FACULTY OF CIVIL ENGINEERING CTU IN PRAGUE

Department of Mechanics Seminar

Professor Zdeněk P. Bažant, Ph.D., S.E.

Northwestern University, Evanston, IL, USA

1 June 2022, 10:00 - 11:00 CET

Room B-168, Thákurova 7, 166 29 Prague 6

Critical Comparison of Phase-Field, Peridynamics, and Crack Band Model M7 in Light of Gap Test and Classical Fracture Tests

The recently conceived gap test and its simulation revealed that the fracture energy Gf (or Kc, Jcr) of concrete, plastic-hardening metals, composites, and probably most materials can change by ±100%, depending on the crack-parallel stresses σ_{xx}, σ_{zz}, and their history. Therefore, one must consider not only a finite length but also a finite width of the fracture process zone, along with its tensorial damage behavior. The data from this test, along with ten other classical tests important for fracture problems (nine on concrete, one on sand- stone), are optimally fitted to evaluate the performance of the state-of-art phase-field, peri-dynamic, and crack band models. Thanks to its realistic boundary and crack-face conditions as well as its tensorial nature, the crack band model, combined with the micro-plane damage constitutive law in its latest version M7, is found to fit all data well. On the contrary, the phase-field models perform poorly. Peridynamic models (both bond based and state based) perform even worse. The recent correction in the bond-associated deformation gradient helps to improve the predictions in some experiments, but not all. This confirms the previous strictly theoretical critique (JAM 2016), which showed that peridynamics of all kinds suffers from several conceptual faults: (1) It implies a lattice microstructure; (2) its particle–skipping interactions are a fiction; (4) it ignores shear-resisted particle rotations (which are what lends the lattice discrete particle model (LDPM) its superior performance); (3) its representation of the boundaries, especially the crack and fracture process zone faces, is physically unrealistic; and (5) it cannot reproduce the transitional size effect—a quintessential characteristic of quasibrittleness. The misleading practice of "verifying" a model with only one or two simple tests matchable by many different models, or showcasing an ad hoc improvement for one type of test while ignoring misfits of others, is pointed out. In closing, the ubiquity of crack-parallel stresses in practical problems of concrete, shale, fiber composites, plastic-hardening metals, and materials on submicrometer scale is emphasized.

Bio: Born and educated in Prague (Ph.D. 1963), Bažant joined Northwestern in 1969, where he has been W.P. Murphy Professor since 1990 and simultaneously McCormick Institute Professor since 2002, and Director of Center for Concrete and Geomaterials (1981-87). He was inducted to NAS, NAE, Am. Acad. of Arts & Sci., Royal Soc. London, the national academies of Austria, Japan, Italy, Spain, Canada, 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 I. Class from Pres. of Austria; 7 honorary doctorates (Prague, Karlsruhe, Colorado, Milan, Lyon, Vienna, Ohio State); ASME Medal, ASME Timoshenko, Nadai and Warner Medals; ASCE von Kármán, Freudenthal, Newmark, Biot, Mindlin, TY Lin and Croes Medals, SES Prager Medal; Outstanding Res. Award from Am. Soc. for Composites; RILEM L'Hermite Medal; Exner Medal (Austria); Torroja Medal (Madrid); etc. He authored nine books on 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. and Qasibrittle Fracture. H-index: 140, citations: 85,000 (Google). 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 New England Ski Museum, Franconia, NH.

doc. Ing. Jan Eliáš, Ph.D.

Brno University of Technology, Czechia

1 June 2022, 11:15 - 12:00 CET

Room B-168, Thákurova 7, 166 29 Prague 6

Mechanism-Based Mesh Objectivity in Stochastic Computational Modeling of Quasibrittle Fracture

Computational modeling of quasibrittle fracture is often conducted using the finite element method and homogeneous material representation. There are several remedies developed to diminish the spurious mesh sensitivity due to strain localization. A mechanism-based approach developed for meshes with elements larger than the fracture process zone width will be discussed. The main subject of the talk will be a recent modification of this regularization technique that takes into account a spatial randomness in the material. It will be shown that the probability distribution functions of constitutive properties must be linked to the damage state, which may evolve during the failure process. Therefore, two localization parameters are introduced to quantify damage state of each finite element. These parameters govern both (i) the energy regularization of the constitutive equation and (ii) the mesh-dependent probability distributions of constitutive properties. The model will be applied to simulate the stochastic failure behavior of quasibrittle structures of different geometries featuring different failure processes including damage initiation, localization, and propagation.

Bio: Jan Eliáš is an associate professor at the Institute of Structural Mechanics, Faculty of Civil Engineering, Brno University of Technology in Brno, Czechia. He received his Ph.D. from the same university in 2009. Jan's research focus spans from general mechanics of transient and steady-state phenomena in solids to soft computing techniques such as optimizations, Monte Carlo integration, and blending of probability and mechanics. His long-term attention is devoted to mesoscale discrete models of concrete mechanical behavior, recently extended by coupled multiphysical phenomena and homogenization. Jan was awarded three research projects from the Czech Science Foundation and one project from the Czech Ministry of Education, Youth and Sports. He conducted research stays with Henrik Stang at the Technical University of Denmark, Jia-Liang Le at the University of Minnesota, and Zdeněk P. Bažant and Gianluca Cusatis at the Northwestern University.

Follow the seminar online:

fsv.cvut.cz/SolidMechanicsSeminar