NSF Workshop on Additive Manufacturing for Civil Infrastructure Design and Construction

Performative 3D Printed Building Skins: Towards an Adaptable Built Environment

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Texas A&M University
College of Architecture
Acknowledgements:

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Ergun Akleman, PhD (co-PI)
Tahir Cagin, PhD (co-PI)
Terry Creasy, PhD (co-PI)

Teaching collaborators:
Alireza Borhani, MArch
Dylan Shell, PhD

+ 66 student collaborators
General Strategy
Negar Kalantar Introduction

Diameter: 22 Ft (open position) and 3.3 Ft (closed position)

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Research Collaborators: Kalantar, Borhani

Based on Hoberman's Geodesic Dome
Expandable Spherical Cup II
Dimension: 10 Ft side (open position) and 2 Ft (closed position)
Material: Wood + Aluminum

Expandable Spherical Cup I
Dimension: 9 Ft side (open position) and 1 Ft (closed position)
Material: Wood + Aluminum

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Research Collaborators: Kalantar, Borhani

http://vimeo.com/negarkalantar/spherical-domes
Negar Kalantar Introduction
PRISM [Design Development 04]

Matt Menocal Jenny Zhou

Within a design iteration phase, we moved forward towards physically refining our notion of the shading system. In our first attempt, we've identified a few technical issues:...
First Skin
Second Skin
Third Skin
Mediator between *Inside* & *Outside*

Reaction to *Environmental* Changes

Responsive to the *Occupant* Needs

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Could our third skin be adaptive similar to our first skin?
NOT REALLY!
The Difference between Natural & Man-made Constructions

**Nature**

- **Material** is expensive BUT **complexity** is free

  - Less material + More complex forms

**Man-made**

- **Complexity** is expensive while **material** is not

  - More material + Less complex forms

A New Way to Design an Adaptive Building Skin

Bio-Inspired Approaches

Additive Manufacturing Techniques

New Computational Design Methods

Smart Materials
Benefits of Additive Manufacturing in Adaptive Design:

- **Local customization** of geometry to change the properties of material
- Reducing the number of **susceptible mechanical** parts such as hinges
- **All-in-one multifunctional** component
3D Printing in Adaptive Design

Geometrically-informed Approach
(Performative properties are linked to the geometry of mechanisms)

Material-based Approach
(A synergetic relation between the material thresholds and performance)

Displacements Strategies

Deformation Strategies

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Performative 3D printing Strategies

Passive Strategies

Active Strategies
Performative 3D printing Strategies

Passive Strategies

Active Strategies

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After further research, a more severe angle of ventilation holes would not allow any direct sand penetration.

Air is directed through the module to be cooled a few degrees, then funneled upwards along the building while sand is stopped by the angle of the opening and shed downwards via gravity.
The breathable wall system aims to satisfy the following criteria:

- **Get fresh air** into the building & exhaust air out;
- **Block sand** from penetrating into the building;
- **Cool down** the air as it travels through the shaded zones; and
- **Prevent light** from directly entering the space.
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Research Collaborators: Kalantar, Borhani & Callen
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Passive Strategies

With Joints (Rigid-link Mechanisms)

Distinct Joints
(For linking multiple rigid elements)

Embedded Living Joints
(For linking multiple rigid elements)

Using 2 different materials
Using a single material

Without Joints (Flexures Mechanisms)

Local zones of flexibility to adjust stiffness

Active Strategies

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tranSTUDIO & transLAB
Research Collaborators: Kalantar, Clark & Kato

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Research Collaborators: Kalantar, Wells, Henry, Yamaya, Al-Sholi & Buckley
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Research Collaborators: Akleman, Zarrinmehr, Kalantar, Borhani, Ettehad & Sueda
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Flexible textile structure was an exploration into 3D printed fabrics.

Research Collaborators: Kalantar, Borhani & The Dream LAB at Virginia Tech
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Project Management Process
Weekly Meetings
Minutes: Thorough Documentation of Each Meeting and Lab Session
Inno-velope

Articles


Project III

Kinetic Overlap: Pt. 2

Part 2 We began building the model a couple of days before the construction science students needed it for their presentation. Once we got the final approval on the final prototype we spent a full day laser cutting and a

May 3, 2016 / Leave a comment

Project III

Kinetic Overlap: Pt. 1

Part 1 This project was about exploring a sun shading device that could control the light and wind that comes into the bridge connecting Langford A,B, and C. When we began this project I did not know what to expect.

May 3, 2016 / Leave a comment

Home

Project 4: KASS System Pt. 3

Sydney Alford (partners with Emily Cloat) Final images of the KASS System. Enjoy! For our final model we have created simulations through grasshopper and rhino to ensure that our solar shading device would in-fact work and produce some shading aspect

May 2, 2016 / Leave a comment

Home

Project 4: KASS System Pt. 2

Shared Website
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Continuous Improvement
• IDEO idea generation method used
• Teams met at the same time each week
• Teams crossed into different departmental labs as well as studios
• Thorough documentation of each meeting
• Information shared on common websites
• Presentations to & feedback from members of industry
• End-of-semester debriefings (plus-delta)
• Continuous improvement “kaizen stairway”
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