TunnelTalk Direct by Design

DISCUSSION FORUM

TBM procurement and contractual processes

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Following publication of his article *TBM procurement, risk, and technology advancement* in November 2020[1], **John Reilly** canvassed and received comments, examples, recommendations and feedback from 18 colleagues in seven countries representing owners (two), contractors (four), TBM manufacturers (five) and consultants (six). In many cases, comments and recommendations were not consistent and represented a range of views held by individuals in specific sectors of the industry. Without quoting the contacts directly, Reilly has reviewed the feedback and presents the findings in a continuation of the discussion focusing on who, and how, TBMs are selected, specified and procured for given projects.

TBM procurement together with consideration of technical requirements, cost and schedule constraints, unknown ground conditions and the risk factors involved, remains a focus of debate and discussion. In the procurement of a TBM, the basic requirements by an owner include a process that:

1. Maximizes contractor competitiveness;
2. Results in a machine that will perform reliably, safely and productively in the geology;
3. Has the necessary face control to avoid settlement and damage to adjacent buildings and underground infrastructure;
4. Addresses all essential design requirements to be deemed fit for purpose; and
5. Protects the interests of the owner and all stakeholders including political representatives.

If intended to reduce cost to the owner, a comment received pointed out that requirement one maybe in conflict with the four following items. This references an over-arching concern that attempts to drive cost down, for example by using a low-bid contract procurement process and/or by seeking to transfer risk to the contractor, in many cases may ultimately result in more cost and risk to the owner.[2] There are concerns of using the low-bid contract procurement process for complex underground projects and for TBM applications that encompass significant unknowns and risks. For routine projects, with low risk and an established owner track record, low-bid contract procurement is a valid and useful process.

TBMs of all types are more than excavators, managing as they do complex underground construction operations

Many and varied procurement options have been used by owners for delivery underground and TBM application projects. The basic choice for such procurement methods relates to the use of either:

1. Prescriptive models, where specifications define the tunneling processes, the ground support operations and the type and characteristics of the TBM required, and
2. Performance-based models which require that the contractor meet defined performance requirements, with freedom of choice regarding means and methods, machine type and components.

Of the two procurement types, prescriptive methods may preclude innovation, compromise selection of a suitable TBM and preclude the addition by the TBM manufacturer of better tunneling and risk avoidance capabilities. Performance models are susceptible to the low-bid procurement syndrome, resulting potentially in insufficiently capable TBMs and follow-on claims and cost and schedule increases. In practice, methods used for procurement of TBM projects are often a combination of performance and prescriptive methods.

Who should choose the TBM?

In comments received, it was reported that, "with all due respect", not all consultants are up-to-date with the latest technology as regards how to properly specify a TBM for a given geology to achieve optimal performance, nor are most owners sufficiently expert for the task with owners having insufficient experience in underground construction. As a result, and assuming a design-build or like-type contract, the final choice of TBM should be the responsibility of the contractor working closely with the TBM manufacturer, following development of a reference design by the owner - assisted by its engaged engineer and in association with specialized tunneling and geotechnical consultants who play a significant role for the owner in framing the TBM selection, consistent with the contractual process and project needs.

Designers engaged by the owners are also concerned that "with a low-bid design-bid-build contract, the designers feel obligated to protect the owner with a more prescriptive set of specifications". However, this may result in many problematic issues, from added cost and procurement of machines that are not suitable for purpose, to providing grounds for claims by the contractor and/or TBM manufacturer that can lead to disputes and litigation. For technically challenging and/or time constrained projects, there is merit in procurement of a TBM by the owner. Some Canadian authorities have used this approach for specific projects going back several decades and there are examples of owner procurement of TBMs in the UK.

UK owner involvement in TBM procurement[3]

For the London Water Ring Main in the 1980s-1990s, the owner, Thames Water, called to together the contractors and prequalified TBM suppliers and invited them to join with the owner to specify machines and suitable linings for the project. Once the owner had selected its preferred supplier, the TBM design was discussed extensively, key features agreed and a visit to the TBM supplier's factory. The process was reported as enormously successful, pushing forward technology, and delivering the project on time and within budget.

For the Channel Tunnel Rail Link section 2 London Tunnels in the 2000s, the owner's project manager specified the machine requirements for the 17.5km of twin 7.15m i.d. running tunnels and invited the three TBM engaged contractor joint ventures to comment and suggest alternatives that they felt appropriate. The project procurement was on a target-cost contract basis from the start and the machine specification in the contract document had been produced for the client or owner by a

respected machine expert. All TBMs, six machines in total, two each for each of the three TBM tunneling contracts and from three different manufacturers, had some issues and the machine specification was not correct in every respect, but generally speaking, the process produced good machines that delivered TBM excavation ahead of programme and on budget. Because of other issues on the rail project programme, the contracts were changed from target cost contracts with aggressive clauses, to a collaborative, cost reimbursable arrangement. Problems were shared and overcome, yielding world-recognized machine performances for the given ground conditions and diameter.

Additional TBM measures, capability, risk

In comments received, one TBM manufacturer reported that commercial terms and cost limitations can often preclude the supply of a machine with the tunneling capabilities and risk mitigation measures that it believes are necessary to reduce risk and result in a successful drive with good cost and schedule performance.

In this regard, it is recognized that the cost of the TBM, or TBMs, is about 5% of the overall project cost, but that they are a key determinant of project outcome. It is therefore foolish to constrain the cost of the TBM and thereby reduce or exclude prudent capability that may be required by the ground conditions. To avoid this dilemma, a sufficiently detailed risk analysis of the machine and the drive or drives should be undertaken to cover machine design, expected performance, issues that may be encountered and anticipated ground conditions. Such a risk analysis should be made in order to inform a TBM design and price that balances machine capabilities to risk exposure. Armed with the analysis, risk mitigation measures should be adopted that produce benefit for the owner and the contractor.

To allow this contractually, and maintain cost and value considerations, it may be that the contract price could be increased above a defined base by the estimated value of the risk mitigation measures. For example, the TBM procurement tender could include a competitive base price for a TBM that meets the owner's prescriptive and performance specifications, with additional monies then authorized to fund additional TBM capabilities related to the estimated value of risk reduction measures. Under this concept, while overall cost to the owner might increase, overall value to the owner across the project and in the long term would also increase.

In a contribution, it was reported that an owner and its contractor could be prepared to pay 10-15% more in capital purchase for a certain TBM if it believes that a greater than 15-20% improvement of tunneling production rates will be gained. This would require early stage collaboration between the owner and the contractor and a contract that allows for, and makes provision for, such early stage collaboration.

What capabilities to specify on a TBM is the question

Clearly, and generally speaking, any new product or innovation offered by a TBM manufacturer, may only be recognised by the contractor as a means of improving the TBM manufacturer's chances of being selected by the contractor and/or the contractor's chances of being awarded the project, and may not be linked to overall project gains.

A noted concern is that strong competition among TBM manufacturers may lead to a market where pricing dumping is a disruption strategy adopted by some TBM manufacturers to gain access to a new market.

There was feedback from those invited to comment, that more problems may come from poor TBM operation rather than a TBM that is not suited for the project, in other words, not fit for purpose. This was challenged by other respondents who pointed to cases where there were problems with both the TBM and its operation. In this regard, a comment referenced a 2005 recommendation of the British Tunnelling Society that "the correct choice of machine, operated without the correct management and operating control, is as bad as choosing the wrong type of machine for the project" [8].

Forms of contract

Of concern, in terms of suitable application to a specific project, are the many forms of contract that are used worldwide. This lack of standardization affects price and requires contractors to adjust to varying and potentially misunderstood conditions of contract and risk exposure. The wide array of differing forms of contract is a result of a broad and diverse array of clients in different countries and in the differing sectors of transportation, water and sewer infrastructure, power generation and procurement agencies that prefer different contracts, procurement processes, have different ability to accept risk, and have varying project administration requirements.

It was stated that there are examples of owners selecting a particular form of contract that subsequently appears to have been the wrong choice, often exposed by the first major dispute. The real problems may not be the form of contract, but the content of contract documents themselves and the way they are understood and administered. This suggests that more use should be made of accepted and standardized forms of contract such as the FIDIC-ITA Emerald Book and others,[4,5,6] and in combination with guidelines from international and national associations including the ITA, BTS (UK) and UCA of SME (USA) [7,8,9]. Other forms may be appropriate for specialized projects or the individual components of mega projects. These might include fixed price for low-risk elements and target cost or shared risk arrangements for others [10,11,12]. Working Group 3 of the International Tunnelling and Underground Space Association (ITA) on Contractual Practices has published an updated second edition of its *Contractual Framework Checklist for Subsurface Construction Contracts,* which contains extensive guidelines for underground contracts and could form a basis for new national or agency contracting strategy.[7]

TBM specification – performance verses prescriptive

Several responses to the November 2020 article about *TBM procurement, risk, and technology advancement*[1] indicated a preference for clear performance requirements with minimal prescriptive elements or a minimal reference design. The procurement process should include detailed consultation with potential or shortlisted contractors and TBM manufacturers before finalization of the request for proposal tender documents, if this is possible under the procurement regulations, which vary greatly by country, state and owner. This is the normal process for some procurement methods, including Progressive Design-Build, Early Contractor Involvement and Alliancing.

Preparation of TBM specifications

Under a performance TBM specification the owner and/or its engineer would prepare a document that defines the owner's performance requirements and provide minimum machine configuration in the reference design, followed by a detailed contract specification developed in association with the contractor and the TBM manufacturer. In competitive environments, this may require the owner and

engineer, with specialized tunneling consultants, working confidentially in parallel with two or more contractor and TBM manufacturer teams.

If significant problems are encountered within a drive, there is a danger that a minimally configured TBM *may not be able to be modified or sufficiently remedied*. Accordingly it should be considered a bad practiced and bad strategy for a contract to be drafted that allows a TBM manufacturer and contractor to adopt a minimalist approach, especially if the experienced manufacturer leads it to believe this is not correct, but is forced to submit a less capable machine due to price constraints by the contractor or owner.

Performance specifications, however, are difficult to write and enforce without ambiguity, so most procurement documents are a balance of performance and prescriptive specifications. In a low-cost environment it was noted that "bidders will only bid what is required by the owner's contract documents". This means that, under a low-bid procurement, if a detailed prescriptive specification is used, the contractor and TBM manufacturer will bid a minimal approach that satisfies that specification and then claim for additional funds and time when issues or circumstances arise that are not covered by the specification.

Procurement and risk evaluation

A now common practice is for bidding proposals to be submitted in two packages: a technical proposal and a price proposal. The first package from each bidder is evaluated and weighted before the cost proposals are opened and reviewed. In a best-value procurement, the successful contractor may not necessarily have the lowest price. Contractor selection could be based on a proposal describing how the contractor will specifically meet the owner's detailed performance measures, including quantified management of risk. Following that selection, a risk-based price determination could be made.

A general theme from several respondents was that compensating contractors for actual cost, with incentives for good performance and disincentives for poor performance, and risk sharing was a desirable contractual environment. There are several contractual structures that allow or encourage this, including Alliancing, the FIDIC-ITA Emerald Book; NEC4 design build and operate contract; NEC4 alliance contract; the USA CSO approach, construction manager at risk, fixed price incentive fee contracts; progressive design-build; and Project 13 in the UK. [4,6,13,14,15,10]

Project 13 is an UK industry-led initiative promoted by the Institution of Civil Engineers to improve delivery and management of high-performing infrastructure. It views the contract as an enterprise with a facilitator to bring together key players at the start, or as near to the start as can be practically achieved, and develop the solution in a collaborative manner focused on outcomes and for contractors, and TBM suppliers for bored tunnel projects, to be rewarded for the long term commitment.[11,12]

Geotechnical baseline reports (GBRs)

The completeness of a GBR depends on the extent and the accuracy of investigations performed. Owners are often reluctant to spend appropriate money on investigations, since they usually represent the first real money to be spent on a project. Geological risks include not only those actual conditions that are different from the baseline but also the possibility that the actual ground distribution could be different from those represented by the GBR, both for ground type and behavior at location.

Compensating the contractor for good performance

When developing the CSO interceptor contracts for the east and west banks of the Willamette River, the City of Portland in Oregon, USA, wanted to avoid the adversarial nature, and the disputes, claims and litigation, it had experienced under its previous conventional design-bid-build contract projects. It

needed participants to focus on solving problems constructively and to not waste time in adversarial contractual claims management or posturing for litigation.

The form of contract adopted was an open book cost reimbursement arrangement plus a fixed fee to cover contractor overheads and profit. The fee was paid commensurate to percent of work completed. Mitigation for identified risks was included in the contract. For risks that could not be mitigated, a $17 million contingency fund was recommended for the west bank CSO contract, which was accepted by the City Council for a contract valued at $293 million.[13]

The owner noted several benefits of the process.

- Having the contractor on board during the design phase provided valuable input on construction, innovation suggestions, and permitted contractor buy-in to the design and construction contract.
- Changes were handled quickly and in the best interests of the job. No major paperwork or delay for changes and no claims. The contract did not recognize Type I differing site conditions for the prime contractor since direct costs were paid as reimbursable. Only Type 2 differing site conditions could increase the fee if they impacted the critical path. In general, there was no markup on extra work, unless it was due to owner directions and affected the critical path.
- Owner and contractor did not have to take a position or be adversarial. They could resolve issues in the best interest of the project, which meant better objectivity and team alignment.
- The owner was directly involved on site. It understood the work and could staff the work appropriately.
- The time taken for decision-making was optimized.
- Bi-annual audits were carried out. Findings of these audits were very complementary.

The Channel Tunnel Rail Link in London in the UK came close to a similar contracting environment. The arrangement developed was that the actual cost of work was paid and any savings below the estimated base cost plus risk were shared between the parties. This allowed the four joint ventures (three TBM contracts and one short cut-and-cover contract) to work together to reduce cost and there were no claims by the joint ventures. They shared and moved work around where appropriate or economic and shared knowledge to better manage risk. Savings on the base cost-plus risk figures were split equally five ways between the four joint ventures and the owner. The potential reward to each party equated to a joint venture profit margin of perhaps 2.5%. At the opening of the project in September 2003, then Prime Minister Tony Blair said: “There are not, frankly, many Prime Ministers of indeed many Ministers, that launch an infrastructure project or accept its completion in front of the words on time and on budget.

Problems that arise with the ability of the contractor to explore the ground during the bid period were mentioned in comments. Related to this is the need for the contractor and TBM manufacturer to update and concur with the GBR from their perspectives as related to means and methods and the characteristics and capabilities of the proposed TBM. This would seem a necessary step, especially in a collaborative procurement and one with pain-gain provisions.

Risk identification, risk management, risk response

A comprehensive risk assessment and evaluation should be completed both by the owner before the bidding process begins and by the contractor during the bidding phase. Risks identified by the owner should be revealed to bidders, perhaps as a risk element description in detail but not in terms of owner quantification of probability and consequence. A discussion of those risks would better inform the

owner and contractor regarding risk sharing and expectations both during the procurement and through the excavation. This may be inconsistent or problematic in a low-bid competitive environment.

The owner and contractor should prepare risk management plans in respect to their areas of responsibility. There are, however, risks that may impact both owner and contractor, which require the open knowledge sharing of most, if not all, risks. There are successful example projects that have achieved this including the Alliance contract adopted for the Sydney Northside sewer interceptor project in Australia, the Waterview TBM highway project in New Zealand and the design-build contract for procurement of the Lake Mead number 3 intake project in Nevada, USA.[16,17,18,19]

In simple terms, the risk management approach consists in identifying and listing the potential risks associated with excavation activities, assigning a probability of occurrence to each, and allocating a quantified consequence or index of severity to the event. Usually a matrix of probability versus consequence is developed and the top ranked risks that have high probability and high consequence are evaluated for risk response and mitigation. Mitigation measures are discussed and agreed to reduce the probability of an event and/or the severity of the consequence. The goal is to reduce risk to an acceptable level or to as low as reasonably practical, and to move from initial risk to residual risk.

Alignment, trust, collaboration, contractual process

The feedback from colleagues included a statement that at the heart of the issue, of how to best deliver complex underground projects and select a suitable TBM, is the matter of trust, collaboration and openness in procurement and delivery. Several respondents indicated that there should be a level playing field with competent players; bound by a fair set of rules, including the appropriate allocation and management of risks; appropriate incentives, rewards and remuneration; and a focus on shared performance goals and outcomes. This should apply to all project participants, including the TBM manufacturer.

Heading into a long distance, high overburden drive holds significant risk and little possibility for second thoughts

To achieve this, the key goals and objectives of all parties would need to be defined, recognized, and an overall process implemented which can achieve those goals and objectives. There are contractual methods that recognize this, although low-bid procurement is not one of them for complex underground projects. The main issue is how to best satisfy the goals of each party when some are in conflict with others.

Several respondents endorsed the statement that alignment of the whole team under a set of key goals and objectives is the desired way forward but stated that this is unlikely to be achieved unless we can solve the problems of selection and procurement systems that assume there is always a cheaper price. If there was general acceptance that the best outcome for an owner would be to pay the actual cost of work efficiently executed, plus a negotiated fee, by working together to reduce costs and manage risks, including those related to selecting machines and their characteristics, then more dependable, efficient and valuable outcomes could result.

Key points as to who should choose the TBM and what processes should be used

- The TBM is a sophisticated and complicated machine whose performance, in the project ground conditions, is critical to the success of the project. Too often, attempts to reduce cost impact the prudent choice of machine and capabilities. A risk analysis, evaluating potential risk, risk mitigation, and risk-based estimates of overall probable cost and schedule, should be a normal part of the selection process.
- Preparatory study that influences the TBM selection, including route, settlement limits, geotechnical information, a GBR and risk allocation, should be guided by experts or knowledgeable and experienced professionals and should influence the form of contract, particularly in addressing risk sharing and provision of allowances, such as for cutterhead interventions. This should lead to a specification for the TBM that reflects the owner's base prescriptive and performance requirements that are to be included in the reference design.
- The contractor and TBM manufacturer bear the responsibility for satisfactory operation and compliance with contract provisions and should therefore be the final decision makers regarding machine type and capability. They should update the owner's TBM specification to reflect the owner's requirements and the specific machine and operating methods to be used.
- Even in a cost-based procurement, it would be of value to be able to compensate the contractor and the TBM manufacturer for added capability, perhaps as a form of insurance and recognition of added value. It may be desirable to make the machine procurement a separate element in the overall project procurement, with award of that element based on a combination of price and probable performance, based on a risk analysis. This should be explored further.
- Most of the feedback was critical of the low-bid environment, especially for large, complex projects with substantial unknowns. Several contractual methods to avoid this have been suggested.
- Several respondents endorsed the objective that alignment of the whole team under a set of key goals and objectives is the desired way forward, with the caution that this is unlikely to be achieved unless we can solve the problems of selection and procurement systems that assume there is always a cheaper price. Several respondents recommended that the best circumstance is for the owner to pay the actual cost of the work plus a negotiated fee, and then work with the contractor to manage risks, which would include selecting the TBMs, as was case for the Portland Oregon East and West CSO projects.[(11)]

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