INTERNATIONAL EDITION
May 2020

Tunnels AND TUNNELLING

ORANGE LINE

Breakthrough on the Contract E3 westbound tunnel for Bangkok's new line

THE CALCULUS OF TUNNELLING

Jason Kolenda, geotechnical engineer and laboratory testing department manager for EBA Engineering looks at the challenges of scheduling and delivery

For large tunnelling projects, particularly in densely populated urban centers, many civic leaders are exploring alternative delivery methods. The ability to forecast potential challenges ahead of time assists in planning efforts for a successful project and helps the process to run smoothly, even enhancing it in pre-planning efforts to mitigate risk.

Building a tunnel comes with many challenges and potential disruptions to the surrounding infrastructure. These types of projects are highly involved, but there is a keen focus on keeping to aggressive schedules and multi-layered phasing.

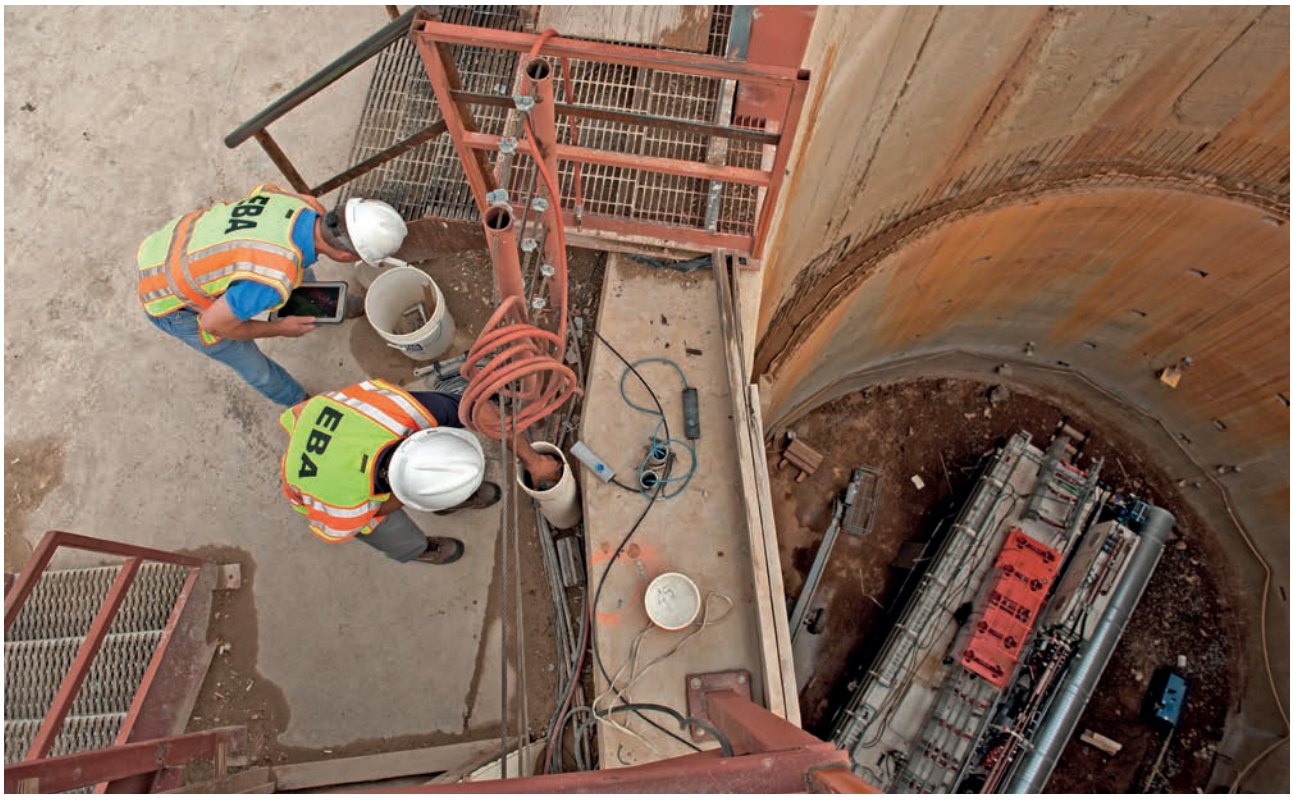
The schedule is vital, and one small issue can throw the entire project off track. Therefore, the project team must vigilantly maintain the project schedule amidst complex planning and process stages.

CHALLENGES AND APPROACH

Permitting. One of the most time-consuming steps is permitting for a tunnel project. This is a complex process involving a variety of permits from multiple agencies. Preconstruction condition surveys are required for the site but, before those inspections can take place, the team must obtain a right of entry agreement with property and utility owners to examine their structures.

This work must be completed prior to design, as the condition of existing structures near the site informs and determines key design decisions. An iterative design review commences, and the long and complex permitting process follows before construction can begin.

Dynamic nature. Because of the dynamic nature of alternative project delivery methods, schedules and planning are more complicated than with traditional methods. Design starts, even as the competitive bidding process is underway. Multiple permits require time, expertise, and coordination in order to obtain them without delaying the project. The compressed schedule and competitive budget present inherent challenges; therefore, selection of a competent team is imperative in this intense environment.



Below: A single schedule issue can throw the entire programme, says Kolenda

Schedule. Contractors, in an alternative delivery scenario, have a vested interest in delivering the project on schedule as the responsibility for the project rests with them and delays cost money. In tunnelling, this means extra coordination up front to get the required permits, select the right subcontractors, and ensure all equipment is on site. Some decisions can accelerate the overall process, but every shortcut also comes with a tradeoff. Experienced contractors will know which approaches are most impactful.

Constructability. Higher levels of planning with respect to constructability factor into the decision-making calculus for tunnel projects.

The first step is to create the design. The owner provides a conceptual plan of what they want in a tunnel, while the contractor is responsible for preparing and executing the design.

It is the job of the contractor to coordinate the budget and the schedule, allocating the proper proportions of time to permitting, engaging subcontractors, and the iterative process of investigating existing site conditions and preparing the design as the design is also iterative.

Understanding execution. It is key for all stakeholders to understand the project at the outset. The tunnel business is increasingly complex and competitive, with more teams in the market, so efficiently organising and maintaining the schedule and budget is essential. When everyone understands what is required for project execution, they can divide the tasks and organise how to accomplish them.

Mitigating delays. With so many steps to complete prior to construction, there are multiple opportunities for delay. These must be anticipated and mitigated in advance by an experienced project team and construction manager.

Once construction begins, the schedule becomes even more aggressive as the TBM drives the project. The machine is expensive to operate, and the team is tasked with ensuring every shaft is ready, designs are complete, every instrument installed, and all condition surveys performed well in advance of the TBM reaching the site.

For the contractor, it is a delicate balancing act to ensure the design is complete, permits obtained, subcontractors vetted, and shafts prepared ahead of the TBM.

Managing unforeseen conditions. In order to perform all the required tasks in advance of the TBM, contractors rely heavily on the expertise of capable teams who are technically competent, willing to put in the hours, and able to anticipate unforeseen conditions that can sabotage a carefully laid out schedule.

Mining has inherent schedule risks, including obstructions and ground conditions at the tunnel face and risks related to completing the surface and shaft work on time, well in advance of the TBM. With underground equipment, there is more control and ability to manage, provided that the setup and equipment are in alignment with the geotechnical baseline report (GBR).

On the surface, there are outside factors that can affect the schedule, including design reviews and the permitting process, both of which involve third parties who may have different priorities than the project team.

LOOKING TO THE FUTURE

Future perspective. A future focus is important in design-build, where the owner allocates risk to the contractor and expects them to deliver a finished project that meets defined criteria.

Experience helps contractors define and prioritise all tasks, keep the schedule and budget in alignment, and mitigate risks.

***Above:** EBA engineer undertaking field inspections*

Knowledge of permit requirements is a key part of this long-term planning process as it sometimes takes months to fulfill all permit requirements. Many projects assign a permit coordinator who processes the permits, fine tunes requirements, meets with permit reviewers, and addresses comments, ensuring execution on schedule.

Community coordination. Coordination with the surrounding community is another important planning effort.

When a shaft is built across a roadway, for example, all the usual permits are required for building the shaft, but there is also an intense coordination effort to tunnel under the road without closing it.

Projects that impact road traffic may be completed in multiple phases with complex traffic control plans that involve detours, closing lanes, adjusting traffic signal timing, and shifting shoulders to close some lanes for work, while leaving enough lanes open to keep traffic flowing. To avoid bottlenecks, teams work with transportation professionals to design traffic control plans that maintain traffic flows at all times. The magnitude of this effort is an important part of early planning if the team wants to avoid delays during construction. Local experts provide experience to help with schedule planning.

PROJECT EXAMPLE: ANACOSTIA RIVER TUNNEL

The Anacostia River Tunnel. The Anacostia River Tunnel in Washington, D.C., is exemplary of the challenges and solutions found in a large tunnel project with an alternative delivery method. It used complex geotechnical instruments as part of a work plan that also included a detailed layout of the site, tables with depths and dimensions, cut sheets, and written procedures.

The work plan submittal took several months to create. Using the alternative delivery method, the design is not yet complete when the instrument layout is prepared, so it is continuously updated throughout the design phase.

As contractors worked through the site, the team was still fine-tuning locations of their instruments based on the final design. To achieve the final design, the team needed other scopes, such as surveys and analysis of existing structures.

CIAR. One of the chief tools for accomplishing the design and execution of the tunnel is the use of the construction impact assessment report (CIAR). The CIAR is a design report that details all impacts related to the proposed construction, including existing structures, groundwater, soil, settling terrain, and excavation, as well as other activities that affect the landscape, such as ground improvement and de-watering.

The report is complex and iterative as various impacts are explored and adjustments made to reduce the impact of construction. The CIAR includes a plan for emergency responses to anticipated problems.

To formulate the emergency response plan, the team relies on data from the preconstruction condition survey, and uses geology and sub-surface calculations to predict potential issues and find solutions to address them in advance.

The geotechnical instrumentation monitors underground and surface conditions, even on weekends when no one is working on site. This serves to protect the infrastructure around the construction site, such as buildings, bridges, and utilities.

***Below:** Unforeseen site and ground conditions can have a huge impact on schedule*

Flexibility + Readiness. Despite its detail, the CIAR is just one tool contributing to the final design, which includes pragmatic considerations, such as economics, available work force, and permit application timeframes.

Flexibility is key, as the entire process is iterative, as are its individual phases, so the ability to adjust when new information presents itself makes a big difference. For example, if you have an aggressive design and conditions do not meet the design requirements, then the capacity to make necessary adjustments may be limited.

Once permits are approved, construction can begin, including installation of geotechnical instruments. Subcontractors, materials, equipment, and personnel to implement construction must be in place. Coordination and timing of all these activities to correspond with the beginning of construction is critical.

Data. During the construction process of mining, shaft, and surface work, geotechnical data will provide information about the effects of construction to the surrounding ground and infrastructure. That data will assist in the evaluation of an unknown condition or validate the performance of the project. Surveys are conducted with various instrumentation.

Data collection can be automated with a data logger that uploads information to a cloud-based management system for analysis. The data must be converted from raw survey or electrical data to a format that can be read and analysed.

If the ground or equipment data readings are in exceedance, the emergency response plan outlined in the CIAR is actualised. Intensified monitoring takes place as the tunnelling progresses, especially if discrepancies emerge in the initial monitoring.

Close out. To close out the process at the end of construction, the team addresses every change order, submits as-built records and completion reports, reviews the data with the client, and ensures the project is to their satisfaction

The closeout phase is sometimes treated as an afterthought, but it is quite complex and requires adequate time to complete.

Planning. With so many complicated processes to balance, planning is essential to maintaining the all-important project schedule. Defining the scope early and allocating enough time and budget to each item ensures no surprises surface late in the project. Thorough surveys of surrounding buildings and infrastructure, coordination with stakeholders and contractors, and the complex process of permitting are all important to plan before construction begins.

Tight tolerances, data monitoring, and action plans to address emergencies are critical to keep construction running smoothly once it has begun. Clear planning and organisation, developed with a contractor's expertise, drives the entire project.

There is a huge amount of coordination and planning that is factored into a tunnelling project, especially in a densely populated urban environment, and the stakes are high when drilling underground. An alternative delivery method, careful and concise planning, coordination of trades, and permits, along with evaluation of competent subcontractors are all crucial to successful project execution.

Navigating the Calculus. For significant tunnelling projects, especially in the urban core, government leaders not only can successfully navigate the calculus of tunnelling but also optimise outcomes with an insightful approach even amidst complex planning and process stages.