ROMA TRE
UNIVERSITÀ DEGLI STUDI

Short Course on

MODELLING FRACTURED ROCKS AND MASONRY STRUCTURES BY JOINT ENRICHED FINITE ELEMENT METHOD

Rome, June 13-14, 2016

University Roma Tre, Department of Engineering, Doctoral School in Civil Engineering

Via Vito Volterra, 62 – 00146 Rome, Italy – Civil Engineering – Seminar Room

Objectives of the course

The objective of this short course is to provide graduate and PhD students with the fundamentals of modelling discontinuities like fractures and rock joints or contact surfaces and masonry joints by means of the Finite Element Method. A Joint Enriched FEM code, DISROC, especially conceived for modeling hydro-mechanical behavior of structures including high number of discontinuities will be presented. The course will be taught by Ahmad Pouya and Michel Chalhoub.

About the instructors

Ahmad Pouya is professor of Rock Mechanics and Tunnels at the Ecole des Ponts Paris Tech. His teaching and research topics cover the theoretical and numerical modeling of Thermo-Hydro-Mechanical phenomena in Porous Fractured Media, with applications to deep underground storage (nuclear waste, CO2, Compressed Air Energy) and petroleum Geomechanics. He is the author of two numerical codes, Disroc and Porofis, which are now widely used for research and teaching activities and engineering design in cracked and fractured media and masonry structures.

Michel Chalhoub is associate professor of Structures at the University of Saint Esprit de Kaslik. A specialist of historical monuments retrofitting, he is the owner and the director of Distruct solutions for engineering and construction. His research activities cover the numerical modeling of fractured rock masses and masonry structures.

Organization and Contacts

The course is organized by the *Doctoral School in Civil Engineering of the University Roma Tre*. No fees are requested. Those wishing to attend the course could contact the Department of Engineering at the following address.
Prof. Gianmarco de Felice or Dr. Marina Cibati, University Roma Tre, Department of Engineering,
Ph. +3906 5733 3259 – Fax +3906 5733 3441 – Email: marina.cibati@uniroma3.it

Course Schedule

Monday 13	11:30 – 12:30	**Seminar: Modelling Fractured Rocks and masonry structures by Joint Enriched Finite Element Method**
	14:30 – 18:00	**1st Course on Disroc: General Introduction**
Tuesday 14	09:00 – 12:30	**2st Course on Disroc: Advanced functions and case studies**

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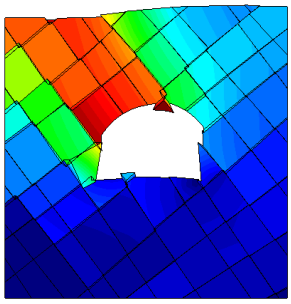
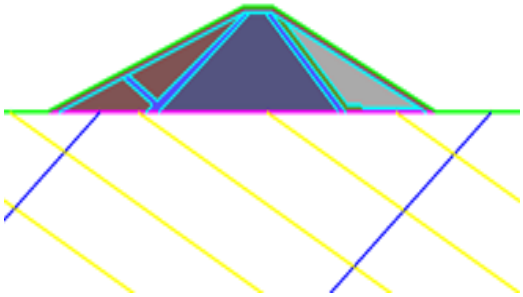
Motivation

Finite Element Method (FEM) is the most powerful numerical method for modelling mechanical, hydraulic and thermal behavior of engineering structures and most of geotechnical projects are designed by Finite Element Method. However, in presence of fractures and discontinuities, other numerical methods Finite Difference or Distinct Element methods are very often used even if they are less efficient, especially concerning calculation times or geometry limitations. Zero thickness Joint Elements were introduced very early in FEM (Goodman 1976) for modeling discontinuities like fractures and rock joints and, with appropriate constitutive laws, these elements can reproduce well the behavior of these discontinuities as well as contact surfaces and masonry joints. However, the difficulty of generating conform FEM mesh in presence of great number of discontinuities, has impeded the use of this method for highly fractured or cracked media and masonry structures. These difficulties have been overcome gradually in recent years and some numerical tools allow now generate easily conform FEM meshes for highly fractured media. Based on these advances, it becomes possible to model the geotechnical projects like tunnels and rock cuttings in fractured rocks and the masonry structures as easily as the classical geotechnical projects in soils and concrete by FEM. DISROC is a Joint Enriched FEM code especially conceived for modeling hydro-mechanical behavior of structures in porous materials including high number of discontinuities. Another problem remaining in presence of high density of discontinuities is that calculations become time consuming. This problem can be solved partially by using homogenization methods, which allow replacing the discontinuous medium by a continuum equivalent medium with appropriate effective parameters. Special homogenization functions for discontinuous media have also been developed in implemented in DISROC. Modeling rock bolts and linear reinforcements interacting with fractures is another challenging problem which has been solved in some extent in DISROC. Some examples of application of this code to the analysis of masonry structures and the design of their reinforcement will be given.

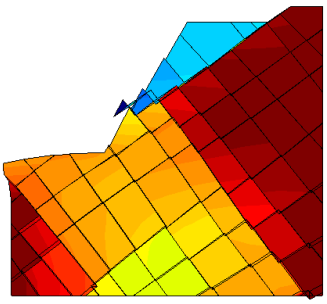
Examples



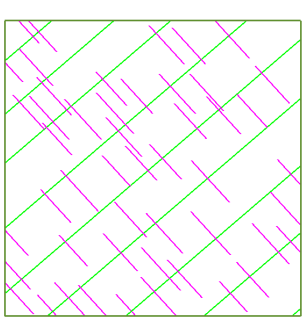
Tunnel in fractured rocks

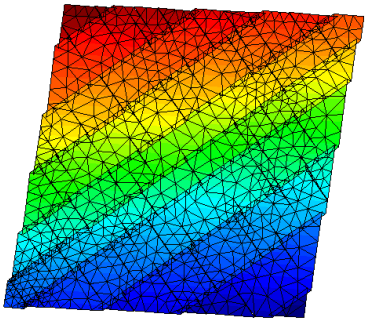


Dams on fractured rocks

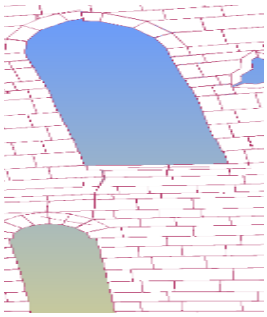


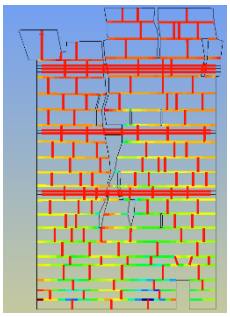
Rock slope instability





Homogenization of cracked/fractured material





Masonry structure and reinforcement design