Thesis Methodology: David Heaton

Overview:

This thesis seeks to understand what "Liveliness" is in architecture and how we can design towards that notion. The main method of inquiry is to construct models using wood for its embedded tensile properties to explore various "precarious" branching typologies that are conducive to response. Each model will be evaluated and studied in how it responds to loading and its ability to amplify forces in and around the structure. Geometry, light, shadow, movement, and the visual perception of movement will all be explored through a series of exploratory models. Using the gained knowledge from the model studies, a full scale, immersive installation will be built that embodies liveliness through its branching tectonics that explore part to whole relationships as well as the use of light and density to affect visual perception.

Precedent Studies:

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Active Bending Units:

The first set of studies consisted of developing single, unit based, active bending prototypes. In this series of studies, Glass Fiber Reinforced rod was used to quickly build multiple geometries. Wood was then introduced to compare tensile properties and behaviors and to begin building with a directionality of material in mind. Though these smaller experiments did not yield results worth pursuing, they did begin to inform things that should or should not be incorporated in further studies. The main take away was the incorporation of strip versus linear element as it added directionality to any system and the idea that any system developed should be an interwoven or interconnected system.

Sinuous Branching Fields:

Moving forward with the idea of interconnected branching structures, a new type of model was developed that explored thin flexible wood elements interconnected in a field condition. These thin elements seen in *Figure 1*, created a light almost bouncy system that visually overlapped each other. This model introduced several generative ideas into the thesis such as further exploring the flexibility of the material, using the sinuous nature of the geometry to further study varying types of wood in the same configuration, and how the system began interacting with forces.

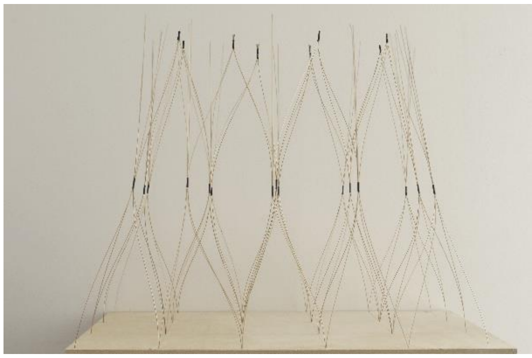

Figure 1: Sinuous Wood Field Model

By applying forces to various parts of the model, long exposure photographs were taken that began to suggest ideas of overlapping subtle motions and what visuals that would create. In *Figure 2,* it is possible to see the ideas generated from this model.

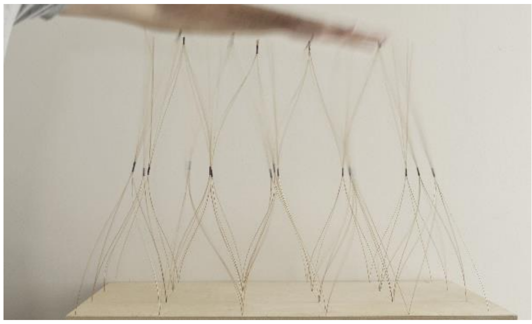

Figure 2: Motion Activated Model

Moving forward from this linear field condition, the same type of model was repeated using strip elements. By changing from linear to strip elements new ideas of connections were discovered as well as issues of directionality were found. Heat shrink tube was used as the primary connection element and at the center node a square spacer was placed to ensure each of the strips were forced initially in the right directions. This model was used to also study forces being applied to it and see how it would react. (*Figure 3*) Surprisingly, it took large amounts of forces well and responded by opening up and expanding in shape. Furthermore, it was discovered that loads did not transfer as expected in the model. When forces were placed above elements one space removed, the bottom half of the strips would bulge in unexpected ways. This unexpected behavior was tested and also found in the previous *Figure 1+2* models. However, this most likely occurred due to the models loose connection on the base.

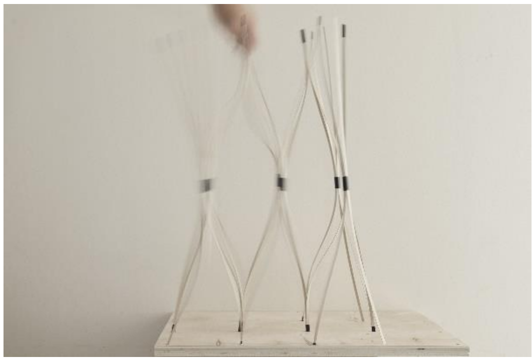

Figure 3: Activated Strip Model

The motion that occurred in these models provided a launching point for the idea of utilizing forces and how those forces act in and around the structure as a central idea to be continued in further studies.

Weighted Experiments:

This next grouping of experiments sought to replace my direct force being applied to the system and begin to find ways of internalizing these forces within the system. The idea being that if there are already forces in homeostasis within the system then any additional forced placed on the system would cause an imbalance and begin to shift all existing forces until the system found a new homeostasis. The first attempt to embed forces within the system came in the form of hanging weights.
A new model was constructed that mimicked the *Figure 3* model, however now it incorporated connection elements for hanging weights to be applied at multiple points in the system. Also, connection strategies were optimized in this version where heat shrink tubing was enhanced with mechanical connections to ensure strong connections within the wood elements as well as to provide support from which the weights could hang (Figure 4).

Figure 4: Hanging weights in system

This system of hanging weights was explored first to find how much weight was needed to create noticeable changes within the system as well as what weights would push the system to failure. (Figure 5)

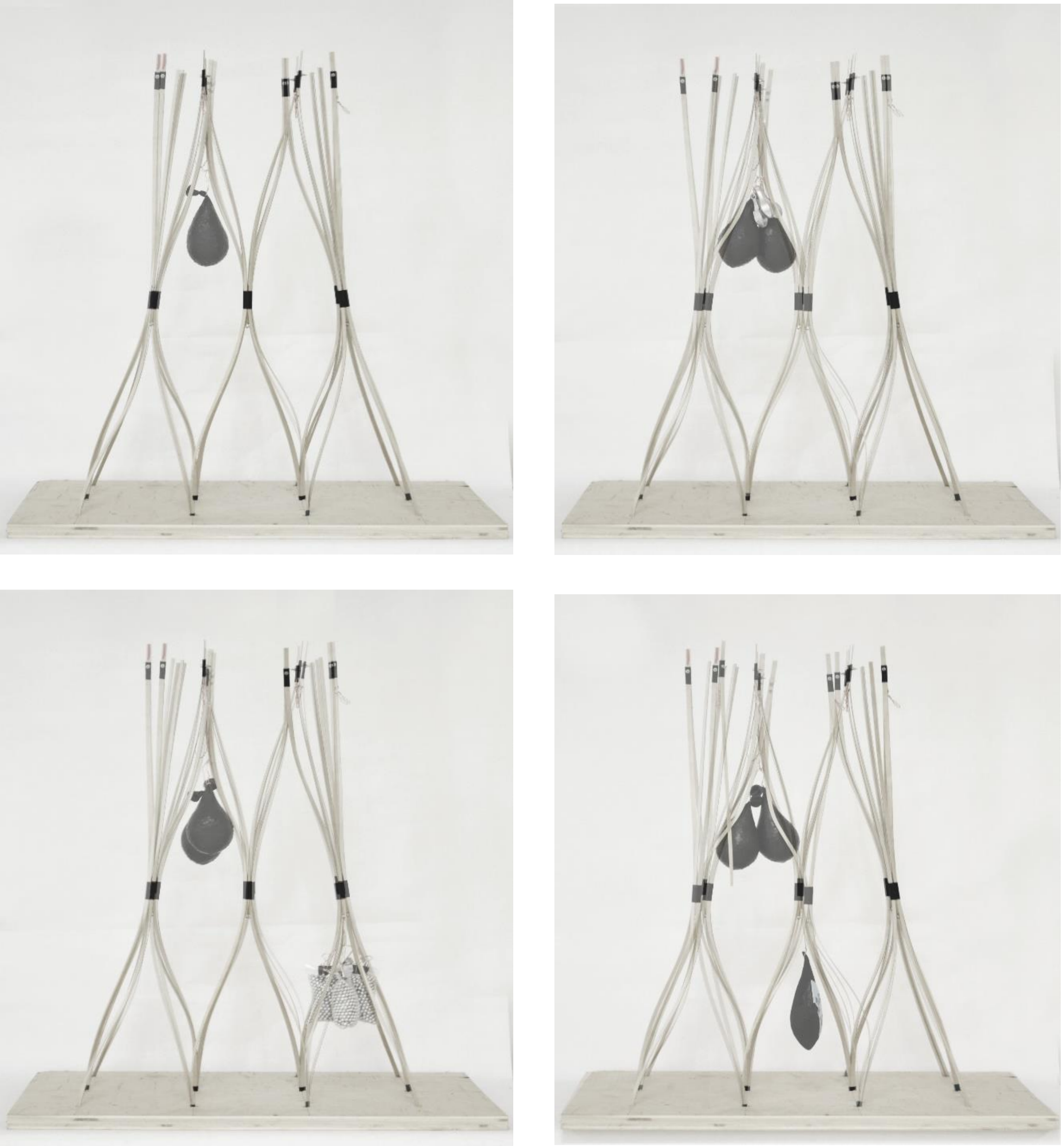

Figure 5: Hanging Weight Study

A minimum weight of 1lb was needed to perceive change and a weight over 2lbs. 6oz. caused the system to buckle and fail. While this was valuable information to be gained in the structural performance of the system, more importantly was the system's ability to now talk about notions of "Liveliness". Here the resonating weights within the system caused pendulum like interactions to create subtle movements throughout the entire system. Now a small force applied caused reverberation in the whole and began to amplify small movements.

Figures 6 and 7 show the overlaps of material and reverberation caused in the system when a new external force was added.

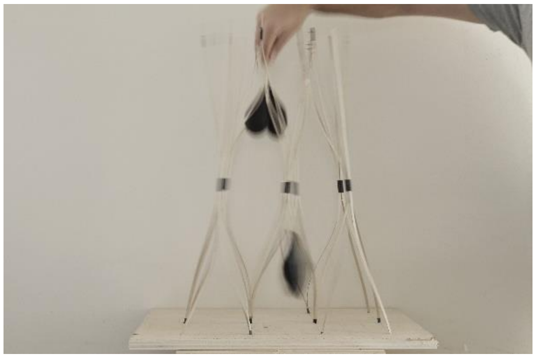

Figure 6: Front View Weight Reverberation

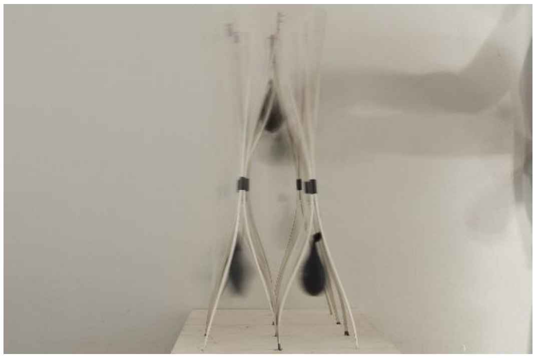

Figure 7: Side View Weight Reverberation

Hybrid Tower:

Having experimented with multiple forces and weights, it was now time to begin finding ways of using these forces to further inform the experiments. One of the very interesting behaviors in the models before was their reaction of expanding in size to the application of force. This along with the ability to read subtle resonance within the model and interpreting these forces and the amplification of the forces as a sort of "Liveliness" was what drove the next experiment.

Up until this point all of the models had only operated at a single vertical layer and had avoided dealing with the new set of problems embedded in adding an additional layer. Previously, all models seemed to gradually pull to the center as they grew vertically. This was offset by applying weights in the weight study, however, it provided issues in moving vertically. The base of the original layer provided a method by which the bottom of the system was spread apart. This was lost as the system grew vertically. Moving forward (Figure 8) shows how now post tensioning steel cable was added to hold system shape while growing.

Figure 8: Tower Hybrid

Figure 9: Detail View

By applying weights to vertical system, the reverberation of forces from the original studies was amplified even more. Small subtle forces were causing changes not just central to where they were applied but also were redirected to other parts of the system. Interestingly, forces of compression and tension were visually amplified because now they were not only read based on the opening of the wood units, but also by visualizing the tension and loss of tension within the cable elements. This visual reading of the forces in the system was of significant interest and was pushed forward into more studies.

Fabric as Visual Amplifier:

Using the steel cable as inspiration for a visual amplification of the forces within the structure the decision was made to explore fabric in the same way. Spandex fabric was chosen for its ability stretch and show tautness vs. looseness as well as its ability to play with filtering light, varying opacities when stretched and its ability to perform in a tensile method.

The first set of studies were purely visual departures each addressing the moiré effect in combination with or without color as a possible method of a visual amplification of forces.


Figure 10: Linear Color String Field


Figure 11: Model Perspective

The initial model shown in Figure 10 and 11 a grid of colored threads that composed a visual gradient field. The field seemingly moved as you walked around it due to the overlapping fibers. Here the onlooker became the activator of motion rather than a physical force causing motion within the system.

The next set of studies directly tackled amplifying forces and subtle movements through explorations of Moiré effects.

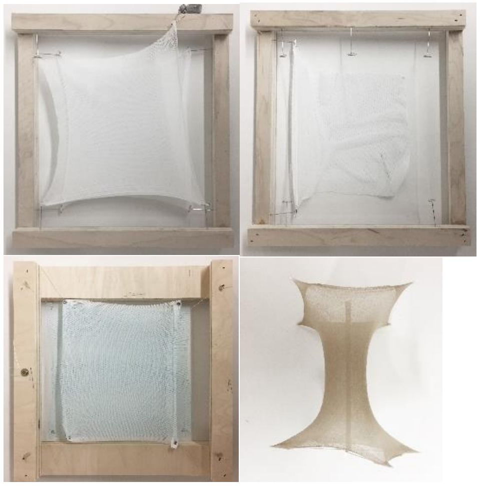
Figure 12: Moiré Effect Visual Models

While these models help to visually understand visual amplification of forces it was decided to begin moving the fabric from purely a visual amplifier into one where the fabric also has a function.

Performance Fabric:

The current point in the thesis is seeking to rethink previous structures by integrating fabric as a performative member within the wood system and also as a member by which forces are visually amplified. The below series of models are all seeking to incorporate ideas of tensegrity in the idea to merge the two systems into one cohesive system by which force amplification creates notions of a “Lively” structure.