Appendix 2.2 Tunnel Construction Methods

1. Introduction

This Appendix gives a general description of the tunnelling techniques reviewed for possible use in the Project, including cut and cover, drill and blast, bored tunnelling and sequential mining construction. A summary of environmental merits and dis-merits associated with these methods are also presented.

With regard to possible use of mini and micro-tunnelling techniques, as the names imply, these techniques are used to construct small tunnels only and find their applications in utility projects. In view of the size required for the railway tunnels, the methods are not considered practicable for use in the Project.

2. Construction Methods

2.1 Cut and Cover Tunnelling

Cut and cover tunnelling is a common and well-proven technique for constructing shallow tunnels. The method can accommodate changes in tunnel width and non-uniform shapes and is often adopted in construction of stations. Several overlapping works are required to be carried out in using this tunnelling method. Trench excavation, tunnel construction and soil covering of excavated tunnels are three major integral parts of the tunnelling method.

Most of these works are similar to other road construction except that the excavation levels involved are deeper. Bulk excavation is often undertaken under a road deck to minimise traffic disruption as well as environmental impacts in terms of dust and noise emissions and visual impact.

2.2 Drill and Blast

This tunnelling method involves the use of explosives. Drilling rigs are used to bore blast holes on the proposed tunnel surface to a designated depth for blasting. Explosives and timed detonators are then placed in the blast holes. Once blasting is carried out, waste rocks and soils are transported out of the tunnel before further blasting. Most tunnelling construction in rock involves ground that is somewhere between two extreme conditions of hard rock and soft ground. Hence adequate structural support measures are required when adopting this method for tunnelling. Compared with bored tunnelling by Tunnel Boring Machine (see below), blasting generally results in higher but lesser duration of vibration levels. A temporary magazine site is often needed for overnight storage of explosives.

2.3 Bored Tunnelling

Bored tunnelling by using a Tunnel Boring Machine (TBM) is often used for excavating long tunnels. An effective TMB method requires the selection of appropriate equipment for different rock mass and geological conditions. The TBM may be suitable for excavating tunnels which contain competent rocks that can provide adequate geological stability for boring a long section tunnel without structural support. However, extremely hard rock can cause significant wear of the TBM rock cutter and may slow down the progress of the tunnelling works to the point where TBM becomes inefficient and uneconomical and may take longer time than the drill-and-blast tunnelling method.

2.4 Sequential Excavation Method

This method is also known as the New Austrian Tunnelling Method (NATM). The excavation location of a proposed tunnel is divided into segments first. The segments are then mined sequentially with supports. Some mining equipments such as roadheaders and backhoes are commonly used for the tunnel excavation. The ground for excavation must be fully dry for applying the NATM and ground dewatering is also an essential process before the excavation. Another process relates to the ground modifications such as grouting, and ground freezing is also common with this method in order to stabilize the soil for tunnelling. This method is relatively slow but is found useful in areas where existing structures such as sewer or subway could not be relocated.

3. Environmental Benefits and Dis-benefits

Selection of the techniques to be adopted for construction of a tunnel section shall take into account the nature of the substrata and the levels of the tunnel involved. A summary of the environmental benefits and dis-benefits associated with the construction methods is presented in the table below.

Tunnel Construction Methods	Environmental Benefits and Dis-benefits (on relative terms)
Cut and cover tunnelling	Dis-benefits: ▪ More dust and noise impact may arise, though these can be mitigated through implementation of sufficient control measures; ▪ Temporary decks are often installed before bulk excavation to minimise the associated environment impacts; ▪ Larger quantity of C&D materials would be generated from the excavation works, requiring proper handling and disposal.
Drill and blast	Benefits: ▪ Potential environmental impacts in terms of noise, dust and visual on sensitive receives are significantly reduced and are restricted to those located near the tunnel portal; ▪ Compared with the cut-and-cover approach, quantity of C&D materials generated would be much reduced; ▪ Compared with the cut-and-cover approach, disturbance to local traffic and associated environmental impacts would be much reduced; ▪ Blasting would significantly reduce the duration of vibration, though the vibration level would be higher compared with bored tunnelling; Dis-benefits: ▪ Potential hazard associated with establishment of a temporary magazine site for overnight storage of explosives shall be addressed through avoiding populated areas in the site selection process.

Tunnel Construction Methods	Environmental Benefits and Dis-benefits (on relative terms)
Bored tunnelling	Benefits: ■ Potential environmental impacts in terms of noise, dust and visual on sensitive receives are significantly reduced and are restricted to those located near the launching and retrieval shafts; ■ Compared with the cut-and-cover approach, disturbance to local traffic and associated environmental impacts would be much reduced; ■ Compared with the cut-and-cover approach, quantity of C&D materials generated would be much reduced;
Sequential Excavation Method	Benefits: ■ Similar to the drill-and-blast and bored tunnelling methods, only localised potential environmental impacts would be generated; Dis-benefits: ■ As the method is relatively slow, duration of potential environmental impacts would be longer than that of the other methods.