HMC 2016

4th Historic Mortars Conference

Scientific Program

10th -12th October 2016

Santorini, Greece

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Laboratory of Building Materials
Dept of Civil Engineering
Aristotle University of Thessaloniki

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12:15 - 12:30	**Design of repair air lime mortars combining nanosilica and different superplasticizers**, J.M. Fernández, M. Pérez-Nicolás, A. Duran, R. Sirera, I. Navarro-Blasco, J.I. Alvarez	**Injection grouts based on lithium silicate binder: a simulated cavity test**, Andrew Thorn
12:30 - 12:45	**POSS-based epoxy soft nanomaterial for repairing historic clay/stone sites**, Yanli Ma, Ling He	**Reattachment of wall paintings in a 16th century post-Byzantine church**, Ioanna Papayianni, Thanasis Karvounaris, Vasiliki Pachta,
12:45 - 13:00	**Influence of combined nano-particles in traditional binding systems,** Maria Stefanidou, Eirini Tsardaka, Eleni Pavlidou	**Performance of grouts with reduced water content: the importance of porosity and related properties**, Chiara Pasian, Michele Secco, Francesca Piqué, Stephen Rickerby, Gilberto Artioli, Sharon Cather
13:30 - 13:30	Discussion	Discussion

13:30-14:00	**Closing Session** Hall A **Chair:** Caspar Groot, Rob Van Hees, Ioanna Papayianni, Rosario Maria Veiga, Jan Valek, John Hughes

14:00 - 15:00	**Lunch break**

15:00-19:00	**Technical visit to the archaeological site of Akrotiri** (optional)

Design of repair air lime mortars combining nanosilica and different superplasticizers

J.M. Fernández[1], M. Pérez-Nicolás[1], A. Duran[1], R. Sirera[1], I. Navarro-Blasco[1], J.I. Alvarez[1]

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Repair air lime mortars and grouts are necessary to successfully undertake restoration of the architectural artworks. This contribution dealt with the design of different air lime mortars and pastes by combining a nanostructured pozzolanic additive, nanosilica, and different dispersing agents, superplasticizers. The use of this kind of admixtures can be helpful to reduce the amount of mixing water, improving workability and avoiding large porosity, detrimental for the mechanical resistance and durability of the mortars.

A comparative study between the performances of two different polycarboxylate ethers (PCE), a polynaphthalene sulfonate-based polymer (PNS) and a lignosulfonate (LS) was carried out. The combined information of the different techniques allowed to propose a star-shaped structure for PCE1, with a short main backbone and longer side length, and a more worm-like form for PCE2 (with high amount of carboxylate groups and a longer main backbone). In fresh mixtures, the addition of nanosilica caused a progressive reduction of the slump, owing to the increase in the water demand. In pure air lime systems, the highest effectiveness was shown by the PCE1, whereas the PNS was the less effective superplasticizer. In samples with nanosilica, the PCE1 was also the most effective superplasticizer. LS was seen to be effective at low dosages. PCE2 was adsorbed in 3- to 4-fold when compared with PCE1. In the presence of the pozzolanic additive, there was a high consumption of polycarboxylates. The examination of the zeta potential of the pastes versus increasing dosages of the admixtures showed that the nanosilica provided no “active” adsorption sites, resulting in a slight decrease of the zeta potential values. The molecular architecture of the superplasticizers had a strong influence on the zeta potential results: for example, PCE1 showed a perpendicular adsorption that caused a displacement of the shear plane, which would explain the zeta potential reduction. In the case of PCE2, the strong reduction was explained by the compensation of the calcium ions layer by the carboxylate groups of the main backbone as a consequence of the flat adsorption of this polymer. PCE1 showed low adsorbed amounts, better dispersing action and required lower dosage of plasticizing agent. Steric hindrance was proposed as the main action mechanism, but the presence in the dispersions of free (non-attached) molecules of the polymer should also be considered.

There was a positive combination between lime mortars with nanosilica and polycarboxylates, which resulted in a mechanical strength improvement. PCEs, acting as dispersing agents, reduced the water demand, leading to a more compact mortar with a strong reduction of the macropores between 1 and 10 micrometers, a reduction of mean pore size and of the total porosity by comparison with the control mortar. Also the combined presence of nanosilica, for example, with PNS or with LS yielded better compressive strengths, being LS more effective than PNS: SEM examinations showed the better formation of C-S-H phases in LS-mortars.

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Introduction

Lime mortars

- ✓ used in the Built Heritage over centuries
- ✓ lime, usually air lime, as the binding material
- ✓ renders, repair mortars and other mixes.

Superplasticizer

- ✓ to guarantee a suitable fluidity of renders and grouts lime
- ✓ cement admixtures used to enhance the flowability
- ✓ Different SPs has been employed (PCE, LS, PNS).

Introduction

Lime mortars with the inclusion of pozzolanic additives: hydraulic mortars

The use of ***pozzolanic additives*** as Supplementary Cementitious Materials has been extensively used with the purpose:

- ✓ to improve the mechanical strength
- ✓ to short the setting time of air lime mortars.

Nanosilica (NS), added as a colloidal suspension, has shown very interesting performance, due to:

- its ***filler effect***
- the ***generation of calcium silicates hydrates*** (CSH).

Conclusions

1. The addition of the different superplasticizers admixtures produced a ***distinct behaviour*** in air lime mortars.
2. ***PCE 1*** turned out to be the ***most effective in increasing the fluidity*** of the pastes and also showed the best dispersion maintaining ability over time.
3. The ***molecular architecture of the polymer showed a great influence*** on this performance:
   - A. In the case of ***PCEs***:
     - ✓ the large specific surface area of NS led to a large SPs consumption
     - ✓ NS provided a high number of inactive adsorption sites and polymers preferentially attached onto NS and not onto CSH.
   - B. The flat adsorption of **PNS** and ulterior formation of organo-mineral phases reduced its efficiency in comparison with **LS**.

Conclusions

5. The highest ***mechanical performance*** of the tested lime mortars was obtained under the combined action of both ***NS*** and ***SP***s:
   - ✓ The rate of carbonation was higher when ***PNS*** was part of the admixtures the opposite to ***LS***-derived polymers.
   - ✓ The formation of CSH was preferred when ***LS*** was added.

Thank you for your kind attention