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Renovation and Protection Project of Peking Union Medical College: Renovation and Reconstruction Design of Concealed Works

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Abstract: Peking Union Medical College (PUMC), as the representative work of Chinese modern architecture, has had a great impact on the development of Chinese modern architecture. Its advanced and complete concealed works contain great value and are valuable materials for the study of Chinese modern architecture. This paper studies the concealed works of PUMC, enriches the research data in this field, and summarizes the transformation design scheme of concealed works in the protection and repair of ancient buildings of PUMC.

Keywords: Peking Union Medical College; Concealed works; Cultural relic architecture; Renovation and protection project

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1. Introduction

Located at No. 9, Dongdan Sanjiao, Dongcheng District, Beijing, Peking Union Medical College (PUMC) is a traditional Chinese palace-style building with a Western-style interior, known as a "Western medical school in a Chinese palace" [1].

As the most important medical school established overseas by the Rockefeller Foundation, the PUMC was built using the most advanced construction technology available at the time, and the architects "did not set a budget." Therefore, the college was already equipped with very complete HVAC system, water supply and drainage systems, and electrical systems at the time, some of which are still in use today, demonstrating the high technology and quality of construction. However, since the medical school has been in use since its construction, it is difficult to conduct a detailed study of its hidden works. On the occasion of the centenary of the founding of PUMC, the historical building conservation and restoration project of the former site of PUMC was officially launched. This paper takes this opportunity to conduct a detailed study of the concealed project of the former site of PUMC, to explore its historical originality, to summarize its current problems, and to summarize and sort out this restoration and conservation project, in hopes that it can provide help and reference for the research, repair, and protection of other historical buildings of the same period [2].

2. Project overview

The former site of PUMC (Courtyard 9) mainly includes the entrance, Buildings 2, 3, and 4, connecting corridors and courtyards. The buildings in this area were the teaching areas at that time, and Buildings 2, 3 and 4 were the anatomy building, chemistry building, and physiology and pharmacology building

respectively (corresponding to Buildings B, C and D in **Figure 2**) [3]. The total construction area is 7962 m^2, including 1848 m^2 for Building 2, 3398 m^2 for Building 3, and 1844 m^2 for Building 4, which is a brick and concrete structure with one underground floor, two above-ground floors for Buildings 2 and 4, and three above-ground floors for Building 3; with two connecting corridors, one underground and one above-ground. There is also an underground equipment corridor in the courtyard. The area of Courtyard 9 is about 1800 m^2 [4]. The current situation of the project is shown in **Figure 1**

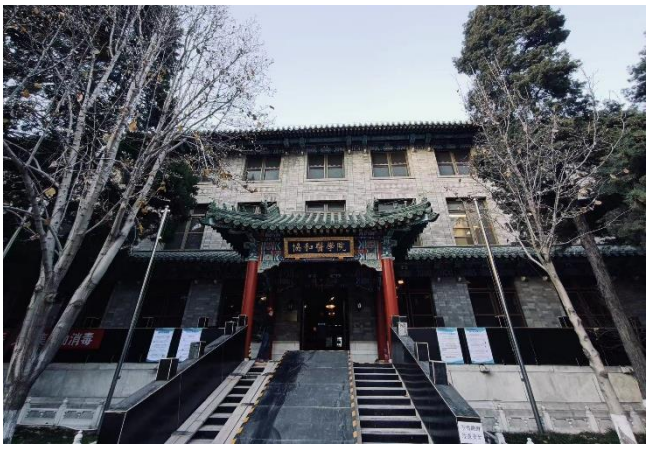

Figure 1. Project status

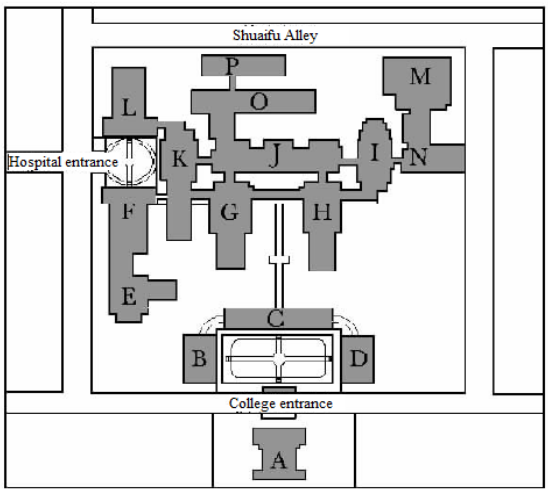

Figure 2. Project plan

3. Analysis of the value of concealed works in heritage buildings

PUMC adopted many of the world's most advanced building technologies, materials and equipment at that time. The concealed engineering of the building is well-designed, and the design of its ventilation, water supply and drainage, and electrical engineering fully takes into account the needs of building use and future development, ensuring the durability and comfort of the building. These equipment have very important historical and technological values, and are important scientific information for studying the development of building equipment, equipment processes and other building functions of the same period.

4. Restoration principles

The repair project strictly follows the relevant requirements for the repair of heritage buildings, to protect the value of cultural relics from damage, to maintain the authenticity and integrity of the heritage body and its environment, "protection-oriented, salvage first, rational use, strengthen management" is the basic policy of the repair project. In addition, the following principles should also be observed: (1) safety, (2) authenticity, (3) minimum intervention, (4) recognizability, (5) reversibility, (6) preserving architectural and cultural diversity.

5. Research on the status of concealed works

5.1. Heating and ventilation project

Most of the buildings in the late Qing and Republican periods relied on the natural environment for heating and ventilation, while a heating and ventilation system was specially designed for PUMC due to the need for a good ventilation system in hospital buildings. The important rooms in Courtyard 9 were connected by rectangular iron air ducts, and air was circulated through the vents.

In this study, we investigated and counted the historical ventilation ducts, vents, and historical equipment in Courtyard 9 of PUMC. The historical ducts in buildings 2, 3 and 4 of the Courtyard 9 are mainly ventilation ducts, which are laid inside the walls of the buildings and run from the first floor to the

top floor of the building, connecting several rooms.

Building 2 is located at the west side of the courtyard. There are three historical ventilation duct shafts on the underground floor, the incinerator air outlet on the southwest side is connected to the shaft through the horizontal duct, and the incinerator chimney leads to the ridge of the roof and discharges to the outdoors. The air in the non-invasive room in the basement on the east side is discharged to the outdoors through the duct shaft leading to the roof, and the room on the north side of the basement has air conditioning equipment to produce cold air along the duct into the large classroom on the first floor and other important rooms. There are two air inlets in the large classroom on the north side of the first floor, from which the cold air enters the classroom, and the indoor air enters the air duct shaft in the adjacent room to the outdoors through the air outlet on the southeast side, forming an air circulation. The main body of the second floor is the anatomy room, and the air in the anatomy classroom passes through two separate shafts to the top floor, and the air in the small classroom on the north side passes through a separate shaft to the top floor. The outermost week of the top floor is a duct gallery, which is connected to the outdoors through a hanging window with an opening for one person to enter for maintenance purposes, and the heating ducts are circulated through the gallery. The location of historical air ducts in Building 2 are shown in **Figure 3.**

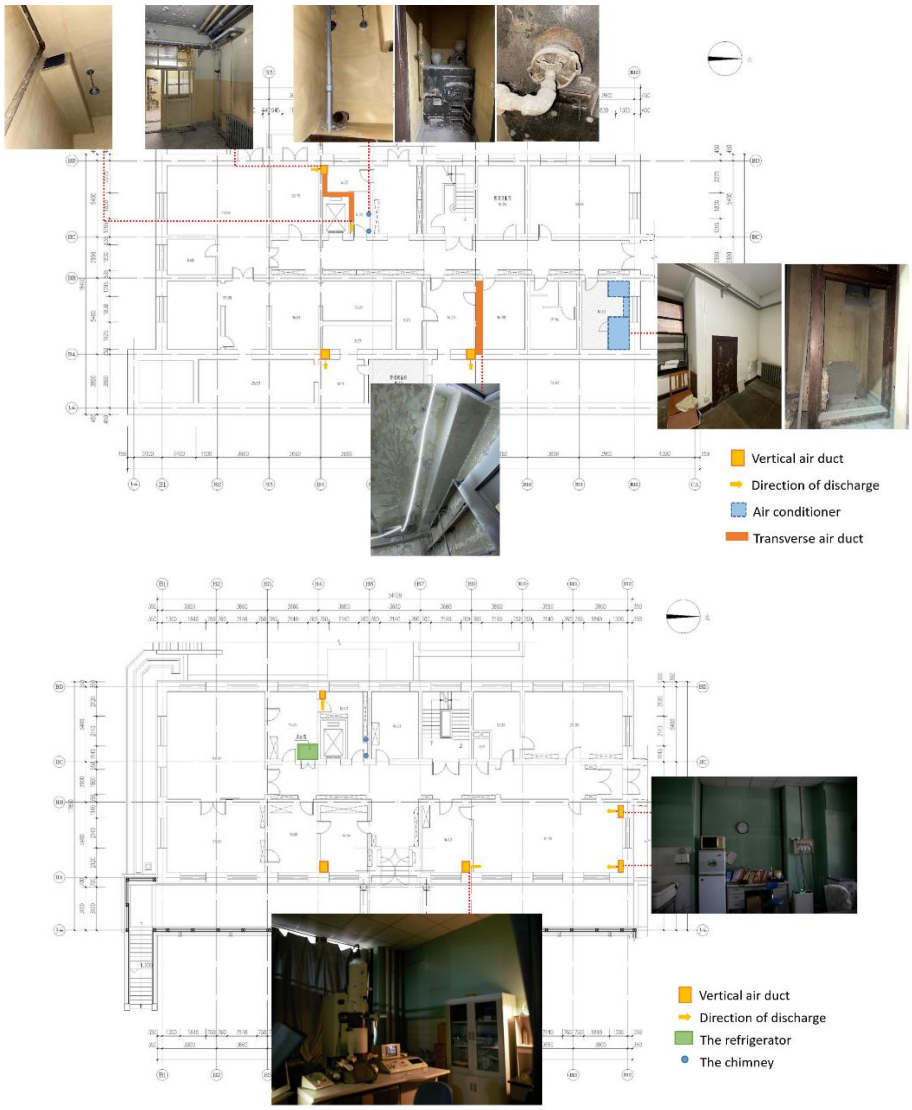

Figure 3. Schematic diagram of historical air duct in Building 2 of PUMC

Building 3 is located on the north side, the room on the southwest side of the basement is equipped

with a horizontal air duct connected to two shafts, the basement found that air conditioning equipment to produce cold air can be connected to the first-floor room along the air duct. In the room at the southwest of the first floor, cold air enters the room from the air inlet, and indoor air flows into the air duct shaft through the air outlet to the outside, forming air circulation. On the second floor, there are three air duct openings, which are connected from the ground floor to the top floor. The classroom on the northwest side has a test bench and is equipped with ducts for transporting gases and ventilation ducts for discharging harmful gases generated by experiments. The third floor to the top floor are equipped with ventilation openings at the corresponding positions of the ducts, which can prove that the ducts pass through the underground to the top floor, and finally pass through the top floor to form an air circulation outside. The location of historical air ducts in Building 3 are shown in **Figure 4.**

Figure 4. Schematic diagram of historical air duct in Building 3 of PUMC

The location of the air duct and air conditioning equipment in Building 4 is a mirror image of that of

Building 2. Cold air from the underground floor of the northwest side of the room with air conditioning can be transported to the first floor corresponding to the location of important rooms through the air ducts. More than one room on the first floor north has duct vents, three in the large classroom, presumably two duct vents on the north side are connected to the first-floor air conditioning, delivering the cold air into the rooms. Two duct shafts were found on the east side of the second-floor rooms, connected to the stuffy top floor and leading to the outdoors to form air circulation.

In addition to the original historical air ducts and equipment, there are also some additional ventilation ducts and air conditioning equipment built later. These exposed ducts and modern equipment such as outdoor air conditioners have caused serious damage to the style and features of historical buildings.

5.2. Water supply and drainage engineering

As the most advanced medical building at that time, PUMC was equipped with a relatively complete water supply and drainage system, but now most of the pipes are aging, causing many problems.

5.2.1. Water supply system status

The water supply system of PUMC has serious aging and rusting problems because they are made of galvanized steel pipes, which are now obsolete. The sanitary ware in the building also suffers from serious aging problems.

5.2.2. Drainage system status

Drainage pipes are clogged and broken, and the problem of leakage worsened due to aging of pipes. Poor local drainage of the roof drainage system causes stagnant water and increases the humidity of the building, which eventually leads to problems such as weathering of stone relics, which severely impacts the preservation of historical information of the relics and buildings. In addition, some modern drainage facilities, such as square rain grates do not match the style of the historical buildings, destroying the traditional appearance.

5.2.3. Status of fire protection system

Due to the confusion of pipeline caused by repeated transformation, it is impossible to confirm whether the hydrant pipe is correctly taken over; due to the rusting inside the pipeline and other causes of insufficient water pressure, the spraying pressure and water level of the hydrant column at the top floor does not meet the requirements; the hydrant, pipeline and tanks are rusted and aged seriously.

5.3. Electrical engineering

The original electrical wiring has been abandoned, the lines are chaotic and there is not enough space in the wiring trough to be used again, and the low-voltage distribution boxes and electrical wiring on each floor are aging. The electric wires of the security system (e.g., the circuit of smoke detector) in the office area are exposed. The pipeline layout needs to be transformed to avoid fires. The low-voltage distribution system on each floor is not standardized, and the corresponding circuit cannot be found. The air conditioner is also aging and needs to be replaced, and the electrical capacity needs to be increased. All areas of the medical school building are not energy-saving and has poor illumination. Besides, the style of lamps and lanterns is confusing and destroys the historical architectural style, so it is recommended to replace the lamps and lanterns.

6. Summary of the renovation design program

6.1. Restoration strategies

6.1.1. Repair strategy based on technological interventions to replace the old with the new

In the process of repair and renovation, we focus on the practicality and safety of the concealed works and the protection of historical buildings. Different structural safety plans are developed according to the specific conditions of the old site, and new technologies are used to repair the damaged parts, preserving the original form as much as possible, making it more recognizable in a historical sense and at the same time meeting the needs of a contemporary life. The repair technology adopted is based on the principle of reversibility, leaving room for future maintenance and conservation.

6.1.2. Diverse restoration strategies based on historical recognition

Based on the principle of minimal intervention and the principle of authenticity, its historical information is retained as much as possible, carrying historical memory and heritage. Repair work can be done according to the original information and historical information of the old site, using original materials and construction techniques as much as possible, respecting the historical value of the buildings, restoring the nostalgia, and passing on the cultural spirit.

6.2. Heating and ventilation system retrofit design

On the premise of not destroying the traditional appearance and structural safety of the historic building, the air conditioning, heating, ventilation and smoke extraction systems are upgraded to meet the comfort and usage needs of the building. Based on the analysis and research of existing problems, conservation objects and historical values, targeted conservation measures are adopted:

(1) Selecting appropriate equipment and solutions, taking into account the traditional appearance and usage needs of historical buildings.
(2) Retain the original equipment and layout as much as possible, and further enhance and utilize its usefulness.
(3) Minimal intervention to explore the value of historic buildings and further enhance their use and historical display value.

6.2.1. Air conditioning system design

(1) Fan coil system

In order to reduce the damage to the overall appearance of the historic building, fan coil air conditioning is used, the original air conditioning and outdoor units are all removed, and the air ducts, water pipes, air outlets and air conditioning ends are concealed. At present, there are no specific requirements regarding air conditioning, so we will maintain the original plan and optimize the design on this basis. The installation method of fan coil is shown in **Figure 5.**

Figure 5. Fan coil

(2) Industrial air conditioners and split-type air conditioners
In order to meet the special needs of medical buildings, we designed industrial air conditioners in special rooms such as laboratories and wall split air conditioners in equipment rooms with weak current. The existing piping and valves are old, and there are problems such as water leakage and damage, so they are replaced from scratch while maintaining their original pattern, so that they are more in line with the needs of the rebuilt building.

6.2.2. Heating system design

In terms of restoration and protection, there are no special requirements for the basement area, the original scheme of radiator heating system is maintained, and only its design is modified.

6.2.3. Ventilation system design

Through the research we sorted out the historical ventilation ducts and equipment in the building, for these valuable historical ducts and air conditioning equipment are to be preserved and protected.

(1) Protect and restore the historical ventilation ducts to their original state, and repair the visible ducts and air outlets for exhibition.
(2) The air conditioning equipment in the basement of Building 2 and Building 4 is retained and a 3D model is created to be retained and displayed as research material.
(3) A mechanical exhaust system is built in bathrooms, storage rooms, storage rooms and other rooms without external windows
Historical air duct and air conditioner can be seen in **Figure 6.**

Figure 6. Historical air duct and air conditioner

6.2.4. Anti-smoke exhaust system

In order to protect the architectural style, the project adopts the natural smoke exhaust system, and the stairwells in the building are equipped with openable exterior windows in accordance to the specifications, maintaining the original design of the building's exterior windows for smoke exhaust, and maintaining the traditional wooden exterior window style.

6.3. Water supply and drainage engineering renovation design

6.3.1. Fire fighting system

The original water source for fire fighting in this project building was supplied by PUMC, but since it was already at the end of the whole fire fighting system, the water pressure and aspects could no longer meet the fire fighting demand, so it was necessary to redesign the fire fighting system. For the protection of the overall structure of the historical building, it was decided not to introduce new water sources from other

buildings of the hospital, but to set up a 50 cubic meter water tank in the basement as the water supply for fire fighting. The original fire hydrant in Courtyard 9 was protected as a cultural relic during construction and could be displayed as an exhibit after the completion of the restoration project.

6.3.2. Drainage system

(1) The project adopts combined sewage and wastewater flow system, and the sewage and wastewater above +0.000 indoors is discharged into the outdoor sewage network by gravity.

(2) The roof adopts the gravity flow outward discharge mode, which is collected and discharged to the outdoor sewage pipe network. In this project, the waterproof characteristics of the roof will be restored and the tile surface will be partially repaired and replaced to ensure that the overall style will not be changed.

Construction status of roof waterproofing treatment is shown in **Figure 7.**

Figure 7. Roof waterproofing treatment

6.4. Electrical engineering retrofit design

6.4.1. Line laying

The original electrical system pipelines in the buildings of this project are basically laid in the walls, and the pipelines are aging and seriously damaged. In addition, the lines are chaotic and difficult to sort out, so the original lines can no longer be used. Therefore, the electrical pipelines will be rearranged in this project. To ensure that the building interior decoration is coherent with the historical style, the project has designed a connecting frame in the corridor. All lines are connected to each room through the connecting frame above the corridor. The lines in the rooms are painted with colors that are consistent with the wall, so as not to affect the overall style of the building.

There are two reasons for choosing open installation indoors. Nowadays, the number of electrical engineering lines in the building has greatly increased compared with a hundred years ago, and the original trunking space in the building wall cannot meet the current demands, so the new lines can only be installed and laid in the open. (2) The walls involved are made out of hollow bricks, these hollow bricks has a hundred years of history belongs to the category of cultural relics. If the lines were to be grooved into the walls, it will be better for the overall appearance, but it will inevitably be a great destruction of cultural relics. Hence, in order to protect the cultural relics, open installation is chosen as the method of electrical wiring. The circuit installation mode can be seen in **Figure 8.**

Figure 8. Surface mounted electrical circuit

6.4.2. Luminaire selection

The style of lamps has a great impact on the style of buildings, so careful consideration should be given to the selection of lamps in the repair and protection work. The lamps and lanterns in the buildings of this project have been replaced in the past hundred years, and their styles are no longer the original ones. Based on the purpose and principle of "repairing the old as the old" and "restoring the original style of cultural relics," the interior decoration style and lamp styles of the PUMC 100 years ago have been basically determined by referring to research literature, historical archives, and also old photos. This repair project aims to restore the original appearance of the building to the greatest extent, and chooses to use lamps with the same style as the original ones. "Qing's palace lantern" is used in the lobby, the same applies for the office area. However, in special rooms such as dissecting room and electron microscope room, professional lamps such as shadowless lamps are used. The lamp styles used can be seen in **Figure 9**

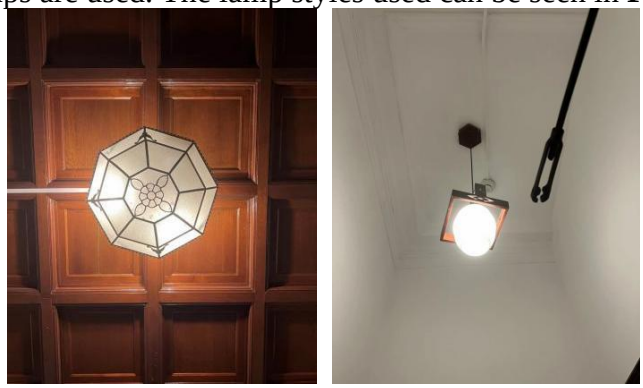

Figure 9. Lamp style

7. Conclusion

PUMC was built by Chinese traditional craftsmen under the auspices of western architects in the context of cultural exchanges between China and the West. Its special cultural background and unique construction skills have created the unique status of PUMC. As a precious architectural heritage, the historical information contained in PUMC is of great value for us to study the society, culture, economy, politics and the development of modern Chinese architecture at that time. As for the historical buildings on the old site of Peking Union Medical College, we should take protection as the first priority, study and explore their value while taking into account their use needs, and repair and transform them to meet modern needs. This paper only explores and studies the concealed works in the old site of PUMC, which also contains great value waiting for subsequent excavation.

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Disclosure statement

The authors declare no conflict of interest.

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