Strand Porosities: Mixing Traditional Textile Techniques with Digital Craft

In the race for novelty and spectacle, architects often focus solely on the newest forms of technology for aesthetic innovation and appropriation. This approach inherently prioritizes newer techniques above older ones. This "new release" version of technological appropriation often forces design innovation into a corner in which subtle versions of strikingly similar techniques can be seen in

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different mediums, magazines, schools, and blogs. This is not a massive detriment to architecture in its own right but the bias toward the newest tools can create a culture of saturation and aesthetic stagnation. Ironically, while these techniques become popular within the practice, they often alienate architecture from a larger audience.

This paper presents three projects in which traditional textile techniques are combined with digital design processes to create novel forms of porosity. The projects appropriate techniques from the textile arts of Indonesia, specifically the Island of Java. In these projects, old and new techniques are valued equally. The projects appropriate the technical intelligences such as patterning, tooling, and efficiency inherent in the textile process. In addition to transferring technical knowledge, cultural information is transferred through the ways of making. The material resistance encoded in these textile processes transfers to computer protocols and through to the materiality of built form.

Combining these techniques does not transfer only the content of *what* was made but translates and borrows from *how* it was made. This technical transfer of cultural content allows for both bottom-up and top-down aesthetic processes to transcend entrenched, singular symbolic meanings. This type of technique sampling[1] allows one to create visual and tactile links to culture through familiar affects without creating static iconographic identity.[2]

In addition to this specific type of technology transfer all three projects deal with domestic space, in particular the surfaces that mediate between interior and exterior. These domestic protocols bias and inform the affects created in the skin. This embedded aesthetic layer works like what Jeffrey

Kipnis refers to as "cosmetics."[3] These cosmetics (used by Kipnis to replace the term ornament) create specific porosity allowing the projects to explore new formation of enclosure. The attenuation, dispersal, and material inflection created using appropriated textile techniques allows the projects to question a static singular reading of domestic space.

Through each of the three projects, parametric models and an iterative set of prototypes were used to refine the strand systems. Through a process of repeated feedback, the parametric models were used to test initial assumptions, and physical prototypes were used to reinforce and legitimize the digital models. Smaller-scale models and prototypes were also used to test aesthetic assumptions.

The first project, Weft House, the design for a residence in West Jakarta commissioned in 2010, initiated our research into Indonesian textiles. The second project, Loom Portal, an installation in a former house turned museum continued that research in an installation in St. Louis, Missouri in the fall of 2011. The final project, Kopo House, uses some of the same software techniques but transitioned our research into different weaving types. The final project is a house currently under construction in Bandung, Indonesia.

INDONESIAN CONTEXT

Indonesia is one of the most diverse and complex countries in the world. The population of 242 million people on 13,000 islands speaking more than 700 different languages has a rich cultural history. The porous nature of Indonesian boarders has led to it being influenced by China, Malaysia, India, Arabia, and the Netherlands. Indonesia's capital city Jakarta exemplifies this rich history through its cultural diversity and institutions. The city's architecture, however, has very little evidence of this rich cultural context. There is tacit agreement among architects and cultural critics alike that the current state of architecture in Jakarta does not reflect the city's broad and deep cultural heritage.[4] Cultural heritage based in endemic craft traditions permeates daily life, traditional rituals, and popular culture.

WEFT HOUSE

The Weft House is located on one of the few undeveloped lots in the dense suburb of Western Jakarta. The subdivision has been developed with almost total disregard for the local, antiquated Dutch building codes originally meant to preserve access to light and air. The code specified a maximum of two-story houses the full width of the site boundary on the first floor with a second floor set back to let in air and light. Homes are built with 25-foot-tall party walls on three sides and up to 80% lot coverage. A tacit agreement between the city and owners allows for relatively small fines to be paid in return for disregarding the daylight-massing and formal stipulations of the colonial era code.

These site conditions create a conflict between daylight and the size of the house. The design negotiates these constraints by weaving solid service and private spaces around a string of open public spaces. These strands shift from sitewall to sitewall to allow for two large voids in an otherwise solid mass. At the rear of the house the bedrooms are arranged around one void which receives east light. At the front of the house a west-facing void allows light into the study, family, and entry.

Two additional contradictions also influenced the massing of the house and its surface. First, the entry for cars and people at the street had to be on the west side of the lot but a garage had to be positioned on the east side. The maneuvering of the cars into the garage took up more space than the required setback so the first floor pushed back and the second floor study was cantilevered four meters over the garage. This created an interesting public space, exposed on three sides and forward of the rest of the house.

The cladding of the house was the final contradiction. As a newlywed couple, the clients were of two minds about the aesthetic feel and opacity of the façade. He required that the mass of the house be "transparent like a modern house" but she wanted a private house that was "solid like a stone". To address this paradox we designed a dense woven screen to shade the upper story of the cantilevered glass façade.

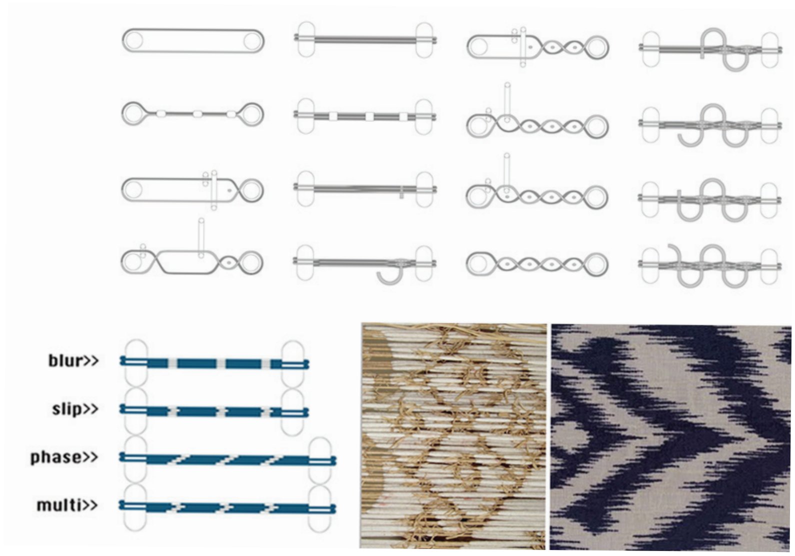
Programmatically, the screen needed to wrap the front of the house for privacy, allowing access and view on the west side facing a private roof garden. To accomplish this, the surface twists and contracts as it wraps from north to west. The screen also had to vary in porosity to allow in light and create an ordered pattern on the façade. Aside from the programmatic function this patterned skin was seen as an asset shared between the client and the public. For this asset acting as both wallpaper and an affirmation of the cultural context of Jakarta we chose to reference the craft of Javanese Warp Ikat.

WARP IKAT PROCESS

The word *ikat* means "to tie a knot". This simple naming of the fabric for its process underscores the elegance and deceptive simplicity of the craft. The production of Warp Ikat begins with the wrapping of a single, white warp thread around an upright frame. Once in the frame the parallel thread is wrapped at intervals with palm leaves or plastic strips. The knotted strips form positive patterns in the un-dyed thread but the design will be reversed when the piece is taken off the frame and dyed. This reversal is also common in tie-dying and Batik patterns but the integration of dying and weaving is unique to Ikat.

This integration is most apparent in the diagonal patterns and repetitive symmetries of Ikat motifs. These motifs come about through the ease of aligning tied bundles in staggered patterns. Reversing these diagonal tendencies creates symmetries, which, along with simple number sequences, allows simple sets of rules for complex rhythmic patterns.

Two other characteristic aesthetic tendencies in Ikat are the noise and blur created at the edges of figures. There are often small discrepancies in fidelity between the tied patterns and the woven cloth. This is because of the strands either slipping or stretching from the tying frame to the loom.



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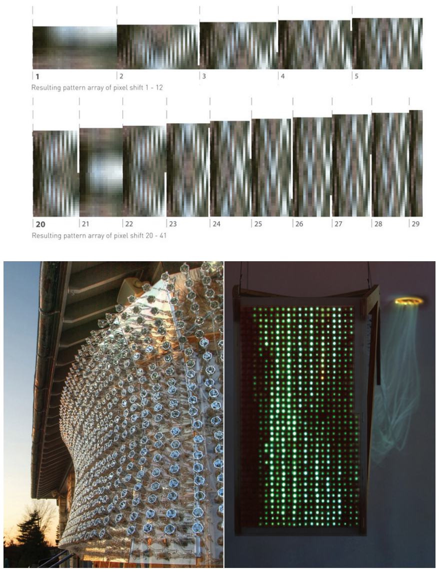
This creates the characteristic noise tendency in Ikat motifs. Blurring of the same edges occurs when bundles are not sealed or tied tightly. These apparent mistakes are considered in the production of motifs and can be augmented or subdued by skilled Ikat artisans.

WEFT HOUSE SCREEN

The first attempt to design patterns for the Weft House used tri-axial weaves. Borrowed from basketry, this technique allows for tessellation patterns to be translated into strands. Patterns were developed using small hand models. Several different strategies were simultaneously used to create mesh frameworks with parametric variability in Grasshopper. This proved productive in making flat patterns but it was difficult to give depth to the three-axis weave. Depth was important because the screen needed to shade the typically vertical midday rays of the sun.[5] So a simpler weave strategy was chosen with a vertical frame like warp fibers and flexible strands to act as the variable weft strands. This allowed the porosity to be controlled separately from the structure. Ikat could be used as a reference in the simple frame, which seemed more culturally appropriate as a domestic decoration because the fabric is used for tablecloths, wall hangings, and clothing during celebrations.

Using this simple weave, frames made of aluminum could act as the vertical warp with 30-millimeter synthetic rattan ribbons for the weft strands. This system could be fabricated by local manufacturers of synthetic rattan outdoor furniture. The aluminum frame controls the porosity through a series of CNC-cut slits calibrated using Grasshopper definitions that rotate and shift the rattan. Just as patterns in Ikat weaving are created by shifting pre-dyed strands, the screen pattern is generated by shifting a pre-determined rotation sequence across the grid of the aluminum frame. Blur and noise in Warp Ikat could be created using the amount of twist in the strands as an analogy to the tying of the threads in Ikat.

Figure 1. Diagrams of Ikat weaving technique, noise, and blur effect through slipping, and example of tied threads and fabric.



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A series of Grasshopper models were used to refine the effects and the details of the screen. The first definition allowed the entire screen to be twisted using bitmap data matrices. Because the screen was a grid this worked well, but it was modified to account for the change in vertical height of the screen. This change was controlled by a refinement that limited the rotation of the rattan as the height diminished. This definition was built upon and refined to use a sequence of diagonal vectors instead of binary matrix. Building up several layers of diagonals created noise and interference patterns. These secondary patterns "blur" the diagonal vectors and create unexpected pattern variation. The resulting patterning is further tempered using a gradient map that allowed the pattern to be mirrored. This layering of control protocols enabled the motifs to remain consistent even through the opacity changed. When a final pattern was chosen, a final set of Grasshopper definitions was developed to create the slotted aluminum verticals and the double-curved frame edge. The screen is still under development with full-scale screen prototypes planned for spring 2013.

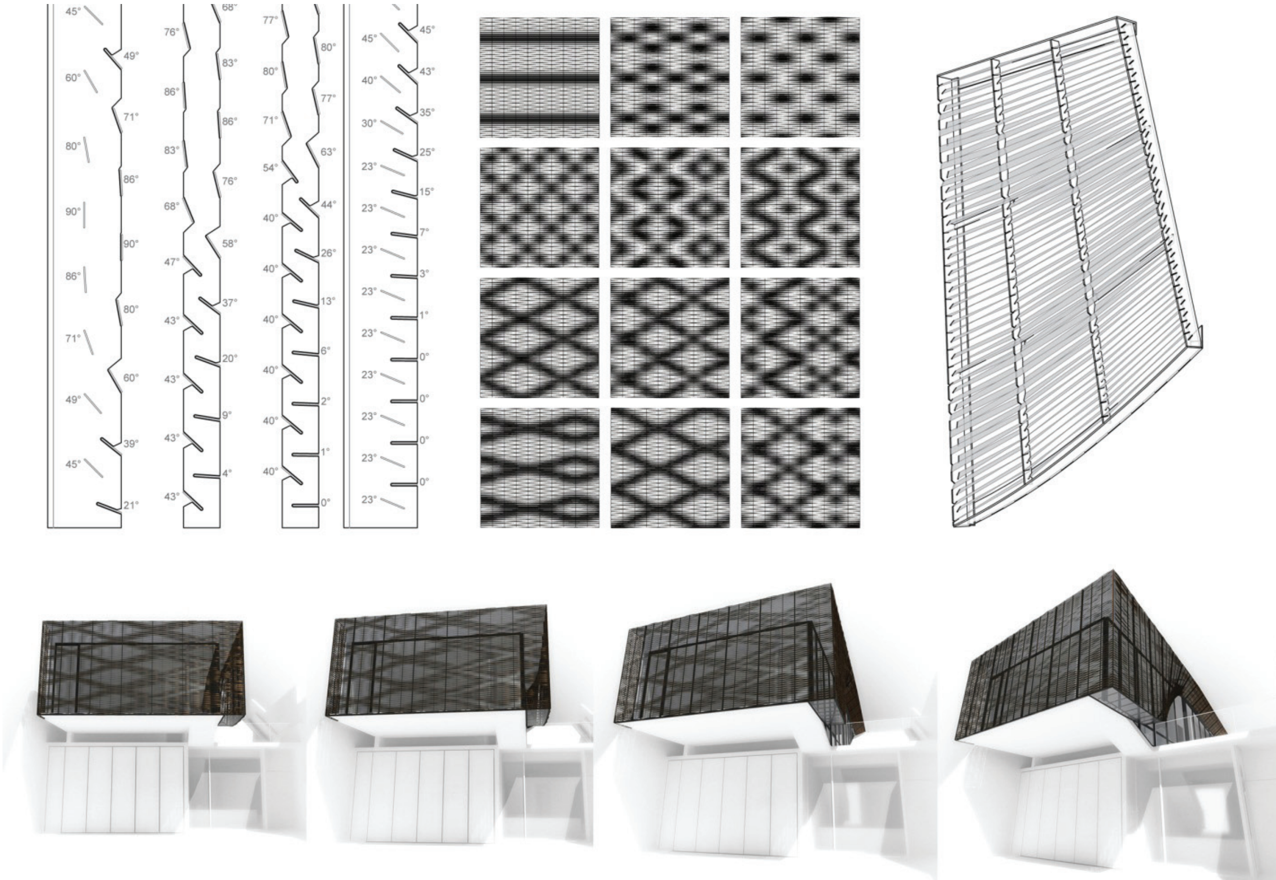
LOOM PORTAL

The Kranzberg Galleries at Laumeier Sculpture Park in St. Louis, Missouri inhabit a former residence at the park's main entrance. A second skin of gypsum walls was added on the inside of the house to cover the windows and provide hanging space for art leaving the original ceiling and floor exposed. The effect is somewhat disconcerting and starkly contrasts the vast, sculpture-filled landscape surrounding the house. We visited the space upon our invitation to create an "electric" installation piece for the gallery. After this visit we decided to create an installation without any active electronic systems and to place most of our work outside of the gallery. Loom Portal was conceived of as a didactic, trustworthy, environmentally dependent piece of technology. The installation also provided an opportunity to use some of the patterning techniques gleaned from researching Warp Ikat.

Loom Portal attenuated the typical path of light from exterior to interior by channeling it through eight miles of fiber optic filaments. Eight hundred parabolic mirrors channel exterior light and color from the park landscape to the unlit museum interior. Each mirror in the concave array aims at a slightly different position taking in discrete samples of light from approximately 120 degrees of the landscape. From the 14' x 9'mirror array, light moves through a 5" x 5" hole in the museum wall, and finally through a "loom" to an interior output array. The interior "loom," consisting of a wood frame and two acrylic heddles hanging from the ceiling, stretched the fibers and organized the matrix of fibers from the exterior input mirrors to the interior output screen. The filaments terminate at a diffusing screen that displays the sampled light through an array of "pixels." The reorganized exterior samples are displayed as a phased pattern that creates an undulating horizon.

Figure 2. Weft House screen vertical aluminum as warp, horizontal strands as weft phasing, prototype drawings, façade entry sequence

Technology appropriated from Ikat weaving guided the Grasshopper definitions used to create the undulating horizon pattern in Loom Portal. The slip inherent in the process of Ikat was exploited and exaggerated to create a phased pattern of sliding columns in the matrix of the loom's "pixels." This



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phased pattern results from sequencing the pixels in a continuous string, like the warp threads held in a frame during the first stage of the Ikat process. However, instead of placing the "string" of points on the same length loom, the proportions are stretched into a vertical pattern. A Grasshopper definition was developed to vary the pattern to any proportion using a rearrangement of a typical matrix to follow the rules governed by the *ikat* "string." The same definition also outputs each, arranging the heddle in the loom. Starting from 40 pixels wide by 20 pixels tall in the exterior array, the samples were stretched to 21 pixels wide by 39 pixels tall in the interior screen. The remainder of pixels in the nearly mirrored proportion creates a slip in the pattern that moves through a phased sequence, creating a criss-crossed double horizon. Surprisingly, this patterning has an effect similar to the manual stepping which created diagonals in *ikat* motifs.

KOPO HOUSE

The Kopo Residence is a two-story single-family residence in the city of Bandung, Indonesia's second largest city. The site lies on Kopo Road, one of only four roads that connect the Javanese highway system to Bandung. Occupying the periphery of the city limits, the Kopo district suffers from lack of governance to reinforce zoning laws, and has been subjected to large-scale experimental development projects. Today, the Kopo district is an amalgam of medium-scale industrial compounds, multi-level shopping centers, small-scale commercial buildings, and sporadic clusters of single-family houses.

Figure 3. Loom Portal proportion shift, exterior and interior view of installation

Exemplary of this dense, informal urban condition, the 200-square-meter Kopo Residence site is bound by the highway, a large factory compound, and a motorbike dealership. To detach the domestic space from its immediate chaotic urban condition, the house internalized all of exterior space forming a series of courtyards and rooms surrounded by seven-meter-high walls. This defensive strategy is reinforced by the client's desire to use cast-in-place concrete construction. Given the severity and opacity of the home's exterior surface, strategies were adopted to soften, puncture, and reduce the scale of the concrete walls. These considerations prompted another set of explorations into the use of textiles for architecture.

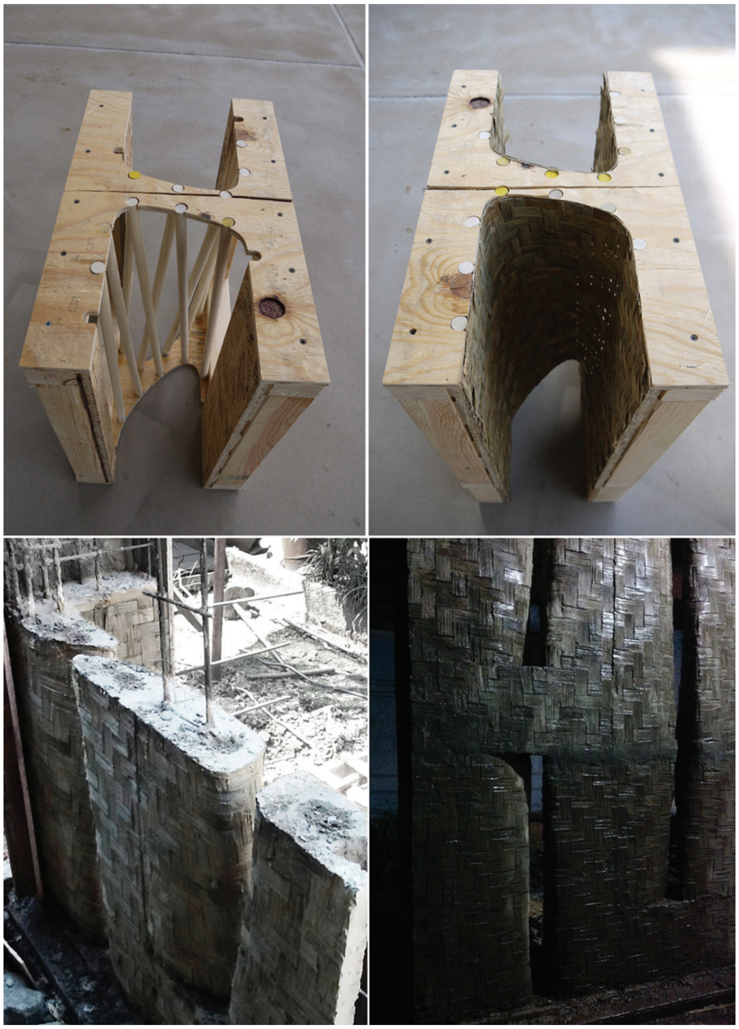
Inspired by *ketupat* (rice dumpling molds made from woven palm leaves) and Andrew Kudless's fabric cast pieces, we investigated different basketry textiles to use for casting concrete. This strategy would allow us to both soften and texture the perimeter walls. Several potential endemic Indonesian crafts seem to provide direct use for casting. Rainproof hats from Bali, watertight baskets from Sumba[6] and the ubiquitous *ketupat* dumpling molds all provide both flexibility and inherent structural qualities through their traditional configurations. Digital and physical models were made to test these different weaving configurations and materials.

Eventually a textile craft, both ubiquitous and close at hand (there is a village that makes it fifteen minutes away from the site), provided the source of technique for casting concrete. *Bilik* mats—a woven assembly of bamboo strips were found to be adequately scaled and impermeable. These mats were also culturally resonant in their use mainly as décor for the interior of rooms or to surface temporary shelters. In either context the texture or pattern of these mats has an immediate visual resonance to the identity of Javanese culture. The project transfers this identity from the scale and materiality of the bamboo mat to the scale and materiality of concrete walls.

In the two courtyards in the Kopo Residence there was a desire to create a perforated exterior surface to allow air circulation and provide some indirect light. These perforations were the primary area of formal experimentation with the mats. By bending two mats into "U" shapes, apertures could be formed. This strategy, along with the general use of the mats as formliners, was the primary formal exploration in the project.

Bilik mats are stiff in one direction and flexible in another. This property and the desire to align the perforation, forming mats with the flat formliner prompted us to design slits made from the discrepancy created when the mats are pinched. This allowed for a material efficiency where the rectangular mats could form angled, varying slits and still align with vertical straight adjacent forms. These slits allow air circulation in different directions while keeping the internal spaces private.

The concrete openings were calibrated through digital modeling. Bending and indenting this flexible surface is tested first through making physical models, and refined in its particular curvatures to create gradual and sharper transitions along its bend. Grasshopper was again used through relatively simple definition allowing for variations in a sequence of lofted



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curves to be tested. Material constraints were transferred directly and found through geometric rules. The initial small physical models established the protocols and limits for the model's flexibility. This model was tested again at full scale and then on site.

Figure 4. Kopo House wall prototypes

CONCLUSION

Through this sequence of exercises, a consistent tactic has been to exploit the nuances of the mined traditional techniques. This might seem to some as a gross distortion of the original content but both the process of researching the crafts and the transfer of them into built affective forms evidences an engagement with the past that is seldom seen in contemporary practice. This investment generates more frameworks for practical use of technologies; designers can engage both old and new aesthetic languages with equal value. This type of discussion between old and new aesthetic practices also allows clients and designers to speak on more level terms. These strategies allow for new content to enter digital practices, which have a tendency to focus inward toward the next new tool. ◆

ENDNOTES

1. As in the sampling used by Steve Reich and later others in the digital prodution of music. See his 1965 piece "It's Gonna Rain" and his 1965 drumming.
2. Silva Lavin. Practice Makes Perfect. symbolism
3. Jeffrey Kipnis. The Cunning of Cosmetics. El Croquis
4. Jakarta Post http://www.thejakartapost.com/news/2010/06/22/on-a-quest-jakarta%E2%80%99s-architectural-identity.html
5. Jakarta is equatorial and the sun dips only a few degrees from vertical during the year.
6. Threads of Life, a non-governmental organization in Ubud Bali provided us with these references and showed us samples of several crafts.