4.510 Digital Design Fabrication
Fall 2008

For information about citing these materials or our Terms of Use, visit: http://ocw.mit.edu/terms.
Lecture 1

Materializing Design

Prof. Larry Sass
Department of Architecture

How does Digital Fabrication Work for architects?

- Method - Materializing Design
- Generating Results - Artifacts
Digital Fabrication
(Systems)

Design
Rapid Prototyping

Construction
CNC Fabrication
Artifacts
(something created by humans usually for a practical purpose)
Vision of Digital Fabrication

Stephen Kieran & James Timberlake

• Increase the quality of the built environment

• Lower building cost

• Integration of building trades

Image of book cover removed due to copyright restrictions.
How is a Design Materialized?

- Materializing a design is transformation of a virtual artifact to a physical artifact

- In theory digital design and digital manufacturing methods will facilitate all forms of constructions

- 2D drafting will be substituted with representations in 3D for fabrication.
Ways to materialize an artifact

• Subtractive
  – Laser cutting
  – Waterjet cutting
  – CAD/CAM cutting

• Additive
  – Layered Manufacturing
  – Mold making
Integrated thinking?

- Benefits of digital fabrication
  - Concept to Construction processing
  - Fewer physical tools
  - Integration of design and manufacturing

- Integration of four sub-fields

1. Material/Structure
2. Assembly
3. Machining
4. Modeling
How is a Design Materialized?

[1] modeling

[2] machine & material

[3] assembly

Measure

Cut or Build

Assemble
Process

- Translation of a virtual artifact to physical artifact
- Design Language
- Constraints

**Physical**
- Structural
- Assembly
- Material
- Machine

**Visual**
- Form
- Spatial
- Ornamental
- Style

Figure by MIT OpenCourseWare.
Integrated Thinking

1. Modeling/CAD
2. Assembly
3. Machining
4. Material/Structure
Error in Fabrication

- Error Correction and Redirection is found in Telecommunications – Ability to detect errors in data transmission across a noisy channel
- What is an architectural Error
- Patterns – Interior & Exterior Finishes
- Error is unpredictable & costly
WALL [A]  
144 tiles \times a = \text{cost}

\[ \begin{array}{c}
\text{standard} \\
10'' \times 10'' \text{ tile}
\end{array} \]

WALL [B]  
144 + (25 \text{ tiles} \times a (m \& c)) = \text{cost}

\[ \begin{array}{c}
\text{error [1]} \\
12 \text{ tiles} \rightarrow
\end{array} \]

\[ \begin{array}{c}
\text{error [2]} \\
12 \text{ tiles} \rightarrow
\end{array} \]
Cost of Error

Wall [A] = Assembly only

Wall [B] = Assembly + Measure + Cut

HouseCostTime = (nWalls x [A]) + (nWalls x [B])
Solutions

Error in fabrication is reduced by

1. cutting or building components with precise machinery

2. Reduction in the number of parts in construction

3. By guiding assembly through smarter components

Results = lower cost, faster construction, higher quality buildings
Methods

Frank Gehry

Kieran/Timberlake

Berhard Cache
Legacy Home Delivery Systems

- Low precision
  - Hand cut parts

- Slow Production
  - Production = \( (m + c + a) \text{ num}_\text{parts} \)

- Each cut part is unique

- Most finishes are hand cut on site

- High cost

Stick build

Factory build
Digital Home Delivery Systems

Benefits

• High precision
• Fast fabrication (machine made)
• Reproducible
• High variety
• Low cost
• Safe construction
Digitally fabricated homes

1. Material waste

2. Few proven systems

3. Labor intensive in design (Building Information Modeling)
Materializing Design @MIT
by Larry Sass
Project Data

- One Room with Furniture
- 114 Sheets of Plywood
- 984 components
- Approximate Cost $2,500
- Translate design model into construction components and fabricate in one month
Generating Compliant Descriptions

Design Model

Construction Model

Cut sheet
Compliance

*Computational (measurable)*

**Physical**
- Structural
- Assembly
- Material
- Machine

**Visual**
- Form
- Spatial (Floor plan)
- Ornamentation
- Style
Start CNC Machine

Material Stock
114 Sheets of Plywood

Assembly with a rubber mallet only
Summary

- How does Digital Fabrication Work for architects

  - **Skills**
    - CAD
    - Machines
    - Materials

  - **Method**
    - Materializing Design

  - **Results Complaint Artifacts**