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Sustainable Design Practice of University Library Building: Take the Guangdong University of Finance & Economics Library as an example

Qionglin Liu^{1*} Jun Chen² Kairui Wu³ Shuwei Du⁴

¹Head of Environment Design Department, School of Art and Design, Guangzhou University of Finance and Economics, 510320, China

²Arch PhD, Dean of Guangzhou Zoneteam Architectural Design & Urban Planning Institute Co., 510641

³Guangzhou Zoneteam Architectural Design & Urban Planning Institute Co., 510641

⁴School of Architecture and Civil Engineering of Xiamen University, Xiamen, China, 361000

*Corresponding author's e-mail: L@gdufe.cn

Abstract. Designing and building sustainable buildings is a trend in the current building industry. Utilizing intensive land resources, three-dimensional greening, integration of architectural design, water resources utilization, optimization of indoor acoustic environment and comfort, education promotion and other sustainable development technical measures, the green building design practice of Guangdong University of Finance & Economics Guangzhou Campus combines the local climate characteristics and organically combines green building design practice with cultural education building, which can provide theoretical and practical references for the design practice of green culture education buildings in China.

1. Introduction

Global climate change has become one of the biggest challenges facing human development in the 21st century. In the 25 countries of the European Union, carbon dioxide emissions from buildings account for 47% of total emissions. ¹Therefore, the sustainable design, construction and operational management of buildings are the primary factor in mitigating the impact of climate change on humans. At the same time, colleges and universities are academic institutions for personnel training and scientific research services, and they assume the role of social model and leadership. Besides, as the document information resource center of the school, the university library is an important base for campus culture and social and cultural construction², and is one of the important landmarks of the school. At present, there are 2,631 institutions of higher learning in China, with 37.79 million college students. ³ In the process of China's higher education transition from elite to mass, the gross

¹ Peter F. Smith. (2009) Building for a Changing Climate: The Challenge for Construction, Planning and Energy. Earthscan Ltd, United Kingdom.

² Department of Higher Education of the Ministry of Education [2015] No. 14 "Regulations of the Library of Ordinary Colleges and Universities", issued on December 31, 2015. Article 2.

³ Ministry of Education of the People's Republic of China, "Statistical Bulletin of the Development of Education in 2017 by the Ministry of Education of China", 2018-07-19.



enrollment rate of higher education has increased from 2.7% in 1978 to 45.7% in 2017.⁴ The building area of university buildings has grown from 33 million square meters in 1978 to nearly 954 million square meters in 2017. University libraries and college teachers and experimental equipment together form the three pillars of a modern university. Under the tide of university campus construction, the sustainable design practice of university libraries is conducive to accelerating the construction of China's conservation-oriented campus and green university campus, which will help accelerate the promotion and popularization of the sustainable values of the whole people and realize the vision of a "resource-saving and environment-friendly" society as soon as possible.

2. The development history of green libraries at home and abroad

In 1991, James and Suzanne proposed that library architecture should maximize the combination of green building theory such as energy saving, water saving, and material saving. Since then, Lewis has proposed how to use energy-saving technology to reduce building energy consumption⁵. As of February 2016, there were 640 library buildings that have been declared LEED-certified by the US Green Building Evaluation Standard, of which 356 had been certified, and only 25 Chinese libraries had been certified for green building evaluation. There are 464 papers on green libraries in China since 2001, and there are only 37 papers on college library architecture. Compared with the massive literature on green library architecture research in Western databases and the increase in the number and scale of Chinese university library construction projects, the design of green library buildings in China's colleges and universities lacks theoretical research and support. "The construction and development of libraries in higher education institutions should be compatible with the construction and development of schools, and their level is an important indicator of the overall level of the school."⁶ Therefore, the research on the sustainable design of such buildings has academic theoretical research value and guiding significance of design practice.

With the use of contemporary electronic technology and centralized air conditioning, the traditional library architectural space model has changed from large spatial modular, transitional analog to modular.⁷ Specifically, the spatial layout is shifted from strict separation to flexible, compact and diversified large space and large column net; in operation mode, the closed-frame management gradually turns to the combination of closed frame and open frame management; the bookstore evolved from a single centralized type to a scattered multi-line book collection. For example, the Kolligian Library of the University of California at Merced, the University of Toronto Mississauga Campus Library, the Linyi University Library of Shandong, and the Guangdong University of Technology Library.



Figure 1 Southern District (Old) Library



Figure 2 Sanshui Library



Figure 3 North District (New) Library

Guangdong University of Finance & Economics was founded in 1983 and founded the school library in the same year. After more than 30 years of development, it currently has three library buildings with a total area of 59,000 square meters (0.5+2.1+3.3). The three libraries are the old

⁴ University school buildings: including school property rights and non-property rights. The Ministry of Education teaches [2015] No. 14 "Regulations of the Library of Ordinary Colleges and Universities", issued on December 31, 2015. Article 2.

⁵ Lewis, Library energy efficiency, Administration & Management, 1993.

⁶ Department of Higher Education of the Ministry of Education [2015] No. 14 "Regulations of the Library of Ordinary Colleges and Universities", issued on December 31, 2015. Article 2.

⁷ Song Zhenyu, Preliminary study on the design of college ecological library suitable for the hot and humid climate in Lingnan [D]. Guangzhou: South China University of Technology, 2006, P24.

library built in 1983, the Sanshui Campus Library, built in 2009, and the new campus of the Guangzhou Campus built in 2016. The old library building (Fig. 1) uses ecological measures such as shading, heat insulation and ventilation of traditional Lingnan buildings. The library uses interior design, sun visors, inner corridors and other design techniques to reduce building energy consumption, which has the characteristics of early large-scale modular layout. The Sanshui Library (Fig. 2) is a transitional modular spatial layout feature that provides natural lighting and ventilation for the building with a progressive open courtyard. The reading room combines the appropriate depth with the inner courtyard to create a good reading environment. The new library (Fig. 3) adopts a unit layout to adapt to the sustainable functional requirements of modern university library buildings with the flexibility and integrity of the large space. These three different periods of library buildings reflect the development characteristics of the various eras of Chinese campus library design practice.

The sustainable design of the construction industry is the organic integration of building and developing sustainable solutions that fully balance economic, social, environmental, cultural and ethical sustainability. Drawing on the intensive, efficient, regional, low-carbon and ecological design strategies of large-scale commercial building complexes⁸, the sustainable strategy of functional intensification, functional compositing, functional continuation and functional full-time of university libraries is formed. The following is a discussion based on the main technologies of green building, such as land saving, energy saving, water saving and material saving.

3. Sustainability technical measures

3.1 Project Introduction

Guangdong University of Finance & Economics is located in the west of the Pazhou International Trade and Exhibition Center in Guangzhou (Figure 4). The library building is located at the intersection of the north-south main axis and the east-west axis of the new campus of 1.5 square kilometers. It is the only comprehensive cultural landmark building in the 9.66 square kilometer of Pazhou International Trade and Exhibition Center.



Figure 4 Building Area Map

⁸ ZHANG Xin-yue, Research on the Design Strategy of Large-Scale Commercial Building Complex Based on Sustainable Development Concept [J]. (Architectural and Structural Design) ,2018.09..



Figure 5 Campus plan



Figure 6 Aerial view of North District (New) library building

Located in the subtropical coastal zone, Guangzhou belongs to the hot summer and warm winter zone.⁹ It is characterized by warm and rainy, abundant light and heat, long summer and short frost period. The annual average temperature is 21.9 degrees Celsius. The hottest July average temperature of the year is 28.7 °C. The coldest January average temperature is 13.5 °C. The average relative humidity is 77% and the annual rainfall is about 1736 mm. In the same period of the year, the water and heat are abundant, and the rainfall is abundant, which is conducive to plant growth. Therefore, Guangzhou has the reputation of "Flower City". Combined with Guangzhou climatic conditions, project requirements and GB/T50378-2006 "*Green Building Evaluation Standards*" requirements, the project adopts a variety of architectural green ecological design methods and technical measures, such as intensive use of land resources, use of atrium space to enhance natural ventilation and lighting technology, shading measures to reduce heat island effect, building three-dimensional greening, self-shading technology, indoor signage system, roof siphon Rainwater system, architectural landscape interior design integration.

3.2 Sustainable design and technical measures

3.2.1 Land saving measures and outdoor environment optimization

The total land area of the new library building is 2,3451.4 square meters, and the base area of the building is 9472 square meters. The total construction area of the project is 32,834 square meters, including 25,909 square meters on the ground and 6,925 square meters on the ground floor. It is a comprehensive high-rise public building. The building is eight stories high with a floor height of 4.5 meters and a total height of 36.45 meters. Besides, the greening rate is 45% and the building volume ratio is 1.4. The first floor of the building is a library for books, reports and equipment; the second to fourth floors are library halls; the fourth to seventh floors are open reading areas; the eighth floor is office and teacher reading areas.

In view of the density and conditions of the surrounding teaching buildings, the project land is based on the green development idea; considering the sunshine distance, floor area ratio and campus landscape of the surrounding teaching buildings, the traditional Chinese business measurement tools are adopted for the ecological design concept of architectural modeling. The planes of each layer of the building are raised layer by layer, and the gradual boundary expansion forms the shape of the small

⁹ The construction climate zoning is to make the building more fully utilize and adapt to different climatic conditions in China, and to achieve the purpose of adapting to local conditions. China's "*General Rules for Civil Building Design*" (GB 50352-2005) includes 7 major climate zones and 20 subclimatic zones for China's architectural climate zone. Summer hot winter warming is a major climate zone. Its main climate indicators are: January average temperature >10 °C, July average temperature 25~29 °C.

Chinese character "Dou" (Fig. 6), which means the measurement.¹⁰ It expresses the fairness of business, the ambition of business, and the creativity of business. It is the interpretation of the essence of traditional business culture in cultural architecture in the era of economic globalization.

The building figure factor is 0.16, which is close to the body shape factor of the most energy-efficient 0.15 building. The "dou" plane of the building is stressed at four corners. The four traffic cores formed by the stairs and the elevator are distributed in the four corners of the building. The upper and lower positions are consistent, which constitutes the integrity and stability of the structural system (Figure. 7).

3.2.2 Energy saving measures and energy utilization

Natural ventilation system: the interior space of the building forms a 37.5-meter square atrium from the center to the center and a 37.5-meter-diameter circular atrium from the fifth to the seventh floor. The bottom part of the building is open and air-introduced, and the middle part of the roof is raised to extract airflow, which forms a gas flow linkage, thereby eliminating the static wind zone and forming a summer monsoon introduction mode to ensure the air circulation between the buildings. The building windows are equipped with radiation protection and light control functions. The number of external windows can be opened to ensure that the natural ventilation requirements are met in more than 50% of the climatic conditions throughout the year.

Air-conditioning system: this project is located in the hot summer and warm winter area. It is not suitable for air conditioning in winter, so it is more suitable for stratified air conditioning. The project has a 37.5-meter square atrium and a circular atrium with a diameter of 37.5 meters. The building space is high. According to the air conditioning zone load and the airflow organization theory calculation, the area adopts the layered air conditioner form of the air supply on both sides. The scheme only provides air conditioning and air supply to the lower area to maintain a certain temperature and humidity; this can save 30% of the cooling capacity compared with the summer full room air conditioner, which is beneficial to reduce the initial input and operating energy consumption. For the library's large space library, the vertical air cabinet heating and recovery unit system is adopted, and the air circulation mode is adopted by the whole air air-conditioner, and the air flow organization adopts the form of sending up and returning. For small rooms, fan coils and fresh air are used for cooling.

¹⁰ See: "The Dou is a measuring container" (Han) Ban Guwen; (Tang) Yan Shi Gu Note, Han Shu • Volume 21 • The Lunar Calendar [M]. Zhengzhou: Zhongzhou Ancient Books Publishing House, 1991.12.P166.

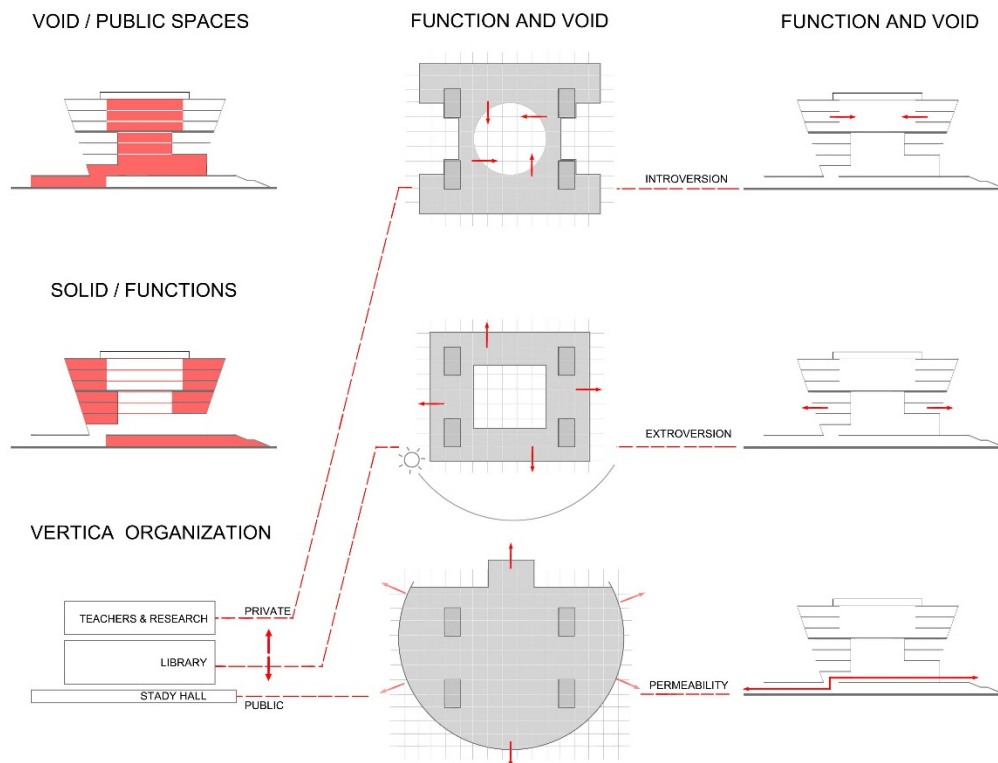


Figure 7 Diagram of building analysis

3.2.3 Water saving measures and water resources utilization

The project system uses a split system of rainwater, sewage, and wastewater. The manure sewage is introduced into the outdoor septic tank by the sewage pipe, and is discharged into the municipal drainage pipe after being treated.

The siphon rainwater system has the advantages of flexible layout on the roof, large single bucket displacement, less roof opening and low drainage noise¹¹, which can save construction space in irregular roof construction. At the same time, the pipe can also be saved, so the building roof rainwater uses a siphonic rainwater drainage system. The siphonic rainwater drainage area of the roof is 6,676 square meters, of which the water collection area is 1,018 square meters, and the middle is a tempered glass roof with a height of 66 square meters. The design uses 50 years of rainstorm return period design and calculation system drainage capacity to achieve good roof drainage effect.

3.2.4 Material saving measures and material reuse

The external wall of the building has a slope angle of 21.25 degrees and is poured with clear water concrete. The verticality of the facade of the wall, the flatness of the surface and the yin and yang angle are inspected according to the method of "The Specification of Building Structure Quality Evaluation for the Great Wall Cup" DBJ/01-69-2003. At the same time, the clear water concrete has been added with special repair materials to enhance the sturdiness due to the inclined construction. The exterior wall of the building is partially covered with 200 thick aerated concrete block walls and a non-toxic, recyclable, low-energy external ceramic plate with good thermal insulation effect. The building interior wall uses 200 thick aerated concrete blocks. The solar radiation absorption coefficient of the overall average thermal characteristics of the building exterior wall is 0.65, the thermal inertia

¹¹ Wang Lin'e, Application of Siphonic Rainwater Drainage System in the Hut Library [J].Beijing Water, 2016, No.6, P43-45.

index D is 3.4, and the heat transfer coefficient K is 1.96.

3.2.5 Indoor environment optimization measures

Integrated shading system: the building's shading technology includes self-shading and external shading systems. The 21.25° inner slope formed by the outer wall of the building forms the self-shading system of the building. There is a three-story sky garden in the east and west of the building. The garden is decorated with clear water concrete blocks and dense shaded vegetation to reduce the sun exposure of the east and west facades of the building. At the same time, the garden subtly introduces the natural landscape into the interior of the building, forming a way to debug the outside of the landscape, which is combined with a metal louver outside the window, pressed wood grain aluminum alloy windows with transverse long windows, and a high-transparent, low-reflection silver-gray LOW-E glass to form the exterior shading system of the building. In addition, the external structures of the east and west walls are provided with 45 thick YD inorganic thermal insulation materials.

Sign system: the overall interior identification system design is dominated by blue and yellow colors, which reflects the modern image of the library's classic art and its information exchange. At the same time, it reflects the humanization, ecology, openness, intelligence and symbolization of modern libraries.

Noise reduction: all devices use a low noise type and reduce noise sources. Equipment such as chillers, cooling towers, pumps, air conditioning units, fans, are all treated with rubber damping pads for shock absorption. The walls in the air-conditioned machine room, refrigerator room and fan room are treated by civil engineering for sound absorption. The water pipes connected to the chillers, cooling towers, water pumps and air conditioning units are provided with soft joints. The air conditioner supply and return air duct, and the air supply and return air duct are provided with a muffler such as a muffler or a muffler static pressure box.

Space utilization: the first circular sloping pedestal outside the building is high in the south and low in the north, forming a space on the south side of the building to become the south entrance of the first floor of the building; the main entrance to the north of the building is a two-story hall that leads directly to the building with a 20-meter wide platform that rises 4.5 meters. The north and south entrances are interspersed in the upper and lower spaces of the same axis, and the space is varied.

3.2.6 Improvement and innovation

The challenges and innovations of the project are mainly structural innovation and design integration.

Design integration: the library's architecture, landscape and interior design maintain an integrated design approach and steps, emphasizing the strength of the building's outdoor and environmental design. The interior design emphasizes tranquility and harmony, reducing blind and redundant construction. The architectural design takes into account the indoor effect at the beginning. For example, the interior design originally only has one atrium. After considering the spatial scale, the atrium is divided into two upper and lower atriums, so the indoor space effect is more pleasant.

Structural innovation: the architectural shape and the layout of the building form the five characteristics of "large slope, large opening, large span, large cantilever and large scale" on the building structure, which constitutes the five "large" innovation of structural design.

Large slope: the building shape is inverted cone shape, the first floor plane is 64.9 meters x 49.9 meters, and the floor layer is increased to 93.6 meters x 78.6 meters, the maximum outer diameter is 14.4 meters, and the camber angle is 21.25 degrees.

Large opening: the second to fourth floors and the sixth to eighth floors of the building have an atrium of 37.5 meters x 37.5 meters around the atrium. The floor is open in the middle and on both sides of the east-west direction. The effective width of the floor in the middle part of the building is less than 50% of the typical width, forming a plane with a particularly irregular structure. It is needed to verify structural integrity and stability of the atrium structure;

Large span: since the 37.5m x 37.5m atrium is set on the first to fourth floors of the building, the

island discussion area on the fifth floor of the building is located in a hollow position, forming a large span structure of 37.5 meters x 37.5 meters. Meanwhile, a 3.6-meter clear water concrete wall along the perimeter of the building has an opening with a span of 36.7 meters. Both ends of the clear concrete wall are supported on a sloping outer structure. Besides, how to reduce the weight of the clear water concrete wall and make the building facade simple and beautiful, which is another key point of the structural design of the project;

Large cantilever: on the east and west sides of the fifth floor of the building, the sky garden are set up by cantilever and the maximum length is 8.4 meters;

Large scale: the first floor plan of the building has a size of 64.9 meters x 49.9 meters and is increased layer by layer to a roof size of 93.6 meters x 78.6 meters. The size of the roof clear concrete is 81.5 meters x 96.5 meters. Due to the characteristics of the inclined structure of the project, it is not suitable to set the deformation joint. How to control the shrinkage crack of the concrete and ensure that the ultra-long concrete structure does not crack becomes the key to the structural design of the project.

3.2.7 Education and promotion

As a cradle for cultivating national high-level talents, the university's library building body of sustainable design practice conveys the concept of eco-environment. Through the presentation of various sustainable technologies in the building, the students will present green building technology on the spot, and truly promote the concept of green development through reality. At the same time, students are encouraged to implement energy-saving, water-saving environmental protection and resource utilization practices in the daily use of the library, thus promoting the campus's green education promotion activities.

4. Implementation effect

The design concept of this project is both novel and traditional. The rich space and volume form a charming visual experience and become a beautiful landscape in the Guangzhou International Trade and Exhibition Area. The design practice fully considers the needs of building functional division, and adopts reasonable measures in fire protection, environmental protection and energy conservation. Meanwhile, the design adopts new technology, new technology, new methods and new equipment to meet the requirements of energy saving, environmental protection and high efficiency. The design is accurate, the key construction measures are reasonable, and the building is safe to use. Besides, various technical applications reduce the building energy consumption comprehensively, and the equipment is treated with reasonable noise and vibration isolation, and the indoor environment of each district is quiet. The project has greatly promoted the development of cultural activities in the surrounding areas.

Since the construction project was planned in 2012 and opened in 2016, the participants of the project have been constantly challenged and innovated. For example, the structural invention patent "a corner joint device and edge node device for shearing and compression resistance" was published; the structural literature "FEM Analysis of Steel Reinforced Concrete Columns and Inclined Column Intersection Joints" and "The huge opening floor slabs stress analysis of the oblique structure" were published. In the library management, the library research team built the library's learning center to support the service system and operation mechanism, and won several national and provincial higher education teaching reform research projects and awards.

5. Conclusion

Under the background of how contemporary Chinese architecture improves people's life quality with the influence of green building design, the new library of Guangdong University of Finance & Economics has proposed a complete practical case. The library building fully exploits the essence of campus culture and the ecological culture of Lingnan traditional architecture, and applies the regional features of the building to architecture, landscape and interior design. Through the sustainable design

concept of the building and the information sharing space, the campus students' daily life is infiltrated and the campus atmosphere is created together.

With the axis of Guangdong University of Finance & Economics gradually connecting with Guangzhou Pazhou City Road Network, the campus building of Guangdong Business School North Campus, which is a campus culture and spiritual symbol, has become a good platform for promoting academic exchange, learning and display between schools and teachers. It also leads the campus buildings, with its modern interpretation of the traditional Lingnan business culture, blending into the bustling urban landscape, thereby becoming a beautiful human landscape in the Guangzhou Pazhou International Exhibition and Trade.

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