The advantages of C-pillars in the large space of the terminal: A case study of Beijing Daxing international airport terminal

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Abstract. This article takes the Daxing Airport terminal as an example to discuss the particular requirement of large terminals in space, energy saving and indoor environment. The interior of the Daxing terminal adopts C-shaped pillars, which comprehensively considers many issues, making the perfect combination of space and structure, function and art.

1. Introduction
As a traffic building, the terminal has the characteristics of large spatial scale, crowd indoor personnel, and complex functions. With the continuous growth of aviation business, the size of the terminal is increasing, and many terminals have become a comprehensive transportation building connected with bus and subway of the city. The new design concept of the terminal has incorporated a large number of ecological, commercial, catering, and exhibition functions, bringing a richer experience to passengers [1]. Complexity puts special requirements on the design of the terminal. How to optimize the comfort of the indoor environment and reduce energy consumption in the huge volume of space is an important issue that should be paid attention to in the design of the terminal.

2. Special requirements for terminal design

2.1. Large space requirements in the terminal
The departure hall of the terminal usually has multiple functions such as check-in, baggage check, security inspection, customs, etc. It is the core area for organizing vertical traffic, and usually has large-scale connecting spaces crossing multi-storey space. The indoor height of the departure hall is usually 15 ~ 30m, and even 20 ~ 40m high from the ground to the ceiling in the atrium space, forming an integrated large space. In addition to the unique functional areas of the terminal, it will also be used for business, dining, and rest. Various functional blocks are organized in large spaces (Table 1). The large spaces place forward higher requirements on the structure.

Table 1. Comparison of the terminal area of Beijing Capital Airport.

| Terminal area | Departure hall | Supporting area | height |
|---------------|----------------|-----------------|--------|
| Capital T1    | 6W             | 6100            | 8200   | 10     |
| Capital T2    | 30W            | 26500           | 11400  | 18     |
| Capital T3    | 98W            | 32000           | 5300   | 27     |
| New airport   | 78W            | 22300           | 8200   | 49     |
2.2. Energy-saving requirements of the terminal
The huge space of the terminal has brought disadvantages and challenges to energy saving. The high space makes the inner area far from the outer wall unable to get natural light, and the artificial lighting efficiency is also very low. The energy consumption of outer area near the outer wall and the inner space far from the outer wall are also very different.

The daylighting and thermal performance of the building are important factors affecting the overall energy consumption of the building. Skylights can introduce natural light into the building, improving the uniformity of light in the deep spaces of the terminal building. It is an important way to reduce the energy consumption of indoor lighting and to save energy consumption of air conditioning. Skylights also strengthen people's closeness to nature. There are three common forms of skylights in the roof of the terminal: linear skylights, point-shaped distributed skylights and concentrated large-scale skylights [2].

2.3. Interior design requirements of terminals
The terminal building is a comprehensive transportation building, and the people moved in it include passengers, greets, office management personnel, stationed commercial personnel, customs quarantine and other departments. The terminal has a huge volume and complex functional areas. The interior design should have a certain direction and guidance for passengers. Therefore, the terminal space design should focus on the following factors: unified, natural and green public Regional and spatial guidance.

3. Application of C-pillars in the terminal of Daxing airport terminal

3.1. Features of C-pillars
The new airport terminal is covered by a huge steel structure roof, which is supported by 10 c-type pillars. The concept of c-type pillars was put forward by Zaha Hadid's office in concept design stage. It was named C-pillars because the plane of the pillar is c-shaped, not closed. The c-pillars is designed to be wide in the top and narrow in the bottom. There is about 23 meters at the top and only 3 meters at the narrowest point at the bottom. The smooth lines are guided by c-pillars all the way from top to bottom, connecting the 49-meter-high roof to the ground (Figure 1)

The terminal originally designed only 8 C-pillars, and the opening direction was inward. During the deepening design stage, it was found that the check-in hall had insufficient day lighting and excessive day lighting central area through lighting analysis. The direction of the opening is turned outward, and at the same time, two c-pillars are added to the check-in hall at the east and west sides, which not only improves the lighting of the check-in hall, but also allows natural lighting to directly reach the luggage extraction hall on the second floor through the atrium [3]. (Figure 2)
Figure 1 the C-pillars

Figure 2 the 8 C-pillars in deepening design stage
3.2. Many advantages of C-pillars

3.2.1. Reduce structure component and expand space
The Daxing Airport Terminal is 1,753 meters long from north to south, and has a width of about 1,591 meters from east to west. The structure is complex and the space span is large. In order to meet the space flexibility requirements of future configuration adjustments, the huge central dome only depends on 8 groups of C-pillars, 12 groups of support tube and the surrounding curtain wall structure supported [4]. With the centre of the terminal as the origin and a radius of 90 meters, all are tall spaces without pillars. The projection area of the steel structure of the roof in the core area is 180,000 square meters. The design of c-shaped pillars can be minimized the vertical structure supported the entire building roof, forming a completely barrier-free indoor interior space. The space can completely freely arrange various functions and service facilities, which can be more efficient organize the flow of passengers in a way to serve passengers with more free space. The huge atrium with almost no columns in the terminal is a perfect combination of architecture and structure.

3.2.2. Combine with skylights to improve indoor environment
The C-pillars is not only a structural component, but also a channel for introducing natural light into the building, and also injects unique design elements into the terminal building.

The tops of the 8 C-pillars are directly connected to eight bubble-shaped skylights (Figure 3), and the sunlight pours down from the skylights during the day, giving people a sense of openness and transparency, creating a comfortable indoor environment. A huge waterfall of light is formed on one side, which provides sufficient lighting for the interior, and there is almost no need for lighting in the terminal during the day. The roof skylight and structure component are integrated into overall effect, which is a perfect combination of functionality and artistry. Natural lighting not only saves energy consumption, but also improves the psychological comfort of passengers, relaxing the journey Generated stress.

In order to avoid direct sunlight, the double-layer insulating glass of the skylights has a built-in metal mesh shading scheme. It is conducive to site construction and later maintenance. The shape of the metal sheet net can change the skylight into a north-facing skylight through the microstructure (Figure 4), which makes the skylight glass have Selective direction of light. Through a large number of calculations and simulations, the final shading scheme can achieve a good performance of 59% in direct summer light blocking rate and 37% reduction in lighting coefficient [5].
3.2.3. Human-oriented

The 8 huge C-pillars of the Daxing Airport Terminal are both supporting members and windows for indoor lighting. A strip-shaped skylight is laid on the top surface of each finger gallery, which runs through the five finger corridors across the entire 600 meters. The distribution of skylights matches the spatial layout of the terminal building and the flow of passengers. Passengers can have clear direction of travel in large-scale buildings depending on the light guide.

4. In conclusion

Taking Daxing terminal as an example, the article analyses the application of the innovative structure of c-pillars. It has many advantages in terms of space flexibility, energy-saving measures and indoor environment design of large terminals, and provides a reference for the terminal of architectural design.

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