

Center of Excellence in Underground Construction & Tunneling (UC&T)

Developing Leaders. Advancing Knowledge.



COLORADO SCHOOL OF MINES

ground
under uct.mines.edu

UC&T = Caverns + Shafts + Adits + Excavations + Tunnels



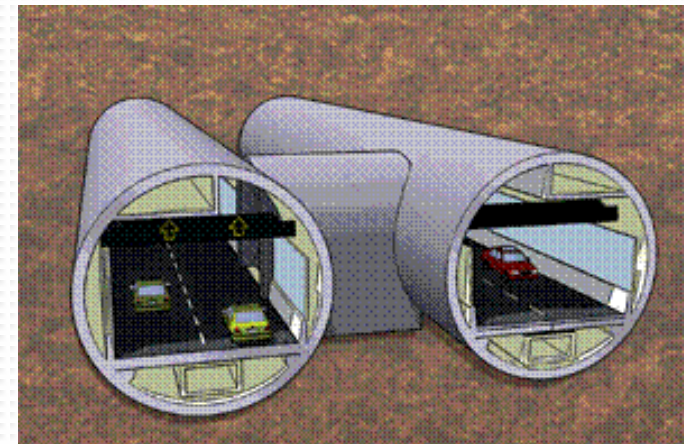
Manhattan Caverns
New York City
(10 blocks long;
under Grand Central Terminal)



Olympic Cavern Hall (Gjøvik, Norway)



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Tunnels: Water Conveyance



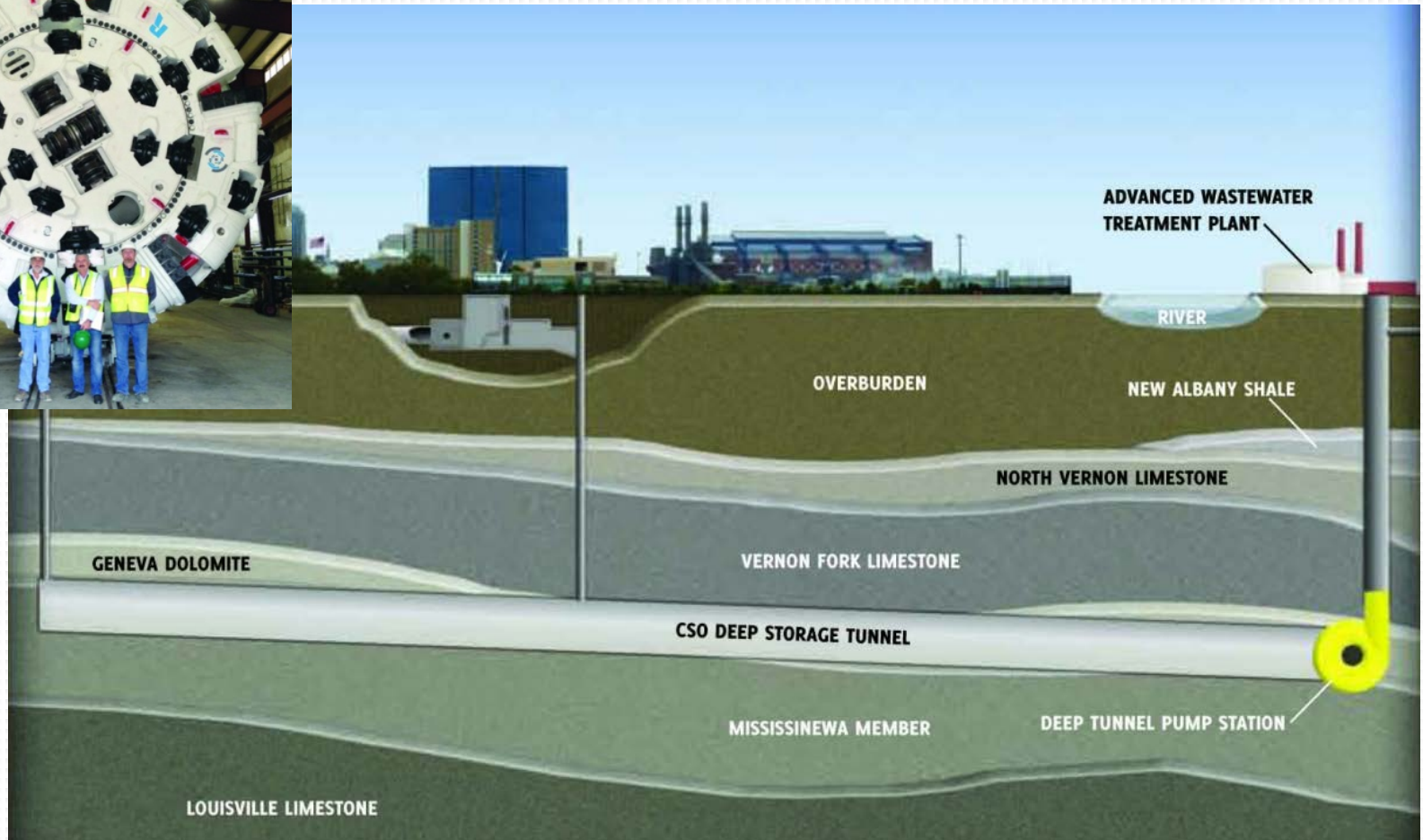
Niagara Falls Hydroelectric Tunnel



Tunnels: Wastewater

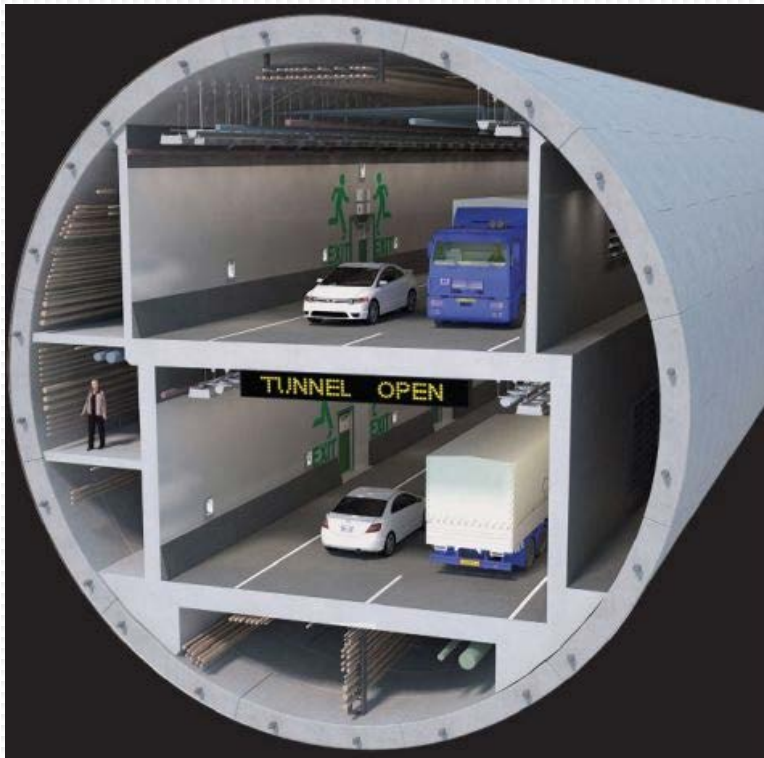


Deep Rock Tunnel (Indianapolis)



Tunnels: Transportation

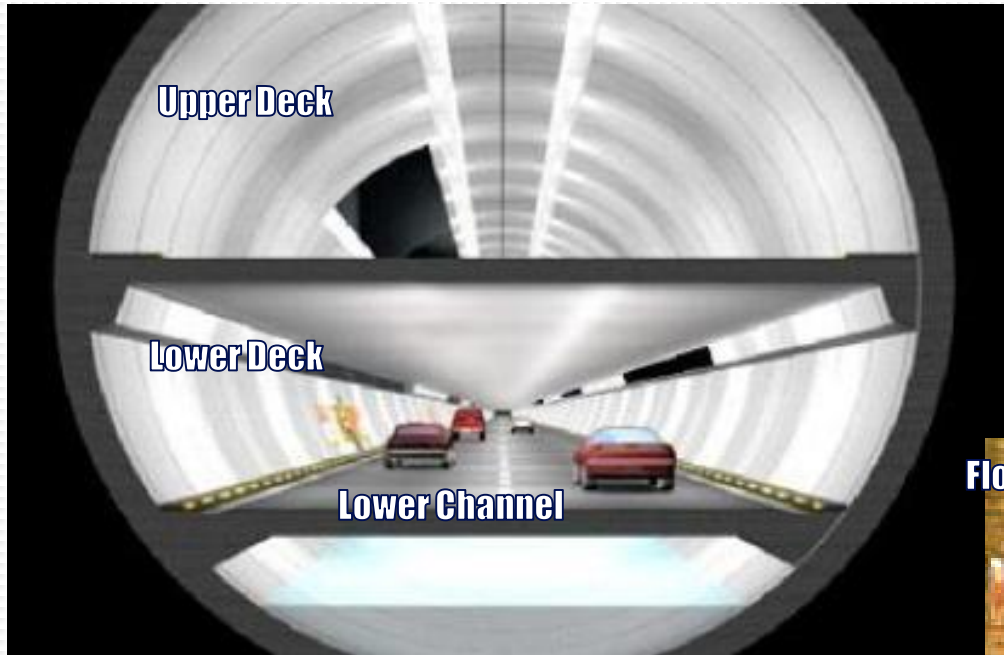
Road



Transit



Tunnels: Multiple Use

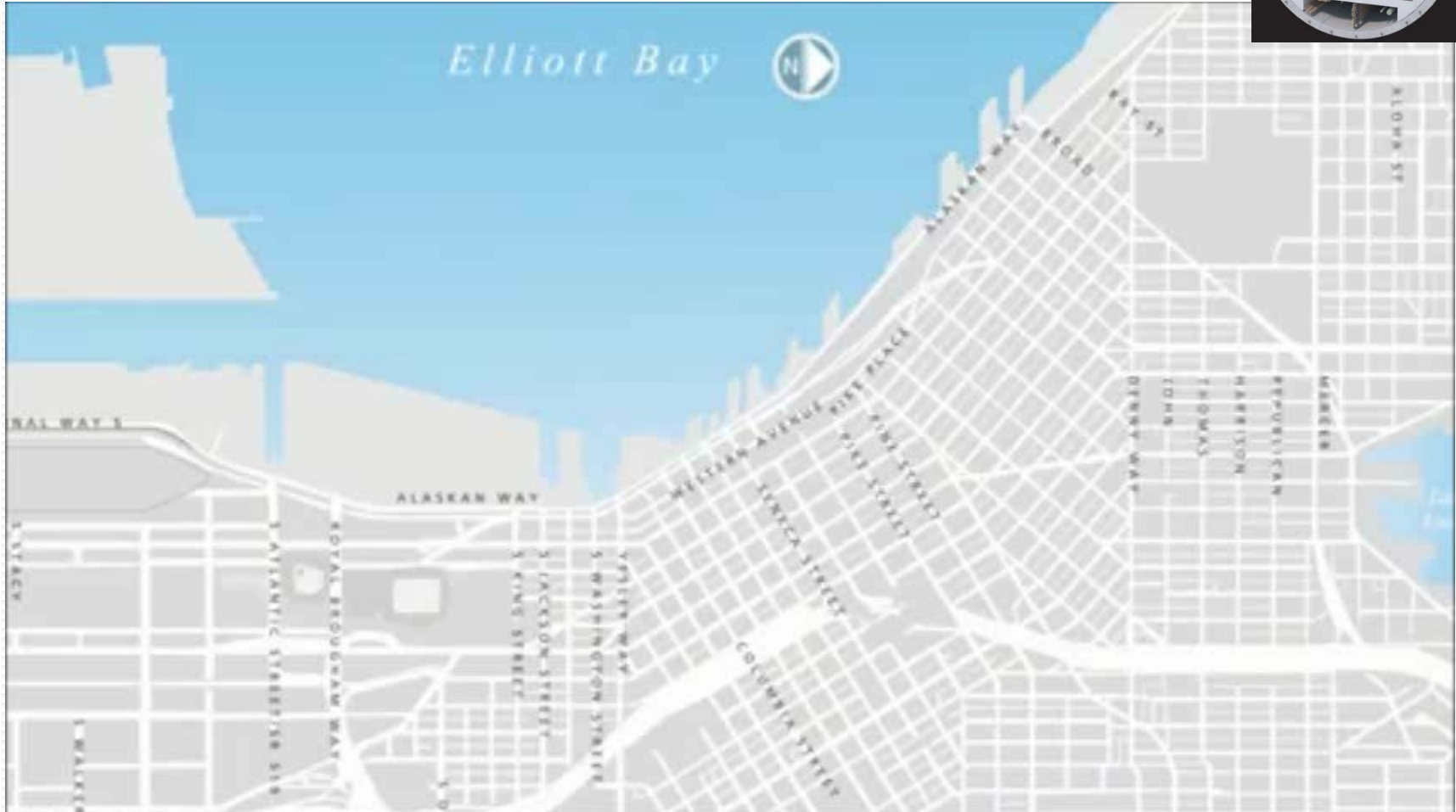
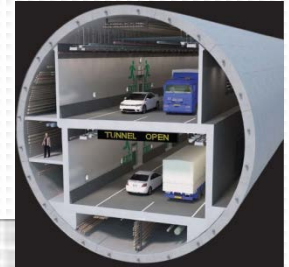


**SMART Tunnel –
Stormwater Management
& Road Tunnel
(Kuala Lumpur, Malaysia)**



Complexity

Seattle Alaskan Way Tunnel



Complexity

NYC East Side Access



Industry Players (focus on North America)

Designers & Consultants

- 10-15 main companies
- Parsons Brinckerhoff, ARUP, Jacobs Assoc., Hatch Mott MacDonald, etc.
- hire M.S., Ph.D.

Contractors

- 15-20 main companies
- Kiewit, Skanska, Traylor Brothers, Tutor Perini, Shea, Dragados, etc.
- hire B.S., M.S.

Equipment Manufacturers

- 8-10 main companies
- Robbins, Herrenknecht, Atlas Copco, etc.
- hire B.S., M.S., Ph.D.

Specialty Contractors

- Geoconstruction, instrumentation, etc.
- 10-15 main companies
- Hayward Baker, Nicholson, Geocomp, Soldata, etc.
- hire B.S., M.S., Ph.D.

Suppliers

- 10-15 main companies
- BASF, Condat, Williams Form, etc.
- hire B.S., M.S., Ph.D.

Owners

- 20-30 main owners
- NYC Metro, DCWater, LA Metro, Sound Transit, Urban Drainage, military, etc.
- hire M.S., Ph.D.

Please visit uct.mines.edu for more on industry and to view excellent videos that describe the current underground construction and tunneling industry.

Engineering & Science Disciplines

civil

mining

geology/
geological

mechanical

electrical

construction
management

environ-
mental

geophysics

computer
science

A Little Bit about Us...

We are a collaborative, interdisciplinary group of faculty and students from:

- Civil and Environmental Engineering
- Geology and Geological Engineering
- Mining Engineering

Additional involvement from
Mechanical Engineering,
Electrical Engineering,
Computer Science,
Economics and Business



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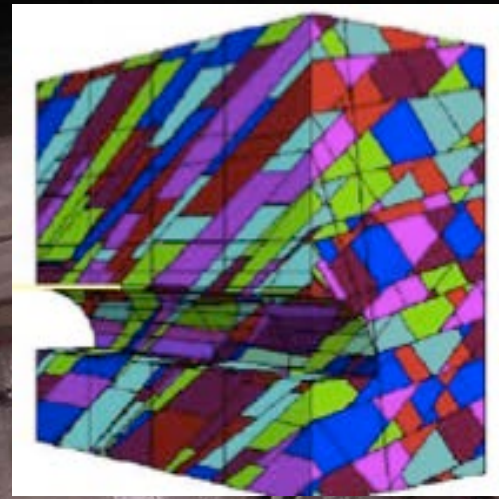
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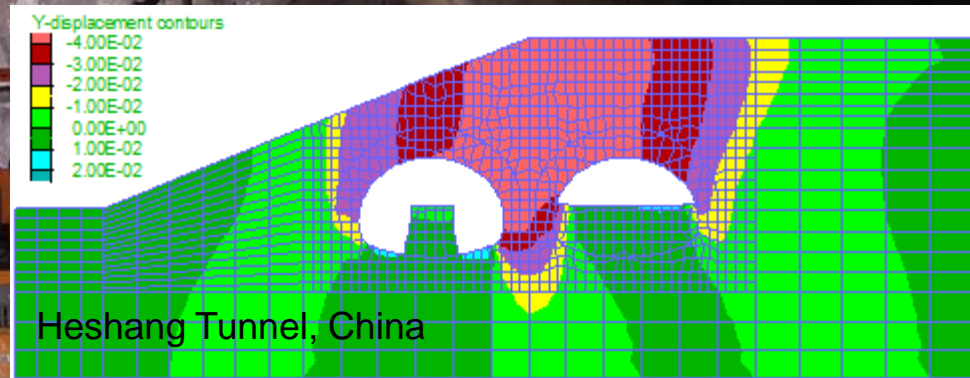
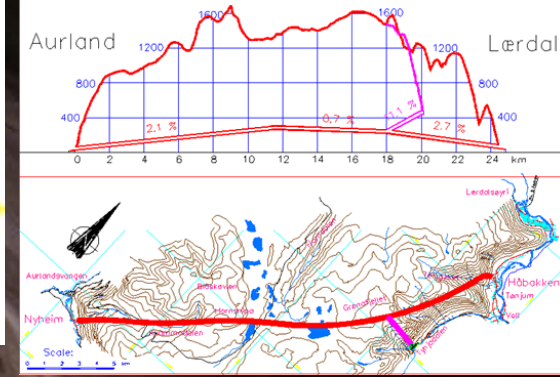
Marte Gutierrez, Ph.D.

*J. R. Paden Distinguished Professor
Colorado School of Mines
Civil and Environmental Engineering
E-mail: mgutierr@mines.edu*

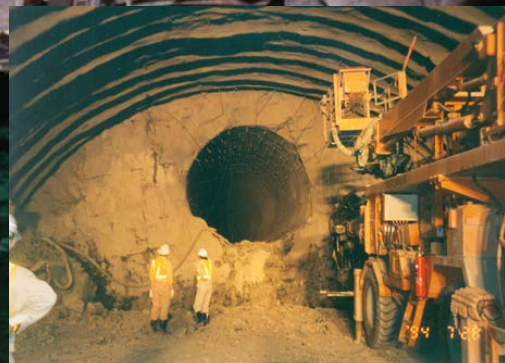
- **Geomechanics** (Constitutive Modeling, Discrete Element and Particulate Modeling, Bifurcation and Strain Localization, Poromechanics, and Laboratory Testing)
- **Environmental and Energy Sustainability** (Underground Excavations in Rocks, Petroleum Geomechanics, CO₂ Geological Sequestration, Geothermal Energy, and Geohazards)



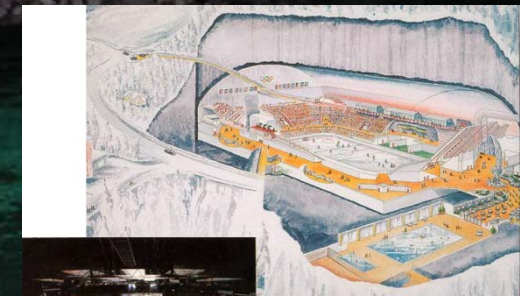
World's longest road tunnel –
Lærdal's Tunnel in Norway
(length=24.5 km)



Heshang Tunnel, China



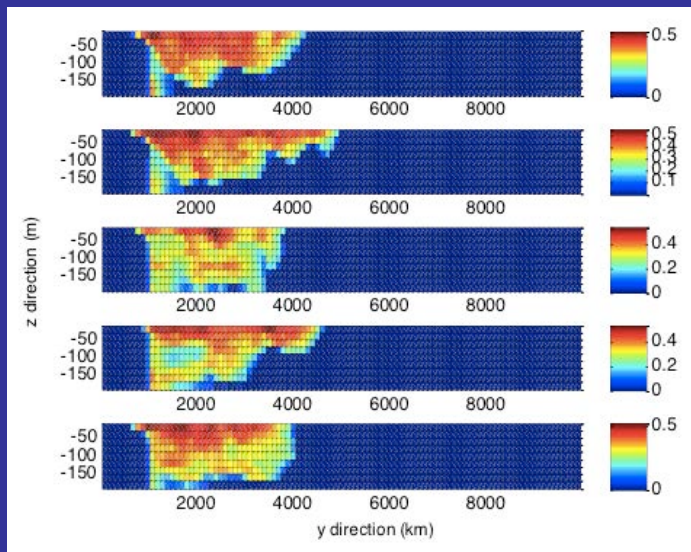
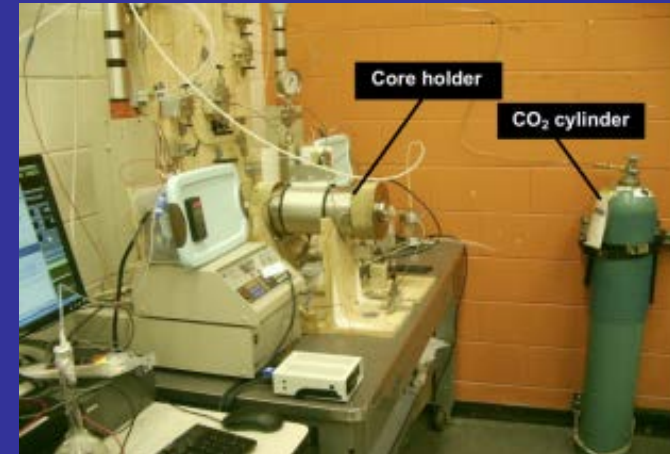
Shimizu Tunnel #3
Tomei II Highway, Japan



Gjøvik Olympic Hall (NORWAY)
World's largest underground
public hall (62 x 90 x 24 m³)

Current Research Projects

- Enhanced Geothermal Systems (EGS)
- Geomechanics of CO₂ Geological Sequestration
- Stochastic Coupled Flow and Geomechanics Modeling of CO₂ Geological Sequestration
- Failure, Fracturing and Leakage in Shales



Wei (Wendy) Zhou

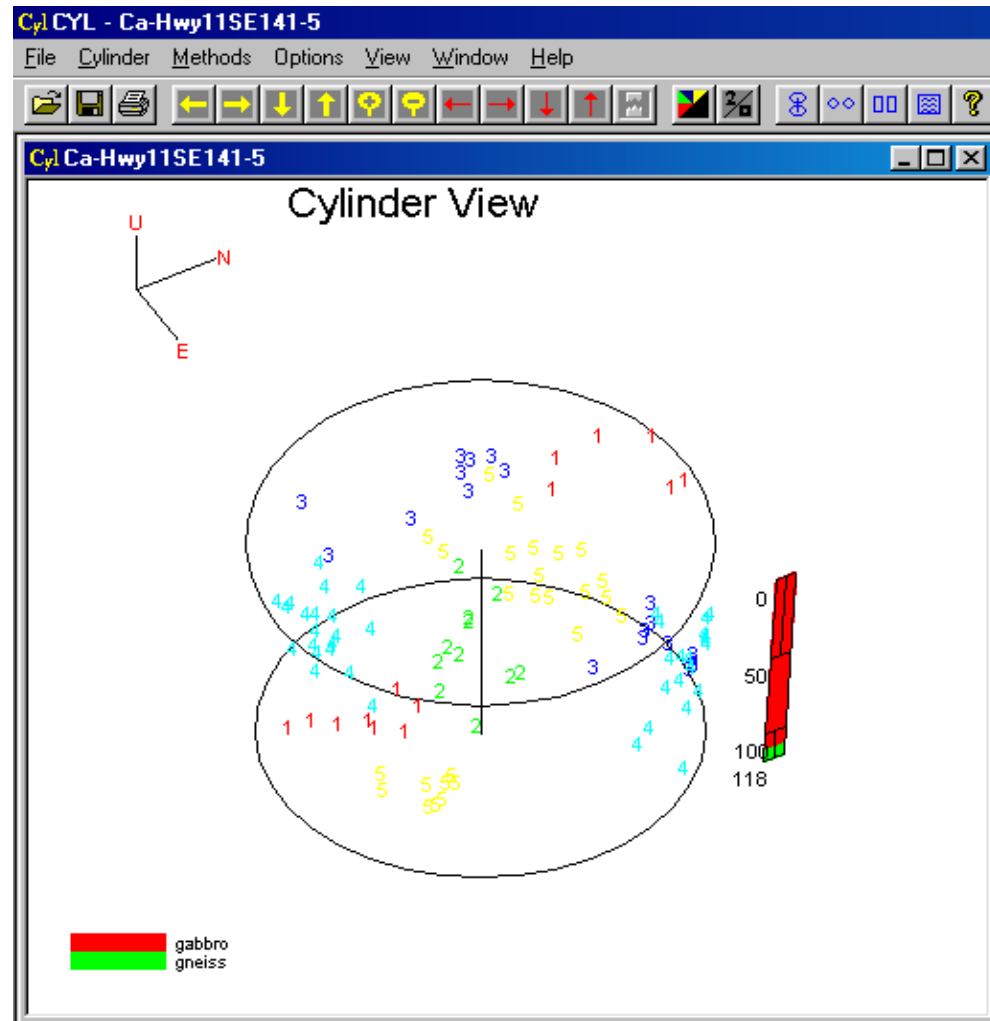
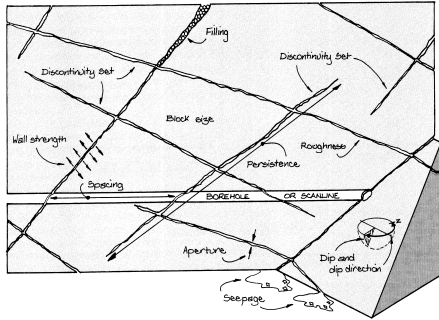
Associate Professor, Engineering Geology and GIS

E-mail: wzhou@mines.edu, Phone: 303-384-2181, Office: BH 305D

Research Interests

- 1) rock mass characterization
- 2) numerical modeling, such as finite element and finite difference methods, for ground thermal regime and stress-strain distribution in the rock or soil mass
- 3) InSAR applications in ground movement monitoring, such as ground subsidence, and landslide deformation rate
- 4) GIS applications in natural resource management, environmental impact study, and geohazard zonation.

Development of CYL - multivariate cluster analysis for characterizing discontinuities in rock



Development of Visualization Tools

- 3-D stereonet
- Stereoscopic view
- Chart view
- Table view

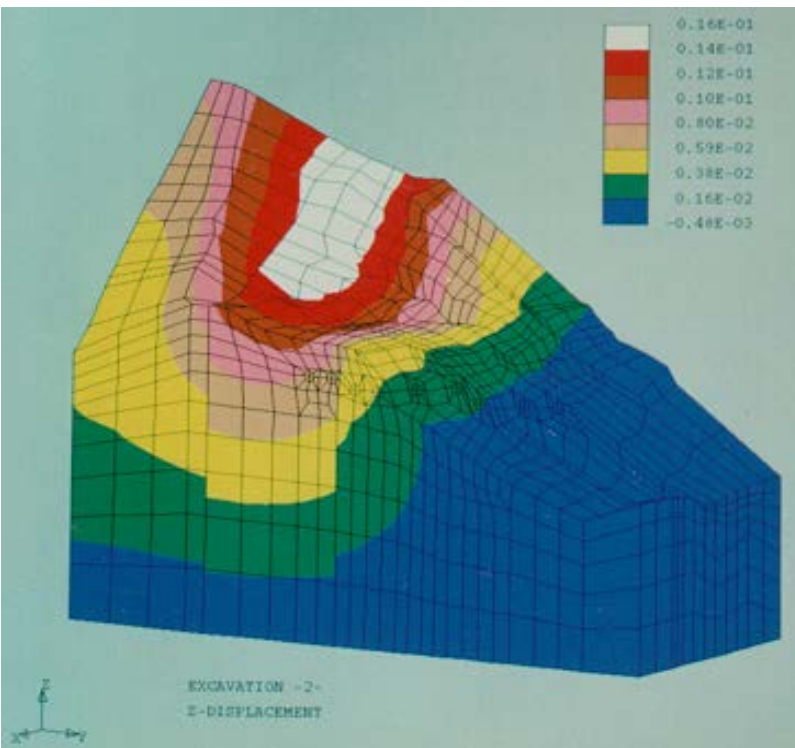
Cyl Data2

Clustering Analysis

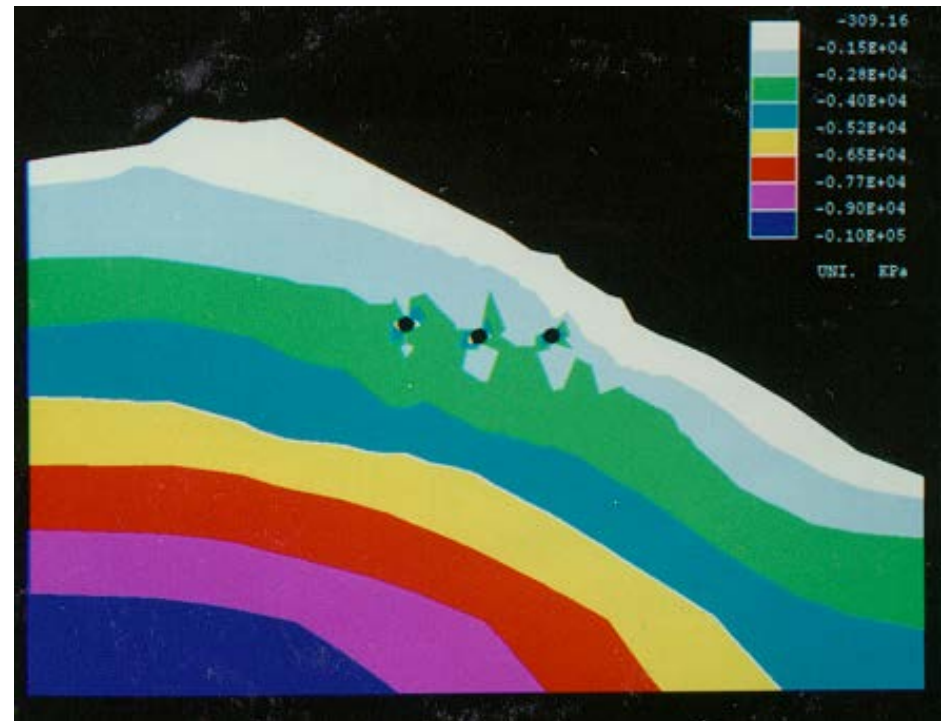
set #	joints	dip dir	dip ang	position	spacing	roughness
1	27	29	82	22.6	1.3	7.4
2	11	166	78	17.3	3.3	7.4
3	12	354	77	14.4	1.8	7.0
4	23	266	4	22.4	1.5	3.2
5	11	128	72	23.6	3.0	6.3

3D FEM Analysis for a High-cut Intake Slope at a Power Station

the analysis simulates a five-step excavation of the slope as well as the excavation of the nine diversion tunnels and two shafts.



(left & below)
Stress
redistribution
and
concentration
due to
excavation of
the tunnels



(above) Displacement is
discontinuous due to the existence
of faults

Earth Mechanic Institute

Mining Engineering Department

Brian Asbury

Mechanical Excavation

Tunneling, Mining, Drilling, etc.

Rock Mechanics Testing

Laboratory Full-Scale Testing

Machine Performance Modeling

Novel Excavation Methods (water jet, thermal/chemical/laser)



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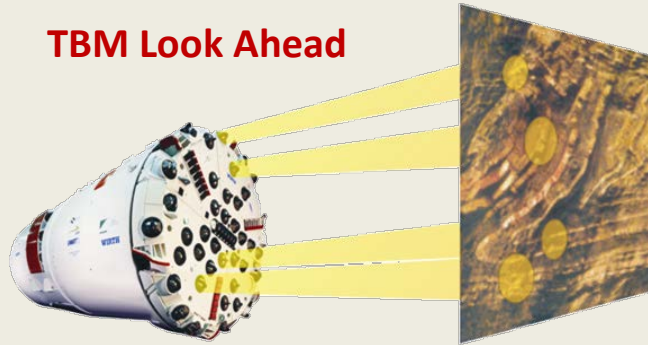
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under

Mooney Research in UC&T

uct.mines.edu



TBM Look Ahead



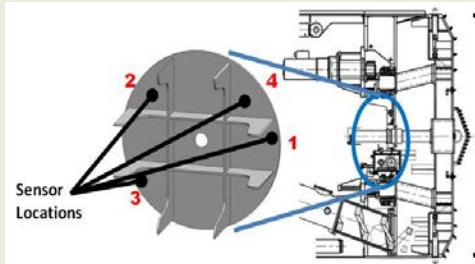
Soil Conditioning



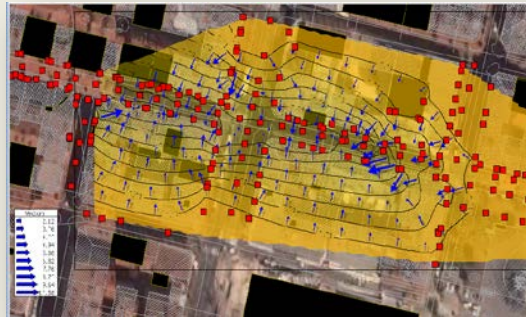
Queens Bored Tunnels



TBM Vibration



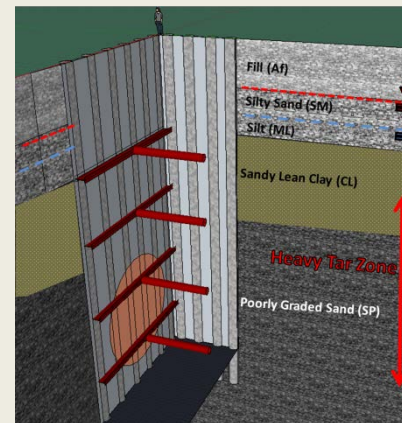
Learning from Data



Seabed Compaction



La Brea Tar Sands



Jet Grout Monitoring



New Office Location! BB 268

How Can U Get Involved in UC&T??

- **Courses and Degrees**
- **Research Projects and Positions**
- **Field Trips**
- **Scholarships: Information and Deadlines at uct.mines.edu**
- **Internships: Career Center and Diggernet**



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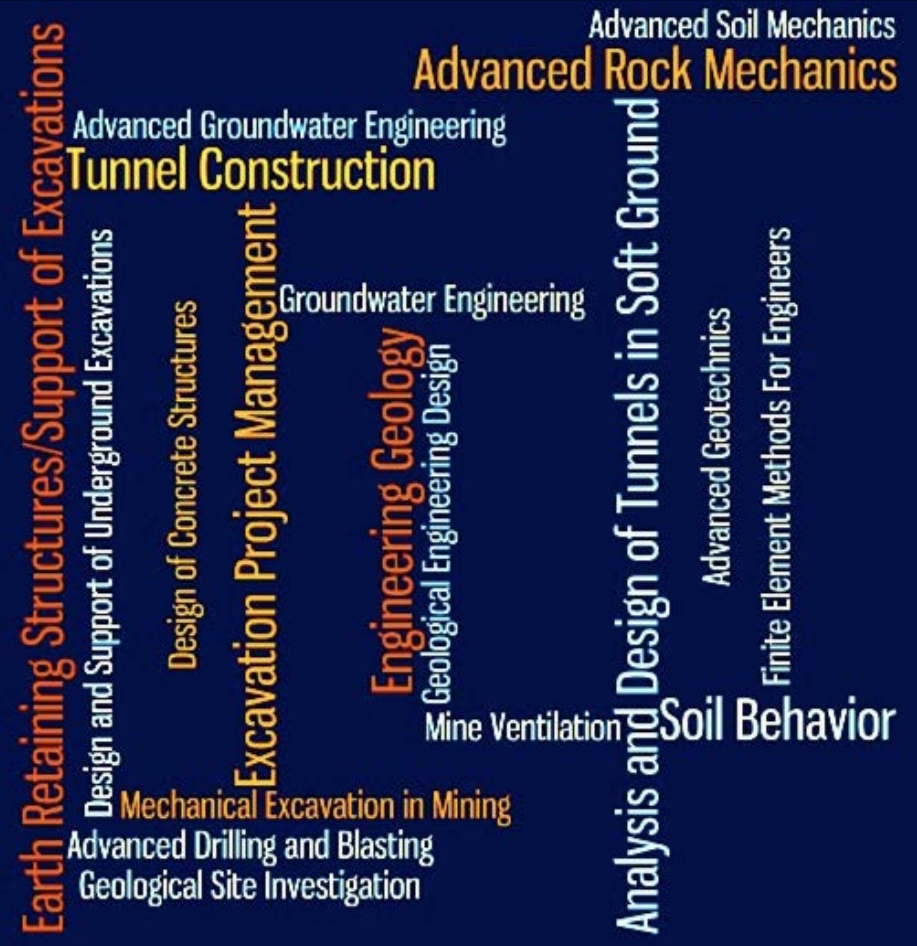
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under uct.mines.edu

Education

- 20+ UC&T Courses
- Undergraduate Minor
- M.S. (Thesis and Non-Thesis)
- Ph.D.

(Only UC&T advanced degrees offered in North America!)

- See CSM Bulletin
(link on uct.mines.edu)



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Undergrad Courses this Fall

- Soil Mechanics (CEEN 312)
 - MWF 9-9:50 + optional lab
- Intro to Rock Mechanics (MNGN 321)
 - MW 9-9:50 + T 1-3:50
- Design of Tunnels in Soft Ground (CEEN 498)
 - MW 11-12:15
- Underground Design & Construction (MNGN 408)
 - F 8-9:50
- Foundations (CEEN 415)
 - TR 12:30-1:45
- Reinforced Concrete Design (CEEN 445)
 - TR 11-12:15



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Grad Courses this Fall

- Design of Tunnels in Soft Ground (CEEN 523)
 - MW 11-12:15
- Soil Behavior (CEEN 512)
 - TR 3:30-4:45
- Advanced Rock Mechanics (MNGN 508)
 - MW 9-9:50 + T 1-3:50
- Reinforced Concrete Structures II (CEEN 541)
 - TR 2-3:15
- Groundwater Engineering (GEGN 466/467)
 - TR 11-12:15
- Engineering Geology & Geotechnics (GEGN 468)
 - MWF 10-10:50 + lab



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Undergraduate Minor

The Underground Construction & Tunneling minor consists of a minimum of 18 credit hours

Required Courses

CEEN312	SOIL MECHANICS	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0
GEGN466	GROUNDWATER ENGINEERING	3.0
or GEGN467	GROUNDWATER ENGINEERING	
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4.0

Example Electives

CEEN 405	NUMERICAL METHODS FOR ENGINEERS	3.0
CEEN 520	EARTH RETAINING STRUCTURES/SUPPORT OF EXCAVATIONS	3.0
GEGN 473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
MNGN407	ROCK FRAGMENTATION	3.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0



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MS and/or PhD in UC&T

Required Courses for M.S. Thesis, M.S Non-Thesis and Ph.D. Degrees

The following 21 credit hours are required. Students are required to attend the UC&T seminar series and **M.S. non-thesis and Ph.D. students must complete an internship-related project**, registering as an independent study in the home department of the faculty advisor (CEEN 599, GEGN 599, or MNGN 599)

GEGN598	ENGINEERING GEOLOGY & GEOTECHNICS	4.0
CEEN512	SOIL BEHAVIOR	3.0
MNGN508	ADVANCED ROCK MECHANICS	3.0
CEEN523	ANALYSIS AND DESIGN OF TUNNELS IN SOFT GROUND	3.0
MNGN598	TUNNEL CONSTRUCTION	3.0
CEEN520	EARTH RETAINING STRUCTURES / SUPPORT OF EXCAVATIONS	3.0
GOGN506	EXCAVATION PROJECT MANAGEMENT	2.0



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MS and/or PhD in UC&T

Example Elective Courses

CEEN510	ADVANCED SOIL MECHANICS	3.0
CEEN541	DESIGN OF REINFORCED CONCRETE STRUCTURES	3.0
GEGN466	GROUNDWATER ENGINEERING	3.0
GEGN573	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
GEGN581	ANALYTICAL HYDROLOGY	3.0
GEGN673	ADVANCED GEOLOGICAL ENGINEERING DESIGN	3.0
MNGN424	MINE VENTILATION	3.0
MNGN506	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS	3.0
MNGN507	ADVANCED DRILLING AND BLASTING	3.0



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Research Projects

Applied Research Project Example:
Improving the Conditioning of Soil
Undergraduate Student:
Adam Moore



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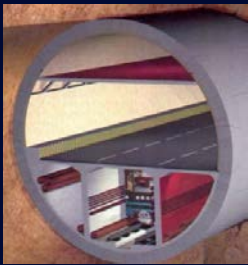
Research Projects – UC&T Undergraduates Fall 2013

Undergraduates in Civil, Geological, Mining, Mechanical, Electrical, Geophysics, Computer Science, etc. - join us and participate in applied research such as site investigation and characterization, ground imaging, numerical modeling, tunnel boring machine performance prediction and more!

5-15 hours per week at CSM or a local company; flexible schedule; possible site visits

See flyers for full information or email uct@mines.edu

Applications due August 28, 2013



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Field Trips

Twin Tunnels this September



Seattle in Fall 2013 or Spring 2014....



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Scholarships – UC&T Students

Scholarships related to the field of UC&T will be listed on the website at uct.mines.edu.

Examples:

UCA of SME Scholarship - Application Deadline November 1, 2013

Established to encourage undergraduate and graduate academic pursuits and careers in the field of tunneling and underground construction and associated disciplines involved in the development, planning, design, and construction of underground infrastructure.

ASA Graduate Scholarship – Application Deadline November 1, 2013

The purpose of the ASA Graduate Scholarship Program is to attract, identify, and assist outstanding graduate students pursuing careers within the field of concrete with a significant interest in the shotcrete process.



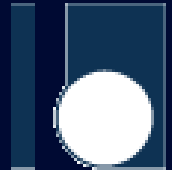
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Internships

Ten UC&T students were employed this summer by eight companies!

- Obayashi Corporation
- Parsons Brinckerhoff
- Barnard Construction
- Kiewit
- Zachry Engineering
- Brierley Associates
- Jacobs
- The Robbins Company



Please work with the CSM Career Center and our UC&T Center Coordinator to find your opportunity, and let's increase that number!



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Internships

Jean Manning-Clark, Director of Mines Career Center and Employer Relations



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UCA – Student Chapter Officers



Martin Levy, President
mlevy@mymail.mines.edu

Erin Keogh, Vice President
ekeogh@mymail.mines.edu



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