Optimising subsurface use for future cities

Thought piece by British Geological Survey:

British Geological Survey's Science Futures & Urban Geoscience Teams

Maximising and sustaining the potential of the urban subsurface

'The lack of organised urban underground space is continually increasing, and sooner or later politicians will have to take measures to avoid it.'

Cano-Hurtado and Canto-Perello (1999)

The subsurface is a dynamic environmental system influenced by the surface through the interaction of heat, water, chemical and biological phenomena and physical stresses. The urban environment modifies the natural link between the surface and the subsurface by interacting and changing the surface drivers or by directly changing the structure of the subsurface. Similar to the concept of 'ecosystem services' (see Ehrlich and Ehrlich, 1981) the urban subsurface may be considered as a resource that can provide several services (Bobylev, 2009). Although we consider the urban subsurface as a single resource, it may be subdivided into four resources relating to: construction space, geo-materials, groundwater and geothermal (Parriaux, 2007). It has long been recognised that the urban subsurface is a complex, scarce and valuable resource.

Through its development, the use of urban underground space has progressed from the shallow subsurface to a much greater "depths". In the UK, cities and towns have evolved to use and exploit the subsurface in a multitude of different ways, each influenced by their individual geological setting. Historical cities have typically interacted with the subsurface through the extraction of groundwater, and the excavation of rock/soil for building materials or to create storage caverns. Conversely, industrial cities have gone through cycles of growth and decline, in which the ground has been overexploited leaving a legacy of environmental degradation and subsequent regeneration. Although different, both of these development routes have imparted a lasting imprint on the shallow subsurface. More recently, advances in technology and the need for improved transport and utilities have driven a rapid increase in the development of the urban subsurface space (both shallow and deep). The combination of legacy and recent urban subsurface use has created three problems. Firstly, congestion of the urban subsurface beneath city centres where development of new infrastructure is hampered by old infrastructure (Admiraal, 2006). Secondly, there is unintended interaction between subsurface urban infrastructure (for example through the transfer of heat (Ferguson and Woodbury, 2007)). Finally, non-renewable subsurface resources (such as space, minerals and cultural heritage) are being exploited unsustainably.

Sustainable utilisation the urban subsurface to its maximum potential in the future will require a greater understanding of subsurface processes and a careful, well considered, integrated planning approach. This approach will require input from, and collaboration between, a broad range of stakeholders including academia, industry, policy makers, urban planners and the general public.

The scientific requirement

'Geology is of fundamental importance as far as the planning of physical facilities and individual structure is concerned and recognition of this allows wise use of urban and rural land.'

LEGGET (1987)

Urban areas have long been known to influence the hydrological environment, leading to physical and chemical alteration of the ground beneath the city and the surrounding peri-urban and rural areas. It is now recognised that subsurface temperatures can also be considerably affected by the urban environment, through heat losses and gains from buried infrastructure and buildings, changing land cover and use, and by the increasing use of the subsurface as a heat source or sink. The subsurface heat island effect has been observed in several cities and can have a considerable impact on shallow urban aquifers (Taniguchi et al., 2007; Headon et al., 2009; Zhu et al., 2010). Because of the complexity and heterogeneity of the subsurface, the lack of monitoring infrastructure and several practical constraints, the spatial distribution of water and heat fluxes in the urban subsurface are poorly characterised in the UK. Current understanding, which has focussed either on individual subsurface system processes or on fast-growing, new urban developments in developing countries, is not sufficient to make the quantitative predictions required to inform a future management strategy.

Before a future planning approach is adopted, it is imperative that we fully understand the geo-systems that operate below the urban environment, their interactions with each other and with infrastructure, and how the subsurface evolves when considered as a single system. To initiate this process we need to identify the current collective knowledge of interactions between UK cities and the subsurface. By improving our quantitative understanding of the system processes we will form a clearer picture of the potential impacts of future changes, not only allowing the UK to minimise the impact of future cities on the environment, but also reaping the potential benefit of an optimal, integrated, harmonious approach.

An integrated planning forum

'A Master plan is one of the best city development documents for the integration of sustainability issues. It is particularly important that any Master plan deals with a long-term development perspective.'

BOBYLEV (2009)

Effectively managing and optimising the use of the subsurface will require a holistic review of subsurface processes, their interactions and their value to society. Following an improvement in our understanding of the urban subsurface, there is an opportunity to optimise how we use, manage and protect the city's environment so that it continues to deliver benefits for society. There are, however many custodians of the subsurface beneath urban areas (local authorities; regulators; service providers – water, energy, transport), which often lead to disconnect in governance and planning. The use of the subsurface within urban environments is evolving in line with changing technologies and environmental pressures and thus management plans must be adaptable and show foresight to be able to cope with (and benefit from) these changes. Building this information together into a single forum, relevant to the UK, and valuing the benefits of urban geo-assets to society will allow for more effective management and policy strategies in the future.

The forum will need to:

- Identify how subsurface infrastructure may be used in an integrated sense for maximum benefit
- Identify geo-assets and estimate their value to society
- Identify ways in which the ground provides essential benefits for people who live, work and travel in major UK cities, through a multi-dimensional city-wide spatial urban planning tool that integrates ground properties and subsurface use
- Assess how future interactions between cities and the subsurface may evolve and assess the subsequent impacts on societal value
- Assess the interdependencies of future cities and their far-field impacts on the surrounding peri-urban and rural environments
- Define new forms of governance, creating a 'land registry' for the subsurface and defining a system wide set of protocols for future use of the subsurface

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