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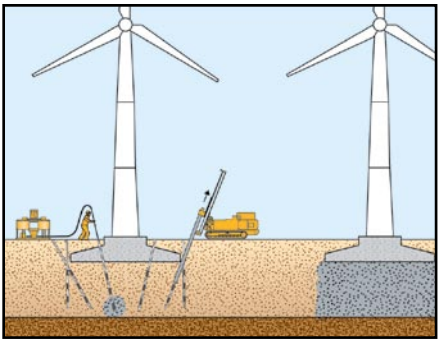
## A proven technique for stopping or reducing settlement, chemical grouting is an effective, cost-efficient alternative to complete reconstruction of the foundation system.

**WIND TOWERS FOUNDED** on spread footings may settle as a result of loose bearing soils either not identified during the preconstruction geotechnical exploration or remaining after inadequate subgrade preparation. Loose granular soils may also be susceptible to liquefaction during a seismic event, which may result in excessive settlement or complete foundation failure. When wind towers are founded on loose granular soils, chemical grouting may be the correct solution for providing long-term support. Chemical grouting is also commonly used to solidify granular soils beneath a structure for both underpinning and excavation support when an adjacent excavation is to take place.



Chemical grouting is a permeation grouting technique that transforms granular soils into sandstone-like masses, by permeation with a low viscosity grout. The most common permeation grout for structural applications is sodium silicate. The grout is injected under pressure through previously installed pipes. The grout permeates the soil and solidifies it into a sandstone-like mass. The grouted soil has increased strength and stiffness, and reduced permeability. Common chemical grouting applications are to underpin existing foundations, create excavation support walls, create water cutoff walls, and stabilize soils for tunneling. Chemical grouting is available as a design-build service by specialty contractors. A thorough geotechnical investigation should be performed prior to design of a chemical grouting program to help to ensure proper injection hole geometry and grout selection. The equipment is relatively small, and therefore suitable for use on sites with restricted access.

Chemical grouting uses injection pipes known as Tube-a-manchette (TAM) pipes to deliver the grout. TAM pipes are typically 2-inch diameter steel pipes with injection ports every few feet along the length of the pipe. Rubber sleeves (manchettes) cover each injection port and serve as one-way valves that open during injection and collapse onto the ports after injection. The TAM pipes are installed in boreholes in a designed pattern beneath a foundation to allow injection beneath the entire foundation footprint. Depending on site access, TAM pipe inclinations can range from vertical to horizontal to create a treatment zone. Once the TAM pipes have been inserted into the borehole, the space between the TAM pipe and borehole wall (annulus) is filled with a weak but stiff grout that seals and stabilizes the borehole and holds the TAM pipe in position. A pneumatic packer is then pushed into the TAM to a specified injection point. Rubber seals at each end of the packer are hydraulically inflated to isolate the injection port. The initial pressure of the chemical grout breaks through the annulus, permitting it access to the soil.

The volume of chemical grout needed to solidify a zone of granular soil is calculated by predicting the shape of the grout flow from the injection point determined by the subsurface conditions. In uniform granular soils, the grout typically flows radially from each port to create a spherical grouted shape. Based on a spherical flow model and the soil void ratio, the required maximum design volume can be calculated.

An effective quality control program requires that all stages be monitored and fully documented. Installation of the sleeve port pipes is monitored to ensure proper alignment. An experienced grout technician should monitor the grout manifold's optical flow meters and pressure gauges during grout injection and record the injection data for each location: pipe number, date, sleeve number and elevation, grout volume, and pressure and flow readings. A geotechnical engineer should review the data to verify the formation and stability of the grouted mass.

Chemical grouting with sodium silicate grout was first used over 100 years ago. Since then, it and many other formulations have been used to strengthen granular foundation soils for structures including bridge and tower piers, utilities, pads, and high- and low-rise buildings throughout Europe and North America. Wind tower construction can take advantage of this effective, cost-efficient alternative to complete reconstruction of the foundation system.

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