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Traditional Chinese Furniture Structure and Its Application in Contemporary Furniture Design

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Abstract- This paper focuses on the Chinese traditional furniture structure, including the basic characteristics of mortise and tenon structure, and the application of mortise and tenon in traditional furniture, such as tapered locking tenon, mitred mortise-and-tenon frame, embracing shoulder tenon, bottom frame. Through the study of traditional furniture structure, the author's research team designed three pieces of works, the triangle stool, the clothes rack and easy stool. It is an attempt to apply the mortise and tenon structure, and explore the application of traditional furniture culture and art in contemporary furniture design which expresses the respect, inheritance and development of traditional furniture.

Keywords- *Traditional Furniture, Furniture Design, Inheritance*

I. INTRODUCTION

Chinese traditional furniture has a high artistic attainment. It is important how to inherit and develop the artistic charm of Chinese traditional furniture, make it integrate with contemporary art design, and form furniture design style with unique Chinese cultural characteristics. This is the theme that contemporary Chinese artists and designers have been constantly exploring to form modern furniture design style with unique Chinese cultural characteristics.

Our team, belonging to North China University of Technology, is devoted to this research. There are two forms of furniture design practice in the system of curriculum and education: the first is the experimental course and curriculum design of furniture design listed in the syllabus; the second is all kinds of extracurricular experimental projects, such as open experimental project set up by the university, the scientific and technological activities and the entrepreneurship projects for students. Extracurricular experimental projects often supported by the certain finance resources, which help students to complete the design extremely. In the practical teaching of furniture design, it is explored the redesign of the structure of furniture, mortise and tenon structure and so on. The first step is to learn traditional culture and art of the furniture and know the background of the furniture. The second step is to measure, analyze, draw, saw, mill, install, etc., and the students begin to learn the basic knowledge of Chinese traditional furniture. The third step is to separate the mortise structure and redesign.[1]

From the following several cases, it is illustrated the specific methods and achievements of research and teaching of Chinese traditional furniture design.

II. ANALYSIS OF THE STRUCTURE OF TRADITIONAL FURNITURE

Chinese traditional furniture is not only beautiful in shape and charming in decoration, but also exquisite in structure. On the one hand, the mortise and tenon is soul of structure, which embodies the essence of Chinese traditional furniture. On the other hand, traditional culture and art provide rich nutrition to the mortise and tenon. Mortise and tenon structure changes endlessly, forming the basic structure of furniture, supporting the form of furniture, so as to show its artistic characteristics.

A. Characteristic of Mortise and Tenon

Mortise and tenon is a major feature of Chinese traditional furniture structure. Mortise and tenon is a concave-convex connection method used on two or more wood components. The protruding part is called tenon; the concave part is called mortise (or mortise groove). When the tenon is inserted into the mortise, the mortise and tenon grip and play a connecting role (Figure 1). This is the main connection of ancient Chinese architecture, furniture and other wooden components. Although each component is relatively thin, it can withstand tremendous pressure as a whole. This structure does not lie in the strength of individuals, but in the combination and support of each other. Mortise and tenon is an ingenious combination wood part of more and less, high and low, long and short. It can effectively restrict the twisting of wood parts in all directions. Therefore, it is a very scientific way of connection. Its characteristics have three aspects.

- Mutual complementarity and interdependence

The mortise and tenon is concave and convex, which reflects the balance of Yin and Yang in the traditional culture and social order of the ancient society. Tenon is Yang, and mortise is Yin. Mortise and tenon contains Yin and Yang, which virtually complements each other, mutually reinforces, restricts and balances each other.

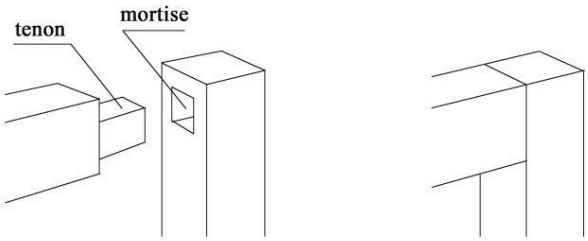


Figure 1. Mortise and tenon

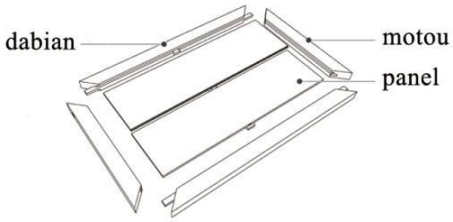


Figure 2. Frame structure

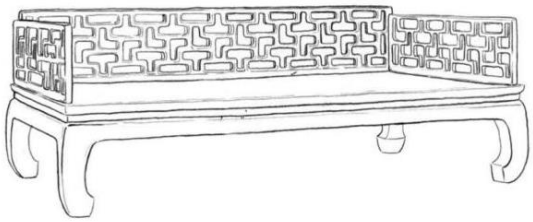
The mortise contains the wisdom of mechanics, aesthetics and philosophy. In furniture, it presents the mechanics between entering and retreating, the aesthetics between concave and convex, and the wisdom between mortise and tenon.

- Accordance with natural environment

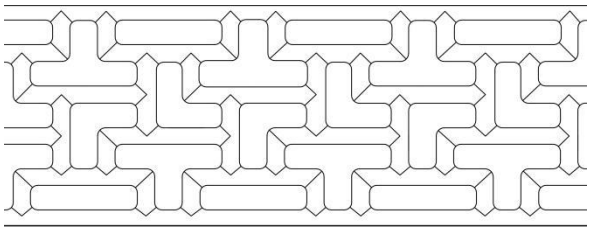
In the production of traditional furniture, cabinet-makers understand the wood properties such as the best features and defeats, and learn to control it. The phenomenon of shrinkage and swelling of wood, make wood changes in seasons, obviously in summer and winter. How to dissolve the properties of wood in furniture processing? Cabinet-makers give a wisdom answer. They have designed framed and panelled construction (Figure 2), which is stable, not susceptible to shrinkage or expansion. No matter how the climate changes, grooved on the inner edge can ensure that the board is flat and not deformed.[2]At same time it provides an excellent support for the panel. So it is often used on large area of board, such as stool seats, chair seats, table tops, cabinet doors etc.

- Efficiency

When wood is processed, it is cut according to the shape. It inevitably produces small materials, and cabinet-makers make small materials together to form patterns using mortise and tenon, which is called cuan by Beijing cabinet-maker. Generally speaking, craftsmen design the small materials into the large geometric figures. Horizontally and vertically, small materials can easily be lengthened to form a large area of patterns, which can be used to decorate different areas of furniture. Figure 3a shows low-back bed with a three-panel-screen-form back using a lattice work of angular form in a right-angle pattern. The back and side panel is assembled from short horizontal and vertical pieces with round edges(Figure 3b). The tight-angle style of latticework is really amazing, because the mortises and tenons on joints are carefully planned and balanced by cabinet-maker, who takes into account the final appearance of form.[3]



a Low-back bed



b Latticework of back

Figure 3. Low-back bed with a three-panel-screen-form back

Mortise and tenon is the soul of Chinese furniture. Between mortise and tenon, they condense the essence of Chinese traditional furniture culture for thousands of years.

B. Mortise and Tenon Structure of the Zodiac Chair

Zitan wood waisted armchairs with burl wood inlayed twelve zodiac animals, (Figure 4 abbreviated as "Zodiac chair"), which is the classic Beijing furniture handed down from Dan Ning Hall in the Summer Palace. “I am convinced that these armchairs are part of an original set of twelve, one for each zodiac character”[4]. Unfortunately, only the tiger and sheep carved in relief on chair back are preserved. The Zodiac chair is a three-panel-screen-form back armchair, also known as Taishi chair. The main frame made of zitan which is matched with the panel of back and arm carved zodiac by beautifully burl. Burl is natural hemispherical outgrowth or a knot usually at the base of a tree. There are some fine and circular grain burl woods known as wenmu or yingmu. It has been prized since ancient times for its beautiful looking.[5] The zitan and burl of zodiac armchair complements each other.

Figure 4. Zodiac chair

Figure 5. Structure of Zodiac chair

The structure of the zodiac chair is exquisite and worth to study thoroughly. According to the basic form of the traditional chair, our team analyzed and duplicated the structure of the zodiac chair. Figure 5 shows the composition of the zodiac chair clearly by axonometric drawing. The structure of zodiac is described below including back and armrests, seat, waist, leg frame and bottom frame.

The connection between the back, armrests and the seat surface uses tapered locking tenon (Figure 6). The structure should be push and lock by two components, so it also called the running horse tenon. The tenon is large on one side and small on the other side, and the mortise is cut large on the one end and small on the other end. The tenon is inserted in the large end of the mortise and slide to the small end of the mortise, so that tapered locking tenon is secured. Tapered locking tenon is planted on the bottom of the armrests of the zodiac chair. A mortise is chiseled on the seat to cooperate with it. The two components can be locked by the armrest downward. If you need to disassemble, just push back the armrest, and back to original position and the take apart.[3] Tapered locking tenon has the advantages of free disassemble and assemble. It has reference significance for the flat design of modern furniture.

The seat is showed by Figure 2 that the four members form mitred mortise-and-tenon frame. The two long members of the framework with tenons are called dabian, and the shorter and mortised are called motou. The inside edge of framework is grooved on all sides, so the panel can be inserted. Under the groove on the inner edge of the tenoned member, mortises are cut for a dovetail batten. It can completely hide the end grain of panel which is dark, dull and unattractive. And the beautiful long grain can be visible.[3]

The connection between the chair seat and the leg frame mainly depends on a long and short tenon of embracing shoulder tenon, which is blind mortise and tenon joint with a tapered dovetail wedge (Figure 7). Embracing shoulder tenon are inserted into the mortise of framed and panelled construction. The waist is matched with chair seat and apron. In order to ensure that the apron, waist and seat surface are firmly and stably tied together, the embracing shoulder tenon joints are slightly weak. A wedge groove with top large and bottom small and narrow inside and wide outside is opened at the middle position of the waist, and they are connected by pins. The pin is pushed up tighter and tighter, and the tenon reserved at the top is inserted into the mortise under the chair surface. [3]The number of pins can be set according to the width of the seat surface, usually one on each side.

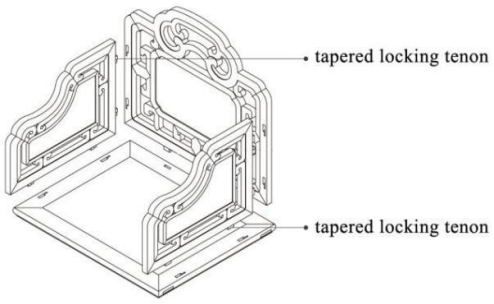


Figure 6. Tapered locking tenon

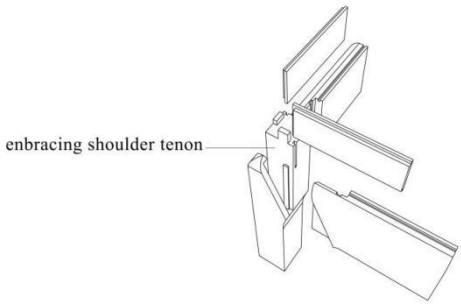


Figure 7. Enbracing shoulder tenon

The leg frame is the joints of the chair seat, and the bottom frame, which is the combination of the horizontal and vertical components. These complex tenons and mortises make furniture components bite each other, forming a stable and solid structure[6].

Bottom frame is the frame that undertakes the legs of a chair. The method of bottom frame is to use the mitre to form a frame, and it is similar to the method of chair seat, except installed panel. [7]There are feet of chair underneath the bottom frame, which are connected with the bottom frame by pins to avoid the corrosion of the ground moisture to the bottom frame and chair legs (Figure 8). The legs, feet and bottom frame constitute a complete frame, thus a strong chair is formed.

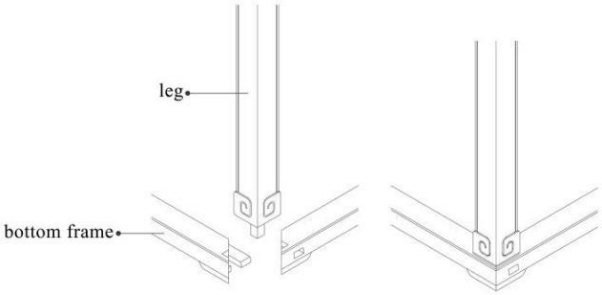


Figure 8. Bottom frame

The original intention of duplicating the zodiac chair was to learn the mortise and tenon in traditional furniture. However, after the completion of parts production, we thought if the

normal installation of the zodiac chair was proceeded, the relationship between mortise and tenon structure was hidden. For learning and displaying purposes, the hiding structure would not achieve our original study goal. In order to display the structural characteristics of the mortise and tenon of the zodiac chair better, the team compared various schemes and decides to deconstruct the duplicted zodiac chair. The back, armrests, seat surface, waist, leg frame, bottom frame were separated and adhered to the transparent supporting materials with seamless glue, so that the overall structure of the furniture could be clearly displayed(Figure 9-10).The transparent supporting materials were chosen to be glass, although glass is relatively heavy, it had good transparency. This display was easy to be reversed back to the components. The connection of the components was easy to assemble and disassemble, so it's convenient for transport, display and storage.

Figure 9. Duplicated Zodiac chair

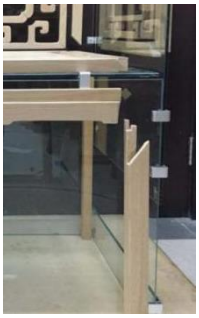
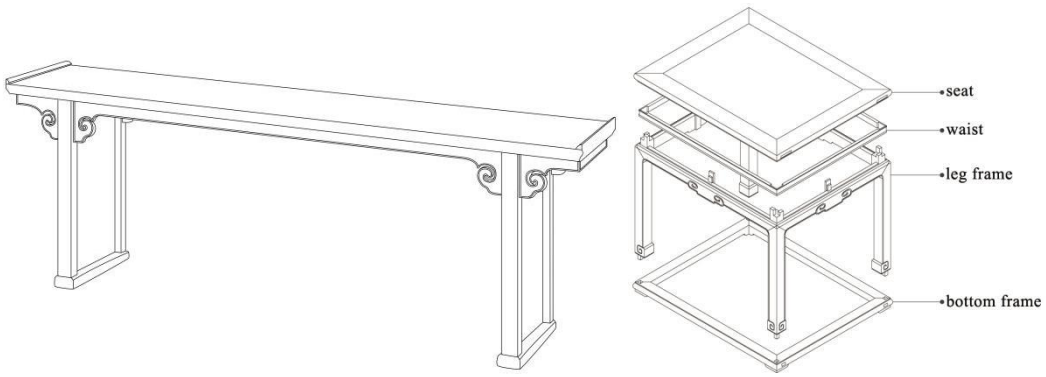


Figure 10. Structure of Zodiac chair

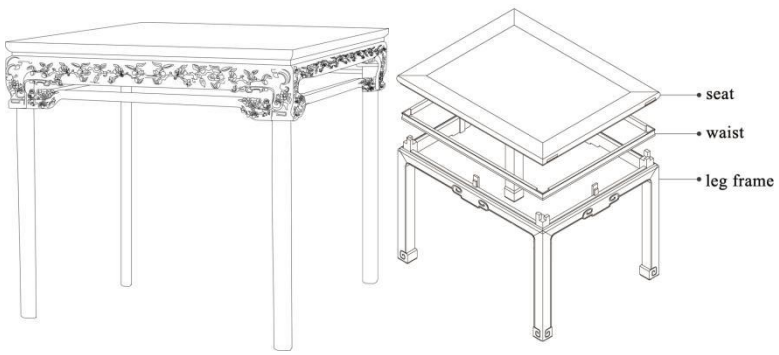
C. Expansion of Zodiac Chair Structure

The Zodiac chair uses mortise and tenon to connect back armrests, seat surface, waist, leg frame and bottom frame. Mortise and tenon has certain flexibility and stability. If the back and armrests are removed, the remaining four parts can form the basic form of the stool and table (Figure 11 a). In fact, the structure of the stool and table are same, except the height and the size of tabletop. If the shape of the table or stool is simplified, only the seat, waist and leg frame will be retained, and a table or stool with waist will be obtained (Figure 11 b). The legs fall the ground directly and neatly. If the waist is removed, the seats and legs are framed with a waistless table or stool (Figure 11c).

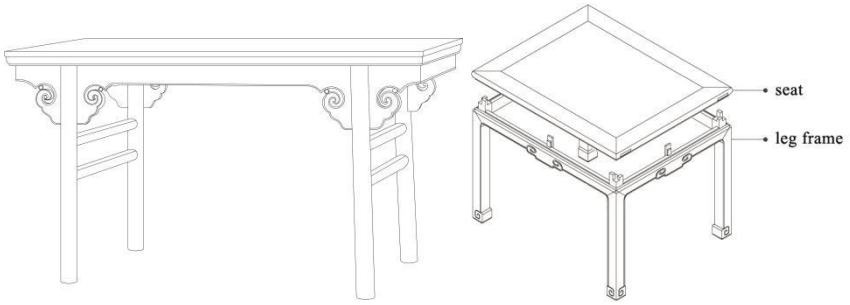
A basic form can constitute variety of types and forms. The redesign, boldly omitted the details of sculpture and pattern, refine beautiful lines and concise form.



a Waist and bottom frame table or stool structure



b Waist table or stool structure



c Waistless table or stool structure

Figure 11. Expansion of Zodiac chair structure

a Triangle stool b Frame structure c components

Figure 12. Triangle stool

III. REDESIGN

It is important to inherit the artistic charms of Chinese traditional furniture by integrating with contemporary art design concepts. Using all kinds of wood materials, and corresponding redesign to the traditional structure, it would generate a variety of design schemes. The following three design cases from our team, the creative practices are our understanding and expression of mortise and tenon in modern Chinese furniture design.

A. Triangle Stool

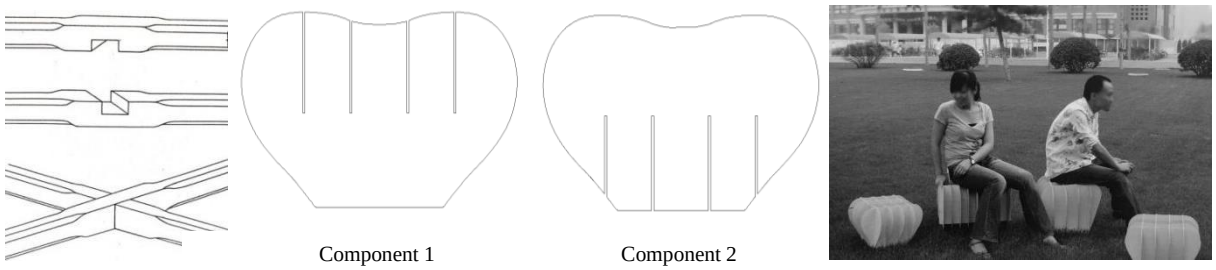
The triangle stool in Figure 12a is composed of two parts, the stool seat and the support. Referring to the mitred mortise-and-tenon framework of traditional furniture, the stool seat of triangle is designed by the frame structure (Figure 12b). The support is composed of three wooden components. The mortise and tenon is made in the middle of the components. By using the occlusion of the mortise and tenon of the three components, smooth and seamless surface of the joints is formed. Without other auxiliary materials, it is completely supported by the connection of its own structure. After turning the key component, space should be reserved for the mortise and tenon of the other two components to facilitate disassembly (Figure 12c). This idea also inspired by the design of Luban lock (It's very famous structure in Chinese design history)[9]. When the stool is disassembled or assembled, it is just like playing with a big toy. When it needs to be stored, the mortise and tenon structure can be disassembled into several parts without other auxiliary connectors, which is very convenient.

B. Clothes Rack

The overall structure of clothes rack in Figure 13a applies the principle of three points to determine a plane. It optimizes the characteristics of three points to form the minimum points of the plane, and determines that the design scheme by using three rods to form a stable triangular structure (this is also the design principle of the tripod, Figure 13b). Fig13c is fixed part that also made of mortise and tenon joints. The three supporting rods are inserted directly through the holes above the fixed part, and the three supporting rods are staggered to form a stable structure (Figure 13c). There are six parts in the clothes rack, which need not be assisted by other connectors. They are connected and fixed by mortise and tenon.

a Clothes rack b Tripod c Fixed part

Figure 13. Clothes rack



a Cross strucure b Drawing of easy stool c Assembled easy stool

Figure 14. Easy stool

C. Easy Stool

The easy stool is inspired by the cross structure. Cross structure composes the X-form stretcher of traditional stool, which is kind of mortise and tenon. This structure is made of removing the half thickness of material from that part of both components where they intersect. When the components are attached, the form gains the thickness of a single component(Figure 14a). Easy stool is composed of two kinds of components. In fact the outline of two parts(Figure 14b) are same, and the cross structure just like Figure 14a. By using the occlusion of the cross structure of the four components 1and four components 2(Figure 14b), smooth and seamless surface of the joints is formed (Figure 14c). It is also completely supported by the connection of its own structure and easy disassembled, just like triangle stool.

IV. Discussion

Chinese traditional furniture has not been forgotten with the passing time. On the contrary, under the background of the development of modern art theory, ergonomics and material science, it provides designers with more design sources and imagination space. Its inherent cultural gene and artistic charm are being more widely disseminated. In practical teaching, we help students make full use of the opportunity to learn from traditional art and complete the modelling. It is consistent with the quality teaching advocated nowadays[8].

A. Core of Traditional Spirit

The structure of the traditional furniture not only embodies Chinese wisdom and aesthetics, but also displays the implicit culture characteristic and traditional spirit. It is from traditional culture and spirit that we explore the relationship between traditional and contemporary furniture design.[9] The traditional culture and spirit express the forms and techniques in different levels, which can guide contemporary furniture design. The deeper we understand the traditional spirit, the more we can get rid of the shackles of the existing forms. Referencing and learning traditional furniture will reduce the limitation of restricting thinking of designer. When we grasp the core of traditional culture and spirit, we can embody aesthetic spirit, various and changing art form[10].

B. Structure

The structure of traditional mortise and tenon was complex, which was mainly made by hand. If contemporary furniture design is kept the structure wholly intact, it is not only complex in technology, but also time-consuming and labor-consuming, which can not meet the demand for purchasing power. So applying traditional furniture structure to contemporary furniture design, the design of structure should be reasonable, safety and simple in processing[11]. The simplified structure should meet the facts that the furniture is easy to assemble and disassemble, based on the structure from traditional furniture. And the features of mutual engagement and mutual restriction are preserved. Mortise and tenon is a magical operated connection that can joins completely invisible structure, or can reveal the structure or beautiful patterns, which give somebody limitless reverie. During the assembled and disassembled furniture process, it is appealing just like playing game.

C. Materials

Generally speaking, the material of high-quality traditional furniture is famous and precious, such as Zitan, Rosewood. Today as shortage of precious wood, it is more important for us to develope sustainable design in order to protect the environment. There are three kind of woods will meet the demand. The first kinds ofwood is certified by the Forest Stewardship Council (FSC), which regard as sustainability because the wood is being managed in a way that preserves the natural ecosystem. The second kind of wood is modified wood or wood-based panels including plywood panel, particle board and fiber board. Reducing of wood resource stress, modified wood is also regarded as sustainable materials which is the third kind[12]. The materials of three design cases from our team used those kinds of woods.

V. Conclusion

In this paper the characteristics and structure of mortise and tenon are studied. And the works which application of mortise and tenon are introduced such as triangle stool, clothes rack, easy stool. It can be concluded that the structure of Chinese traditional furniture expresses the wisdom of the Chinese people. Exploring the tradition and its reproduction in contemporary furniture design is rooted in our deep love for Chinese culture

and tradition. Innovating the style of traditional furniture is the original intention of our research on traditional furniture. Furniture design is the process of expressing ideas, and every piece of furniture comes from a need and a concept, which is the origin of design ideas. Design is not just a simple shape, but a re-understanding of life, and a perfect combination of beauty and function.

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