Heat of hydration in clays stabilized by a high-alumina steel furnace slag

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Introduction

- Supplementary cementitious materials (SCMs), such as fly ash or ground granulated blast furnace slag (GGBFS), have been widely used as a partial to full replacement of portland cement (PC) in geo-materials - soil stabilization, **but not steel furnace slag (SFS)**.
- It is generally **unclear if the stabilization effect in SFS-stabilized soil is mechanical** (e.g., reduced the optimum water content, shear strength, internal friction), **chemical** (pozzolanic reactions), **or a combination of both**.

Objective

- **Solution**: this study utilizes isothermal calorimetry (IC) for the first time to quantify the heat of hydration of SFS-stabilized clayey soils and confirm the statement that there are chemical reactions. It was further confirmed by X-ray Diffraction (XRD).

Materials and Methodology

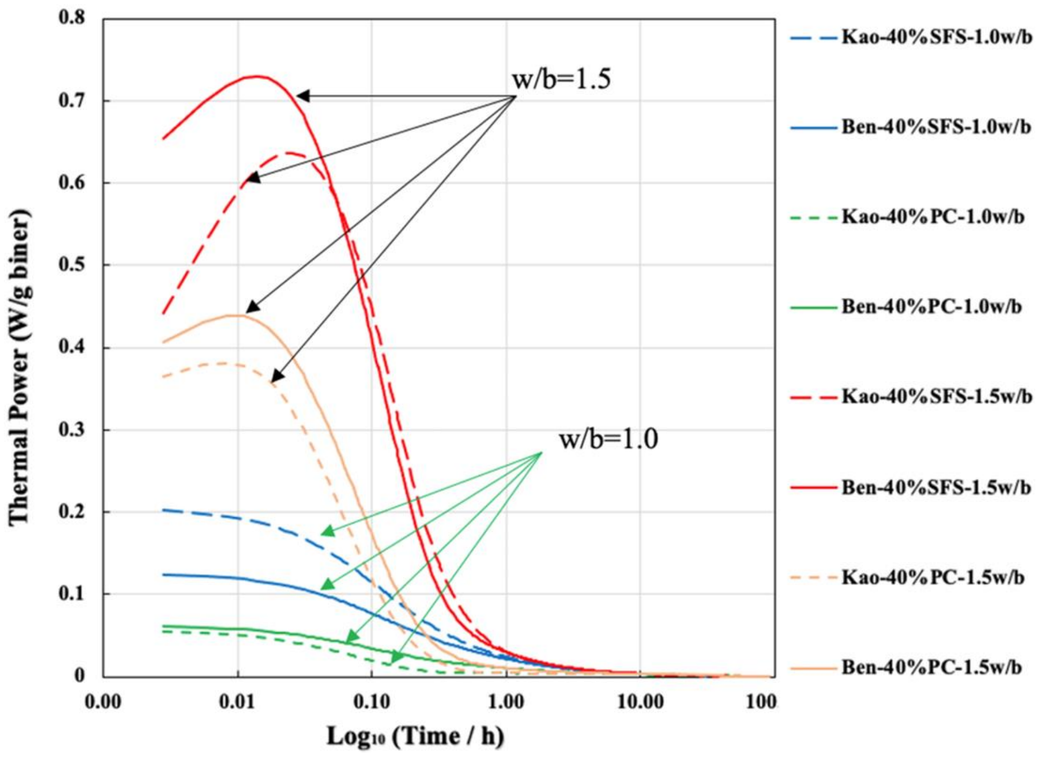
- **Materials**: two commercial clays were studied: kaolin and bentonite. The kaolin clay was found to consist of kaolinite, while the bentonite clay was composed of montmorillonite and quartz.
- SFS has a particularly high alumina content with 33.23 wt.% Al_2O_3, through the presence of tricalcium aluminate ($Ca_3Al_2O_6$) and mayenite ($Ca_{12}Al_{14}O_{33}$).

- **Experimental program**: Kaolin and Bentonite were each mixed with 40% of ground SFS by mass at the water-to-binder (w/b) ratios of 1.0 and 1.5. At the same experimental conditions, the heat evolution of stabilized mixtures with 40% by mass CaO or PC was also evaluated for comparison.
- To exaggerate the effects of SFS on clay mixtures, the amount of ground SFS was increased to 100% and 300% by clay mass at w/b =0.5 for XRD and TGA analysis.

Results

Heat of hydration

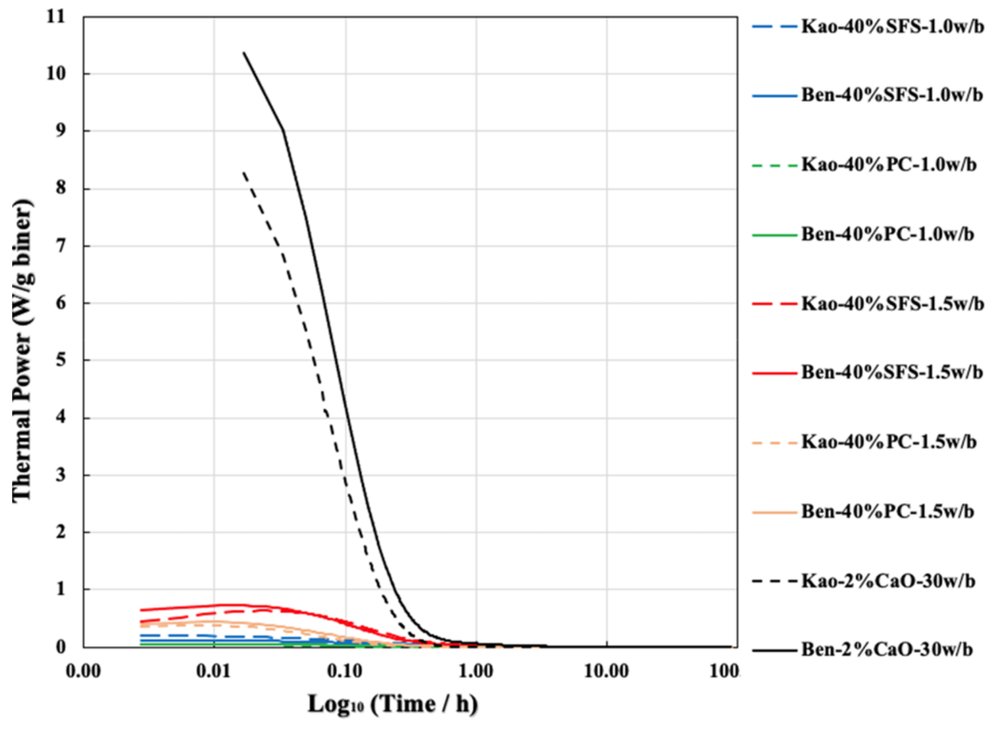
- The clay type, particle size, and specific surface area affected the hydration behavior of stabilized clay.



- The hydration process of all SFS stabilized mixtures generally occurred faster than that of portland cement or lime due to high calcium aluminate content.
- The "peak delay" of the thermal power curve strongly depends on the amount of water available in the soil matrix.

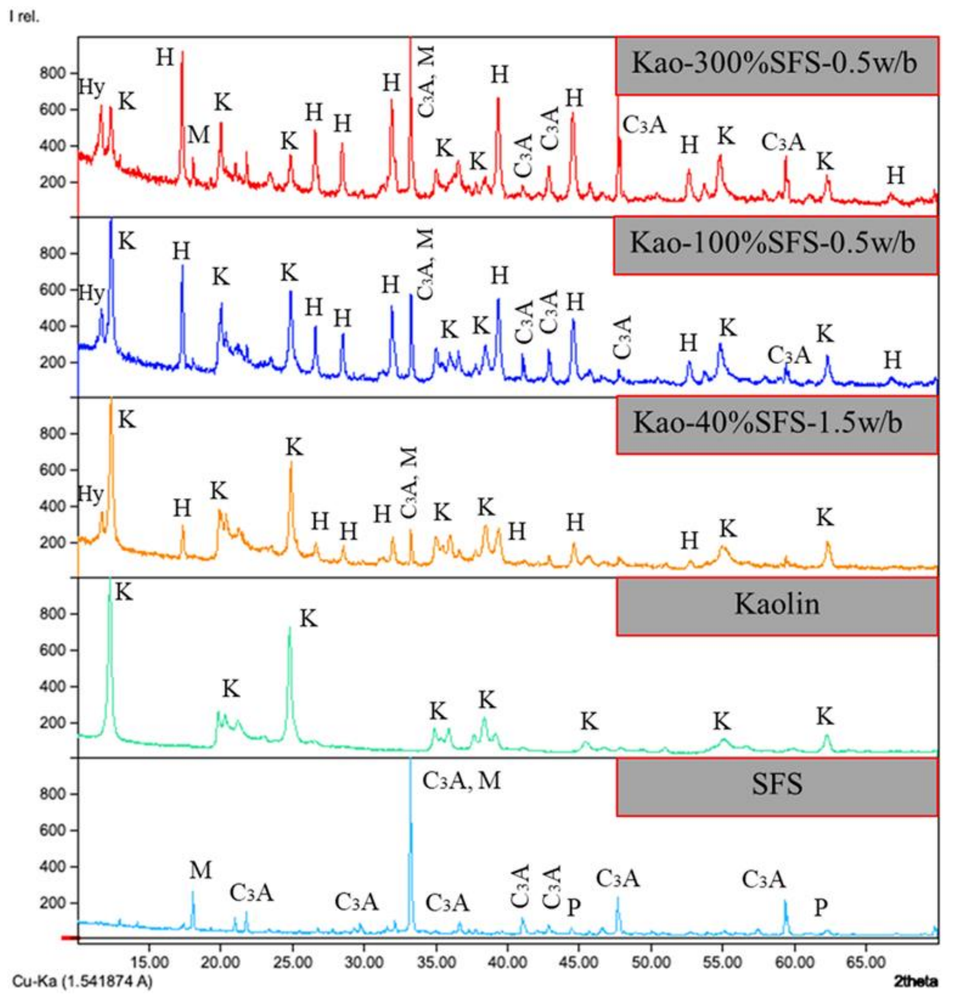
Results

- The CaO-stabilized mixtures generated much more heat than that of SFS and cement.



X-ray Diffraction (XRD)

- New hydration products - hydrogarnet (H) and hydroxy-AFm phases (Hy), formed from the reaction of C3A and mayenite in the presence of water.



Conclusions

- It was evidenced that **there are chemical reactions between SFS and clays** for the soil stabilization mechanism.
- SFS with different chemical compositions will affect the resulting hydration products.
- **Next step work**: More research needs to be done at the very end step to examine the practical performance of the stabilized soil using SFS (i.e., strength, durability).
- **We are open to funding and collaboration!**

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Publication link

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