Discussion of "How Many Components in a Grout Mix?"

Marcelo Chaqui

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I read with interest the article_How Many Components in a Grout Mix,_by Marcelo Chaqui and offer the following considerations, as contribution from an old field specialist:

1. **Resistance to pressure filtration** is in my opinion a very important characteristic as in most cases the grout is subject to a similar process in the ground: if a filter cake is created at the walls of the hole or in its surroundings the grout will not penetrate the ground and therefore will be useless. Unfortunately the Filter Press is seldom used in the field for quality control purposes.

Please note that what I am saying may appear to be in disagreement with Giovanni Lombardi's "Grouting of Rock Masses" (Proceedings of the ASCE Specialty Conference in Grouting in Geotechnical Engineering, New Orleans – 2003) as he indicates the theory of "presso-filtration" outdated, but note that he is just addressing the theme of "Cement grouting of jointed sound rock masses of dam foundations", and in fact he clearly says that he is excluding in his considerations "granular or fine soils, which present a high percentage of voids and thus a high deformability. They require the use of special techniques different from the ones we will deal with thereafter."

The obvious limit of Lombardi's theory is that he is excluding those granular formations that often are encountered in dam foundations (for instance the sugary limestone at Tarbela dam in Pakistan and at Mosul dam in Iraq) and also special discontinuities, that "are in fact weakness surfaces in layered or schistous rock" (such as the milonite in the fault of Kainji dam in Nigeria).

2. **Bleed** will give very little information on the behavior of the grout in the ground unless the grout is used for a pre-treatment focused only to the filling of cavities and/or large fissures at low pressure; in fact in pressure grouting in a fissured soil bleeding will occur as in pressure filtration; and
3. **Prevention of particle aggregation** is a very important aspect and in my experience the quality of the mix with respect to dispersion (or aggregation) of the particles can vary largely depending upon the way the mix is prepared. For instance in a cement-bentonite mix, one has to mix first the bentonite in a colloidal mixer, let the bentonite mud rest to hydrate, then mix it with cement again in a high velocity mixer, before transferring the grout into an agitator. This procedure and sequence must be strictly adhered to.

Note that laboratory tests should always be double checked in the field adopting the field equipment: in fact laboratory tests can only give a guideline, but the final testing to determine the grout should be run in the field or in a laboratory equipped with field mixing equipment (Paolo Gazzarrini is right to say: "The grouting is done in the field and not in the lab")

I have some special consideration to make on the **grouting** to be done **in moving water**. This is a problem I had to face while doing some maintenance grouting in a foundation of a dam, which was already partially impounded and where we encountered deep leaks of water at high velocity in the rock due to fissures that occurred after the first curtain grouting, due to the solution of gypsum layers.

The first consideration is that when potentially soluble formations are present in the ground, curtain grouting should be carried out to such an extent that the residual permeability be close to zero, as any water leaking would be opening up even the micro fissures by soluting the soluble layers.

In our case we made various attempts with fast setting mixes with no success as the grout was washed away rapidly by the leaking water ; vice versa by reducing the setting time to few seconds we were plugging the holes and not the leak.

We had therefore to change tactics: we pumped, at the highest practical pumping velocity, concrete into the fissures through the grout holes until refusal, then we did the cement mix (with accelerator) grouting into the partially washed out concrete.

The process was immediately successful, as we could notice from the piezometers readings.

I suppose that we could have tried a Low Mobility Grout, but I doubt that it would have solved the problem, as determining the set times was the problem: in fact I don't think inline mixing would have been feasible in a small diameter (65 mm.) hole and the set time had to be much less than 1 minute (probably 10-15 seconds).

As far as **multiple injections** is concerned in any grout hole, I remember that it was usual in grouting of alluvial soils to use the "tubes-a-manchette" starting with a cement-bentonite mix

first for the grout hole sleeve, then for a first stage grouting of the more coarse levels, then move to a silicate gel to complete the grouting.

When there was the requirement of multiple injections in rock, we adopted the MPSP grout pipes and used cement based grout to fill the bags acting as packers between grout valve, then grout the different mixes required, such as a first thicker stable grout to fill the larger voids and fissures, then a "finissage" grout to complete the treatment.

As far as **prevention of filler segregation** is concerned**,** I believe that mortars of grout and sand should be used only when backfilling cavities by a tremie pipe and should never used in pressure grouting: in fact a mortar that enters into a fissure will always segregate.

In the early days of my grouting experience, we used three-component mixes, made of cement, clay and bentonite in grouting very coarse gravels found in alluvial grouting; the clay was generally silty clay or clayey silt found in the alluvial deposits.

Clay had to be broken up, as in natural status was generally in lumps and this process was done by means of a hammer mill where the clay was dissolved with water into a mud that was then kept in agitation in large tanks where the content of clay in the mud was then checked with a Baroid Mud balance, by verifying the specific gravity of the mud.

The other two components of the grout mix were cement and bentonite (to guarantee stability).

I would still recommend clay rather than sand when constructing a cutoff.

Finally I have to say that Marcelo Chaqui's article covers a large number of components that may be used in grouting, but now the next question is about the drilling and grouting methods. I think we should address the issue of the methods that is generally the subject of the method statement that the specialist contractor has to submit prior to starting the field operations.

The method statement covers that portion of the specifications regarding the equipment proposed, the methods, the preliminary testing, the quality control, etc. that it is up to the specialist contractor to propose.

In fact it would be wrong for the engineer to try to give instructions on the method, the equipment, etc. I mention as exemplification that I found several times specifications addressing the type of jet grouting method (three fluids rather than two fluids) or the type of mixing plant for chemical grouting (batch plant not acceptable): this is wrong, the specialist contractor has to make the proposal in his methods statement providing at the same time all site testing of mixes, etc. in order to demonstrate the suitability of the proposed grouting methods.

My proposal is to encourage the specialist contractors to present articles on works done with a particular emphasis on special methods.

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Glossary of Grouting Terminology

Grouting Committee of the Geo-Institute
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Abstract:
This glossary is a compilation of terms used in the field of grouting, with an emphasis on the definitions that are specific to usage in grouting practice. It updates and replaces the corresponding Glossary contained in the July 1980 issue of the *Journal of the Geotechnical Engineering Division.*

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Introduction

This glossary is an attempt by the Grouting Committee to compile and standardize many of the terms used in the field of grouting so that communications about grouting projects, and interpretation of reports on grouting projects, can be understood and coordinated. It is an update of and a replacement for the Preliminary Glossary of Terms Relating to Grouting, which was published in the July 1980 issue of the *Journal of the Geotechnical Engineering Division.*