

The Site of Ornament

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ABSTRACT:

Historically, ornament has provided a tether to cultural meaning in the built world. Ornament is tied to specific cultural attributes. As an integral part of the construction, ornament negotiates with the culture from which it emerges. It is a built grammar, but it is also expressive of its own making as well as the society that shaped it. Modernity has largely reversed this connection with some important exceptions. There is a strong history of architects developing space through the design of the construction that provides what Louis Sullivan would call an “organic” link to the ornament that emerges, and this nexus of structure and form becomes the “site” of the ornament. Luigi Nervi’s ferro-cement shells and Frank Lloyd Wright’s textile blocks are two salient examples that have, through necessity or interest, developed details that generate entire projects, which then generate new projects as that construction/detail is refined and builds on the culture that inspired it. Ornament is thus a negotiation between the built artifact and the meaning of its “ornamented” expression.

As architects, we now operate in a world of off-the-shelf selected components. This attitude, combined with the integration of building components into BIM programs, has made the architect a selector/consumer rather than a designer of the construction, making ornament a part of this selection process – i.e., decoration. The research project *Woven Blocks* is an attempt to reexamine the way in which architects can shape space through the design of the construction itself. Pulling from Frank Lloyd Wright’s textile block system, *Woven Blocks* imagines a 3D-printed block capable of taking advantage of a self-supporting system of enclosure that can be “programmed” with function, take on aspects of the context it resides in, and reflect the nature of its making. The project is the design of the manufacturing process as well as its end-product. This enables the building material to respond directly to its program, shaping space/meaning in potentially a more “plastic” way.

This paper is first a consideration of architects thinking through construction, then a reflection on the cultural implication of their production. The site of ornament also implies a shift in perception from the textile patterns of specific cultures found in ceramics, clothing, wall mats, or flooring onto the building surface and into its lashing to the frame and the integration of its various services/systems. This lens will serve to frame the research around the project *Woven Blocks*, examining the efforts of the authors to shape the process of construction as a place from which ornament can emerge and meaning can be rediscovered.

KEYWORDS: 3D Printing, Additive Manufacturing, Frank Lloyd Wright, Ornament, Construction

INTRODUCTION

[Frank Lloyd] Wright attempted to derive an authentic ornament from the process of fabrication, irrespective of whether this entailed the mechanized manufacture of basic building blocks or the systematic assembly of prefabricated modular timber elements... - Kenneth Frampton (Frampton 1995, 101)

Historically, ornament has provided a tether to cultural meaning in the built world. We can see this in ancient Greek, Mayan, and Egyptian temples – the ornament on the walls and integrated sculptures like caryatids quite literally or abstractly tell stories and convey meaning. Ornament is tied to specific cultural attributes – as an integral part of the construction, ornament negotiates with the culture from which it emerges. As Michael Hann describes in his book, *Symbol, Pattern, and Symmetry*, ornamentation is also a system of abstract communication, “...when visual forms resonate with such strength that they are retained again and again.” (Hann 2013, 301) It is a built grammar, but it is also expressive – expressive of its own making as well as the society that shaped it. This is echoed in the study Wright and Sullivan made of Owen Jones’ *The Grammar of Ornament*, which laid the foundation for their own “...geometric design methods.” (McCarter 1997, 15) Additionally, and as Farshid Moussavi elaborates on Louis Sullivan’s *The Function of Ornament*, Sullivan posited that ornament, “...emerges from the material substrate, the expression of the embedded forces through processes of construction...” (Moussavi 2006, 8) Ornament, for Sullivan, was an organic, or natural, outgrowth of the building construction that becomes the “site” of ornament, where culture and building systems meet. Frank Lloyd Wright, building on Sullivan’s approach to ornament, saw ornament and form as fundamentally tied to the environment through the construction, where “form and function are one.” (Wright 1949, 298)

Modernity espoused building as a universal technological endeavor, rather than as a craft tied to a specific cultural base.¹ This has led to a disassociation between technology and tectonic, where the expression of the building's construction is no longer tied to the technological means of its production. As Kenneth Frampton argues:

The maximization of comfort, verging on gratuitous consumption leads... to a phenomenological and cultural devaluation of the tectonic and a state of affairs in which *simulation* rather than *presentation* and *representation* becomes the main expressive mode. (Frampton 1995, 381)

The expression of a building becomes something that is no longer part of its making, converting the building into a vessel (or shed) on which meaning can only be added/applied (decoration). Many inhabitants of modern architecture, whether of its best examples or of its more average derivations, out of a necessity for meaning that the abstraction of Modern space didn't fill, bring vestiges of their personal cultural past (i.e. immigrants, refugees, etc.) to these unadorned buildings in the form of specific decoration that is then hung on its largely unarticulated walls. This unintentional cross-fertilization between the modern, universal, technological and the traditional, cultural, persistent/specific provides a strong impulse to be intentional with ornament, finding a way to integrate these dialectical ideologies more literally into a kind of built tension that can acknowledge the past and present, universal and cultural.

Where do we find ornament both in the past and today? Textile (rugs, clothing, fabric) and tile (terracotta, ceramics, mosaics) ornament elaborates something or enhances something that has utility. You can't add it on, or it becomes merely decorative. Architects like Sullivan and Wright, and later Nervi with his ferro-cement shells, all used material, structure and pattern as a means of creating space that required no decoration for the conveyance of meaning. Their ornament was timeless, in the same sense as Hann introduces in *Symbol, Pattern, and Symmetry*, and crossed multiple cultural lines as abstraction. These architects through necessity or interest, developed details derived from textile production and then used that analogy for their principles of construction. These details generated entire projects and were often reexamined in a later project(s) as the construction (and meaning) was refined. Ornament is thus a negotiation between the built artifact and the meaning of its "ornamented" expression.

1.0 ORNAMENT THROUGH PROCESS

For Tadao Ando, the wall is the site from which architecture emerges. Ando typically uses the traditional scale of the woven tatami mat (Curtis 2001, 16) (which historically served as a means of modulation for traditional Japanese floors and which is a textile) to create the formwork. The lines of the formwork left on the concrete then create an intentional pattern that echoes Japanese scale and culture throughout his architecture. This is reinforced through his detail drawings where lines (formwork boards) and circles (form tie holes) are deliberately drawn in elevation and carefully arrayed on the facade, acknowledging both the construction and the ornamentation that is left by the formwork. This expression of site cast concrete as a building system, like that of Louis Kahn, presents the wall as the premier location through which cultural meaning is presented. For both Kahn and Ando, the modulation of the wall is important. Both are interested in the development of space animated by light on and from the surface of the wall.

...the surface of the walls is not created by the concrete but by the regular rectangular design of the small circular holes made by the concrete, and that inside this surface... unfolds a landscape, or rather a wash drawing, the image of a landscape. (Andreu 1991, 97)

His work then uses the wall to negotiate between outside (universal/heavy) and inside as a reflection (cultural/light). In their adherence to the Modernist notion of building with industrial technology, both Ando and Kahn put faith in the idea that the wall should express both heaviness and lightness at the same time by way of the material (fabricated stone) and by way of light revealing lines of modulation and the scars of its making (form ties as evidence of the walls once erected to form the final concrete wall).

Reading Sullivan's idea of "organic" ornament onto Ando and Kahn, it could be said that the traces of the production (the material substrate) of the site cast concrete wall exhibit a desire for the ornamentation of the blank Modernist surface and thus a belief in the need for architecture to be less a universalist proposition and that there is something lacking in the Modernist agenda for the specific cultures it has come to serve. This is also a larger (not Ando-specific) way to open history to reinterpretation through architectural expression without it becoming pastiche. As Antoine Picon frames it:

...history reveals itself more productive when the present does not appear as a mere extension of the past but seems, rather, to stem from a complex reinterpretation of some of its elements, a reinterpretation in which continuities and discontinuities need to be carefully sorted and weighted. (Picon 2013, 14)

The opportunity is not in regurgitating historical forms, but in their reinterpretation and re-grounding through the method of construction. This is reflected in Sullivan's work, and by extension in the work of Frank Lloyd Wright, and it comes out of a Semperian foundation where the wall acts as textile and also the locale for ornament. This is also the lineage from which Woven Blocks emerges. (Fig. 1)

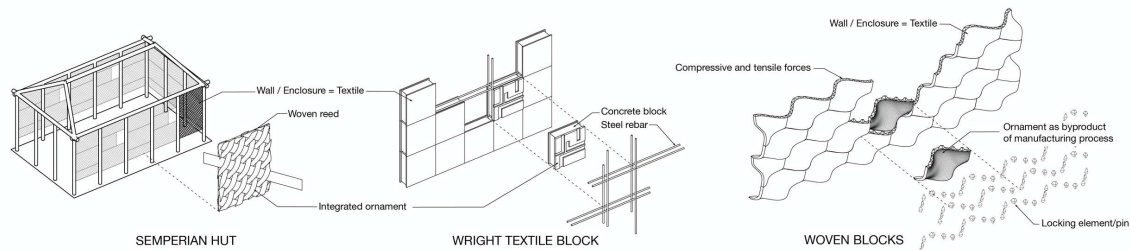


Figure 1: Lineage from Semper's primitive hut through Wright's Textile Blocks to Woven Blocks. Source: (Authors 2022)

Another approach to this kind of thinking emerges from Luigi Nervi. Thomas Leslie, writing on Nervi, states that:

Nervi insisted that his forms arose not from sculptural ideals or historical precedent but rather from ironclad economic and static logic. (Leslie 2017, xiii)

While even Nervi was one to admire the forms generated through structural optimization, (Nervi 1955, 526) the cathedral-like qualities that he could lend to the humble airplane hangar and sports stadium were produced through the geometric means and structural understanding that built the cathedrals themselves. Nervi's knowledge of construction emerges from the same knowledge that gave flight to the most impressive domes in architecture. The resultant systematic forms often bridge abstractly (in terms of their geometry) to the culture of Islam, Japan, and more. The work is ornamented, but that ornamentation is embedded in the construction process and the assembly design of the prefabricated precast module that pervades Nervi's work.

Architectural history is a history of construction and materials, and within this history, there is an arc that spans critical moments where assembly and material exploration combine and provide a point of departure for the invention of novel construction systems and their resultant spatial orders. Often this is immediate, as in the case of Le Corbusier's Maison Domino system of concrete columns and floors, which is a system still in use today. Alternatively, this moment lies dormant, in advance of its time, as in the case of Frank Lloyd Wright's concrete textile block system. Wright was interested in a construction system that was of its time and that could integrate more fully the ornament with the building:

For a true integration of ornament and building...he had to invent an entirely new architectural language that was based on forms that the machine could make and based on the true nature of materials. (Hanks 1979, 7)

His block's system of ornament and wall spanned from the ancient Egyptians and Greeks to the Celts and even the Aztecs and Mayans, with a material as a generalized construction system of pattern and woven concrete block. It incorporated glass as punctuation within the block itself and was tied/woven together with metal threads (rods) to complete the structural action of the system. (Authors 2021, 2-4)

2.0 WOVEN BLOCKS

The project Woven Blocks takes inspiration from Frank Lloyd Wright's textile block system as well as the manufacturing processes and integrated ornament found in Islamic tile pattern, Salish Coast imbricated coiled baskets, Congoese Kuba cut pile cloth, Japanese Sashiko stitching, and Quipu Incan Knotting. These systems of ornament literally weave strands that become spatial, whether as calligraphy intertwined with lines, circles and polygons as in the case of the Islamic system, as unique woven motifs as illustrated by the Salish Tribes of the Pacific Northwest who produced baskets that could weave ornamentation into highly functional yet minimal objects, Japanese Sashiko, where reinforcing threads could make a fabric last longer and introduce elaborate patterns, or by the Inca who used a system of knotting for accounting purposes that acted as a kind of wearable ledger that still holds visual intrigue. What unites these disparate systems of ornamentation is the

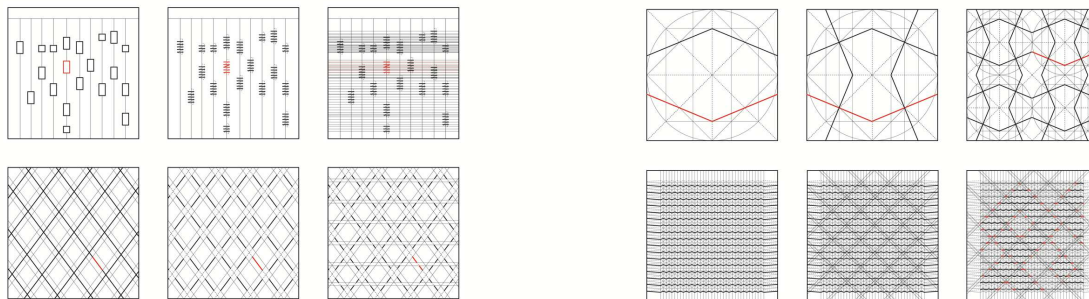


Figure 2: Diagrams illustrating woven ornament generated through process of construction. Top left: Incan Quipu knotting; bottom left: Japanese Sashiko stitching; top right: Islamic tile; bottom right: Congoese Kuba cloth. Source: (Authors 2023)

way functional items are elaborated through their method of manufacture to produce a culturally significant “reading” to that object. The ornamentation is intentionally abstract and systematic (Fig. 2).

To return to Sullivan, “...he believed that ornament must be ‘of the surface and substance, rather than *on* it.” (McCarter 1997, 15) The ornamentation shown in Fig. 2 is derived through the construction of the functional item. Woven Blocks is an evolving hypothetical design that utilizes additive manufacturing to create a block that can integrate modern/universal technology while pulling cultural meaning out of the block through its suggested ornamentation. The design of Woven Blocks began as two offset sinusoidal surfaces, then evolved into a flat surface offset from the more undulating surface. Both surfaces are “woven” together by an infill that both separates and stitches these surfaces together (in structural action similar to cardboard). (Fig. 3) This allows the overall system to be quite thin, operating more like a stressed skin system, while still being self-supporting in its structure.

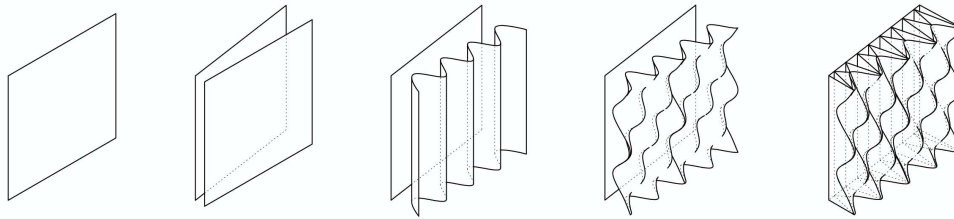


Figure 3: Diagrams illustrating evolution of Woven Block design from single surface to a woven structural patterned hollow block. Source: (Authors 2023)

Laid in sequence, the blocks undulate to provide lateral stability. The voids in the block naturally create space for services. As Kahn states it:

In Gothic times, architects built in solid stones. Now we build with hollow stones. The spaces defined by the members of a structure are as important as the members. (Kahn 1953, 23)

Because of the undulation in the block the more resistantly vertical services puncture the block and, like the sashiko stitch or Kuba cut-pile ornamentation, the services become visible through the surface of the block. Electrical conduit, interrupted by outlets that operate like the quipu knotting, push through this system to create a kind of third order to the façade. When a service is oversized to the block, the block can distort to accommodate that service, enveloping it and marking its presence on the façade and taking advantage of the opportunities that the digital fabrication process provides. Horizontal services also offer another layer of disruption/ornamentation to the block. The resultant figure/ornament celebrates a thesis of function and form (Fig. 4). Cultural meaning emerges from the prototypical weave, which can then absorb more specific patterns from both the building program and its attendant systems, drawn from the historical or current patterns of a particular culture or society, by which the block prototypes varies and thus becomes site specific.

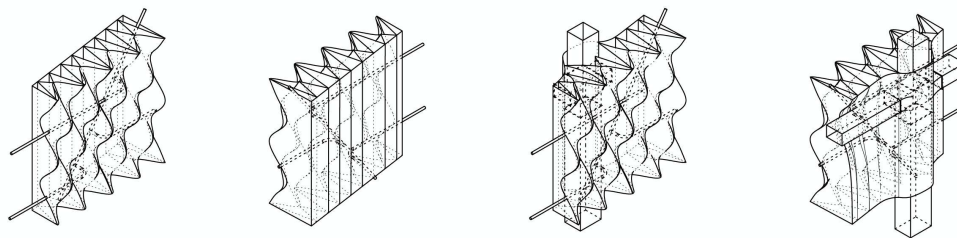


Figure 4: Diagrams illustrating the potential to use services (plumbing, electrical, HVAC) as integrated ornament with structure. Source: (Authors 2023)

2.1 Construction Process

Woven Blocks began by considering FDM (fused deposition modeling) printing’s potential as a manufacturing process for construction. This process essentially lays down a line of material much like you might imagine drawing with a tube of toothpaste. The hand squeezing the toothpaste is “extruding” the material. This material is either heated or allowed to dry to “cure” and fuse the layers together. The printing process simply tells the extruder where to lay down material and how quickly (“drawing” in the toothpaste analogy). The challenge with

this manufacturing process is in the limitation of available materials – primarily concrete, plastic, and clay. 3D printed concrete is where many architects collaborating with manufacturers see potential,² but the timing of the curing process and the viscosity of the concrete are very tricky to perfect and when there are failures (like air bubbles in the tube of toothpaste to extend the analogy), there is also a large amount of waste because you can't repair or reuse the material. While a material like clay can be reworked and reused, concrete and plastic take much more effort to re-process. The design for this project always considered a block form because of the manufacturing process's inability to recover from failure. A block not only restores the scale of the human being to the construction process, it acknowledges the necessity to reduce the scale to prevent monolithic failure. This does introduce another complexity to the system: how the blocks can join together. With the FDM printing process, this became a separate linking pin that could allow these blocks to lock together, not unlike a LEGO. This created a potential structural weakness in the system as the point of load transfer was enabled through a separate locking pin. This necessity was created by another disadvantage to FDM as a manufacturing method. It is best utilized as a kind of continuous line of printing, without what's called "retraction" where the material ("toothpaste") is essentially sucked back into the extruder to then allow it to travel to another printing point. Retraction enables a tremendous amount of variation in the form of the thing being printed, however it can also exponentially increase the potential for failure as it is picking up and moving to a new location. Continuous line printing does not use retraction, but the limitation in the process is then how one can accommodate interruptions to a surface (such as a hole) and support for overhanging surfaces (anything that tilts more than 45 degrees from vertical), which is why a separate pin to interlock the blocks was introduced (Fig. 5).

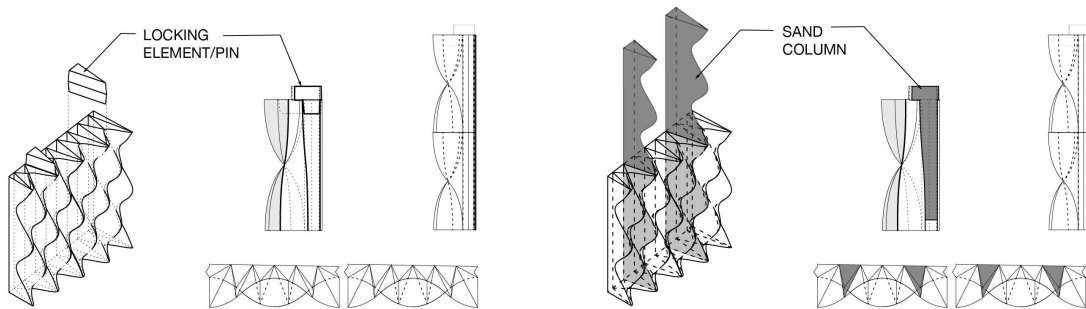


Figure 5: Diagrams illustrating the tiling, the initial FDM locking pin and the binder jet "sand column" encased in a shell of bindered sand. Source: (Authors 2023)

The design of Woven Blocks has evolved to consider an alternative method of construction more akin to what's called BJP (binder jet printing). The Diné (Navajo) painted with sand – now we can print with sand. The structure of Woven Blocks is a weave of printed sand, a line/thread, where the thin is made thicker in order to bring more lateral resistance to the block. Within the block there are several scales of weaving that occur simultaneously or in layers. A primary stitch is the truss-like infill that operates to lace the outer shells together to stiffen the basic block. The design imagines a hypothetical system of production where a layer of dry, coarsely sorted sand is rolled out and a layer of binder is then "printed" on the layer of sand, similar to a basic inkjet printer. This research is a part of a larger collaborative effort where the material and manufacturing process are being developed simultaneously through a National Science Foundation Grant.³ The formal potential of both iterations of the block is the same. They utilize a kind of stressed skin outer shell with an infill that weaves the opposing sides of the outer shell together to create a stiff, thin block. A key structural difference with binder jet technology is the potential to "encase" the sand within a print, creating an additional embedded structural frame that can stiffen the overall wall. Because the sand is also the support structure for the print, this method of manufacturing can much more easily accommodate disruptions in a surface. This also enabled the design of an integrated pin within the block (making it even more like a LEGO than its FDM iteration) that could essentially stack columns of encased sand within the block to create the basic load-bearing frame.

The Woven Block begins thin and is distorted by the routing of systems within and through it. This produces visible variation and advances a point of departure. Where Wright or Sullivan might begin the process of ornamentation through the methodical examination or analysis of nature or a natural element, Woven Blocks begins with structural and programmatic/Semperian elements (structure, wall, void) to shape the larger formal ordering system that can adapt to particular functional/programmatic needs (Fig. 6). The systems – electrical, plumbing, air – are then fed through that formal order to create a densely interwoven wall where the structure and services push and pull to create ornamentation that can pay homage to the culture from which it springs. A key introduction to the evolution of this design is the possibility for on-site manufacturing. This provides

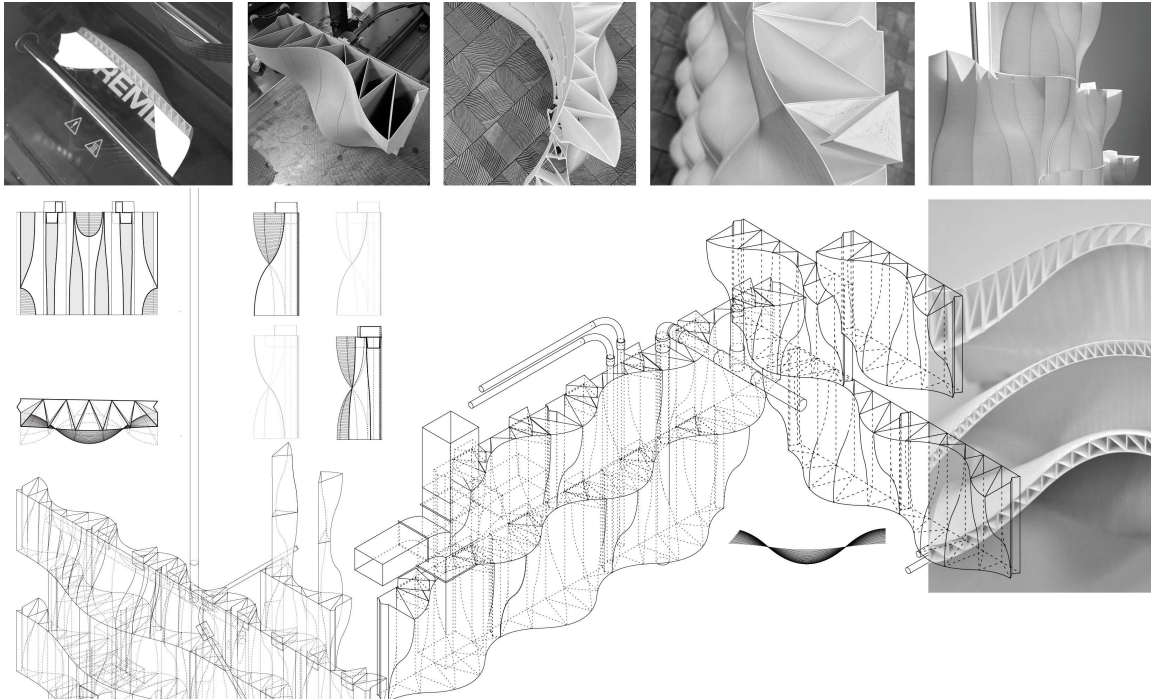


Figure 6: Composite Drawing showing the evolution of Woven Blocks from initial FDM-printed structural prototypes to hypothetical iterations utilizing binder jet processes and integrating services to create ornament. Source: (Authors 2023)

advantages for reducing transportation costs and the labor to move the blocks to site. Phenomenologically, it also allows the block to be literally built from the site, tying the ephemeral, tectonic wall/screen to the heavy, stereotomic ground. Returning to the larger formal ordering system, currently the Woven Blocks system has been designed from a kind of middle typical condition. It is the intention of the project to move from the wall to a more solid foundation block and a transitional roof block configuration, looking at how the block can be printed out of the land, shaping the transition from stereotomic base to screen/wall.

CONCLUSION

Woven Blocks attempts to reconcile industrial convenience and precision with the human need for variation and intricacy as provided by cultural ornament. Woven Blocks weaves pattern (cultural expression) and space while integrating structure, skin and services/systems in a unique on-site printed design for a specific context. Woven Blocks operates from the perspective that contemporary buildings, whether residential, commercial or public, are already woven constructs, and that this weaving is deliberately not expressed. Rather, the interwoven nature of services/systems with structure is intentionally repressed. Consider the consumer/client's desire to hide or obscure electrical, mechanical, plumbing and other systems that run in strands or threads throughout the building that follow and necessarily diverge from the main structure to adequately serve the building. This project questions both the necessity and the cultural loss of this repression.

In a dawning age of environmental concern, perhaps an expression of these essential services/systems would continue and enhance the prospect of energy stewardship. An obvious way to achieve this is simply to expose these systems as they weave to their destinations. This exposure is made far more complex because as architects, we now operate in a world of off-the-shelf selected components. We assume that the services can only arrive in certain configurations and assemblies, and the work of their integration is in the hands of the mechanical engineer. There are architects, like Richard Rogers and Renzo Piano, who have charted a path towards exposing services as an integral part of the architecture, but they are the exception, not the norm. And the more normative "off-the-shelf" attitude, combined with the integration of building components into BIM programs has made the architect a selector/consumer rather than a designer of the construction. This in turn, has also made ornament a part of this selection process – i.e., decoration. The research project *Woven Blocks* is an attempt to reexamine the way in which architects can shape space through the design of the construction itself. It is also a provocation - can a printed building system develop spatially and morph to convey a residue of the services/systems and then offer this intersection as a site of ornament, forming unique functional patterns which are then modified towards local custom?

Architecture has long grappled with the advent of new technologies and building materials, and what may be clear to those developing cutting edge high technologies in places like Silicon Valley is that what is typical practice today will not be typical practice in a decade, whether we are talking about architecture, telecommunications, or pharmacology. Woven Blocks attempts to explore and test the latest technological advances in building construction systems in a manner that can continue the relevance of human expression and the long trajectory of meaning tied to both ornament as derived from its history as a culture-based textile, and from modular unit construction. The potential of this convergence could create a site-fabricated building system that can interlace wall, space, and cultural identity with mechanical, plumbing, electrical, and future systems as yet defined. There are many precedents from the arts and architecture to draw from in this search. The notion of systems integration, as inherited from Rome's infamous concealed hypocaust floor heating system, was refined by Wright in the ventilation system of the Larkin Building and then reclaimed by Kahn in the Richards and Salk Laboratories. In reality, Kahn may not have fully integrated the systems, as he hid them in giant structural tubes in order to save the expense of shaping these oversized chases to the step downs and transitions of the services themselves. But rather than focus on the compromises that were made, the trajectory of the design intent is significant. Wright's interest in integrating systems was not without failures (such as the radiant heating in many of the concrete slab constructed homes he designed), but it is not a reason to negate the design intent nor to shy away from the larger idea of making the technology a part of the design.

Today's technology can allow architects to immediately integrate the services/systems and facilitate an appropriate expression tied to site and culture, where site is both the architecture's locale and the location where cultural meaning intersects with physical building that becomes spatial practice. This expression can aid in the stewardship necessary for our planet in the near future. We have returned to a moment of possibility that Wright saw in the Textile Block. Former President Obama has stated that 3D printing "...has the potential to revolutionize the way we make almost everything..." (Obama 2013) This "revolution" is the potential democratization of the design and the construction process. 3D printing in the construction industry is still nascent, but as it is refined and perfected, the ability for anyone and everyone to one day design and print their own buildings (or even their home) and integrate their personal/cultural history by way of the surface/structure/system is there. This may ultimately put the architect side by side with the owner, but it also has the potential to restore cultural expression to the making of the architecture through the nature of its materials.

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ENDNOTES

¹ This is elaborated on in Kenneth Frampton's "Towards a Critical Regionalism: Six Points of Architectural Resistance" as well as the epilogue in *Studies in Tectonic Culture*.

² There are many examples published on collaborative partnerships between 3D printed concrete manufacturers and architectural firms, such as ICON / Lake Flato or ICON / Bjarke Ingels Group. This article elaborates on the ICON / Lake Flato relationship: Symone Strong, "House Zero," in *Builder*, 2022, Vol.45 (6), 28.

³ Please refer to the Acknowledgments regarding the details of this grant.