



# 732-005: MATTER, MAKING, AND TESTING: DESIGNING WITH NEXT GENERATION PRECAST CONCRETE

TUE 12:00 – 2:45 AUGUST 30 – DECEMBER 6, 2022, 1.0 CU

## COURSE OVERVIEW:

This seminar will focus on precast concrete and specifically its history, materiality – how it is manufactured and the logistics of its assembly - and cultural affects through both its traditional uses within the urban environment as well as new approaches to building typologies such as housing. Through a strategic partnership with Northeast Precast (NEP), based in Millville, NJ, students will gain access to places where precast concrete is made, formed, and put into action. The class will be organized as a seminar, with a group of 18 students. The course is being run in a “hybrid” context, meaning lectures will primarily be remote, however, physical access to materials and methods is an important aspect of the class. In addition to readings and case studies via remote delivery, students will have access to Northeast Precast’s state-of-the-art facility where they will:

1. Conditions permitting, over two weekends, attend two six-hour sessions to learn about the precast concrete manufacturing process. Students will be exposed to the fabrication process from material selection to formwork production, to pour, and disassembly [in lieu of four (4) class periods]. Note weekend sessions are *optional*, but highly encouraged. Transportation will be provided.
2. Utilize NEP’s facilities and their workforce, a group of professional engineers and concrete experts. Students will work in teams to produce panel prototypes for wall assemblies that respond to structural, thermal, and water-proofing performance; and receive feedback from NEP’s expert staff on the construction feasibility and applicability of student-proposed prototypes. Students will be expected to produce digital and to the extent possible physical content to be exchanged with the team at NEP.
3. Develop a delivery workflow utilizing digital tools to communicate with and transmit panel, assembly and formwork concepts to NEP staff, fostering a collaboration opportunity for students that is not regularly experienced in architecture school. This workflow will allow students to virtually study panelization schemas and jointing, as well as panel performance characteristics, ahead of actual prototype preparation.

## LEARNING OBJECTIVES:

The seminar will have three distinct parts which will be equally divided in course delivery over the 15 scheduled meetings. A final presentation and discussion will be held with representatives of Northeast Precast prior to the end of the semester. The idea being that participating students build knowledge and content through the semester in:

### Lectures on the History and Technology of Precast Concrete

A history of reinforced concrete from the turn of the 20<sup>th</sup> century, and more specifically the rise of precast in the 1950's as part of an offsite, factory-based movement within the construction industry, will be explored. Specifically, concrete's relationship (or lack of) with both modernity and nature will be considered. As a material, it is equally an advancement of 19<sup>th</sup> and 20<sup>th</sup> century technology in both engineering and chemistry – becoming synonymous with new architecture and various utopian movements; as well as a result of simple and time-tested labor operations requiring no special knowledge or expertise. In 1913, Walter Gropius published, in the German magazine *Deutscher Werkbund*, images of large reinforced concrete grain elevators from America, captivating European architects and ushering in a 20-year period associating the material with modernity. Lectures will also engage topical issues including sustainability, carbon entrapment, and concrete's relationship to ecology; and be supplemented through a variety of readings to be distributed to the class.

### Introduction of Novel Precast Precedents

Following an introductory lecture on the first day of class, precedents will be presented throughout the seminar that range in scale from houses to larger scale buildings of various typologies. Case studies will include buildings by **August Perret**, **mOorphosis**, **Steven Holl**, and **Herzog & de Meuron**, as well as the instructor. Each will be introduced and paired with weekly readings. Readings will introduce concepts surrounding the case study and the workflow that produced it. Projects are selected not only for their cultural and technical novelty, but for the unique and increasingly digital processes that bore them. Student groups will organize brief presentations for each case study following by a lecture that links the precedent to the weekly reading. It is expected student teams study understand both the architectural or technological significance of each case study, as well as the workflows that bore them.

### Group Collaboration / Development of Digital Content / Mock-ups

Students will ultimately be responsible for a precast mock-up that will be produced at and in collaboration with Northeast Precast. Working in teams of three (3) to four (4) students will work collaboratively to produce all (virtual) information required to realize the precast mock-up at full scale, as well as a panel schema with joint patterning and formwork images that will position the mock-up within both larger and more local scales. Final seminar deliverables will be the mock-up, produced in conjunction with NEP, as well as documentation including shop drawings that express the mock-up production process and simulations that study panelization and structural feasibility. During the seminar's two scheduled workshops, students will have access to NEP's various CNC capabilities, including plasma cutters, multi-axis routers, wire-based foam cutters, and full metal shop. NEP works primarily with Revit and has requested the seminar work with Autodesk's Structural Precast Extension for Revit as a basis for shared documentation. In 2022 we will specifically be focusing on *leanness* using Ultra High-Strength Concrete (UHPC) a cementitious composite material composed of an optimized gradation of granular constituents with a low water-to-cementitious materials ratio and a complete replacement of rebar with discontinuous internal fiber reinforcement. The goal is to propose thinner panels with less cement to achieve a more sustainable basis.

## MEANS OF EVALUATION:

As an upper-level graduate seminar, it is understood that all students will attend all classes whether virtual or otherwise, participate in class lectures and discussion, and complete all assignments. While the weekend workshops are necessarily voluntary, students are strongly encouraged to participate on the two (2) trips to the Northeast Precast facility. Grades will be based on class participation, group presentations, and a final project in which student teams will develop a digital workflow to yield a product, which will be an object or architectural component. Some readings will be assigned to ground introductory lectures.

- Class participation and readings (25%)
- Mock-up documentation (30%)
- Final mock-up (30%)
- Attendance (15%)

## GRADING:

Weitzman instructors, except for the Department of Fine Arts, apply a grading system of letter grades as follows:

A+	=	4.0	
A	=	4.0	
A-	=	3.7	
B+	=	3.3	
B	=	3.0	
B-	=	2.7	
C+	=	2.3	
C	=	2.0	
C-	=	1.7	
F	=	0.0	Failure
I	=	0.0	Incomplete

Students enrolled in Architecture degree programs are issued letter grades.

## SCHEDULE

Week	Date	Topic
01	August 30	Introduction, a history of reinforced concrete, development of precast
02	September 6	Precast houses and simulation
03	September 13	Reinforced concrete and utopia
04	September 20	The precast production plant
05	September 27	Rise of prefabrication: precast buildings 1950's thru 1970's
06	October 4	Shop drawings
	October 8	Northeast Precast Work Session 1 (6 hours) (TBC)
07	October 11	Panelization, Rhino > Revit workflows (in-class work session)
08	October 18	In-class work session with NEP team
09	October 25	Advanced forming techniques and robotics
10	November 1	NEP feedback via Skype 10AM
	November 5	Northeast Precast Work Session 2 (6 hours)
12	November 8	No class
13	November 15	No class
14	November 22	No class, Thanksgiving break and final reviews to follow
15	Final Meeting	Group presentations, guests TBD

## ACADEMIC INTEGRITY:

Codes of Student Conduct and Academic Integrity: Please familiarize yourself with these documents as published in the University of Pennsylvania PennBOOK - <http://provost.upenn.edu/policies/pennbook>, and as recommended on the Provost's website:

<https://provost.upenn.edu/policies/pennbook/2013/02/15/code-of-student-conduct>

<https://provost.upenn.edu/policies/pennbook/2013/02/13/code-of-academic-integrity>

## SELECTED BIBLIOGRAPHY

As an upper-level graduate seminar, students are expected to read a series of selected essays and participate in group discussion as part of our weekly class. All readings will be provided.

Reyner Banham, **A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture**, MIT Press, 1989

Martin S. Briggs, “**Architectural Models I**”, The Burlington Magazine for Connoisseurs, April 1929

Le Corbusier, **Towards a New Architecture**, Dover Publications edition, 1986

Esther Da Costa Meyer, **The Work of Antonio Sant'Elia: Retreat into the Future**, Yale, 1995

Manuel DeLanda, “**Philosophies of Design: The Case of Modeling Software**”, Verb: Architecture Boogazine, Alejandro Zaera-Polo and Jorge Wagensberg (eds), Actar (Barcelona), 2002.

Andrea Deplazes, “**On the Metaphysics of Exposed Concrete**”, in Constructing Architecture, Birkhäuser 2005

Adrian Forty, **Concrete and Culture**, Reaktion Books 2012

Richard Garber, **BIM Design: Realizing the Creative Potential of Building Information Modeling**, John Wiley & Sons 2014

Sanford Kwinter, “**La Cita’ Nuova: Modernity and Continuity**” Zone 1|2 The Contemporary City, Jonathan Crary and Sanford Kwinter (eds), Urzone, 1986

Eric Owen Moss, **Construction Manual 1988-2008**, AADCU, 2009

W. Noble Twelvetrees, **Concrete and Reinforced Concrete** (*Pitman’s Common Commodities and Industries*), Sir Isaac Pitman and Sons, Ltd. 1922

**APPENDIX:** Work session 1 at Northeast Precast (NEP) Saturday, October 8, 2022 (*date to be confirmed*)

- 10:30 Introduction to NEP with short PPT
  - Highlight of capabilities and past projects
- 11:00 –12:30 Plant tour
  - NEP team will have various stages of production staged for the students to witness. They will get to witness the following:
    - EPS Foam cutting
    - Panel forming
    - Pouring Concrete
    - Panel Stripping
    - Yard Storage
    - Concrete Batching
- 12:30-1:00 Lunch
- 1:00-2:00 Presentation on Engineering process
  - Introduction to how we take a project from concept to production
    - Panelizing a building
    - Construction/Erection drawings – 2D/3D modeling processes
    - Review process
    - Shop Tickets – highlighting digital information to be included in shop drawings
- 2:00-2:45
  - Presentation on the properties of concrete
- 2:45-3:30
  - Participate in hand batching small quantities of concrete
- 3:30-4:30
  - Discuss how the students will design their mockup panels
    - Review deadlines
    - Discuss material selection including formwork types and concrete materials

Northeast Precast will host visits to its precast plant on October 8 and November 5, 2022.

