Newsletter

Inland Empire Chapter News

Southern California Section, Association of Environmental and Engineering Geologists

Editor: Rick Gundry rick.gundry@verizon.net (951) 924-6756

Oct 18, 2006, Vol. 2, No.10

"Rock Slope Stability Analyses – A Case Study"

and

"Three Dimensional Rock Mass Fracture Geometry and Fluid Flow modelling for a tunnel site in California"

Wednesday 18-October-2006

5:15 - 6:00	Geologist Orientation	Patio/Banquet Room
6:15 - 6:45	Dinner Served	Banquet Room
6:45 - 8:45	Meeting	Banquet Room

PAT & OSCARS Family Restaraunt, Temecula

(Meeting Cost $23, incl. Large Room, tax & gratuity)

(Fund-raising donation suggested is $5.00, or more)

(***RSVP/Directions below***)

Dear AEG Members:

Details and directions, see further ahead and other news potentially of interest to you.

RSVP by 9-Oct rick.gundry@verizon.net, or call RSVP message at (951) 924-6756.

! ARRIVE EARLY – TWO TALKS !

This Month's Speaker:

Dr. Pinnaduwa H.S.W. Kulatilake, Professor, Geological Engineering Program, Department of Materials Science and Engrg. University of Arizona, Tucson, Arizona

[Note: tunnel site: San Bernardino Mountains, MWD Arrowhead East Tunnel **]**

Speaker Biographical History (Sketch)

Pinnaduwa Kulatilake – BSc (Civil Eng.), MEng. (Geotechnical), PhD (Geotechnical Eng.), Professional Engineer (Civil), Fellow Member American Society of Civil Engineers, Professor Department of Materials Science & Engineering, University of Arizona, U.S.A.

Pinnaduwa Kulatilake is a Professor of Geotechnical Engineering at the University of Arizona. He has over 25 years of experience in rock mechanics, geotechnical engineering, and application of probabilistic and numerical methods to geotechnical engineering. He has written over 140 papers and is a member of several technical committees. He has been serving over 20 years as an examiner for the geological engineering professional exam conducted by the Arizona State Board of Technical Registration. He has delivered 12 keynote lectures and 40 other invited lectures throughout the world on topics related to fracture network modeling, probabilistic geotechnics, mechanical properties of joints, rock slope stability and mechanical and hydraulic behavior of rock masses. He was a Visiting Professor at the Royal Institute of Technology and Lulea University of Technology in Sweden as part of his sabbatical leave. Also, he was a Visiting Research Fellow at the Norwegian Geotechnical Institute, for another part of his sabbatical leave. He is a research paper reviewer for 16 technical Journals and an editorial member for Int. Jour. of Rock Mechanics & Mining Sciences and Int. Jour. of Geotechnical and Geological Engineering. He has taught short courses on stochastic fracture network modeling, rock slope stability analysis and Block theory in Sweden, Mexico, Austria, USA, Canada, Hong Kong, Poland, Finland, Australia and South Korea. Due to the contributions that he made on teaching, research, consulting and service activities, he was elected to the Fellow Rank of the American Society of Civil Engineers at the relatively young age of 45. In 2002, he received Distinguished Alumnus Award from the College of Engineering, Ohio State University and Outstanding Asian American Faculty Award from the University of Arizona in recognition of his distinguished achievements and eminent contributions made to the advancement of his profession. In 2005, he was conferred "Honorary Professorship" at the Eurasian National University, Kazakhstan.

Talk Descriptions

ROCK SLOPE STABILITY ANALYSES--A CASE STUDY

P.H.S.W. Kulatilake, Ph.D., P.E., F.ASCE
Professor, Geological Engineering Program, Dept. of Materials Science & Engineering, University of Arizona, Tucson, AZ 85721

ABSTRACT

Different technical components associated with a typical rock slope stability analysis will be covered through the presentation. Discontinuity geometry mapping conducted at a mine site will be addressed first. Development of a three-dimensional mine visualization model for a section of a mine will be covered next. Discontinuity orientation and location information is taken from this visualization model for use in slope stability analyses. Estimated shear strength properties of discontinuities and mechanical properties of intact rock from the rock mass samples obtained from the mine will be discussed next. The presentation will then focus on the calculated maximum safe slope angles based on the performed kinematic and block theory analyses using the mapped discontinuities at the mine. Finally, the effects of water that exist in the rock mass, tension cracks, slope face inclination, overall wedge height and double benching on factor of safety of wedge stability will be illustrated through limit equilibrium rock slope stability analyses.

References

Tulatilake, P.H.S.W., Um, J. and Morin, B., "Investigation of slope stability for a section of Phelps Dodge Sierrita Open Pit Mine", *Transactions of the Society for Mining, Metallurgy, and Exploration* Vol. 314, pp. 177-182, 2003.

THREE DIMENSIONAL ROCK MASS FRACTURE GEOMETRY AND FLUID FLOW MODELING FOR A TUNNEL SITE IN CALIFORNIA

P.H.S.W. Kulatilake, Ph.D., P.E., F.ASCE
Professor, Geological Engineering Program, Dept. of Materials Science & Engineering,
University of Arizona, Tucson, AZ 85721

ABSTRACT

The first part of the presentation will focus on the fracture geometry network modeling performed in the gneissic rock mass of the Arrowhead East Tunnel site located in San Bernardino Mountains, California. Eight hundred and fifty nine fractures of a gneissic rock mass were mapped using 16 scanlines placed on steep rock exposures that were within 300m of a tunnel alignment before the tunnel excavation. These data were analyzed using the software package FRACNTWK to find the number of fracture sets that exist in the rock mass, 3-D fracture frequency for each set and the probability distributions of orientation, trace length, fracture size in three-dimensions (3-D) and spacing for each of the fracture sets. In obtaining these distributions corrections were applied for sampling biases associated with orientation, trace length, size and spacing. Developed stochastic 3-D fracture network for the rock mass was validated by comparing statistical properties of observed fracture traces on the scanlines with the predicted fracture traces on similar scanlines. The one-dimensional (1-D) fracture frequency of the rock mass in all directions in 3-D was calculated and is presented in terms of a stereographic plot. The 1-D fracture frequency along the tunnel alignment direction was predicted to be about 6.48 fractures/m before the tunnel excavation. This prediction was found to be in excellent agreement with the observed values obtained (6.40-6.48) about one year later during the tunnel excavation. This was another validation conducted for the developed 3-D fracture network.

Currently used methods for estimating three-dimensional (3-D) hydraulic conductivity tensor using either aquifer pumping test or packer test data are based on the assumption that the groundwater is flowing through a geologic continuum. These methods can generally be applied when wells penetrate the porous geological media such as alluvial deposits, but may have limited applicability when the geological medium is dominated by a fracture system that has well defined fracture sets. The porous, continuum media assumption is based on an average flow within a Representative Elementary Volume (**REV**). Even though the REV is small for porous media, for fractured rock masses it can be very large or in some cases may not exist. The REV for the hydraulic behavior is defined as the size beyond which the rock mass hydraulic conductivity tensor remains the same. If the REV does not exist, or is larger than the distance between the pumping and observation wells or the packer test hole and observation wells, it is not appropriate to use the equivalent continuum approach to analyze the aquifer pumping or packer test data for fractured rock masses. Before applying an equivalent continuum approach for a rock mass, one should investigate the REV for the hydraulic behavior of the rock mass. For sizes larger than or equal to the REV size, the equivalent continuum approach can be applied for the rock mass with a hydraulic conductivity tensor. Estimation of the REV for hydraulic behavior of a highly heterogeneous, anisotropic rock mass requires monitoring of groundwater level of a significant number of observation wells placed at different distances in different directions from the pumping well or the packer test hole. This is a very time consuming and expensive exercise. On the other hand, the discrete fracture flow approach along with a good set of fracture data and results available from a few hydraulic tests performed at the field site has the capability to investigate and capture the hydraulic behavior of the fractured rock mass at any scale, irrespective of the distance between the pumping well and the observation wells or between the packer test hole and the observation wells, without worrying about the REV size of the fractured rock mass.

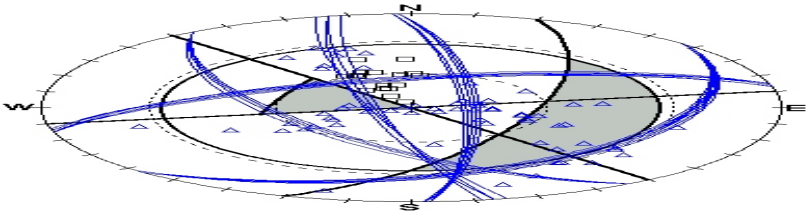
The second part of the presentation will cover the new methodology used to determine the REV size and 3-D hydraulic conductivity tensor for a fractured rock mass. The aforesaid validated fracture network model was combined with the fracture data observed in a borehole to generate a stochastic-deterministic fracture network system in a cubic block around each packer test conducted at a different depth region in the same borehole. Each packer test was simulated numerically applying a developed discrete fracture fluid flow model to estimate the influenced region or effective range for the packer test. A cubic block of size 18m, with the packer test interval of length about 6.5m located at the center of this block, was found to be suitable to represent the influenced region. Using this block size, the average flow rate per unit hydraulic gradient (defined as the transmissivity multiplied by

mean width of flow paths) field for fractures was calibrated at different depth regions around the borehole by numerically simulating the packer tests conducted at different depth regions. The average flow rate per unit hydraulic gradient of the fractures that intersect the borehole was considered to be quite different to the average flow rate per unit hydraulic gradient of the fractures that do not intersect the borehole. A relation was developed to quantify the ratio between these two parameters. By studying the directional hydraulic conductivity behaviour of different cubic block sizes having the validated stochastic fracture network and calibrated hydraulic parameters, an REV for the hydraulic behaviour of the rock mass was estimated to be a block size of 15m. The hydraulic conductivity tensor in 3-D computed through regression analysis using the calculated directional hydraulic conductivity values in many directions was found to be significantly anisotropic. The principal directions of the hydraulic conductivity tensor were found to be agreeable with the existing fracture system of the site. Further, the geometric hydraulic conductivity calculated was found to be comparable to the hydraulic conductivity estimated through the radial flow assumption in continuum porous media.

References

Kulatilake, P.H.S.W., Um, J., Wang, M., Escandon R.F. and Narvaiz, J., "Stochastic fracture Geometry modeling in 3-D including validations for a part of Arrowhead East Tunnel site, California, USA", Int. Jour. of Engineering Geology, Vol. 70, Issues 1-2, pp. 131-155, 2003.

Wang, M., Kulatilake, P.H.S.W., Um, J. and Narvaiz, J., "Estimation of REV size and three dimensional hydraulic conductivity tensor for a fractured rock mass through a single well packer test and discrete fracture fluid flow modeling", Int. Jour. of Rock Mechanics and Mining Sciences, Vol. 39, No. 7, pp. 887-904, 2002.



Message from the President

Please look forward to meetings and events this coming year. Meetings will be directed by the respective Vice Presidents Mike Cook and Frank Jordan in northern and southern areas as they occur, and some meetings will be replaced by field trips and the National AEG Meeting in Los Angeles next Sept. '07.

Thanks

Thanks to the 14 Professionals that attended the September 2006 Meeting in Riverside "The Physics of Interacting Faults" (Dr. David Oglesby, UC-Riverside), as follows:
David Oglesby, Ph.D.Associate Professor of Geophysics, Department of Earth Sciences, University of California, Riverside; **Gary Wallace; Scott Mathis; Doug Cook; Rick Gundry; Frank Jordan; Dave Gaddie; Daniel Costamagna; Mark Spykerman; Tracy Houghten; Kerry Cato, Ph.D.; Richard Orr; and Zack Freeman**

Welcome to New AEG Member

Welcome to **Tracy Houghton**, CEO of Houghton Backhoe & Excavation, who last month joined and is an official Affiliate Member of the AEG **!** This occurrence certainly expands the breadth of attenders: Members, Affiliate Members, Student Members, and the rest who are non-Member attenders (who we welcome as non-Members; ? think about becoming a member for the benefits one will receive in return).

Meeting Location

The meeting site is located in the City of Temecula East of I-215 on Rancho California Road.

PAT & OSCARS Family Restaruant
29375 Rancho California Road
Temecula, CA 92593
(951) 695-2422

Venue for Meal

* Openers
  - Assorted non-alcoholic beverages, tea and coffee. Refills free in mtng room
  - Cheese Tray - cheddar, jack and swiss
* Meal sections (all)
  - Warm soft bread sticks (all you can eat)
  - Salad of your selection (or both)
    - Caesar
    - Greek
      Choice of dressing
  - Tomato Fredo Pasta
    (Marinara/Alfredo)
  - Main Choices (any and all)
    - Lemon-grilled Chicken
    - BBQ Chicken (lemon-grill base)
    - BBQ St.Louis Baby Back pork ribs
      (More Ribs: add $2.00)
    - Desert - Giant Cookie (4 choices)
* Beer/wine selections (additional cost)

Directions to Meeting

Proceeding South on I-15 or I-215 to Temecula, after Freeways merge, prepare to EXIT at Rancho California Road. Turn LEFT at end of off-ramp on Rancho California Road to head EAST across I-15 less than 1/4-mile to turn Right (SOUTH) and park at Pat N Oscars.

Proceeding north on I-215 to Temecula watch for Rancho California Road and EXIT, to turn Right (East) on Rancho California. Proceed EAST <1/4-mile to turn Right into Pat N Oscar's parking lot.

RSVP **Please:** send **RSVP** to Rick Gundry at rick.gundry@verizon.net by Thursday close of business 9-OCT-06, or call RSVP (951) 924-6756 to leave message. **IMPORTANT !** Thanks.

Future Meetings

NOV Wednesday NOV, 15, 06 Rancho California
- Claim Jumper, Rancho Cucamonga
" Refraction Microtremor for Shallow Shear Velocity"
__ Tiana Rasmussen, Geophysicist, Project Geologist, Gary S. Rasmussen and Associates, Inc., San Bernardino, California
"2007 AEG Annual Meeting, Los Angeles"
__ Jeffrey R. Keaton, AEG Annual Meeting Chair MACTEC, Los Angeles, California

DEC Wednesday DEC 20, 2006, Corona
- Cask 'N Cleaver Steakhouse, Corona
"Secondary Fault-Rupture-Hazards at a School Damagaed by the 1971 San Fernando Earthquake"
__ Jefrey R. Keaton, MACTEC, Los Angeles, CA

JAN Wednesday JAN 20, 2007 HI or LO Desert
- FIELD TRIP Saturday 7am-3pm
(NO Regular Monthly MEETING)
"Field TripTopic to be announced"

FEB Wednesday FEB 21, 2007, Temecula
- Hungry Hunter, Temecula
"The Search for PaleoTsunami Deposits in Southern Thailand"
__ Dr. Brady Rhodes, Professor, Department of Geology, California State University, Fullerton, Fullerton, California

49th Annual Meeting AEG "From Till to Fill"
30-Oct to 4-Nov, Boston, Massachusetts

50th Annual Meeting AEG 24-28 Sept. 2007, Los Angeles, California
Anniversary - AEG founded in Southern California

If you have ideas for future speakers or field trip topics or leaders, please contact us

NOT A MEMBER ?

Just think, become AEG Member and immediately save money for course enrollment as a Member on most AEG functions and $30 discount for 3 years for new Members. See new website of AEG

www.aegweb.org

Classes of members include:

Member
Affiliate Member*
Student Member
Honorary Member

***For those who may not know:**

Affiliate Member Class

Qualifications. Affiliate Members are persons who do not meet the educational requirements for Member class but are interested in furthering the application of geological sciences to the solution of environmental, groundwater, and engineering problems.

Connecting . . .
Professionals
Practice,
And the Public

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AEG Inland Empire Chapter, Southern California Section, and National Headquarters

www.aegweb.org
National AEG Homepage (NEW , check it out)

http://www.aegsc.org/
Southern California Section Web-site

http://www.aegsc.org/chapters/inlandempire/
Inland Empire Chapter Home-Page

OROS Sponsors

AEG Inland Empire Chapter is seeking Sponsors for financial assistance to support and build on existing foundations for education and outreach, scholarship assistance, and special events. We are seeking donors to expand and reach even further above the base or plane of generous Petras Sponsors, for mounting a more aggressive and purposeful contribution to society, students, and educators. Currently, we already have two OROS Sponsors, as follows:

SILVER OROS SPONSOR ($250, or more)`please see next page

Kelly Robertson, GREGG Drilling & Testing, Inc., Signal Hill, California

Titanium OROS Sponsor ($100 or more)

Richard R. Gundry, Inland Geologic, Moreno Valley, California

Oros is a latin term like *oro* for rise or rear, as a mountain, as if lifting itself above the plain, or hill or a mount. Partly rooted in the term *adar* to expand honorably, as in great, glorious and magnificant . This is such as to build-upon and maintain the foundation provided by Petras Sponsorship already dedicated to this effort. (See web-Page regarding Petras Sponsorship.)

We are seeking funds in amounts of $10, $25, $50 or more for OROS Sponsor. $10 OROS Sponsor; $25 Bronze OROS Sponsor; $50 Steel OROS Sponsor; $100 Titanium OROS Sponsor, $250 Silver OROS Sponsor, $500 Gold OROS Sponsor, and $1,000 Platinum OROS Sponsor. Sponsors at the Titanium or above level will have free advertizing in monthly Newsletters (must submit Logo, and company name with contact information).

Please help us in this endeavor, as we are a relatively new Chapter in a new-chartered area now, and in an area where outreach to the public, students, and educators has been direly needed in the past.

If you have any questions, please contact me. To remit a donation send payable to "AEG Inland Empire Chapter" at the address as indicated in the above letterhead.


GREGG