The disadvantages of top down technique construction essay

The purpose of this report is to investigate the methods and requirements of cut and cover tunnelling and to determine its best use in the field of engineering. In this report the methodology, resources/equipment used, advantages, disadvantages of cut and cover tunnelling will be researched and discussed, this information will then be used to analyse the construction of the Auckland Victoria park motorway tunnel, determining the reason for choosing this method of tunnel construction.

2. 0 General

2. 1 The cut and cover tunnelling method is one of the more simple forms of tunnel construction available where the area to be tunnelled is excavated and a tunnel built within the excavation with a strengthened roof system which can support the loading of any soil or structures to be constructed above itself. This method is used where a shallow tunnel is recommended or required. There are two main methods of the cut and cover technique used in tunnel construction: the bottom up (commonly known as the cut and cover method) or top down method (also known as cover and cut). Both methods involve some form of excavation after the installation of supporting retaining walls and backfilling the excavation after tunnel installation but have several differences in the actual way that the construction of the tunnel itself is carried out.

3. 0 Bottom-up method (cut and cover)

3. 1 Methodology

3. 1. 1 This method involves excavation of a trench, with ground and trench wall support as required. Construction of the tunnel itself is carried out within

the trench using either poured in situ reinforced concrete, precast concrete or arches (precast concrete or steel). The tunnel floor is the first to be constructed following excavation.

3. 1. 2 Once the tunnel is constructed the trench is then backfilled to cover any gaps not filled by the tunnel, to allow for reinstatement of any ground features, utilities or structures to be built above the tunnel.

3. 1. 3 The use of any retaining walls in conjunction with a cut and cover tunnel is always considered due to the weak nature of the surrounding soil, especially in a situation where the excavation has been done in an area of sloping ground. The retaining walls used with the tunnel system provide extra lateral support both while the tunnel is being constructed and also once it is in place and any other materials, utilities and soil have been reinstated. Sheet piles and anchoring’s as well as Berliner walls are commonly used to help stabilise slopes and soils providing pressure and/or force against the tunnel.

3. 1. 4 Reinstatement of soil above the tunnel is not necessary but often required or requested as a way of environmental restoration in a project. In some cases this consideration of reinstatement may also be due to the fact that by restoring the excavated soil can provide some form of ground stabilisation to the surrounding soils.

3. 2 Requirements

3. 2. 1 used in areas of dominant soil, gravels or soft rocks. This method is also commonly applied in highway engineering where excavation depths do not exceed 100ft.

3. 2. 2 This method is used where soft soils are present due to the risk if tunnel collapse, either while workers are present in the partially constructed tunnel or when the tunnel is complete and the public are using it.

3. 2. 3 Cut and cover tunnelling is often used for safe initiation of a larger underground excavation or where slips or slides are possible above the tunnel portals. This is due to the fact that a tunnel entering the side of a hill has to first go through soft soils and weaker or less stable materials before reaching harder, more stable clays and/or rock. Initiating a large tunnel using cut and cover is common as it makes the rest of the tunnels construction much safer as the softer, weaker soils and rock are properly retained by the tunnel walls and roof and any possible slips or rock falls will not endanger workers lives while construction is underway

4. 0 Top-Down Technique

4. 1 Methodology

4. 1. 1 This method of cut and cover tunnelling involves a similar process to cut and cover; however, the excavation only goes to above the tunnel roof. After this excavation is complete drilling begins to create cast in place piles or walls along the side edges of the tunnel and a roofing protection casing which will provide enough strength to protect workers from the tunnel collapsing while either hand or mechanised excavation is carried out within the “ shell”.

4. 1. 2 Once the walls and roof supporting the soil are in place reinstatement of the soil can begin, meaning that the reinstatement works can be finished even before the construction of the tunnel begins. The floor is then cast or

lifted into place and tied back to the previously cast in situ walls. Once the majority of the construction is complete the secondary (or finishing) walls can be cast onto the previous walls. This provides a cosmetic finish to the tunnel and smooth’s out the walls to provide both a safe and visually pleasing finish to the load bearing element of the tunnel wall. Each separate tunnel must have its own walls and roof to support the soil as excavations and installation of the tunnel is carried out

4. 1. 3 by drilling and casting in place concrete piles and attaching a suitable cast in place roof slab, a protective area has been created allowing for safe excavation of the material to create the tunnel. This protection is as safe as excavating in an already established tunnel.

4. 2 Requirements

4. 2. 1 Most of the requirements are the same as for the bottom- up technique but is a preferred method in portal tunnels where there is excessive risk of rock falls that will run parallel to the road are present.

4. 2. 2 This method can also be useful in any tunnel excavation situation where extended opening of an excavation is not permissible or possible. This could be due to local laws and regulations, public safety issues or because or ecological constraints in the area.

4. 2. 3 This method can be useful in adverse conditions where standard excavation will be difficult. Soil remains undisturbed until piles and a roof system are put in place which will have the capacity to prevent any slips or failure of the soil while excavation work inside the tunnel takes place.

5. 0 Excavation Support

5. 1 Retaining Walls

5. 1. 1 Due to the nature of the soils being excavated, retaining walls are almost always used in both the bottom up and top down methods of cut and cover tunnelling.

5. 1. 2 temporary retaining methods include sheet piling, braced solider piling and tie backs. Of all these methods braced solider piling is the most versatile as it can be installed in a wider variety of ground conditions to both sheet piles- which can only be placed in shallow excavations and are most efficient in cohesion less soils and tie backs which require a rock to anchor onto deep within the soil. Solider piling is also useful due to the fact that it can be constructed around any existing utilities, eliminating the need for more expensive replacement jobs due to installing sheet piles or similar retaining wall types

5. 1. 3 Rigid retaining wall methods include slurry walls where a bentonite slurry mix is poured into a wide trench and reinforcing bar is lowered into the mix to add strength to the retaining wall. Other methods include both tangent and secant pile walls.

5. 1. 4 There is no clear preferred method for the construction of rigid retaining walls. This is due to all methods being possible in any ground conditions. Even with cohesion less soils as a sheet pile/ tube can be installed before commencing the construction of a section of the retaining walls.

5. 1. 5 Temporary retaining walls can be useful as it provides temporary protection from trench collapse while the tunnel is constructed and external waterproofing or utilities are put in place, while still being relatively cheap and disposable or having the option of being dismantled.

5. 2 Open Cut Slope

5. 2. 1 Used where there is a large area of space to carry out excavation works. It involves excavating the material with a batter slope that allows the soil to naturally support itself without any retaining wall or extra support.

5. 2. 2 This method can only be used where space is not limited, otherwise a retaining wall system (flexible/temporary or rigid/permanent) for supporting the excavation walls vertically

6. 0 Method Comparison

6. 1 Advantages of Bottom-Up Technique

6. 1. 1 Cut and cover tunnelling is very cost effective in shallow depth tunnel construction

6. 1. 2 effective when dealing with loose or weak material

6. 2 Disadvantages of Bottom-Up Technique

6. 2. 1 leaves surface unusable during the construction process

6. 2. 2 requires large spaces for long periods of time, even when retaining walls are in use over open cut excavation

6. 3 Advantages of Top-Down Technique

6. 3. 1 useful when great care is required due to existing services and utilities underground which cannot be moved or removed

6. 3. 2 used where there is risk of failure with open excavations,

6. 3. 3 minimal disruption to above ground operations due to surface being reinstated before tunnel works are complete

6. 4 Disadvantages of Top-Down Technique

6. 4. 1 excessive construction due to having to build a " shell" to protect tunnel excavation workers

Comparison of the two methods of cut and cover tunnelling, bottom-up technique on left, top-down technique on right. Source: http://www. ejge. com/2008/Ppr0864/Ppr0864. pdf

7. 0 Case Study

7. 1 Victoria Park Tunnel

7. 1. 1 The main reason for the cut and cover method being chosen for the Victoria Park motorway tunnel was because of how shallow the tunnel was to be built. Its lowest point below ground level is 12 metres (approximately 39 to 40 feet) which easily falls within the 100 foot limit of cut and cover tunnelling. The specific method used was the bottom up technique, excavating a trench with secant retaining walls installed to hold the soil.

7. 1. 2 The safety features included in the tunnel include fire/ emergency exits, an emergency stopping shoulder, ventilation and isolation fans which

can either provide air to breathe or extract unsafe air pollution from the tunnel and a water/foam deluge systems to help fight fires within the tunnel. Emergency messages can also be broadcast through the car radios of tunnel users if the need arises.

Photo showing completed tunnel with safety features fitted: ventilation (circled), watere/foam deluge system (arrows), emergency stopping shoulder and emergency exit (one of many throughout the tunnel). Source: http://www. aucklandmotorways. co. nz/northern/victoriaviaduct. php

7. 1. 3 the floor slab was a cast in place reinforced unit. This was the easiest method to carry out due to the size of the floor area. It also meant that tying back the floor slab to the retaining walls was much easier than having to accommodate for precast units

7. 1. 4 The use of a retaining wall was the only option as a way of carrying out the excavations as there are numerous houses, businesses and roads in the area and an open cut slope would have taken up too much space to carry out the tunnel works.

Photo of Victoria Park tunnel construction showing the constructed secant walls along with the pouring of the concrete floor slab. Source: http://www. stuff. co. nz/auckland/local-news/auckland-city-harbour-news/4299591/Park-tunnel-shapes-up

7. 1. 5 Precast panels and beams were used for the construction of the side walls and roofing of the tunnel. This meant that there was no need to wait for any concrete on site to dry after the floor slab was completed, resulting in

reinstatement of the utilities, services and above ground features commencing immediately after erection of the tunnel roof.

After the installation of the beams, roof slabs and wall slabs, reinstatement of anything above the tunnel could begin. Source: http://www. stuff. co. nz/auckland/local-news/5854863/Victoria-Park-Tunnel-walk-booked-out

7. 1. 5 The only major issue that the contractors of the Victoria park tunnel had was the location of a historic pub above the tunnel. This was resolved by lifting the building up onto lubricated concrete beams to act as rails, sliding the building 40 metres to a temporary location to allow for trenching works to take place in order to build the tunnel.

Temporary relocation of the historic “ birdcage” pub underway. Source: http://www. 3news. co. nz/Aucklands-Birdcage-makes-way-for-tunnel/tabid/423/articleID/173559/Default. aspx