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A variety of methods and machinery used in drilling tunnel

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Abstract

Tunnel is a horizontal or almost horizontal underground corridor that From both sides or one side is connected with the open air. The world's oldest known tunnel is in Mesopotamia which dates back to about 4000 years ago. Tunnels made in recent years are classified into three general categories tunnels, transportation, industrial and mining. Type of ground, dimensions tunnel and environmental features are important factors in the design and selection of drilling tunnels. Tunnel digging carried out with hand tools or machines mechanized and in different ways. In mechanized tunnel drilling used a variety of machines such as jumbo drills, boom type machines and tunnel boring machines .In this paper presented a revision in relation to number of tunnel drilling methods in different fields and machines used in each of these methods.

Keywords: Tunnel , Drilling, NATM, Blasting, Shield

1. Introduction

There are different meanings for tunnel. In the old definitions tunnel is defined as a long underground corridor or a horizontal or almost horizontal underground corridor that from both sides and one side is connected with the open air. Other definitions for the tunnel can be considered, including the mineral corridor which is open on one side or horizontal and also diagonal underground corridor that is drilled in rocks for mining and may have routes one or two sides to open air.

The world's oldest known tunnel is in Mesopotamia which dates back to about 4000 years ago. This tunnel is one kilometer long with dimensions of 4/5m × 3/6m it is Crossed the Euphrates River from below and the palace of the king of Babylon made connected to a dedicated temple. In the year 525 BC Plykrat for access to water, a tunnel dug by the Greek historian Herodotus regarded as one of the three large buildings in Greece. [1]

For tunnel construction the following steps should be following:

- Drawing tunnel project
- Detail-location survey and engineering research
- Drilling tunnel

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- Temporary maintenance tunnel
- Implementation of technical services such as ventilation, water discharge, ...
- Permanent maintenance of the tunnel

Overall tunnels can be divided into three general categories:

- Transport tunnels
- Industrial tunnels
- Mine tunnels

Transport tunnels constructed for people and vehicles movement and easy transport and they are divided to the following groups:

- Railway tunnels
- Road Tunnels
- Pedestrian tunnels
- Navigation Tunnels
- Subway tunnels

Industrial tunnels are constructed in order to transport materials and facilities and are divided into the following groups:

- power plants tunnels
- Water transfer tunnels
- Public use tunnels and bunkers
- Sewer Tunnels
- Military depots
- Nuclear waste tunnels

Mine tunnels are dug to construct mines and include the following tunnels:

- Exploratory tunnels
- Service tunnel
- Drainage Tunnel

Mining and transport tunnels are different with together in some cases such as time operation, dimension and the presence of humans in the tunnel.

2. Effective factors in the design and selection of drilling methods

Type of ground, dimensions tunnel and environmental characteristics are effective factors in the design and selection of drilling methods. Land can be hard and rocky, loose and soil or a combination of both. In hard rocks drilling is done by mechanical machinery or blasting. The most common method tunnel drilling in hard rocks The most common method is the use of explosives. Drilling on the loose ground is done manually and mechanically. Choose a method of tunneling in the soil and how maintenance is done according to the structural conditions of ground, drilling dimensions and the amount of the progress at any stage. In general, the construction of tunnels in soil includes excavation, retaining of placement and soil discharge. [2]

Sometimes during tunnel construction in rock we face a special case that one part of the tunnel is located in rocks while other part is in more resillent stones. This situation can cause problems for machines and temporary maintenance. So drilling methods and arrangements for maintenance should be selected in accordance with the terrain. Where ever the rocks are weaker the tunnel should be divided into more parts and do the drilling sectors separately.

Located in the urban environment, location of underground aquifers and changes in phreatic water levels are environmental factors in the design of tunnel. Other factors such as temperature, humidity and air pressure can also have a major impact on the choice of drilling method. Items such as traffic volume, the level of prices, quality and quantity of manpower staffing of such cases are effective in drilling method.

3. Drilling methods in rock and soil

Various methods are used to drilling in rock and soil which some of them are listed below:

a) Top heading short bench method
b) Center diaphragm method
c) Side drift method
d) New Austrian tunneling method
e) Blasting method
f) Shield tunneling method
g) Cut and cover method
h) Tunnel boring machines method
i) Boom type machines method

In this article, items (d), (e) and (f) are briefly introduced.

4. Introducing the new Austrian tunneling method

NATM (new Austrian tunneling method) is one of the methods tunneling which the rock mass to be used for maintenance, in fact paid more to strengthen the stone. The method of NATM is composed of sections drilling and temporary protection the upper part, drilling and temporary protection the lower part, run the floor tunnel lining and run walls and roof of the tunnel lining.[3] The first operational activities in the Austrian method is drilling the upper section of the tunnel. This section of the tunnel should have a minimum volume, because the probability of loss is higher here. Also air ventilation is difficult at this stage. [Fig.1][4]

Done in order to consolidate chamber and prevent loss. Temporary protection involves the following steps:

1. Implementation the Initial orthogonal mesh reinforcements [Fig.2]
2. Implementation the profile frame [Fig.3]
3. Initial Shotcrete [Fig.4]
4. Implementation the secondary orthogonal mesh reinforcements
5. Secondary Shotcrete

After drilling the upper section, temporary protection is after consolidation of the upper part and controls required by the monitoring device, will start drilling the lower section.

Fig. 1. Example of an air conditioning system

Fig. 2. Implementation the Initial orthogonal mesh reinforcements

Fig. 3. Implementation the profile frame

Activity in this sector is quite similar to the upper part and while drilling the lower section of the upper part is easier than drilling but safety considerations must be adhered to strictly because the sudden removal of lower soil is the occurrence of adverse events and loss of the tunnel. Then temporary protection the lower part of the tunnel begins and similar operations consolidation of the upper part mesh and frame to be installed and shotcrete. The batt insulation implement prevent water entering to the tunnel [Fig.5]

Figure 4. Dry mix Shotcrete

Figure 5. Batt insulation

Figure 6. Implement foundation

Then implement reinforcement and concreting the bottom of the tunnel. [Fig.6] and finally the last stage of construction of the tunnel is reinforcement, formwork and concreting casing and ceiling of the tunnel. [5].

5. Introducing the blasting tunneling method

In this method, a number of boring close together and with specific angles is created according to the drilling pattern. Borings can be parallel or non-parallel. [Fig.7] Boring drilling devices can have a variety and different factors such as diameter, depth and tilt boring could have an impact on the selection of drilling machine. .[Fig.8]

This machines can be rubber wheels or sprocket wheels or that move on rails.[6] Breast tunnel inspection, locating borings, boring drilling, cleaning and controlling borings, connecting to the network explosion, explosion, ventilation after the explosion, shipping and handling, retaining installation and maintenance, survey and installations is the process blasting tunneling method.[fig.9][7]

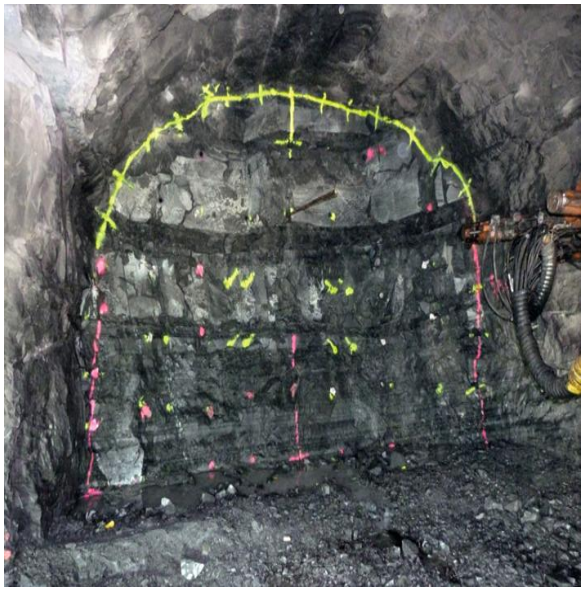

Figure 7. Example of a drilling pattern. borings

Figure 8. Example of drilling machine

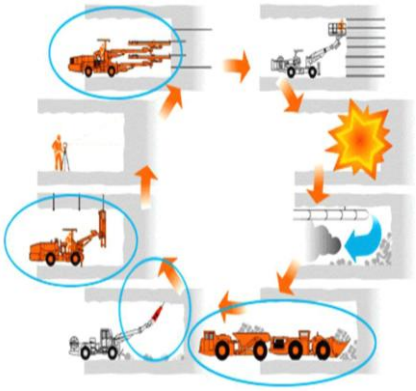

Figure 9. Blasting tunneling method

6. Introducing the shield tunnelling method

Tunnel drilling in loose yard is usually done using steel shields. The shields are often circular and tunnel space may be placed under open air or under the influence of compressed air. There shield causes the drilling can be done safely circumstances and build the basic maintenance system and controlled the earth summit.[8]

Shields divided into three categories:

- Open shields
- Close shields
- Half-shields

Open shields are used on lands that are rigid enough and not lose ground in front of the shield. The main characteristic closed shields is having drilling chamber for withstand to water pressure and earth. [Fig.10]

Closed shields are classified as follows:

- Compressed air shield
- Slurry shield
- Earth pressure balance shield (EPB)
- Combined shields

Fig.11 shows the mechanism of action of a slurry shield.

Figure 10. Examples of Open shields

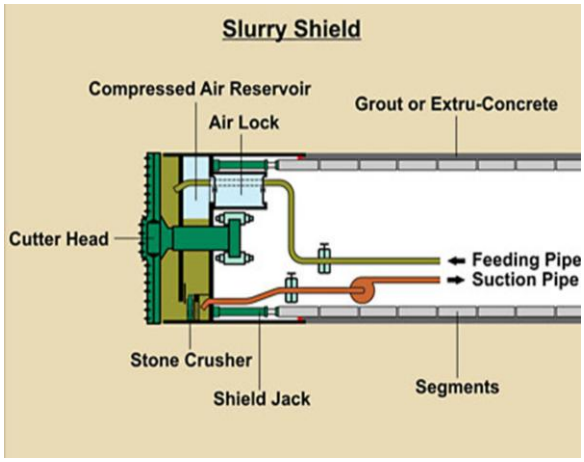

Figure 11. Slurry shield

7. Conclusion

Tunnel drilling methods has been significant progress from past to present and the obsolescence of manual drilling methods and bowed to the use of mechanized devices, has greatly increased the quality and speed of tunnel construction. Shield tunneling method, especially EPB compared to the other methods is faster, because in this method of drilling, lining and installation takes place of mechanized and at the same time.

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