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From Sun Mao to Emergent Structure

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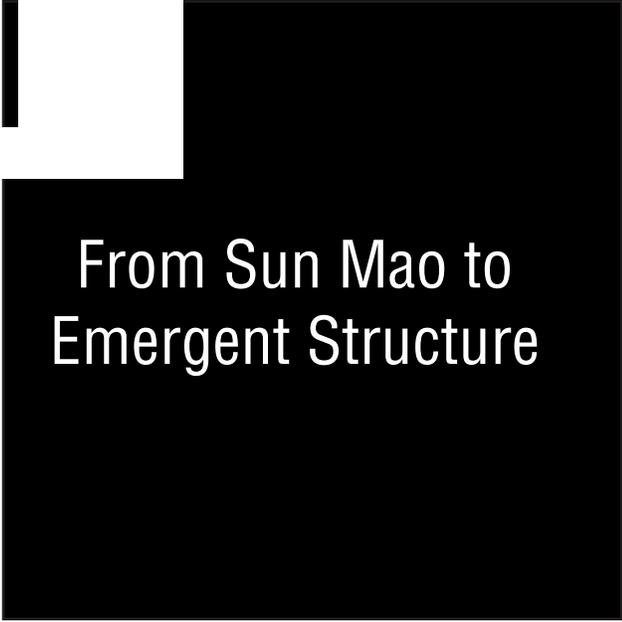


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From Sun Mao to Emergent Structure

Thesis Prep
Documentation
Fall 2016
Yang Song

Statement



Background



Emergence



Typological Research



Testing Ground



Algorithmic Design



Digital Fabrication



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.

Statement

Background

History

Furniture Design

Fabrication Tools

Precedent, Kengo Kuma

Precedent, Shigeru Ban

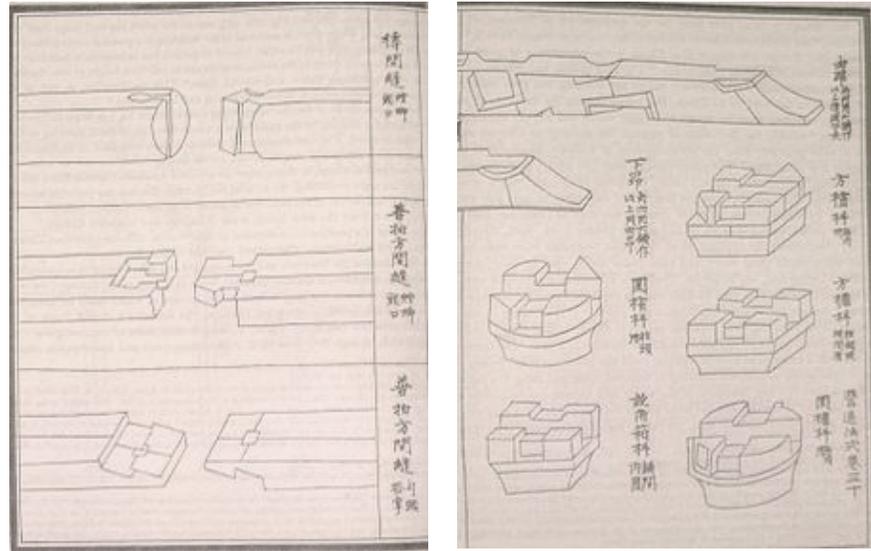
Emergence

Typological Research

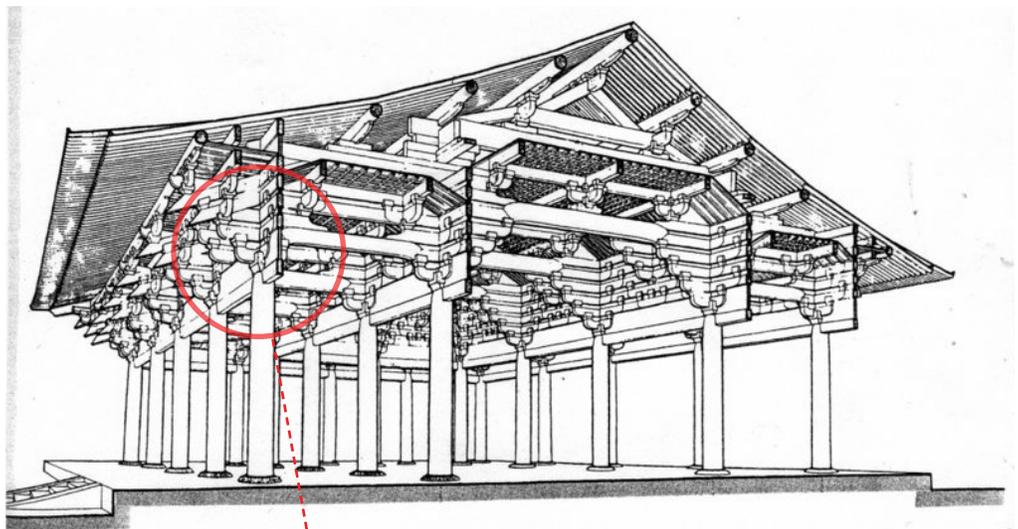
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Digital Fabrication



1. Diagrams from the building manual *Yingzao Fashi* (published in 1103) of the Song Dynasty

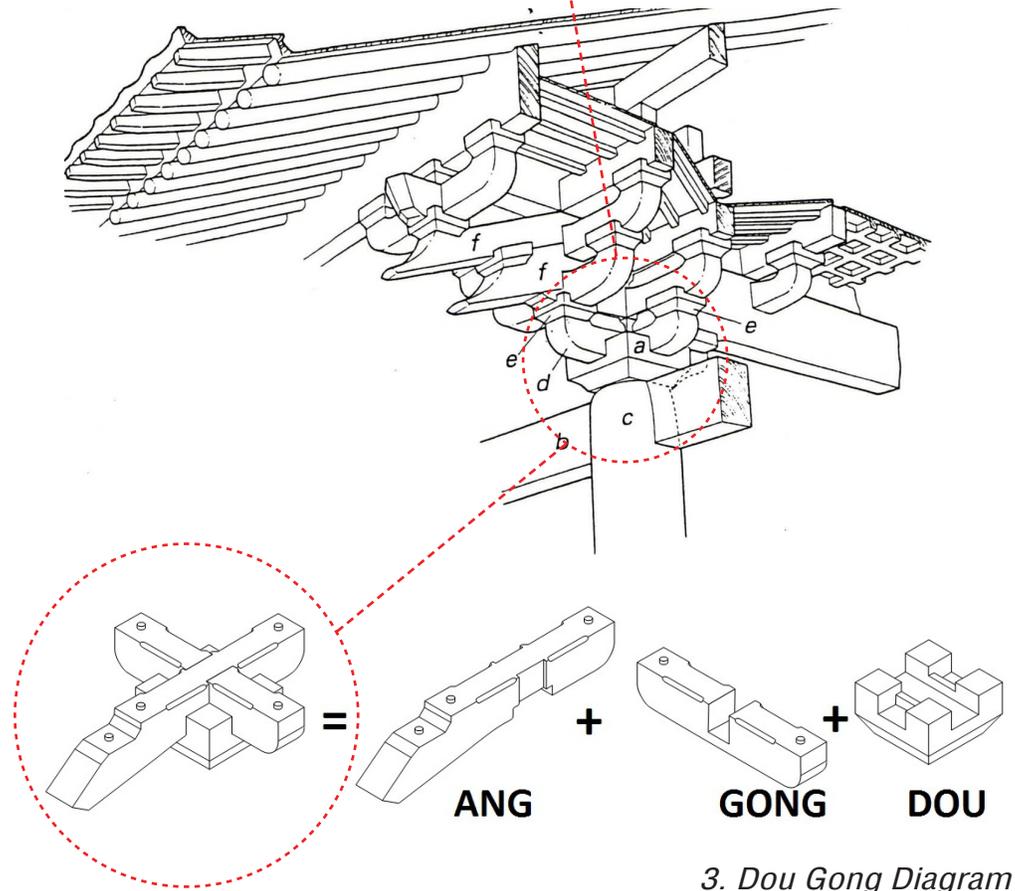


2. Traditional Chinese Architecture Diagram

- Statement
- Background
- History
- Furniture Design
- Fabrication Tools
- Precedent, Kengo Kuma
- Precedent, Shigeru Ban

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- Digital Fabrication

Sun Mao and Dou Gong



3. Dou Gong Diagram

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



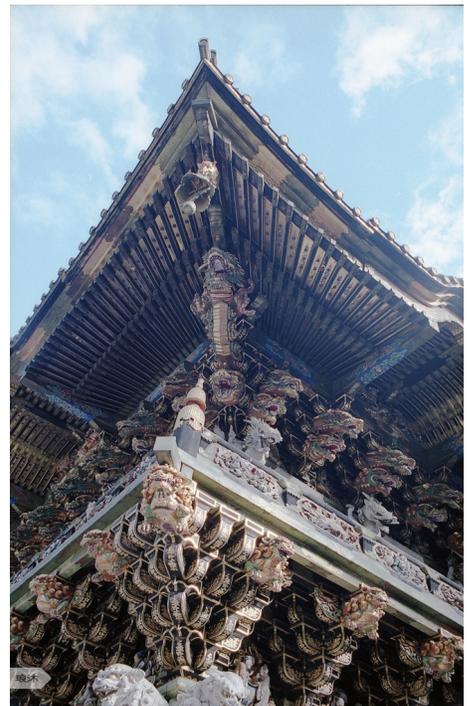
4. Residential building in Yunnan Province

2. Ornament



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

3. Symbol



6. Complexity/ Decoration/ Cantile-

Statement

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Sun Mao



Sun Mao



Screwed Butt Joint
3D Printing Joint

4. Joint- Structure

Joint + Structure

Statement

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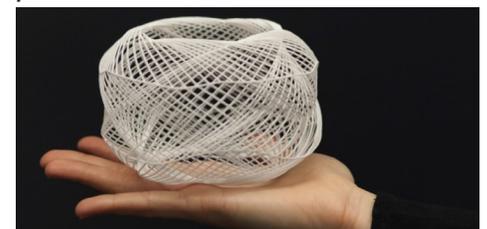
Digital Fabrication



Chinese woodworking tools



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

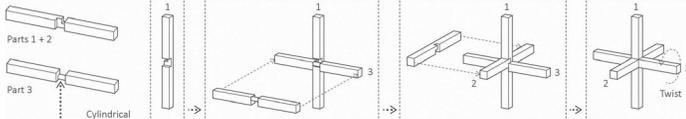
Emergence

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*Prostho Museum,
Japan / Kengo Kuma &
Associates*

*Galerie Phillipe Gravier
Pavilion / Kengo Kuma
& Associates*



*Tsumiki Stacking Blocks / Kengo
Kuma & Associates*

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*Starbucks Office / Kengo Kuma
& Associates*



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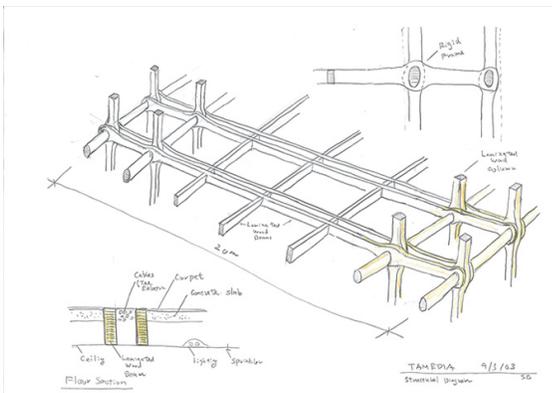
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Tamedia Office Building, Zurich / Shigeru Ban Architects



Aspen Art Museum, Colorado / Shigeru Ban Architects

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Background

Icon

History

Furniture Design

Fabrication Tools

Precedent, Kengo Kuma

Precedent, Shigeru Ban

Precedent, He Jingtang/ OMA

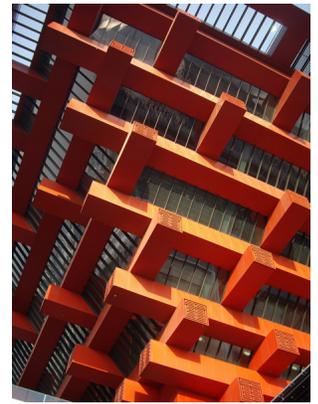
Emergence

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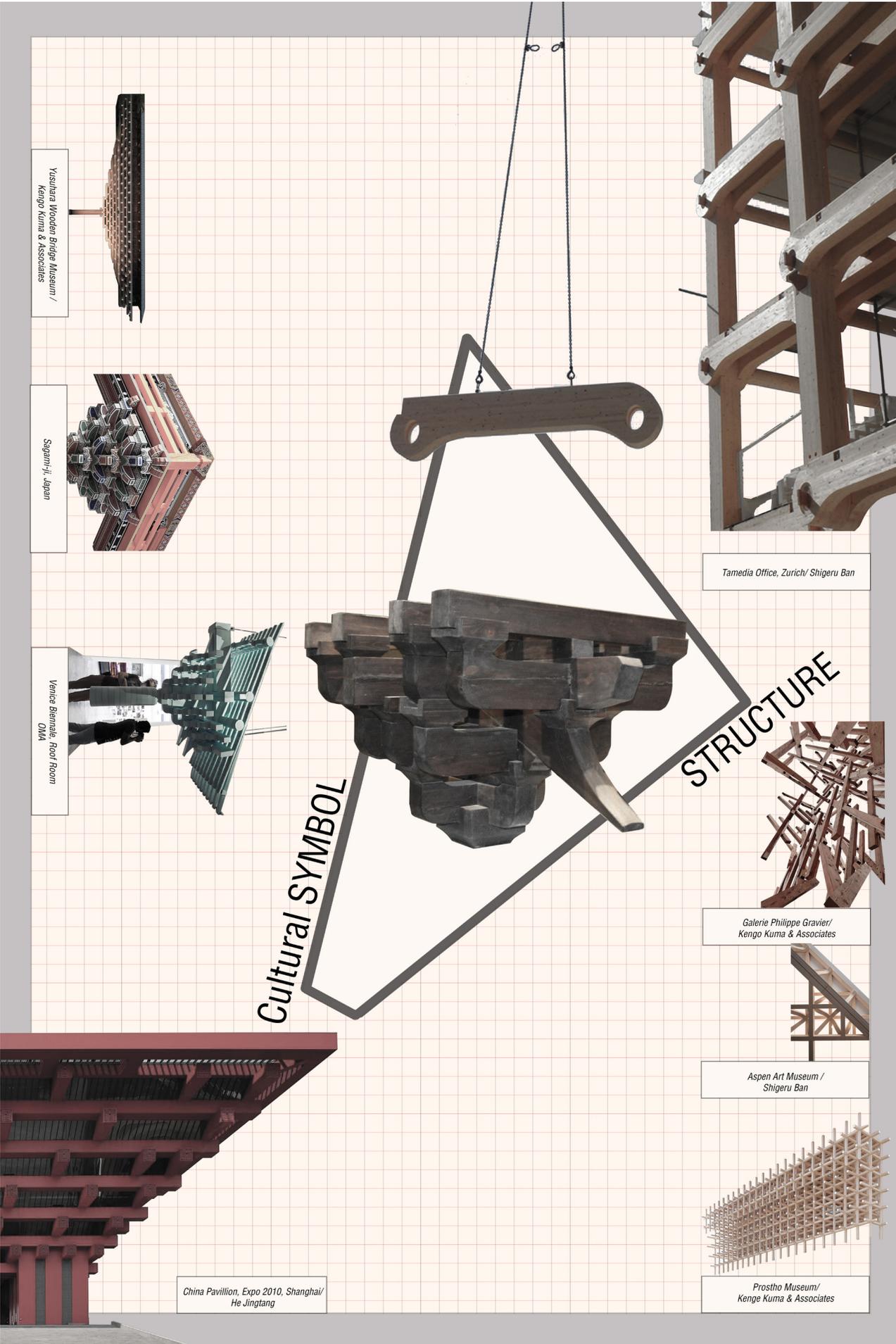
Digital Fabrication



China Pavilion, Shanghai EXPO 2010 / He Jingtang



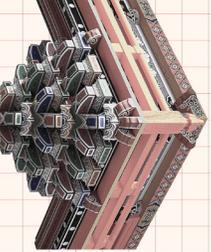
Venice Biennale 2014 / OMA



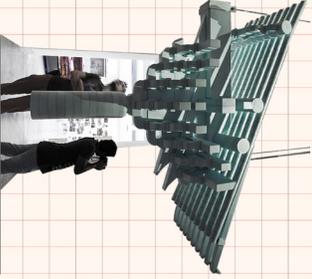
Yusuhara Wooden Bridge Museum /
Kengo Kuma & Associates



Sagamihara, Japan



Venice Biennale, Roof Room
OMA



Tamedia Office, Zurich / Shigeru Ban

STRUCTURE

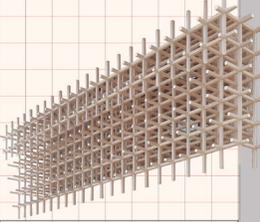
Galerie Philippe Gravier /
Kengo Kuma & Associates



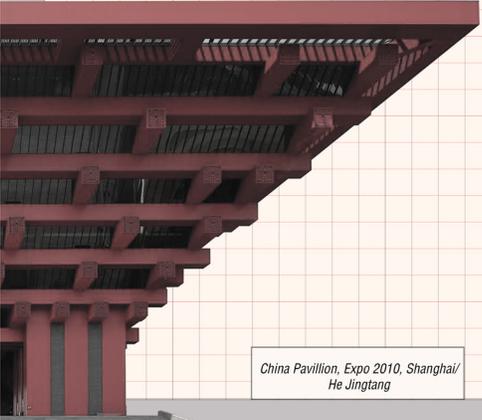
Aspen Art Museum /
Shigeru Ban



Prostho Museum /
Kengo Kuma & Associates



China Pavillion, Expo 2010, Shanghai /
He Jingtang



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Testing Ground	<input type="checkbox"/>
Algorithmic Design	<input type="checkbox"/>
Digital Fabrication	<input type="checkbox"/>

Romanesque

One would be 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)

Pre-ordained 'Template'

Static

Process

Top-down

Gothic

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

Programmatic requirements

Dynamic

Process

Bottom-up

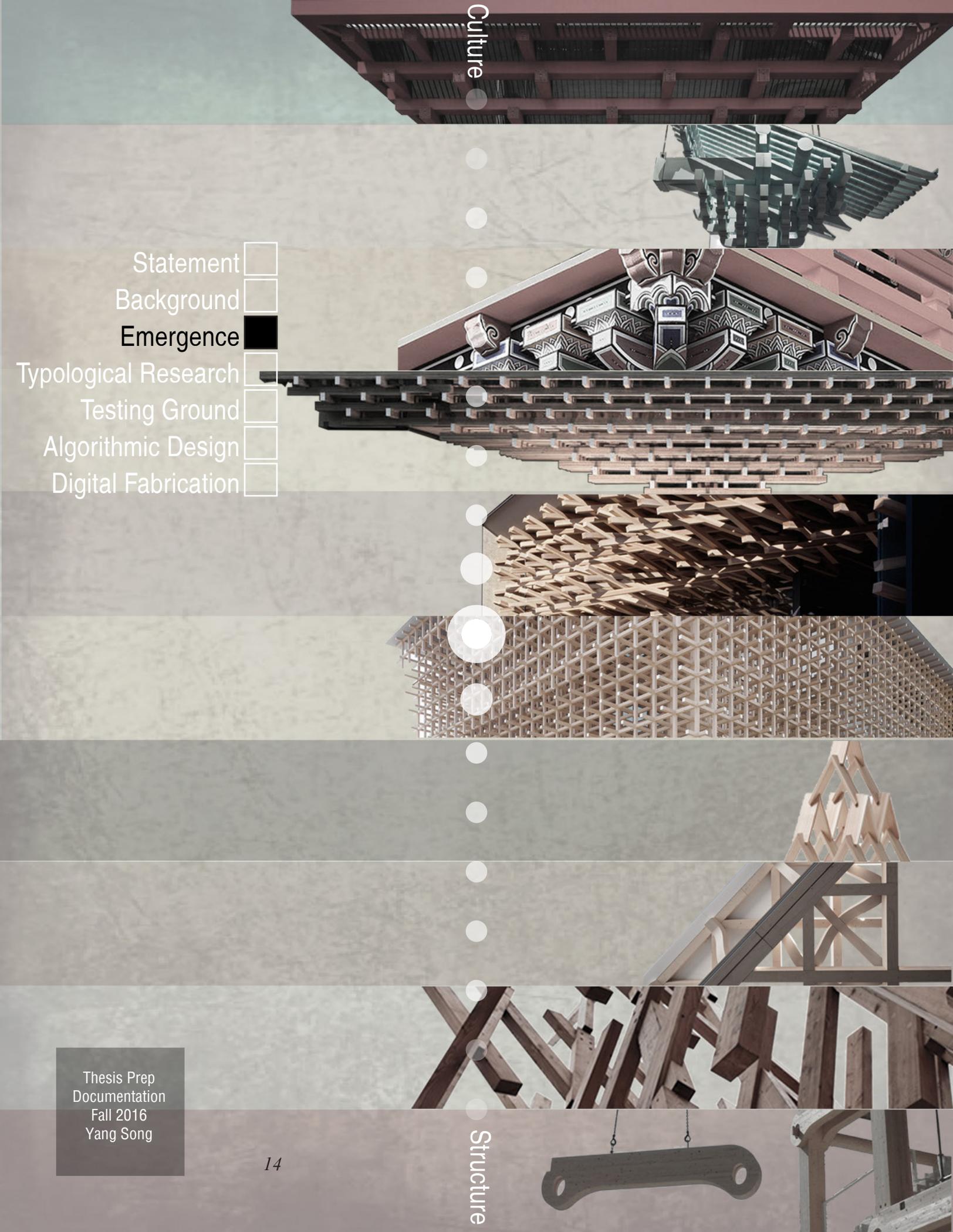
Gilles Deleuze and Félix Guattari,
A Thousand Plateaus: Capitalism and Schizophrenia.

Culture

- Statement
- Background
- Emergence**
- Typological Research
- Testing Ground
- Algorithmic Design
- Digital Fabrication

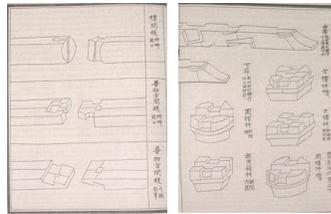
Structure

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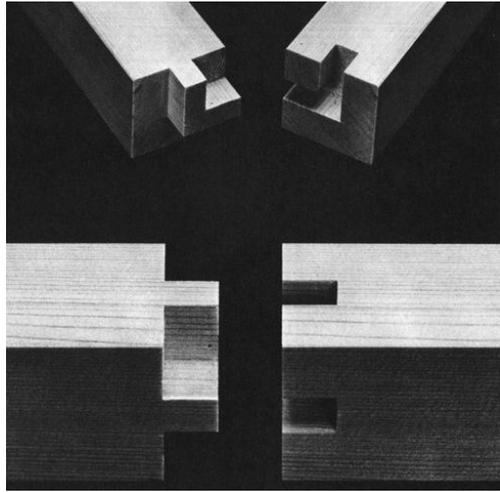
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- *Diagrams from the building manual Yingzao Fashi (published in 1103) of the Song Dynasty*

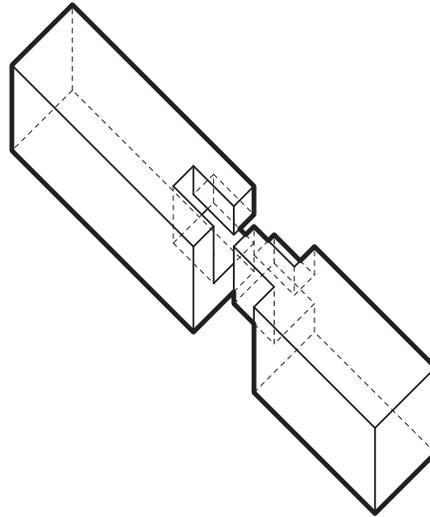


- *Kanasaki, Kenji, and Hiroya Tanaka. "Traditional Wood Joint System in Algorithmic Design." (2013).*
- *50 Digital Wood Joints, Jochen Gros, <http://www.flexiblestream.org/project/50-digital-wood-joints>*
- *@TheJoinery_jp Twitter Account*
- *Photos from Internet*

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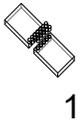
<http://godbouldandsons.tumblr.com/>



Axon



Section



1



8



15



22



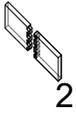
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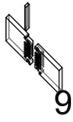
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43



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9



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23



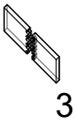
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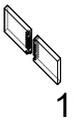
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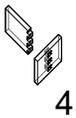
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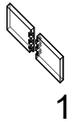
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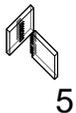
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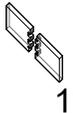
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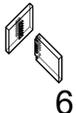
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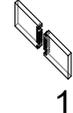
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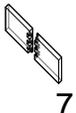
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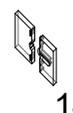
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48



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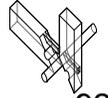
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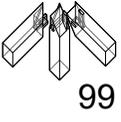
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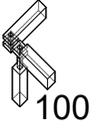
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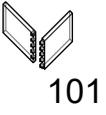
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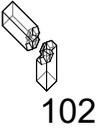
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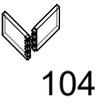
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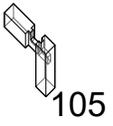
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103



104



105



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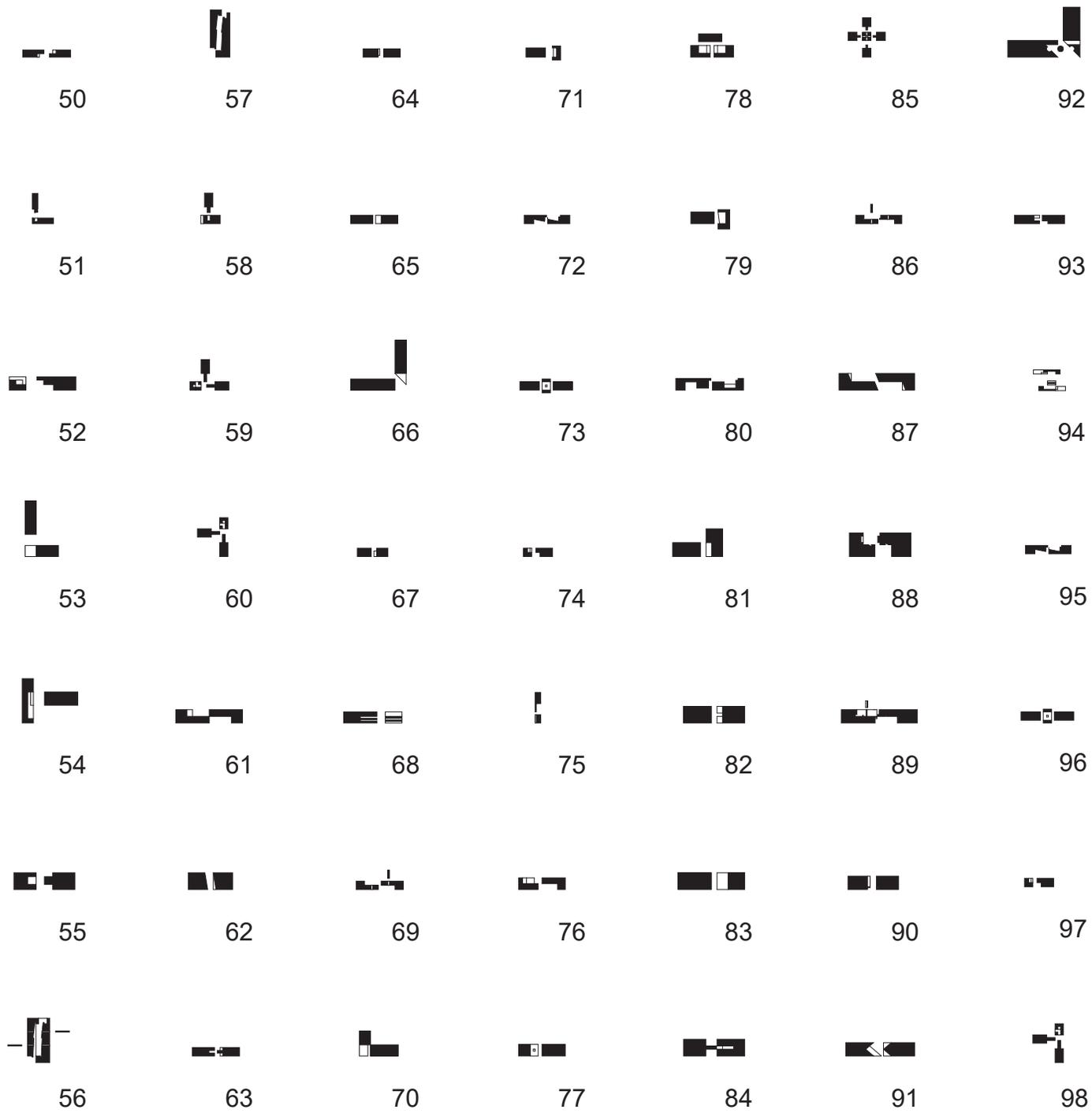
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102



103



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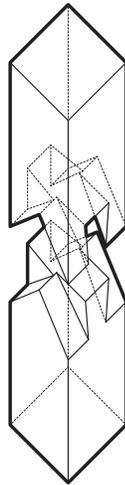


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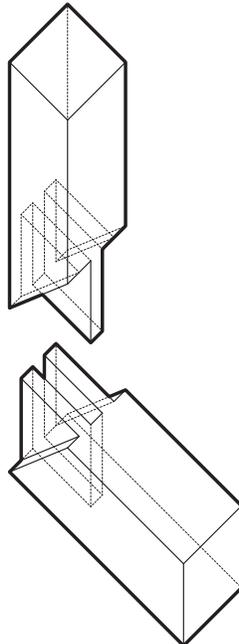
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Typological Research	<input checked="" type="checkbox"/>
Resource	<input type="checkbox"/>
Typology	<input type="checkbox"/>
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Testing Ground	<input type="checkbox"/>
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1. Tugite and Shiguchi.

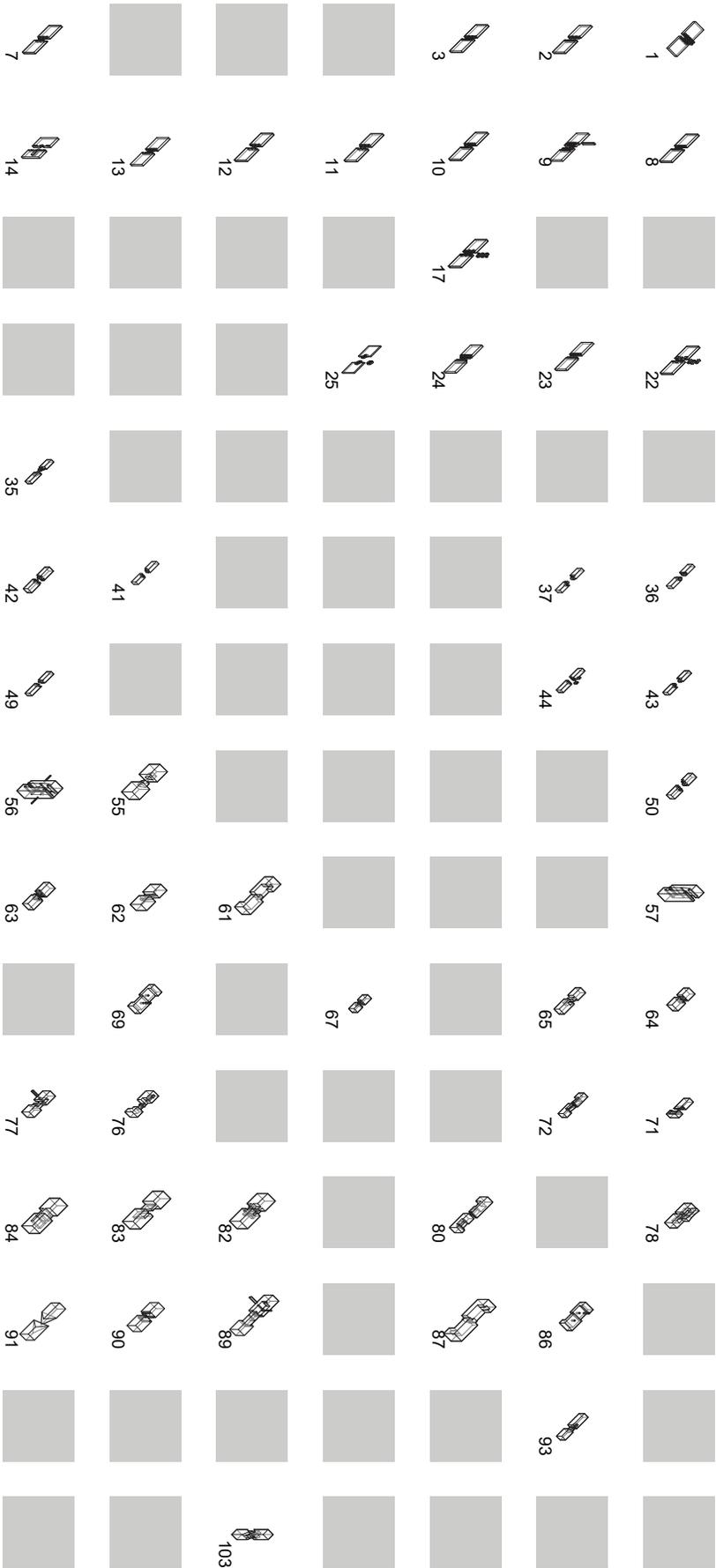
Tugite and Shiguchi are traditional architectural techniques of Japan.



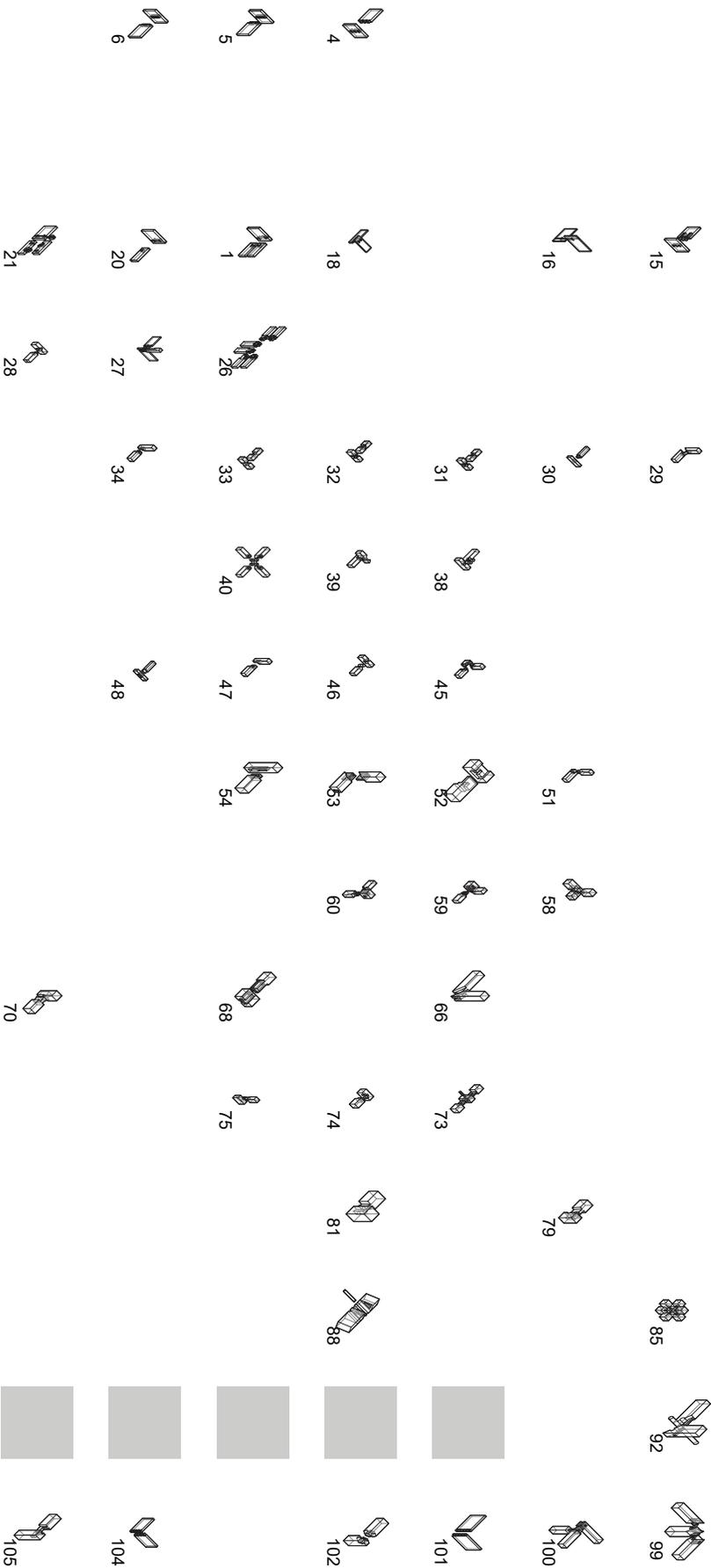
Tugite is the technique to connect materials to augment the lack of length of available materials.



Shiguchi is a technique to connect materials at an angle.

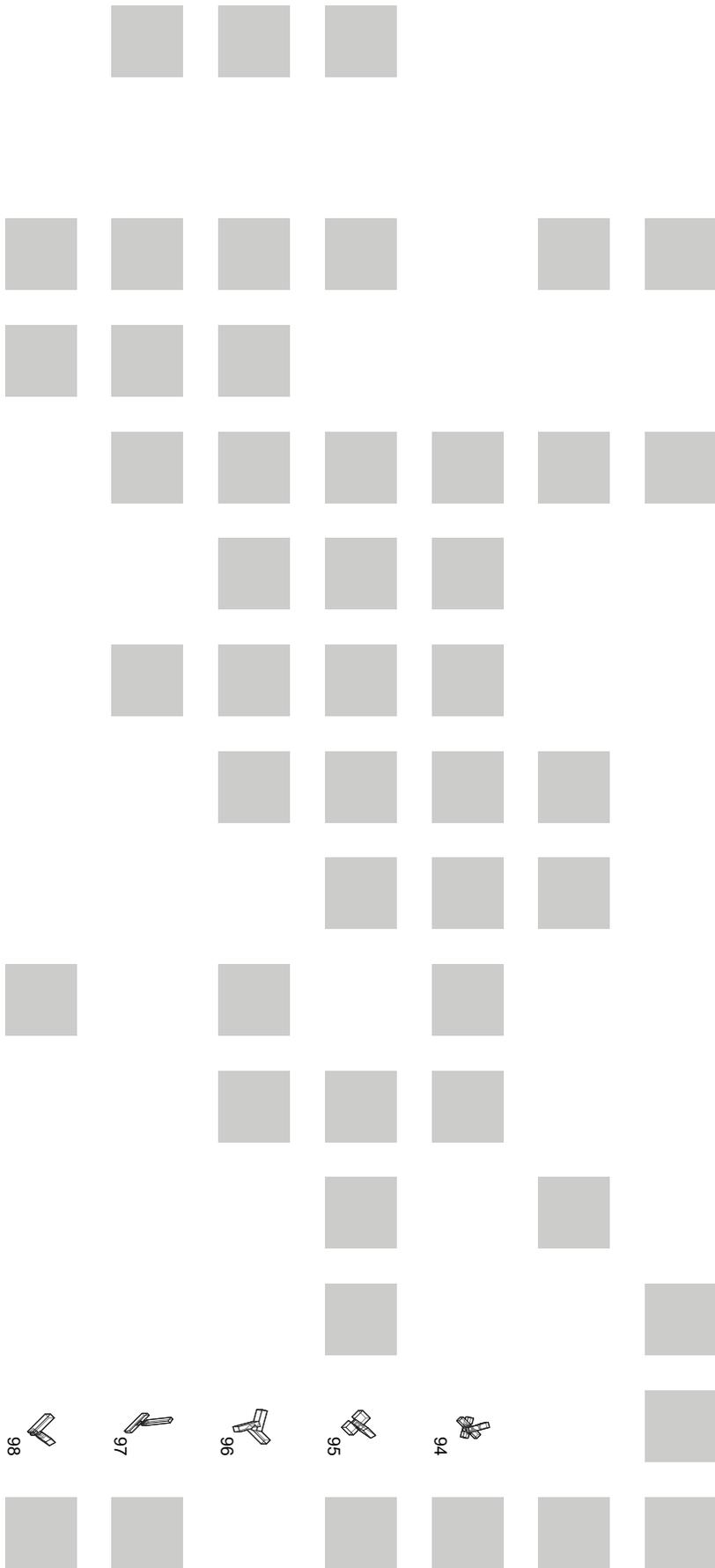


Tugite



Orthogonal

Non-Orthogonal



2. Number of Joint Members

Statement

Background

Emergence

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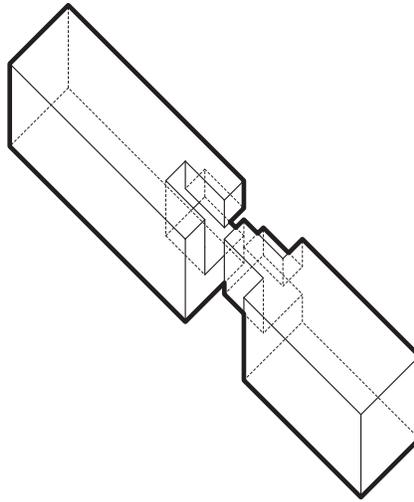
Typology

Categorization

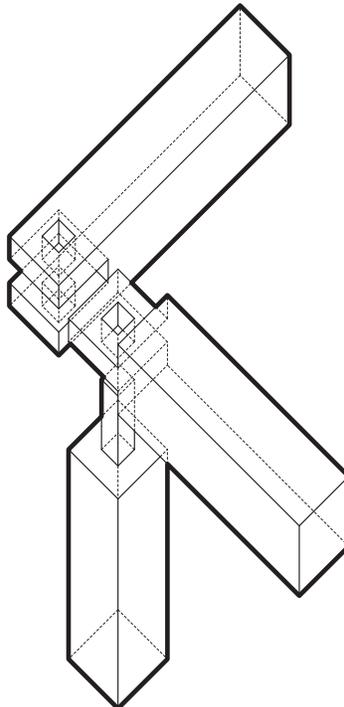
Testing Ground

Algorithmic Design

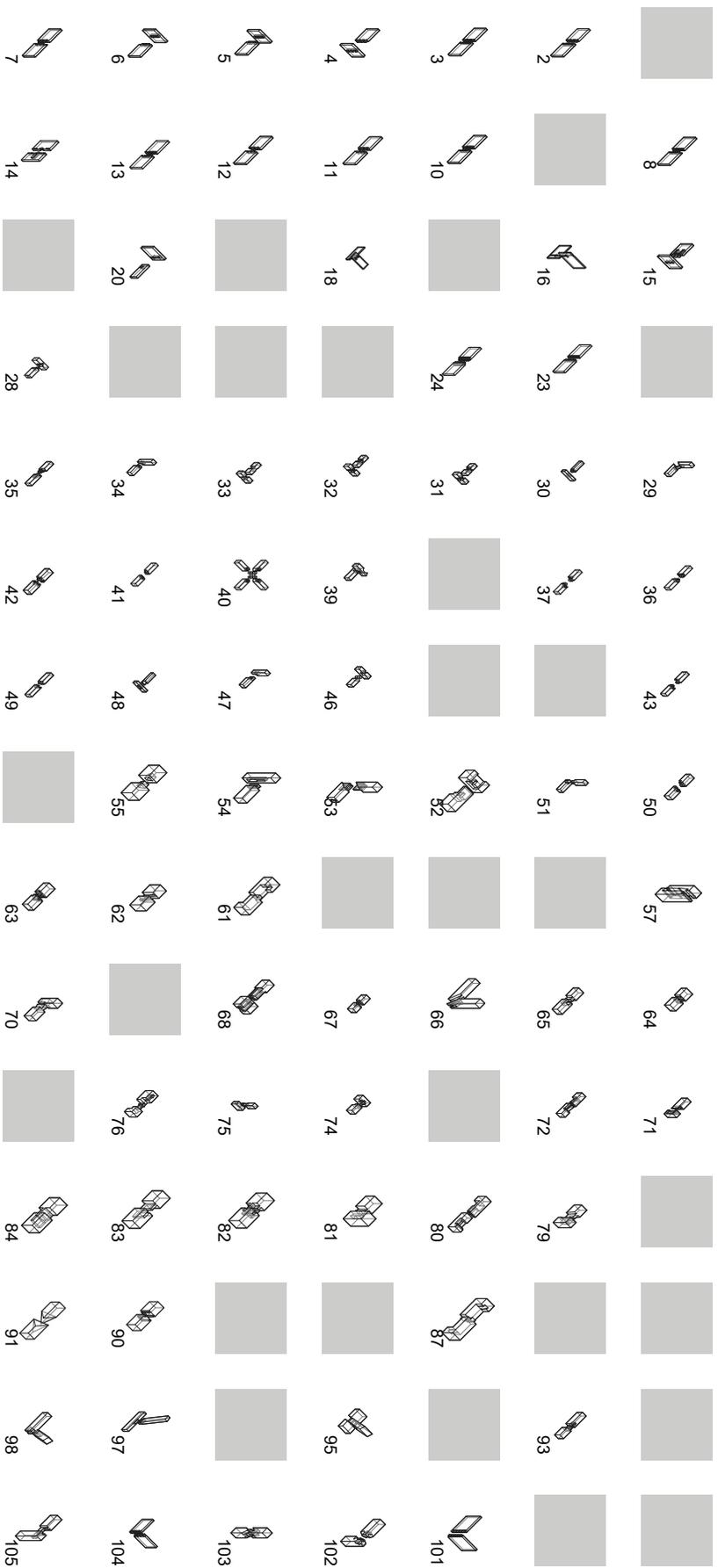
Digital Fabrication

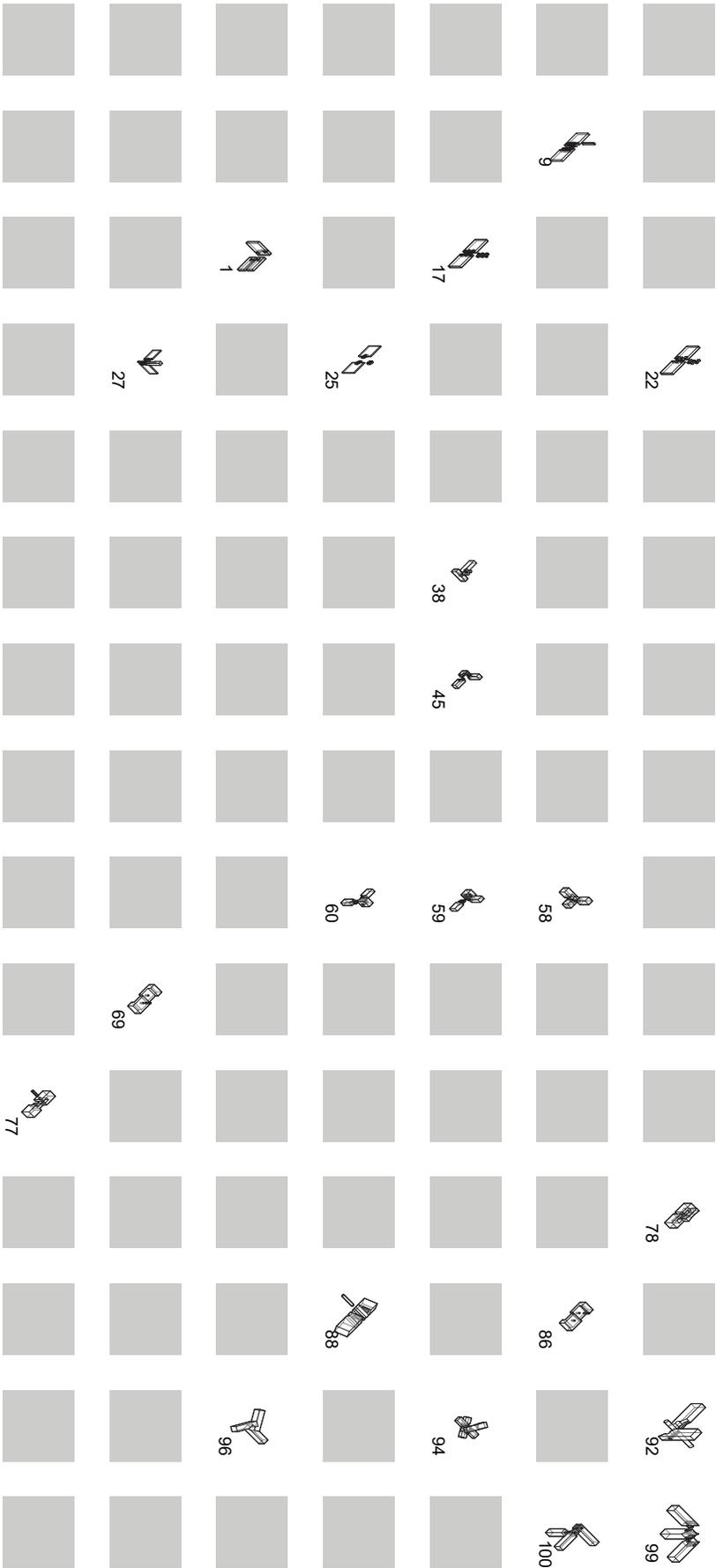


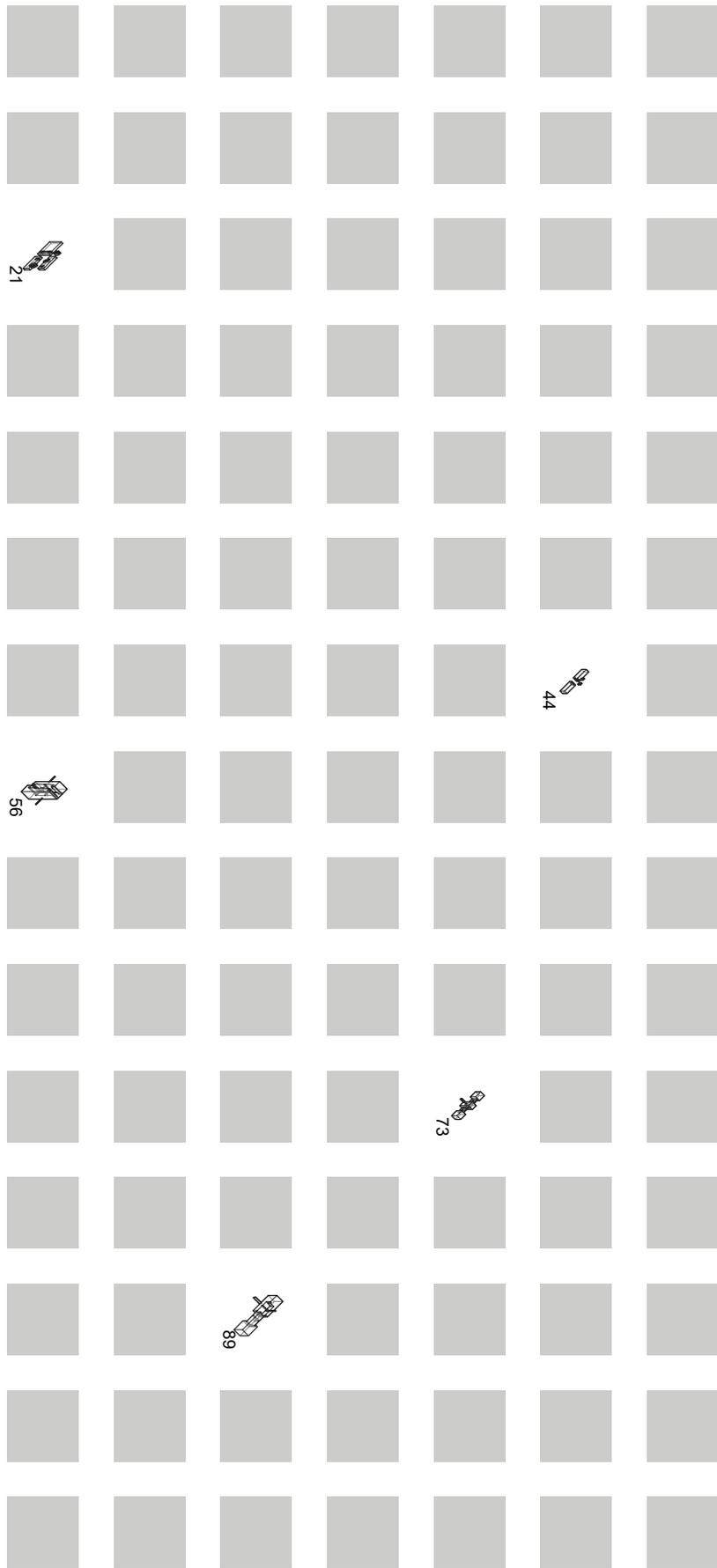
2 Members

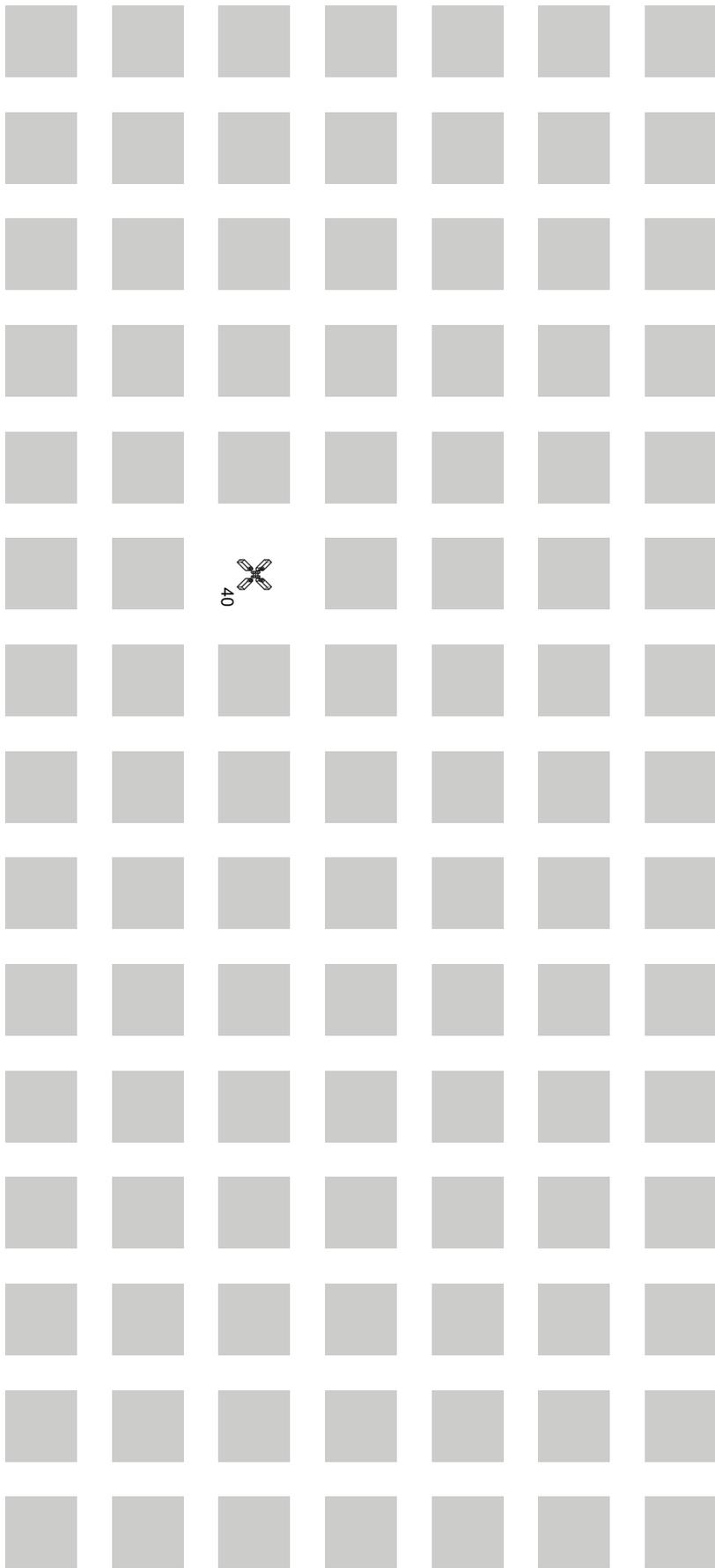


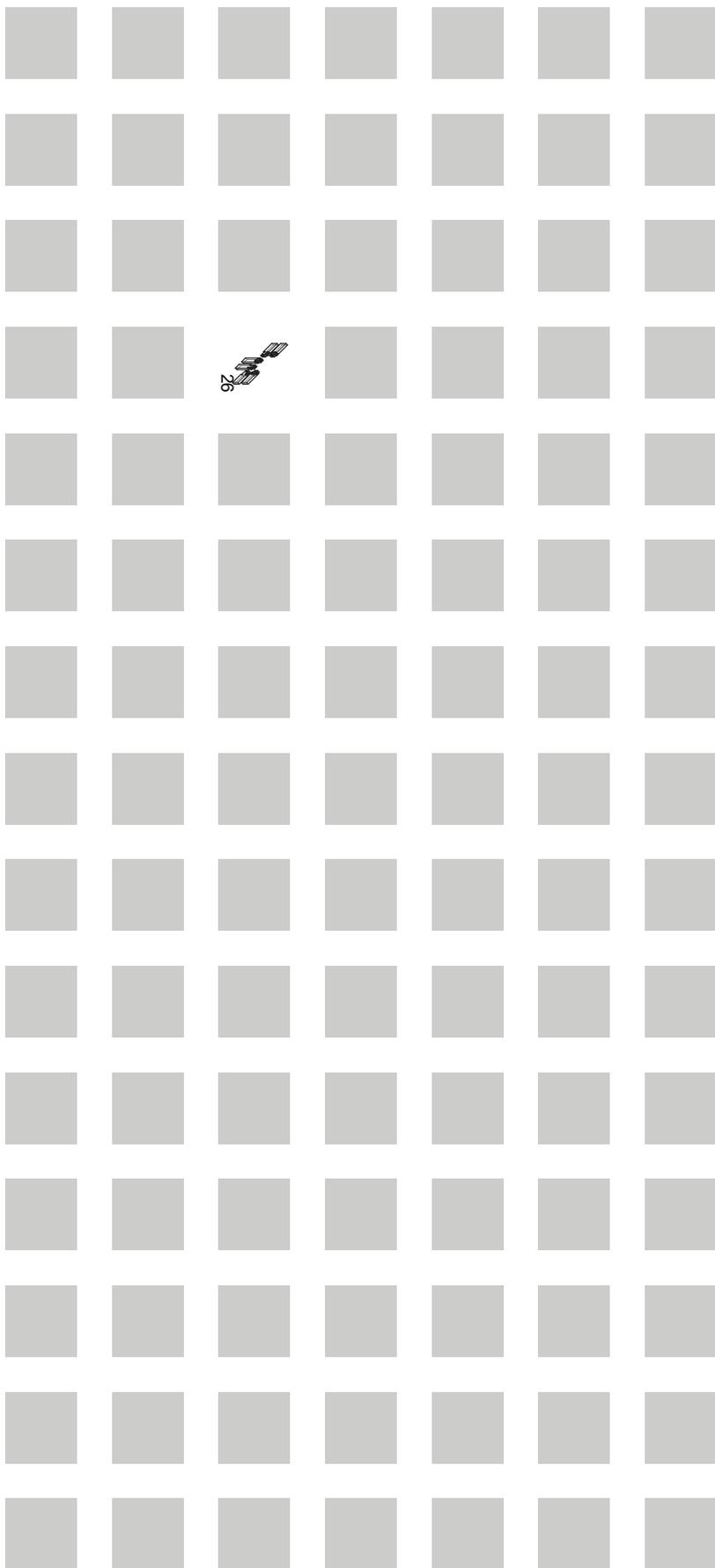
3 Members

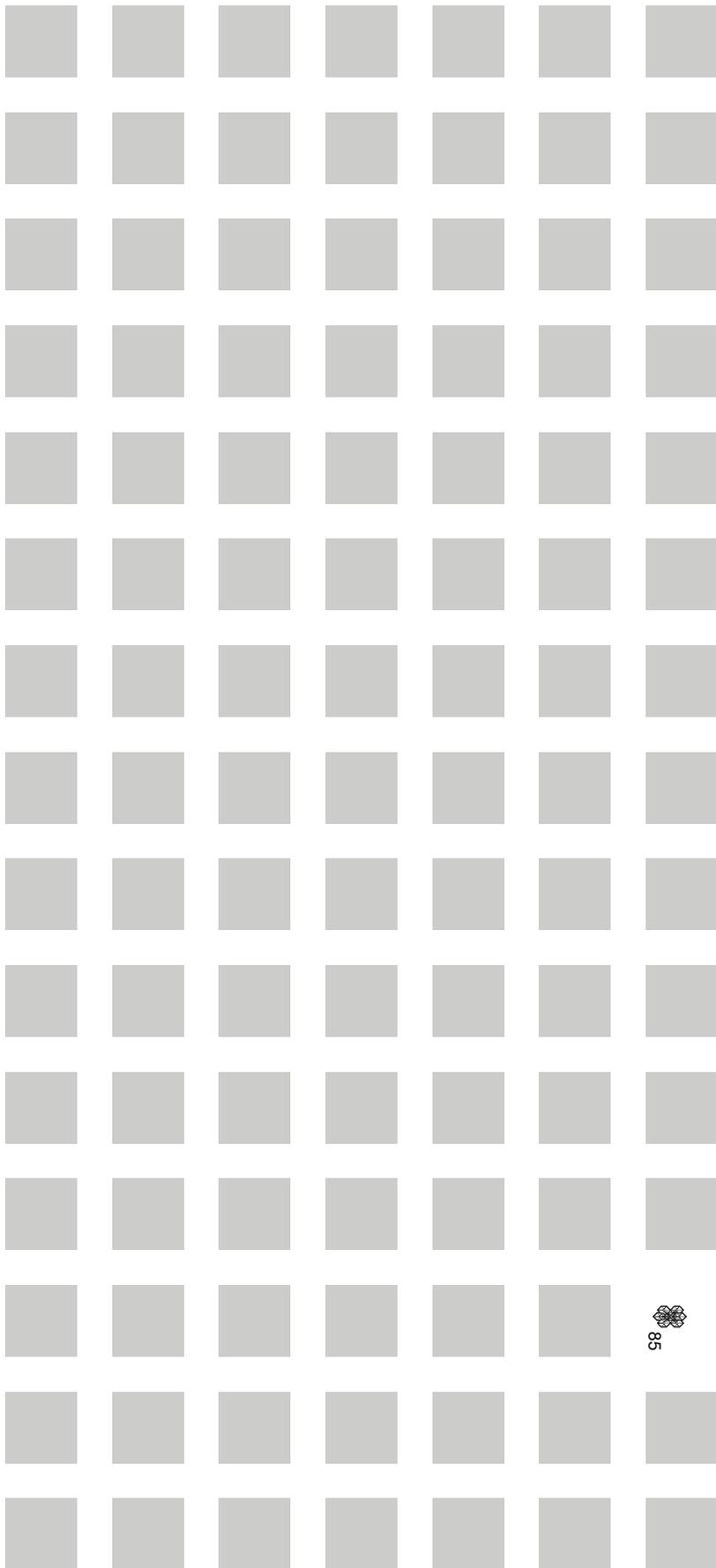












3. Position

Statement

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Resource

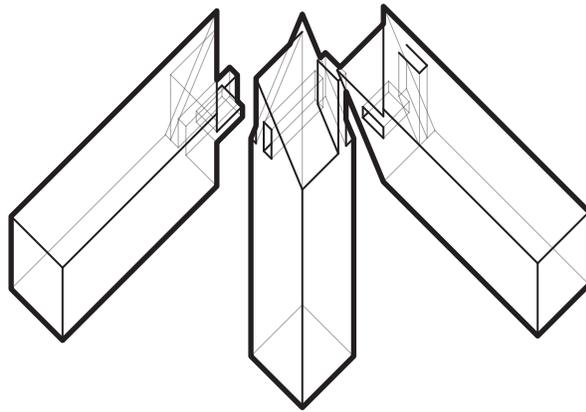
Typology

Categorization

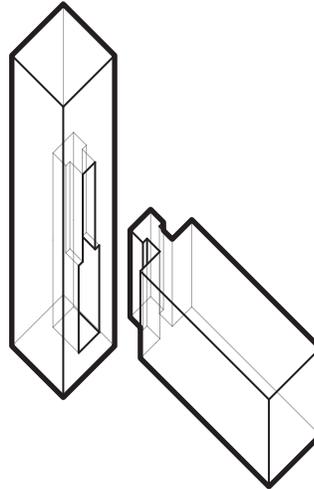
Testing Ground

Algorithmic Design

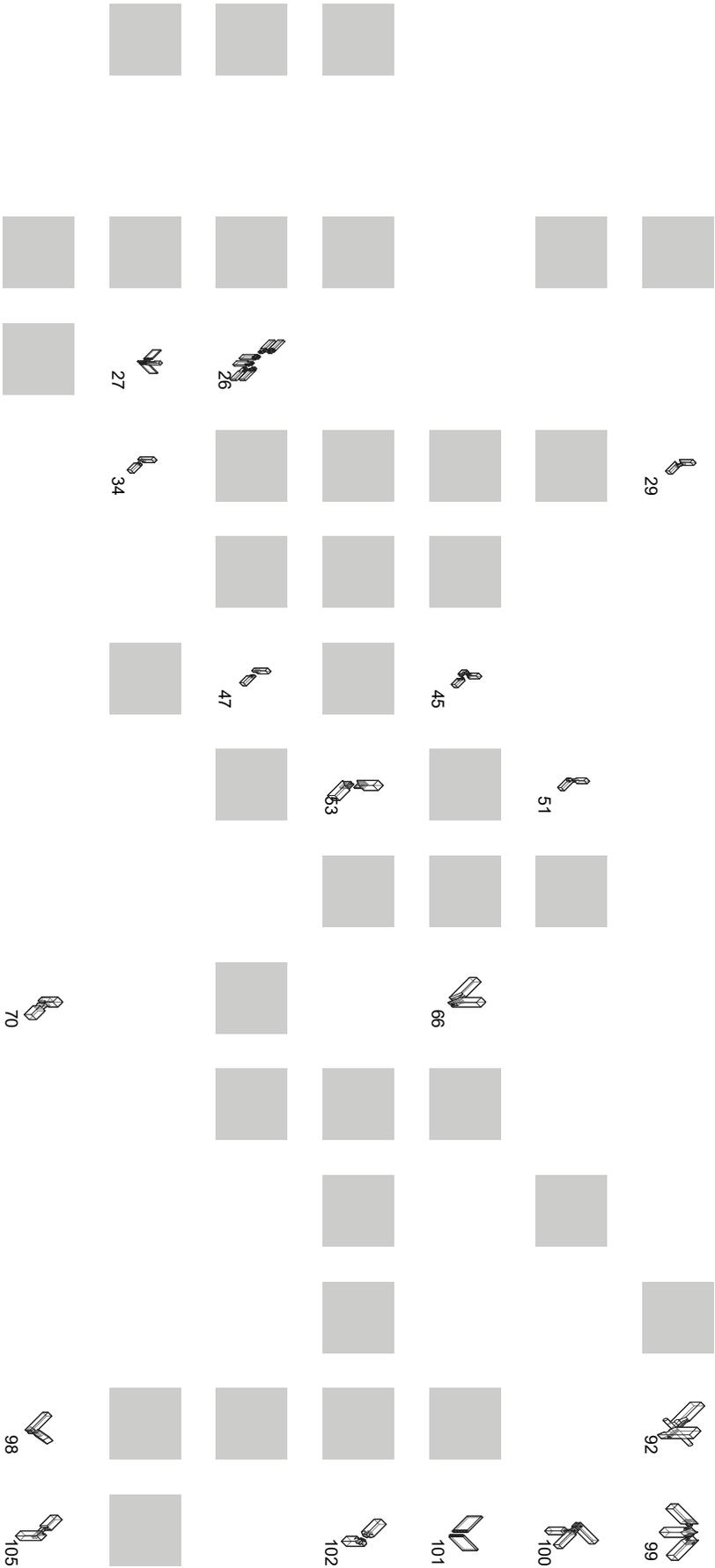
Digital Fabrication



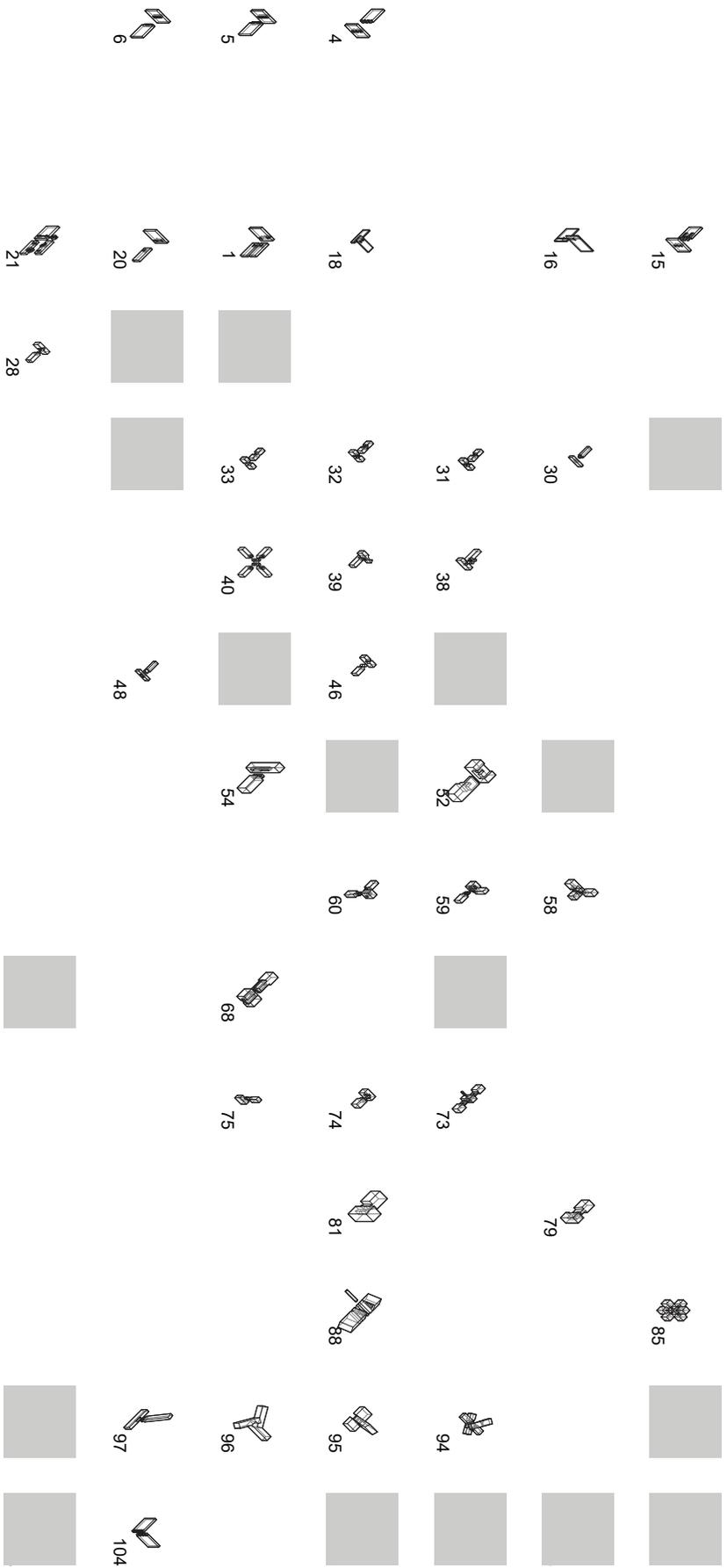
Corner



Housing



Housing



4. Structural Performance

Statement

Background

Emergence

Typological Research

Resource

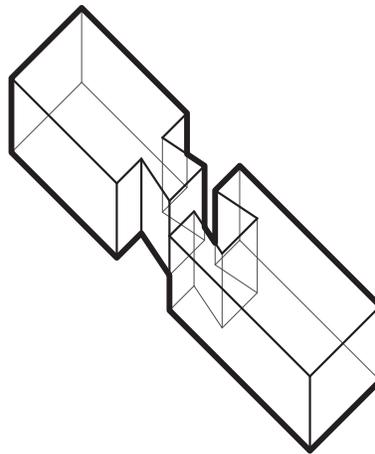
Typology

Categorization

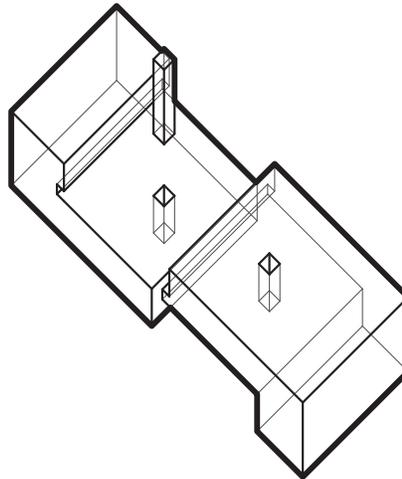
Testing Ground

Algorithmic Design

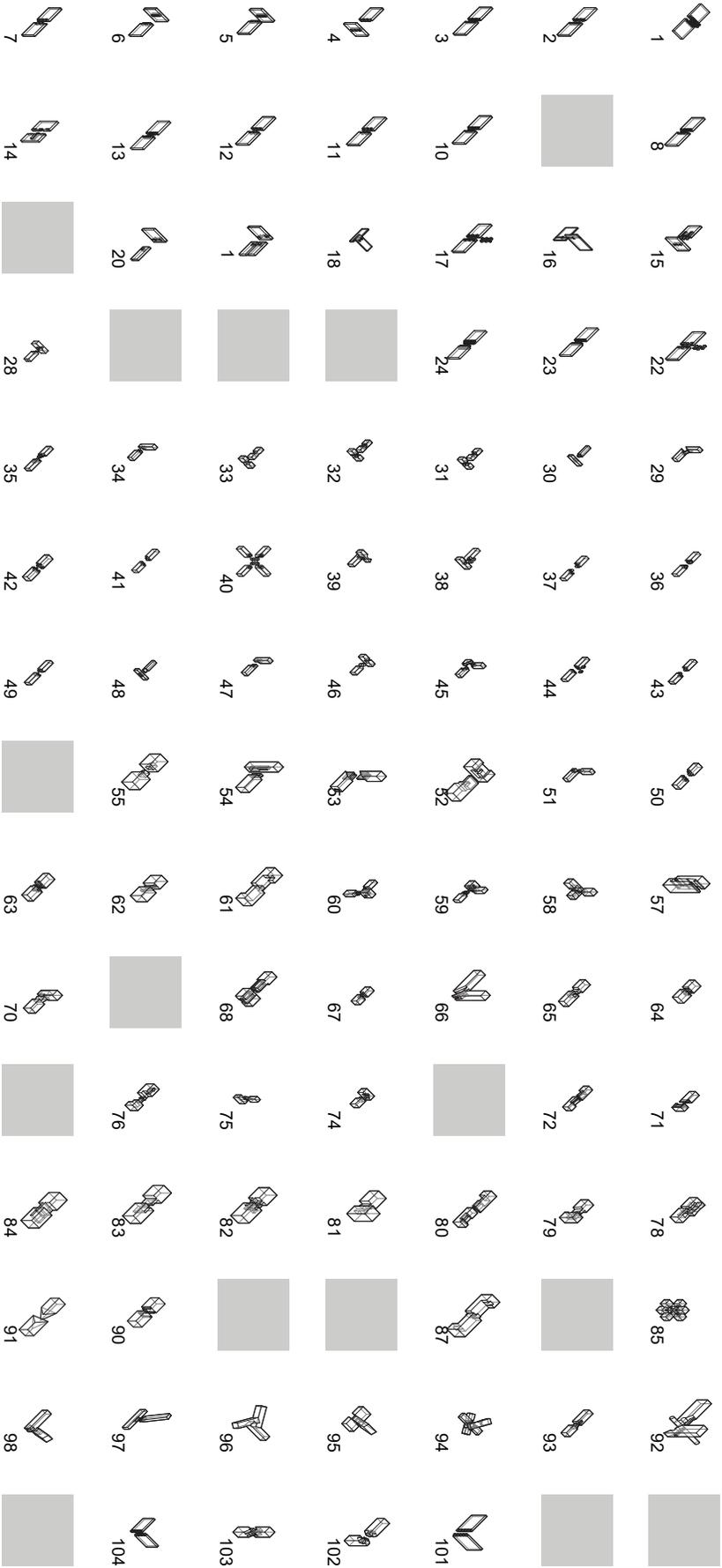
Digital Fabrication



Friction

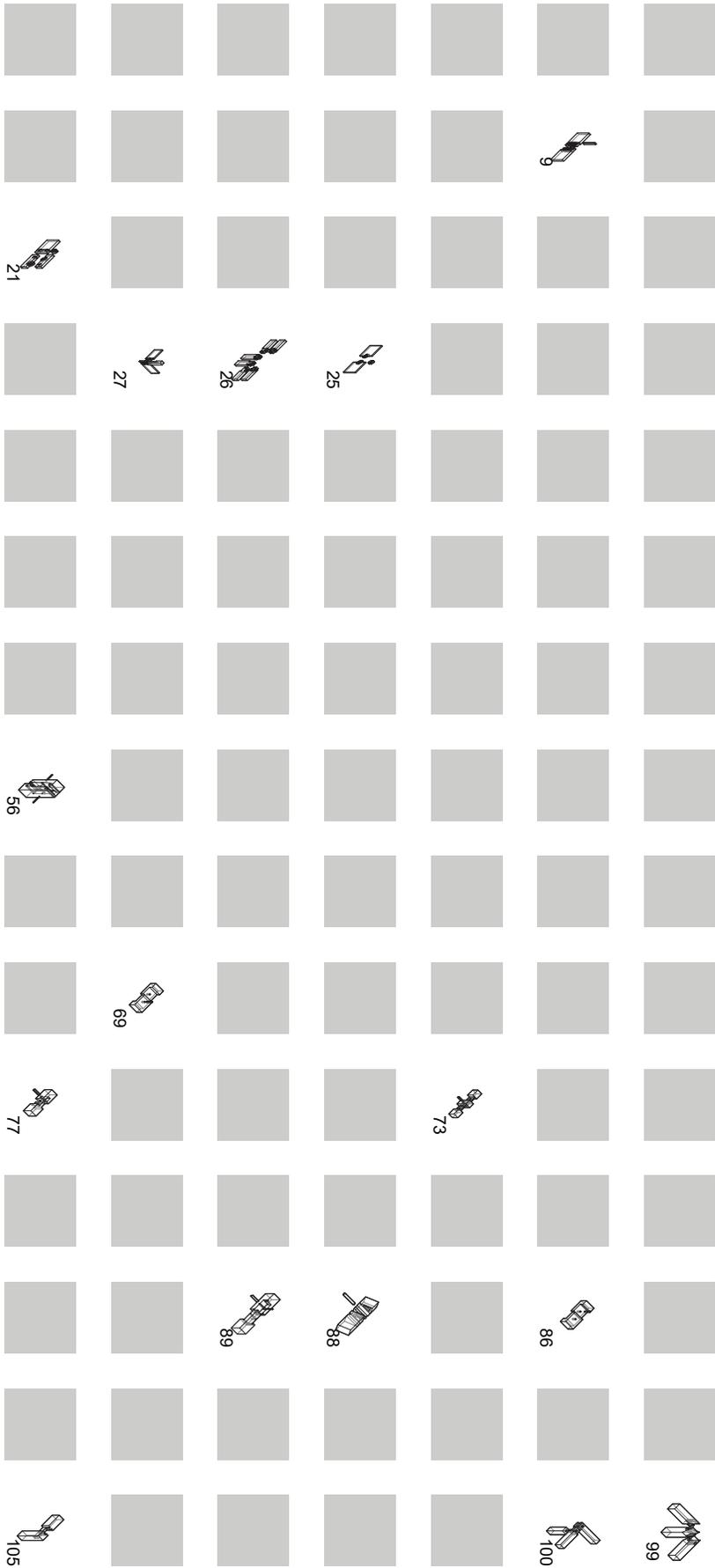


Friction + Interlock



Friction

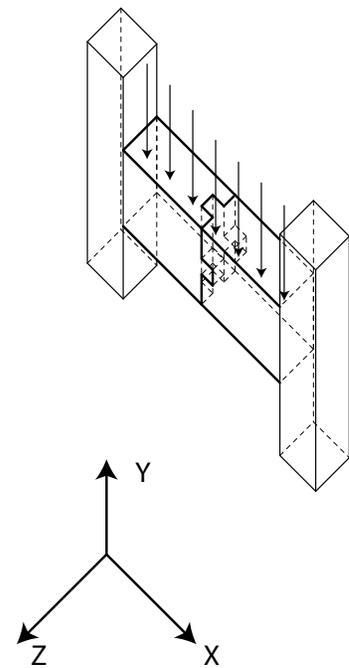
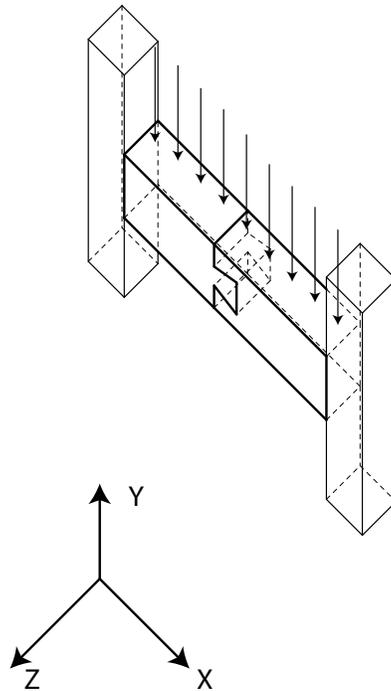
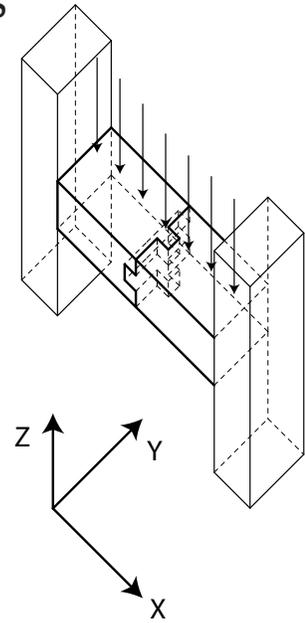
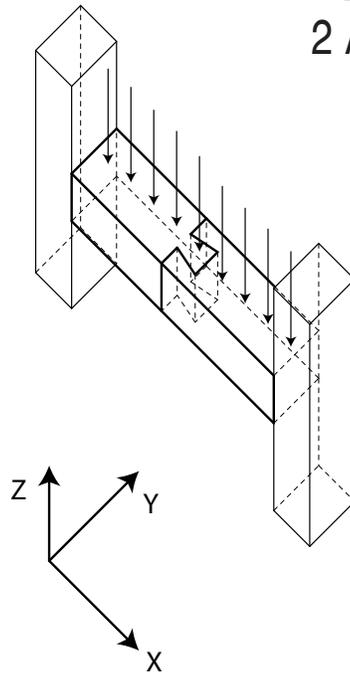
Friction + Interlock

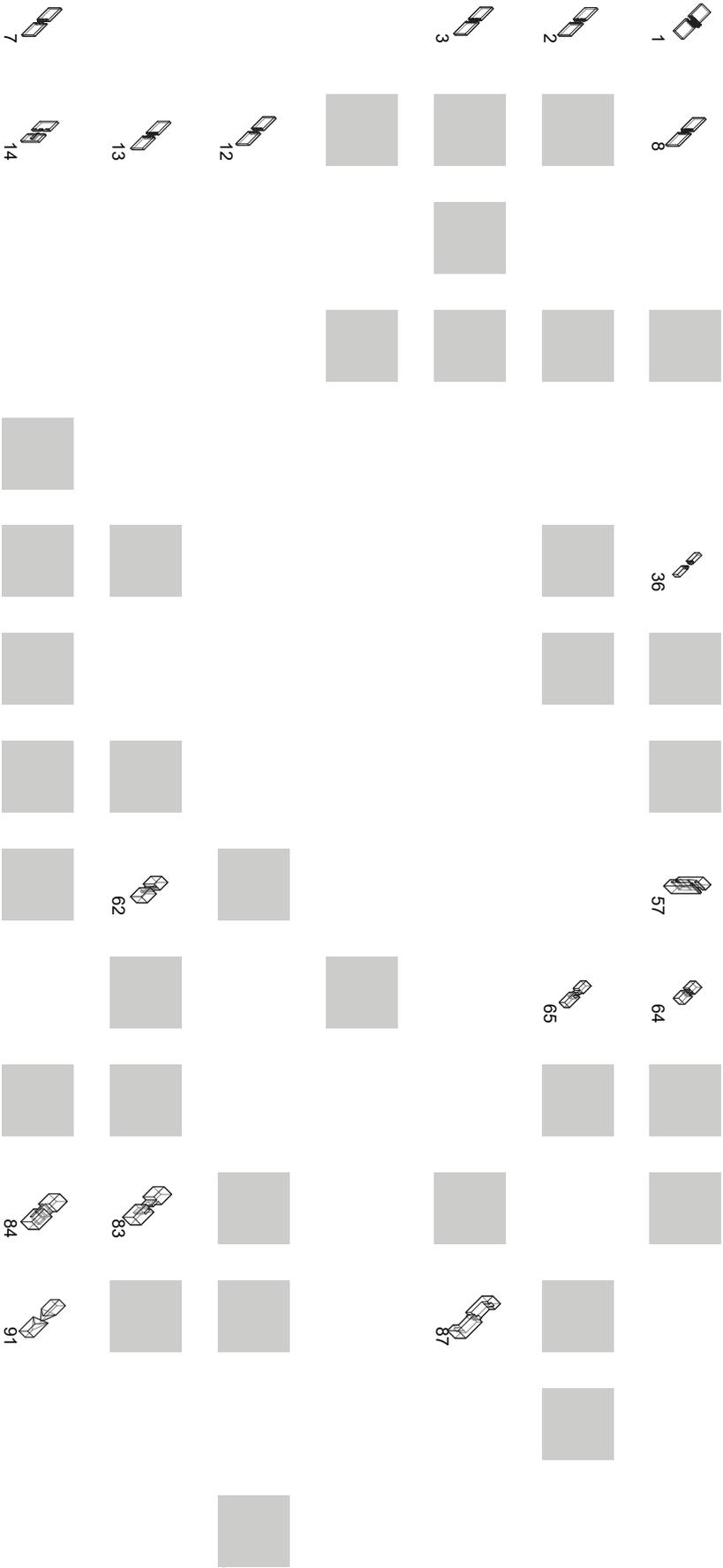


4. Structural Performance(Tugite)

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

Compression
2 Axes 3 Axes





3 Axes

4. Structural Performance(Tugite)

Statement

Background

Emergence

Typological Research

Resource

Typology

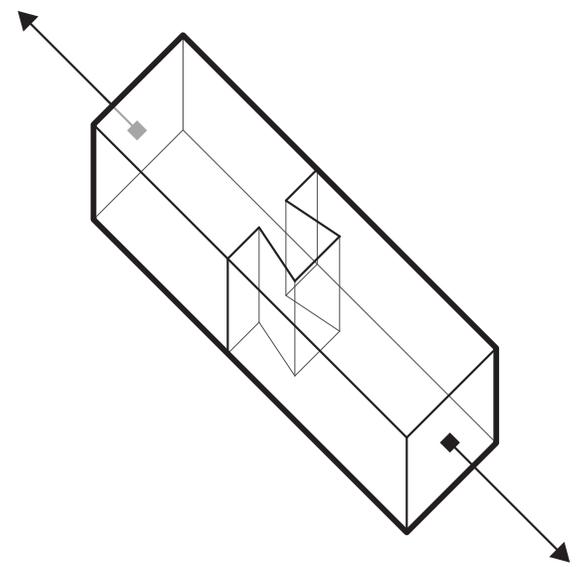
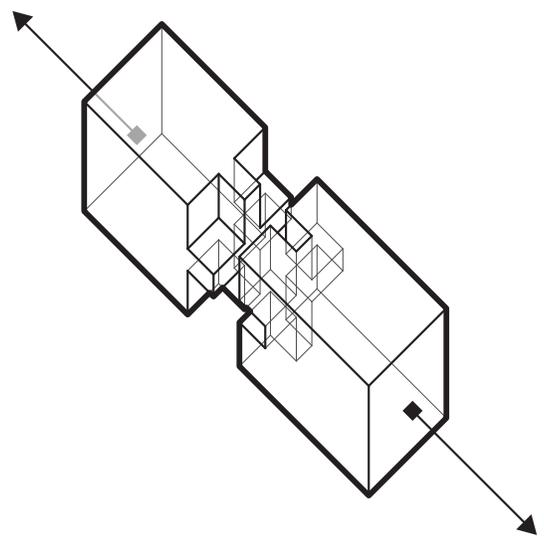
Categorization

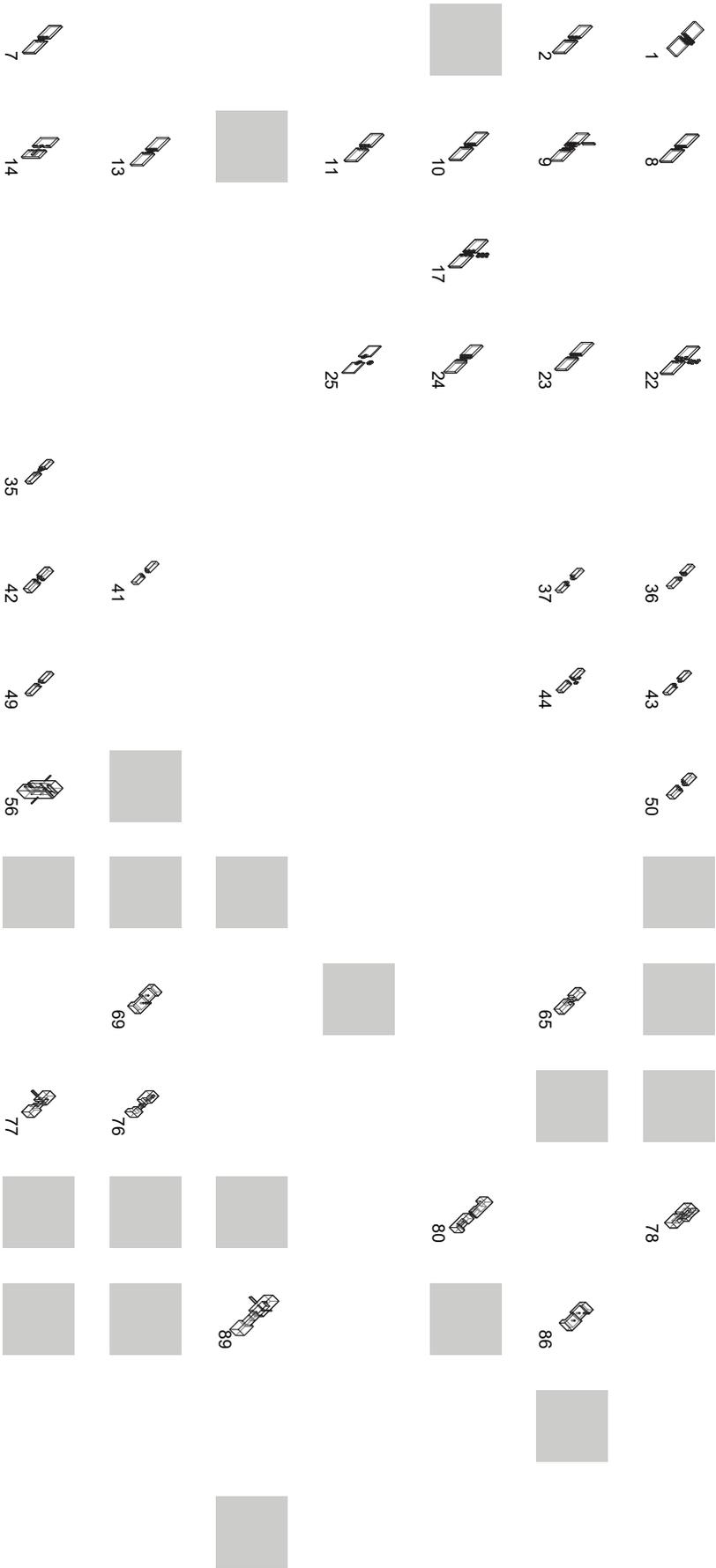
Testing Ground

Algorithmic Design

Digital Fabrication

Tension





Tension

4. Structural Performance

Statement

Background

Emergence

Typological Research

Resource

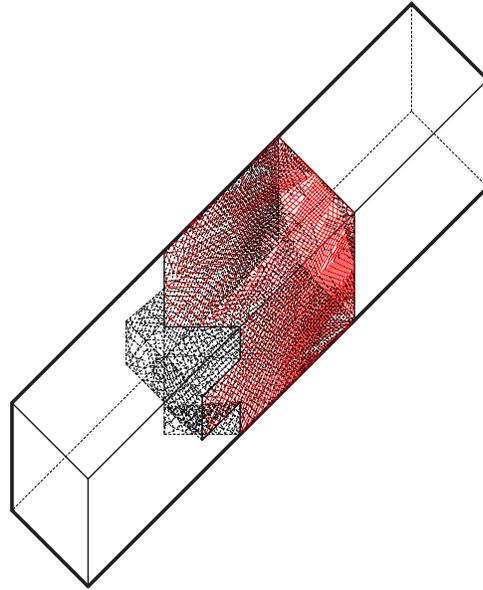
Typology

Categorization

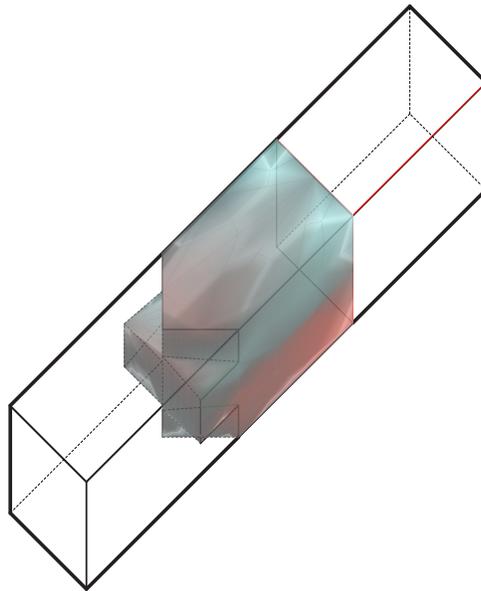
Testing Ground

Algorithmic Design

Digital Fabrication



Stress Pattern



Principle Stress

5. CNC Milling Axes

Statement

Background

Emergence

Typological Research

Resource

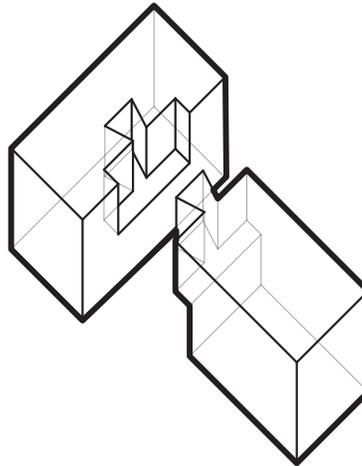
Typology

Categorization

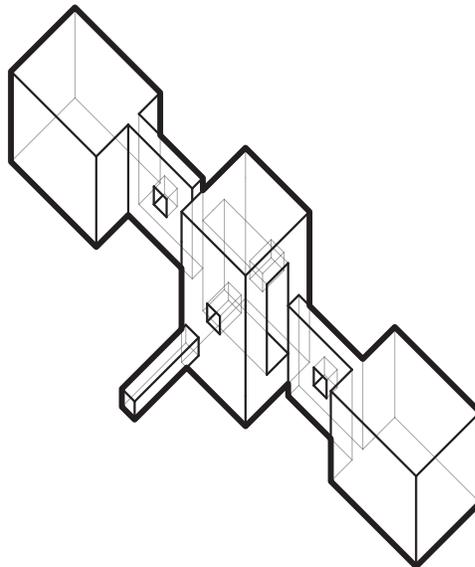
Testing Ground

Algorithmic Design

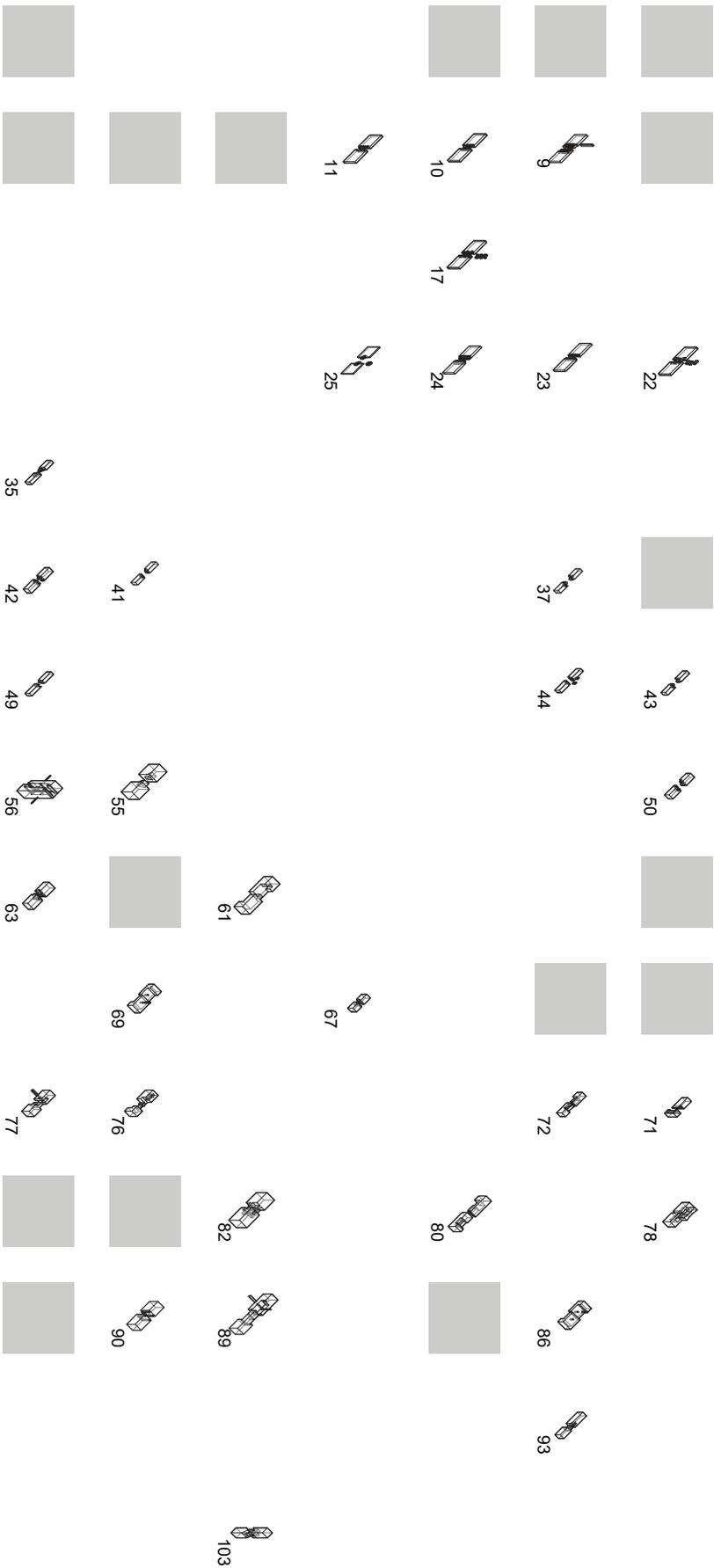
Digital Fabrication



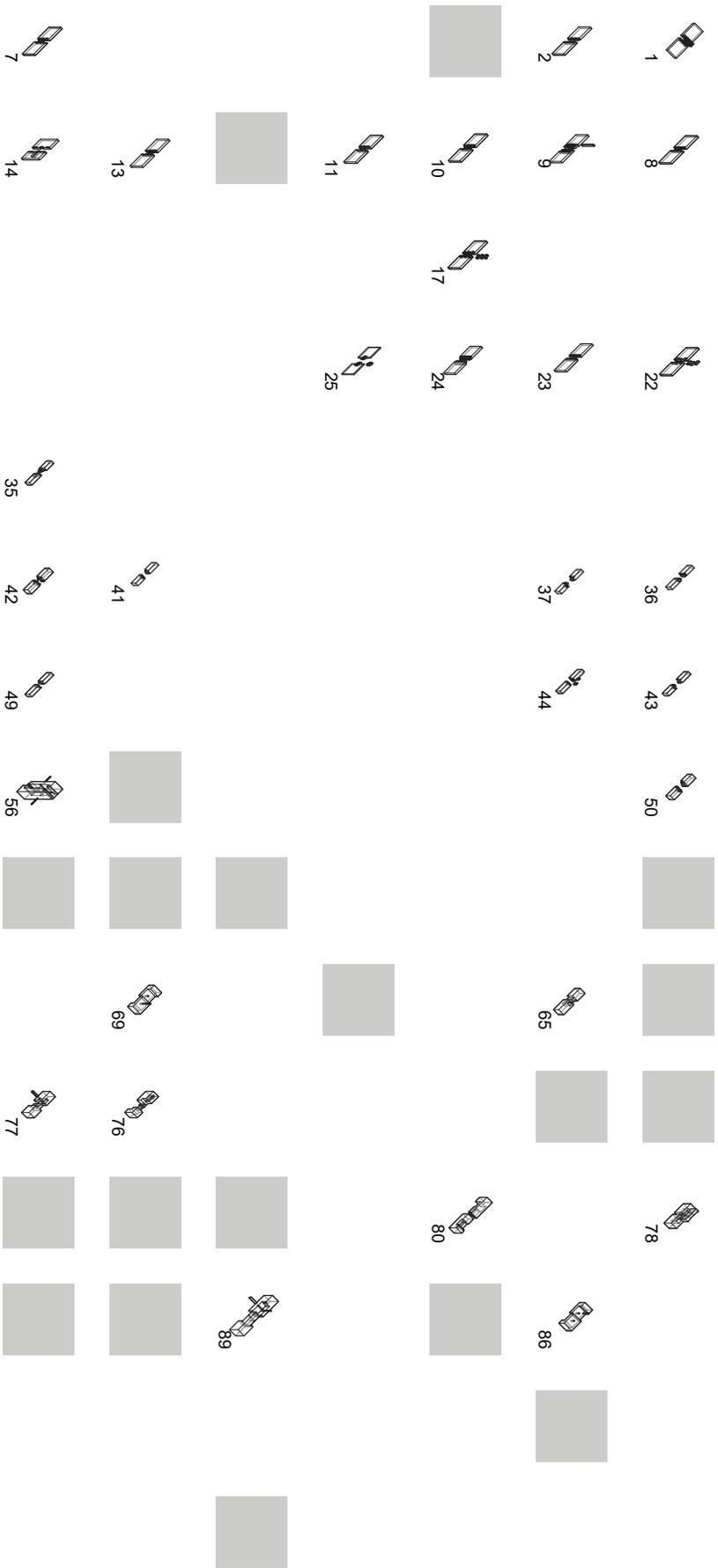
3 Axes



> 3 Axes



3 Axes



> 3 Axes

6. Matrix

Statement

Background

Emergence

Typological Research

Resource

Typology

Categorization

Testing Ground

Algorithmic Design

Digital Fabrication

No.	Tugite/ Shiguchi	logol/Non-Orthogol (Sh)	Number of Joint Membr	Structural Performanc	uctural Performance (T)	er/Housing (Shigi	>3 Axis CNC	ision (Tugi
1	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
2	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
3	Tugite	NA	2	Friction	2 Axes	NA	3	No
4	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
5	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
6	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
7	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
8	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
9	Tugite	NA	3	Friction + Interlock	3 Axes	NA	3	Yes
10	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
11	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
12	Tugite	NA	2	Friction	2 Axes	NA	3	No
13	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
14	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
15	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
16	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
17	Tugite	NA	3	Friction	3 Axes	NA	3	Yes
18	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
19	Shiguchi	Orthogol	3	Friction	NA	Housing	3	NA
20	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
21	Shiguchi	Orthogol	4	Friction + Interlock	NA	Housing	3	NA
22	Tugite	NA	3	Friction	3 Axes	NA	3	Yes
23	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
24	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
25	Tugite	NA	3	Friction + Interlock	3 Axes	NA	3	Yes
26	Shiguchi	Orthogol	6	Friction + Interlock	NA	Corner	3	NA
27	Shiguchi	Orthogol	3	Friction + Interlock	NA	Corner	3	NA
28	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
29	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
30	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
31	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
32	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
33	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
34	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
35	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
36	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
37	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
38	Shiguchi	Orthogol	3	Friction	NA	Housing	3	NA
39	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
40	Shiguchi	Orthogol	5	Friction	NA	Housing	3	NA
41	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
42	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
43	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
44	Tugite	NA	4	Friction	3 Axes	NA	3	Yes
45	Shiguchi	Orthogol	3	Friction	NA	Corner	3	NA
46	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
47	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
48	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
49	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
50	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
51	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
52	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
53	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
54	Shiguchi	Orthogol	2	Friction	NA	Housing	>3	NA
55	Tugite	NA	2	Friction	3 Axes	NA	3	No
56	Tugite	NA	4	Friction + Interlock	3 Axes	NA	>3	Yes
57	Tugite	NA	2	Friction	2 Axes	NA	>3	No
58	Shiguchi	Orthogol	3	Friction	NA	Housing	3	NA
59	Shiguchi	Orthogol	3	Friction	NA	Housing	3	NA
60	Shiguchi	Orthogol	3	Friction	NA	Housing	>3	NA
61	Tugite	NA	2	Friction	3 Axes	NA	3	No
62	Tugite	NA	2	Friction	2 Axes	NA	3	No
63	Tugite	NA	2	Friction	3 Axes	NA	3	No
64	Tugite	NA	2	Friction	2 Axes	NA	3	No
65	Tugite	NA	2	Friction	2 Axes	NA	3	Yes
66	Shiguchi	Orthogol	2	Friction	NA	Corner	3	NA
67	Tugite	NA	2	Friction	3 Axes	NA	3	No
68	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
69	Tugite	NA	3	Friction + Interlock	3 Axes	NA	3	Yes
70	Shiguchi	Orthogol	2	Friction	NA	NA	3	NA
71	Tugite	NA	2	Friction	3 Axes	NA	3	No
72	Tugite	NA	2	Friction	3 Axes	NA	3	No
73	Shiguchi	Orthogol	4	Friction + Interlock	NA	Housing	>3	NA
74	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
75	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
76	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
77	Tugite	NA	3	Friction + Interlock	3 Axes	NA	3	Yes
78	Tugite	NA	3	Friction	3 Axes	NA	3	Yes
79	Shiguchi	Orthogol	2	Friction	NA	Housing	3	NA
80	Tugite	NA	2	Friction	3 Axes	NA	3	Yes
81	Shiguchi	Orthogol	2	Friction	NA	Housing	>3	NA
82	Tugite	NA	2	Friction	3 Axes	NA	3	No
83	Tugite	NA	2	Friction	2 Axes	NA	3	No
84	Tugite	NA	2	Friction	2 Axes	NA	3	No
85	Shiguchi	Orthogol	7	Friction	NA	Housing	>3	NA
86	Tugite	NA	3	Friction + Interlock	3 Axes	NA	3	Yes
87	Tugite	NA	2	Friction	2 Axes	NA	3	No
88	Shiguchi	Orthogol	3	Friction + Interlock	NA	Housing	>3	NA
89	Tugite	NA	4	Friction + Interlock	3 Axes	NA	3	Yes
90	Tugite	NA	2	Friction	3 Axes	NA	3	No
91	Tugite	NA	2	Friction	2 Axes	NA	3	No
92	Shiguchi	Orthogol	3	Friction	NA	Corner	>3	NA
93	Tugite	NA	2	Friction	3 Axes	NA	3	No
94	Shiguchi	Non-Orthogol	3	Friction	NA	Housing	3	NA
95	Shiguchi	Non-Orthogol	2	Friction	NA	Housing	3	NA
96	Shiguchi	Non-Orthogol	3	Friction	NA	Housing	3	NA
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98	Shiguchi	Non-Orthogol	2	Friction	NA	Corner	3	NA
99	Shiguchi	NA	3	Friction + Interlock	NA	Corner	>3	NA
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101	Shiguchi	Non-Orthogol	2	Friction	NA	Corner	3	NA
102	Shiguchi	Non-Orthogol	2	Friction	NA	Corner	3	NA
103	Tugite	Non-Orthogol	2	Friction	3 Axes	NA	3	No
104	Shiguchi	Non-Orthogol	2	Friction	NA	Housing	3	NA
105	Shiguchi	Non-Orthogol	2	Friction + Interlock	NA	Corner	3	NA

7. Filter

Statement

Background

Emergence

Typological Research

Resource

Typology

Categorization

Testing Ground

Algorithmic Design

Digital Fabrication

Shiguchi/ 2 Members/ Corner

					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
Tugite/ Shiguchi Orthogonal/Non-Orthogonal	Shiguchi (All)				3	10	17	24	31	38	45	52	59	66	73	80	87	94	101
Number of Joint Members Structural Performance	2 (All)				4	11	18	25	32	39	46	53	60	67	74	81	88	95	102
Structural Performance (Tugite) Corner/Housing	(All) Corner				5	12	19	26	33	40	47	54	61	68	75	82	89	96	103
>3 Axis CNC Tension	(All) (All)				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
Row Labels																			

- Statement
- Background
- Emergence
- Typological Research
- Testing Ground
- Algorithmic Design
- Digital Fabrication



Hannover 2000



Aichi 2005



Shanghai 2010



Milan 2015



Connecting Minds, Creating the Future.

EXPO 2020
DUBAI, UAE
 CANDIDATE CITY
Bid Supporter



<http://intertravel-agency.com/dubai-to-host-the-world-expo-2020-connecting-minds-creating-the-future/>



2020 DUBAI EXPO
China Pavilion

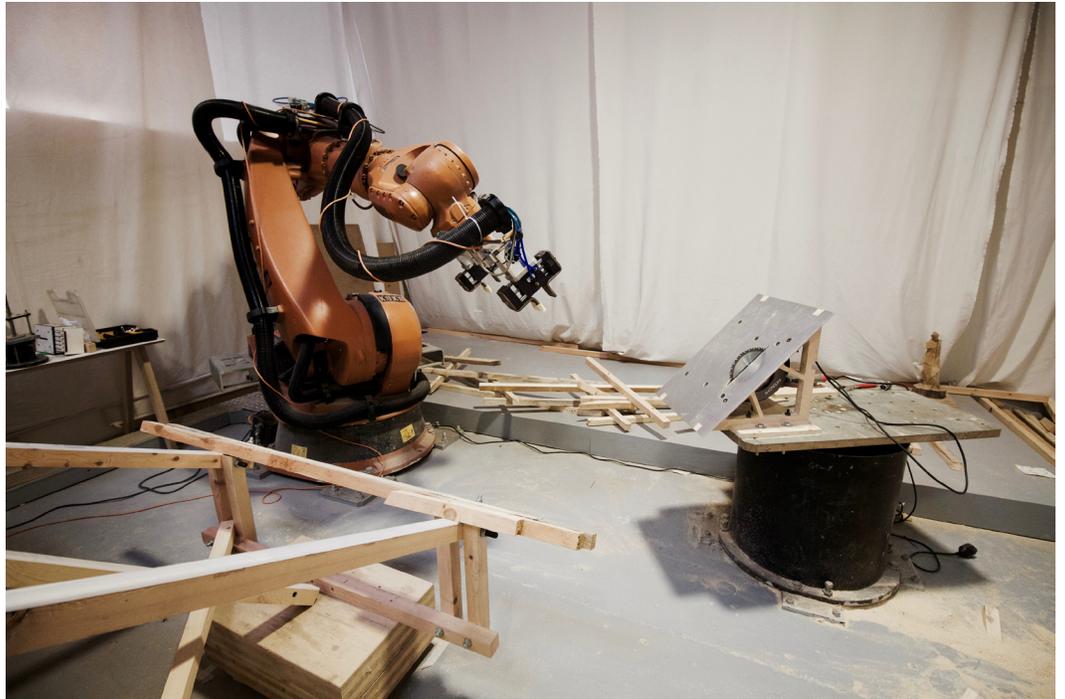
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Typological Research	<input type="checkbox"/>
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- *Grasshopper for Rhino*

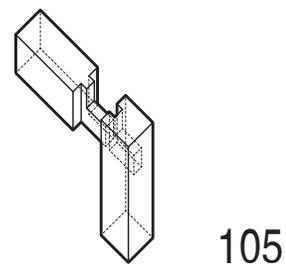
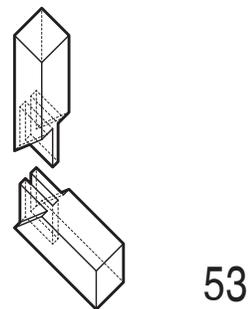
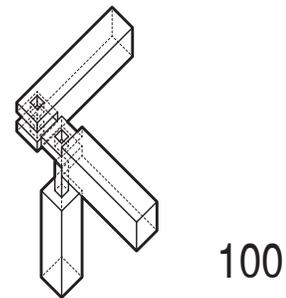
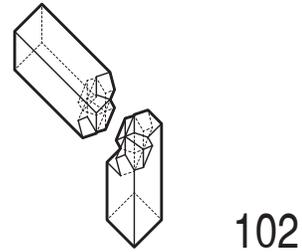
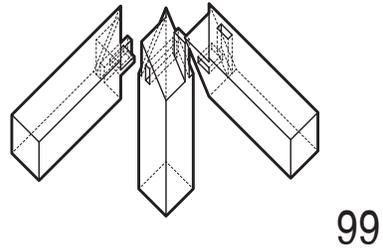


- *Grasshopper Python Component*

Statement	<input type="checkbox"/>
Background	<input type="checkbox"/>
Emergence	<input type="checkbox"/>
Typological Research	<input type="checkbox"/>
Testing Ground	<input type="checkbox"/>
Algorithmic Design	<input type="checkbox"/>
Digital Fabrication	<input checked="" type="checkbox"/>



Statement	<input type="checkbox"/>
Background	<input type="checkbox"/>
Emergence	<input type="checkbox"/>
Typological Research	<input type="checkbox"/>
Testing Ground	<input type="checkbox"/>
Algorithmic Design	<input type="checkbox"/>
Digital Fabrication	<input checked="" type="checkbox"/>
Preliminary Test	<input checked="" type="checkbox"/>



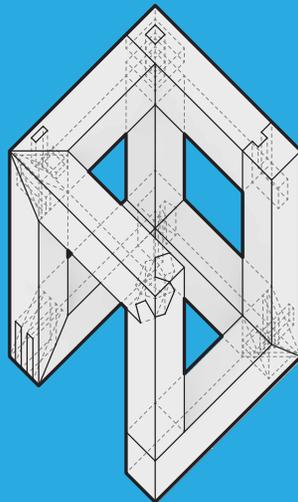
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Preliminary Test	<input checked="" type="checkbox"/>



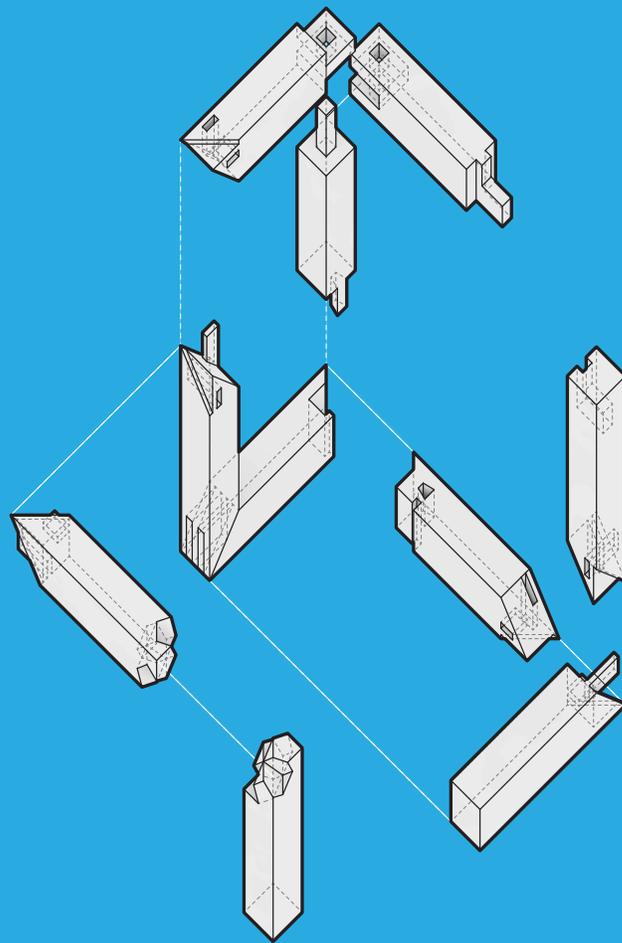
File Set



*Form Labs
Form 2*



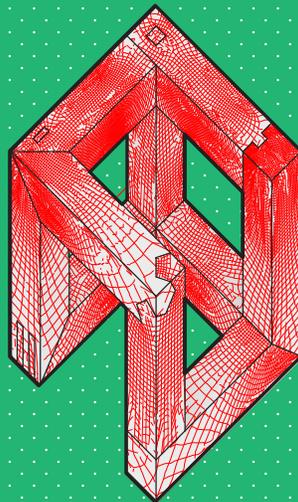
Axonometric



Exploded Axon



Principle Stresses



Stress Pattern

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Image Citation

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