Reflexive Architecture Machines

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Abstract
Reflexive Architecture Machines is a research into material and computational processes where quantities like volume, weight, temperature, moisture and gravity are instrumentalized for making more responsive architectural materials. It investigates reflexive tools that are sensitive to the contingencies of their situation in order to develop materials and components that have complex relations between parts and wholes. This fundamentally challenges the static nature of industrialized materials like rubber, concrete, plastic and plywood and opens them to the ephemeral and dynamic qualities of the environments in which they are fabricated and eventually deployed.

Keywords
Architecture machine, responsive architecture, casting, biomimetic materials, evolutionary forms.

Introduction
The “architecture machine” [1] was Nicholas Negroponte’s term for an artificial intelligence that “assisted, augmented and eventually replicated” architectural design processes. In the last chapter of *Soft Architecture Machines* (1975), he postulates the distant future of such machines which “won’t help us design; instead, we will live in them.” A key component in their evolution from tools to environments would be the coalescing of computational processes with the material substrate of building systems. This is imagined through two strategies: that of “softs”, in which building materials are mutable to reshaping, retaining memory of past forms that can be recalled for present conditions, and “cyclics” that deal with the ability of materials to continually assemble and disassemble, similar to the way they do in nature. The research presented in this paper picks up where *Soft*

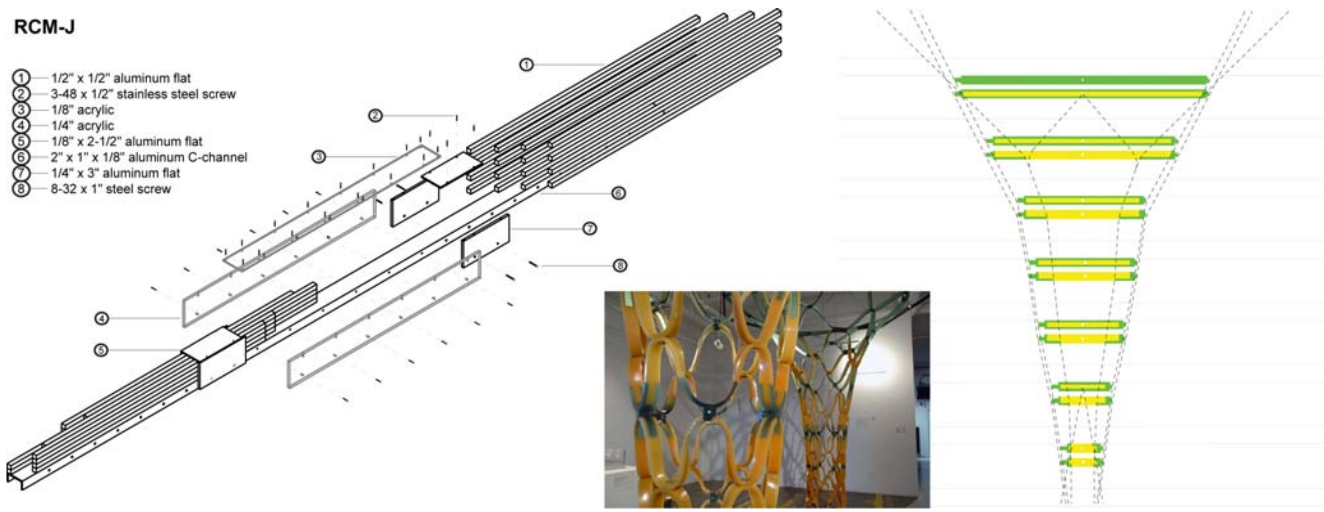


Figure 1- Reconfigurable Mold RCM-J, prototype and column recipe

Architecture Machines leaves off- to propose a series of architecture machines that *reflexively* address material and information agency in the forming of space.

Reflexive Architecture Machines

Reflexive architecture machines work on multiple orders of complexity. At their most basic they are manufacturing tools in the form of reconfigurable molds (RCM), assembly patterns and recipes that can be used for fabricating materials like rubber, concrete, plastic and plywood. These provide the basic building parts which can be combined to produce more complex wholes recognizable as architectural components like columns, ceilings and screens. Because of their mutability at the level of parts they are able to create responsive and adaptable wholes. This second order of complexity, wholes, allows for reprogramming (in the architectural sense of the word) the spaces in which such constructions are deployed.

Open Columns

Open Columns (Figure 1) is a system of nonstructural columns, made from composite urethane elastomers, that can be deployed in a variety of patterns to reconfigure the space beneath them. They are the products of a reconfigurable mold, RCM-J, that creates the column's parts from a combination of hard and soft rubbers. By altering its volume it provides cavities for subsequent pours of rubber resulting in a wide variety of composite elastomers with radically different elastic properties. The columns themselves, as an adaptable architecture, are reflexive architecture machine that create *gradations* of enclosure based upon the quantity of CO2 in the vicinity. Working from a simple set of rules, they respond to data coming from a carbon dioxide (CO2) sensor. In a reasonably enclosed environment CO2 values can radically change with the inclusion of people. The columns are programmed to come down when CO2 levels are going up resulting in people dispersing into smaller groups and go up if CO2 levels are going down. If however the CO2 value stays static the columns cycle through a random set of configurations in search of a form in which the CO2 either goes up or down. These are put into the system's memory and reused the next time a similar occurrence happens.

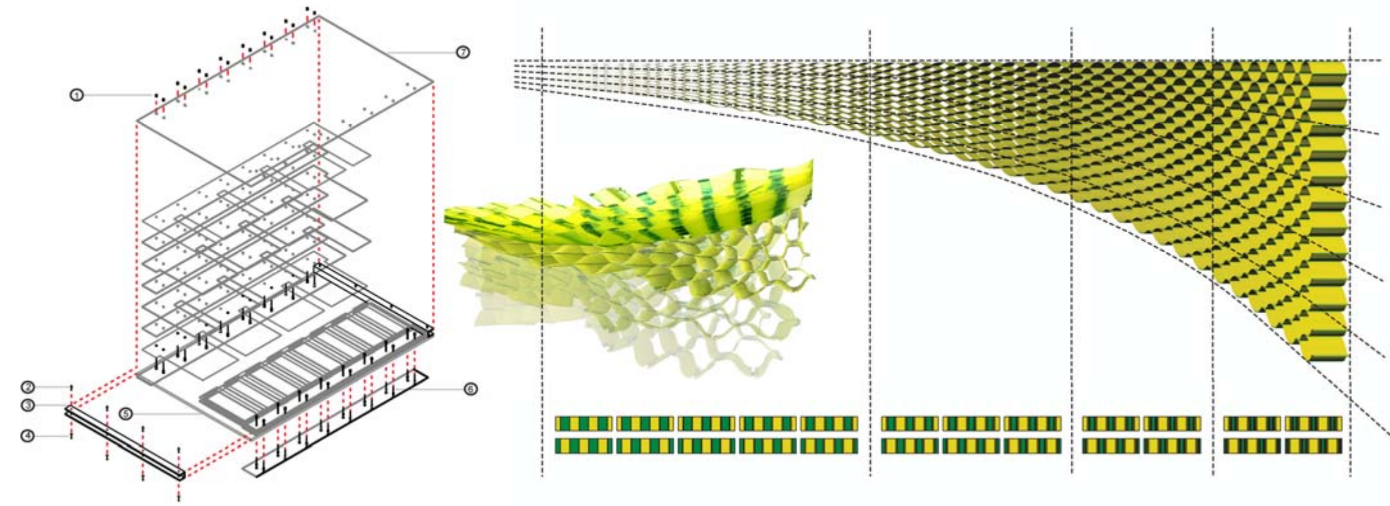


Figure 2- RCM-D, screen pattern and prototype

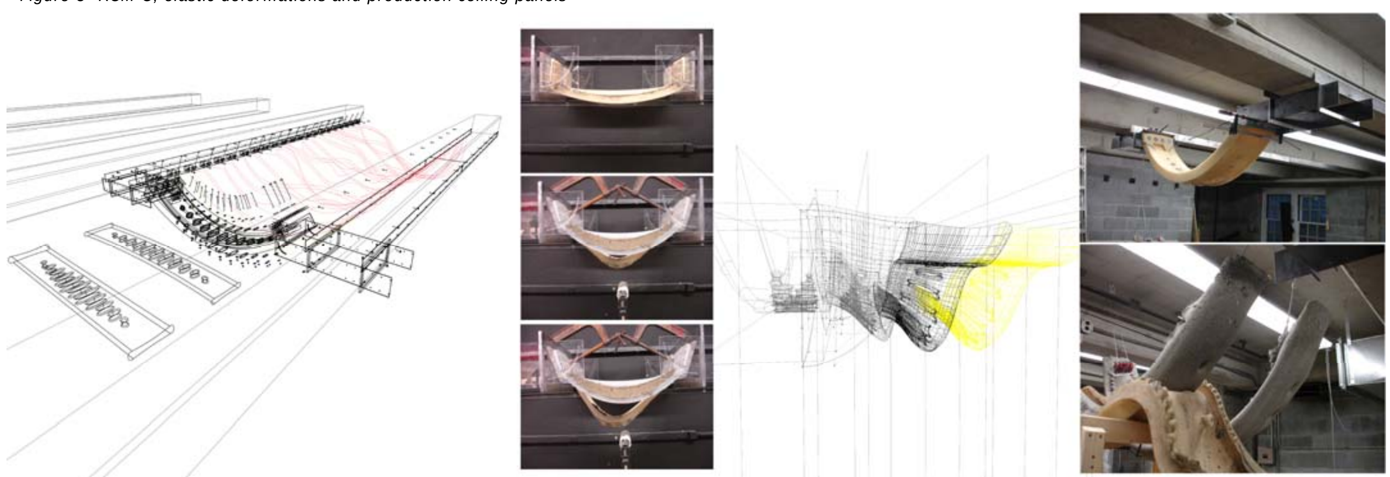
Gravity Screen

Gravity Screen (Figure 2) is a surface construction whose morphology results from gravity's effect on its material patterning. It is made from a reconfigurable mold, RCM-D, that combines two elastomers of different shore hardness in a layering process of bar patterns. These patterns weave the screen together which when hung and takes an organized form. The screen's morphology can be dynamically altered by changing the weight acting on it moving its apertures firm closed to open and its shape from flat to concave. The screen can be deployed in combination with others to form an enclosure that can dynamically alter the acoustic quality of a space.

Elastic Catenaries

Elastic Catenaries explores the use of flexible rubber molds to produce structural self-similar concrete casts (Figure 3). The mold's elasticity becomes a means for synthesizing structure

Figure 3- RCM-C, elastic deformations and production ceiling panels



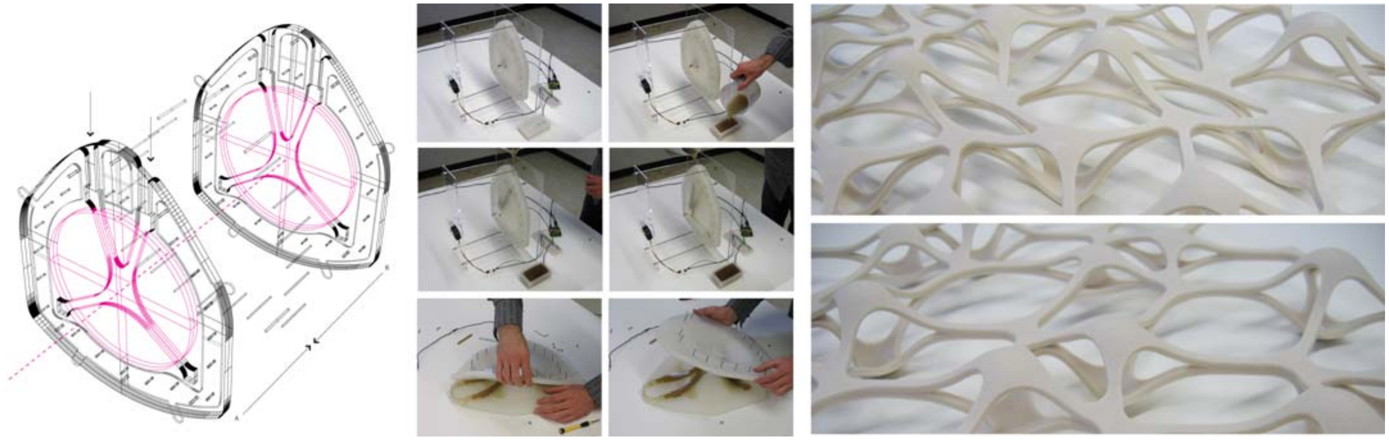


Figure 4- RCM-T, fabricating plastic components and 3D prints of potential screens

and other performative effects like light transmission and formal expression. A soft rubber reconfigurable mold, RCM-C, is hung from two points. When concrete is added to the mold it deforms in direct relation to the additional weight. The mold is able to take on a variety of geometries including catenaries, parabolas or other conic sections. In this way it negotiates structural form (geometry) in direct response to the material's properties (weight). The mold also provides the means to fabricate larger assemblies of self-similar parts as a sequence of iterative suspended casts.

Allotropic Systems- Thermo-sensitive Reconfigurable Molds

A thermo-sensitive reconfigurable mold, RCM-T (Figure 4), proposes a way to utilize the generative possibilities of scripting with prototyping. The heat sensitive mold, in the process of fabrication, feeds the chemical heat gain from the poured material as it cures, directly into a generative algorithm. This contextual data drives the behavior of the algorithm, a CA, which in turn alters the morphology of the

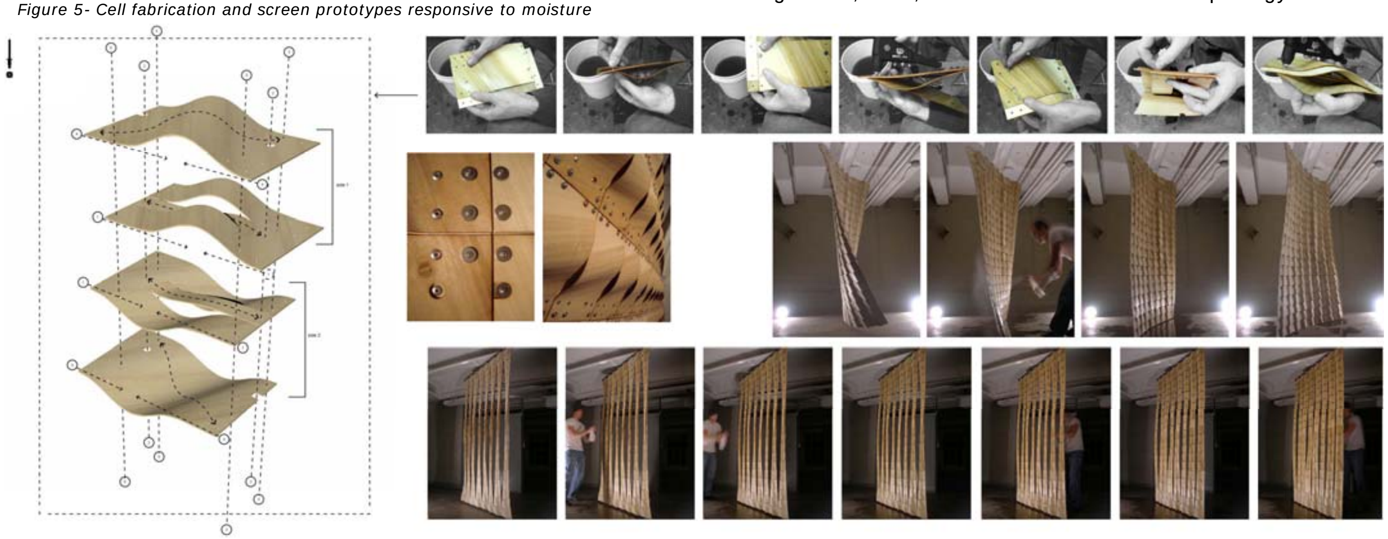


Figure 5- Cell fabrication and screen prototypes responsive to moisture

mold and hence the casted unit. One mold can produce several unique casts, each specific to the event of their making. The part-to-whole relationship of the resulting structures is allotropic, that is that the elements that form the network are individually shaped by the event of their making so that the same network can take on a variety of shapes. Such a system proposes a means to make moldable materials, like plastics, more responsive to the contingencies of their making. As a network structure parts can not be conceived in isolation but must be dynamically constructed with direct feedback from the entire assembly.

Warped

Warped is a set of walls, columns and arches composed from mechanically joined wood plys that respond to changes in atmospheric moisture by twisting and bending between open and closed conditions (Figure 5). This is done by re-developing plywood manufacturing methodologies which in the past relied on cross graining techniques to create rigidity and stability within the material. Warped discovers new uses for the ply process by introducing space and shape between the subsequent layers of veneer. It uses the directionality of the wood grain and its reshaping during shrinking and swelling to re-negotiates the means by which different layers can be controlled. By using mechanical fasteners rather than uniform gluing, surfaces can be endowed with moments of intensified strength and stability to areas with no connections that allow the material to reshape itself in direct response to environmental moisture.

Conclusion

The ideas underlying our research into reflexive architecture machines contemplate more efficacious ways to deals with our limited material resources. It argues that a first step involves the way in which we form architecture's basic building blocks. Rather than continue to invoke the "industrial" architecture machines that produce "sameness through repetition, amortization through duplication," [2] our approach suggests more responsive architecture machines that produce customizable and reflexive products. In addition, we are not interested proscribing a best practice as that is relative and unproductive. In contrast, we would rather present a gradient of possible qualities which such machines could emulate as they search for their own performative relevance.

References

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