

## **Rate effect in tool-rock frictional contact on porous rocks**

Y. Zhou<sup>a</sup> and G.Z. Voyiadjis<sup>a\*</sup>

<sup>a</sup> Louisiana State University, Baton Rouge, LA, USA

\* corresponding author: voyiadjis@eng.lsu.edu

### **Abstract:**

The rate-dependent mechanism is analyzed for frictional contact between a blunt tool and a fluid-infiltrated porous rock under pressurized condition. The dimensional analysis is adopted to derive a dimensionless number  $\lambda$  that predominantly governs the rate-dependent mechanism from pore pressure diffusion. The governing nature of  $\lambda$  is analyzed by finite element modeling using the software ABAQUS for an idealized plane strain frictional contact problem. After validating the finite element model against analytical solutions for special cases, the rate-dependent frictional contact is analyzed for poroelastic, poroelastoplastic, rigid-poroplastic, and elasto-visco-plastic rocks, respectively. Three pore pressure regimes exist depending on  $\lambda$ : low-speed ( $0 < \lambda \lesssim 10^{-1}$ ), transient ( $10^{-1} \lesssim \lambda \lesssim 10^3$ ), and high-speed ( $\lambda \gtrsim 10^3$ )<sup>1</sup>. The pore pressure generally increases, and the average effective contact stress decreases with increasing  $\lambda$  for a poroelastic rock and a typical poroelastoplastic rock. The average effective contact stress generally decreases with increasing  $\lambda$  for a rigid-poroplastic rock at a small dilatancy angle due to compactive weakening, but increases with  $\lambda$  at a large dilatancy angle due to dilatant strengthening. A transition occurs from compactive weakening to dilatant strengthening with increasing the dilatancy angle. The average effective contact stress increases with decreasing the interface friction angle for a rigid-poroplastic rock. It is inferred from numerical results that the high-speed regime dominates with cavitation for frictional contact on shales in deep drilling, and that the strain rate effect is negligible in typical experiments on dry rocks at ambient pressure.

---

<sup>1</sup> Zhou, Y. and Voyiadjis, G.Z. (2021). *Rate effect in frictional contact on porous rocks*. Rock Mechanics and Rock Engineering.