Since the early 1800s, tunnels have been constructed to serve North American society, which began with water tunnels to serve the drinking water needs of cities to water tunnels to serve the construction of canals. With the invention of the railroad and its meteoric expansion, the need for tunnels grew as the railroads expanded their service across North America. By 1850, more than 16 railroad tunnels had been constructed. One of the most important infrastructure programs in our history is the Transcontinental Railroad Act signed into law by Abraham Lincoln on May 6, 1862. Connecting the east and west United States would not have been possible without the 15 tunnels built in the Sierra Nevada mountain range.

The need for tunnels grew in the post-Civil War economic expansion period as the railroads flourished. Cities built tunnels to bring fresh water into the city and to safely transport wastewater to plants for treatment. At the turn of the 20th century, Boston and then New York City built tunnels for their subway systems to improve the quality of life in the urban environment. Because of their success, these subway systems were expanded and other cities soon built their own underground transportation systems. With the advent of the automobile, more tunnels were soon needed to facilitate vehicular movement across North America.

Technological Advances

The underground construction industry has faced many technological changes beginning in the mid 1950s with the introduction of wheeled tunnel boring machines for cutting through soft rock, the introduction of multi-boom hydraulic face...
drills for conventional tunnel and cavern excavation, and the introduction of earth pressure balance tunnel boring machines for soft ground applications that precludes the need for workers to build tunnels using very harmful compressed air procedures.

Innovations occurred in the tunnel support marketplace with the introduction of one-pass precast concrete segmental tunnel linings for soft ground applications replacing cast iron tubbings, rock bolts, high performance shotcrete and shotcrete application equipment, and new developments in final lining concrete and forming equipment. Major innovations also occurred in supportive excavation methods and procedures that allowed the tunnel designers to place tunnels where they were needed while providing safe and proven supportive excavation systems constructed for worker safety and project cost controls.

In 2017, the Underground Construction Association (UCA) of the Society for Mining, Metallurgy and Exploration (SME) published a book titled *The History of Tunneling in the United States*, which details the history of tunneling beginning with the first tunnels, as noted above, to the current tunneling programs underway in urban areas. The book provides details about railroad tunnels, transit tunnels, highway tunnels, water tunnels and wastewater tunnels, in addition to a chapter dedicated to innovations in tunneling that describes how technology has changed the industry. This book highlights the many societal
benefits that are and have been derived from the tunneling industry. Additional details about the book and purchasing information can be found in the SME Store at www.smenet.org.

**Ongoing and Proposed Major Tunnel Programs**

Presently, there are more than $25 billion of ongoing and planned major tunnel programs across North America, representing more than 380 mi (610 km) of underground construction work. The projects include major Combined Storm Overflow (CSO) programs in many cities throughout the U.S. and Canada. Major transit upgrades and expansions are underway in or planned for New York, Seattle, Washington D.C., Dallas, Toronto and Vancouver.

The California WaterFix project in central California is an extensive water distribution program being proposed that will present many industry challenges because of its size and complexity. In Los Angeles, an expansion of the subway program is underway with additional sections being planned to accommodate the upcoming 2028 Olympics transportation requirements.

The proposed Amtrak Gateway Tunnel Project in New York is a multibillion-dollar railroad tunnel program to tunnel under the Hudson River. In addition, the New York Metropolitan Transportation Authority (MTA), with a daily ridership of about 8,600,000, is designing Phase II of the Second Avenue Subway line, and the New York City Department of Environmental Protection (NYCDEP) is planning a major CSO project near Flushing Bay.

Tunnel construction represents a growing and vibrant segment of today’s construction economy. Tunneling projects integrate not only tunneling but also other aspects of deep foundations and specialty construction practices to create the infrastructure of tomorrow. These projects create and require continuing advancement in
methods and materials in a broad spectrum of technology and opportunities. The challenges ahead require us to recruit and train new talent to continue to allow this industry to thrive.

Innovation Through Industry-Academia Engagement

As part of their capstone design project, a group of undergraduate seniors at Michigan Technological University (MTU) have been working on developing a potential and feasible solution to protect the gas, oil and electrical lines beneath the Straits of Mackinac while also protecting the Great Lakes from an environmental disaster. The project entails learning about tunnel design and construction, geo-socio-environmental concerns, and evaluating how to construct a tunnel beneath the straits.

New DFI Tunnel and Underground Systems Technical Committee

The challenges for the tunnel industry are to continue to develop the technology and personnel to design and build these complex construction projects that are demanded by a modern society. The role of the new DFI Tunnel and Underground Systems Technical Committee is to assist in the development and promotion of these technologies and people. Our objective is to create a committee that allows all people from the industry to participate in task groups pertaining to their area of expertise or interest that promote and share new ideas and technologies that solve problems and meet the challenges of the industry. The task groups are being formed to include not only senior industry people but also young people who have an interest in a particular aspect of the industry and want to contribute and learn.

If you have a specific tunnel industry subject that you would like addressed or if you are interested in being the chair a specific task group, please contact either of the authors, who are both the co-chairs of the Tunnel and Underground Systems Technical Committee.

David R. Klug is president of David R. Klug and Associates and co-chair of DFI’s Tunnel and Underground Systems Technical Committee. Klug provides international and national manufacturer representative services to the underground heavy civil and mining construction industries. He has more than 40 years of industry involvement in many of the major tunnel programs constructed in the U.S. and Canada.

James Morrison, P.E., is a vice president of COWI, co-chair of DFI’s Tunnel and Underground Systems Technical Committee and past president of DFI. He has more than 35 years of civil engineering experience. His career has covered a broad spectrum of large and complex underground and heavy construction working on bridges, dams, hydroelectric generating plants, highways, deep excavations, transportation and water/wastewater tunneling projects.

As Professor Michael T. Drewyor, P.E., P.S., explains, the capstone project entails designing a conceptual tunnel that would carry Enbridge’s Line 5, TransCanada’s natural gas line and American Transmission Company’s six electrical lines currently crossing the straits, while incorporating space for future utility lines within the tunnel. As an added design consideration, the tunnel would be supplied with rails running through the center, which would allow maintenance vehicles to pass through and could also allow emergency access between Michigan’s two peninsulas should the Mackinac Bridge need to be closed.

The MTU students worked in four teams to develop solutions to the challenge—(1) above-ground buildings, permitting and land acquisition, (2) the straits’ geology, (3) design of the tunnel’s cross-section and (4) evaluating the best access route for the corridor. The students received input from industry experts and used actual geotechnical information obtained from different sources, including actual core samples and data from the U.S. Army Corps of Engineers.

Four recent MTU students with industry advisor Jim Morrison (fourth from right) and lawmakers after presenting their design project.