Exploratory Study of Lime Conditioning for Drilled Shafts

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Hydrated lime [Ca(OH)2] has long been known to produce strengthening of clay soils through the formation of carbonates in the presence of CO2, destructuring of clay minerals by raising the pH of the soil to a value in excess of 12.4 and by ion exchange, in which natural monovalent ions adsorbed onto the clay minerals are exchanged for divalent ions, which reduces the diffuse double layer thicknesses and leads to higher angles of internal friction.

The current exploratory research seeks to determine whether the exposure of the face of drilled shaft boreholes to hydrated lime can restore all or part of the shear strength of clay soils that have been remolded and thereby weakened by the drilling process. If such exposure is successful, unit side shear in drilled shafts can be increased, and the sizes of foundation shafts can be reduced, thereby producing cost savings on infrastructure renewal projects.

Laboratory studies of the shearing of lime-conditioned concrete-clay soil interfaces, conducted on samples of soil from the NGES-UH by investigators at Bogazici University in Istanbul, have shown a substantial increase in the angle of internal friction at the interface, suggesting improvement via the ion exchange process, and possibly the destructuring process. This phenomenon suggests that the simple addition of hydrated lime in slurry form to the drilled shaft borehole prior to concreting the shaft, or to the concrete directly, may improve side resistance. Six small, full-sized drilled shafts were constructed and load tested, including a reference shaft that had no lime conditioning. The various test shafts were constructed in such a manner that the lime is delivered to the soil in various ways: through lime slurry, through lime mixed with the concrete and through the addition of fly ash to the concrete, which enhances the production of lime as CaO during the hydration of the cement.

The gross results of the loading tests on the full-sized shafts, which have just been completed in the same clay soils (at the NGES-UH), indicate that the use of 7 per cent lime slurry was effective in increasing the side resistance of the shaft by about 20 per cent and that replacement of 7 percent of the cement in the concrete mix by an equal weight of lime increased the side resistance by about 15 per cent. Addition of the lime to the concrete did not have a negative effect on its compressive strength. The use of fly ash was less successful. The economic benefit of these capacity increases is currently being studied.

Parallel studies are also being conducted to measure the effect of drilling on the amount and radial extent of soil disturbance caused by auger drilling in stiff clay and the effectiveness of the lime in penetrating and regenerating the shear strength of the soil in the remolded zone. These studies are being conducted in cooperation with the University of Texas in order to obtain a more fundamental understanding of the stabilization process.
