Tunnelling Journal

AI's role in tunnelling cost reduction

ALICE's Founder and CEO, René Morkos here explains how AI can reduce risk during planning and bidding, and assist in the winning of more profitable projects.

Tunnel excavation is one of the most expensive construction activities. While cost and time estimation plays a vital role in the successful completion of any linear construction project, the geological and geotechnical factors specific to tunnelling add additional complexity. This creates uncertainties, which add to tunnelling's notoriously high costs and further raises the stakes in terms of planning and risk assessment.

The variable costs associated with construction of underground infrastructure (such as transportation systems and transit routes) are immense. A recent breakdown of cost drivers for U.S. infrastructure excavation, for example, showed that nearly 55 percent of total project expenditures for transit tunnelling works were directly attributed to construction costs. This is high, even when compared to completion costs for other complex projects or major infrastructure builds.

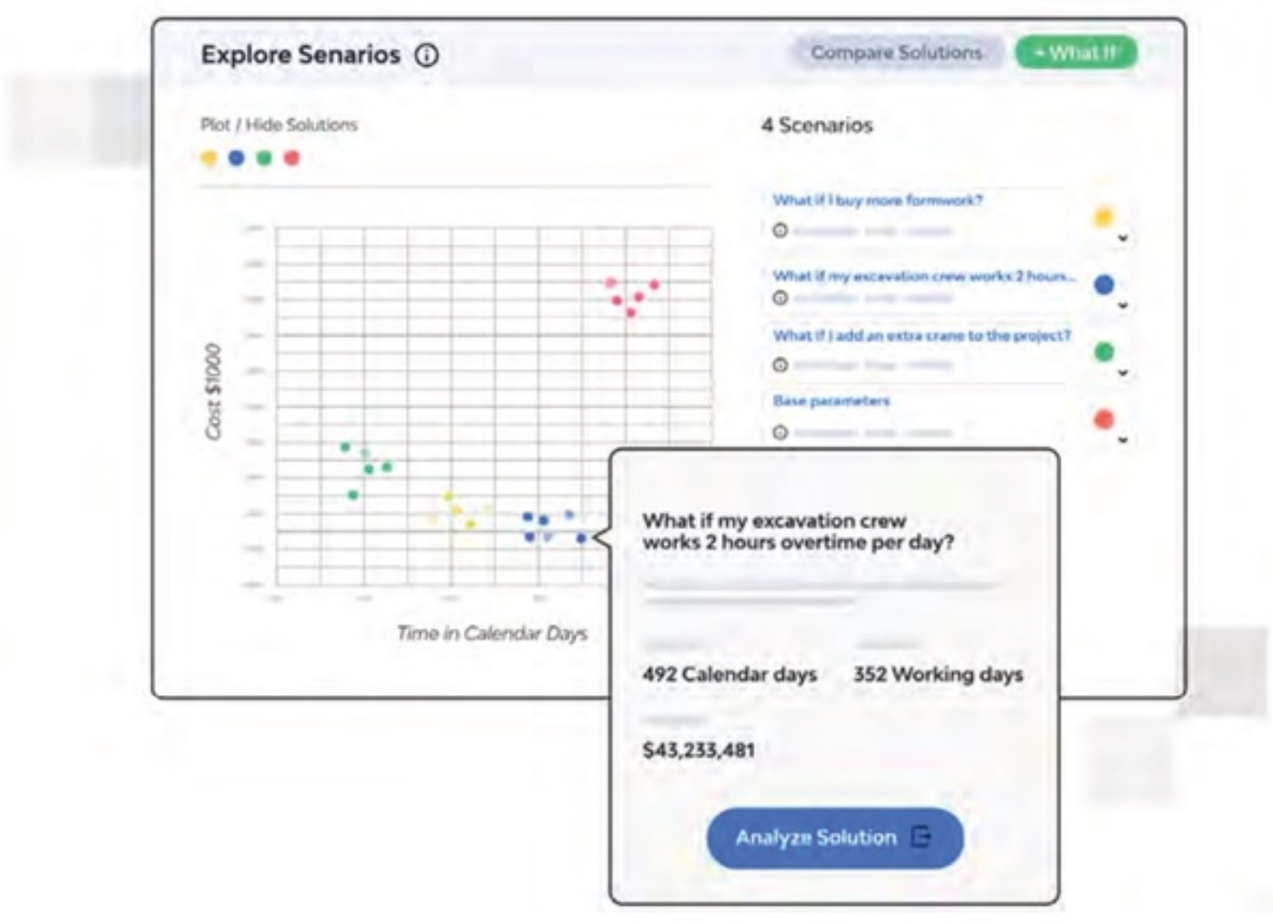
A matter of complexity

While the cost of labour, site management, equipment, and supply logistics all contribute to the rising cost of construction projects in general, there are a lot of unique expense factors that weigh into tunnelling and excavation. The need for specialised equipment such as tunnel boring machines (TBM), horizontal directional drills, and excavators can quickly stack up significant costs. Combined with material expenses, contracted equipment absorbs most of a tunnelling project's remaining budget.

Method of construction should also be central to conversations on cost reduction, however, it varies from project to project, and is often somewhat predetermined by the project environment and scope. Because tunnelling work is, by nature, conducted in unusually hazardous conditions (underground, and also often underwater), risk management is critical. With so many complex challenges, and so many interdependencies at play, it's easy for a tunnelling project to go sideways, and unplanned delays can snowball into an avalanche of liquidated damages.

Artificial Intelligence (AI) takes over where human minds strain, offering unique data-driven construction perspectives that can help address the challenges specific to tunnelling. Just as adoption of BIM is revolutionising global construction projects, AI can revolutionise your cost reduction strategy for complex excavations.

An ALICE Explore page screenshot



Here are just a few tunnelling problems AI can solve:

Linear Dependencies - Due to the linear nature of tunnelling projects, it is difficult to reduce costs through project acceleration. With construction labour and equipment expenditures stacking the project budget, accurate scheduling is critical to completing a project on time, and within budget. However, the increased complexity posed by limited ingress and egress, as well as the need to cover projects with extensive pathways (think: kilometers of linear rail or roadway), can challenge even the most comprehensive schedule. Effective optimisation of a tunnelling and excavation schedule is nearly impossible for a human team - especially one operating under the pressure of looming deadlines.

Using generative scheduling technology by ALICE Technologies, AI can reduce costs related to linear dependencies by pinpointing weaknesses in project timing and scheduling. This data can be used to reveal critical points in the project lifecycle, mitigate risk surrounding potential bottlenecks or breakdowns, and create a project recovery plan that anticipates and mitigates likely risks.

Environmental Factors - Ground conditions, groundwater status, length and diameter of the tunnel drive, tunnel depth, and support logistics all weigh into tunnel cost, as well as introducing additional risk vectors. Factors unique to excavation (such as accurate estimation of ground squeezing) are critical to project success. Shifting atmospheric conditions or environmental hazards revealed mid-construction can

easily trigger astronomical expenses, leaving projects vulnerable to the unexpected.

AI can be used in several ways to reduce costs relating to environmental factors. Analysis and assessment of site conditions during the preconstruction phase inform iterative and generative design efforts, allowing stakeholders to optimise their plans to fit best-case scenarios. Detailed atmospheric, ground, and weather forecasting can accurately predict conditions that might cause equipment damage or failure, as well as seasonal or environmental delays. Factoring these considerations into a tunnelling project plan from the beginning can help stakeholders save millions in unnecessary damages.

Site Logistics - Tunnelling and excavation projects pose a unique set of logistical challenges. On underwater projects, ingress and egress can be very limited. And when boring for railway or roadway projects, the construction site may go on for literal kilometers. Underground conditions compress the hazards of a typical site into a confined location, and when chaos occurs, it can expand quickly.

By analysing site specific details, AI-based site optimisation can improve worksite flow and organisation. AI can provide optimised solutions for removing excavated material and waste, staging materials and equipment, and managing workforce movements to improve safety and labour efficiency. With the click of a button, AI can improve decision-making for onsite conditions and movement, thereby eliminating costly bottlenecks and inefficiencies and improving workforce safety and productivity.

Management Complexities - Effective site management is essential in achieving stakeholder goals and objectives - function, performance, quality of construction, cost, schedule, and future operability and maintenance. However, teams managing major or complex underground excavation and tunnelling projects must deal with many inputs, conditions, and variables. Different organisational approaches, techniques, and processes may offer varying levels of success in varying environments. What works for the unique conditions of one project may falter on the next site.

Consolidating all project objectives, restrictions, and parameters into one unified, AI-driven platform is key. With access to all relevant project data, AI can analyse and assess all options available, running millions of possible scenarios in a matter of minutes. Managers can then make an informed choice from a selection of best-case scenarios for the given moment - and continue reviewing those choices dynamically, to realign their project plans in real-time.

Specialised Equipment - Excavation equipment is expensive, and adds a lot of variable costs to large-scale projects. When a boring machine costs a million

dollars per day on-site, even a minor scheduling blunder can obliterate profits. Improper maintenance can result in equipment failures that derail a project indefinitely. Efficient equipment allocation and equipment use forecasting are critical to a successful tunnelling project.

Using AI on the job site enables us to think strategically about tunnelling equipment optimisation. The latest technological advancements can automatically compare and contrast the cost savings or expenses associated with different scheduling and sequencing options. To minimise transportation costs for heavy equipment and resources on a linear site, careful staging in alignment with the project schedule is paramount.

Would applying a second TBM to a project result in time efficiencies that justify its cost? Is using multiple excavators simultaneously more productive than using them sequentially? Is the current allocation of equipment supporting our best time-to-completion? Project productivity pivots on dynamic reallocation of equipment as usage shifts from one location to the next.

Use of AI reduces equipment idle time, and maximises the use of resources, thereby increasing potential profits between 1 to 1.5 percent of the total project cost. It can also be used to predict expected maintenance (circumventing expensive downtime and repairs), prevent equipment failure and breakdowns, and assess potential actions and reallocation options when schedule disruption occurs.

Workforce Safety - Excavation is hazardous by nature. It's underground, underwater, and often requires navigation of sites with limited access and transit options. While most delayed construction projects can throw additional labor at their delays, onsite conditions unique to excavation may make an increase in workforce unwise - if not impossible.

AI can help address questions related to labour optimisation and workforce safety. Will adding more crews speed up completion time, or create site congestion? Can using AI to monitor site conditions and PPE use improve worker safety? Should teams work together, or sequentially? Are onsite conditions safe for workers, or should they be rescheduled to reduce risk exposure? Data-backed responses to these challenges can help make the most of available labor, while improving worker safety and wellbeing. This, in turn, mitigates stakeholder exposure to risk, reducing the cost of construction even further.

Into the future

The use of AI for construction project optimisation has advanced substantially over the past few years, and tunnelling and excavation stand to benefit. By revealing what really matters, AI-driven tools unlock innovative solutions for curbing the cost of expensive excavation and eliminating delays caused by common challenges and unforeseen circumstances. This transformative technology is already improving site and workforce conditions - along with profitability - on projects all over the world. We can expect to dig into the benefits of further advancements in AI in the coming years.