2017-2018 Creative Achievement

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32708
SCALING UP!
CRAFTING THE FUTURE OF CONCRETE IN THE ANTHROPOCENE

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6 credit: ‘Directed Research’ Professional Elective

The Design / Research Studio, “SCALING UP” is the first of its kind at Syracuse University, known as ‘Directed Research’ that combines research (seminar) and design (studio) to form a new collaboration between students, professors and industry. This studio was sponsored by CEMEX Global R&D to support the study of innovative architectural design that combines concrete, infrastructure and the environment.

Objectives: The course explores the future opportunities for full scale architectural elements that arise from the combination of high performance concrete, contemporary design and fabrication with climatic issues we face today. The world of concrete is moving at a rapid pace, from complex geometries to the latest material and digital technology available and they are interested to see how students can redefine the concrete industry through new and innovative design strategies that will Craft the Future of Concrete in the Anthropocene. And in turn, those design strategies have the potential to begin Crafting the Future of Our Cities. But how do we begin to ‘SCALE-UP’ beyond small-scale objects and pavilions to achieve high quality and efficient infrastructural strategies that respond to the environment?

New concrete technology being studied was no longer seen as ‘fixed’ and permanent but rather as an emergent material that adapts to its environment. The focus was on opportunities that create more dynamic interaction between materiality and the environment to preserve and protect nature and bring more biodiversity to the city. In turn, this offered better living conditions for humans and non-humans alike. Questions asked of the studio: What infrastructural forms can serve as a provocation for productive change? Is there a new type of urban public space that derives from merging infrastructure, ecology, and materiality to create more sustainable cities?

Constraints: To give students a guideline, the design investigation dealt with issues of materiality and environment. The students designed stacked forms within a given bounding box to become infrastructural interventions that sustain biodiversity in the city. Questions asked of the studio: How does the ‘responsive structure’ connect to local ecologies? What systems exist for controlling environmental conditions, such as ventilation, filtration, or flooding etc.? How does materiality play a role in infrastructure and public space?

Design Research: We were asked to participate in the the Malaysia Biennial 100YC, and the goal set forth was to ‘identify disruptive patterns of global change and impacts on architecture, urbanism and life for the city of Medini.’ The aim of the research was to discover infrastructural opportunities within the city through the lens of a material. The students studied the environment and climatic changes of the site in Medini, Malaysia, some of which addressed issues of wetland depletion in the region, loss of ecosystems and local species, flooding due to heavy rainfall, and polluted storm water runoff leading to rivers and reservoirs. They also studied and attempted to hybridize various types of high performance concrete, such as high strength, porous, and extremely lightweight mixes to invent new uses for the material.

Design Response: In response to the above research, each group designed a ‘Responsive Urban Concrete Structure’ that could become new green infrastructure for Medini. The aim was to use concrete, the most commonly used infrastructural material in the world, and transform it into new, green infrastructural opportunities within the city. All of the projects take on water, concrete, and conservation as a framework for the design strategy. Concrete becomes stronger when exposed to water and has the opportunity to be rethought for more intelligent purposes when using more sustainable, high performance concrete technology. Each project takes on a common urban problem, whether that be reducing the urban heat island effect, controlling storm water runoff, addressing pollution and water filtration, introducing local ecologies for more biodiversity, or reducing energy consumption. In turn, the students used their architectural interventions to play a pivotal role in redefining the City of Medini through infrastructure, ecology, and materiality.

Submission: The following pages outline the class structure, assignments, research, early design strategies, concrete casts, and final student projects. Each of the projects outlines the student’s conceptual goals for the urban intervention and how the project addresses an environmental need with an infrastructural strategy using new concrete technology and fabrication techniques. The final project had additional time during a summer internship at CEMEX Global R&D to develop their ideas and casting methods further.
SCALING UP: CRAFTING THE DIGITAL FUTURE OF CONCRETE | JULIE LARSEN | APPLICATION FOR 2017 ACSA CREATIVE ACHIEVEMENT AWARD

The course explores the future applications of digital fabrication and design thinking, focusing on the integration of new digital tools and processes. The course will be divided into two main parts: SPECULATION and IMPLEMENTATION.

SPECULATION

The first 8 weeks of the course will focus on SPECULATION. During this time, students will explore new concepts, ideas, and techniques through digital tools and processes. This part of the course will emphasize the exploration of new materials, technologies, and design approaches. Students will work in small groups to develop a series of speculative design ideas.

IMPLEMENTATION

The last 6 weeks of the course will be dedicated to IMPLEMENTATION. During this time, students will work on translating their speculative design ideas into physical prototypes. The course will culminate in a final exhibition of student work.

REQUIREMENTS

- Digital proficiency in 3D modeling software such as Rhino, Grasshopper, or Maya
- Proficiency in research and writing
- Collaboration and teamwork
- Ability to work independently and as part of a team

SUPPLIES / MATERIALS

- Laptop with Rhino, Grasshopper, or Maya software installed
- Access to 3D printing facilities
- Access to 3D scanning equipment
- Access to concrete casting and forming equipment

SYLLABUS

COURSE EXPECTATIONS

- Produce design ideas at the highest standards
- Connect ideas to techniques
- Understand the depth of new techniques
- Produce work at the highest standards

OBJECTIVES

- Students will learn how to design, construct, and evaluate buildings using the latest digital tools and processes.
- Students will develop a deep understanding of the digital tools and processes used in the concrete industry.
- Students will learn how to work with real-world clients and projects.

ASSESSMENTS

- Design as Speculation (research): 40%
- Design as Implementation (making): 40%
- Project proposals: 20%

PICTURE

Student work, CRAFTING THE DIGITAL, spring 2016
Pic - Sample Pages of Course Booklet. Before the class began, we worked with research assistants to develop the 'scaling up' booklet that would be given to the students on Day 1. We used the semester before to develop a working document that could continuously be updated. The course booklet is a collection of information ranging from precedents in concrete, to structural diagrams, to fabrication techniques and readings. Part of the class assignment was to expand upon and supplement the research in the booklet with additional diagrams, text, and drawings.
**DESIGN ASSIGNMENT 1**

**PURPOSE**
Using one of the formal/structural principles from one of the precedents researched thus far, repeat the element into a stacked tower. The structural logic of the element should already be inherent in the form but might need to be adapted to account for the vertical expansion. Feel free to deform / skew / twist / etc. the original structural grid or element and scale up or down. Spans may vary, so you can omit bays to create larger spans.

The 3D gradient of the elements can vary from small to large as desired as long as the structural logic of the element stays in tact. Load must continue down, no hovering forms. If there is a point load on an element, that element must get deeper to accommodate additional load distribution to nearest vertical elements, this whatever digital 3D means necessary to achieve desired goals. Complexity in ideas and formal output should be tested!

The footprint of the tower is 50 feet x 100 feet. Each ‘story’ is approximately 12-15 feet. The tower can be anywhere between 6 to 10 stories.

**WEEK 1**
- One ALTERED element from original precedent list stacked into tower:
  1. Arch/Shell
  2. Hollow Core
  3. Folded Plates
  4. Slabs
  5. Other

**WEEK 2**
- Based on new technologies researched, choose 1 type of casting method + 1-2 Cemex materials of choice to deform / alter original element. How does formwork method influence formal output? How can a particular material alter the formal expression?

**Cemex Material Selections + Technology**
- Casting Methods
- 2D to 3D
- Additive Manufacturing
- Digital Assembly
- Other

**REQUIREMENTS**
- Design Exercise Week 1 - Form
- Design Exercise Week 1 - Technology + Material
- See Template on google drive for specific drafting requirements
Pic. - Early studies of stacked forms in sequence from each design group. The initial exercise of the semester was to stack elements digitally to form a vertical structure. Each of the groups refined their ideas as they began to test and cast their techniques in concrete.
Pic - final diagram of Pier Nervi roof structure (Image: Minglu Wei)
Pic - precedent studies / diagrams + axonometrics of structural forms
Pic - stacked forms of hybridized concrete forms (mixture of high strength, porous and/or lightweight concrete mixes)
According to the Malaysia Biennial 100YC, the goal is to ‘identify disruptive patterns of global change and impacts on architecture, urbanism and life for the city of Medini Iskandar, Malaysia, now and in the extreme future’. It was Buckminster Fuller’s vision and desire to speculate on new futures and made him one of the first modern thinkers to connect ecology and the environment to architecture and design. If we are now in the ‘Anthropocene Era,’ defined as the current geological age and viewed as the period during which human activity had the most influence on climate and the environment, how do we speculate on new futures for the urban environment that can provoke productive change?

**TASK:**
Each group is to create a ‘Responsive Structure for the Anthropocene’ with your speculative stacked form that is responsive to the urban environment. The notion of a concrete structure as a ‘fixed form’ is obsolete and should be seen as an emergent and responsive structure that can continuously adapt to its environment. Urbanization will forever change our environment but also has the most potential to save it. If we focus on the opportunities that cities offer to create more sustainable development that protects nature, rather than exploiting it, we can create more biodiversity within cities to preserve nature beyond them. Your construct will be located in Medini but is ‘siteless’ in such that each group will have to ‘site’ their proposal in a particular environment based on the performance and effects your group is aiming to achieve.

**What is a Responsive Structure for the Anthropocene?** Your responsive structure should negotiate between spectacle (‘events’) and ecological constraints (water, earth, energy, resources, etc.) that sustains biodiversity in a particular environment. A speculation is an open-ended response; therefore you are not limited to a particular scale (if justified, your structure can go taller or wider) but the structure should be inhabited by humans and/or non-humans. How does it connect to local ecologies? What systems exist for controlling environmental conditions, such as thermal, ventilation, filtration, etc.? How can you leverage formal / spatial / experiential potential from a systematic approach to ecology?

**Responsive Structure Examples (but not limited to):**
- **Filtration:** How do we filter and purify water to reduce pollution, harness for agriculture, etc.?
- **Accretion:** How do we instrumentalize and accrete particulate matter (wind, energy, sedimentation, etc.)?
- **Carving and Branching:** How does water, waves, thermal change, or wind form productive territories and flows?
- **Flow Control and Storage:** How do we store and contain a substance like water to regulate distribution over time?
- **Harnessing:** How can we use hydraulics, waves, or energy harnessing structures to generate electrical currency?
Pic - diagrams of algae system applied to the concrete surface as passive green system to soak up CO2 emissions (Image: Andrea Dominguez)
Pic - Final Review with students, professors, outside critics, and CEMEX Global R&D Representatives
Project 1 - Urban Nesting

This urban infrastructure becomes a new nesting ground for local species and migrating birds in the Medini region. The goal is to scatter ‘urban green dots’ as urban pocket parks that form a network of nests for various ecologies. There are varying degrees of nesting, water filtration, and water retention for growing plant medium to attract birds and other local species. Four types of sites were used for their potential to be prolific throughout the city, such as bus stops, parking, loading docks, and balconies.

Students: Minglu Wei and Le Yang
Project 1 - Urban Nesting
Fabric was used as the formwork to create a warped form in section. Porous concrete was used to allow water to move through the structure as it is passively filtered through the plant roots. In order to have a strong enough structure, high strength was poured as a second layer, covering the porous concrete but leaving a void in the center for the water to pass through both layers.

Students: Minglu Wei and Le Yang
Project 2 - Biological Concrete
Malaysia has pledged to cut CO2 intensity by 45% by 2030 and is looking for new techniques to reduce carbon dioxide. Microalgae is amongst the most productive biological systems for capturing carbon and a natural vehicle to clean the air by taking in CO2 and emitting O2. The project focuses on sites that have large amounts of CO2 emissions, such as industrial sites and highways, with infrastructural solutions, such as parking lots and sound walls.

Students: Shaguni Gupta and Andrea Dominguez.
**Project 2 - Biological Concrete**

The project incorporates ‘biological concrete’ into a three layered concrete system to capture CO2. The algae surfaces are an undulating ‘shingle,’ made with folded plates of concrete with algae growing on its surface. Since algae needs different amounts of sun radiation to The formwork is initially flat and then pops up into place to create the folded surfaces. The shingles provide varying types of shading and coloring on the facade where the algae grows. With its productive use of algae, concrete, and vehicles, the project provides a new of infrastructure that reduces CO2 while providing a new urban space to inhabit.

Students: Shaguni Gupta and Andrea Dominguez.
Project 3 - Mushroom Water Towers
A network of vertical ‘mushroom shaped’ water towers circumvent ground water from parking lots and filter it before reaching the river basin. There are above ground cisterns scattered in urban infills that cool off the urban spaces around it as it collects, filters, and releases rain water. The project reconsiders water conservation in the form in the long tubes of concrete. This new infrastructure is proactive in how to bring productive change to the environment for the city and its users.

Student: Chenghan Peng
Project 3 - Mushroom Water Towers

The project uses water as the falsework for casting the concrete. The fabric formwork, for the shape of the mushrooms, is positioned and connected to a simple frame that can be adjusted, lowered or raised. There are potentially infinite formal variations to one single formwork. The fabric formwork is then lowered into the water where the concrete is cast and cured. The water contributes to the curing process.

Student: Chenghan Peng

Pic - diagram outlining steps of fabrication process
Project 4 - Urban Wetland: An Above Ground Cistern

Due to its proximity to the Equator, Malaysia is strongly affected by El Nino, which leads to constant floods and draughts. The project proposes a new type of infrastructure: an above ground cistern for the city of Medini. The cistern pops up throughout the city; from fountains in residential neighborhoods, to infill strategies attached to buildings and floating urban parks.

Students: Gabriel Maese and David Knaide
Project 4 - Urban Wetland: An Above Ground Cistern
Twisted concrete tubes perform as a cistern; holding and pumping water up through the structure to create green spaces, pools and waterfalls. The structure becomes a cooling system to reduce the heat island effect with water continually running through the structure and keeping the spaces cooler than the hot outside temperatures. The forms comprise of porous concrete on the inside and high strength concrete on the outside to retain water at night and slowly release it back by day to keep the space cool as wind moves through the open-air structure.

Students: Gabriel Maese and David Knaide
Project 4 - Urban Wetland: An Above Ground Cistern
These two students were selected for a summer internship to develop their ideas and build mock-ups of their design strategy at the research lab of CEMEX Global R&D. This was an amazing opportunity to work alongside some of the best material scientists and engineers in the world. They were able to build their design modules at half scale and test how water can move through the system.

Students: Gabriel Macse and David Knaide