Making Architecture: Let's Be Tangible
Establishing Ground Between the Conceptual & Real

by

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ABSTRACT
This thesis interrogates the architectural potentialities of materials and their ability to inform space. Contemporary digital design techniques have allowed, more than in the past, the exploration of new complex formal languages, free of materiality. Current construction techniques have made meager attempts at achieving equivalent complexities, resulting in a severance between the drawing [conceptualization] and making [realization] of architecture.

Using chipboard, the material of the architectural model, this project develops an “a posteriori” logic of material performance by exploring physical properties through multiple techniques of fabrication and manipulation. In a broader sense, this project demonstrates how the physical properties of any material influences the conceptualization, manipulation, and fabrication processes of output. Working through established constraints of materiality, representation and design, this project establishes a catalog of methodological insights demonstrating how the conceptual design and physical construction of architecture can be more closely integrated.

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To Mom & Dad, for your support in all my crazy endeavors...this one by far the most tumultuous

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Mom & Dad Lawrence, for loving me as your own

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René Elizabeth Graham
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This thesis interrogates the architectural potentialities of materials and their ability to inform space. Contemporary digital design techniques have allowed, more than in the past, the exploration of new complex formal languages, free of materiality. Our current construction techniques have made meager attempts at achieving the same complexity, and as such there is a severance between the drawing [conceptualization] and making [realization] of architecture. This project focuses the design process by using material and fabrication constraints as guides for the generation of architectural form and the creation new construction techniques.

Using chipboard, the material of the architectural model, I have developed an “a posteriori” logic of material performance by exploring and testing its physical properties [its density, tensile strength, etc] through different techniques of fabrication and manipulation [lasercutting, folding, casting, etc]. The project takes as architectural settings of departure three parallel inquiries, each requiring that a single variable remain constant: form, manipulation, or performance. Each line of inquiry develops construction logics related directly to the constant. As such, each begins to tell a different story of how chipboard can function as a material of both construction and formal investigation. As each inquiry develops iterations, congruences begin to emerge, illustrating the relationships between form, manipulation, and performance, revealing how these interactions enable or constrain physical output.

In a broader sense, I aim to demonstrate how the physical properties of a material influence the conceptualization, manipulation, and fabrication processes of output. By working independently through established constraints of materiality, representation and design, I have produced a series of methodological insights in the form of a catalog demonstrating how the conceptual design of architecture and the physical construction of architecture can be more closely integrated. Each catalog entry documents the extensive, diagrammatic, and intensive properties of the material experiment to establish its qualities as both a conceptual element and a physical construct.

While this thesis takes chipboard as the subject of inquiry, its most important function is to establish a framework and process for material studies in architecture.
Architecture participates in the conceptualization and realization of the built environment, a task that straddles both the physical [real] and immaterial [conceptual].
The conceptual realm of architecture is the architect’s playground. Free of limitations, other than the designer him/herself, it provides infinite opportunity to explore the virtual, envision utopias, and foresee the unforeseen.
The realization of architecture becomes a new problematic, a new set of rules, tools, and laws guide the outcome of the built environment. And, rather unfortunately, the translation between idea to physical form can require compromises.
Collage of ten architectural projects in various stages of construction taken from Archinect.com December 2009
Time and time again we see masterpieces of design that push the extremes of architectural thought, yet fall short in their ability to perform as constructions or completely ignore physical ramifications. Or on the contrary, perfectly detailed constructions that fail to explore design potential because of their adherence to time-tested building logics.

In an increasingly digital world, scale and materiality are ephemeral and disposable to the modern-day designer. Yet this increasingly digital world cannot circumvent the tangible realities of the physical environment in which we exist. The question then becomes, how can we as architects, builders, and thinkers in the modern world mitigate between these two realms more successfully?

It is at this juncture that I insert my investigation.
How do we mitigate?
Technology has been a great asset to the conceptualization and study of architecture. Within the past decade, a plethora of new design tools have unlocked a digital playground where form can be explored untethered and free of material constraints. 3D modeling, vector and raster manipulators, parametric modelers, the list goes on... We embrace these tools as they are viable, elastic, and forgiving mediums of inquiry.
However, the output of this medium is largely constrained to conceptual mediums, most commonly the image. With the apparent triumph of these tools, and as such the image, in architectural thought & production, confronting the reality of the construction has become less and less a priority. Easily subsumed and obscured by other legitimate issues that are more readily accessible through conventional analytical and representational tools like the diagram, drawing or rendering. The tangible consequences of architectural decisions often become an afterthought.
Technology has also played a hand in the innovation of materials, the common denominator of all our physical constructions. Advances in the early-mid twentieth century gave us material consistency and determinate quality at quantities of mass production. Current advances in material engineering and science bear “smart” materials that are capable changing performance in response to environmental stimuli. In this way, materials are becoming more and more tuned to certain performance criteria.
WWI - WWII (1920s-1940s)

*the WW's.

Mass production is popularized by Ford Motor Company.

**PVC** (1926)
- Plastics resulting in modern a method to produce.
- B.F. Goodrich Company developed.
- Duralex introduces a tempering process that increases the strength of glass by 6 times.

**First purely synthetic fiber**
- Fiberglass and resin created high strength and durability.
- Researchers at DuPont began exporting countries with silk that were searching for airplane parts.

**Tempered Glass** (1939)
- Owens-Corning to import Fiberglass as a synthetic since US were searching for.

**Nylon** (1939)
- 1940 - 1930
- Fragile.
- Resorcinol adhesives developed allowing engineered woods to be mass produced.

**Waterproof Adhesive** (1946)
- Fully waterproof phenol-formaldehyde.

**Polystyrene** (1941)
- Replacement for zinc began in Germany.

**Plexiglass** (1942)
- Invented as a result of trying to combine by.

**Silicone** (1943)
- Corning and Dow, silicone is developed as a material for.
- A joint venture between.

**Synthetic Rubber** (1945)
- Began to be mass produced.
- Increased & it became a major industry in the space race, annual.

**FHA Accepts Plywood** (1948)
- Interiors and exteriors of plywood.
- Included performance tests for both.

**LD Process** (1952)
- Strength steel becomes stronger. High content & impurities, therefore making that reduces carbon.
- Oxygenation process in steel manufacturing that allowed uniformity. Standard for.

**Float Glass Process** (1959)
- Photographs for glass optic cables patented.

**Carbon Fiber** (1963)
- Weave of extremely thin.
- Material consisting of a composite reinforcement to strengthen materials.

**Concrete Fiber-Reinforced** (1970)
- Commercialized.

**Fiber-Reinforced Concrete** (1970)
- First commercialized fiber-reinforced structural concrete introduced.

**Structural Glazing** (1972)
- UK glass making giant Pilkington begins experimenting and patents its first structural glass system.

**OSB 1978 - 80**
- Oriented Strand Board is introduced into the market. Instead of solid sheets of veneer, OSB is made of small wood strands that are glued together in cross-laminated layers.

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**1980**
- **Fiber-Reinforced Concrete** (1970)
  - First commercialized fiber-reinforced structural concrete introduced.

**Nanoscience 1980s**
- Discovery of fullerenes and carbon nanotubes gives birth to studies of nanotechnology and nanomaterials.

**SFB 1974**
- Founding of the Society for Biomaterials.

**MRS 1973**
- Founding of the Material Research Society.

**1990**
- **Thin Film Production 1999**
  - Thanks to Harold McMaster, thin film technology can be mass produced.

**Tri-Chord Steel 1999**
- Thermally efficient steel that minimizes thermal bridging.

**ISOGrid 1993**
- Patent for ISOGrid, Thin sheet metal reinforced with integral fibers in a triangular pattern.

**Ductal 1995**
- Patent for Ductal, fiber-reinforced concrete that offers ductility, strength & durability with high compressive and flexural strengths.

**Aerogel 1999**
- Developed by NASA and deemed the material of the future, aerogel is the lightest material known that has great compressive strength and insulation properties, but allows light transfer.

**Ductal 1995**
- Patent for Ductal, fiber-reinforced concrete that offers ductility, strength & durability with high compressive and flexural strengths.

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**USGBC 1995**
- Founding of US Green Building Council marks an invigoration of the sustainable building movement.

**Panelite 2002**
- Recycled glass solid surface translucent panels structurally efficient.

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**Aluminum Foam 2001**
- Patent of open cell aluminum foam.

**Panelite 2002**
- Honeycomb composite structurally efficient translucent panels.

**IceStone 2003**
- Recycled glass solid surface.

**SwissPearl 2000**
- Fiber-cement composite facade system.

**Light-Sensitive Concrete** (2006)
- Technology that allow concrete to be sensitive to ambient light levels.

While material advances open a new realm of possibilities for our built environment, the specificity of their applications and the technology required to manufacture them can potentially constrain their usage. Not only do manufacturing costs become an issue, but so does their ability to take hold as viable construction materials within the market.
The Problematic
Capitalizing on the fluidity of the digital tool and the performative qualities of the material, there is a potential for a dynamic relationship to exist; a relationship beyond the simple input to output of digital fabrication; a relationship of design invention and interaction where material realities can inform conceptualizations and conceptualizations can inform realizations in an iterative fashion.
ASKING THE BRICK VS. ASKING THE DIAGRAM //

The potential dynamic between digital and material media is evident. However, this exchange raises the issue of priority. The discipline of architecture perpetually seeks design legitimization. That is, some underlying reasoning that relinquishes full authority over the design. Classical orders, Renaissance proportions, Vitruvius’ Ten Books, Le Corbusier’s Five Points; these are all examples in architectural history of attempts to formulate a system of priority in design. Today, although not as apparent, the same legitimization exists: terms like “translate”, “generate”, and “derive” have become a commonplace in the description and defense of design solutions. Contemporary deliberation between conceptual and real further provokes this inquiry, and in addition raises the issue of authorship. Most specifically, which takes priority, the brick [material, real] or the diagram [conceptual, digital]?

The brick = the tangible medium. Governed by laws and phenomenon of physics and nature, it is the medium of finite resolution. By allowing the material to take priority, the architect plays a participatory role, acting as a vehicle or conductor of these tangibles into spacial organization.

The diagram = the intangible medium. A representation of relationships that create abstract models of materiality, the diagram is rooted in qualities of the physical but can be abstracted from both scale and origin. It is the medium of infinite resolution where the only system of constraint is the author him/herself.
What should the role of the architect be? Are we vehicles of materiality or authors of diagrams? Theoretical discourse has debated this issue time and time again. Over the years architects have situated themselves somewhere along this spectrum. With huge innovations occurring at both digital and material mediums, how is the role of the architect affected and consequently change our built environment?
Chipboard scored & delaminated to represent a weathered tile-like texture.

Chipboard layered together to represent topography and stairs.

Chipboard laser-cut with varying apertures to represent a screen wall.
INTRODUCTION TO CHIPBOARD

For the purpose of investigation for this thesis, I chose chipboard as the material subject. Chipboard is a composite material comprised of

- 95-97% recycled paper
- 2-3% water
- 1-2% glue

It is a highly sustainable material that is relatively simple to make. It is, by industry standards, a thick, low-grade paper product.

WHY CHIPBOARD?

The most common commercial application for chipboard is packaging:

As packaging it provides structure for and forms protective enclosures for commercial products.

However, in the discipline of architecture chipboard operates as a material that completely lacks materiality. That is to say, it is used as a surrogate for other “true” materials that operate at larger scales.
The Problematic
By choosing a material that within this discipline is most commonly denied its materiality, it raises the very issue that thesis is trying to question: how can we bridge the gap between the conceptual and real?
SITE OF INVESTIGATION //

YOU ARE HERE

THE CONCEPTUAL

digital/diagram
author
model

THE REAL

material
vehicle
construction
METHOD OF INQUIRY //

This system of inquiry was devised to approach the material as both a conceptual tool and a material for construction. In order to do this, it was necessary to set up constants in how the material was tested and how the results were analyzed.

TESTING//Three Parallel Inquiries

01 Form

This series of material inquiries uses form as a constant. Each investigation in this series begins with a formal object and uses chipboard as the medium to construct that object. There is no restriction on the manipulation, assembly or construction technique employed to realize the form.

02 Manipulation

This series of material inquiries uses manipulation as a constant. Each investigation begins with chipboard in its natural state of the sheet. The sheet is first altered using one type of simple manipulation (for example a fold, a cut, a score). Then the altered sheet is finessed to texturize, inflate, embellish, and support. The aim of this series is to infuse the flat sheet of chipboard with an entirely different disposition by employing a single operation, and then investigating variations within that operation.

03 Performance

This series of material inquiries uses performance as a constant. Each investigation begins with a specific performance as its objective. These objectives are framed around architectural criteria such as structure, temperature, tactility and light. The chipboard undergoes whatever manipulation, assembly, or construction, required to fulfill the performance objective. The aim of this series is to engage the material with performance as the only constant.
ANALYSIS/

01 Extensive
This documents the properties of the resultant that are dependent upon the size of the system and the amount of material within the system [quantitative]. These properties explain the physicality of the manipulation, its size, shape, weight, dimension, etc. It is also where the processes of making is catalogued step by step so the experiment can be reproduced.

02 Diagrammatic
This documents how the resultant operates as a geometry, figure, formal strategy, diagram, or abstract model of materiality. This documentation is meant to be scaleless so the resultant can be analyzed without discrimination to size and physicality.

03 Intensive
This documents the properties of the resultant that are independent of the system size and material quantity. These are quantitative plus qualitative properties that illustrate the performative potentials of the resultant as a physical construction. Information is captured via measuring devices (such as a thermometer, a scale, a microphone, a camera) and through visual inspection in order to document quantitative data.

[See page 34 for potential areas of Intensive Analysis. For the purpose of this investigation Light & Compression were documented]
Possible Intensive Studies derived from Typical Architectural Performance Criteria

<table>
<thead>
<tr>
<th>APERTURE</th>
<th>small/complex</th>
<th>large/simple</th>
<th>fluctuating</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE</td>
<td>human</td>
<td>building</td>
<td>room</td>
</tr>
<tr>
<td>DENSITY</td>
<td>compressed</td>
<td>expanded</td>
<td>heterogenous</td>
</tr>
<tr>
<td>RIGIDITY</td>
<td>pliable</td>
<td>brittle</td>
<td>resilient</td>
</tr>
<tr>
<td>TACTILE</td>
<td>smooth</td>
<td>jagged</td>
<td>weathered</td>
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<tr>
<td>MOISTURE</td>
<td>wet</td>
<td>dry</td>
<td>humid</td>
</tr>
<tr>
<td>LIGHT</td>
<td>bright</td>
<td>dim</td>
<td>moderate</td>
</tr>
<tr>
<td>SOUND</td>
<td>high frequency</td>
<td>low frequency</td>
<td>mid frequency</td>
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<tr>
<td>TEMPERATURE</td>
<td>hot</td>
<td>cold</td>
<td>variable</td>
</tr>
<tr>
<td>STRUCTURE</td>
<td>compression</td>
<td>tension</td>
<td>tension/shear</td>
</tr>
</tbody>
</table>
The following pages document a series of forty chipboard experiments conducted between October 2009 and December 2009. These experiments, their documentation, and the formulation of this catalog are to serve as a preliminary template for future material experiments in architecture and design. For up-to-date information and new experiments please visit www.materialmanipulations.com
Identify Key Relationships

As the experiments progress, it is important to find overlaps and relationships. These relationships lead to an understanding of the relationship between each line of inquiry. That is to say, with each line that we draw or with each cut that we make, there is a performative result whether intended or not. Inversely, to create certain performative result, certain manipulations and conceptualizations are required. By identifying the congruences across these inquiries, those relationships will be revealed. By cataloging these experiments as a continuing or ongoing database, designers/builders/thinkers/inventors can build upon this logic.

What does it mean to cut in performance? What does it mean to conceptualize sound?

These are some of the lines of inquiry that the growth of this experimentation and knowledge can help us to understand.

A Call To Action

Within the qualitative/intensive analysis of each experiment, there is room to grow. Each experiment can be rebuilt, reformed, and tested for different criteria than what has been explored within this project. Refer back to the table on page 24. The possibilities are endless. If you are interested in pursuing a similar investigation, please visit www.materialmanipulations.com.
This project serves as an open framework for future inquiries, experiments, and investigations can live, grow, and develop relationships.

It is a space that is both real and virtual

finite and infinite

material and digital.

It is a space where you can expect the unexpected.

Reiser + Umemoto stated, "Material practice is the shift from asking ‘what does this mean?’ to ‘what does this do’?”. As architects of real and virtual space, we must not only be able to answer both, but understand how one affects the other.
Oral Defense

Photographs courtesy of Chris Lawrence.


Testa, Peter, and Devyn Weiser. “Emergent Structural Morphology.” AD Architectural.

