Ductile Empiricism

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Evolving modes of representation and communication continue to redefine the flow of information between designer, fabricator and manufacturer, while nimble means of fabrication recalibrate customization. As various types and scales of design practice reveal, opportunities for strategic collaboration between designer and fabricator abound. The work illustrated is the result of the first phase of a university – industry partnership with a global manufacturer of metal façade systems. Our industry partner sought to capitalize upon the alternate perspective the students and by extension the academy afforded to reconsider the standard metal façade panel that has served as the core of their business. We sought to structure a collaboration that strategically leveraged the material expertise of our industry partner while encouraging structured experimentation by the students, that was initially unconstrained from the myriad of technical and economic considerations associated with building cladding systems. The resultant sponsored course relocated the design process from the studio to the lab-workshop, moving design decisions upstream to include considerations of tooling and material processing as inputs for design experimentation. This first phase of the partnership decontextualized the work from the building façade and the technical challenges of enclosure systems, to provide student teams with sufficient opportunities to develop and refine processes of robotic metal forming.

Our partner was motivated by a desire to use the collaboration to stimulate a broader discussion within their organization about the business model and corporate culture of standardized production. Engaging future architects (students) in processes of procedural and material experimentation provided a means to understand generational values while also providing fresh perspective and vision to products that are often seen as conventional and pedestrian.

Our collaboration relied upon the robotic fabrication facilities at our university to develop workflows that afforded versioning processes to explore alternative ways of forming metal sheet. Our partnership sought to leverage the robustness and precision of industrial robots to explore a limited number sheet metal forming techniques that, by virtue of their recalibration, afford a subset of formed panels. Simple adjustments in robot tool position, rotation, force, etc. informed the behavior of the material and contributed to a range of possible outcomes or versions. Three distinct trajectories of research emerged that can be described through techniques of folding, buckling, and incremental forming. Each sought to reduce the need for material preprocessing, such as cutting or drilling of the sheets, in order to economize the workflow through the least number of tools or actions while yielding a range of potential versions.

The collaboration provided our student cohort with the perspective and rigor of industry and challenged the frequent desire for ultimate design freedom and its association with complete customization. The fabricated results and dialogue with our partner centered on the establishment and negotiation of constraints that were informed by the design motivations of our students and the seasoned expertise of industry. The partnership served as a means to explore alternative trajectories of design and fabrication that leverage material behavior and high fidelity fabrication to reveal a spectrum of possibilities.

DUCTILE EMPIRICISM: Industry sponsored coursework at Carnegie Mellon University

Jeremy Ficca

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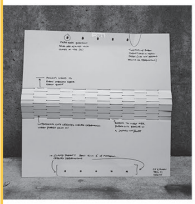
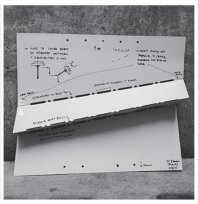
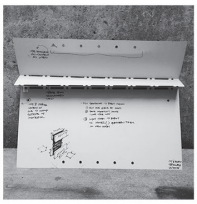
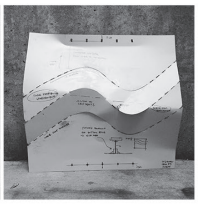
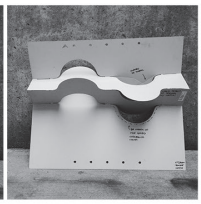
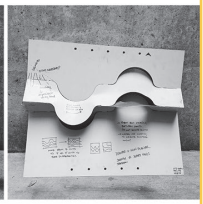
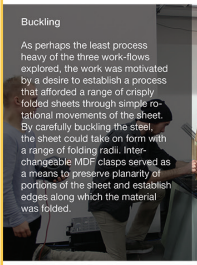
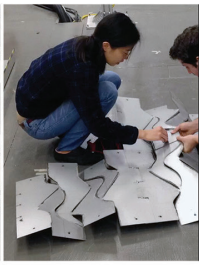
Dialogue with our industry partner revealed a shared interest in leveraging the robustness and precision of industrial robots to explore a limited number sheet metal forming techniques that introduce the potential for customization or versioning and begin to speak to potential assemblages and types of surface articulation. The work sought to reduce the necessity for dies, stamps or breaks. Simple adjustments in robot tool position, rotation, force, etc. influenced material behavior and contributed to a range of possible outcomes or versions. Three distinct trajectories of research emerged that can be described through techniques of folding, buckling, and incremental forming. Each sought to reduce the need for material pre-processing, such as cutting or drilling of the sheets, in order to economize the work-flow through the least number of tools or actions while yielding a range of potential versions, each with distinct visual characteristics.

Buckling

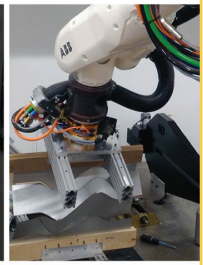
As perhaps the least process heavy of the three work-flows explored, the work was motivated by a desire to establish a process that afforded a range of crisply folded sheets through simple rotational movements of the sheet. By carefully buckling the steel, the sheet could take on form with a range of folding radii. Interchangeable MDF clasps served as a means to preserve planarity of portions of the sheet and establish edges along which the material was folded.



Folding

A series on non parallel folds are achieved through the simultaneous application of pressure and rotation in a 'stair-step' sequence. The pattern of cuts across the sheet establishes lines for the resolution of stress forces and results in predictable and repeatable folds across the sheet.



Incremental Forming

The incremental forming process affords the development of complex three-dimensional sheet form through the consistent and controlled displacement of the metal sheet. A case hardened metal stylus tool affixed to the end of the industrial robot is moved across the metal sheet at progressive scaled depths in the z-axis, to expand the sheet in accordance to the pre-determined robot motion path. A plywood fixture registers the sheet relative to the robot and elevates the sheet above the table surface. The 'floating' metal sheet is subsequently formed down toward the table surface.