Weaving as an Analogy for Architectural Design

CRAIG S. GRIFFEN
Philadelphia University

PREMISE

Practicing architects today are expected to absorb and employ an ever-increasing quantity of information. They must retain small bits of knowledge from a broad range of disciplines. Yet beyond the traditional fields of business, construction, environment, history, law, sociology, etc., they also need to stay informed of our rapidly expanding technology. Because they are required to retain such a broad range of knowledge, architects must remain generalists in a world of specialization. But this raises the question of how can an architect continue to retain and process such a wealth of information? These can not remain separate fields existing on their own. Rather, as in weaving, each becomes a thread in a complex matrix from which they must glean and weave together individual strands to produce an integrated product.

Weaving, as a practiced craft, has been a common cross-cultural phenomenon for thousands of years. While patterns and techniques differ between cultures, the basic craft of weaving can be found in most. Because the concept of weaving is so accessible, it is often used as an analogy to describe various systems in our world. It describes fabrics of different races, religions, beliefs and values all co-existing. It is an apt analogy for how systems overlap and work together to create a harmonious living environment, as well as the possible destruction caused by the breaking of a single element or strand in the fabric. The fact that we exist as individual members of a cohesive team also applies directly to the building design industry. A look at the range of trades composing any building design team will clearly demonstrate this. Architects, as generalists, 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.

By investigating 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

The history of textile use in architecture is broad. The most visible form of woven material today is tensile membrane structures. However, rather than concentrating on a single physical material, I chose to focus on the process of weaving as an instructional analogy in the design process. For example, in architectural design this analogy can inform the interlacing of ideas, people, place, space and construction. The comparing of weaving and architectural design from the analogical/conceptual viewpoint constitutes the basic premise of this paper.

WOVEN CONSTRUCTION

Before applying the weaving analogy to abstract notions of space or culture, it is helpful to first understand 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 waddle and daub, was common up to about a hundred years ago 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 exterior woven wall is a major reason why we do not see more buildings utilizing this technique. As an exterior wall 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.[4] Even traditional masonry construction when bonded with mortar in overlapping coursework can be considered a form of weaving.

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. The desire to admit an abundance of light without excessive overheating or ultraviolet damage creates one role for woven screens as shading devices. When combined with a sealed envelope they make an effective system against the elements in exterior walls. They can also be extremely effective as vision screens to increase privacy or hide undesirable views. 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. 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 form is changing and woven construction could play a major role.

Fig. 1. Student Weaving a Wall Panel

WEAVING ANALOGY AS INSTRUCTIONAL DEVICE

Literal woven construction is only one example of the overlaps between architecture and weaving. The weaving analogy can also be used as an instructional technique to help explain the complex design process. The impetus for this approach arose through the prominence of the textile school in our university. As our college was originally established as a textile school, we are consistently trying to find 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 people and facilities to investigate how the two disciplines also share other ideas about construction and form, specifically through the process of weaving. Architecture students see what is involved in the production of woven structures and textile students see the possibilities of weaving with non-fibrous materials. The studio follows one program throughout the semester divided into three topics of weaving and architecture that range from the literal to the theoretical. The first project involves the actual creation of a woven wall, the second investigates the abstract conception of weaving, and the third looks at the relationship of weaving to building construction. Though the studio course requires a linear format, the analogy excels as a reminder that design is a non-linear process that requires constant re-evaluation of site, program and construction throughout a project. The weaving model, in its capacity to intertwine varying elements and patterns, demonstrates the need to consider the many possible combinations of major and minor influences on the design. Following are the descriptions of how each project employed the weaving analogy.

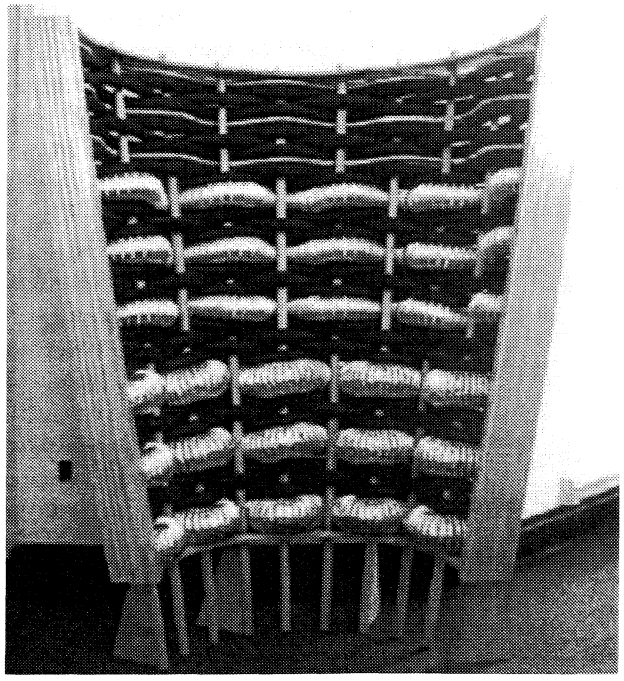

Fig. 2. Woven Ductwork Wall by Chris Bombardier. Debra Clark and Jaclyn Toole

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 that are each assigned a weaving student to act as an advisor. They must then design and build a woven wall structure at full-scale. 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 triaxial 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. 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.

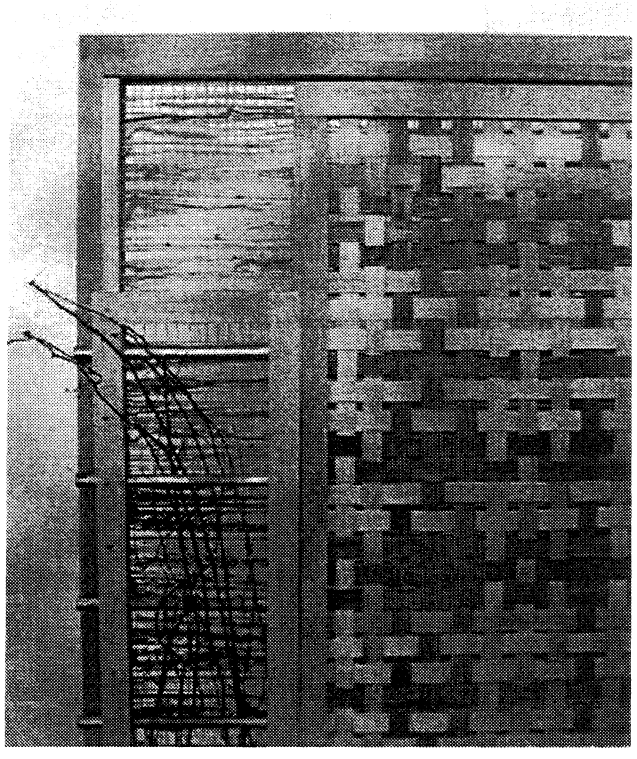

Fig. 3. Wood Screen Wall Detail by Kerissa Gaudioso. Jon Park and Michael Pavelsky

WEAVING AN IDEA: CONTEXT, CULTURE AND CONSTRUCTION

For this first part of the major building design project, students employ the weaving analogy in its most abstract form to understand

how the site, program and construction are inextricably intertwined in the design of architecture. The multiple strands of information derived from analyzing the context and program demonstrates the need for a strategy to integrate all the influences of a design. Students first analyze the climatic, social/cultural, legal and especially intuitive aspects of the site to discover how it fits into, or conflicts with the urban fabric. It is generally accepted the orthogonal geometry of American city plans originally derived from Greek city grids. However, these may have been derived from the structure of woven cloth. The tightly woven, right-angled patterns of cloth were seen as "harmonious" by the Greeks. This pattern may have been applied to the colonial cities as a way to create a "harmonious" and recognizable living environment in a foreign and hostile land.[8] Students investigate the various patterns of their urban site to seek out their own weaving analogies, analyze the contextual factors that influence a site and thereby determine a site design strategy. The location for the project is chosen in a prominent area of the city where the urban fabric has become "unraveled" and lost its sense of an urban place. The students must investigate its history, analyze the various factors that remain and propose a way to re-stitch their site to the fabric of the city through circulation patterns, built-form, and landscape design. Three groups each present an analysis of either the environmental, social or legal influences on the context. Each presentation is constructed in a transparent medium and interlaced with the others to present a collective analysis. This exercise provides an introduction to the way in which external factors impending on a site must be balanced and interwoven to recreate a harmonious urban environment.

After analyzing the site, the students research the programmatic aspects of the project such as the functions as per occupant needs, the history of the type and local traditions as a source of regional identity. They concentrate on programmatic aspects to determine not only the relationships of spaces but also, more importantly, how the building can fulfill the diverse needs of the people who will use it. At about the same time they will analyze the constructive aspects of the program that influence the direction of initial design ideas. Materials, structure, assemblies and services of physical building are studied to develop a basic tectonic concept within the legal code constraints and spatial requirements of the program. By sorting through all of these jumbled 'threads' of information, they begin to organize priorities en route to developing a design concept. Just as woven cloth has major and minor threads and patterns, the students will compose a conceptual textile of ideas to integrate the various influences. The weaving analogy performs as an instructional vehicle for describing the non-linear design process.

The concept is then expanded into three-dimensional spaces that reveal the interwoven experience of architectural space and construction. They examine the overlap of light and shadow, solid and void, all within the aspect of movement in time. As Steven Holl states: "When we move through space with a twist and turn of the head, mysteries of gradually unfolding fields of overlapping perspectives are changed with a range of light-from the steep shadows of bright sun to the translucence of dusk."[9] Students need to understand a space is not static but made up of multiple layers that continually change as one moves around and through it, something rarely evident in orthographic drawings. Through sketches and study models, they study interior spatial conditions by establishing hierarchies between public and private, service and served space, vertical and horizontal circulation, bearing and non-bearing construction, as well as how they overlap, parallel and penetrate each other. Space is approached as a three-dimensional cloth pulled apart to reveal changing sizes, shapes and rhythms of space and structure.

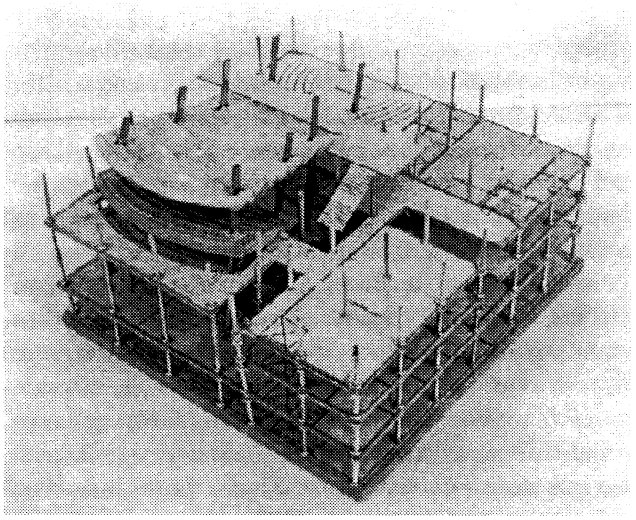

Fig. 4. Structural Study Model by Carmen McKee

INTERWEAVING CONSTRUCTION

This phase concentrates on the numerous construction systems of a building which are "woven" together to create a comprehensive product. 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 presented 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".[10] 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.[11] The simple bearing wall building has become rare. Instead it has been divided into separate systems providing support, comfort and convenience which, while allowing greater freedom for design, also create an abundance of information to coordinate. As the skeletal frame has become the major structural system used today, it func-

tions as a type of "loom" framework onto which the other systems of the building can be interwoven.

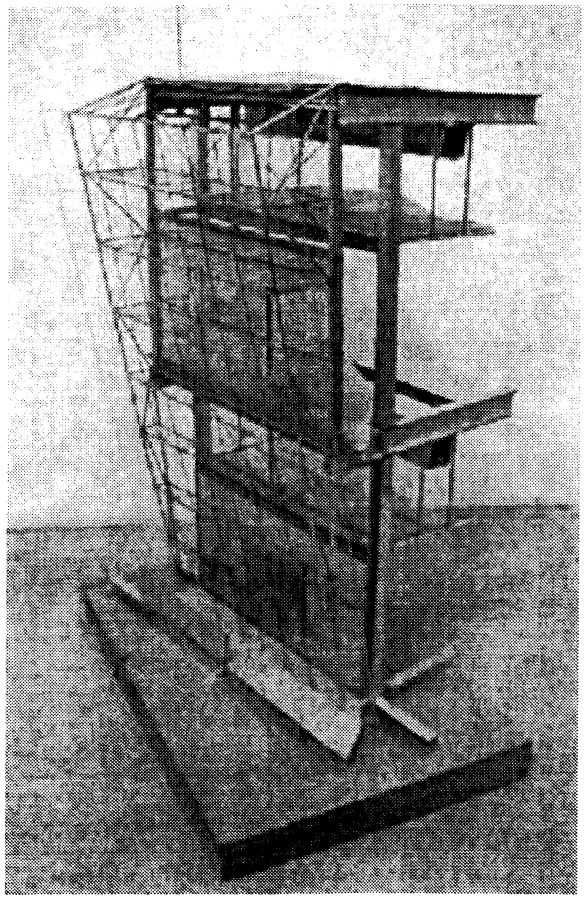

Fig. 5. Perimeter Wall Section Model by Jennifer Crane

Students study the structural system in a manner that reveals the qualities of the space inside. Too often models present the external form of a building without revealing the critical space inside. Therefore, they 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 computer 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 now 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 next study the envelope in detail. They 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 coexist 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.

For a textile to exist as a cohesive work, all the individual yarns and varying patterns must be bound together in a synergistic and integrated whole. Similarly in architecture, all the influences on the design must ultimately coalesce into a final product. Therefore to document this phase, a digital, compositional drawing is created that integrates the wall section with the most critical building design drawings into one interwoven layout similar to an analytique. Relevant plans, sections, elevations and three-dimensional drawings are interlaced with construction details in a drawing summarizing the design. Students take advantage of CAD's flexibility to overlay drawings of different scales and views and 'weave' them together by an appropriate graphic technique. This drawing becomes a comprehensive tapestry of the entire semester-long project in one document.

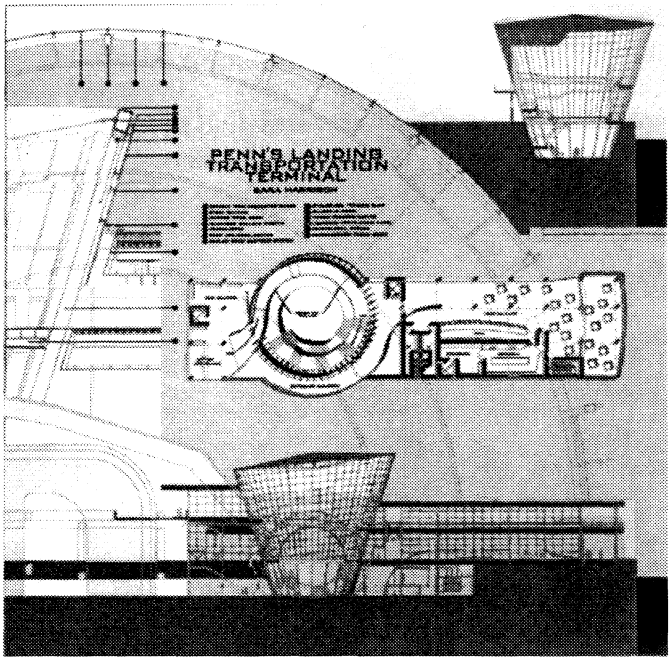

Fig. 6. Compositional Drawing by Sara Harrison

CONCLUSION

By the end of the semester students have studied the analogy of weaving in architecture from the hands-on to the virtual. After going through all phases, they can draw associations between them-

selves, their work and the larger world. To improve this course, the first objective would be greater involvement fore the weavers. Although they served well as advisors, the new palette of materials often acted physically opposite of what they expected which deterred them from deeper involvement. The next step would be to improve the presentation of the figurative analogy. The students had more success understanding the weaving analogy through the literal projects such as the woven wall, the threaded rod model and the technical wall section drawings. Finding better ways for them to understand the abstract notion of weaving an idea or space could be further developed.

Whether used in this particular studio format or in a general studio, the weaving analogy has a relevant application to architectural design. Students are always 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. Weaving, as an analogy, is a useful tool for explaining the benefits, indeed the necessity, of a wide range of knowledge. Architects must continue to operate as generalists to acquire a multitude of ideas that someday may be retrieved and woven into another tapestry of architectural design.

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]Indra Kagis McEwen, *Socrates' Ancestor. An Essay on Architectural Beginnings*, (London :The MIT Press, 1993)

[9]Steven Holl, *Intertwining*, (Princeton: Princeton Architectural Press, 1995)

[10]Herrmann

[11]Frampton, 1998