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MODULAR ANATOMY

Antifragile Housing Systems

Columbia University GSAPP

Spring 2020, 115 Avery Hall

Wednesdays, 9 - 11 am

Instructor: Andreas Tjeldflaat

Rationale

Providing adequate housing is a challenge for nations around the world – both in advanced and developing economies. The challenge will only grow worse in the coming decades, and by 2025, a third of the global urban population – 1.6 billion people, could be living in substandard housing or be severely financially stretched by housing costs[1]. In the world's twenty largest cities alone, an estimated 36 million new housing units will be needed [1]. Meanwhile, productivity in the construction sector has grown by a mere 6% between 1947 and 2010, compared to an estimated 760% in the manufacturing sector [2].

One of the biggest leaps in productivity could be achieved through the use of more prefabrication and modularization in the construction process [2]. As a result, the modular construction industry is predicted to grow at a staggering rate in the coming decade. However, current modular construction practices present inherent weaknesses: a severely limited design range and restricted capacity for customization. Consequently, standardization is well-suited to meet the quantitative housing needs, but unsuited to meet the need for variety in the housing market.

This course proposes a framework to capitalize on this inflection point by leveraging a system-based, modular approach to architectural design with emerging material and manufacturing technologies. This coupling eliminates the trade-off between design complexity and variation on one hand and labor cost/time on the other, allowing components to take on systemic and geometric complexity and facilitate rich programmatic organization of space. This approach has the potential to galvanize housing into a flexible, agile system that enables adaptation to different modes of living, eases integration of new technologies, prolongs market relevance, and establishes substantive feedback loops between use and design. Modularization is not merely a pragmatic, cost-saving proposition, but an elegant way of designing change into buildings – enabling conservation and innovation to coexist.

> "Antifragility is beyond resilience or robustness.
> The resilient resists shocks and stays the same;
> the antifragile gets better."
>
> Nassim Nicholas Taleb

Aims and Objectives

The principal objective of the course is to equip students with an advanced toolkit for developing modular systems and to explore how modularity can enable adaptive housing environments, treating time as a key design parameter.

While the notion of modularity in architecture usually refers to the fabrication and assembly of a series of standardized building components, the concept forms an intricate, comprehensive body of knowledge in the fields of mechanical engineering and interaction design. An adoption and re-appropriation of these methodologies will serve as the primary departure point for the course and will provide the student with a broadened understanding of the organizational, hierarchical, and spatial capacity of modular systems.

The course will investigate the design intelligence of modularity at three different scales. At a unit and assembly level, it will explore parameters such as geometry, materiality, scale, and proportion to strategically respond to functional, experiential, and social needs. Secondly, through studies of aggregation, the course will investigate the system's internal capacity for structure and spatial organization – calibrating factors such as density, porosity, hierarchy, and diversity – as well as its fitness for interfacing with external systems. At the highest level, the course will explore modularity's potential to reposition relationships between the architect, the client, and the services of architecture: supporting new ownership models, advancing participatory design practices, and integrating architectural services into circular, product-service systems.

Format and Procedures

The course is structured around weekly workshops with mini lectures, class discussions, and student presentations. The introductory weeks of the course will focus on historical and current states of modularity in architecture and design, principles of design for manufacturing, emerging trends and patterns of urban housing, and how modular systems are capable of intervening and supporting changing needs and wants. This is intended to give the students a collective foundation for the production-focused period of the course.

Students will form teams of two and be tasked with the development of a modular housing system in response to a set of design constraints. The project will be advanced and iterated through four sequential assignments, intended to progressively increase design resolution and prompt refinement of system modules, interfaces, and assembly protocol. The project will be reviewed in weekly progress meetings and continuously tested through digital and physical prototyping.

The production of physical prototypes is a critical component of the project synthesis and will be used in tandem with digital discrete modeling and aggregation studies. Each student will develop a set of models and drawings, describing the project catalogue of modules, assembly logic, aggregation capacity, and formal expression.

Course Requirements

Participation

Students are expected to attend all classes and be active participants in class discussions. All absences require proper notification no later than the morning of the class. Please see attendance policy described below. The use of cell phones or other distractions (unrelated software etc.) is not permitted during class.

Self-instruction

Students are expected to expand their knowledge of subject matter and technical skills beyond those presented in class. Encountering problems and developing solutions is part of both the design and software learning process. Your first response to any design or technical problem should be to resolve the issue on your own or with the help of your peers. If you need additional help, you should contact the instructor, while allowing for time to review and respond. Please plan for these setbacks and accommodate their time constraints as part of the learning process.

Recommended Reading

- Karl Ulrich, “Fundamentals of Product Modularity”, Management of Design: Engineering and Management Perspectives, pp. 219-231, Springer Netherlands, 1994. ISBN 978-94-011-1390-8
- Branko Kolarevic et. al., Mass Customization & Design Democratization, Routledge, 2019
- G. Pahl, W. Beitz, Engineering Design, pp 496-500, Springer, 2007
- Karl Ulrich, “The Role of Product Architecture in the Manufacturing Firm”, Research Policy, Vol 24, Issue 3, pp 419-440, http://www.ktulrich.com/uploads/6/1/7/1/6171812/ulrich-architecture.pdf
- Christopher Alexander, A Pattern Language: Towns, Buildings, Construction, Oxford University Press, 1977.
- David Celanto, Innovate or Perish: New Technologies and Architecture’s Future, Harvard Design Magazine No. 26, 2007 (http://www.harvarddesignmagazine.org/issues/26).
- Niklas Maak, Living Complex: From Zombie City to the New Communal, Hirmer Publishers, 2015.
- Cedric Price, Cedric Price: Works II, The Architectural Association, 1984.
- Michael Benedikt, Less For Less Yet, Harvard Design Magazine, No. 7, 1997, (http://www.harvarddesignmagazine.org/issues/7/less-for-less-yet).
- Andrew Blum, Plug+Play Construction, Wired Magazine, January 2007, (https://www.wired.com/2007/01/home1/).
- Stewart Brand, How Buildings Learn: What Happens After They’re Built, Penguin Books, 1995.
- Stanley Mathews, The Fun Palace: Cedric Price’s experiment in architecture and Technology, Technoetic Arts: A Journal of Speculative Research Volume 3 Number 2, 2005

Software

Students are not required to use a particular 3D-modeling software, but encouraged to select software based on their level of proficiency and the program's capability to support formal project ambition (geometry, surface complexity, etc.). The use of external editor plugins (Grasshopper, Wasp, RhinoScript, etc.) is encouraged, but not critical for successful project development.

Grading Procedures

Grades will be based on the student's ability to engage in the projects, their participation in class, timely and adept completion of assignments, and their presentation and production quality of the assignments at the time they are due.

Attendance & Participation:	20%
Assignment 1:	20%
Assignment 2:	20%
Assignment 3:	20%
Assignment 4:	20%

Grading Descriptions

Final grades will be given by the course instructor per grade chart below:

HP (high pass)	Superior level of work.
P (pass)	Acceptable level of work.
LP (low pass)	Work that meets minimal standards.
F (fail)	Work that is unsatisfactory.

Attendance

Attendance at each class and through the assigned time period is mandatory.

2 unexcused absences: Course grade will be affected.
3 unexcused absences: The mark of UW (unofficial withdrawal) will be assigned.

Notification of legitimate absences due to health situations, family issues or similar situations should be made via email to the instructor as early as possible. Documentation of reason for absence will be required by the instructor.

Academic Integrity

Each student in this course is expected to abide by the Columbia University GSAPP Honor System and Plagiarism Policy (https://www.arch.columbia.edu/plagiarism-policy). Any work submitted by a student in this course for academic credit must be the student's own work, except in the cases of projects that are specifically structured as group projects.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from other students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of the work done by someone else.

Notes.

1. Woetzel K., et al.,, A blueprint for addressing the global affordable housing challenge, McKinsey Global Institute, 2014.

2. Changali S., et al., The construction productivity imperative, McKinsey Productivity Sciences Center, 2015.

Tentative Course Schedule

01 | January 22	Presentation of Course Aim, Objectives, and Expectations
02 | January 29	Lecture & Discussion: Modularity in Architecture
03 | February 5	Lecture & Discussion: Modular Product Architecture
04 | February 12	Lecture & Discussion: Functions of Housing Introduction of Assignment 1
05 | February 19	Lecture & Discussion: Dynamics of Housing Assignment 1 Progress Review.
06 | February 26	Lecture & Discussion: Mass Customization & Co-Designing Submission, Assignment 1 Introduction of Assignment 2
07 | March 4	Lecture & Discussion: Organization & Change Assignment 2 Progress Review
08 | March 11	Submission, Assignment 2 “Mid Term” Presentation with guest critics
09 | March 18	Spring Break. No Class
10 | March 25	Lecture & Discussion: Adaptive Systems Introduction of Assignment 3
11 | April 1	Working Session Assignment 3 Progress Review
12 | April 8	Guest Lecture Submission, Assignment 3 Introduction, Assignment 4.
13 | April 15	Working Session.
14 | April 22	Final Review.