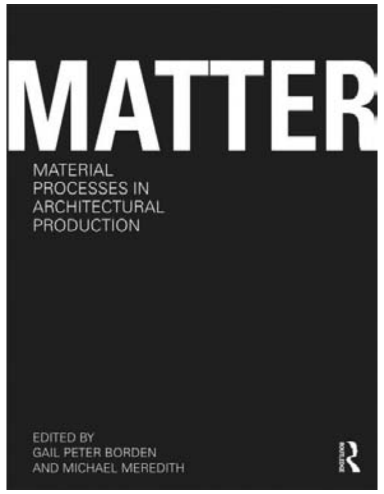


MATTER:
Material Processes in Architectural Production
Gail Peter Borden and Michael Meredith

Chapter Contribution: Material Resistance
Publication date: July 28, 2011

100/101

LEFT: Detail of CNC panel with graded entry and exit tool paths.
RIGHT: Installed CNC panel.
Photos: Jeremy Ficca

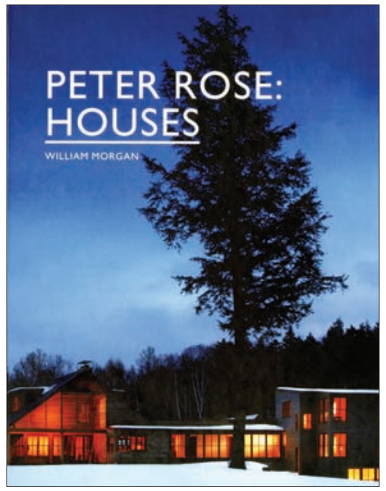
CNC Panels
Jeremy Ficca, 2004

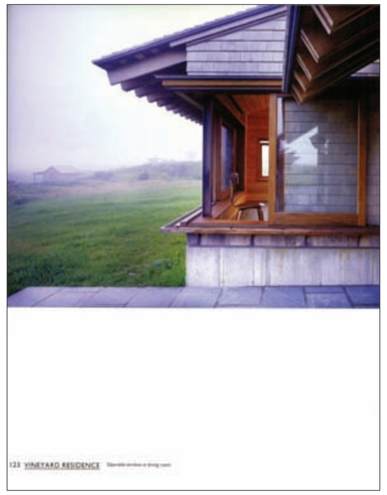
Plywood is an affordable, widely available building material, utilized by the construction and furniture industries alike. This off-the-shelf product provided the palette for investigating of digital-fabrication techniques, specifically two-and-a-half-axis CNC routing, for which two-dimensional vector CAD drawings determined the tool paths. This plywood investigation produced a surface that could respond to the changing programmatic or environmental requirements of a given space, either through material mutability or built-in flexibility.

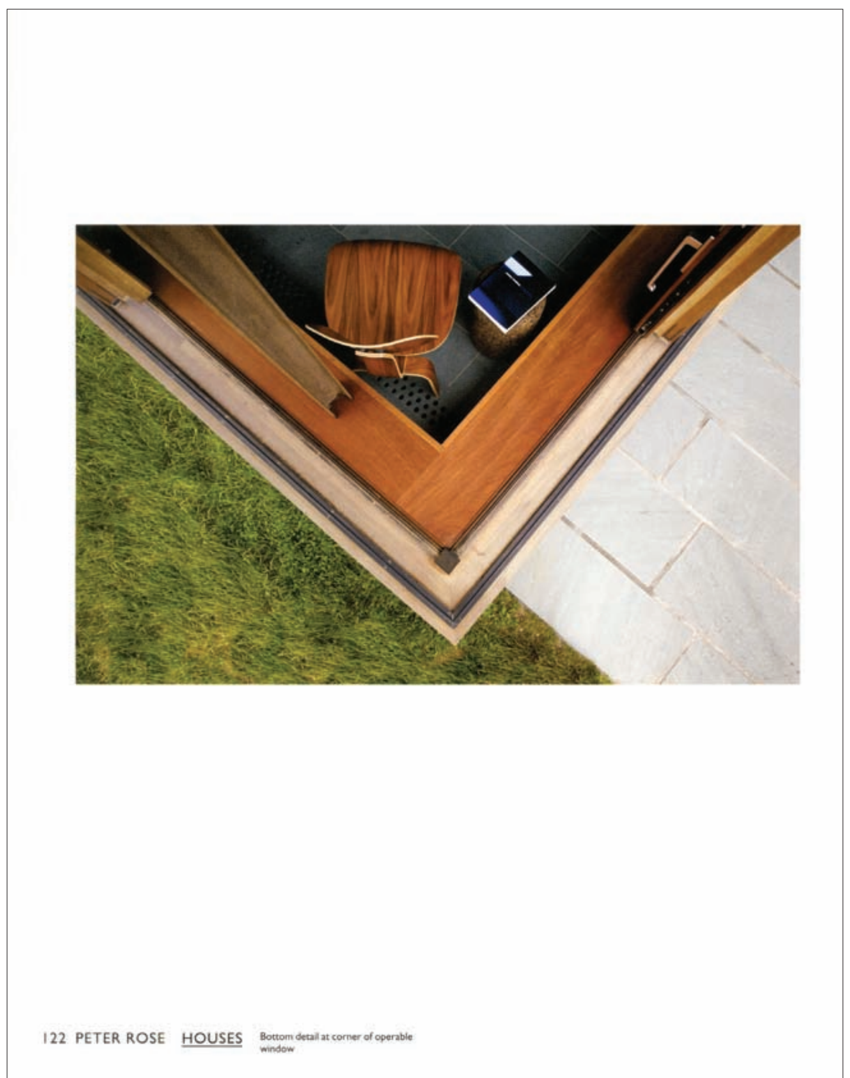
The general premise was to allow for the product to evolve through specific tooling investigations, the limits of which were largely dictated by the material itself. Seven-ply Baltic birch was chosen for its strength and finish quality. Initial routing was primarily two-dimensional, producing kerfs and cuts that allowed bending in response to push and pull, effectively transforming a rigid sheet into a pliable surface. A subtle change in the depth or spacing of kerfs dramatically affected the ease of bending and general stability. Milling too deep resulted in precarious sheets that were easily broken. Milling to shallow left the sheet rigidity effectively unchanged. As these investigations progressed, the milling moved to both faces of the plywood: the registration and intentional misregistration between cuts on both faces produced a lattice-like condition. At the scale of a room, the series of panels encourage a modulation of view and light.

DIGITAL FABRICATIONS
Architectural and Material Techniques
Lisa Iwamoto

Plywood Panels

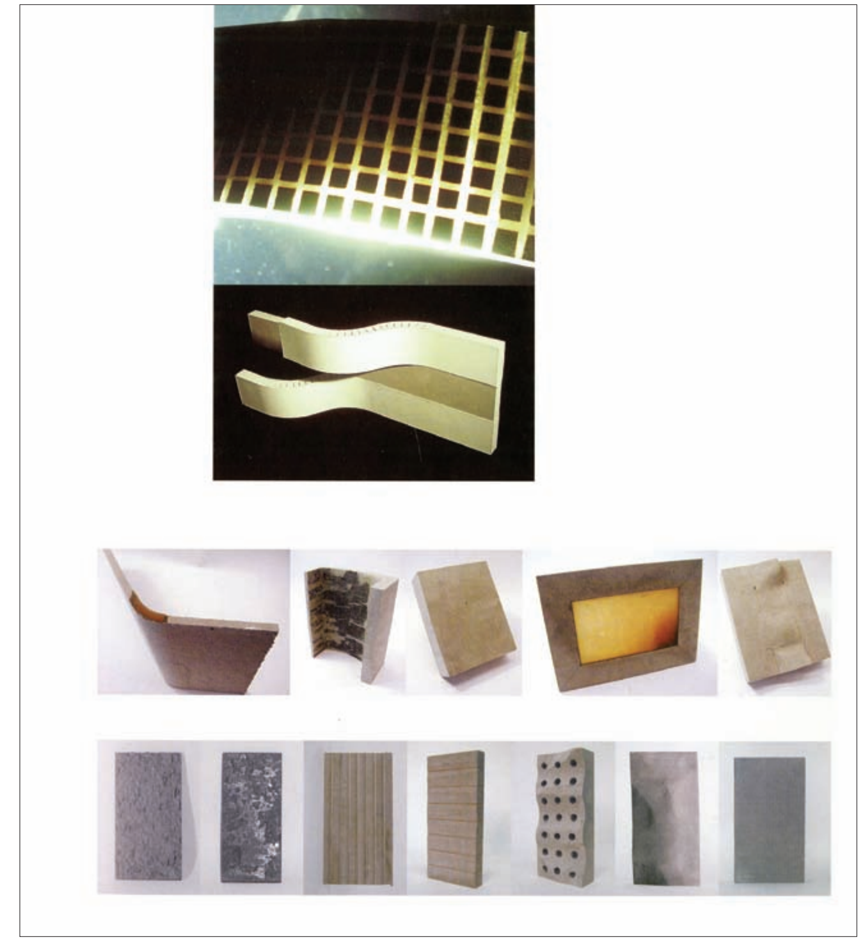


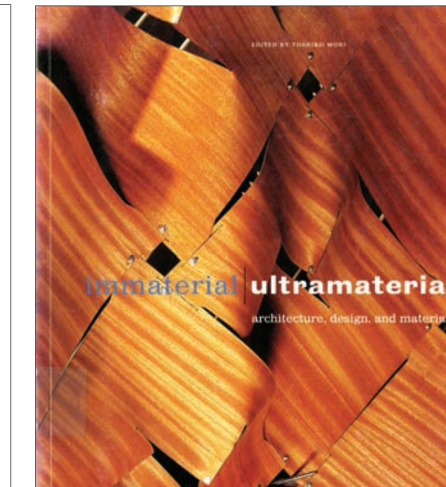




PETER ROSE: HOUSES
William Morgan

Vineyard House





IMMATERIAL | ULTRAMATERIAL
Toshiko Mori

Surface Research

fessors. "School projects rarely go much further than 'design development,' and although most of us had had internships in which we had participated in making construction documents, being the ones solely responsible for the entire process simply does not compare."

This year's group of students has started proposals of their own Design Build project, for the community of Homewood-Brushton. When asked about how constraints of constructability might modify the conceptual design process fourth year architecture student Kaitlin Miciunas responded that "constraints for constructability are a source for innovation – there are many parameters to take into account from finances to feasibility to time restraint to community impact to code restrictions and more."

The relationship between thinking and making is one critically engaged at Carnegie Mellon throughout the five years of the school's B.Arch. program. Materials and Assembly, a second year course taught by assistant professor Dale Clifford, specifically spotlights the mind-to-hand and hand-to-mind communication. Students are encouraged to explore and experiment through model-making, combining this tactile experience with their rational understanding of structure to produce a series of iterations responding to this rigorous process.

Clifford, emphatic about the importance of working models to contribute to the development of a design, explains, "For us, working models are a vehicle to discovery, innovation, and practical application. [...] A working model–differentiated from a 'presentation' model–gives us information on how to proceed with a design prospect. A working model helps us to gain new knowledge about the project from multiple and varied viewpoints; it is literally a creative, pragmatic, and experimental window into the possible contribution of our work."

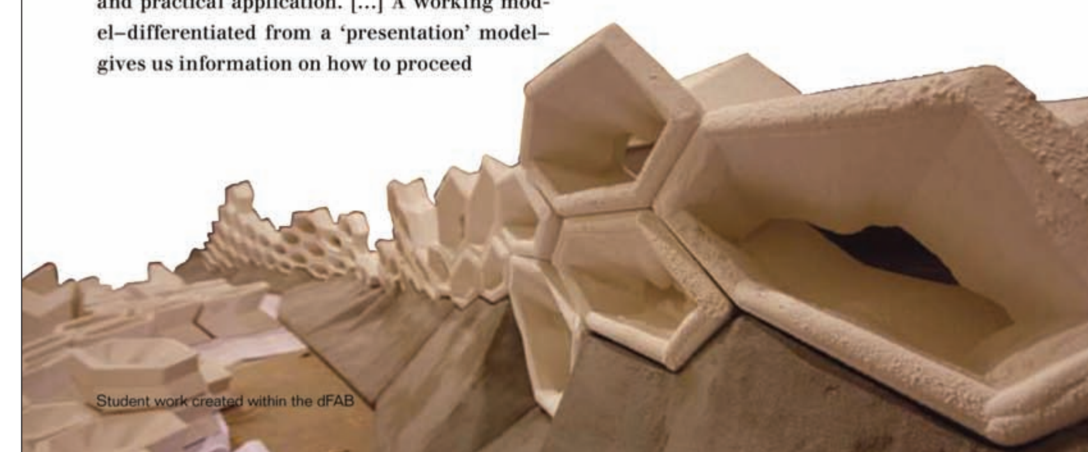
The 'real world' us students have heard whispers of throughout our academic lives sometimes seems like a threatening storm cloud of anxiety ready to pour down on us the second we graduate. But gradual introductions to this untested ground have proven sturdy enough to carry our heavy academic baggage while establishing a new comfort zone in this place you call 'reality.'

ARCHITECTURE AND TECHNOLOGY: WE HAVE ROBOTS – ARE WE AS COOL AS GREG LYNN?

BY MATTHEW HUBER

We live in a world where five-year-olds navigate YouTube with the same mundane ease that their parents assume while perusing the morning paper. New software, sustainable gadgetry, and automated manufacturing daily appear with the revolutionary vigor of the latest iPhone app. The relationship between technological fascination and respect for tradition is becoming ever more important. The School of Architecture at Carnegie Mellon University is exploring how the analog and the digital, the real and the virtual, can grow together.

For Carnegie Mellon, however, this brand of forward thinking is nothing new. Littering its


Student work created within the dFAB

[PRESS]

As students quickly learn, materials and processes present resistance and limitations and as a result inform design. This is not a linear process but rather a continuos feedback loop. JEREMY FICCA, AIA

archives are as many photos of students working lathes as drafting details or hitting the books. Founded in 1900 as the Carnegie Technical Schools, the institution owes its origins to training the sons and daughters of mill workers through a hands-on approach to the latest technologies. The recent trend of bolstering novel digital processes with physical corollaries is just the latest manifestation of the school's legacy.

The most obvious and perhaps compelling advancement on this front is buried five floors below the first-year studios in Margaret Morrison Carnegie Hall. The recently established Digital Fabrication Lab or dFAB is a menagerie fit for a technophile's dreams. The facility grants access for students to a range of equipment, including two 3-D printers, a laser cutter, a vacuum former, a CNC milling machine, an additive robot, and a massive, versatile, 7 axis industrial robot rigged for milling or other operations.

The host of a recent symposium entitled Robotic Tectonics, Jeremy Ficca, AIA, assistant professor and director of the lab, invited leading innovators from similar institutions to discuss and demonstrate the possibilities of robotic fabrication in architecture. As the title of the symposium and much of the work presented indicate, Ficca believes that dFAB tools are reintroducing materiality and tectonics to the discourse of architecture.

He sees the seamless integration of the lab into studio coursework as a crucial strength of Carnegie Mellon's curriculum. Not only does the lab offer a direct bridge between digital modeling and the real world, but experience there also provides students with crucial insight into the reality of otherwise abstract drawings and images on screens. Ficca explains, "as students quickly learn, materials and processes present resistance and limitations and as a result inform design. This is not a linear process, but rather a continuous feedback loop."

The dialogue begins as early as students' first semester. As part of the required curriculum, Lucian and Rita Caste Professor of Archi-

TOP: Digital Fabrication Lab facilities, BOTTOM: Recent student work from the dFAB

tecture and Urban Design, assistant professor Pablo Garcia teaches the course Introduction to Digital Media I (IDM). Students are taught to investigate the relationship between digital and analog methods of representation.

In addition to researching advanced digital procedures, Garcia is using funding from the *Ferguson-Jacobs Prize* to rebuild analog drawing machines from the 16th to 19th centuries. He explains the importance of maintaining a hybrid position between the digital and the analog: "The absolute state is not relevant; the suppleness and flexibility of the user to navigate both sides, to be multilingual and multi-dextrous, is paramount in the 21st century."

Offered in the same semester as IDM, professor Ramesh Krishnamurti – who is known for research in computational design - instructs students in Descriptive Geometry. Invented in 1765 by Gaspard Monge, the practice marries mathematics and drawing to describe complex three-dimensional geometry in two dimensions. Armed with nothing but drafting tools and calculators, students are rigorously prepared for the complexities of computer modeling programs, such as Rhino and 3ds Max.

In advanced courses, Krishnamurti teaches students to discover shape grammars in various architectural typologies, from Palladian villas to the ornamentation of Frank Lloyd Wright, to the configuration of traditional Taiwanese houses. These explorations predate computer-generated grammars, but inform the algorithmic and parametric design courses that implement advanced software and basic scripting. In addition to pure form, Krishnamurti is also introducing the analysis and generation of sustainably performative architecture through BIM.

The work of architecture's latest digital prodigies – Greg Lynn, MOS, and Lars Spuybroek included – obviously involves the latest technologies: seven axis robots, CNC mills, BIM, scripting, or parametrics. But a historical and theoretical grounding in the architectural traditions these technologies advance make the work significant.

At Carnegie Mellon, students are prepared not simply to operate advanced computer-controlled equipment, photoshop like a Hollywood professional, and model irregular geometry; they learn to understand the complexities underlying these tools and to translate abstraction to reality. As Garcia summarizes, "the technology is always there, and the collaborative demands force a great leader, a conceptual thinker, and an adept manager to corral all the methods and talent around them. So let's make architecture school a laboratory, a place of experimentation, a place where ideas are tested and making takes precedence." C