Geosciences and Geoengineering Department

PhD Position # 1

Micro-seismicity and Thermo-Hydro-Mechanical behavior of rock masses

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OBJECTIVE: Drilling deep boreholes can lead to the rupture of the rock mass or to the reactivation of existing faults. The recording of the induced micro-seismicity allows one to locate the rupture or the damage zone for each seismic event. Using numerical modeling, it is then possible to back analyze the state of stress in order to predict the development of the rupture zones. This requires a good knowledge of the geomechanical model, that is to say, the "architecture" of the geological formations (nature of the layers, layout and extension of faults) to which the knowledge of the initial state of stresses and fluid pressures (in the pores or in the fractures of the rock) must be added. With these data and the mechanical properties of rocks, it is possible to simulate different scenarios using Thermo-Hydro-Mechanical numerical modeling.

APPROACH: The proposed work consists in developing a coupled numerical constitutive model (THM) from an existing Finite Element platform. The model parameters will be calibrated based on well-documented case histories for which, the micro-seismic and the geomechanical model are known. In a second stage, the numerical model will be applied to different project configurations. Because of the uncertainties in the knowledge of natural environments, statistical analysis will be conducted to assess the influence of changes in input parameters on the risk of fracture and fault reactivation.

KEYWORDS: Geomechanics, Numerical modeling, THM couplings, Focal Mechanism

APPLICATIONS: Unconventional natural resources (Geothermal, Shale gas)

PREREQISITE: Candidates will have a good understanding of Solid Mechanics, essential knowledge of Fluid Mechanics and Statistics, plus a pronounced interest for Earth Sciences. He will have to perform numerical simulations using the Finite Elements Method and he will be familiar with one or several computer languages (FORTRAN, C ++, ...).

REFERENCES:

F. L. Pellet, (2013), Thermal and mechanical damage to rocks under different loading conditions and consequences for behavior of underground openings Scandinavian Rock mechanics meeting, Ed. BeFo, Stockholm, pp 1-13.

F.L. Pellet (2007), Rock deformation and rock failure precursors for earthquake prediction, State of the Art Paper, 5th International Conference on Seismology and Earthquake Engineering, SEE5, Tehran, Iran, CD Rom 12 pages.

Geosciences and Geoengineering Department

PhD Position # 2

Anisotropic viscoplasticity of geomaterials for deep underground excavations

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OBJECTIVE: Excavating deep tunnels remains technically difficult because of the uncertainties on the geological and hydrogeological conditions of the environment in which the underground structure is built. The diversity of geological formations encountered, their fracturing and their spatial variation, further complicate the task. One of the most important potential risks is the delayed deformations that develop over time. In this context, the designer should not only be able to rely on robust design tools (computer modeling), but also on data for which uncertainties are quantified or reliably estimated.

APPROACH: The first stage of the work will deal with the development of a rate dependent constitutive model (viscoplasticity) accounting for the anisotropy of the rock. In a second stage, a procedure for the identification and the calibration of the model parameters will be proposed based on well-documented case studies. Finally, to optimize the design of underground structure in the event of unforeseen conditions, a semi stochastic approach, combining geomechanical analysis and statistical data processing, will be run to provide a Decision Aid Tool for the evaluation of the taken risk.

KEYWORDS: Numerical modeling, rate dependent constitutive model, stochastic approach

APPLICATIONS: Transport infrastructures

PREREQISITE: Candidates will have a good understanding of Solid Mechanics, essential knowledge of Statistics, plus a pronounced interest for Geo-engineering. He will have to perform numerical simulations using the Finite Elements Method and he will be familiar with one or several computer languages (FORTRAN, C ++, ...).

REFERENCES:

F.L. Pellet (2009), Contact between a tunnel lining and a damage-susceptible viscoplastic medium, Computer Modeling in Engineering and Sciences, Tech Science Press, vol. 52, no. 3, pp. 279-296.

H.H. Einstein (2006), Use of decision aids for tunnelling , Geotechnical Risk in Rock Tunnels - Selected Papers from a Course on Geotechnical Risk in Rock Tunnels, Aveiro; Portugal; April 2004, pp. 63-73

F.L. Pellet (2004), Viscoplasticity and rock damage in modelling the long-term behaviour of underground excavations, Chapitre 14, X Ciclo di Conferenze di Meccanica e Ingegneria delle Rocce - MIR, Patron Editore, Torino, Italie, pp 423 - 448.

Geosciences and Geoengineering Department

PhD Position # 3

Consequences of blasting excavation techniques for tunneling in urban areas

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OBJECTIVE: When tunnels are excavated in urban areas, with the drill and blast method, the elastic wave propagation can cause damage to the existing structures, building and underground networks. Therefore, to prevent such an occurrence, the adjustment of the blasting energy needs the accounting for the properties of both the excavated rock formation and the upper ground layers.

APPROACH: In the first stage, the proposed work will consist to study wave propagation and their consequences in geological formations (bedrock and soil cover). It will requires accounting for the true nature of the rock formation (discontinuous anisotropic, etc.) together with their spatial variability. Then, a constitutive model will be developed to treat the rock damage propagation in dynamic loading. This model will be used in numerical modeling to back analyze measurements recorded in a recently excavated tunnel. The data recorded in terms of vibration measurements and induced displacements will help to calibrate the model parameter. The expected results will allow a better consideration of damage to building into the design of the drill and blast methods for underground structures in urban site.

KEYWORDS: Blasting energy, Dynamic loading, Seismic wave propagation, Rock strength and damage, Inverse analysis

APPLICATIONS: Transport infrastructures

PREREQISITE: Candidates will have a good understanding of Dynamics and Solid Mechanics, essential knowledge of Statistics, plus a pronounced interest for Geo-engineering. He will have to perform numerical simulations using the Finite Elements Method and he will be familiar with one or several computer languages (FORTRAN, C ++, ...).

REFERENCES:

M. Keshavarz, V.K. Dang, K. Amini Hosseini, F.L. Pellet, (2013), AE thresholds and compressive strength of different crystalline rocks subjected to static and dynamic loadings, Proc. 1st International Conference on Rock Dynamics and Applications, Lausanne, Switzerland, pp 213-218.

F.L. Pellet, V.K. Dang, C. Baumont, M. Dusseux, G.J. Huang, (2013), Determination of dynamic rock strength to assess blasting efficiency, Proc. Eurock Symposium, Wroclaw, Poland, pp 757-762.