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

Developing Leaders. Advancing Knowledge.
UC&T = Caverns + Shafts + Adits + Excavations + Tunnels

Manhattan Caverns
New York City
(10 blocks long; under Grand Central Terminal)
Olympic Cavern Hall (Gjøvik, Norway)
UC&T = **Caverns + Shafts + Adits + Excavations + Tunnels**
UC&T = Caverns + Shafts + Adits + Excavations + Tunnels
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
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

civil mining
government/geological
electrical
mechanical
environmental
geo physics
construction management
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

Developing Leaders. Advancing Knowledge.
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)
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
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.

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

(left & below) Stress redistribution and concentration due to excavation of the tunnels.
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)
Soil Conditioning
Queens Bored Tunnels
Jet Grout Monitoring
Seabed Compaction
La Brea Tar Sands
TBM Vibration
TBM Look Ahead
Learning from Data
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
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)
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
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
The Underground Construction & Tunneling minor consists of a minimum of 18 credit hours.

### Required Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CEEN312</td>
<td>SOIL MECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN321</td>
<td>INTRODUCTION TO ROCK MECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN404</td>
<td>TUNNELING</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN466</td>
<td>GROUNDWATER ENGINEERING</td>
<td>3.0</td>
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<tr>
<td>or GEGN467</td>
<td>GROUNDWATER ENGINEERING</td>
<td>3.0</td>
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<tr>
<td>GEGN468</td>
<td>ENGINEERING GEOLOGY AND GEOTECHNICS</td>
<td>4.0</td>
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### Example Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CEEN 405</td>
<td>NUMERICAL METHODS FOR ENGINEERS</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN 520</td>
<td>EARTH RETAINING STRUCTURES/SUPPORT OF EXCAVATIONS</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN 473</td>
<td>GEOLOGICAL ENGINEERING SITE INVESTIGATION</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN407</td>
<td>ROCK FRAGMENTATION</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN410</td>
<td>EXCAVATION PROJECT MANAGEMENT</td>
<td>2.0</td>
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</tbody>
</table>
# 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)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEGN598</td>
<td>ENGINEERING GEOLOGY &amp; GEOTECHNICS</td>
<td>4.0</td>
</tr>
<tr>
<td>CEEN512</td>
<td>SOIL BEHAVIOR</td>
<td>3.0</td>
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<tr>
<td>MNGN508</td>
<td>ADVANCED ROCK MECHANICS</td>
<td>3.0</td>
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<tr>
<td>CEEN523</td>
<td>ANALYSIS AND DESIGN OF TUNNELS IN SOFT GROUND</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN598</td>
<td>TUNNEL CONSTRUCTION</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN520</td>
<td>EARTH RETAINING STRUCTURES / SUPPORT OF EXCAVATIONS</td>
<td>3.0</td>
</tr>
<tr>
<td>GOGN506</td>
<td>EXCAVATION PROJECT MANAGEMENT</td>
<td>2.0</td>
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</table>
MS and/or PhD in UC&T

Example Elective Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CEEN510</td>
<td>ADVANCED SOIL MECHANICS</td>
<td>3.0</td>
</tr>
<tr>
<td>CEEN541</td>
<td>DESIGN OF REINFORCED CONCRETE STRUCTURES</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN466</td>
<td>GROUNDWATER ENGINEERING</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN573</td>
<td>GEOLOGICAL ENGINEERING SITE INVESTIGATION</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN581</td>
<td>ANALYTICAL HYDROLOGY</td>
<td>3.0</td>
</tr>
<tr>
<td>GEGN673</td>
<td>ADVANCED GEOLOGICAL ENGINEERING DESIGN</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN424</td>
<td>MINE VENTILATION</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN506</td>
<td>DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS</td>
<td>3.0</td>
</tr>
<tr>
<td>MNGN507</td>
<td>ADVANCED DRILLING AND BLASTING</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Research Projects

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

Twin Tunnels this September

Seattle in Fall 2013 or Spring 2014....
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.
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!
Internships
Jean Manning-Clark, Director of Mines Career Center and Employer Relations
UCA – Student Chapter Officers

Martin Levy, President
mlevy@mymail.mines.edu

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