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## A Novel Cellulose Based Stabilizing Admixture for Self Compacting Concrete



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### ABSTRACT

A Novel Cellulose Based stabilizing Admixture (NCBA) with unique rheological properties was introduced. Rheological effects of NCBA were studied in cement paste, mortar and self compacting concrete. It was observed that NCBA increased only the mixes yield stress, whereas commercial melamine sulphonate based stabilizer increased mixes' yield stress and plastic viscosity. This phenomenon made it possible to produce a good quality self compacting concrete with relatively low performance aggregates and a high water /cement -ratio.

**Key words:** Self compacting concrete, stabilizing admixture, rheology, Bingham model

### 1. INTRODUCTION

Self compacting concretes (SCC) have shown great promises in their usability in various casting processes. Economically, the use of SCC is not greatly favoured because low cost and robust SCC is not easily achievable. Therefore SCC has been identified as potential development target for nanotechnology-based materials [1]. Today, low cost SCC usually demands higher water/cement- ratios, where the use of supplementary cementitious materials or stabilizing agents is forced. This study introduces a novel stabilizing agent based on unique properties of cellulose-based materials. Adding a small portion (dry weight <1 %) of cellulose-based stabilizing admixture forms a stabile gel-like structure with water. This structured gel has a high yield stress and a considerably low viscosity with thixotropic nature. In this study, it was shown that some of these properties can be attained in SCC mixes having a moderately low cellulose based admixture addition. These qualities build a foundation for a new type of SCC stabilizer, which modifies only the mixes' yield stress value.

### 2. MATERIALS AND METHODS

The cement used was CEM II/A-M(S-LL) 42,5N, Yleismentti from Finnsementti. Standard sand according DIN EN196-1 was used in mortar experiments. In concrete experiments, natural aggregates and filler were used. Two grades of Novel Cellulose Based stabilizing Admixtures (NCBA) were received from UPM and were used as received. The used superplasticizing agent was polykarboxylate ether -type Glenium 51 (17.5 %) from BASF. Commercial melamine sulphonate -based stabilizer was used as a reference stabilizer. Paste and mortar mixes were prepared in a small Hobart mixer. Concrete mixes were produced with a normal laboratory mixer (Zyklos).

Cement pastes were mixed during a 5 min mixing period. Extra water was added to NCBA pastes, in order to produce equal yield stress for each sample. In mortar samples, the aggregate/cement -ratio was 1 and the superplasticizer dosage was 0.37 % of cement weight. Various water / cement -ratio mortars were studied. Concrete samples were produced for a constant water/cement -ratio 0.6 with- and without the NCBA admixture.

Rheology of NCBA was measured with a RHEOTEST RN4 -rheometer with a coaxial cylinder geometry (S1). In paste mixes, serrated (1mm grooves) S1 geometry was used. Mortar rheology was measured with a Rheotest VK -geometry, specially designed for cementitious materials. Rheology of concrete was evaluated with Mk II impeller [2] in Tattersal -apparatus. According to the Bingham model, values for yield stress and plastic viscosity were calculated.

### 3. RESULTS AND DISCUSSION

#### 3.1 Cement pastes

Cement pastes were proportioned experimentally for equal yield stresses (according Bingham model). The reference paste was pure cement paste with a w/c -ratio 0,4. Addition of NCBA increased the pastes' yield stress which was compensated with water addition. In Figure 1, it can be seen that appropriate NCBA + water addition produced pastes with relatively equal yield stresses compared to the reference paste. If the w/c -ratio was increased without NCBA, lowering of yield stress values was observed (Fig. 1 top left). Plastic viscosities of NCBA stabilized cement pastes followed the same w/c -ratio dependency as the reference paste without NCBA (Fig.1 top right). This phenomenon was especially pronounced with NCBA type 1 - stabilizers. Type 2 stabilizers had a slight increase in plastic viscosities. The commercial stabilizer was observed to increase both yield stress and plastic viscosity of the paste samples (Fig.1 top). Approximately five times larger NCBA type 2 -dosage was needed compared to NCBA type 1 stabilizers (fig. 1 lower left).

#### 3.2 Mortar mixes

Rheology of mortar mixes was studied with a VK- measuring geometry. Absolute values for yield stress and plastic viscosities of mortar mixes are not possible to calculate with this measuring geometry. For approximately values, linear regression for torque (mNm) and speed of rotation (rpm) were done. Figure 2 presents "yield stress" torque and "plastic viscosity" for torque -values for the studied pastes. Similar behaviour of NCBA -stabilized mortars was observed comparing to cement paste results. It can be seen from Figure 2 that "yield stresses" of mortars can be affected, without a large effect to "plastic viscosity". This phenomenon could be especially seen with NCBA type 1 -stabilizer and dosage 0.15%. It was possible to increase w/c-ratio from 0.35 to over 0.5 with equal yield stress, but significantly lower "plastic viscosity

#### 3.3 Concrete

In concrete experiments a similar approach was applied as in mortar studies. Pressure and revolution rate were approximated as shear stress and shear rate. Rheology measurements with Tattersal -apparatus are presented in Figure 3. Concrete rheology studies were done with w/c -ratio 0.6 and relatively coarse natural filler. It was impossible to proportion a mix with SCC -type slump flow, with usual good concrete qualities (no bleeding and segregation). With an appropriate NCBA dosage, it was possible to produce a good quality SCC. If the NCBA -

dosage was increased, the "yield stress" was observed to increase, whereas no significant changes in "plastic viscosity" were seen. A rough estimate of values for these qualities can be estimated by comparing ratio of angular coefficients and intersection points in the Tattersal apparatus measurements. The ratio of angular coefficients was 1.4 and for intersection points 2.3. It can be concluded that similar behaviour of NCBA in paste and mortar studies can also be detected at the concrete scale.

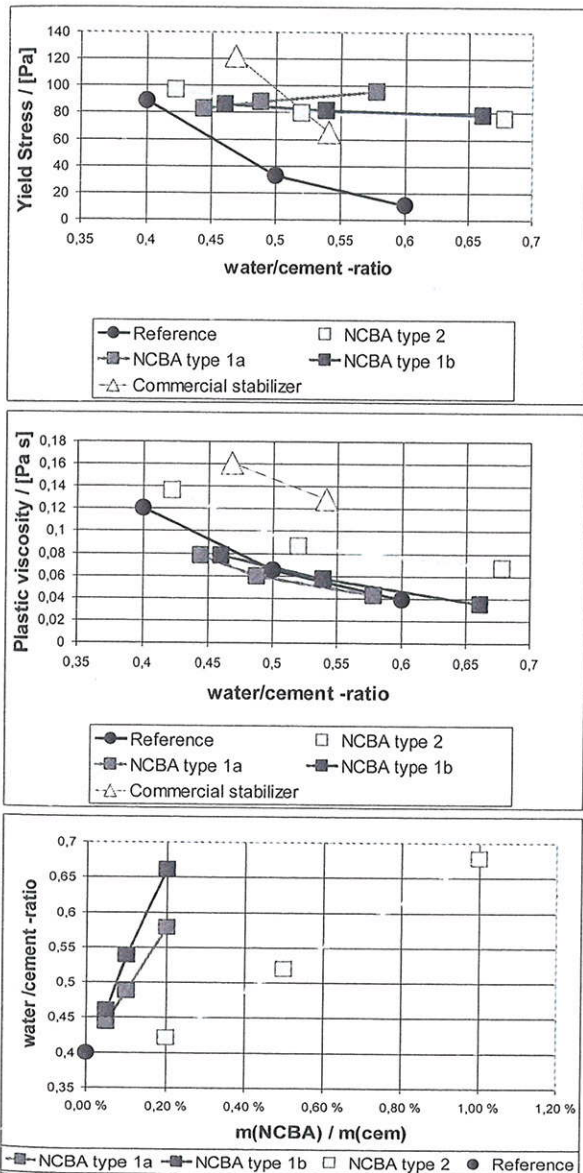


Figure 1. Results from rheological studies of cement pastes. Top left: Yield stresses of cement pastes as function of w/c -ratio. Top right: Plastic viscosities of pastes as function of w/c -ratio. Lower left: w/c -ratio as function of NCBA dosage.

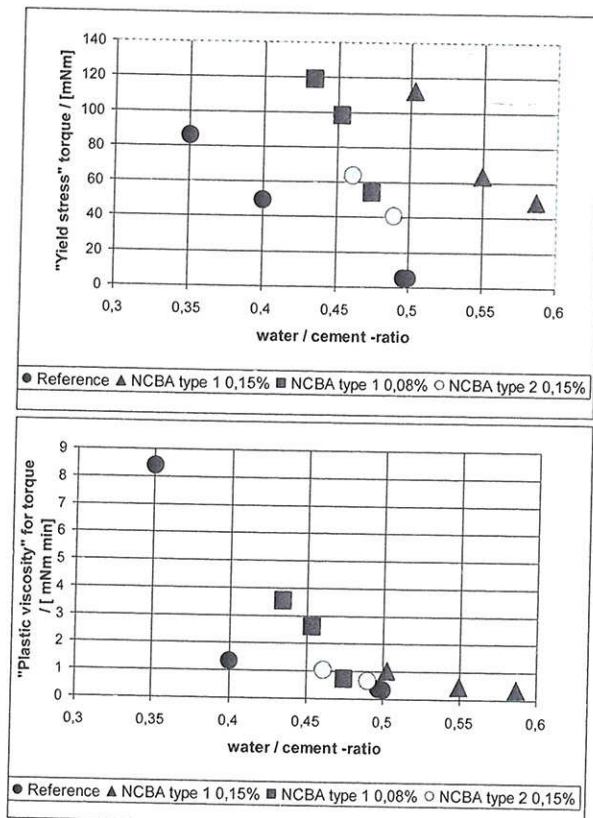


Figure 2. Results from rheological studies of mortar pastes. Left: "yield stress" -values as function of w/c -ratio. Right: "plastic viscosity" values as function of w/c -ratio.

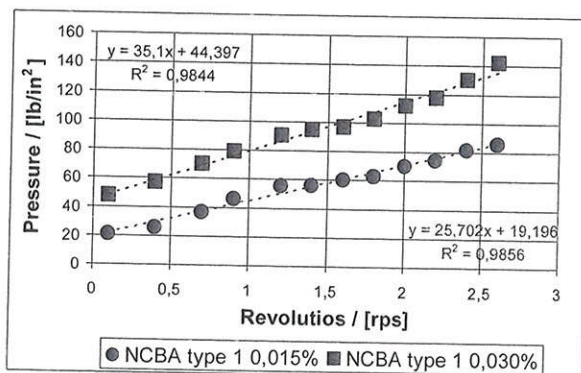


Figure 3. Rheology of NCBA type 1 -stabilized self compacting concretes. Addition of NCBA -stabilizer increased concretes' yield stress. Without NCBA -stabilizer, it was impossible to prepare SCC.

#### 4. CONCLUSION

Effects of Novel Cellulose Based stabilizing Admixture (NCBA) were introduced. Rheological properties of NCBA stabilized cement paste, mortar and self compacting concrete (SCC) were studied. It was observed that NCBA increased mixes yield stress and thus made it possible to produce high water / cement -ratio self compacting concretes with low performance aggregates and fillers. In comparison to a commercial melamine sulphonate -based stabilizing admixture, a

different mechanism was observed. With NCBA it was possible to modify yield stress independently without affecting plastic viscosity.

A complementary study of robustness qualities of Novel Cellulose Based stabilizing Admixture is also available [3].

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