Mechanics and Control of Hydraulic Fracturing: Problems and Prospects

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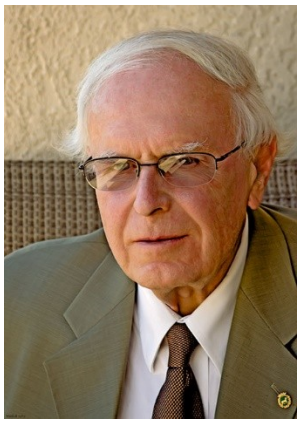
Thursday July 22, 2021, 9 a.m. Central Time



Prof. Zdeněk P. Bažant, W.P. Murphy and McCormick Institute Professor, Northwestern University, will speak on Thursday, July 22, 2021, at 9:00 a.m. Central Time.

The topic is "Mechanics and Control of Hydraulic Fracturing: Problems and Prospects."

Abstract

Mechanics and Control of Hydraulic Fracturing: Problems and Prospects

Zdeněk P. Bažant[1], Hoang T. Nguyen[1] and Wenfeng Li[2]

Despite the remarkable success of fracking technology in the U.S., unsolved problems remain, and improvements are desired. Four prospects are examined: 1) Detection and suppression of detrimental Sneddon's stress-shadow effect, which causes the spacing of parallel hydraulic cracks to increase. A rigorous prediction of this effect calls for bifurcation stability analysis of a parallel crack system, and its mitigation requires achieving a more uniform fluid pressure profile along the hydraulic crack, which is controllable by changes of injection rate and fluid viscosity. 2) Inducement of lateral branching of secondary cracks from the primary crack faces, facilitated by permeability of micro- or nano-cracked weak layers that remained after the natural cracks had been closed by creep over geological time span, or sealed my mineral deposition. 3) Increase of the poromechanical Biot coefficient, which stems from fluid permeation along the weak layers and is engendered by oriented micro- or nano-

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cracking.4) The crack-parallel stress effects, which are revealed by the new “gap test”, and are capable of doubling the material fracture energy or reducing it to almost zero. In poromechanics, the crack parallel stresses cause stress redistributions between the solid and fluid phases. These four prospects are supported by available experiments, as well as by crack-band finite element simulations of shale fracking, capturing damage nonlocality and cohesive behavior. The simulations are based on the recently developed spherocylindrical microplane model for the facture process zone in shale, which captures anisotropy and triaxial stress effects. The role of osmotic pressure gradients in crack spacing and in geological genesis of parallel cracks is also discussed. For comparison, some dubious aspects of tackling these problems with the phase-field models or peridynamics are also pointed out.

Biography

Born and educated in Prague (Ph.D. 1963), Prof. Bažant joined Northwestern University in 1969, where he has been W.P. Murphy Professor since 1990 and simultaneously McCormick Institute Professor since 2002, and Director of the Center for Concrete Geomaterials (1981-87). He was inducted to NAS, NAE, Am. Acad. of Arts & Sci., Royal Soc. London, the academies of Austria, Japan, Italy, Spain, Czech Rep., Greece, India and Lombardy, and Academia Europaea. Honorary Member of: ASCE, ASME, ACI, RILEM. Received Austrian Cross of Honor for Science and Art; 7 honorary doctorates (Prague, Karlsruhe, Colorado, Milan, Lyon, Vienna, Ohio State); ASME Medal, ASME Timoshenko, Nadai and Warner Medals; ASCE von K´arm´an, Freudenthal, Newmark, Biot, Mindlin and Croes Medals, and Lifetime Achievement Award; SES Prager Medal; Outstanding Res. Award, Am. Soc. for Composites; RILEM Gold Medal; Exner Medal (Austria); Torroja Medal (Madrid); etc. He authored nine books: Scaling of Struct. Strength, Creep in Concrete Str., Inelastic Analysis, Fracture and Size Effect, Stability of Structures, Concrete at High Temp., Creep & Hygrothermal Effects, Probab. Mech. of Quasibrittle Str., QuasbrittleFrac. Mech.; He is one of the original top 100 ISI Highly Cited Scientists in Engrg. (www.ISIhighlycited.com). H-index: 137, citations: 81,000, i10 index: 660 (Google, incl. self-cit.). In 2019 Stanford U. weighted citation survey (see PLoS), he was ranked no.1 in CE and no.2 in Engrg. worldwide. In 2015, ASCE established ZP Bažant Medal for Failure and Damage Prevention. His 1959 mass-produced patent of safety ski binding is exhibited in the New England Ski Museum, Franconia, NH. http://cee.northwestern.edu/people/bazant/

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