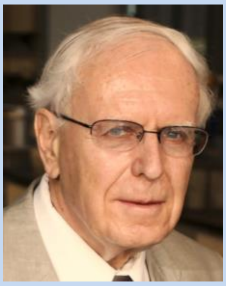
KTH SOLID MECHANICS KEYNOTE SEMINAR; Thursday, March 7^{th}, 16.15; https://kth-se.zoom.us/j/69767274865

Zdeněk P Bažant, "Spress-Sprain Crack Band Model Based on Lagrange Multiplier Constraint and Its Verification by Gap Test" *

Preceding studies showed that the resistance of a heterogeneous material to the displacement field curvature is the physically most realistic localization limiter for softening damage and fracture. The curvature was characterized by the second gradient of the displacement vector field, which differs from the strain gradient tensor by the material rotation gradient tensor, and was named the 'sprain' tensor, whose work-conjugate force variable was called the 'spress' tensor. In the preceding work, the partial derivatives of the associated sprain energy density were used to obtain self-equilibrated sets of curvature-resisting nodal sprain forces, some of which had to be applied on nodes adjacent to the finite element. But this led to an enormous computational burden. This burden is eliminated by formulating a finite element with linear shape functions for both the displacement vector and the approximate displacement gradient tensor. The derivatives of the latter then yield the tensor of displacement curvature (or hessian), obviating the need for adjacent sprain forces. The main idea is to use a Lagrange multiplier tensor to constrain the approximate gradients to the actual displacement gradients. A user element for Abaqus is formulated and used to demonstrate mesh-independent crack band growth, capturing the band width variation and smooth damage distribution across the crack band. The spress-sprain energy dissipation is shown to match various distinctive fracture tests of concrete, including the gap test and its simulation by the LDPM (discrete particle) model. Generalization to plastic-hardening metals (e.g., aluminum), which requires distinguishing energy dissipations at the micrometer scale crack front and in the wake of a millimeter scale hardening yielding zone, is presented in closing.



Born and educated in Prague (Ph.D. 1963), Bažant joined in 1969 Northwestern faculty, where he has been W.P. Murphy Professor since 1990 and simultaneously McCormick Institute Professor since 2002, and Director of Center for Geomaterials (1981-87). Inducted to NAS, NAE, AAAS, Royal Soc. London and 8 other national academies. He received Austrian Cross of Honor for Science and Art I.Class from President of Austria; 9 honorary doctorates; ASME Medal, ASME Timoshenko, Nadai and Warner Medals; ASCE von Karman, Freudenthal, Newmark, Biot, Mindlin, TY Lin and Croes Medals, SES Prager Medal; ACI Boase Award; Guggenheim Fellow; Murray Medal (SEM); Outstanding Res. Award (Am. Soc. Composites); RILEM Medal; etc. Honorary Member: ASME, ASCE, ACI, RILEM, CSM. Authored nine books on structural stability, fracture, its probability, and concrete creep and hygrothermal effects. In 2019 Stanford University citation survey (weighted/filtered for self.cit., first/last author, number of authors, reciprocal citations, citation farms), he ranked worldwide no.1 in CE and no.2 in engineering overall. In a similar 2022 Elsevier survey no. in CE. In 2015, ASCE established Bažant Medal for Failure and Damage Prevention and in 2023 ASME established Bažant Medal for contributions to mechanics.

*This seminar is co-authored by Houlin Xu, Anh Nguyen and Karel Matouš.