

Introduction of Wooden Kagome Structure to the Furniture Design¹

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ABSTRACT

This study is carried out to introduce the concept of Kagome structure as the new trial for the furniture design and the feasibility of its utilization in furniture industry. Kagome means originally the two dimensional bamboo-basket woven pattern that is composed of interlaced triangles whose lattice points each have four neighboring points, which was used in traditional bamboo craft design like 'Jukbuin(bamboo-wife)'. Its unique truss structure has been widely used by many kinds of the domain of science and engineering in mechanical and architectural industry with some merits, i.e, material utilization efficiency and robust strength. Here we tried to introduce two dimensional and three dimensional form of Kagome which are supposed to be a furniture design elements. Authors think these Kagome design could be realized with domestic lumber of inferior properties. Both of them would be used as a decorative element or mechanical supporter in furniture design.

Keywords: Kagome structure, Wood furniture, Domestic lumber, Truss structure.

1. INTRODUCTION

Design plays such an important part in the practicability and beauty of a piece of furniture. Three things of primary importance must be considered in designing any piece of furniture. They are utility, strength, and beauty. When any furniture has these three qualities, it may truly be said to be well designed.

Utility in furniture design could be gained by adopting the definite need in the home and perfect harmony in design, material, and color with the other furniture. It should be also of suitable size and style so it will fit into its place in the room in a natural manner and be conducive to comfort, efficiency, and good living, and the design should sincerely express the purpose for which the furniture is intended to get the utility.

Furniture should be strong, It should be planned to last, not only through a lifetime, but for several centuries. The designer must know all about joints and about methods of bracing and fastening pieces together so as to get the sturdiest possible construction. This would be a comparatively simple matter if important element of beauty could be ignored. But beauty is the essential element giving value to furniture.

Beauty is of paramount importance in furniture. Anyone who is handy with tools may build a table or chair which has a maximum of utility and strength. But strength is not all that is desired in a

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piece of furniture. Beauty is the more desirable than strength or utility. People seek beauty in their architecture, in their automobile, in their furniture, and pay higher prices to get it. Beauty is the greatest factor in determining the value of furniture as well as of many other things.

We have decided to try the new approach to get these qualities using domestic lumbers which have some defects such as small diameter and cumbersome shape and to introduce 'Kagome' structure to furniture design for the activation of furniture industry.

The Japanese word 'Kagome' has been become popular with the magnetism community in discussing the lattice structure of geometrical spin frustration. Kagome means a bamboo-basket(kago, 籠) woven pattern(me, 目) that is composed of interlaced triangles whose lattice points each have four neighboring points.

As a truss structure, Kagome was first introduced into statistical physics by Kodi Husimi at Osaka University. Husimi's research associate Itiro Sy Ô zi studied the Ising ferro and antiferromagnets on this lattice. Itiro Sy Ô zi(1951) found that the decorated honeycomb lattice turns into a new lattice by star-to-triangle transformation. The first paper on this subject appeared in Progress of Theoretical Physics in 1951. Kenji Kano and Shigeo Naya of the Hisimi group calculated the residual entropy of the Ising spin Kagome lattice in 1953. In 1972, Sy Ô zi reviewed Ising models on various lattices. Subsequent theoretical studies of the Kagome lattice in the 1980s covered effects of magnetic field, randomness, second neighbor interaction, spin freedom, and combination of interactions(M. Mekata 2003).

Here, we want to introduce general idea of Kagome and its utilization possibility as the new design trial in furniture industry.

2. Concept of Kagome truss

As mentioned before, the name of Kagome is from bamboo baskets(Fig.1). Now that bamboo baskets have been largely replaced by plastic containers, the word Kagome may seem a bit old fashioned. Now, let we start to introduce the Kagome from two dimensional form. Kagome is composed of interlaced triangles which means obtained by decorating the hexagonal lattice with a point at the midpoint of each side, joining these points and dissolving away the original lattice. From the Fig.2 you can see the regular triangles and regular hexagons. These triangles and hexagons are arranged in kind of pattern. In other words, the Kagome lattice consists of a periodic arrangement of three sets of parallel planes, rotated by 60° with respect to each other.

From the Fig.3, you can see the three dimensional Kagome. It is a unit of cell. Of course, we can make many kinds of three dimensional unit cells from a two dimensional form. Fig. 3 only represents one aspect. This cell looks like two regular tetrahedrons are upended each other. Or you can just imagine that three lines cross each other in a certain angle(60°). We used a three dimensional unit cell to make a tetrahedral structure which could be a concept design of building or furniture (Fig.4). This tetrahedral is made by arrangement of unit cell of three dimensional Kagome. Also, we analyzed the structural stability(Chung etc 2010). As a lattice structure, Kagome has optimal passive stiffness. The rigid jointed planer Kagome lattice has the required properties for use in high authority shape morphing structures. At the same time, if considered as pin-jointed, any bar can be actuated without resistance(A.C.H. Leung etc 2004).

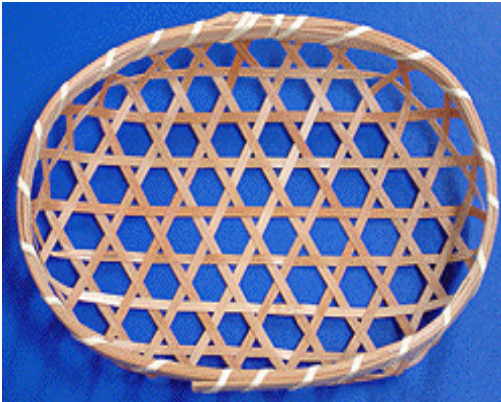


Fig. 1. Bamboo basket woven in Kagome pattern⁵

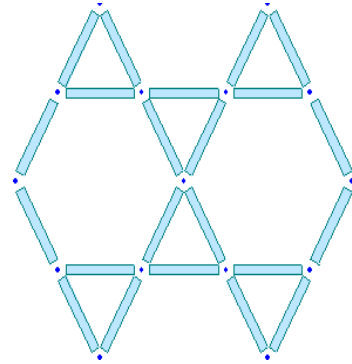


Fig. 2. Two-dimensional Kagome pattern.

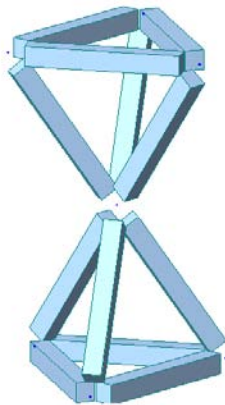


Fig. 3. Three dimensional unit cell of Kagome

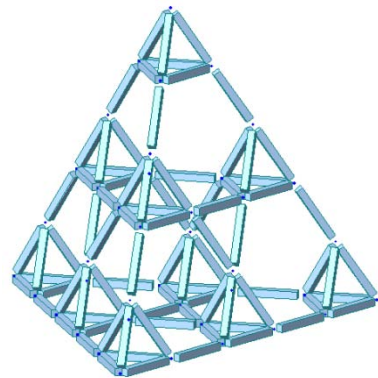


Fig. 4. Tetrahedral structure using three dimensional Kagome

3. Kagome Utilization in Furniture Design

As a truss structure, Kagome is used in engineering, building work by many engineers. Of course, it can be used in furniture industry as a design element which is not only the two dimensional frames but also the three dimensional structures.

Fig.5 shows the two dimensional Kagome frame used in window as a decorating pattern in old China. From this figure we can see that the pattern of Kagome shows balanceable and refinable vision. As a decorative element, two dimensional Kagome can be designed with a blend of traditional designs and contemporary look.

We can use three dimensional Kagome structure to make many kinds of furniture. For example, there are truss furniture, bed mattress, kids' toys etc. Furniture using truss structure is not a new concept(Fig.6). Truss furniture lends a clean, modern look and refined elegance to any room or bar.

As mentioned before, performance of mechanical stability of Kagome is well. So not only as a decorative element but as a mechanical supporter, Kagome can be used widely.

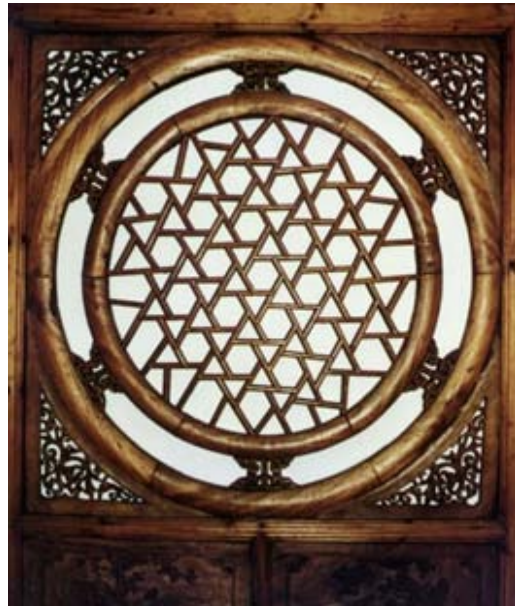


Fig. 5. Window decoration using similar 2 D Kagome pattern⁶



Fig. 6. Furniture using ordinary 3 D truss structure⁷

4. CONCLUSION

In this paper, we tried to introduce the general idea of Kagome structure and pattern characteristics and to suggest its utilization possibility as the new design trial in furniture industry. Kagome is a lattice structure originated from bamboo basket design. Kagome truss has two important benefits comparing ordinary truss structure. One is the frame can be shorter than those of ordinary truss (pyramidal or octa-tetra hedral structure), the other is the higher space efficiency.

Two dimensional and three dimensional Kagome elements can be used by furniture design with aesthetical and structural performance. Consequently, both of them can be used as a decorative element or mechanical supporter for the furniture and other wooden structure.

In the future research, the joint methodology and connector will be studied for the construction of furniture using domestic lumber.

5. REFERENCES

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