Controlling Risk of Tunneling Projects Implemented by Alternative Delivery Method

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Abstract

The unpredictability inherent in underground projects and the accelerated pace of design-build or P3 tunnel projects can result in additional risks, construction delays, added costs and potentially expensive litigation if risk management strategies are not implemented early. This paper examines risks associated with alternative delivery methods of tunneling and underground projects from the owner, contractor, and engineer perspectives and identifies potential remedial measures to deal with them.

INTRODUCTION

A recent study indicates that approximately 55% to 60% of the tunneling and underground projects in North America will be delivered using Alternative Delivery Method (AD) such as Design Build (DB) or Public-Private-Partnership (P3). Tunnels and underground projects are inherently more risky than vertical projects, which typically utilize more conventional design and construction approaches and are in relatively defined conditions. However, on tunnel and underground projects, there are a host of special risk factors, including unknowns and uncertainties of the physical and behavioral characteristics of the ground, the complicated interdependence and interaction of design decisions and construction means and methods with those ground conditions, and the manner in which risks are allocated among project participants for unanticipated subsurface conditions. Tunnels delivered using alternative delivery (AD) methods such as design-build (D-B) or Private-Public-Partnership (P3), in their own respects and independent of any major subsurface component pose additional significant risk for all participants. Although the main driver of owners to procure projects using AD is financial and/or schedule improvement, often they transfer all, or substantially all, design and construction risks to the private sector consortium delivering the project including the design-build team. Often, this risk transfer includes rather onerous and aggressive contractual terms which allocate to the private sector participants substantially all risks associated with the encountering of unanticipated subsurface conditions. These aggressive risk allocation provisions impact all participants in the Alternative Delivery team and often have intensifying effect on the consulting engineer professional liability exposure.

With the increased use of D-B and P3 contracting, owners and their legal and commercial advisors may be losing sight of the importance of risk sharing especially as it relates to

subsurface conditions. Furthermore, P3 projects add more complications due to the involvement of financiers, concessionaires, and sometimes the facility operators. It is recommended that risk mitigation measures be implemented with a focus on the variations between the traditional procurement of design-bid-build versus the alternative delivery methods of D-B or P3 in term of contractual arrangements and the roles and responsibilities of the various entities.

RISKS OF UNDERGROUND PROJECTS USING ALTERNATIVE DELIVERY

Tunneling and underground projects by definition carry higher risks than any traditional infrastructure projects. However, these risks have higher consequences and more impact on the owner and the alternative delivery team including the contractor, the designer and, in case of P3 projects, the financing and operation and maintenance entities. Some of the risks are transferred from the owner to the delivery team while others are flawed down by the concessionaire to the CJV and to the designer. These risks include:

- Geotechnical and geological risks
- Design development risks
- Quantities risk
- Schedule Risk
- Contractual risks

The geotechnical and design development risks will be discussed below.

Geotechnical and Geological Risk Allocation

There are several factors that influence geotechnical risk allocation in D-B and P3 tunnel projects:

- The scope of geotechnical investigation undertaken by the owner often is less comprehensive in D-B or P3 projects than in the traditional D-B-B projects because owners expect that the final design will be prepared by the D-B or P3 teams and therefore they will be responsible of the investigations, analyses and the development of design parameters.
- Owners often limit its geotechnical investigation during the preliminary design and the preparation of the bridging documents for cost saving and because they recognize that the geotechnical investigation for tunnel projects are driven by the final design of the underground facilities and by the means and methods to be used and the judgments and risk taken by the DB entity.
- The expectation that the DB or P3 team will do its own geotechnical investigations, analyses, and the development of design parameters either during the pre-award or post-award of the contract. However, the limited time and funding available during the tendering period prohibits D-B contractors from doing additional geotechnical investigations.
- Owners often transfer more of subsurface risks to D-B or P3 than in the traditional D-B-B projects. And often they include disclaimers regarding subsurface conditions and the accuracy and the reliability of data and reports furnished by the owner.

As a result, the geotechnical and subsurface risks are often shifted to D-B or P3 team rather than developing an equitable approach for risk sharing considering that the owner owns the ground whether the contract is executed by the traditional D-B-B or by alternative delivery methods.

Design Development Responsibility of Alternative Delivery Teams in tunneling Projects

Unlike in the traditional D-B-B contract, in D-B and P3 projects the contractual requirements are that the D-B or P3 team will be responsible for the development of the final design of the permanent work elements in accordance with the project criteria, owner's requirements and standards, and the adequacy and constructability of the design. And in many cases, the design must meet "fit for purpose" standards. This last issue could be a potential significant risk for the designer as it may not be covered by its professional liability insurance.

There are several factors in the roles and responsibilities of the project owner and D-B or P3 team that may influence whether those contractual expectations relating to the responsibilities of design development are achieved:

- Whether the owner furnishes and mandates design criteria which are appropriate in the context of anticipated and actual subsurface conditions.
- Often the owner and/or the contractor does not allow sufficient time or funds for the D-B engineer to conduct its own subsurface investigations needed to support its final design or construction approaches.
- Whether the owner provided subsurface conditions and ground behavior during excavation are compatible with the D-B team's intended design approach and construction means and methods including equipment selections
- If the owner provides detailed design or detailed prescriptive specifications which are mandated that the D-B or P3 team is deprived from the development of innovative design, exercise judgment, or discretion of the design.
- Whether the owner imposes its preferences on the D-B or P3 team exceeding its rights under the contractual terms. In this situation, the owner restricts the D-B team's ability to exercise its judgment in the design and the development of innovative approaches.
- Whether the owner contractually (or otherwise) retains and exercises a dominant and controlling role over the review and/or rejection of the D-B team's proposed design submittals

It is important to acknowledge the interrelationship between the roles and responsibilities of the owner, the D-B contractor, and the D-B engineer when allocating risk sharing among the various entities. In D-B and P3 tunneling projects, given the roles and responsibilities of the D-B team with respect of the geotechnical assessment and the design development, logically it is expected that the D-B team to have greater responsibility for unanticipated subsurface conditions. However, the lack of funds and time to perform geotechnical investigations prior to bidding, the actual degree of project owner involvement in those areas, and the fact that the owner owns the ground, limit the ability of the D-B team to have a greater control and thus responsibility on the ground conditions and behavior. This in turn influences the design development that is adequate for the anticipated and actually encountered subsurface conditions. That said, fairness of risk

allocation should be accomplished based on the different roles and responsibilities of the various entities.

The interrelationship between roles and responsibilities of the project participants in D-B and P3 of underground projects related to the geotechnical and subsurface conditions and design development must to be acknowledged in the decision making process regarding risk allocation or sharing.

ROLES AND RESPONSIBILITIES

The roles and responsibilities of project participants in D-B or P3 underground projects influence the risk allocation models. The risk allocation models often utilized in the traditional D-B-B projects do not precisely work with the differing roles and responsibilities of project participants in D-B and P3 projects. Unfortunately, the industry have seen the same approaches in risk allocation provided by the owner on projects delivered using alternative delivery methods as they are for the traditional D-B-B projects.

Roles and Responsibilities in the conventional Design-Bid-Build:

In the conventional DBB approach, the owner retains a design engineer; directs the scope of work and the geotechnical investigations; oversees the characterization of the ground and its behavior during excavation. He also elects to disclose (or not) the subsurface data and related reports; he defines subsurface conditions risk allocation based on the geotechnical investigations and interpretations using a Geotechnical Baseline Report (GBR). He through his designer prepares a final and complete design documents. He often also retains a construction manager to evaluate construction work for conformance with the design and the contract document requirements, and to observe and evaluate subsurface conditions encountered during construction to validate consistency and appropriateness of the encountered conditions with those contemplated in final design assumptions and approach.

In the traditional D-B-B contract, the contractor has the obligation to plan and price the work required by the contract documents; bid it based on the contract terms and conditions, to construct the work in accordance with those requirements; to plan and implement construction means and methods; and to procure the equipment appropriate for the performance of the work and to deliver the final facility in accordance with the design requirements provided by the owner.

In this situation, the risk allocation is often straight forward, but not necessarily fair and appropriate which may result in higher contingency imposed by the contractor to address potential risks whether they materialized or not.

Factors that contribute to the risk allocation/sharing in the traditional D-B-B projects include:

- The scope of geotechnical and geological investigation and their inclusion (or not) as part of the contract documents. And the presence of a provision in the contract for a potential equitable adjustment if subsurface conditions encountered during construction materially differ from the conditions indicated in the contract documents.

- The actually encountered subsurface conditions are consistent with the expected conditions in the design and in the implementation of construction approaches and methodologies.
- The adequacy and the constructability of the design provided in the contract documents consistent with the anticipated and actually encountered subsurface conditions.
- The implementation of suitable construction means and methods and the quality and conformance of construction work with the contract document requirements.

Based on the above, in D-B-B it is possible to more precisely define the roles and responsibilities regarding subsurface conditions than in D-B or P3. However, even in D-B-B of underground projects there are interdependencies in those roles and responsibilities that often result in disputes and claims. For example, the means and methods are significantly influenced by ground behavior during excavation, yet the ground behavior is the owner's responsibility while means and methods are the contractor responsibilities.

Roles and Responsibilities in Design-Build and Public-Private Partnership Projects:

In D-B or P3 projects, the owner retain an engineer (or self-perform) to develop the project definition and design concept, perform preliminary geotechnical investigations and establish design parameters. The owner's engineer also prepares the preliminary design and the bridging documents for bidding. Design criteria and standards, owner's requirements, and performance specifications will also be developed and included in the contract documents.

The D-B entity develops the final design of the final work elements, performs more geotechnical investigations if desired/needed, plans construction sequencing and staging, and develops construction means and methods, and implements the work in accordance with the project design criteria, standards, and owner's requirements. In P3 contracts, the P3 team also finances and sometimes operates and maintains the facility for a number of years. This adds additional complications with respect to the relationships between the owner, the P3 concessionaire and the D-B team.

The allocation of risks in D-B or P3 underground projects is more complex and difficult than in the traditional D-B-B contract. In D-B and P3 projects there is less experience and thus less standardization of the risk allocation than in the traditional D-B-B. Also, for D-B or P3 projects, there are significant variations within the industry in the contractual terms delineating the roles and responsibilities among the entities. Furthermore, often there is inconsistency between the contract terms and the actual conduct of the various entities. This poses a greater challenge in achieving fair and effective risk allocation/sharing because the roles and responsibilities among project participants are blurred often resulting in claims and disputes.

The lack of experience and understanding of many project participants (owners and design-builders or P3 entities) of the roles and responsibilities, and resistance to change in their traditional roles often result in disputes. Such behavioral changes are critical for successful delivery of D-B or P3 tunneling projects. Furthermore, the dependency of tunneling projects on

the geotechnical conditions and ground behavior complicates the risk allocation/sharing in D-B and P3 projects.

It should be acknowledge that whether the project is delivered using the traditional D-B-B or by alternative delivery method, the owner "owns" the ground, as such, ground behavior during excavation should be well defined either by the owner, or the D-B team and agreed to by the both parties via the GBR. Various approaches of reaching a final contractual GBR in D-B and P3 projects have been implemented including the use of GBR-B (bidding) and GBR-C (construction). GBR-B is usually established by the owner's engineer on the basis of the owner's geotechnical investigation program and the preliminary design prepared for the tender documents. The focus of GBR-B is the physical nature of the subsurface conditions likely to be encountered, consistent with the layouts and geometries represented in the preliminary design and the owner's anticipated construction means and methods. This will allow all bidders to bid on a common basis. The degree to which the GBR-B provides behavioral baselines will be a function of the level of specificity in the preliminary design, and the imposition of the means and methods by the owner, and the desire of the owner. GBR-C reflects the physical baselines established by the owner and its design team (as augmented by any supplemental geotechnical investigations done by the D-B team) and as clarified or modified by the D-B team, and the behavioral baselines described by the D-B team consistent with its design approach, equipment, and means and methods. GBR-C becomes part of the contract and "relied upon" document. Materially different conditions encountered from those anticipated will be legitimate changes.

RISK MANAGEMENT

Although there are generally accepted approaches for allocating or sharing risks among the various entities in the traditional D-B-B tunneling projects, such standardization rarely exist in alternative delivery projects because these projects rarely fit in the standards of D-B-B projects or with other alternative delivery methods. The variability of the site conditions, the roles and responsibilities of the various entities and the owner's desire of risk sharing require that risk allocation be implemented on a case by case basis. However, it is prudent that risk allocation be sensible and assign to the entity that is most suited to deal with the specific risks. Regardless, project specific risk allocation decision making process would be enhanced by the availability of more industry wide generic guidelines that identify relevant factors for consideration during the risk allocation. A simple example would be, regardless of the type of project delivery, unforeseen ground condition risks should be allocated to the owner, while risks related to means and methods would be allocated to the contractor. However, the situation gets murky regarding risks associated with geotechnical aspects because, although the owner owns the ground, the D-B engineer, who is often the engineer of record, should determine the ground behavior during excavation.

The challenges of risk allocation are further impacted by disconnects and deviations between the contractual definitions of roles and responsibilities, and risk allocation and the actual

performance of project entities during implementation due to their lack of experience in D-B or P3 projects or their desire to retain control.

Achieving fair risk allocation for D-B and P3 underground projects needs to adequately account for the interrelationships among the geotechnical investigation and assessment performed by the owner, identification of anticipated subsurface conditions, determination of the ground behavior during excavation, and the level of design completion by the owner and how those conditions relate to the project mandated design criteria and standards.

In addition, it is critical to delineate the roles and responsibilities between the owner's engineer and the D-B team's engineer with respect to the geotechnical investigation and the development of design parameters and the anticipated ground behavior during excavation and the ability of the D-B team engineer to exercise judgment and discretion in the development of the design especially during pre-award (bidding phase) and the suitability of that design for the anticipated and/or encountered subsurface conditions.

The delineation of roles and responsibilities between project owner and the design-builder or the P3 entity for subsurface conditions and for design development has a major impact on risk allocation. Furthermore, the actual performance from contractually defined roles and responsibilities could result in more disputes and that the ultimate risk allocation determination for may not align with or conform to the contractual expectations of project participants. The potential of dispute, the dispute resolution process, and the unpredictability of the outcome will further impact negatively the relationship among the project participants, add cost, and increase contractor's contingency.

RISK SHARING

Although the main drivers of owners to procure tunneling projects using D-B or P3 are schedule and cost improvement and in case of P3 access to private funding, owners have tended to transfer most, if not all, design and construction risks to the D-B or P3 entities. This is often done using onerous contractual terms that allocate to the D-B or P3 entities substantially all the risks including unanticipated subsurface conditions risks.

Geotechnical and subsurface condition risks are by far the most important in any tunneling and underground project regardless of the method of procurement. Unknown ground conditions and unanticipated ground behavior during excavation pose serious risks. Furthermore, design solutions and construction means and methods are based on the anticipated ground conditions and its behavior during excavation. These decisions are made by the D-B or P3 contractor within short period of time and with limited geotechnical investigations relying solely on the geotechnical investigation performed by the owner's engineer and provided as part of the tender design; often are not part of the contract documents and provided as reference documents only. The geotechnical and subsurface risks are magnified when the project is being delivered in alternative delivery method especially if the owner transfers these risks to the private entity. This

is further complicated in D-B and P3 projects when the D-B contractor proposes an alternative technical concept (ATC) and the owner accepts it. In this case the applicability of the owner provided geotechnical information and risk sharing tools such as the GBR (GBR-B or GBR-C) is questioned when disputes arise and when claims of differing site conditions (DSCs) are made. Owners often take a position that the D-B contractor, through its contractual obligations, should investigate and evaluate the geotechnical conditions affecting its proposed ATCs prior to its submittal. However, time limitation would prohibit the design-builder for conducting in-depth geotechnical evaluation and would rely on the owner provided geotechnical data and GBR. Therefore, it is important to clearly define where the subsurface risks are allocated under these conditions keeping in mind that contractors will add contingencies to their bids when unanticipated risks are allocated to them whether these risks are materialized or not.

Subsurface conditions are the single most cause in disputes and claims in tunneling and underground projects. Therefore, it is critical that the principles of fairness and balance in risk sharing should be adopted and implemented.

For a successful delivery of D-B or P3 tunneling projects, a fair and equitable risk sharing rather than risk shedding should be implemented. Risks should be identified during the preparation of the tender documents and assigned to the entity most suitable to deal with them. Furthermore, it is logical for the owner to assume risks related to the site and subsurface conditions provided clear definitions and delineations in the contract documents as to the limits, scope, and conditions covered.

STRATEGIES FOR SUCCESS

To achieve a successful delivery of a tunneling or underground project using D-B or P3 it is recommended that the following principles should be used when preparing the contract documents and when implementing the work.

- Fair and balanced risk-sharing, fully disclosing geotechnical information and using judicious parameters in the geotechnical baseline report (GBR) reduces risk and avoid placing large contingency budgets in the bids. The use of GBR-B and GBR-C has proven to result in less disputes and claims and successful delivery of D-B tunneling projects.
- Early contractor involvement provides opportunities for innovative approaches, collaborative strategies, and risk sharing practice.
- Pre-qualifying the design-builder or the P3 concessionaire ensures the team’s technical expertise and personnel availability aligns with the project’s specific needs and provides the team financial and technical viability to deliver the project successfully.
- Implementing a comprehensive risk register through design and construction, owners and contractors work together to identify potential risks that may surface over the project’s lifetime.

- Placing contingency funds by the owner to deal with unknowns reduces unallocated contingencies by contractors and allows owners to control the project contingency. However, sensible and fair allocation provisions of the contingency funds must be provided.
- Escrow bid documents, impartial dispute review board, and partnering help owners and design-builders promptly resolve disputes, claims and controversial issues

CONCLUSIONS

It is undeniable that more tunneling and underground projects will be delivered using alternative delivery methods such as DB, P3, CMAR or similar methods. To be successful, it is prudent for project participants (owners and private entities) to understand the potential risks with respect to their roles and responsibilities and to develop a fair and sensible risk sharing mechanism, rather than risk transfer, in which the risk is assigned to the entity most suitable to manage it. Similarly understanding the roles and responsibilities in the design development at the various stages of the project is critical for the success of D-B or P3 underground projects. Fair, and realistically achievable risk sharing is important to not only the primary project participants, such as the project owner and the design-builder or P3 teams, but also to other involved parties critical to the success of the project, such as designers, insurers, and financiers and above all the public who will suffer when projects are delayed and costs are escalated.

REFERENCES

1. D. J. Hatem and N. A. Munfah “Controlling Risks of Tunnel Projects” RETC 2015
2. D. J. Hatem, “Design-Build and Public-Private Partnerships: Risk Allocation of Subsurface Conditions”, Geo Strata (April 2014)
3. D. J. Hatem, “PPP and DB: Who is Responsible for Risk? A call for Guidelines”, North American Tunneling Journal (October 2014)
4. D. J. Hatem and D. Corkum, eds., Megaprojects: Challenges and Recommended Practices (ACEC 2010)
5. D. J. Hatem and P. Gary eds., Public-Private Partnerships: Opportunities and Risks for Consulting Engineers, Chapter 8 (ACEC 2013)
6. D. J. Hatem, “Public-Private Partnerships and Design-Build Subsurface Projects: Consulting Engineer Professional Liability Risk”, Design and Construction Management Professional Reporter (April 2014)
7. D. J. Hatem and D. Corkum, eds, Megaprojects: Challenges and Recommended Practices (ACEC 2010)
8. D. J. Hatem “Risk Related to PPP Tunneling Projects for Design Professionals,” Tunneling and Underground Construction June 2014
9. D. J. Hatem and N. Munfah “Risk Related to P3 Tunneling Projects for the Design Professionals” – T&UC Magazine – June 2014
10. N. Munfah et al. “Contractual Challenges of Conventional Tunneling in the US”, World Tunneling Congress Proceedings, Bankok, Tailand, May 2012
11. N. Munfah "Contracting Issues for Conventional Tunneling," ITA Conference Proceedings, Prague, Czech Republic, 2007.

12. N. Munfah "Contracting methods for Underground Construction," NAT 2006 Proceedings, Chicago, 2006
13. N. Munfah "Contracting Practices for Underground Construction," Underground Construction Conference Proceedings, 2003, London
14. N. Munfah et al. "Minimizing Risks in Underground Construction Using the DBOM Approach: A Case Study". Proceedings of the International Congress of Underground Construction in Modern Infrastructure, Stockholm, Sweden, 1998