Planning the Use of Underground Space: Asset or Liability

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1. Introduction

The concept of underground space use is one of the spatial assets which still needs to be discovered to its full potential. Those that do believe in the use of underground space see it as an asset which will prove to be of vital importance to society to survive in adapting to the many challenges that face mankind in the coming decades. Population growth is one of the major concerns as the sprawl of cities comes to an end; concentration will be the next development stage. How to cope with this population increase, which is even further accelerated by the migration from rural to urban areas, is one of the major challenges facing city planners. As the climate changes, further demands are made on available space to cope with these changes. In this paper the author will argue, that in order to make use of the asset and create spatial value, the asset of underground space needs to be managed. One of the most important aspects of managing the asset of underground space is planning the use of this asset. In planning lies the key to developing this asset to its full potential. In urban underground space use, more often than not, the use of underground space has been limited to incidental use of the underground rather than a structured use. Although many cities now have underground mass rapid transport systems which, in fact, form vast underground networks, these networks together with other underground networks are not seen to be part of one system. The result of this is that each subsystem is developed in its own right but without looking at the complete system. The interaction between these networks and the other uses of the underground by facilities is not considered in most cases. The vast underground shopping centres in Toronto and Montreal being the exception. In order to be able to plan the use of underground space, a model needs to be considered which brings all functions together.

2. Modelling Underground Space Use

Parriaux et al [1] suggest that Underground Space can be modelled to be comprised of four basic resources: space, materials, water and energy. The observation made by these authors is that the use of underground space is often suboptimal, and in some cases conflicting, in that the collective resources are not considered when deciding on the use of underground space. Instead, these four resources are most often considered individually. The reason being that these four resources often fall within separate policy categories and therefore different government departments. This can be easily seen when considering that the resource space is most often part of a planning department, but the resource material or minerals is governed by a mining department. The consequence of this is that as far as policy is concerned the use of underground space is either not considered at all or, when it is considered, leads to policy conflicts, as each
department competes for its share of underground space. In Poland for example, this causes a
debate between the mining and civil engineering communities as Polish Law states that the
underground is governed by mining regulations. As illustrated by Parriaux et al [2] the competition
between the development of a mass rapid transport system and geo-thermal applications is
commonly won by public transport which is deemed to be the more beneficial to society. The
authors also point out that the possibility of developing a mass rapid transport system
underground in which the actual construction is also a geo-thermal construction is never
considered. Because the decisions on the use of underground space are made from a mono-
functional perspective, the use of underground space is often suboptimal from the perspective of
the total system. As Parriaux et al state: an integrated approach to the use of underground space
is required, if it is to be used optimally.

Historically, the use of underground space has been common in many cities. Paris is famous for
the way its city sewers formed a vast underground network. Gandy [3] quotes Pinkney: “Yet, as
David Pinkney wryly notes, most visitors to the Paris sewers over the years have probably been
disappointed to find, not the dark and dangerous caverns through which Jean Valjean made his
perilous escape in 1832 but the spacious, clean and well-lighted galleries of the Second Empire”.
This underground network was conceived and constructed from the 1830s onwards and was
marvelled at by those that visited these underground spaces. In other cities the consequences of
this subterranean development was being considered. As Webster [4] points out: “Although much
careful study has been given by trained experts to the preparation of plans for the rebuilding and
extension of large cities and the laying out of new towns, and to the development and
improvement of street systems so as to provide for present and future surface traffic and to best
serve the convenience, health and welfare of the people, but little thought has been given to the
subterranean street. In only a very few of our large cities has any attempt been made to plan
subterranean streets or to chart the structures which they contain”. Webster wrote this paper in
1914, thereby illustrating that the concept of underground space use is not new but that the
awareness of the need to plan has been around for a long time as well.

One country that is well known for spatial planning is the Netherlands. During the late 1990s the
awareness grew that planning the use of underground space could become a public issue. This
awareness was based on two separate developments. On the one hand there was the major task
of coping with soil and groundwater pollution caused by decades of storing society’s waste
underground. This led to a massive campaign for not only cleaning up these sites but also to the
development of policy and legislation intending to prevent this kind of pollution from occurring in
the future. The whole issue was further enhanced by environmental awareness and the
emergence of sustainable development awareness. At the same time the awareness was
growing that underground space use could be a vital solution for coping with spatial demands in
the Netherlands and the need to maintain spatial quality and thereby liveability. Both these
developments led to an appreciation of underground space as being a last frontier waiting to be
developed and indeed being developed from an almost autonomous perspective. The demand on
space in the Netherlands was famously described in 2001 when the Fifth White Paper on Spatial
Development was published. The total demand on space was such, that an extra ‘Province of
Zuid-Holland’ would be needed to cope with these demands. Over 20% of the area of that extra
province was needed to cope with the effects of water in terms of climate change adaption
programmes [5,6].

The result of the new awareness in the Netherlands was that a new model of analysis was
introduced for urban and land planning. The model (Fig. 1) consisted of introducing three layers
of analysis: the occupation layer, consisting of plot orientated developments, e.g. housing and
offices, the network layer, consisting of all networked functions, e.g. road and rail infrastructure,
and the underground layer, consisting of all subsurface functions, e.g. storage of water. By
analysing these layers and by considering the interaction of these layers, in theory, planning
could incorporate the underground and its functions and uses and take decisions on future use
and developments from an integrated perspective. In [7] the research is mentioned by this author,
which led to a comprehensive modelling of the underground layer. It further subdivided the
underground layer into five sub layers describing the diversity in uses and functions of this layer.

The biggest gain made by the above model is that for the first time a comprehensive approach,
which brings together all concerns but also opportunities that come with the use of underground
space, was introduced. Concerns came from parties that deemed the underground to be an area
of outstanding importance for life on the surface and should be kept free from human influence
whenever possible. It was the contamination of the subsoil over many years that sparked this
concern. But also the simple fact that processes in the subsurface often have a completely
different time scale to processes on the surface.

Figure 1: layer model for analysing and planning (occupation, network, underground)

From the above one could conclude that through both the research of Parriaux et al and the work
in the Netherlands, it is shown that planning the use of underground space is possible and
needed to identify conflicts in space use and resolve them. We need to consider both the present
uses and functions and the planned ones. Planning also needs to consider future uses as the life
span of underground facilities and networks differs from those on the surface. Conflicts can be
resolved by decision making and giving preference to one use above the other. They can also be
resolved by identifying multi-uses and combining these in often new and unique ways. The author
feels that this is one of the major advantages of planning the use of underground space: the
possibility of combining functions and creating multi-functional usage often in an innovative way,
as will be illustrated in paragraph 3.2 below.

On the surface, public open spaces, are deemed to be vital to any city. Public spaces offer people
the opportunity to meet each other and to enjoy themselves. Public open spaces on the surface
are not only planned but also exist through the way buildings are placed and spaced. As such the
space needed for the public open spaces is created through the placement of these buildings and
can then be developed. Below the surface these public open spaces do not exist. They only come
into existence if they are created as such. The creation of a new underground urban tissue needs
to be planned for this to happen. This insight is important as it underlines a second advantage of
planning the use of underground space: it provides the way forward for creating this new underground urban tissue.

3. Planning Underground Space Use Practices

3.1 City of Arnhem approach

The City of Arnhem in the Netherlands is one of the few cities where the City Council has supported and promoted the use of underground space. The reason for this was the simple fact of shortage of space for development and at the same time the need to redevelop to maintain and enlarge the spatial qualities of the city. The one decision that was really innovative in this respect was the decision that when planning the future of the city, due consideration was to be given to including the development of underground space. All parties involved in the process of city planning, both public and private, need to adhere to this decision. The result was that although not in every case the use of underground space was deemed feasible, new developments were carried out. The new developments fall into both the solitary underground space use development category and the multiple intensive land use category.

In two instances, buildings were constructed underground in areas where no surface construction was allowed. Planning regulations prohibited the construction of an extension for an educational facility along the Rhine embankment as did they a development of a museum in the Bronbeek Park. Both developments were however carried out completely underground, thereby showing that underground development can create new spaces in areas that from a traditional conservation point of view allow no development.

Figure 2: cross section of the Arnhem Central Station development
The development of the Arnhem Central Station district (Fig. 2) was undertaken by incorporating use of underground space in the plans for the project. By combining surface development with underground development, not only a more intensive use of the land is gained but also multiple in the sense that it combines different functions. The underground space development in this case not only included the building of a underground car park but also a utility tunnel which combined both traditional utilities as well as new geo-thermal applications and a underground waste disposal system. The utility tunnel was combined with the development of the underground car park. In the second phase of the developments the new office blocks which were developed only needed to connect to the utility tunnel to be linked up with all services.

One of the major advantages of underground space development in the case described above is that the actual underground construction can take place from the surface as it is part of the whole development. Rather than having to develop underground space once all surface space has been developed, an integrated approach to area development combining all three layers (occupation, network and underground) proves worthwhile in that it makes projects feasible that most often are not feasible when not combined. The obvious limiting factor for underground projects being that the development beneath an already existing city is technically much more complicated and poses risks of a different magnitude.

3.2 City of Zwolle approach

In a different approach to the City of Arnhem, the City of Zwolle has created a ‘Vision on the Underground of Zwolle’ [8]. This document comprises of a complete analysis of the underground space beneath the city. It gives an overall vision from the perspective of 2020 and it then identifies four areas within the city boundaries in which, using the layer model approach described above, a further in depth analysis is made which leads to identifying opportunities and development tracks.

The vision document was approved by the City Council in October 2007 and although it is not a legally binding document, it is for the first time a city in the Netherlands has developed such a strategic policy document in which the vision on development of the underground is laid out. Given the process of urban planning, it is always the question whether or not to prescribe development and more or less define what the private sector has to develop, or whether to have a more liberal approach in terms of stimulating private sector development without prescribing all the solutions. It is the latter approach which, within the Netherlands, is now growing into a planning practice whereby a focus on a certain area, rather than on a plot, leads to a spatial dialogue with all stakeholders on how to best develop the area¹. In this process the vision document on the underground can play an important role as it indicates which future directions are possible and could prove worthwhile in considering future needs for the area.

One other advantage of developing such a vision is the fact that the overall integrating vision knows no departmental boundaries as such. In the case of Zwolle, this has lead to the identification of an opportunity to combine a heat/cold storage scheme for a new city development with a groundwater decontamination scheme. Traditionally these programmes would have been carried out separately. City development would not have been allowed until the groundwater had been decontaminated. In combining these schemes, made possible because the vision document identified both needs, not only is the groundwater cleaned over a period of 10 years, but the actual heat/cold storage system of which it is part means that no gas mains are needed in the

¹ The process was further stimulated as the national government moved away from a centrally led policy development on spatial planning.
area as heating is generated in a different way. This impacts the carbon footprint of the new development in a positive way, thereby making the whole project sustainably sound. This example clearly shows how planning can help in coming up with new solutions involving underground space. It also shows the broad scope of underground space use.

3.3 City of Helsinki approach

Another example of a city leading the way in terms of planning the use of underground space, is the City of Helsinki in Finland. Helsinki has created an Underground Master Plan for the city in terms of underground space use [9]. The aims of the master plan are to not only show the current use of underground space but to reserve space for future use. The master plan has categories of underground space use: (1) community technical systems; (2) traffic and parking; (3) maintenance and storage; (4) services and administration; and (5) unnamed rock resource. It also distinguishes four different planning levels from project to provisional space requirement. One of the interesting things to observe in this case is the fifth category ‘unnamed rock resource’. The bedrock beneath the city has many opportunities for usage. But there are also areas which are less likely to be used or cannot be used from a geological point of view. So areas that can be used are identified as potential usage areas, although no plans exist or it is not known yet for what they will be used. It does however illustrate the need to connect present use, planned use and possible future use with each other in the planning of underground space. A second interesting observation is that the Helsinki Underground Master Plan is a legally binding document in terms of urban planning. In that sense it goes further than the example of the City of Zwolle. It also goes further than the City of Arnhem in that it shows where underground space development will take place rather than making it obligatory to consider the use of underground space in development schemes.

3.4 City of Shanghai approach

In the article from the Shanghai Daily News (Table 1) a clear example is given of how a city can run into problems if no planning regulations exist. Although the use of underground space seems to be common practice, sometimes the city planners need to divert the alignments of planned metro lines because of developments going deeper than the expected 16 metres below grade.

**Shanghai Daily News (27 April 2005)**

The city government will enact rules this year regulating the amount of underground space property developers can use under high-rises, to ensure there is enough convenient space for the expansion of the city's subway system, a senior government official said last week. "Setting strategies for properly utilizing underground space is crucial for the city's future development," Huang Jianzhi, a spokesperson for the Shanghai Construction and Transport Commission, said at a recent news briefing. He said the government will organize experts in underground construction to help draft rules and policies regulating the use of underground space for parking or other commercial uses. Existing residential buildings across the city use 5 to more than 7 meters of underground space. According to the city's urban planning bureau, Shanghai is home to more than 2,800 buildings that are at least 18 stories high and 2,000 additional high-rises are under construction. Officials from the commission said the government's new rules will strictly control the development of underground space. Those who disobey will be punished. "The government should have created an underground plan before so many high-rises were built," said Yu Mingjian, a senior engineer with the Shanghai Engineering Design Institute. He said normally the space 16 meters below a building, about the location of the third underground floor, should be reserved for subway lines. In the past, however, many property developers have
ignored regulations on the use of underground space, forcing the city to change the routes of some of its planned subway lines. (...)

Table 1: article taken from the Shanghai Daily News

It also poses the question how cities are going to cope with the major influx of geo-thermal and geo-storage applications in terms of energy or heat/cold storage. These applications often have vertical pipes running beneath buildings several hundreds of metres into the underground. Certain applications even call for reaching deeper layers. This can theoretically severely restrict underground space functions using the horizontal plane. This development is also taking place on a large scale in China and in Shanghai and, in Beijing, local regulations have now been put in practice to coordinate the use of underground space and to prevent spatial conflicts. As observed by Li Xun et al [10], nearly 20 cities in China now have plans compiled for the use of their underground space. The plans show the size, layout, function, development depth and timescale. Even more detailed plans exist in certain cities, however, the authors also observe that a complete regulatory framework is needed to make these plans statutory and to align regulations for surface use and underground space use.

4. Discussion

The cases which were identified above show that in terms of planning the use of underground space there are many approaches which can be taken. The actual planning tradition of a country does play a major role in the way the practice of planning underground space is implemented. Some countries have a strong centrally-led planning tradition, others have moved to a more liberal participatory area development approach. The planning of underground space requires awareness from decision makers not only on the role that they can play in terms of spatial demand but also of the fact that underground space consists of many resources with various functions and uses. Some of these uses already exist and have supported life on the surface for thousands of years. This awareness requires an analysis of underground space at local level. Having made the analysis, a further vision on the use of the underground can be developed as was the case in Zwolle. This vision can then lead to more statutory approaches which can vary from Master Plans as in the case of Helsinki to local zone regulations or even to the more global requirement (as was used in the case of Arnhem) to at least make the consideration to use underground space compulsory when developing plans. Whether an extensive system of regulations is put in place or a more open approach is adopted, planning the use of underground space should aim at crossing the borders which are so often drawn up by diversified policies. The concept of underground space use can only really be developed when underground space is seen as one system. This system not only contains many functions and uses, it also interacts with the surface.

5. Concluding Remarks

In not planning the use of underground space a lot of opportunities are missed, and the underground can turn out to become a liability for society rather than an asset. This is the one and only reason why we need to consider planning the use of underground space. For the concept of underground space use to remain a societal asset means that we need to plan the use of this asset and to manage its use, just like any asset. By not doing so, the beneficial potential of underground space will be degraded and will eventually cease to be an effective instrument as we cannot develop further using a structured approach because of the manmade chaos created through autonomous incidental development.
References


