

## Application of ground freezing technology for a retaining wall at a large excavation in the centre of Rotterdam, The Netherlands

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Proposed Discussion Sessions:

- Session 2. Deep excavations and slopes, or:
- Session 3. Underground works

In the centre of Rotterdam, The Netherlands, extensive reconstructing works on the existing underground station CS are being executed during the period 2006 - 2009. The present station, which is the terminal station of the Erasmus line, is going to be rebuilt from a two-track, single platform lay-out into a three-track, two platforms configuration. Engineering of this project is mainly performed by the Consulting Division of Rotterdam Public Work. CDM Consult GmbH has been involved in ground freezing engineering. Dimensions of the required excavation are: length ca. 230 m, width ca. 30 to 50 m, maximum excavation depth ca. 14 m. Major design condition is that underground traffic and passenger transfer must not be affected during all stages of the building activities.

Diaphragm walls were constructed to a depth of ca. 40 m below ground surface for retaining soil- and water pressures, except for the eastside [photograph # 1] of the excavation where the existing underground tunnel enters the building pit. A collar construction around the tunnel is generated here using ground freezing techniques, as the construction of a normal diaphragm wall is not possible at this location.



A total number of 100 freeze-pipes and temperature monitoring pipes were installed mainly vertically to a depth of ca. 40 m. Installation was done from the ground surface and from inside the underground tunnel. The ground freezing duration period was estimated to be at least 9 months.

This paper describes the design optimisations of the collar construction with respect to a.o. the following ground freezing related topics:

- Contractual aspects, since the installation of the freeze pipes has been part of a separate building contract
- Methods of freeze-pipe installation
- Evaluating of as-built data of freeze pipes
- Thermal calculations, including effects of groundwater velocity
- Application of liquid nitrogen and brine freezing, as both techniques have been applied
- Frost heave effects on the existing tunnel, considering the complex soil conditions at the site
- Growth control of the frozen soil body, and provisions to allow for the installation of a pile foundation nearby the collar construction

*[Photograph # 1 – Collar construction location at east side of building site; existing underground tunnel (heading west, top at 4 m below street elevation) is located in between the high-rise buildings.]*

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