Experimental fast matter

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From documents to directives

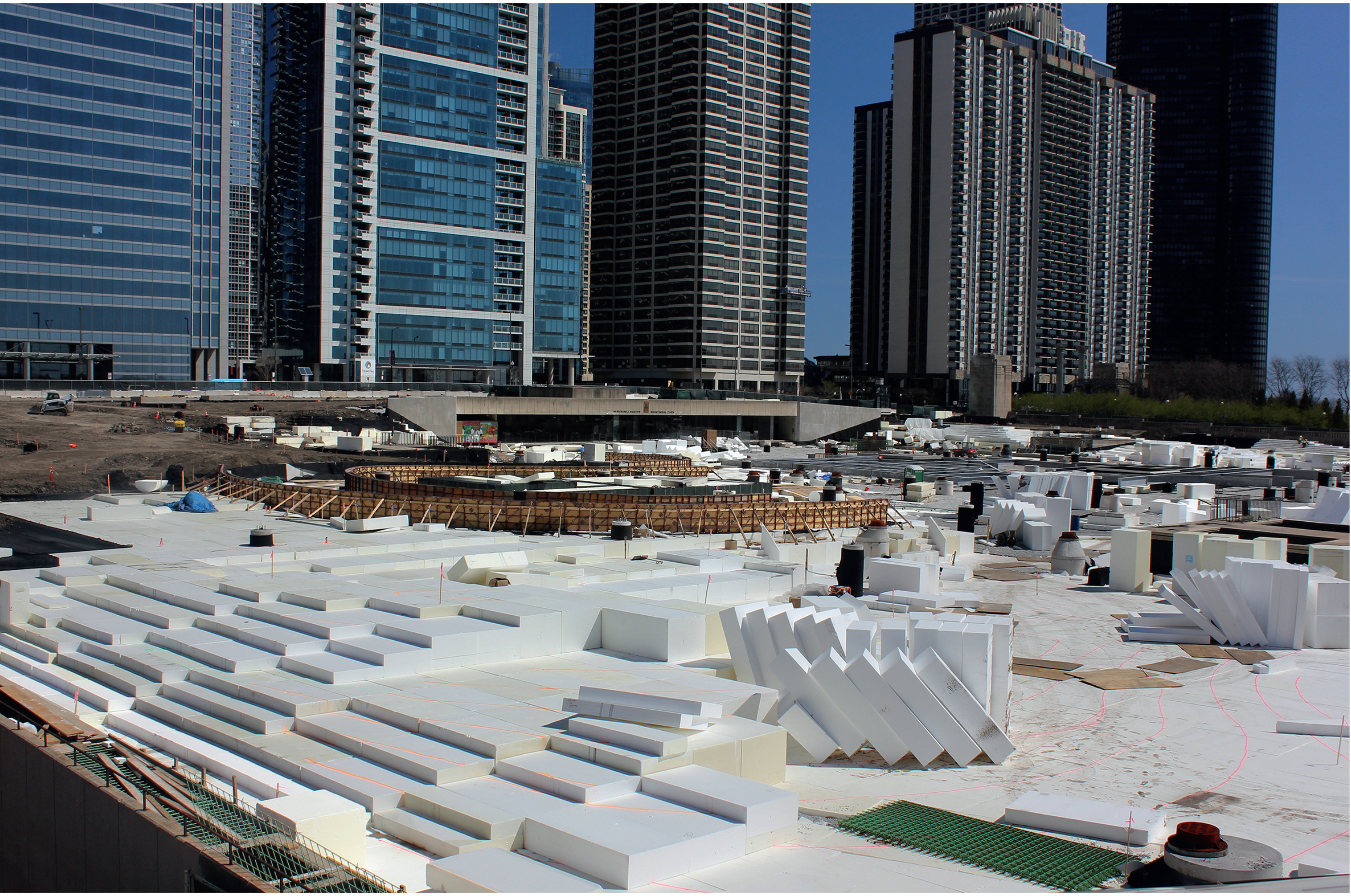
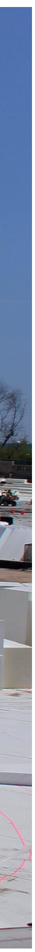


FIGURE 4.2.1 **Installation of Geofoam at Maggie Daley Park**
Photo: Lynn Becker



In 1871, debris from a catastrophic landscape change, the Chicago Fire, was dumped into Lake Michigan to expand what was known then as Lake Park. One hundred years later, parts of Grant Park had still not been developed and much of the ground at the northern edge was used for rail yards and parking lots.

Daley Bicentennial Plaza, built on top of a parking garage that, itself, was built to replace a surface parking lot, finally connected Grant Park to its planned northern edge at Randolph Street. For little more than 40 years, Daley Bicentennial Plaza served as a quiet formal garden in the northeast corner of the park, especially after its much more flamboyant neighbor, Millennium Park, was built in 2007. In that same year, the deterioration of the waterproof membrane between Bicentennial Plaza and the garage below became untenable and the park was designated for redevelopment.

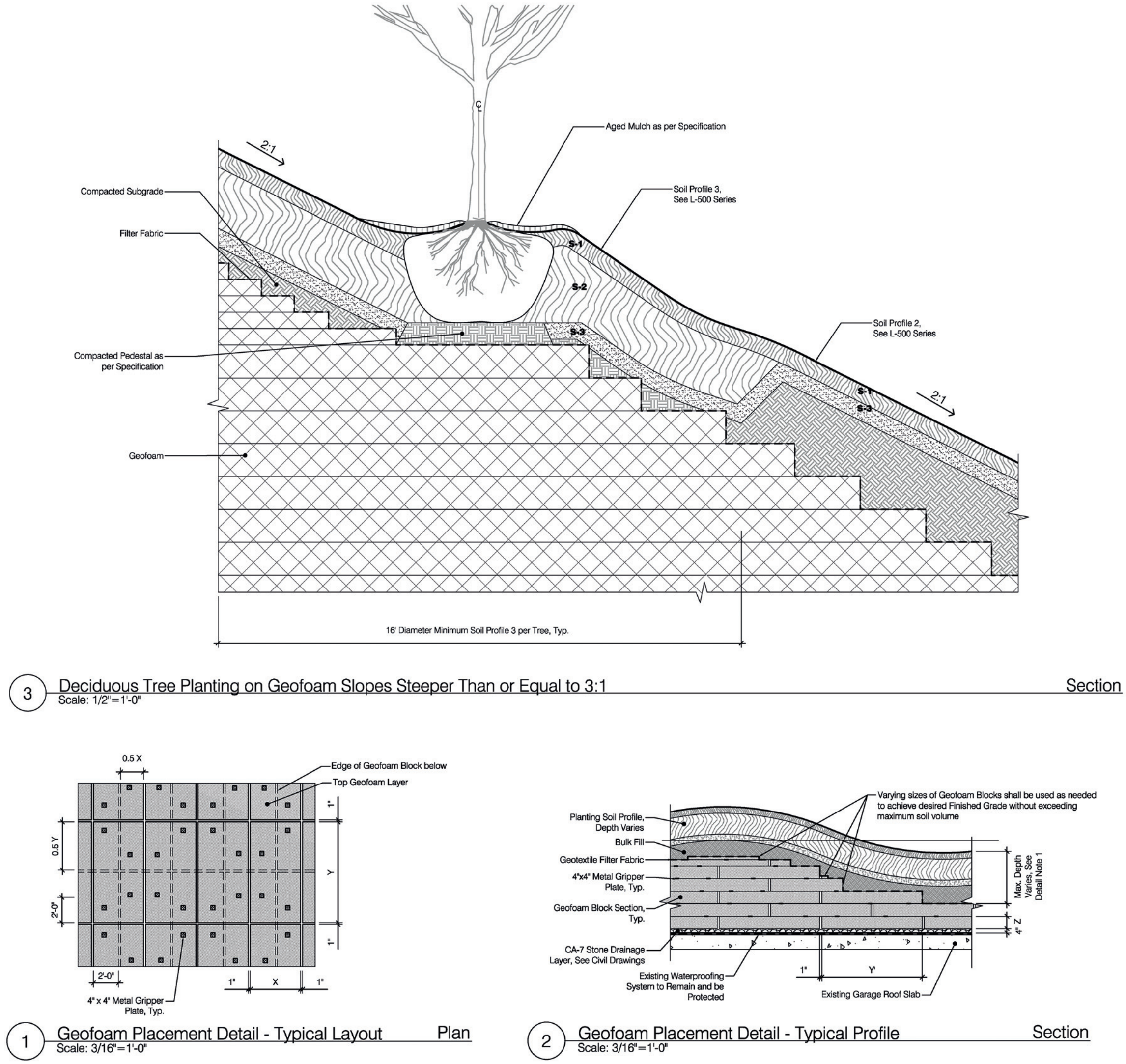
Maggie Daley Park, the replacement that would be named for another member of the Daley family, was conceived of, by Michael Van Valkenburgh, as a collection of highly programmed spaces along, what he calls, both an active axis and a passive axis. These programs were to be nestled between rolling hills that would stand in sharp contrast to Chicago's flat landscape. The hills were formed by a layer of 150,000 cubic yards of Geofoam,[1] some of which was recovered from beneath Daley Bicentennial Plaza and reused in the new park.[2]

In addition to the Geofoam, mature trees were harvested and reused in the new park as parts of the play garden and benches, but the Geofoam was the only material that was reused without modification. Considering the history of this corner of Grant Park, one can only imagine that in a few decades the park will need to be replaced again, its programs and facilities updated, and the parking garage membrane reapplied.

In *Re-Placing Process*, Anita Berrizbeitia calls for parks to "require a process driven approach that does not intend to provide a definitive plan for the site as much as it seeks to guide its transformation into public recreation space."[3] In fact, one could even conceive of places, such as Maggie Daley Park, as ongoing design projects, not only with no definitive plan but also with no definitive end to the design process.

In the age of parametrics, when no parameter is ever final, the idea that design happens before construction is outrageous—as are design phases, construction schedules, paper sets and as-built drawings. In the profession, we already see these norms eroding. On "Fast Track" projects, many decisions are finalized before others are designed. The Nestle Chocolate Museum in Mexico City was designed with architects on site designing just days ahead of construction.[4] During contract negotiations, savvy clients are beginning to request a copy of BIM models for future tasks, which has resulted in whole new set of AIA Contract Documents.[5]

Landscape architects have consistently addressed the evolving landscape: water flow, plant growth, seasonal temperature variations and more. Yet the flow of the design process, the feedback loop that is generated from a completed project, is only considered the next time a landscape architect is hired. Postoccupancy studies within a landscape architect's own offices are rare. The "parametric landscape" promises more than a method to quickly iterate though options only to settle on a single solution, as Grasshopper is often used today, or to handle the complex data in sets of construction documents, as in the current state of BIM software. The parametric landscape wants to be an open system that



FIGURES 4.2.2 AND 4.2.3 **Geofoam as installed at Maggie Daley Park**

Images: Michael Van Valkenburgh Associates self-organizes in order to, with every feedback loop, consistently arrange itself to meet the complex and changing parameters set forth by a landscape architect. In this effort the landscape architect becomes the author of an algorithm rather than designer of a specific, even if flexible, site solution.

This work is also beginning to take shape within the design professions. Andrew Heumann developed a Grasshopper plug-in named Human UI that allows users to create an easy-to-use interface that references specific Grasshopper components. Human UI allows clients to take control of specific elements within a digital model and see, in real time, what happens if they increase the height of the building or change the cut and fill balance of a landscape.

What once would have required several meetings and hours of revisions on the part of designers can now be communicated in a matter of minutes. These methods are fundamentally changing the current design process for designers. As the easily accessible parameter expands into construction, maintenance, and deconstruction tasks, one can begin to imagine the continuous design process and resulting fast-matter landscape.[6]

The difficulty with operating a landscape that responds to feedback at the speed of an algorithm is that the actual matter used to create landscapes—such as rock, soil, and vegetation—are not easily rearranged at the speed of electricity, the speed at which sensors deliver updated data sets. With the exception of water flows, or sand dunes, there are few landscape changes that alter our spatial experience of a site within 24 hours, or even seven days.

In *Landscape Ecology*, by Richard T.T. Forman and Michel Godron, Chapter 12 opens with catastrophes: the 1906 San Francisco earthquake, the Chicago Fire, Second World War bombings, and the inundation of Dutch dikes in 1953.[7] These are the given examples of high-speed landscape changes, before the chapter moves into more familiar topics such as seasonal changes and vegetal succession. This leaves landscape architects to wonder if there are forms of fast matter that can encourage high-speed landscape change without calamity.

Since the 1990s, in the same decades that the word parametric infiltrated the landscape architect's lexicon, the use of a lightweight fill material, Geofoam, has also exploded. Geofoam is an expanded polystyrene product marketed specifically for terrain alterations. Since the 1960s, it has been used for projects such as road and rail construction, retaining wall fill, and public parks. In spite of the name lightweight fill, the product is able to bear heavy loads at a low cost. At only 2.85 pounds per cubic foot, EPS Geofoam is able to bear 18.6 pounds per square inch, similar to that of sand or gravel.[8] The product is in high demand: some estimates put US production alone at 1.3 billion cubic yards per year, enough volume to cover the island of Manhattan in 36 feet of Geofoam.

Generally we are conditioned to think of EPS, Styrofoam,[9] as something that is environmentally disastrous because it lasts forever. Geofoam, as fast matter, will change our thinking about materials like EPS, as it's incredibly useful for matter that is intended to spend most of its life under a layer of soil and to have the tendency not to rot or otherwise degrade. It is the exact reason EPS is thought of negatively that gives it the potential to be a high-quality fast-matter aggregate.

Fast matter in landscape architecture will realign both the cultural and physical productions of landscape architects toward a parametric landscape based in computation.[10] Using Geofoam as a potent case study, this argument is made in three parts. First, that materials like Geofoam fit into existing conversations on aggregates, or easily rearranged materials that can be programmed. Second, that the alignment of modeling methods and construction techniques sets up a feedback loop that compresses the steps between design and construction. Finally, that a parametric series of instructions ultimately serves as a better translation and index of construction directives than the documents typically called for in professional practice.

Geofoam as landscape aggregate

In 2015, a group of architects, led by Ryan John King and Ekaterina Zavyalova under the name Foamspace, won the New Museum's Ideas City Competition with an entry that reimagined funding strategies for architecture competitions. The Foamspace project utilized the $20,000 fabrication funding to buy standard-size[11] blocks of Geofoam that were arranged along the street for the day of the festival. At the end of the day the manufacturer picked up the blocks and a percentage of their cost was refunded. These blocks went on to be resold for other projects and uses, and the competition monies, rather than being exhausted for one festival, were rolled over into a fund for future projects.[12] While the arrangement of the blocks was more "building" than "landscape," the project demonstrated how aggregated Geofoam can act as fast matter.[13]

Landscape architecture is familiar with aggregates in design, from the movement of sand dunes to the angle of repose of a pile of gravel. Geofoam opens up a conversation about designing synthetic aggregates. The form of each Geofoam block could have a function, which manifests itself as a specific form, designed into the aggregate, whether it be to direct water flow, or encourage a particular type of vegetal growth, in addition to its role as lightweight fill. These functions would be more complex versions of the functions we already assign to other aggregates: coarse stone for easy drainage, or peagravel to create a level surface. These Geofoam aggregates could be made using a subtractive method that removes parts of a large block of EPS, or they could be formed in molds like EPS in packing materials, an additive process. In both cases the Geofoam would function structurally as a part of the ground section, just like any other subsurface material.

As an aggregate, Geofoam taps into a timely conversation in (landscape) architecture discourse on the design of granular systems and their structural characteristics. This discourse includes the work of Achim Menges, Skylar Tibbits, and Heinrich Jaeger.

At the Institute for Computational Design at the University of Stuttgart, Achim Menges is working on what he has titled "aggregate architecture." He describes the aggregates as programmable matter that can be reconfigured rapidly, not by downcycling but by simple reuse in a new arrangement, much the same way the Geofoam from Daley Bicentennial Plaza was reused or the foam from the Foamspace installation at New Museum was also reused.[14]

In his research, Menges and his team are focused on highly designed aggregates that are intended to affect the possibilities of a whole made from thousands of individual pieces. According to Menges, these aggregate systems

FIGURE 4.2.4 **"Foamspace" by SecondMedia. Design team: Ryan John King, Ekaterina Zavyalova, Bettty Fan, and Nikolay Martynov. Project Documentation: Varvara Domnenko**

> challenge conventional architectural design principles: whereas an architect precisely defines the local and global geometry of a structure, in a designed granular system he can only calibrate the particle geometry in order to tune the overall behavior of the aggregate formation.[15]

In Maggie Daley Park, the desired ground surface of the park was designed first and the Geofoam was simply a means to create that surface with a minimum amount of soil between the top of the foam and the park's grassy surface, while keeping minimal weight on the parking garage below.

In order to harness the potential of fast matter, Geofoam landscape architects need to design the entire thickness of the foam, not just the soil surface: how each piece interlocks, the form of the foam, and its function or program. In Menges's work, each aggregate is categorized as either nonconvex, double nonconvex (hooks), or actuated materials. Convex materials (ball shapes) won't interlock to form a stable construction. The typical rectilinear volumes of Geofoam already function as an interlocking aggregate, but greater formal diversity could move Geofoam past a purely structural function.

At the 2015 Chicago Architecture Biennial, Skylar Tibbits, working alongside Gramazio Kohler, developed a project titled Rock Print. The project used a robotic arm to lay down a continuous string within a wooden formwork. A lightweight rock was then poured into the form one layer at a time.[16] Eventually the formwork was removed and those rocks not held in place by the textile filament fell away to reveal a designed form. While the "in-person" experience of the project was stunning, the truly remarkable part of the project was a later published video of the project's disassembly. As the string was pulled from the top of the print onto a motorized spool, the rocks are projected into the air before falling back to the floor. Finally, the rocks are swept up and placed back into the bags from which they came months earlier at the beginning of the Biennial.

The disassembly of aggregates allows them to be moved directly from one project to the next as part of an open system. The unused aggregates from one generation of a landscape that are not used in the next do not become waste but are simply moved to another site, or set aside for a future, more populated generation of the landscape. These aggregates would become part of their own economy, bought, sold, and traded as needed. Like a highway Jersey barrier, or a returnable milk bottle, the aggregate is a component in a much larger system that can be used over and over again with minimal processing between uses.

Aligning systems of feedback

In architectural practice, SHoP Architects is already working on reinventing construction documents and eliminating paper documents with its work on the Barclay's Center Façade and B2 modular towers at Atlantic Yards. At Barclay's Center, SHoP was brought on as façade consultants to design a new wrapper for an already-designed building. Politics, land acquisition schedules, two architects, and a multiplicity of contractors were some of the site's myriad challenges. The contractor had already assigned the foundations and steel work to a subcontractor when SHoP came on board to redesign the façade.[17] The availability to work with the contractors and architects across a single model allowed the changes to be made quickly in a series of short feedback loops.

Pushing the model integration further, SHoP designed a system of barcoding so that each of the 12,000 pieces of the complex façade could move directly from the firm's digital model to the fabricator, to its installed location on site. All the while, each piece was tracked like a FedEx package. No paper documents were ever produced. One can imagine some affinities between the 12,000 complex steel façade pieces and the many rectilinear pieces of Geofoam beneath Maggie Daley Park. The same feedback loops used for complex facades could be engaged for complex ground surfaces.

Philip Bernstein, the vice-president of Autodesk, relates the move from hand drafting to two-dimensional drawing in CAD to modeling in the BIM environment as analogous to Nicolas Negroponte's argument in *The Architecture Machine* that "digital technologies first mimic the processes that they are designed to replace, then extend them, and eventually disrupt them completely."[18] While Bernstein believes we are still in the "mimicking" phase in architecture, the SHoP approach begins to disrupt a one-way flow of information with feedback loops. Landscape architecture is also at a critical juncture at which the relationship between design modeling and construction execution can merge into an evolving, but always active, system.

In studios across professional landscape architecture programs, students download digital elevation models in ArcGIS, create surfaces in Rhino, manipulate those surfaces with Grasshopper "scripts," and then contour those surfaces at even intervals to create two-dimensional drawings that represent a three-dimensional landscape. This workflow uses extraordinary computational power to create a representational device that has been used for hundreds of years: the contour line. Those same students will then import that surface into a software program, such as MasterCAM, to create tool paths, which in turn will generate NC code for a CNC router to excavate material that creates a physical manifestation of the designed surface, often in an expanded polystyrene material. These workflows result in many steps of unnecessary translation.

Outside of academia, professional surveyors, civil engineers, and excavators have all started to use GPS-enabled hardware and software to guide their workflow. In 2005, *Engineering News-Record* published the cover story, "3D grade control puts designers right in the operator's seat; automation is rocking traditional earthmoving and project teams have to make changes." The early complaints from contractors who were utilizing these systems were centered on the time it took to translate two-dimensional drawings into three-dimensional models that the grade control systems could understand.

As digital modeling becomes the standard in design offices, replacing two-dimensional representations, one can imagine that soon the contractor will not be building the model at all but instead will simply execute it, like SHoP's panels on the Barclay's Center. It is the compression of model information into two-dimensional paper documents that interrupts the feedback loop.[19]

Autodesk is also starting to deliver products such as Autodesk BIM 360, which integrates with Topcon (one of the leaders in producing GPS-based automation systems for excavation equipment) products. Autodesk allows equipment operators and installers to understand exactly where they are in the model and on site, closing the feedback loop between design and construction with a commercial product.[20]

While commercial software is changing the way the construction industry thinks about manipulating the Earth's surface, it is not the technological advancements that contribute to faster landscape change. Instead, the evolution of techniques are simply the symptoms of an ideological shift, one in which we move from thinking about the construction process as a series of linear steps or the passing of a baton to an open flow of three-dimensional information that is accessible by all agents involved in the project.

Directives instead of documents

In 1970, John Horton Conway created the Game of Life, a program that is represented by an infinite two-dimensional grid in which each cell can be either "on" or "off." The game has four simple rules: a live cell with fewer than two live neighbors dies; a live cell with two or three live neighbors lives; a live cell with three or more neighbors dies; and a dead cell with three neighbors comes to life. The system, given these four initial directives plus an initial seed layout of live and dead cells, runs for generation after generation. Depending on the seed layout, the system could die, grow, or reach a state of equilibrium.

An algorithm is a set of rules or tasks that can be executed over and over again until a particular state is reached. In data sets, we use algorithms such as Bubble Sort, which sorts numeric values one after the other until all values are in ascending order. As new data sets arrive, they too can be sorted. If we think of the landscape architect as the author of an algorithm and the feedback loop consistently moving through that algorithm, then the possibilities of fast matter exponentially increases. If the landscape design process is continuous, and the algorithm is periodically updated in response to the feedback loop, then fast matter has even more potential to respond to specific site conditions, such as changing water flows, poor growth areas, or programming. With directives, the role of the landscape architect is to observe and direct, rather than create a final product. Kostas Terzidis calls algorithms a "vehicle for exploration."[21] Like the Game of Life, the designer must set the system into motion, watch it evolve, and then make adjustments or restart the game, as necessary.

Parametric design software, such as Grasshopper, is already allowing designers to think in terms of logical questions and commands: copy this; scale according to the distance from X, etc. While Grasshopper is not iterative the way an algorithm is, it does begin to make designers respond in code, observe the results, and enact a response. Once the process is iterative, the exploration is amplified. Graphic-based coding, such as Grasshopper, also places design firmly in the realm of directives instead of documents. With Grasshopper, the design work is in creating the process. The drawing, a representation of the process, can be created again and again.

By positioning Geofoam as "fast matter," we can begin to see the emergence of a new paradigm for landscape design and construction in three territories: first, the possibility of a system for providing feedback in aligned construction and design tools; second, a material of the proper size and design that functions as an "aggregate"; and, third, a method for delivering instructions, "the algorithm."

The methods by which we are already interacting with Geofoam have eliminated the need to think of construction as a specific time that is between design phases and a finished landscape. This opens the possibility for landscape architects to eliminate the oppositional ideas of model and reality. Instead, in this new mode, the model is always forming the reality and the reality is always influencing the model, so they are both "real" parts of a feedback system.

The idea of aggregates gives us a way to think about Geofoam (or other materials) that is not based on achieving a specific surface (or form) but instead provides a way to design and tune landscape qualities. And, finally, the feedback system can be controlled by algorithms designed by landscape architects that set out the necessary rules for both the feedback system and aggregate design.

Geofoam is the critical example for the potentials of fast matter in landscape architecture because it is readily available for scale modeling in design contexts and widely used in existing construction processes. It is lightweight and almost ubiquitous in both academic and professional settings. But the list of fast-matter materials could be a much longer. The salvaged beams of demolished barns, precast concrete soakways and culverts, or the ubiquitous stone paver are all materials that could be harnessed as fast matter.

Why does fast matter, in fact, matter? It represents a potential for the design profession to stop making the wrong decisions at high speed. Since the computerization of many architectural tasks began in earnest in the 1990s, huge amounts of readily accessible data have inundated the design process.

Parametric design software such as Grasshopper seems to have allowed an endless number of options, yet the options do not necessarily improve our current condition. As the project to create open systems of infrastructure that responds to natural processes continues we must rely on feedback from the materials in these systems to inform the next generation of ideas.

Notes

1. www.architecture.org/architecture-chicago/topics-news/chicagos-playscapes/six-things-you-need-to-know-maggie-daley-park, accessed February 2017.

2. www.dnainfo.com/chicago/20140401/downtown/maggie-daley-park-development-update-tree-planting-follow-geofoam, accessed February 2017.

3. Berrizbeitia, A. "Large Parks," in Czerniak, J. and Hargreaves, G. (eds.), *Re-Placing Process*, 2007, p. 175.

4. Rojkind, M. "Building on Speed," in Ruby, I. and Ruby, A. (eds.), *Re-Inventing Construction*, Ruby Press, 2010.

5. See AIA Document E203–2013 section 4.9: Post Construction Model.

6. Andrew Heumann in discussion with the author, October 2016.

7. Forman, R.T.T. and Wilson, E.O. *Land Mosaics: The Ecology of Landscapes and Regions*, Cambridge University Press, 1st ed., 1995, p. 427.

8. Arellano, D., Bartlett, S., and Stark, T.D. *Expanded Polystyrene (EPS) Geofoam Application & Technical Data*, The EPS Industry Alliance, 2012.

9. Styrofoam is a brand name trademarked by Dow Chemical Company that covers Dow's expanded polystyrene products, as well as extruded polystyrene products and other foams.

10. For more on the differences between computation and computerization see Kwinter, S. "The Computational Fallacy," in *Thresholds 26, Denatured*, 2003.

11. There are not actually standard sizes of Geofoam. Block sizing depends on the capabilities of individual manufactures, but is usually around 4' x 3' x 10'.

12. The agenda of Foamspace is based in financial, not material systems, so the aggregate could be considered the funding, but project is relevant here because of the materials and the way they were used. You can read more about Foamspace, which is now part of a larger project called the decentralized architecture office, online at foamdao.space.

13. www.newmuseum.org/ideascity/view/foamspace, accessed February 2017.

14. Dierichs, K. and Menges, A. "Towards an Aggregate Architecture: Designing Granular Systems as Programmable Matter in Architecture," *Granular Matter*, 18(25), 1–14, 2016.

15. Ibid., p. 1.

16. Aejmelaeus-Lindström, P, Willmann, J., Tibbits, S., Gramazio, F., and Kohler, M. "Jammed Architectural Structures: Towards Large-Scale Reversible Construction," *Granular Matter*, 18(2), 1–12, 2016.

17. Post, N. "Complexity on the Face of It," *Engineering News-Record*, July 16, 2012.

18. Bernstein, P. "Parameter Value," in Poole, M. and Shvartzberg, M. (eds.), *The Politics of Parametricism*, Bloomsbury, 2015, p. 205.

19. Of the standard contract documents used by the AIA, those that specifically address digital practice were not released until 2013. Generally they do not yet address the legal repercussions

of sharing a live model, so in some cases it is not a methodology that needs to change to achieve a feedback loop but a legal structure.

20. This is not an argument for technological determinism. These commercial software packages are examples of the way the design industry is engaging a feedback loop, not implying that the software's feedback loop is providing a "solution." See Kludge, K.M. *Models of Models* from Actar's UrbanNext project for an in depth analysis of the role of simulation in design.

21. Terzidis, K. "Algorithmic Form," in Menges, A. and Ahlquist, S. (eds.), *Computational Design Thinking*, John Wiley & Sons, 2011, p. 96.