A combined deflocculation and coagulation process for development of self-compacting clay concrete: identification of mechanisms

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A COMBINED DEFLOCCULATION AND COAGULATION PROCESS FOR DEVELOPMENT OF SELF-COMPACTING CLAY CONCRETE

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Clay minerals are widely used and are of importance to the processing in many sectors. In earthen construction sector, clay acts like binder for earth as it displays colloidal interactions and adhesion forces between particles and grains. While extensive research exists on clay dispersion [1,2] or coagulation [3,4], the purpose of this study is to understand and to control clay properties in earth material in order to propose an innovative strategy to develop a self-compacting clay concrete without use of cement. To do so, we studied the modifications of clay properties using inorganic and mineral additives.

As clay rheological behaviour is controlled by their surface charge, it is observed that an addition of dispersants such as sodium hexametaphosphate or silicate decrease clay surface charge and reduce considerably the yield stress that allows to caste earth based material. We performed extensive series of rheological and zeta potential measurement on kaolinite clay paste to identify the driven mechanism of clay dispersion and the stability during time. The results show that for sodium hexametaphosphate, it exists a linear relationship between yield stress and square zeta. We then suggested that it disperses clay particles via electrostatic repulsion forces. Furthermore, we noted that at low percent of dispersant, without reaching the maximum coverage determined with zeta measurement, kaolinite clay displays thixotropic and aging behaviour. Besides, we stress that when dispersed, at high volume fraction it is possible to observe shear thickening behaviour in clay suspension.

Although the deflocculation process allows to caste easily earth based material, it is important to accelerate the formwork removal by flocculating the clay suspension for rapid construction process. To do so, rheological measurements on dispersed clay is used to characterize the effect of magnesium ions on dispersed clay suspensions. The results show that adding magnesium cations permanently increases the yield stress during time. This process similar to internal coagulation or cement hydration [5] allow accelerating the hardening process. In this study, it is suggested that the cations annihilate the effect dispersant and interact with clay particles which enable the coagulation of clay particles. Yet SEM and DRX analysis are carried out to identify the precipitation products and the interaction with clay in order to justify and understand the hardening process.

In conclusion, we stress the dispersion mechanism of sodium hexametaphosphate and we highlight the thixotropy and shear thickening behaviour in dispersed and dense kaolinite suspension. Furthermore, we note that adding coagulants agent enable to transform permanently the rheological behaviour of clay and suppress the shear thickening and thixotropy behaviour. These findings suggest that the combined deflocculation-coagulation process and understanding of mechanism allow proposing a new sustainable route for self-compacting clay concrete.