The rehydration enthalpy after 60 min of the investigated CSA paste is about 25% of the value reported by Struble & Brown (1986) for pure ettringite. This can be explained by the facts that (i) the ettringite content of the CSA paste was roughly 50%, (ii) the paste was probably not fully hydrated, which is also indicated by the higher heat release in the second cycle, (iii) the applied dehydration conditions need to be optimized.

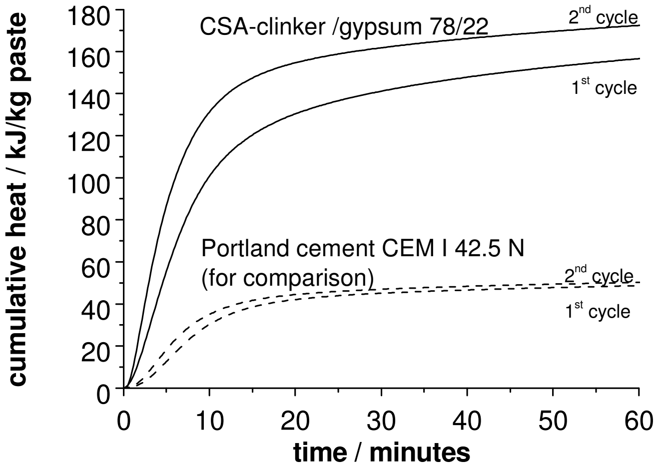

Figure 5. Heat development as measured by isothermal conduction calorimetry during rehydration of hardened binders previously heated at 110°C for 24 h (Kaufmann & Winnefeld (2010)).

3.3 Possible realisation

Energy is stored in a CSA-based concrete block by the dehydration of ettringite at moderate temperatures, e. g. between 50 and 160°C. The concrete is composed in a way that it does not lose its structure. It may be reinforced with steel or textile reinforcement or fibers for this purpose.

The energy is recovered by rewetting the concrete, allowing the metaettringite to recover a crystal structure containing more water molecules. The heat released is captured by a heat exchange system. The amount and moment of the heat release can be triggered by the moment/amount of water added. For long/medium term storage the concrete block has to be prevented from water access during storage. While for medium storage time dry climate storage may be sufficient, special measures like impermeable membranes or vapour dense concrete confining the system may have to be applied for long term storage.

The concrete block is equipped with one or two piping systems. Generally the first piping system containing water or another heat carrying liquid substance is used (i) to heat the massive concrete block or a pile of concrete plates or smaller blocks to a certain temperature to allow dehydration and (ii) for heat exchange upon rehydration. The second loop is used to (i) allow the vapor resulting from dehydration to be removed and (ii) for the supply of water or vapor for rehydration. It may be possible to use just one loop for both heat supply/water remove upon dehydration and water supply/heat exchange upon rehydration by circulation dry (dehydration) or wet (hydration).

The water obtained from dehydration may be collected in storage tanks to be used for the later rehydration. The concrete may be produced with sea water. Like that the system may be installed in desert regions. Combined sensible and latent heat storage systems are possible due to the relatively high specific heat capacity of ettringite (about 1.3 J/(g·K) (Struble & Brown (1986)).

4 CONCLUSION

Concrete based on calcium sulfoaluminate cement is proposed to be used as latent heat or energy storage system e. g. for solar energy. The storage principle is based on the dehydration and subsequent rehydration of ettringite, the main hydration product of CSA cements. The dehydration takes place at temperatures above 30°C (50-150°C for practical application) and is connected with a high dehydration enthalpy. Thus, ettringite based storage systems exhibit superior properties compared to many other materials used for heat and energy storage.

The potential use of ettringite-based cementitious materials for heat and energy storage was filed into a Swiss patent application (Kaufmann & Winnefeld (2010)). Currently a prototype involving a piping system for wetting and heat exchange is constructed. A further development to realize economical technological solutions and commercial products will be necessary. This is planned together with potential industrial partners.

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