

Digital Craft Meets the Ancient Art of Ceramics: Would the Bauhaus Approve?

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Abstract. *The Bauhaus was founded upon the controversial premise that emergent mechanical processes offered new and creative ways to explore materials. Today, we encounter equally tendentious scenarios where the designer often appears one step further removed—automated CNC machines are driven by computational machines. Like the early activities of the Bauhaus some view digital pursuits with suspicion; however, digital design/fabrication is the “Nächster Bauhaus Bewegung” offering opportunities for design innovation equal in significance to that of the Bauhaus. This paper partially examines the theoretical implications of digital design/fabrication, then presents a collaboration between an architect and artist re-examining the architectural cladding possibilities using digital tools to shape one of mankind’s most venerable materials—ceramics.*

Keywords. *Ceramics in architecture, mass customization, digital fabrication, parametric design.*

The Bauhaus and emergent technologies

The Bauhaus, started by Walter Gropius in 1919, was founded “with the vision of creating a total work of art, in which all arts including architecture would eventually be brought together.” (Fleming, Honour, Pevsner, 1998). Many aspects of the Deutscher Werkbund (formed in 1907 by Hermann Muthesius) served as founding principles for the Bauhaus—especially the desire to harness new, creative potentials for mass production. As readers know, the Bauhaus remains one of the most influential forces in modern design and architecture and is arguably the exemplar for pedagogical methods that incorporate now-commonplace fabrication training for architectural students and industrial designers.

Digital design/fabrication today is enabling novel creative exploration and production in a fashion similar to that of the early Bauhaus. A nascent phenomenon, digital concerns represent the “Nächster Bauhaus Bewegung” (Next Bauhaus Movement), and will be viewed with equal significance decades hence. However, at this time a number of mistaken impressions and objections exist further mirroring the conditions encountered by both the Bauhaus and the Deutscher Werkbund. Though some architects and theoreticians currently question the value of digital design/fabrication—especially those trained prior to the 1990’s when computers and software were in their infancy—from a philosophical and sociological point of view these technologies are entirely consistent with the logic and intentions of the Bauhaus. Technological advancement and adoption today is similar to the conditions experienced in the early days of the Bauhaus—even if the tools are quite different. Curiously, many who vigorously embrace what are now called “Bauhaus traditions” are often the most vocal critics of emergent digital design/fabrication explorations. Not only is this illogical, these criticisms seem both shortsighted and reactionary, since a lack of comprehension of digital tools (or an aversion to them) is hardly sufficient reason to decry their potentials.

Today, practitioners and institutes of higher learning who fail to assertively embrace the creative potentials for digital tools do so without suitable regard for the lessons of history. The fate of those who are slow (or resistant) to embrace digital tools may be partially forecast by examining the trajectory of the tailoring industry during the 20th century since architects—much like tailors—are reliant upon clients with a penchant for bespoke items. In the early 19th century, when confronted with mass-produced goods from the textile

industry, the once thriving tailoring profession has now shrunk to 1/16th its size as a percentage of the population. What is noteworthy is that this dramatic decline occurred in less than one lifetime, during the seventy years from 1920 to 1990 (Garreau, 2006). Given that manufactured clothing was once viewed as an aberration—yet is now the defining convention—even the least imaginative can partially forecast the results if (read: when) various forms of mass-produced housing becomes more desirable than the developer built catalog houses which currently dominate the American landscape. Extend this logic to urban buildings (many also built by developers) and this scenario might suggest greater concern for those who currently scoff at the prospect of mass-produced developer-driven design. (Hint: think BIM).

Misimpressions and Objections

Many of those who are unfamiliar with digital design/fabrication endeavors mistakenly consider digital fabrication tools to be a direct extension of digital design visualization; however, there are some significant differences between the two fields that do not automatically support this impression. First, computers can visualize a variety of ideas that do not take into account the forces we enjoy on this planet—the least of which includes gravity. Accordingly, only a subset of what can be visualized on a computer may actually be produced by any method, whether by hand or machine. Second, the means and methods to create a digital file that can be fabricated with digital tools are in many ways more exacting than hand drawn intentions on paper. CAD (Computer Aided Design) files that are to be digitally fabricated require very high tolerances (often within thousandths of an inch) suggesting a degree of precision not previously required in analog architecture. Third, for a 3D CAD file to be physically produced by a CNC (Computer Numeric Controlled) machine, the designer must have tremendous knowledge of the capabilities of the materials used and be able to model these appropriately. This process requires an unprecedented level of comprehension regarding material properties, manufacturing techniques, and assembly methods by designers working in the digital milieu. Craftsmanship, rather than being lower when practicing digital pursuits, is in fact significantly higher, resulting in a new and precise form of digital craft required for digital fabrication.

David Pye’s seminal work, *The Nature and Art of Workmanship*, (1968) identifies two different types of workmanship; that of workmanship of certainty, generally involving machine production, and workmanship of risk, generally involving manual production. Digital design/fabrication blurs these distinctions through parametric

variation and variable tooling methodologies to create an unusual hybrid, which I call (with apologies to Pye) workmanship of certain risk. Digital design intentions often involve (and sometimes benefit from) risk and uncertainty, particularly by inviting serendipity into the process. Simultaneously, physical production with CNC equipment may also be radically and easily varied to create wildly different effects during proof-of-concept development, yet chosen results are infinitely repeatable once the intent is resolved. This certainty of risk is embraced by digital provocateurs—however, it is viewed by detractors with great suspicion.

Some, like Michael Ostwald (Dean of Architecture, University of Newcastle, Australia) have significant concerns about the novel forms created by computer-driven auto-generative architecture. In a paper presented at the recent Ethics and the Built Environment Conference he cites concerns regarding parametric design issues of: A) clarity of authorship (which he terms responsibility), B) appropriate comportment (termed care and attention), and C) motivation. His supposition is that these three analytical aspects, "are all useful for divining the moral or ethical merit of a process and its resultant design." Ostwald's conclusion is that, "the auto-generative design process has several qualities or characteristics that undermine any claims that the work is ethically or morally justifiable." (2009). What Ostwald perhaps overlooks is that the laws of nature, which parametric architecture often draws heavily upon, may in fact provide a more captivating and satisfying solution than "decorated sheds"—especially if one is to believe James Wise's argument that humans seek comfort and healing through fractal complexity.

Wise, an Associate Professor of Psychology at Washington State University, Tri-Cities, "believes that the beneficial psychological effects of fractals have the same evolutionary basis as other aspects of biophilia but that these benefits can be achieved by fractals alone, obviating the need for actual images of nature." (Wilson, 2006). Ostwald's criteria might be equally descriptive of other processes and phenomena such as collective crowd management at soccer matches or concerts, which occasionally results in people being crushed to death (Johnson, 1987) or even highway designs. Accordingly, one might readily conclude that Ostwald is not only arguing against parametric design, but also any other process related phenomena where responsibility, care and attention, and motivation are unpredictable or uncontrollable. While other critics may be less polemical, concerns about non-traditional forms in the urban context remain a rallying cry for many, such as the new urbanists (Katz, Scully, Bressi, 1994) who are intent on fashioning the artifice of tradition for any number of instant communities. Meanwhile, the transformative effects of the voluptuous Guggenheim Museum by Frank Gehry that has breathed new life into the once overlooked city of Bilbao goes unrecognized by these critics. Alternatively, for those who are participating in the digital design/fabrication movement, this project which opened in 1997, arguably commemorates the awakening of their collective consciousness (Lindsey, Gehry, 2001).

Though digital design/fabrication is thought to be a specialty area and optional to current pedagogy and practice, it is highly relevant since it:

- A) Easily permits crossing of disciplinary boundaries due to shared software and production tools offering beneficial exchanges for theory and practice to create transformative results.
- B) Allows for advanced means of design visualization and physical production enabling the creation of artifacts that hand methods do not easily permit, or may not achieve at all.
- C) Enables advanced methods of form generation utilizing biological, analytical, and environmental data.
- D) Permits forms to be constructed, visualized, and tested computationally prior to fabrication, reducing errors.
- E) Synthesizes the (often disparate) areas of analysis, design, theory, representation, computation, and material assemblies.

CeramiSKIN: applying digital technologies to architectural ceramics

What follows is the result of a collaboration between myself (an architect) and Del Harrow, (a ceramic's artist) while exploring architectural ceramic cladding considered through the lens of digital design/fabrication and inspired by the biophilic writings of E. O. Wilson (1984) and Stephen Kellert (Kellert, Wilson, 1993). The projects presented explore biophilic data utilizing laser scanning and aerospace engineering software, simulated fluid dynamics used in the film industry, rapid prototyping studies, and digital interpretations of ancient Iranian Girih patterns using CNC processes. Traditional hand moulding, slip-casting, and extrusion processes in clay are utilized in conjunction with various digital techniques. The majority of the work presented was recently completed during a competitive three month Combined Residency for Ceramics and Architecture at the European Ceramic Work Centre (EKWC) in The Netherlands.

1. Lily Facade (Celento & Harrow)

This project utilizes laser-scanning as a technique for topological studies of a lily petal. The degree of curvature was decimated using the aerospace engineering software, Geomagic. Maya was used for modeling, then forms were CNC routed using Visual Mill to create foam positives to make slip-casting forms in plaster. This piece is a scalar study for a facade application that would utilize insulated aperiodic ceramic tiles of up to 25 feet square to form large surfaces. This work was inspired in part by the provocative book by Sir D'Arcy Wentworth Thompson, *On Growth and Form* (1917).



Figure 1. Laser scanned lily petal

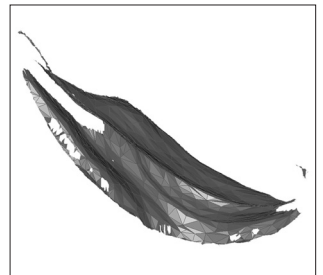


Figure 2. Decimated lily petal in Geomagic



Figure 3. Final glazed assembly

2. Fluid Wall (Celento & Harrow)

This project utilizes computationally simulated fluids generated using RealFlow software employed by the film and animation industries. The intention is to create non-repeating ceramic tiles for architectural cladding using low investment molds based upon unfolded digital forms generated in Rhinoceros. Clay is placed using traditional slab construction with the results intended for large scale insulated tiles capable of self supporting structural applications for facades.

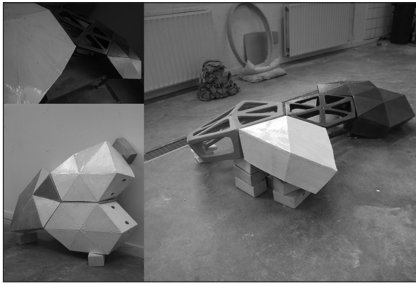


Figure 4. Glazing and form studies



Figure 5. Mold installation

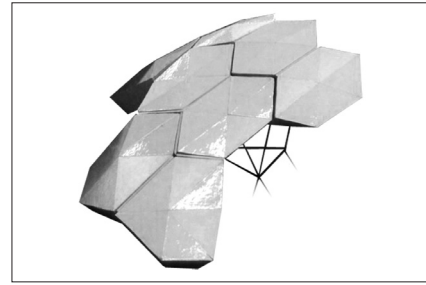


Figure 6. Partial mockup

3. Penrose Screen Wall (Celento & Harrow)

This project uses Penrose geometries to generate screen walls that provide light filtration and evaporative air conditioning for arid climates. Complex dies for the clay pug extruder were plasma cut in steel shapes that generated five interlocking shapes. Interiors will be glazed for light transmission and filtration, while the space between tiles permits the introduction of water, providing evaporative cooling and ventilation. Shown here is a small scale mockup prior to glazing. This work was inspired by the analysis of Iranian aperiodic tiles by Peter Lu (Lu, Steinhardt, 2007).

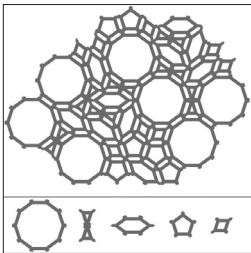


Fig.7. Pattern study

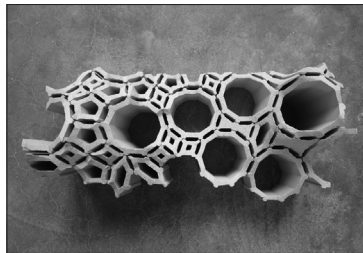


Fig. 8. Assembly study prior to firing

4. Digital Islam (Celento)

This final project utilizes CNC processes for fabrication of slip-cast ceramic tiles. Extending the research for the Penrose Screen Wall, this project explores CNC milling of forms to create lightweight insulated tiles that can be applied to surfaces with complex curvature in a variety of uniform or random patterns. Scalar studies were created as proof-of-concept tiles at 1/10th the final size, with final tiles being on the order of 25 square feet.

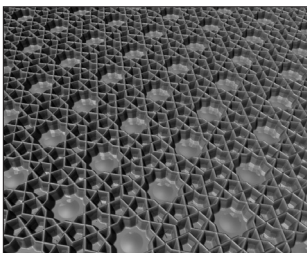


Figure 9. Digital study in Maya

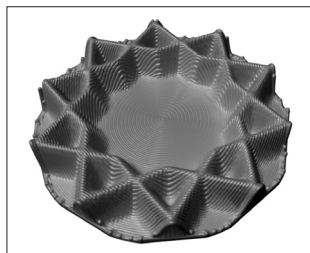


Figure 10. Digital study of tooling patterns in Visual Mill and Maya

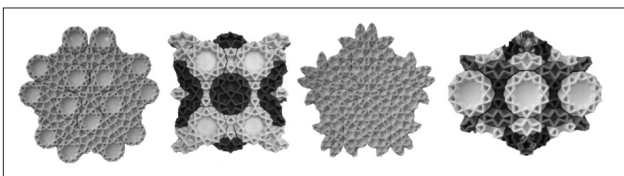
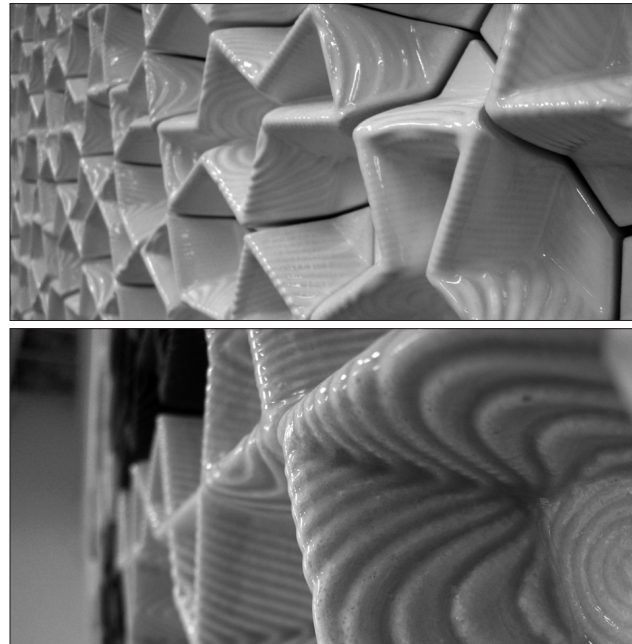


Figure 11. Four glazed ceramic assemblies



Figures 12 and 13. Detail of assembly

Acknowledgments

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References

- Fleming, J., Honour, H., & Pevsner, N. (1998). *The Penguin Dictionary of Architecture and Landscape Architecture* (5, illustrated ed.). Penguin Books.
- Garreau, J. (2006). America, Minus A Human Factor: From Guns to Bunions, A Statistical Portrait That Doesn't Quite Add Up. *The Washington Post*. Retrieved September 19, 2009, from <http://www.washingtonpost.com/wp-dyn/content/article/2006/04/25/AR2006042502244.html>
- Johnson, N. R. (1987). Panic at "The Who Concert Stampede": An Empirical Assessment. *Social Problems*, 34(4), 362-373.
- Katz, P., Scully, V. J., & Bressi, T. W. (1994). *The New Urbanism: Toward an Architecture of Community* (illustrated ed.). New York: McGraw-Hill Professional.
- Kellert, S. R., & Wilson, E. O. (1993). *The Biophilia Hypothesis*. Washington, D.C.: Island Press.
- Lindsey, B., & Gehry, F. O. (2001). *Digital Gehry: Material Resistance, Digital Construction* (illustrated ed.). Basel; Boston: Birkhäuser.
- Lu, P. J., & Steinhardt, P. J. (2007). Decagonal and Quasi-Crystalline Tilings in Medieval Islamic Architecture. *Science*, 315(5815), 1106-1110.
- Ostwald, M. J. (2009). Evaluating Digital Architecture: Ethics and the Auto-Generative Design Process. *Ethics and the Built Environment*. Retrieved September 19, 2009, from http://www.adelaide.edu.au/ebe2009/submit/EBE2009_OSTWALD_Paper.pdf
- Pye, D. (1968). *The Nature and Art of Workmanship*. London, Cambridge U.P., pp 4-8
- Thompson, D. W. (1917). *On Growth and Form*. University Press.
- Wilson, A. (2006). *Biophilia in Practice: Buildings that Connect People with Nature*. *Environmental Building News*, 15(7).
- Wilson, E. O. (1984). *Biophilia*. Cambridge, Mass.: Harvard University Press.