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The planning and construction of a large underpass crossing urban expressway in Shanghai: An exemplary solution to the traffic congestions at dead end roads

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ABSTRACT

To alleviate the increasing pressure from traffic chaos and congestion at peak hours in urban areas, more and more city expressways are constructed to facilitate the transportation. However, due to lacking of integrated traffic planning, massive arterial roads are separated as so called “dead end roads” by the expressways, leading to the inconvenience of commuting, even a sever to the transportation of the local network. In order to solve the problem, this paper investigated the traffic characteristics of dead end roads and the effect of underground crossing project, then proposed an innovative method of construction of large underpass in Shanghai soft ground. The experiences learnt from this project can provide useful references for solutions of dead end roads as follows: (1) The existing of dead end roads has direct influences on the traffic congestions of local roadwork, it’s necessary to take measures to solve the transportation problems induced by it. (2) Underground solution is effective for tackling the problems induced by dead end roads. The commuting time is shortened by 70% and more than 34% of the surficial traffic flow of auxiliary lanes are diverted into the underpass. (3) The underpass can improve traffic conditions of road intersection and adjacent arterial roads. Turning traffic flows at the intersection between Tianlin Road and Mid-Ring Road has a dramatic decline from 65% to 81% and the traffic saturation of adjacent arterial roads has a reduction of about 10%. (4) For the advantages of little impact on traffic and environment, the Roof-box jacking method with earth pressure balanced cutter head is recommended for shallow buried undercrossing project in urban intensive areas.

1. Background

Shanghai is going through an unprecedentedly urbanized process with sustained and rapid economic growth over 20 years (NBSC, 2011; Shen et al., 2014). According to NBSC (2011), the population of Shanghai will reach 25 million in 2020, implying the urban transportation system of Shanghai is thus facing increasing pressures. In order to solve the increasing transportation problem, Shanghai has been building a road traffic system since the mid-1990s (SMTC, 2013). Fig. 1 shows the distribution map of urban expressway planning of Shanghai, consisted of three circle lines (Inner Ring Road, Middle Ring Road and Outer Ring Road) and two cross lines (South-North Viaduct and Yan'an Viaduct). This shape of skeleton road network has greatly facilitated the transportation of Shanghai, especially between main urban area and suburb area (Sun et al., 2015). However, due to lacking of integrated traffic planning, massive arterial roads are separated as so called “dead end roads” by the city expressways, leading to the inconvenience of commuting, even a sever to the transportation of the local network (Li et al., 2011). Fig. 2a is the distribution of tens of dead end roads induced by the construction of Mid-Ring Road and Fig. 2b is a typical case of Tianlin Road in Caohejing Hi-Tech Park (Fig. 1) separated by Mid-Ring Road.

Not just separated by expressways, dead end roads are widespread in Shanghai induced by rivers, railways and other hindrances, especially among the inter-district areas. By the end of 2017, there are 56 dead end roads with a total length of 65.8 km need to be connected. The existence of dead end roads restricts traffic capacity severely and disfunctions the local road network (Li et al., 2011). According to the 13th Five-Year Plan (2016–2020) of Shanghai, the city is striving for relieving traffic node congestion, improving road network and promoting inter-district integration development (Shanghai Municipal Peoples Government, 2016). Taking a typical dead end road called Tianlin Road

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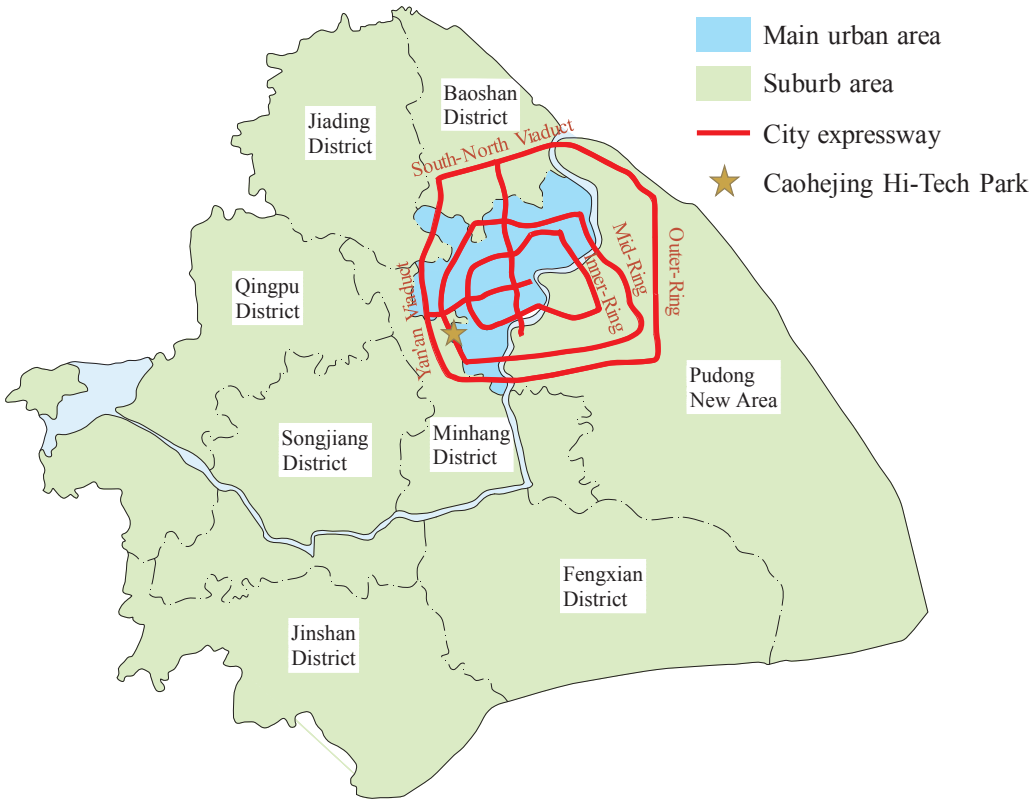

Fig. 1. The distribution of urban expressway in Shanghai.

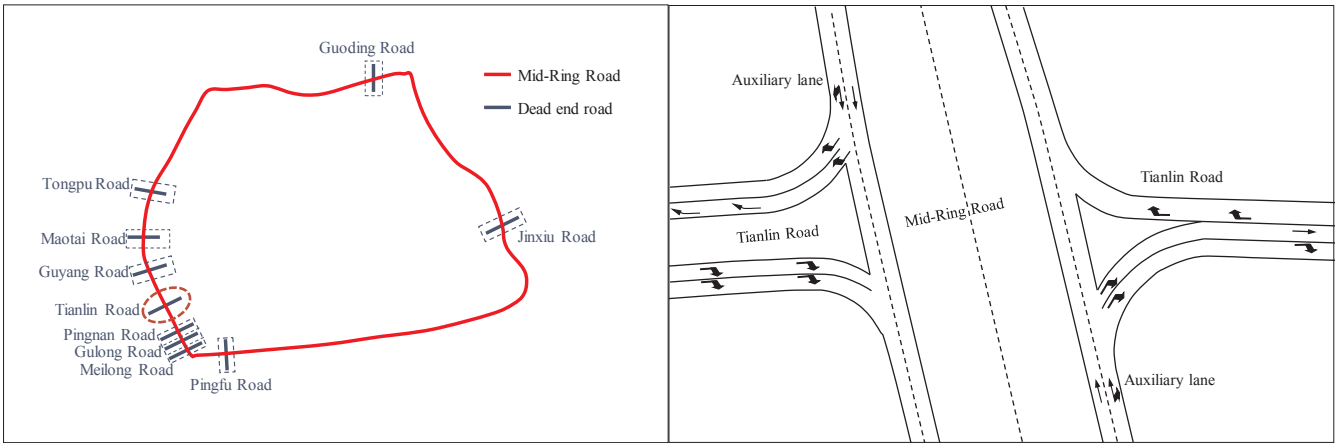

Fig. 2. The distribution of dead end roads along Mid-Ring Road and an example of Tianlin Road.

of Caohejing Hi-Tech Park as an example (Fig. 2b), this paper investigated the traffic characteristics of Caohejing Hi-Tech Park and the effect of an underground crossing project, then proposed an innovative method of construction of large underpass in Shanghai soft ground. The experiences learnt from this project can provide useful references for solutions of dead end roads.

2. Traffic characteristics of Tianlin Road

Tianlin Road is one of three main west-to-east roads of Caohejing Hi-Tech Park in Shanghai, which is separated by the construction of Mid-Ring Road. The disconnection of Tianlin Road has greatly influenced the local road network and caused traffic congestions at peak hours.

2.1. Traffic distribution of Caohejing Hi-Tech Park

Caohejing Hi-Tech Park is an urban agglomeration area located at the southwest of Shanghai. As a national level development zone, the park include economic-technical development zone, high-tech industrial development zone and export processing zone with a total planning area of 14.28 km^2 (Yuan and Wang, 2011; Han and Xu, 2016). Fig. 3 shows its favorable geographical location, the convenient transportation network attracted more than 2500 Sino-foreign joint venture enterprises (Cheng, 2011).

The park stretches across urban area (Xuhui District) and suburb (Minhang District) as Fig. 4 shows. According to urban road hierarchy, the regional road network is characterized by different colors. The main north-south roads are composed of Mid-Ring Road, HongCao Road and