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Study of a Three-Dimensional and Multi-Functional Urban High-Rise Complex in the High-Density Environment: Design Practice of Yiwu World Trade Center

Linxue Li†, Miaomiao Hou, and Qi Zhang

College of Architecture and Urban Planning Tongji University, Shanghai, 200092, China

Abstract

Facing the challenges of urban form and space quality in a high-density environment, the paper puts forward the development trend of three-dimensional and multi-functional design for an urban high-rise complex, and analyzes the design methods of establishing an urban landmark, including multi-functional composition, three-dimensional space integration, three-dimensional traffic organization and energy flow programming. Meanwhile, combined with the specific design case of Yiwu World Trade Center, the practical experience of designing a high-rise complex in China's medium-sized cities is analyzed.

Keywords: High-density environment, Urban high-rise complex, Three-dimensional and multi-functional design, Contemporary practice

1. Development Trend of Three-dimensional and Multi-functional Urban Building Complex

Compared with Western countries, China and most of the fast-growing and densely populated Asian countries are characterized as “high-density” and are associated with the development of compact cities. On one hand, this is due to the austerity of the urban form that results when solving for the disorderly spread of the city, on the other hand, this is because that the growth of the urban population puts more demands on the sustainability and livability of the city.

With the process of modernization and urbanization, urban density is inevitably proliferating. Aristotle's ancient definition of the city, that “people gather in the city for a better life,” still holds true today. Meanwhile, the concept of density should be freed from the shadow of earlier days, when it was seen as a co-indicator of squalor, becoming an objective indicator, and even a favorable factor in the evaluation of the city. According to the data released by the National Bureau of Statistics, China’s urbanization rate reached 58.52% by the end of 2017, which is rapidly advancing at a rate higher than the world average, and is expected to reach 70% by 2030. It means Chinese cities, from the first through the third tier, can expect to face challenges of high-density settlement.

The “multi-functional” city concept is the best response to urban environments of high-density and development trends of compact city. The diversification of functions is the basis of sound urban development. Under the premise of objective conditions, such as population and density, it is necessary to promote the diversification of functions as much as possible to avoid the large-scale accumulation of a single function in a given area. This should be taken into consideration when it comes to the development of an urban complex.

Compared with an ordinary building complex, an “urban” complex emphasizes more consideration of the urban habitat. The complex is like a small city, whose interior is composed of the various main functions of a city. The relationship among the various functions of the complex is similar that of the larger city, requiring coordination and symbiosis. The three-dimensional and multi-functional aspects of the urban complex are mainly embodied in three points: First, it contains three or more functions (such as retail, entertainment, office, residence, leisure space, etc.), and each function can support ther other and provide mutually complementary benefits. Second, there is spatial and functional integration between the various parts (such as pedestrian connections, atria, etc.) to achieve high-intensity use of the land. Third, it needs to be developed according to a well-organized program, including the types of functions and their proportions.

2. Design Practice of Yiwu World Trade Center

2.1. Regional Position and Base Analysis

Yiwu World Trade Center is located in the financial and

†Corresponding author: Linxue Li
Tel: +86-13901737520; Fax: +86-21-65025560
E-mail: land_well@hotmail.com

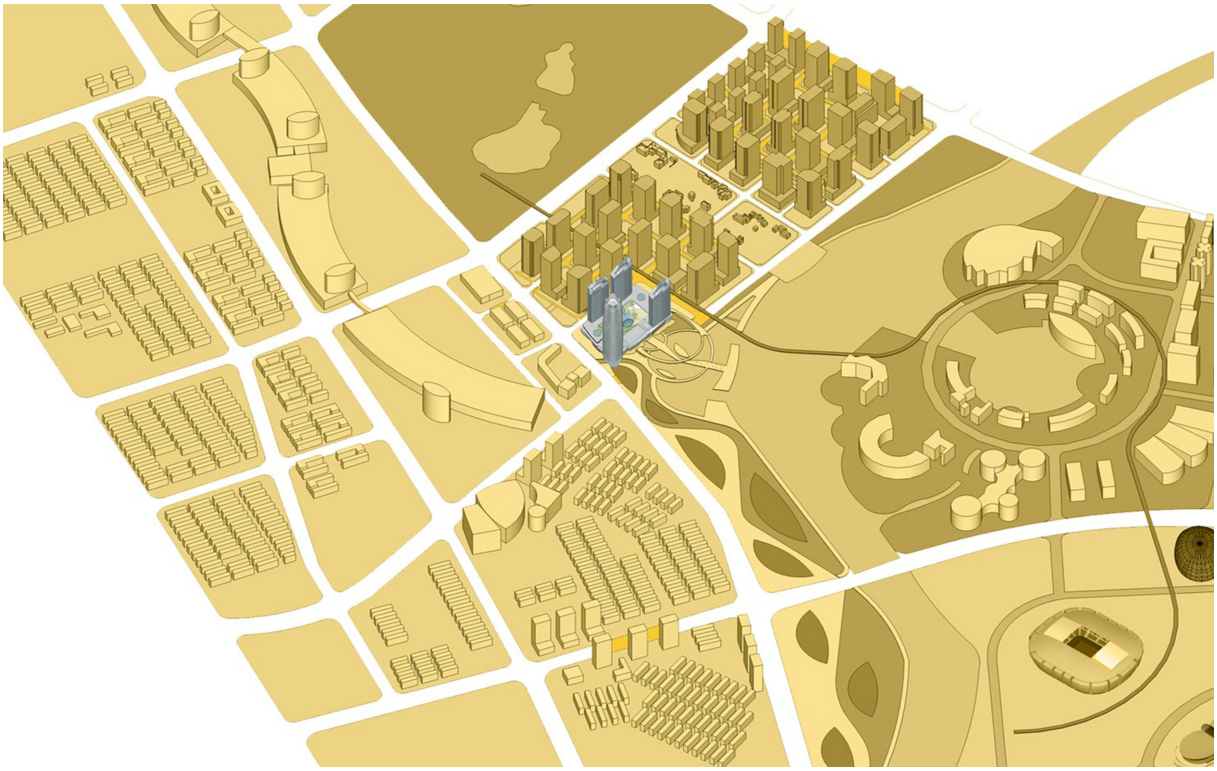


Figure 1. Regional position of the Yiwu World Trade Center complex.



Figure 2. The Yiwu World Trade Center complex.

commercial district of Yiwu, close to the International Trade City. The site is located between Chengbei Road and Futian Road, with an urban light rail station along the west side of the base. The project is surrounded by imp-

ortant facilities such as the Municipal Customs Office and International Trade City. The CBD, led by Yiwu World Trade Center, will soon become the core of regional economic development, and will play a more positive role in promoting the integration of internal resources in the regional economy of central Zhejiang (Fig. 1-2).

2.2. Introduction to the Functions and Layout of the Complex

Yiwu World Trade Center consists of high-rise hotels, serviced apartments, commercial plazas and high-end residences. The four towers are located at the corners of the commercial podium, forming a highly aggregated spatial distribution, each with a good landscape view. The building group faces a park and the Yiwu River (Fig. 3).

The project is a typical city complex of balanced development, with hotels, businesses and apartments as the three leading functions, and the proportions of the three being 34%, 18.4% and 18.6%, respectively. In addition, Yiwu World Trade Center has complete supporting functions, including supermarkets, department stores, bars, restaurants, banquets, conferences and other commercial functions, as well as sports facilities, a spa, karaoke, cinema, swimming pool and tennis courts. Although the scale of development is not very large compared to many in China, the functions enrich the activities and enhance the vitality of the complex (Fig. 4).

3. Three-Dimensional and Multi-functional Design Method of Urban High-Rise Complex

3.1. Urban Landmark Establishment

Yiwu World Trade Center, close to Binjiang City Landscape Park, faces the Cultural and Art Center across the Yiwu River. It is located at the intersection of Yiwu International Trade City and International Finance and Trade District, which is becoming one of the most dynamic areas in Yiwu and Central Zhejiang. The World Trade Center will also become a new landmark in Yiwu (Fig. 5).

In this context, the World Trade Center faces high-intensity land development, and the design should match the multi-functional needs of the project to meet the requirements of commercial, residence and office functions. At the same time, considering the surrounding traffic capacity, the project and the city's overall traffic will be coordinated and developed. Therefore, the three-dimensional and multi-functional design is particularly important.

3.2. Multi-Functional Composition

Due to its high degree of complexity, this urban building complex includes almost all common functions of urban public buildings, including office, residence, hotel, retail, entertainment, culture, public facilities, conferences, leisure and parking, etc. Generally speaking, the urban building complex is a “city in the city,” integrating the five core functions of commercial retail, business office, hotel catering, apartment residence and comprehensive entertainment, making it an urban economic aggregate of multi-function composition and an intensive use of available land.



Figure 3. The model of the Yiwu World Trade Center complex.

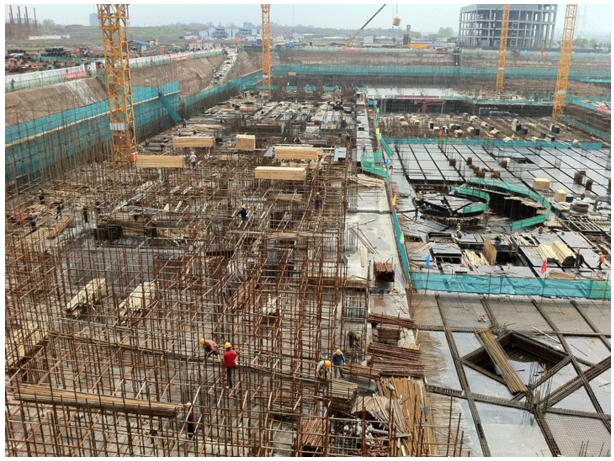


Figure 4. The Construction site photo of the Yiwu World Trade Center complex.



Figure 5. Yiwu World Trade Center is in an advantaged position with great views and convenient transportation.

3.2.1. Composite organization of hotels, residences and shopping malls

The lower part of the hotel is equipped with more public functional spaces, such as an office business center, banquet hall, multi-function hall, and swimming pool, while hotel residences are located in a higher section of the tower. The malls contain complete facilities, including supermarkets, department stores, clothing and other retail functions, as well as many leisure and entertainment functions, such as catering, karaoke, and cinema. The two kinds of space are connected on the second floor through the mall corridor, which establishes connectivity between the hotel and the shopping mall, which allows hotel visitors to enter the shopping mall and participate in various activities, such as shopping, leisure and entertainment, realizing the synergy between the hotel function and the commercial function (Fig. 6-7).

At the same time, the building towers of Building A, Building B and Building C are directly connected to the shopping mall by way of stairs, elevators and other vertical circulation, to meet the living needs of shopping, leisure and entertainment, and to realize the integration of residential and business functions (Fig. 8).

3.2.2. Composite organization of hotels, apartments and roof gardens

A roof garden is set on the roof of the mall, and a horizontal communicative space is formed on the sixth floor, where a space for public event is located. Users of the hotels and apartments can reach the rooftop park through an entrance on the 6th floor, which enhances the connection of the two. As a kind of public space, the roof garden also



Figure 6. The high-rise hotels of the complex.



Figure 7. The entrance to the high-rise hotels of the complex.

heightens the urbanity and civic qualities of the complex.

3.2.3. Composite organization of shopping mall atrium

The vertical spatial system plays an important role in the synergistic effect of an urban building complex, often with the result of better overall accessibility and higher space efficiency, resulting in greater traffic and a more balanced dispersion of people, promoting the place effect while creating more profitable opportunities for the whole.



Figure 8. The serviced apartments of the complex.

The central part of the mall is a five-story atrium space. Around the atrium, the retail store is arranged on the first to third floors, the retail store and the international cinema on the fourth floor, the dining plaza and the large KTV on the fifth floor. Different types of shopping mall space are integrated through the atrium space to form a mode in which the main store drives traffic to smaller stores, sales and entertainment activate each other, creating a stronger business climate and driving overall economic and social benefits (Fig. 9).

3.3. Three-Dimensional Integration of Space

The Yiwu World Trade Center project is a typical urban complex of balanced development type with a high degree of functional complexity. In a high-density urban environment, functional composition is not only reflected in the layout of the plan, but also further reflected in the vertical section, through the recombination of the three-dimensional space. Above the fifth floor of the podium, there is a 215-meter main building, known as the highest building in Central Zhejiang, and three 150-meter high-rise buildings. The vertical extension of the space brings opportunities for the maximum three-dimensional comprehensive development and utilization. In the urban complex, there are three main types of such three-dimensional composite space: functional space, public space, and circulation space.



Figure 9. The public walkway and atrium of the complex.

3.3.1. Three-dimensional integration of functional space

For the three-dimensional partition, the taller high-rise locates a high-end hotel below the 35th floor, and offices are set above, with the highest sightseeing layer on the roof enjoying a bird's-eye view of the city. The hotel's banquet halls, multi-function halls and other public functions which need to be more closely related to the ground floor, are placed in the podium part, and integrated into the functional entity of the podium through the double-height atrium of the hall. The guest rooms section from the 7th to 35th floor is interspersed with public leisure space, such as the air corridor in double-height atrium of the 33rd and 34th floors, combined with recreational functions. The main building's space is seperated into different layers, but rather than isolating uses, the clear zoning allows the layers to work together in a synergistic way (Fig. 10-11).

3.3.2. Three-dimensional integration of public space

In a high-density urban environment, the public space on the ground that meets the demands of ecological development and public use is frequently lacking. Starting from the needs of composite space and environmental quality, the Yiwu World Trade Center project transforms the ground-level public space from an undifferentiated horizontal experience to a three-dimensional experience, fully emphasizing the urbanization of three-dimensional space. The sunken commercial plaza is open to the city streets, letting the public walkway run through the podium in the east-west direction. Its full-height atrium integrates the space of the shopping mall from the basement level to the 5th floor, to form the circulation and connection of three-dimensional space, which enriches the user's spatial experience, and brings the energy of the surrounding city into the volume.

In the three-dimensional development of space, by expanding the ground level to the "secondary ground" in the air, the urban environment and the building itself are provided with more open space and outdoor space at height. The Yiwu World Trade Center project has a public garden on the top floor of the podium, and the hotel and apartment also have a sub-hall on this floor. Through the combination of leisure sports functions such as tennis courts and swimming pools, as well as landscape designs such as green plants and fountains, the design not only expands the available space for people's leisure and communication activities, but has also created a sustainable ecological environment (Fig.12).

3.3.3. Three-dimensional integration of traffic space

The connection and composition of the urban transportation system and the urban complex is the basis for the efficient operation of the complex. A successfully designed

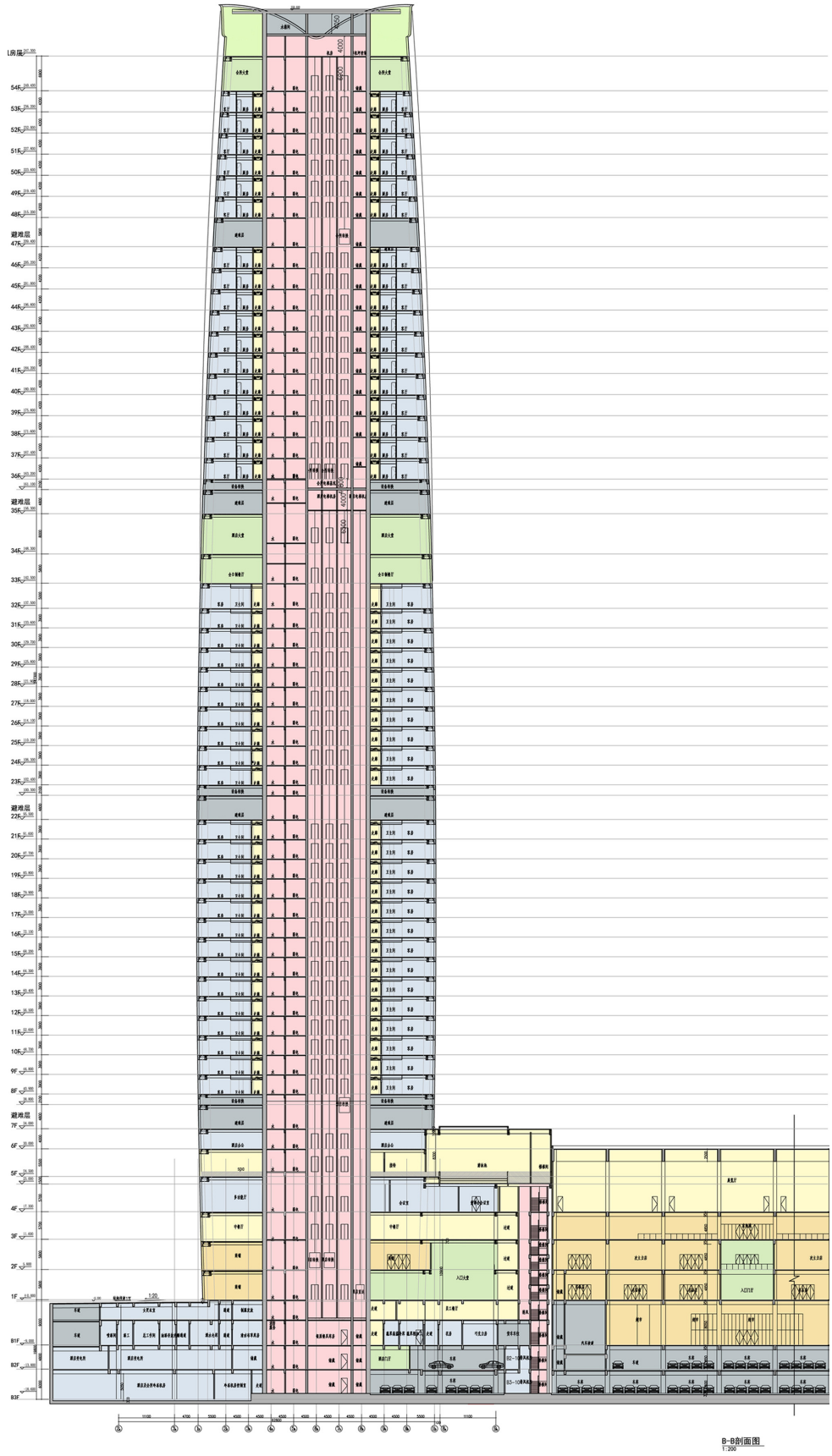


Figure 10. The three-dimens.ional and multi-functional layout of the main building.



Figure 11. The night view of the complex.

LRT (light rail transit) station and the parking lot are necessary conditions for the integration of high-density human flow into the complex. In the Yiwu World Trade Center project, because of the huge amount of parking demand, the underground parking extends from level B3 up six floors to level 3, mainly serving the shopping mall. The link plays a secondary role in connecting the underground and above-ground spaces, and even plays a role as a climate buffer zone.

3.4. Three-Dimensional Traffic Organization

The Yiwu World Trade Center project is located in the Finance and Trade Area of Yiwu, which possesses locational and transportation advantages. There are huge amounts of various types of traffic flow, so the connection with the external transportation system is very crucial. Chengbei Road on the south side is the urban main road through which the city traffic can pass and directly enter the entrance or parking area of the complex (Fig. 13). The shopping malls and residential traffic flow separately, entering and exiting through separate portals on the north and east sides, and additional partitions keep through-circulation and parking lines well-separated (Fig. 14).

For pedestrians, the zoning and three-dimensional organization of circulation enhances the urbanity of the complex as a public place. Commercial, residential, hotel and office each have their own entries. The high-rise separates the hotel, office and tourist flows from each other, which is convenient for management and operation, and the elevator core is partitioned accordingly. The high-rise tower adopts the layout of the divided high-rise and low- rise

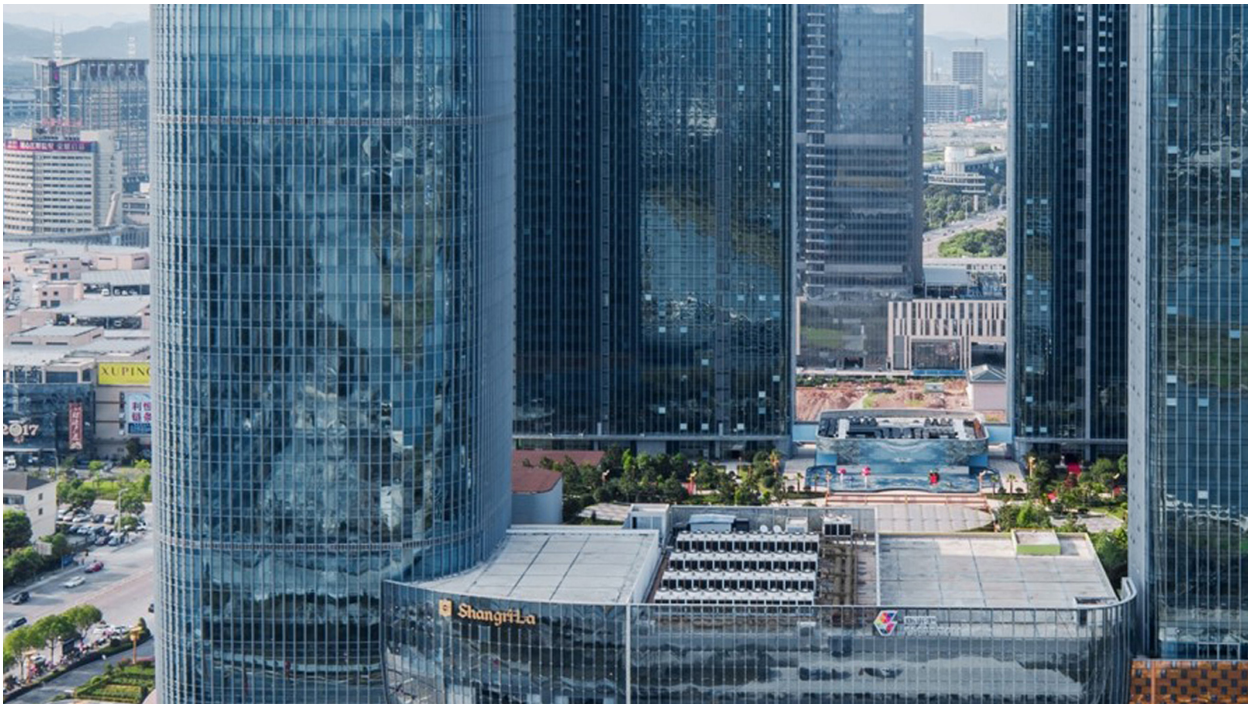


Figure 12. The public garden on the roof.



Figure 13. The Chengbei Tunnel, which connects to the complex directly.

elevators. While the low-rise elevator serves the hotel, the high-rise elevator can directly reach the office portion above the 35th floor. Tourists mainly start from the underground floor and ascend directly to the sightseeing level on the roof at the height of 200 meters, thanks to separated circulation systems.

According to the Yiwu City Master Plan (2013-2030), several planned light rail lines will have stations around the block of the project site. Therefore, the project is designed to fully consider integration with the light rail, so that future visitors can easily find their way into the project via the underground connection to the light rail station, driving pedestrian circulation into three-dimensional space through the atrium, further strengthening the development's connectivity to the city.

3.5. Energy Flow Programming

The high-density and intensive space utilization of the urban building complex results in huge energy consumption. Efforts to reduce energy consumption by way of high-tech energy-saving technologies has led to a significant increase in construction and maintenance costs. Rather than rely too heavily on machinery, the project combines the three-dimensional composite of building complex with climate-adaptive design from the perspective of energy flow, reflecting ecological and social values.

The project firstly analyzes the local climate characteristics of Yiwu, and determines the orientation strategy and the passive strategy by using a psychrometric chart that comprehensively considers the factors of the annual temperature and wind fluctuations. In addition to supporting connectivity to the urban transportation system and commercial value, the functional layout of the complex is fully considered to maximize the capture of wind, light, and thermal energy flows. The high-rise parts are all facing south, which is more suitable for absorbing natural light

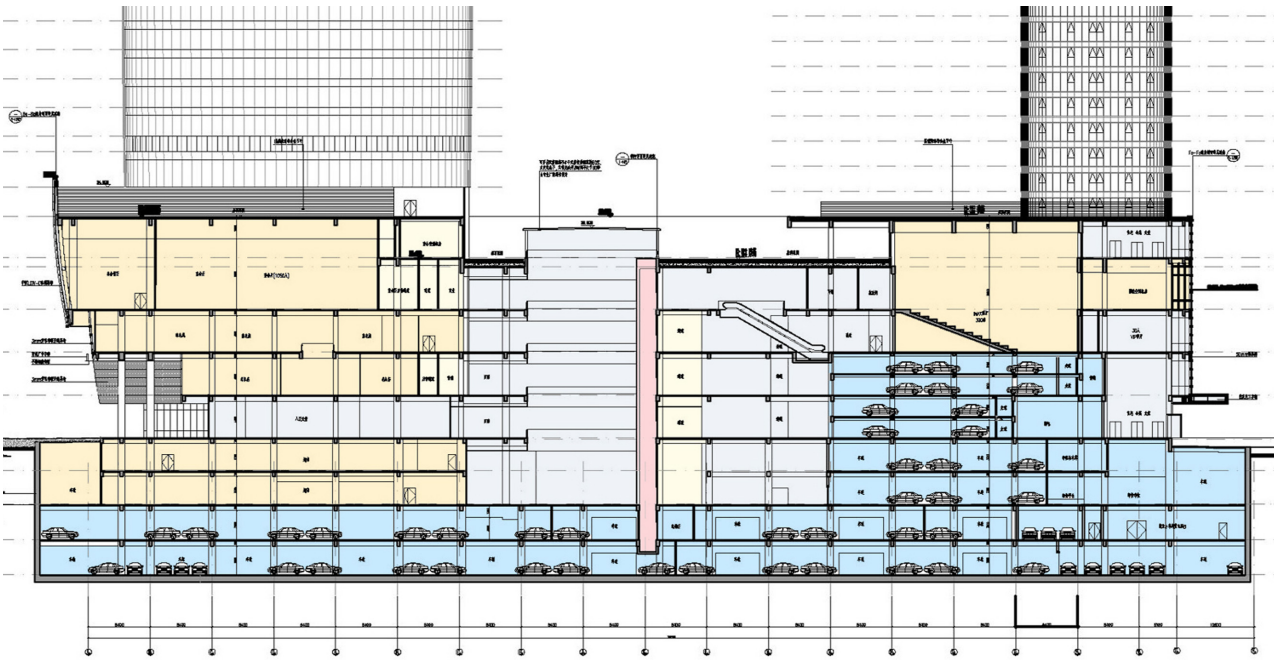


Figure 14. The multi-level parking lot within and below the podium.

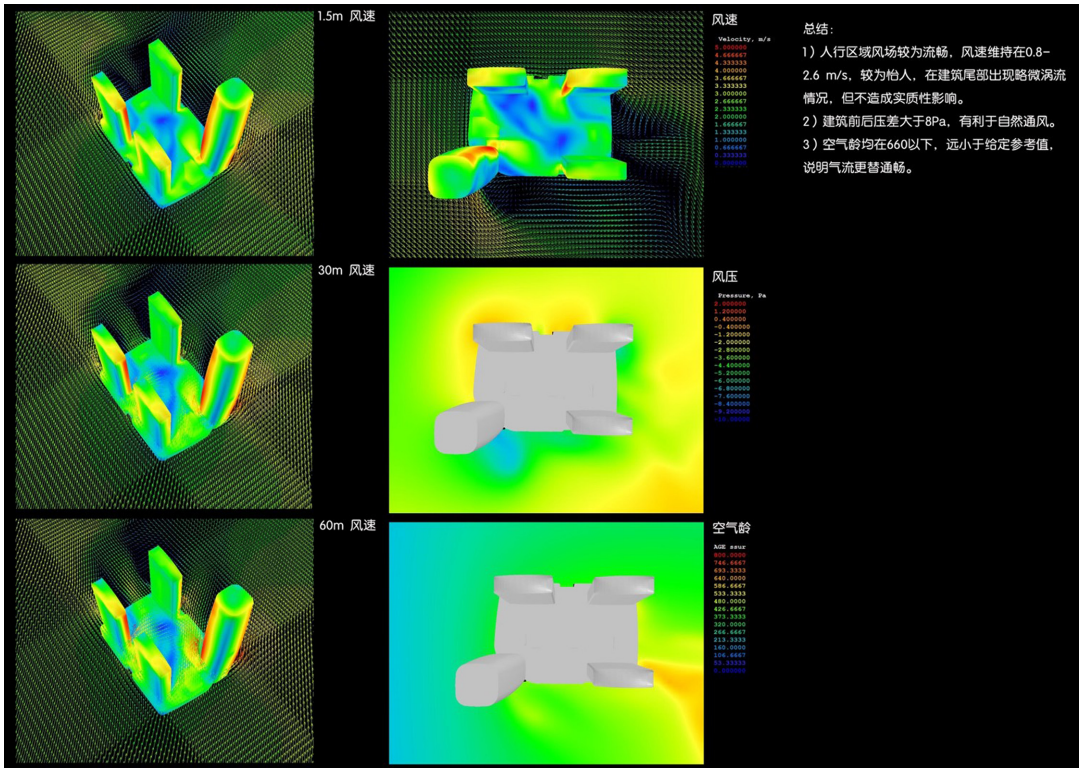


Figure 15. The wind simulation of the complex.

and solar radiant heat. At the same time, the two residential slab-type buildings on the north side can play a barrier role, blocking the cold north wind of the Yiwu region and improving the micro-environment of the roof garden. The resulting layout reduces the occlusion between the high-rise on the south side to the north block of the site (Fig. 15).

In the podium, the functional layout is designed accord-

ing to the needs of the micro-environment in different functional spaces, and the energy flow between the spaces is further considered to reduce energy consumption. The walkway in the atrium running through the deep-plan podium not only increases the flow of natural energy inside the building, but also makes a "living patio" in the subtropical monsoon climate condition, through an adjustable atrium skylight. When the temperature difference between indoors and outdoors is large in winter, the top interface of the pedestrian street is closed, and the atrium space can be regarded as a "thermal buffer layer" between other indoor and outdoor spaces. The top interface of the atrium is made of glass, which can increase the flow of heat and light energy of indoor and underground spaces in winter. The greenhouse effect here is used to provide heat to the surrounding space, and the inner pedestrian street of the atrium also compensates for the lack of outdoor public space in winter, enriching the climate gradients of the building. In summer, the exterior interface of the atrium is opened as much as possible, turning the atrium into a semi-open space, which can promote indoor ventilation and through differences of temperature and wind pressure.

Based on the full use of natural energy and rational allocation of artificial means, the project combines the principle of energy flow with its three-dimensional composition to reduce energy consumption while achieving high-density compact space, providing users with a comfortable and livable environment.

4. Conclusion

In a high-density urban environment, the high-rise building complex breaks through the traditional planar layout of cities, realizing three-dimensionality and multi-functionality through spatial integration in the vertical direction. Its advantages include high-intensity land-use, a high complexity of various urban functions, and 24/7 operation. These characteristics are favored by the government and developers in both new construction and historic city renewal. Yiwu World Trade Center is a balanced urban complex, which takes hotels, commerce and apartments as the three leading functions and supports a wealth of auxiliary functions. At the same time, combined with the principle of energy flow, it reduces energy consumption while achieving high-density compact land utilization, providing users with a comfortable and livable environment. Facing the challenges of urban form and spatial quality in a high-density environment, the three-dimensional and multi-functional design of high-rise building complexes will become more and more integral to their success, and to that of the cities they serve.

Acknowledgements

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