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Stability of air-entrainment with PCE-superplasticizers

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ABSTRACT

Air content is an extremely important aspect of today's concrete performance and durability characteristics. Lately in Finland, elevated air contents (>15%) have been observed from the samples drilled from structures. The high air contents have caused deficiencies in the compressive strength of concrete structures.

One of the main factors affecting the stability of air content in concrete is the use of combination of Air-Entraining Agent (AEA) and Polycarboxylate Ether (PCE) –superplasticizers admixtures. This study is investigating the stability of air-entrainment in concrete using different types of PCE-SP, AEA and concrete mix designs. A literature study was conducted parallel with ongoing laboratory work. The result of this study will set requirements of the concrete mixtures so that a stabile protective pore system can be achieved.

Key words: Air content, Superplasticizer, Air-entraining, Admixtures, Cement, Mix Design, Testing.

1. INTRODUCTION

1.1. General.

Air content is an extremely important aspect of today's concrete mix design criteria and subsequent in-place concrete performance and durability characteristics. For example, the frost resistance of concrete is determined by the air-void system's ability to prevent the development of destructive pressures due to freezing and associated movement of moisture in the concrete pores. The specific requirements of the air-void system depend on the amount and movability of the water in the concrete pores.

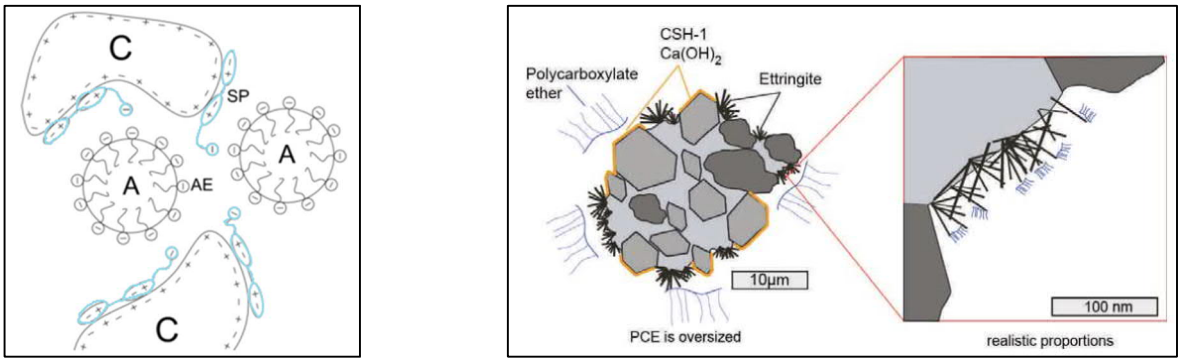
Current specifications on air content also make little distinction among various service life of structures and the maximum aggregate size used. Structures directly exposed to deicing salts and freezing temperatures (XF2 and XF4) require more air entrainment (In Finland around 5.5%) than structures that are not exposed to de-icing salts (XF1 and XF2) [1].

Lately, elevated air contents have observed especially in bridges. Air contents exceeding 15%

have been observed from the samples drilled from structures. In addition, low concrete densities (app. 2000 kg/m^3) have been measured from samples taken from close to the casting surface. The low concrete density is due to the elevated air content of concrete or/and segregation of concrete. One of the main factors affecting the stability of air content in concrete and thus is believed to be the use of combination of Air-Entraining Agent (AEA) and Polycarboxylate Ether (PCE) – superplasticizers admixtures. A research project "Robust Air – Securing the stabile protective pore system of concrete" for investigating the stability of air content in concrete was started in the beginning of 2017 at Aalto University, Finland. The research is still undergoing and we expect that the result will set requirements of the concrete mixtures so that a stabile protective pore system can be achieved

1.2. Stability of air-content in concrete with superplasticizers

Superplasticizers are chemical admixtures for concrete, which are added in order to reduce the water content while retaining the flowing properties of the concrete mixture. Lignosulphonates are generally regarded as '1st generation' superplasticizers, while the sulfonated melamine and sulfonated naphthalene are called '2nd generation', and the polycarboxylates and polyacrylates are termed as 3rd generation superplasticizers [2].



(a) (b)

Figure 1 – (a) The mechanism of sulfonated based superplasticizer and air-entraining agent [3] and (b) the adsorbance of PCE superplasticizers in cement paste [4].

Eickschen and Müller (2015) investigated the action mechanisms occurring during the production of air-entrained concrete with different superplasticizers. The results show that the combinations of synthetic air-entraining agent and a PCE-based plasticizer exhibited a greater range of fluctuation in air content than combinations with natural air-entraining agents and conventional plasticizers.

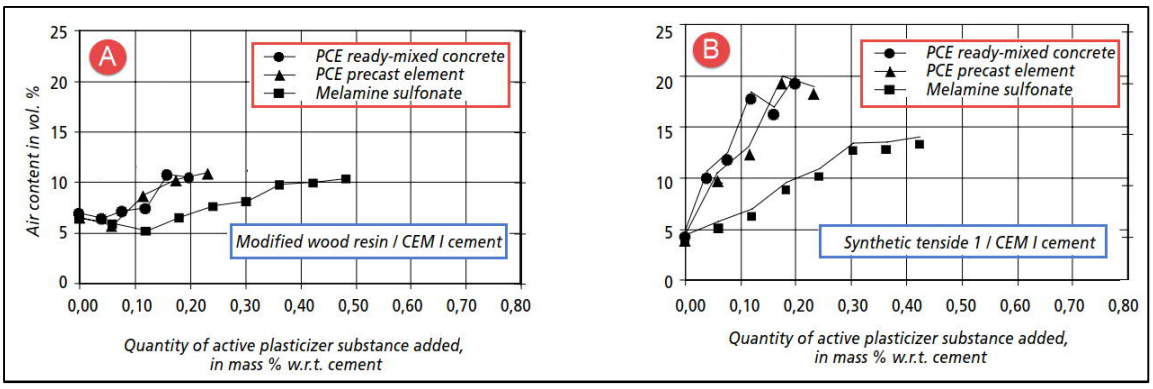


Figure 2 – Air void formation relative to the type and addition level of the SP when using CEM I cement: (A) air-entraining agent based on wood resin, and (B) synthetic tenside 1 [5].

Lazniewska et. al. (2015) studied the effect of different types of superplasticizer on the stability of air content on concrete [6]. The study proved that the superplasticizer based on polycarboxylate ether (PCE-1) double the air-content of mortar comparing to the reference mortar, while admixtures based on sulfonated melamine formaldehyde (SMF) and lignosulfonates (MGL) stabilize the best the air-entrainment. Admixtures based on modified powder naphthalene (MN) and admixtures based on amino phosphonates (AAP) decrease the air content of mortar after 5 minutes comparing to the reference mortar, but stabilize the air content after 60 minutes. Admixtures based on naphthalene (SNF-2) slightly increase the air-content of mortar after 60 min.

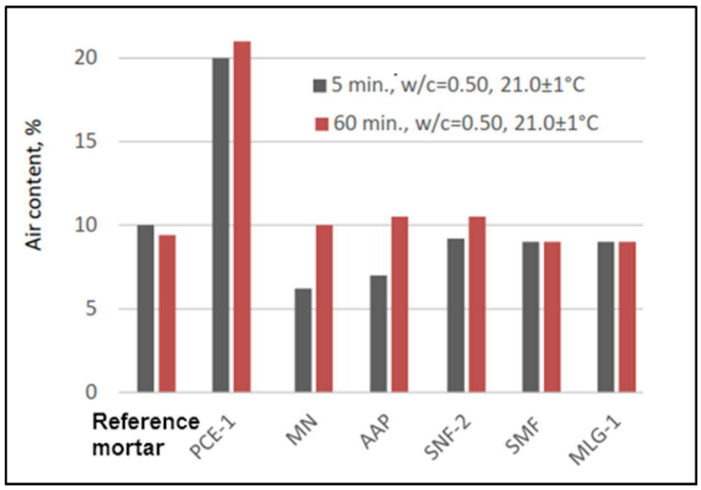


Figure 3 – Comparison of air-content of air-entrained mortar with different type of plasticizers and superplasticizers after 5 and 60 min [6].

2. LABORATORY TESTING

As a part of Robust Air-project at Aalto University, concrete tests with different types of AEAs and PCE- superplasticizers are carried out and the stability of entrained air is investigated. The aim of the project is to clarify the factors affecting the stability of the air entrainment. Both the effects of the concrete composition and admixture combination on the stability of the air entrainment are studied. The following variables are tested:

- Cement type
- Water-cement ratio and air content of concrete
- Consistency of concrete
- Maximum particle size of the aggregate
- Mixing time
- Compaction power / -time
- Superplasticizer and air-entraining agent combination

Admixture combinations from seven different admixture producers are investigated. All the superplasticizers tested are polycarboxylate ethers.
Effects of the above-mentioned variables on the air content of concrete at different moments after mixing are analysed. The air content is measured immediately after mixing, 30 min and 60 min after mixing. In addition, after 60 min superplasticizer is added to compensate the workability loss and air content is measured after 75 min after mixing. Also, the density variation of the concrete is monitored. The research is still undergoing and the laboratory testing will be completed during Spring 2017.

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