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Research Article

A Structural Analysis of A Thai Cylindrical Hexagram Wicker

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Abstract

In this work, we restructure a Thai traditional cylindrical hexagram weave basket to investigate the connecting components, structure volume, along the total length of material used in the finishing figure. We also compare the accuracy of our computational method with actual data in the material total length.

Index Terms: Cylinder, Hexagram, Wicker, Weave Basket.

1. Introduction

Weaving patterns analysis has raised attention in the context of modern textile manufacturing, especially, when the expected production in a mass quantity seems to be more concerned. The efficiency of using valuable raw materials plays an important role in controlling costs. These lead the designer back to grasp long-established traditional weavings elaborately. The cylindrical hexagram wicker is one of the most famous packaging in Thai culture. Even though the patterns are common in different ancient cultures, the cylindrical hexagram woven baskets are still be used in Thai contemporary everyday life.

Chalom is the local Thai name for this type of useful basketry. This particular class of weave is also known as Kagome woven for Japanese. The remarkable aspect of the structure is the self-bracing capacity, shear resistance, ability to locally repair, and potent aesthetic qualities.

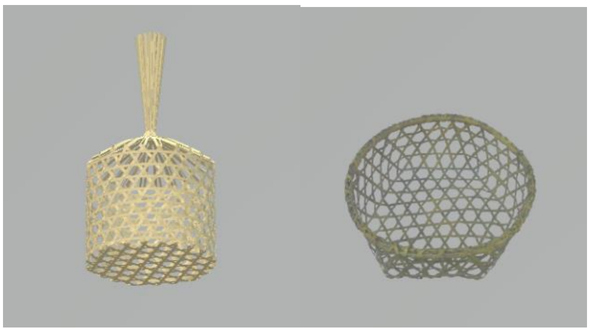

Figure 1: (a) Chalom, (b) Kagome

Researches focusing on these type of wicker were mostly also encouraged by some applications of applied in architecture [3] as well as in fragments manufactured [3], In parallel, there has been studying in a purely mathematical perspective on woven pattern [1,3].

This paper aims to extend investigations to find out the method for computing the total length function of the entire strips using a single chalom, varied by the given size. Finally, we discuss the accuracy of our computational method and offer some perspectives for future study.

2. Fabric pattern

A fabric, as we use the term, consists of two or more sets of "strips" (or "strands") that are "woven" together subject to certain conditions. Our first aim will be to reformulate this statement as a rigorous mathematical definition. According to [1] a strand means a doubly infinite, straight, open strip of constant width, that is, the set of points of a plane that lie strictly between two parallel lines. In a chalom, the geometrical archetype arranges these three sets as a regular trihexagonal.

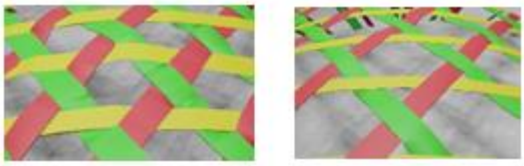

Figure 2: a woven version of a trihexagonal tiling.

The archetypal chalom lattice is a woven version of a tri-hexagonal tiling; the weavers in one direction incline at an angle of $\pi/3$ to those of the other two directions, and the lattice, consisting of equilateral triangles and regular hexagons, will cover an infinite flat plane see Fig 2.

There are two types of the infinite flat plane in this wicker style, a single curvature and a double curvature one.

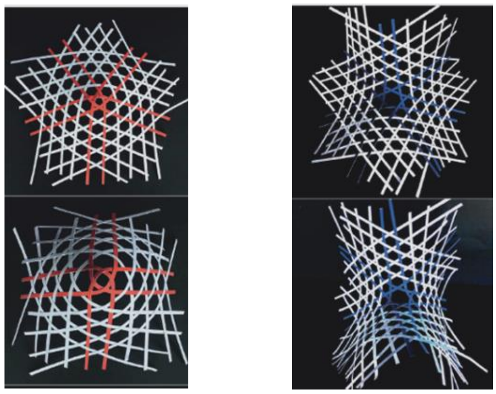

Figure 3: (a) single curvatures, (b) double curvatures

A Single curvature of the lattice is easily achieved by bending the plane, creating a developable surface. If the axis of curvature exists across the center points of opposite edges in the unit hexagon, one set of weavers will act as arches perpendicular to this axis ,see Figure 3(a). Double curvature Breaking topological symmetry of a regular trihexagonal tiling by the introduction of geometric singularities will induce double curvature [2] as shown in Figure 3(b).

2. total Strips-length function

Instead of the pattern approach seen before, this section provides a structural analysis based on elementary geometry. Let $F(R,r,H,h)$ be a real-valued function illustrates the total length for a chalom, where the following variables denotes chalom's parameters as shown in Figure 4:

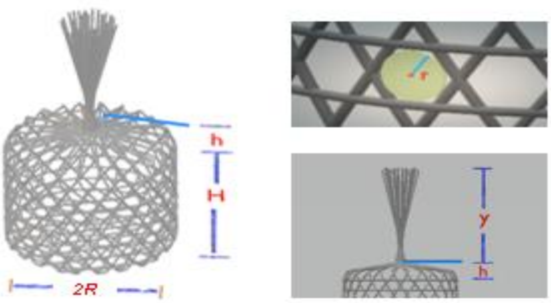

Figure 4: chalom's parameters.

R denote the radius of the inscribed cylinder, r denote the radius of the inscribed circle in each unit hexagram, H denote the height of the inscribed cylinder, h denote the height of the inscribed cone just under the tip of a chalom, y denote the height of the handle beyond the tip of a chalom. These parameters are naturally identified when a chalom was produced. The values of R and H used to adjust the size varied in the volume of the desired container. The values of r used to adjust to be suitable for the size of product contained, mostly fruit and eggs. The values of h and y used to adjust to satisfy the design appearance.

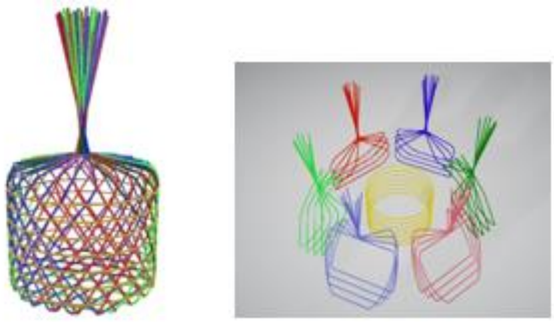

Figure 5: dividing the wicked wires into 7 groups.

The traditional method starts by identifying the volume of the container then considers the gap width between any two strips varied by the size of which to contain. To simplify the weaving process, we consider a strand as a wire and divide the wicked wires into 7 groups: there are 6 similar groups consist of strands continuing from the bottom along the lateral and joining together at the tip of the chalom before becoming the handle for the basket, see Fig 4a. These vertical structures locked each other to another group of strands, the horizontal circular rings, located in the middle position of Figure 4c. We calculate length of each types of the wire groups separately and then combine together to obtain $F(R,r,H,h)$.

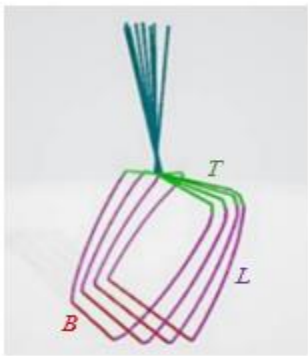

Figure 6: The bottom, lateral and tip of the chalom.

The initial step of weaving always begins with the central hexagon at the bottom of a basket as shown in Figure 7. As the value of r were given, we span numbers of strips from the center with the distance between two of them determined by $2r$. The bottom radius of the chalom is determined carefully by $R^* = \left\lceil \frac{R}{r} \right\rceil \times r$, the least multiple of r that is not smaller than R. This makes the total number of strips expanded in each direction equals to R^* / r, which will be denoted by N.

Figure 7: The central hexagon at the bottom.

Let B be the sum of the length of all strips in the bottom of chalom in each group of strip, see Fig 5, we now compute each strip as a chord of a circle with a diameter $2R^*$, see Fig 8. We have

$$B = \sum_{i=1}^{N} 2\sqrt{(R^*)^2 - \left((i-1)r\right)^2}$$

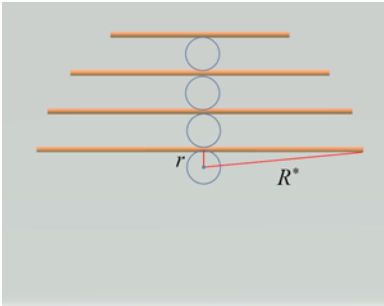

Figure 8: The length of all strips in the bottom.

Next, we consider the length of strips along the lateral, this quantity depends on the given height of a chalom. Similar to the previous variable, we have to adjust the value of H to be divisible by r, that is, we consider $H^* = \left\lceil \frac{H}{r} \right\rceil \times r$ instead. Since in this type of weaver, strip in one direction incline at an angle of $\pi/3$ to those of the other two directions, we can find L, the sum of all strips length in the lateral of chalom in each group of strip as $L = 2N \times \left(\frac{H^*}{\sin(\pi/3)} \right)$, see Fig 9.

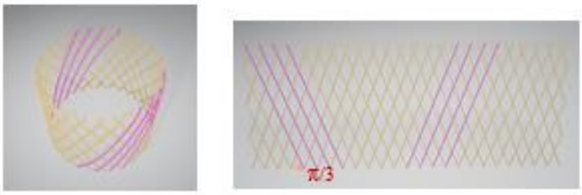

Figure 9: The length in the lateral.

For the part of strips joining together at the tip of the chalom, the computational comes directly from the value of h. We then have $T = 2N \times \sqrt{\left(R^*\right)^2 + h^2}$, see Fig 10.

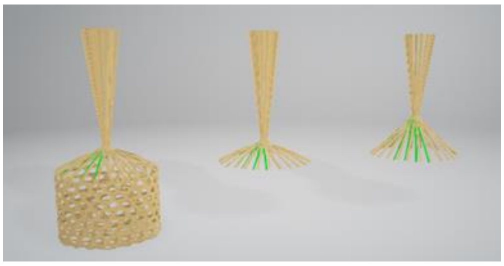

Figure 10: The length in the tip.

The rest is the horizontal circular rings whose number varied by the chalom height, we have the sum of the length of all strips in this group $C = \left(\frac{H^*}{r} \right) \times 2\pi R^*$.

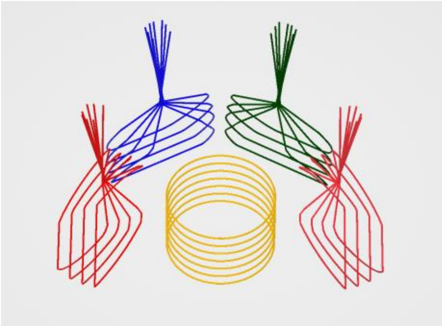

Figure 11: The length in the horizontal circular rings.

Together with the length of the adjustable handle, y, we obtain

$$
\begin{aligned}
F(R,\ r,\ H,\ h) &= 6\times(B+L+T)+C+y \\
&= 6\left(\sum_{i=1}^{N} 2\sqrt{(R^*)^2-((i-1)r)^2}\right. \\
&\quad \left. +2N\left(\frac{H^*}{\sin(\pi/3)}\right)+2N\sqrt{\left(R^*\right)^2+h^2}\right) \\
&\quad +\left(\frac{H^*}{r}\right)2\pi R^*+y
\end{aligned}
$$

3. Model accuracy

To illustrate the difference between the actual data gathering from 6 samples of chaloms and the model that was developed. We present 4 sets of comparison data together with the real chalom strip widths which were regardless in our elementary model. In Table 1, the difference between the average of the total length of samples and the value obtained from our model is presented in percentage error.

$F(R,\ r,\ H,\ h)$	strip widths		
	3 mm	6 mm	10 mm
$F(80,\ 2,\ 150,\ 50)$	6%	14%	26%
$F(86,\ 4,\ 180,\ 50)$	11%	21%	34%
$F(92,\ 6,\ 188,\ 50)$	12%	24%	39%

Table 1: The difference between the average of the total length of samples and the value obtained from our model.

Looking at the information in greater detail, it can be seen that the wider strip widths evaluate the less accuracy of the model. Where the work presented in this paper has limited itself to the assumption of strands that are specific to the wire instead of the strip. Further study on outcomes generated by the strips approaches is poised to be taken forward into this domain of analysis

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