AUTOMATED CONSTRUCTION SYSTEMS WITH UP-CYCLED MATERIALS

Spring 2018 Student Sustainability Committee Grant Proposal

Objectives

1. *Identifing locally sourced bio-based materials that can be up-cycleded*
2. *Refining those materials with a non-toxic, organic binding agent*
3. *3D-printing full-scale building components, using a large robotic arm*
4. *Engaging a wide range of students across campus through design-build seminars*
5. *Promoting UIUC and its sustainability efforts nationally through a public installation*

Team

Martin Rauber, ISoA Graduate Research Assistant in Robotics + Advanced Manufacturing

Kevin Erickson, Architect, Associate Professor, Chair of Detail + Fabriactaion Program Area

WHY SHOULD THE SSC FUND RESEARCH AND INNOVATION IN THE BUILDING SECTOR?

WE SPEND 90% OF OUR TIME INSIDE BUILDINGS...


image credit: Hans Lienhart

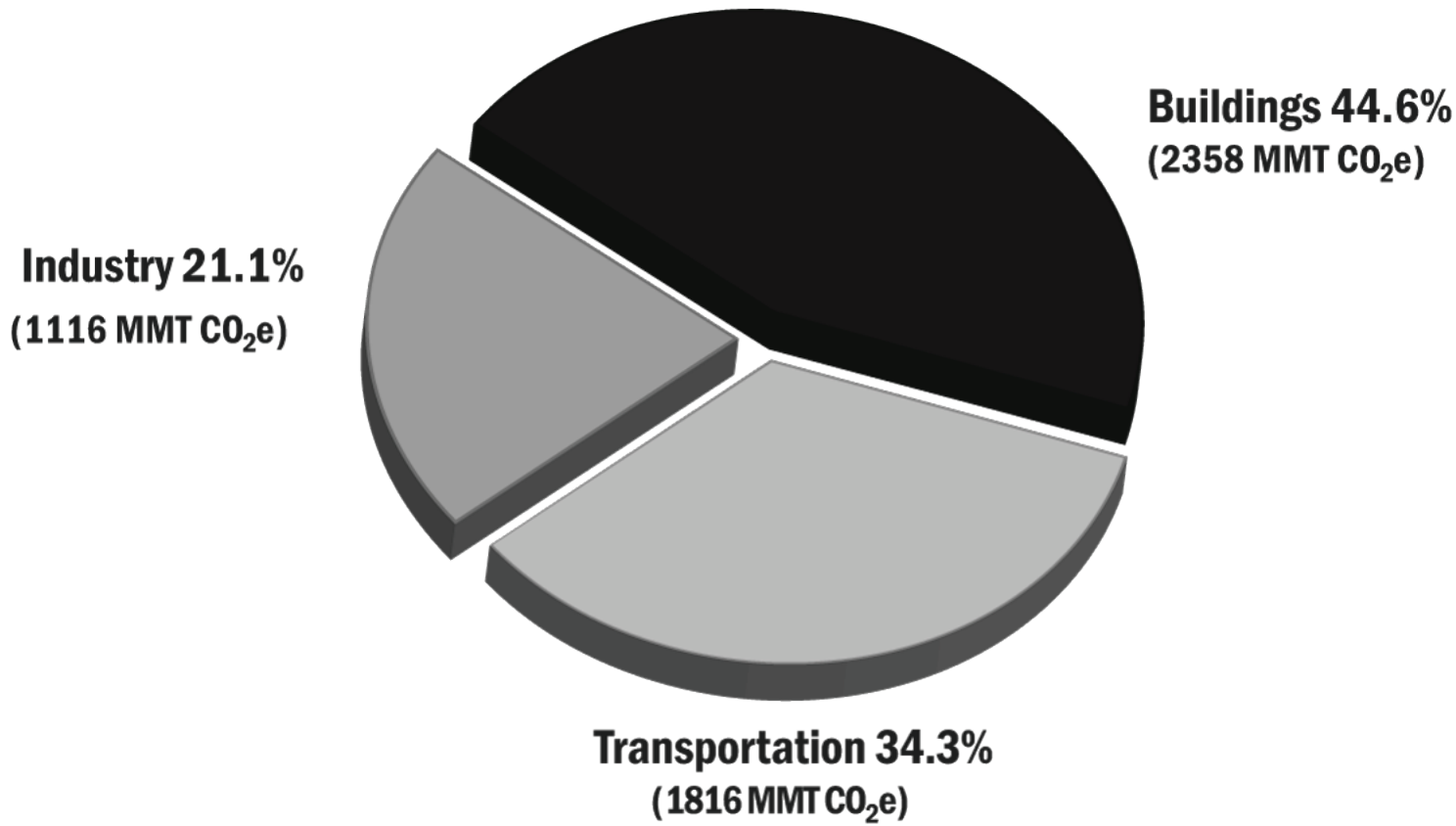

image credit: Nyree McFarlane

...BUILDINGS MADE OF WOOD, CONCRETE, STEEL AND GLASS, THAT ARE INEFFECIENT TO CONSTRUCT AND MAINTAIN


image credit: Peter Morgan from Nomadic


image credit: Pavel Arshavsky

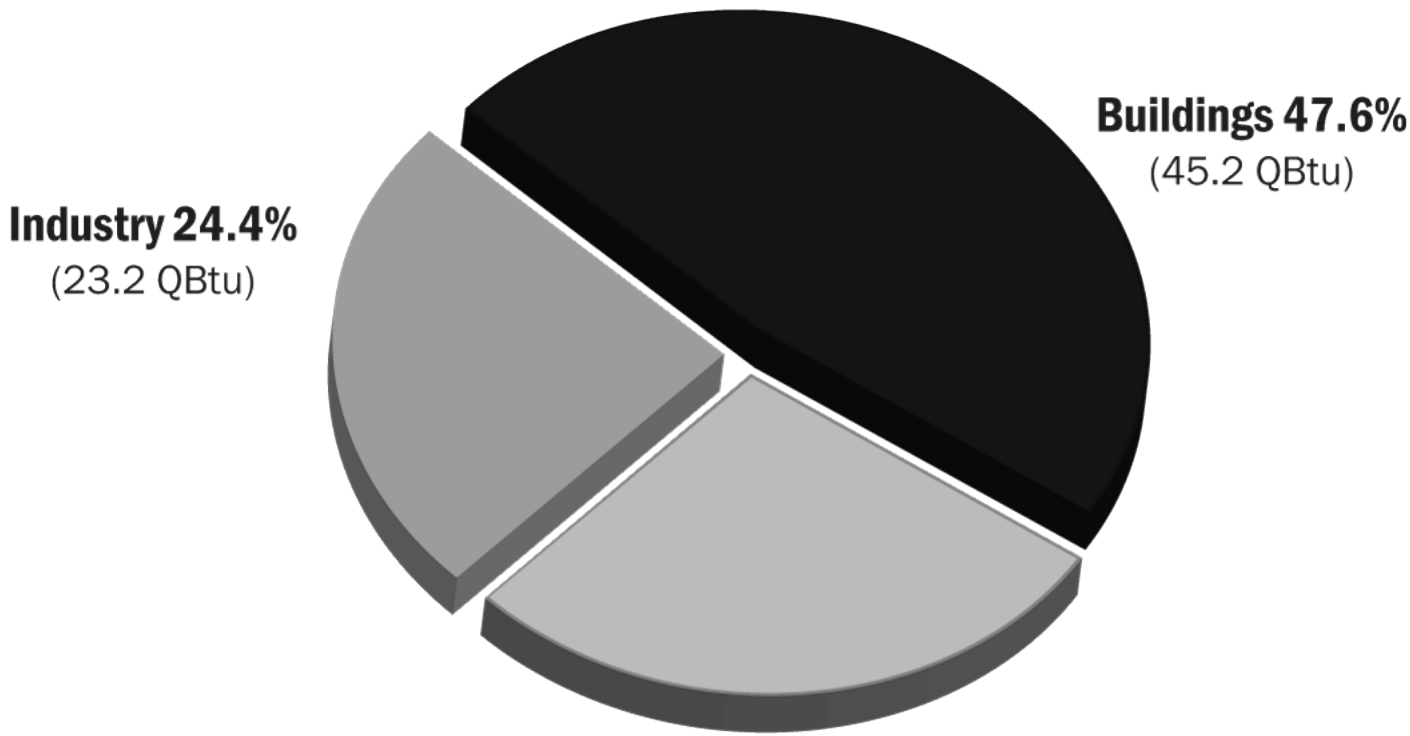
CONSTRUCTION AND MAINTAINANCE OF BUILDINGS CONSUMES NEARLY HALF OF U.S. C02 EMISSIONS...



U.S. CO_2 Emissions by Sector

Source: Architecture2030, http://architecture2030.org/buildings_problem_why
Data Source: U.S. Energy Information Administration, Year 2010

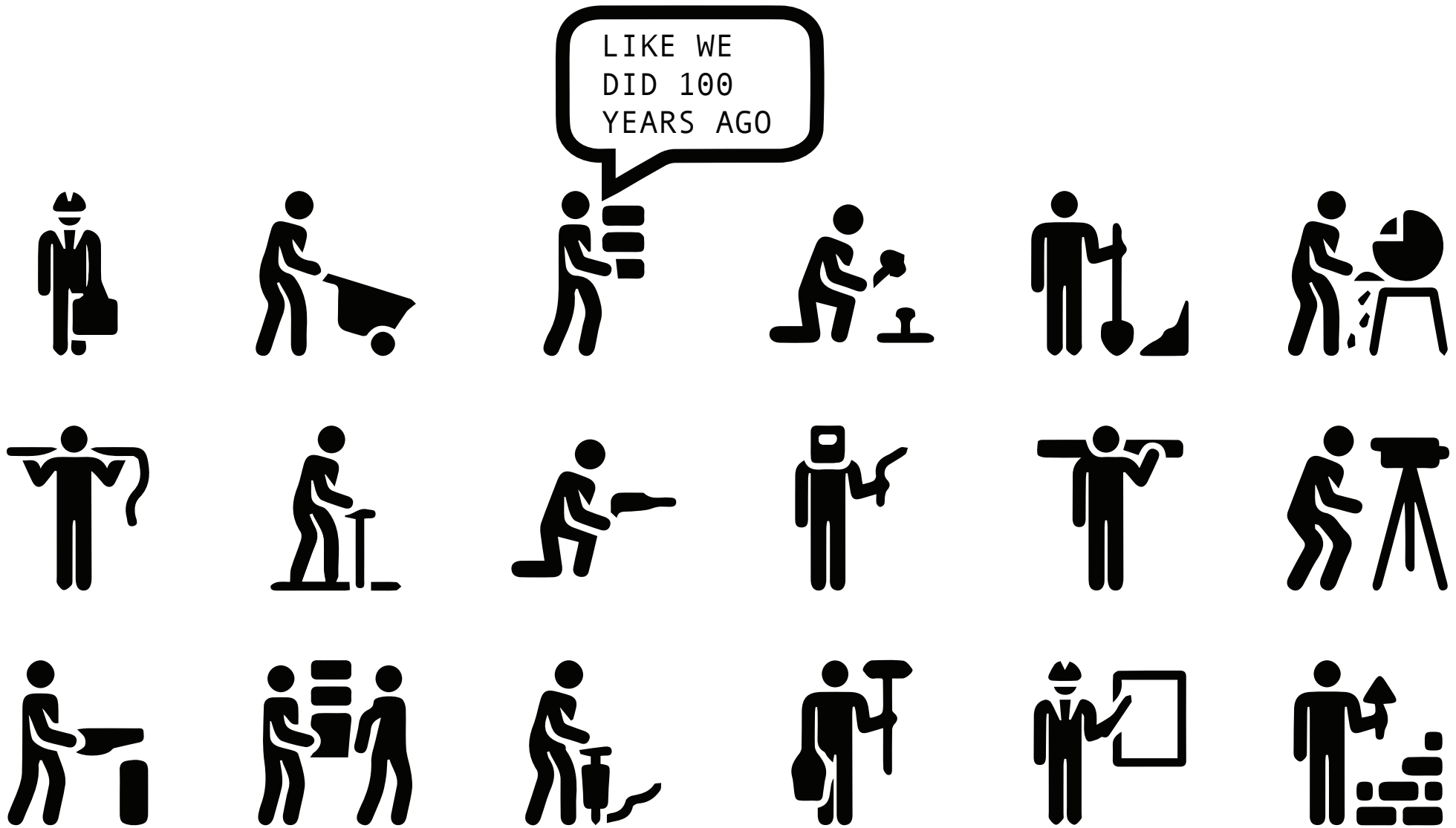
...AND NEARLY HALF OF U.S. ENERGY CONSUMPTION



U.S. Energy Consumption by Sector

Source: Architecture2030, http://architecture2030.org/buildings_problem_why
Data Source: U.S. Energy Information Administration, Year 2010

SO, HOW DO WE CONSTRUCT BUILDINGS TODAY?


LIKE WE
DID 100
YEARS AGO

HOW DO WE MANUFACTURE CARS TODAY?


333-1
333-2
HYUNDAI

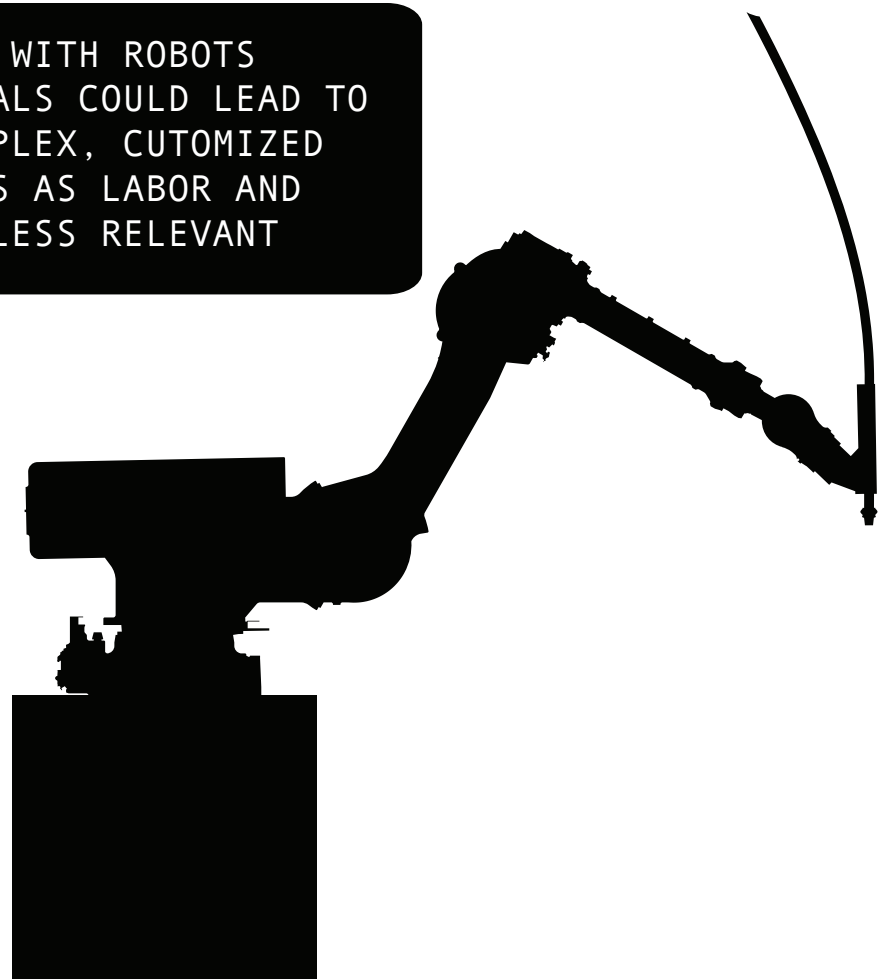
...THERE IS AN APPARENT RIFT BETWEEN TECHNOLOGICAL ADVANCEMENTS AND HOW BUILDINGS ARE CONSTRUCTED TODAY.

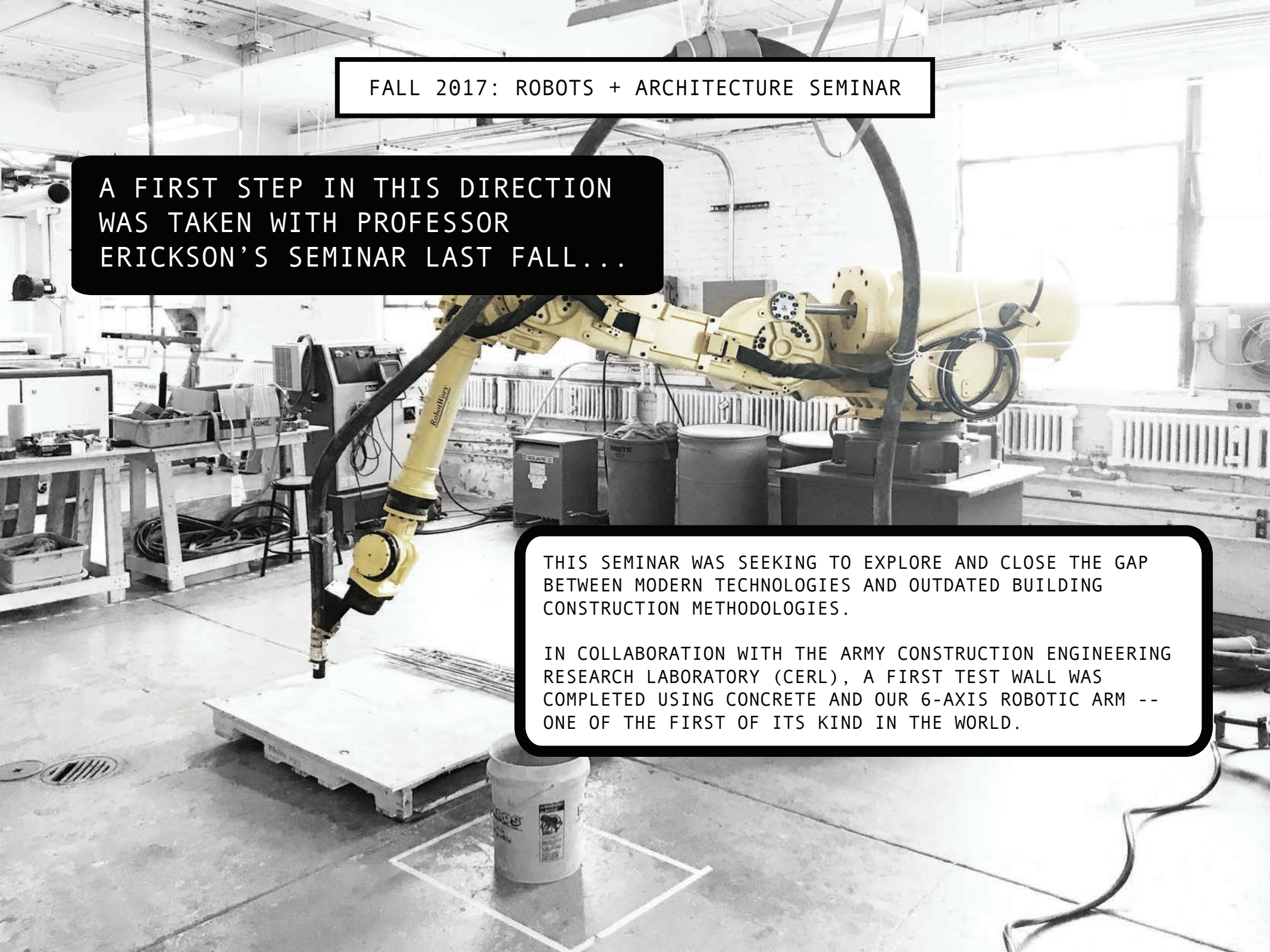
TO DECREASE ENERGY USE AND PHASE OUT C02 EMISSIONS IN THE BUILDING SECTOR, WE NEED TO FUNDAMENTALLY RETHINK HOW BUILDINGS ARE DESIGNED, CONSTRUCTED, AND MAINTAINED.

- HAZARDOUS WORK ENVIRONMENT
- LIMITED WORK/TIME SCHEDULE
- INCREASING LABOR COSTS

+ INCREASED CONTROL & ACCURACY
+ CAN OPERATE 24/7
+ SCALABLE EFFICIENCIES

CONSTRUCTING BUILDINGS WITH ROBOTS USING UP-CYCLED MATERIALS COULD LEAD TO INCRAEASINGLY MORE COMPLEX, CUTOMIZED AND EFFICIENT SOLUTIONS AS LABOR AND MATERIAL COSTS BECOME LESS RELEVANT





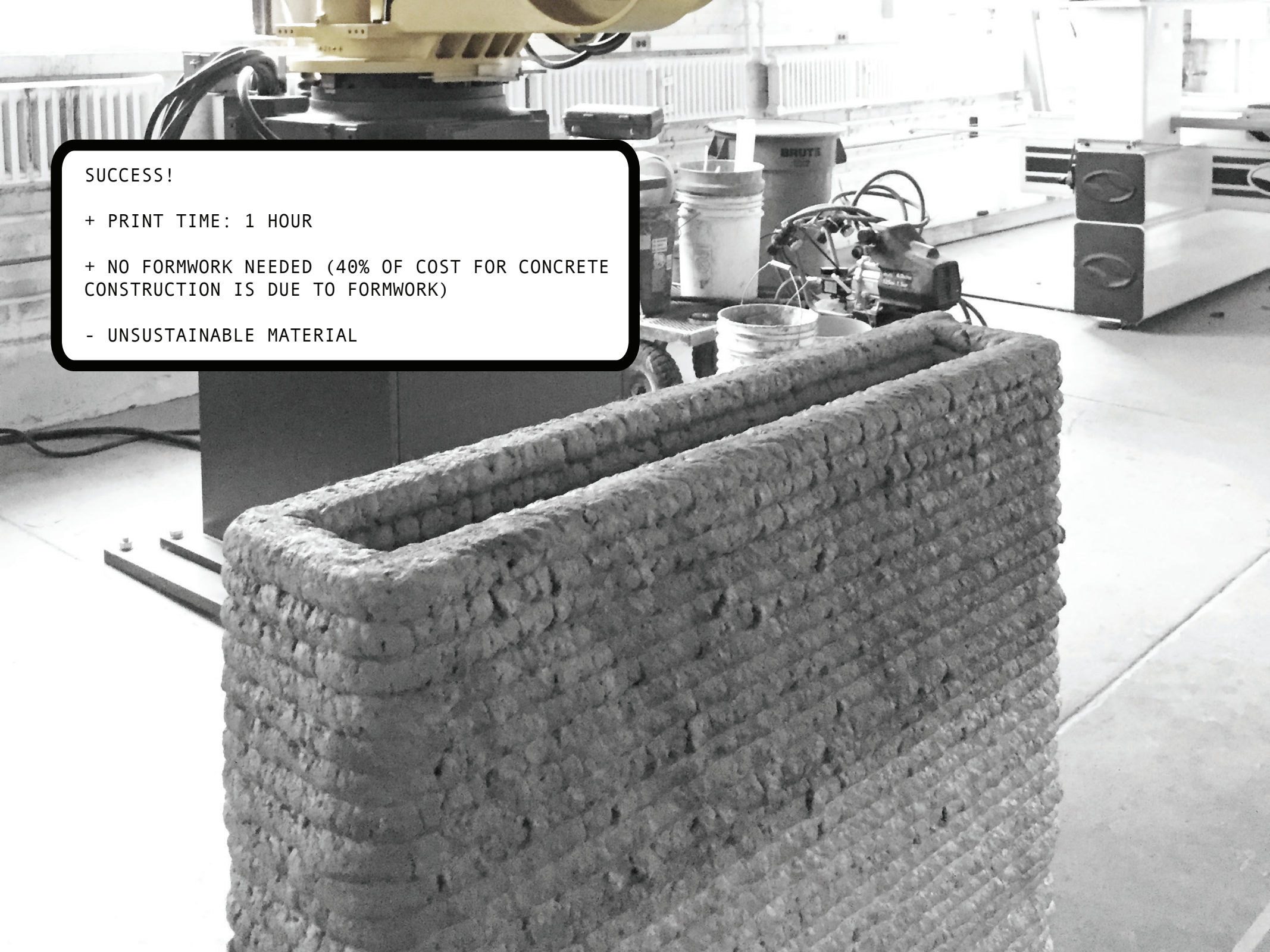
FALL 2017: ROBOTS + ARCHITECTURE SEMINAR

A FIRST STEP IN THIS DIRECTION WAS TAKEN WITH PROFESSOR ERICKSON'S SEMINAR LAST FALL...

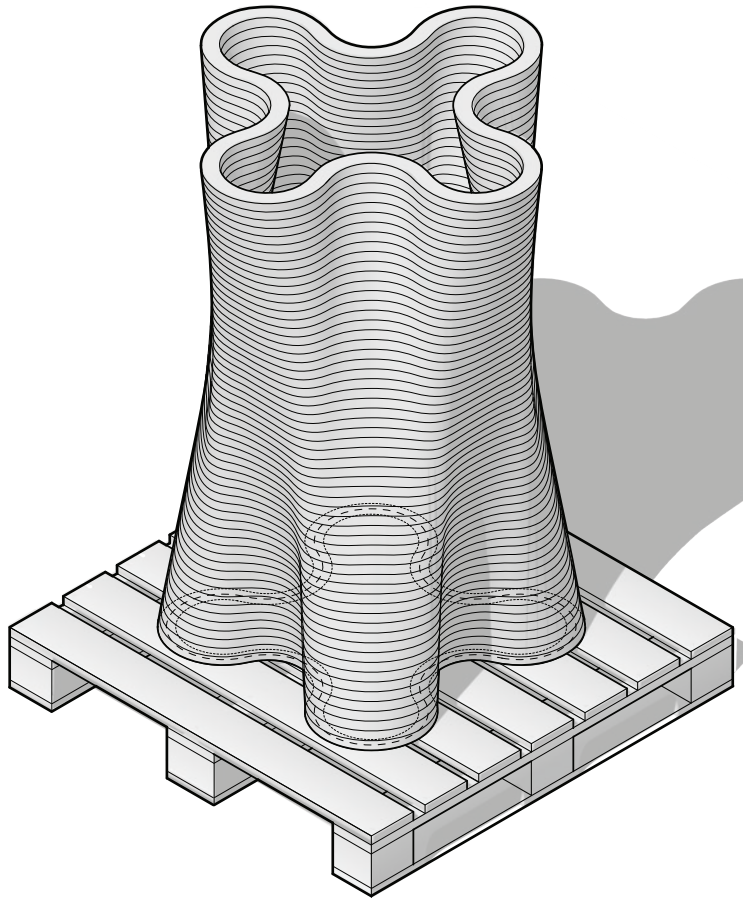
THIS SEMINAR WAS SEEKING TO EXPLORE AND CLOSE THE GAP BETWEEN MODERN TECHNOLOGIES AND OUTDATED BUILDING CONSTRUCTION METHODOLOGIES.

IN COLLABORATION WITH THE ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY (CERL), A FIRST TEST WALL WAS COMPLETED USING CONCRETE AND OUR 6-AXIS ROBOTIC ARM -- ONE OF THE FIRST OF ITS KIND IN THE WORLD.

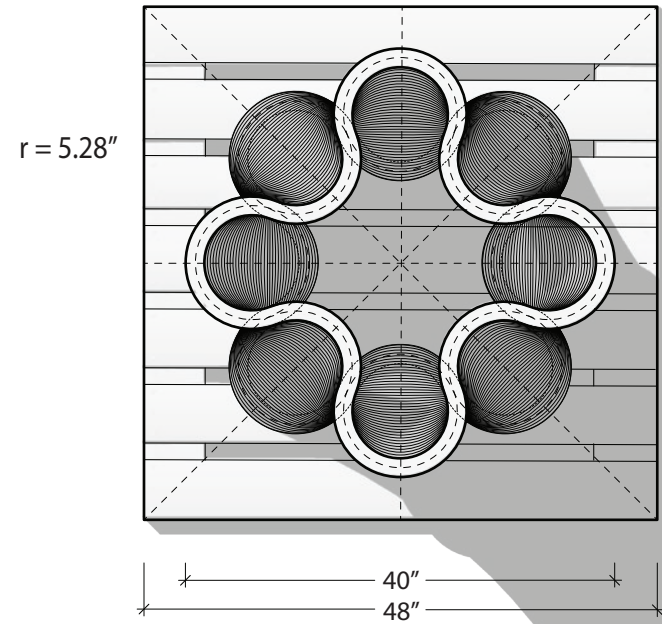
FALL 2017: ROBOTS + ARCHITECTURE SEMINAR


SUCCESS!
+ PRINT TIME: 1 HOUR
+ NO FORMWORK NEEDED (40% OF COST FOR CONCRETE CONSTRUCTION IS DUE TO FORMWORK)
- UNSUSTAINABLE MATERIAL

FALL 2017: ROBOTS + ARCHITECTURE SEMINAR



A STUDENT'S DESIGN FOR FURTHER TESTING THE LIMITS OF THIS TECHNIQUE...



+ CONTINUOUS RADII FOR A CONSISTENT MACHINE SPEED

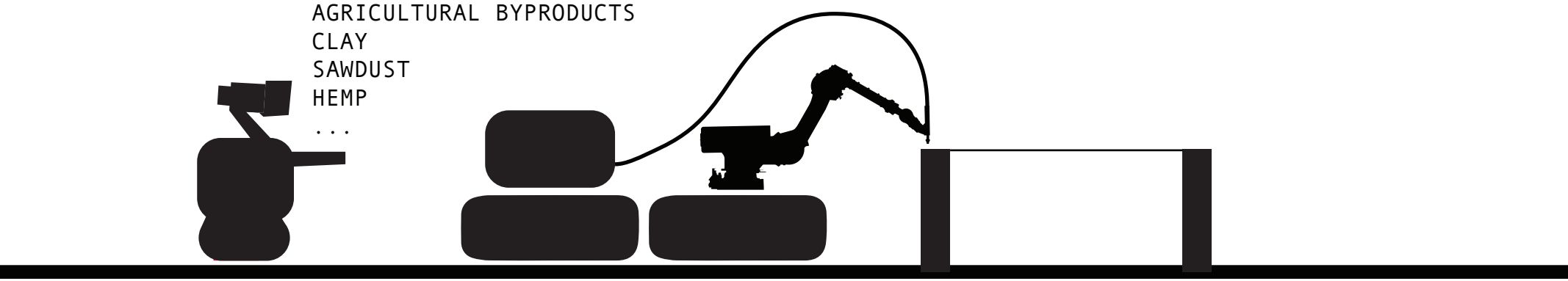
+ RECIPROCAL SHAPE ALLOWING FOR ~50% GREATER OVERHANGS (HYPOTHESIS)

NEXT STEPS...

WE ARE SEEKING FUNDING TO PURSUE STUDENT RESEARCH ON 3D-PRINTING WITH UP-CYCLED AND LOCAL MATERIALS AND EXPLORING ITS POSSIBLE APPLICATIONS

WHAT IF WE COULD BUILD A STRUCTURE SOLELY USING MATERIALS ALREADY ABUNDANT ON SITE?

WASTE
DEMOLITION DEBRIS
AGRICULTURAL BYPRODUCTS
CLAY
SAWDUST
HEMP
...



PROJECT SCHEDULE

SPRING 2018

SUMMER 2018

STUDENTS EMPLOYED TO CONDUCT MATERIAL RESEARCH AND TESTS WITH FACULTY

FALL 2018

INTERDISCIPLINARY DESIGN-BUILD SEMINAR, 3D-PRINTING PROTOYPES AND TESTING SUSTAINABLE MATERIALS

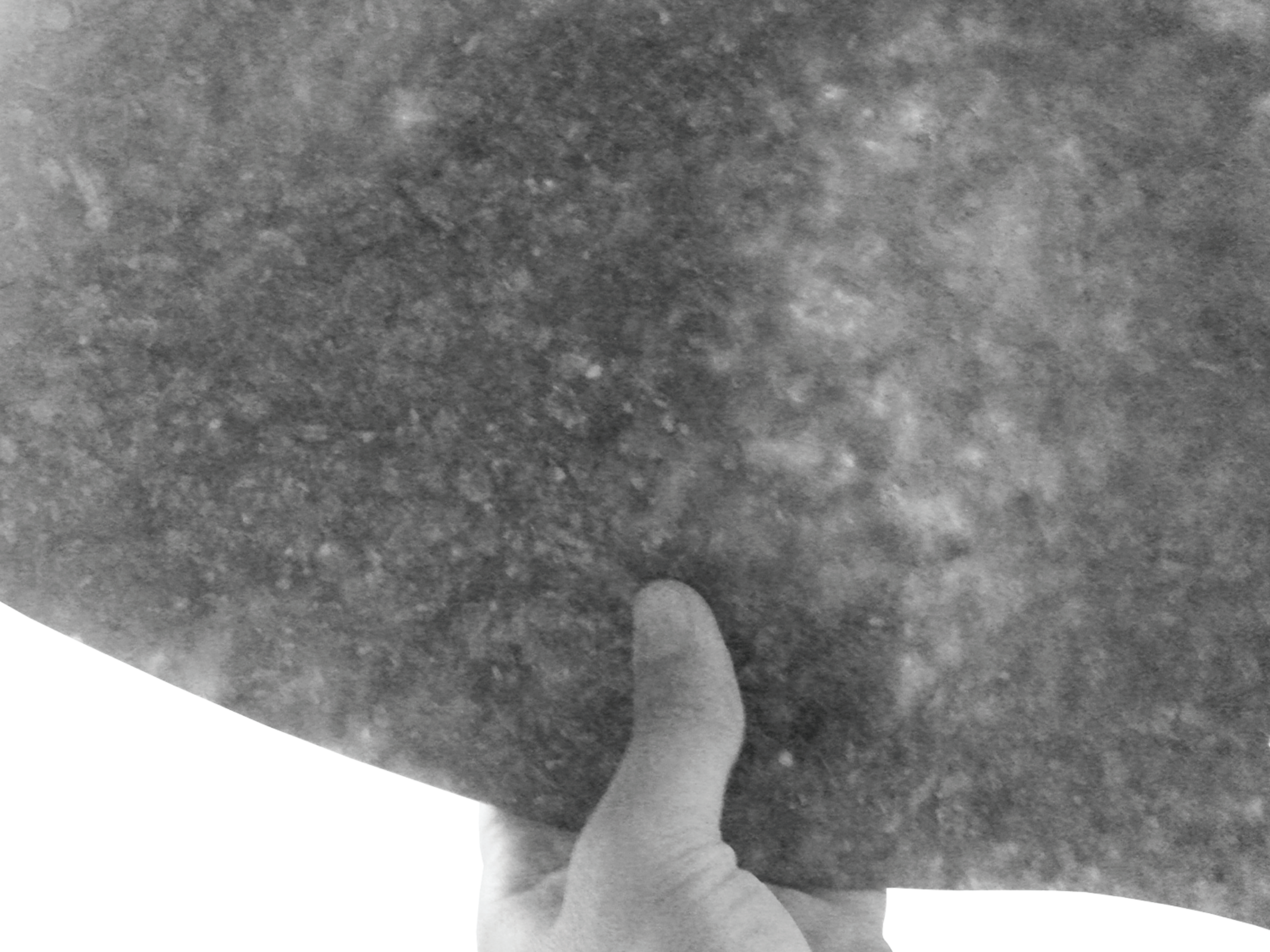
SPRING 2019

INTERDISCIPLINARY DESIGN-BUILD SEMINAR, CREATING PUBLIC INSTALLATION TO PROMOTE UIUC SUSTAINABILITY EFFORTS AND ATTRACTING MORE STUDENTS

SUMMER 2018: MATERIAL RESEARCH

PRECEDENT #1

PROFESSOR ERICKSON'S MASTER'S THESIS,
AN UP-CYCLED MATERIAL BASED ON SAWDUST



SUMMER 2018: MATERIAL RESEARCH

PRECEDENT #2

THE LIVING FOR MOMA PS1 – BRICKS GROWN FROM AGRICULTURAL BYPRODUCTS AND MUSHROOM MYCELIUM AS A NATURAL DIGESTIVE GLUE

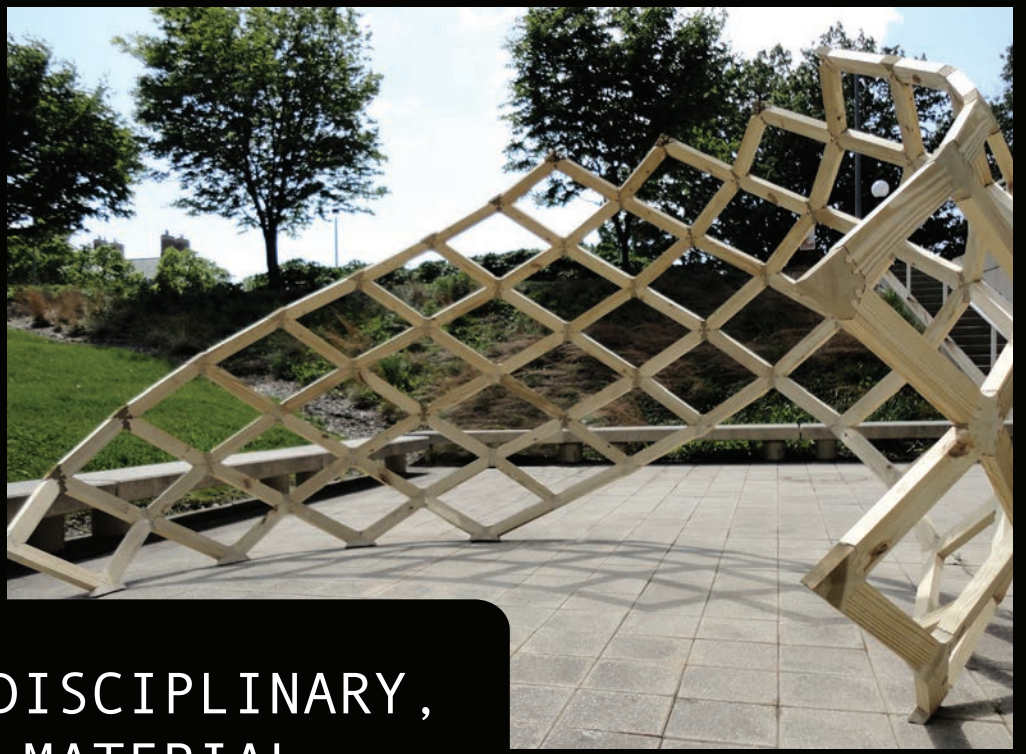
OBJECTIVES:

1. IDENTIFYING LOCALLY SOURCED BIO-BASED AND OTHER UP-CYCLED MATERIALS
2. REFINING THOSE MATERIALS WITH A NON-TOXIC, ORGANIC BINDING AGENT
3. 3D-PRINTING FULL-SCALE BUILDING COMPONENTS
4. ENGAGING A WIDE RANGE OF STUDENTS THROUGH DESIGN-BUILD SEMINARS
5. PROMOTING UIUC AND ITS SUSTAINABILITY EFFORTS NATIONALLY THROUGH A PUBLIC INSTALLATION

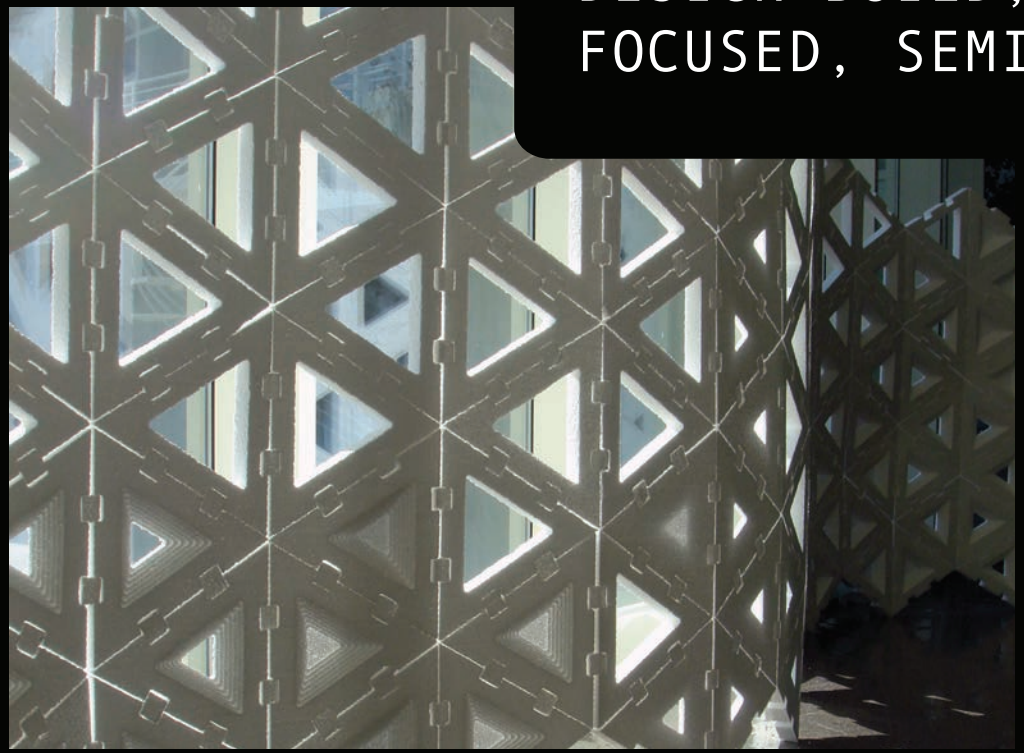
BUDGET:

$12,000 – GRADUATE RESEARCH ASSISTANT (2 SEMESTERS AT 25% APPOINTMENT)
$ 4,000 – STUDENT HOURLY EMPLOYEES
$ 6,000 – FACULTY COURSE OVERLOAD
$ 5,000 – ROBOT CONFIGURATION (FIXTURES, MOUNTS, HOSES, PUMPS, ETC.)
$ 6,500 – UP-CYCLED MATERIALS (GATHERING, PROCESSING, BINDERS, ETC.)
$ 1,500 – STRUCTURAL TESTING PROTOTYPES

$35,000 – PRELIMINARY BUDGET TOTAL



...PAST INTERDISCIPLINARY, DESIGN-BUILD, MATERIAL FOCUSED, SEMINAR COURSES



THANK YOU FOR YOUR TIME AND CONSIDERATION!