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INVITATION

Séance Technique
jeudi 5 décembre 2013
CNAM
292 bd St-Martin, 75003 PARIS
Amphithéâtre Robert Faure (Z) Accès 3 niveau -2

15 : 00 **Remise du prix Pierre Londe 2013**

Dr Laura Blanco Martin
Lawrence Berkeley laboratory, Ca, USA
Étude théorique et expérimentale du boulonnage à ancrage réparti sous sollicitations axiales

Conférenciers Invités :

16 : 00 **Prof. Robert W. Zimmerman**
Department of Earth Science and Engineering Imperial College London, UK
Measurement and modelling of the failure of anisotropic rocks such as shales

17 : 00 **Prof. Charles Fairhurst**
University of Minnesota, USA
Mechanics in Rock Engineering

17 : 45 **Pôt de la Sainte Barbe**

Dr Laura Bianco Martin (Prix Pierre Londe 2013)
Lawrence Berkeley National Laboratory, CA, USA
Étude théorique et expérimentale du boulonnage à ancrage réparti sous sollicitations axiales

Résumé : Le boulonnage et le câblage à ancrage réparti sont deux techniques de renforcement du terrain couramment utilisées dans l'industrie minière et dans le génie civil. Au fil de cette recherche, on s'intéresse à la réponse de ces éléments sous des sollicitations axiales de traction, en régime statique. Dans ces conditions, l'expérience montre que la rupture se produit le plus fréquemment à l'interface barre-scellement via un processus de décohésion qui commence dès que la force sur la barre atteint une valeur limite. L'objectif est de mieux comprendre le comportement de cette interface, avant et après rupture. Premièrement, on revoit l'état de l'art afin de comprendre le travail effectué et les aspects non maîtrisés à ce jour. Deuxièmement, on décrit des outils analytiques qui permettent de comprendre la réponse d'un boulon ou d'un câble à ancrage réparti soumis à une force de traction. Ensuite, on présente les études expérimentales menées en laboratoire et in situ. Des essais d'arrachement ont été effectués pour déterminer les principaux facteurs qui régissent la réponse de l'interface. Finalement, on analyse les résultats des essais effectués en laboratoire sur les boulons. Après l'obtention des variables nécessaires, on propose un modèle semi-empirique d'interface, qui devra être validé par des essais complémentaires. Cette perspective et d'autres améliorations sont également présentées.

Professor Robert W. Zimmerman
Department of Earth Sciences and Engineering, Imperial College, London, UK
Measurement and modeling of the failure of anisotropic rocks such as shales

Abstract: Some rocks, such as shales, are highly anisotropic in their mechanical behavior. The value of the maximum principal stress that is needed to cause shear failure in a shale will depend not only on the values of the other two principal stresses, but also on the angle β between the maximum principal stress and the normal to the bedding plane. We have carried out triaxial compression tests at Schlumberger TerraTek laboratories on a suite of Mid-Bossier shale samples, at different confining stresses, and at a range of angles β. The data were fit with Jaeger's plane of weakness model, as well as with Pariseau's model for transversely isotropic rocks. After failure, the samples were examined with CT scans, and thin section images, to investigate the trajectory of the failure planes.

According to the plane of weakness model, at values of β near 0° or 90°, failure will occur at a stress determined by the Coulomb failure criterion for the "intact rock", and the failure plane will cut across the bedding planes. At intermediate angles, failure will occur at a stress determined by the strength parameters of the bedding plane, and the failure plane will be parallel to the bedding plane. The data were fit reasonably well with the four-parameter plane of weakness model, except in the range of $15° < \beta < 35°$. In this range, the rock was weaker than predicted by the model, and the failure "plane" was much more irregular than would be predicted by any Coulomb-type model.

Pariseau's model is an extension of the Drucker-Prager model that satisfies the symmetry requirements for a transversely isotropic material; it contains five fitting parameters. Unlike the plane of weakness model, this model predicts a smoothly continuous variation of strength with β.

Pariseau's model was found to provide a slightly better fit to the data than did the plane of weakness model.

Bio: Robert Zimmerman obtained a BS and MS in mechanical engineering from Columbia University, and a PhD in continuum mechanics from the University of California at Berkeley. He has been a lecturer at UC Berkeley, a staff scientist at the Lawrence Berkeley National Laboratory, and Head of the Division of Engineering Geology and Geophysics at the Royal Institute of Technology in Stockholm. He is currently Professor of Rock Mechanics at Imperial College in London. Since 2006 he has been the Editor-in-Chief of the International Journal of Rock Mechanics and Mining Sciences. He is the author of the monograph Compressibility of Sandstones, published by Elsevier in 1991, and is the co-author, with J.C. Jaeger and N.G.W. Cook, of the 4th edition of Fundamentals of Rock Mechanics, published in 2007 by Wiley-Blackwell. In 2010 he was awarded the Maurice A. Biot Medal for Poromechanics by the American Society of Civil Engineers.

Prof. Emeritus Charles Fairhurst
University of Minnesota, Minneapolis, MN, USA
Mechanics in Rock Engineering

Abstract: Rock in situ is arguably the most complex material encountered in any engineering discipline. Pre-loaded by tectonic and gravitational loads for many millions of years, transected with fractures and a variety of planar discontinuities; deformed heterogeneously etc. the mechanical response of rock 'in situ' to changes in loading can be complex – and difficult to predict reliably.

Continuing impressive advances in computational power and numerical modeling procedures in mechanics together comprise a powerful tool to overcome some of these limitations, but significant obstacles remain. Given the broadening scope and variety of subsurface engineering applications, a concerted international initiative to advance significantly the current 'state of the art' of rock engineering is needed.

As a traditional international leader in the development of mechanics, both fundamental and applied, French colleagues and institutions can and should play a major role in this effort.

The talk will include examples of the successful application of mechanics to field scale problems.

Bio: Dr. Fairhurst, Professor Emeritus of the University of Minnesota, has more than 50 years of experience in mining rock mechanics and has consulted on rock stability problems for tunnels, dams, mines and excavations throughout the world. He remains active in consulting, with current emphasis on geological isolation of radioactive waste and on efforts to establish, in the USA, a Deep Underground Science and Engineering Laboratory (DUSEL) for research in

1) elementary particle physics,
2) micro-biological studies of ancient life and
3) geosciences/ geoengineering.

He served as President of the International Society of Rock Mechanics from 1991 through 1995, and has been elected to the U.S. National Academy of Engineers and the Royal Swedish Academy of Engineering Sciences. Dr. Fairhurst has been awarded honorary doctorate degrees from

University of Nancy, France; St. Petersburg Mining Academy, Russia; University of Sheffield, England; and University of Minnesota, USA, and is Advisory Professor to Tongji University, Shanghai, China.

Prof. Fairhurst was recently awarded the medal “officier de la legion d’honneur” by the French Foreign Affairs Minister. He will be in France for this occasion in early December, and has accepted to come and share his experience.