From Sun Mao to Emergent Structure

Yang Song

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From Sun Mao to Emergent Structure
With the exploration of the cultural meaning and structural capacity of the traditional Chinese joinery, Sun Mao, the intent of this thesis is to propose a joinery-driven design system, which merges architecture and structure, and bridges the vernacular Chinese culture with the contemporary fabrication technology.

Key Words: Tectonic; Joinery-Driven; Computational Design; Geometry Rationalization; Typology Optimization; Material Behavior; Robotic Fabrication; Algorithm-aided Design.
1. Diagrams from the building manual Yingzao Fashi (published in 1103) of the Song Dynasty

2. Traditional Chinese Architecture Diagram
Sun Mao and Dou Gong

Dou Gong is the building component that connects a beam and a column, passing down the load.

Sun Mao is the joining technique.

Dou Gong is the best expression of Sun MAO.
Dou Gong

1. Bracket system

4. Residential building in Yunnan Province

2. Ornament

5. Colourful dougong supporting a structure at Saga-mi-ji, Japan

3. Symbol

6. Complexity/Decoration/ Cantile-
4. Joint- Structure

Screwed Butt Joint
3D Printing Joint
Statement
Background
  History
  Furniture Design
    Fabrication Tools
      Precedent, Kengo Kuma
      Precedent, Shigeru Ban
  Emergence
  Typological Research
  Testing Ground
  Algorithmic Design
  Digital Fabrication
Stockholm-based Reed Kram and Munich designer Clemens Weisshaar have devised, coded and built a pop-up robotic plant for CODE_n, a digital innovation platform.

Complex form from 3D Printing
Statement

Background

History
Furniture Design
Fabrication Tools
Precedent, Kengo Kuma
Precedent, Shigeru Ban

Emergence
Typological Research
Testing Ground
Algorithmic Design
Digital Fabrication

Prostho Museum, Japan / Kengo Kuma & Associates

Galerie Phillipe Gravier Pavilion / Kengo Kuma & Associates

Tsumiki Staking Blocks / Kengo Kuma & Associates

Starbucks Office / Kengo Kuma & Associates
Statement
Background
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Precedent, Kengo Kuma
Precedent, Shigeru Ban
Emergence
Typological Research
Testing Ground
Algorithmic Design
Digital Fabrication

Tamedia Office Building, Zurich / Shigeru Ban Architects

Aspen Art Museum, Colorado / Shigeru Ban Architects
Statement
Background
History
Furniture Design
Fabrication Tools
Precedent, Kengo Kuma
Precedent, Shigeru Ban
Precedent, He Jingtang/ OMA
Emergence
Typological Research
Testing Ground
Algorithmic Design
Digital Fabrication

Icon

China Pavilion, Shanghai EXPO 2010 / He Jingtang

Venice Biennale 2014 / OMA
One would be a broadly aesthetic outlook that tends to 'impose' form on building materials, according to some pre-ordained 'template' (And here one immediately thinks of the role of 'proportions' and other systems of visual ordering).

The other would be a broadly structural outlook that tends to allow forms to 'emerge' according to certain programmatic requirements.

Statement
Background
Emergence
Typological Research
Testing Ground
Algorithmic Design
Digital Fabrication
Diagrams from the building manual Yingzao Fashi (published in 1103) of the Song Dynasty


@TheJoinery.jp Twitter Account

Photos from Internet
Axon

http://godbouldandsons.tumblr.com/

Section
1. Tugite and Shiguchi.

Tugite and Shiguchi are traditional architectural techniques of Japan.

Tugite is the technique to connect materials to augment the lack of length of available materials.

Shiguchi is a technique to connect materials at an angle.
2. Number of Joint Members

- 2 Members
- 3 Members
3. Position

Statement
Background
Emergence
Typological Research
Resource
Typology
Categorization
Testing Ground
Algorithmic Design
Digital Fabrication

Corner

Housing
4. Structural Performance

Friction

Friction + Interlock
4. Structural Performance (Tugite)

Compression
2 Axes  3 Axes
3 Axes

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4. Structural Performance (Tugite)

Tension
4. Structural Performance

- Stress Pattern
- Principle Stress

Typological Research

- Resource
- Typology
- Categorization

Testing Ground

- Algorithmic Design
- Digital Fabrication
5. CNC Milling Axes

- 3 Axes
- > 3 Axes
3 axes
6. Matrix
7. Filter

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| Raw Labels |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| 1 | 8 | 15 | 22 | 29 | 36 | 43 | 50 | 57 | 64 | 71 | 78 | 85 | 92 | 99 |
| 2 | 9 | 16 | 23 | 30 | 37 | 44 | 51 | 58 | 65 | 72 | 79 | 86 | 93 | 100 |
| 3 | 10 | 17 | 24 | 31 | 38 | 45 | 52 | 59 | 66 | 73 | 80 | 87 | 94 | 101 |
| 4 | 11 | 18 | 25 | 32 | 39 | 46 | 53 | 60 | 67 | 74 | 81 | 88 | 95 | 102 |
| 5 | 12 | 19 | 26 | 33 | 40 | 47 | 54 | 61 | 68 | 75 | 82 | 89 | 96 | 103 |
| 6 | 13 | 20 | 27 | 34 | 41 | 48 | 55 | 62 | 69 | 76 | 83 | 90 | 97 | 104 |
| 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 | 91 | 98 | 105 |
Algorithmic Design

- Grasshopper for Rhino
- Grasshopper Python Component
Axonometric
Exploded Axon
Principle Stresses
Bibliography


Image Citation

7. https://read01.com/vx2ARQx.html
8. http://blog.sina.com.cn/s/blog_3f0c1e2a0101njol.html
10. http://www.ultimatehandyman.co.uk/how-to/woodworking/butt-joint
11. http://lumberjocks.com/brentmore/blog/35076
17. http://www.spoon-tamago.com/?s=kengo