MOBILIZED MATERIALS

Textile Constructs

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Abstract. This paper investigates textiles techniques and their potential for creating ornamental and structural systems investigated through a sequence of design studios. Within the paper 3 examples of textile systems are introduced that range from a Semperian approach (wall as dress) to form finding experiments with active textile materials (Frei Otto).

Keywords. Textiles; form-finding; analogue computing; design methodology; craft.

1. Introduction

All materials, when sufficiently mobilized, find ways to organize themselves. In human crafts we find similar ways to create patterns, as long as the materials are allowed to be flexible and to configure step by step into a final shape. The research focuses on textile techniques and uses analogue computing or “Formfindung” to mobilize the materials. Materials are allowed a certain amount of freedom to act as agents and process forces in order to configure into a more structural state. The term “analogue computing” is linked to Frei Otto’s experiments on form finding and Gaudi’s catenary techniques, but can also be applied to Semper’s Stoffwechselthese, where one material system informs another.

2. Methodology

The methodology of the studios is based on a systematic procedure that Lars Spuybroek has developed and documented in the R+D series (Spuybroek, 2009; Spuybroek, 2011; Baerlecken and Riether, 2012). He adapted his design
methodology to fit within the framework of a second year studio and coordinated the presented design studios that proceed in three phases:

- **Phase I:** All patterns systems have figures that configure into more complex configurations. Pattern systems are studied through material studies. The configurations lead to vertically hanging or standing “nets”, two-dimensional systems that have ornamental surface qualities as well as structural qualities.
- **Phase II:** The flat nets are thickened or multiplied. More complex operations such as peeling or small distortions are explored.
- **Phase III:** The spatial and structural effects are studied and developed. Circulation, routing, lighting, etc. are developed.

The materials used for this exploration start with flexible threads (from yarn to plastic tubes to wood fibers), but transition then to flexible strips (from paper to cardboard to wood) or to rigid sticks (wood) or to flexible surfaces (from rubber, to textile to paper).

Materials are subsequently researched within the realm of certain techniques. Some techniques will fit exactly with the proposed material (weaving with thread), others less, and some not at all (weaving with rigid sticks) – this is intended to introduce the problem of transferring the diagram to architectural materials.

### 3. Performative Ornament

In order to understand which outcomes of this procedure are desired, we want to look at the role of ornamentation. Following Kant (1790) ornament is defined with a negative connotation as parergon, as an addition, as supplement, as decoration, as applique, as accident in contrast to the ergon or substance. Ornamentation becomes synonymous with veiling and hiding. Ornament is extrinsic and hides the Ding an sich, the thing-in-itself, the substance. Kant gives us three examples, where real beauty suffers from ornament: cloths that cover the naked body in sculptural decoration, decorative columns of classical architecture, and the frame of the paintings.

Through Derrida in the Truth in Painting, we know that Kant’s degradation of ornament is based on the clear distinction between intrinsic and extrinsic. Critiquing Kant Derrida (1987) asks:

> “What about the frame framing a painting representing a building surrounded by columns, columns in the form of clothed human bodies?”

He demonstrates that there is an in-between state: the parerga operates separately from the ergon, but is at the same time not entirely extrinsic to it.

The research focuses on these in-betweens or folds, as Derrida also calls them. We are not following a modernist logic of separation and differentiation of parts, but try to generate systems that integrate a variety of parts with multiple functions.
into one system, as one can observe in natural systems (Weinstock, 2010). For example a certain pattern performs as ornament, structure and shading devise.

Within the process of transferring a textile system to architecture through the introduction of different materials (from soft to rigid) this approach tries to foster integration of systems, which have been separated in Modernist architecture.

There are two groups of techniques. The first group has more precisely described techniques where existing figuration (the type of loop, knot or interconnection) lead to specific patterns: lacework, macramé, plaiting, knitting, weaving, plaiting, and braiding.

The second group offers a more abstract sense of techniques, where individually distinct figurations have to be invented leading to specific configurations: felting, pleating, interlacing, figuring, combing, and wettening.

In the following three paragraphs we are discussing three examples, each a different technique, demonstrating the process of material computation and their transference to another material system in connection with digital tools. All presented techniques create patterns that perform as ornament and structure. But the three different examples vary in their emphasis of these two aspects. The first example focuses on dressing (Semper), second example studies figuring as a technique that equally balances ornament and structure (Gothic), and the last group foregrounds structure (Frei Otto). But there is always an ornamental and structural component present in all three examples.

4. Technique 1: Dressing

In order to understand the importance of Semper for this research procedure, we have to look at two theories developed by him: his theory of dressing (Bekleidungstheorie) and his Stoffwechselthese.

During the Crystal Palace exhibition (1851) Semper sees a Caribbean hut, which reinforces his theory of the Four Elements. As a counterthesis to Laugier’s primitive hut Semper formulates a model of four fundamental types: the earthwork (masonry), wooden frame (carpentry), the textile membrane (textile) and the hearth (ceramics, metal). Challenging Laugier Semper emphasised the textile membrane through his “theory of dressing” (Bekleidungstheorie), which makes the aesthetic performance of the wall through ornamentation more important than its structural performance. For Semper architecture has its origins in textiles, in weaving, and in braiding, through the light and highly ornate nomad tent architecture. Subsequently Semper contrasts two types of enclosure: (a) die “Mauer” and (b) “die Wand”. Both translate as wall into English. In German there is an etymological difference between the two words. “Mauer” is a construct that is put together through masonry (mauern = to lay bricks), whereas Wand refers to
“winden” (to twist, to wind) as a construct that is assembled through bending, winding, twisting thin, bendable, soft twigs. The “Mauer” is a fortified, solid, monolithic wall serving to create security. In German “Wand” can be linked etymologically to Ge-wand, dress. So the “wand“ is a type of enclosure that is a light textile carpet in the likeness of a screen-like wicker work or an ornate dress. The fortified wall provides security and structure whereas the wall-carpet creates spatial enclosure. The two can exist in direct relation to each other (medieval castles/tapestry) or in loose relationships.

The second Semperian theory, the Stoffwechselthese, is highlighted in our work. Stoffwechselthese is sometimes translated with metabolism thesis, but could be read as Stoff- (stuff/matter/material) –wechsel (change/transformation)- thesis. One material is exchanged through another. We see a technique where one material is transferred to another substance in Semper’s example of the textile transferred through stone carving. Semper sees this theory proven by the translation of textile motifs into the polychromatic dress of Greek temples.

Figure 1 and 2 show two examples of textiles techniques that transform through a change of material process. Figure 1 shows lace as a textile technique.

![Figure 1. Lace configuration and their transference to a linear, rigid material system.](image1)

![Figure 2. Knitting with wooden blocks (left) and digital model based on a loop stitch (right).](image2)
In phase 1 different lace types are studied such as: needle lace, bobbin lace, knotted lace, knitted lace, crochet lace, etc. In this first phase the technique is studied through a textile material/thread. The focus lies upon understanding the complexity of pattern making linked to the techniques applied. In next step the material changes: thread is replaced with bendable wire and rigid sticks. The study of bendable wire is less successful, since it introduces unintended deformation of the pattern and does not increase the rigidity of the wall system significantly. The study with rigid sticks is far more successful, since the wall becomes structural and the pattern maintains its complexity, but the lace pattern also changes its properties through the introduction of the new material. In a Semperian sense Stoffwechsel is taking place, as the lace informs the wood and the wood sends information back to the pattern. The rigid wooden sticks allow for certain operations to be performed as in the lacework (loops with larger radii), but edits out operations that cannot be performed with a rigid element (loops are no longer curvilinear and the dimensions of the material dictate the intricacy of the pattern).

Figure 2 shows a study of knitting. Knitting is a technique that uses yarn to create consecutive rows of loops, which secure each other in the process of making. After the initial phase that studied a series of techniques with different stitches which allow the creation of different textures (such as warp knitting, knit and purl stitches, cable stitches), the study focused on different surfaces types in order to increase structural properties of the system and to create spatial enclosure: from flat surfaces over twisted surfaces and single curved, open surface to enclosed cylindrical surfaces. Figure 2 shows the process of transferring the knitted surface to a structure made from blocks. The ability of a knitted surface to create different spatial and structural wall types informs the making of a block-based model. Again, two material systems communicate bi-directionally. The digital model in figure 2 shows how a precast concrete block could be developed by reading, in this case, information from a single-loop knitting pattern.

5. Technique 2: Figuring

The ornamental and structural qualities of figuring are best illustrated in the work of Gothic architecture. Gothic architecture combines ornament as tracery characterized by a rhythmic organization, and a system of geometric construction following a structural logic. The configuration of curvilinear figures is informed through a material. The change of material produces variation in the lightness of the structure: stones (Chartres), brick (les Jacobins) or metal (Labrouste). The translation of one material into another in these examples reflects an increase in “structural lightness” which follows the same structural systemacy: bundled columns transfer into ribbed vaults creating ribbon surfaces. The gothic wall is
very close to a Semperian textile “wand”: the gothic wall synthesises both Semperian wall types into a structural wall carpet.

In modern architecture the structure is detached from the wall - the post and slab structure of the Domino frame. The curtain wall has replaced the wall-veil; the maximized “lightness” of the curtain is achieved. However, the curtain wall has lost the ability to form complex configurations, and remains dependent on separate structural systems.

We respond by studying the construction of structural surfaces through active figures (Spuybroek, 2011). The following example employs figuring as a generative system to creates structural surfaces. Figuring is a technique that follows the methodology of gothic structures that use I-, J-, S-, and C-figures. In the chapter titled, “The Digital Nature of Gothic” (Spuybroek, 2011, p. 20) Spuybroek argues, per Ruskin’s description of gothic, that ribs are the elements of constant variation and in order “to keep getting new configuration, one needs both different figures and different combinations of figures”. “Figuring” within the basis of gothic design allows a new form of rigid structure that can free itself from the rules of earlier gothic systems, which only work in compression. The evolution of flat surfaces to three-dimensional structural surfaces results from specific transformations such as shifting, pinching, or warping.

Figure 3 show a figuring project, which develops a structural façade attached to an existing building. The project starts by defining the minimal set of figures that can produce the maximum configurations. Variations are a matter of size/scale and diversity of curve. The challenge is to create a system of line work that is continuous and can perform at different levels. The figures once transferred to rigid material can become structure, ornament, screen, or window.

The design is based on a set of figures generated by the offsets of a circle to create nested figures with relationships of 1 to 1 or 1 to 2. Straight and curved ver-

Figure 3. Figuring.
sions of each type produce a total set of 6 figures. The figuring process builds up complexity through the controlled variability of configurations, arrangements, and scale. Scale and arrangement breed the hierarchy within the technique’s system. Using the individual parts, the project explores creating a series of similar figures that begin to interlock with each other. Methods of reflection and translation are used to create a repeatable pattern that can continuously expand. As developed patterns are repeated and connected, variations are introduced to the original movements, allowing for a flexible and adjustable system for growth. The pattern then reacts to its environment through variation. The surface achieves three-dimensionality in two ways: by duplication and rotation of elements, and by bending elements inwards and outwards. The deformation generated by the last technique is palliated by insertion of more figures to reinforce the structure.

In phase 2 the project proposes a structural skin with solar-responsive cladding elements. Using figural variations, the skin performs in high visual density and almost complete obscurity, as well as open and porous conditions, which act as “windows” where desired. The skin changes with each face, with small apertures and built-in shades on the South and West sides, and large apertures on the East and North sides. In some cases the skin presses outwards into a two-layer system. The elements are designed to be precast concrete, mounted to the existing frame by a direct-to-slab anchor. The skin performs the two main functions as noted above and proposes responding to solar radiation on the site. The figures relate to human scale in what is otherwise a larger-than-life proportional system.

6. Technique 3: Analogue Computation

In the early 1990’s Frei Otto and the Institute for Lightweight Structures in Stuttgart investigated what they termed “optimized path systems”. Material machines were devised to test complex material behaviour, reorganizing the system by introducing one material with another, creating a transformation of the material system. The organization of matter through a material machine process involved the use of liquids and solids, where material began as liquid and ended as rigid. (Spuybroek, 2011) These material machines restructure themselves through interactions among elements in a restricted time, and the material “finds [a] form”. The material forces by transformation, computes these interactions, and resolves in a geometry that is derived from a complex material behaviour. This is a form of analogue computation. These textile machines generate complex structures as they transform from their wettened state to their rigid form. Otto explored the potential of a material machine to restructure a system of dry wool threads by dipping them in water. Bound at determined ends, the wool threads are free to bind to one another, creating a new flexible network, which varies with each dip, as agents are free to restructure. (Figure 4)
Wettening is a technique used to configure flexible elements (ex. wool thread) through sticking. In one study students explored wettening as a method to compute an architectural structure. A material machine is made by dipping a matrix of wool threads, which are suspended between two acrylic plates with fasteners into a pool of water. A variety of thread relationships and slacks are tested with each dip and the threads compute structural relationships with one another. (Figure 4)

The number of paths is minimized, sharing geometries of merging and bifurcating, much like a vectorized system.

As seen in Figure 5, the felting technique defines the nesting of loose fibers or strips into a surface or volume. The study explored agitating paper strips, behaving as fibers would in a glue and water liquid for several seconds as new strips are added periodically. A screen is lifted through the liquid, straining the paper strips through the liquid mixture. The nested strips become hardened and fixed, creating

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Figure 4. Wetening configurations and their transference into a structural façade system.

Figure 5. Felting patterns and their transference into a rigid structural system.
a static patterned net. The pattern’s variation in density and area is dependent on the duration of the machine’s agitation. The pattern’s surface is folded and nested vertically to create cylindrical vertical volumes.

Weaving is a technique that works from a loom with elements fixed in one direction. The computing machine for this study (Figure 6) blended two analogue computing techniques. The first, like the wetting study, dips a network of fibers softly structured in a rectilinear swatch of a woven pattern into a water and plaster solution. The soft structure is coated by the solution, creating additional weight and freedom for movement. After the dip the soft structures are hung upside down from a horizontally braced frame. The weight of the solution and with the addition of weights creating force and movement to a soft flexible material system. These soft structures behave much like Gaudi’s inverted net study where a structural system of catenary curvatures calculated for projects like La Sagrada Familia in Barcelona, Spain. After the initial analogue experimentation digital tools allowed students to develop a building that explores multiple structural shells in connection with programmatic and contextual forces.

In these studies the use of digital tools became necessary in developing the project. Students moved between software applications, utilizing the digital computational tools to advance the precision of the project.

7. Discussion

The methodology has been productive in creating ornamental and structural wall systems. The material transference from yarn to another material has allowed the study of architectural problems. Nonetheless, future research could foreground
tectonic aspects linked to construction through the construction of large-scale mock-ups.

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References