RESEARCH OPEN HOUSE 2021

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DEVELOPING DIGI-MECHANICAL FORMWORK FOR PLASTIC CONSTRUCTION MATERIALS:

TESTING FORMING CAPABILITIES AND MOTION CONTROL USING 3D-PRINTED WORKING MODELS

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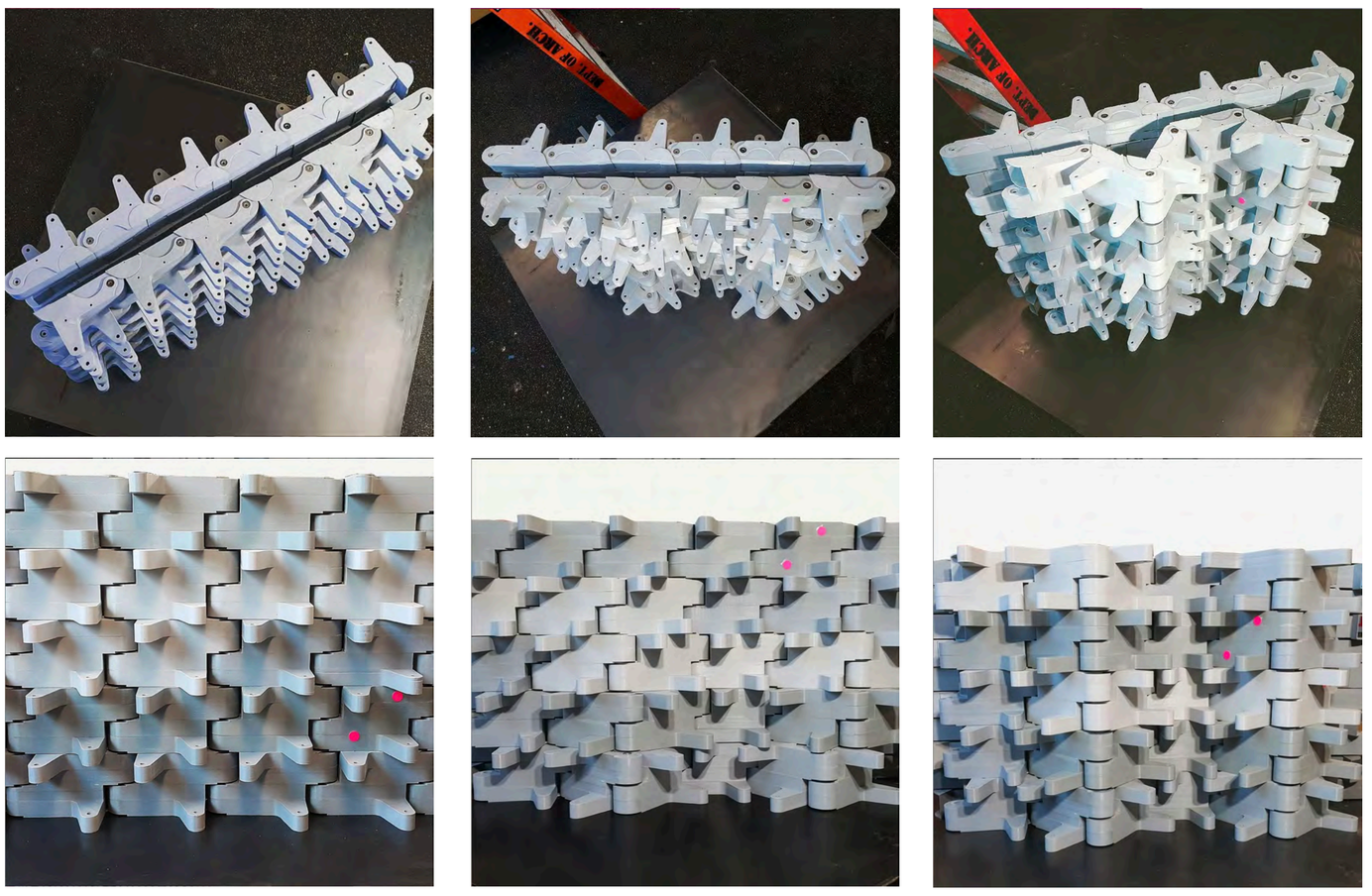
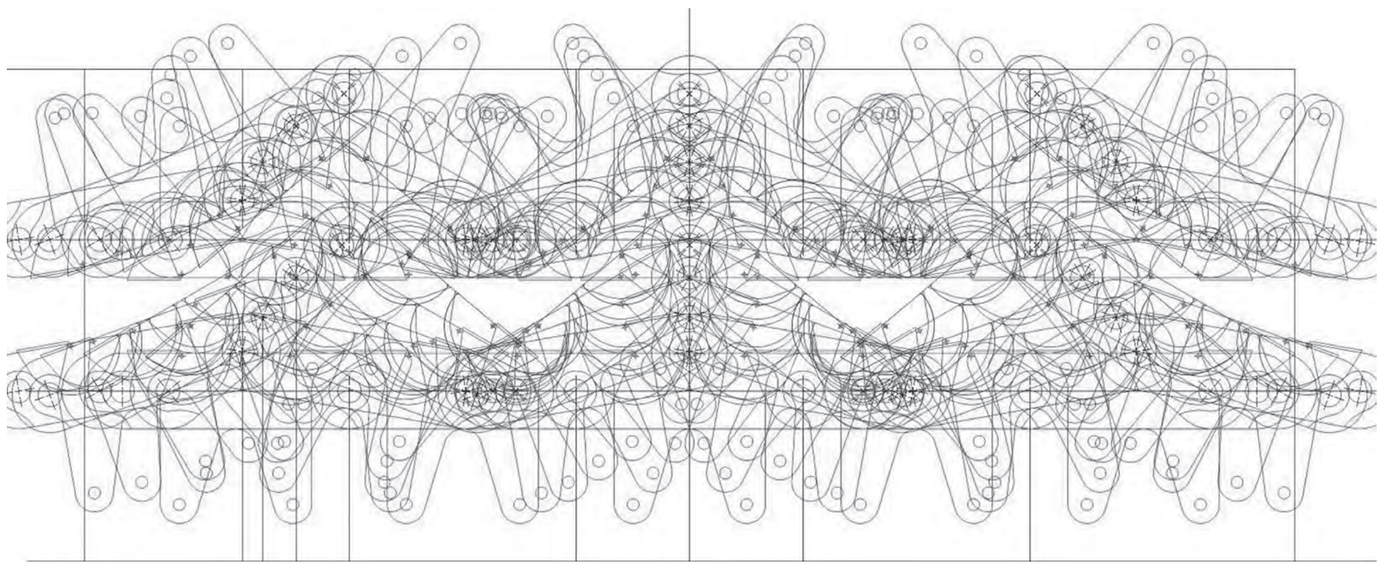
ABSTRACT

This project essentially applies mechanization and computational control to the basic concept of formwork (common to concrete and earth construction), enhancing the qualities of mobility and variability that are characteristic of contemporary single-use sheet-based formwork systems. The resulting digi-mechanical "formwork machine" could potentially reduce placement, setup, and breakdown costs, and address the significant worker safety issues associated with traditional hand-set formwork systems. Robotic formwork could simultaneously enhance the technology's unique capacity to respond to architectural form requirements with increased digitally-driven customization and variability. Contemporary developments in creating sustainable concrete formwork systems are working to replace or eliminate sheet-based, hand-set formwork with factory-situated alternatives. This project alternatively keeps formwork on site, addressing the material and economic wastefulness associated with sheet-based formwork by evolving the current parts-based, disposable system (sheets/planking, connections, bracing, tie hardware, etc.) into a more robust robotic machine. This robotic formwork can be maintained and used repeatedly — with the extended durability inherent in construction machines — on pre-mapped construction sites, and/or in construction environments that inhibit or restrict human labor.

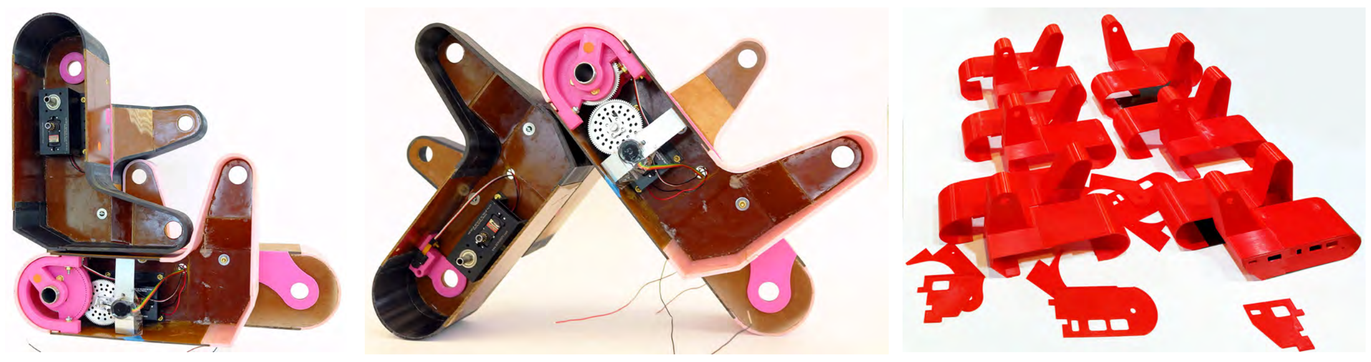
Current developments in this project, detailed here, include 3D-printed working models at quarter-scale (60 casting cartridges), half-scale (eight casting cartridges), and the design and development of "walking" attachments for large-scale movements of the machine. The quarter-scale working model will be used to cast five different wall configurations (five automatic walls) made of plaster. The half-scale models will be fully mechanized, employing servo motors, Arduino, and basic coding to test motion control — set up and breakdown of the machine for casting simple shapes, such as beams, walls, and arches. The walking attachment development represents the first attempts at envisioning how this "formwork machine" could make larger movements, such as walking from a truck to the specific building site, and positioning itself on the site to receive plastic materials.



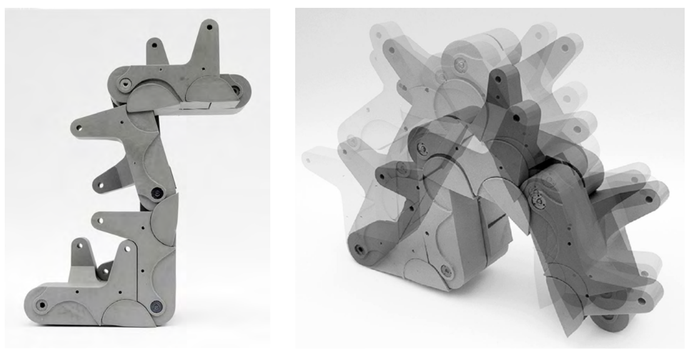
Sixty linked quarter-scale casting cartridges arrayed to form a linear wall (L), a linear wall w/a modulated base (C), and a modulated wall with integral columns (R).



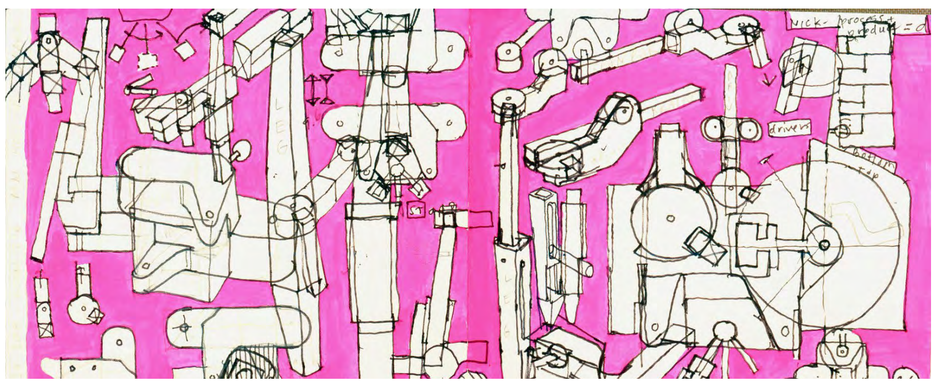
Plan view of the machine forming Automatic Wall No. 5 — a wall with a linear base and modulated top.



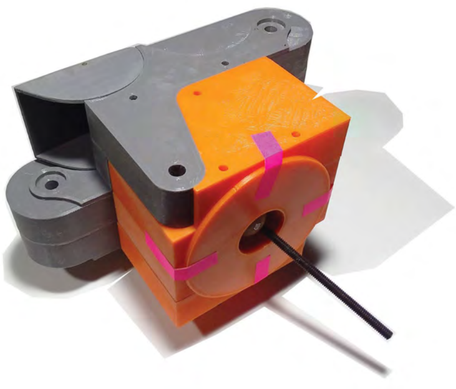
Half-scale models of linked casting cartridges with the drive exposed (left and center). Six of eight 3D printed half-scale casting cartridge shells.



Four linked quarter-scale casting cartridges.



Design studies for walking attachment at quarter scale (L) and 3D printed swing attachment prototype (R).



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