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Discussion of "Numerical Simulation of the Shear Behavior of Rock Joints Filled with Unsaturated Soil" by Libin Gong, Jan Nemcik, and Ting Ren

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The paper under discussion essentially reports a numerical study of the behavior of infilled rock joints tested under unsaturated conditions. The numerical attempt has merit but there are several issues around the model validation against experimental data that could be considered inadequately or improperly addressed.

The authors state that experimental data are not available to verify the results obtained through their numerical model; however, this is definitely not the case. In fact, the authors have ignored their own work reported in a recent publication (Gong et al. 2018). Furthermore, there is a wealth of data available for the shearing of infilled rock joints under unsaturated conditions reported by Khosravi et al. (2013, 2016a, b). In addition, the authors could have validated their model using past data available for constant water content tests (e.g., Oliveira 2009; Indraratna et al. 2014) and specific tests where negative pore water pressure was measured (e.g., Indraratna and Jayanathan 2005; Mylvaganam 2007).

The authors state that the study "proposed a general framework of modeling the shear behavior of rock joints filled with unsaturated soil." However, with laboratory data already available from past literature, it seems inappropriate to present a model framework without any attempt to verify its accuracy in predicting the shear behavior. Furthermore, they claim "to the authors' knowledge this is the first time the infill degree of saturation and porosity is taken into account when numerically modeling the infilled joint shear behaviour." While it may be that this is a first-time attempt using a commercial numerical modeling software like FLAC, it is certainly not the first time that infill degree of saturation and associated void space have been taken in to account by past researchers. For example, the paper by Indraratna et al. (2013) described an analytical model capturing the effects of infill unsaturation, and the corresponding equations could be discretised in to numerical tools such as FLAC using a computer subroutine (e.g., in FISH). There may be other efforts too of which the discussers are unaware.

In addition, there are a number of aspects that influence the behavior of infilled rock joints that have not been considered, as follows:

- Role of soil fabric: The importance of the soil structure in compacted material behavior is very well established in the unsaturated soil community but the authors have omitted it in their model.
- Fabric inhomogeneity and anisotropy: The discussers note a change in suction of one order of magnitude (1,000 kPa) for the locations undergoing dilation and compression (Fig. 12); this value seems abnormally high and is probably the result of not considering changes in soil fabric and associated void ratio taking place within the joint during shearing. In contrast, the first author's recently published study (Gong et al. 2018), in which matric suction was measured with two high-capacity tensiometers in a constant water content test, reported only a small change of dozens of kilopascals and it has also been omitted from the current paper.
- Asperity degradation: Although it is understood that the study has been limited to shearing prior to rock-to-rock contact, the consideration of asperity degradation is vital to describe the behavior of infilled rock joints, and more so when dealing with compacted infill (e.g., Indraratna et al. 2010a, b). This is particularly important to adequately predict volumetric strains generated during shearing.
- Constitutive Model: Considering the intended level of detail in the model, where both joint roughness and the infill are explicitly modeled, the use an M-C model for the soil infill is not justified, especially when more sophisticated models for capturing the unsaturated soil behavior are available. In particular, coupled shear and volumetric

strain as well as other salient aspects such as collapse upon wetting have now been implemented in various commercial software packages (e.g., Barcelona Basic model, is described in Alonso et al. 1990).

- *Shear rate*: While the authors have mentioned that "the physical shear rate has little effect on the joint shear behavior in undrained condition within the range simulating static loading," due caution should be exercised because they have shown no experimental validation to substantiate this statement. In fact, past studies on compacted specimens (e.g., Mun et al. 2016) have demonstrated that the shear behavior is substantially influenced by the strain rate, and difference is more accentuated on the lower water content range.

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