Scanning electron microscopy (SEM) investigation of stabilized loess soil

Изследване на заздравен льос със сканиращ електронен микроскоп (СЕМ)

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Introduction

Specific geotechnical problems emerge in construction in loess soil due to its aptitude to collapse and its sensitivity to water content changes. Ground stabilization has been widely applied to improve loess soil. There are various cement based stabilization materials, and different additives, that can be used to improve engineering properties of loess soil including soil-cement, soil-cement-bentonite, soil-cement-zeolite, etc.

This paper discusses the microstructural peculiarities of cement-zeolite-treated loess soil without compaction aiming to elucidate the processes of strength formation. The microstructure was investigated using scanning electron microscopy.

Materials and methods

Selection on appropriate stabilizer and mix proportion was done as it was obtained in previous study (Tchakalova, Todorov, 2008). The selected mixture contains loess soil, 10% Portland cement and 10% zeolite containing rock (from the Beli Plast quarry in the Northeast Rhodopes with ~70% of clinoptylolite; grain-size >0.08 mm), by the dry weight of loess soil. The test specimens were prepared in accordance with JGS 0821-2000 without compaction at 41.5% moisture content by a procedure described in Tchakalova and Todorov (2008). The test specimens of stabilized loess were analyzed after 7, 14, 28 and 90 curing days. The observations were performed on specimens of untreated loess soil as well.

Scanning Electron Microscope model JEOL Superprobe 773 equipped with an ORTEC EDS was used in the study.

Results

The SEM image of untreated loess soil (Fig. 1) exhibits an open type of microstructure, with sheetlike shape particles situated in a random order. The placoid and flaky particles were identified as quartz and illite.

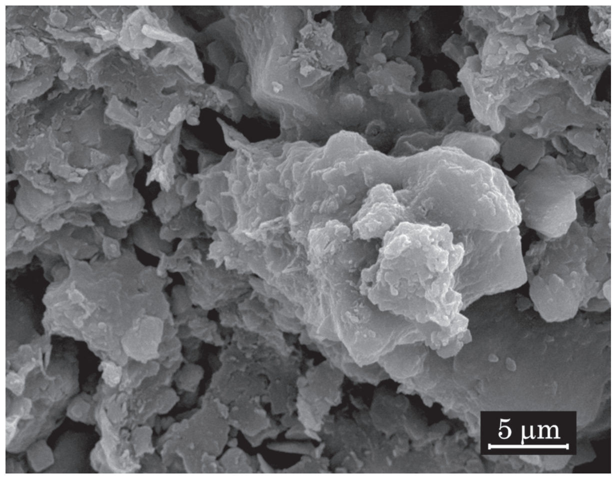

Fig. 1. SEM micrographs of untreated loess soil

Reaction products and subsequent changes on microstructure due to chemical reactions are clearly seen on Fig. 2. Fig. 2a illustrates the early stage formation of CSH cementitious products. The micrograph shows incipient sign of reticulation. As curing time increased, CSH phases growth and degree of reticulation enhances (Fig. 2b). Development of cementorious processes can be seen on Fig. 2c. The micrograph shows that growing CSH phases start to form fabric which coats soil particles. The long-term curing micrograph (Fig. 2d) picturizes the formation of more new cementitous compounds as a result of the pozzolanic reaction continuing to coat the soil particles and starting to fill the pore spaces. Growing of CSH within the pore spaces resulting in a reduction of the size of the pore spaces, where the pore spaces after 180 days curing

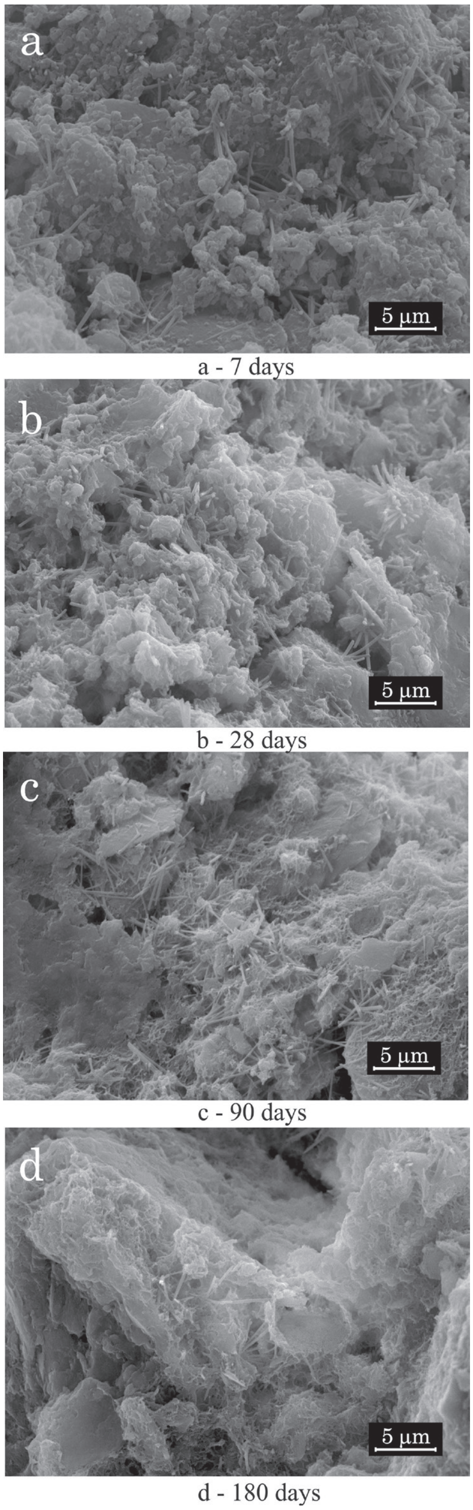

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Fig. 2. SEM micrographs of treated loess soil at various curing times

are relatively smaller than the pore spaces of the same mixture after 28 days curing.

This is consistent with the results of the SEM analyses on stabilized cement-treated soils (Evstatiev, 1984; Angelova, Evstatiev, 1990; Nontananandh et al., 2005; Kamruzzaman et al., 2006).

Conclusions

The cement-zeolite stabilization with a suitable mixing proportion could be effectively used to stabilize loess soil. SEM images of the untreated loess soil displayed an open structure, while micrographs of cement-zeolite treated loess soil indicated the presence of a reticulated matrix within the soil material. The structure of the loess soil gradually transformed from open (loose) into dense states.

It was also observed that the created cementitious products were attached to the soil particles, coated particle surfaces, and formed fabric that filled the gaps between the loess aggregates which will markedly improve engineering properties of loess soil such as collapsibility/compressibility, strength and permeability.

References

Angelova, R., D. Evstatiev. 1990. Strength gain stages of soil-cement. – In: *Proceedings of the 6th International IAEG Congress.* Amsterdam, 3147–3154.

Evstatiev, D. 1984. *Strength-formation of Soil-cement*. Sofia, Bulg. Acad. Sci. Publ. House, 94 p. (in Bulgarian).

Kamruzzaman, A. H., S. H. Chew, F. H. Lee. 2006. Microstructure of cement-treated Singapore marine clay. – In: *Proc. Inst. Civ. Eng. Ground Improv.*, *10*, 113–123.

JGS 0821-2000. *Practice for Making and Curing Stabilized Soil Specimens without Compaction*. Japanese Geotechnical Society Standard.

Nontananandh, S., T. Yoobanpot, S. Boonyong. 2005. Scanning electron microscopic investigations of cement stabilised soil. – In: *National Conference on Civil Engineering*, *10.* Thailand, GTE, 23–26.

Tchakalova, B., K. Todorov. 2008. Plastic soil cement mixtures for isolation barriers. – *Geologica Balc., 37*, 1–2, 91–96.