Key Factors of Metastable Phase Formation for Strength Development in Steel Slag and Dredged Soil Mixtures

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Abstract

The usage of by-products from industrial activities, as construction resources is awaited in Japan to decrease the environmental impacts. Steel slag from ironworks and dredged soil extracted beneath the ports are examples for such resources. Recently, it is discovered that mixtures of steel slag with dredged soil are hardened. This discovery may expand their application into building materials for undersea construction which may solve the problem. Nonetheless, different combinations of a type of steel slag and dredged soil from various areas show gaps in strength development. The relationship between mixing condition and strength development is not clarified, making the mixture difficult to be utilized for the above application.
Understanding of the hardening mechanism of the steel slag-dredged soil mixture would enable the prediction of the strength with a particular combination of steel slag and dredged soil. To achieve it, clarifying the secondary mineral formation that contributes to hardening is essential. Previous studies suggested that the strength development was related to the pozzolanic reaction, which results in cementation by the formation of calcium silicate hydrates (C-S-H). Key factors in the pozzolanic reaction are the increase in pH of the pore water and the supply of calcium and silica ions to pore water. While calcium supply is determined to be $Ca(OH)_2$ in steel slag which also increases pH by its hydration, silica supply is only suggested to be originated in dredged soils.
The objective of this study is set to understand the effects of silica-bearing phases in dredged soil on the strength development of steel slag-dredged soil mixture.
In this study, dredged soils from various sampling locations (A, B, C and D) and steel slag from ironworks-1 were mixed for the investigation. The unconfined compressive strength showed mixtures with soil-A exhibits the highest strength, followed by those with B, C and D. Firstly, the silica ion which is most likely to be supplied from dredged soils was investigated. The biogenic silica content and inorganic amorphous silica such as volcanic glass content were quantified. XRD analysis showed no significant difference between the mineralogical compositions of all the dredged soils including clay minerals. Then, the effect of humic acid which may limit the supply of soluble calcium is quantified and its functional groups are analysed to see the effect on strength development of the mixtures. Through geochemical modeling for estimation of C-S-H formed from above silica supply, we suggest that the silica supply from each silica-bearing phase of dredged soils may be the driving force for the pozzolanic reaction for the strength development.

Keywords: Amorphous silica, C-S-H, Dregded soil, Steel slag