An Integrated Modern Industrial Machine — Study on the Documentation of the Shanghai Municipal Abattoir and its Renovation

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Abstract

The Municipal Abattoir was constructed in the former Shanghai International Settlement in 1933, which was recognized as the largest and most modern one in the Far East, and is now accorded 'Shanghai Outstanding Modern Architecture'. Its architectural space, originated from a unique design and construction process, is as complicated as a huge integrated machine. In order to understand the early influence of English colonial architecture design on settlements in China, this paper investigates a series of problems associated with the abattoir, such as the design process, construction techniques, material quality control etc. by studying many original documents. The abattoir represents the international level of Shanghai modern industrial buildings at that time. After being abandoned for a long period, the abattoir was renovated in 2008 and soon drew plenty of attention both here and abroad. A successful renovation effectively establishes a new contact between people and a site. This paper further explores the methods for reconstructing a creative platform from an industrial heritage.

Keywords: Shanghai Municipal Abattoir; industrial heritage; renovation; 1933 Old Millfun

1. Introduction

Shanghai International Settlement is the first settlement in modern China. As the largest concession, it had complete legal management, and operated for the longest period of time. The United Kingdom carried out systematic municipal and industrial constructions that effectively promoted the modernization of the city. Decades had elapsed before the city embarked on its development. Recently, many old factories have been recovered and accorded industrial heritages, as people have realized that they are important carriers of urban industrial civilization. This paper investigates the largest and most modernized abattoir in the Far East at that time (Fig.1.). It was located at No. 10 Sawgin Road in the northeast part of Shanghai, next to Sawgin Kiang, surrounded by intensive factories and Shanghai Lilongs.

The Municipal Abattoir was built on two separate sites. The total site area was around 8000 m² and the total floor area was 26300 m² (Fig.2.). The abattoir went through several function changes and was eventually abandoned in 2002. It was accorded 'Shanghai Outstanding Modern Architecture' in 2005 and was repositioned as a creative park branded '1933 Old Millfun' in 2008.

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Stepping into the abattoir, one could immediately be astonished by its labyrinthine space. Its spatial relationship was so difficult to interpret that the abattoir was merely known by photos and internet rumors during a long period. The abattoir failed to attract public attention due to its special function, and hence was not considered worthy of recording at that time. This resulted in a lack of archival materials. Nevertheless, since it was an official building for the Shanghai Municipal Council (SMC), most of the original documents could be found in the Shanghai Municipal Archives (SMA) and Shanghai Urban Construction Archives (SUCA).

This paper investigates many correspondences both in Chinese and in English, puts together the entire construction process under the historical background, and aims to answer three questions: (1) The abattoir, like a killing machine, was an industrial building with special requirements for the production process, so how did its space, structure, and form correlate with each other to ensure its high efficiency and economy? (2) What valuable experience could be learnt from the construction management by SMC? (3) The abattoir completed one life cycle and started a new one. How did designers reconstruct a new public creative platform under conditions of minimal intervention?

2. Architecture Generation

2.1 Organizational Process

SMC was the government administration of the Shanghai International Settlement. It consisted of decision-making and executive departments. Three of the executive departments were related to the construction of the abattoir: Public Works Department (PWD), Public Health Department (PHD), and Finance Department (FD). PWD is the most important department that directly relates to construction control. It was responsible for design and construction supervision. PHD proposed the functional requirements of the abattoir, i.e., the design specifications. FD examined and approved the estimation of budget. The three departments needed to coordinate with the secretariat and the committees (Fig.3.). Although it took more than 10 years from project establishment to completion, the decision-making process involved extremely sufficient communication, and ensured the final results were accurate and practical along with the economy (Fig.4.).

2.2 References from North America

Land prices in Shanghai were increasing constantly; therefore, the key factor to take into account was intensive land use. In April 1924, two lots were selected as locations for the Municipal Abattoir. The railway station and pier were both nearby, making it more convenient for animal/products transportation and sewage disposal. The location was selected on the basis of urban context, facilitation of production, and better service for foreigners living in the settlement. In March 1930, the Acting Commissioner of Public Health of Shanghai made an enquiry to the Commissioner of Public Health of New York about the proposed abattoir, because SMC 'doesn't have any experience on such a modern form'. The Acting Commissioner was informed that a slaughterhouse built in 1916 in Toronto was the best in the world and was the only municipal abattoir in the city (Fig.5.). It was suggested in the letter that the slaughtering process should take place on the top floor, so that the offal would gravitate to the floors below and meat products could be conveyed to the market through bridges. In that case, intervening with other parts of the building could be avoided (SMPHD, 1930). These suggestions also provided useful references for the subsequent construction and equipment arrangement. In a word, the abattoir was a unique architecture based on extensive experience from around the globe. It reflected the construction management with an internationalized perspective in Shanghai.
2.3 Function Arrangement

Due to the insufficient area of one single site, the abattoir was built on two sites separated by a road. An abattoir disposal plant was located on one site, and a principal abattoir building on the other. The principal abattoir building consists of a reinforced concrete outer rectangular building and an inner cylinder building with basement. The two structures consequently form a ring-shaped court in between, and were connected by 13 bridges on each floor. The rectangular building is 78.90 m wide by 81.20 m long, with four chamfered corners (Fig.6.). In addition, a staff dormitory on the east of the rectangular building is still extant, while the Meat Market & Cold Storage had already been demolished in the early 1990s. The awaiting block has different awaiting slaughter lairages. Livestock could enter the internal plaza by two different entrances as designated. Two ramps are provided in the court, which are the only ways to the lairages. One of them also forms a relief fire escape to the other. In the lairages, there were fodders, water troughs and drainage channels. A food boiler and a flue straight up to the roof are placed at the corridor close to the turning of the ramp (Fig.7.). After waiting for 24-48 hours in the lairages, animals were led directly to the slaughter block along bridges. The bridges were gates to death, as they were designed to give free passage for one animal only, but of insufficient width for it to turn back.

The Slaughter Hall (Fig.8.) is in the center. After being bled, dressed and eviscerated, a carcass was lifted into a vertical position by means of an electric hoist, and then moved with pulley runner onto the overhead conveyor rail 8 feet (2.43 m) further towards the center of the hall where dressing was completed. The dressed carcasses were prevented from touching the floor and transferred along the conveyor railing over a bridge within the Slaughter Hall, and aggregated around the center core. There were two chutes installed by each slaughtering table. One chute led to the hide processing room on the ground floor, and the other led to the organ processing room on the mezzanine floor above the ground floor. Sorted offals were thrown to the chutes accordingly (Fig.9.). After being frozen in the cooling hall, some carcasses were lifted by crane and loaded onto the trucks parked to the west side of the abattoir, and transported to the markets in the concession. Other carcasses were moved across the bridge to the Meat Market and Cold Storage on the south of the abattoir.

Fig.6. Functional Diagram for the Abattoir

Fig.7. The Ramp and Bridges

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Fig.8. Interior of Slaughter Hall

Fig.9. Chutes Leading to the Hide Processing Room

The abattoir possesses a versatile form on the basis of meticulous logic. According to PWD, the abattoir was a self-contained building, partially because a logistic circulation was planned to make the best use of gravity (SMC, 1934). Offals were transferred to the processing rooms on the ground floor by gravity through inclined chutes. Ramps were widely adopted in the abattoir, making animals easy to move. Admittedly, it doesn't seem difficult to satisfy the requirements for
sunshine exposure, ventilation, and circulation with today's complex equipment. However, dating back to 80 years ago, it was an extremely delicate plan to take into account the psychological feelings of both humans and livestock. Designers had to put visual effect aside temporarily, and control environmental elements such as wind and light as well as air in an active and accurate manner. The complex design of the multi-story abattoir was completed by using low technologies, which shows real technological improvements for modern architecture.

2.5 Structure System

The abattoir adopted a flat slab supported system, an advanced structure of the same era. There are two types of mushroom columns in the building: columns in the center areas with square cross-section, and those along the corridors with octagonal cross-section. The longitudinal and transverse post distances are 6.81 m and 6.96 m respectively. The flat slab supported system was invented by an American engineer C. A. P. Turner, which has been widely applied for large industrial constructions such as warehouses and garages. The flat slabs significantly improved natural daylighting, ventilation and hygiene conditions; floors were plastered directly without using suspended ceilings. The structural depth was minimized, which greatly reduced the floor-to-floor height and maximized the floor-to-ceiling height. The flat slab supported system is suitable for non-seismic zones, because its seismic resistance is poor due to lack of beams (Zhu, 1999). Since Shanghai is a non-seismic zone, it was continuously and widely adopted. The supporting soft curves are very expressive with their octagonal columns and 11/2'' (38 mm) thick drop panels (Fig.10.). Such mushroom columns express plenty of western taste, and are key elements for creating the form, space, and artistic conception of the building.

3. The Chinese Contractor An Hon & Co.

3.1 Ah Hong & Co. Won the Bid

PWD usually gave instructions for tenders of municipal constructions of a certain scale. The abattoir included both above-ground and underground structures, but what made it even more complex was that a variety of high standard construction materials were required, and that the construction techniques adopted would greatly affect the strength and durability of the concrete. Therefore, it was necessary to consider structure, material, construction and space as an integrated historical problem, which was also a focus of the globalization of early industrial building technology.

In May 1931, Ah Hong & Co. bid for the construction of the abattoir's main building, and was accepted by SMC. Ah Hong & Co. was founded in 1895, and completed many projects such as the Shanghai District Head Post Office on North Sichuan Road, the Former British Consulate in Shanghai, the Grandstand of the Shanghai Race Club, etc. (Wu, 1997). SMC signed a contract with Ah Hong & Co. on May 20, 1931 (SMC, 1931). According to which the work must be finished by 19 November 1933 within 30 months. Actually, the progress was even faster: the second floor of the principal building was completed in October 1931. In January 1932, the project was suspended temporarily owing to hostilities by the Japanese military. Apart from that, a shortage of construction materials also had some effects. Generally, Ah Hong & Co. was able to complete such a complex project one year in advance (SMC, 1934). The specifications were in English. With 10 sections and 106 items in total they could be divided into two parts. The first part (Section 1 with 32 items) describes problems associated with the relationship between SMC and the contractor. The second part (Section 2-10 with 74 items) specifies the technical requirements for each type of work in terms of materials, techniques, and construction. In particular, it detailed the procedures for excavation and filling, reinforced concrete work, special concrete fittings, floor surfacing, wall finishing and surfacing, carpentry and joints work, metal work, glazing, painting, cleaning and so on, which indicates a high level of complexity and strict construction requirements. Since there were no national standards for construction and acceptance check at the time of its erection, this document was essential and had legal effect.

3.2 Construction Quality of Reinforced Concrete

The quality and strength of concrete decreases as the amount of sand and broken stones increases or that of cement decreases. Lower quality concrete is usually used for non-loadbearing structures or structures of large volume. The volumetric proportions of materials for concrete for different applications are shown in Table 1. Additionally, some other proportions were adopted such as 1:4:8 for beds for foundations and 1:3:4.5 for leveling layers, with the purpose of saving cement. The materials discussed above indicate strict regulations implemented for the construction materials storage, purchase, quality inspection, and specimen tests. Particularly, steel bars must be produced by approved foreign manufacturers, and sand must be from Ningpo or Wusong, which were designated material origins. Standards related to concrete materials were exactly the same as international levels. Nevertheless, the structural reliability and durability of a building constructed in 1933 could be very good only if based on high quality construction and maintenance. So how about the completion quality?
In 2007, the Shanghai Research Institute of Building Sciences conducted tests on the strength and carbonation depth of concrete members in the abattoir. The measured strength of concrete poured in 1933 is C22, and the carbonation depth ranges from 2-35 mm. The carbonation depths of most members are less than the thickness required for the protective layer (SRIBS, 2007). This result is very encouraging, because C22 reaches 3430 P.S.I 236.5 (kg/cm²), which exceeded the original design strength requirement (SMC, 1931). The carbonation depth did not increase much over more than 80 years; it is indeed gratifying to the outstanding construction quality that ensured the concrete compactness (Zhu and He, 2011).

4. 1933 Old Millfun

Industrial heritages in the downtown area with complicated property relationships and mismatched functions had gradually become a declining part of the city. The Shanghai government therefore decided to put them to long-term lease and allow alteration by investment companies on the condition of 'retain use of land, land property, and building size unchanged' (Sun, 2010). The Shanghai Creative Industry Center was founded in November 2004. Up until 2010 75 creative parks had been developed from old factories, warehouses and other historical buildings supported by some favorable government policies. Based on such a background, the abattoir was converted into the '1933 Old Millfun'.

The abattoir was completely unrecognizable before being renovated in 2007: the west façade had been painted pink, the interior space had been partitioned like a labyrinth; pipes and wires added year by year had covered the interior walls; two additional simple bridges had been added. All of these blocked the building and masked the real historical information. The objective of studying historical buildings is to rejoin disconnected historical fragments, match the information with the specific building, then put it into adaptive reuse. There is little doubt that the recreation of '1933 Old Millfun' provides a new opportunity for making use of historical documentation.

(1) Minimal interventions

Thankfully the Art Deco facade survives nearly intact despite the changing trends of architecture in the outside world. Minimal intervention is used for the pink west facade, sealed windows were reopened, and pipelines were replaced. The authentic relationship between the past and the present must be integrated by differentiation. Mushroom columns are one of the features of the abattoir. Their interior surfaces with hollow parts and cracks were repaired, and the marks of renovation were kept to show a comparison between old and new (Fig.11.). The mysterious space created by the bridges is another characteristic of the abattoir. Only two bridges were damaged, and the rest were in good condition. In order to bring it back to when it was just completed in 1933, the two damaged bridges were repaired, and simple bridges added later on were removed. The establishment of the creative park retained the spatial pattern of the original design, which reflected the respect for the authentic architectural space with a very special significance. Last but not least, maintenance of many details also follows the principle of minimal intervention. Iron-wrought ventilation decorations were very important as mentioned in the Specifications, they must be anti-corrosive and anti-rust, meanwhile introducing natural ventilation effectively. The sealed ones were drilled through; replicas replaced the damaged and missing ones (Fig.12.). As a result, the original ventilation now works properly; this means that energy-saving design may contribute to saving costs in the long term.

Table 1. Proportions of Materials for Concrete

| Proportion | Cement (bag) | Sand (feet 3) | Broken stone (feet 3) | Strength (PSI) | Application |
|------------|--------------|---------------|----------------------|---------------|-------------|
| 1:2:4      | 1            | 2.35          | 4.7                  | 2000          | 140         | Normal RC members |
| 1:1.5:3    | 1            | 1.76          | 3.5                  | 2800          | 200         | Basement wall and floor |
| 1:1.5:2    | 1            | 1.76          | 2.35                 | 3000          | 210         | Water tower |

PSI: pounds per square inch

Fig.11. Work Process in 2007

Fig.12. Ventilation Before and After Renovation
continue its life to satisfy new social requirements. The '1933 Old Millfun' is not only a historical building, but also an interactive platform open to the public, which offers more creative potential. Occupant comfort must be taken into account in the renovation. In the absence of modernized equipment design, it is necessary to reorganize the drainage, electrical, and HVAC equipment on the basis of respect for historical information. The abattoir had few toilets, so three toilets of high quality are installed on each floor with a 400 mm drainage layer added onto the existing slab without altering the original structure. A total of six lifts make maximum use of the existing lift wells to ensure the integrity of the structure, thus satisfying the requirements for passenger and cargo flow. Most of the partition walls added later on, weighing around 50 tons in total, were demolished according to the original drawings. Lightweight new partition walls were adopted to re-divide the interior space to adapt it to a creative park (Zhao, 2007). Without a large space, it was impossible to hold big events. To keep the old building relatively complete as well as structurally independent, a transparent glass hall of steel frame structure was therefore built in the center of the top floor, the hall has 600 seats and can hold operas and musicals, and may be used as a 'stage in the air' (Fig.13.).

5. Conclusions
By the early twentieth century, Shanghai had already become a platform for international architects (Chen and Zhang, 1988). The open values in modern Shanghai society and effective discussion procedure of SMC offered possibilities of innovation. Although located in Shanghai, the abattoir was not confined to the corner, but became an excellent example of Chinese construction companies stepping onto the international stage. Being an integrated modern industrial machine, the building embodies the very advanced global construction level of the 1930s, and represents Shanghai’s achievement as an architecture center in the Far East. Its pioneering completion quality qualified it for adaptive reuse and eventually brought it new social value. The area around the 1933 Old Millfun retains an 'organic and original' feel because it hasn't been markedly reconstructed in recent years. However, the project greatly promoted its neighborhood after seven years' management. The Sawgin Kiang area has evolved from a single creative park into a creative industrial district. By integrating daily living space and creative space, 1933 Old Millfun broke the introverted space, and thus became the anchor for regeneration of Shanghai industrial heritages.

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