Rock Mechanics solutions for ornamental rock protection and archaeological site conservation

EUROCK 2014 –Vigo

26th May 2014

Price 80 € (including lunch and 2 coffee-breaks)

Course director: José Delgado Rodrigues, geologist, Principal Research Officer, LNEC-Portugal

This course aims to provide a dialogue between rock mechanics and conservation of architectural and archaeological sites with the objective of identifying, in the field of geotechnical engineering, analysis and application technologies or novel theoretical premises able to characterize, diagnose and treat the conservation problems of the rocks used in architectural and archaeological heritage.

Participants are invited to deliver a presentation of their problems or case studies for discussion.

PROGRAM SCHEDULE (J. Delgado, Chairman)

Monday, 26th May

9.30: Presentation of the Workshop. J. Delgado, LNEC-Portugal (ret.).

10-11: *Geological information for monuments preservation: from macro to micro scales*. J. Delgado, LNEC-Portugal (ret.).

11-12: *Physical and mechanical characterization: limitations on the study of rocks used in cultural heritage.* T. Rivas, ETSI Minas, Universidad de Vigo-Spain.

12.-12.30. Coffee break

12.30--13.30: *Evaluation of treatments for conservation and restoration of ornamental rocks.* M.J. Mosquera, Department of Chemistry-Physics, University of Cádiz, Spain.

13.30-14:00 Roundtable

14-15.30: Lunch

15.30-16.30: *Modelling of masonry structures*. J. Lemos, researcher of LNEC-Portugal.

16.30.-17.00. Coffee break

17.00-18.00: *Rock mechanics methodologies for the mechanical characterization of masonry structures*. J. Muralha, researcher of LNEC-Portugal.

18.00: presentation of issues by the participants and discussion roundtable.

Geological information for monuments preservation. From macro to micro scales

J. Delgado Rodrigues. Geologist, Principal Research Officer, LNEC (ret.), delgado@lnec.pt

Geological knowledge is instrumental when preservation of monuments is concerned. It may be integrated at distinct scales and with different levels of expertise, and can be used as simple identification purpose, or as an essential support to explain processes and to find solutions in conservation actions.

Geological information can be operated at different scales of analysis: from a global scale (assessing seismic risk), to regional (floods and landslides), to local (foundation settlement) as well as at macro and micro scales (explaining a black crust or a swelling problem in stone degradation).

The presentation will highlight the use of concepts that are current in geological and geotechnical sciences trying to find bridges that may help users to cross the border between traditional geotechnical expertise and the activity of monuments preservation.

Case studies will be shown to exemplify the use of petrographic and mineralogical concepts in real conservation problems. Natural rock weathering will be discussed in the context of conservation of granitic rocks and clay swelling will be integrated as a tool to explain degradation of sandstones and carbonate lithotypes. Other typical conservation problems will be explained and illustrated.

A few conservation projects will be used to illustrate how this information is integrated in real conservation interventions.

Physical and mechanical characterization: limitations on the study of rocks used in cultural heritage.

T. Rivas. ETSI Minas, Universidad de Vigo-Spain

Physical and mechanical parameters and properties whose determination is essential for a correct diagnosis of the state of conservation of the rocks used in monuments and for the estimation of their durability are described in this conference. Also, the problems that conservation professionals and restorers found when characterizing the rocks used in cultural heritage on the basis of the knowledge provided by geomechanics are also described. Thus, many of the physical and mechanical characterization procedures commonly used in geomechanics are not applicable when trying to understand the deterioration mechanisms on the monuments. Moreover, the deterioration processes affecting monuments manifest themselves generally into surface structural changes so that the application of conventional volumetric geomechanical tests do not provide enough information to make a correct diagnosis. It also happens that the design of several geomechanical characterization protocols is not adapted to the real (environmental, physical, structural) conditions affecting the rocks on the monuments. For all this, in the field of conservation and restoration of monuments, technical limitations in characterizing rocks and deterioration processes are important, thus requiring the opening of an interdisciplinary dialogue between conservators and geotechnical specialists who allow solving them.

Evaluation of Treatments for Conservation and Restoration of Ornamental Rocks

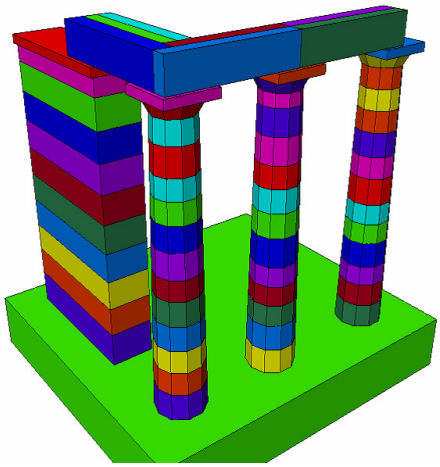
María Jesús Mosquera. Departamento de Química-Física. Facultad de Ciencias. Universidad de Cádiz. Campus Universitario Río San Pedro. Puerto Real. 11510 Cádiz.

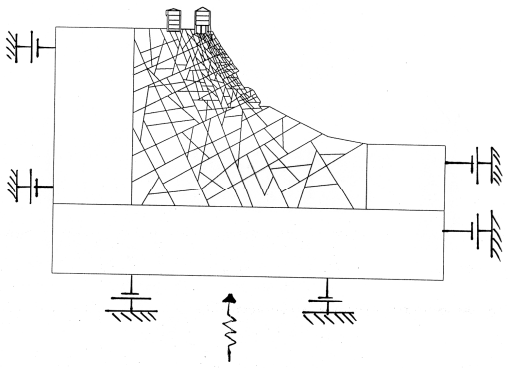
A brief description of the different procedures usually applied for evaluate the effectiveness of conservation and restoration interventions, including consolidation and protection of rocks, is presented in this lecture. The different techniques, the standardized regulations and required number of samples will be described, stressing the problems that arise during the assessment of the effectiveness of this type of interventions and how geomechanics can solve them. Evaluation techniques applied to effectiveness evaluation both in laboratory conditions and in situ will be described. Finally, the procedures for assessing the durability of the treatments will be discussed, with particular emphasis on the problems associated with these procedures in terms of their ability to reproduce actual conditions affecting monuments. All the cases described will be illustrated with real examples.

Modelling of masonry structures

J.V.Lemos, LNEC

The study of masonry structures, whether for safety assessment, prediction of behaviour or design of rehabilitation projects, requires appropriate methods of analysis, with the capability to address the specific nature of the materials and construction techniques. In the lecture, the main conceptual models that support the structural analysis of masonry are reviewed, and the numerical implementations most commonly employed are discussed. Continuum and discrete representations are presented, as well as the constitutive models that may be used to simulate the behaviour of the masonry units and the joints. In particular, the methods to study the response under seismic loads will be addressed. A set of examples of application of various types of masonry structures will be presented, which illustrate different approaches, covering both simplified and more detailed methods of analysis.





Rock mechanics methodologies for the mechanical characterization of masonry structures

José Muralha, Laboratório Nacional de Engenharia Civil (LNEC)

Common Rock Mechanics practices, techniques, procedures and methodologies can be used for the characterization of a wide range of structural elements from archaeological sites and architectural heritage. This characterization aims at providing parameters for the models used to predict the behaviour of rock masonry structures and for the design of rehabilitation works. A review of the methodologies and tests that are commonly used in Rock Mechanics, and that can also be applied to ornamental stones or architectural heritage rocks, will be presented. Special emphasis of the implications of using more or less invasive practices in such particular types of structures will be discussed.

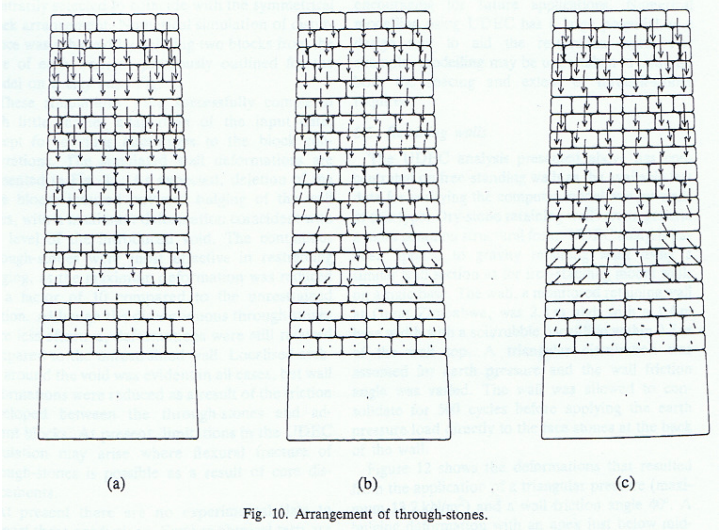


Fig. 10. Arrangement of through-stones.

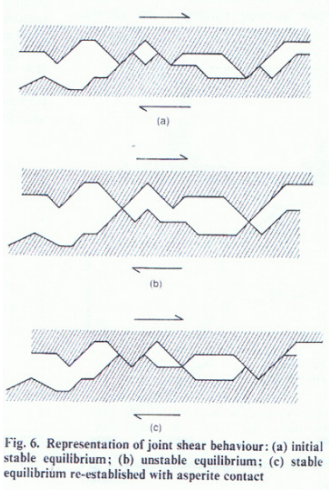


Fig. 6. Representation of joint shear behaviour: (a) initial stable equilibrium; (b) unstable equilibrium; (c) stable equilibrium re-established with asperite contact