ITASCA Consultants AB
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Bruno Figueiredo

Geomechanical Engineer

Expertise	Rock Mechanics and Rock Engineering
Education	Ph.D. (Geophysics), 2013 Strasbourg University (IPGS), Strasbourg, France
	Master in Structural Engineering, 2007 Higher Technical Institute (IST), Lisbon, Portugal
	Graduation in Civil Engineering, 2004 Higher Technical Institute (IST), Lisbon, Portugal
Professional Affiliations	Member: International Society of Rock Mechanics, Member: Portuguese Order of Civil Engineers.

Professional Experience

2018 – Present	*Itasca Consultants AB, Globen, Sweden* *Geomechanical Engineer*
2015 – 2018	*Uppsala University, Uppsala, Sweden* *Researcher in Coupled Thermo-Hydro-Mechanical (THM) Processes*
2013 – 2015	*Uppsala University, Uppsala, Sweden* *Postdoc in Coupled Thermo-Hydro-Mechanical (THM) Processes*
2009 – 2010	*New University of Lisbon (FCT-UNL), Lisbon, Portugal* *Invited Teaching Assistant*
2007 – 2013	*Portuguese Laboratory for Civil Engineering (LNEC), Lisbon, Portugal* *Assistant Researcher in Rock Mechanics*
2005 – 2006	*Higher Technical Institute, Lisbon, Portugal* *Research fellow in Structural Engineering*
2004 - 2005	*CivilSer-Estudos e Projectos de Engenharia, Lda* *Structural Engineer*

Project Experience

Mining:

Review of stress measurement data at the Resolution Copper deposit, Arizona, to derive a stress model for the site.

Analysis of the potential for hydraulic fracturing or hydraulic jacking between the exploration boreholes and the drift at Tara site through a literature review, experiences from other projects and applications, and engineering judgment.

Analysis of alternative locations, sizes and profiles for footwall drifts, as well as alternative mining layouts for future sublevel caving at the LKAB Kiirunavaara mine.

Three-dimensional continuum analysis of a study evaluating reduction of seismic potential at the Kiirunavaara mine with a concept involving "yielding pillars" and a "chevron shaped mining sequence".

Analysis of effect of alternative mining rates and seismic response at the Malmberget and Kiirunavaara mines.

Analysis of caving and effect on ground deformations in Malmberget, using *FLAC3D* and *CAVESIM*. The work included analysis and interpretation of the cave shapes at the ground surface and ground surface area with fulfilled environmental criteria.

Probabilistic analysis of the Modified Stability Graph method for Copperstone Resources. The work consisted of developing a macro spreadsheet for Monte Carlo simulations of the several input parameters and evaluation of the output statistical distributions.

Geomechanical study of crown pillar extraction at the Kemi Mine, using *FLAC3D*. The work included compilation of geomechanical parameters, numerical stress analysis and interpretation.

Discontinuum numerical analysis for Boliden Tara Mines, using *3DEC*, to evaluate the influence of ground water pressure on the consequences of the extraction of the crown pillar, with focus on the surface deformation.

Three-dimensional modelling of hydraulic preconditioning in sublevel caving at the LKAB Kiirunavaara mine.

Civil Engineering:

Three-dimensional continuum analysis of the escalator shaft at Hagalund station for the new subway towards Arenastaden. The purpose of the analysis was to verify the stability of the area with low rock coverage at the start of the escalator shaft resultant from several excavation stages. Reinforcement and external loads from traffic and buildings were included in the model.

Three-dimensional discontinuum analysis of the Slussen Bus Terminal in Stockholm. The purpose of the analysis was to verify the performance of the rock pillars, and various excavations as part of the project, including the action of the ground support and influence from external loads.

Three-dimensional continuum modeling, using *FLAC3D*, of the pylon foundations and anchor chambers for the new Grenlandsbrua in E18 Norway.

Two-dimensional continuum modeling, using *FLAC*, of the Korsvägen part at the West Link Project (Västlänken) in Gothenburg.

Evaluation and interpretation of initial rock stresses for Stockholm and Gothenburg. Use of fully tensorial to characterize the stress variability.

Monitoring the behavior of tunnels and caverns through the analysis of data (e.g., ground displacements, convergences, water pressure) provided by geotechnical instrumentation devices.

Numerical modelling of an underground repository intended for storing hazardous material using *FLAC3D*. The repository life-span is expected to be 3000 years, and analyses included long term stability and rock mechanical effects on flow paths.

Two-dimensional and three-dimensional continuum modeling, using *FLAC* and *FLAC3D*, to integrate the stress measurements conducted in the powerhouses of Picote, Salamode, Bemposta and Paradela, located in northern Portugal.

Analysis and interpretation of large flat jack and dilatometer test results to characterize the deformability of rock masses.

Nuclear Waste Disposal:

Three-dimensional discontinuum analysis of the fracture transmissivity sensitivity to seismic activity. The purpose of the analysis was to improve the understanding of the key processes and assess if seismicity induced variations of *in situ* fracture transmissivity are significant, in the context of the Forsmark site.

Analysis of the influence of rock foliation and large-scale structure deformation zones on hydraulic, overcoring, and LVDT stress data, at the Olkiluoto site in Finland. Inversion of stress data for assessment of the stress field. Characterization of the stress dispersion, by using a tensorial approach.

Probabilistic analysis of spalling location and depth around deposition tunnels for Sweden's planned spent nuclear fuel repository.

Development of a computational code for SKB to consider a fully tensorial approach in the characterization of the stress heterogeneity in rock masses. The methodology was applied to in situ stress data and numerical modelling results.

Stress Measurements:

Analysis and interpretation of data provided by overcoring, flat jack, hydraulic fracturing and hydraulic tests of pre-existing fractures to determine the in situ rock stresses. Integration of in situ stress measurements data with geomechanical models developed in *FLAC* and *FLAC3D* to assess the regional stress field for the design of several underground hydroelectric power schemes in northern Portugal that include large caverns and hydraulic pressure tunnels. Analysis of the effects of topography, tunnels and caverns on the in situ stresses. Development of back-analysis methodologies to estimate the transversely-isotropic elastic constants from biaxial tests done on the overcored rock samples.

Teaching and Academic Experience:

Teaching experience at the Civil Engineering department of the New University of Lisbon (FCT-UNL). Courses: Dynamic and Earthquake Engineering, Structural Analysis II and Continuum Mechanics.

Research Experience:

Regional stress field assessment, investigation on the rheological properties of rock masses, development of geomechanical models for the interpretation of field and laboratory data, integration of laboratory and field data with geomechanical models in inversion schemes, sparse channel models for fluid flow and solute transport in fractured rocks, numerical modelling of coupled processes in fractured rocks induced by the injection and storage of CO2 in deep underground formations, the hydraulic fracturing to extract oil or gas from underground shale formations and the injection of cold water in hot dry underground rocks.

Software Testing:

Testing of the conversion from *3DEC* to *FLAC3D* with interface elements at the location of the joints and comparison of the results