Nanotectonica: Architectural Design Studio and Table Top SEM

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Inspired by architect Frei Otto [1] and design scientist Buckminster Fuller [2], third year Pratt Institute design students from Jonas Coersmeier's design studio and research seminar (of Spring 2008) utilized a Table Top SEM to observe micro and nano-scale features produced solely by Mother Nature. After analyzing and documenting the intricacy, beauty and functionality of natural structures, students selected structural entities typically not observed on the macro scale, and utilized the micrograph data to generate analytical drawings followed by generative models for design of a large span structure that would become an aquatic center in the Williamsburg neighborhood of Brooklyn, N.Y..

The theory of the course was to challenge the student's ability to operate between the very small and the very large when creating an architectural structure. In the coupled fabrication seminar (where the Hitachi TM-1000 SEM was operated, Figures 1A and B) and research studio were students created drawings and paper models [3] students first chose micro and nano-scale features from natural structures viable for building long span models. This process included several analog and digital optimization routines and parametrically revisited several such procedures developed by Frei Otto and his Institutes.

Analog optimization techniques were met with and put in close exchange with advanced geometric operations. Embracing Otto's notion of natural structures, students went beyond idealizing living structures as resolved and completed systems (bionic), and beyond copying those systems in their full complexity (biomimicry), to instead search for procedurally optimized building methods employed in the natural model. At the nano-scale the physics and material properties of natural organizations change drastically. Gravity is no longer the dominant force when the size of the system radically decreases. The SEM allowed glimpses into organizational systems that work beyond the logic of primary gravitational considerations.

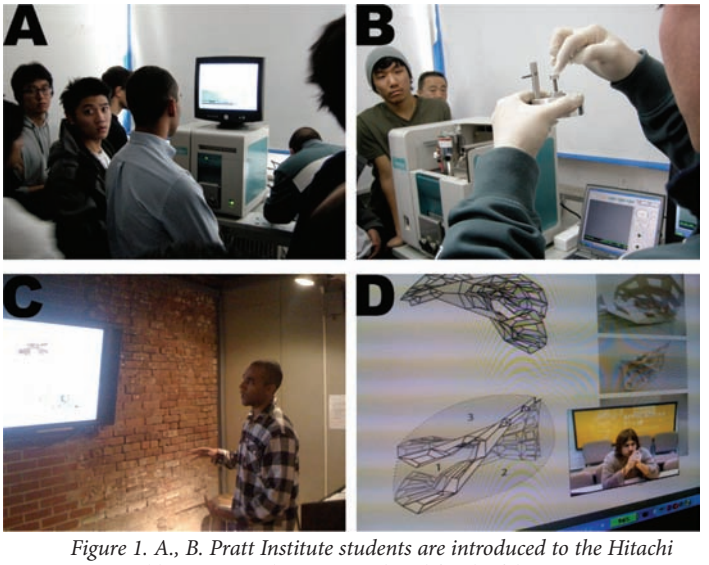

Figure 1. A., B. Pratt Institute students are introduced to the Hitachi TM-1000 Table Top SEM that was employed for the fabrication seminar. C., D. Students presented their SEM findings, methodology as well as generative drawing results during video over IP sessions between Pratt Institute and Appalachian State University, receiving expert feedback in nanotechnology related discussions. [Seminar Jonas Coersmeier, Pratt Institute NY, Spring 2008. Students: Changyup Shin, Edwin Lam, Jerome Hord (A.); Won Choi (B.); Jerome Hord (C.). Application specialist Terry Suzuki, Hitachi (B.).]

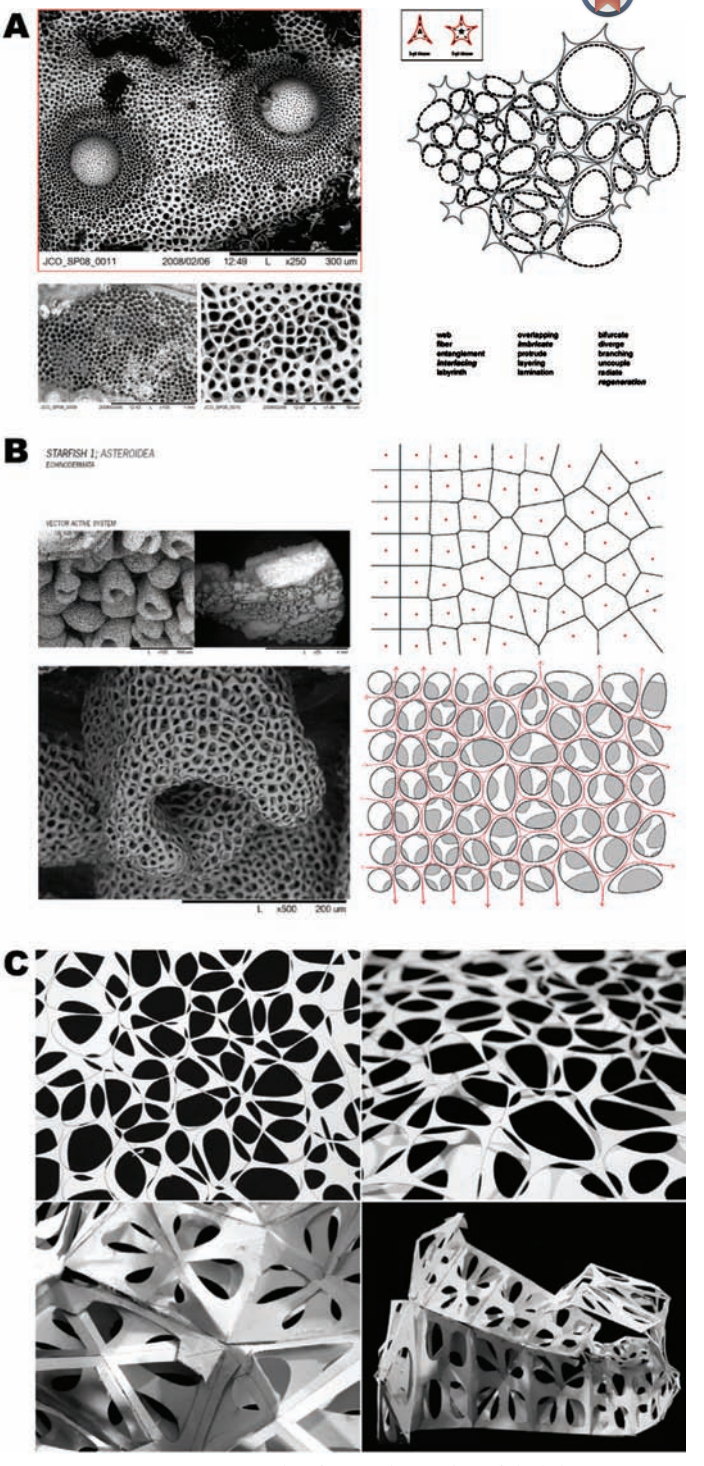

Figure 2. SEM micrographs of sea urchin and starfish skeletons were analyzed by means of architectural drawing techniques and processed in generative drawings, revealing vector active regions of ultrastructure. Laser cut paper models are derived from the drawings. The transition between various media parallels the transition from the scientific method to the speculative design method. (Scale bar A top left is 3mm; B bottom left is 200 mm.) [Seminar Jonas Coersmeier, Pratt Institute NY, Spring 2008. Student work: Jerome Hord (A., B., C.).]

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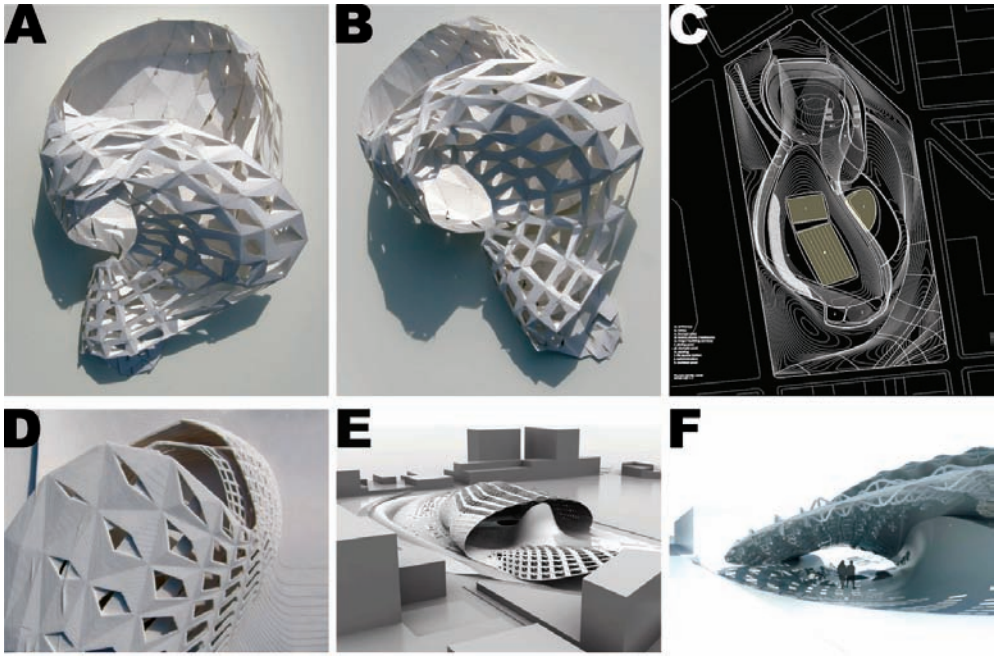

Figure 3. Laser cut and manually assembled paper models (A., B., D.), Nurbs based line drawings (C.), 3-D printed physical models (E.) and computer generated renderings (F.) and are main media employed in Studio Jonas Coersmeier. Constant transitions between various media act as design catalysts in the architectural process. [Studio Jonas Coersmeier, Pratt Institute NY, Spring 2008. Student work: Won Choi, Changyup Shin (A.,B.,D.); Jerome Hord (C.); Ivan Delgado (E.,F.).]

Students chose to explore structural moieties contained in a variety of specimens that included star fish, fish scales, shrimp tails, sea weed, sea urchins, and coral. Following micrograph data collection, the students created generative drawings from the natural patterns present on the aquatic SEM samples (Figure 2). Digital models were developed parametrically and provided source data for both 3-D printed physical models and laser cut templates to be assembled as tectonic propositions. Ultimately, the fabrication techniques were an approach to analyze, process and enhance the source material. These physical models were then tested in the context of a long-span structure and employed in the comprehensive design studio.

The studio, while focusing on production and fabrication, based its exploration in the context of the history of science. Science proper emerged out of proto-science in the 17th century. The driving forces of this first scientific revolution emanated out of the exchange between technological innovation, such as aids for superhuman perception (microscope, telescope) and early modern philosophy. What resulted was discussed in the context of materialism, in our current paradigm shift and in relation to this earlier phase transition including its ideal of objectivity, (the world as it is). Combining Table Top SEM research and digital production, the studio and seminar offered a critical understanding of such fundamental concepts in the history and theory of technology.

The seminar also offered a discussion of structural system taxonomies as they were established in the 20th century by Frei Otto, Heino Engel and Robert le Ricolais. According to Otto, the building structures that we have been occupying for ten thousand years are still not entirely understood, nor were they put in relation. His matrices of principal systems and applied structures have open cells, which distinguishes them from other completed classification systems and thus invited the students to fill in blank spots. Attempts to address these 'blanks' were made by identifying nano-structures within the taxonomy. The students were encouraged to read their structural propositions in the context and against these classification systems, identifying hybrid- and possibly novel structure systems.

The seminar portion of the course was held in the form of group discussions between instructor (Jonas) and student presenters as well as integrating three guest lecturers: Rhett Russo (University of Pennsylvania); Lily Zand (Principal Q LLP) and Donovan Leonard (Appalachian State University). To promote collaboration between two distant locations, Brooklyn, N.Y. and Boone, N.C., video over IP was used for student presentations and discussions (Figures 1B and C).

Success of the course was gauged by the creativity and quality of artifacts students submitted for the mid-term and final reviews. Figures 2 and 3 show examples of the students design process, originating with SEM micrographs, followed by analytical drawings and resulting in laser cut 3D paper models. Students were challenged by requiring critical understanding of universality and of scale through the transposition of nano systems into long-span structures. Size, form and craft were all considerations that needed to be included in the final projects and from the results shown in Figures 2-3 and as well as references [3] and [4], it is clear the class overcame many obstacles to produce stellar examples of architectural design that challenged conventional perception of both use of space and aesthetics. Creating this novel approach to a design course, which introduced and implemented electron microscopy, was a pioneering undertaking that demonstrated an application of Table Top SEM in the architectural design process. It is the hope that the vast landscape available at the micro and nano-scale will continue to be an inspiration for the next generation of architects and design students who can bridge the parallels between art and science. ■

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References:

[1] Frei Otto: Sonderforschungsbereich 230, Universität Stuttgart and Institute für leichte Flächentragwerke, Stuttgart.

[2] http://www.bfi.org

[3] http://www.probelog.com/span

[4] http://www.probelog.com/span/works