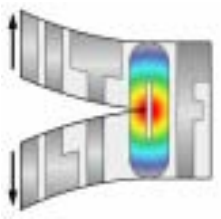

Course code	Course title
ILTOF/02	FUNDAMENTALS IN LINEAR ELASTIC FRACTURE MECHANICS

Course Summary

The course intends to provide the fundamental concepts of Linear Elastic Fracture Mechanics. After introducing the pioneering energy approach by A.A.Griffith (1920), the stress-intensification concept is widely discussed, presenting the two fundamental mathematical approaches to solve the singular stress field in the crack tip vicinity: (i) the complex potential method by Westergaard (1939), and (ii) the series expansion method by Williams (1952). With the latter, it is possible to study also the stress intensification at the vertex of re-entrant corners. Then, the fundamental relationship between the energy and the stress-intensity approaches is illustrated according to the original demonstration due to G.R.Irwin (1957). The stress-intensity fracture criterion is also generalized to Mixed Mode conditions. In addition, the size of the plastic zone at the crack tip is evaluated, according to the different approaches by Irwin and Dugdale (1960). Finally, the brittleness number is defined as a function of yield strength, fracture toughness and structural size-scale. It may consistently describe the fundamental ductile-to-brittle transition occurring when the size-scale of the structural element increases.

Training Objectives

The course is addressed to Master and Ph.D. students, post-doctoral fellows, young researchers, specialists in Fracture Mechanics working in the industry. A widening of knowledge is intended towards brittle fracture phenomena and microcracking processes.

Prerequisites

Basic concepts of solid and structural mechanics are necessary.

Author's Curriculum:

Prof. Dr. Alberto CARPINTERI

Chair of Structural Mechanics
Politecnico di Torino
10129 - Torino - Italy

Academic Positions:

Professor of Structural Mechanics, Politecnico di Torino, Torino-Italy, 1986-.
Director Dept. Structural Engineering, Politecnico di Torino, Torino-Italy, 1989-1995.
Founding Member and Director – Graduate School in Structural Engineering, Politecnico di Torino, Torino-Italy, 1990-.
Visiting Professor, Lehigh University, Bethlehem-Pennsylvania, USA, 1982-1983.
Member of the New York Academy of Sciences (founded in 1817), New York, USA, 1997-.

Member of the American Association for the Advancement of Science (founded in 1848 at the Academy of Natural Sciences in Philadelphia, Pennsylvania, USA), 1999-.
Member of the American Academy of Mechanics, USA, 2003-.
Fellow of the Turin Academy of Sciences (founded by G.L. Lagrange in 1783), Torino-Italy, 2005-; Member, 1995-2005.
Member of the Istituto Lombardo – Accademia di Scienze e Lettere, Milano-Italy, 2006-.
Member of the Accademia Teatina per le Scienze, Chieti-Italy, 2006-.

Scientific Activity:
President of the European Structural Integrity Society (ESIS), 2002-2006.
President of the International Association of Fracture Mechanics for Concrete and Concrete Structures (IA-FraMCoS), 2004-2007.
President of the Italian Group of Fracture (IGF), 1998-2005.
Senior Vicepresident of the International Congress on Fracture (ICF), 2005-2009.
Vicepresident of the National Research Institute of Metrology (INRIM), 2006-2009.
Chairman of the Organizing Committee of the 11th International Conference on Fracture (ICF11), Torino, Italy, March 20-25, 2005.
Member of the Congress Committee of the International Union of Theoretical and Applied Mechanics (IUTAM), 2004-2008.
Co-Editor of the International Journal "Strength, Fracture & Complexity", 2003-; Member of the Editorial Board of six international journals.
Author of over 500 papers on fracture mechanics, material fatigue, thermoelasticity, seismic structures, reinforced concrete, structural monitoring, contact mechanics, fragmentation and comminution, drilling.
Author or Editor of 38 volumes.

Honours and Awards:
Recipient of Robert l'Hermite International Prize, RILEM, Paris, France, 1982.
Recipient of JSME Medal, Japan Society of Mechanical Engineers, Tokyo, Japan, 1993.
Doctor of Physics Honoris Causa, The Constantinian University, Cranston-Rhode Island, USA, 1994.
Recipient of International Cultural Diploma of Honor, American Biographical Institute, 1995.
Honorary Professor, Nanjing Architectural & Civil Engineering Institute, Nanjing, China, 1996.
Honorary Professor, Albert Schweitzer University, Geneva, Switzerland, 2000.
Recipient of WIT Eminent Scientist Award, Wessex Institute of Technology, Southampton, U.K., 2000.

Topic list

n.	Title	Summary	Lecturer	Duration
1	Griffith's Theory	The pioneering energy approach by A.A.Griffith is illustrated, leading to the well-known formula where the critical stress of crack extension is expressed as a function of the material properties (elastic modulus, specific surface energy) and of the crack length.	Alberto Carpinteri	1 h
2	Westergaard's method of complex potentials	The mathematical method of the complex potentials is completely treated, leading to the fundamental concept of stress-intensity factor. All the three fracture Modes (opening, sliding, tearing) are represented, with their characteristic displacement fields.	Alberto Carpinteri	3 h
3	Williams'method of series expansion	The mathematical method of the series expansion is completely treated, leading to the description of the singular stress field at the vertex of a re-entrant corner. When the corner angle is tending to zero, a semi-infinite crack is obtained with its characteristic order ½ stress singularity.	Alberto Carpinteri	2 h
4	Irwin's fundamental relationship	The fundamental relationship of Linear Elastic Fracture Mechanics (LEFM) is demonstrated, connecting stress-intensity factor and strain energy release rate. In the particular case of critical condition, the relationship between fracture toughness and fracture energy is obtained.	Alberto Carpinteri	1 h
5	Mixed Mode fracture criteria	The problem of defining the critical condition, when both Mode I (opening) and Mode II (sliding) are active, is considered. In particular, the Maximum Circumferential Stress Criterion is discussed in the details.	Alberto Carpinteri	1 h
6	Crack tip plastic zone	The crack tip plastic zone is evaluated following two different paths: (i) the cut-off of the stress-singularity with stress redistribution (Irwin); (ii) the cohesive closing stress distribution imposing zero intensification (Dugdale).	Alberto Carpinteri	1 h
7	Brittleness number and size-scale transition	Considering independent structural failures due to brittle crack propagation or to plastic collapse at the ligament, a nondimensional number can be defined	Alberto Carpinteri	1 h

		according to Buckingham's Theorem for physical similitude and scale modelling. This number governs the ductile-to-brittle transition occurring when the size-scale of the specimen increases.		