CEE-430 **COHESIVE FRACTURE AND SCALING** **Winter 2013**

29 lecture hours, MWF 2-4, Room: LG62, Instructor: Prof. Zdeněk P. Bažant, Illinois Registered Structural Engineer

Day	Hours	Introduction
M 1/7	1.5	Historical Perspective. Overview of main concepts. *1.1,1.4**.
		Reasons for fracture and size effect analysis. Relevance to concrete, rock, composites,ice.
		2. Essentials of Linear Elastic Fracture Mechanics (LEFM)
		Energy release rate and fracture energy *2.1*
W 1/9	1.5	Westergaard's solution of crack in infinite plane. *4.2, 4.3*
F 1/11	1.5	Asymptotic near tip fields, modes I, II, III, stress intensity factors, fracture toughness.
M 1/14	1.5	Rice's *J*-integral for energy flux. Determination of LEFM parameters. *2.1.5-6, 4.4*
		Energy-based calculation of displacements from stress intensity factors. *3.5*
W 1/16	1.5	Size effects in fracture mechanics vs. plasticity, scaling of energy release. *1.2.5,6.1, 6.2*
		Failures at very small cracks. Asymptotic far-away field and crack interactions.
		3. Nonlinear Fracture Mechanics and Cohesive Crack Model
F 1/18	1.5	Fracture process zone and crack bridging zone in concrete, rocks, ceramics, etc. *5.2*
		Fracture process zone size and Irwin's characteristic length. *5.2*
W 1/23	1.5	Models of Dugdale and Barenblatt. Cohesive (fictitious) crack model of Hillerborg.*5.2*
		Compliance formulation of cohesive crack model. *7.1, 7.2, 7.4.2, 7.4.7*
F 1/25	1.5	Softening stress-displacement relations, and relation to fracture energy. *8.3*
		Work-of-fracture method for measuring fracture energy. Two-parameter model. *5.5*
M 1/28	1.5	Crack-band model. Strain softening laws and their regularization. Material char. length.
		4. Equivalent LEFM, *R*-Curves and Fracture Stability *5.6, 5.7*
W 1/30	1.5	Resistance curve (*R*-curve). Crack equilibrium and energy analysis of fracture stability.
		R-curve determination as the envelope of fracture equilibrium curve for different sizes.
M 2/4	1.5	Fracture analysis based on *R*-curves. Snapback instability at ligament tearing.
		5. Scaling and Size Effect *6.3, 6.4*
F 2/8	1.5	Geometrically similar structures, power scaling laws. Size effect as a principal characteristic of quasibrittle fracture. Exper. evidence for concrete, rock, ice, composites.
M 2/11	1.5	Energy derivation of size effect law for quasibrittle materials. Asymptotic analysis. *6.3*
		Transitional size. Experimental evidence for concrete, rock, ceramics, fiber composite.
W 2/13	1.5	Determining fracture energy and process zone length from size effect measurements.*6.4*
		Size effect on apparent fracture toughness or fracture energy.
M 2/18	1.5	Calculation of *R*-curve from size effect data. Applications to various types of structures.
		Brittleness and size effect in structural design. *6.2.3, 10.1, 10.2, 10.5*
		Size effect in cohesive crack models for concrete, rocks, composites, ice, wood. Slopes.
		6. Statistical Fracture Mechanics
W 2/20	1.5	Statistical Strength Theory and Size Effect. *12.1, 12.2, 12.3*
M 2/25	1	Weibull's weakest link theory. Extreme value distribution. Stability postulate of extreme value statistics. Statistical size effect. Finite weakest link model for quasibrittle materials. Distributions of strength, static lifetime, and Evans law. *12.2, 12.5, 12.7*
W 2/27	1	**QUIZ** (1 hour, written). **TAKE-HOME EXAM** assigned.
		7. Effects of Time, Rate, Creep, Temperatures, Load Cycling and Distributed Damage
M 3/4	1	Rate and thermal effects in fracture. Effect of creep, and influence on size effect. *11.2*
W 3/6	1	Generalization of cohesive crack model. *11.6* Parallel crack spacing.
		Fatigue crack growth in quasibrittle materials, Paris law and its size dependence. *11.7*
M 3/11	1	Nonlocal continuum modeling of damage localization. Material models for damage.
		Stability of crack systems, and variational microplane concept. *13.1, 13.3, 14.1*

PREREQUISITES: **Solid background in mathematics and mechanics at the undergraduate level, including calculus, differential equations, mechanics, mechanics of materials, elements of continuum mechanics and theory of structures.**

Recommended Texts: 1) Z.P. Bažant and J. Planas (1998). Fracture and Size Effect in Concrete and Other Quasibrittle Materials, CRC Press, Bocca Raton, FL. 2) Z.P. Bažant (2002). Scaling of Structural Strength, 2nd ed., Elsevier, London.

**These numbers denote related chapters or sections in Bažant and Planas' book. However, coverage has been condensed and updated*,