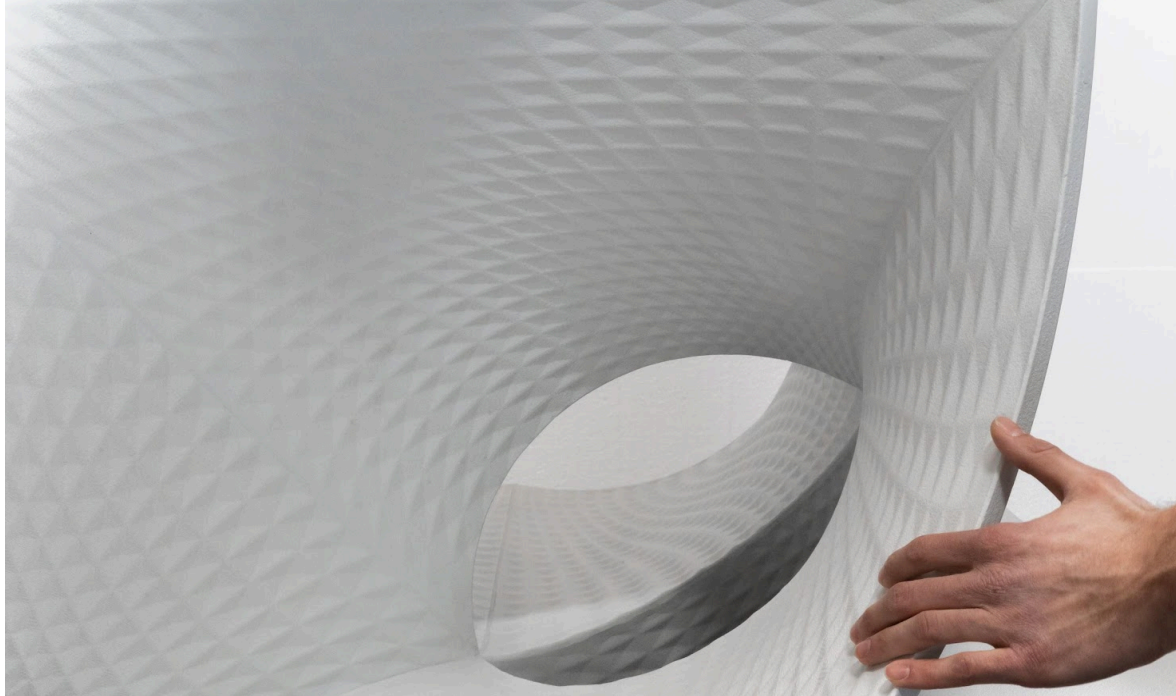


Taubman College of Architecture and Urban Planning | University of Michigan | Winter 2021 | ARCH 571 | Fri 1:00-4:00pm | <https://umich.zoom.us/j/93093456790> | Meeting ID: 930 9345 6790 | Mania Aghaei Meibodi | meibodi@umich.edu Instructor: Mania Aghaei Meibodi meibodi@umich.edu



Shaping concrete through 3D printed formwork, Batwing Minimal Surface, Mania Aghaei Meibodi (University of Michigan), Pietro Odaglia and Benjamin Dillenburger (DBT, ETH Zurich)

Computing Minimal Surfaces

The Winter 2021 Advance Digital Fabrication course will focus on creating novel facade systems through exploring Minimal surfaces combined with additive manufacturing.

A minimal surface is the surface of minimal area between any given boundaries. Physical models of minimal surfaces can be made by dipping a wire frame into a soap solution, forming a soap film, which is a minimal surface whose boundary is the wire frame. The soap film is the result of an equilibrium of homogeneous tension. Frei Otto had extensively experimented with minimal surfaces via soap films. Thorough material computations – physical “form finding” – he discovered optimal shapes for tensile structures relative to given or selected boundary conditions.

This course will further explore the materialisation through additive manufacturing. Additive manufacturing, also known as 3D printing, is revolutionising architecture and building processes. When applied to architectural elements, it enables geometric

complexity, customisation, precision, material reduction, and integration of multiple functions. This technology will not only lead to the materialisation of novel geometrically-complex forms, but it will also enable the integration of multiple functions in a single building element through a fully digitized design-to-production process.

How will the coupling of this technology with minimal surface transform the building facade and its production process? While there are many additive manufacturing technologies that could produce a facade, this course will focus on the fused deposition modeling (FDM) as the primary fabrication method. Using FDM for facade will:

- Enable the economical production of lightweight parts in any shape regardless of their geometric complexity.
- Create a zero waste fabrication process.
- Allow for the use of recyclable building materials, for a more sustainable built environment.
- Cut down on transportation costs.
- Reduce the overall weight of the building.

To create a part, FDM uses thermoplastic to deposit material layer by layer. Precedent projects such as the Fluid Morphology installation developed by Moritz Mungenast, Cloud Affects and B515 Studio directed by Roland Snook, and Digital Composite by Hyunchul Kwon showcase the potential of this technology when applied to large-scale freeform facades and architectural screens. The combination of this technology with minimal surfaces are explored in Functionally-graded facade by Yoana Teseva, etl. and Min-Max by Mania Aghaei Meibodi, etl.

In this course, students will work in groups of two to design and build a facade prototype. Facades require a high degree of customisation in order to respond to the site-specific context. Using the geometric freedom offered by 3D printing, students are asked to rethink the facade and its many functional layers, in response to the environmental, social, economical, and political changes of the twenty-first century.

Functional Layers

Sun shading

Acoustic

Rain water flow

Daylight penetration

Natural ventilation

Thermal insulation

Structural performances

Directing views

Transparency and opacity
Etc

Assignment 1:

Students will work in pairs to explore a minimal surface:

1. Each group will select a triply periodic minimal surface to explore
2. Explore will experiment with soap film to create a minimal surface. Document its material computation through video and series of photos presenting form finding processes. Ensure to have a clean and plane background in your videos and pictures.
3. Using Rhinoceros construct your minimal surface and document the process in one page. Make sure to add thickness to your minimal surfaces.
4. Reading selection
5. Watch the following videos

[Alan Schoen performs a presentation on Soap Films and Minimal Surfaces](#)

['Shapes of Soap Films': Triply-Periodic Minimal Surfaces \(Alan H. Schoen\) part 1](#)

['Shapes of Soap Films': Triply-Periodic Minimal Surfaces \(Alan H. Schoen\) part 2](#)

['Shapes of Soap Films': Triply-Periodic Minimal Surfaces \(Alan H. Schoen\) part 3](#)

['Shapes of Soap Films': Triply-Periodic Minimal Surfaces \(Alan H. Schoen\) part 4](#)

Submission Deadline: January 29 2021 @ 6.00 AM

Deliverables:

- Rhino file of the minimal surface without thickness and with thickness and its digital construction stages. The file should include the evolution steps of the surface.
- two presentation boards A3/legal that illustrates the digital construction of minimal surface (evolution of Surface), renderings, drawings that indicate its dimensions (in PDF format).
- one-two A3 presentation board that presents the physical form finding process.
- a folder with picture series and rendering

Name your two files as: A1_LastName_LastName

Submission Folder:

<https://drive.google.com/drive/folders/1thGRcB5VbXxzaqdyRU3kRD7uubuabgMe?usp=sharing>

All Deliverable must be uploaded the night before the assignment to:

Each person/group must upload their material in the assignment folders in the link below:

https://drive.google.com/open?id=1Pd_Df5Q3tUeLRN4rm6bxm6sHs5FvuJmd

Name your file as: Arch 571_A(Assignments number)_LastName/s_Filetype

Example: Arch 571_A1_Mcgee_Meibodi_Rhino

GRADING Assignments 1, 2, 3 30% (10% each for 30% overall) Assignment 4 (MidReview) 15% Assignment 5 (Main Project) 35% Independent learning, Workshop and Presentation 10%** Readings, Discussions, and Presentations 10%** Attendance / Teamwork Engagement 10%

A=Excellent,

Work must reflect outstanding achievement in both content and execution. Work must far surpass the given requirements. Outstanding in collaboration and teamwork. B=Good,

Work must reflect high achievement in both content and execution, and must excel beyond the given requirements. Outstanding in collaboration and teamwork. C=Adequate,

Work simply meets the given requirements. D=Poor,

Work is less than satisfactory and minimally fulfills requirements. E=Inadequate,

Work fulfills few if any requirements. I=Incomplete

Grade is ONLY available due to health reasons or other emergency circumstances.

Software We will be using Rhinoceros 6.0 with Grasshopper Plug-in for 3D modeling, IdeaMaker for slicing geometry, Keyshot for rendering. Students are required to provide their own laptops loaded with the proper software and Plug-in for use during class time.

Physical prototyping material We will be using PLA filaments, pellets and concrete mix (cement, fiber, silica flour, silica fume and water). Students are required to provide their own material throughout the course.

Office hours If you require to meet with me outside of class time I can typically meet the following class or contact me via email to set-up another time.

Attendance Policy: Show up and participate in all class meetings and events. You should want

to be there to learn from your instructors and peers. Attendance during all class time is mandatory. More than 1 unexcused absence will result in 1 lower letter grade.

*The topic of independent learning should be with the agreement of the instructor. ** Students can choose between Independent learning of a software/computational method/ algorithm or reading the selected text. Students can also conduct both and gain a bonus point.