Bandsaw Cutting Head for CNC

Capstone Project Proposal

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Intent

Architectural production is increasingly leaving its traditional boundaries to engage other disciplines. As the SALA website states on a page dedicated to Design and Construction Futures,

"...digital fabrication and sustainable materials processing are reformulating not only the relationship between designers and engineers, but also the positive impact that designers can have on global environmental challenges. Similarly, computational and data-driven techniques for building simulation, modeling, and construction - topics that are increasingly impacted by innovation in the computer sciences - are also making it easier and cheaper to translate the raw creative expression of designers into built form."

An ongoing research project within HiLo Lab is Zippered Wood. Zippered Wood utilizes waste stream light wood frame members (2x4's) to construct usable construction components that twist and bend to create a flexible design system that can be leveraged by architects and designers to push the boundaries of typical light wood frame construction. The Zippered Wood members are a combination of two lengths of milled wood with a tooth pattern, that when pressed together, wedge each piece into the desired shape and lock together (fig. 1). Present manufacturing of these zippered members utilizes a 3-axis CNC router to mill the tooth pattern. This presents many obstacles to overcome for optimal milling, the primary obstacle being the manufacturing time for each assembled length of Zippered Wood. With a decreased milling time we will be more efficient with machine time and reduce the cost of Zippered Wood, increasing the probability of uptake within the construction industry. A secondary obstacle is the surface finish of the milled areas. Using our current 3-axis mill and a ball end router bit, the finished tooth surface is rough and does not fit within the tolerances needed. Developing a cutting head that uses a flat blade to cut parallel to the finished surface will result in a smoother finish, allowing for increased tolerances. Using this method we can also achieve a greater stock removal rate decreasing the machining time.

Fig.1 Milled 2x4's locking together to form 135° bend

Background

The Zippered Wood research of HiLo Lab began with a single question: Can we generate a new vocabulary of built form using readily accessible and familiar stock material (the 2x4) and by repurposing waste material (Salvaged lumber)? This line of inquiry led to the development of a zippered wood system. Using sophisticated computer simulations a developable surface is simulated and analyzed. A

tooth geometry is then created that is cut into two 2x4's. The two can be 'zipped' together and deform into the shape of the simulated surface. The Zippered Wood technology allows us to design with digitally flexible 2x4's. During the manufacturing process of the Zippered Wood pieces, the majority of production time is spent in the milling process. Currently HiLo lab is using a 3-Axis CNC Router to mill the pieces used in the process, and has successfully completed one pavilion on the UBC campus, located next to the Lasserre building (fig. 2).

This past year we have begun to investigate new methods of manufacturing for the zippered pieces. Work has begun on a new bespoke 5-axis CNC machine that uses a circular saw blade to cut the tooth profiles into the 2x4's (fig. 3). This project has been in partnership with a previous MECH Capstone team. The CNC machine project will be developed concurrently with the Bandsaw cutting head.

Project Description

In conjunction with using a circular saw blade to cut in the tooth pattern, we are working towards developing a bandsaw cutting head attachment for a variety of CNC machines. This cutting head will have the ability to be mounted on any standard CNC machine and transform the CNC into one capable of milling out Zippered Wood pieces. A bandsaw blade can cut geometries that a circular saw blade cannot. This will allow us to further refine the quality and strength of the Zippered Wood pieces. Preliminary testing will be done using a KUKA robot arm in the Center for Advanced Wood Processing (CAWP) on the UBC campus, pending approval.

To perform the cutting operations necessary, a custom bandsaw blade has been conceptualized by the HiLo team. This design will be developed and refined further to allow for ease of manufacturing and cutting efficiency. The blade has the need to cut on both it's front and back edges, and without deflection. To achieve this a custom drive train will be developed as well to drive the blade. The final product will be a complete custom bandsaw attachment that can be integrated onto a 3-axis CNC or KUKA arm.

The first stage of the project will include researching and prototyping, where possible, different bandsaw blades and their ability to perform the cuts necessary. At the same time as the blade, a system will need to be developed that enables the bandsaw blade to be driven while maintaining a consistent cut and blade tension. After initial prototyping a working model will begin to be developed and manufactured. At the completion of the project a working prototype will be finished and test cuts will be done, with hopes that it can be used to manufacture Zippered Wood for future pavilions on UBC campus.

Fig. 2 Completed Zippered Wood pavilion

Fig. 3 Custom CNC Saw designed by previous Capstone team

Expected Outcome

At the conclusion of the project it is expected that the team will produce a complete digital model, a functional prototype (to the best resolution of completion that access to facilities allow), and all documentation (images, diagrams, instructions, etc) required for assembly and operation of the bandsaw head. Should access to facilities not allow for the completion of the prototype due to the current health and safety concerns related to Covid-19, the full set of completed assembly drawings will be regarded as sufficient completion of the expected prototype.

This project does not have the expectation that the students will have to generate any custom computer coding for the function of the bandsaw head. Any custom computer coding will be done by the HiLo team.

Customer Requirements

The requirements for the project will depend on the ability to produce a physical prototype. Should a prototype not be feasible the requirements will focus on analysis and simulation of the bandsaw head. In this case it will be required to simulate the cutting action to gauge the performance of the saw.

In the case that a physical prototype can be produced, the requirements for the bandsaw head is to have the ability to be mounted to a standard CNC faceplate and easily integrate into the existing control system of a CNC. With the exact specifications of the mounting systems being determined over the course of the project. The Bandsaw head will need to be able to accurately perform test cuts in 2x4 material. The speed and accuracy of the cuts will be measured against a standard 3-axis CNC. It is the hope that upon completion that the prototype will match the performance of the standard 3-axis CNC.

Available Resources

Fabrication support is available through the SALA workshop, type and amount subject to evolving COVID safety guidelines.

For specialized manufacturing needs off-campus facilities will be used.