Compete to Fabricate – TEX-FAB: A New Model For Computational Design Research

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INTRODUCTION

A brief survey of major public and civic works of architecture over the past 250 years will undoubtedly reveal the role of the international competition in shaping some of the most influential buildings in our cities around the world. From Charles Jean Louis Garnier's Paris Opera House in 1874 to Richard Rogers and Renzo Piano's Georges Pompidou National Center of Art and Culture in Paris nearly 100 years later, it is possible to see within one city how the competition has facilitated the evolution and discourse about public space and ornament. Or, in the case of the Chicago Tribune Competition in 1922, won by John Mead Howells and Raymond M. Hood, the collection of entries comprised a pivotal moment in the development of the skyscraper and also illustrated how a competition could serve as a vehicle for public education and discourse on architecture. It can also easily be said that some architects have started their practice on the basis of winning a significant international competition. From Rafael Viñoly's Tokyo International Forum to Bernard Tschumi Parc la Villette, their winning commissions led to international prominence and continued design opportunities. From the quintessential public space of Olmstead's Central Park in 1858 to the iconic presence of the Gateway Arch by Eero Saarinen in St. Louis, Missouri, in 1946, the competition has also provided other significant aspects of what defines our urban experience.[1]

Regardless of the typology, context, or scale, the design competition functions best when it facilitates innovation and excellence in design outcome. A competition has the potential to synthesize a zeitgeist out of which a community can generate a compelling and significant

Figure 1: Yokohama Port Terminal by Foreign Office Architects, winner of the international design competition.

Figure 2: Map of participant location for the REPEAT competition.

dialogue. In the case of the Yokohama Port Terminal in 1994 (fig. 1), Alejandro Zaera-Polo summarizes this as *"...the opportunity to crystallise a type of investigation that I believe involved a whole generation of architects, and to test it with reality. The hybridisation of infrastructure, landscape and architecture, the integration of computer-aided design into the practice of architecture, and maybe the exploration of a global practice were tested through this project into a real building."*[2] While the words of Zaera-Polo strike an ambitious trajectory, the project as completed by the Foreign Office Architects team did establish a new benchmark for a generation of young architects seeking examples that personified the interplay between the digital, the infrastructural, and the urban landscape. It is the capacity for a competition to engender such moments that set up a powerful dialogue with not just the competitors, or eventually the built commission, but ultimately those seeking footholds in what will push the architectural discussion forward for generations to come.

TEX-FAB BACKGROUND

TEX-FAB started as a nonprofit between professors Andrew Vrana at the University of Houston, Kevin Patrick McClellan at The University of Texas at San Antonio, and Brad Bell at The University of Texas at Arlington. The organization was initiated as a platform for the gathering and dissemination of information pertaining to computational design and fabrication. At the time of inception, in 2009, there was growing intelligence within the sectors of the AEC profession, academia, and the manufacturing industry, but very few mechanisms for facilitating a more robust dialogue between these groups. TEX-FAB intentionally stepped into this space and did so with the goal of interconnecting regional and global communities. To this end, TEX-FAB has established three primary modalities for creating a platform to facilitate dialogue between disparate sectors around issues of computational design and fabrication. The first of these tenets is *Theoria* (Lectures/Exhibitions), wherein the regional community is engaged with presentations of work. The second is *Poiesis* (Workshops), which, in a practical sense, centers on active learning and sharing of knowledge with hands-on activities. Finally, *Praxis* (Competitions/Commissions) opens up the discourse to a global network and allows TEX-FAB to apply itself as a catalyst for exploration. Each of the three areas has a particular scope and duration, thus integrating into the platform for dialogue in a very intentional manner. The organization has grown now to include The University of Texas at Austin (2013) and will add additional universities in 2014. With five conferences, three international competitions, and five exhibitions, the organization has grown to reach deeply into the context of the region while broadening a discourse with an international audience from around the world.

Figure 3: "Minimal Complexity" final installation. College of Architecture, University of Houston, February 2011.

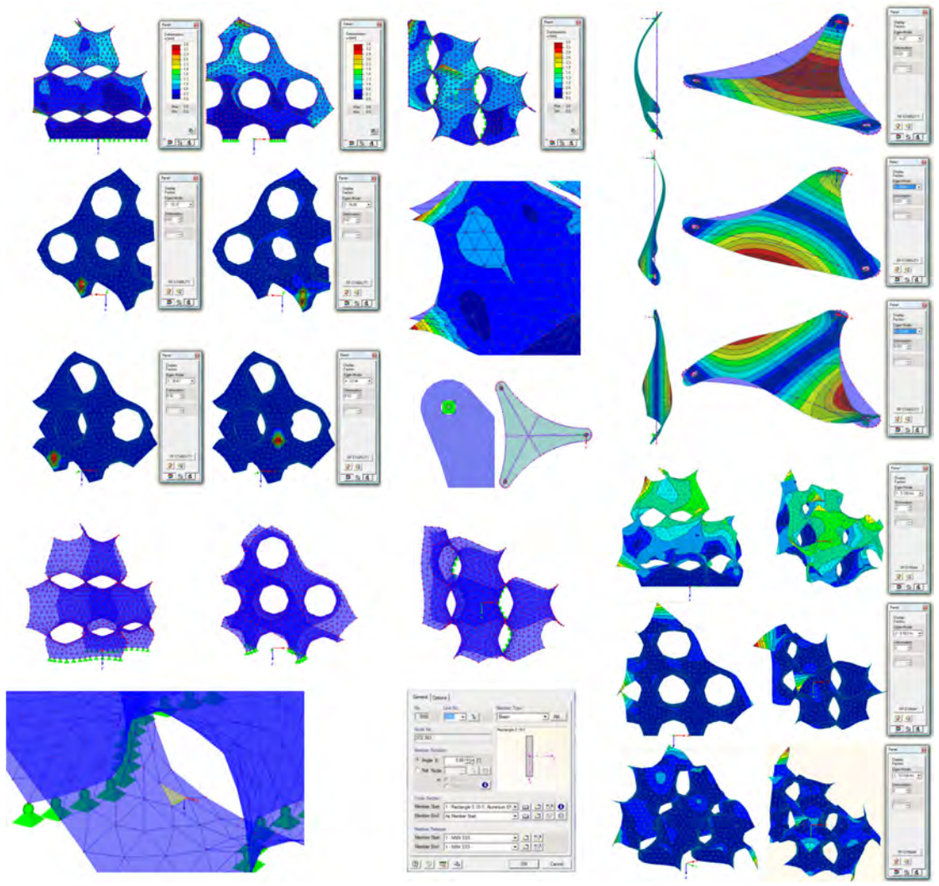


Figure 4: Structural analysis of Minimal Complexity, performed by Buro Happold of New York.

TEX-FAB: PRAXIS

"Ideas and things, the materialism that is so often invoked by the last and most hysterical of the theory avant-garde, should itself become part of a constantly transforming design in which design is never understood as a static object but is always a dynamic movement. This kind of design approach is perhaps best seen today in the emerging world of rapid-prototyping where the search for 'new' prototypes that solve specific problems has been replaced by prototypes which are focused on binding together teams that innovate." Michael Speaks[3]

For Speaks, the role of the prototype and its inherent connection to a more articulated research agenda looks to a new and repositioned role of the emerging practice that is not preoccupied with stylistic impulses or even moral ones. The prototype is a manifestation of a research process that, when linked with a more robust digital toolset capable of enhanced simulation, can create data points for feedback loops into an objective and rigorous design process. This is the mark of a new generation of practitioners who are not situated solely inside of academia, the profession, or manufacturing, but who are navigating across these boundaries and who are traversing this landscape in a manner that sees research not just as a vehicle for obtaining specificity within a design process, but ultimately as the way to achieve innovation.

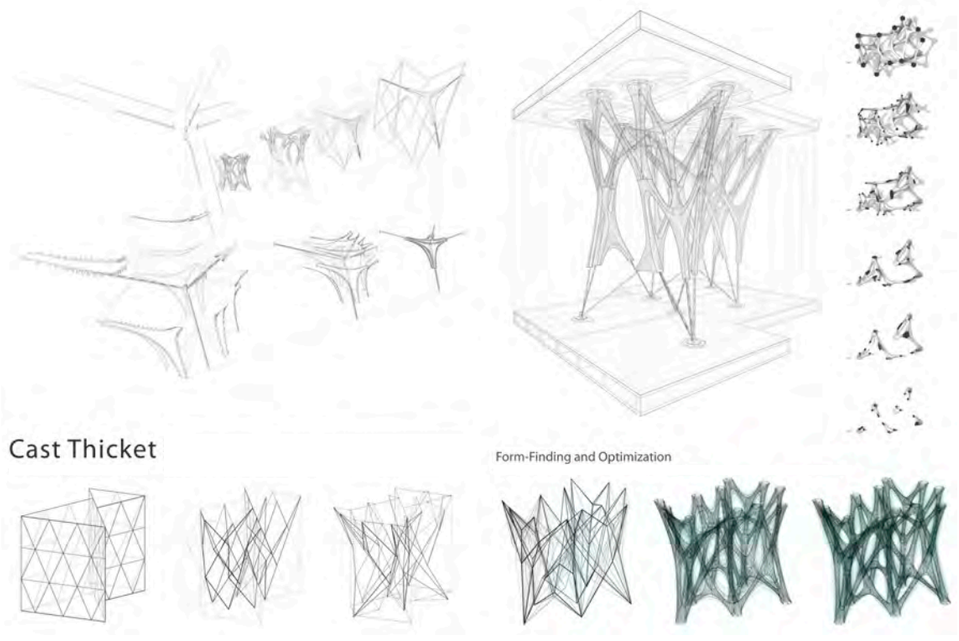


Figure 5: "Cast Thicket" boards for the APPLIED exhibition illustrat.

It is based on emergence of research-based design practices that TEX-FAB now recognizes that the regional and global networks can speak most conclusively. In response to this broader context, the third modality of Praxis has been developed as the most far-reaching and the most intimate. The competition, which, as conducted by TEX-FAB, results in a commission, is a platform for a very diverse set of designers to explore the potential of parametric modeling. Unique to the mission, however, is a desire to see the competition result in a built commission leveraging the resources and relationships of the professional offices and fabricators cultivated through the TEX-FAB network. So to this end, TEX-FAB sees the process of implementation coming out of the competition to be one that can leverage the network and utilize its inherent values to provide a robust support system for fabrication, installation, and construction. The past three competitions have drawn participation from around the world, (fig. 2) and the winners have all then gone on to demonstrate a unique capacity to sharpen their research and methodology through the platform of the commissioned work. This partnership of working with young designers to assist in furthering research trajectories and collaborate in bringing larger proposals into existence is one area that most clearly demonstrates the unique position of an organization like TEX-FAB. The commissioned pieces are the nexus of the various intersections of academic, industry, and profession; they are the extension of a theoretical research agenda; and, they are the physical testing ground for the integration of new working methodologies.

REPEAT

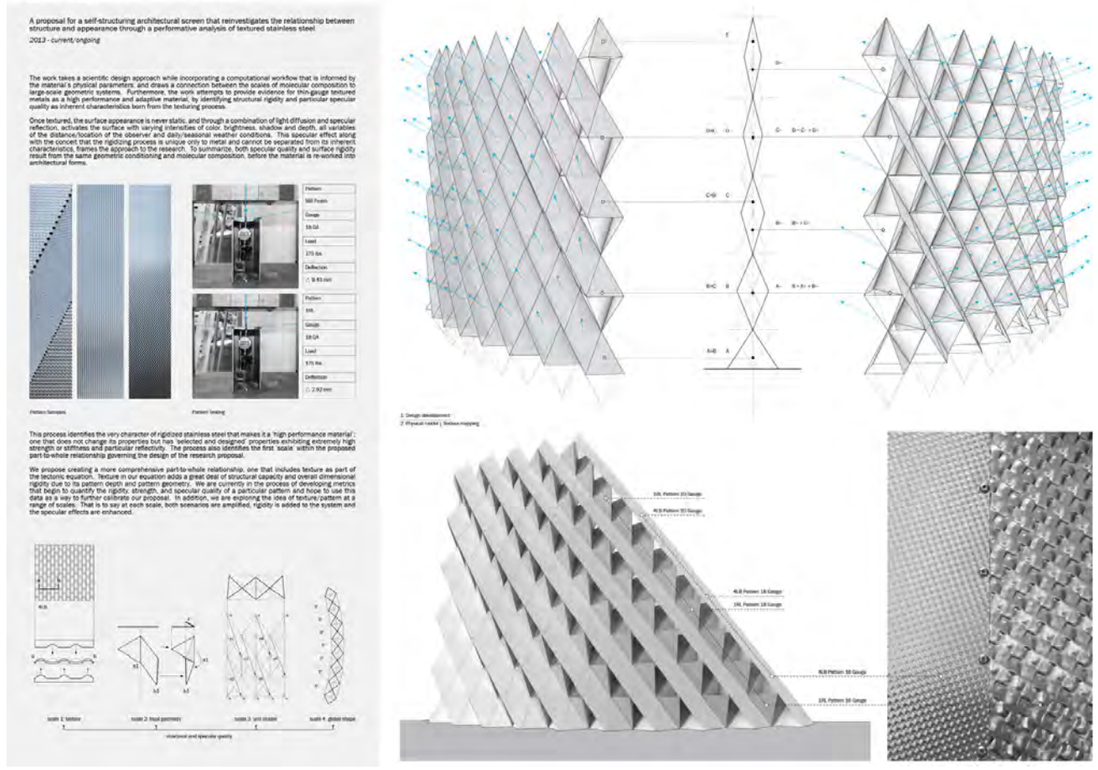
In June of 2010, the REPEAT competition launched, asking entrants to look first at the connection and then, through repetition, define the whole. By reevaluating the design process and looking at it from the connection, what might emerge? We encouraged the generation of cutting-edge design proposals for a structure, and the only caveats were that it be generated and conceived digitally, incorporate repetitive elements, be optimized for relocation and transportation, and be produced through fabrication technologies available in Houston, Texas. These four 'programmatic' parameters served to be very open-ended and broad, while another constraint was included to delimit the work: a budget. No more than $10,000 could be used in the competition proposal's production costs. The role of Houston as context was also significant and provided the perfect backdrop for the objective put forth by the competition. Within cities with atomized light manufacturing capabilities, such as Houston, there exists a potential for designers to engage fabrication via connection with so-called "job shops" that are open to small run projects and customization due to their association with the energy industry. Harnessing the network of fabricators already affiliated with TEX-FAB, we established the means and methods of production for the winning entry and ensured that production costs were not exceeded.

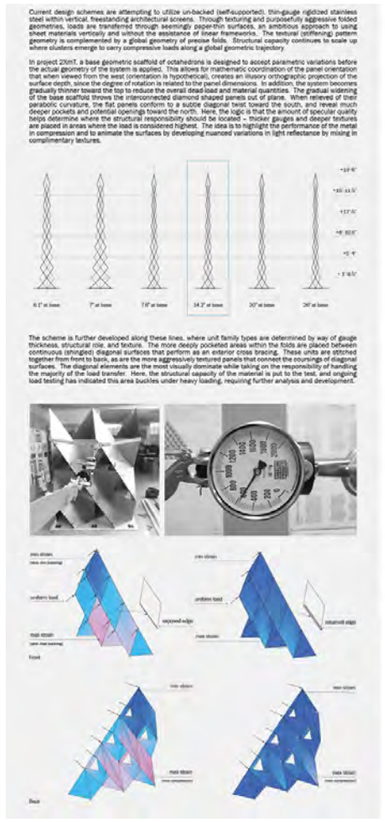
The jury, comprised of Patrik Schumacher, Marc Fornes, Lisa Iwamoto, Chris Lasch, and Blair Satterfield, selected Minimal Complexity for its aesthetic beauty, technical superiority, and elegance of detailing (fig. 3). It employed structural robustness, material efficiency, and an inherent logic of assembly embodying the principals of the competition brief to the highest degree. The competition was predicated on the ability to utilize resources for materials and fabrication partners in the greater Houston area. To that end, very early on in the process of developing the project for construction, Crow Corporations, which is a metal fabrication company located in Houston and a digital fabrication partner with TEX-FAB, was brought in to help resolve technical issues for laser cutting aluminum. Once TEX-FAB, Vlad, and Crow Corporation established that 14-gauge aluminum was the desired thickness for the several thousand pieces that needed to be cut, the next step was to check for structural soundness of the design, material properties, and connection detail. For this, Buro Happold in New York was enlisted to coordinate a detailed structural analysis. The Finite Element Analysis model was run on the geometry as both a shell and beam structure. The Global Shell Model, using iso-parametric finite shell elements, indicated to be very sound under the dead load of the piece overall (fig. 4). The final structure is composed of 148 basic quad sections of the Schwarz's P Surface, with each section being made out of 16 parts, resulting in 2,368 total pieces. The true strength of the design is found in the simplicity of repeating the same 16 parts throughout the entire surface. When each of the basic quad regions is set up for assembly, the double-curvature of the surface is introduced through the alignment of the 16 parts with fasteners.

Figure 6: "Cast Thicket" final installation. School of Architecture, The University of Texas at Arlington, February 2013.

TEX-FAB took control of the means and methods of final assembly by employing a series of templates, base plates, ballasts, shoring, scaffolds, and hoists to manage the vertical development of this self-organizing structure. The process of building the system up into 16-part quads led the planning and construction of larger subassemblies or sections of the structure that could be built on the ground and then positioned correctly and bolted in. The choice of 14 gauge laser cut aluminum with ¼" holes proved to be ideal for workability and joining with a variety of fasteners that served to align the parts progressively. A pattern of tightening and loosening the fasteners at adjacent components was learned by the assembly team in order to allow for hole alignment before final bolting was accomplished. The structure's progressive rigidity as the fasteners became fully engaged was further proof

Figure 7: "Cast Thicket" fabrication sequence.





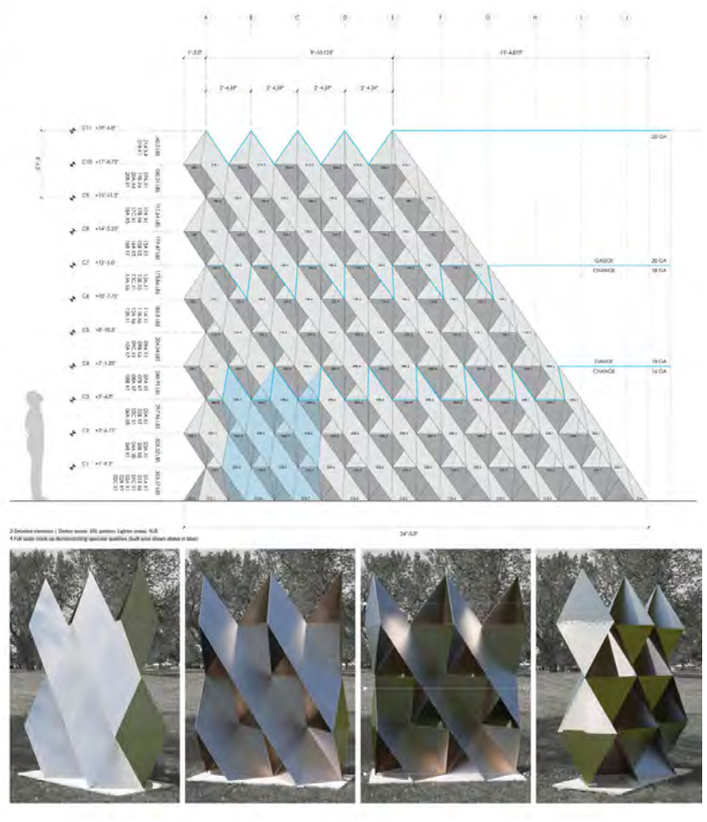


Figure 8: Final boards showing the integration of the tetrahedron and octahedron geometry to the global geometry of the facade.

of the designer's concept, the engineers FEA analysis, and TEX-FAB's expertise as fabrication and logistical consultants. The main assembly took approximately 20 hours with a team of four.

APPLIED: RESEARCH THROUGH FABRICATION

Following the REPEAT competition, the TEX-FAB directors organized a competition in 2012 that intentionally started with the position of applied research. The call invited participants to leverage existing or even proposed research agendas onto the TEX-FAB network and find a useful and productive conduit for advancement. In October of 2012, a jury composed of Andrew Kudless, Branko Kolarevic, Vlad Tenu, and Nadar Tehrani, convened and selected Cast Thicket by yo-cy (fig. 5). Led by Christine Yogiaman and Ken Tracy, yo-cy is a young design firm working through a variety of methodologies to research the material logic's implication on the design process. Specifically, the Cast Thicket proposal examines tensile concrete molds through the use of plastic formwork and a layered structural network. For this production, Buro Happold and Crow Corporation were once again used as the structural and metal fabricators, respectively. TOPOCAST Lab provided fabricating and casting services, with yo-cy coordinating with the TEX-FAB team to provide production details and project development.

Cast Thicket builds off of an existing trajectory of tensile formwork dating back to the turn of the 19th century that has gained more traction with the work of practitioners like Miguel Fisak and more recently, with the work of Mark West. The current work of Cast Thicket differs from some of the past precedents using fabric formwork on several levels. First, the use of .03" polypropylene sheets in small patches with integrally fabricated seam connections puts increased emphasis on the seams, both formally and logistically. Second, the overall organization uses a tensile network of struts and nodes to distribute load and create space. These combined strategies allow for a series of discrete mold patches to make interconnected struts from a single pour (fig. 6).

The formwork is stitched and laced up throughout a larger scaffolding that provides an overall tensioning and rigidity to the piece prior to casting (fig. 7). The polypropylene parts, which have all been custom cut on the CNC, are formed around the structural steel. The steel is a series of 3/16th plate stock parts that have been cut to a specific length and profile on a metal laser cutter in order to lock into pipe nodes throughout the entire system. The steel then floats internally of the polypropylene to provide the space for the concrete to be poured. The concrete is a custom-formulated mix of high-strength, low-viscosity, white concrete. With a series of admixtures that provide controlled set-time, flowability, weight, and color, the yo-cy and TOPOCAST team arrived at a composition that ensured that the pouring of the highly-intricate forms could be accomplished given the mixing and delivery method of the concrete.

One of the key factors in the APPLIED competition was to establish a case study for how specific research knowledge could be transferred to a different working group. In this regard, the procedural approaches of both material testing and digital tool implementation had to be closely documented and specifically communicated. This was tested through a series of prototypes done by TOPOCAST Lab prior to initiation of the large cast, to ensure a higher probability of success and to formulate best practices as well as continued research development in mix composition. In addition, all production and development between yo-cy, TOPOCAST, Buro Happold, and Crow Corporation was conducted through a common digital database and parametric model. This approach further solidified a growing belief within the manufacturing/design paradigm that the use of a 2D drawing is no longer relevant. At no point in the process of production were 2D drawings needed or used. While it might be premature to abandon this completely, the discussion on this issue has evolved significantly over the past decade, and within this research context, it was valuable to evaluate the effectiveness of this working methodology for the purpose of research collaboration.

SKIN: PERFORMATIVE FACADES

In February of 2013, TEX-FAB launched the SKIN: Performative Facades Competition with the intention of leveraging parametric and fabrication research methodology towards a targeted building component. The building envelope represents the most complex and fundamentally linguistic element of architecture today. Its formal development and performative capacity is foundational to its purpose and presents a dialogue the building has with itself and that of its context.

Once again, an internationally recognized panel of experts judged the competition. Neil Denari, James Carpenter, Mic Patterson, Bill Zahner, Skyler Tibbits, Randy Stratman, Gregg Pasquarelli, and Maria Mingallon evaluated entries from around the world from a diverse set of competitors. The jury selected Nicholas Bruscia and Christopher Romano's proposal, 2xMT, for its rigor and clarity. The team is able to leverage a technical elegance out of the material capacity of a self-structuring architectural screen using textured stainless steel. By focusing on the relationship between the structural and the specular qualities of the surface, their research explores a unique territory that relies on the methodological implications of rolled thin-gauge metal. After the metal has been processed with the appropriate texture for both strength and specular qualities, it is then precisely folded into either tetrahedron or octahedron configurations. Once clustered, the surface begins to take on self-structuring capabilities and leads to a freestanding wall. To further refine the scheme, the team coordinates gauge thickness, module geometry, and texture relative to location within the global system to implement specificity into the facade.

The 2xMT team evolved into the 3xLP team for the prototype for the TEX-FAB 5 exhibition. The nomenclature reflects an associated shorthand used to describe the texture and module in each prototype (fig. 8). The 3xLP team, assisted by Phil Gusmano and Dan Vrana, has a longstanding research relationship with Ridgidized Metals Corporation. The company is located in Buffalo, which has allowed Nicholas and Christopher an opportunity to cultivate a critical relationship with the manufacturer of the material and leverage the research capacity of the University of Buffalo SUNY where they both teach in the Department of Architecture. It is precisely the discovery of these types of relationships that the TEX-FAB platform is set up to further cultivate and promote. As part of the sponsorship as well as the larger mission of TEX-FAB, the A. Zahner Company was secured as a fabrication and technical sponsor for the competition. This meant the execution of the 3xLP project was a collaborative effort between the team from the University of Buffalo, Ridgidized Metals, Zahner, and TEX-FAB, all working together to produce the prototype. The final piece of the team was the inclusion of ARUP as the engineering consultant, providing FEA analysis. All production took place in Kansas City at the main Zahner facility and was shipped to Austin in mid-February in time for installation by the 3xLP team (fig. 9).

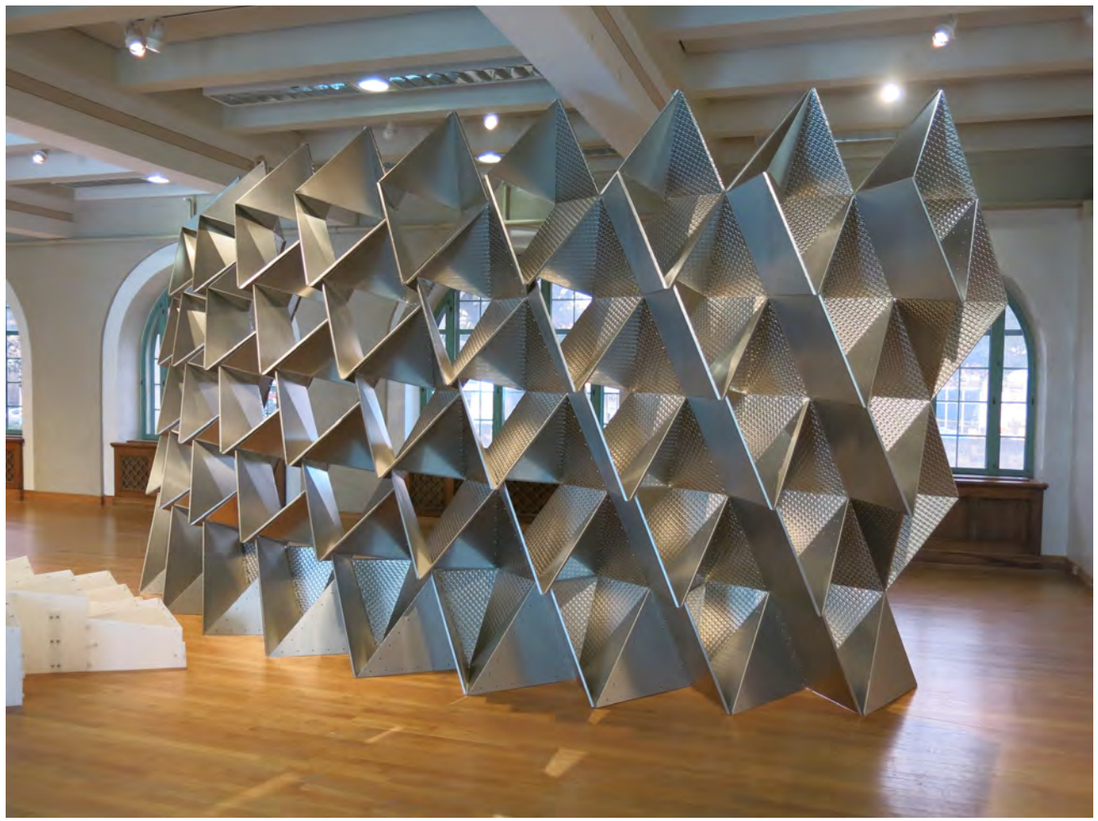


Figure 9: 3xLP, winner of the SKIN: Performative Facades Competition, by Nicholas Bruscia and Christopher Romano. SKIN: Digital Assemblies Exhibition, The Mebane Gallery, UT Austin School of Architecture, 2014.

This working process marks a new turning point in the competition model. With sponsors providing not just technical advice or financial support but also taking over complete production, there is a more rigorous integration between the design research and fabrication research. The overlay of industry methodologies introduces procedural techniques that must either be accepted or modified in order to make something. It is at this intersection that the desire to innovate becomes the sharpest within the architectural component.

CONCLUSION

In Finland, it is customary to hold a competition for almost every public and civic work of architecture that is constructed in the country. It is embedded into the DNA of the design culture and is oftentimes the launching point for many young Finnish design firms. The history of this goes back to the Eliel Saarinen's winning proposal in 1904 for the Helsinki Railway Station. Nearly 100 years later, Steven Holl's Kiasma, resulting from an invited international competition, stands next door as the first significant cultural work done by a U.S. architect in Finland. The government has actively and consistently pushed for new ideas in architecture. In this regard, it is an agent for innovation and opportunity that is equally as important as any of the buildings being brought forward through this process. However, all this can only happen because culturally, there is a collective value placed on design. This reciprocity facilitates interest matching opportunity and vice-versa.

TEX-FAB is not a cultural agent, but it is an organization that is leveraging the competition to connect a growing interest in design research with computational design and fabrication. Specifically, TEX-FAB is doing this in a way that is providing a novel space for young designers to collaborate with technical, professional, and manufacturing experts to advance their research agendas. The TEX-FAB competitions are a new collaborative model for how local and global networks can blur boundaries and find greater opportunity in the knowledge base of many versus just a few.

ENDNOTES

1. A brief history of major global design competitions over the past 250 years can be found in Paul D. Sprieiregen, *Design Competitions* (New York: McGraw-Hill, 1979).

2. http://www.think-space.org/en/competitions/past_forward_competitions/yokohama/

3. http://www.archilab.org/public/2000/catalog/speaksen.htm

IMAGE CREDITS

Figure 1: Forgemind ArchiMedia

Figure 2: Brad Bell

Figure 3: Kevin Patrick McClellan

Figure 4: Erik Verboon, courtesy of Buro Happold New York

Figure 5: yo-cy: Christine Yogiaman & Ken Tracy

Figure 6: Kevin Patrick McClellan

Figure 7: Brad Bell

Figure 8: Christopher Romano & Nicholas Bruscia

Figure 9: Andrew Vrana