Study on the Design of the Upper Space Parking Lot of Urban Multi-layer Tunnels

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Abstract. In recent years, with the continuous acceleration of the urbanization process, underground parking lots have developed rapidly, and they are continuously moving towards intelligence. Based on the multi-layer tunnel section of the Xiamen Haicang Subsea Tunnel, this paper conducts theoretical research on the liquid analysis of the surrounding area of the tunnel area, the graphic design of the parking lot, the architectural design, the function, and the fire prevention design. The research results are of great significance to the rational use of urban underground space, increase the utilization rate of underground parking lots and ease parking difficulties.

1. Introduction
The construction of China’s underground parking lot started roughly in the 1970s[1-2]. At that time, some dedicated garages were mainly built under the “preparation for war” guideline, and guaranteed to be used normally. With the rapid economic growth and the needs of urban development, the large-scale construction and development of parking lots has made great achievements[3-5]. A considerable number of enterprises in major cities in China have built underground parking lots for their own use or public use, and some underground parking garages have been combined with underground streets. The underground parking lots planned in many cities in China are mostly attached underground parking garages, which are mostly located in the underground floors of high-rise buildings and buildings. Since then, the problem of difficult parking in urban development has been solved[5-6].

Judging from the status quo of the construction of existing large underground parking lots at home and abroad, many underground parking lots are irrational in design and low in utilization rate, which not only aggravates the dynamic traffic load of the city, but also wastes urban facility resources and increases urban operating costs. As a result, the city’s vitality is impeded, and the normal operation of the city is impeded. At the same time, modern urban tunnels, such as the open-cut supporting sections near the receiving tunnels of shield tunnels, and deep-buried sections of open-cut tunnels, due to the deep burial depth of the tunnel, the upper soil loads Too high, leading to the use of double-layer, three-layer and other multilayer tunnels. Moreover, since the lower level of the tunnel is a driving space, most of the upper level is a cavity structure from an economic point of view[7-8]. How to conduct reasonable commercial development for similar spaces has not been studied in depth at home and abroad.

Facing the difficulty of parking and the inconvenience of using large underground parking lots during the construction and development of today's cities, most of the time they are idle. This article combines the multi-layer space of the open tunnel in Xiamen Haicang tunnel, Research on the design of underground parking lots. The result of research is great significance for the rational use of urban
underground space, increasing the utilization rate of underground parking lots and alleviating the difficulty of parking.

2. Project Overview
Xiamen Haicang Subsea Tunnel is a subsea tunnel under construction. After passing through the sea from Haicang District, it will use open-cut tunnels to enter Xinghu Road. Due to the large longitudinal slope of the route, which results in a large buried depth of the tunnel, the design unit adopted a double-layer tunnel structure. The lower layer of the tunnel is a traffic tunnel layer, and the upper layer is a superimposed layer. The cavity space is huge and can be used for underground space development. The multi-layer tunnel section is located in the middle of Xinghu Road section from the east of Chang'an Road to Changhao Road in the west of Huli District, Xiamen. The south side is Guangben Shengyuan Automobile 4S shop. This section is 4.8km from Siming District of the central city; 6.1km from Jimei District; 8.1km from Haicang District; 5.9km from Xiamen Station; 3.6km from Xiamen Gaoqi International Airport.

![Fig 1 Location of Project](image1.png)
![Fig 2 The graphic design of Tunnel](image2.png)

The usable area of the upper layer of the tunnel is about 7000-9000 m². The indoor clear height of this part decreases from 7.9 meters on the west side to 3.6 meters on the east side. The indoor elevation rose from west to east in turn, showing a general upward trend.

![Fig 3 The clear height of the underground space that can be exploited by the tunnel](image3.png)

3. Development and design of underground parking lot

3.1. Liquid analysis
According to the analysis of the surrounding road network and business form, it can be found that the development of the underground space above the tunnel is of great significance:

- Make full use of the underground free space in the city to enhance the space value:
  The project can be developed and used in an area of about 7000-9000 m², which has a large area and has great development and utilization value.
- Create an underground parking garage to ease the pressure of parking on the ground:
  The plot is located on the north side of Guangzhou Honda Shengyuan 4S shop, and can be used as a dedicated parking lot for car 4S shops.
  Based on the current tight parking needs of motor vehicles, build underground parking garages to alleviate the pressure of parking on the ground.
- The possibility of reconstruction is reserved to pave the way to meet the needs of the city and the subsequent connection and development.

3.2. Overall design
1) Graphic design

Considering the current situation of the plot and the later landscape effect, the design of the adjacent underground evacuation entrances and exits is combined to reduce the number of ground exits. While minimizing the impact of underground space on urban space, it also ensures the effective width of the ground pedestrian road. Main technical and economic indicators: total construction area: 8071.02 m².

2) Architectural design

According to the specifications, strictly control the indicators that affect the parking area of the unit, such as the area occupied by a single parking space of 2400mm × 5300mm when a small car is vertically parked; the turning radius of a circular road of 3.9 to 4.2 meters must be at least 6 meters of the minimum turning radius of the car; Vertical parking is the main vehicle parking mode; later
retreating and forward driving is the main vehicle parking mode; about 10% of mini-car parking ratios, etc.

Reduce the invalid area of the basement construction area: For example, the equipment room should be mainly located below the tower to make full use of the space that is not good for parking; the driveway is generally not arranged separately from the external wall; the compact design of the outline of the external wall of the garage; the optimization design of the dead corners at the corners and much more.

According to the optimized building design, there are 190 retrofittable parking spaces available on the upper level of the tunnel.

3) **Functional partition design**

Separate urban underground parking lots need to be set up with separate evacuation routes in accordance with the setting of the fire protection zone.

Multi-level basements, pump rooms and pools should all be located on the ground floor of the basement. The pump room is best located near the power distribution room and near the professional water well, which can reduce the length of the pipeline to reduce equipment costs.

4) **Fire compartment design**

The regulations stipulate that there should be no less than two safety exits for each fire-prevention zone (area 4000m²) in garages; the regulations also stipulate that the safety exits for personnel and evacuation exits in garages should be set separately. In other words: cars entering and leaving the ramp cannot be used as evacuation routes.

With reference to the "Code for Fire Protection in Architectural Design" and "Code for Fire Protection in Automobile Garages, Garages, and Parking Lots", the parts of the garage: the maximum area of the fire zone is 4000 m²and the evacuation distance is not more than 60.0M; the total length of the fire shutter door is not more than 20M ; Each fire zone meets the fire protection requirements of at least two evacuation exits; the fire-resistant rolling shutter door is considered for the delimitation passage of the fire zone.
The first fire zone (2584.60 m$^2$), the second fire zone (2983.27 m$^2$), and the third fire zone (2503.15 m$^2$)

4. Conclusion
This article discusses the design of urban underground parking space from the aspects of liquid analysis, around the urban multi-layer tunnel, parking lot graphic design, architectural design, function, and fire prevention design, and draws the following conclusions:

Combining specifications with strict control of various indicators affecting the parking area of a unit can effectively increase the number of parking spaces to 190.

The design and optimization of the underground basement of the urban multi-layer tunnel can reduce the direct energy consumption of the project construction, reduce the energy consumption after the completion, and reduce the direct cost investment of the project construction. It is a resource-saving and environmentally friendly social development goal in the field of engineering construction.

References
[1] ZHU Hong-bo. Study on the Design of Metro Underground Parking Lot, Railway Standard Design, 2017, 61(05): 167-171.
[2] FAN Lei, JIANG Pengpeng, XUE Guangji. Key Technologies of Split-unit Rectangular Pipe Jacking Machine: a Case Study of CREG Underground Parking Lot, Tunnel Construction, 2019, 39(03): 504-510.
[3] ZHOU Jian-nan, Li Keming, WU Peng, et al. Thinking about the Construction of Underground Parking Lots, Underground Space, 2004, 24(03): 370-372.
[4] Tan Zhongsheng, Wang Mengshu, Wang Yonghong, et al. Present Situation and Application of Urban Underground Parking Lots, Strategic Study of CAE, 2017, 17(06): 100-110.
[5] Wang M S, Wang Y H, Tan Z S, et al. Exploration on the comprehensive utilization of underground space in China's smart city [J].Journal of Beijing Jiaotong University, 2016, 40(4): 1–8.
[6] Yu S J, Yin B C, Liu Z P. Study on the development of static traffic at home and abroad [J]. City, 2011 (9): 89–91.
[7] Wen Q Y, Lu L Q. A Review of the present situation and development of stereo garage at home and abroad [J]. Logistics Engineering and Management, 2016, 38(7): 159–161.
[8] Shen L H. Stereoscopic parking planning—Discuss intensive land use mode of parking planning [J]. Traffic & Transportation, 2016(z2): 112–116.