Concrete Lattice | Unitized Architecture of Assembly

RYAN GOOLD
University of Michigan

TSZ YAN NG
University of Michigan

DANIEL FOUGERE
University of Michigan

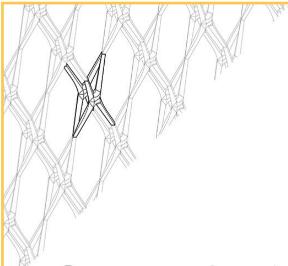
Concrete Lattice, a project produced for the graduate thesis studio Concrete Labor(1), seeks to challenge our normative association with this building typology by developing a lattice system of prefabricated units using Glass-Fiber Reinforced Concrete (GFRC). Lattice systems are porous, lightweight, and deployable; terms that are not typically associated with concrete structures. The design of parametric units rather than linear components (typical of lattice systems), highlights issues of assembly in precast building systems using integrated components. While design workflows and CNC fabrication aided in efficiently manufacturing the units, the assembly is post-tensioned during the construction process to limit the amount of scaffolding necessary. Our goal was to explore the development of a complex lattice system using digital technology to explore formal and manufacturing processes.

Building on the work of Maciej Kaczynski, et al, in his 2013 project “Crease, Fold, Pour”, which used thin sheet plastics for formwork, our work moves away from a cast-in-place construct to working with a set of self-similar precast units as a comprehensive building system. The advantages of precast enabled us to control the concrete mix and casting process more consistently and to also explore the logistics of mass-customization and fabrication. Grasshopper was used to develop the units and Kangaroo informed the structural performance through simulation and optimization.

While folding techniques of origami patterns made possible the efficiency of production and cost-savings for formwork production, PETG as a material proved insufficient for concrete casting due to hydrostatic pressure and susceptibility to cracking from chemical reaction to the concrete. As such, an external adjustable jig was designed to help both support the mold during the casting process and ensure accuracy and precision across all unit types at joints. The reconfigurable jig accounts for all the various parameters of both the unit types and the overall lattice design.

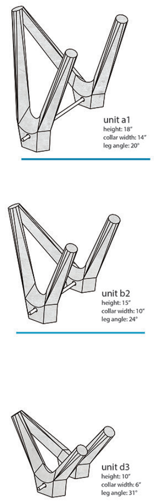
The complexity demonstrated through Concrete Lattice argues for the use of computational design in both informing design decisions and managing the myriad of contingencies involved in the production of new modes of architecture. Complexity in this respect addresses not only formal and experiential concerns, but also structural performance and manufacturing constraints. Our Concrete Lattice makes explicit the role digital technology plays in the integration of design, engineering, and building construction. While this discourse is not new, our design aims to take full advantage of lessons from precedents and offer a unique project uncharacteristic of what we’ve come to expect of concrete as a material.

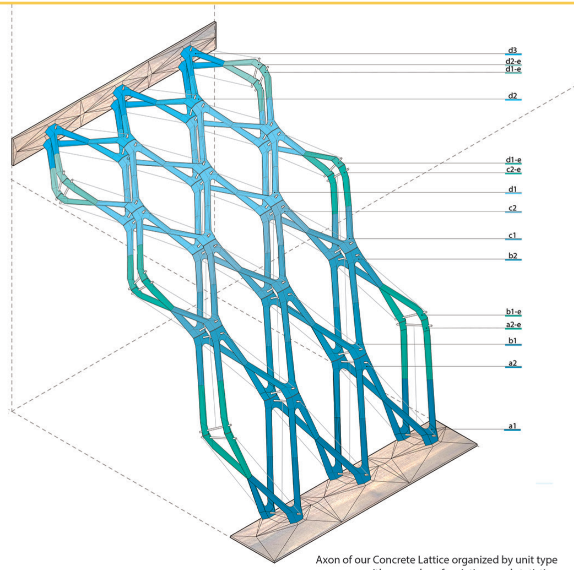
1. Concrete Labor was taught by Assistant Professor Tsz Yan Ng during academic year 2015-2016. This thesis section was linked with the course Advanced Digital Fabrication taught by Assistant Professor Wes McGee.



Concrete Lattice

Unitized Architecture of Assembly





Axon of our Concrete Lattice organized by unit type with examples of variations and statistics.

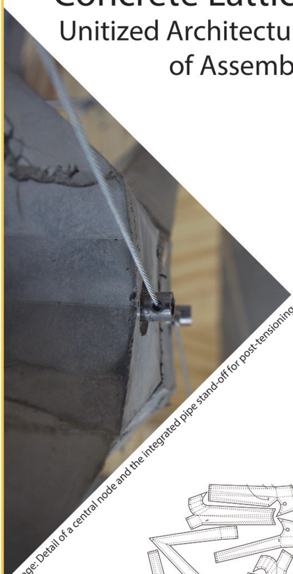
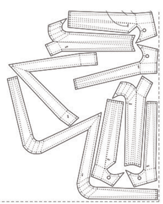
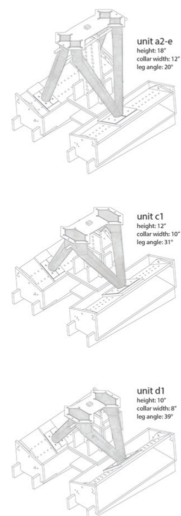
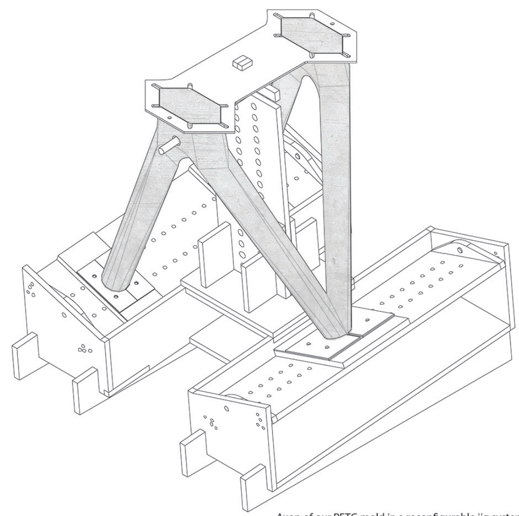


Image: Detail of a central node and the integrated pipe stand-off for post-tensioning.



PETG formwork cutsheet diagram.





Axon of our PETG mold in a reconfigurable jig system with steel plates at each node to ensure precision.

Image: Detail of the edge condition and compressive node in the final construct.

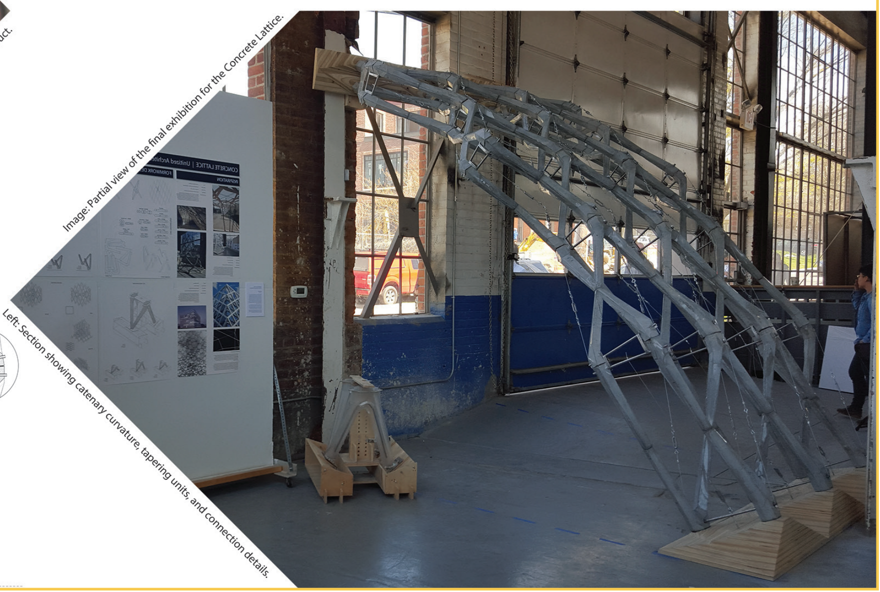
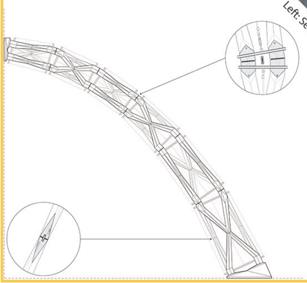


Image: Partial view of the final exhibition for the Concrete Lattice.



Left: Section showing catenary curvature, tapering units, and connection details.