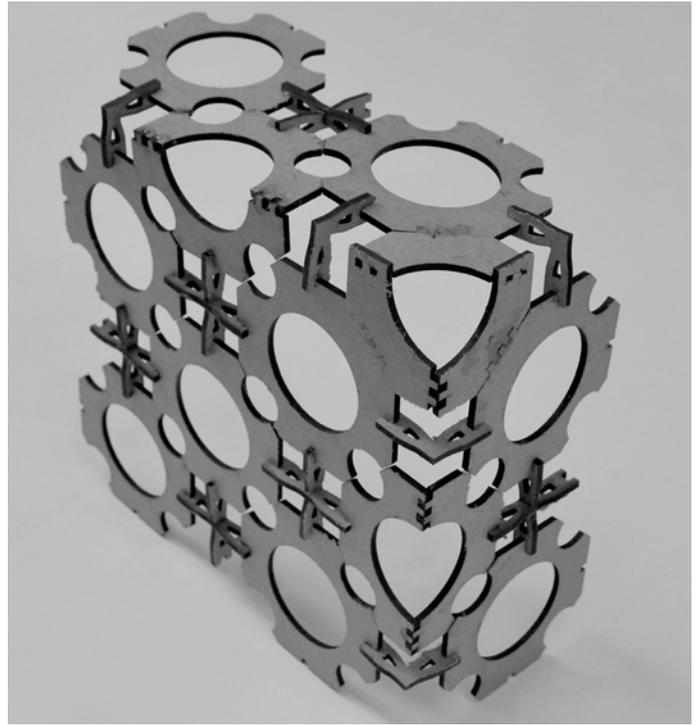


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4.510 Digital Design Fabrication  
Fall 2008

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## DIGITAL FABRICATION FOR QUICK ASSEMBLY

4.510 Digital Fabrication Fall 2008

### Introduction

Having digital fabrication of accurate sizes of panels and components, the challenge of construction then lies on the easiness of assembly and disassembly. Therefore, it is important to have simple connection principle and keep a small number of components so that the assembly work can be done easier and faster. It also save time for labelling different components and the sequence of assembly. The chance of making errors will also be lowered. Therefore, the goal of the investigation described below is to explore how panels can be connected by one simple connection principle with the least number of components.

In each trial of model making, I have counted carefully the number of components that I have used to make a plane and how many more components that I need in order to turn the panels for the corner. Since the form of my design for the water taxi station is rectangular, the focus of the design is to enable the panels to turn 90 degree angle rather than for different angles. The investigation also tests out the elasticities and flexibility of different materials, including masonite, acrylic and aluminium sheet with the use of laser cut and waterjet.

### Hypothesis

In order to simplify the connection principle and number of components, I would expect the joints should be simple enough for easy assembly but at the same time complex enough for connecting panels and fixing them in desired position. If minimum components are desired, the panels should have structural rigidity so that they do not need extra supporting components.

### Methods

tools for design

computer models: rhino, sketchup and autocad

apparatus: materials: 1/8 inch thick masonite, 1/8 inch thick aluminium sheet, 1/8 inch thick acrylic sheet and 1/16 inch thick acrylic

equipment: lasercut for masonite and acrylic sheet, waterjet for aluminum sheet

design: the size of interlocking parts between panels and joints depend on the thickness of the materials

FIRST APPROACH

The first approach is to design a joint that can combine four panels easily. In this experiment, there are only three types of components being used as shown in the figure 1. The panels are hold up by two joints from both sides and locked together by a key shape component (figure2, figure3). However, the connection rely on the flexibility of joint2 to be squeezed into the slots of joint1. I first test with 1/8 inch of acrylic and the joints work very well. In order to make the joint very tight, I try to have rectangular angle around the turning area and it do help to hold the panels better in place. However, when testing with 1/8 inch thick aluminum, the flexibility of aluminum for such a short length is rather limited. Therefore, this connection system is difficult to develop. As a result, I change my strategy to exploring the rigidity of frame so that it does not require extra support.



figure 1 three types of components

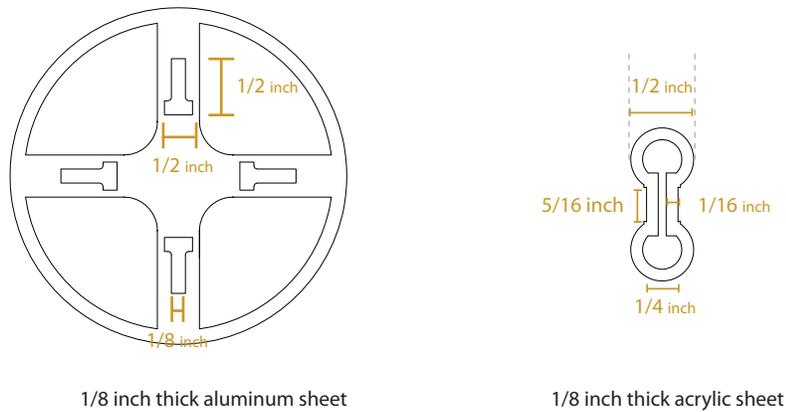


figure 2 actual dimension for testing

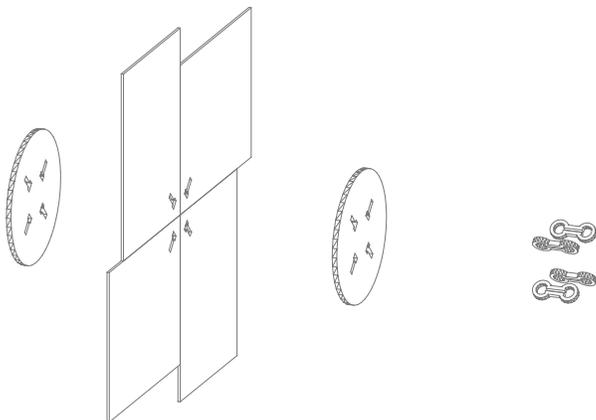


figure 3 connection method

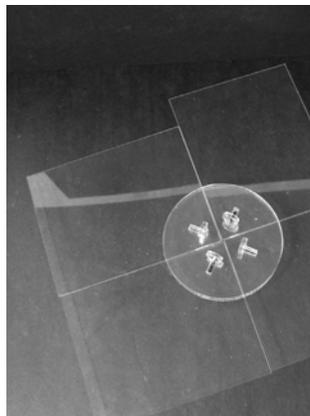


figure 4 testing with acrylic sheet  
-the test is very successful with acrylic as 1/8 inch thick acrylic has good flexibility for joint2

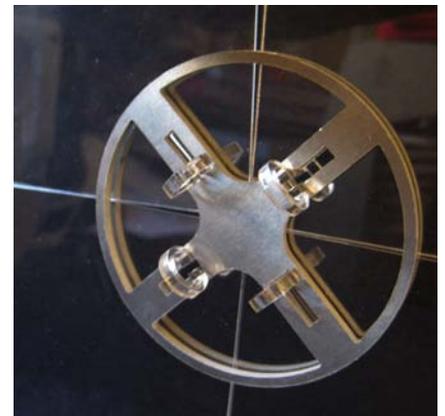


figure 5 testing with aluminium  
-using 1/8 inch thick aluminium for joint 2 is not very successful as it does not have enough flexibility, so joint 2 are made of acrylic sheet.

## SECOND APPROACH

My second approach focuses on the exploring the rigidity of the frame so that it can minimize the extra support as well as keep exploring a simple connection principle. After testing with different configurations with triangle, hexagon and octagon and their potential location of the connection point, I choose to explore the octagon frame. It is because when the frame and joints are overlapped as in the triangle and hexagon configuration, it is more difficult to turn angle in the later stage of design.

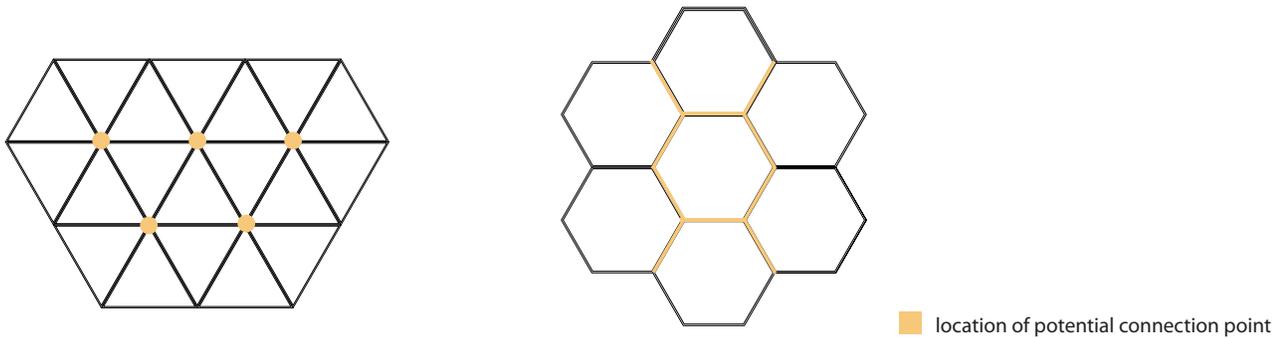


figure 6. exploration of potential configuration triangle and hexagon

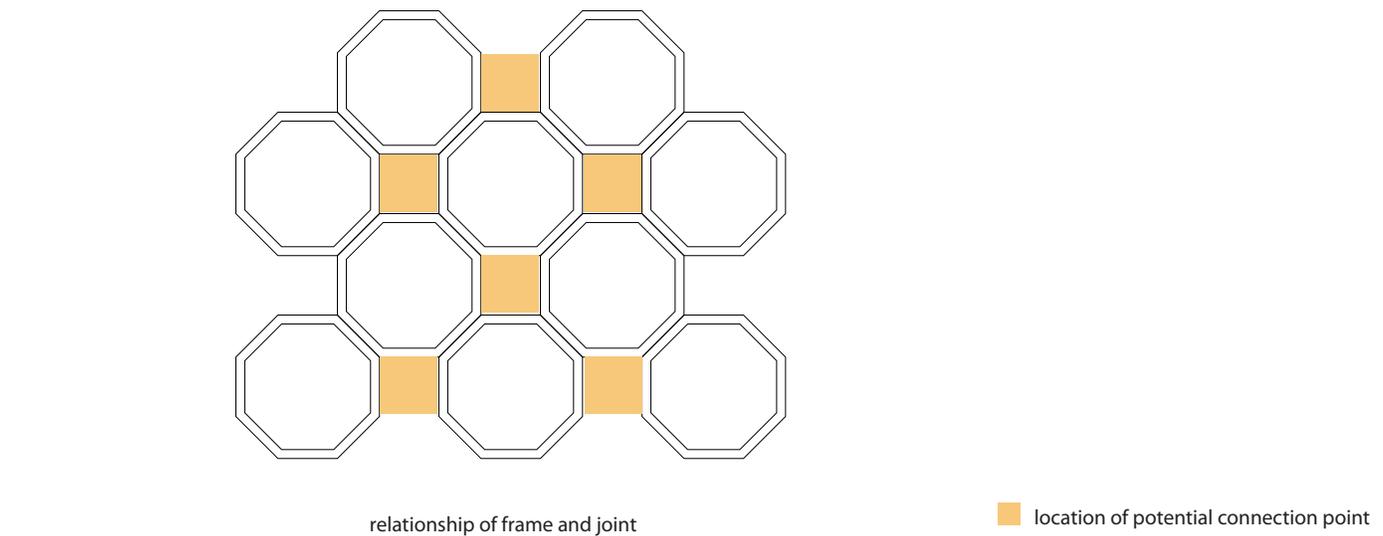
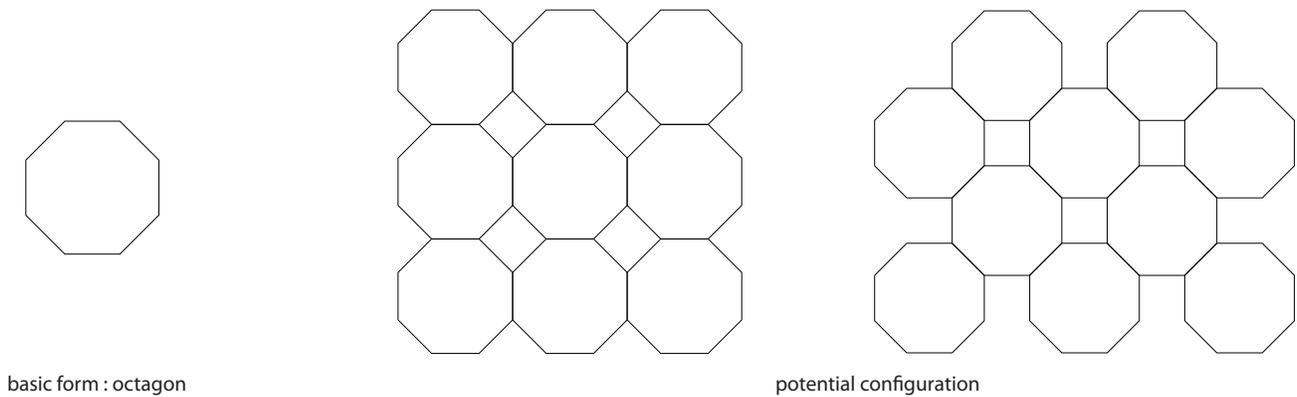


figure 7. exploration of potential configuration octagon

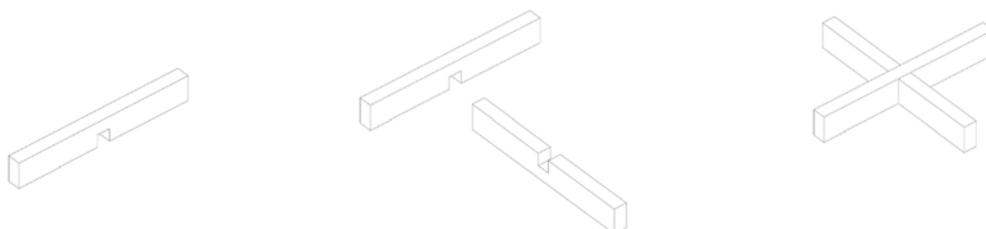


figure 8. connection principle

A) FIRST TRIAL

The first trial mainly focus on testing the rigidity of holding the octagon frame by the joints in between. With this configuration, each octagon frame is held by four sides only and they are connected to the joint in-between with the same connection principle as the joints are connected (figure 9 and 10). I first test with 1/8 inch thick of masonite. The principle of system works very well and the assembly work takes less than 1 minutes for each joint (figure 11). However, the laser cut cuts off some material and the joints are not tight enough. Therefore, I try to use to 1/8 inch thick aluminium sheet for making the joints by waterjet (figure12). I also test out several tolerance level for cutting the aluminium sheet. For that time of cutting, the aluminium joints are loose if the tolerance is 0.9, but they can be very tight if the tolerance is 0.15. However, we need to test every time for a suitable tolerance level as the exact figure varies in the next time of cutting.

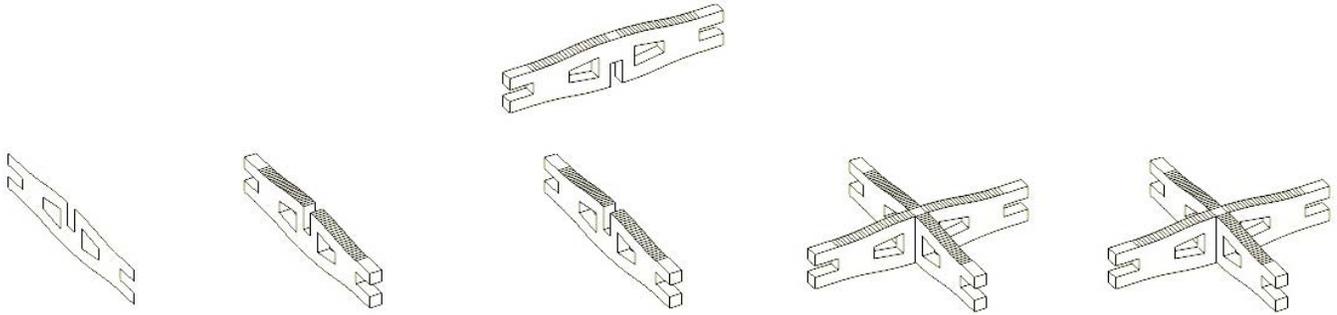


figure 9. connection principle for the joint

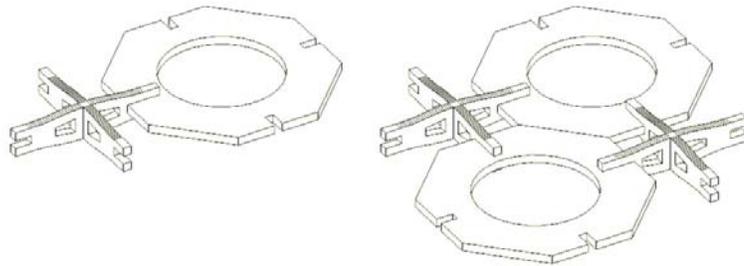


figure 10. connection principle for the joint and the frame

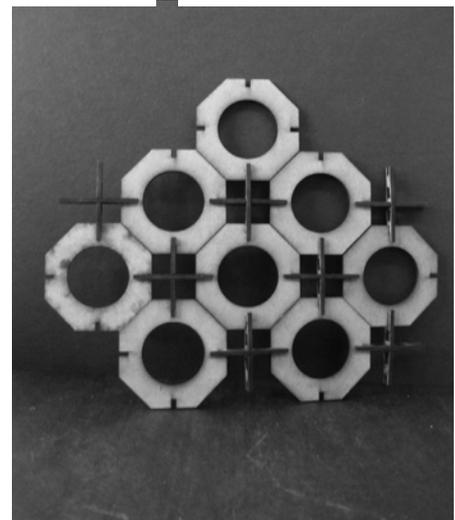


figure 11. first assembly by masonite

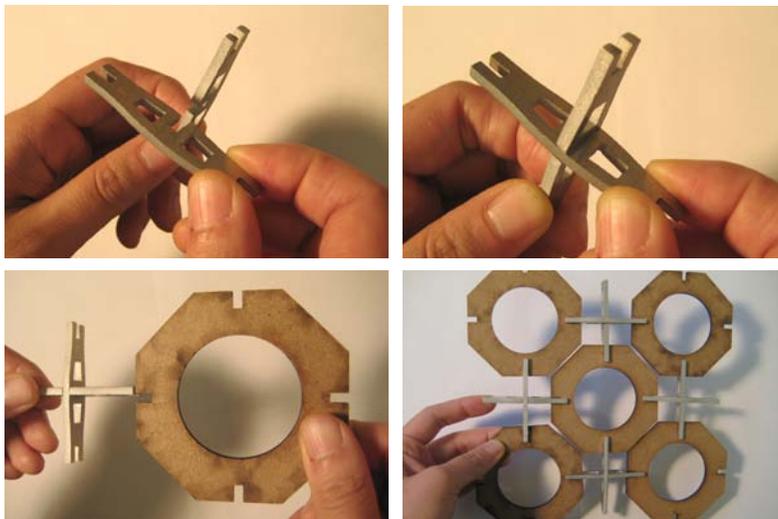
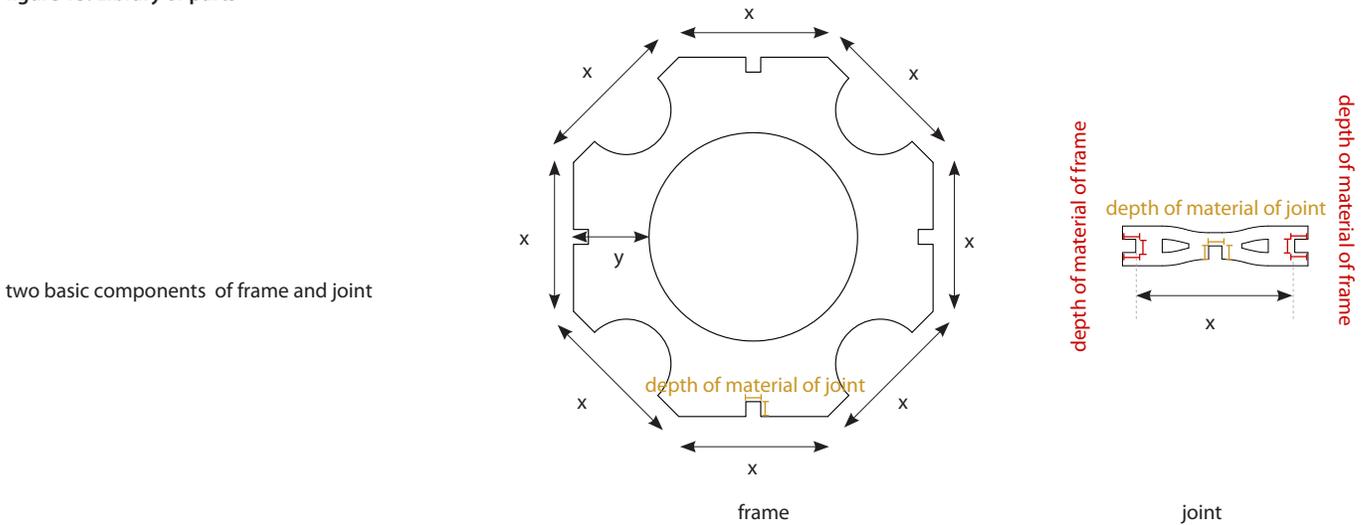


figure 12. testing with aluminium sheet for the joint

B) SECOND TRIAL

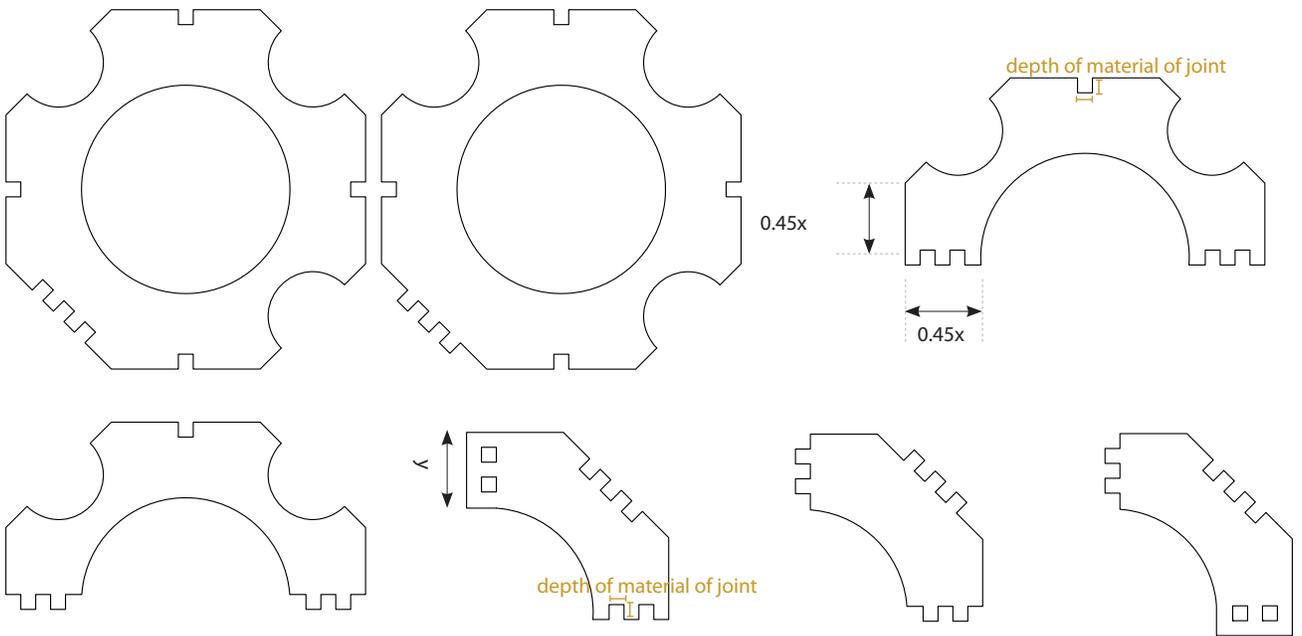
The second trial focuses on modifying the form of the octagon so that the overall shape can be more coherent. Also, I try to explore if the panels can turn around the corner with the same connection principle and how many extra components that are required. With the separation of the frame and the joints, I find it more easy to turn the angle and the same connection principle is applicable. I first test out with masonite and the system works very well. For making a plane, only two types of components are required. However, once we need to turn the corner, eight more components are required. Even though they are modified from the basic units, the changes required for the variation make the number of components increases more than two times. The assembly process also becomes more complicated and a careful labelling for the parts are necessary as some components look very similar.

figure 13. Library of parts



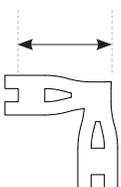
extra components for turning corner

frame



joint

$$z = 0.45x + \text{depth of material}$$



for turning corner

actual dimension for testing:

material: 1/8 inch masonite for both frame and joints

x: 1.25 inch

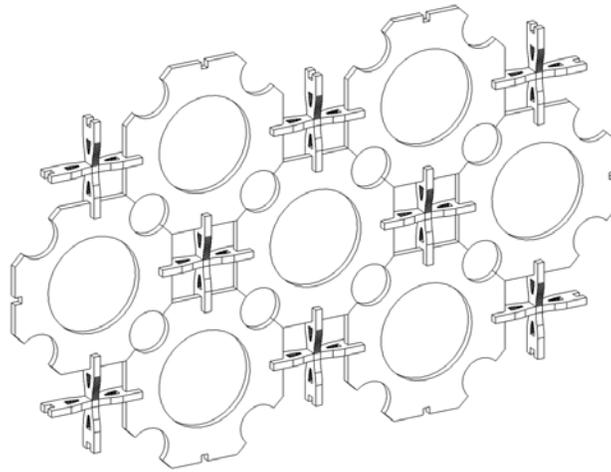
y: 1.615 inch

z: 0.875 inch

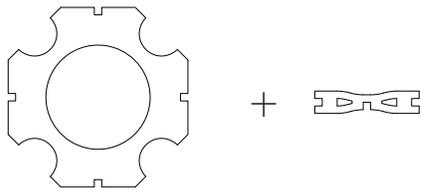
size of slots= depth of material= 1/8 inch x 1/8 inch

B) SECOND TRIAL

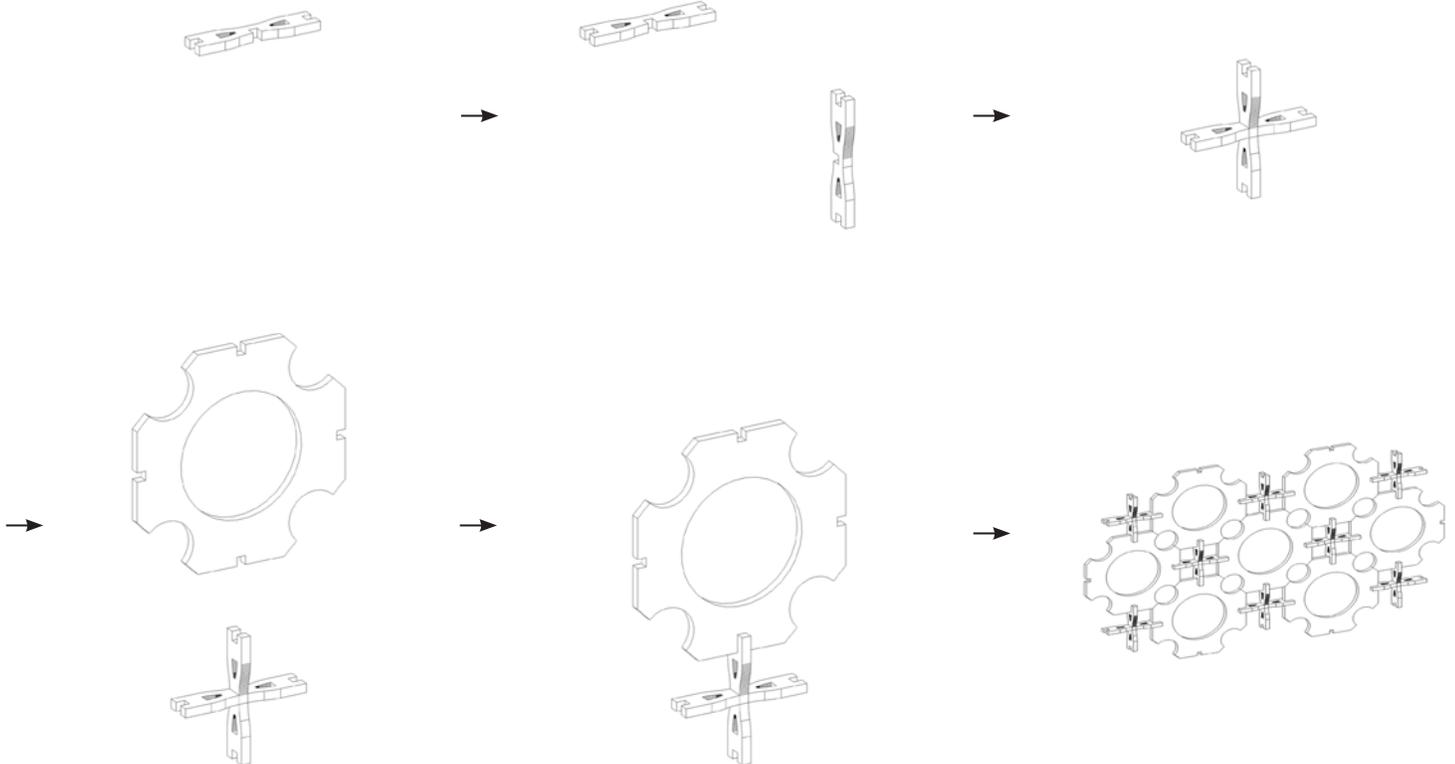
making of a plane



required components

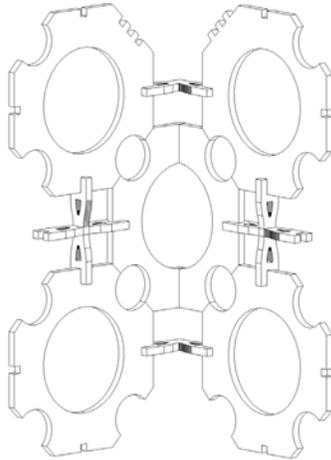


construction sequences

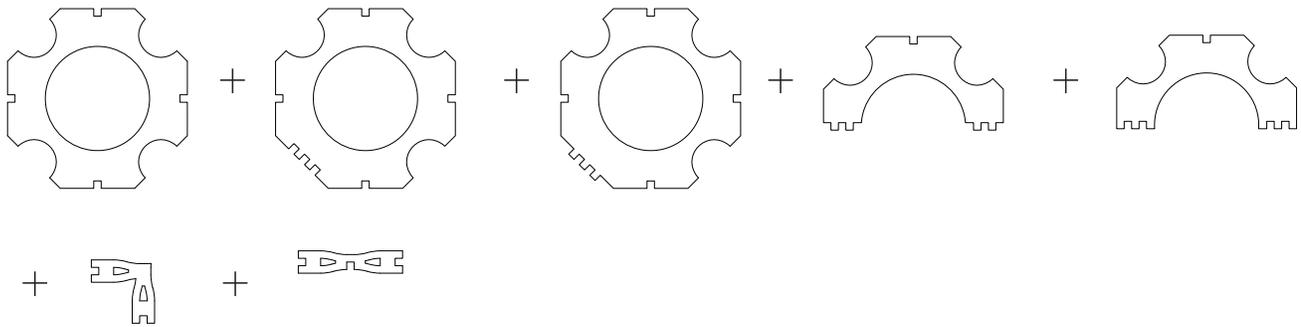


B) SECOND TRIAL

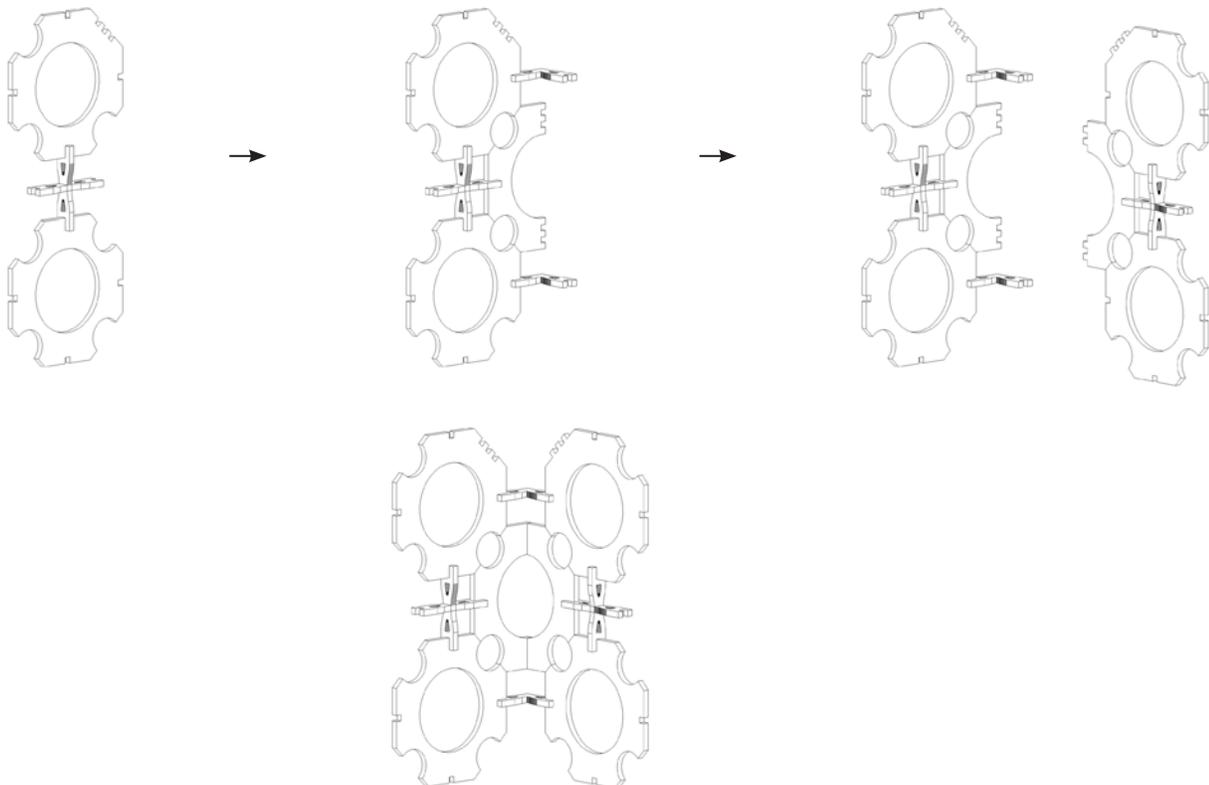
turning 90 degree corner



required components

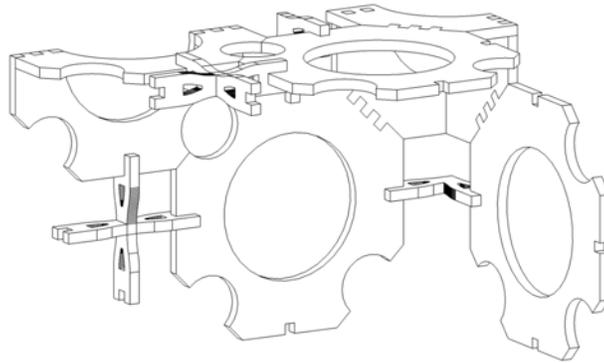


construction sequences

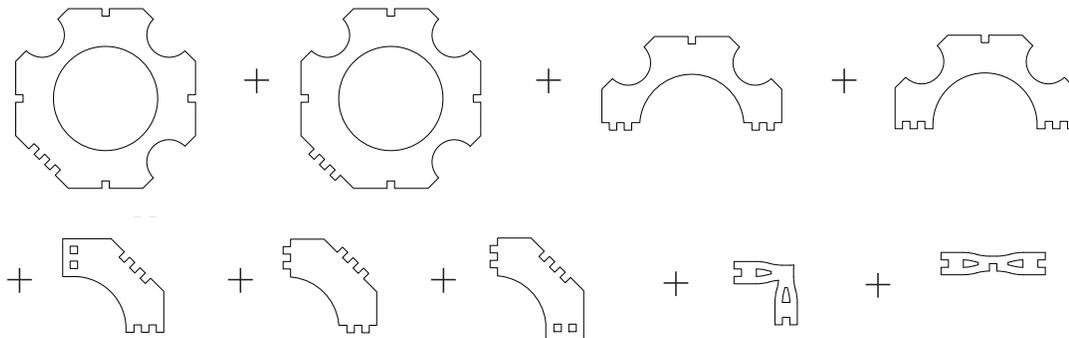


B) SECOND TRIAL

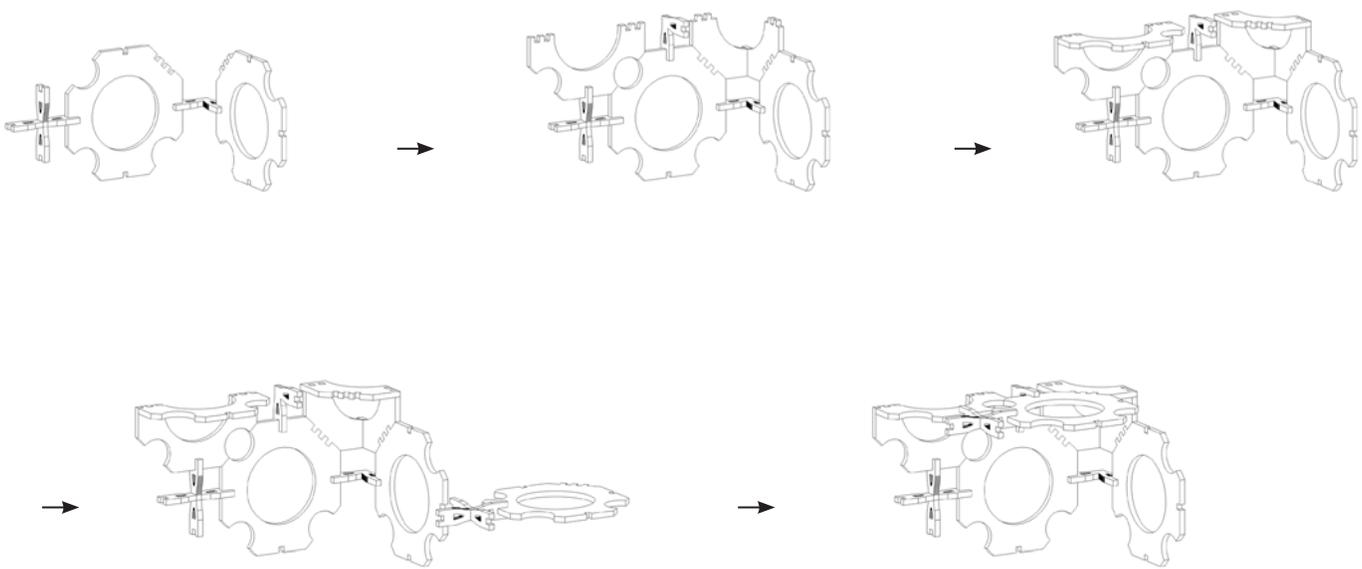
turning two 90 degree direction



required components



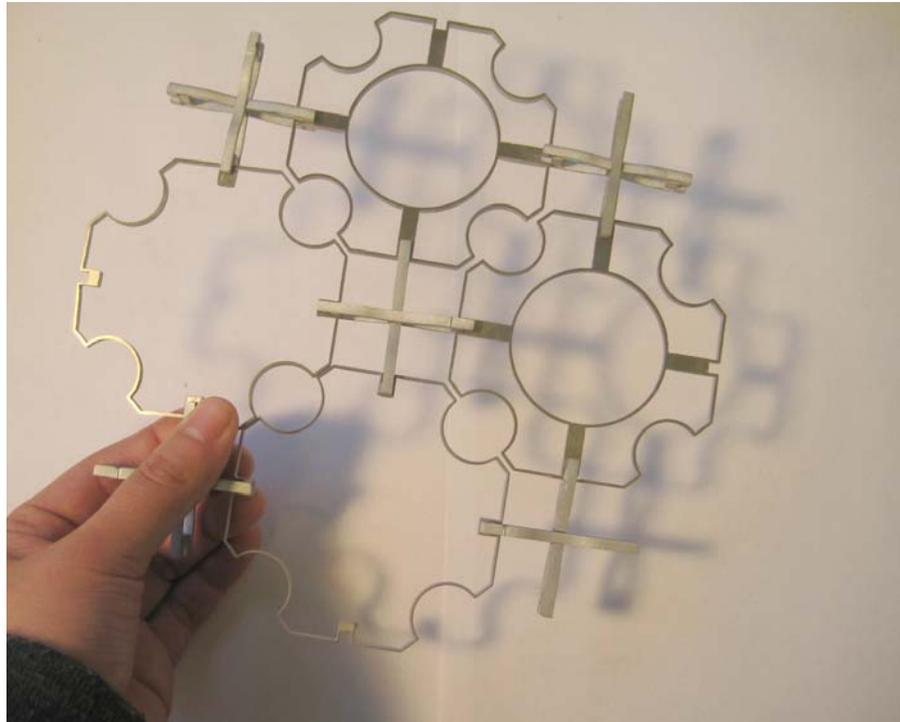
construction sequences



## B) FINAL MODEL



1/8 inch masonite, lasercut



1/8 inch aluminium sheet, waterjet

I try to test out how rigid the octagon frame can be with 1/8 inch thick aluminium sheet. Therefore, I cut out the frame with the most narrowest width that the waterjet can go with this thickness of material, i.e. 1/32 inch. Although the frame looks much more elegant with a narrow width, it loses quite a lot of rigidity particular when there is no internal support in between.

## CONCLUSION

After so many testing by physical models, I have achieved to have simple connection principle to connect the joint and the frame and it requires two types components only to form a plane. However, once we would like to turn a horizontal plane for 90 degree in both direction to form the roof and another plane of wall, the number of components increase dramatically from 2 to 10 in this case. The assembly process also becomes more complex and a clear label of components are required as some components looks similar.

Since the exploration is only limited to a small scale of model making, the rigidity of the frame requires more testing to find out an appropriate thickness and width. The dimension for a rigid frame and joint is critical for this design as the joints are responsible for holding the frame in place and the frame plays the role of structural stability. However, since the models are made in a small scale and it is difficult to know if the frame can maintain its rigidity if they are made larger and if the joints are strong enough for holding the frame in place.

For turning the corner, while the same connection principle is still applicable for this scale of experiment, it might be structurally more stable if the joints are integrated with the frame to form a stronger system around the edge. Also, it is also questionable if the system is still structurally rigid after turning the corner and the plane on the top might need extra support for rigidity.