FORMATIVE PROCESS OF HOUSING GROUPS OF WU-FENG LIN FAMILY AND RECONSTRUCTION AND RESTORATION METHOD AFTER 921 EARTHQUAKE

— Comparison between Da-Hua-Ting and Kung-Pao-Ti —

台湾霧峰林家の建設プロセスと921地震後の復原および修復手法

— 大花廳と宮保第との比較 —

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This study aims to compare the reconstruction and restoration of Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) in the Mansions of the Wu-Feng Lin Family which were destroyed in the 921 Earthquake in 1999. After the 921 Earthquake, the Taiwanese government promulgated the “Cultural Heritage Preservation Act” (文化資産保存法), which allowed heritage monuments to adopt modern technologies and construction methods in order to enhance monument’s durability. The concepts of the reconstructions of Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) follow different directions. This paper focuses on this contrast.

1. Introduction

The Mansions of the Wu-Feng Lin Family(霧峰林家) is the largest of Min-Nan style (閩南式) group of buildings and was expanded from 1830s to 1930s in Taiwan. It reflects the Taiwanese life of the pioneering period during early 19th to early 20th century via the variety of building types which including Min-Nan style (閩南式), Japanese style (和式) and Western style (洋式) because Taiwan was controlled under Ching Empire (1683-1895) and Japanese government (1895-1945). After the 921 Earthquake happened in 1999, the Mansions of the Wu-Feng Lin Family were serious damaged.

After that, Taiwanese government revised the “Cultural Heritage Preservation Act” (文化資産保存法) in 2000. Article30 mentions that “The monument shall be preserved in its original appearance and construction method, if necessary, modern technologies and construction method in order to enhance the monument’s durability.”.

The restoration projects of the buildings in the Wu-Feng Lin Family’s Mansion, including Jin-Syun-Lou (景薰樓), Yi-Pu, Kung-Pao-Ti (宮保第), Da-Hua-Ting (大花廳) and Er-Fang-Cuo (二房厝), were undertaken between 2003 and 2009, where we saw two different approaches were applied to two different buildings; the modern structural system was adopted to the reconstruction of the traditional form of Kung-Pao-Ti(宮保第), and disadvantage of the traditional structural manner was modified

without replacing it by new structural system in Da-Hua-Ting (大花廳), although these two buildings share the same Min-nan style (閩南式). This paper focuses on this contrast.

1.1 Research Process

According to the documents, I drew the site plans to explain their development in the different time periods. I also refined the official reports’ (Reference No.15, 16) drawing such as the plans, the sections, the sketches and the photos to draw the isometric drawings to explain the details of the reconstruction.

2. The development of the Wu-Feng Lin Family Mansion

Map 1. Location of the Mansions of Wu-Feng Lin Family.

2.1 Development period in Ching Empire (1837-1895)

The Wu-Feng Lin family divided into two family system which were

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Figure 1. The Lin Family was divided into an Upper House and a Lower House.

Figure 2. The Lower House was expanded rapidly in Ching Empire period.

Figure 3. Da-Hua-Ting (大花廳) was completed in 1894, and the development of the Lower House building groups was finished. Taiwan belonged to Japan since 1895.

Figure 4. Lin Family invited a research group of Taiwan University (台灣大學城鄉研究所) to record it during the period from 1984 to 1988.

Figure 5. The 921 Earthquake seriously damaged the Mansions of the Wu-Feng Lin Family.

Figure 6. The Mansions of the Wu-Feng Family re-opened to the public in 2013.

called Upper Family (頂厝) and Lower Family (下厝) in 1837, and they moved to the location today. (See Figure 1.)

2.1.1 The Lower House: The Lower House expanded faster than the Upper House in the beginning because most of Lower House members served in the Army of the Ching Empire, and they had more chances to be promoted. Lin Wen-Cha (林文察) was a high-ranking military officer, and served the Ching Empire. He built Kung-Pao-Ti (宮保第) as his official

residence, and Er-Shi-Ba-Jian (二十八間) was a row house which had 28 units for military use, including soldier dormitories, offices and stables, etc. After Lin Wen-Cha died on the battle field in 1864, the Ching Empire allowed the Lower House to expand their house to honor his bravery. (See Figure 2.)

Da-Hua-Ting (大花廳) was designed as the social functional theater in 1890. The development of the Lower House building group was completed in 1894. (See Figure 3)

2.1.2 The Upper House: Lin Tien-Kuo (林奠國) started to build Jing-Syun-Low (景薰樓) as his residence in 1864, and Lin Wen-Chin (林文欽) built Rong-Jing-Zhai (蓉鏡齋) as a school for the Lin family in 1887. The Lin family still taught kangaku (漢學) in the Japanese period. (See Figure 3)

2.2 Development in the Japanese period (1895-1945)

The building groups of the Upper House were expanded rapidly during the Japanese period due to their monopoly business with the Japanese government. The Upper House family totally transformed into a scholar family because the leaders of the Upper House family, Lin Wen-Feng (林文鳳) Lin Wen-Chin (林文欽) encouraged their descendants to study business and literature during the Japanese period.

Lin Chi-Tung (林紀堂) cleaned the barn and guest house to be Yi-Pu (頤圃) as his private garden in 1906, and he built an eclectic style house with double roof structure in 1910. The right and left hulung (護龍) parts were completed in 1920s. The building group of Yi-Pu was mixed Min-Nan (閩南) style, Japanese style and western style. (See Figure 4.)

Hsin-Cuo (新厝) was built for residential use by Lin Tien-Tung (林澄堂) in 1916, and it was also a mixed styles building group. (See Figure 4.)

In the 1930s, Jing-Syun-Low (景薰樓) was remodeled by Lin Hsien-Tung (林獻堂) who was an important person for the democracy in Taiwan. He remodeled parts of it as Japanese style, and replaced parts of columns and materials of wall to reinforce the strength of the structure.

2.3 From 1984 to the 921 Earthquake (1984-Sep. 1999)

2.3.1 Completely Recorded during 1984-1988:

After the Japanese period ended, the Mansions of the Wu-Feng Lin Family were in poor condition, so the Lin Family invited the Graduate Institute of Building and Planning of Taiwan University (台灣大學城鄉研究所) to record it during the period from 1984 to 1988. After that, 《霧峰林家建築圖集》 was published in 1988, and the reconstruction would depend on these documents in the future. (See Figure 4.)

2.3.2 The 921 Earthquake in 1999:

The first reconstruction period lasted from 1995 to 1999. It should be completed on September 24, 1999, but was almost completely destroyed in the 921 Earthquake which had a magnitude of 7.3 on the Richter scale and which occurred on September 21, 1999. Only parts of Jing-Syun-Low (景薰樓), Er-Fang-Cho (二房厝) and Yi-Pu (頤圃) survived the 921 Earthquake. (See Figure 5.)

The 921 Earthquake caused serious damage by some reasons as follows: (1) The Lin Family hired craftsmen from their hometown, where no serious earthquake happened. The craftsmen didn't design any reinforcement system for the buildings in the beginning. (2) The location of the Mansions of Wu-Feng Lin Family is too close to epicenter located

in Ji-Ji (集集). (3) The Taiwanese Government announced Cultural Heritage Preservation Act (文化資產保存法) in 1982 (non-current regulations) was unsuitable. Especially the article 35 (announced in 1997): "The heritage should be preserved in its original condition. If it's damaged, it should be recovered to its original condition as when it was built.". It won't allow the re-constructor apply any reinforcement to strengthen the original buildings.

2.4 Cultural Heritage Preservation Act (文化資產保存法, 1999-)

The economic and urban development had a great growth after the 1980s in Taiwan, so in 1982 the Cultural Heritage Act was announced to protect the monuments. The main idea of preserving its original conditions without changing is trying to renovate its historical value as much as possible, but it caused some heritage buildings to sustain serious damage in the 921 Earthquake due to a lack of any reinforcement.

After the Taiwanese Government revised the law in 2000, the reinforcements and modern technologies would be applied, and the scholars and the members of Lin family discussed the original appearance of Wu-Feng Lin's Mansions and their properties. After four years of discussion, the reconstruction finally started in 2003.

There is no precise rule to explain how to renovate the monument in improving traditional process or modern technologies until Cultural Heritage Act was regulated in 2016 July. According to Article No. 24: "...its main structure and building materials survive, restoration shall be made to restore its original appearance according to the principle of giving priority to preservation of the value of cultural heritage.".

3. The contrast of the reconstructions

The group of buildings of the Mansions of the Wu-Feng Lin Family was announced a heritage site in 1985, and the Taiwanese government spent TWD 200 million to repair Da-Hua-Ting (大花廳) and Jing-Syun-Lou (景薰樓) in 1997. Unfortunately, most of the Wu-Feng Lin's Mansions were destroyed in the 921 Earthquake in 1999.

The Taiwanese government rebuilt Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) during 2004 to 2009, and it cost TWD 259,335,488. The idea of the reconstruction of Kung-Pao-Ti (宮保第) is improving the traditional construction process, but the architect adopted the steel framing in Da-Hua-Ting (大花廳) as the main structural system. The average cost of Da-Hua-Ting (大花廳) is 61,528 TWD/m² around, and it is the twice average cost of Kung-Pao-Ti (宮保第) (29,760 TWD/m² around). (See Table 1.)

Building Group	Kung-Pao-Ti(宮保第)	Da-Hua-Ting(大花廳)
Established Period	1858-1895	1890-1894
Original Function	Official Residence	Theater
Family Group	Lower House	Lower House
Architecture Style	Min-Nan (閩南)	Min-Nan (閩南)
Reconstruction Period	2005.01.19- 2009.11.18	2004.11.29- 2007.06.13
Budget	109,850,000 TWD	91,350,000 TWD
Cost	156,953,700 TWD	102,381,788 TWD
Building Area	5274 m ² around	1664 m ² around
Average Cost	29,760 TWD/m ²	61,528 TWD/m ²
Structure Systems	Wood + Brick	Wood + Brick + Steel
Current Function	Museum	Museum
Open to the Public	2013.10.27	

Table 2. Contrast of the reconstruction of Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳).

Structure Systems	Details	Kung-Pao-Ti 宮保第	Da-Hua-Ting 大花廳
A. Column & Foundation	01. Connecting the column and foundation stone with steel bar.	O	X
	02. Adding the Connection of foundation stone and the ground with steel bars.	O	X
	03. Gluing the steel bars and components with Epoxy Glue.	O	X
	04. The concrete layer be the base.	O	X
	05. The independent concrete footing.	X	O
	06. The wood column and foundation fixed with the concrete footing by anchors.	X	O
B. Wall	01. Adding the bamboo piece in horizontal direction.	O	X
	02. Adding the bamboo stick in vertical direction.	O	X
	03. Adding the steel stick in vertical direction.	O	X
	04. Adding bamboo piece mesh in vertical direction.	O	X
	05. Concrete wall base.	O	X
	06. SRC wall base.	X	O
	07. Adding Steel mesh in vertical direction.	X	O
	08. Adding angle iron.	X	O
	09. Rammed earth bricks.	O	O
	10. Adding steel plate in horizontal direction.	X	O
	11. Strengthening the door opening through brick framing.	O	O
C. Wooden Framing	01. Fixing the partially damaged piece.	O	O
	02. Connecting with the new component to replace the most damaged parts.	O	O
	03. Fixing the flaws with Epoxy glue.	O	O
	04. Improving the joint systems.	O	O
	05. Improving the original wood component design.	O	O
	06. Steel joint cover.	X	O
	07. Locking the components of wood beams on the top of the wall with rebars.	O	X
	08. X-Shaped steel piece in the floor.	X	O
	09. Steel braces in the wall.	X	O
	10. Steel brackets under the stage.	X	O
	11. Clip angles between the column and beam.	O	X
	12. Implanting the rebars to connect the wooden column.	O	O
	13. Connecting the wooden and the steel column by the steel stick pieces.	X	O
	14. Gluing Carbon mesh on the roof.	O	X
D. Steel Framing	01. Steel framework.	X	O
	02. Merging steel framework into the brick wall.	X	O
	03. RC framework.	X	O

Based on the different parts of the building, there are four parts as follows: (1) columns and foundations (2) walls (3) wood framing (4) steel framing (See Table 2.) The contrast of the reconstruction of Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) are described in the next paragraph.

3.1 The column and the foundation

The new foundation design in Kung-Pao-Ti (宮保第) followed the traditional construction process, but the new design in Da-Hua-Ting (大花廳) adopted the modern structural system in partial column positions. The

original materials of the foundation in Kung-Pao-Ti (宮保第) was replaced with modern materials such as concrete and steel bars. Some of the new foundation design in Da-Hua-Ting (大花廳) was reinforced concrete footing which was connected with the wooden columns.

3.1.1 The column and the foundation stone in Kung-Pao-Ti (宮保第)

The new process adopted the steel sticks in both sides of the foundation stone, and glued it with epoxy. The original joint design had some problems because the end of the wood column was rotten during a long period of time, and there was no connection to the ground. The layer which under the foundation stone plate is the concrete, it can help to fix into the ground stably. The original material in this concrete layer was the earth. Under the concrete layer are pebbles, but some parts are bricks. Part of the foundation stone plates are pyramid shaped. (See Figure 7.)

3.1.2 The column and the foundation stone in Da-Hua-Ting (大花廳)

The most of the independent columns adopt this design in Da-Hua-Ting (大花廳), but some columns located in other positions were improved on the traditional design. In this case, the new strategy is cutting off the end of the wood column, then tie them with foundation stone and the 3000psi concrete independent footing via a steel bolt. (See Figure 8.)

3.2 The wall

Both of the new brick wall designs in Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) have kept the traditional appearance as much as possible. For the strength of the structure, all of the wall bases were designed as concrete. The brick walls were improved by adding the

traditional materials such as bamboo sticks and pieces, and to the brick wall in Da-Hua-Ting (大花廳) steel clip angle were added to strength the window frames.

3.2.1 The brick wall system in Kung-Pao-Ti (宮保第)

The main proposal for the reconstruction of the walls in Kung-Pao-Ti (宮保第) was adding the traditional materials to improve the strength of the wall structure. Adding bamboo sticks and bamboo pieces also can be found in the original wall design of Er-Fang-Cuo (二房厝). The vertical bamboo sticks and the horizontal bamboo pieces as the reinforcement system, and the rammed-earth-brick walls were filled in the space of the tile plates. The rammed-earth-brick walls were connected with the concrete wall base via steel sticks and vertical bamboo sticks. (See Figure 9.)

3.2.2 The brick wall system in Da-Hua-Ting (大花廳)

This brick wall design adopted in the spectator seat area in Da-Hua-Ting (大花廳). It was designed to use new modern materials such as steel clip angles to be the window opening reinforcements, and steel mesh was added between the rammed-earth-brick to the finishing coating. The new main structural system of Da-Hua-Ting (大花廳) is the steel framing which was covered inside by the brick wall. (See Figure 10.)

3.3 The wooded framing

In this reconstruction, the first mission is repairing the useable original materials with epoxy, quartz powder and yellow earth powder. It was necessary to improve the wooden joints which was eroded and damaged. The ideas of the reinforcements are also different between the

two building groups. It is enhancing the connection of the joints in Kung-Pao-Ti (宮保第), but it is a part of structural systems in Da-Hua-Ting (大花廳).

3.3.1 The reinforcement of wooden framing in Kung-Pao-Ti (宮保第)

To protect the wooden joints, clip angles were installed and glued on the connection of the columns and beams. The drawing only shows the clip angles on the upper part of the connection. (See Figure 11.)

The traditional Min-nan style (閩南式) housing is a hybrid structural system building which made of brick walls and wood framing. The connections between the brick wall to wood framing were not strong enough, so it was necessary to fix the wooden beams on the top of the brick wall with rebars. (See Figure 12.)

Ma-Huang-Ding (螞蝗釘) is a metal piece component which was used to pin two components of the round beam together as when Kung-Pao-Ti was built. (See Figure 12.)

3.3.2 Improving the original wooden joint design

The original joint design is called ping-sun (平榫) which is a rectangular joint, but it can't lock the components tightly. The craftsman had to improve it, so there are some examples about the joint improving:

The gou-dao-sun (勾倒榫) is a traditional joint which is a hook shaped locking into the brick wall or wood column. (See Figure 11.)

Figure 11. Gou-Dao-Sun (勾倒榫)

Yin-Ding-Sun (銀錠榫) is a rectangle shaped wood piece, and the central part is thinner than the both sides. In this case, Yin-Ding-Sun was glued with the round beams together with resin.

Figure 12. Yin-Din-Sun (銀錠榫)

3.3.3 The reinforcement of wooden framing in Da-Hua-Ting (大花廳)

The structure of the rooftop is huge and heavy in Da-Hua-Ting (大花廳), so the wooden framing required reinforcement. It was necessary to install huge brackets under the stage to improve the strength of the wooden framing. (See Photo 7.)

Photo 7. The brackets under the stage of Da-Hua-Ting (大花廳)

Photo 8. The back stage of Da-Hua-Ting (大花廳).

Figure 13. The steel bracing in the back stage of Da-Hua-Ting. (大花廳)

Steel braces were installed inside the wooden partitions in the backstage area of Da-Hua-Ting (大花廳), and two steel brace pieces were welded together. When people look in from the outside, it will look like a normal wood structure. (See Figure 13 and Photo 8.)

3.3.4 Modifying the original component

Modifying the original components and the composition is helpful to enhance the strength of the structure. Taking the stage of Da-Hua-Ting (大花廳) as an example, it will not easy to be twisted because the columns are linked by short beams. (See Photo 9 and 10)

Photo 9. Da-Hua-Ting. (大花廳) (Photographer: 松山虔三)

Photo 10. Da-Hua-Ting (大花廳) in 2015

3.4 The steel framing

Da-Hua-Ting (大花廳) is the only one building group with a steel structure in the Mansions of the Wu-Feng Lin Family. Da-Hua-Ting (大花廳). The structural system of brick walls and wood framing was totally transformed into modern steel framing.

3.4.1 The steel framing

Figure 14. The isometrics of steel structure in Da-Hua-Ting (徐明福：第二級古蹟霧峰林宅下厝大花廳修復工程工作報告書，台中縣文化局，p8-5)

The steel framing is the main structural system of Da-Hua-Ting (大花廳), except the center part which is the back stage and the theater stage.

Some of the SRC wall base goes beneath or separate for the door opening. The concrete was grouted to cover the steel framing in the final step. (See Figure .14, 15)

3.4.2 Wood-Steel structure

Figure 15. The steel structure combined with the wooden structure.

This drawing is the part of the 3rd jin (第三進) of Da-Hua-Ting (大花廳), and it shows how the wood structure and the steel structure combined (See Figure 14). The wood column was locked with steel columns via two steel sticks. This can help to transfer the forces from an earthquake in the future. The steel plates were welded onto the steel column, and placed in three layers of rammed earth bricks. The steel framing was covered with the brick wall, wooden framing and a finishing layer.

4. Conclusions

The reconstructions of Kung-Pao-Ti (宮保第) and Da-Hua-Ting (大花廳) are due to different ideas of preservation. The main idea is improving the traditional construction process such as the columns and the brick walls in Kung-Pao-Ti (宮保第), but the main structure of Da-Hua-Ting (大花廳) is modern steel framing which supports the original brick and wooden structure. Both of their original wooden components and the joints needed to be repaired and modified. The idea of wooden framing reinforcement focuses on the joint and the rooftop parts in Kung-Pao-Ti (宮保第), but it focused on enhancing the strength of wood framing in Da-Hua-Ting (大花廳). The reconstruction of the Wu-Feng Lin Family Mansions is a successful example of improving the traditional processes and adapting the modern structure and the reinforcement systems after 921 Earthquake in 1999. Taiwan is a country with many earthquakes, and plenty of heritage sites are at risk. The Mansions of the Wu-Feng Lin Family are the largest group of buildings with varied building styles which include Min-Nan style, Japanese style and Western style in Taiwan, and its spatial composition also reflects the life of Taiwanese from the pioneering period to date. The Wu-Feng Lin family also played many important historical roles in different time periods in Taiwan, which is the strongest reason to support the Taiwan government to rebuild it. This reconstruction brought a successful experience of the heritage preservation, and it will be an important example to serve Taiwan in the future.

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