Analysis on Design of Underground Space in Tianjin: an Example of Langxiang Underground Street

Jing Zhao¹*

¹ Tianjin University, Tianjin, 300000, China
*Corresponding author’s e-mail: zhaojingliz@163.com

Abstract. The design of underground street in the central area of the city is not reversible, and the design of underground space that needs consummate consideration urgently should try hard to form three-dimensional integrated development with the city. The paper summarizes experience and deficiencies of the design from design background, design of underground street layout, elements of space design, evaluation and analysis by the case of the most representative Xiaobailou Langxiang Underground Street in Tianjin. It also forecasts problems that may need to be solved and development direction, then tries to provide reference for the design of underground space in the future.

1. Introduction
The crisis of living space is a problem that has been plaguing the whole world like population explosion and shortage of natural resources. The development and utilization of underground space as an effective way to solve the problem has been put on the agenda of urban design. As a kind of utilization of underground space, underground street is one of the most common ways to explore the extension from urban underground to public space. Tianjin Xiaobailou Langxiang Underground Commercial Street is a representative of the three-dimensional development of urban space at Tianjin and creates a number of Tianjin’s first tries. As the first special underground store in Tianjin, it adopts the reverse construction method with full cover and provides a reference experience for underground construction in the bustling area of central urban area. More importantly, as the first underground commercial street of Tianjin subway, the design of underground space is worth our analysis and reference.

2. Design background
Xiaobailou District is the commercial center of Tianjin and the main urban center, which is made up of the cultural center and its surrounding areas. The urban spatial structure of one axis, two belts and three districts was mentioned in the urban master plan of Tianjin (2005, 2020) (revision) in 2005. As the core of the central district of the city, Xiaobailou seeks to become an international modern cultural and commercial core district, which plays a key role to Tianjin internal development, and construction of surrounding areas in the public transport system as a key factor to realize the sustainable development of city is also the focus of the reasonable planning.

3. Design of underground street layout
The underground space layout of Langxiang Street combines regional traffic fully. The above ground part is the landscape leisure plaza, and the underground part is the commercial subway complex. The underground street has three floors, and the two-storey commercial street has a total operating area of
18,000 square meters. The composition of the underground street is shown in Table 1. Total construction area of the first floor underground is 13,588 m$^2$ and the column spacing is 8.4m. The second floor underground is 4466m$^2$ and the column spacing is 4.6m. The third floor underground is the parking lot which is the first deepest underground parking lot connecting subway station in Tianjin, with a total construction area of 31,444 m$^2$.

Table 1. The composition of underground street.

| Landscape Node | Location       | Plane modality | Remarks                                                      |
|----------------|----------------|----------------|--------------------------------------------------------------|
| Sunken plaza   | 2nd floor underground | Semicircle         |                                                              |
| Commercial Street | 1st floor underground and 2nd floor underground | Rectangle          | The first floor underground is mainly featured catering.                  |
| Parking lot    | 3rd floor underground | Rectangle          | The second floor underground is for men's and women's clothing. |
| Subway station | 2nd floor underground and 3rd floor underground | Line shape         | The subway line 1 is on the third floor underground and the subway hall is on the second floor underground. |

4. Elements of space design

4.1. Space entrance design
The entrance and exit are the only visible elements in the underground building, so they play the irreplaceable roles in space transition and building appearance. There are 4 entrances and exits in Xiaobailou subway station. Entrance A and exit D are located in the sunken plaza, while entrance B and exit C which are made of glasses are separate ground entrances. There are five entrances and exits in underground street. Three above-ground entrances are located near the concert hall of Xiaobailou. All of them are designed as independent vitreous bodies with relatively simple appearance and low identification. The two are located in the sunken plaza of underground street, which solve the problem of external image and are the entrances of ground environment transition. They bring natural lighting to the underground street, so that the underground pedestrians also have some ground vision. At the same time, people could have a clear and unique image when they overlook the underground plaza from the ground, and the European stone fence is easy to identify from a distance. In addition, the semicircular entrances and exits, escalators and stairs of the sunken plaza have the clear form of opening on the ground.

4.2. Shape design and space composition of underground street
Langxiang Street belongs to plaza kind of underground street, which is connected with underground street by ground sunken plaza, and then connected with railway hub by underground space. As a large underground street in Tianjin, the stores adopt large hall layout, with the underground plaza and atrium as the core, and other spaces are set around it. Such a spatial organization mode has a clear mark and direction, and the internal space is wide and unobstructed, which is consistent with the main activity pattern of people and architecture[1]. At the same time, through the integration of the two parties in landscape design and moving line design, functions and efficiency could be improved.
4.3. Design of sunken plaza
As a design method connecting the upper and lower spaces, sunken plaza has the advantages of not blocking the sight, less impact on the ground landscape, high accessibility and close combination with ground activities. However, it is also necessary to avoid excessive land use and pay attention to rich spatial levels[2]. The main functions of Xiaobailou underground street sunken plaza are as follows:

- The entrance effect of underground space eliminates the negative psychological effect of entering underground space via stairs.
- Effective introduction of natural light not only plays the role of daylighting patio and improving visual sense, but also is conducive to disaster prevention and evacuation.
- Stay away from the noise. Langxiang Street is located in the commercial center of Xiaobailou and the traffic hub of the road. The surrounding commerce and traffic are prosperous, and the sunken plaza could be far from urban roads and the interference of vision, forming the quiet space of the courtyard in the downtown, which is in contrast and complement with the open space of the ground plaza.
- The sunken plaza has the function of channelling people to gather and disperse. In terms of function and form, sunken plaza could be combined with surrounding traffic facilities to better guide people, traffic flow and organize transfer. There are several entrances to the plaza beside the subway passageway which enable people to realize the existence of the sunken plaza when they do activity in underground street and often cross from it.
• The underground shops around the sunken plaza all open a large area of glass doors and windows toward the plaza, or open without doors or windows. So the underground space around the plaza is integrated with the open space of the plaza.
• The wall of sunken plaza is an important element to enclose and define the space. Wooden bar type setting wall effect instead of ordinary painted walls were used in the interface treatment of sunken plaza and underground street entrance. The space appears diverse and lively.

Areas for improvement:
• From the perspective of space composition, people's feeling of street space could not be separated from the street width (D), the height of building external wall (H) and the proportion between them. The sunken plaza is an effective transition between above ground and underground space. The elevation of the plaza level is the same as the second floor underground of the street, resulting in the plaza being too deep in the vertical direction and restricted by the surrounding roads. Its maximum width for walking is the radius (D) of the semicircular tangent, which is greater than one to the vertical building height (H), D/H > 1, but in the other location, D/H < 1. The lack of horizontal space creates a sense of urgency.

![Space diagram of plaza surroundings.](image)

• The plaza lacks natural green landscape, and there are no public facilities for rest, dining and meeting.
• The shop advertisement on one side of arc wall presents too diversity, which lacks unity and breaks the harmonious sense of plaza.

4.4. Design of atrium shared space
The circular permeable roof of 60 m² is composed of space grid structure and lighting glass surface. It could not be disturbed by the interference of bad natural environment outside and also could receive the natural light from the above. Plants, benches and other facilities have been set up to allow people to rest. The atrium is also a shared space on the second floor underground, which alleviates the sense of underground sealing. From underground layer, people could overlook below and the field of vision is extended. At the same time, as the atrium connects the upper and lower two spaces, each space extends and expands in the atrium space in the horizontal direction, and integrates with the open space on the ground along the vertical direction. It makes the underground street space structure form a far-reaching, three-dimensional and diversified space[3]. However, for the atrium running through two floors, the space with diameter of 7m is too small and the open environment is insufficient.

4.5. Interior design of underground street

4.5.1. Color processing. On the basis of considering functional requirements fully, according to the commercial character of underground street and people's psychological and physiological needs, the overall underground street is mainly in the colors of milky white and light yellow, which gives people a soft and bright feeling.

4.5.2. Sign system design. The direction sign is placed in the obvious traffic flow line. Because the subway line 1 in Tianjin takes underground street as the entrance and exit, it is very important to strengthen the internal guidance so that consumers could effectively get to the subway. The
4.5.3. **Indoor facility configuration.** In addition to the general configuration of comfort and functions, the designs pay more attention to the bright color. The color of seats is bright orange. Natural plants mixed with artificial green vines create a natural environment in underground space. At the same time, the dynamic elements are directly applied, and the atrium space uses light green curtains, colored spheres, artificial weeping willows and other dynamic decorations to create a lively and dynamic space effect.

4.5.4. **Lighting design of underground building.** In addition to the natural lighting of the sunken plaza and atrium, the main source of underground street light is artificial lighting. Natural light could hardly reach every place in the underground space, so artificial lighting is particularly important. Langxiang Street mainly uses the white cold light source, the artificial light which has the natural characteristic is placed in the translucent strip glass, which causes a kind of natural daylighting illusion. Using point light source makes lamplight illuminate natural and clever simultaneously. The sign board that overhangs on the ceiling uses curtain type of blue dot light to connect, which gives a person the wonderful move feeling. The ground uses smooth ceramic tile, which reflects the lamplight of the ceiling and makes the interior is brighter. It eliminates negative mental associations that people have underground.

4.5.5. **Disaster prevention design of underground building.** Due to the negative psychological hint of underground buildings, such as difficulties in evacuation and rescue, firefighting and smoke exhaust, etc., it is necessary to pay more attention to disaster prevention design. Langxiang Street is equipped with escalators, elevators and vertical walking stairs, which could provide safe refuge in emergency.

In addition to paying attention to internal space and evacuation streamlines, the corridor also has evacuation guidance instructions, and the use methods of fire hydrants, fire extinguishers, alarms and so on are clearly marked with transparent glass walls, so that people could find them in panic. Meanwhile, in order to prevent the disaster, Langxiang Street is designed as a smoke-free commercial street with public safety video monitors to prevent the disaster from happening.

5. **Evaluation and analysis of design**

As an urban public space, Langxiang Street's design features are mainly shown in the following aspects:

5.1. **Humanized design could meet the requirements of urban public space design**

Attention should be paid to the needs and feelings of the underground street crowd, such as psychological and physical feelings of consumers, psychological demands of a closed environment and so on. In order to reduce the psychological burden brought by closed environment and meet the needs of emotional experience in urban public space, designers use set nodes, introduce natural light and use clear guiding signs in the design [4].

5.2. **Pay attention to the penetration of the space**

On horizontal penetration: underground street shops form a wide range of visual transparency. On vertical penetration: in addition to the interpenetration of the same floor interior space, it also uses the
staircase and atrium space to make different floors of the underground street penetrative. On the penetration of internal and external spaces: the transparent circular glass of the atrium directly reaches the ground to form the direct communication and penetration of the indoor and outdoor space.

6. Conclusion
For reasonable planning and layout of underground space in urban center area, the whole urban structure of Tianjin would be sped up to comply with the goals of Tianjin’s pace and make Tianjin a modern city with sustainable development. At the same time, two major development trends of underground street could be seen in the future. First, qualitative change. The development of underground street pays attention to the humanization, characteristic and integration of spaces. Second, the impact of urban space. It has become a phenomenon of urban public space composition and extension. It is undeniable that there are still many problems in space design of Xiaobailou Langxiang Street, but it could be seen from the case analysis that the future urban underground complex would promote the balanced development of urban areas, and the optimization of the environment design in underground space would also promote the positive development of the whole city.

References
[1] Dong, Y. (2004) Humanized Design for the Underground Space in Subway Station of Russia. Architectural Journal, (11): 79-81.
[2] Zhou, W.M. (2016) Initial Research about the Integration Strategies of Pedestrian Traffic System in City Center Regeneration: Case Study of Underground Space Design in Lujiazui Center Area. Architecture Technique, (4): 98-101.
[3] Hamilton-Baillie, B. (2008) Shared space: Reconciling people, places and traffic. Built environment, 34(2): 161-181.
[4] Xu, T. (2016) On Humanized Design of Underground Commercial Space. Chinese & Overseas Architecture, (9): 79-80.