The Woven Wall:
A Physical and Conceptual Influence for Design

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Over the past century, the exterior enclosure systems (walls) of our buildings have been increasingly divided into separate systems intended to work together as one. The all-encompassing monolithic masonry wall, acting as structural support, thermal/moisture barrier, shading screen, mechanical chase and occasionally interior finish, has become rare. Instead each system has become specialized, usually produced by separate manufacturers. While this can create a coordination nightmare for the architect, it also opens up new design possibilities. Particularly with shading and interior finish systems, we have an opportunity to revisit one of the oldest forms of building construction, the woven wall. Yet by studying the links between weaving and architecture, we can see other commonalties beyond the physical object. Weaving as an analogy for architecture can also be used to describe various aspects of building construction and the design process.

If we investigate the similarities between weaving and architecture we begin to see overlapping concepts. Architects and weavers both recognize the need to look beyond surface appearances in the process of designing. In the same way architects realize that quality design is more than skin deep, weavers understand the quality of a textile is dependent on the structure of the weave and not just the visual appearance of its fibers. As Anni Albers, a weaver from the Bauhaus, revealingly states:

> *"Surface quality of material, that is matière, being mainly a quality of appearance, is an aesthetic quality and therefore a medium of the artist; while quality of inner structure is, above all, a matter of function and therefore the concern of the scientist and engineer. Sometimes material surface together with material structure are the main components of a work; in textile works for instance, specifically in weavings or, on another scale, in works of architecture"*[1].

In their common need to relate a design's physical properties to its aesthetic implications, weaving and architecture share a trait worthy of further exploration

Fig. 1. The First Walls Were Woven *from* Socrates' Ancestor

WOVEN CONSTRUCTION

It is helpful to first review the history of physical woven construction. In terms of architecture, weaving in its fabric form has been used in tent structures for thousands of years. However, the history of planar wall construction also has weaving in its roots as the earliest building walls were likely woven. In 1851, Gottfried Semper published his well-known theory of the *Four Elements of Architecture.* Basing his theory on the form of the primitive hut, he categorized its construction into four basic elements of *Hearth, Roof, Mound* and *Fence.*[2] For the last of these, the *Fence*, he proposed that the walls of ancient houses were not made of stone but rather of hanging cloth or woven 'mats', thus suggesting the idea of the wall as a textile hung off of the supporting structure, similar to the curtain wall today. (Semper further proposed the knot as the oldest tectonic form of the joint based upon similar German roots of the two words.[3]) To construct these walls, branches and grasses of differing sizes were interlaced to form a supportive structure that in colder climates was covered with a weather resistant shell of mud and/or leaves. Without this additional protective layer the cold and damp climate would be allowed to penetrate. This type of construction, generally known as wattle and daub, was common up to the nineteenth century with the woven support always hidden. Even our closest modern relative, plaster on lath, has been generally replaced by gypsum board construction. The permeable nature of the uncovered woven wall is a major reason why we do not see more buildings utilizing this technique. They are best adapted to tropical climates where the temperature is relatively constant and airflow is encouraged. However if we expand the analogy of the woven wall to conceptual level it allows for the inclusion of solid wall construction. For example, Frank Lloyd Wright developed a system of custom concrete blocks interwoven within a metal reinforcing mesh into a double-layered wall. In this form the thin walls could retain the solidity of concrete while providing the flexibility of fabric to be shaped into any form (within two dimensions).[4] Even traditional masonry construction when bonded with mortar in overlapping coursework can be considered a form of weaving.

Due in part to their economical cost and design potential, the glass curtain wall has become a common form of exterior wall construction. The advent of "new" materials and joining methods has shifted the focus of construction away from what Kenneth Frampton calls "wet" techniques such as masonry.[5] The current trend of "de-materializing" glass walls into separate "dry" systems of structure, enclosure and shading/climate control opens up new opportunities to appropriate the woven wall. While not an efficient acoustic, thermal or moisture barrier, the woven wall does function well as a shading device and as a visual screen. The desire for large expanses of glass to admit an abundance of light without overheating or ultraviolet damage creates one role for woven screens as shading devices. When combined with a sealed glass envelope they make an effective exterior barrier against the elements. They can also be extremely effective as vision screens to increase privacy or hide undesirable views. This can be seen quite clearly in Dominique Perrault's design for the National Library of France. Here he uses woven metal fabric as a screen for the exterior fire stairs of the towers as well as on the interior for wall panels and draped ceilings to hide mechanical systems.

The future of woven wall construction looks promising in light of the proliferation of curviplanar forms in building design today. While our current construction systems are not well suited for complex shapes and stresses, a new material has yet to emerge. Woven materials can work well as they easily conform to the constantly changing curves, yet still require an additional material to impart rigidity to the weave. However there is research being done on various solutions. One relevant example can be found in the research of Doug Garafalo who is investigating the potential of a stainless steel mesh to realize structural curved shapes. "The mesh behaves like a fabric that can curve in all directions but it does have structure and can act and react according to the forces applied - it's a weave that can handle torque."[6] The way we approach construction is changing and woven materials could play a major role.

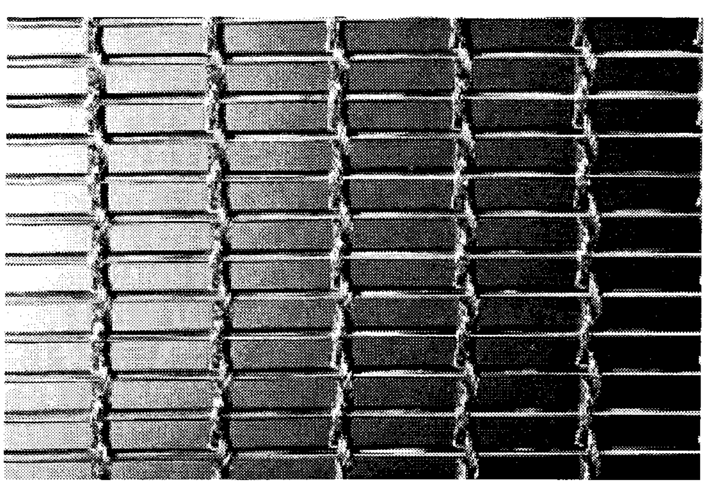

Fig. 2 Woven Metal Fabric, National Library of France, Dominique Perrault

WEAVING AS AN INSTRUCTIONAL DEVICE

The impetus for my study of the woven wall arose through the prominence of the textile school in our university. Our college was originally established as a textile school so we are continually searching for ways to relate architecture to textiles. Previous collaborations with the school have dealt with the production of fabric structures. However, I wanted to engage its faculty, students and facilities to investigate how the two disciplines also share other ideas about construction and form, specifically through the process of weaving. I have run several semesters of a fourth-year design studio which investigate commonalties between weaving and architecture that range from the literal to the theoretical. In this studio, architecture students see what is involved in the production of woven structures and textile students see the possibilities of weaving with non-fibrous materials.

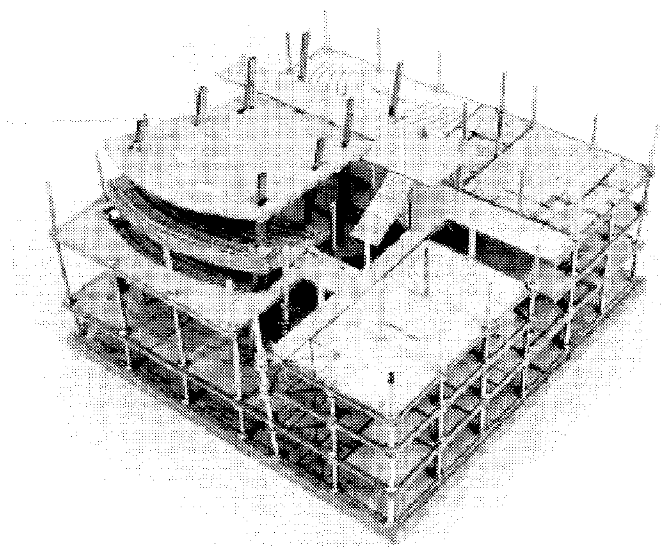

Fig. 3 Woven Screen Detail (by Michael Pavelsky, Kerissa Gaudioso, and John Park)

THE STRUCTURE OF WEAVING

As students typically have had little experience with the process of weaving, the first project introduces them to the basic patterns and techniques involved. In this phase they work directly with members of the textile school. A general goal of this design studio is to examine how materials and methods of construction influence and direct the design process. Weaving provides an excellent example of how materials and patterns of weaving have a critical influence on the outcome of the fabric. The specific goal of the project is to study the characteristics of actual weaving through the empirical, hands-on *making* of an object at full-size. Weaving a textile by hand reveals much about the tactile qualities of the materials not evident by sight. In the same way, creating a piece of architectural construction by hand reveals qualities of the materials not evident in representational drawings. Architects have become separated from the tactile experience of construction. "Our materials come to us already ground and chipped and crushed and powdered and mixed and sliced, so that only the finale in the long sequence of operations from matter to product is left to us; we merely toast the bread".[7] Both architecture and weaving students need to understand the physical properties of materials that they normally represent by electronic pixels on a screen. To test this idea, students divide up into groups which are each assigned a weaving student to act as an advisor.

They must then design and build at full-scale a woven wall structure or panel. To introduce them to the craft of weaving they tour the textile school's weaving facilities to watch both hand and power looms in action. They see first hand how the process of production and the structure of the weaving inform the final appearance; how plain, twill, satin or tri-axial patterns produce varying results. Professors from the textile school act as consultants and reviewers for the architects as they design their screens. Instead of typical fibrous materials, they are required to use materials associated with building construction such as wood, metal and plastic. This places the project in-between the realms of architecture and textiles (more akin to basket weaving) which means neither the architect nor the weaver is an expert but both can contribute equally. While students utilized basic layout drawings to confirm overall dimensions, many of the design decisions were made during construction by adapting available hardware and materials to meet their intentions. Properties of the materials dictated many of the decisions. For example, many materials proved to be too stiff for weaving and had to be replaced. The project required at least one of the materials to be metal so for most of the students it was their first hands-on experience with cutting, drilling and welding steel, copper or aluminum. The empirical knowledge about the properties of metal gained by physically working it can not be matched by representational means. Through trial and error they learn how an initial concept can change over time as issues of real construction influence and affect revisions in the design. They understand how materials used for weaving are critically dependent on the manner in which they are assembled.

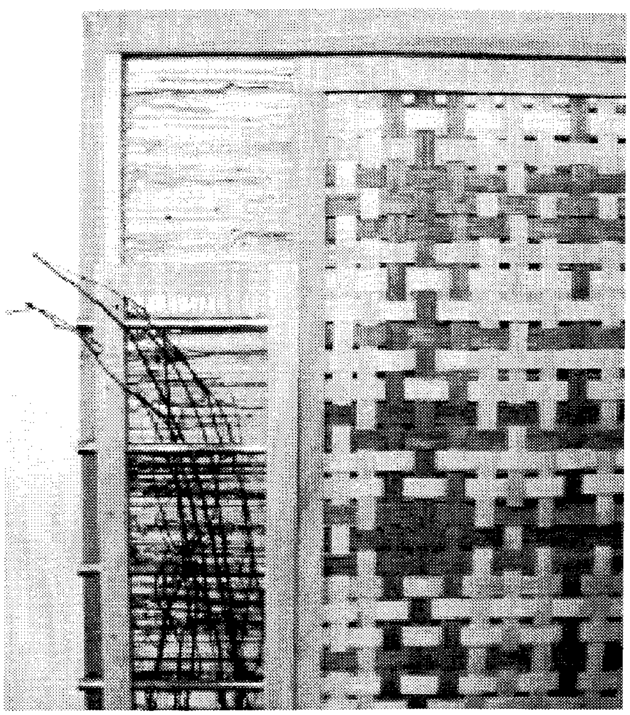

Fig. 4 Woven Screen Changing Room (by Michael Pavelsky, Kerissa Gaudioso, and John Park)

INTERWEAVING CONSTRUCTION

With the advent of the iron frame in the mid-nineteenth century, the enclosing walls of buildings began separating into distinct structural, envelope and service systems. In 1852 Joseph Paxton gave a speech to explain the structural principle behind his "Crystal Palace." In it he compared the iron structural frame and the enclosing glass envelope to a "table and tablecloth". By this description he wanted to represent the glass skin as a tablecloth separate from the structure (table) that would now allow it to be "greatly varied to suit changing conditions and uses".[8] Kenneth Frampton employs R. Gregory Turner's study, *Construction Economics and Building Design* to further describe the shift away from the monolithic masonry wall toward a division into his categories of *podium, services, framework,* and *envelope.* In terms of percentage of construction cost, the structure has been reduced while services and envelope now make up the majority of the expense.[9] The simple monolithic bearing wall is seldom built these days. Instead it has been divided into separate systems providing support, comfort and convenience which, while allowing greater freedom for design, also creates an abundance of information to coordinate. However by conceptualizing the wall as a textile, it can help explain how each of the various systems must be interwoven to work efficiently and beautifully.

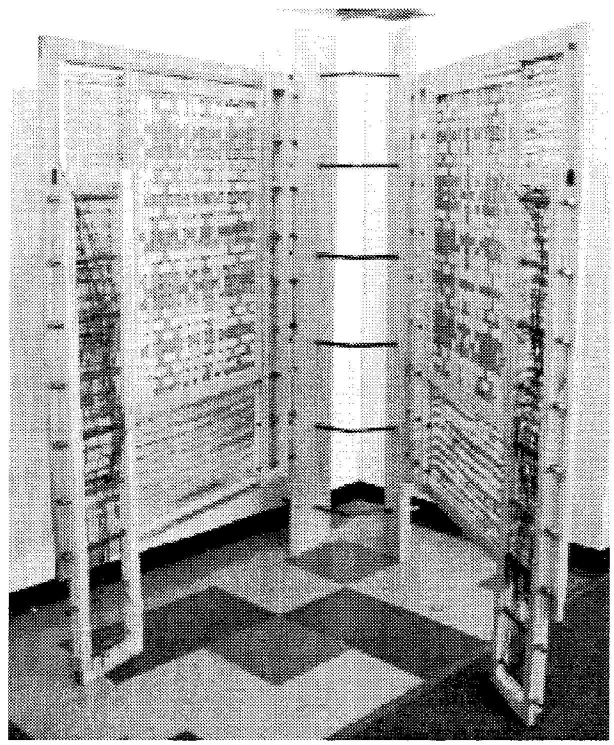

Fig. 5 Structural Model (by Carmen McKee)

After completing the basic building design, students turn their focus towards the constructive aspects of their design, especially as they relate to weaving. In typical plain weaving on a loom, the lengthwise set of fibers, the warp, are anchored to the loom and are unchangeable. Color and pattern changes are accomplished with the widthwise fibers, the weft. In typical building construction, I like to compare the structural system to the warp of a textile, which like Paxton's *Table*, remains relatively constant. This leaves the exterior and interior surfaces to act as the weft, or *Tablecloth*, which can respond to changing influences on the building. Students are asked to study the structural system in a manner that also reveals the qualities of the space inside. Too often models present the external form of a building without revealing the critical space inside. Therefore, students make a physical model of the structural system with templates created from current floor plans that can be mounted to board and woven together with threaded rod 'columns' and basswood 'bearing walls'. By allowing the student to see inside the building, these "woven" study models reveal spatial and structural issues not always evident on digital or physical massing models. Threaded rods also allow for quick revisions by adjusting the nuts up or down and replacing floor plates to create new spatial conditions. As mentioned earlier, in both textiles and architecture, the inner structure plays an integral role in the overall form. Thereby through this exercise, students begin to see the overlaps evident in the spatial, organizational, and especially the structural systems of a building.

To understand how enclosure systems affect their design, students study the envelope in detail. They first complete their structural model by clothing it in an envelope of transparent, translucent or opaque cladding to convey their design intentions and thus adding another element to the weave. The skin is detailed by studying a portion of the enclosure critical to the concept and developing it at a larger scale in partial section, plan and elevation. Typically this is a wall section that depicts an important relationship between the structure, services, envelope and shading systems to demonstrate how they must interweave within a thin slice of space. They develop the wall section by selecting the specific materials and systems required to create assembly details. While students may desire an unbroken wall of glass, they must first address the complicated issues of supporting, shading, fire rating and heating it. The goal of this exercise is to demonstrate how all the physical components concentrated at the perimeter of a building must be interwoven to allow each to function efficiently while still reinforcing the design concept.

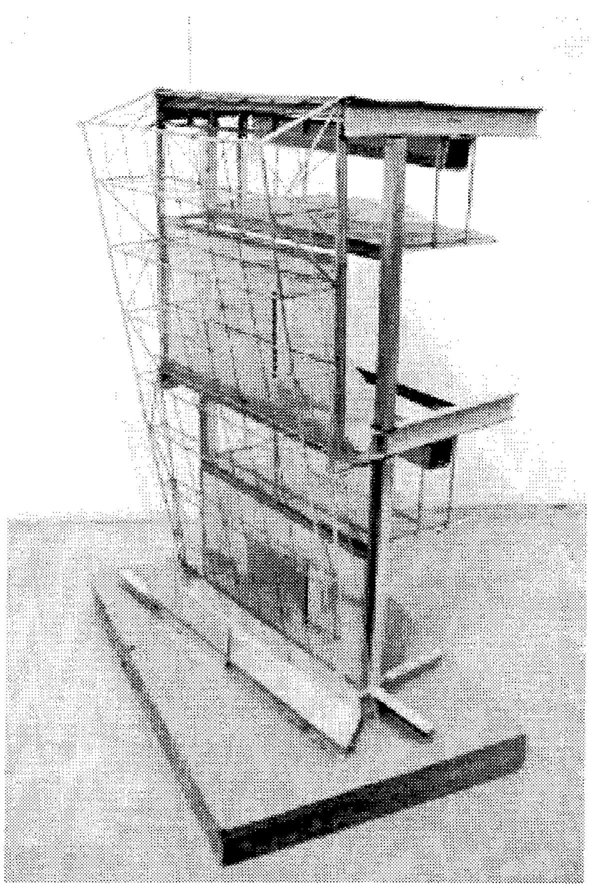

Fig. 6 Wall Section Model (by Jennifer Crane)

CONCLUSION

By the end of the semester students have studied the woven wall in architecture from the physical to the conceptual. Even if the students never encounter an opportunity to design a woven wall, the weaving analogy has relevant application to architectural design in their academic and professional careers. In school, students are continually searching for a way to make sense of all the information they acquire in college. Beyond studio, they receive indoctrination in professional courses on structures, building construction, environmental systems, history, and professional management that can be applied to their design projects. Yet they often question the need for their liberal arts courses that reveal little evident application to their main area of study; design studio. The fact that we exist as individual members of a cohesive team also applies directly to the profession. A look at the range of trades composing any building design team will clearly demonstrate this. Architects have traditionally occupied the role of supervisor for a building project. They are responsible for coordinating and 'interweaving' the interests of the related consultants, owners, occupants and contractors to produce a meaningful work of architecture. Therefore weaving, as an analogy, is a useful tool for explaining the benefits, indeed the necessity, of a wide range of knowledge.

NOTES

[1]Anni Albers , *On Weaving* (Middletown Connecticut: Wesleyan University Press, 1965)

[2]Wolfgang Herrmann, *Gottfried Semper: In Search of Architecture*, (Cambridge, Massachusetts: MIT Press, 1984)

[3]Kenneth Frampton, *Studies in Tectonic Culture; The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, (Cambridge, Massachusetts: MIT Press, 1995)

[4]Frampton, 1995

[5]Kenneth Frampton (Editor), *Technology, Place and Architecture, The Jerusalem Seminar in Architecture*, (New York: Rizzoli, 1998)

[6]Joseph Giovanni, "Building a Better Blob", *Architecture*, September 2000

[7]Albers

[8]Herrmann

[9]Frampton, 1998