

Connecting to the Real: Digital Fabrication

Eric Weber

University of Nevada, Las Vegas

With the advent of computer modeling and animation, architects today are able to develop new ways of thinking about how to conceive of and deliver buildings of ever-greater complexity, responding to the challenges of speed, flexibility, and cost in ways that seemed unimaginable a generation ago. One of the unintended side-effects of embracing the virtual has been the tendency among many students towards a lack of rigor in considering the actual materials from which their buildings are to be constructed. Yet these are the notes that, strung together, become the symphonic whole of any great architectural work.

From Fall 2011 to Fall 2013, the Design Build Studio created its first project, a vacation home to be located in the Mojave Desert near Las Vegas, Nevada. We explored how technology can assist in reconnecting with materiality, texture, light, and time, creating opportunities for memorable experiences. During the first semester, we began studying some of the critical parts of the house at full-scale; these components became loci for crystallizing essential design concepts. The most provocative of these was the design process for the perforated screen system. The following passage from the project narrative describes the conceptual intent for the screens:

The journey begins with a pathway where dappled light filters through perforated screens, seemingly dissolving the building in its pattern. The effect recalls light passing through the native mesquite tree. The movable screens respond to seasonal differences: in the summer, they can enclose the patio space and provide shading for the building. In the winter, the screens can be opened completely to allow the sun to penetrate the building, providing passive heating.

This describes, both poetically and pragmatically, the *raison d'être* for the house's perforated screen system. The students responded to this by photographing Native Mesquite trees, and selecting images that best captured the desired qualities. While the finished product was striking, the process used to create the mock-up was extremely time intensive. Students spent many months developing a process that would make the screens affordable, efficient, and functional while still retaining the effect demonstrated by the mock-up.

For the final screens, students developed a script in Grasshopper, a plug-in for Rhinoceros that sampled a gray-scale image using grid coordinates that then created circles corresponding on the percentage of gray found in each area of the image. Lighter grays were drawn as larger circles and darker grays were drawn as smaller circles. This brought the files for each screen down to a much more manageable size that could be loaded into the CNC machine's computer.

The constantly shifting perception, between solidity and dematerialization, is particularly noteworthy. The premise underpinning the Design Build Studio's work – that architecture is the creation of memorable experiences, was powerfully demonstrated by this evocative installation. It was the synthesis of digital technology and thoughtful application of tectonic principles that made this project possible. Maintaining this balance was a key challenge as the project moved from concept to construction.



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The first challenge was developing an appropriate cutting pattern. The mock-up pattern was developed using a series of Adobe Photoshop and Illustrator files that converted an image into a bitmap file. This file was then traced in Illustrator to generate a DXF file consisting of millions of lines, creating hundreds of thousands of unique holes that represented the original image. The resulting file was so large that the CNC fabrication machines did not have the required memory to cut the screens in one pass.

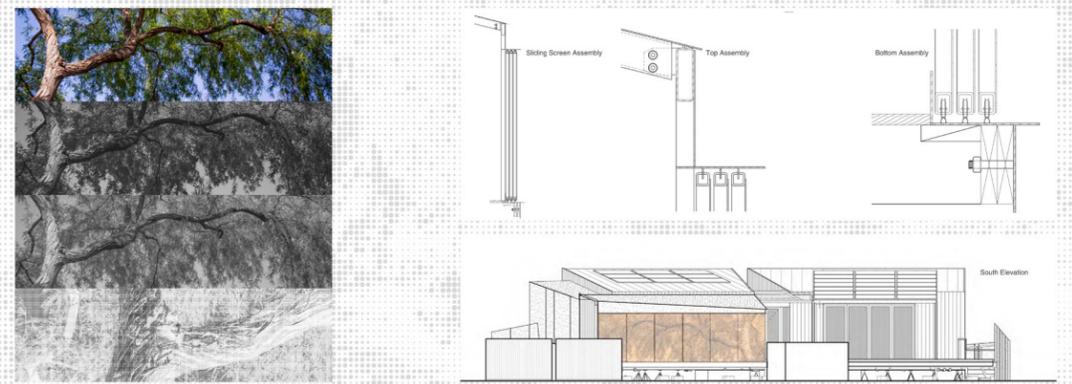
For the final screens, students developed a script in Grasshopper, a plug-in for Rhinoceros, that sampled a gray-scale image using grid coordinates that then created circles corresponding on the percentage of gray found in each area of the image. Lighter grays were drawn as larger circles and darker grays were drawn as smaller circles. The resulting process reduced the file from thousands of lines per hole to just hundreds per hole, one to represent the location and another number which represented the radius of the hole to be cut. This brought the files for each screen down to a much more manageable size that could be loaded into the CNC machine's computer.

The next challenge was deciding upon the most appropriate process for cutting the screens. The house had approximately 300 square feet of custom screens, divided into nine panels. When considering the ability to cut the screens, students requested quotes from different companies with different methods of cutting. CNC plasma was discarded early in the search because of the intense heat generated by this fabrication process. The heat meant that the holes had to be too large for a recognizable image to be created; the panels would warp, creating an unacceptably distorted sheet.

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Students experimented with different perforation shapes and densities before deciding upon the final pattern. Using chipboard samples, the pieces were cut using a 100 watt laser which was the most appropriate laser method as the final panel panels were cut with a high power laser.

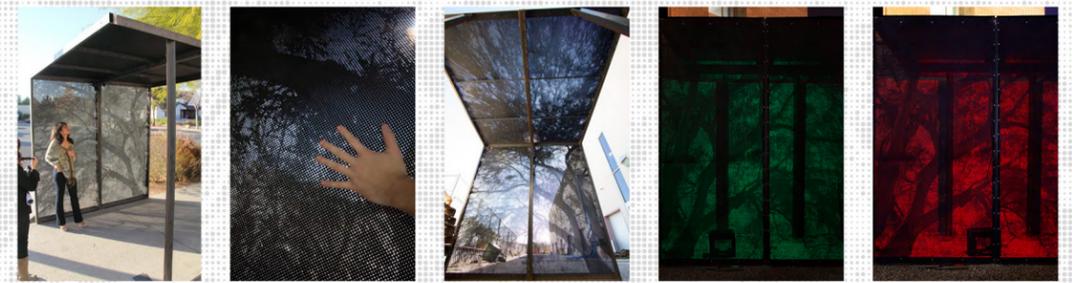
The mock-up used four 4'x8', 1/16" thick, acrylic sheets for proof of concept. The mesquite tree image was cut over the top of the installation to simulate the feeling of being under a mesquite tree in the Mojave Desert. Students also experimented with different LED lighting techniques for the light condition.



The house utilizes the final custom perforated screens as a cooling device which gives the home's occupants the feeling of being under a desired mesquite tree. This not only shades the home, but makes the user "feel" cool as if sitting in the shade of a large tree. The screens then open in the winter, as a sliding system, to allow direct solar heating.



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