IMPROVEMENT OF JET TECHNOLOGY FOR SOIL STABILIZATION

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A geotechnology is described for soil stabilization on the basis of an improved design of jet monitor, which makes it possible to change the traditional procedural process and mix soil with grout on the surface; this makes it possible to save significantly on cementing materials, and also to completely replace the natural soil with a hardening grout or another soil.

Jet geotechnology is an extremely effective method of stabilizing soils owing to use of a liquid jet as the effective cutting tool, use of the in-situ soil as a structural material, combination of the processes of soil excavation and its mixing with a stabilizing grout over time, and the possibility of its use in any granular deposits and under various hydrogeological conditions. This technology has, however, a number of drawbacks, which have suppressed its widespread implementation.

The following are classed among these drawbacks:

- an insufficient rate of removal of part of the volume of jet-failed soil by an ascending flow of a liquid and air mixture;
- negligible mixing efficiency of the loosened soil and stabilizing grout delivered in the form of a fine jet with the hydraulic monitor turning at a low rate; and,
- the relationship between the strength of the resultant soil-concrete and the characteristics of the stabilized soil.

The causes of the first two deficiencies consist in the character of the hydrodynamic processes that take place in the mass being eroded.

In the general case, the transport capacity of the ascending flow is fully adequate for vigorous removal of the eroded soil for a three-component jet technology, when the soil is failed by a water jet in an air flow, which is rotated about the vertical axis, and some of the failed soil is carried away by the aerated liquid (mixture of spent water and air). The failed soil in the eroded cavity collapses downward, however, and its rate of capture by the ascending flow is limited by the small radius of the washout and by the unfavorable hydraulic conditions for movement toward the upper opening of the working hole. The section of the flow and its intersection by the scoring jet is sharply diminished in that case. This position requires a reduction in the rate of ascent of the monitor.

The limitation placed on the rate of ascent of the flushing unit is explained by the fact that when the settled soil loosened by the jet has been mixed with grout delivered from a special nozzle, the small diameter of this jet and the slow turn rate of the monitor determine other-than-optimal values of the mixing parameters. A reduction in the nozzle diameter and pressure of the grout to certain values is inadmissible, since the grout jet should overcome the resistance of the semi-liquid medium, whereupon the density of the medium is increased in the direction toward the periphery of the eroded cavity, and the dynamic pressure of the jet drops. These causes determine the minimal volume of grout delivered, which significantly exceeds the value required for soil stabilization. It is empirically established that the volume of grout delivered should exceed the volume of soil being stabilized. It is precisely this that determines the large unproductive losses of grout when soils are stabilized using jet geotechnology.

All of what we have stated for the three-component technology is also valid for the one- and two-component technologies, where some of the stabilizing grout is used to remove excavated soil.

The third drawback is caused by the direct relation between the strength of the soil being stabilized and its grain-size distribution and texture. In soils containing a large amount of fine and clayey particles, including clays and muds, soil-concrete structures have a low strength for the same cement outlays as in sandy-gravelly and gravelly-rubbly structures, where the strength of the soil-concrete is maximum. In laminar soils with appreciably different layer characteristics after the formation of a soil-concrete column, the strength of its material varies markedly on the boundaries between layers, and the variation in particle size, as well as the texture and strength of the layers is adequate.

In Russia, where cement has recently become a marketable material, and the component of material cost in the structure of the operations (in contrast to foreign countries) significantly exceeds the wage component, these drawbacks limit use of jet geotechnology for soil stabilization. Under our conditions, therefore, it is necessary to improve jet geotechnology and, above all, the production equipment.

The removal of failed soil from the eroded cavity should be intensified, reducing, and, in certain cases, also completely excluding its settlement. For this purpose, it was decided to use a supplementary vortex flow artificially created in the cavity being eroded.

Vortex flows, which can be used to improve the soil intake in different units, were first employed in the Moscow Geologic-Survey Academy on large-scale machines. Highly efficient hydraulic-transport and soil-intake devices previously successfully tested in different countries, including Scotland and the Republic of South Africa, have been developed on the basis of research results.

For better mixing of the failed soil and grout, it was decided to withdraw all eroded soil, dewater it, remove the finest particles, and mix it with grout on the surface of the ground in mixers with subsequent delivery to the eroded cavity. Sealing of the eroded cavity was employed for vigorous removal of slurry with a simultaneous reduction in the required flow of compressed air.

In a number of cases, it is expedient not to stabilize weak soils, but replace them with a sand-cement grout.

In addition to elements existing in familiar designs (water and air nozzles concentrically located in a housing, a grout-intake pipe or grout nozzle, and conducting pipes), the improved jet monitor (Figs. 1 and 2) included the following: a sealing device in the form of an umbrella-like shell, which is opened after the monitor is submerged into the hole; slurry-lifting pipe; and, a vortex-generating unit. The latter creates an involuted circular jet around the feed pipe, which forms an annular vortex exhibiting a high entrapment capacity.