The ground beneath cities: where should future development occur?

Thought piece by British Geological Survey:

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Consideration of the ground for urban development and current state of knowledge

> *'Development can be carried out in almost all locations but there is a need to take 'permissible risk' into account; that is, to be aware of the costs of development and mitigation from the outset'.*
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> MARKER (2009)

Urban development, whether that is redevelopment within cities, expansion of existing cities or creation of new cities, is largely driven by economic, political and social trends. This is reflected in current planning policy where ensuring the vitality of towns means making them resilient to future economic change (DCLG, 2012)

Ground conditions rarely prohibit development entirely but instead govern the suitability of land use, urban design and the cost of development. Marker (2009) notes 'Development can be carried out in almost all locations but there is a need to take 'permissible risk' into account; that is, to be aware of the costs of development and mitigation from the outset. In an urban context the cost of development arguably includes cost (or benefit) to environmental and societal well-being as well economic factors related to direct development costs and indirect financial implications e.g. sterilisation of resource and land value. Where the ideal urban form is for compact cities with efficient integrated infrastructure (Shell International, 2014) and greater utilisation of underground space, there is increased pressure on the ground beneath cities and the platform for development it provides.

While ground conditions rarely prohibit development entirely they do introduce material planning considerations including flood risk, development of contaminated land, capacity of subsurface infrastructure, incompatible or unacceptable use (which extends to land stability and shallow geological hazards) and implementation of sustainable drainage systems (DCLG, 2012)). At a practical level the current approach to planning tends therefore to consider the ground from a hazards perspective with a focus on 'where development *shouldn't* take place'. In addressing this question a wide range of multi-themed spatial datasets relating to the potential for geo-hazards and difficult ground conditions have been developed by BGS and others, e.g. landslide hazards, ground instability, soluble rock and flood risk maps, which are accessible to planning authorities, developers, environmental regulators and the insurance industry but not necessarily well understood. Adopting the forewarned is forearmed principle these maps and tools allow potentially difficult ground conditions to be identified and mitigated from the outset. Difficult ground conditions are more manageable if they are anticipated, if there is sufficient money, technology and expertise to deal with the problem and if the land provides sufficient economic return to warrant additional investment. However unforeseen (difficult/adverse) ground conditions remain problematic and are a significant source of project overruns and overspend. Insufficient understanding of subsurface ground conditions is generally recognised by the construction industry across the UK and Europe as a key factor in overspending, project delays, and overly conservative design (e.g. Clayton 2001; Parry 2009; Baynes 2010). Cumulative loss to the economy is substantial. Improving this situation demands much better use, and re-use, of data and knowledge than is currently the case. A 1983 NEDO review of 5000 industrial buildings found 50% overran by at least a month, 37% of which were attributed to ground problems.

Key to this problem is variability in ground properties beneath urban areas which are often reworked through multiple phases of development, particularly in historical cities, and frequently poorly characterised. The potential to assimilate ground data in urban areas, use it to develop robust ground models and serve the interpreted ground information to end-users is a current focus of research in European cities with London and Glasgow providing UK exemplars. Through this, there is a growing recognition that multiple and integrated approaches may be required to suit different city-types (historical cities, new towns, growing cities and shrinking cities) and multiple drivers (environmental, economic, social). As a result there is an increasing propensity for open-data sources, 3D datasets, predictive models and web-hosted planning tools with the UK a world leader in terms of spatial data analysis, modelling and visualisation of the urban subsurface.

The opportunity

'A methodology that combines subsurface characterisation, ecosystem service classification and future scenario analysis'.

PRICE ET AL *(In Press)*

The geosciences have an important, but often under-appreciated part to play in securing more sustainable cities. Where the current geological approach to planning may be centered on constraints, the future focus should be one of value, opportunity and optimization – 'where *should* development take place'. While in theory current planning policy recognizes the benefits of ecosystem services and the ideology of 'best use of land' it is yet to become standard practice. However there is a growing appreciation that the services provided by our natural environment are intimately linked to the way we develop our built environment and the social, environmental and economic advantages of a more integrated approach to city planning and operation need greater promotion. What is the potential economic return of the ground through provision of services e.g. through increased utilization of ground heat and subsurface space, what contribution does the ground make to the city well-being and the environmental justice agenda, where links between health and ground conditions are now being realized (Morrison et al., 2014).

The ground may be viewed as part of the city's infrastructure and embedded within the urban business model to inform volumetric spatial urban planning (3D & 4D). Urban planning requires a methodology that combines subsurface characterisation, ecosystem service classification and future scenario analysis (Price, In. press). By matching the properties of the ground (subsurface characterisation) and the services the ground provides (ecosystem service classification) to the intended land use, spatial planning may be optimised and the multiple and "complimentary" uses of the ground assessed to avoid potential conflicts and competition for space and function to achieve sustainable development of the subsurface. At the heart of this approach lies a city-scale ground 'model': a solid evidence base (data collection, archiving and access to data, tools to serve information) on which decisions may be made. Within this framework individual development may be embedded in a wider urban spatial planning model that has optimised the use of the city subsurface and through which whole life costings can be determined and align to Building Information Modelling (BIM).

City performance

'Decisions about city development need to stand the test of time, cities need to be sustainable, to be resilient and to thrive no matter how the future unfolds.'

There are many parties with a vested interest in the sustainable use of the ground beneath urban areas (local authorities; regulators; service providers – water, energy, transport; private land owners) which often leads to a disconnect in governance and planning, particularly in urban areas where there is a high turnover of land. Frequently this leads to inefficiency, a general lack of reuse of subsurface data, and even to a loss of such data and knowledge. There are however opportunities for reform, to consider the city as the unit of measure. Birmingham Policy Commission on Future Urban Living calls for a City Narrative driven by a collective of governors, stakeholders and citizens with a city-centric leadership. In tandem it calls for a radical upgrade to planning where planners are integrators, models of governance aggregate upwards and a long-term view of city sustainable and resilience is accounted for (University of Birmingham, 2014).

Practical steps to achieve this from the ground engineering and geo-service perspective might include the development and integration of city-scale data, maps, models and tools, for example:

- An illustration of where the ground is most suited for different uses.
- A multi-dimensional city-wide volumetric (3D) spatial urban planning tool that integrates ground properties and subsurface use and aids the development of Statutory Planning Guidance specifically developed in relation to the subsurface.
- Development of city modelling that couples physical geo-environmental models with social and economic models.
- Implementation of a system for long-term monitoring to measure the performance of individual developments and wider urban areas.
- Application of the Urban Futures Methodology (Lombardi et al., 2012) for major city development to ensure that the development performs regardless of how the future unfolds.

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