Underground at Mines

By Michael Mooney

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In 2011, realizing a need to identify a unifying program dedicated to underground construction and tunneling education across campus, Colorado School of Mines established the Center for Underground Construction and Tunneling, or generally referred to as "Underground at Mines." Core faculty members from civil engineering, geological engineering, and mining engineering work together to provide Mines students with an interdisciplinary curriculum and provide the industry with focused research projects relevant to current underground challenges and development.

Over the last 6 years, additional departments on campus have joined the efforts, including mechanical engineering, computer science, and geophysics. The core faculty has grown from three to eight, ensuring students involved in Center research and courses are receiving an all-encompassing education.

Underground at Colorado School of Mines operates with two primary goals: preparing leaders through educational programs and advancing knowledge through research and development.

Underground at Mines educates both undergraduate and graduate students. Undergraduates can enroll in any number of underground-related courses, participate in independent study research, attend the biweekly industry lunch-and-learn series, and attend field trips to underground projects.

Graduate students (both masters and doctorate levels) can pursue degree programs in civil, geological, mining, geophysics, and more, or enroll in the newly developed Underground Construction and Tunnel Engineering (UCTE) masters or doctoral program. The UCTE graduate degree program—the only such program in North America—is an interdisciplinary blend of civil, geological, and mining engineering that reflects the modern-day practice of underground engineering. The program attracts the best and brightest from around the world.

Educational efforts span beyond the classroom, with field trips, conference trips, and internships for students on project sites. For example, in March 2017, a group of 17 graduate and

Fig. 1: Graduate student looking at the ground-freezing techniques used in the cross-passage construction on the SR99 tunnel in Seattle

Fig. 2: Students and faculty attending March 2017 field trip to Seattle in a field of precast segmental liners

undergraduate students traveled to Seattle, WA, to visit three underground projects: the 57.4 ft (17.5 m) diameter Alaskan Way Viaduct replacement tunnel, the Sound Transit Northlink extension transit tunnel and stations, and the Sound Transit Eastlink tunnel in Belleview. This was the fourth field trip by Colorado School of Mines in recent years.

In a deeper effort to prepare future industry leaders, students involved with the Center attend industry conferences to cultivate an awareness of industry trends, technical challenges, and research needs. Conferences also provide important opportunities for networking with top industry experts. Nine graduate students from Mines were recently awarded scholarships to attend the Rapid Excavation and Tunneling Conference held in San Diego, CA, in June 2017, where they participated in sessions and met potential employers and collaborators.

Internships are an integral part of the underground tunneling construction and curriculum. On-the-job training provides students with the depth of knowledge necessary to enter the workforce immediately upon graduation. The Center provides recruiters with a focused group of budding tunnel experts ready for hire. Mines students involved with the Center, either through the degree program or research, are regularly placed in internships—and ultimately full-time positions—with companies throughout the underground industry.

Fig. 3: Shotcrete application instruction at Shotcrete short course in September 2016

Colorado School of Mines is at the forefront of advancing knowledge in underground construction. Through the Center, faculty and students work together on projects ranging from "blue sky" ideas to very applied. Student internships and longstanding professional relationships with industry partners ensure Mines has a finger on the pulse of the current challenges facing tunnel engineers, project managers, owners, and consultants. The university's dedicated underground construction and tunneling community is focused on solving current research topics, including sensing, control and automation of tunnel boring machines, advancing performance modeling of underground equipment, abrasivity and wear, imaging ahead of the face, shotcrete materials, soil conditioning, and many more. A complete list of projects can be found at **underground.mines.edu**.

Colorado School of Mines has recently expanded its reach in underground construction and tunneling research with the addition of a U.S. Department of Transportation-funded University Transportation Center (UTC) for Underground Transportation Infrastructure. The newly established UTC pursues research in rehabilitation and renewal of aging infrastructure with several projects related to aging lining, shotcrete behavior, and advances in shotcrete materials and construction methods.

In addition, Colorado School of Mines provides continuing education for industry professionals to expand on its mission to advance knowledge. Mines offered four short courses in 2016: Shotcrete; Geotechnical & Structural Instrumentation, Monitoring, and Information Engineering; Underground Grouting and Ground Improvement; and Tunneling Fundamentals, Practice and Innovation. These courses attracted hundreds of attendees from all levels of employment and provided professionals with opportunities to network and discuss research with Mines faculty and students. All net revenue generated from these professional short courses are fed back into tunneling education, providing Mines students with funding for field trips, lab equipment, guest-lecture seminars, and internships.

This September, Mines will hold their annual short course in Tunneling Fundamentals, Practice and Innovation. In 2016, this course drew over 120 participants and more than 20 speakers, representing a broad perspective on the tunneling industry from young and seasoned professionals alike. Colorado School of Mines is well-positioned for recognition as home to the most advanced tunneling research in the world. 2018 short course dates will be announced later this year. More information can be found at **underground.mines.edu**.

There are many ways for companies to get involved with Underground at Colorado School of Mines. Please contact the school if interested in sponsoring research, attending short courses, hosting interns, or presenting at a lunch and learn (**www.mines.edu**).

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