Assemblies and Aggregations: Design and Production of Variable Cast Units

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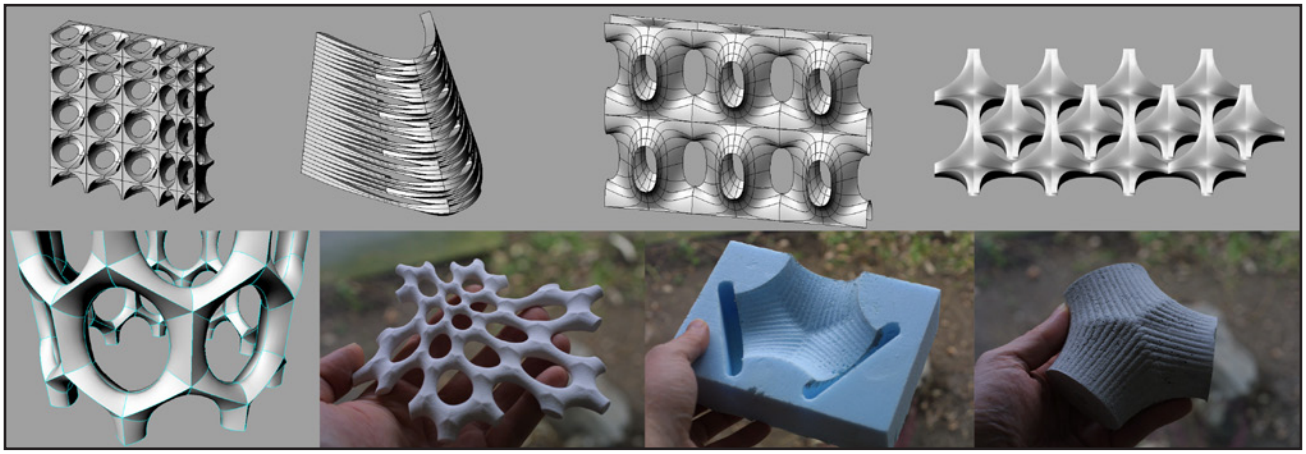


INTRODUCTION

Developments in computer technology over the past 10 years or so have significantly altered our capacity as designers to produce and manipulate form and space. When coupled with numerically controlled fabrication technologies the designer's ability to work directly with the means of production and the capacity to vary the results of process are unprecedented. However, anyone familiar with parametric modeling used in conjunction with digital fabrication understands the process is never quite as simple as the often stated promise of push button mass-customization. One must have the knowledge of fabrication – to a certain degree – to determine how and what will be modeled and fabricated. Also, there are limits to the tool, limits to the material, limits determined by site or function – that provide a feed-back loop on the process of design and modeling – which is to say within the actual process of making are productive limitations that can and will inform the design – and this may be best engaged when one is involved in all aspects of design and production. Lastly, in such a process, which requires an immersion in what is becoming a specialty of technologists and software engineers (of which I am neither), what role might the visual play in recovering design thinking from technological determinism where often the word parametric is a false stand-in for subject, object, or aesthetic in architecture?

The ability to produce variation in form, the production of difference, and the consideration of part to whole relationships in the development of full-scale cast units are subjects of the work presented here developed in the graduate seminar Arch571: Digital Fabrication.

Mold-making / Casting are some of the more complex processes in digital manufacture as they involve

many aspects, materials, software and hardware in design and production in addition to the conundrum of moving from 3D positive forms to viable negative molds. As such – the subject serves as both a thorough introduction to digital manufacture and a challenging field in which to broaden a student's capacity to think through making. However, in addition to working materially and understanding the technology, particular emphasis is placed on situating the work in a broader context of design and stressing role of the visual - initially through graphic means - that subsequently structure specific formal and spatial approaches in the work.

MOTIVATIONS

One of the primary theoretical motivations of the course is the assumption that there is parity between ornament and structure. In the development of cast units and logic of assembly, the students were urged to consider the structural as a subset of the ornamental and decoration as an effect, an expression of the structure/ornament complex. From this way of working new considerations of tactility of material, emergence of form, consideration of the joint, and the imprint of the tool could form.

Following this line of thought the Gothic as a precedent is of particular importance, not as a style necessarily, but as an approach, process, or way of thinking about material and form. The distinction between this approach and an alternative is made cogent in Deleuze and Guattari's brief references to architecture in their book *A Thousand Plateaus.* "Gothic architecture is indeed inseparable from the will to build churches longer and taller than the Romanesque churches. Ever farther, even higher…But this difference is not simply quantitative; it marks a qualitative change: the static relation form-matter, tends to fade into the background in favor of a dynamic relation material-forces."[1] In his book *Camouflage* Neal Leach notes that for Deleuze and Guattari, "it is as though the whole history of architecture can be divided into two contrasting yet reciprocally related outlooks."[2] The 'Romanesque' in which the aesthetic form is imposed on building materials through an a priori template such as proportions, this would necessarily include the classical lineage – Roman and Greek styles and their mutations – Romanesque, Renaissance, Mannerism, Baroque, and Neo-classical – but also any architecture that privileges appearance over performance. Alternatively the Gothic is a form which privileges performance over appearance. Forms are part of a process of becoming, as in the emergence and refinement of the fan vault over centuries of development. The architecture, as such, is the result of forces and programmatic development – which aims at an effect rather than producing a preordained appearance. For Deleuze and Guattari this is a distinction between 'static' and 'dynamic' models of architecture. "It is as if Gothic conquered a smooth space, while Romanesque remained partially within a striated space." [3]

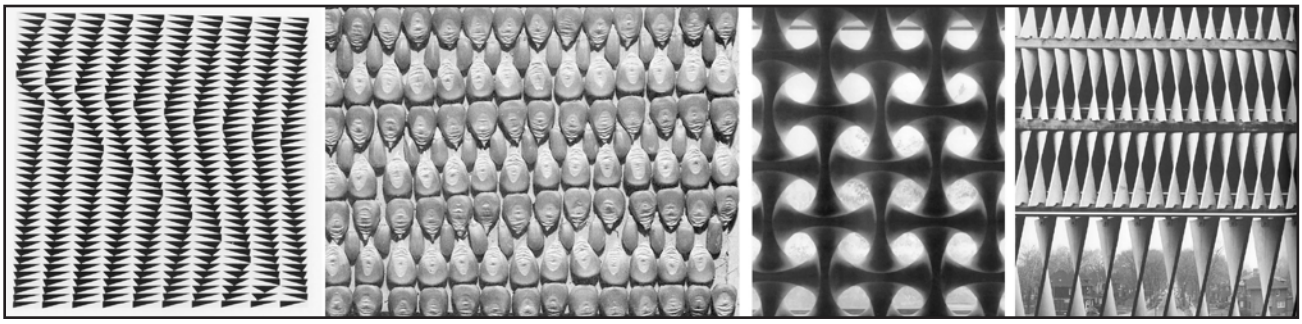
Leach goes on to point out that rather than defining these two distinctions in terms of style, Deleuze and Guattari use them to clarify what they term as "sciences."

> One is a science of intensive thinking that perceives the world in terms of forces, flows, and processes. The other is a science of extensive thinking that seeks to understand the world in terms of laws, fixity, and representation. In other words, the one is smooth science, the other striated.[4]

However, Leach goes onto warn that we must be wary of reducing a discourse on architecture to a simple opposition between process and representation. That in Deleuzian terms one will always fold into the other – there is necessarily a mutual dependency on paired terms. Leach states, "architecture is based on both process and representation. It is an amalgam of intensive and extensive thinking, minor sciences and major ones." [5]

> *As for Deleuze and Guattari's distinction between the Gothic and the Romanesque, between structure and ornamentation, it is a question of treating structure ornamentally and ornament structurally. For architecture has only ever consisted of the ornamentalization of structure and the structuration of ornament.*[6]

This distinction is particularly relevant in light of current tools which imbue the designer with access to technologies (sciences) that seem to equally allow great variation in form and openness of process yet demand a set of 'parameters' (templates) in which to work. In its development the Gothic may collapse distinctions between structure and ornament and privilege performance over appearance – it nonetheless is visual and is rigorous in its effect – to a great degree de-materializing the wall while shaping space and experience with light. However, the Gothic is largely architecture of the frame, in which the surface (typically stained glass) is the in-



The work of Bridget Riley, Anni Albers, Erwin, Hauer, and Albert Kahn were studied as precedents of graphic and material aggregation.

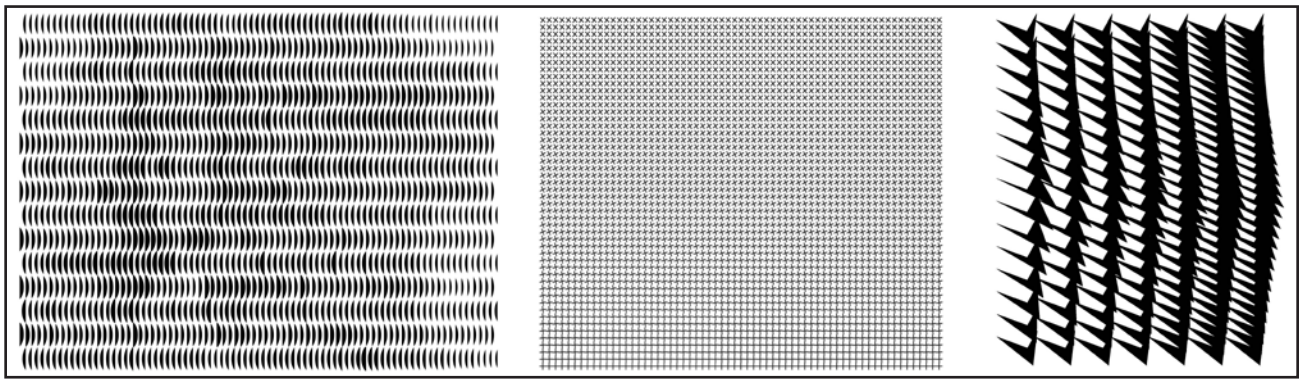
fill between structural/ornamental elements. Only in the most elaborate fan vaulting does the structure reach a fine-ness to such a degree as to produce a surface. It's no surprise that Phyllis Lambert, in her text on Mies – a designer whose work we might naturally assume to fall under the classical idiom - points out both the gothic and classical trends and tendencies in his projects.[7] The question for us then is how might we acknowledge certain affinities and continuities with the Gothic yet rethink others and more specifically direct the development of our projects to the emergence of a particular type of form.

PRECEDENTS OF AGGREGATION

Following a basic introduction to 2D and 3D CNC milling and 3D print technologies the students conducted research in precedents both within and outside the discipline of architecture that focused on projects which utilized techniques of aggregation and variation. Part of the intention being to debunk the assumption that it's primarily new technology that produces such emergent effects – rather there are a vast collection of precedents in design that engage issues of aggregation – at the graphic and material / construction level, from Islamic tile patterning, weaving, the work of Anni and Joseph Albers, Eva Hesse, Bridget Riley, to more recently Tara Donovan and others. In the discipline of architecture the historic examples are atypical; the work of Michael Blampied in the UK, sculptor Malcolm Leland's work on the American Concrete Building in LA, a parking garage by Albert Kahn in Detroit, and of particular importance the architectural screens from the 50's and 60's by Erwin Hauer.

One could describe much of this work specifically and 1960's opti-art in general along the same lines as minimalism in that it engages the viewer at an experiential level. One doesn't ask necessarily what the work means – but what work does it do – what is its effect on the viewer and how is the viewer implicated in the work? In studying Bridget Riley's black and white paintings and drawings of this period we are struck not only by the logic of part to whole – they way individual elements, such as the triangle in *shift* are progressively transformed by the order of the whole forming a coherent field – but how that order is dictated also by the order of the part – the form of the triangle. These are both visual and relational constructs – fundamentally parametric logics. But critical to the functioning of the work and important to our analysis is its effect – in this case an oscillation between foreground and background, positive and negative space – a functional characteristic one can't simply attribute to any part or any whole – but is the product of specific graphic intent. One also finds this oscillation, though now spatially, in Hauer's work – where a visual shift occurs between the continuity of solid forms that compose the wall and the volume of space they create. One moment it is matter which is the figure – the next it's the space. We find an affinity with this de-stabilization of a clear reading between figure and ground – in that it is a particularly modern sensibility toward space and that it has the potential of engaging the viewer in the work.

Growing out of this research the students were asked to explored concepts of aggregation and part to whole relationships simply at first through the manipulation of 'textual' units in adobe illustrator. Utilizing basic macro scripts to perform a series of routine transformations (such as rotate10deg, scale by 5%) of a single piece of text, produced profound and unanticipated (i.e. emergent) effects when multiplied to fill a sheet. These investigations eventually led to 2D 'graphic' units in Rhinocerous modeling software – manipulated by establishing cer-

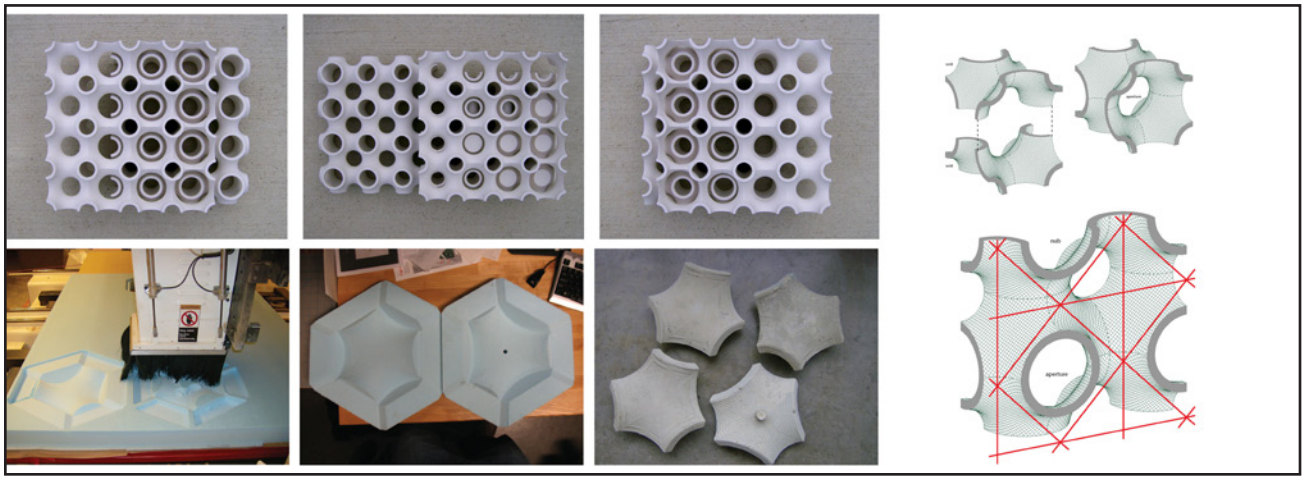


Students initially worked graphically with the transformation of 'textual' units in illustrator and then with 2D forms in Rhinocerous with Grasshopper plug-in in order to establish a working and conceptual basis for techniques of aggregation and difference.

tain parametric relationships with the Grasshopper plug-in. This research and exercises established a historic, conceptual, and technical base from which to proceed – as the degree of complexity in terms of modeling and manufacture ramps up considerably when one begins to work in 3D. To establish a working methodology in 3D and explore advanced techniques for modeling complex form, a number of Hauer's screen projects were studied and modeled – the attempt was first to adhere as closely as possible to the original forms. This required an analysis of the overall geometric order of the screens and a mental disassembly to the basic unit. Within the unit, logics of symmetry (sometimes multiple) and transformation (flipping, mirroring, rotating) were identified, and as much as possible, a speculation on the process of casting and assembly.

UNIT DEVELOPMENT

From the graphic studies and Hauer unit modeling the student's initial 3D studies developed. A number of trajectories became evident in the work through these studies – one directly from Hauer, in how the internal characteristic of a unit could be formed to capture and reflect light and by extension modulate transparency and opacity through the surface and oscillate between positive and negative space. The other had to do with the manner in which they would treat the problem of difference and variation in the overall form – a condition which is not present in Hauer and other historic precedents – but which contemporary technology may facilitate. In Reiser + Umemoto's book *Atlas of Novel Tectonics*, an eloquent outline on the reason and possibilities



Sequence of development of student work – limitations of tool leads to rethinking what constitutes 'part.'

for ubiquitous difference in the universal, they reject both the "modernist model of simple repetition of an unchanging unit" and the collagist model of "accumulations of the merely different," for two potential trajectories for the production of difference:

1) An unchanging unit deployed along a variable trajectory – as in the slight shifting of a brick unit to create a curved wall.

2) An infinitely variable unit deployed along a simple trajectory – in this case every unit would vary to a certain degree.□

The students were urged to consider not one or the other of these poles exclusively – but to look at the possibility of developing a practice which lies between. In lieu of using the simple repetition of a standard unit or the open-endedness of an infinitely variable unit – the development of a smart unit or family of units was proposed, in which slight formal transformations – when deployed in number would produce great variations in the whole. How does one design into a unit a greater intelligence of assembly – one which deals with both continuity of connection and the possibility of variation in the overall form? This sprung from a desire to imbedded in the projects a broader consideration and engagement with both, division of labor and systems of production – considering the scale of the unit, practicality of variation in production, flexibility of use, and logics of assembly. Unlike the Gothic, the structural frame in our explorations was subsumed in the wall – although beyond the scope of the course one might potentially explore the porosity and thickness of the wall in relation to structural load.

Initially, scale 3D prints of units were output to test these logics – then to study the problem of full-scale fabrication. When confronting the specific limitations of 3-axis CNC routing to develop the full-scale molds – issues such as undercutting and tool depth made some units impossible to produce or required further understanding of the casting process and the development of more irregular cut lines in the molds. In either case a continuous open loop of development was established in which variations were produced and tested at the small scale then single test molds were fabricated producing test casts – which would re-inform the 3D model development. An interesting aspect of this process is not only confronting the relation between the physical and digital, but negotiating the shift from 3D positive modeling to 3D negative form modeling for production – which requires a developed consciousness about materials, tooling, and production – only truly understood through trial and error.

Conditioning many decisions was ultimately the assembly of the whole, the treatment of connections and joints between parts, confronting the sheer weight of material and the capacity of the assembly to self support through configuration of form. These along with decisions about the texture of the tooling on parts – its direction and scale, the composition and color of the casting material allowed the students to refine their understanding of craft directly while expanding their knowledge of a fairly sophisticated set of tools. Primary too was

Selection of student's final assemblies.

the visual effect of the work – to what degree the work engaged and extend the visual subjects established through the preliminary research and to what extent the work presented a robust and variable system were two factors upon, beyond technical mastery, the work was judged.

ENDNOTES

1. Deleuze and Guattari, *A Thousand Plateaus*, trans. Brain Massumi (Minneapolis: University of Minnesota Press, 1987), 364.
2. Neal Leach, *Camouflage*, (Cambridge, Mass.: MIT Press, 2006), 95.
3. Deleuze and Guattari, *A Thousand Plateaus*, 364.
4. Leach, *Camouflage*, 96.
5. Ibid.
6. Ibid.
7. see Phyllis Lambert, "Clear Span," in Phyllis Lambert, ed. *Mies in America*, (New York: Canadian Center for Architecture and Whitney Museum of American Art, 2001), 423.
8. Reiser and Umemoto, *Atlas of Novel Tectonics*, (New York: Princeton Architectural Press, 2006), 52.