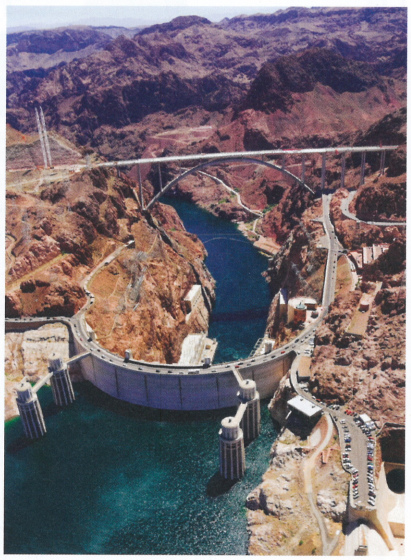
Sorting out the grout

Tunnel contractors can choose whether to use cement or chemical grouts. To help them out, Britt Babcock discusses both types, which to use, when to use them and why... and an idea of how much it will all cost

USED in a myriad of new and rehabilitation construction projects, cementitious and chemical grouts share a common category and name, but the distinct differences far outweigh the common qualities.

Both grout types are used in civil applications, ranging from sewer-pipe rehabilitation to new tunnel construction, used to fill narrow cavities/cracks and rock fissures, or to permeate soils for the control of groundwater, void filling or to increase structural support. Cement and chemical grouts can differ in composition, application and cost, and are ultimately complementary products on the same projects. This article will explore when and why to use the various types of grouts and the cost range of each product.

The practice of injecting grouts and the wide array of grout products available can make choosing the right grout for the project complicated. Because it is difficult to summarise the complexity of the topic in a single article, some specific topics within this piece have been generalised for simplicity. If a situation exists on a project where grout injection is required, a qualified grouting contractor should be engaged to provide installation recommendations; in addition, a knowledgeable grout supplier should be consulted to assist with proper grout selection.



Left: Hoover Dam, Nevada, US, where ultrafine grout was used within Intake Tunnel No. 2
Right: engineers inspecting Ultrafine Grout within Intake Tunnel No 2 of Hoover Dam

GROUTS

Grouts used in civil construction and rehabilitation projects can be generally categorised into cement and chemical types. Within each grout family, there are primary grout sub-types: within cement grouts, these are defined by ordinary Portland cement (OPC) and ultrafine cements. The chemical grout family includes sodium silicate, acrylic gels and polyurethane expansive foams. Although each parent grout type has primary grout spawns, this is where the commonalities end and the individual grout types split into their own unique characteristics.

> "The wide array of grout products available can make choosing the right grout for the project complicated"

Cement grouts are considered to be suspended-solids grouts, because they have particulates in their composition. Basic cement grout in the US is derived from Portland cement clinker while the microfine grouts are either domestic pumice- or foreign slag-based. Portland cement generally has particulate sizes ranging from 50µ to 100µ (microns). Microfine cement particulates range from 6µ to 10µ, while ultrafine cements have average particulate sizes from 3µ to 5µ.

The project specification determines the average particulate size required that can be custom-manufactured by US Grout. The consistency of the cement grouts is accomplished through controlling the water/cement ratio and including a super plasticiser to reduce viscosity. While additives can be introduced to slow the cure time, once mixed with water, cement grouts begin to cure to high compressive strengths. Cements are considered long-term solutions for either water control or structural improvement, having lifespans ranging between 100 and 200 years. Portland and ultrafine cements will typically range between US$1 and US$4/gallon in cost.

The primary types of chemical grout (silicates, acrylics and polyurethanes) are each unique in composition. Like cement grouts, sodium silicates are considered to be a suspended-solids grout with glass particulates as its composition. Sodium silicate is a two-component grout that typically has very low viscosity but will often expunge water after gelling, through a process called syneresis. Sodium silicates have short gel times and are commonly used as temporary solutions for water control or structural improvement, with an estimated life span of approximately 10 years. Sodium silicates typically cost between US$2 and US$3/gall.

Acrylics are defined as 'true solution grouts', which are free of suspended solids and have extremely low viscosity – similar to water. The acrylic family consists of acrylamide, acrylic and acrylates. Each type requires a base resin to be mixed with a catalyst in order to create a gel or gel/soil matrix within a predictable gel time. Acrylamide changes from a liquid to a solid in a controllable gel time ranging from three seconds to 10hrs. Acrylate gel times range from →

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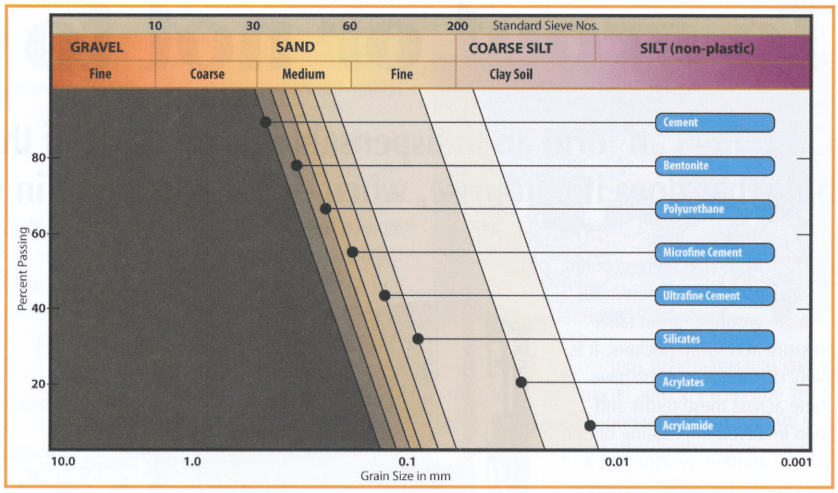


Data supporting the permeability of various injection cements and materials in different soil types

→ approximately one minute to one hour. The life span of an acrylamide is estimated to be greater than 300yrs, while that of an acrylate is estimated to be 50-60 years. The cost of acrylic gels will typically range between US$6-US$10/gall.

There are two primary types of polyurethane grouts, defined as hydrophilic and hydrophobic. Hydrophilic grouts are typically single-component systems that react with water and cure to an expansive flexible foam or non-expansive gel requiring a moist environment after curing. Hydrophobic expansive foams require little water to react, approximately 4%, and easily withstand wet/dry cycles.

Hydrophilic foams expand to four to six times their original volume, while hydrophobic foams expand anywhere up to 20 times their original volume and may cure flexibly or rigidly. Most manufacturers carry polyurethane resins having NSF or UL certifications, approving their use in potable-water applications.

The life span of polyurethane foam is estimated to be between 75 and 100 years. The cost of polyurethane resins (before expansion) will typically range between US$60 and US$90/gall.

APPLICATIONS

Cement and chemical grouts are used in a wide variety of construction projects ranging from new construction to rehabilitation. For example, Portland and ultrafine cement grouts are predominantly used to stabilise soil and/or control water in civil projects, including earthen dams, levees, mines, tunnels, subways, vertical shafts, below-ground structures and waste encapsulation. These large-scale projects will often require significant volumes of grout to be injected.

On civil projects, where grouting is expected, the engineer or grouting consultant will have prepared a grouting programme defining which grout is planned. However, in some cases, the need for water control or soil stabilisation is not anticipated and a grouting programme is developed quickly.

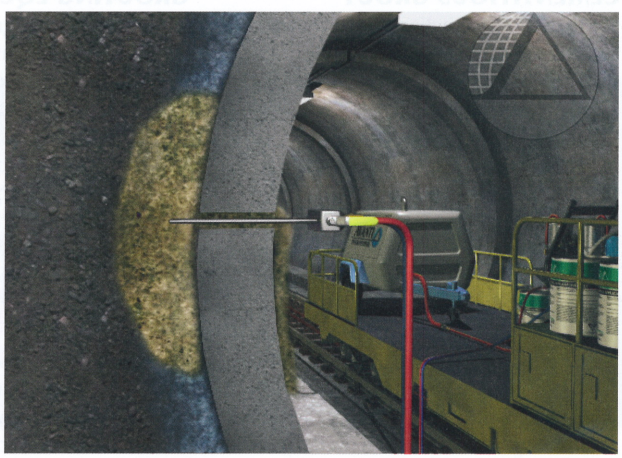
"The type of grout material generally goes through a trial-and-error process"

The type of grout material used for injection for an immediate need generally goes through a trial-and-error process. Because of its economic advantage, Portland cement grout will often be the first attempted. If geologic conditions will not accept the Portland cement grout, then an ultrafine cement grout will be utilised. If Portland or ultrafine cements are unsuccessful, an acrylic resin-like acrylamide will often be employed.

Grouts are also used extensively in the rehabilitation of deteriorating sanitary sewer infrastructures, concrete dams or below-grade structures. Generally, acrylic gels and polyurethane foams are used for these types of projects. However, certain applications can require cement grout. Both are used to seal leaking cracks and joints. However, acrylamide gel is predominantly used in the pipeline system, whereas the polyurethane foams are used in and around manholes and vaults.

Where voids have occurred behind below-grade structures, the highly expansive polyurethane hydrophobic foams are commonly used to fill the void. Specially designed polyurethane foam is also used for the lifting of concrete slabs, which provides structural support by using a lighter-weight solution that will not promote additional slab settlement. Cured structural foam weighs approximately 4lb/ft^3 (64kg/m^3), much lighter than mud-jacking material.

When faced with the need to stop leaks, stabilise soil or control water, it is recommended that a qualified grout consultant and grout-injection contractor be engaged to provide installation recommendations, and a knowledgeable grout supplier should be consulted to assist with proper grout selection. Avanti International is the only full service producer and the most experienced supplier of acrylamide, acrylic, acrylate, hydrophilic, hydrophobic, foam, gel and cement grouts in the US.



Grout injection through the concrete wall to control ground water in the Toronto subway system with a specially designed rig (background) for the grouting operations
Photo: Avanti International

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