SHEAR BAND ANALYSIS OF WEATHERED BROKEN ROCK IN DRY AND WET STATES

E. Bauer*, *S.F. Tantono
Institute of Applied Mechanics, Graz University of Technology, Graz, Austria

1. Mechanical properties of weathered broken rock

The degree of geological disintegration, i.e. by chemical weathering or by the intensity and the orientation of micro-cracks, has a significant influence on the granular hardness and as a consequence on the resistance to compaction and shearing, which leads to phenomena such as rockfill creep and collapse. It is experimentally evident that the mechanical properties of weathered broken rock are different for dry and wet states of the material [1]. Furthermore for rockfills with coarse-grained and uniform particles under stress the forces at the contact areas are much higher than in a well graded granular material. Thus grain abrasion and grain crushing caused by the plastification of contact zones and the progressive development of micro-cracks are usually more pronounced in rockfills. When water penetrates the micro-cracks, the disintegration of the granular hardness of the grain ensemble can be accelerated. Grain abrasion and grain crushing change the grain size distribution and consequently the value of the limit void ratios of the material.

Recently the essential mechanical properties of coarse-grained weathered broken rock were modeled within the framework of hypoplasticity by extending the model for unweathered stable grains and simple grain skeletons with a granular hardness depending on the degree of weathering and the moisture content [2]. In particular the granular hardness is defined as the pressure at which the isotropic compression curve in a semi-logarithmic representation shows the point of inflection (Figure 1.a). It was found by experiments that the point of inflection is related to the state where grain crushing becomes dominant. For the wet material the granular hardness is lower (Figure 1.b). The constitutive equation for the evolution of the stress is based on nonlinear tensor-valued functions depending on the current void ratio, the stress, granular hardness and the rate of deformation. The model also includes inelastic material properties, a pressure and density dependent stiffness and peak friction angle, strain softening and critical states. Creep and stress relaxation during the time-dependent process of degradation of the granular hardness are taken into account with an additional term added to the constitutive relation [3]. As the hypoplastic concept does not need to distinguish between elastic and plastic deformation the calibration of the constitutive constants is rather easy. It is demonstrated that for weathered broken granite the model captures the essential mechanical properties within a wide range of pressures and densities both for dry and wet states.

2. Shear band analysis for plane strain element compression

While for unweathered granular materials modeled with hypoplasticity shear banding has already been extensively investigated in earlier publications [4], the results obtained for a weathered broken rock [2] will be discussed in the present paper. Based on the general bifurcation theory the possibility of a spontaneous formation of a shear band in plane strain biaxial compression under a constant lateral stress is studied for the dry state and the water saturated state of weathered granite. Figure 1.c shows the evolution of the stress ratio and the volume strain under a homogeneous and drained element deformation starting from an initial isotropic stress state. It is obvious that for the dry material the incremental stiffness at the beginning of compression and also the maximum stress ratio is higher than for the water saturated material. Densification is more pronounced for the saturated material and dilatancy can only be observed for the dry material after the peak. The bifurcation analysis show that the first possibility of a shear band (marked with a dot) may appear before the peak. States above the first bifurcation point (dotted curves) again fulfill the bifurcation criterion. It can clearly be seen that the smallest stress ratio and shear band inclination for a possible shear band bifurcation is a little higher for the dry state of the material.

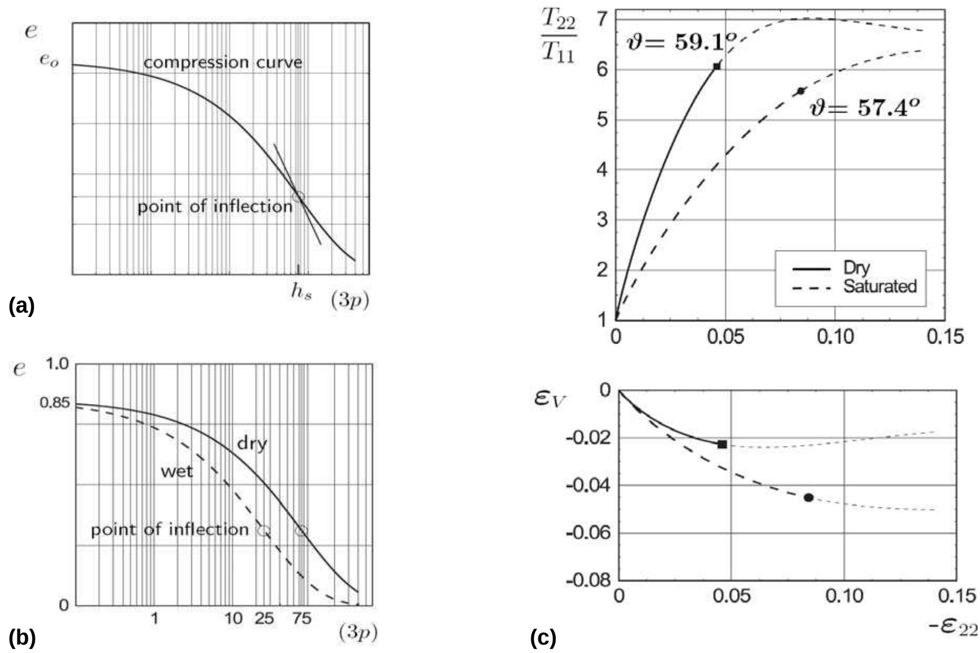

Figure 1. (a) Compression curve; **(b)** reduction of the granular hardness for the wet material; **(c)** Plane strain compression under constant lateral stress T_{11} = -0.8 MPa: stress ratio T_{22}/T_{11} against the vertical strain ε_{22}, volume strain ε_V against the compression strain ε_{22}.

(solid curves: dry state; dashed curves: saturated state; ϑ = shear band inclination)

3. References

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