scripting CONCRETE

by **Athanassios Economou and Nader Tehrani**

Exploration of problems of geometry and form vis-à-vis specific means and methods of assembly and construction has always been a central question in architectural pedagogy and practice. Not all types of geometries are possible within given construction domains and not all construction techniques are suitable to solve given formal problems. An iterative loop is clearly suggested at the outset of the problem and novelty is warranted by the designer's reflective understanding of the interplay between both domains of composition and construction. This paper discusses the design of an architectural pedagogy that is based on this reflection-in-action ethos and gives a brief account of its implementation in an advanced graduate architecture studio curriculum.

Among many and different kinds of ways that an architectural pedagogy can be designed to foreground specific relations between composition and construction, computation promises a most significant role: computer-controlled design algorithms visualize designs that would be difficult or even impossible to be thought and described otherwise; similarly, computer-controlled fabrication machinery produces designs that would be very difficult to or even impossible to be produced otherwise. The specific methodology described here has been particularly choreographed around issues pertaining to the design and fabrication of concrete structures. If generally, construction methods are rooted in problems of aggregation, of assembly, and of joinery using conventional 'units' of construction, the foundational difference in the construction of concrete is its indexical relationship to those very processes: concrete imprints the marks of formwork, it registers it, it mirrors it, and it tattoos it; its raw liquid state is defying any immediate additive assembly process. This dialectical relationship between the figuration of concrete form and the corollary configuration of elements that create formwork define the medium at its core. Alternatively, if concrete has seen a range of expressions throughout history, it is due to the varied techniques for formworks that have produced the mold for which these casts have become known. These techniques are examined here further as a way of understanding the nature of concrete construction- and moreover the nature of casting as a broader tectonic and computational medium.

The studio was structured around a series of four studies that were all meant to explore different aspects of the nature of casting; aspects of its representation, its parametric definition, its algorithmic definition, and its prototyping. For the first exercise, the students were asked to research categorically the various techniques that history has practiced, among others: cast-in-place, fabric-formed, pre-cast, and more recent digitally oriented practices. Specifically, the students were to examine how two-dimensional surfaces were formed to define frameworks for three-dimensional molds: that is, how two-dimensional surfaces of, say, wood, steel, fiberglass, etc., have to be manipulated in order to render orthogonal precision, curvature, folds, ruled surfaces, and complex geometries (Figure 1).

For the second exercise, students were asked to design a bounded surface unfolded in three dimensions featuring at least one or more holes – that is to say, a closed surface of topological genus n, for n>1. The feature of the opening was a significant part of the design problem to guarantee an encounter with the geometrical complexities of surface boundary, continuity, and closure, and

Figure 1: **Samples from the joint studio research on casting concrete (Richard Aeck, Erin Lindley, James Okelley, Lorraine Ong, Wendi Rahm).**

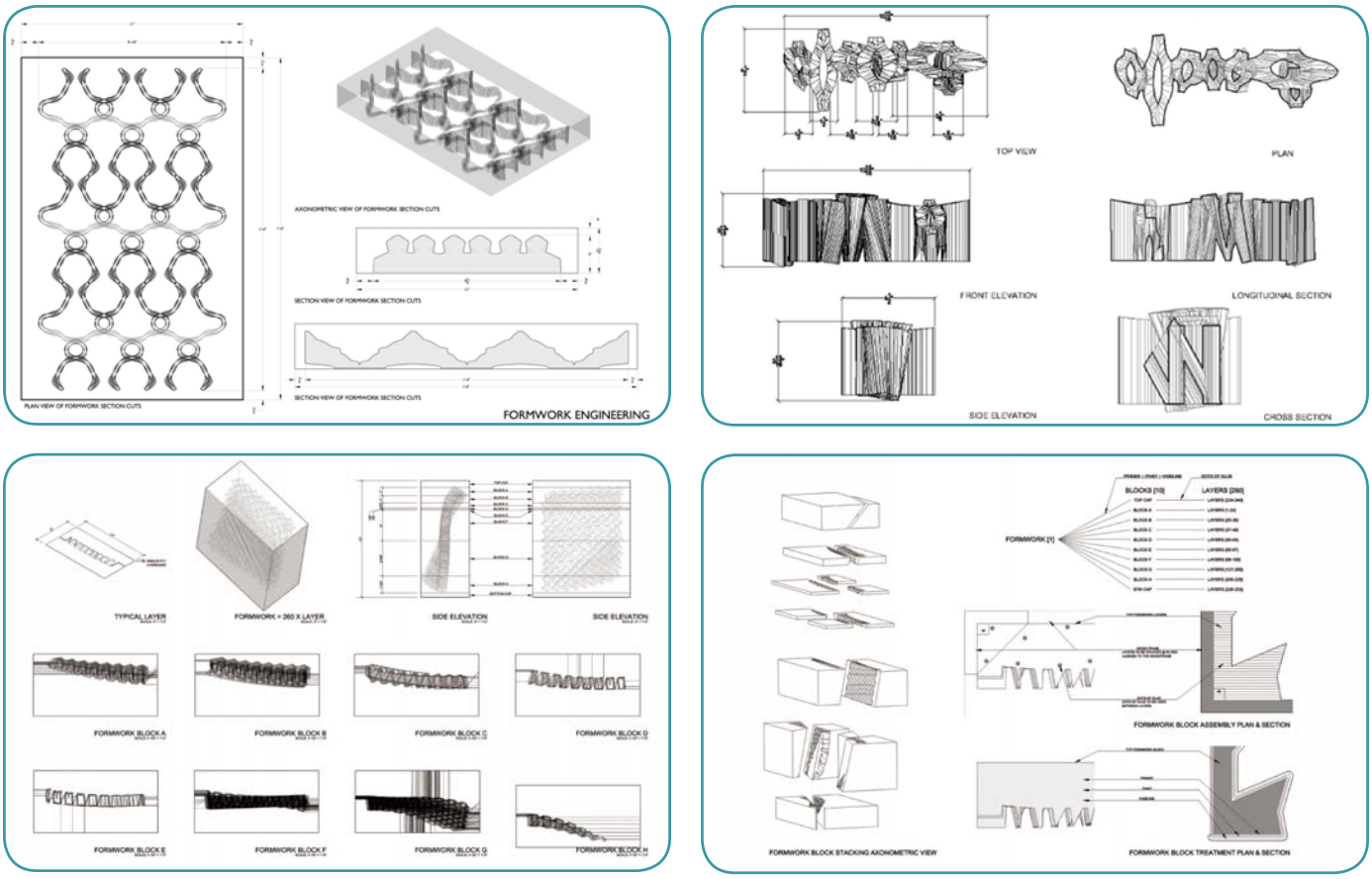
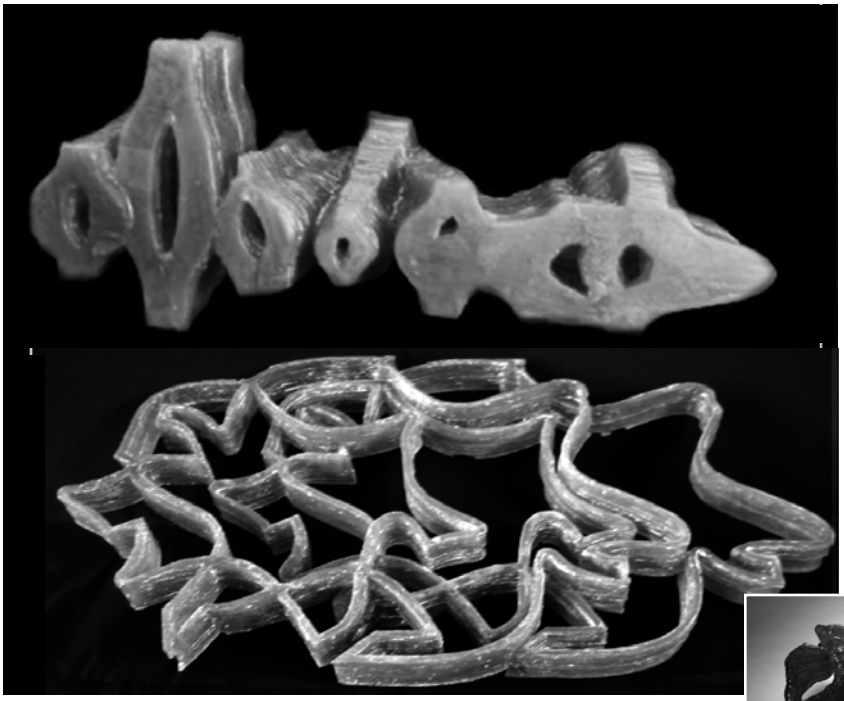


Figure 2: **Samples of the drawing specifications of the formwork of the surfaces (Richard Aeck, Erin Lindley, James Okelley, Lorraine Ong, Wendi Rahm).**



to evoke apt functional vocabularies such as windows, doors, staircases, chimneys, gutters and so forth. The outcome of the computation was the specification of the formwork -not the form (Figure 2).

For the third exercise, the students were asked to use the results of their first two exercises to create a cast module of 1x3x4 meters, within which multiple architectural contingencies could be embedded. The module was to be conceived as a programmable zone that could define the liner of a building. As such, its architectural duties were to establish some relationship between structure and skin, to calibrate the passage and quality of light, and most importantly for this exercise to establish a specific relationship to the body. Furthermore, this threshold between the inside and outside of the building was considered

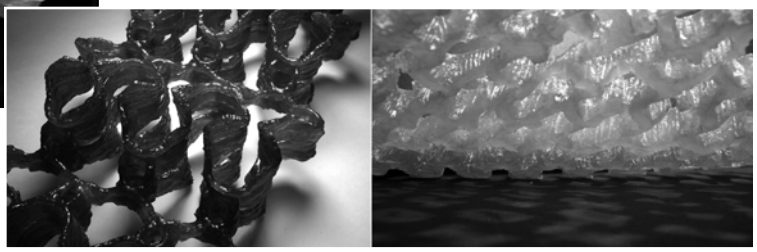


Figure 3: **Samples of the cast modules and the prototypes developed (Richard Aeck, Erin Lindley, James Okelley, Lorraine Ong, Wendi Rahm).**

as an opportunity for the students to investigate the relationship between architecture and furniture, using the body as the ergonomic measure of the cast. As a hand fits in a glove, the body was suggested to be molded into the building liner, not only for establishing a scale for the exercise, but as an alibi to negotiate the relationship between complex and simple geometries (Figure 3).

For the fourth exercise-iteration of the formwork-cast study, the students were asked to think of the formwork studies they had produced so far algorithmically; more specifically, they were asked to script these forms, -or other ones if so desired, and express them in terms of functions, variables, statements, expressions, complex data types and arrays. This encoding of form and formwork would challenge conventional ways of thinking about the designs they had produced so far and would bring to the foreground underlying assumptions and conventions used in their design and generation. In essence, the task was a parametric description of the designs dealt so far. It was expected that the attempts to describe their forms in this manner would not only describe a whole class of designs that share similar characteristics with the ones described or produced so far, but that they would also suggest possibilities that would have been entirely off the discourse unless this parametric definition had been attempted. Various methods were suggested to foreground this parametric definition; most of them coalesced around the notion of a simultaneous exhibition of all spatial variants on a single surface simulating a gradual growth. The granularity and scale of the module, the number of iterations to show the gradual morphing of one variant to another, and the number of discrete variants found in each complete design were left to each student team. All studies, scripts, implementation of matrices, execution and fabrication instruction were worked out within **form•Z** (Figures 4-6).

Epilogue

All series of design studies described here are presented as systematic studies exploring the nature of casting including aspects of its representation, its parametric definition, its algorithmic definition, and its prototyping. An underlying motivation for the whole project was based on our conviction that if conventional buildings thrive on mass production, recent possibilities of mass customization to adapt concrete to particular circumstances, may very well emerge from computational, technological, structural, programmatic, and geographic contingencies. All work discussed above emerged at the graduate advanced architectural design studio at the College of Architecture, Georgia Institute of Technology during Spring 2006.

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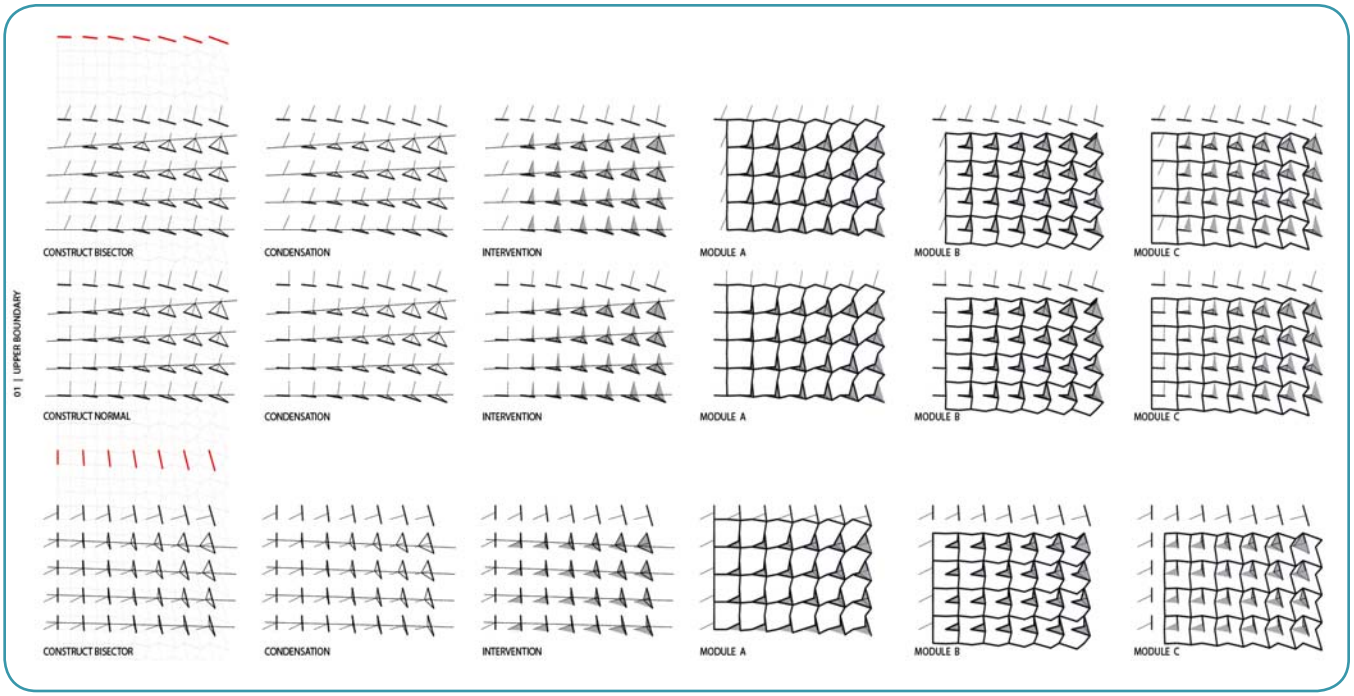
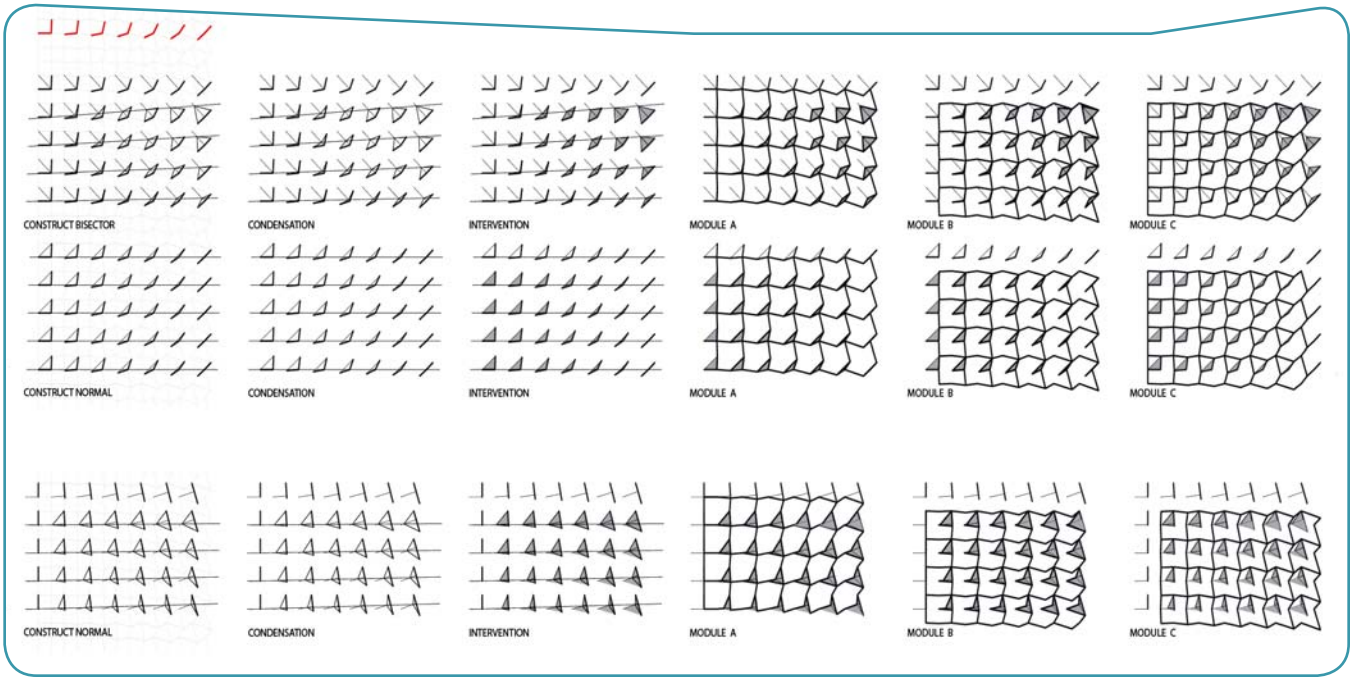
Athanassios Economou is Associate Professor in the College of Architecture at the Georgia Institute of Technology. He teaches graduate and undergraduate architectural design studios and a series of core and elective courses in the field of Design and Computation. Design projects from his graduate studios at Georgia Tech have received prestigious awards and honorable mentions in international and national architectural competitions. He has served on the Technical committee for the Association for Computer-Aided Design in Architecture (ACADIA), the Scientific Committee of Mathematics and Design (M&D), the Scientific Committee of Computational Aesthetics, and others. He has been invited to lecture at several Universities including the University of Michigan, Ann Arbor, MI, the University of California at Los Angeles, (UCLA), the Ohio State University, Columbus, OH, the National Technical University of Athens, Greece, the University of the Aegean, Greece, and others. He holds a Diploma in Architecture (1990) from the National Technical University, Athens, Greece, a Masters of Architecture (1992) from the University of Southern California, and a PhD in Architecture (1998) from the University of California, Los Angeles. Email: thanos.economou@coa.gatech.edu. URL: www.coa.gatech.edu/~economou.

Nader Tehrani is the 2005-6 Ventulett Chair in Architectural Design at Georgia Institute of Technology and an Associate Professor of Architecture at the Graduate School of Design. Professor Tehrani has earned several prestigious honors, including the Architectural League of New York's Young Architects Award in 1997 followed by its Emerging Voices award for 2003. In 2002, he received the American Academy of Arts and Letters' Award in Architecture, one of its youngest recipients ever. Born in London of Iranian origin, Tehrani has resided in the United States since 1978. In partnership with Monica Ponce de Leon, Tehrani heads the firm Office dA and has been practicing architecture in Boston since 1987. He has also taught architecture at Northeastern University, Rhode Island School of Design. Tehrani received a BFA and BArch from the Rhode Island School of Design in 1986, and continued his studies in the History and Theory Program at the Architectural Association in 1987. He received a MAUD from the GSD in 1991. Email: da@officeda.com. URL: www.officeda.com.





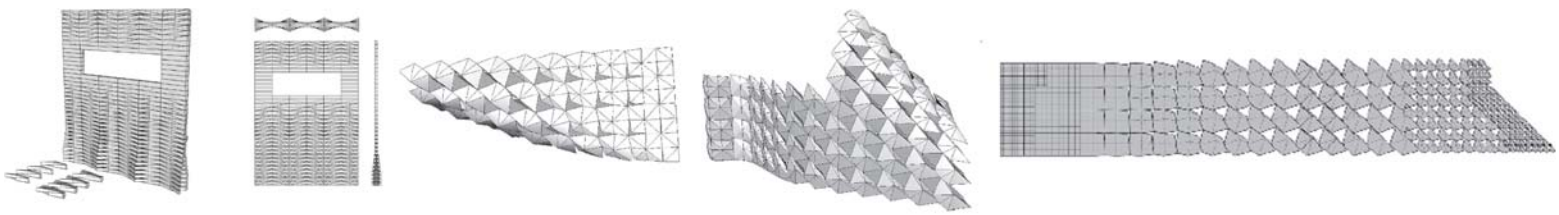
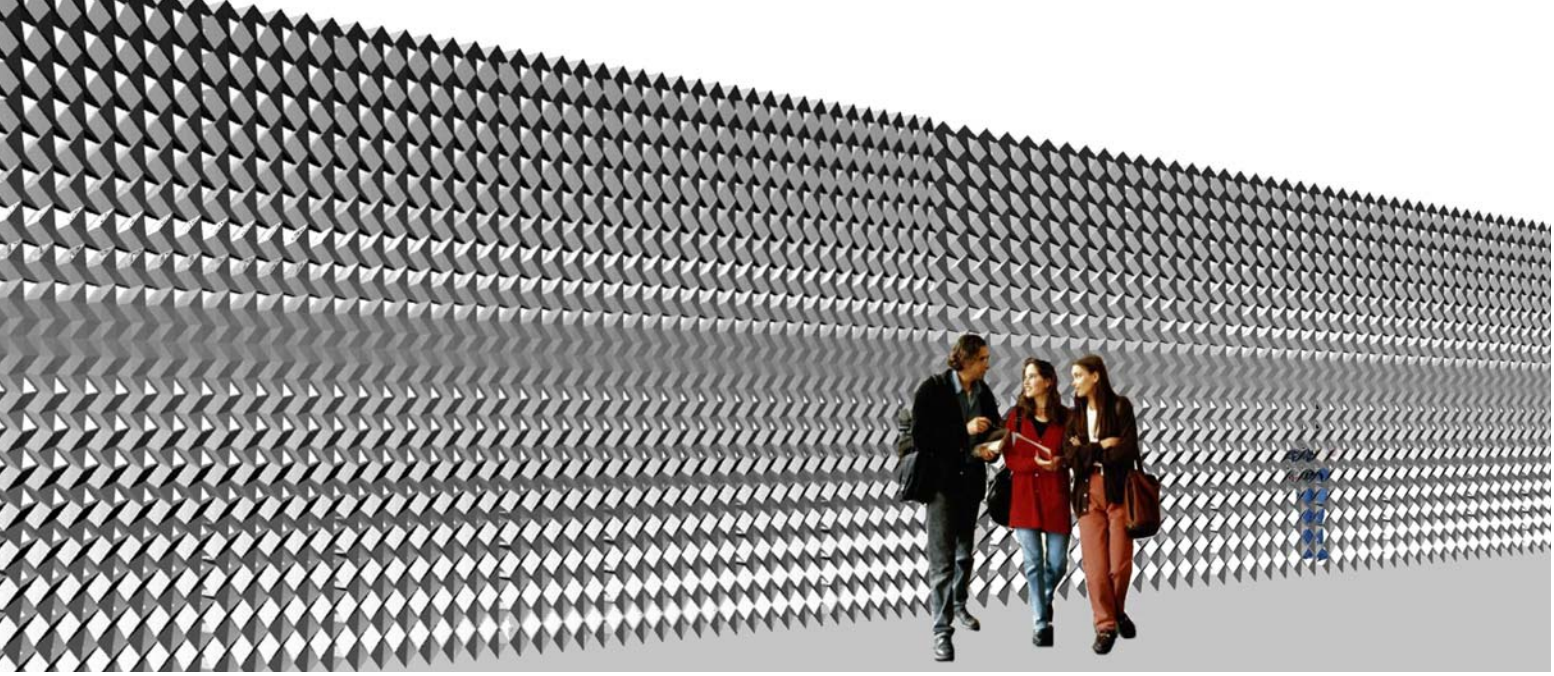
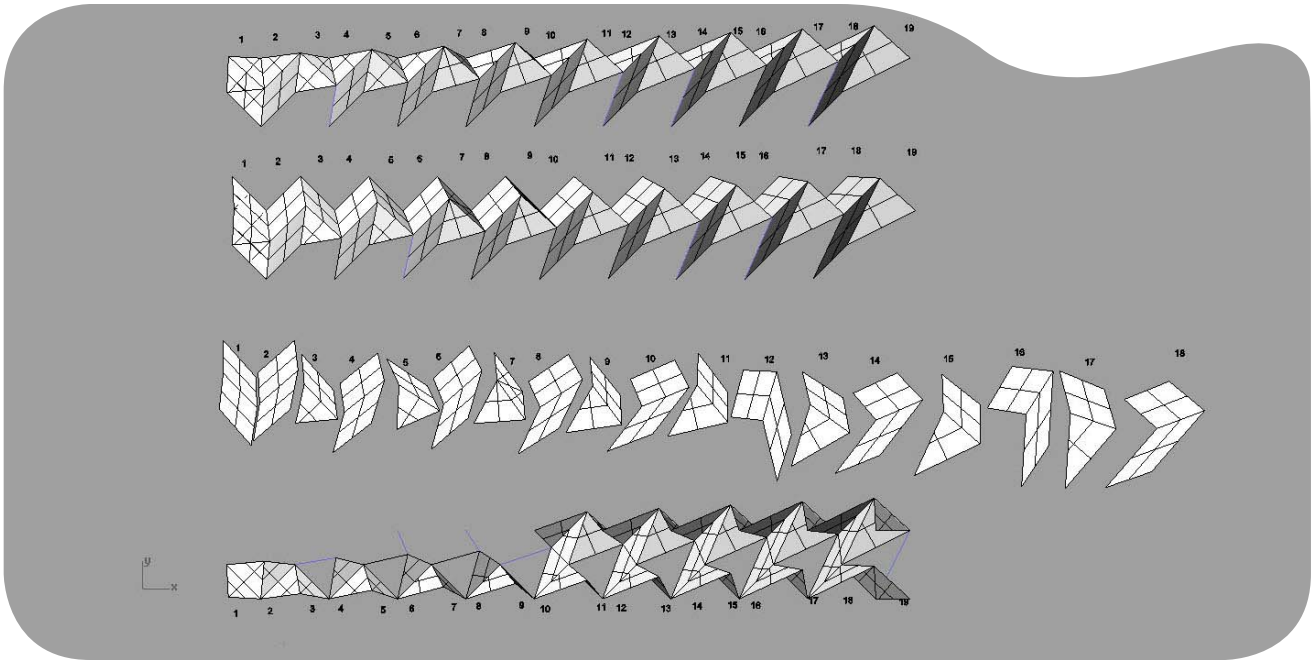


Figure 4: **Algorithmic description of forms and formworks by Richard Aeck and James Okelley.**





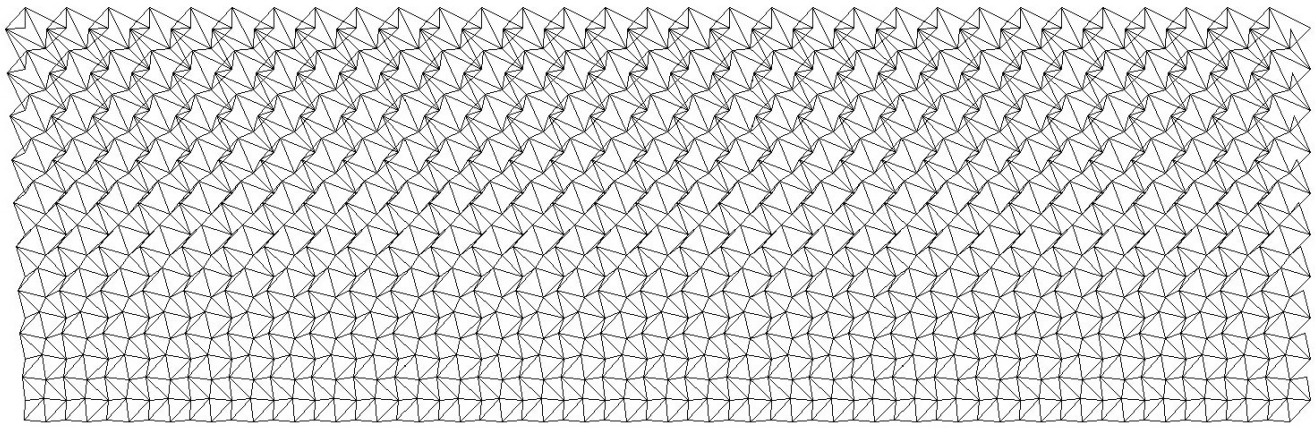


Figure 5: **Algorithmic description of forms and formworks by Erin Lindley and Wendi Rahm.**

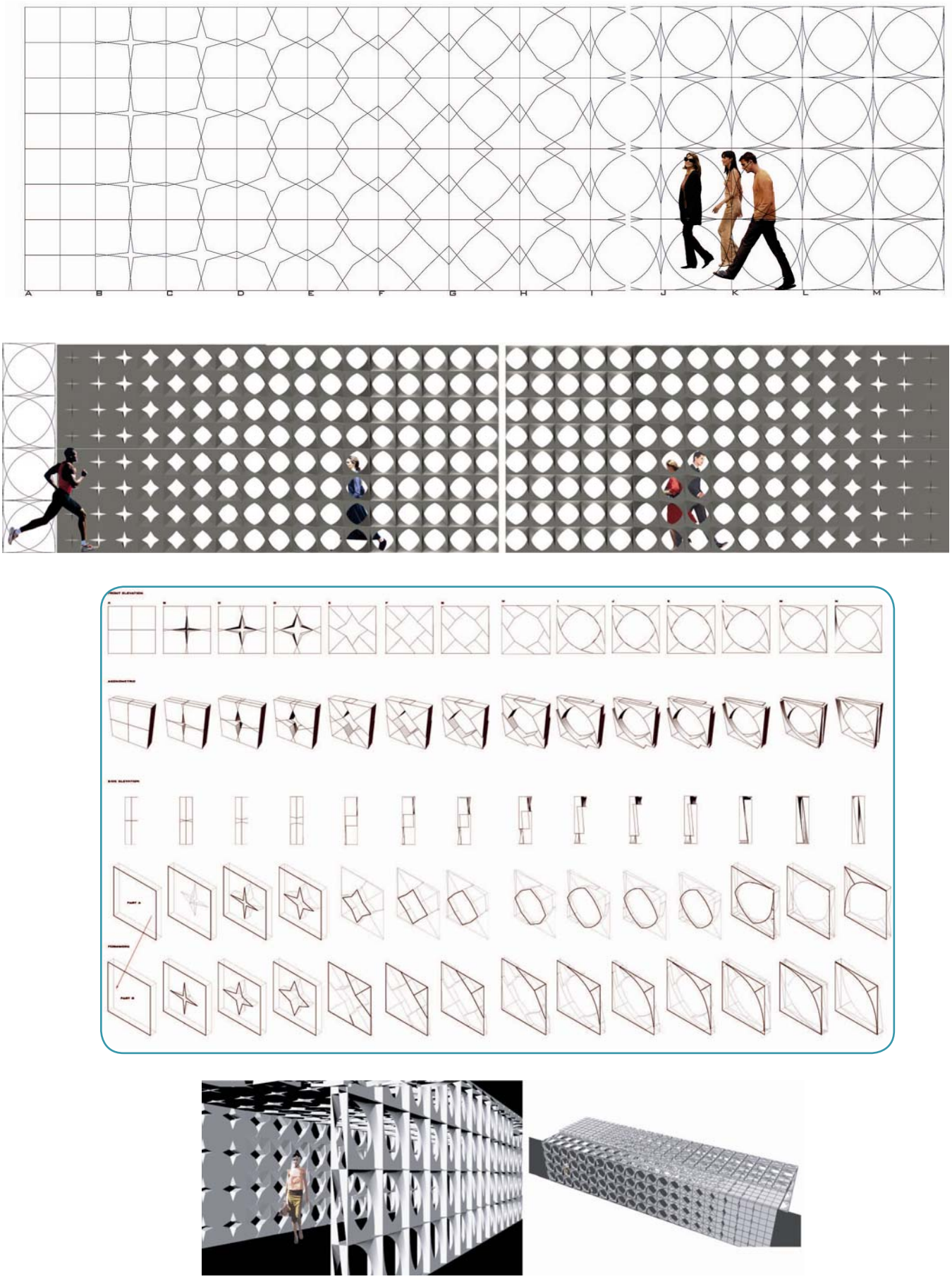


Figure 6: **Algorithmic description of forms and formworks by Lorraine Ong.**