

The Creation of SpiderLACE

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Figure 1. A rendering for the Powerhouse Museum Love:Lace Competition.

Over one year ago, the Powerhouse Museum in Sydney, Australia held a Love Lace competition. The competition brief was to create an artifact that embodied the reforming and rethinking of lace in the categories of traditional techniques, fashion, digital multimedia or built environment. This type of pattern-driven project would allow the design to test new visual script-based software, Grasshopper, a plug-in to Rhino. Working with Grasshopper allows one to not only formulate patterns and formal aspects of design, but also create a seamless workflow of design to fabrication. With the latest wave of algorithmic software, of which Grasshopper is only one of many, this provides a realistic design->fabrication workflow.

Another consideration that drove this design was the prospect of making the second tier of the competition. Should the concept be selected as a finalist, the museum would expect an actual artifact to be shipped to Australia. This parameter of shipping became a major hurdle. Given the category of built environment, the piece would best be realized at full-scale, where not only the fabrication, but the personal interaction would be 1:1. The design strategy would also need to withstand both assembly and disassembly for testing and shipping.

A flat-pack delivery strategy was immediately adopted. Each panel would be individually fabricated with a custom pattern and then assembled. The form would have to be lightweight and, not knowing the type of space the piece would occupy, it would have to be structurally independent.

Pragmatic concerns aside, to create an entry that was aesthetically beautiful in its own right, but playful in its use of light and shadow was a difficult design task. Lace is a complex system of closed and open patterns that must be inherently structural. Delving into the research of lace design, the parallels of spider web form and fabrication became an interesting formal point of departure. The density near focal points and the tension literally and figuratively created by spider webs gave the piece a formal strategy for the panels. The tension of the pattern begins to reveal itself in the Figure 1.

As seen in the competition rendering (Figure 1), SpiderLACE is a panelized system with a diamond-type cross section and center pieces tying either side together. The 30-ft. x over 6-ft. installation snakes through space in a serpentine fashion to give it lateral support.

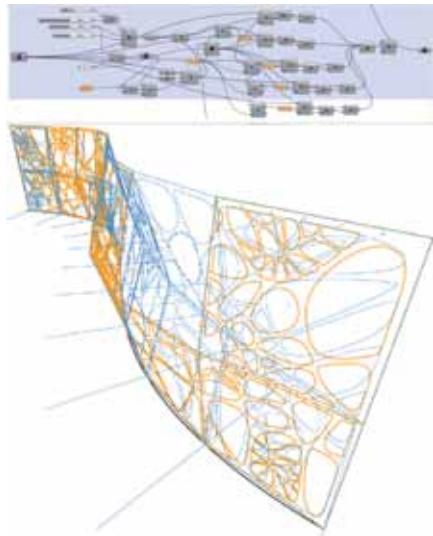


Figure 2. A portion of the script with the base geometry below.

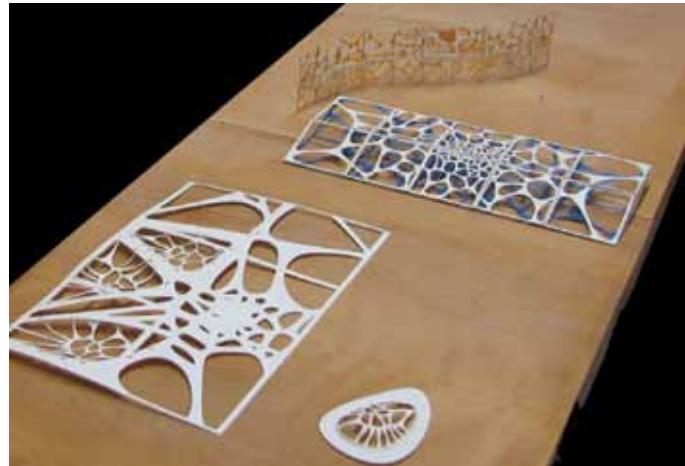


Figure 3. Initial prototypes at various scales and exploring various interior colors.

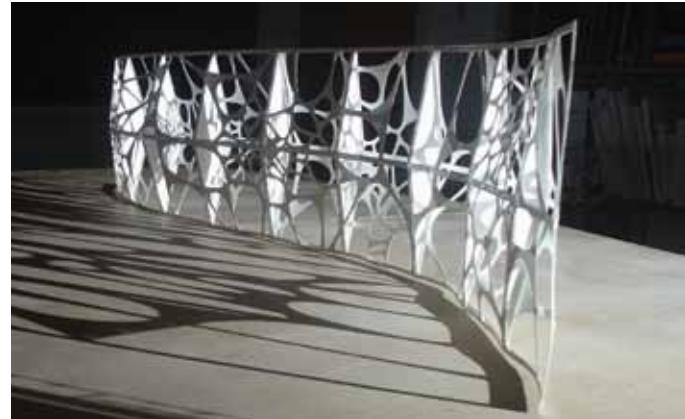


Figure 4. Three-quarter inch scale prototype with solid vertical fins.

Once the conceptual phase was concluded in April, in July 2010, it was learned SpiderLACE had been chosen as a finalist and the museum wanted the actual piece submitted in six months. With the assistance of five fifth-year students, Tim Meyers, Mark Andre, Keegan Thompson, Josh Doss and Victoria Suprin, the prototyping and fabrication of the entry commenced.

Over the next few months, many prototypes at various scales were fabricated using the APDesign's laser cutter. The laser cutter was the essential small-scale prototype source for immediate design output needed to meet the objective of design->fabrication workflow. During the prototyping phase, the script was elaborated upon to allow for each panel's geometry to be created and distributed across the entire form. The script then took this base geometry and prepared CAD files for the laser cutter.

As can be seen in the full SpiderLACE prototype (Figure 4), the diamond cross section was originally a solid fin. While this fin gave obvious stability, it diluted the overall effect and beauty of the pattern, a physical manifestation of staccato notes within a graceful melody. The desire to lose its visual interruption became the next design and structural hurdle.

In Figure 5, the initial attempt to create a nearly invisible connective tissue, much like web stitching the two opposing panels together, is seen. These structural webs were eventually cut out of acrylic. Fiberglass rods were added later for compressive strength. The connection points for the webs were developed organically from intersections of the lace pattern. Since the geometric construction was so intricate, the Grasshopper script was necessary to develop all the custom cut files for manufacturing (Figure 6).

Through the use of early prototypes, many of the geometric issues of patterning and rules were established. The logic of the geometries was mostly aesthetic. However, due to the thinness of the panel, the pattern had to be adjusted to allow enough connective tissue to structurally complement the other panels. As the large-scale paper mock-ups were tested, the idea that the full-scale piece might be able to be fabricated from paper was interesting. This would decrease its weight and cost (the final installation weighs just 50 lbs.), yet could paper be rigid and strong enough?

With each panel measuring over 3 ft. x 3 ft., the small-scale laser cutter would need to be replaced. A die cutting manufacturer was located whose cutting tool was modified

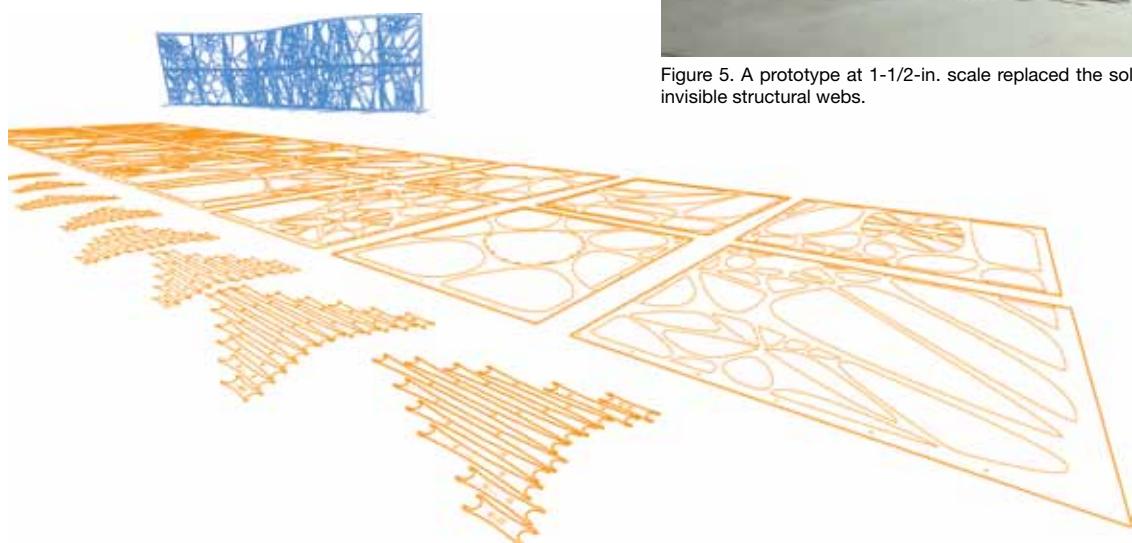


Figure 6. This image shows the virtual SpiderLACE created by the Grasshopper script. The flattened panels and all the acrylic structural webs are laid out in front, ready to be cut by the various CNC devices.

to work with a local 4-ft. x 8-ft. bed CNC router (Figure 7).

Finally, with the CNC router becoming a glorified die cutter and the laser cutter fabricating structural webs in 1/8-in. acrylic, the tie between design->fabrication had been connected. Up to the last moments, the script was constantly changing given input from tests, with output files immediately being created in real-time and going to the CNC production tools. The final result shows an incredible piece of art that is at once beautiful as a sculpture but also fascinating as a process of design.

In December 2010, as the full-scale tests were being performed, a neighbor's old stone barn provided a large enough area for complete assembly of SpiderLACE. This space became an ideal location with a beautiful juxtaposition between the rustic barn and the crystalline pattern of SpiderLACE.

In Figures 8-10, one can see how light plays across the surface of SpiderLACE. The reflective light from within reacts to the painted interior surfaces, making the blue of one side fade away as the yellow on the other reflects on it. This effect of light creates gradients and highlights

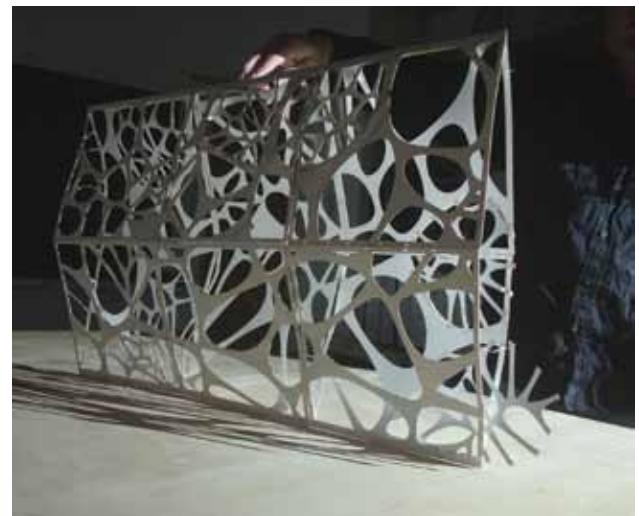


Figure 5. A prototype at 1 1/2-in. scale replaced the solid fins with nearly invisible structural webs.

playing across the surface, providing an organic quality to the colors and form. The overall effect of SpiderLACE becomes a delightful play of light, shadow and surface. Its sinuous form snakes through space creating a literally and figuratively lightweight poetic form.

Throughout its creation, SpiderLACE pushed the design->fabrication process. This methodology allowed unique and intricate panels to be custom designed, manipulated and adjusted quickly, and each piece was carefully considered for its aesthetic and structural necessity. The challenge of making a material such as paper create a rigid structure, both beautiful and incredible in how color and light play across its surface, has married the hand, eye and technology in this wonderful architectural installation.

The next chapter of SpiderLACE's construction is its final assembly in the Powerhouse Museum. It opened in July of 2011, and will be on display to 2012.



Figure 7. This is the die cutting device fabricated to fit in the routers ½-in. collet along with a compression added to allow for exact pressure to be applied during cutting.



Figure 9. The two colors of blue and yellow playing against each other.



Figure 8. SpiderLACE's first full assembly in an old stone barn.



Figure 10. This view of SpiderLACE is seen from above in the rafters of the barn.