



Development and applications of common utility tunnels in China

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ABSTRACT

Common utility tunnels (utilidors) are attracting more and more attention in China with the rapid urban development and growing need for public facilities. China is a large country with a huge north–south divide, which leads to different situations of construction, types of utilities incorporated, route design and governance issues for utility tunnels in different cities. This paper introduces the latest status for such tunnels in China by collecting and analyzing existing and planned utility tunnels in China from 1959 to 2020. Furthermore, the key issues that may influence the development of utility tunnels in the next decade in China are summarized. These, in combination with the domestic and foreign research status, suggest typical cases and a policy orientation which may be helpful to the future development of common utility tunnels in China and other countries.

1. Introduction

The world-wide trend of increased urbanisation creates problems for expanding and newly-developing cities alike. The increasing population also leads to a great demand for reliable infrastructure, nowadays combined with a need for increased energy efficiency and a higher environmental awareness of the public. The use of underground space can help cities meet these increased demands (Broere, 2016). Building underground utility tunnels to solve the problems has been implemented in urban municipal services for about two centuries now (Cano-Hurtado and Canto-Perello, 1999). From the combined water-supply and sewer system left by the Roman Empire to the underground lifelines in a metropolis such as Paris, Tokyo, Madrid and Shanghai, the system has been employed and improved to incorporate multiple utility pipelines and cables. The essence of this idea today is to build a man-accessible tunnel in the city underground space, which incorporates some or all of the electric power, telecommunication, gas, water supply and other municipal cables and pipelines integrated with special maintenance shafts and monitoring systems. Such tunnels also need to be carried out with unified planning, design and management to attain sustainable development of urban underground space (Canto-Perello and Curiel-Esparza, 2001; Carmody and Sterling, 1993; Duffaut, 1996; Legrand et al., 2004).

Common utility tunnels originated from the urban utility systems of Paris reformed by Haussman in 1855. As a great admirer of Roman engineers, Haussman designed the Paris sewage system as a man-accessible tunnel and incorporated several water supply pipelines, compressed air pipelines and sewage (see Fig. 1) to solve the water

pollution and transport problems (Laistner and Laistner, 2012). Since then, common utility tunnels have been widely used around the world (Cano-Hurtado and Canto-Perello, 1999; Zhang, 2014).

In England, the government also developed utility tunnels as communal facilities. Initially, the city drainage system was constructed using tunneling. Then, different kinds of pipelines such as telecom, power cable, gas pipeline, etc. were incorporated in the underground tunnels which evolved into the use of utility tunnels in England (Zhang, 2014). For example, an arched utility tunnel was built in London in 1861 (see Fig. 2).

In 1893, a 450-meter utility tunnel was built under Kaiser-Wilhelm Street in Hamburg, Germany containing a heating pipe, water supply, power cable, gas pipeline and telecom (see Fig. 3). Although problems appeared when the water supply pipe ruptured and there was a lack of space because of the bad design, the application of the utility tunnel received a high evaluation. More than 15-km of utility tunnels were built in Suhl and Halle before 1970, and the concept began to be promoted all over Germany (Shun, 2008; Zhang, 2014).

The research for common utility tunnels in America started in 1960 owing to the rapidly-growing cost of traditional buried construction and the intrusion of overhead methods. Because of this, utility tunnels were usually built in the center of cities and campus. Almost all kinds of utilities except gas pipelines were incorporated in the utility tunnels (Shun, 2008).

Utility tunnel projects require better strategies and understanding at an early stage in the city planning (Canto-Perello et al., 2016). The Singapore government has evolved good strategies for its long term development as an island country with a strong imperative to convince

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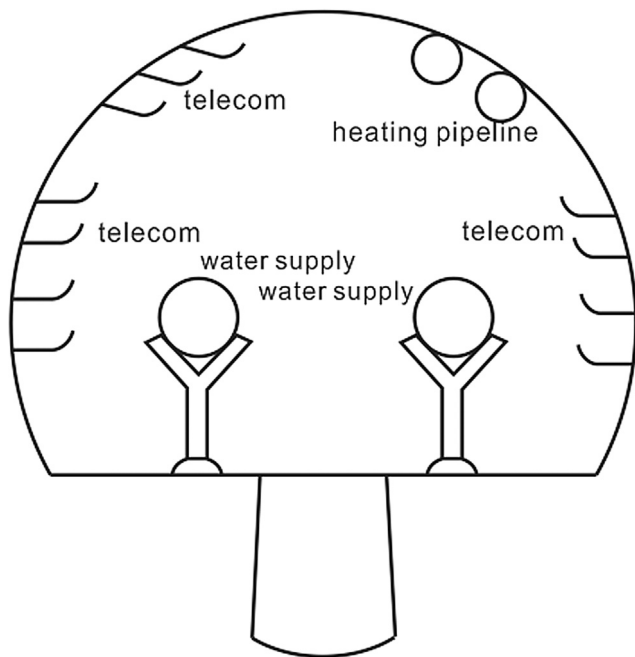


Fig. 1. Common utility tunnel built in 1855, Paris.

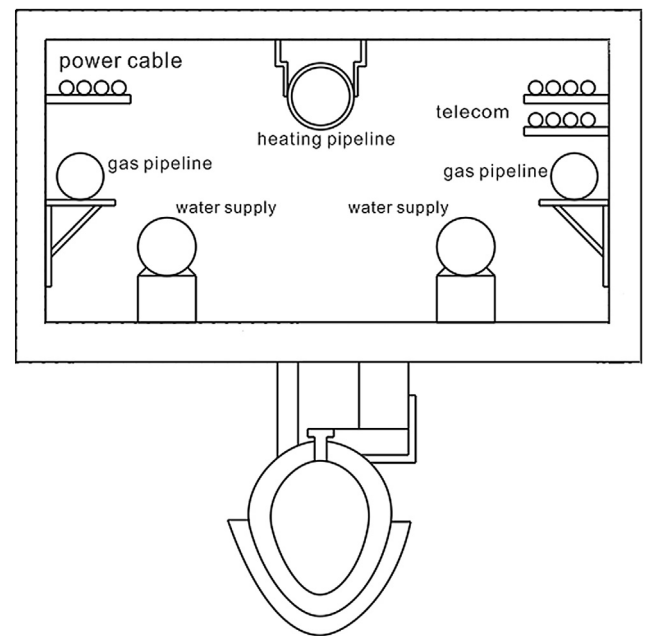


Fig. 3. Utility tunnel built in 1893, Hamburg, Germany.

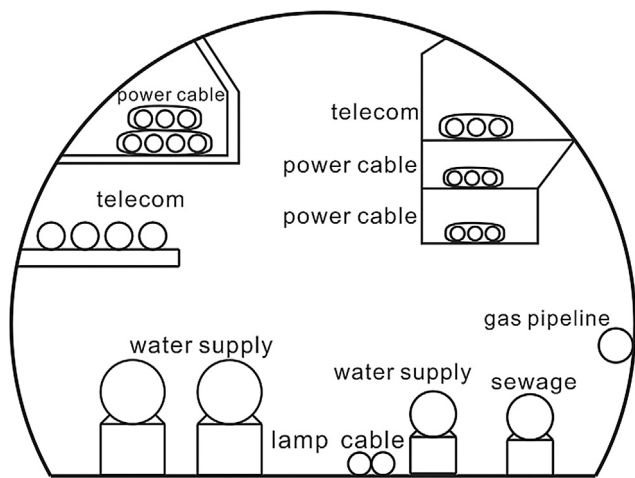


Fig. 2. Utility tunnel built in 1861, London.

the public that their decisions are made for the public good in the long-term. In the later 1990s, a large common utility tunnel was built for the new development area next to Marina Bay in Singapore. As the lifeline of the business and financial center in Marina Bay, the 3.9-km utility tunnel was built 3 m deep with water supply, reclaimed water supply, power cable, telecom, district cooling, garbage collecting and transporting system incorporated (Li and Mo, 2015). The whole underground construction project cost about 0.52 billion U. S. dollars and it has anchored a major new development area for Singapore in a coordinated way.

Japan perhaps owns the most advanced technology and the most complete scheme and laws for utility tunnels in the world. The first utility tunnel in Japan was built in 1926 in Chiyoda, Tokyo with power cable, telecom, water supply and gas pipelines incorporated (see Fig. 4). Utility tunnel construction in Japan had little further progress until the 1950–1960s. Then the Japanese government started to develop utility tunnels rapidly at the same time as its road construction program. The *utility tunnels law* was set out in 1963. Up to now, there are more than 2057 km of utility tunnels in more than 80 Japanese cities such as Tokyo, Osaka, Nagoya, etc. (Qian and Chen, 2007; Koyama, 2003;

Zhang, 2014).

The development of utility tunnels in foreign countries has a history of more than 100 years old. Systematic research has been carried out with a variety of engineering practices. It led to the establishment of reasonable design, planning, financing and standard systems which has been worked out successfully in the mass construction of their own countries such as Japan. At present, the research emphasis of utility tunnels in foreign countries is shifting from the planning and design to environmental protection technology and new construction methods (Xue et al., 2007.).

The common utility tunnel, as well as the idea of a “Sponge City” (i.e. a city storm drainage system to reduce flooding and allow groundwater recharge) was introduced to the municipal construction field in China as a solution to encourage sustainable development in urbanizing areas. As the modern, prosperous society is expanding in China, the density of utility cable networks and pipelines has grown rapidly to meet the new demand. The resulting maze of utilities and other underground infrastructure has been termed “the spaghetti sub-surface problem” (Oude Luttikhuis, 1992).

In concert with the rapid urban development, the open-cut (cut-and-cover) method of construction with its environmental and social cost produced by repeated surface excavation is no longer acceptable for city governors, and the traffic flow, safety and health have become primary goals that cannot be ignored by civil engineers (Hunt et al., 2014). A consensus also has been achieved that a proper and long term underground space planning is critical to maintain the sustainable development in cities (Besner, 2002; Hunt and Rogers, 2005; Pucker et al., 2006; Ma and Najafi, 2008). The definition of “sustainable development”, referring to the report *Our Common Future* submitted to the World Commission on Environment and Development, reads: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987; Butlin, 1989).

Utility tunnels have many benefits such as being environmentally friendly, providing long-term economic benefit and creating an efficient service capability. However, the high construction cost, technical difficulties and other issues must also be considered (Canto-Perello and Curriel-Esparza, 2013). The main disadvantages are that the management of the common utility tunnels is not easy, and obtaining financing support for projects is often difficult. It was announced at the Fourth

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