Development for urban underground space in Helsinki

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Abstract

Underground space is a resource for those functions that do not need to be on the surface. From the point of sustainability there are several benefits of locating technical networks in bedrock such as expenses are shared by several users, land is released for other construction purposes, the city’s appearance and image are improved as the number of overhead lines can be reduced. The Underground Master Plan of Helsinki shows both existing and future underground spaces and tunnels, as well as existing vital access links to the underground. It has been claimed by some non-Finnish experts that the favourable characteristics of the bedrock and the very severe winter climate conditions have been the main drivers for the underground development. While rock material is one of them, there are other main drivers heading the list over winter, such as the Finnish need to have open spaces even in the city centre. Real estate owners may restrict the use of underground space under their lot or get compensation only if the space to be used is harmful or it causes some loss to the owners. The capital areas of Helsinki and Tallinn have grown enormously during the last 20 years. The 80 kilometre-wide Gulf of Finland separates the cities and restricts the movement of people and goods. A tunnel between Tallinn and Helsinki would be an extension of the Rail Baltica rail link, a project to improve north–south connections between EU Member States. The most up-to-date results for developing coastal areas are about the sea level scenarios. This new data has a lot to do for example with the safe and adequate levels of accesses to underground spaces.

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1. Introduction

The roots of this paper lie in a lecture in 2009 at the World Tunnel Congress in Budapest, Hungary. Following this, the theme has been a major subject of interest around the world, mostly in the Far East. Using the City of Helsinki, a forerunner in the field, as a prime example, several papers have been written, numerous interviews given, many questionnaires completed and a number of site visits arranged in order to give inspiration and encouragement to other cities and decision makers on the possibilities of underground space use [1,2].

The most up-to-date results for developing coastal areas are about the sea level scenarios. As a result of ‘Safe levels for construction at coastal areas of Helsinki in 2020, 2050 and 2100’ project we got the maximum levels of wave crest elevation during a storm surge in the year 2020, 2050 and 2100. The short-term variation in the sea level data was calculated from the per-minute mareograph observations. The rise in the mean sea level due to climate change was taken into account by making use of the mean sea level scenarios. Besides estimating the largest wave field, this report also estimates the combined effect of the water level and the wave field on the coastline. Directly adding together the maximum values of water level and wave height gives too restrictive an estimate, producing values that are impractically large. This new data has a lot to do for example with the safe and adequate levels of accesses to underground spaces [3].

Finnish Tunnelling Association MTR-FTA has also been active in promoting the use of underground space to planners, decision makers and politicians. The Fourth Wave of Rock Construction [4] gives several examples of environmentally responsible underground design and execution.

2. Key considerations for the use of underground space

There are 10,000,000 m³ underground spaces in Helsinki (parking, sports, oil and coal storages, the metro, etc.), more than 400 premises, 220 km of technical tunnels, 24 km of raw water tunnels and 60 km of ‘all-in-one’ utility tunnels (district heating and cooling, electrical and telecommunications cables, and water). Some unique examples of the use of underground spaces are shown in Fig. 1 and 2.

![Fig. 1. Interior of the Temppeliaukio Church, which was designed by architects and brothers Timo and Tuomo Suomalainen and opened in 1969. It is also known as the Rock Church. (Photo: Juha-Pekka Järvenpää)](image-url)
According to architect Suomalainen [5], “The church hall was excavated using a certain system: first a large pit was made while leaving a layer of one or two metres unexcavated. The last few metres were then excavated very carefully while planning at the same time how to accomplish an acoustically suitable surface as well as some angles and ‘rough spots’ for the sake of outer appearance. The background wall of the altar was left last because it was the most important part. The final stages of the excavation went very well. As we were roaming round the hall we began to feel the strain disappear and knew then that the work would go well to the end. However, we had a shock when the foreman called us – he was really upset. The wall where the altar was to be situated had crashed down. Everything was ruined!

We told him to remove the loose pieces of rock and we would come and have a look immediately. When we arrived in the church we saw our altar. It had a really fine surface. We thought that just by placing a cross or crucifix on it, it would be perfect!

The altar is situated so that the sun shines during the service while the sun wedge comes in through the glass roof onto the altar wall.”

Alonso [6] discovers that “there are two Helsinkis, the city that we all know and another Helsinki underground. Many passages and facilities are ‘hidden’ in the underground of the city, like the ‘Itäkeskus’ Swimming Hall, one of the world's nicest sport facilities”. In Finland, property owners must include civil defence shelters in buildings of at least 1,200 m². Today, however, it is more common to have an underground defence shelter that serves some other purpose during ‘normal times’. In reality, such spaces are now designed to meet the needs of normal times with ‘just’ strengthening for ‘exceptional times’. This enables property owners to transform the swimming pool, for example, into a defence shelter quickly and economically should the need arise. The underground swimming pool in ‘Itäkeskus’ (Fig. 2) has facilities on two floors and can accommodate some 1,000 customers at a time. The hall attracts some 400,000 customers a year. Quarried out of solid rock, the hall can be converted into an emergency shelter for 3,800 people if necessary.

3. Planning for the Use of Underground Space

Space allocations for long-term projects, such as traffic tunnels, must be maintained for future construction. The same applies to those resources that are worth conserving for future projects. The exploitation of such resources must be carried out according to plan since excavating bedrock is a ‘one-off action’ (an action that can only be performed once). Underground master planning in Helsinki today is a significant part of the land-use planning process (Fig. 3).
When planning and carrying out new construction projects, it is important to ensure that the space reservations for public long-term projects, such as tunnels and ducts for traffic and technical maintenance, are retained for future construction. Similarly, the use of the valuable and unique rock and ground must be practical and exploited without wasting any future resources [7].

The City of Helsinki has also reserved rock resources for unclassified future use for the construction of as yet unnamed underground facilities. The aim is to identify good sites for functions that are suitable for locating underground, and which would also reduce the pressures on the city centre’s rock resources. The suitability of rock areas for different purposes will be studied when preparing town plans. There are now some 40 unnamed rock resource reservations without a designated purpose with an average area of 0.3 km². Unnamed reservations have a total area of almost 14 km², representing 6.4% of the land area of Helsinki. When selecting these resources, the survey took into account their accessibility; the present and planned ground-level uses of these areas; traffic connections; land ownership; and possible recreational, landscape and environmental protection values so the selection of unclassified resources is both purpose- and rock-resource driven [8].

![Fig. 3. Extract of the Helsinki Underground (UG) Master Plan (Image: Helsinki City Planning Department).](image)


4. Twin-city Talsinki (Tallinn-Helsinki)

Finnish Estonian Transport Link (FinEstLink) is a full scale feasibility study and assessment on regional impact. The project focuses on a wider Finnish-Estonian perspective, European TEN-T perspective, transport technology development, environmental aspects and in changing socio-economic context of the emerging twin-city region [9,10].

Growth of mobility between the two cities has been very strong. Today the passenger ferry line is the number one in Europe in terms of passenger transport. The main challenge is to make such a project viable, despite the small sizes
of the Finnish and Estonian population. A first preliminary study encouraged the ministers of transport to commit themselves together with mayors and governors to continue studying the feasibility of the fixed link.

Partners:
- Uusimaa Regional Council
- Harju County Government
- City of Helsinki
- City of Tallinn
- Finnish Transport Authority
- Estonian Ministry of Transportation and Communication

Some figures about the circumstances between Tallinn and Helsinki:
- 8.21 million trips in 2015 between Helsinki and Tallinn
- 2.1 million inhabitants in facing capital regions (Uusimaa 1.59 million, Harju County 0.56 million)
- 2002-2010 seaborne cargo increased 76% from 2.28 to 4.01 million tons
- Unitised cargo (trucks & trailers) increased 430% 1993-2010
- Continuous annual growth of 10% of cargo volumes on Helsinki -Tallinn route expected

Forecast 2022:
- Increase in passenger car traffic estimated +50%
- Increase in cargo flows +60%

Malmö-Copenhagen example [11]
- A clear societal change has happened between the cities
- Malmö was a declining manufacturing city in the 1980s
- Copenhagen is a significantly wealthier region than Malmö
- A bridge between Copenhagen and Malmö was opened in 2000
- 15-minute commute between the cities
- Currently, Malmö is praised as a start-up hub and has shown dynamic economic growth

![Malmö population growth +34% since the lows in 1980s.](image-url)
At the beginning of April, a twin-city event was held in Helsinki and Tallinn [12]. This event brought together key public officials from Helsinki with their relevant counterparts on the Estonian side, to host talks about a planned fixed link project that could in the future be connecting the two cities that are now separated by the Baltic Sea. At the event the participants included planners, transport experts, cargo specialists, engineers and geologists to discuss the impact of bringing the twin cities closer by means of a fixed link.

ITA-AITES is the leading international organisation promoting the use of tunnels and underground space through knowledge sharing and application of technology to encourage the use of the subsurface for the benefit of public, environment and sustainable development. Further information and international examples of the use of underground space is given by the International Tunnelling and Underground Space Association ITA-AITES [13].

5. Aesthetical and sustainable aspects for urban underground space development

Buildings in Helsinki are mainly quite low with skyscrapers only being built in some special areas. The historic inner city (as seen in Fig. 5) is therefore remarkably different from the centre of Singapore, for instance. Helsinki can be classified by the term ‘down-rise city’ (= using underground resources effectively) while Singapore, in turn, is a ‘high-rise city’, which was fashionable in the 1900s. The deepest underground space in Helsinki is situated only about 100 m below sea level. Nevertheless, underground resources may also be found in the inner city in the future, if needed.

Fig. 5. Helsinki Market square (Photo: City of Helsinki Media Bank). Downtown Singapore in 2004 (Photo: Ilkka Vähäaho).
The comparison cities (Helsinki/Singapore) are similar from the underground building point of view as they both have favourable rock resources. In Helsinki, however, significantly more and diverse functions have been placed underground. Underground dimension is utilized open-mindedly in Finland, and in particular in Helsinki. It has been claimed by some non-Finnish experts that the favourable characteristics of the bedrock and the very severe winter climate conditions have been the main drivers for this development. While rock material is one of them, there are other main drivers heading the list over winter, such as the Finnish need to have open spaces even in the city centre, the excellent and long-lasting cooperation between technical departments and commercial enterprises as well as the small size of Helsinki. It is among the smallest by area and clearly the biggest by population in Finland.

A good example of land property resources made use of several times is the Katri Vala Park situated in the city centre (Fig. 6). Nowadays, there are four underground activities under the park totally independent from each other. The possibility to build one more space between the existing underground ‘floors’ is currently being investigated. The Katri Vala Park is also an example of the concept called 0-land_use (~ sustainable use of underground space) adopted by Sterling et al. [14].

As many deep cellars, underground spaces and tunnels already exist in the centre of Helsinki, the new underground cold water reservoir for district cooling was excavated between 50-90 meters from ground level (Fig. 7). Although all underground space below the surface of real estate owners’ land belongs to them, they may only restrict its use or get compensation if the space to be used is harmful or it causes some loss to the owner. This is mainly the case in (Local) Government Underground projects. In non-government projects, such as private car parks, a (servitude) agreement is drawn up between the construction company and the landowner even when the company is not paying for the use of the underground space.

There are several benefits of locating technical networks in bedrock: a reliable energy supply via a network with multiple links; the optimization of energy generation; expenses are shared by several users; land is released for other construction purposes; the city’s appearance and image are improved as the number of overhead lines can be reduced; construction work carried out on underground pipes and lines has significantly fewer disadvantages than similar work carried out at street level; blast stones and construction aggregates resulting from excavating the tunnels can be utilized; pipes and lines in tunnels require less maintenance; tunnel routes are shorter than those of conventional solutions; any breakages in pipes, lines and cables do not pose a great danger to the public; and tunnels are a safer option against vandalism.
4. Conclusions

Underground space is a resource for those functions that do not need to be on the surface. The underground master plan of Helsinki shows both existing and future underground spaces and tunnels, as well as existing vital access links to the underground. It also includes rock resources reserved for the construction of as yet unnamed underground facilities, with the aim of identifying good locations for functions suitable for locating underground, and which would also reduce the pressures on the city centre’s rock resources.

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Acknowledgements

The close cooperation that the City of Helsinki has established with the numerous ‘partners’ involved in planning, financing and designing as well as the actual construction and maintenance of tunnels and underground spaces has perhaps been the most important issue for sustainable underground property development. As much of this work is also carried out unofficially, trust between the parties is central, particularly when developing processes and sharing risks.

The demanding work that so many people have done in the field of urban underground space has strived to advance the long-term sustainable use of underground space.

References