

# A Consultant's Perspective on Design and Build Tunnelling Projects in Hong Kong

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## ABSTRACT

While aspects of geotechnical design are particularly challenging in the Hong Kong Special Administrative Region (HKSAR) with regards to building in the physical environment, a consultant's role in the management of design and build tunnelling projects can be as equally demanding.

This paper will discuss the prescriptive nature of the HKSAR government approval process and the impact that this can have on innovative design. On Design and Build (D & B) projects the process of concurrent design puts even greater demands on consultants acting as the intermediary between the contractor and government approval departments.

Aspects of managing business relationships and working within the government approval system will also be discussed within the context of the authors experience on the China Light and Power HK Limited (CLP) Tsz Wan Shan cable tunnel project.

## INTRODUCTION

### Job Description

As part of the ongoing upgrading of the power supply network for CLP, construction of two new cable tunnels at Tsz Wan Shan and Kwai Chung in the HKSAR were proposed. Dragages HK Joint Venture (DJV) were appointed as the contractor to undertake construction of the cable tunnels and associated works. The discussion in this paper will focus on the 650m long bored tunnel at Tsz Wan Shan.



Fig 1. Tsz Wan Shan and Kwai Chung Tunnel Locations

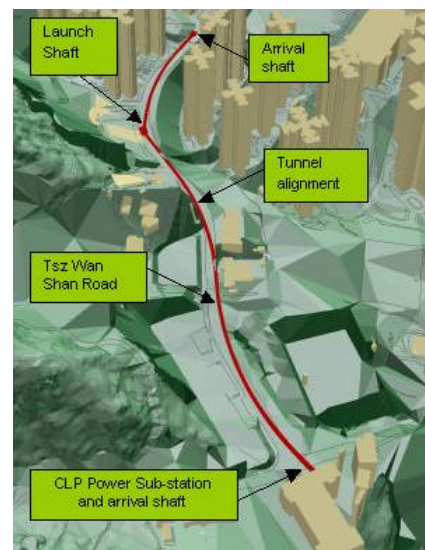


Fig 2. Tsz Wan Shan Cable Tunnel Route

The tunnel is being excavated using a Bessac Tunnel Boring Machine (a boom head TBM with pressurised face) and lined with a pre-cast concrete segmental lining. The Tsz Wan Shan cable tunnel runs either at the toe or along the crest of a number of registered slopes, and the low cover combined with highly variable soil stiffness and ground water level have had major influences on the design.

The temporary works for the launch and retrieval shafts have been formed by a combination of sheet-pile, pipe-pile, soldier-pile and composite-pile walls, with the composition changed to suit site constraints and avoid existing utilities where required.

## Relevant Parties

Other than the Client and Contractor as previously discussed, parties relevant to the Tsz Wan Shan cable tunnel project are; Ove Arup & Partners Hong Kong Ltd (Arup) acting as the contractors design consultant, Atkins China Limited acting as the Clients Engineer, and Maunsell Group in the role of Independent Checking Engineer (ICE).

## Tsz Wan Shan Cable Tunnel Design Development

In accordance with the conforming design at tender, a cut and cover proposal was submitted by DJV along the entire length of the proposed route. Due to the constraints of cut and cover works with regards to the impact of extended design programme, public disturbance and environmental impact, particularly so in the HKSAR, the client encouraged alternative bids. The extended design programme was a key factor as the government approval process in the HKSAR only permits cut and cover works to be carried out on small sections of roadway at a time to minimise public disturbance. A pipe jacking tunnelling alternative was submitted by DJV as part of the tender design.

DJV subsequently were awarded the D & B tunnelling works based on the proposed pipe jacking alternative. However, during scheme design, the pipe jacking option was replaced by a more cost effective segmental lining. The selection of this method of construction came as a result of a series of front end value engineering meetings which facilitated open discussion and input from all parties involved in the D & B works.

Significant capital cost savings were generated by selection of the TBM over cut and cover method as DJV were able to use the Bessac machine on an associated tunnelling project in the region, in similar 'soft ground' soil conditions, prior to the commencement of works on the Tsz Wan Shan tunnel project.



Fig 3. Bessac TBM



Fig 4. Segmental Tunnel Lining

## HKSAR DESIGN APPROVAL PROCESS

While there are many government departments in the HKSAR with which a tunnelling D& B team may interact, it is through the Buildings Department (BD) that approval must be obtained. Specialist consultation to BD is also often provided by other government departments. One such department that the design consultants on D & B tunnel projects must liaise with is the Geotechnical Engineering Office (GEO).

### Buildings Department

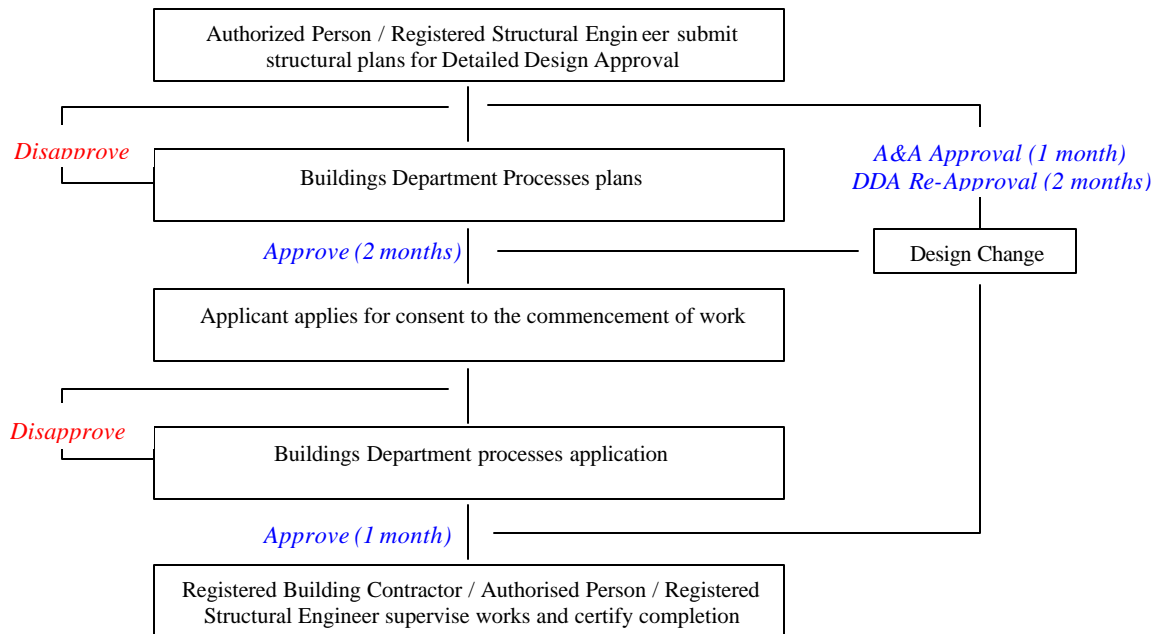
Any party that intends to carry out building works in the HKSAR is required by law to appoint an authorized person, and where necessary a registered structural engineer, to prepare and submit plans for the approval of BD. There are however exceptions to this in the form of BD approval exemptions, permitted to government projects and some quasi-government projects such as MTRC and KCRC railways. In many of these cases BD consultation is required but approval is not. This has been common in the past given the relatively few number of private sector D & B tunnelling projects in the HKSAR.

### Geotechnical Engineering Office

GEO is the government geotechnical arm of the Civil Engineering Department (CED), which provides recommendations to BD on geotechnical aspects of tunnelling and shaft design.

Outlined in the flow chart below are the stages in the BD approval and consent process.

## Detailed Design Approval Process



**Fig 5. Buildings Department Design Approval Process**

While the BD design approval process outlined above appears straight forward, it is the duration of each approval and consent stage that can impact on the desirable efficiencies of a D & B project. The first stage of the approval process, Buildings Department Detailed Design Approval (DDA), requires a 2 month processing period. Should the initial application be rejected, application for approval must be resubmitted for a further 2 months of processing. Future Alterations and Additions (A&A), referring to minor design changes, must be submitted to BD in the form of an amended submission. These require a 1 month processing period. Significant changes to the approved design require a complete re-submission for DDA. Re-submission for DDA similarly requires a 2 month processing period.

### Applications for Consent to Commence Works

As indicated in Figure 5, application for consent to commence works requires a 1 month processing period by BD. However, as in the example of Tsz Wan Shan shaft design and construction, multiple applications for consent are required. Application for consent to commence installation of piling works is first required. Consent to commence excavation following these works must be applied for separately and application for consent for this stage may not be carried out until completion of the previous stage of works, as built drawings are submitted, and any other requirements are fulfilled such as pumping tests.

This clearly indicates the lengthy timeframe and requirements of the approval process and how this is not ideally suited to the tight programme restrictions of a D& B contract. While it appears that there are no obvious alternatives to this process, it is a practical matter of making allowances for time delays and modifying the design and construction management process to accommodate.

On a D & B project however, it is sometimes difficult to predict when a design change will be required and it is very easy for a 2 month period to be wasted on an unforeseen amended submission followed by a reapplication for consent to proceed. This may come about for example if design piling depths are not reached during installation for shaft Excavation Lateral Support (ELS) works. ELS refers to the temporary works involved in shaft design and construction. Failing to reach design pile tip elevations will call for an amended submission under BD guidelines and a reapplication for consent to proceed

One of the reasons for the HKSAR's tight engineering controls imposed by govt departments is believed to have been brought about largely by "sins of the past" of corrupt building contractors and the break down of the certification process. A recent example of this was the practice of "short piling" by some contractors in the late 1990's. This has led to a prescriptive design approach which impacts on a design consultant's ability to develop innovative, challenging and efficient designs. To this end, BD release highly conservative design guidelines (Practice Notes for Authorised Persons – PNAP (1)) which are expected to be strongly adhered to. Similarly conservative design guidelines are produced by GEO in the form of the Geoguide Series (2).

## RELATIONSHIP MANAGEMENT

Arguably the most important aspect of D & B contracts in the HKSAR is relationship management. While the importance of symbiotic management relationships between the client, contractor and designer in the D & B team is discussed and accepted on an international level, the importance of building strong working relationships to work within the approval system that governs private sector projects in the HKSAR is paramount.

In this design environment, where it is essential to minimise the likelihood of future changes in design, the necessity for close communication between the client contractor and design consultant, particularly at the front end of a D & B project is imperative. Early involvement of design consultants and contractors, and effective communication of client requirements, are important to close out as many design issues as possible and set as many aspects of the design as possible to avoid unnecessary re-engineering.

Whilst open and effective communication and the development of Relationship Management is essential at the front end, it should also be maintained and developed throughout the life of the D & B project. Major design changes, or continual minor changes, have the potential to greatly effect the economics of a project and cause work to be held up due to the timely BD approval process. While it is accepted that the concurrent nature of D & B contracts may not be economical within the HKSAR approval system, effective relationship management along with effective project planning both in terms of programme and finance, should minimise its impact.

## **DEVELOPING A CONTRACTOR/CONSULTANT DESIGN AGREEMENT**

Fundamental to the detailed design consultancy is to establish a fair design agreement and clearly document the roles and responsibilities of the relevant parties in the D & B team throughout the project life. Considerable time spent at the front end on the elements outlined below will lead to significant avoidance of conflict and cost savings throughout the project.

### **Clear Scope of Works/Services**

At the outset of a D & B project it is important to agree upon, and document, a clear scope of works. This should be fundamentally based on a detailed list of client requirements. The design consultant should also document their 'scope of services'. It is however important to emphasise to the contractor that the 'scope of works' is not the same as 'scope of services'. It should not be assumed that the consultant's ability to carry out certain services means that these services are included as part of the scope of works. These services should not be assumed to be part of the original design agreement. This is an element that has appeared on the Tsz Wan Shan and several other projects.

### **Designer/Contractor Obligations**

The obligations of the Client, Contractor and Consultant should be outlined in detail prior to any consideration is given to the commencement of work.

One element of the design that is not often considered and often results in becoming the obligation of the consultant is the responsibility of miscellaneous minor tasks, or 'loose ends'. While this may be considered a minor concern, on smaller D & B projects this has the ability to eat away profits for the consultant who has notably smaller margins than the contractor. Such examples of miscellaneous minor tasks include the detailing of cabling brackets, as -built drawings, Operation and Maintenance Reports, and the outlining of rebar schedules.

When detailing the agreement it is important that the design consultant does not agree to the terms, or accept the obligation of performing 'the most economical design' or providing a design that is 'fit for purpose'. An efficient and economical design to an international standard, and produced within the time and fee constraints, is all that can be promised to a contractor. Agreement to most economical design is an unrealistic design agreement, particularly in the HKSAR where:

- i) there is not the fee nor the time luxury of carrying out highly economical and innovative design; and
- ii) there is not the ability of a design/contractor team to make economical variations to designs that require rapid approval to proceed.

At the completion of any job the contractor will have no problem in seeking out secondary advice on the "economical" nature of an 'as built' design when the limitations of the design process are forgotten.

As discussed by Garvey (3), "an adequate design in time is generally more useful and economic than a 'perfect' design at some unspecified future date". This could not be more accurate in the context of the HKSAR BD approval system.

## **Change Order Processing**

It is important that early in the D&B process the Contractor and Consultant come to an agreement and document an efficient method for handling Change Orders (CO's). Further to this it is important that both parties appreciate that regardless of the demanding nature of carrying out concurrent design on D & B projects, particularly when facing the additional time pressure demands of rapidly carrying out amended designs to submit for BD approval, it is imperative that the contractor and consultant agree on variations prior to the commencement of additional works.

In the case of the Tsz Wan Shan Cable Tunnel a process for handling CO's was initially not well documented between the contractor and the consultant. The heavy demands of negotiating the BD approval process, where the needs to progress to maintain the design programme led to, in many cases, early progress on design variations prior to any documented agreement on the status of the work, and subsequently outstanding claims.

During the course of the project the contractor and consultant came to an agreement on the arrangement for CO payments. Three options were available for agreement prior to the commencement of works:

- i) Lump Sum agreement
- ii) Time basis
- iii) Lump Sum with BD Approval Commission

Option iii) entails an agreement for a portion of payment that represents the cost of performing the design work for the consultant. A further amount, which is agreed upon prior between contractor and consultant, for time spent in the approval process, is paid upon BD approval. This option was commonly adopted to act as an incentive for the consultant to progress through approval process as quickly as possible. Options i) and ii) were outlined in the design agreement and option iii) was used in practice on site for efficient handling of design changes with BD.

## **Design/Deliverables Programme**

It is essential, particularly in the HKSAR, to include a detailed deliverables program into the design agreement. Clear indication of milestones and the end date will be beneficial for all parties in fairly processing CO claims as well as effectively monitoring progress.

## **Document the Assignment of Liability**

The assignment of liability should be clearly documented in the project contractual documents. Typically the liability for D & B contracts resides largely with the contractor, as is the case for DJV on the Tsz Wan Shan D & B contract. The greatest element of risk in a D & B tunnel project is unforeseen ground conditions and the design consultant should ensure that this is clearly defined in the contractual documentation as a contractor liability. Resulting design changes should be clearly identified as in or out of the designer's scope of works to allow the risk to be assessed.

## **BENEFITS OF DESIGN AND BUILD CONTRACTS**

Outlined below are the typical benefits that are associated with D&B projects. Where relevant, discussion is provided on how these common benefits are affected by the HKSAR D & B environment.

1. It can provide both flexibility and innovation in design – This is one of the greatest benefits of D & B projects as it takes advantage of the rapid and free flow of information between the Client, Contractor and Consultant. As previously discussed this flexibility and innovation is limited in the HKSAR due to the government buildings approval process;
2. An efficient design can be provided – While the D & B project in the HKSAR may not be considered 'efficient' with regards to operating within the approval system, it is actually the efficiencies within the D & B project setup that minimise the effects of the approval process on the project programme;
3. It is possible to provide a more buildable design as a result of early contractor and consultant involvement. This was found to be particularly true in the case of the Tsz Wan Shan cable tunnel;
4. The overlap of design and construction programmes leads to a considerably shorter delivery time – While this is true it can also lead to inefficiency in the HKSAR where construction works are placed on standby due to disruptions in the approval process or amendments to design;
5. It provides a single point of contact for the client to the contractor by combining contractor/sub consultants into a single group;
6. The risk is largely transferred from the client to the contractor. This is beneficial in that the contractor is in the best position to manage it's own risk. The main interface is now between the contractor and the designer;
7. The contractor's own plant, preferred methods and expertise are maximised.

## **FURTHER CONSIDERATIONS FOR THE DESIGN CONSULTANT**

### **Factor into the Bid the Cost of BD Liaison**

As a design consultant in the HKSAR, with the responsibility of being the interface between BD and the contractor on D & B projects, it is essential to factor into bids the cost of time spent liaising with BD. This can be quite hard for consultants to quantify given the variability of BD involvement. It is advisable to attempt to come to an agreement with the contractor that this is an element of design that should be done on a time basis.

### **Documenting Meetings**

For a design consultant it is important when managing D & B projects to develop common practice in the documenting of meeting proceedings, particularly in the case where instructions to proceed are involved. In D & B projects the informal agreements that are common place have a tendency to lead to conflict when claims for CO's are submitted to the contractor. Further to this, unrecorded meetings allow for parties to walk away with a variety of interpretations on the actual outcome of the meetings.

### **Use of Option Reports**

These are reports/sketches issued by the designer which clearly outline to the contractor a series of options on a particular design issue. Option Reports are very effective at obtaining rapid responses from the contractor rather than permitting the decision making process to be avoided and the design issue to remain unresolved. Option Reports are an effective tool for design consultants on D & B projects when it comes to discussing CO's as the designer is clearly covered with sufficient documentation.

### **Establishing a Joint venture system for Profit/Loss share**

A joint venture system for Profit/Loss share was not established for the Tsz Wan Shan D & B project. However the benefits of this option can be seen in that:

- i) It would encourage the free flow of information within the D & B team and increase the efficiency of the design process;
- ii) It would provide encouragement for the design consultant in managing the BD design approval process.

### **Caveat Tender Drawings**

Contractors carry out pricing based on tender drawings. For this reason it is important that the design consultant ensures that they sufficiently caveat tender drawings. Further to this, in protecting the contractor from a rapid escalation in costs during the detailed design, it is important that the design consultant does not pursue an unrealistically aggressive design at tender which will be un-buildable in detailed design within the bounds of the BD approval guidelines in the HKSAR.

## **CONCLUSION**

This paper outlines a consultant's perspective on the key considerations and aspects of the management of D & B projects in the HKSAR. Consideration has been given to the fundamental aspects of D & B projects and this has been discussed within the context of the government design approval system and the authors experience on the Tsz Wan Shan Cable Tunnel project.

The development of Relationship Management is arguably the most important element in a D & B contract, particularly in the HKSAR. Other essential aspects of the D & B process that should be given considerable attention, particularly at the front end of projects, is the detailing of a clearly defined design agreement. It is recommended that particular attention is given to defining the scope of works, developing a clear design/deliverables program, and coming to an early agreement on and clearly detailing an efficient process for handling CO's.

## **ACKNOWLEDGEMENTS**

Many thanks go to my colleagues at Arup for sharing their individual perspectives on D & B projects in the HKSAR. Special thanks to Glen Plumbridge, David Salisbury, Nathan Wilmot and Kenny Wong.

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