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Project acronym: NEWSOL

Project full title: NEW StOrage Latent and sensible concept for high efficient CSP plants

Deliverable D4.3 - Concrete long-term performance model

ABSTRACT

The goal of the current work is to assess the long-term performance of the two developed structural concrete material solutions due to the combined effect of charging/discharging cycles similar to those expected in the real TES system of a CSP plant. The two concretes are based on a Calcium-Aluminate-Cement, CAC, for the Thermocline Tank, and Ordinary-Portland-Cement, OPC, for the Module (mix design development is reported in D3.4). The long-term performance is measured as the load bearing capacity of the two concretes, given here as the compressive strength, as a function of the charging/discharging cycles until 10 000 cycles (25 years service life).

No indication of critical long-term concrete deterioration (beyond the strength loss during the dehydration taking place during the first cycle) has been found, given the present structures, load conditions and temperature cycling, that will question the long-term structural performance of the Module nor the Tank. Based on this and results from testing at increasing number of cycles, models are proposed for prediction of long-term compressive strength of both CAC and OPC concretes as function of number of cycles. The CAC model predicts a compressive strength loss of approximately 77% at 10 000 cycles. It corresponds to a compressive strength of 12 MPa, which is considered to be in the order of a magnitude higher than the strength needed for the actual structural performance. The OPC model predicts a compressive strength loss of approximately 71 % at 10 000 cycles.

The models are valid assuming that the concretes are un-damaged prior to the operation phase. Two sources of pre-operation phase damage were identified; cracking due to critical temperature gradients caused by heat of cement hydration (construction phase) and cracking due to critical pore vapor pressure during the first heating of the operation phase (as result of the de-hydration of cement paste). Work was done to suggest solutions to avoid such damage; using a numerical simulation tool to suggest cooling and insulation measures to avoid critical temperature gradients, and development of a numerical model to calculate needed pre-drying time of the Module to avoid critical vapor pressure.

The results are considered to be important input to the final design as well as for planning of the construction phase and first heating procedure, to avoid any additional damage.