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Bridge DNA

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Rochester Institute of Technology
A Thesis Submitted to the Faculty of
The College of Imaging Arts and Sciences
School for American Crafts
In Candidacy for the Degree of
Master of Fine Arts
Furniture Design

BRIDGE DNA

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I. Abstract

This thesis work centers on the relationship between bridge structure, construction methods and timberwork, coming from the processes of design and manufacturing. In this thesis, I intend to discover and develop different characteristics of different structures and materials and create works that are visually powerful using different visual languages. I began to learn about bridge design after I started working full time after graduating from university. During that period I was involved in the creation of several bridge designs and obtained experience as a builder. The bridge that I helped to design and build during that period is still one of the largest and most important works for me. Since the experience was so influential I planned to apply that exceptional experience in designing furniture and creating unique works in my graduate program.

In my work, the process of research and design is as follows:

1. Start with the foundations of bridge structure
2. Ensure reasonable structure is embedded into design
3. Receive feedback, determine problems and limitations
4. Continue designing and find the best ways to settle problems and address limitations
5. Develop structural forms and apply them to the next projects

Through my thesis work, I carried out interactive creation through observing, investigating and probing the possibilities of applying different bridge structures to the building of furniture.

II. Discussion of Sources and Research

My research concentrated on the method of embedding bridge structure forms into furniture design. Long before I started pursuing my career in design, I was a music lover. Although music set the foundation for my design to a certain extent, I found that arrangement and composition in music belong to two different worlds. For popular music, arrangement is important because most essential structures of songs are identical. Arrangement not only makes music richer, but can also make songs with the same elements sound different. When arrangement is used in the design world, it is a technique used when applying decorations that could make an object look and feel different and better. As for composition, the most elementary and original demo is composed of three elements—melody, chord and rhythm—and it determines the core value of each song. Going back to design, function is the melody, determining the pattern of an object; appearance is the rhythm and is determined by function and style of the object while structure is like the chord that holds up both function and appearance. However, a bare structure without any decorations could be directly used and taken as the appearance of a piece of work, like a bridge. Even though bridges have no or only very minimal decorations, people still think it is beautiful. Because budget plays a large role in bridge design, it requires the designer to use the least amount of money to achieve the best effect. In addition, a bridge should stand the test of time, and any waste of materials should be avoided. Being budget cautious can be achieved by selecting an approach that is the most structurally effective in terms of building and by using materials that are available at the lowest cost. The economic structural composition should also make people feel the beauty of a bridge without sacrificing its functionality.

In this study, I selected the steel-structured bridge as my main research topic. The steel-structured bridge has both advantages and disadvantages that I will consider in my furniture design.

5 advantages:

1. Long span: The steel-structured bridge can support a longer span than any other type of bridge, thus when the need is to connect to a distant land or over water, a longer span steel structured bridge is adopted.
2. Lightweight: It has a lighter-weight static load, so it is applicable to various foundations as well as forms of furniture, with a lower requirement on the construction environment.
3. Higher vibration tolerance: The structure features a greater strength and easy absorption of vibration when force is applied. Also, it can disperse forces when that

occurs.

4. Beauty: Steel-structured bridge has various beautiful patterns.
5. Convenient for construction: It's easy to build and it is fairly easy to add extensions. Jointing parts of the structure is also straightforward.

It also has several disadvantages:

1. Easy to be bent: Attention must be paid to the slenderness ratio and the lateral strut.
2. High level of expertise required: A higher degree of precision is required in construction compared to other bridge structures.

I borrowed lessons from my experience in architecture, which I learned during my university years, for my research. Also, as previously noted, I gained very important knowledge during my experience designing bridges, which was also very helpful for my research. In the following sections, I'll start by introducing the two elements—materials and truss—that are going to be used in my study.

1. Materials

In this study design, I vertically placed the material top-down. The vertically downward force from the upward side becomes pressure, a force that can easily damage material structures. The material is pulled upward and downward at the same time to obtain tension. PIC1 is a material that is strong and durable. If the material is shortened by applying a force, it will obtain increased strength in compression, while having no impact on the strength of extension. I take pressure and tension into consideration when designing a project. Specifically, when the batten is under pressure, the span will be shortened; and when the batten is under tension, the span will become longer.

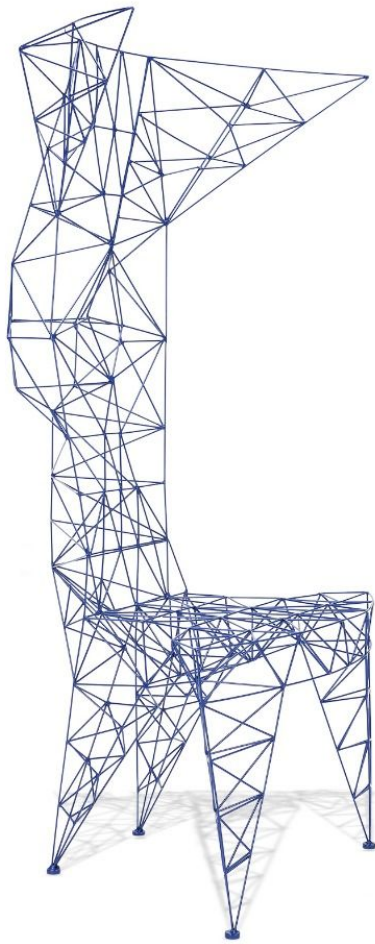
2. Truss

When building a bridge, there is a commonly used construction called a truss. A truss is composed of triangular frame units in serial connection, and it is applicable to long-span structures such as bridges, high towers, and crane jibs. Considering when under stress, a rod piece only transmits tensile force and pressure if an external force acts on a node. Also, to prevent distortion of the structure, the frame structure must be triangular. So, after analyzing the structural body and the joint connection of bridges, I tried to embed and develop them in timberwork.

[1].Weiwei Lin, Teruhiko Yoda. Bridge Engineering: Classifications, Design Loading, and Analysis Methods. May 2017. Print page12- 43

My current design is affected by Tom Dixon's work. Inspired by bridges, towers and

space frames, Dixon designed a chair named Pylon for Cappellini in 1992. He used steel wires to construct multiple triangular frameworks in the pattern of a fiber network and then piled them up to obtain the shape of a chair. Bridge structure is mostly composed of triangular forms as the basic elements. However, as the bridge should have the function of crossing over the barrier with one passageway connecting two places, it is also the extension of the road. As per its purpose, the bridge is designed to carry weight. Then, a parallel structure is adopted along with a deck as the structure under the road surface. Triangular structural bodies are mostly at the two ends. Furniture is different from bridges in that its load-bearing structure is from multiple directions rather than a single direction such as from the top of the structure. For example, the chair directly bears the sitter's weight from the top and the backrest supports the force when the sitter lies on his back. It also has to bear the wag from side to side caused by the sitter's movement. Pylon has had a significant influence on my ideas of three-dimensional spatial structure when taking different forces that are going to apply to a piece of furniture into consideration.



Tom Dixon, Pylon Chair, (1992). [2]



Tom Dixon, Pylon Chair, (1992). [2]

III. Critical Analysis

Before I started designing my first work for this thesis project, I studied different types of bridge structures and tried to bring them into my design. The first piece was originally designed as an armchair, with the bridge as the guiding concept, and all the materials are 1" by 1" battens, with four feet on the ground, and using planar triangular structure as support at the armrest and back. However, discussions with professors made me realize that the significance of the bridge structure was lost in this configuration as a bridge does not need so many supports. Meaningless structure with too many decorations is against the core design of a bridge which needs to be economic as well as practical. This made me rethink what is the core in my idea, taking the bridge as my guidance.

Bridge Coffee Table

My first design was a coffee table that could be used in front of a sofa. The main structure is in a horizontally positioned cross form. The tabletop is in a diamond shape on the main structure. A triangular matrix is used as a vertical structure, like the armchair studied before. All components are in two major components: $\frac{3}{8}$ " by $\frac{3}{8}$ " battens and round plates made by $1\frac{1}{2}$ " plywood used for connecting parts. The connecting angles of all the battens are different. Connecting a round board to the battens of different angles does not seem

abrupt, and can create a sense of wholeness. I selected walnut as the connecting plate material to highlight this connection. Meanwhile, I used glue and screws as my connection materials. Considering the vision and intensity, I have set some rules. Specifically in my design, there are at most four screws on one connecting plate, and glue is used for other connections so it does not seem crowded visually and it is convenient for construction. Screws can be directly used to fix the major glued parts, like clamps, and misplacement seldom occurs if this method is applied. I designed several different structures using the same approach and put together the first table according to these structures.

The main function of a bridge is to cross terrain like a valley or a river with the main supporting beams standing on the ground of two ends. It has to be a planar geometry so that transporting goods or people is possible. Essentially, the difference between a bridge and a piece of furniture is that furniture is movable with no fixed connection to the ground. From that, I put the whole structure of the bridge upside down, and made the ground become the tabletop, while the steel cable and support on it became the structure as table feet. I found several problems after the completion, mainly the downward bearing capacity was enough but the table would wobble during use, just like a bridge. The use of screws as a connecting method for a bridge is for resisting earthquakes and wind. Hence, when a bridge wobbles, these connections will help to disperse or absorb kinetic energy and prevent material from fracturing. However, furniture is made for people to use in everyday life, so when applying these special functions to a piece of furniture, some problems occur. When the table wobbles, drinks on top of it might spill, for example.



Bridge Coffee Table, Maple and Walnut, 75" L x 23" W x 18" H, 2016

Bridge Chair

In my first design, I showed the nature of the bridge, but I did not translate it into the form of furniture. With this experience, I started my second work: a bridge chair. The appearance of this work is derived from my previous work, *Fast Chair*, which was one of my class projects created in 2013. I readjusted the size and angle to make this chair ergonomic, rearranged all the battens, and abandoned all redundant structures and decorations. In order to increase its bearing force, I also added a triangular structure under the chair surface. Unlike my first design, *Bridge Coffee Table*, this chair is not at a vertical level, and does not consist of simple geometric shapes. Because of the many different complex angles and structural requirements, I added different elements in my design. From the longitudinal view, I cut the battens into different shapes, including the ladder shape, diamond shape, “T” shape and “L” shape. I redesigned it based on people’s needs such as cutting the back and the bottom of the seat surface into a cambered surface, and designed a downward bending at the seat and back to make it comfortable for sitting. For the round connecting plate, I used maple as my material so that the overall structure became the visual focus.

With the completion of the second design, I had succeeded in designing the chair with the spirit of a bridge. It is very light in all aspects: both visually and from a weight perspective. It has no superfluous decoration and relies on the structural design to show its charm and beauty. Additionally, it can carry a weight of two hundred pounds or more.



Bridge Chair, Maple, 24” L x 18” W x 38” H, 2016

Bridge Console Table

In the third design, I took into consideration whether the object I created could be more practical and user-friendly instead of focusing only on demonstrating the unique sculpture. I also put one of my own passions into it. As mentioned at the beginning, I fell in love with music a long time before moving into furniture design. As a result, many of my designs are based on music and incorporate some elements from music.

I have a collection of more than 500 CDs and I wanted to make a design for storing the most important 30 CDs. I wanted a unique space that can accommodate 30 CDs and a table top, so that I can put the CD boxes on it as I select which one I will listen to. The table should be big enough because I'm accustomed to taking out several CDs and playing certain songs uninterrupted. Ideally it has two areas, one for the CD that is playing or those have been recently played, and the other for the CDs that are going to be played.

Since I had learned from designing the first table that furniture should be used by everyone and anyone rather than a pure demonstration of design In my third design I abandoned the fence tabletop design of the first table, and used flat plywood for both tabletop and box itself. The pattern of plywood overlapping conformed to my structural design visually. In the principle of wood, the problems arising from wood extension caused by climate change can be avoided. I planned to show the strength and beauty of the structure from the whole form, so I designed a big table composed of several large triangles. Then I used the triangular structure as support on each plane. I designed a tetrahedral box with penetrability so the structure behind the box can be seen. I also installed a stop at the bottom of the internal box to prevent CDs from dropping out, and used the same plywood material and structure for one of the corners of the table so that the user won't be affected by the structure of the triangle.

In the third design, I succeeded in putting my ideas into practice conceptually and practically. Complex structures can show the power of structure. Visually, it can show the uniqueness of the concept and it is light and firm at the same.



Bridge Console Table, Maple, 60" L x 24" W x 47" H, 2016

IV. Conclusion

My aim was to use all the works and structures that I have created to link all my designs. The minimum components I had designed are linked and by connecting all the components in a certain pattern, I was able to demonstrate and present my topic: In the first design, I followed the basic components of bridge design and developed a unique three-dimensional structure. In the second design, the complexity was increased due to the structure and support requirements so I developed basic components and made them correspond to complex angles. With the first two projects, I came to the realization that the basic components I designed can mitigate the potential limitations and be developed into a new structure. In the third design, I tried to ignore the rules and go straight to the design, then modify the components according to the design requirements to make them conform to the design.

During the process of design, my goal changed. At first, my goal was to create the work with bridge DNA, and then my goal changed to utilize bridge DNA help me develop my

work. This shift in goal took place organically. At the early stage, I focused on the work with bridge DNA, put too much of my experience into the work and tried to connect my experience to my work, which was stiffly reflected in the stiffness of my early projects, and resulted in several limitations. The characteristics of a bridge were imposed on the furniture so the structure was reasonable, but not natural. In my later works, a more appropriate process was established. I focused on the most important things in the process, thus the characteristics of a bridge were naturally presented, making the work conform to the theme of bridge DNA.

For me, a piece of furniture is a miniature building. I had obtained different types of professional knowledge and in the future, I will integrate this knowledge and make it the core of my creations. From music to building and from building to furniture, structure is the language that I use. I am passionate about gaining more knowledge and contributing to multiple areas of furniture design. I will use my knowledge to create unique designs and then apply these designs in different areas that I am going to explore in the future. During my architecture and interior design period, the biggest problem that I perceived is that there is a very few communications and interactions between different but somewhat related professions. There are not necessarily good buildings to match good urban planning, good interior spaces in good buildings, nor good furniture to complement good interior spaces. I plan to make good furniture to match good interior spaces and to develop original concepts. My goal is to continue to accumulate professional experience and myself become the bridge between different areas.

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