Soil/Cement Slurry Strengthens Weak Soils

By Jonathan Bussiere, E.I.T.

Improved soil properties, such as greater strength and reduced compressibility, can lead to more efficient structural designs.

Soil/cement slurry is a mixture of Portland cement, water and soil which has better engineering properties than soil alone. Also known as soilcrete, soil/cement slurry is created by introducing cement and water to soil *in situ* (i.e. without excavating the soil) and blending the mixture by either mechanical mixing or by injecting high pressure fluid.

Applications

If every project site was underlain by dense sand and gravel, soil/cement slurry would have few practical uses. In reality, the condition of the underlying soil is not always perfect, so designers must recognize and address the problems associated with building structures on soft soils. The main structural risks posed by soft/loose soils are excessive static settlement, bearing capacity failure and settlement due to seismic liquefaction.

Options such as driving piles or drilling shafts to bedrock eliminate concern about soft soil by transferring structure loads to stronger layers in the subsurface. Similarly, excavating and replacing poor quality soil is effective in some situations. However, in other cases, neither of these alternatives may be feasible from either an economic or constructability viewpoint. In many situations, soil/cement slurry can effectively mitigate bearing capacity and settlement hazards with lower cost and shorter construction time compared to conventional deep foundations or excavate/replace options.

Soil/cement slurry can be used either as a global foundation treatment, wherein the entire area below a uniformly loaded building slab, bridge abutment, storage tank, etc. is treated in a grid pattern, or in a surgical manner by pinpointing treatment locations under column footings, shear walls, heavily loaded areas or other critical building components.

Techniques

Construction of soil/cement slurry foundation elements typically utilizes four key pieces of equipment: a drill rig to advance the slurry to design depth, a batch plant or tank to mix the cement slurry, a pump to push the slurry to the drill rig, and specialized tooling to blend the cement slurry with soil *in situ*. Two of the most prevalent methods for constructing structural soilcrete elements are jet grouting and soil mixing.

Jet grouting is the process of injecting cement slurry (grout) into the ground to erode and replace the existing soil with soil/cement slurry. This technique involves drilling a 4- to 8-inch diameter hole from ground surface to design depth typically 120 feet or less, but greater depths are possible, and then injecting grout through a set of nozzles near the bottom of the drill rods. Grout and air or water is pumped through the nozzles at very high pressure, up to 5,000 psi, while the drill rods are slowly rotated and withdrawn from the hole. The resulting product is a rigid soilcrete column, typically 3 to 10 feet in diameter, which will have average unconfined compressive strength in the range of 250 to 1,250 psi.

Jet grouting is widely used for tunnel stabilization, utility support, excavation bottom seals, and underpinning applications, particularly in confined spaces. Low headroom drill rigs are commonly used within existing buildings to mitigate ongoing settlement beneath footings or to upgrade older buildings to meet current seismic codes.

Soil mixing, also known as deep soil mixing, is a soil treatment method wherein cement slurry (grout) is injected through a hollow mixing tool and mechanically blended with the *in situ* soil. The mixing tool consists of paddles, blades or cutters designed for agitating and mixing the soil/cement slurry to form soilcrete columns of 3 to 8 feet in diameter that will typically achieve compressive strength of 200 to 600 psi.

Cement may be injected either as slurry or, if the soil is already saturated, injected in powder form and completely hydrated *in situ*. The process of injecting and mixing powdered cement without water is termed dry soil mixing, and achieves the same benefits as injecting and mixing the soil with cement slurry (wet soil mixing) without creating any significant waste.

Like jet grouting, both wet and dry soil mixing are used to increase bearing capacity, reduce settlement, and mitigate seismic liquefaction hazards in soft soils. Soil mixing is especially well suited to treating soils below structures with large footprints, such as storage tanks or building slabs. Interlocking soil mix columns are commonly installed for excavation support, either as standalone elements or to reduce lateral loads on retaining structures such as bulkhead walls and sheet piles. When required, steel elements such as rebar cages or beams can be installed in soilcrete prior to initial set, adding strength and bending resistance to soil mix columns.

Wet soil mixing to stabilize soil and reduce lateral loads behind a sheet pile wall at the Port of Los Angeles Harbor. Courtesy of Justin Sharman.

Soil/cement slurry construction techniques, such as soil mixing and jet grouting, are tools for improving the strength and stiffness properties of weak soils. Like good craftsman, designers should recognize the capabilities and limitations of the tools in their toolbox and choose the correct one for the given task. For the same reason that a carpenter should think twice about pounding a framing nail with a sledge hammer, a structural designer should consider soil/cement slurry techniques before opting for driven piles, drilled shafts or other potentially more expensive options for dealing with weak soil.

Other applications of soil/cement slurry include shoring wall construction and support, ground water cut offs, contaminant plume stabilization, break ins/outs for tunneling machines and slope and landslide stabilization.▪

Jonathan Bussiere, E.I.T., is a Field Engineer for Hayward Baker's Seattle office. Jonathan can be reached via email at ***jbussiere@haywardbaker.com****.*