

Drilling down

The R&D aspects of modern tunnel design and construction

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Tunnel design and construction is an innovative and evolving industry. With crowded cities, growing populations and sensitive underground infrastructure, cutting edge technology and creative solutions often are necessary to complete any project.

Engineers face challenges not only in digging the tunnel, but also in designing a safe and lasting structure that is compatible with hidden pipes, electrical wiring, other tunnels, and a conglomerate of buildings, roads and parks.

As innovation continues to grow, there is a wide range of technologies available to assist engineers in meeting these challenges. Tunnel boring machines are increasingly being used to carve out the initial path through the soil as they become more flexible, durable and precise. Sensors are becoming the common method of collecting data, not only from the soil and ground movements before construction, but also from tunnel conditions after the project is complete.

In addition, cutting edge computer software is increasingly becoming more detailed, accurate and intelligent, which not only helps engineers and designers make accurate predictions about the effects of the tunnel on the environment, but also analyze traffic patterns, water flow and deterioration over time. Federal and state tax incentives area available to encourage and support innovation related to tunnel design and construction..

The Federal Research & Development Tax Credit

Enacted in 1981, the Federal Research and Development (R&D) Tax Credit allows a credit of up to 13 percent of eligible spending for new and improved products and processes. Qualified research must meet the following four criteria:

- New or improved products, processes, or software
- Technological in nature
- Elimination of uncertainty
- Process of experimentation

Eligible costs include employee wages, cost of supplies, cost of testing, contract research expenses and costs associated with developing a patent. At the end of last year, President Obama signed the bill extending the R&D tax credit for the 2014 tax year.

Tunnel boring machines

Tunnel boring machines are increasingly being used for tunneling in a range of different geological conditions. Rock and soil mixtures can vary widely, not only from project to project, but also within projects themselves.

Due to the soil variance, boring machine disc rotors must be designed for high effectiveness even as the machine moves between differing environments. Creating the optimum disc rotor for any given project involves an in-depth understanding of geological conditions and a process of experimentation using simulation.

Numerous attempts have been made to make disc cutters that are not only effective in a range of different environments but that also have longer useful lives. Some solutions involve applying a hardened coating. But during each rotation, the disc cutters experience a combination of tensile and compressive stresses that undermine the effect of the coating.

One team of innovators from the Oak Ridge National Laboratory has developed an innovative solution called the NanoSHIELD. This technology involves a nano-structured protective coating that is not only versatile but can also extend the life of disc cutters by at least 20 percent. That 20 percent increase can often mean millions of dollars in savings over the life of a project.





In fact, the project was such a success that the team of scientists and engineers was awarded an "R&D 100" award for their product innovation.

Smart tunnels

Modern technology has given some tunnels the ability to collect data about their dynamics and environment. Small sensors scattered throughout the tunnel measure physical conditions such as temperature, vibration and strain. This produces a stream of data that can be analyzed by a computer to provide continuous monitoring and alert engineers when maintenance is needed.

In addition, infrared technology, automatic incident detection (AID) and innovative video technologies are implemented in traffic tunnels in order to achieve an optimized traffic flow. The infrared sensors can detect overheating vehicles, while the laser scanners recognize vehicle shapes, composition of traffic flow, vehicle height and estimation of the number of persons in the tunnel at any given time.

Tunnel lining & fire protection

Even simple technologies like tunnel walls involve innovation. Automated robots are increasingly utilized for painting tunnel walls with fireproof coatings, products, which often are patented themselves for their innovative properties. Lindstrand Technologies Ltd created a product that fights tunnel fire by sealing off oxygen to parts of the tunnel that catch fire.

The deflatable tunnel plug actually inflates in the case of an emergency in order to seal in smoke and other harmful agents in the air. Siemens, the large global automation company, also has innovative technology that can detect a fire, verify by human review and, in some cases, put it out without assistance.

Modern tunneling is an evolving industry. Today's infrastructure in crowded cities means that engineers must consider the extremely complex dynamics that come into play when altering the ground under buildings, roads, and parks. Not only that, but the tunnels constantly must be maintained and monitored in hard to reach places.

Engineers and consulting firms often use innovative technology in tunnel design, construction, and maintenance. Companies engaged in innovative activities related to tunnel technology are eligible for federal and state R&D tax credits. **CCR**

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