Tunnelling and Underground Space Technology xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Tunnelling and Underground Space Technology

journal homepage: www.elsevier.com/locate/tust

Utilisation of underground pedestrian systems for urban sustainability

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ARTICLE INFO

Article history:
Received 29 June 2015
Received in revised form 3 November 2015
Accepted 10 November 2015
Available online xxxx

Keywords:
Underground pedestrian system
Sustainable urban development
Urban resilience
Compact city
Sustainable transport
Urban renewal

ABSTRACT

Underground pedestrian systems (UPS) have emerged as an urban phenomenon in the city centres of mega-cities, providing alternative walkways that are safe, accessible, efficient and pleasant for pedestrians. Despite many successful UPS in operation around the world, the application and performance of UPS are not yet well understood by local authorities. While previous studies debated the impacts on cities and people that the development of UPS would bring, an understanding of how to develop UPS to contribute to sustainable urban development, including economic viability, environmental livability and social equity, should be improved. This paper presents a detailed discussion of potential contributions and challenges in developing UPS within the context of sustainable urban development. It contains a comprehensive analysis of the relationship between UPS and urban development with regard to urban planning concepts such as the compact city, city resilience, sustainable transport and urban renewal, within the context of contemporary challenges such as the need to achieve economic sustainability, managing a non-renewable and vulnerable underground resource, and humanisation and social sustainability. It demonstrates why UPS development presents opportunities for and challenges to achieving economic viability, environmental livability and social equity, how to develop UPS so that they make effective contributions to sustainable urban development, and how the challenge of each issue has been addressed in light of the experiences of cities with UPS developments globally.

1. Introduction

'Sustainable development' is a type of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It has been widely used in scientific, business and public institutions since it was defined and propagated in 1987 by the United Nations (UN) Environment and Development Commission. The three objectives of sustainable development are ecological integrity; equity among nations, individuals and generations; and economic efficiency (as shown in Fig. 1). To improve social equity, the necessities of life and an improvement in the quality of life of present and future human communities need to be satisfied; to improve economic efficiency, there needs to be optimal usage of human, natural and financial resources; and to maintain the integrity of the environment, it is necessary to integrate holistically the actions of human communities and achieve the preservation of ecosystems (Besner, 2012a; Brundtland, 1987; Sterling et al., 2010).

Underground space is defined as 'the space created below the ground surface... Underground space may either be developed by open excavation in soft strata or soil, the top of which is subsequently covered to get the space below, or created by excavation in hard strata or rock' (Goel et al., 2012, p. 1). Urban underground space (UUS) has been developed for various functions, including residential, recreational, commercial, storage, infrastructure and military use. It was recently recognised that UUS utilisation has the potential to contribute significantly to urban sustainability. While the issue of using UUS to contribute to sustainable urban development has been proposed to world nations, it has received increasingly intense global attention in the context of countries having to fulfil international goals and commitments related to sustainable development. In December 2007, a UN-ITA (International Tunnelling and Underground Space Association) Workshop was held at the UN headquarters in New York to discuss how to use UUS for promoting sustainable development by UN Member State delegations. In September 2014, UN-Habitat and Associated Research Centers for the Urban Underground Space (ACUUS) signed a memorandum of understanding regarding agreement to collaborate on sustainable usage of underground space within the context of urban development, resilient cities and disaster risk reduction.

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http://dx.doi.org/10.1016/j.tust.2015.11.004
0886-7798/

Please cite this article in press as: Cui, J., Lin, D. Utilisation of underground pedestrian systems for urban sustainability. Tunnel. Underg. Space Technol. (2015), http://dx.doi.org/10.1016/j.tust.2015.11.004

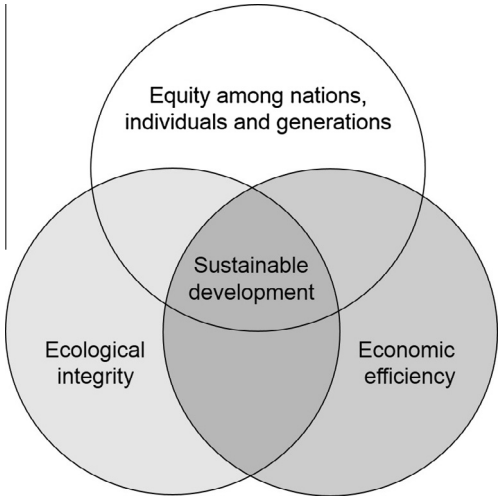

Fig. 1. The concept of sustainable development and the three constituent objectives.

The underground pedestrian system (UPS), as a comprehensive approach to utilize UUS, is an emerging phenomenon in increasing numbers of cities in the world. According to Belanger (2007), UPS includes: (1) a retail complex that is made up of numerous stores; (2) a small city that connects office buildings, hotels, department stores and underground parking garages; and (3) a transportation infrastructure that integrates subway, national or regional transit terminals. Extensive UPS, such as UPS in Montreal, were originally seen as consisting largely of transport and shopping functions but later included recreation functions (Sijpkes and Brown, 1997). There are many UPS in operation across the globe. North American cities have developed the most extensive UPS in the world. Montreal's UPS, RESO, with 32 kilometres (km) of corridors, covers more than 41 city blocks (Besner, 2007). In Chicago, the Pedway system includes 40 city blocks covering 8 square kilometres (km^2), connecting 50 city centre buildings (Wang and Liang, 2010). East Asia has cities with numerous well-developed UPS. The Umeda underground system in Osaka City, the largest UPS in Japan, connects three subway stations and 24 buildings. In China, Shanghai People's Square UPS, containing 10,000 m^2 of underground commercial spaces (as shown in Fig. 2), connects underground parking and subways. European cities have concentrated on massive UPS developments. In the city centre of Munich, Germany, the Karlsplatz (Stachus) UPS connects Europe's largest underground shopping centre with public transport, such as Munich's S-Bahn and U-Bahn. Underground pedestrian systems are also found in other parts of the world, including Sydney, Australia, which has a 3-km UPS winding throughout its core retail precinct around Sydney's Town Hall, and UPS connecting underground shopping arcades to major transport hubs (Sterling, 1997).

The development of UPS generally has many goals. The appeal of UPS to policy-makers is not only their potential to facilitate people's movement and to counter the effects of severe climate and traffic congestion, but also their intrinsic potential to reinvigorate urban areas (Belanger, 2007). Understanding the contributions of UPS in urban economic, social and environmental development is becoming increasingly important, especially as sustainable urban development plays an increasingly significant role in the decision-making process. Although UPS have been in operation throughout the world, there is little discussion about how to develop UPS in the context of sustainable urban development. Accordingly, the research question is proposed: how do we develop UPS within the context of sustainable urban development? This raises the issues of how, why and in what circumstances UPS contribute to sustainable urban development. What are the challenges in using UPS to contribute to urban sustainability?

This paper explores the development of UPS in the context of sustainable urban development. It identifies and discusses contributions and challenges of UPS for urban sustainability, based on the investigation of the application of UPS and the functionality of UPS from around the world. First, it discusses the situations in which UPS has the potential to contribute to urban sustainability; it then discusses the challenges in developing UPS within the context of sustainable urban development. Based on these findings, this paper explores the use of UPS as a tool for sustainable urban development with a view to determining more effective strategies for UPS and its implementation. It is worth noting that the paper focuses only on UPS, which is just one form of UUS utilisation. The planning for UPS needs to fully consider city plans and plans for UUS. The UUS plans also need to take into account the potential of UPS development in city centres to avoid any difficulties in the future in developing UPS based on other established UUS utilisation.

2. Literature review

The majority of research related to UPS development, especially on those UPS developed prior to this century, barely considers the relationship between UPS and sustainable urban development. The UPS developed during the last century were, to a large extent, built to solve specific urban problems such as the negative impacts of climate (Belanger, 2007; Cui et al., 2013a,b; Terranova, 2009); transport-related issues including car–pedestrian conflicts, traffic congestion and the decreased popularity of walking (Bhalla and Pant, 1985; Boisvert, 2007; Corbett, 2009); and competition between suburban shopping malls and economic development in city centres (Corbett, 2009; Robertson, 1993a,b). As urbanisation has rapidly advanced globally, the sustainable development of urban areas has emerged as an issue of global importance (Bobylev, 2009). As a component of urban infrastructure in central areas of many cities, integrating UPS development into sustainable urban development is a significant task, since UPS development can be optimised to help create environmentally, socially and economically desirable urban settings.

Considerable research has already explored, confirming that UUS utilisation can contribute to sustainable urban development (Admiraal, 2012; Cornaro and Admiraal, 2012; Sterling et al., 2010). Research into the utilisation of UUS has suggested the requirements of sustainable urban development as a new driver for underground system development. The development of UUS was associated with building a compact city (Durmisevic, 1999; Ronka et al., 1998; Sterling et al., 2010), urban renewal and revitalisation (Sakakura et al., 2007), city resilience (Admiraal, 2012; Cornaro and Admiraal, 2012; Sterling and Nelson, 2012) and environmental, economic and social sustainability (Bobylev, 2009; Sterling et al., 2010). However, previous research does not provide a balanced understanding of the utilisation of UPS focused on sustainability that should include both the potential contributions and the challenges of UPS. There is a lack of systematic discussion in previous research about how UPS could be developed in the context of sustainable urban development.

Sterling et al. (2010) comprehensively analysed the contributions of UUS utilisation, concluding that UUS utilisation can positively contribute to climate change mitigation measures through achieving high living standards in compact urban areas. By protecting the surface environment whilst enhancing access and service provision for continued economic viability, urban sustainability is achieved; infrastructure improvements with low environmental

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