Cross-connections for Botlek Railwaytunnel in the Netherlands

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ABSTRACT: This paper presents an outline of the cross-connections at the Botlek Railwaytunnel. The applied design and workmethod for the execution of the cross-connections proved to be both safe and effective. The project was completed successfully and has contributed very useful information about soil freezing and self compacting concrete in The Netherlands.

1 INTRODUCTION

The Botlek Railwaytunnel near Rotterdam (construction completed in 2001) is part of the Betuweroute railway and has a bored length of approximately 1800 meters. The tunnel consists of two separate bored tubes. Between the two tubes there are three cross-connections designed as an escape route in case of emergency. It is the first project in the Netherlands where such cross-connections, under the given conditions, have been built.

The following criteria were used during the design of the cross-connections:

- Planning: influence of the construction of the cross-connections on the progress of the TBM (Tunnel Boring Machine)
- Risks: inundation from groundwater
- Experience in construction methods

Several alternatives, such as jetgrouting, low strength concrete and soilfreezing, where evaluated using these criteria. Ultimately this resulted in a combination of deep shafts and soilfreezing for the design and construction of the cross-connection at the Botlek Railwaytunnel.

2 WORKMETHOD

Before the passage of the TBM the deep shafts (max. depth 30 m below ground level) were constructed using diaphragm walls. The shafts were situated between the two tunnel tubes. The geometry of the shaft was so designed that the use of struts was avoided. After the first passage of the TBM the soil between the shaft and the tunnel was bridged by soil freezing. During the freezing process the connection between the shaft and the tunnel tube was made with self compacting concrete. When the concrete had formed a constructive and watertight connection the freezing process was be stopped. After the passage of the TBM for the second tunnel tube the same process was followed to make the connection to the second tunnel tube. Only when its was ascertained that both connections to the tunnel tubes were watertight, and the risk of inundation of the tunnel was reduced to zero could the tunnel lining of the bored tunnel be opened and the total cross-connections be finalized.

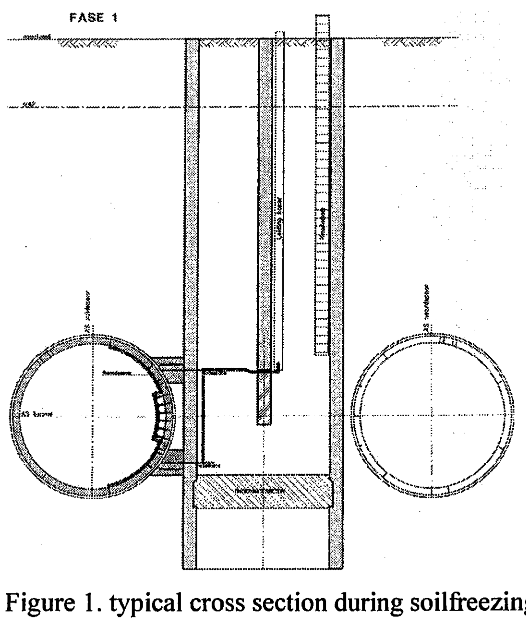

Figure 1. typical cross section during soilfreezing

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Due to the fact that the cross-connections were constructed from within the shafts the construction works did not interfere with the logistics and progress of the TBM.

3 DESIGN & ENGINEERING

The design and engineering of the cross-connections has the following characteristics:

- Accessibility of the location on ground level.
- A maximum horizontal (longitudinal) shift of the actual location of the tunnel lining of 0.75 m.
- Joints between the bored tunnel, the shaft and the connection prevent stresses due to deformations.
- The size and location of the opening in the tunnel minimizes the structural effect on the lining. No steel lining, but special concrete elements with additional reinforcement are used.
- A limited amount of auxiliary works inside the tunnel.

4 SOILFREEZING

Soil freezing can be executed by using cooled brine or liquid nitrogen (LNO2). Because of the relatively small volume of soil which has to be frozen and the short period of time needed for the execution of the concrete works liquid Nitrogen (LNO2) was used at the Botlek Railwaytunnel. Freezing with liquid nitrogen is much faster than freezing with brine due to the very low boiling point of liquid nitrogen (-196° Celsius).

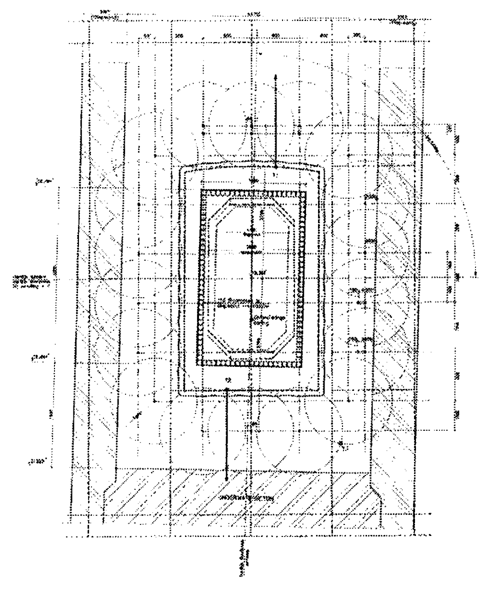

Figure 2. Layout freezetubes

From the shaft a total of 18 freezetubes were installed horizontally around the future cross-connection (figure 2). These 18 freezetubes were separated in four groups. Each group was monitored and controlled separately. Additionally three temperature tubes were installed to monitor the development and thickness of the frozen soil. On the inside of the tunnel lining thermocouples were installed to monitor the adhesion of the frozen soil on the tunneling.

5 SELF COMPACTING CONCRETE

The concrete of the cross-connections was specially designed for this application. The design of the concrete mix had to comply with the following working conditions:

- Cast without compacting behind the formwork.
- Cast directly against surrounding frozen ground.

Therefore a self compacting concrete was designed. The materials were transported dry and premixed to the site, where a measured amount of water was added at ground level, before pumping the concrete down the shaft directly into the framework.

The temperature behavior of the mix in contact with the frozen ground (minus 20° Celsius) was extensively studied in advance using a trial casting. The experiment was completed successfully without freezing of the self compacting concrete during hardening.

Figure 3. Self compacting concrete

6 CONCLUSIONS

The chosen solution as described above for the execution of the cross-connection proved to be both safe and effective.

The project was completed successfully and has contributed very useful information about soil freezing and self compacting concrete in The Netherlands.