How a Willow Tube Turns Into a Torus

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Abstract

Weaving with willow is an appropriate technique for making volumnious objects. Last year I started making objects with the tube as a starting shape. It is a small step from a tube to a trumpet shape. And while weaving, a trumpet shape can easily develop into a sphere. This paper describes the making of a kagome willow torus.

Figure 1*: Just a matter of copying the other half!*

Introduction

Since prehistoric times wickerwork has been used to make fences and baskets. They became necessary utensils in housekeeping, agriculture, fishing and industry. As a primitive technique wickerwork requires almost no tools but over centuries it developed into a respected craft. Basketry was useful in many ways;

baskets were made in all kinds of shapes and with different types of handles, not only to carry fruits and vegetables, but also upside down to keep bees and as traps to catch fish and ducks. Basically a basket is a tube with a bottom and that makes the tube an obvious and practical three-dimensional shape. Last year the tube became a trefoil knot [1], this time it turns out to be the axis for a torus.

Weaving and Braiding

In wickerwork, weaving is an easy way to make a shape and construction at the same time. That is easily experienced when working with willow twigs, named 'rods'. The flexibility of the willow determines the density of the mesh. Basket weaving does exist because of tension and that is a significant difference with fabric weaving. If a 'willowy' and fine mesh is desired then thin and more pliable rods should be used. On the other hand, sturdy rods creates more tension and the weave will be rigid but coarse. During twenty years of weaving with willow I have discovered different ways of weaving and the use of the clamping technique (Figure 2). In its basic form, weaving is applied in knot making and braiding.

Figure 2: *A sphere consisting of chaotically intertwined twigs by using a combination of weaving and clamping.*

A combination of weaving, braiding and clamping results in a strong grid. In this way a mesh takes on the function of a construction. Simple weaving produces not enough tension for large willow shapes, since a single rod is curved between the upright stakes, like a slalom. But, instead of one rod, two can be used in an alternate way, this is known as 'pairing'. For this technique two weavers cross each other after every turn, but here they intertwine too: every turn the rods change up and down position. This is called: crossed-warp twining. A steady twining distributes the tension evenly in the mesh. For this technique also two or three rods can be used in one stroke (Figure 3).

The pliability of the willow is not only determined by the quality of its wood fibres but also by its diameter. To prevent the rods from kinking or even snapping it is important to estimate the degree of their tension tolerance. It takes practice and love to learn how to bend willow. As willow is a natural material, kinking here and there cannot always be avoided and will not affect the construction. If too many rods get kinked the risk of a collapse increases, which can be limited by using a small bundle of them. In the worst case you have to replace the broken ones.

Figure 3: *'Pairing': weaving and braiding at the same time.*

This technique offers a lot of possibilities in terms of size of the object and structure of the mesh. But a bigger shape requires a more rigid construction. Sturdy rods are needed to get and maintain the desired shape. Weaving thicker, tougher and heavier rods requires physical strength, but above all technical skills. It is somewhat like judo: use dynamics and weight to get your opponent in the right direction! The strength and flexibility of willow is amazing and makes it possible to create large objects (Figure 4). So much for willow construction and shape in general. Back to the tube, the starting point for the funnel, and finally a torus.

Figure 4: *Shape, structure and material is strong enough to support a person.*

Starting With a Willow Tube

The easiest way to start a willow tube is using a template with holes for the upright stakes. Drill holes in circular shape in a wooden plank and attach it to a working table. The number of holes depends on the desired diameter of the tube and the thickness of the stakes. If they are quite sturdy, more spacing is needed otherwise weaving without kinking becomes impossible. By experimenting with the number of uprights in a certain diameter, the correct spacing can be found. I decided to drill 11 holes with a diameter of 1.2 cm divided on a 26 cm diameter circle, which give a spacing of around 7.4 cm. When you start working make sure the upright stakes are slightly thicker than the weavers (Figure 5). During weaving always be aware of the tension and if necessary add an extra weaver. While progressing upwards, you can use a separate template to maintain the desired diameter of the tube.

Figure 5*: The tension of each twig varies.*

From Tube to Funnel

Slowly the tube becomes a funnel by using a willow circle template with a wider diameter than the tube. Divide and attach the upright stakes to the circle with enough space to keep on weaving for a while until the shape is set. More surface is created by inserting an extra rod next to every upright stake of the tube. If necessary insert another series of tension rods and the funnel becomes wider (Figure 6).

Figure 6*: First use a circle to widen the tube, then insert extra series of stakes to create more surface.*

It was a beautiful surprise to see how the inserted stakes start to reveal geometry just by itself. In a natural way it presents the first stage of a spherical shape and the crossing of the inserted stakes. It is very exciting to discover the logic of nature in a playful way. Nature provides a magical and endless playground. Although the idea of an infinite funnel is interesting I decided to get down to earth and bring the ends together!

A Kagome Torus

Fortunately I had inserted enough stakes to create a spherical mesh that would be rigid enough. It was quite hard to get and hold the structure in the right position because of tension flowing in multiple directions. Especially when the mesh is not based on a perpendicular structure, the effect is comparable with a windswept framework. But this diagonal mesh is very useful to weave spherical surfaces and shapes (Figure 7). To stabilize the spherical mesh you weave a horizontal set of weavers between every crossing, using the cross-warp twining technique (Figure 8). At this point, half of the torus is made, and it is big enough to use as a parasol!

Figure 7: *A natural diagonal crossing.*

Figure 8: *Adding horizontal loops.*

Without knowing at first, the pattern of the parasol resembles a kagome lattice. Kagome is a traditional Japanese woven bamboo pattern. The name consists of two words: *kago*, meaning 'basket' and *me*, meaning 'eye', referring to the holes in the structure [2]. Originally this weaving was based on three 'laths', thin narrow strips, and therefore called 'lattice'. With equally sized, flat strips it is quite easy to construct a perfect hexagonal pattern, but weaving with rods is a whole different story! Their round and tapered shapes makes them roll and slide easily.

The most practical way to make a regular willow mesh is using a square weave. With this technique the rods are easy to control because the pressure in a perpendicular crossing is evenly distributed. Ofcourse a square weave can be used in a diagonal way by tilting it but remains square as long as the crossing is 90 degrees. In kagome the diagonal angles are 60 and 120 degrees. Any other than right-angled is difficult to use in willow weaving and therefore hardly used in basketry.

To learn more about the difference between the original kagome lattice and my horizontal twining variant I made a drawing of both weaves (Figure 9). Beside the horizontal twining it differs in the way the diagonals are woven. In the original kagome both the diagonals and horizontals are woven, it is a triaxial weave. In my variant only the diagonals are woven and the horizontal twining holds them in place. But, and this is interesting, if one of the three weaver sets is removed from the kagome structure there is no weave left!

Another interesting feature of weaving is the direction of the weave. Kenneth Snelson analyzes the logic of weaving direction as follows: ‘In three-way, or Kagome weaving, hexagons alternate with triangles. If the hexagons have a clockwise helix the triangles are counterclockwise. If the hexagons are counterclockwise the triangles are clockwise.’[3]. Practically it means that direction is depending on whether the weaver is right or left handed. As I am right handed, the drawing in Figure 9 shows a clockwise hexagon.

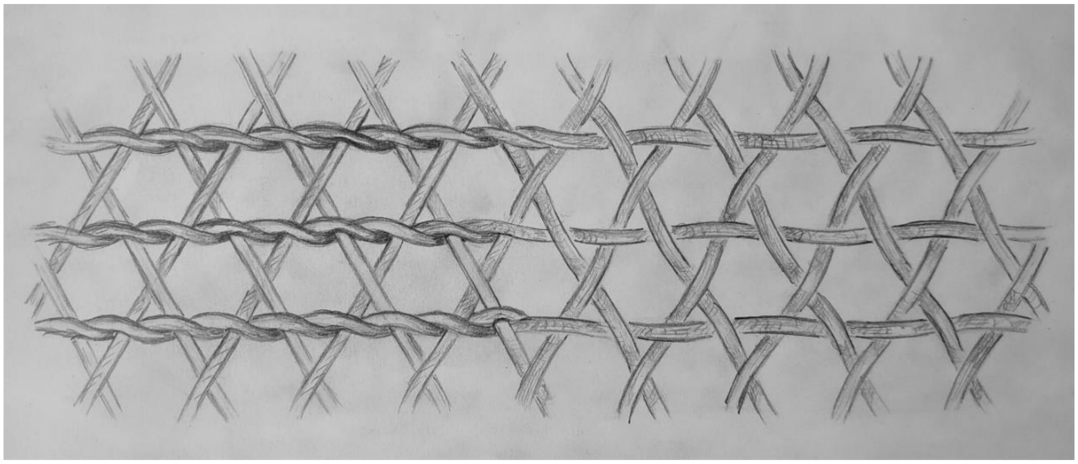

Figure 9*: On the left my horizontal twining weave, on the right the original kagome lattice.*

From Chaos to Mesh

Building a large object has the benefit of being able to place yourself inside and you can get to know the shape and structure from a different perspective. I love this view because from here you discover the secret and beauty of logic (Figure 10).

Figure 10*: Willow kagome structure from below.*

Halfway done, it has already become an interesting shape, but it is too tempting not to continue. This object needs more thinking about the construction than about weaving; if you need too much time to figure out the technique you will get lost easily (Figure 11 and 12). The fun I am looking for is a balance between thinking and doing. Look at the apparent chaos! How to proceed from there?!

Figure 11*: Finding the right shape takes time.*

Figure 12*: Trying to connected both halves is a challenge.*

It takes patience to figure out how both halves should come together (Figure 13). Again, it is a matter of feeling how much tension the inside tube and the diagonal rods can handle. Especially when their flexibility decrease as they dry out in the wind and sun, but it got finished just in time.

Figure 13*: Finally, both ends have come together perfectly.*

Summary

What makes the torus shape so beautiful? For the maker, when working with willow and trying to make a well-built shape, at some point you will find out how to make a willow-wired construction without being aware of the rules of logic. Without knowing I used the hexagonal pattern that is called kagome lattice. By weaving willow I have experienced very consciously the hidden soul of the torus: intertwining inside and outside spaces. For the viewer, obviously it looks like a sphere but walking around it suddenly reveals another and different kind of space. The willow makes it energetic, humorous and dynamic. All credit goes to Nature, the greatest inventor of all time!

References

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[3] http://kennethsnelson.net/Tensegrity_and_Weaving.pdf, p. 7.