SUMMARY

題　目　Analysis of Strength Development Mechanism of Cement-Treated Soils under Different Curing Conditions through Chemical and Microstructural Investigations

（異なる養生条件下のセメント改良土の強度発現機構に関する化学・微細構造分析）

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This study aimed to investigate the strength development of cement-treated soils under different curing conditions through chemical and microstructural tests. First, three types of soil mixture (sand, sand-loam, and sand-bentonite) were prepared with 8% of cement and cured under sealed, drying, and water adjustment to consider effects of pozzolanic reaction, carbonation, and water content change on strength development. Second, the cement-treated sand mixture used 8% of cement was made and cured under different amount water spraying to investigate effects of internal water content on carbonation process as well as the compressive strength. Finally, cement-treated soil mixtures were prepared with 8% cement content using different types of cement and cured under different curing temperatures in order to investigate effects of cement type and curing temperature on strength development. The unconfined compression test was conducted to determine the compressive strength over time. The changes in chemical and microstructural properties were examined using thermal analysis, X-ray diffraction, and mercury intrusion porosimetry.

The results revealed that the mineralogy of the mixture had an impact on strength development under the drying condition. The compressive strength increased rapidly for all mixtures at the early age. After that, the strength slightly increased for the sand and sand-loam mixtures, but slightly decreased for the sand-bentonite mixture in the later age. The rapid short-term increase was explained by the suction effect and carbonation under drying, while the slight long-term increase can be explained by suction and pozzolanic reaction. The slight decrease in the long-term compressive strength of the sand-bentonite mixture can be explained by bentonite shrinkage or by a strong negative impact of C–S–H carbonation. Carbonation changed pore size distribution, resulting in the coarser pore. In addition, the relationship between the strength and water content was well established, and the effect of suction was quantified using an equation proposed on the basis of the experimental results. Under the sealed condition, the strength development mechanism mainly included cement hydration and the pozzolanic reaction. However, the mechanism under the drying condition was different from that under the sealed condition; the strength development was provided not only by cement hydration and the pozzolanic reaction but also by carbonation and the suction effect.

Second, the carbonation coefficient determined by the phenolphthalein spray test was the highest under the drying condition without water sprayed and decreased as the water content increased by water sprayed. Spraying appropriate amount of water can extend the semi-carbonated zone, resulted in the increase in the amount of $CaCO_3$ and the compressive strength. It was found that the compressive strength increased linearly with the amount of $CaCO_3$. It indicates that the amount of $CaCO_3$ is a good indicator to represent the effect of carbonation on the strength development of cement-treated sand.

Finally, the compressive strength of cement-treated soils increased for both short and long-terms under 40^{o}C when using OPC. However, the compressive strength of the specimens decreased under 40^{o}C when using HPC. It was revealed that the compressive strength of the specimen using HPC was much higher than that of the specimen using OPC under 20^{o}C. It suggests that HPC has a significant impact on the strength development in cement-treated soils and it can be a potential binder for applying in cement-treated soils to achieve high strength in both short and long-term.

In conclusion, this study could contribute a better understanding of strength development in cement-treated soils under different curing condition for improving practical issues related to material design and construction method.