University of Colorado Boulder

Presents

On-line Certificate in Tunneling

Endorsed By

ASSOCIATION INTERNATIONALE DES TUNNELS ET DE L'ESPACE SOUTERRAIN AITES | ITA INTERNATIONAL TUNNELLING AND UNDERGROUND SPACE ASSOCIATION

Director: FULVIO TONON

Start date: Anytime!

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1 Who should attend

Engineers or engineering geologists with an MS and BS in Civil Engineering, Engineering Geology or Mining Engineering who want to obtain a working knowledge of tunnel design and construction by applying the fundamentals acquired in their BS and MS degrees (and possible professional experience).

2 The International Tunnelling and Underground Space Association (ITA)

ITA is a non-profit and non-governmental organization in consultative status, Special Category, with the United Nations Economic and Social Council (ECOSOC). The aims of the ITA are to encourage the use of the subsurface for the benefit of public, environment and sustainable development; and to promote advances in planning, design, construction, maintenance and safety of tunnels and underground space, by bringing together information thereon and by studying questions related thereto. Currently, the ITA is composed of 71 member nations. www.ita-aites.org

3 Where the Program is Housed

3.1 University of Colorado at Boulder (UCB)

- One of the largest public universities in the United States. http://www.colorado.edu/
- 786-acre main campus, 7,200 faculty and staff, 10 colleges and schools and 30,000 students
- 7,500 degrees awarded each year
- Annual research funding exceeding $350 million.

3.2 College of Engineering

- Annual research funding exceeding $72 million.
- 32nd best engineering school in the US (US News).
- 185 professorial faculty. http://www.colorado.edu/engineering/
- 5,400 students enrolled in 17 undergraduate and 10 graduate programs.

3.3 Department of Civil, Environmental, and Architectural Engineering (CEAE)

- Annual research funding exceeding $9 million.
- 19th best program (undergraduate) and 13th best program (graduate) in the US (US News).
- 49 professorial faculty. http://ceae.colorado.edu/
- 651 undergraduate students, 260 graduate students.

3.4 Be Boulder Anywhere

Be Boulder Anywhere has been providing distance education for more than 30 years. Its online, flipped, and hybrid programs are ideal for working professionals who want convenient, flexible graduate and professional education. Be Boulder Anywhere offers access to a variety of graduate degrees, professional certificates, and individual courses. http://beboulderanywhere.colorado.edu/

4 Motivation for the UCB Program

The motivations behind this program are as follows:

- Working professionals may hardly leave their current assignments for an extended period of time.
- Sustainability: each traveling individual creates 0.6 to 1 pound/mile (150-300 g/km) of carbon emissions.
- Industry demand for tunnel engineers is extremely high and ever increasing.
- Contractors cannot bid on projects because of lack of tunneling-educated manpower.
- Consulting firms cannot take on (more) projects because of lack of tunneling-educated manpower.
- Owners may lack expertise in tunneling because their last tunnel project was built a long time ago (>30 years), and personnel involved in those projects have long retired. However, more and more tunnel alternatives now pass the Environmental Impact Statement (EIS) because of increased environmental sensitivity, cost of land/real estate, congestion, and population increase.
- Because of the high demand and good compensation, engineers or engineering geologists enter the "tunneling business" by simply acquiring the nomenclature on tunneling "on the street" or "on the fly" without a firm understanding of the fundamentals.
- No ITA-endorsed program is currently offered in the Americas (North, Central and South)
- Very few tunneling courses are offered at US universities, and therefore it is very likely that civil engineers are not exposed to tunneling in their formal education.

5 Objectives of the UCB Program

At the end of the program, students will be able to:

- Move beyond acquiring nomenclature on tunneling.
- Acquire core fundamentals as they apply to tunneling.
- Acquire *working knowledge* of design or construction management of tunnels. In detail:
- Understand the mechanics of tunnel advance.
- Formulate investigation and monitoring programs for underground construction, and interpret their results for design and construction.
- Based on face stability analyses, subdivide an alignment into tunnel behavior categories.
- Select and design the appropriate excavation method.
- Select, compose and design the appropriate stabilization methods.
- Prepare and interpret construction specifications.
- Identify, quantify and manage risk in underground construction with an understanding of tunneling contractual practices.
- Proceed through detailed design of support and reinforcement.
- Manage a tunnel construction site, handle disputes, interpret and prepare contracts, schedules, and cost estimates.
- Work in a multi-cultural environment.

Students will be exposed to state-of-the-art/practice in tunneling and will rigorously master the material through homework assignments, projects, and internships.

6 Structure of the UCB Program

- Duration: depends on student's pace, but limited to 4 years.
- 11 Modules: General Tunneling Aspects; Engineering Geology, stresses, strains, and anisotropy; Engineering Rock Mechanics; Soil Mechanics and Geotechnical Engineering, Investigations Using Rock and Soil Mechanics; Analytical and Numerical Methods for Diagnosis Phase; Therapy Phase for Preliminary Confinement; Type A tunnels: Analytical Methods of Analysis and Design; Type A tunnels: Excavation in Rock; Therapy Phase and Construction Phase for Preconfinement (Type B and C Tunnels) and Final Lining; Mechanized Tunneling with Face Control for Type B and C Tunnels; Monitoring and Surveying; Risk Assessment and Management.
- Each Module is composed of: lectures and assignments by the Program Director that form the backbone of the Certificate and ensure continuity throughout the program; reviews by industry leaders; in-depth seminars with case-histories by industry leaders.
- Over one hundred seminars on tunneling topics by leading international experts. They drill deep into a specific topic and bring the industry perspective and case histories into the program. Comprehension questions or more complex homework assignments are assigned at the end of each seminar.
- All lectures and seminars have been recorded, and can be accessed by the students over the internet at any time and from any location.
- Over 40 homework assignments are reviewed and graded.
- Because students may have very different backgrounds and depths of knowledge, Modules 2, 3, and 4 form a common stepping stone for the rest of the program. The Program Director's teaching and homework assignments are at the level of: R.E. Goodman, Engineering Geology; R.E. Goodman, Rock Mechanics; J.A. Hudson and J.P. Harrison, Engineering Rock Mechanics; B.M. Das, Geotechnical Engineering; K. Terzaghi, R.B. Peck, G. Mesri, Soil Mechanics in Engineering Practice; D.M. Wood, Soil Behavior and Critical Soil Mechanics. All concepts and homework assignments are, however, geared toward underground design and construction: e.g., when the Atterberg limits are reviewed, they are immediately applied to the evaluation of ground stickiness in mechanized tunneling.
- Starting in Module 5, all homework assignments are taken from actual case histories, i.e. students are given the same data that was available to the designers, and are asked to proceed as if they were the actual designers. Students' solutions are compared against the actual design and construction solutions.
- All modules are tightly intertwined and build one on the other. This makes students understand that all aspects of tunneling (from the investigation phase to the construction phase) are connected, and forces students not to forget what they learned in previous modules. For example, in Module 8 students design a tunnel liner in the subsurface conditions analyzed in a homework assignment in Module 4.
- Use of RocScience codes Slide, Dips, Swedge, and Phase2 (www.rocscience.com); Midas GTS (www.tnodiana.com); ITASCA FLAC, UDEC, and PFC is included in the homework (www.itascacg.com). Theoretical background to the codes is explained in the lectures and mastered in the homework by

carrying out problems “by hand” and then checking the results with RocScience software. Hands-on applications of Midas GTS and ITASCA codes are included. Time-sensitive educational licenses are included in the fee and allow students to become familiar with industry standard software.

- Three-month internship at a construction site. Internship objectives are established in coordination with the Program Director and the construction site supervisor; a 2-page final report addresses how objectives were met, and is reviewed and approved by the construction site supervisor. **All students are responsible for finding and accomplishing their own internships**. This requirement is waived if a student demonstrates equivalent experience.
- A final face-to-face evaluation to be arranged with the Program Director, e.g., at the ITA World Tunneling Conference closer to the student’s graduation date.
- The cumulative number of lectures and time needed to complete the homework assignments positions the Certificate at about 60% of the load typically required for a Master’s Degree in a US university. This is the typical workload for a Certificate issued by a US university.

Although students have flexibility in pacing the lectures, it must be borne in mind that one week of lectures entails from 3 to 6 hours of lectures. Enough time must be allowed to master the material, and each homework assignment may take 9-12 hours to complete. “Road blocks” are established along the program curriculum at the end of each program module listed below so that students cannot advance unless all previous homework has been completed. **Therefore, a firm commitment must be made in order to be able to complete the Certificate.**

The following is a tentative list of modules and lectures. Changes may be made at any time to improve the program.

Module 1: General Tunneling Aspects

Lectures:
General aspects of tunnel design and construction; worldwide demand Experimental evidence and basic principles of tunneling

Industry Seminars:	
General Tunneling Aspects and Geometric Design of Tunnels, Relationships between Geotechnical/Structural Aspects and Functional Aspects of Tunnel Design and Planning	Nick Chen (AECOM, USA)
Architectural Design of the Underground Space	Kevin Peterson (Peterson Design, USA)
Underground Master Plans for Cities: the Helsinki Example	The City of Helsinki (Finland)
Water Tunnels to Clean River Waters: Portland CSO Project	The City of Portland (USA)
Fire safety in tunnels	Gary English (Seattle Fire Department, USA),
Ventilation Constraints in Tunnel Design and Planning: Road and Rail Tunnels	John Kennedy (Parsons Brinckerhoff, USA)
Tunnel inspection and rehabilitation: a consultant perspective	Henry Russell (Parsons Brinckerhoff, USA)
Design for Maintenance and Operation of Water Tunnels from the Owner's Viewpoint	Terry Fallesen (Southern California Edison, USA)
Design and Construction Management in Tunnel Projects	Chris Bennett (AECOM, USA)
Consulting in a worldwide market	William F. Brumund (Golder Associates, USA)

Module 2: Engineering Geology, stresses, strains, and anisotropy

Lectures:	**HW**
Introduction Rock Forming Minerals Plutonic Igneous Rocks	2.1
Volcanic Rocks Epiclastic Sedimentary Rocks	2.2
Soluble Sedimentary Rocks Metamorphic Rocks Summary and Folds and Faults	2.3 2.4
Review of Mathematical Concepts Strain Stress Elasticity and Anisotropy	 2.5 2.6

Review of MS-level material and its application to tunneling:	
Applied Geophysics and its Application to Tunneling *Assignment*: Proposal for a geophysical exploration and analysis of actual geophysical data from case history	Claude Robillard (Associated Geosciences, Canada)

Industry Seminars:	
Geophysical Methods for Investigating the Ground Ahead of the Tunnel Face	Thomas Dickmann (Amberg Technologies AG, Switzerland)
Engineering geology for tunnels: sedimentary rocks	Russell Jernigan (Brierley Associates, USA)
Case histories of tunneling in Karst terrain	Mingzhou Bai (Beijing Jiaotong University, China)
Engineering geology for tunnels: igneous rocks	Höfer-Öllinger Giorgio (Geoconsult, Austria)
Engineering geology for tunnels: metamorphic rocks	Chris Snee (Sneeconsult, USA)
Drill Holes, Core Borings, and in-the-hole Tests in Rock	Rebecca Russo (Fugro, USA)

Module 3: Engineering Rock Mechanics

Lectures:	**HW**
In situ Stress and its Measurement	3.1
Intact Rock: Index Properties, Permeability, Uniaxial Compressive Strength Intact Rock: Triaxial Test, Failure Criteria, Swelling	3.2
Discontinuities: Mechanical Properties and Testing Techniques Characterization, Geometric Properties, Stereographic Projection (c, d) Fracture Patterns and Discrete Fracture Networks	 3.3 3.4, 3.5
Rock Mass Classifications Rock Mass Behavior and Continuum vs. Discontinuum	3.6
Water Flow in Single Fracture Water Flow in Rock Masses Effect of Clusters on Groundwater Flow and Grouting	3.7

Review of MS-level material and its application to tunneling:	
Physical Hydrogeology *Assignment*: Read UTRC case-histories on groundwater inflow. Study geo-hydrology report for an actual construction site and predict groundwater inflow	Höfer-Öllinger Giorgio (Geoconsult, Austria)

Industry Seminars:	
Case histories in rock stress measurement	Eivind Grøv (Sintef, Norway)
Case histories in hydraulic fracturing rock stress measurement	Tom Doe (Golder Associates, USA)
Some Observations on Modes of Failure and Their Analysis for Jointed Rock Masses	Richard Goodman (University of California, Berkeley, USA)
Ongoing challenges in Engineering Geology for tunnelling in difficult ground (Janhs Lecture)	Paul Marinos (University of Athens, Greece)
Groundwater inflow: current simplified methods and case histories	Jon Kaneshiro (Parsons, USA)
Tunneling through Mountain Faults	Don W. Deere (Deere and Ault, USA)
Discrete Fracture Networks for Tunneling: 1. Overview continuum vs. discontinuum 2. Intro to DFN Modeling 3. Derivation of fracture properties 4. DFN Workflow - Portugues Dam Example 5. Fractured Rock Conceptual Models 6. Tunneling Hydrogeology 7. Upscaling Hydrogeology to Grid Models 8. Conclusions	Bill Dershowitz (Golder Associates, USA)

Module 4: Soil Mechanics and Geotechnical Engineering, Investigations Using Rock and Soil Mechanics

Lectures:	**HW**
Weight-volume Relationships, Permeability, Seepage, Effective Stresses in Drained Conditions	4.1
Effective Stresses in Undrained Conditions, Triaxial and Shear Tests	4.2
In situ Tests	4.3
Shear Strength and Deformability of Soils, Effective vs. Total stress	4.4
Critical State Soil Mechanics, Cam-Clay	4.5
Investigations for Underground Design and Construction	4.6

Industry Seminars:	
Investigations for Soft-Ground Tunneling	Red Robinson (Shannon and Wilson, USA)
Geotechnical baseline report	Timothy Smirnov, (Parsons Brinckerhoff, USA)
Examples of Geotechnical Baseline Reports	Barry R. Doyle (MWH, USA)
Shafts	Glenn Boyce (McMillen Jacobs Associates, USA)
Slurry Walls, a contractor's perspective	Giancarlo Santarelli (Bencor, USA)
An Overview of Soft Ground Tunneling from a Consultant Perspective	Timothy Smirnov, (Parsons Brinckerhoff, USA)
NATM and sequential excavation method	Harald Wagner (Consultant, Austria)
Analysis of COntrolled DEformations (ADECO)	Pietro Lunardi (RockSoil, Italy)

Module 5: Analytical and Numerical Methods for the Diagnosis Phase; Primary Confinement for the Therapy Phase

Lectures:	**HW**
Diagnosis Phase: Action and Reaction • Convergence Curves to Determine Action and Reaction	5.1
• Characterization of tunnel behavior A, B, C with: • Convergence Curves, • Numerical Methods for Soils and Equivalent Continuous Rock Masses • Numerical Methods for Discontinuum	
The Finite Element Method for Non-linear Problems: • Principle of Virtual Works and its FEM Discretization, Residual Force Equations and Stiffness Matrices • Special Aspects of Tunneling Applications	5.2
Therapy Phase: • Overview and choice of excavation system	5.3
• Confinement and Preconfinement as Stabilization Methods, Composition of Sections	
• Convergence-confinement Method and 2-D FEM Analysis of Ground-Structure Interaction	
• Preliminary Confinement: Steel Ribs	
• Preliminary Confinement: Radial Bolts and Dowels, Shotcrete	5.4

Industry Seminars:	
Geological constraints and geotechnical issues in mechanized tunneling	Paul Marinos (University of Athens, Greece)
Continuum Analyses: Boundary Element (BE) Analyses and Coupled FE-BE Analyses for Underground Excavations	Christian Dunser (University of Graz, Austria)
Continuum Analyses: Practical Aspects of Finite Element (FE) Analyses in Geotechnical Engineering and Tunneling	Ahmed Elkadi (Midas GTS, The Netherlands)
Continuum Analyses: Finite Element Analysis of Underground Excavations and Ground-Structure Interaction	Taner Aydogmus (Hochtief, Germany)
Continuum Analyses: FLAC	ITASCA
Discontinuum Analyses: UDEC and 3DEC	ITASCA
Discontinuum Analyses: PFC and PFC3D	David Potyondy (Itasca, USA)
Discontinuum Analyses: DDA and 3D-DDA	Gen-Hua Shi (Consultant,USA)
Rockbolts and rock dowels technology	Robert Weir (Williams USA)
Reinforcement Systems and Swellex	Bill Warfield (Atlas Copco, USA)
Use of fibers for tunneling applications	Bruno Rossi (Maccaferri, Italy)
Shotcrete and concrete technology	Mapei and Sika
Steel set, lattice girders and liner plate technology	Ron Smith (American Commercial-DSI, USA)

Module 6: Type A tunnels: Analytical Methods of Analysis and Design

Lectures:	**HW**
Discontinuum Rock Masses: Block Theory and its Applications to Surface and Underground Excavations Introduction and Basic Equations Finiteness, Removability, Mode and Stability Analyses Portals and Tunnel Face, Active Forces, Design Considerations	6.1 6.2 6.3
Discontinuum Rock Masses: Rock Slope Stability	6.4
Equivalent Continuum Rock Masses: Elastic Solutions	6.5
Discontinuum Rock Masses: Tunnels with a Single Discontinuity Tunnels parallel to a Fracture Set: Slippage and Buckling Tunnels in Horizontally-Bedded Rock Masses Tunnels in Rock Masses with Ubiquitous Joints	

Industry Seminars:	
Application of Block Theory to Tunnels and Portals with Case Histories	Matthew Mauldon (Virginia Tech, USA)
Case histories of rock slope analysis and stabilization at tunnel portals	Duncan C. Wyllie (Wyllie & Norrish Rock Engineers, Canada)
Case Histories of Reinforcement Design for Tunnels in Discontinuous Rock	Michael McRae (Jacobs Associates, USA)
Case Histories of Rock Cavern Design	Ed Cording (University of Illinois, USA)
Water taps and sewer outfalls: why we need them, what they are, hydraulic constraints, design and construction considerations, case histories.	Jon Kaneshiro (Parsons, USA)

Module 7: Type A tunnels: Excavation in Rock

Lectures:	**HW**
Excavation Principles	
Blasting: Introduction Analysis of Blasting Effect Design of Rounds for Slopes and Tunnels, and Controlled Blasting Vibrations and Vibration Control	7.1
Hard rock TBMs: Principles and boring operation Thrust and different types of machines	

Industry Seminars:	
Drilling technology	Juha Kukkonen (Sandvik, Finland)
Blasting Technology: the European Perspective	Demostenes Efstratiadis (Consultant, Italy)
Blasting technology: the US Perspective	Gordon Revey (Revey Associates, Inc., USA)
Rock tunnel boring machines: Manufacturer’s perspective	Brian Kalighi (Robbins, USA)
Rock tunnel boring machines: Contractor's perspective	TBA
Choice of rock tunnel boring machines	Stefan Skuk (Brenner Base Tunnel, Italy-Austria)
Prediction of cutter life and penetration rate for hard rock TBMs	GianCarlo Cardone (SWECO, Sweden)
Roadheaders	Sandvik (Austria)
Rail-based equipment for tunneling applications	TBA
Conveyor systems for tunneling applications	TBA
Equipment for lifting and charging, scaling and hauling, spraying	Normet (Finland)
Case History: Gotthard Base Tunnel, Switzerland	Heinz Ehrbar (Alptransit, Switzerland)

Module 8: Preconfinement for Type B and C Tunnels; Final Lining and Waterproofing

Lectures:	**HW**
Tunnels under the water table and preconfinement by drain umbrella Final Confinement: one pass and two pass segmental lining Final Confinement: cast-in-place lining and invert Construction Phase: Waterproofing	8.1 8.2
Preconfinement with grouting umbrella and compensation grouting Preconfinement: jet grouting umbrellas Preconfinement: fiberglass dowels	8.3
Preconfinement: freezing Preconfinement: precut and pretunnel, Presupport: micropile umbrellas	8.4
Seismic Design of Tunnels	8.5

Industry Seminars:	
Plants for and Production of Concrete Pre Cast Segments	Bruno Candeloro (CIFA, Italy)
Concrete Pre Cast Segments: Design, Interface with TBM, Transport, Installation	Harald Wagner (Consltant, Austria)
Fiber-reinforced Concrete Precast Segments and Cast-in-Place Final Lining	Giovanni Plizzari (University of Brescia, Italy)
Grouting for Segmental Lining	David Crouthamel (Jacobs Associates, USA)
Formworks and Work Cycle for Cast-in-Place Concrete Lining	Eugenio Bertino (CIFA, Italy)
Pressure Tunnel Linings: • Design Considerations for Locating Pressure Tunnels and Shafts • Stabilization of Tunnel and Shaft Excavations • Concrete Tunnel and Shaft Liners • Steel Tunnel and Shaft Liners	Greg Raines (MWH, USA)
Jet grouting for Underground Works	Trevi, Italy
Fiber-glass Reinforcement of Tunnel Core	Carla Zenti (Elas, Italy)
Micropiles in Underground Construction	Trevi, Italy
Freezing for Underground Construction	Joe Sopko (Mortrech, USA)
Permeation Grouting	Hayward Baker (USA)
Hot bitumen grouting in Karst terrain	ECO Grouting Specialists
Compensation Grouting	ECO Grouting Specialists
Waterproofing	Alberto Scuero (Carpitech, Switzerland)
Organization of Tunnel Construction Sites	Antonio Nicola (Impregilo, Italy)

Module 9: Mechanized Tunneling with Face Control for Category B and C Tunnels

Lectures:	**HW**
Shield Tunneling methods in soft ground Transport facilities, separation and depositing, tailskin seals, grouting and injection procedures	
Slurry Machines Face Support for Slurry Machines	9.1
Earth Pressure Balance Machines EPBMs Face Support for EPBMs	9.2

Industry Seminars:	
Double-shield tunnel boring machines	Alessandro Tricamo (Impregilo-SA Healy, USA)
EPBMs: Manufacturer's perspective	TBA
Soil conditioners for EPBMs	Richard Schulkins (Mapei, Singapore)
Slurry Machines: Manufacturer's perspective	Steve Short (Herrenknecht, USA)
Slurry Machines and EPBMs: Contractor's perspective	Alessandro Tricamo (Impregilo-SA Healy, USA)
Bearings, Seals, and Drives	TBA
Settlements	Verya Nasri (AECOM, USA)
Mechanized tunneling in boulder-laden ground	Glen Frank (Jae Dee Contractors, USA)
Microtunneling and Trenchless Technology	Ray Sterling (Luisiana Tech, USA)
Shanghai Yangtze River Tunnel	Qunfang Hu (Tongji University, China)
Major Mechanized Tunneling Projects in the United States	Timothy Smirnov (Parsons Brinckerhoff, USA)

Module 10: Monitoring, Surveying and Safety

Lectures:	**HW**
Monitoring	10.1

Industry Seminars:	
Tunnel Monitoring for NATM	Klaus Chmelina (Geodata, Austria)
Tunnel Monitoring for ADECO	Alberto Ballestrieri (3S, Italy)
Surveying for Conventional Tunnels: Use of Total Station, Laserscanner, Guidance Systems for Roadheaders, Excavators, and Bolters	Amberg Technologies (Amberg, Switzerland)
Surveying for TBM Tunnels: Machine Guidance and Precast Segment Erection Control	Nod Clarke-Hackston (VMT, Germany)
Health and Safety in underground construction: United States	Gerald Fulghum (Consultant, USA)
Health and Safety in underground construction: European Union and UK	Donald Lamont (UK Health and Safety Executive, UK)

Module 11: Risk Assessment, Risk Management, and Contracting

Industry Seminars:	
Project Controls and Cost Estimating	Jim Peregoy (Peregoy Construction Services, USA)
Contract Documents for Subsurface Projects	David Corkum (Donovan Hatem LLP, USA)
Decision and Risk Analysis	Bill Roberds (Golder Associates, USA)
Risk Registers	Bob Goodfellow (Aldea Services, LLC, USA)
Dispute Resolution Mechanisms for Differing Site Conditions Claims	Robert Fitzgerald (Watt, Tieder, Hoffar & Fitzgerald, L.L.P., USA)
Professional Liability and Risk Allocation/Management Considerations for Design and Construction Management Professionals Involved in Subsurface Projects	David Hatem (Donovan Hatem LLP, USA)

7 Diplomas

After completion of all assigned homework and comprehension questions with 70% passing grade, and completion of internship, the University of Colorado at Boulder will award the “Certificate in Tunneling”.

8 Registration and Cost

Registrations are accepted all year round and students may start at any time. Please contact the Program Director with your CV and enquiry about registration.

Cost (does not include cost of books, which must be separately purchased by the attendee): USD 15,000 (fifteen thousand). Students may cancel after the first or the second module. Payment is module by module.

9 Reviews

“The program you have set up is impressive in both scope and the degree of connection with tunneling practice. It is definitely meeting particularly the requirements of the overheated American tunneling market. But also I am sure that young engineers educated in the way your program facilitates will not have a problem to find their way internationally too. Anyway, we would welcome them to apply for a job in tunneling with HOCHTIEF internationally.” Hansgeorg Balthaus, Vors. der Geschäftsleitung/Management Chairman HOCHTIEF Consult HOCHTIEF Construction AG Alfredstraße 236, 45133 Essen, Germany.

“I have the opportunity to participate in the lectures held by Prof. Tonon from my base London through the means of e-learning. The scope of the course is focused on the tunnelling industry with particular attention paid to both the Design and Construction phases. The competence of the professor is very high and this is reflected in the technical level of the lectures. The topics are well presented and are supported by Technical Papers as well as Homework Assignments. On a personal level I am finding the course very challenging and worthwhile. The online system is very flexible (the lectures are viewed on-demand) and this allows me to conjugate the course with work. The handouts will be very useful as reference material in the future. I hold a MSc in Civil-Structural Engineering and I would recommend the course to Graduates exposed to the tunnelling industry as I have been.” Paolo Perugini, Graduate Tunnelling Engineer, Crossrail AADT, ArupAtkins Design Team, UK.

“Dr. Tonon, I have to say that the material has been great so far and I look forward to start the tunneling course and apply all this theory.” Santiago Camino, tunnel design engineer, Ecuador, on the Modules 1-4 of the Certificate.

“I find the course material very useful in my day-to-day job.” Enrico Brandoni, Field Tunnel Engineer, CMC-Ravenna, Italy.

10 ITA Level of Endorsement

The UCB program was formerly offered at the University of Texas at Austin, where it was endorsed by the ITA-CET at the end of 2010 as an “International Grade Type A – On line Teaching”. The program at UCB was endorsed by the ITA-CET (ITA Committee on Education and Training) during the Dubrovnik meeting of the ITA-CET. According to the current ITA endorsement classification, the endorsement level is “ITA-5y-En” (ITA endorsement for a program that requires 5 years of university education as a prerequisite, and that is taught in the English language).