

TECHNICAL INFORMATION

Permeation Grouting

INFLUENCE OF SOIL CHARACTERISTICS ON CEMENT GROUTING OPERATIONS

The suitability of various cement grouting materials for permeation grouting of granular or sandy soils may be evaluated using the following formula:

$$\text{GROUTABILITY } (N_c) = \frac{d_{10}(\text{soil})}{d_{95}(\text{grout})}$$

Satisfactory grouting results can be consistently obtained with cementitious grout mixes for site conditions where $N_c > 11$. For site conditions where $N_c < 11$, it becomes increasingly difficult to obtain satisfactory grouting results. For site conditions where $N_c < 6$, injection by permeation grouting using suspension grouts is not possible.

Grout penetration by permeation of suspension grouts into sandy soils can be facilitated by selecting grouting materials to accommodate site conditions as shown on the following table:

<u>Cement Product</u>	<u>d_{95} (grout) Cement Particles</u>	<u>d_{10} (soil) Soil Particles</u>
ordinary Portland	80 - 100 microns	> 800 microns
high early strength	40 - 60 microns	> 400 microns
microfine cement	10 - 12 microns	> 100 microns

Within the coarser d_{10} (soil) ranges, relatively low water:cement ratios may be used to achieve higher soil strengths. When grouting outside of the specified soil ranges, it will be necessary to use relatively higher water:cement ratios, which will result in lower compressive strengths and higher residual soil permeability. Grouting with suspension grouts in finer soils will also result in gradual reductions in the degree of soil permeation and increased occurrence of hydrofracturing.

Soils containing more than 5% silt cannot be effectively sealed by the injection of suspension grouts.



The exterior granular soils surrounding trench boxes to be used as drilling pits can be stabilized by using cement grouts prior to drilling large diameter horizontal drill holes for pipe crossings beneath busy roads and highways. In such cases, permeation grouting operations are performed using perforated sleeve pipes.

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SELECTION OF CEMENT PRODUCTS FOR PERMEATION GROUTING

The use of ordinary Portland cement will only be applicable for grouting in coarse granular soils or backfill due to the relatively large particle size of such materials. High early strength cements, although featuring relatively smaller particle size diameters, are still considered relatively coarse for most permeation grouting operations.

In most soil permeation applications involving medium-to-fine sandy soils, the use of microfine cement will be the only practical choice available.

In cases where fine sandy soils require homogeneous grouting, the use of solution grouts such as acrylate or polyurethane should be considered as alternates to the use of microfine cement suspension grouts.



This highway bridge construction project utilized sleeve pipes, seen in the background behind colloidal mixer, for soil stabilization as part of the foundation design requirements

GROUT FORMULATIONS FOR PERMEATION GROUTING

High quality permeation grouts will typically utilize small dosages of high-yield bentonite to provide grout stability, as well as incorporating a high-range superplasticizer to prevent flocculation of cement particles and to reduce the apparent viscosity of the fluid grout.

A stable, balanced grout formulation will be less susceptible to pressure filtration and will permeate further than simple water-cement grout mixtures. Such grout mixtures will also result in less bleed after placement, thereby minimizing the potential for problems involving residual permeability.

GROUTING EQUIPMENT AND ACCESSORIES FOR PERMEATION GROUTING

The use of high-shear colloidal grout mixers is required for high quality cement grouts to be produced that are suitable for permeation grouting. The high-speed impeller ensures that recirculating grout particles are individually separated and fully wetted before being released to the pump agitator tank.

PVC perforated sleeve pipes are commonly used in permeation grouting operations to enable the dispersion of grout through soil layers in a homogeneous manner. Sleeve pipes have the added feature of separating the drilling and grouting operations, so that the drilling and grouting crews and equipment can be productively employed with a minimum of interference to one another.

Water pressure testing can be used to establish soil permeability prior to grouting operations, as well as to measure the effectiveness of previous grouting operations.

The use of progressive-cavity pumps, recirculating grout lines, diaphragm control valves and electronic flow meters facilitate maintaining control of grouting operations in response to a wide range of changing site conditions. Consult our technical specialists for advice in the selection and proper use of such equipment and accessory items in permeation grouting operations.