Contract Models: FORMwork for Manufacturing

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1. INTRODUCTION

> With the realization of the possible we witness the representation of figuration of what already is (since the idea of the possible is always taken from the real), and in the actualization of the virtual the becoming-other of something that, though real, has not yet been.– (Michael Speaks 1995)

Before the students were given digital models from the collaborating firms, it was important that they first understand who the collaborating firms are and what their intentions and innovations are as contemporary practicing architects.

Students took a week to research the collaborating firms as well as the processes of firms from Frank O. Gehry to Kennedy & Violich Architecture and the work being done at schools such as MIT and Yale. Common themes in regards to technology and architecture were an increasing use of digital softwares, rapid prototyping with Computer-Numerically-Controlled hardwares, and an interest in the repetition and variation of a series of designed components and even archetypes. This idea of a series stems from the modernization of Capitalism which created mass-production and the recent evolution of businesses and manufacturers toward mass-customization.

Mass-customization, as opposed to mass-production, involves the same high-production rate without the lack of consumer and contextual differentiability of production. Mass-customization is the direct result of Computer-Numerically-Controlled machining which can produce repetition and difference at synchronous rates. This creates products and projects that have similar structures with the potential of variation within that structure. The intention then for mass-customization technologies is to be able to create customized goods and services at the same financial and temporal rates as old methods of mass-production.

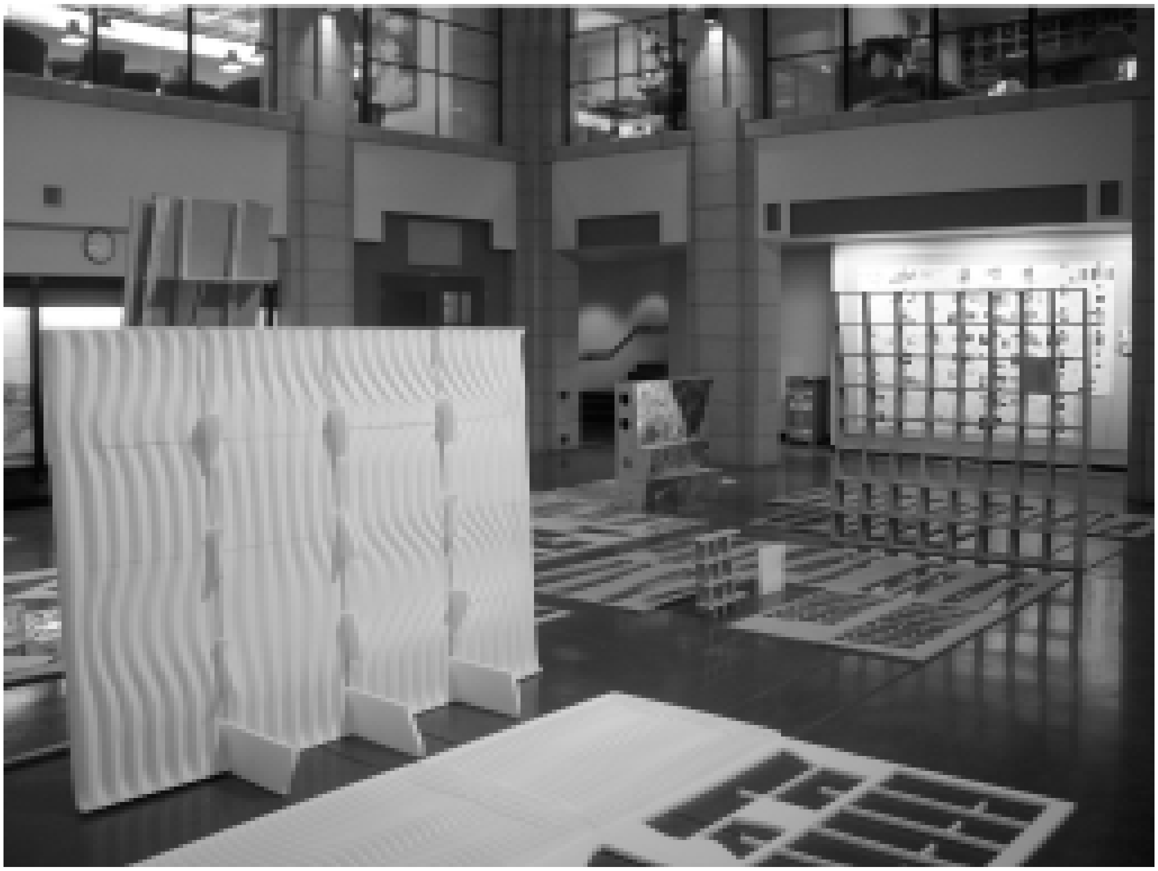
Mass-Customization as a concept for architectural process, specifically in the work of the collaborating firms would prove to be the theme for the work produced in the seminar. Students would not only explore the brushes with mass-customization that exists in the work of the collaborating firms, but in the ‘contract models’ manufactured from the digital models provided, students would have to customize the projects to fit their production capabilities and needs for flexibility (Figure 1).

2 PROJECTS

> The virtual moves directly into the actual while the actual simultaneously reinforms the virtual.– (William Massie 2002)

The twelve students in the class were broken up into four groups according to the projects most interesting to them. Two groups would work on the Camera Obscura and A-Wall designed by SHoP architects, while one group would work on the panels from the Uniserver project designed by Greg Lynn, and one group would work on the wall manufactured at Montana State University by William Massie. Each group evaluated their project relevant to the scale, materials, program, and context for which it was designed, before having to reinterpret their project for each criterion. Students would have to manipulate and reconfigure each project based on the scale, materials, program, and context achievable by that group.

Figure 1. Photograph of Final Seminar Exhibition.



2.1 A-Wall

The A-Wall project was designed and fabricated by SHoP: Sharples, Holden, and Pasquarelli, an architecture firm in New York, for Architecture Magazine as a traveling exhibition trade show booth. It was designed to be lightweight and it is composed of 17 pieces that are easily portable. The exploration of series occurs not only in the multiple pieces of varying sizes, but also in its façade. The face of each piece is comprised of a varying number of folded titanium triangles of different sizes and relationships.

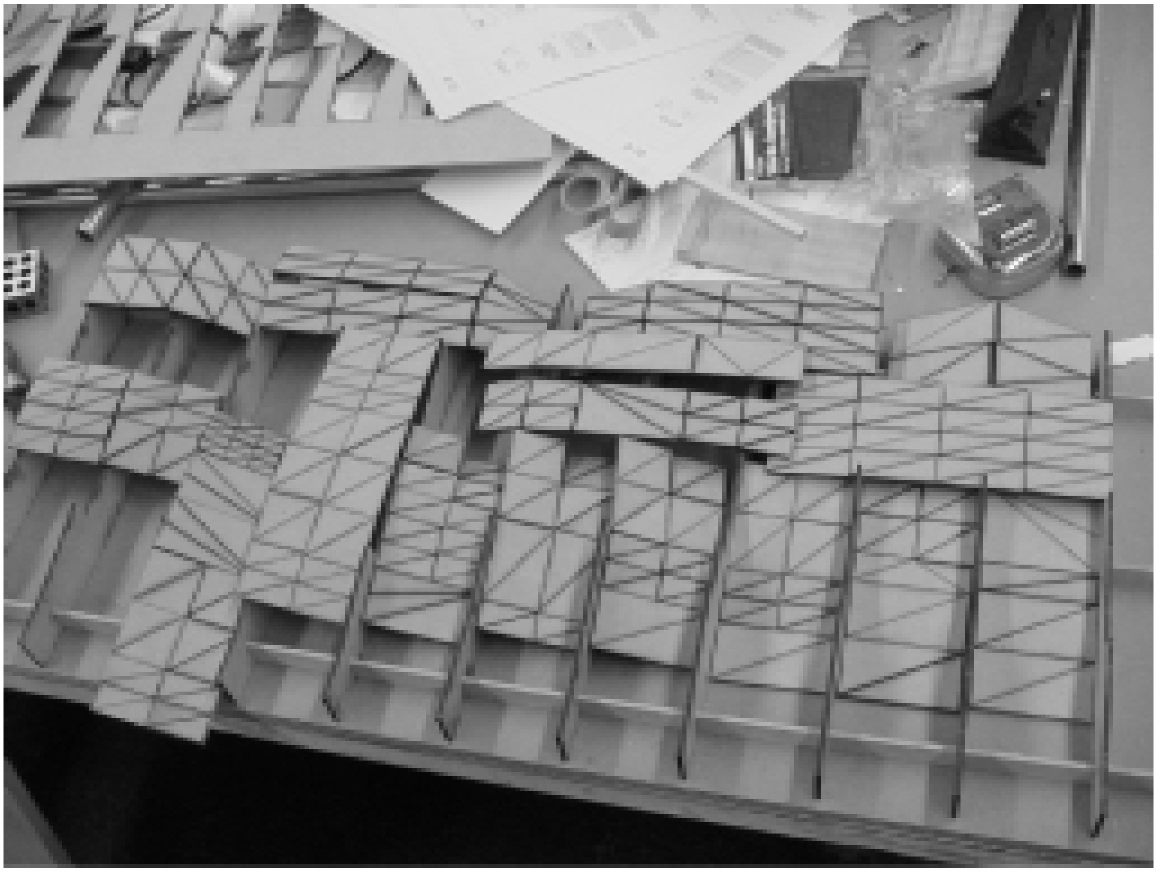
The group which chose the A-Wall found immediately that they would not able, financially or physically to build the entire 10’ x 20’ wall at full scale with a titanium facade. They chose instead to build the entire wall at 1/2” = 1’-0” from CNC laser cut acrylic and to build one section at full scale with an identical backing structure cut from a CNC mill and steel face panels (Figure 2). The steel panels were also cut with a CNC laser cutter which cut the panels and scored the tabs to be folded with a manually operated brake.

The primary exploration and manipulation of the A-Wall dealt with modes of production. The group was challenged with really finding the optimal path for bringing the digital concept into a physical construct. The small-scale model was simple enough. CNC laser cutting produced all of the pieces and the group simply had to keep the series organized and glue them together. In moving to full scale however, the line between CNC production of the pieces and manual assembly had to be found and optimized. Ultimately the CNC laser cutting and scoring held the precision of the project and tolerances for the support structure and manual assembly reduced construction time and margin of error to a minimum.

2.2 Visionaire Panels

The research and work done involving models provided by Greg Lynn were perhaps the most difficult for students to interpret. Lynn, whose professional practice is called FORM, is involved in an incredible range of design and research ranging from architecture and interiors to products and

Figure 2. Small Scale Laser-Cut Model of A-Wall Project During Assembly.



exhibitions and a great deal of corresponding theoretical texts. His work explores a number of formal/tectonic ideas that have a nomenclature ranging from ‘flowers’, ‘skins’, and ‘lattices’, to’‘teeth’, ‘blobs’, ‘folds’, and ‘shreds’. The primary exploration for this group was the formal idea of ‘skins’, which Lynn has developed with the use of a large CNC router for over 12 projects across the full range of his interests and practice. This routing is done from a high-density foam from which Lynn has researched methods of vacuum-forming and surface painting as methods for programming and informing the’‘skins.’

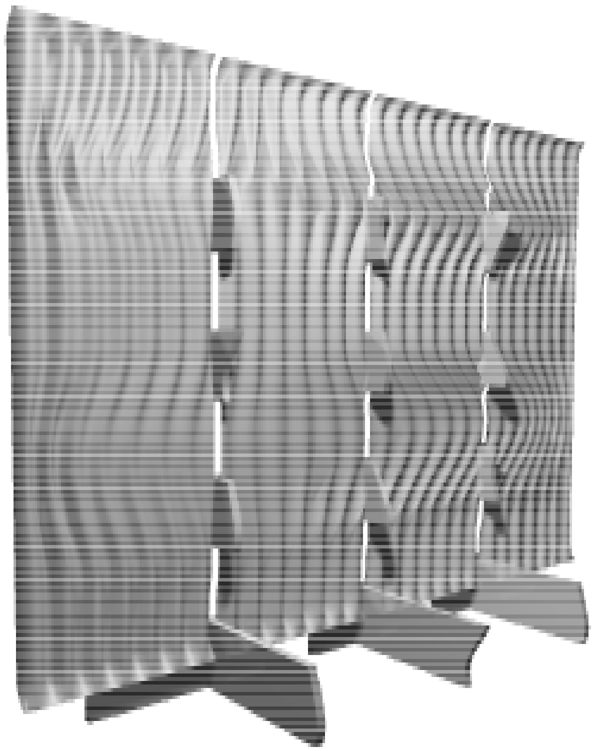
This group, because of the theoretical nature of the work, along with the vast number of applications of the idea of ‘skins,’ was really working more with a formal tectonic than with a single project. By the vary nature of Lynn’s work, the skin of the Visionaire Panels carries a great deal of intricacy as it is full of digital information. This made local manipulations of the model difficult. Themes such as symmetry and logarithmic repetition and variation of surface geometry also kept strict rules on what derivation could be made from the original design (Figure 3). The group instead chose to focus on modulating the surface into units and manipulating the scale of the design.

Scale and unit size were integral to the groups ability to manufacture the design based on a 4’x4’x2” maximum CNC routing volume that certainly does not correspond with the larger maximum routing volume capability or Greg Lynn’s FORM. Using scale as a positive design constraint rather than a negative inhibition gave the students a range of exploration within which to explore foam routing, surface treatments, and vacuum-forming to achieve different surface qualities.

2.3 Massie Wall

William Massie received a research grant while teaching at Montana State University to manufacture a 7’x7’ concrete wall using CNC-milled formwork. The intention of the research was to

Figure 3. Digital Model Rendering of Final Visionaire Panels Project.



prove that by producing the formwork from designer-produced architectural models, the difficulty of drawing interpretation and time consumption of formwork building by contractors would be significantly reduced if not eliminated. The resultant reduction of labor and precision of formwork would make CNC driven concrete work financially comparable to and formally more flexible than traditional concrete work.

The initial interpretation of Massie's wall and digital surface model was quite simple, due to its small size and monolithic nature. Massie sectioned the wall, which is a bilaterally symmetrical compound curve, every 12" vertically to CNC mill steel ribs that act as the concrete formwork. These sections, though not provided, would be easy for the group to reproduce. All work produced in the seminar would however, need to be portable for exhibition in any location, which makes concrete and any affordable casting material non-viable. This would require design and re-interpretation by the group a research and development exercise.

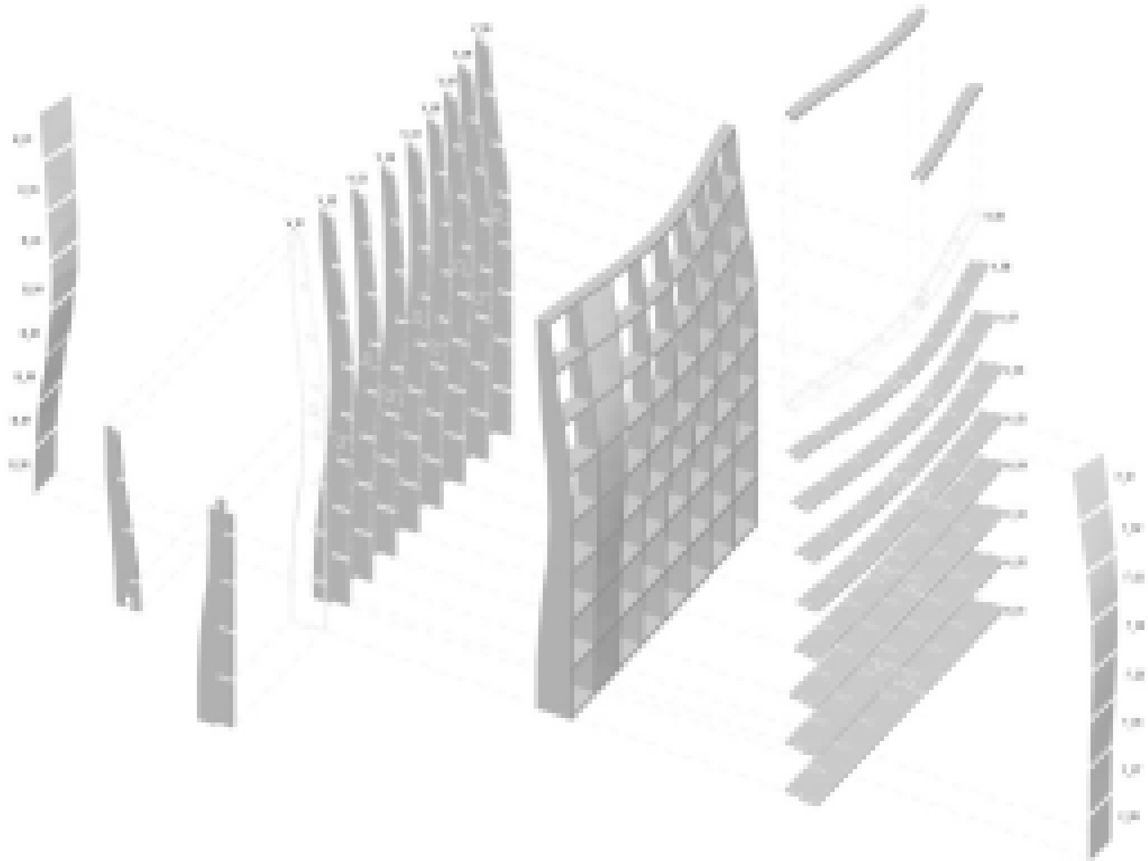
The group began by carrying on the vertical sectioning and eventually choosing to horizontally section the wall to create a lattice that would represent the 3D solid. Once sectioned the pieces could be manufactured from CNC milled 2D sheets. Connections for the horizontal and vertical sections would be created with finger joints designed into the sections by the group. These joints would have to be drawn and milled with ultimate precision to act as the only fastening device between horizontal and vertical. The group faced a limitation of 4'x4' maximum sheet cutting size as well which would make manufacturing the 7' sections impossible as one piece (Figure 4). Researching Massie's work would prove to provide a solution to the problem. Massie often talks about his work as a number of puzzle pieces that tell you how to put the project together. The puzzle joint that appears frequently in his work would provide a connection that could create the 7' sections. Similar to the finger joint, the puzzle joint would allow zero tolerance as a structural connection. These connections and tolerances that CNC milling provides created a idea of assembly that gave the monolithic project its own complexity.

2.4 Camera Obscura

The Camera Obscura is also a project designed by SHoP. Perhaps the most complex of all the projects, it is described as "...a kit of custom parts accompanied by a set of instructions much like those included with a model aeroplane kit. Primary aluminum and steel components will be laser cut using digital files directly extracted from the computer model, with crucial information etched into the components for ease of fabrication.""– (SHoP/ Sharples Holden Pasquarelli) Similar to the other SHoP project, the A-Wall, this project would be far too large and too expensive to build in its entirety at full scale.

After a rigorous process of working with and interpreting the digital file a 1/2" = 1'-0" physical model was laser cut from acrylic (Figure 5). This model enabled the visualization and testing needed to determine what could be built at full scale and how it might be manufactured inside the physical and financial constraints of the 3-person group. After those decisions were hypothesized, the group began milling the"'kit of parts' for sections 24 and 25. Specific adaptations had to be made in order to build a free-standing section at the full height of over 9' that would support the cladding and shelving dead-loads and the live-loads of being

Figure 4. Exploded Axonometric Rendering of Massie Wall Project.



physically moved. Medium Density Fiberboard, for financial reasons, was substituted for aluminum components and much of the steel bracketing as well as the concrete slab, which was substituted with 12 sections of milled 3/4” MDF.

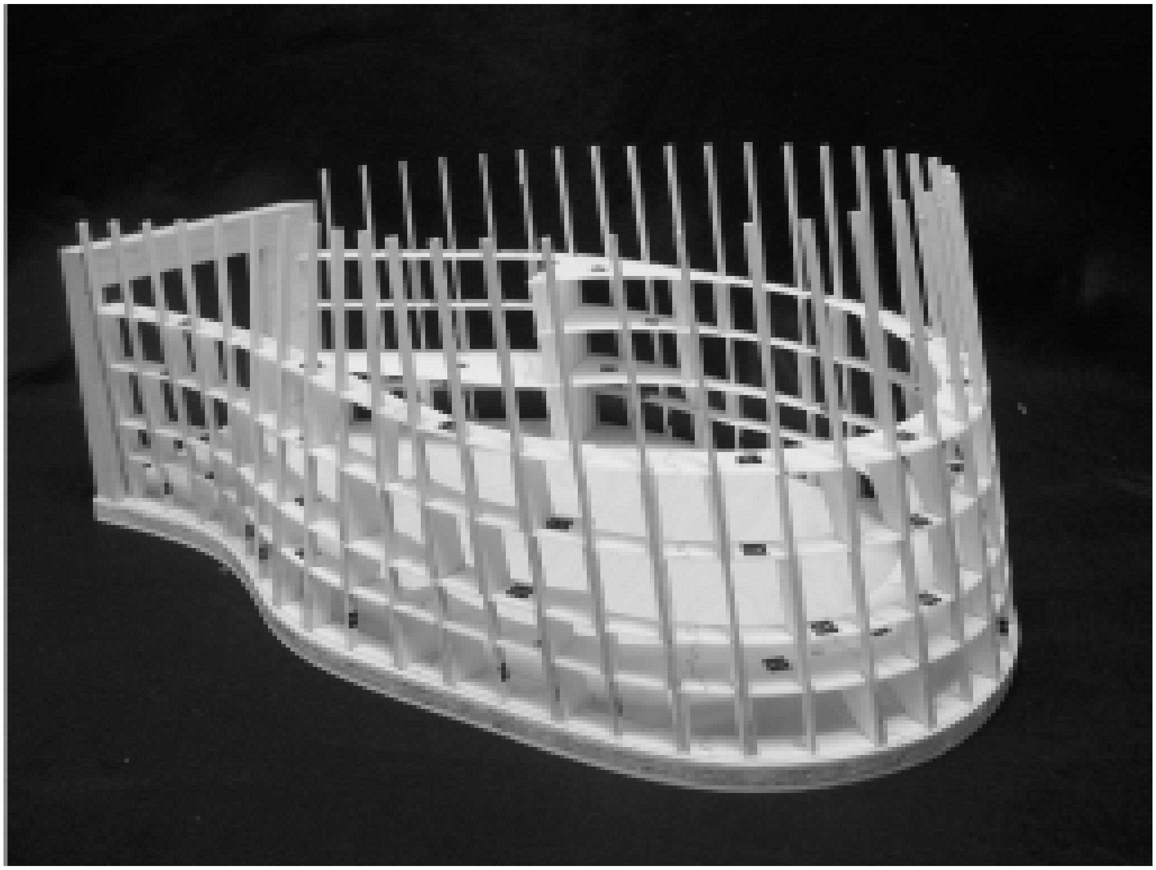
Among other innovations, the group used the CNC machine to cut precisely angled units to be used as physical cutting templates to fabricate steel base mounting brackets. These brackets help reinforce the connection of the vertical members to the fabricated base. A series of extra connections also had to be designed to substitute for the welded joints that create the cantilevered shelving system. These specifically angled steel mounting brackets were fabricated from a hybrid process of digital milling and physical plasma cutting. Here again templates were cut from the CNC mill to serve for guiding the plasma cutting. Similar to the Massie Wall this group were exploring the use of CNC technology for low tolerance assembly, however the Camera Obscura required many more types of assembly to accommodate the”‘kit of parts’ condition.

The research from these seminar projects was perhaps most strong when presented as a whole. Each project dealt with CNC technology, but they were all different in that they all addressed a different design constraint. In the end the seminar was not about making architectural product, but instead about the process of finding project limits and making “contract models” that work within those constraints. This realization and the potentials that it opens up has sparked more ongoing and upcoming research.

3 FORWARD THINKING

> “Instant synchronization of numerous operations has ended the old mechanical pattern of setting up operations in lineal

Figure 5. Small Scale Model of Camera Obscura Project.



sequence…mechanical standardization is now past."– (Marshall McLuhan 1999)

3.1 Research and Tool paths

The research from these seminars specifically in the exploration of surface models such as the Greg Lynn and William Massie projects generated a series of independent studies into the nature of tool paths, or the patterned line in which the CNC machine traces the model coordinates. For the exploration, a surface model was made in the same format that the Massie surface was made using a Paul Klee painting as its subject. This surface model would then be milled on the CNC machine more than a dozen times with different tool paths, hybrids of multiple tool paths, and different tools of varying sizes and shapes.

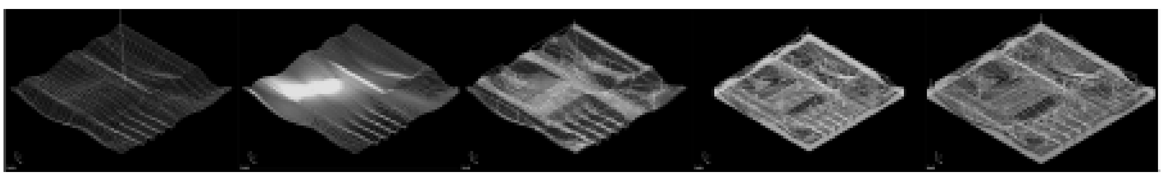
Each tool path and tool combination cuts the same surface model coordinates; the resultant form always remains the same. The potential of the varied tooling however, can be controlled to create different surface qualities tailored to the desires of the designer, project, or client (Figure 6). While some tooling conforms to the contours of the 3D surface, carving and accentuating the graduating elevations, others apply themselves in an ornamental fashion by creating such patterns as a radiating tool path.

3.2 Objects and Landscapes

Much of the research done has been part of a very open ended learning process. Many of the discoveries made and the constraints manipulated were not foreseeable. As research continues, future work can move from general discovery toward much more focused investigations. A divergent series of studies will continue as an interdisciplinary seminar of architecture students and others interested where designs of objects or products can appeal to industrial design students and designs of field conditions can appeal to landscape and planning students.

Upon reviewing and looking forward with the seminar, certain parameters have been established and at the same time new parameters need to be determined. The new parameters will be inherently flexible so as to allow for a continuous updating from year to year. A specific example of such parameters deals with the idea of materials. A single material type and quantity will be fixed at the beginning of projects as a datum for construction. In other words, an entire furniture piece will be cut from a single sheet of material as a design problem. Another example will involve the idea of landscape as a means of tiling entire surfaces with textured milling patterns. The seminar on many levels is component driven and discoveries are associative in nature when viewed overall. The manufacturing processes also establish a tectonic upon which students build direct ties to their own designs. Practice and the collaborative nature of the information transferred between designers and manufacturers was made smooth by a free exchange of all involved parties.

Figure 6. Series of Screen Captures from CAM Model of Tool Path Research.



4 CONCLUSION

If Computer-Numerically-Controlled technologies, rapid prototyping, and mass-customization are the cutting-edge present and developing future of design, then not only is it important for students to learn to utilize this technology, but it is imperative that they understand its limits and its possibilities. Exposure to a variety of uses of this technology in contemporary practices, the ability to understand and manipulate the models that drive such practices, and the ultimate ability to use that understanding for original research and design provides the insight that students can use in future practices.

The direct translation from digital design to physical construct eliminated the need for translation drawings and interpretation by a third party builder. Students can then move more deftly between digital and physical prototypes and eventually between education and the profession. This allows student designers and ultimately architects to be their own manufacturers as a logical alternative to contract documents. This not only allows them to collaborate with builders, but also brings the knowledge and control of how things are assembled back to designers making them more capable of interaction with contractors for the future.

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