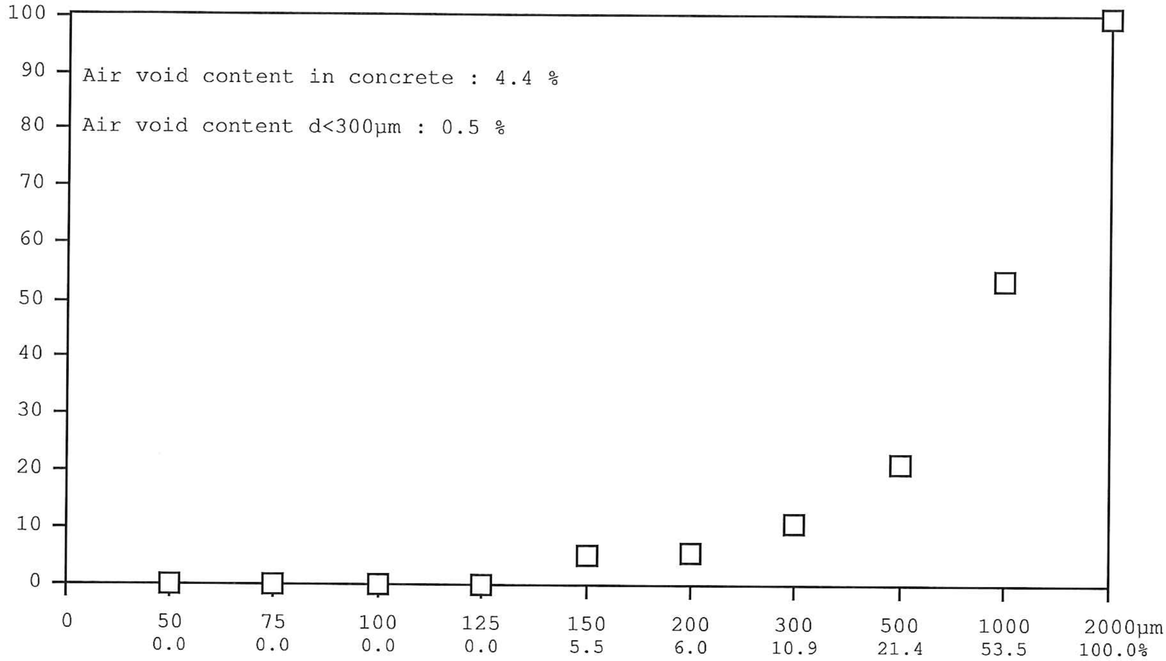
> Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

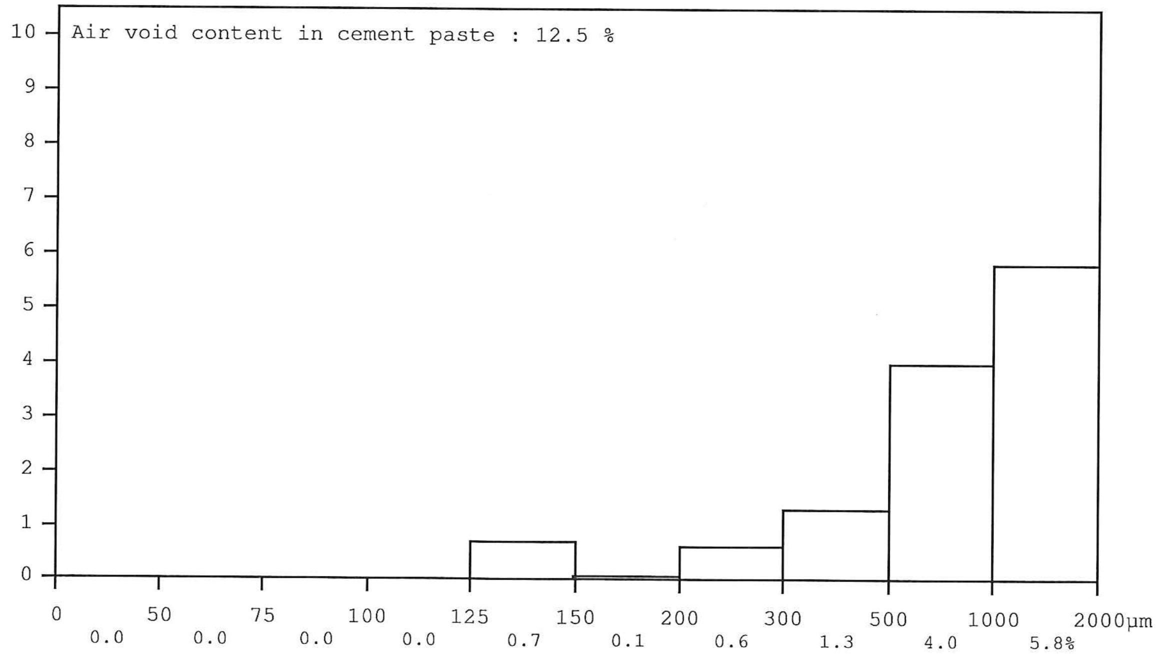
**Measurement of Mar 1, 2017 1:22 PM**

```
Case number   :   1
Sample number :   2
```

### Distribution of air void content for voids < 2 mm (%)




### Distribution of air void content in cement paste for voids < 2 mm (%)



AEA-SP 2

# Air Void Analyzer AVA-3000
## Type Company name

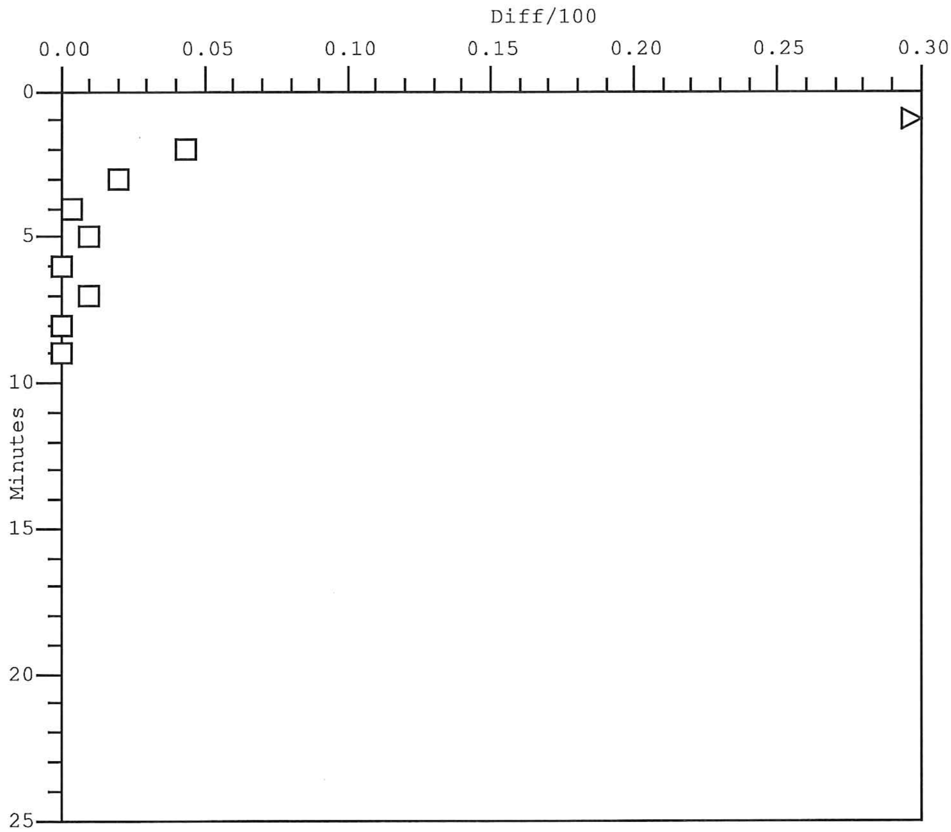
GI

**Measurement of Mar 1, 2017 2:44 PM**

| | | | |
|---|---|---|---|
| Sampler | : o | Mortar<6mm | : 87.0 % |
| Ordered by | : a | Expected air | : 4.0 % |
| Sample location | : n | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 3 | | |

**Analysis**

Start: 0.0g     +5sec.: 0.04g     +30sec.: 0.66g     Temp: 20.6°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 72.3 | 0.70 | 0.73 | 0.74 | 22.0 |
| 4.3 | 0.76 | 0.77 | 0.77 | 21.8 |
| 2.0 | 0.78 | 0.79 | 0.79 | 21.8 |
| 0.3 | 0.79 | 0.79 | 0.79 | 21.7 |
| 1.0 | 0.80 | 0.80 | 0.80 | 21.7 |
| 0.0 | 0.80 | 0.80 | 0.80 | 21.7 |
| 1.0 | 0.81 | 0.81 | 0.81 | 21.7 |
| 0.0 | 0.81 | 0.81 | 0.81 | 21.7 |
| 0.0 | 0.81 | 0.81 | 0.81 | 21.7 |

**Results (adjusted to correlate with ASTM C457)**

| Chord length | < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | 3.6 % | 2.7 % | 0.8 % |
| Air-% paste | 9.9 % | 7.3 % | 2.2 % |
| Air-%putty | 9.0 % | 6.8 % | 2.0 % |
| Specific surface | 8.8 mm-1 | 10.2 mm-1 | |
| Spacing factor | 0.726 mm | 0.713 mm | |

**Comments**

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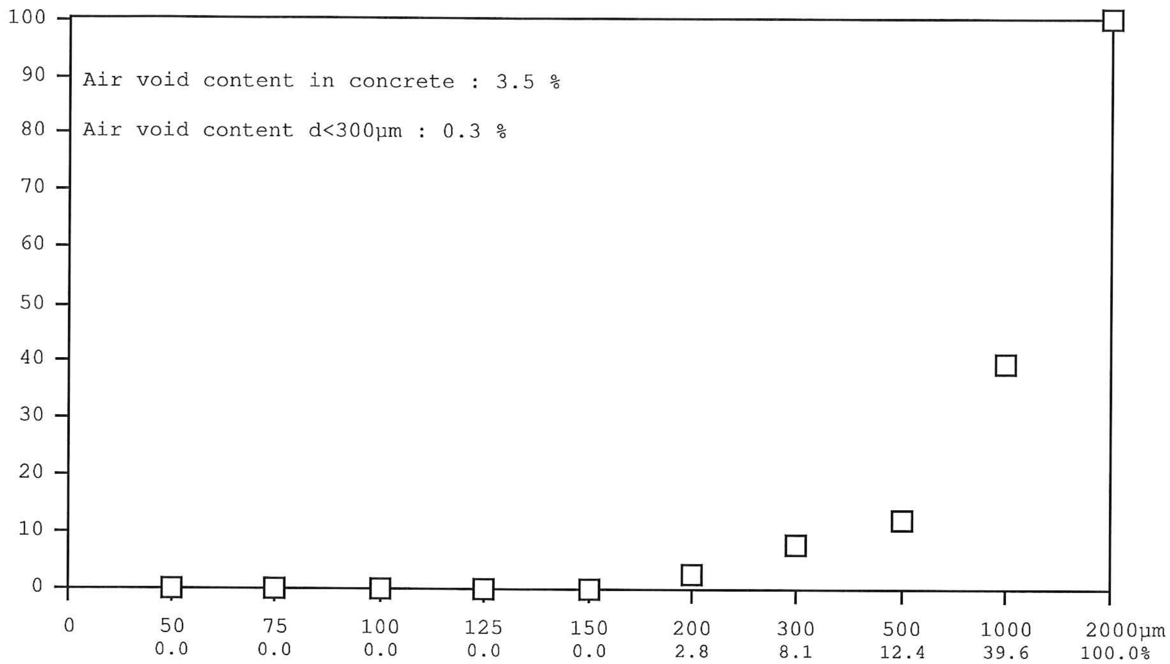
Sign.:________________________

Air Void Analyzer AVA-3000
Type Company name

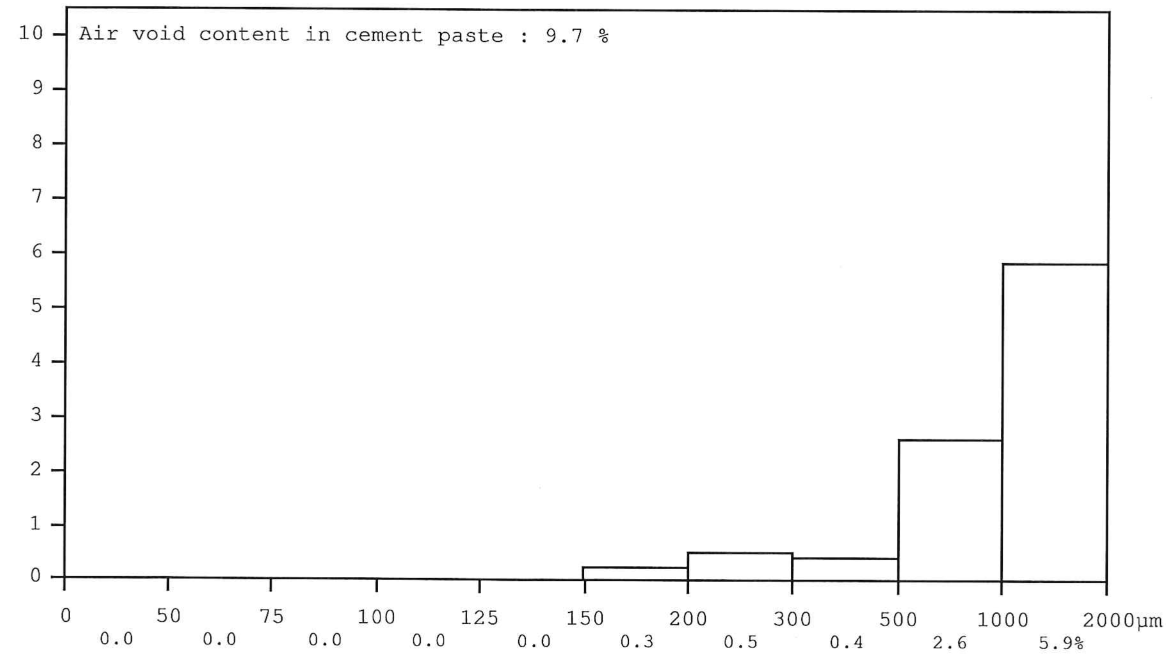
**Measurement of Mar 1, 2017 2:44 PM**

Case number : 1
Sample number : 3

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



AtA-SP 2

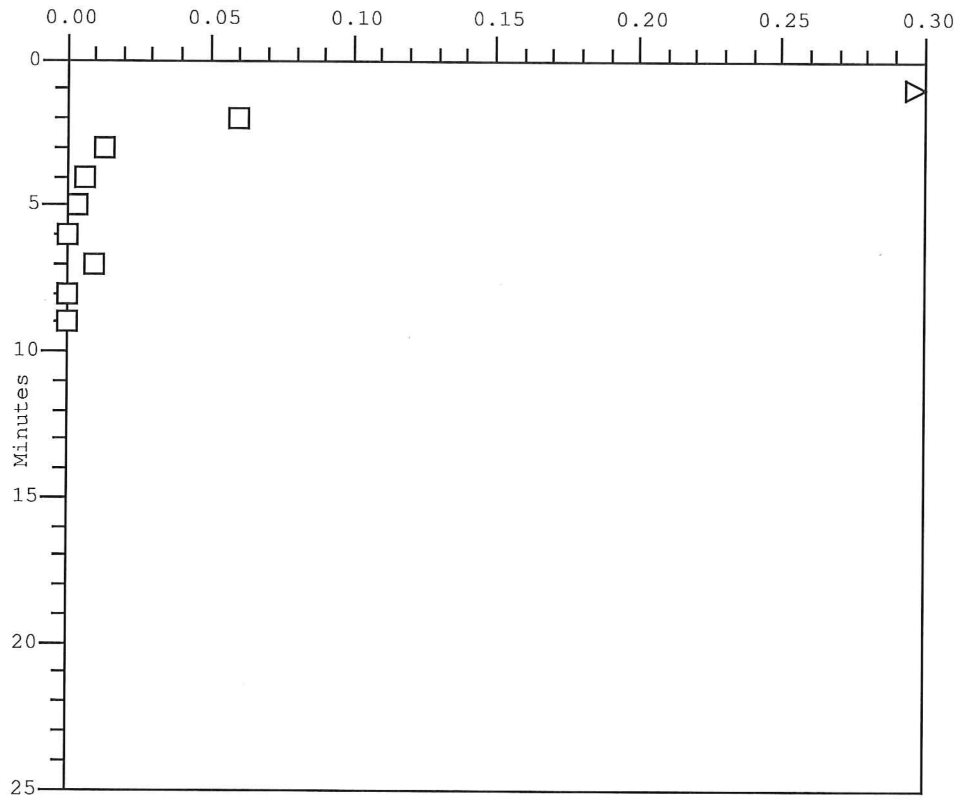
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of Mar 1, 2017 3:08 PM

| | | | |
|---|---|---|---|
| Sampler | : o | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : n | Expected air | : 4.0 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 4 | Sample volume | : 20.0 cm3 |

### Analysis

Start: 0.0g +5sec.: 0.09g +30sec.: 1.6600000000000001g Temp: 22.3°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 176.7 | 1.74 | 1.77 | 1.79 | 23.7 |
| 6.0 | 1.82 | 1.83 | 1.83 | 23.7 |
| 1.3 | 1.84 | 1.84 | 1.84 | 23.7 |
| 0.7 | 1.84 | 1.85 | 1.85 | 23.7 |
| 0.3 | 1.85 | 1.85 | 1.85 | 23.7 |
| 0.0 | 1.85 | 1.85 | 1.85 | 23.7 |
| 1.0 | 1.86 | 1.86 | 1.86 | 23.7 |
| 0.0 | 1.86 | 1.86 | 1.86 | 23.7 |
| 0.0 | 1.86 | 1.86 | 1.86 | 23.6 |

### Results (adjusted to correlate with ASTM C457)

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 8.3 % | 6.0 % | 1.3 % |
| Air-% paste | : 24.1 % | 17.0 % | 3.7 % |
| Air-%putty | : 19.4 % | 14.5 % | 3.0 % |
| Specific surface | : 6.7 mm-1 | 7.5 mm-1 | |
| Spacing factor | : 0.644 mm | 0.669 mm | |

### Comments

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Sign.:____________________

SP sin AEA (Copo., AEA125) Copolymer + Hemi...  SP-AEA 1 C2  23/2-17

44 min etter laging

# Air Void Analyzer AVA-3000
## Type Company name

**Measurement of Feb 22, 2017 12:10 PM**

| | | | |
|---|---|---|---|
| Sampler | : Ole | Mortar<6mm | : 87.0 % |
| Ordered by | : Andrei | Expected air | : 7.5 % |
| Sample location | : 1 | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 3 | | |

$\frac{w}{b} = 0,40$

$\frac{FA}{b} = 0,35$

$\frac{Si}{b} = 0,03$

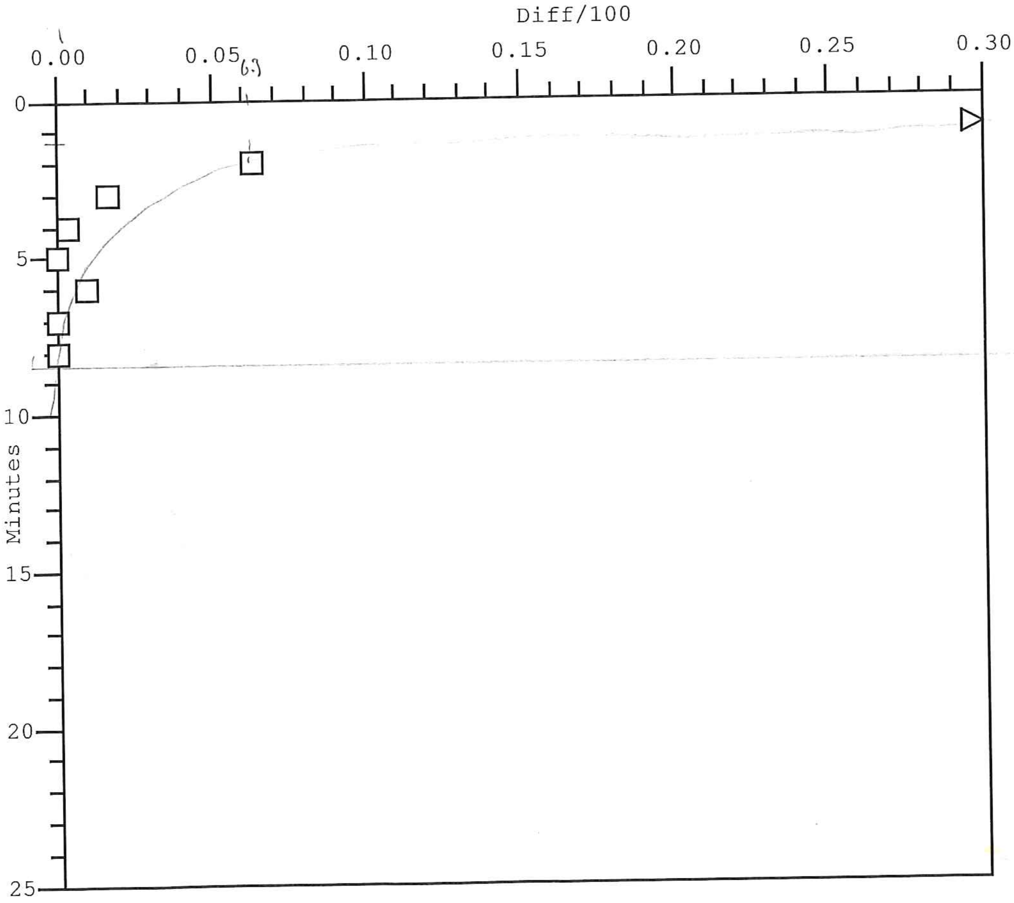
SX130 (3.9 kg)

dette

AEA 25 1.9 (--)

**Analysis**

Start: 0.0g   +5sec.: 0.01g   +30sec.: 0.67g   Temp: 21.8°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 79.7 | 0.76 | 0.80 | 0.83 | 22.6 |
| 6.3 | 0.85 | 0.86 | 0.87 | 22.7 |
| 1.7 | 0.87 | 0.88 | 0.88 | 22.6 |
| 0.3 | 0.88 | 0.88 | 0.88 | 22.6 |
| 0.0 | 0.88 | 0.88 | 0.88 | 22.6 |
| 1.0 | 0.89 | 0.89 | 0.89 | 22.6 |
| 0.0 | 0.89 | 0.89 | 0.89 | 22.7 |
| 0.0 | 0.89 | 0.89 | 0.89 | 22.7 |

Fresh density = ?

L pressure meter = ? (target 6-8%)

Syn (target 100mm)

+ 110 cm³ fenning

→ IMA

↓

- 2 prøve a drill
- 2 — n m — h —
  → 2 timer
- Tøffelt luftinnh. 6–8%
- Excel, plott av alle kurver i etdiagram

**Results (adjusted to correlate with ASTM C457)**

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 4.2 % | 3.3 % | 1.0 % |
| Air-% paste | : 11.2 % | 8.7 % | 2.7 % |
| Air-%putty | : 10.1 % | 8.0 % | 2.5 % |
| Specific surface | : 8.7 mm-1 | 9.8 mm-1 | |
| Spacing factor | : 0.679 mm | 0.674 mm | |

**Comments**

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Sign.:____________________

$$t^2 = t_1^2 + t_2^2 + t_3^2 + \dots \dots f_n^2$$

$$t = \sqrt{t_1^2 + \dots}$$

N(0,1)

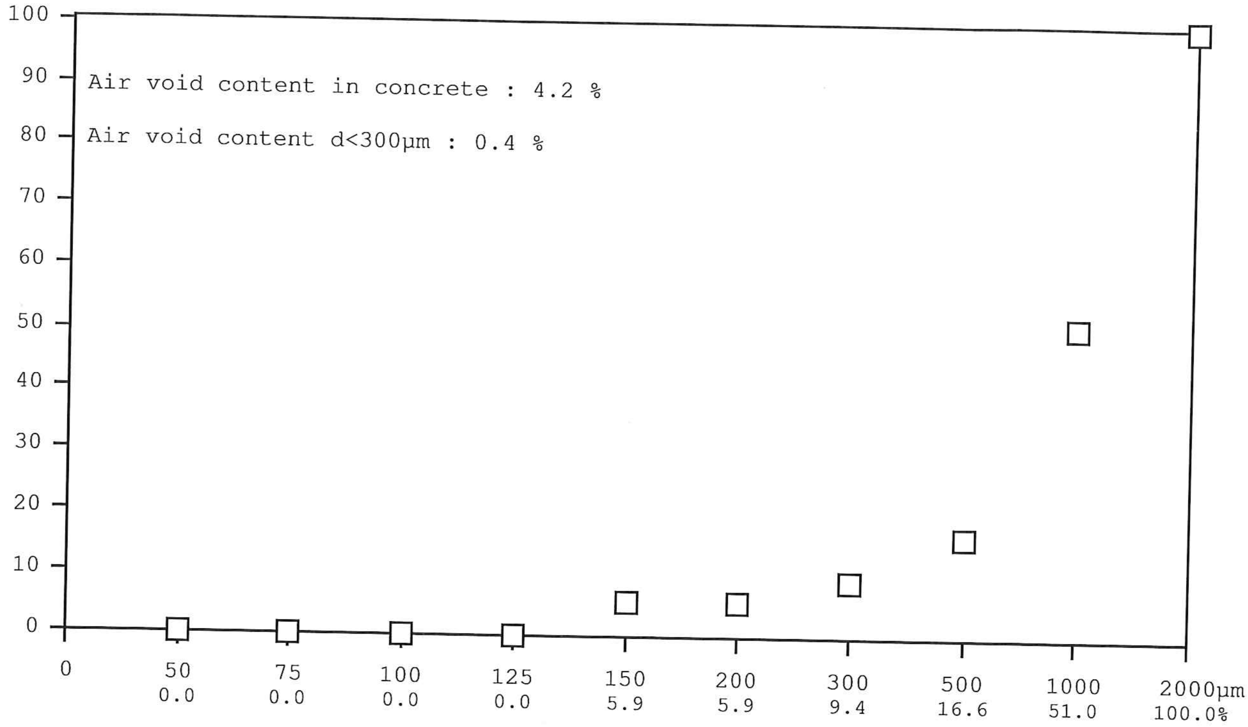
$\int f(x)dx = 1$

## Air Void Analyzer AVA-3000
## Type Company name

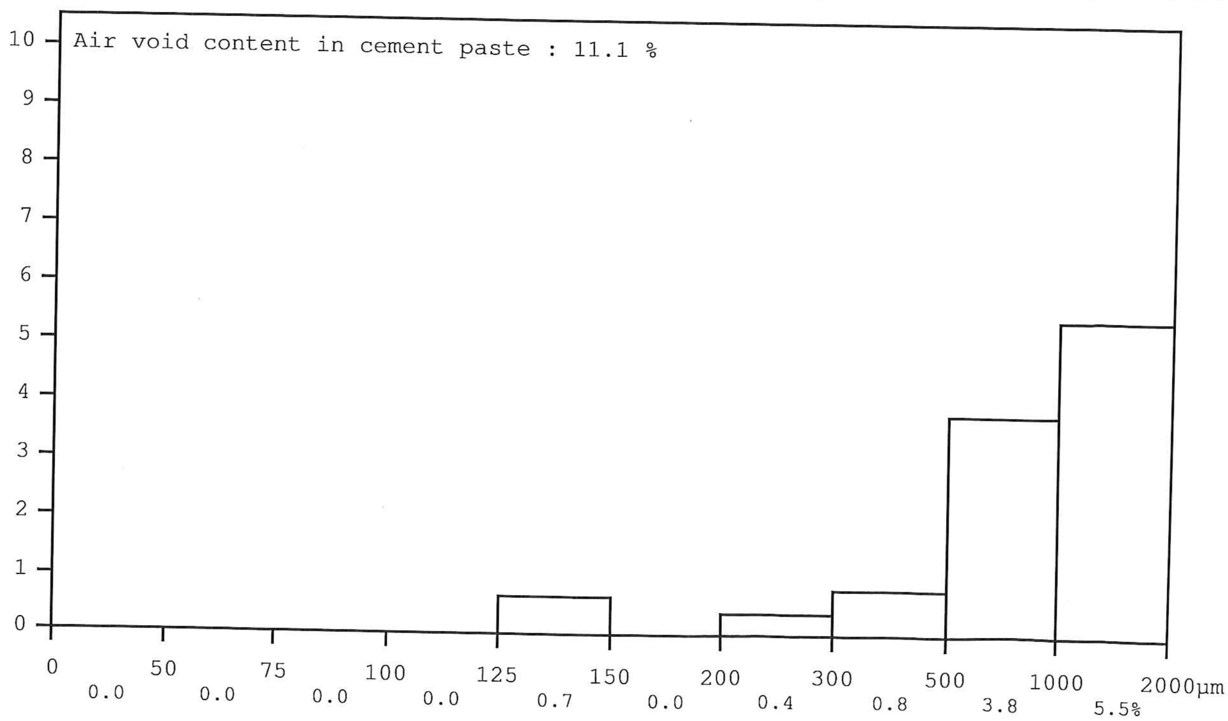
**Measurement of Feb 22, 2017 12:10 PM**

Case number : 1
Sample number : 3

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



74 min etterkamp

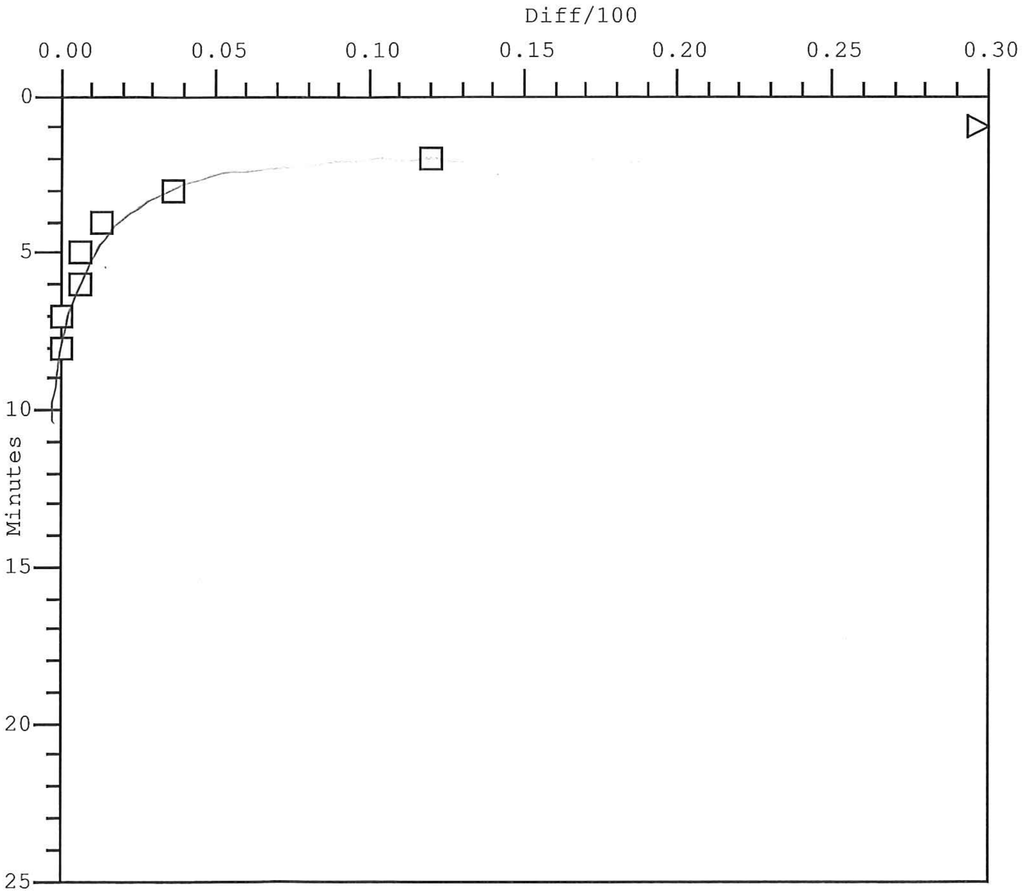
# Air Void Analyzer AVA-3000
## Type Company name

**Measurement of Feb 22, 2017 1:00 PM**

| | | | |
|---|---|---|---|
| Sampler | : ole | | |
| Ordered by | : a | Mortar<6mm | : 87.0 % |
| Sample location | : 1 | Expected air | : 7.5 % |
| Case number | : 1 | Paste | : 36.0 % |
| Sample number | : 2 | Sample volume | : 20.0 cm3 |

**Analysis**

Start: 0.0g +5sec.: 0.14g +30sec.: 0.63g Temp: 22.2°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 85.7 | 0.79 | 0.87 | 0.91 | 23.2 |
| 12.0 | 0.96 | 0.98 | 0.99 | 23.2 |
| 3.7 | 1.01 | 1.01 | 1.02 | 23.1 |
| 1.3 | 1.02 | 1.03 | 1.03 | 23.1 |
| 0.7 | 1.03 | 1.03 | 1.04 | 23.1 |
| 0.7 | 1.04 | 1.04 | 1.04 | 22.9 |
| 0.0 | 1.04 | 1.04 | 1.04 | 23.1 |
| 0.0 | 1.04 | 1.04 | 1.04 | 22.9 |

**Results (adjusted to correlate with ASTM C457)**

| Chord length | : < 2mm | < 1mm | < 0.35mm |
|---|---|---|---|
| Air-% concrete | : 4.6 % | 3.9 % | 1.7 % |
| Air-% paste | : 12.3 % | 10.3 % | 4.5 % |
| Air-%putty | : 10.9 % | 9.4 % | 4.0 % |
| Specific surface | : 11.3 mm-1 | 12.6 mm-1 | |
| Spacing factor | : 0.507 mm | 0.488 mm | |

**Comments**

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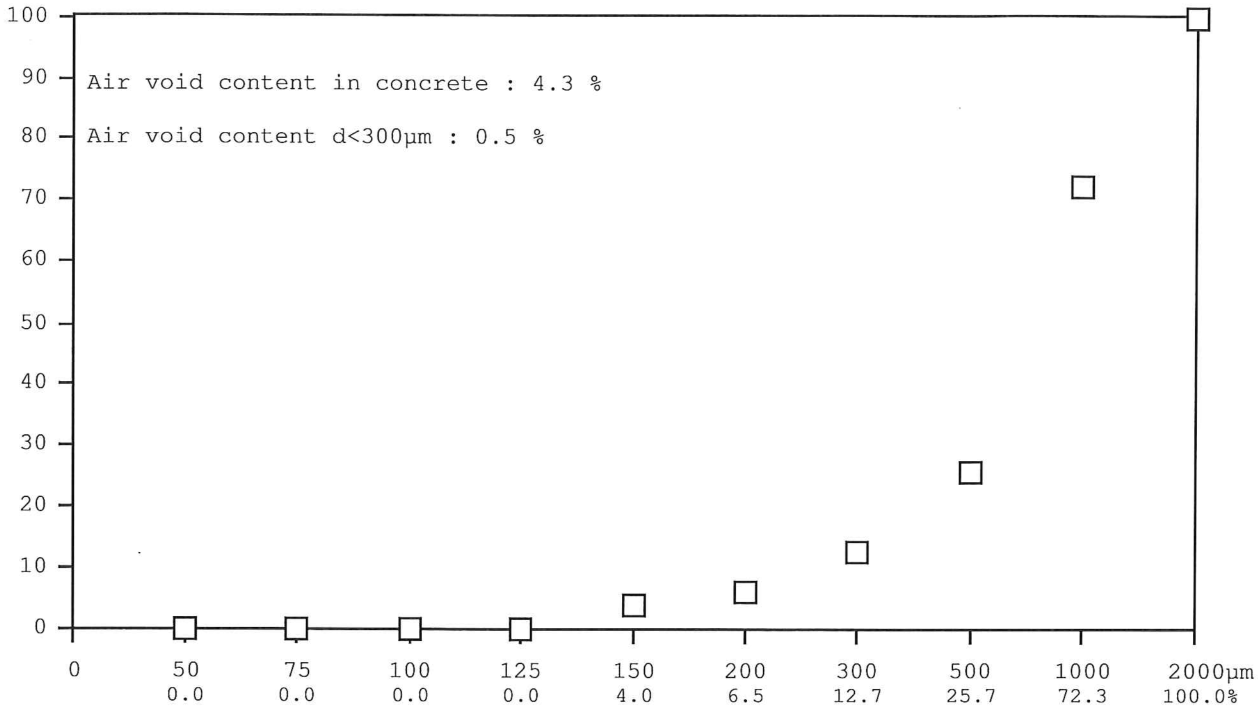
Sign.:_______________

# Air Void Analyzer AVA-3000
## Type Company name

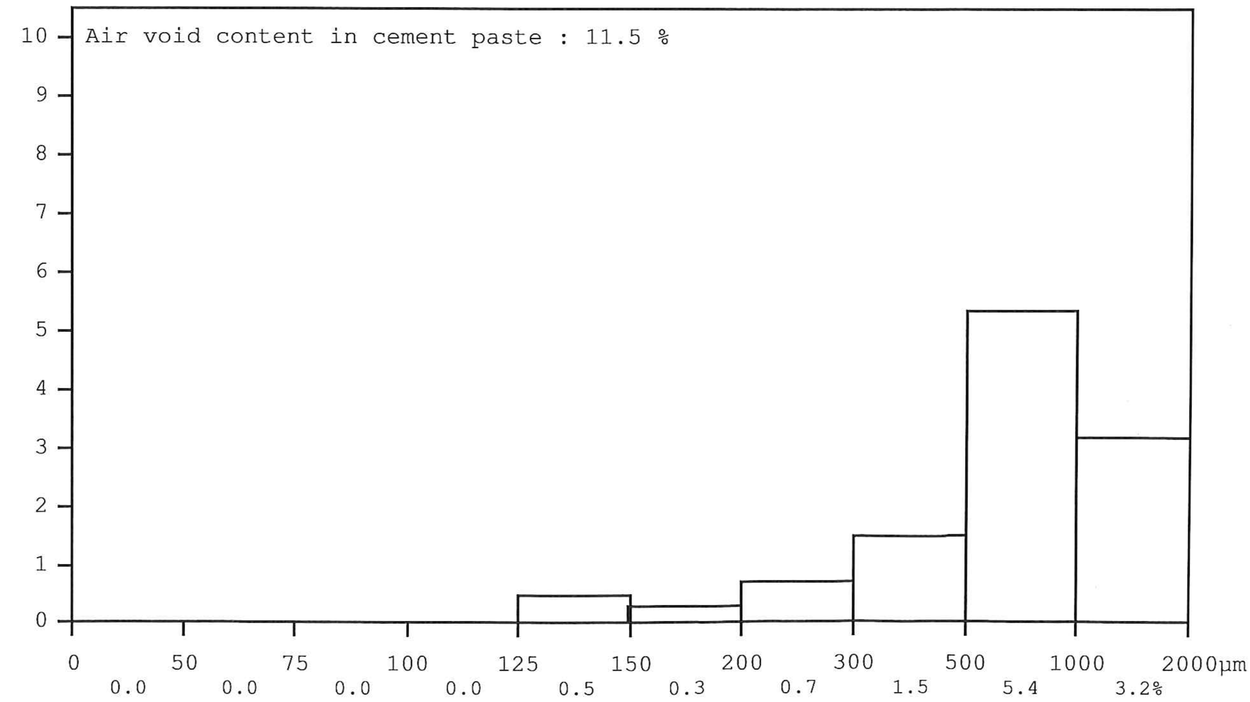
**Measurement of Feb 22, 2017 1:00 PM**

Case number : 1
Sample number : 2

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



No drill sampl. 120 min [illegible]

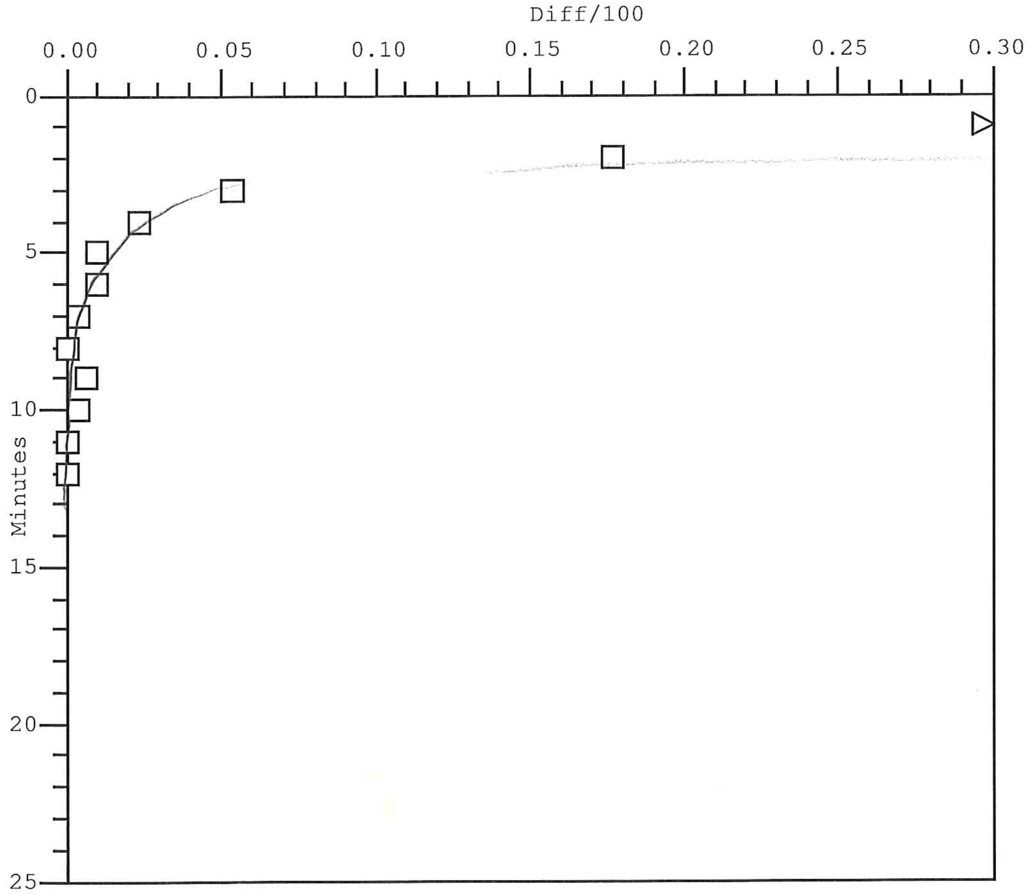
# Air Void Analyzer AVA-3000
## Type Company name

### Measurement of Feb 22, 2017 1:26 PM

| | | | |
|---|---|---|---|
| Sampler | : o | Mortar<6mm | : 87.0 % |
| Ordered by | : a | Expected air | : 7.5 % |
| Sample location | : n | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 3 | | |

### Analysis

Start: 0.0g    +5sec.: 0.0g    +30sec.: 0.38g    Temp: 22.2°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 58.3 | 0.49 | 0.60 | 0.66 | 23.1 |
| 17.7 | 0.74 | 0.76 | 0.78 | 23.1 |
| 5.3 | 0.80 | 0.82 | 0.82 | 23.1 |
| 2.3 | 0.83 | 0.84 | 0.84 | 23.1 |
| 1.0 | 0.84 | 0.85 | 0.85 | 22.9 |
| 1.0 | 0.85 | 0.86 | 0.86 | 22.9 |
| 0.3 | 0.86 | 0.86 | 0.86 | 22.9 |
| 0.0 | 0.86 | 0.86 | 0.86 | 22.9 |
| 0.7 | 0.86 | 0.87 | 0.87 | 22.9 |
| 0.3 | 0.87 | 0.87 | 0.87 | 22.9 |
| 0.0 | 0.87 | 0.87 | 0.87 | 22.9 |
| 0.0 | 0.87 | 0.87 | 0.87 | 22.9 |

### Results (adjusted to correlate with ASTM C457)

| | | | |
|---|---|---|---|
| Chord length | : < 2mm | < 1mm | < 0.35mm |
| Air-% concrete | : 4.1 % | 3.7 % | 2.0 % |
| Air-% paste | : 11.0 % | 9.9 % | 5.4 % |
| Air-%putty | : 9.9 % | 9.0 % | 4.9 % |
| Specific surface | : 15.2 mm-1 | 16.3 mm-1 | |
| Spacing factor | : 0.394 mm | 0.384 mm | |

### Comments

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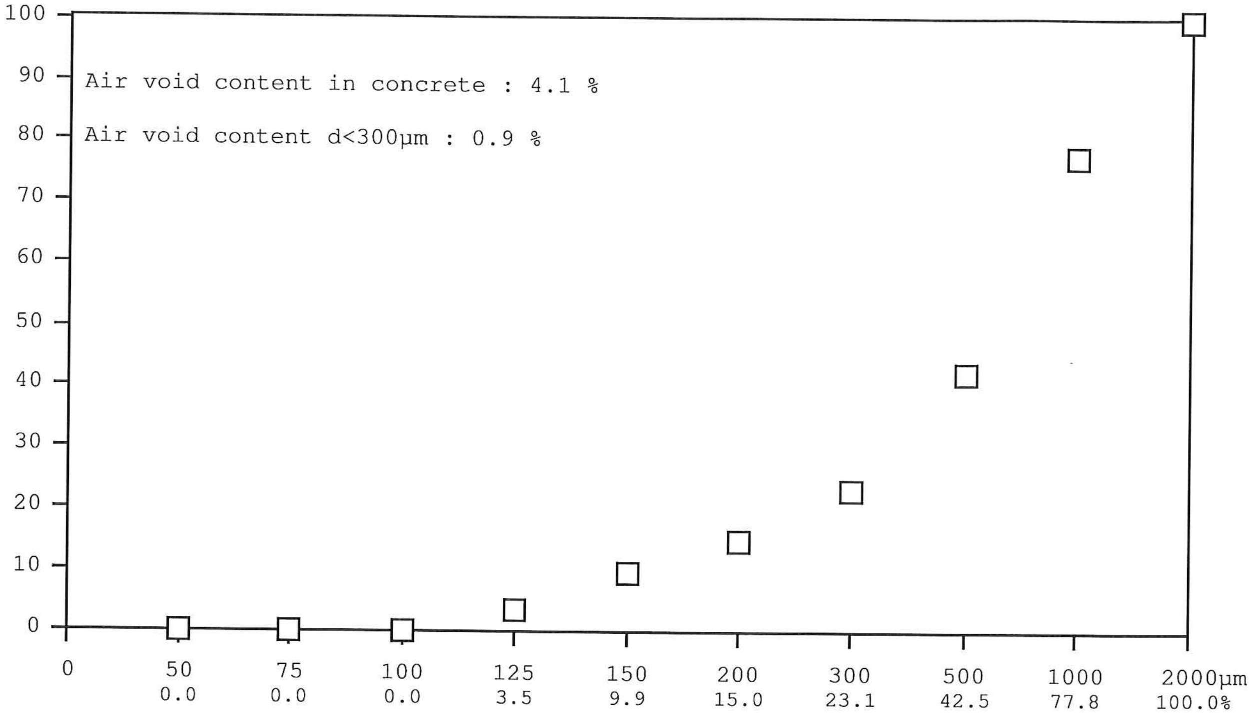
Sign.:________________________

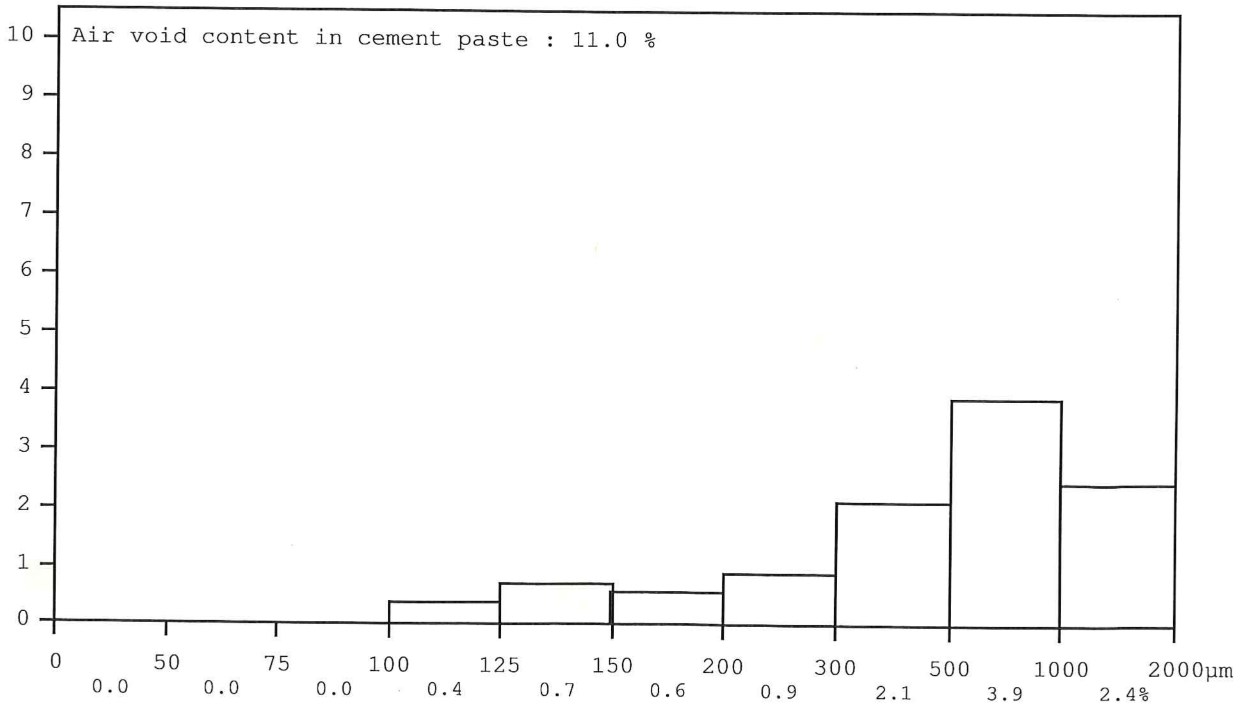
**Measurement of Feb 22, 2017 1:26 PM**

Case number : 1
Sample number : 3

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



drill sampl.

135 min etter vann

# Air Void Analyzer AVA-3000
## Type Company name

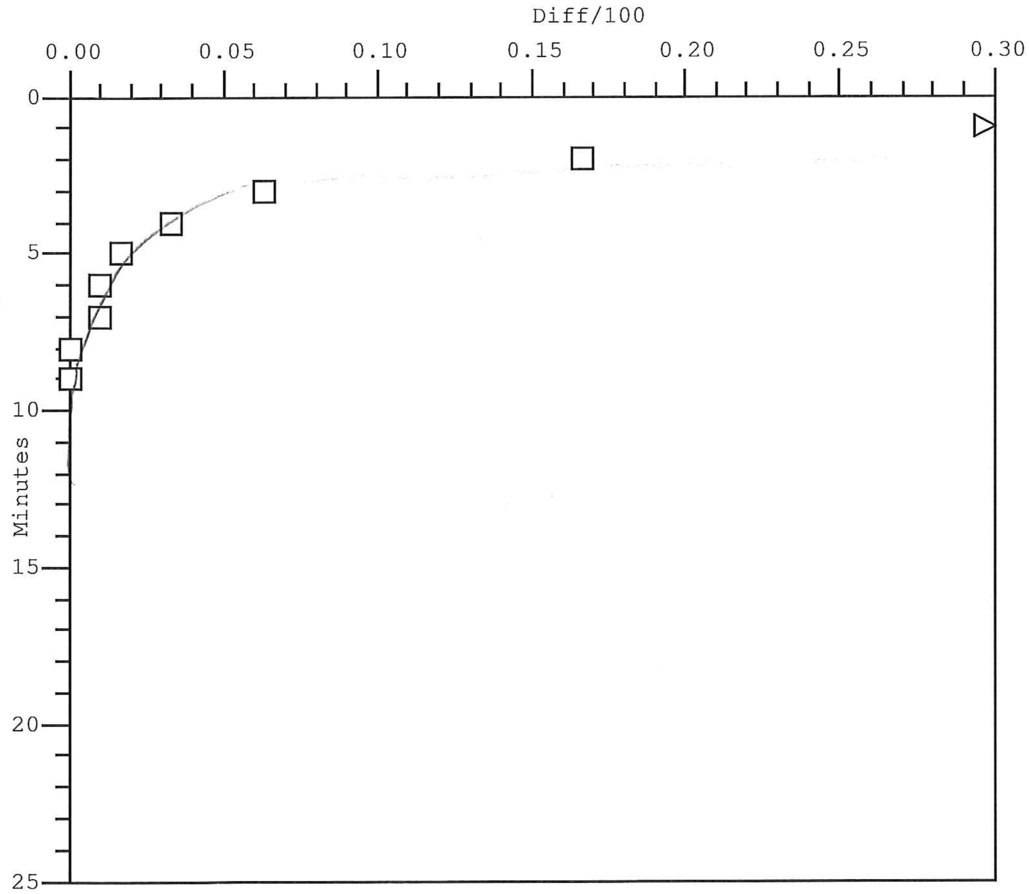
G

**Measurement of Feb 22, 2017 2:01 PM**

| | | | |
|---|---|---|---|
| Sampler | : o | Mortar<6mm | : 87.0 % |
| Ordered by | : a | Expected air | : 7.5 % |
| Sample location | : n | Paste | : 36.0 % |
| Case number | : 1 | Sample volume | : 20.0 cm3 |
| Sample number | : 4 | | |

**Analysis**

Start: 0.0g +5sec.: 0.09g +30sec.: 0.47000000000000003g Temp: 22.3°C




| Diff | -15 | Min | +15 | T/°C |
|---|---|---|---|---|
| 70.0 | 0.62 | 0.72 | 0.76 | 22.6 |
| 16.7 | 0.84 | 0.87 | 0.89 | 22.6 |
| 6.3 | 0.92 | 0.93 | 0.94 | 22.5 |
| 3.3 | 0.96 | 0.96 | 0.97 | 22.6 |
| 1.7 | 0.98 | 0.98 | 0.98 | 22.6 |
| 1.0 | 0.99 | 0.99 | 0.99 | 22.6 |
| 1.0 | 1.00 | 1.00 | 1.00 | 22.6 |
| 0.0 | 1.00 | 1.00 | 1.00 | 22.6 |
| 0.0 | 1.00 | 1.00 | 1.00 | 22.6 |

Σ 100.0 (=4.5% luft)

**Results (adjusted to correlate with ASTM C457)**

| | | | |
|---|---|---|---|
| Chord length : | < 2mm | < 1mm | < 0.35mm |
| Air-% concrete : | 4.5 % | 4.0 % | 2.2 % |
| Air-% paste : | 12.1 % | 10.8 % | 5.9 % |
| Air-%putty : | 10.8 % | 9.7 % | 5.2 % |
| Specific surface : | 15.3 mm-1 | 16.6 mm-1 | |
| Spacing factor : | 0.376 mm | 0.363 mm | |

**Comments**

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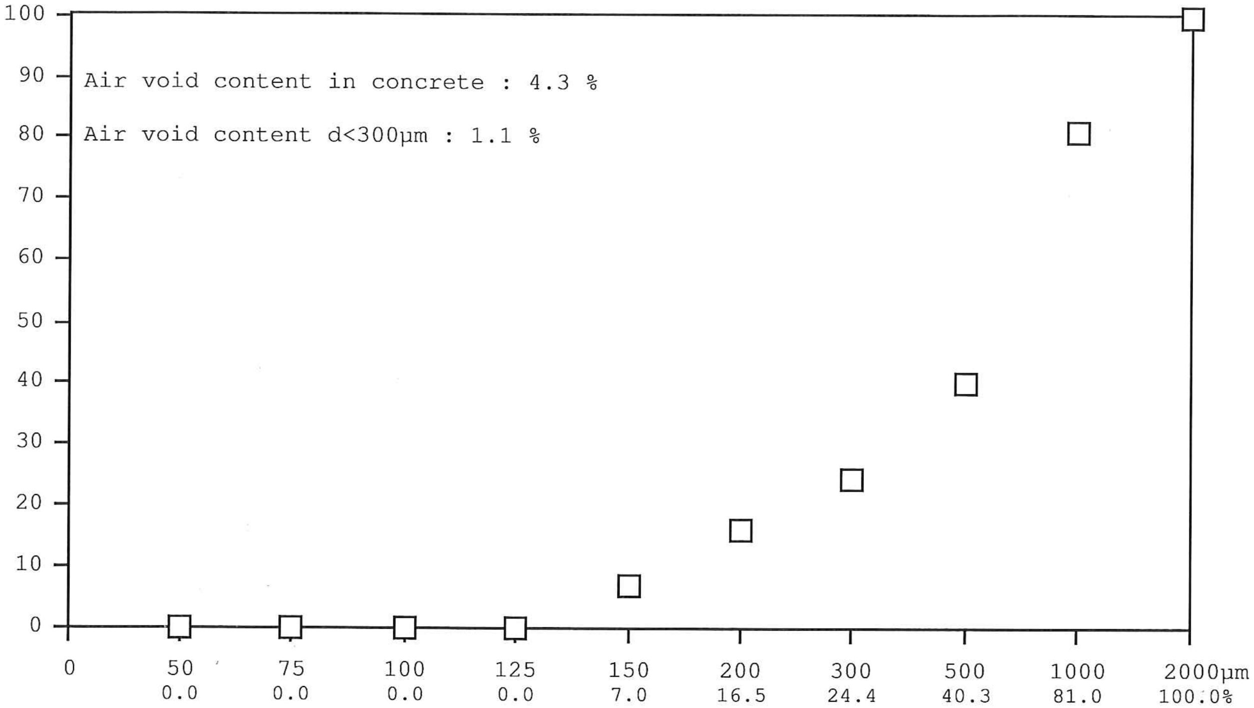
Sign.:______________________

# Air Void Analyzer AVA-3000
## Type Company name

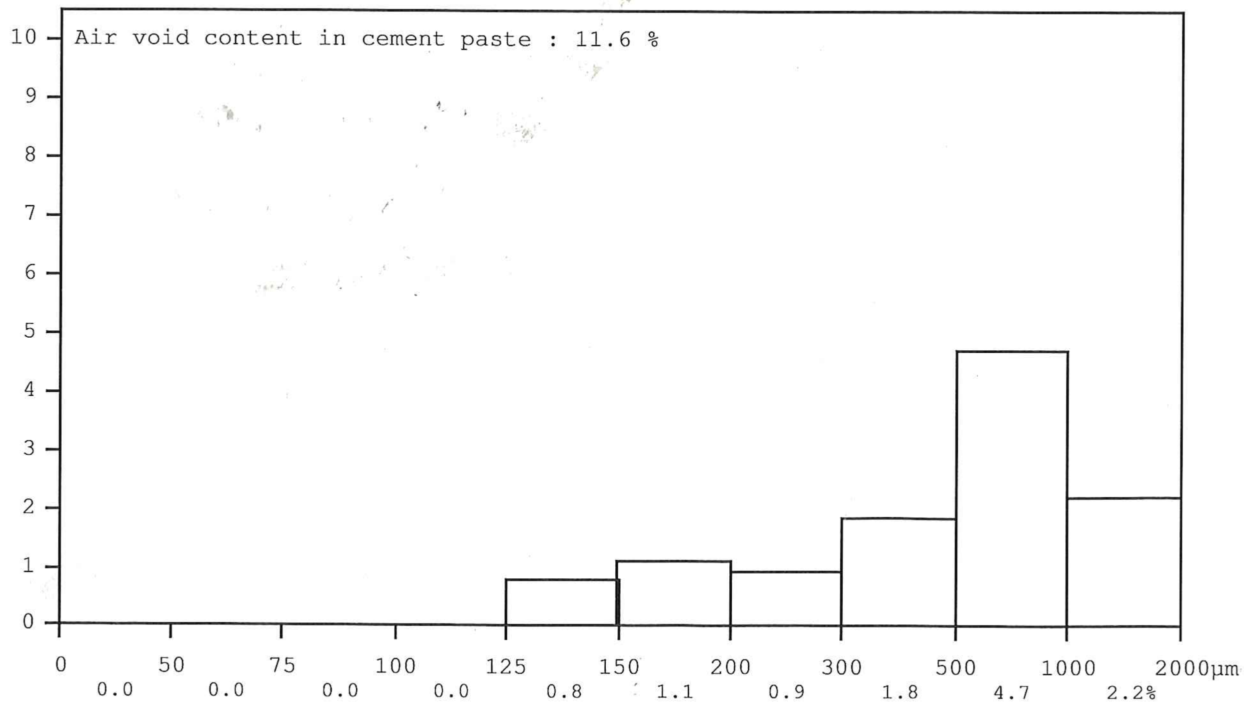
**Measurement of Feb 22, 2017 2:01 PM**

Case number : 1
Sample number : 4

**Distribution of air void content for voids < 2 mm (%)**




**Distribution of air void content in cement paste for voids < 2 mm (%)**



# Appendix N

**Skanska proportions sheets**

Cem 2 14:45 SP: 0,6% AEA-SP AEA: 0,76%

| Blandeskjema | SKANSKA |
|---|---|
| Prosjekt | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| Reseptnummer | ~~CEM1 SP før luft prøvebl.1 (av 2)~~ AEA - SP 6 |
| Tilsiktet kvalitet | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6.1 liter |
| Dato: | ~~21/4~~ 2/5 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 353.1 | 2.154 | | | 2.154 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.086 | 0.0 | 0.000 | 0.086 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.643 | | | 0.643 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.1 | 1.153 | | -0.366 | 0.787 | 0.815 |
| Absorbert vann | 4.5 | 0.028 | | | 0.028 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 9.235 | 3.6 | 0.332 | 9.568 | |
| Mapei Dynamon SX-130 | 2.8 | 0.0173 | 70 | 0.012 | 0.0173 | |
| Mapeair 25 1:9 | 3.6 | 0.022 | 99.58 | 0.022 | 0.0219 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| Fersk betong | 12 min | | 1,5 t | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 105 | | 65 | | |
| Utbredelsesmål | | | | | |
| Luft | 7,5 | | | | |
| Densitet | 2238,3 | | 2296,9 | | |

| Prøvestykker (antall) | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AVA tatt 45 min etter vann

AVA tatt 2. gang 1,5 t 21,9 - 2,15 = 19,7)

Støpt kube 15:20



Ferdig 16:50

SP-AEA AEA 0,79% 11:15 cem II SP: 0,77%

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 21/4 2/5 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 352.9 | 1.765 | | | 1.765 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.071 | 0.0 | 0.000 | 0.071 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.527 | | | 0.527 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.0 | 0.945 | | -0.304 | 0.641 | 0.664 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 3.6 | 0.273 | 7.842 | |
| Mapei Dynamon SX-130 | 3.6 | 0.0182 | 70 | 0.013 | 0.0182 | |
| Mapeair 25 1:9 | 3.7 | 0.019 | 99.58 | 0.019 | 0.0187 | |

*Se fotnote på delark "Resept"　　** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 98 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 8 | | | | |
| Densitet | 2202,9 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

18,7 - 1,87 = 16,83

Støpt kube

AVA test 44 min

2 AVA test - 1 t og 30 min

13:20 2% AEA

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | ~~CEM1 SP før luft prøvebl 1 (av 2)~~ Cem 2 AEA-SP |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6.1 liter |
| Dato: | ~~21/4~~ 2 mai |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 353.2 | 2.154 | | | 2.154 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.087 | 0.0 | 0.000 | 0.087 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.643 | | | 0.643 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.1 | 1.154 | | -0.400 | 0.754 | 0.781 |
| Absorbert vann | 4.5 | 0.028 | | | 0.028 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 9.235 | 3.6 | 0.332 | 9.568 | |
| Mapei Dynamon SX-130 | 2.4 | 0.0144 | 70 | 0.010 | 0.0144 | |
| Mapeair 25 1:9 | 9.5 | 0.058 | 99.58 | 0.057 | 0.0577 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 90 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 15 | | | | |
| Densitet | 1930 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

57,7 - 5,77 = 51,93

+ 1,45 SP

SP: 0,77% - AEA: 0,7%        12:45 - 13:30

## Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | ~~CEM1~~ SP før luft prøvebl.1 (av 2) cem 2 |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | ~~21/4~~ 28/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 352.9 | 1.765 | | | 1.765 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.071 | 0.0 | 0.000 | 0.071 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.527 | | | 0.527 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.0 | 0.945 | | -0.302 | 0.643 | 0.666 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 3.6 | 0.273 | 7.842 | |
| Mapei Dynamon SX-130 | 3.6 | 0.0182 | 70 | 0.013 | 0.0182 | |
| Mapeair 25 1:9 | 3.3 | 0.017 | 99.58 | 0.016 | 0.0165 | |

*Se fotnote på delark "Resept"        ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 95 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 3,9 | | | | |
| Densitet | 2299,8 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

16,5 - 1,65 = 14,85

SP: 0,77 % AEA: 0,76 % 13:45 - 15:00

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | ~~C5M~~1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | ~~21/4~~ 28/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 352.9 | 1.765 | | | 1.765 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.071 | 0.0 | 0.000 | 0.071 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.527 | | | 0.527 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.0 | 0.945 | | -0.303 | 0.642 | 0.664 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 3.6 | 0.273 | 7.842 | |
| Mapei Dynamon SX-130 | 3.6 | 0.0182 | 70 | 0.013 | 0.0182 | |
| Mapeair 25 1:9 | 3.6 | 0.018 | 99.58 | 0.018 | 0.0180 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 105 | | | | |
| Utbredelsesmål | | | | | |
| Luft | ~~[illegible]~~ | 4 % | | | |
| Densitet | 2289,4 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

18-1,8=16,2 g water

SP: 0,7 AEA: 0,8 11:00

## Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | ~~21/4~~ 28/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 353.0 | 1.765 | | | 1.765 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.071 | 0.0 | 0.000 | 0.071 | |
| Norcem Fly Ash - FA (NO) | 105.4 | 0.527 | | | 0.527 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.0 | 0.945 | | -0.303 | 0.642 | 0.665 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 3.6 | 0.273 | 7.842 | |
| Mapei Dynamon SX-130 | 3.3 | 0.0163 | 70 | 0.011 | 0.0163 | |
| Mapeair 25 1:9 | 3.8 | 0.019 | 99.58 | 0.019 | 0.0189 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 82 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 10,1 | | | | |
| Densitet | 2118,4 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

19-1,9=17,1 g W

0,65
+ SP

SP-AEA 1 SP: 0,71% AEA: 0,82

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6.1 liter |
| Dato: | ~~21/4~~ 27/4 14:15 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.1 | 2.874 | | | 2.874 | |
| Elkem Microsilica | 14.6 | 0.089 | 0.0 | 0.000 | 0.089 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.3 | 1.185 | | -0.371 | 0.814 | 0.841 |
| Absorbert vann | 4.5 | 0.028 | | | 0.028 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 9.235 | 3.6 | 0.332 | 9.568 | |
| Mapei Dynamon SX-130 | 3.4 | 0.0210 | 70 | 0.015 | 0.0210 | |
| Mapeair 25 1:9 | 4.0 | 0.024 | 99.58 | 0.024 | 0.0243 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 109 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 6 % | | | | |
| Densitet | 2302,4 | | ~~m³~~ | = | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

Slept 15:15

Ny dens kube: 2271 g

Pasta 35,87 %

243 - 2,43 = 21,87

0,89

AVA: 36 min etter vann

Vasking 45 min

2,8% i Sand
0,65% SP 0,84% AEA | SP - AEA

# Blandeskjema **SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6.1 liter |
| Dato: | ~~21/4~~ 26/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole og Andrei |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.2 | 2.874 | | | 2.874 | |
| Elkem Microsilica | 14.6 | 0.089 | 0.0 | 0.000 | 0.089 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.3 | 1.185 | | -0.297 | 0.888 | ~~0,916~~ 0,841 |
| Absorbert vann | 4.5 | 0.028 | | | 0.028 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 9.235 | 2.8 | 0.259 | ~~9.494~~ | 9568 |
| Mapei Dynamon SX-130 | 3.2 | 0.0193 | 70 | 0.013 | ~~0.019~~ | 21 g |
| Mapeair 25 1:9 | 4.1 | 0.025 | 99.58 | 0.025 | 0.025 | 25 g |

*Se fotnote på delark "Resept"  ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | 1 | 2 | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 82 | 92 | | | |
| Utbredelsesmål | | | | | |
| Luft | 12 | 8,4 | | | |
| Densitet | 2085,6 | 2205,5 | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

1 g AEA
9 g vann

25 g AEA

3 g AEA 9.3 g vann =

3 30 g AEA 1:9

14:50 0,81% AEA 0,7% SP

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 21/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.1 | 2.356 | | | 2.356 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.3 | 0.971 | | -0.243 | 0.728 | 0.751 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.8 | 0.212 | 7.782 | |
| Mapei Dynamon SX-130 | 3.4 | 0.0170 | 70 | 0.012 | 0.017 | (16,9 g) |
| Mapeair 25 1:9 | 3.9 | 0.019 | 99.58 | 0.019 | 0.019 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 105 | | | | |
| Utbredelsesmål | | | | | |
| Luft | ~~[illegible]~~ | 5 % | | | |
| Densitet | 2301,4 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

12:00 0,7 % SP 0,7 % L-stoff

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 21/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.1 | 2.356 | | | 2.356 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.3 | 0.971 | | -0.241 | 0.731 | 0.753 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.8 | 0.212 | 7.782 | |
| Mapei Dynamon SX-130 | 3.4 | 0.0170 | 70 | 0.012 | 0.017 | |
| Mapeair 25 1:9 | 3.4 | 0.017 | 99.58 | 0.017 | 0.017 | |

*Se fotnote på delark "Resept"     ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | 12 | 14:00 | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 100 | 105 | | | |
| Utbredelsesmål | | | | | |
| Luft | 3 % | 3,2 | | | |
| Densitet | 2327,3 | 2327,6 | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

CEM1 SP- AEA 11:15 21/4 SP: 0,7 %
AEA: 0,9 %

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 21/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.1 | 2.356 | | | 2.356 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.3 | 0.971 | | -0.246 | 0.726 | 0.748 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.8 | 0.212 | 7.782 | |
| Mapei Dynamon SX-130 | 3.4 | 0.0170 | 70 | 0.012 | 0.017 | |
| Mapeair 25 1:9 | 4.4 | 0.022 | 99.58 | 0.022 | 0.022 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 97 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 10,5 | | | | |
| Densitet | 2126,2 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

4,6 g og 4,6·9 w = 41,4
3 g AEA
og 3·9 = 27
4

≈ 50 g AEA
6 g AEA og 6·9 g Water
= 6 + 54 = 60 g
54,9 - 52,8 =
8,8·6 = 52,8

$\frac{1,9}{5}$ =

SP: 0,9 %    AEA: 0,7 %    12:45    SP-AEA

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 20/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 470.8 | 2.354 | | | 2.354 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.2 | 0.971 | | -0.251 | 0.719 | 0.742 0,749 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.8 | 0.212 | 7.782 | |
| Mapei Dynamon SX-130 | 4.4 | 0.0218 | 70 | 0.015 | 0.022 | 0,022 |
| Mapeair 25 1:9 | 4.9 | 0.024 | 99.58 | 0.024 | 0.024 | 0,0178 |

*Se fotnote på delark "Resept"    ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 109 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 2,7 | | | | |
| Densitet | 2374,3 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

SP: 0,8 % AEA: 1 % SP-AEA

| Blandeskjema | SKANSKA |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 20/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem Anlegg | 471.0 | 2.355 | | | 2.355 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.2 | 0.971 | | -0.250 | 0.721 | 0.744 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.8 | 0.212 | 7.782 | |
| Mapei Dynamon SX-130 | 3.9 | 0.0194 | 70 | 0.014 | 0.019 | |
| Mapeair 25 1:9 | 4.9 | 0.024 | 99.58 | 0.024 | 0.024 | |

*Se fotnote på delark "Resept"   ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 110 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 2,6 | | | | |
| Densitet | 2342,5 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

12:15 19/4 SP: 9,7 AEA: 1%

| Blandeskjema | SKANSKA |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM2 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 353.4 | 3.180 | | | 3.180 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.128 | 0.0 | 0.000 | 0.128 | |
| Norcem Fly Ash - FA (NO) | 105.5 | 0.949 | | | 0.949 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.2 | 1.703 | | -0.482 | 1.221 | 1.262 |
| Absorbert vann | 4.5 | 0.040 | | | 0.040 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 13.497 | 3.1 | 0.418 | 13.916 | |
| Mapei Dynamon SX-130 | 3.3 | 0.0298 | 70 | 0.021 | 0.030 | |
| Mapeair 25 1:9 | 4.7 | 0.043 | 99.58 | 0.042 | 0.043 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| Fersk betong | 12 min | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 85 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 5,6 | | | | |
| Densitet | 2260,4 | | | | |

| Prøvestykker (antall) | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

3180-2153=1027
949-643=306
128-86=42
13916-9521=4395

19/4 12:45 AEA: 1,1% SP: 0,8%

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM2 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 6.1 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 352.9 | 2.153 | | | 2.153 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.086 | 0.0 | 0.000 | 0.086 | |
| Norcem Fly Ash - FA (NO) | 105.3 | 0.643 | | | 0.643 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.0 | 1.153 | | -0.316 | 0.837 | 0.865 |
| Absorbert vann | 4.5 | 0.028 | | | 0.028 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 9.235 | 2.9 | 0.268 | 9.503 | |
| Mapei Dynamon SX-130 | 3.8 | 0.0231 | 70 | 0.016 | 0.023 | |
| Mapeair 25 1:9 | 5.2 | 0.032 | 99.58 | 0.032 | 0.032 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 100 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 2,7 | | | | |
| Densitet | 2338,4 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

SP: 0,7 %   AEA: 0,8 %   18/4   14:00

SP-AEA

# Blandeskjema **SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM2 SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 9 liter |
| Dato: | 18/4 |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | Ole |
| Utført av: | Ole og Andrei |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 353.4 | 3.180 | | | 3.180 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.2 | 0.128 | 0.0 | 0.000 | 0.128 | |
| Norcem Fly Ash - FA (NO) | 105.5 | 0.949 | | | 0.949 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 189.2 | 1.703 | | -0.473 | 1.230 | 1.270 |
| Absorbert vann | 4.5 | 0.040 | | | 0.040 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 13.497 | 3.1 | 0.418 | 13.916 | |
| Mapei Dynamon SX-130 | 3.3 | 0.0298 | 70 | 0.021 | 0.030 | |
| Mapeair 25 1:9 | 3.8 | 0.034 | 99.58 | 0.034 | 0.034 | |

*Se fotnote på delark "Resept"   ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | 12 min | 40 min | 100 | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 75 | 55 | 50 | (Bilder | tatt) |
| Utbredelsesmål | | | | | |
| Luft | 4,4 | 4,7 | | | |
| Densitet | | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AVA 20 min   AVA 60 min   AVA 100 min (ikke gjennomført)

# Blandeskjema

**SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | CEM1 SP før luft prøvebl.~~1 (av~~ 2) 2 |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | 10/3 |
| Tidspunkt for vanntilsetning: | 14:00 |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | | |
|---|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | | |
| Norcem AnleggFA | 0.0 | 0.000 | | | 0.000 | | |
| Norcem Anlegg | 471.2 | 2.356 | | | 2.356 | | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | | |
| Norcem Fly Ash - FA (NO) | 0.0 | 0.000 | | | 0.000 | | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | | |
| Fritt vann | 194.3 | 0.972 | | -0.249 | 0.722 | 0.745 | |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 3.0 | 0.225 | 7.723 | | |
| Mapei Dynamon SX-130 | 4.9 | 0.0243 | 70 | 0.017 | ~~0.024~~ | 17,4 24,1 | (74,9) ↓ 57,5 |
| Mapeair 25 1:9 | 1.5 | 0.007 | 99.58 | 0.007 | 0.007 | | |

*Se fotnote på delark "Resept"

** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 90 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 5,1 | | | | |
| Densitet | 2300 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

SP: 1 %

AEA: 0,3 %

3 mars 14:30 og 9/3 V

# Blandeskjema

**SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA ~~SP før luft prøvebl 1 (av 2)~~ SP og AEA |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.1 | 1.820 | | | 1.820 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 195.0 | 0.975 | | -0.212 | 0.762 | 0.785 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | |
| Mapei Dynamon SX-130 | 2.4 | 0.0122 | 70 | 0.009 | 0.012 | |
| Mapeair 25 1:9 | 7.8 | 0.039 | 99.58 | 0.039 | 0.039 | |

*Se fotnote på delark "Resept"

** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | 3/3 | | 9/3 | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 100 | | 96 | | |
| Utbredelsesmål | | | | | |
| Luft | 6 | | 8,1 | | |
| Densitet | 2202,7 | | 2131 g | | |

AVA 33 min

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

SP: 0,5 %

AEA: 1,6 %

AvA gjennomført

AVA 9 mars 36 min 5,7 %, 75 min: 6,1

120 min:

13:-16

9.3

3245-skål

3245-1114 =

2131

3/3 13:15

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA ~~SP før luft prøvebl 1 (av 2)~~ SP og AEA |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.0 | 1.820 | | | 1.820 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.9 | 0.975 | | -0.192 | 0.782 | 0.805 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | |
| Mapei Dynamon SX-130 | 2.9 | 0.0146 | 70 | 0.010 | 0.015 | |
| Mapeair 25 1:9 | 3.4 | 0.017 | 99.58 | 0.017 | 0.017 | |

*Se fotnote på delark "Resept"

** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 105 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 2 | | | | |
| Densitet | 2289,4 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AVA ikke gjenfort

SP: 0,6 %

AEA: 0,7 %

3 mars 11:30

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA ~~SP før luft prøvebl.1 (av 2)~~ SP før luft |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.1 | 1.821 | | | 1.821 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 195.0 | 0.975 | | -0.193 | 0.782 | 0.804 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | |
| Mapei Dynamon SX-130 | 2.4 | 0.0122 | 70 | 0.009 | 0.012 | |
| Mapeair 25 1:9 | 3.9 | 0.019 | 99.58 | 0.019 | 0.019 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| Fersk betong | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 87 | ok | SP ned | | |
| Utbredelsesmål | | | | | |
| Luft | 7 % | | | | |
| Densitet | 2189,1 | | | | |

| Prøvestykker (antall) | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AVA ikke gjennomført

SP: 0,5 %

AEA: 0,8 %

2 mars 14:00 og √ 9/3

# Blandeskjema SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA SP ~~før luft prøvebl.1 (av 2)~~ AEA → SP |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.1 | 1.820 | | | 1.820 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 195.0 | 0.975 | | -0.222 | 0.753 | 0.775 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | |
| Mapei Dynamon SX-130 | 2.4 | 0.0122 | 70 | 0.009 | 0.012 | |
| Mapeair 25 1:9 | 9.7 | 0.049 | 99.58 | 0.049 | 0.049 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | 2 mar | | 9 mars | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 101 | | 95 | | |
| Utbredelsesmål | | | | | |
| Luft | 6,6 | | 6,5 | | |
| Densitet | 2194,5 | | 2205,2 | | |
| AVA | 30 min | 9 % | | 60 min | 9,1 % |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

SP: 0,5 % 9/3 10:00 - 13:00

AEA: 2 %

1. AVA 9 mars. 39 min
2. 9 mars 70 min

2 mars 13:00 1.

# Blandeskjema

**SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA ~~SP før luft, prøvebl.1 (av 2)~~ AEA → SP |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.0 | 1.820 | | | 1.820 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.9 | 0.975 | | -0.212 | 0.763 | 0.785 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | |
| Mapei Dynamon SX-130 | 2.9 | 0.0146 | 70 | 0.010 | 0.015 | |
| Mapeair 25 1:9 | 7.3 | 0.037 | 99.58 | 0.036 | 0.037 | |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 107 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 4 % | (2236,6) 4,5 % | | | |
| Densitet | 2236 | | | | |

AVA 30min 60 min

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

o AEA: 1,5

SP:

1 mars 13:00

# Blandeskjema

**SKANSKA**

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA SP [redacted] AEA for SP |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** ~~kg/m³~~ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 363.9 | 1.819 | | | 1.819 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.6 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.9 | 0.974 | | -0.274 | 0.701 | 0.723 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 3.2 | 0.240 | 7.738 | |
| Mapei Dynamon SX-130 | 3.4 | 0.0170 | 70 | 0.012 | 0.017 | |
| Mapeair 25 1:9 | 4.4 | 0.022 | 99.58 | 0.022 | 0.022 | |

*Se fotnote på delark "Resept"

** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 105 | | | | |
| Utbredelsesmål | | | | | |
| Luft Pressure | 3% | | | | |
| Densitet | 22,73 | | | | |

AVA 30min 60 min

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AEA: 0,9 %
SP: 0,7 %

1 mars 15:00

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA ~~SP før luft prøvebl.1 (av 2)~~ AEA → SP |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | Antatt luft = 7,5% |
| Ansvarlig: | |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.0 | 1.820 | | | 1.820 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 108.7 | 0.543 | | | 0.543 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.9 | 0.975 | | -0.277 | 0.698 | 0.72~~0~~8 0,718 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 3.2 | 0.240 | 7.738 | |
| Mapei Dynamon SX-130 (0.7·2.9 ikke nå) | 2.9 | 0.0146 | 70 | 0.010 | 0.015 | 15 g |
| Mapeair 25 1:9 (ikke i dens) | 5.4 | 0.027 | 99.58 | 0.027 | ~~0.027~~ | 29 g |
| *Se fotnote på delark "Resept" | 2187 | ** NB! Våte mengder, også for silikaslurry | | | | |

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål (+12·13 min) | 103 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 4 | | | | |
| Densitet | 2381,1 | | | | |

AVA 30 min 60 min

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AEA: 1,2 %
SP: 0,6 %

1/3 – kontroller oppnådd Dens kan proporsjon – kommentar

$1 - \frac{2381}{2187} = -0.089$

forenkling: porevolum = 1 − Smålt/Spesifikt
evt. Δ(porevolum): 1 − Smål/S7,5%

Luftberegn. (4% istedet for 7.5)
Vol. blanding = 1 + 0.035 = 0.965 m³

7.5 → 4% ⇒ ÷3.5 Vol% luft

Delark "Blandeskjema"

22 feb 1. blanding 12:00

## Blandeskjema — SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA SP før luft prøvebl.1 (av 2) SP → AEA |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| Materialer | Resept kg/m³ | Sats kg | Fukt* % | Korr. kg | Oppveid** kg | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | Vol |
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | | |
| Norcem AnleggFA | 363.8 | 1.819 | | | 1.819 | | 0.1205 |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | | 0.0066 |
| Norcem Fly Ash - FA (NO) | 108.6 | 0.543 | | | 0.543 | | 0.0363 |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | | |
| Fritt vann (inkl. TSS) | 194.8 | 0.974 | | -0.198 | 0.776 | 0.798 | .1948 |
| Absorbert vann | 4.5 | 0.022 | | | 0.022 | | Σ .3582 |
| Årdal NorStone NSBR 0 - 8 mm | 1499.7 | 7.498 | 2.2 | 0.165 | 7.663 | | |
| Mapei Dynamon SX-130 | 3.9 | 0.0195 | 70 | 0.014 | 0.019 | | .3591 |
| Mapeair 25 1:9 | 3.9 | 0.019 | 99.58 | 0.019 | 0.019 | | = 0.964 |

*Se fotnote på delark "Resept" ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | 44 | 74 | 120 | 135 | |
| Synkmål | 100 ? | | | | |
| Utbredelsesmål | | | | | |
| Luft | ? | | | | |
| Densitet | ? | | | | |
| AVA | 4.8 | 4.6 | 4.1 | 4.5 | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | 1 stk | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

Vol bidrag fra TSS

Press og synk ikke gjennomført

0,8 % SP
0,8 % AEA

14:00 13/02

# Blandeskjema

SKANSKA

| | |
|---|---|
| **Prosjekt** | AVA test. Mastr OPV, efefkt av doseringsrekkef SP AEA på luft, AV |
| **Reseptnummer** | 35 % FA SP før luft prøvebl.1 (av 2) |
| **Tilsiktet kvalitet** | Air-entrained mortar w/b - 0.40, plastic-flowable consitency |

| | |
|---|---|
| Blandevolum | 5 liter |
| Dato: | |
| Tidspunkt for vanntilsetning: | |
| Ansvarlig: | |
| Utført av: | |

| **Materialer** | **Resept** kg/m³ | **Sats** kg | **Fukt*** % | **Korr.** kg | **Oppveid**** kg | |
|---|---|---|---|---|---|---|
| Norcem StandardFA | 0.0 | 0.000 | | | 0.000 | |
| Norcem AnleggFA | 364.9 | 1.824 | | | 1.824 | |
| Norcem Anlegg | 0.0 | 0.000 | | | 0.000 | |
| Elkem Microsilica | 14.6 | 0.073 | 0.0 | 0.000 | 0.073 | |
| Norcem Fly Ash - FA (NO) | 107.0 | 0.535 | | | 0.535 | |
| Limestone filler | 0.0 | 0.000 | | | 0.000 | |
| Fritt vann | 194.6 | 0.973 | | -0.197 | 0.776 | 0.799 |
| Absorbert vann | 4.5 | 0.023 | | | 0.023 | |
| Årdal NorStone NSBR 0 - 8 mm | 1514.0 | 7.570 | 2.2 | 0.167 | 7.736 | |
| Mapei Dynamon SX-130 | 3.9 | 0.0195 | 70 | 0.014 | 0.019 | |
| Mapeair 25 1:9 | 3.4 | 0.017 | 99.58 | 0.017 | 0.017 | |

*Se fotnote på delark "Resept"  ** NB! Våte mengder, også for silikaslurry

| **Fersk betong** | | | | | |
|---|---|---|---|---|---|
| Tid etter vanntilsetning | | | | | |
| Synkmål | 185 | | | | |
| Utbredelsesmål | | | | | |
| Luft | 3,5 | 3,2 | (AVA) | | |
| Densitet | 2266,2 | | | | |

| **Prøvestykker (antall)** | | | | | |
|---|---|---|---|---|---|
| Utstøpningstidspunkt | | | | | |
| Terninger | | | | | |
| 150x300 sylindre | | | | | |
| 100x200 sylindre | | | | | |

AEA: 0,7
SP: 0,8

AVA gjennomført?