Mitigating risk on tunnel projects

Andreas Beil, managing director, D2 Consult International GmbH and Kevin McArdle, works superintendent, Currie & Brown UK, discuss the risk issues inherent in large infrastructural tunnel projects.

Andreas: The 4.8km Bosruck tunnel on Highway A9 between Linz and Graz in Austria may not have the cachet of 'super tunnel' projects like the Channel Tunnel, but it is fairly unusual in the industry as it was opened on time and almost within budget.

This is because there was a great deal of geotechnical data available before the contract was drawn up, allowing us to properly assess the risks to the project and to agree a realistic budget with the client, the Federal Austrian Road Authority (ASFINAG).

Tunneling projects are inherently high-risk civil engineering enterprises, and many end up with considerable overruns on budget and completion dates because of underground conditions that were not considered or anticipated when the contract was drawn up.

These risks include design and construction issues created by changing geological conditions, the safety of workers, and third-party issues, such as health and safety, environmental risk and property/infrastructure damage – particularly when tunnelling in urban areas. Then there are the risks to the clients in terms of delay and cost overruns.

In our work for large public infrastructure projects over the past 15 years, clients have seen the advantages of adopting a comprehensive risk assessment process before the contract is even put out to tender.

The aim of our risk assessment model is to identify the risk factors at the earliest stage of the project and to develop strategies and allocate funds in order to offset this.

Once we know what the risks are we can develop countermeasures to reduce them and incorporate these into the project’s design, as well as in the construction methods.

This risk assessment is dynamic, and the design of the contract must make allowances for adjustments to accommodate new information and changes to the underground conditions or other risk factors as work progresses.

So, the earlier we start with the risk assessment process, the more money we can save during the project.

The more information you have on a tunnel project, the greater the ability to predict potential risk, so we have to convince any client that a comprehensive geotechnical investigation is a must at the beginning of any project.

While clients may want to keep costs down, the risk assessment model is able to show them the risk they carry by not having more geotechnical information. This way they can make a decision about the amount of risk they want to carry.

The underlying geology affects not only the design of a tunnel, but also the construction methodology.

On large projects, a tunnel boring machine (TBM), costing many millions of euros, will be constructed and delivered to the site. Each machine is built with different specifications to
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match the unique demands of each tunnel project, eg hard rock boring for the Austrian Alps compared with softer tunnelling conditions in the clay under London in the Crossrail tunnel project.

So, once the TBM is commissioned on site, there is no opportunity to make any adjustments later on if the geological conditions in the tunnel change.

There are several examples around the world where the TBM failed because of problems with variable rock conditions underground.

**Kevin:** Once the boring has started then constant communication is crucial between the contractor and the client. It’s critical to continually assess underground conditions and to communicate how changes could affect the risk to the overall project.

I worked on the Crossrail project, which is the biggest construction project in Europe and is one of the largest single infrastructure investments ever undertaken in the UK. When we were tunnelling through the clay, we came across thick sand lenses with water under pressure, known as ‘running sands’. These would spill into the excavated area of the tunnel when we hit them. This required significant mitigation measures such as applying sprayed concrete lining (SCL) to the tunnel walls to seal them and keep conditions safe.

This intervention hindered progress, as these sands could not be anticipated, so when we hit them we’d have to reverse the excavator and spray the face with SCL to stop any collapse, then continue with excavation for the tunnel drive.

The challenges for engineers and consultants working on the Channel Tunnel were even greater – the team had not anticipated how fractured the seabed rock was and there were times when we were flooded up to our waists in cold seawater until the water pumps could clear the tunnel segments out and allow us to continue with lining the walls.

Whenever you are tunnelling you need regular briefings on the conditions underground so that you can anticipate any changes as soon as possible – it could change within a 12-hour shift… or within 10 metres of boring.

**Andreas:** That’s what’s so unique about tunnelling projects – the ground conditions can change and this can have serious consequences for the projects.

For example, the 8.8km Rohtang Tunnel, being built under the Rohtang Pass in the eastern Pir Panjal range of the Himalayas in India, has been delayed for more than two years after they came across a fault zone that had originally been estimated at 70 metres, but in reality was more than 400 metres wide.

We don’t really know what the overrun on the budget will be, but it’s estimated to be in the order of 50-60%.

Although the terrain in the Himalayas makes it difficult for vertical drilling to obtain detailed geological data, there are other options available, such as drilling horizontal investigations in advance of the work while it is under way. A good risk assessment model would have included this type of option in the contract.

The successful completion of the Bosruck tunnel project in Austria is an example of how risk assessment is a good tool not only for identifying risk, but also to give the client the opportunity to provide a realistic budget.