Journal of Rock Mechanics and Geotechnical Engineering 6 (2014) 387–398

Contents lists available at ScienceDirect

Journal of Rock Mechanics and Geotechnical Engineering

journal homepage: www.rockgeotech.org

Full length article

Underground space planning in Helsinki

Ilkka Vähäaho*

Geotechnical Division, Real Estate Department, City of Helsinki FI-00099, Finland

ARTICLE INFO

Article history:
Received 16 April 2014
Received in revised form
12 May 2014
Accepted 13 May 2014
Available online 23 August 2014

Keywords:
Land use planning
Underground resources
Underground master plan (UMP)
Sustainability
Urban development
Three-dimensional (3D) cadastral system
Drill-and-blast (D&B) method
Ownership of the land

ABSTRACT

This paper gives insight into the use of underground space in Helsinki, Finland. The city has an underground master plan (UMP) for its whole municipal area, not only for certain parts of the city. Further, the decision-making history of the UMP is described step-by-step. Some examples of underground space use in other cities are also given. The focus of this paper is on the sustainability issues related to urban underground space use, including its contribution to an environmentally sustainable and aesthetically acceptable landscape, anticipated structural longevity and maintaining the opportunity for urban development by future generations. Underground planning enhances overall safety and economy efficiency. The need for underground space use in city areas has grown rapidly since the 21st century; at the same time, the necessity to control construction work has also increased. The UMP of Helsinki reserves designated space for public and private utilities in various underground areas of bedrock over the long term. The plan also provides the framework for managing and controlling the city's underground construction work and allows suitable locations to be allocated for underground facilities. Tampere, the third most populated city in Finland and the biggest inland city in the Nordic countries, is also a good example of a city that is taking steps to utilise underground resources. Oulu, the capital city of northern Finland, has also started to 'go underground'. An example of the possibility to combine two cities by an 80-km subsea tunnel is also discussed. A new fixed link would generate huge potential for the capital areas of Finland and Estonia to become a real Helsinki-Tallinn twin city.

1. Introduction: geological conditions and challenges in Helsinki—experiences and advice

Finland has 320 independent municipalities as of 2014. Helsinki, the capital, is clearly the biggest city in Finland. While the average size of all the municipalities is 950 km^2, the surface area of Helsinki is only 214 km^2 spreading across a number of bays and peninsulas, and encompassing a number of islands. The inner city area occupies a southern peninsula where the population density in certain parts can be as high as 16,500 inhabitants per square kilometre.

The Greater Helsinki area is the world's northernmost urban area among those with a population of over one million and the city itself is the northernmost capital of a European Union (EU) member state. Altogether, 1.3 million people, or approximately one in four Finns, live in the area.

Helsinki is located in southern Finland on the coast of the Baltic Sea and has a humid continental climate. Owing to the mitigating influence of the Gulf Stream, temperatures in winter are much higher than its far northern location which might suggest with an average in January and February of around −5 °C (23 °F). Due to its latitude, days last for approximately six hours around the winter solstice and up to nineteen hours around the summer solstice. The average maximum temperature from June to August is around 19–21 °C (66–70 °F).

Helsinki's landscape is quite flat—the highest natural point is only 60 m above sea level. One third of Helsinki's ground is clay with an average thickness of 3 m and shear strength of around 10 kPa. The average depth of soil material upon bedrock is 7 m, but varies from 0 to almost 70 m. The bedrock quality in Finland is for the most part ideal for tunnelling and for building underground spaces, because the bedrock mainly consists of old Precambrian rocks and only a few places where younger sedimentary rocks exist (Fig. 1). This can be observed in Fig. 2 where a typical bare uncovered rock surface is visible. There are no sedimentary rocks in the Helsinki area; however, there are several fracture zones formed by rock block movements that cross the bedrock in the city centre. It is important to identify the locations and properties of these zones in the planning and excavation of rock constructions. At early stages of the Svecofennian Orogeny, rock deformations were ductile; later,

* Tel.: +358 500 464 132.
E-mail address: ilkka.vahaaho@hel.fi.

Peer review under responsibility of Institute of Rock and Soil Mechanics, Chinese Academy of Sciences.

http://dx.doi.org/10.1016/j.jrmge.2014.05.005

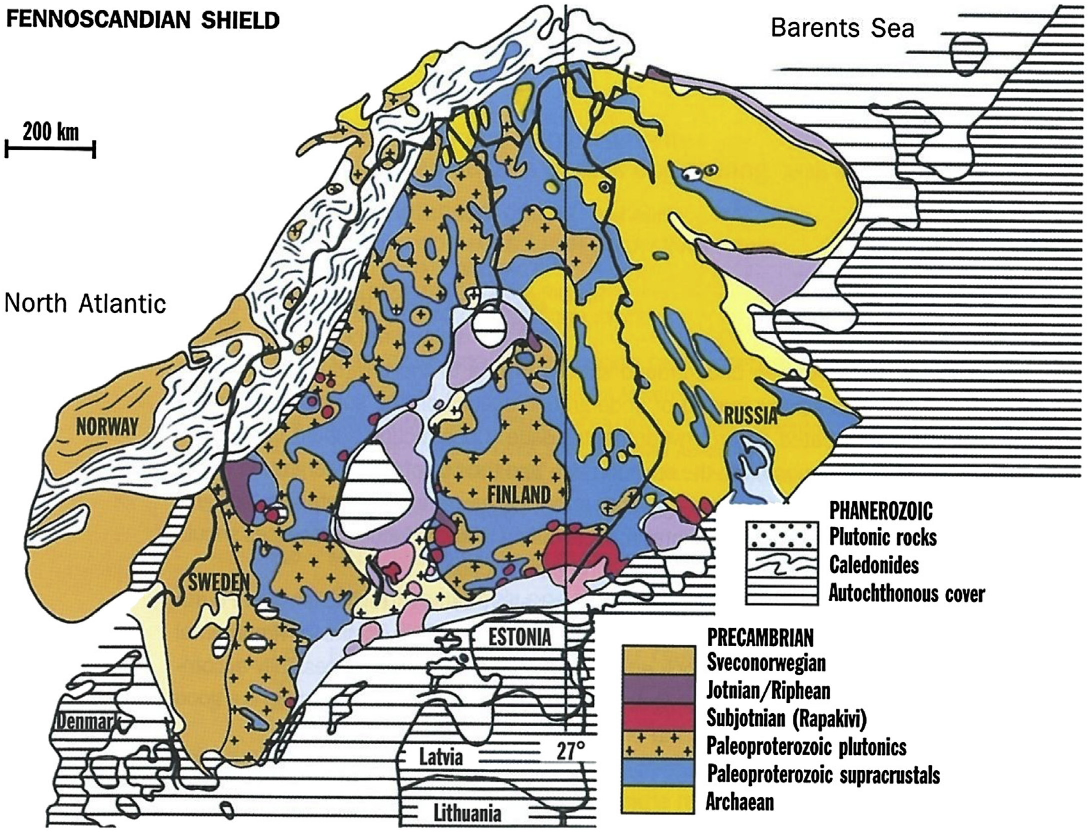

Fig. 1. Geological conditions in Finland and Scandinavia (Image: Geological Survey of Finland).

the rock cooled down and the deformations at the topmost layers became brittle and formed faulted structures. The fault zones were subsequently fractured by weathering, hydrothermal alterations, recrystallisation and later movements. Being more fragmented than surrounding areas, the fracture zones have been eroded more rapidly and are seen as depressions in the topography. The fracture zones have had a great impact on defining the shoreline of Helsinki city centre (Vänskä and Raudasmaa, 2005).

The fracture zones are usually under thick layer of soil and therefore hard to be examined. However, there are signs of movements on nearby rock surfaces which help to locate the zones.

The average price of tunnels and underground spaces is 100 euros/m^3 (including excavation, rock reinforcement, grouting and underdrainage). To date, only the drill-and-blast (D&B) method has been used for rock excavations, and the use of tunnel boring machines (TBMs) has not been competitive in Finland so far.

In cases where pre-grouting is needed, it is always carried out since it is practically impossible and much more expensive to achieve a dry underground space later on (Fig. 3).

The reason for the low cost of tunnelling in Finland is due to the practice of not using cast concrete lining in hard rock conditions, effective D&B technology (Fig. 4) and extensive experience of working in urban areas.

The author argues that cast concrete lining was used without any good reason, for example in the Hong Kong MTR West Island Line (Fig. 5) which was under construction during September 2011. Cast concrete lining can mean up to 200% extra costs and is a waste of money in conditions where there are excellent rock materials.

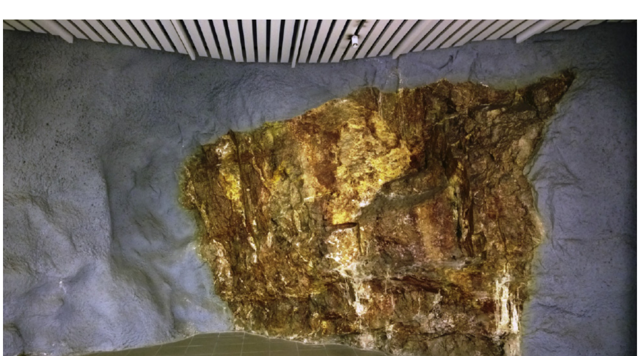

Fig. 2. A bare uncovered rock surface 'window' in the Kluuvi underground parking hall in Helsinki (Photo: Ilkka Vähäaho).

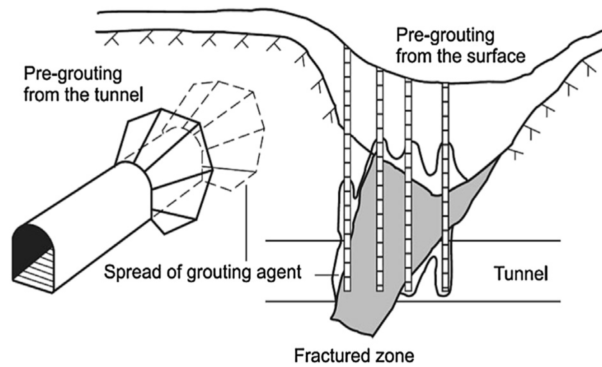

Fig. 3. Pre-grouting is most important because of the conditions in Helsinki (Image: Sandvik Mining and Construction Finland).