Schooling in earth systems

Levent Ozdemir conducted a tour of the CSM campus and stands here beside the full-scale linear cutting machine.

Educating tomorrow's engineers and operating a professional engineering laboratory is the successful combination of the Colorado School of Mines (CSM). Established more than 125 years ago - intentionally to train engineers for Colorado's fledgling cold mining industry - the CSM now boasts some 14 departments in the different fields of mining, tunneling, petroleum exploration, ground engineering and earth sciences. CSM is ranked the largest earth sciences school in the United States and has a current enrollment of some 3,300 students from 85 different countries.

"The school has widened its range of engineering studies considerably," explained Tibor Rozgonyi, Professor and Head of the Mining Engineering Department. "We are well known by our name but the limitations implied the Colorado School of Mines is misleading. We are still fully committed to our mining engineering program, but our areas of interest now extend into civil tunneling, technology research and development, computer aided design studies, and an ever growing emphasis on ecological and environmental studies. With these expanding fields of interest, our aim is to be a leading center of knowledge, learning, research and expertise in the varied fields of earth systems engineering. Our experience to date, our facilities, and our staff provide us with the resources to achieve this goal."

A recent tour of the school revealed the institution's dynamic mix of education and working laboratory. The rock excavation and tunneling research is undertaken by the school's self-supporting Excavation Engineering and Earth Mechanics Institute (EMI) established in 1974 .

"Providing a professional service to the international engineering industry is a positive policy of the school," said Levent Ozdemir, Professor of Mining and Director of EMI and the school's Center for Mine Mechanization and Automation. "Through its close ties to the school's faculty and student programs, EMI keeps the faculty up to date with industry developments and trends; it is a major source of research funding for the school; it provides students with real issues to investigate and study; and it creates thesis subjects for MSc and PhD students."

Over the years EMI, has been involved in high-ranking government projects which have assisted the school in obtaining sophisticated equipment and computing systems and has exposed it to leading edge technologies. "We were involved in the research during the 1970s and 80s of using TBMs to excavate rapid deployment missile egress tunnels and shafts for example," explained Ozdemir. "We have also been involved in the proposed Yucca Mountain nuclear waste storage repository in Nevada since 1982, exploring not only the excavation technologies but also the environmental issues and the long term geotechnical concerns."

On a more regular basis, EMI undertakes research studies for both equipment manufacturers and for design engineers and contractors. "We have the facilities to undertake all types of physical property measurements of rock and soils as well as apparatus for the full scale testing of machinery, cutting tools and mechanical components. We are also equipped to develop accurate performance predictions for all types of mining and rock excavation machinery, as well as undertake microseismic monitoring of the rock or soil mass stability analysis or as an early warning of impending failure. Ours is one of the most well equipped laboratories in the world and our record of projects completed is extensive and varied."

Machine performance predicability - now a more accurate science

For design engineers and contractors, EMI's rock testing facilities can conduct a full suite of rock property measurements including dynamic elastic constants, slake durability, and thin-section petrographic analysis. Its services also extends to Cerchar tool wear predictions; on-site or laboratory digital signal analysis of cutting tool vibrations for machine performance evaluation; and portable data acquisition and processing equipment for recording a wide range of operating parameters.

Among the school's most valuable assets is its library of computer-models and its extensive database for TBM performance prediction. The database is founded on 20 years of extensive laboratory research and field machine performance and analysis with validation using field data collected from projects worldwide.

Using the database, the modeling service can establish the required machine specifications for a new tunneling project; predict production rates and tool cost estimates for an existing machine in a given rock type; select the best cutting tools or develop the optimum cutter design to achieve maximum advance rates at the lowest tool cost for an excavation project; or redesign an existing cutterhead to minimize potential vibrations and optimize cutting efficiency.

"With this wealth of knowledge, we have seen major developments even in the most recent years," said Ozdemir. "TBMs of today for example can cut much harder rock than was the case 10 years ago. There have been significant power-based performance enhancement, but much of the improvement is also based on making the rock cutting process more efficient by optimizing the rock/machine interaction parameters through cutterhead geometry and cutter layout. With this and additional information at hand, owners, engineers, and contractors can plan projects with a much greater degree of confidence. Of course we still encounter incidents of unforeseen conditions, or rock behaving differently than anyone could have anticipated, but the overall outcome of a tunnel operation has become more highly predictable - depending on the amount of pre-project study, site investigation and rock property testing undertaken. Minimum preconstruction investigation should include basic computer modeling to develop estimates of construction schedules and costs which would further minimize the risk of tunneling projects for all parties."

Together with large diameter TBM studies, EMI has also established a research institute for microtunneling technology. Much of the existing equipment at the laboratory is applicable to the study of these mini- and microtunneling systems and programs have been added for design development of jacking pipes and associated ancillary equipment .

With the possibilities now available, tunneling has become a dedicated profession and less an offshoot of civil or mining engineering. In recognizing this, CSM introduced in 1998 a dedicated graduate two-year MSc and three-year PhD degree course in Earth Systems Engineering with particular emphasis on underground excavations, construction, and tunneling. At present there are 16 students in years one and two of the program and this is expected to increase to a total of about 60 in the next few years. "Our intention with these courses is to give an appreciation of various disciplines working together as a team," said Ozdemir. "Projects these days are the sum of various centers of expertise which must combine to present the whole package and the objective is to provide students with the knowledge and competency to approach projects in this combined manner."

In addition to preparing students for careers in earth sciences, the school also conducts 3-5 day short courses to familiarize those already in the industry with new developments and technologies.

"Tutors for these courses are invited professionals and experts within the various disciplines of the industry," said Ozdemir. "Our most successful series of courses are those conducted in conjunction with the NAT (North American Tunneling) conferences. We had 118 attendees at the last NAT and the next course is to be held on June 10-11 with the NAT conference in Boston in June this year. Courses overseas are also being organized. There is to be one in Korea in September 2000 and another is planned for Hong Kong during 2000."

Information about the course s and all services offered by the school and the EMI is available on the web at http://www.mines.edu/Acadmic/mining/emi/. ■