GIN AGAIN MISUNDERSTOOD

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GIN Again Misunderstood

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Based on theoretical considerations as well as on tests on various grout mixes some incorrect conclusions about said method were drawn. They are due mainly to misunderstandings as well as to a lack of information. Also, some well-known facts are presented as new findings.

Introduction
In a recent paper by Vafa Rombough, Grant Bonin and Dawn Shuttle [1] some comments about the GIN Grouting Method were presented.
Mathematical Model
To analyse the flow in a theoretically flat open joint the so-called Chhabra Richardson (1999) formula is used. In doing so it was however overlooked that this formula, among others, was developed by the writer already in 1985, that is 14 year earlier, in the paper "The Role of Cohesion in Cement Grouting of Rock" /2/ although using somewhat different symbols.

By the way in that paper, the plane joint was considered to be grouted radially in all directions out from a borehole. This assumption appears to be a bit more realistic than to grout a strip of constant width (w) as done in the paper mentioned hereabove/1/.

Grouting Process
First of all it was overlooked that the "Intensity number" (GIN) refers to the final status of the process, so it corresponds to the target (penetration distance) and applies thus to a flow rate nil; it does not refer to the actual grouting path.

Indeed, the reach is function only of the cohesion of the mix, while the time required by the grouting process depends mainly on the viscosity of the same, as well as of the grouting path.

Thus the statement by the authors "The GIN method ... assumes a Bingham material" is correct, but the comment "... (it) makes only reference to the yield stress c' to compute the penetration distance" is out of place, because this is not an assumption, but a fact. Indeed it is overlooked that, as said in paper /2/, "The duration of the process is determined by the viscosity of the grout mix and the pump characteristics. Theoretically the duration of grouting can be infinite but the injected volume is always finite as long as a cohesive grout is used."

The grouting process of a plane joint of constant thickness is represented by Figure 1, which reproduces Figure 11 of said 1985 ICOLD Congress paper /2/.

To avoid to have to grout for an infinite long time in order to reach the theoretically required penetration distance, which corresponds to a given GIN number, it is usual to overpass somewhat (let say by 10%) for a short time interval said intensity and then to return to it checking that the flow rate is actually nil. This fact was explained at various opportunities so in the papers /4/ and /5/ as well as in the final discussion in New Orleans /3/.

It is shown again by Figure 2 taken from these papers.

The main remark to the paper by Yafa Rambahou and co-authors is therefore that the target was confused with the way to reach it.

Very amazing is indeed the fact that the authors of paper /1/ did overlook that the penetration distance considered by the GIN method can be directly derived from their formulae in a very simple way.

This shows that the reach of the grouting process (possibly at an infinite time) depends only on the cohesion not on the viscosity. This is in fact not a "GIN idealisation", which would imply

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1 At the end of the grouting process - indeed after an infinite time in their case - the flow rate q will be nil. Consequently according formula (5) r = 0, thus following (7) q = c cos θ (1) = 0, further with (5) q = 2 cos (13 π) = 1, then according (4) \[ \frac{dP}{dx} = \frac{2c}{b} \] thus \[ \frac{dP}{dx} = \frac{2c}{b} \] (linear pressure distribution, see Fig. 1), and finally in accordance with GIN: \[ L = x = \frac{P - b}{2c} \]
a "theoretical limitation of the GIN method". It is simply a fact following the assumptions made.

The way to overcome the infinite duration of the process and to shorten the actual grouting time was already explained. It consists simply in stopping grouting shortly before reaching a slightly overestimated GIN-Value.

The Model and the Reality
The simple model of a single plane joint of constant thickness perpendicular to the borehole used in [2], as well as in [1], represents in fact just a first quite schematic approximation of the reality. Indeed the joint will be only occasionally of constant opening but will present, as a rule, a variable thickness and also possibly a number of contact points, which have to be circumvented by the grout; therefore the average volume to be filled by the grout may be higher than the one which would correspond to "hydraulic opening" of the joints and the actual way of the grout will be greater than the radius. These facts do imply the use of corrective factors. Additionally, the joints are generally not perpendicular to the borehole nor perfectly plane. This fact needs to be taken into account, for example, the thickness of the grout curtain or the distance between the boreholes to be selected.

Obviously, the frequency of the joints needs also be considered.

Finally, it must be recalled that, as a rule, not a single joint's system, but a complex intersection of a number of them with different characteristics and of erratic discontinuities has to be grouted. Not to forget also, that the actual opening of the joint is not fix and given beforehand but may be somewhat influenced by the grouting process itself. Following, said simple model cannot claim to be able by itself allowing to compute the GIN value to be used in an actual grouting process, but is intended to define the main principle, that is the actual "dimension" of the problem and to confirm the theoretical validity of the GIN-concept. The real value of the GIN to be used must thus be defined by grouting tests on the site and by a correct interpretation of the actual results of the process.

By the way, it is a pity to ascertain how many useless water pressure tests and how few useful grouting tests are generally carried out worldwide. Indeed, the "groutability" of a given rock mass by a given mix has little to do with the so-called "permeability" measured by any water pressure test. It depends mainly on the cement grain size.

The Merits of GIN
In fact the main merit of the GIN-concept is to have shown that the reach, or the practical penetration distance, at the end of the process, that is at a nil flow rate, depends only on the cohesion of the mix, not on its viscosity. This last property influences the time required completing the process. To shorten the grouting duration, higher pressures can and should be used for a while during the same.

Indeed, the GIN method makes also the final grouting result practically independent of the actual viscosity of the mix.

Even more, it makes it largely independent of the actual "pressure-take" path and needs to consider only the final values of these variables.

Exactly this aspect of the question was misunderstood by Vaša Rombough and co-authors; so some of their conclusions are not acceptable in spite of a number of interesting theoretical and experimental results presented by them in their paper.

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