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PRELIMINARY TECTONIC PHENOMENA OF DIVERSIFIED ARCHITECTURAL SPATIAL FORMS IN DIGITAL AGE

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Abstract. The research on tectonics in the architectural field began from the middle of nineteenth century and in recent twenty years digital technology gradually developed and permeated through the field of architecture. Liu and Lim (2006, 2009) integrated classic and digital tectonic factors a present framework of new tectonics. However, the previous studies related to the tectonics in this digital age were only on architectural cases that use a great deal of digital media. The research wants to know what and how the tectonic factors affect the different spatial forms of modern architecture and focused on a case study of the diversified spatial forms, orthogonal, folding and curving. The results show the classic tectonic thinking is imperative until now. It is critical to prove the significance of adding the new digital tectonic factors in digital age.

Keywords. Digital and classic tectonics; spatial form; digital media.

1. Introduction

1.1. NEW TECTONICS: CLASSIC AND DIGITAL TECTONIC THINKING

The research on tectonics in the architectural field began from the middle of nineteenth century (Botticher, 1843; Semper, 1951; Sekler, 1965; Gregotti, 1983; Frascari, 1984; Vallhonrat, 1988; Frampton, 1990; 1995). They proposed many tectonic observations and then gradually established the theory of classic tectonics today. Liu and Lim (2006, 2009) integrated the previous

viewpoints with the seven classic tectonic factors, including joint, detail, material, object, structure, construction, and interaction.

In recent twenty years, digital technology gradually permeated through the field of architecture. The digital procedure implying the process of architectural design and construction was exactly different from the way of traditional architectural thinking (Mitchell, 1998; Cache, 2002; Spuybroek, 2003; Cook, 2004; Leach, 2004; Fang and Zhou, 2007; Vanggaard and Pontoppidan, 2007; Deplazes, 2008). The development of digital free-form is the most obvious aspect of digital techniques (Imperiale, 2000; De Luca and Nardini, 2002; Ham, 2003).

Therefore, the application of digital media opened a new page for the development of the free-form architecture. A new spatial form of digital architecture was emerging (Mitchell, 1998; Pongratz and Perbellini, 2000). According to the previous views, Liu and Lim (2006, 2009) thought classic tectonic theory could not totally cover digital design and construction with the seven tectonic classic factors in the digital architectural age and afterwards presented the four additional digital factors, motion, information, generation, and fabrication. The eleven of classic and digital tectonic factors came into being a present framework of new tectonics.

1.2. THE RELATIONSHIP OF ARCHITECTURAL SPATIAL FORMS AND TECTONICS

Architectural theories evolved time after time and tectonics theories also followed them. Building technique was not a tool for solving the problem of form, but was just the source for considering architectural spatial form (Giedion, 1967). To view the architectural history, the discussion of the architectural progress always followed the revolution of technologies. The technique at that time could directly reflect the presentation of architectural structure and even change the spatial form of architecture (Wachsmann, 1959; Giedion, 1967). The spatial form of architecture was regarded as an extended result of the structure and construction. When the process of architectural production underwent changes, then changes in the form of architecture followed (Gao, 2004). In other words, the spatial form of architecture reflected a series of fabrication process (Gregotti, 1983; Frascari, 1984). Architecture spatial form should be studied and examined through tectonics, forming an inseparable bond between architectonics and tectonics (Semper, 1952; Frampton, 1995).

We found that the novel spatial form which was created from some historic stage of architecture never disappears in the later age, but revives into an innovative form as a result of the new techniques, new materials and new building

methods. The progress of architectural design thinking is from 2D drafts to 3D models, from straight lines to free-from curve. In this time, the diversified spatial forms of architecture are deeply affected by the digital age in the 21st century. Architecture of nowadays shows every kinds of spatial forms.

2. Problem and objective

However, the previous studies about the tectonics in this digital age almost only selected the architectural cases that usded a great deal of digital media to be the research subjects. It was not adequate to reflect today's diversified spatial forms and discuss them in accordance with the classification.

Therefore, this paper is base on Liu and Lim's (2006) framework of new tectonics, eleven new tectonic factors (joint, detail, material, object, structure, construction, interaction, motion, information, generation, fabrication), to be the analytical basis. The authors want to know what and how the tectonic factors affect the different spatial forms of modern architecture. The objective of this paper is to indicate the tectonic phenomena of the different spatial forms and the orientation of the tectonic factor in the diversified special forms.

3. Methodology and steps

In order to reach the objective, the research focused on a case study of the diversified spatial forms of architecture in the 21st century and integrated several phenomena of the above factors on the different spatial forms.

The case study selected the real architectural case of NEXT-GENE as the subject, which was a group design for a residential site in Taipei County in 2007. The NEXT-GENE project invited 20 noted architectural teams to this international contemporary architecture forum and exposition. They had to design one house on the site. The characteristics of this case were that the 20 architects collectively designed in the same site, for the same program, but from different countries. The analysis data included design concept, diagrams, sketches, drawings, renderings, and physical models.

These works of 20 architectural forms could be classified into three kinds of spatial forms, orthogonal, folding and curving spatial forms, according to the previous style of designers and this design presentation. The definition of orthogonal forms (O) was that all walls are 2D plane and it is vertical between all walls and the roof. The definition of folding (F) was that all walls are 2D plane, but with more than two adjacent walls are *not* vertical. The definition of curving (C) was that more than one wall are 3D curve.

In order to definitely distinguish into the three of the spatial forms and avoid confusing the results of the following analysis, the authors selected only

three works of each spatial form from the 20 buildings. The selections had to completely match the above definitions.

This study analysed nine cases of table 1 based on the eleven new tectonic factors of Liu and Lim (2006, 2009). Figure 1 is the analysis framework.

Table 1. The selected cases from 20 houses of NEXT-GENE project.

Spatial Form	Case [No.]	Project Name	Designer	Country
O	Case [1]	FlexiVilla	Toshiko Mori	USA
	Case [2]	Floating Courtyard	Ray Chen	Taiwan
	Case [3]	Triptych House	Yungho Chang	USA
F	Case [4]	Ridge House	Hailim Suh	Korea
	Case [5]	Latent Dragon	Irving Huang	Taiwan
	Case [6]	Radix House	Shu-Chang Kung	Taiwan
C	Case [7]	Architecture Farm	Akihisa Hirata	Japan
	Case [8]	Calligraphic House	Yu-Tung Liu	Taiwan
	Case [9]	Symbiotic Villa	Zaha Hadid	UK

4. Case study

The 11 new tectonic factors were proposed by Liu and Lim (2006, 2009). For their definitions, please refer to Liu and Lim's (2009) publication of *New tectonics: classic and digital design thinking in Feidad Award.*

However, owning to the special demands of housing program, all of the 20 cases did not generally consider the "information" factor. Therefore, the research did not take "information" into account temporarily and would

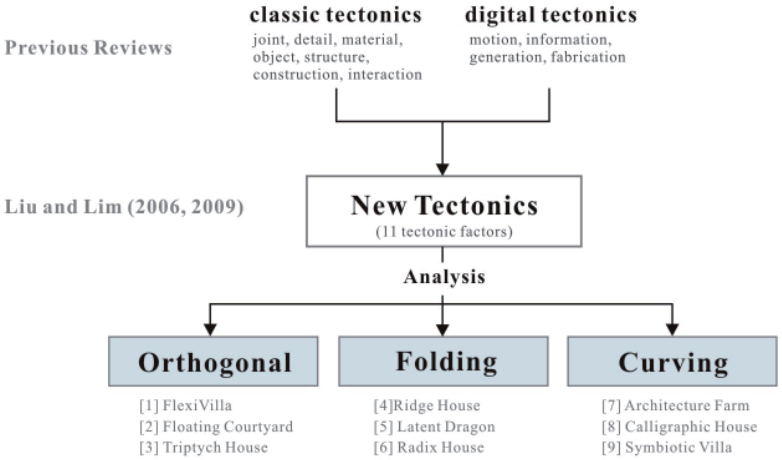

Figure 1. Analysis framework.

proceed to the discussion in the future. The following was going to analyse the remainders of ten tectonic factors.

4.1. JOINT

In the orthogonal forms, joints mainly figured on the skin for the additional requirements beyond the architectural form, including the ornament of minor structure, the special effect of light, and the assembly of mobile joints as figure 2a, 2b. Joints were a kind of expression. There were not directly related to the whole spatial form.

In the folding forms, there were two kinds of purposes in regard to the presentation of spatial forms. First was for the additional requirements attached to skin similar to the orthogonal ones (figure 2c). Second was for the connection between two segments of the whole, which usually hided behind the skin to present the whole form as the curving ones (figure 2d).

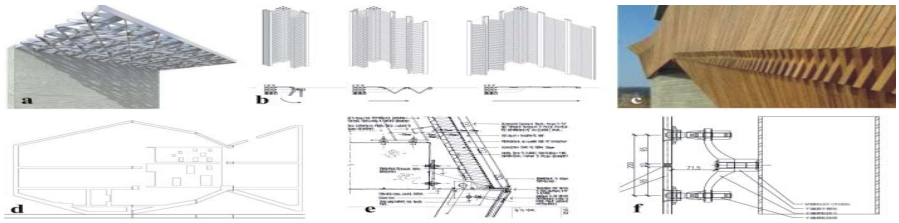

Figure 2. a. case[1], b. case[3], c. case[4], d. case[6], e. case[8], and f. case[9] of joint.

In the curving forms, they were assembled by several units, so the joint design came from the free-form curve, which were usually hided behind the skin in order to present the whole form as figure 2e, 2f.

4.2. DETAIL

In the orthogonal forms, details mainly appeared in the architectural skin. Amount of repeated units followed a rule and recombined together and then produced a weaving, complicated pattern as figure 2a. Therefore, the presentation of this form expressed the enriched and detailed texture, and then created an open space and produced magical lighting effects.

In the folding forms, there were two different kinds based on the expression of spatial forms. One stressed the decoration of architectural skin in order to create detailed skin and lighting effects as the orthogonal ones. The other purely stressed the connection of function. Details were hided behind the skin as the curving ones.

In the curving forms, details only possessed of the functional meanings. They derived from the spatial form. Details usually came up between a frame-

work and skin and were wrapped in the architecture.

4.3. MATERIAL

In the orthogonal forms, it emphasised to use some specific materials for the presentation of detailed skin. Designers particularly mentioned what kinds of materials were used in the external skin as figure 3a, 3b. The multiple collection of colours was an important feature for design expression.

In the folding forms, designers used single material to unify the style in the part of the folding form. They also specially addressed it to be the main materials in the concept design stage. However, in the part of the vertical and horizontal form, more materials were used for function as figure 3c.

In the curving forms, designers stressed simplicity of material and used less than three kinds. There was no steam on the curving skin and it only used only one kind of material. Structural materials were the exhibition materials showing on the external skin. The enclosure system usually used transparent glass to make the form purer.

4.4. OBJECT

In the orthogonal forms, some classic architectural elements of the explicit door, window, beam, column, floor, and wall, assembled around the building form. Space functions were clearly separated into interior and exterior by the geometric module objects. Objects in this form emphasised the object combination system of function demands.

In the folding forms, parts of classic objects were still recognised clearly such as the door, window, etc. However, the objects of external ones were less distinct than internal. The relationship between ceilings and walls disappeared and then integrated into a new “skin object” as figure 3d.

In the curving forms, the classic objects disappeared and were hard to identify because of the free-form curve. They came into being a whole object system, which was composed of many irregular customised objects for the design form as figure 3e, 3f.

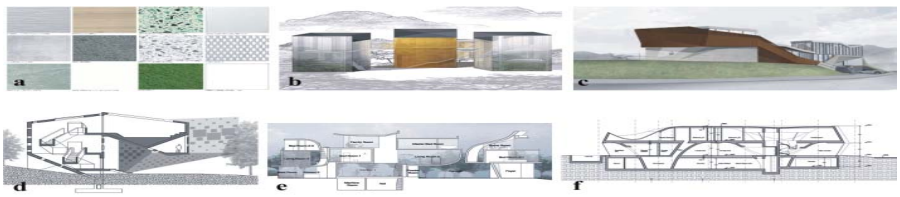

Figure 3. a. case[1], b. case[2], and c. case[5] of material; d. case[6], e. case[7], and f. case[9] of object.

4.5. STRUCTURE

In the orthogonal forms, there were most vertical and horizontal structural systems of beam-columns. The transmitting direction of force was vertical. The main structural system was reinforced concrete or steel structure as the frame of design form and attached to an ornamental skin structure.

In the folding forms, they still adopted the structural system of beam-columns, but the distribution of beams and columns was irregular in order to be closer to the site condition. Because of folding walls, there were other transmitting directions of force besides vertical.

In the curving forms, the form of structure had to be regarded as the building appearance. They usually developed with a steel framework of 3D curve or a whole cast of camber. The transmitting direction of system of force followed the building form.

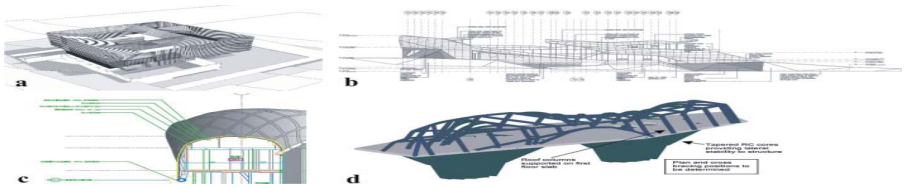

Figure 4. a. case[2], b. case[4], c. case[8], and d. case[9] of constructions.

4.6. CONSTRUCTION

In the orthogonal forms, construction was according to the orthogonal structure. The procedure of construction should be prioritised from the main structure to the attached skin. The order was usually bottom-up as figure 4a.

In the folding forms, the part of vertical and horizontal form was built of reinforced concrete in the site (as the orthogonal forms). The part of inclined plane needed to precast customised units in the plant and transport to the site to fabricate (as the curving forms). See figure 4b.

In the curving forms, they usually adopted the customised construction. The form was cut into segments, made in a plant, and transported to the site to fabricate as figure 4c, 4d.

4.7. INTERACTION

In the orthogonal forms, owing to that forms usually followed functions, they tended to create a partly-open courtyard. People did not directly contact with surroundings. The building created multi-level spatial perception and emphasised the interaction with people.

In the folding forms, there were two characteristics of the expression of spatial form. More than two building complexes created the inner space and added the levels of interaction with people and surroundings (as the orthogonal ones). The other expression is that forms followed topographies. Architecture interacted with site and people with direct contact with surroundings (as the curving ones).

In the curving forms, they emphasised form would be apart from topography. People in the building were just like in nature. They stressed the interaction with architecture and site. Therefore, the relationship between people and the surroundings became natural.

4.8. MOTION

In the orthogonal forms, the motion mainly presented in the process of function units such as stacks of volume, pull of partition, and fold of object. Finally it showed the suite space form based on the function.

In the folding forms, the purpose of motion was for the pursuit of esthetics and the condition of the site. They started from the move, twist, stack, or deformation of regular units and then displayed irregular folding forms in the end.

In the curving forms, motion came from the dynamic deformed process of a simple form. It was to fit the condition of the site and the pursuit of esthetics.

4.9. GENERATION

In the orthogonal forms, generation created inextricable 2D patterns which were used on the design of details and saved time and costs as figure 5a, 5b.

In the folding forms, there was less tectonic thinking of generation in the design process. Only case [6] was for the product of inextricable 2D patterns that was the same as the orthogonal ones.

In the curving forms, there were two kinds of form generation. One was the process from single to multiple of unit forms. The other was deformed by the free-form itself.

4.10. FABRICATION

In the orthogonal forms, fabrication was used on the detailed parts, such as small components on the details of the complex skin. It usually displayed with 2D plane and used the laser cutting and CNC machine to replace the artificial efforts. The advantages were cost saving and accuracy promotion.

In the folding forms, fabrication was used on the folded plates for the convenience and accuracy of construction. At first, the folded plates had to be

flatten a plane surface, and then precast conveniently in the plant for the final fabrication.

In the curving forms, fabrication proceeded to the precasting way. There were many modes of output, such as flattening, lofting, cutting, assigning, and assembling using the CAD/CAM tools. See figure 5c, 5d.

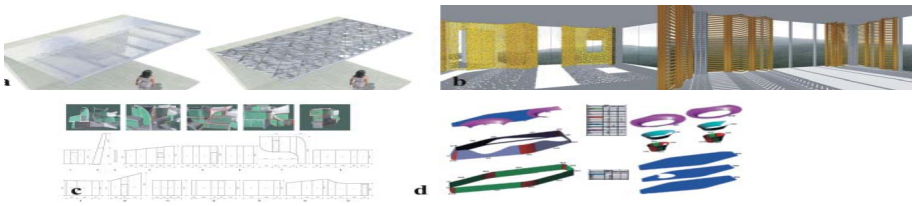

Figure 5. a. case[3] and b. case[6] of generation;c. case[7] and d. case[9] of fabrication.

5. Conclusion

The research finds that the seven classic factors all emerge in the three spatial forms of nine cases. The result shows the classic tectonic thinking is imperative until now. However, there is not an obvious discrepancy in the degrees of the three kinds of spatial forms dependent on the digital tectonic factors. It is critical to prove the significance of adding the new digital tectonic factors from Liu and Lim (2006) in digital age. Not only do the generally-known curving spatial forms greatly consider the digital tectonics, but also every kind of spatial forms emerges the phenomena of digital thinking.

For the further discussion, it is the difference of tectonic thinking among the orthogonal, folding and curving spatial forms in the case study. In the classic tectonic factors, the tectonic thinking of folding forms almost has the thinking as the orthogonal and curving. However, the digital factors are not clear. The tectonic thinking of folding forms usually tends to be the orthogonal or curving. Moreover, the thinking of the orthogonal form stresses on the regulation of function and the details of skin. The thinking of the curving forms stresses on the presentation of architectural forms and the interaction with the surroundings.

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