Six Facets of Matter: Material Futures for the Architectural Object

The speed of technology presents a significant dilemma for any architectural pedagogy that is focused on matter. Working with any material and learning how it can be altered, formed, and manicured takes time, resources, and space, all of which, to a lesser degree, can be comfortably supplanted by a laptop. As soon as the deep qualities of matter are deduced, they are often thrust into a process of encryption that makes them accessible

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to computation if only for the sake of speed and the protocols of practice that demand automation. This leaves many forays into material behavior unanswered. Alternatively, any unknown aspect of material behavior may be circuited into other known materials or processes where success is more certain, effectively putting an end to speculation. This essay will explore material as a behavioral mechanism, its relationship to geometry, and its tendency toward variability.

The separation of the material code from the object and its material relations presents a short-circuiting to any discourse surrounding matter. What often results is a self-regulated curtailing of material expertise. This is adversely affecting the kinds of risks that graduate architecture students are willing to take. With the increased introduction of parametric software and optimization plug-ins, the educational appetite for physical experimentation is reaching obsolescence. This demands a careful retinkering of the current pedagogy and a broadening of material inquiry to combine contemporary tools and techniques with the broader history of materials, craft, and tectonics. Part of knowing when to automate something relies on understanding that it is difficult, expensive, or even painful to perform and, perhaps more importantly, that the consequences of any optimization process may be contrary to the design intent.

During the semester, the studio will investigate six facets of the architectural object.

I. Architectural Excess

II. The Aesthetics of Scarcity

III. Optimized Constructs: Utzon's Shells

IV. Physical Contingency and Variability

V. Robustness: Sash Bars and Pendentives

VI. Compositional Pressure: Competition and Segmentation Among Parts

I. ARCHITECTURAL EXCESS

ex▪cess (n.) a: the state or an instance of surpassing usual, proper, or specified limits; superfluity; b: the amount or degree by which one thing or quantity exceeds another.

In his book *The Accursed Share*, Georges Bataille positions excess as a fundamental component of civilization. For Bataille, surplus is a mark of success and a form of energy that is expended in the social spectacle of memorials and fireworks. In the Midwest, excess and agricultural surplus have given rise to the farmer's market. The studio project will focus on the redesign of the Soulard Farmer's Market built in 1841 in St. Louis.[1] The renovation of the existing market will allow it to operate four days a week, throughout the year. It will offer a temporary place for farmers to sell a variety of local fruits, meats, and vegetables while serving as a significant tourist destination with shops and restaurants. The current demands of the market and the configuration of the block present significant opportunities to reconsider the interspersing of pedestrian access, vehicular distribution, parking, and integration of public space. In addition to being a significant public building, the current zoning encourages greater density along with mixed-use development. A denser development presents a challenge to the current viability and iconography of the historic market and its nineteenth-century industrial shed.

The studio will consider how the attributes of dynamic models, specifically, the role of variability and its effects on time and material organization, can alter the character of the market, its use as a temporary structure, and its consolidation into the existing block. The studio will be concerned with the physical and material interactions between objects in both virtual and analog environments and the exploration of their merits in relation to optimization and the production of architectural excess. How can the excessive qualities of dynamic modeling be employed to consolidate the heterogeneous spatial characteristics that comprise public space, infrastructure, and architecture?

II. THE AESTHETICS OF SCARCITY

scar▪ci▪ty (n.) the quality or state of being scarce; especially: want of provisions for the support of life.

Assignment II: Formalize a recipe for mixing together five different objects of your choice (figure 1). Characterize their scarcity based on the amount of labor or the RAM that is associated with producing them, as well as their frequency in the recipe.

Scarcity is not often considered a design parameter with tangible material qualities. It is a force that alters the design process, in often less than obvious ways. The desire for a particular physical trait is subject to a wide


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Figure 1: Fischmarkt (Zinsgroschen?). Künstler: Frans Snyders, 1579–1657 Antwerpen, Künstler: Anthonis van Dyck, 1599 Antwerpen, 1641 London (Figuren). Photografie und Digital Image ©Kunsthistorisches Museum Wien mit MVK und OETM. Reproduction.

range of factors that limit its availability. It is the designer's response to the absence of traits that makes scarcity an important factor. When simple substitution is not desirable or efficient, a more elaborate or crafted response is necessary in order to compensate for what is no longer possible.

Rarely do we consider color a material or the fact that pigment is a derivative of minerals or plant dyes. The fact that color might be scarce is counterintuitive to the digital paradigm. The history surrounding the use of blue pigment during the Renaissance is one such example. Blue pigment was extremely difficult to acquire. Ultramarine (meaning "beyond the seas," not for its color but because of where it came from) was derived from lapis lazuli.[1] Centuries ago it could be mined only in the most remote part of Afghanistan and it had to be acquired through trade. Because of this, its assignment in a painting was reserved for the most significant figures.[2] Its scarcity was the cause of many debates between painters and patrons. Some artists made the choice to use substitutes such as citramarino ("this side of the seas"), also known as azurite, a more inferior substitute that would fade over time, while others simply used less ultramarine by laying up a foundation layer of more readily available pigments.[3] In each case, what ensued was a series of responses that reflect the material's scarcity.

Three things stand out. First, the desire for blue was not abandoned. Its use persisted even in moments of scarcity. Blue became even more coveted, and simply having a sky without it was not an option. Second, painters developed techniques in response to the scarcity of the material that approximated the intensity of ultramarine, giving rise to a series of alternatives that ultimately diversified the intensity and hue of blue as we know it. The artist Yves Klein patented his own recipe of blue pigment. Last, scarcity fuels speculation, competition, and accident. In 1828 a French chemist invented a synthetic ultramarine that came to be known as French ultramarine, making it available for a fraction of the cost of the real thing.[4]

Any endeavor that engages matter in the design process involves some degree of scarcity. The manner in which matter is assigned value constitutes a reflection on the aesthetic status of the object. Leveraging scarcity is an integral part of constructing the architectural object.

III. OPTIMIZED CONSTRUCTS: UTZON'S SHELLS

> op▪ti▪mi▪za▪tion (n.) an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible; specifically: the mathematical procedures (as finding the maximum of a function) involved in this.

Assignment III: Using your recipe, establish a surface optimization for the following: the representational clarity of overall form and the subdivision of the surface. What are the consequences of the optimization of each object? What is the role of geometry in this process?

Optimization is representative of a shorthand approach to a problem, and, as such, it is not a form of authorship. It may be beautiful in its ability to reduce the complex to something simple, straightforward, repeatable, or compact; however, it should be recognized as a method that approaches the mean.[5] It requires a subject in order to operate, and it may be carried out in such a way that it remains undetected and transparent to the character of the architectural object. It has traditionally belonged to the expertise of engineers, but it is now being extended to a broader set of architectural principles related to composition, variability, and behavior, all of which have traditionally belonged to the Vitruvian principle of *venustas*, or delight. This breed of misbehavior is no longer a question of theory, but it has become an active force in practice, tethering the virtual behavior of the architectural object to physical capital.

Another form of optimization transpired during the infamous design of the concrete shells of the Sydney Opera House. It is well known that Utzon's winning competition entry was largely incomplete. The construction of the iconic ship sails that he had imagined for the roof shell was geometrically unresolved. Many failed attempts to rationalize the "shells" based upon parabaloids and ellipsoids would follow.[6] Utzon's father was a boat builder, and both Jørn and Ove Arup had considerable knowledge of the ruling lines used to draw ship hulls. In conjunction with Ove Arup, a decision was reached after three years of study to orient the geometry of each of the shells on the surface of a 75-m sphere, effectively describing a ruling arch of constant curvature that is rotated around a base point every 3.65 degrees.[7] All ten shells are defined using the same parameters.[8] More importantly, the approach toward optimization is unprecedented given that there was no norm to optimize for. What is unique about the solution is that it constituted a new recipe of geometry, matter, and computational processes that had never been achieved before.

IV. PHYSICAL CONTINGENCY AND VARIABILITY

> con▪tin▪gen▪cy (n.) a: an event (as an emergency) that may but is not certain to occur <trying to provide for every contingency>; b: something liable to happen as an adjunct to or result of something else.

Assignment IV: Pack, Relax, Fill. Use a virtual physics solver to (a) pack a large volume, (b) relax a sheet, and (c) fill an envelope. Develop a method to construct a physical model of each of the results.

We will now consider how the attributes of dynamic models, specifically, the role of variability and its effects on time and material organization, can destabilize the design process. What representational methods might be developed to visualize physically excessive forms of organization, especially clusters of objects that do not behave or aggregate in a uniform manner? Generally speaking, dynamic models are characterized by the following: (a) they self-organize in the presence of disequilibrium; (b) they are subject to contingency; and (c) they exhibit multiscalar properties that recur across a range of scales. The use of dynamic models in architecture has existed for centuries, but only in the past two decades have they been explored using digital tools. Early collision-detection software was used by Boeing primarily as a means to avoid construction delays and to minimize the design of service clearances within the bodies of aircraft.[9] Commercial software can

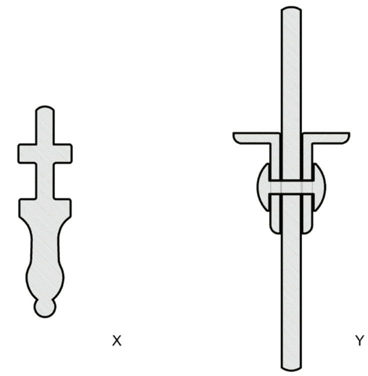

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Figure 2: Wrought iron sash bars designed by (X) Ludwig Persius, 1838, and (Y) John Kibble, 1865, 1872. Image redrawn by the author. Original image from *Houses of Glass: A Nineteenth-Century Building Type.*

now simulate physical collisions between objects. These “physics solvers” were developed to animate the complex physical interactions between multiple objects, such as bouncing fruit or filling a jar with jelly beans, and to complete the task while expending a minimal amount of memory. Solvers are used to design complex animations and to address complex situations that previously had been considered too tedious or impractical to model independently. It is now much easier to simulate and study the physical packing of multiple objects in space (Figure 3). Consistency and contingency are important aspects of a dynamic apparatus. Consistency refers to the ingredients of the mix. How do the specific features of certain objects affect the spatial consistency of the heap? It is important to accept the fact that these are objects—physical or virtual, things with properties that can be defined and employed specifically to the design process. The nature of the object is an open question. It is generally accepted that all things are objects; however, the disciplinary distinctions in architecture between materials and program do not meet comfortably with this consensus. How might the use of the physics engine alter these categories?

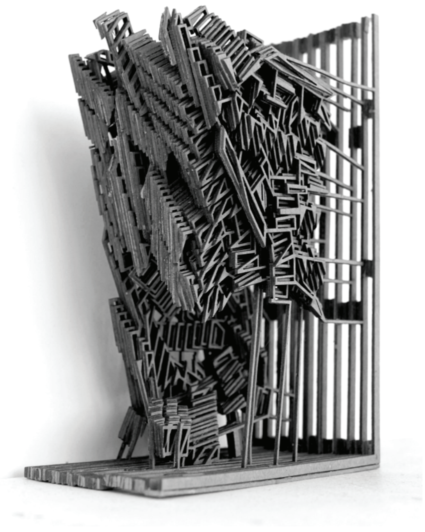

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Figure 3: Physics solver volume model with erasers—fall 2012. Washington University, St. Louis, options studio. Model and photo by Jingwen Shi.

V. ROBUSTNESS: SASH BARS AND PENDENTIVES

Assignment IV: In response to the physics simulations, choose one of the three architectural conditions—volume, sheet, or envelope. Establish the scale of the components. Chose an architectural material to work with and produce a more robust architectural alternative.

> ro▪bust▪ness (n.) Latin *robustus oaken*, strong, from “robor-,” “robur” oak, strength.

Even the most optimized parts of architecture cannot be reduced purely to mere optimal considerations.[10] The developments of the hothouse sash bar and the architectural pendentive are two examples where a seemingly adaptive approach toward functionality is not enough to complete the object. These objects are robust in the sense that their forms are the result of multiple considerations that result in a formal convergence of the object.

This consolidation of forces makes it easy to overlook the role of aesthetics and materiality in their formation and the role that each object fulfills in the building.

The historical development of the sash bar resulted in a robust object that brought unprecedented transparency to the hothouse, and it became the precursor of the curtain wall sash bar (figure 2).[11] A cursory survey reveals at least five forces that led to the evolution of the iron sash bar and its replacement with wrought iron: (1) the consolidation from an iron assembly to one of composite extrusion, (2) increased strength due to the composite cruciform shape, (3) a reduction of the overall depth and weight, (4) a gross increase in daylight entering the roof, and (5) the workability of wrought iron allowing for the extrusions to be more easily bent.[12] One element that remains partially unexplained is the specific nature of the curved profile of the extrusion. The final determination of these profiles, outside of the production of the dye, is concerned largely with the aesthetics of their appearance when observed obliquely in space. The design aspects associated with the choice of the architect are an essential characteristic in the epistemological development of the architectural object. The profile of the curvature is more visible than the series of abstract relationships that constitute the optimal sash.

In the case of the sash design, the term "robustness" pertains to the strength to which each design factor has an effect on the final object. The relationship between the extruded wrought iron and the elimination of the assembly is clear, and it brings a robust legibility to the object. In a similar way, the architect's role of designing the profile is also robust. This relationship, between the form and the design constraint, appears many times, and the competing objectives are finely balanced. It is this balance of design factors with the choice of the architect that lends the object its robustness.

V. COMPOSITIONAL PRESSURE: COMPETITION AND SEGMENTATION AMONG PARTS

Assignment VI: Primacy has been given to the excessive activities of the market. Compose the whole of the building and consolidate its volume, with the sales surfaces and the building envelope. Exact the necessary parts from your previous models to address the lighting, apertures, and display systems.

Composition is necessary when designing the market and for sorting out the essential character of the heap. The wild organization of the market is a necessary tactic for making things scarce and desirable. Even within the recipe of virtual objects lies a physical bias for a certain mixture but no reliance on a diagram. There are very few formalized relations among the parts other than their unusual tangencies. The presence of gravity in the simulations establishes a hierarchy for large objects to remain on top while the smaller objects fall to the bottom. Objects and spaces are not associated with a single orientation. They tend to fall over and repeat but vary. Patterns start and stop abruptly, and shifts in scale belong to the particulars of each object. Relationships among objects are hard to identify, and the whole resists any causal logic. Unburdened by any parametric relationships, the excessive spatial compositional logic of the market takes precedence. Outside of the informality of the plan lies an open territory for invention and the presence of an architectural object that remains open to novelty. ◆

NOTES

1. Finlay, Victoria, *Color a Natural History of the Palette* (New York: Random House Trade Paperback Edition, 2004), 280.
2. Finlay, *Color a Natural History of the Palette*, 280-282. It has been speculated that the incomplete figure in Michelangelo's Entombment (1501) was supposed to be Mary Magadelene but it was left uncompleted in part because of the scarcity of ultramarine. Its importance second only to pure gold made it a worthy choice to represent the robe of the Virgin Mary.
3. Finlay, *Color a Natural History of the Palette*, 280-282.
4. Finlay, *Color a Natural History of the Palette*, 312.
5. Reiser, Jesse, and Umemoto, Nanako, *Atlas of Novel Tectonics* (New York: Princeton Architectural Press, 2006), 83. For a diagram of the "mean," see p. 83.
6. Watson, Anne, ed., *Building a Masterpiece: The Sydney Opera House* (Sydney: Powerhouse, 2006), 89. According to the technical definition of a shell, the roofs are not shells or structural membranes but frameworks.
7. Watson, *Building a Masterpiece*, 111. The same logic was applied to the design of the erection scaffold, allowing it to be repositioned along the same path.
8. Watson, *Building a Masterpiece*, 112.
9. Petroski, *Henry, Invention by Design: How Engineers Get From Thought to Thing* (Cambridge, MA: Harvard university Press, 1996), 130.
10. Dennett, Daniel, *Darwin's Dangerous Idea* (New York: Simon & Schuster, 1996), 269-280. For more on the pendentive, see Dennett's adaptationist critique of Stephen Gould's explanation of the pendentive. According to Gould, spandrels are "a necessary architectural by-product of mounting a dome on four arches." Gould cites this condition in support of his evolutionary theory of pervasive adaptation. Dennett presents an alternative view of things that are not optimally designed.
11. Kohlmaeir, Georg, and Sartory, Barna von, *Houses of Glass: A Nineteenth-Century Building Type* (Cambridge, MA: MIT Press, 1991), 135.
12. Kohlmaeir and Sartory, *Houses of Glass*, 135.