The Computer in the Glass: Evan Douglis and His Modes of Formal Generation

KRISTINA LUCE
University of North Carolina at Charlotte

In the early Renaissance, architecture emerged as its own profession. A development of such scope relied on several others that preceded it. First, the act of design had to be isolated from the activities of the builder or craftsman, and its practitioners had to be legitimized with their own body of essential knowledge and skills. Second, and perhaps more radically, the act of design was tied to orthographic drawing, design's new medium. This new alignment emphasized an understanding of design predominantly concerned with the prefigurement, stabilization and control of a projected building's final forms, which is to say that form became the primary arena of architectural contemplation. The study of drawing's evolving role in architectural design reveals that drawing's rise and adoption as a medium in architecture is completely intertwined with these developments; a motivating factor in both the definition of the architect's professional role, and the changing aesthetic definitions of design. In other words, the medium is the discipline.

One can predict, then, that the rise of process and adoption of a procedural medium of design will also effect architecture on both a professional and aesthetic level. As part of my earlier thinking, I have attempted to weave together some of this new tapestry, sketching part of the early cultural bases for the shift during the nineteenth century to process-based knowledge, and detailing some of architecture's early attempts to adjust aesthetically to a focus on process during the twentieth century. This current paper attempts to move further into the shift, examining the design practices of one architect whose work exhibits a more mature deployment of generative logic.

The approach taken by Evan Douglis is representative of this more mature use of computation and its logics, and of these shifting definitions (or redefinitions) within architecture. Brooklyn based, Douglis is currently the dean at Rensselaer Polytechnic Institute, although he has taught previously at Pratt, Columbia and Cooper Union. Through his use of algorithmic/autogenic design techniques, Douglis consistently attempts to marry the aesthetic systems of form with those of process. His practice, Evan Douglis Studio, has received many accolades and awards, and in 2005, was selected as part of *Architectural Record*'s Design Vanguard Competition. Invested in taking an interdisciplinary stance to design, Douglis views his work as research into both the fields of computer aided digital design and into new materials and fabrication technology.[1] His methods of design have moved him beyond the regime of drawing, but he has not completely stepped outside it. Even so, Douglis' work presents a set of movements within the discipline of architecture that mirror the disciplinary shifts of the Renaissance brought about by drawing. His work challenges both the architect's role and the expected outcomes of the design process. The signature of Douglis' approach can be found in long-lived nature of his design process. Each of his projects tends to produce a solution family defined by the specific solution to the design problem motivated by the initial project or competition, and a more generalizable solution to the problem of design generation. This second solution may be iterated at a variety of programmatic scales. As he says, "The beauty of working with algorithmic processes is that they can scale, they form a library that can be adapted to various materials, which doesn't mean there is

a seamless crossover, each material has its own tolerances but you are never starting over."[2]

Perhaps the best example of this iterative approach can be found in his fLORA_flex projects. Originally an entry for the European Ceramic Workcenter (EKWC) competition entitled *Brick: The Exhibition,* participants were selected from a worldwide field in two rounds of competition for display at Rotterdam 2007 Biennale. The design of a new brick may initially seem a strange project for Douglis to attempt. Known for his ornate, geometrically complex surfaces and his use of algorithmically or parametrically generated forms, bricks are usually understood as anything but intricate and complex. However, the call for entries postulated that,

> Now that the facade no longer has a structural supporting function, but is simply the skin of the building, brick can shake off its rectangular nature. And that is where the challenge lies... Could the new brick be round, hexagonal, perforated or transparent?[3]

Such an invitation to rethink the form of brick taps into Douglis' interest in material and fabrication research as well as providing an opportunity for him to continue his exploration of algorithmic design.

To generate his brick form Douglis generated a governing geometry in the form of a master path, and then he set the rules by which a second geometry would use this master path to scribe out the brick's form. A standard parametric means of producing form, Douglis' focus is actual on process as opposed to the direct refinement of form. He may alter his processes in order to produce forms that he finds more pleasing or appropriate, but the never directly manipulates the forms themselves. The object of his design is the material form but also, and often more importantly, the processes by which such forms are determined. In this way Douglis' work bridges the objectives of both drawing-based and process-based aesthetic systems.

For example, the initial master paths or lines that Douglis attempted to use to create the fLORA_flex bricks were calligraphic. They weren't simple easily comprehended forms but were instead formally elegant in their own right. However, because the movement of the secondary geometry would be both translational and rotational, it quickly became apparent that the forms generated by the complex master paths were too intricate. The shapes created from these calligraphic lines were overly dynamic both in terms of their own aesthetics and in light of their function as a modular unit that could be stacked to define space. [Figure 1, subfigures 01.1 and 01.2]. To simplify these initial forms, a less complex master path was necessary, and Douglis finally settled on the use of double circle or "ghost cylinder" as the most basic geometric key for the design. Because the cylinder has similar geometric and packing properties as a standard brick, this choice in master geometry ensures that his brick would potentially function the same way. In this case the end result is a refined form, but the motivations informing the choices and refinements were not strictly formal. Instead a blending of material and procedural considerations motivate the design. At each recursive stage the form is judged aesthetically, but also as a representation or index of the processes which have informed it. When the form is altered, it is often to correct an omission in parametric requirements for the design rather than solely on the basis of refining formal composition. The corrections have formal implications, of course, but the motivations for refinement were procedural.

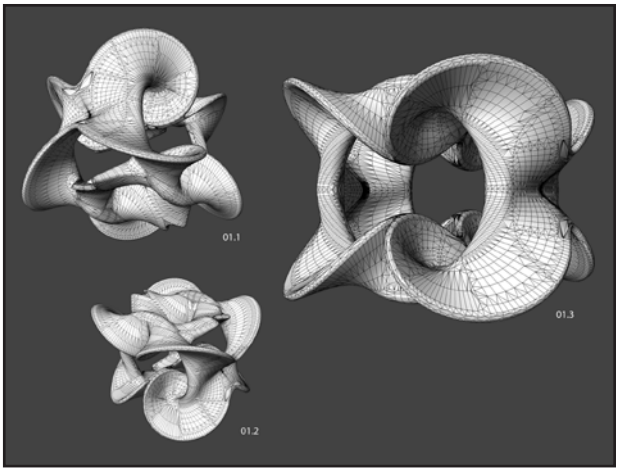

Figure 1 Evan Douglis, Initial stages of fLORA_flex brick design examining forms produced by a variety of calligraphic lines.

Once Douglis settled on a "ghost-cylinder" as his master geometry to generate the new brick form, he propelled and rotated a flange along the path of each circle. As the flange intersected itself, Douglis set up governing rules to control how the flange would be cropped at the intersection. Once these instructions were sufficiently refined, the path the flange traced

out became the shape of the new brick. [Figure 1, subfigure 01.3 is the final geometry].

In the past, much of Douglis' work was built prototyped using 3-d printing and built using CNC routers. The Prouvé Exhibit/Auto-braids projects use CNC techniques to directly manufacture forms where HAKU Restaurant/REptile projects created tiles from a 3-D print which served helped generate the molds for the final fiberglass tiles. In a sense, these production tools allow Douglis to meld some of the processes of design and construction together. Since Douglis uses very similar languages to design as these machines use to govern the creation of the work, there is a deep logical sympathy between the design and craft.

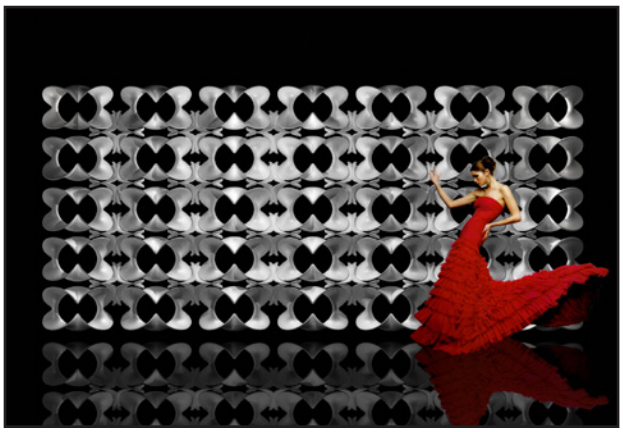

Figure 2 Evan Douglis, fLORA_flex wall system as submitted to Brick: The Exhibition.

The fLORA_flex project, however, introduced its own constructive logic. While the EKWC encouraged a re-thinking of brick's form, the use of ceramic as the new brick's material was taken as a given. For Douglis this meant further considerations of craft, as after his brick was designed, he had to engineer a way for it to be mass-produced. Unlike the case when using CNC routers to produce his designs, the geometries of his new brick did not share a deep logic with the techniques of slip casting. Indeed, Douglis had to break the final brick up into quadrants, casting these parts and reassembling them into the final form, it was possible to piece together the final brick. While this solution is a common one in the slip-casting of ceramics, it is still not an ideal solution for mass production. However, part of Douglis' signature hybridism is a result of his mindfulness of both his processes of design and the processes of making those designs. By keeping both aspects of a project in his sights, Douglis' work always carries the signature of hybridism. His designs are always marked by the feeling of two or more systems existing simultaneously.

In the case of the fLORA_flex brick design, it is possible to sense the collision of systems in the construction photos, but the same sense exists in the design itself. Douglis' insight in selecting the circle/ghost cylinder as his master geometry created a great degree of sympathy between his final forms and those of a typical brick. Because the ghost cylinder exhibits the same bi-lateral symmetry, as does a traditional brick, the two forms share some general similarities. The preference for 90-degree axes encoded by this symmetry allows him to assemble his bricks using many of the same geometric rules that govern the typical brick. Due to the dynamic nature of the brick forms, it was necessary for Douglis to create a substitute for the typical mortar joints. Rather than using a malleable material that might fill in much of the dynamic geometry, the mortar joints were designed themselves as fixed pieces. In the end two of these were necessary, one for brick-to-brick bearing conditions and another for brick-to-floor (or other flat surface) bearing. This more rigid mortar design means that the fLORA_flex system has inherently less potential for manipulation during assembly than a more traditional brick. While Douglis' brick might appear to break free of the rectangle, rather than choosing a new 'dynamic' geometric system like the hexagonal system the brief suggests, the rules that allow the traditional brick to become a larger-space defining unit generally still hold.[4] The brick itself may reflect the parametric geometries enabled by computation, but the system of assembly is imbued with the orthogonality of more typical design and construction.

Between the submissions to Rotterdam Biennale and to *Brick: The Exhibition* and the date of this article (late 2009), Douglis created two further evolutions of his design. The first of these worked to re-introduce some of the formal flexibility that the original submission omitted, not by allowing different arrangements of the bricks, but by iterating different designs for each brick. These new designs were generated algorithmically with variations based on the speed of rotation for the form-gener-

ating flange. By scripting the entire wall generation rather than just the generation of a single brick, Douglis creates a wave of motion across the wall as the aperture of each brick opens and contracts. This new design is less amenable to mass production through slip-casting, although a large enough demand for the bricks could justify the creations of all the moulds necessary. That said, mass-customization trends could make such a modular wall system easy to construct so long as ceramic was no longer the material of choice. Notice, as well, that Douglis has introduced a third mortar joint in this design as means of terminating the wall edge. In the more simple wall design the edge bricks were cantilevered from the last mortar joint. Such a move further illustrates the feedback loop that exists for Douglis because of his investment with craft as well as design.

By looking between both of the wall designs that Douglis produced, it is possible to see an amplification of the hybridity, which I believe mark of all his projects. The original assembled the fLORA_flex system generates an ornate but regular perforated screen. The doubled geometry is clearly visible; the wall consisting of both a standard rectilinear geometry of assembly and a dynamic parametric pattern based on calculus. The design fuses both systems and both systems can be easily perceived working together to create the total effect of the wall. In the second proposed assembly, a third system of ordered variation is introduced into these original two. The wall demonstrates the hybridism of not two, but three systems of logic. In this way Douglis is colliding the orthographic geometries of traditional, drawing-based architectural design with the generally calculus-based geometries of parametric calculations and the emergent patterns that stem from the use of algorithm. His work is a reflection of this particular moment as the collision of each of these logics, each of these processes of design, the orthogonal, parametric and algorithmic, is occurring in today's practice of architecture.

The third iteration of the design system, the fLORA_flex house, has not yet reached the level of maturity of the other two projects, but it is still deserves to be mentioned. What distinguishes the house is the degree to which the dynamic geometries of the fLORA_flex were allowed to become space-defining features. Unlike the brick and wall designs in which the twists and curves of the fLO-

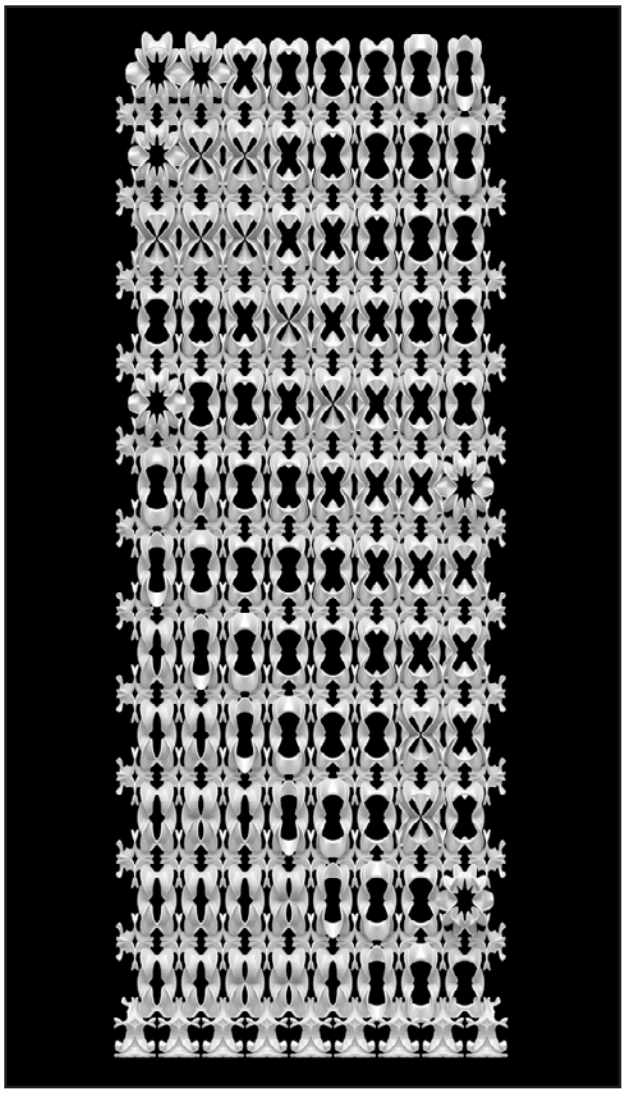

Figure 3 Evan Douglis, fLORA_flex wall system demonstrating formal modifications as a result of a changing the speed of rotation in the form-generating flange.

RA_flex are constrained to being surface features in an otherwise normative wall, the fLORA_flex house beings to explore how the dynamics of the system can become spatial at the level of occupation rather than just surface. In the fLORA_flex brick project,

> the system was originally a closed one, closed loops that received a flange…the house is exploring a series of alternative units some of which will be closed as discrete pieces, albeit pieces that stack, while others will work off an open line. The open line system, like the new woven project, will be more seamless.□

By growing the size of the flange (rather than just the speed of its rotation) or by opening the closed circuit of the ghost cylinder, the curves of the system become more wall-like in and of themselves, and they can begin to dictate a spatial pattern within the house on a programmatic level. Rather than serving to merely ornament normative rooms, rather than sharing a scope of influence common to material choice and its ramifications, the fLORA_flex house attempts to put its means of generation into dialog with the greater architectural questions posed by the house itself. In other words, within the house the rules of the fLORA_flex system become integral to the modes in which forms and spaces can emerge. The complexity of its engagement with such larger questions, however, have made the house a more difficult project to develop without a specific commission or competition to support it. As a result, the fLORA_flex house has now evolved further at this time.

To see where Douglis' thinking has grown, it is necessary to leave the fLORA_flex system in order to discuss one of his more recent projects. This project is the interior design for Choice, a restaurant in Brooklyn, New York. Rather than discussing the whole of his design, however, I will focus on one specific feature, the chandeliers. In this concentrated moment Douglis' work reaches a moment of eloquence at the intersection of material and formal hybridity so evident in his designs.

As part of the ceiling system for Choice, Douglis has designed a hexagonal tiling that features a secondary geometric pattern of cones which work to lessen the centrality of the hexagons. Intended to hang from the largest of these cones are glass chandeliers.

While the tiles feature the more typical intersection of the doubled geometric systems evident is Douglis' work, the chandeliers are a collision of the material and computational systems of simulation. The production of the chandeliers embodies a translation of the formal control usually provided by a digital-based algorithmic design into an analog process. Douglis has not designed the form of these poly-lobed chandeliers, but instead has designed the "line-work" which controls how their forms are produced. As part of his normal process this line-work would take the form of a parametric equation, but here it takes on a physical manifestation. Made

Figure 4 Evan Douglis, Ceiling Tiles for Choice Restaurant, Brooklyn, New York.

up of a series of wire loops attached and held in place by small tube-like washers, the chandelier is created when glass is blown into this armature. The shape of the glass is dependant on how the wires adjust and redistribute pressure as the molten glass bubble grows, fills and is divided by the "lines". The model is dependant on a set of algorithms internalized within the behavior o molten glass as it cools: viscosity, variable pressure and flow are all qualities ripe for computational modeling and simulation, but they are also embedded in the physical simulation of Douglis' mock-ups. Working directly with a glass artist, Douglis' efforts create a dialog between the implicit, tacit knowledge of the artist and his or her materials and the lens into this knowledge provided by his "line-work."

He describes his investment with the glass as follows: "I am interested in the aesthetics of it but I'm also interested in regulating the aesthetics…. The glass is living, and it's bouncing and pushing and twisting and breaking and oozing off of this line-work."□ Outside of the physical laws which govern the behavior of molten glass, this line-work is Douglis' only means of control over the final form of the chandelier. While the contact between the wires and glass is direct material to material, and while it would be possible to mathematically model the same procedure, the "intelligence" of the materials carries with it is own physical algorithms. As is the case with traditional parametric design, the

forms are still remotely rather than directly controlled, even if this remote control occurs through physical contact. The point of the work is, on one level, to tease out these algorithms through experimentation at the intersection of materiality and form. As part of this experimental phase, Douglis chooses not to digitally predict or predetermine the form. In doing so, he collides outputs of computation and craft. Actual physical rather than simulated process are used, thus conflating the object of design and its representation. In Douglis' chandeliers, the simulation has become the object.

Figure 5 Evan Douglis, Mock-ups of Chandeliers for Choice Restaurant, Brooklyn, New York.

Douglis' work offers a new definition of design that fully engages process as its medium. In his case the artist and the artistic eye are still present, and in this sense he is still operating in the realm of the architect as defined by the Renaissance shift to drawing, but his medium is no longer drawing. He still evaluates the formal implications of design, but his engagement is not directly with form. Rather than the continuous refinement and perfection of a singular object, Douglis oversees the creation of whole families or potential families of objects. Rather than a perfected form being the harbinger of successful design, Douglis values the formal latency within a process. His work becomes particularly interesting when Douglis transposes the lessons he learned from computation as his procedural medium back onto the world of materiality, seeking to tease out its inherent algorithms. Douglis parameterizes the logic and laws of molten glass as a means of colliding material and computational making.

The paradox here is that, seemingly, through algorithm Douglis pushes architecture towards an even greater abstraction than that of drawing, but his embrace of craft and materiality collapses not just this greater distancing implied by the computer *cum* media simulator but drawing's initial abstracting qualities, as well.[□] His internalization of craft-processes taps into the tacit knowledge that architecture has maintained along side drawing since its adoption of that medium. This tacit knowledge is of the same ilk that Kahn struggled to translate into form with his carefully designed indices of construction. Like Kahn, Douglis draws on the unarticulated algorithms that architecture has always processed, those built into the physical constraints of construction and materials. Unlike Kahn who could only work within the rules that drawing had laid out for architecture, however, Douglis can engage these processes more directly. He works with these not as the physical constraints of materials and craft which must be overcome, but as the un-verbalized and implicit codes that might be brought into the very basis and logic of design. Douglis finds, for example, the algorithm in glass and wire. Through the dance of their interaction he creates a chandelier whose process of formation reiterates and teases out the natural laws and processes encoded within the materials. In so doing Douglis shows the similarities that exist between everyday materials and the computer. He demonstrates why the process of simulation on the computer might be understood as a mystical representation in the same what that the Renaissance understood perspective and orthographic projection to be mystical in their ability to connect the physical world to the divine realm of the ideal. His work thus demonstrates how the architecture might be seen as a microcosm, a reflection of the world which in turn can itself be understood as one great computer.

In light of the cynical viewpoints of post-modernist theory and aesthetics, such connections hardly seem appropriate today. And yet, throughout the larger arc of history it has been common for building, which is to say human creativity writ large, to emulate its moment's best understanding of how the world was structured. The logics that structure the core of architecture's aesthetic system are habitually aligned to the logics of science. In the Renaissance, the best of this science was the geometry of projection, which was thought to link the physical, material forms of this world to the pla-

tonic ideals which were believed to structure divine thought, and therefore, the universe. During the Renaissance the mathematics of projection were equivalent to Divine logic. During the nineteenth-century, science diverted its focus off of form and on to formative processes. Evolution replaced geometry. Early reflections of this shift had architecture internalizing the principles of morphology and seeking to classify its own formal patterns just as natural forms were being classified. The purpose of such orderings, however, reached beyond mere classification. Their point was to discover the generating patterns that motivated the formal similarities, in the first place. The focus was really on the underlying principles that regulated form, not just the organization of form for the sake of classification. Today, after the sequencing and our partial understanding of DNA, the architectural aesthetic has become procedural and generative in part because these are the processes believed to govern the natural world. It may not be openly recognized or acknowledged, but architecture has re-aligned both its creative motives and methods with those believed to shape the universe's creation. Architecture, then, stands at a remarkably similar precipice now to the one it stood at in the beginning of the sixteenth-century. Shifts within the scientific model of the universe have created a new episteme which is being processed on a cultural, technological, and aesthetic level. To remain relevant, these shifts demand that architecture reconsider its definitions and therefore, its design medium, Through such a new medium, questions can asked about architecture's purposes, processes and meanings. We have only recently arrived at the point where projects have begun to offers the first tentative answers to these questions, and therefore we are just now at a moment when critical writing can begin.

ENDNOTES

1. Evan Douglis, "Bio," http://www.evandouglis.com/Evan_Douglis.pdf.
2. Evan Douglis, Phone Interview, October 27, 2007.
3. Ceramic Workcentre European, "Brick: The Exhibition," http://www.ekwc.nl/index.cfm?art_id=188.
4. A variety of different 'bond' designs also allow bricks to fill three-dimensional space. Running and stacking bonds inherently fill only one brick thickness or wythe, while Flemmish or English bonds make interlocking packings that take up several thinknesses. While standard bricks can be made to curve or form arches, such flexibility occurs in the spaces between the individual bricks. The voussoirs of an arch are created out of the mortar, not shaping the bricks into wedges as is the case with stone masonry. Other masonry systems do exist that encourage non-rectilinear layouts. For example, the Catalan vault uses ceramic tiles arranged in a herringbone pattern to create shallow, self-centering vaults, and curved retaining walls are often now made with interlocking tetrahedral masonry units. Each of these other systems allows for a greater range of three-dimensional curvature, but again such systems rely on the interstitial spaces between the units to provide the range of curvature. The unique shapes of the masonry units in these systems are designed to increase the degree to which these interstitial spaces might be manipulated.
5. Douglis, Phone Interview.
6. Ibid
7. I am here referencing Lev Manovich's idea of the computer as remediation machine. Please see: Lev Manovich, *The Language of New Media*, 1st MIT Press pbk. ed., Leonardo (Cambridge, Mass.: MIT Press, 2002).