Computational Design

computational

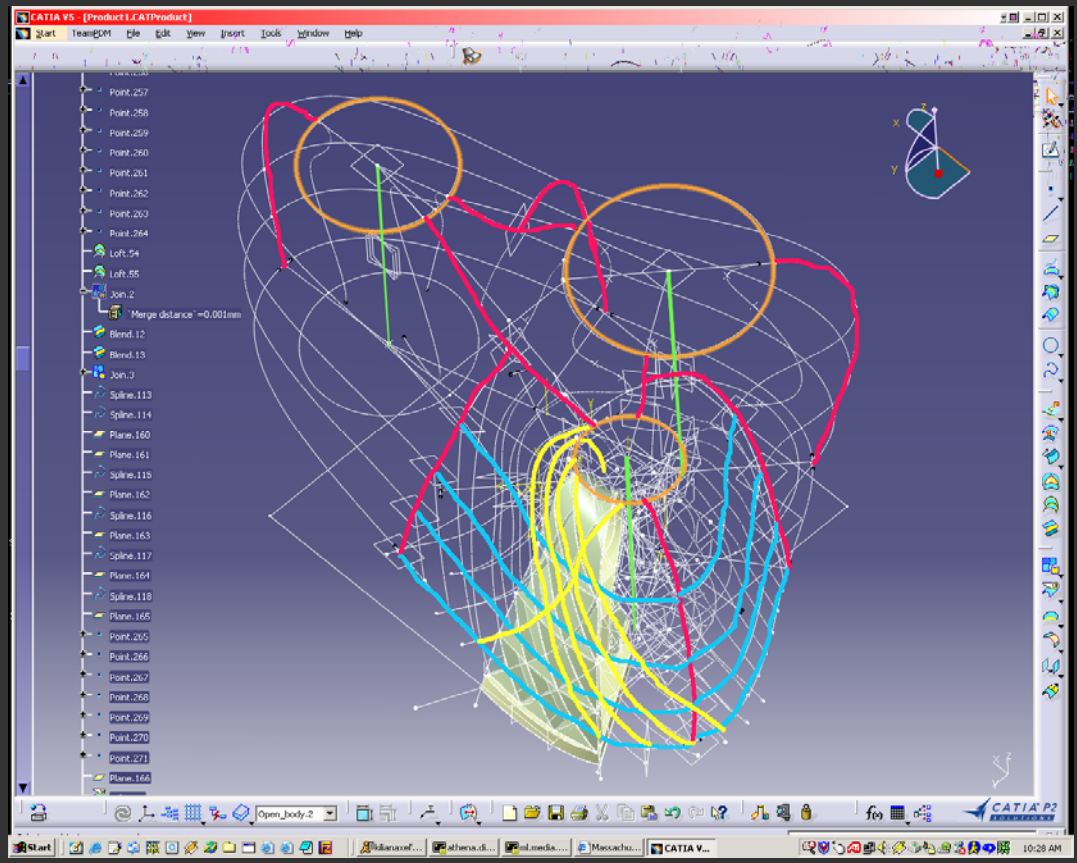
algorithmic, procedural, generative, rule-based

design

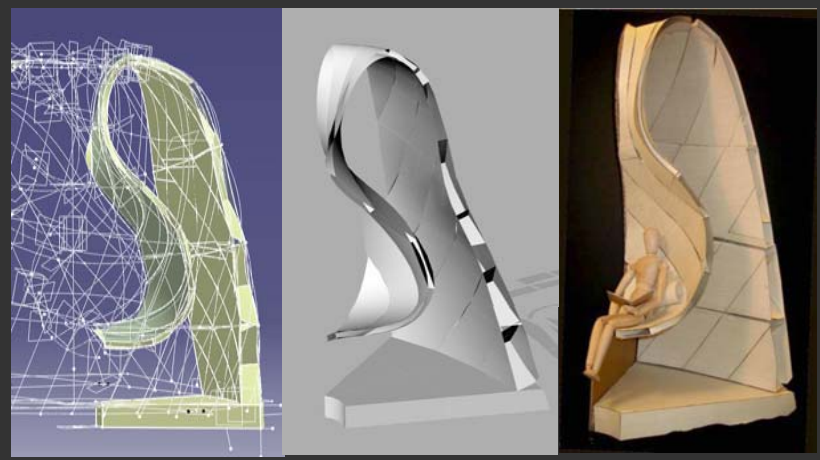
making, creating designs

computational design

- exploration
- innovation
- explanation (dynamic)

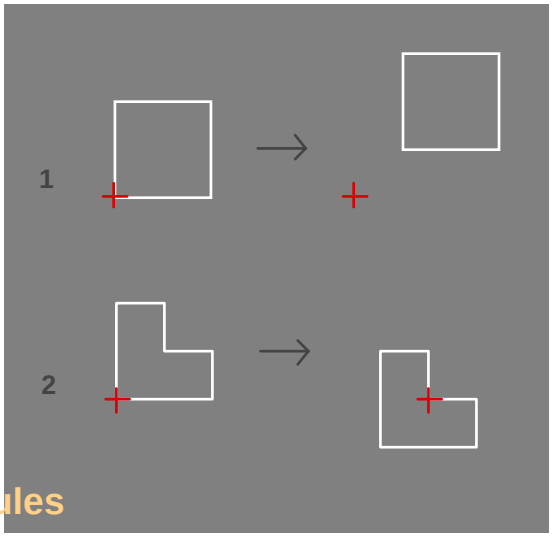


parametric design (CATIA)
Reading Room: Barrios, Kilian, Morshead

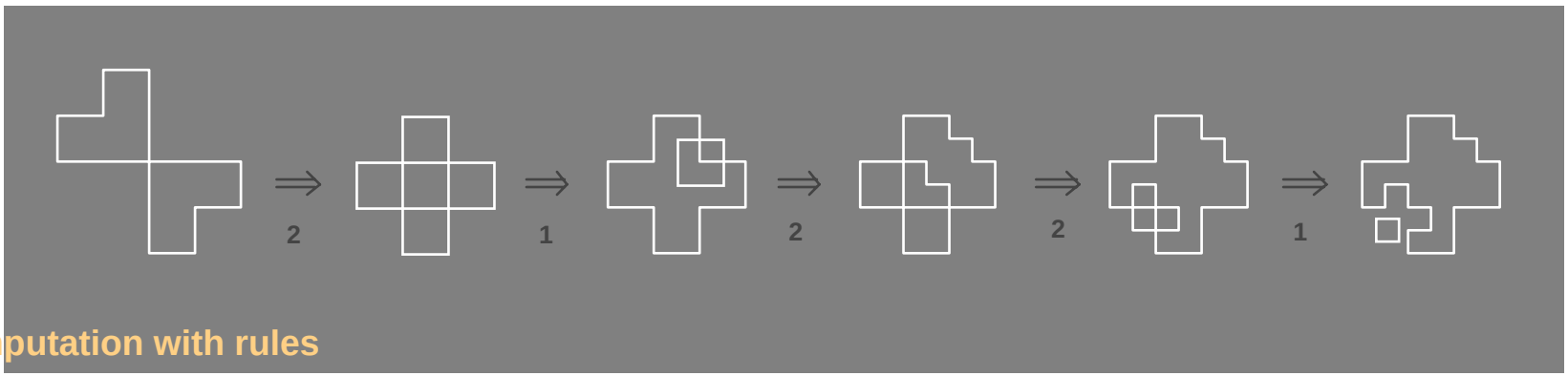


Shape Grammars

spatial algorithms



rules



computation with rules

history of computation

1930s	formal theories of computation (Turing, Godel, Church, etc)
1940s	first computer *neural nets (McCulloch and Pitts)* production systems (Post)
1950s	*parallel computation (von Neuman)* *cellular automata (Ulam, von Neuman)* generative grammars (Chomsky)
1960s	*evolutionary computation* pattern grammars (Fu)
1970s	shape grammars (Stiny, Gips)
1980s	*artificial life (Langton), self-organizing systems*

GENERATIVE GRAMMAR

start symbol: [SENTENCE]

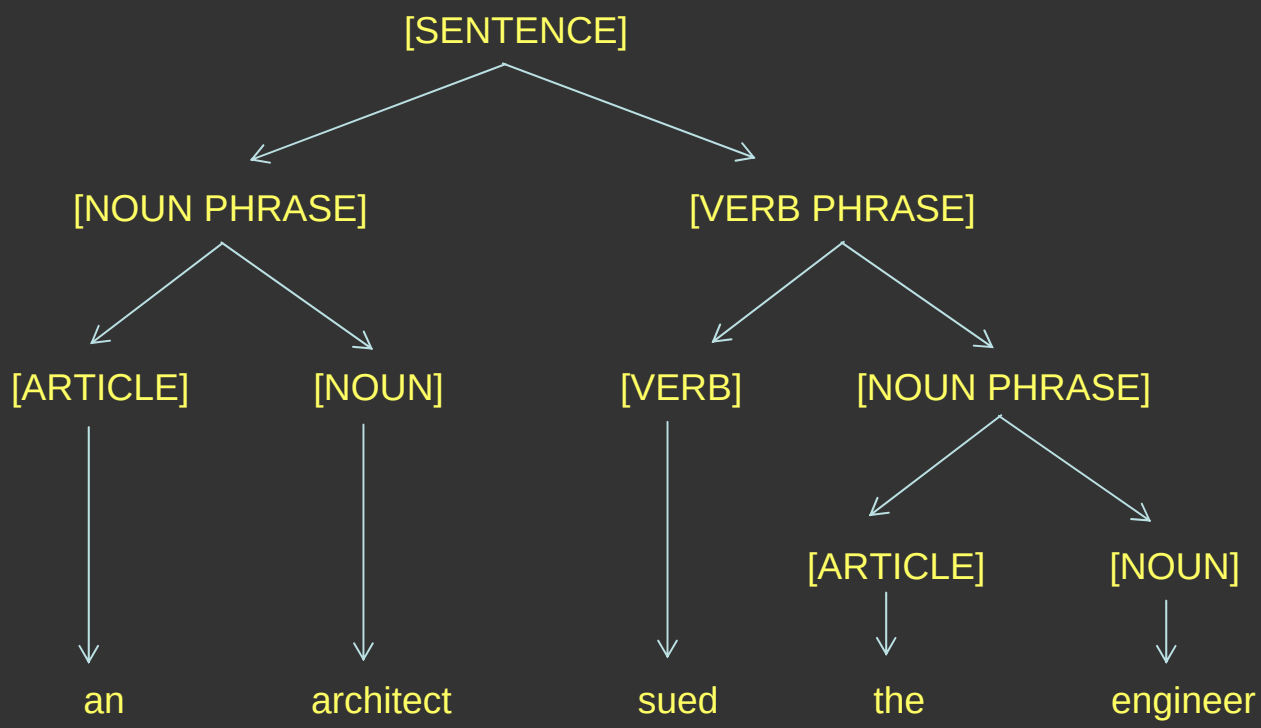
rules:

[SENTENCE] → [NOUN PHRASE] [VERB PHRASE]
[NOUN PHRASE] → [ARTICLE] [NOUN]
[VERB PHRASE] → [VERB] [NOUN PHRASE]
[ARTICLE] → an
[ARTICLE] → the
[NOUN] → architect
[NOUN] → engineer
[VERB] → met
[VERB] → sued

language:

* the engineer met the architect
* an architect sued an engineer
* the engineer met and architect

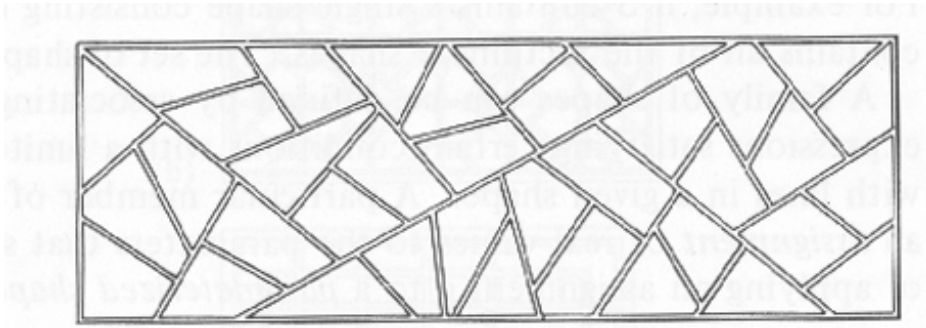
GENERATIVE GRAMMAR

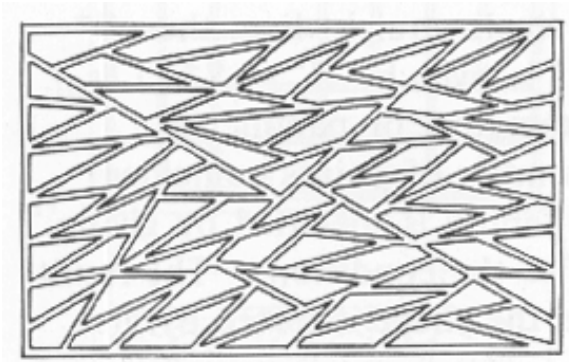


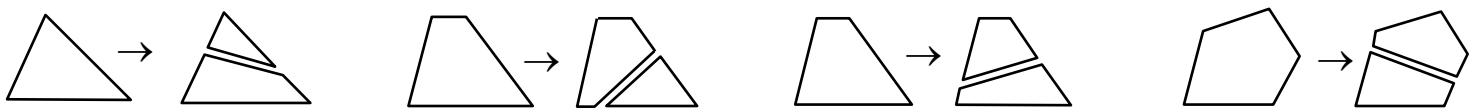
shape grammar applications

analysis

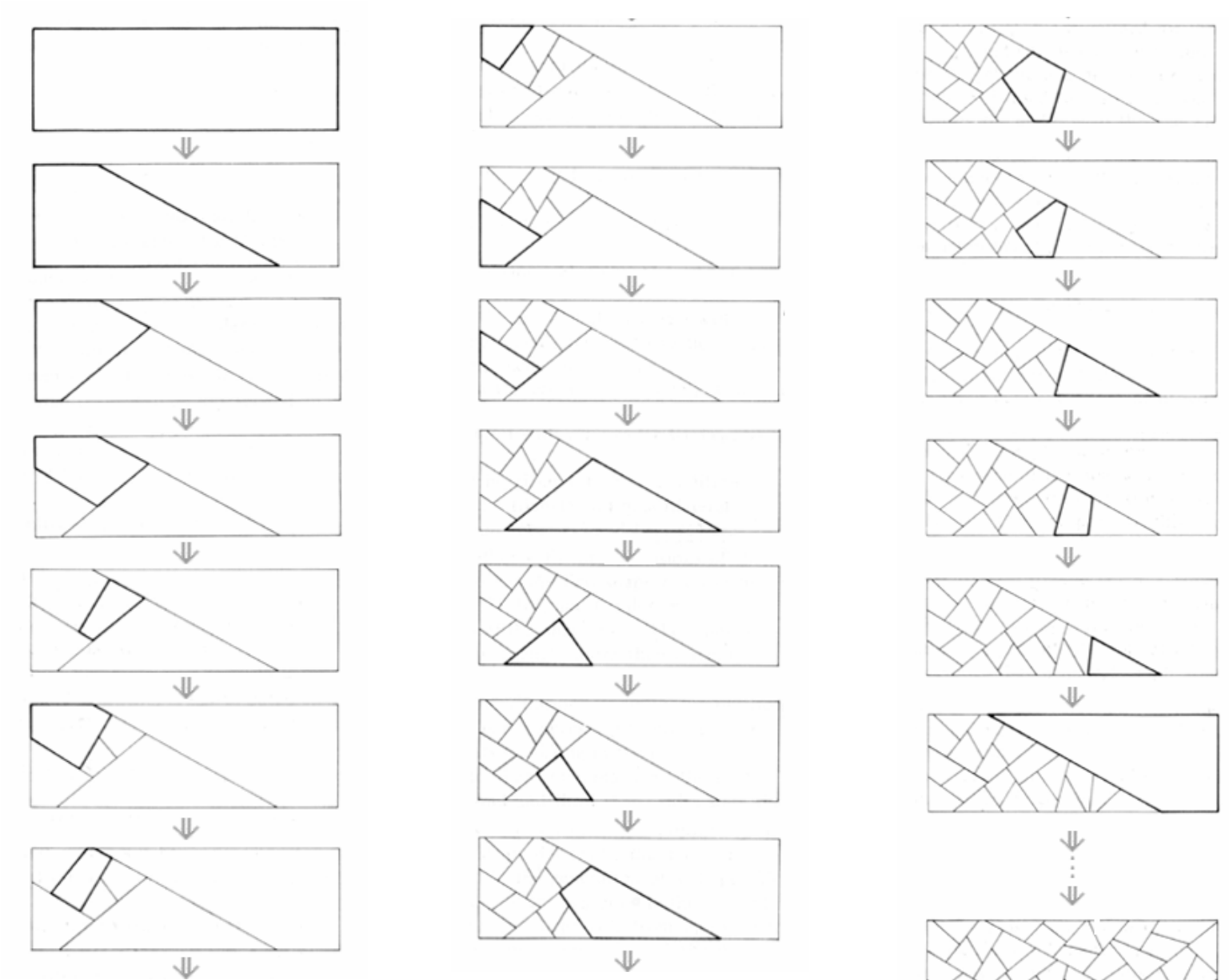
synthesis
(original design)



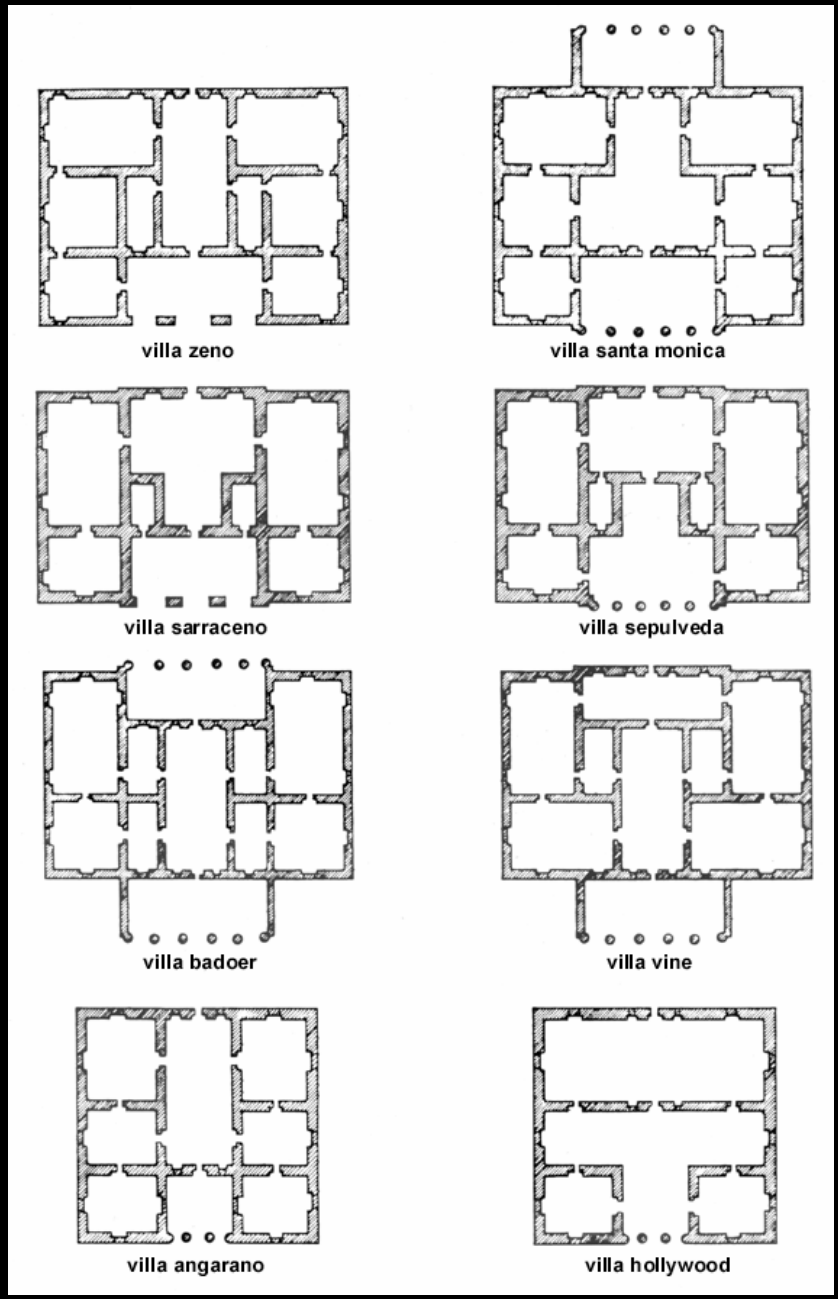




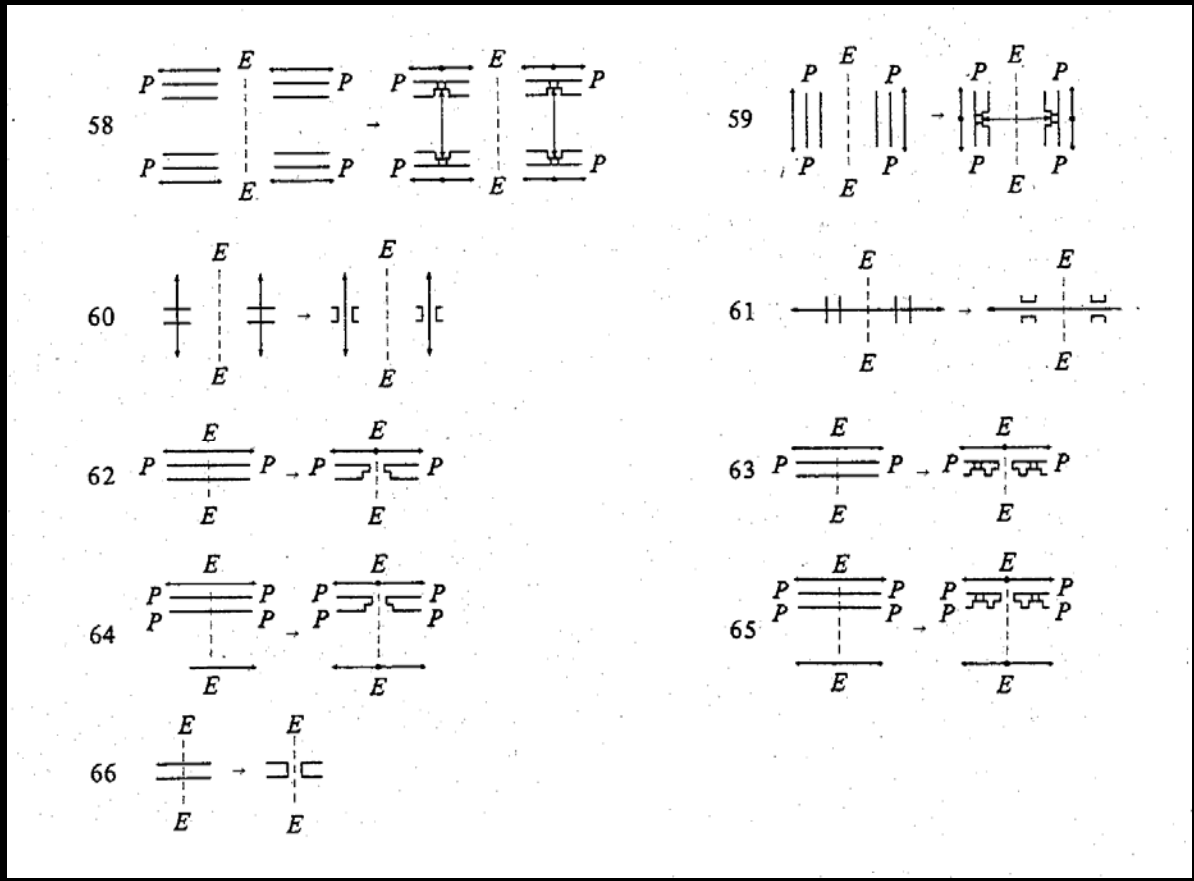
Chinese ice-ray shape grammar (Stiny, 1977)



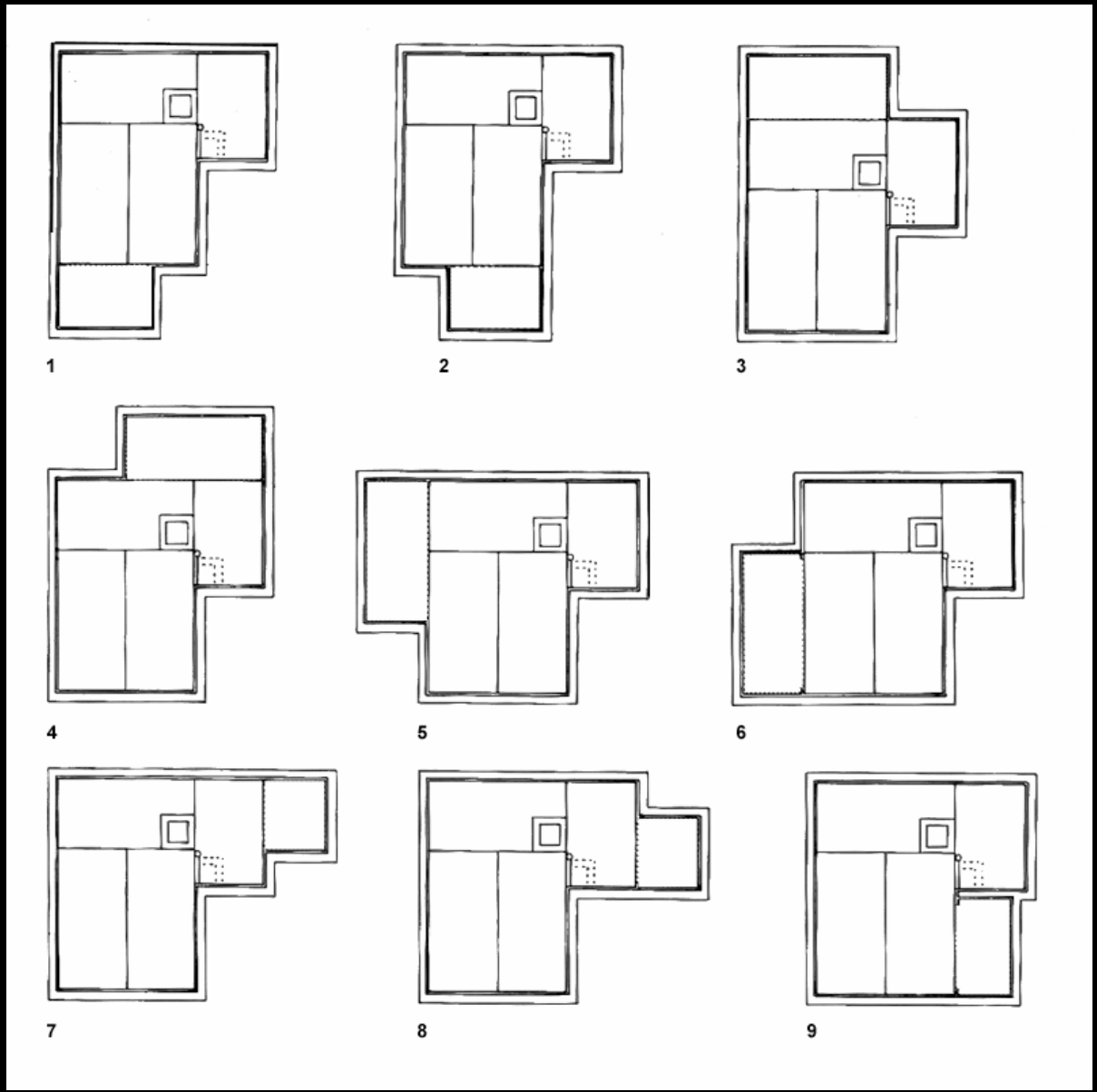
derivation of an ice-ray design



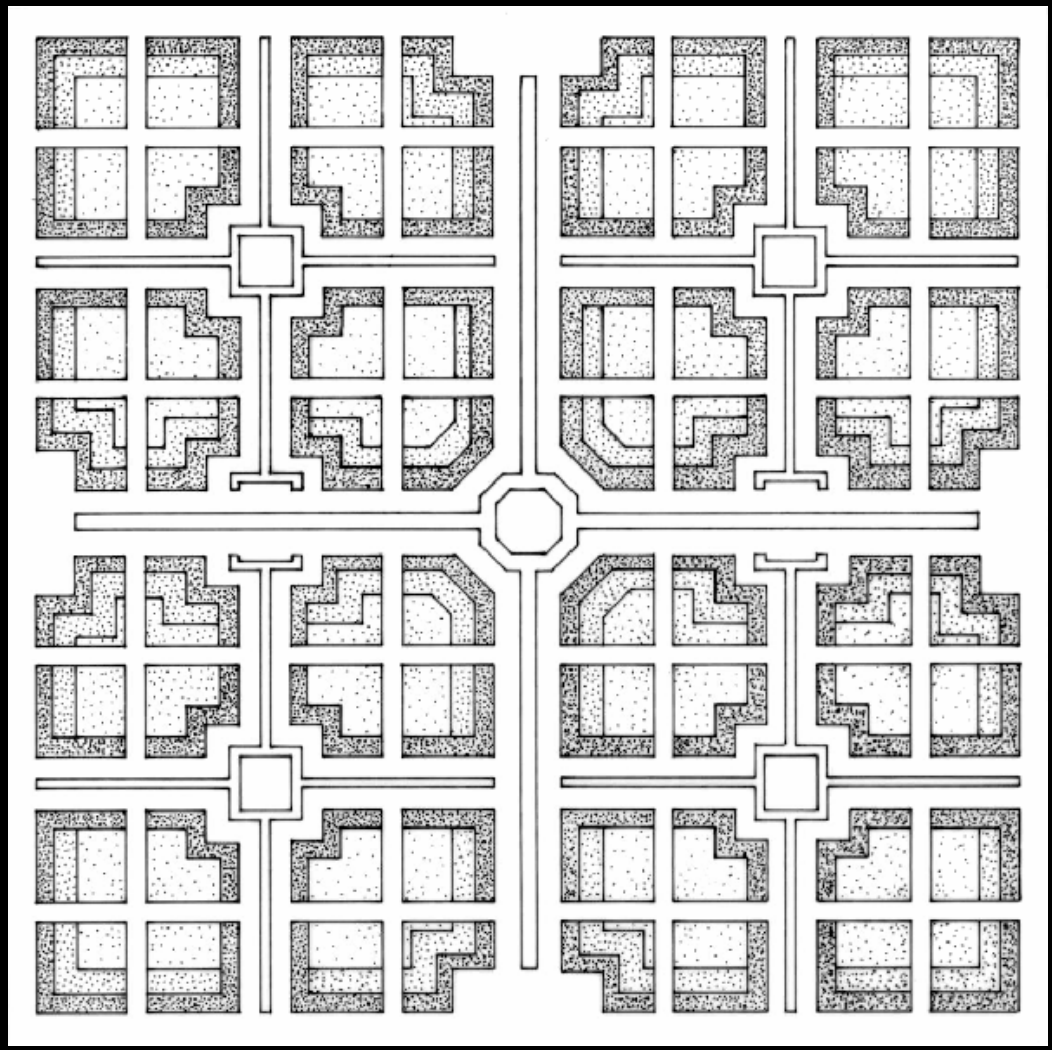
Palladian villas
(Stiny and Mitchell, 1978)



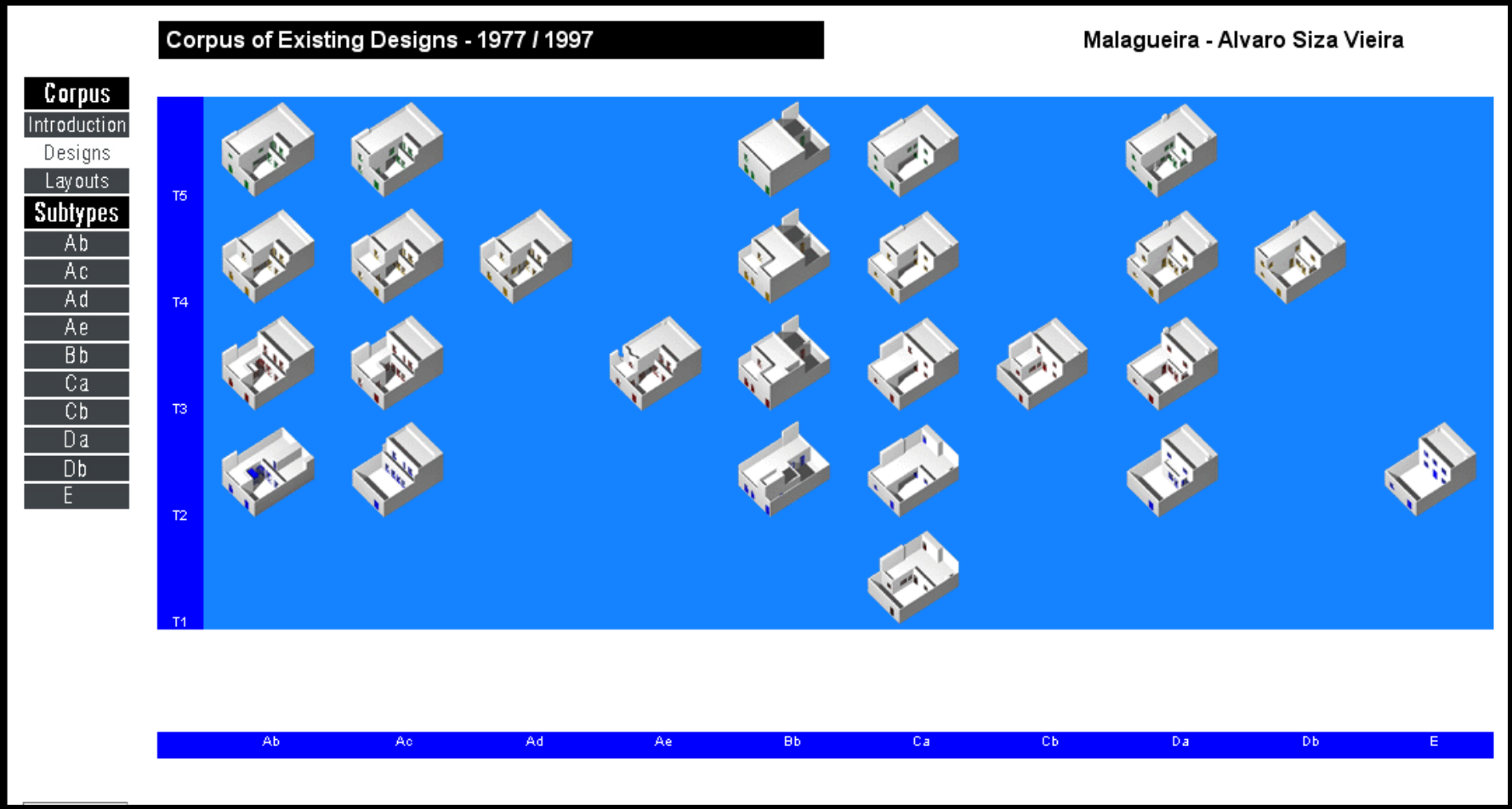
The Palladian grammar: enfilade rules



Japanese tearooms
(Knight, 1981)

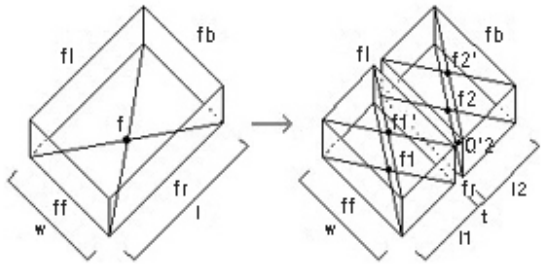


Mughul gardens
(Stiny and Mitchell, 1980)



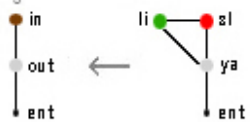
Malagueira housing designs of Alvaro Siza (Jose Duarte)

Rule 9: dissecting the outside zone

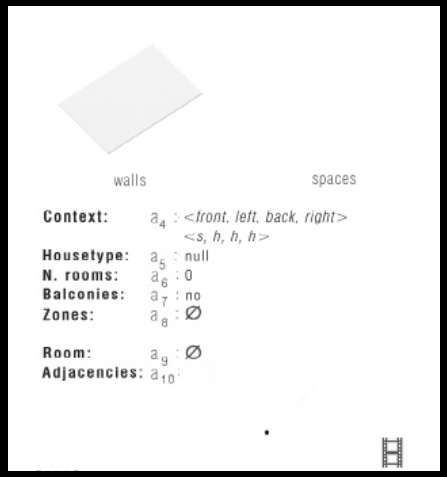


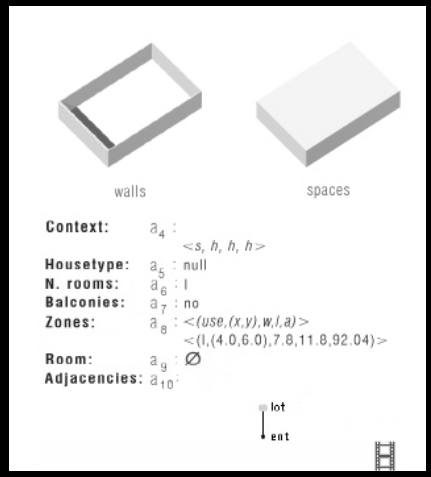
R9: $<F_1; f_b, f_r, f_f, li; o; Z> \rightarrow$
$<F_1; f_b, f_r, f_f, f_l; ya, sl; Z - \{ya, sl\}>$

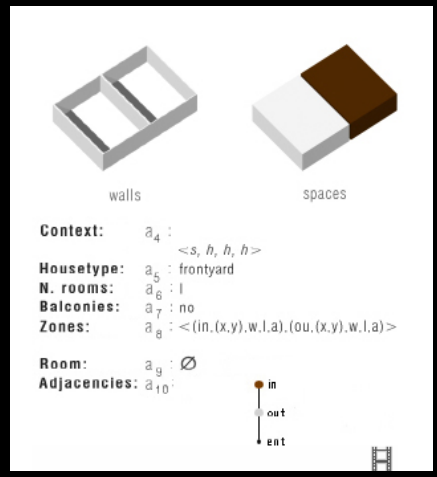
Context: $g_4 : a_4 \leftarrow a_4$
Housetype: $g_5 : a_5 \leftarrow a_5$
N. rooms: $g_6 : a_6 \leftarrow a_6$
Balconies: $g_7 : a_7 \leftarrow a_7$
Zones: $g_8 : a_8 \leftarrow a_8 <$ -(in, (x,y), w, l, a),
+(li, (x,y), w, l, a),
+(sl, (x,y), w, l, a),
Room: $g_9 : a_9 \leftarrow a_9$
Adjacencies: g_{10} :

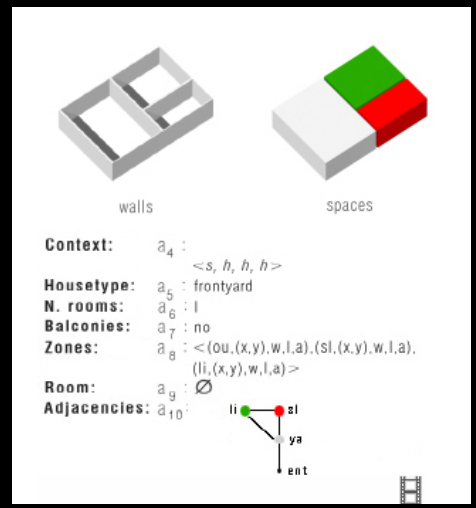


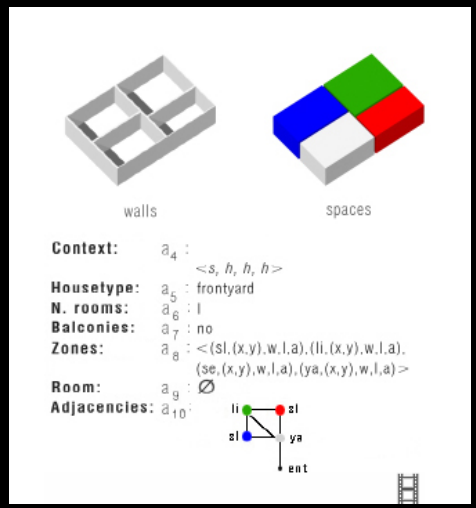
rule from Siza grammar



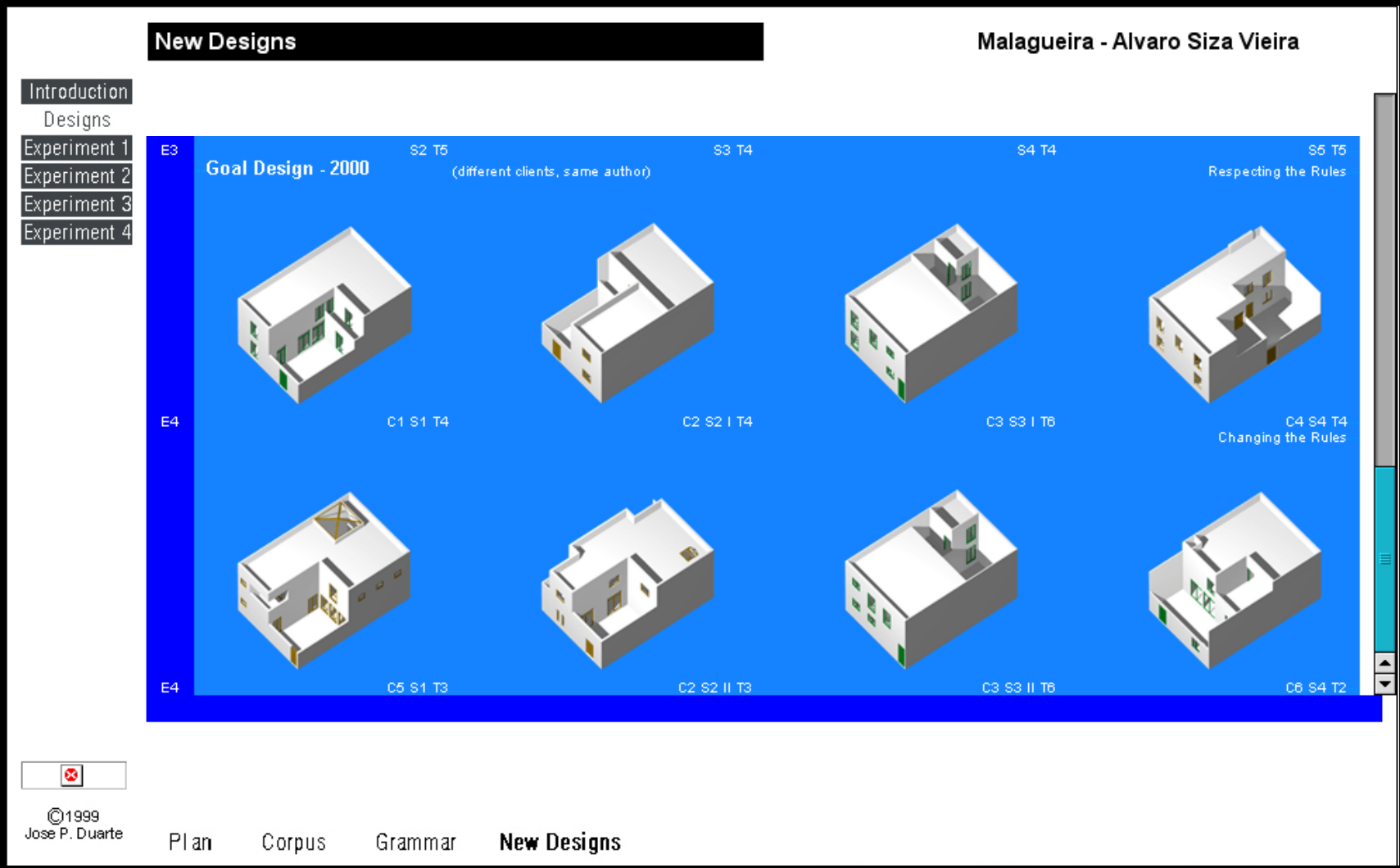








part of a computation
in Siza grammar

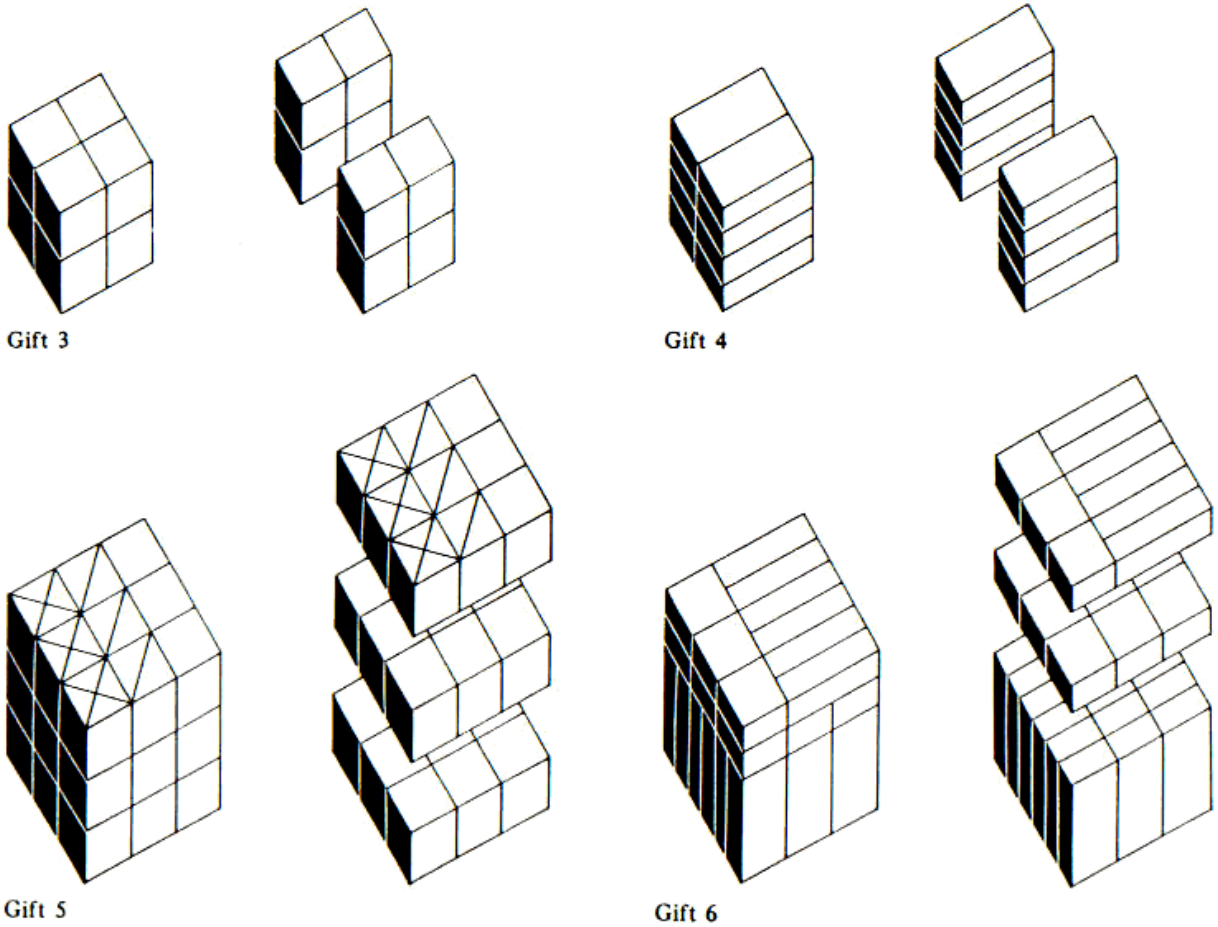


new Malagueira houses

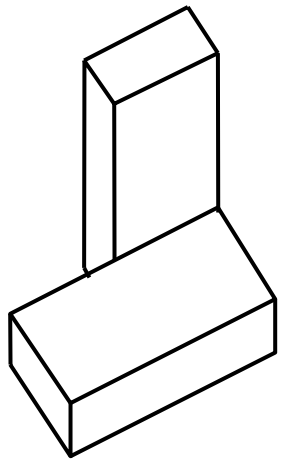
shape grammar applications

analysis

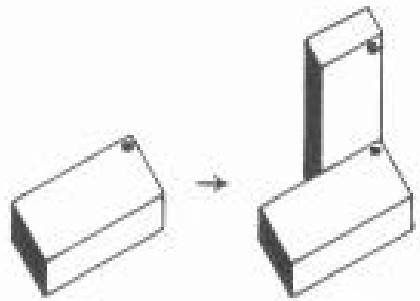
» synthesis



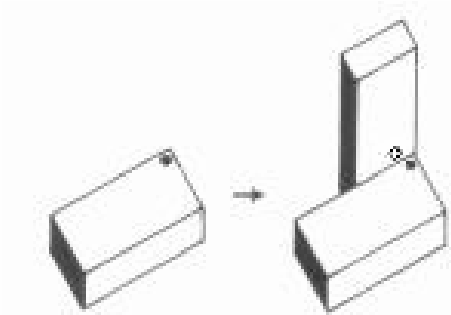
Froebel building gifts



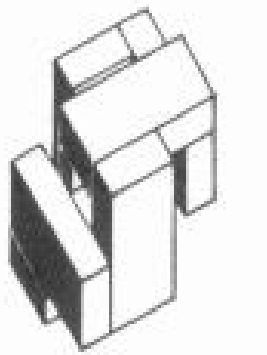
spatial relation



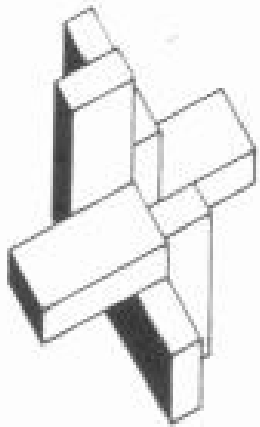
rule



rule

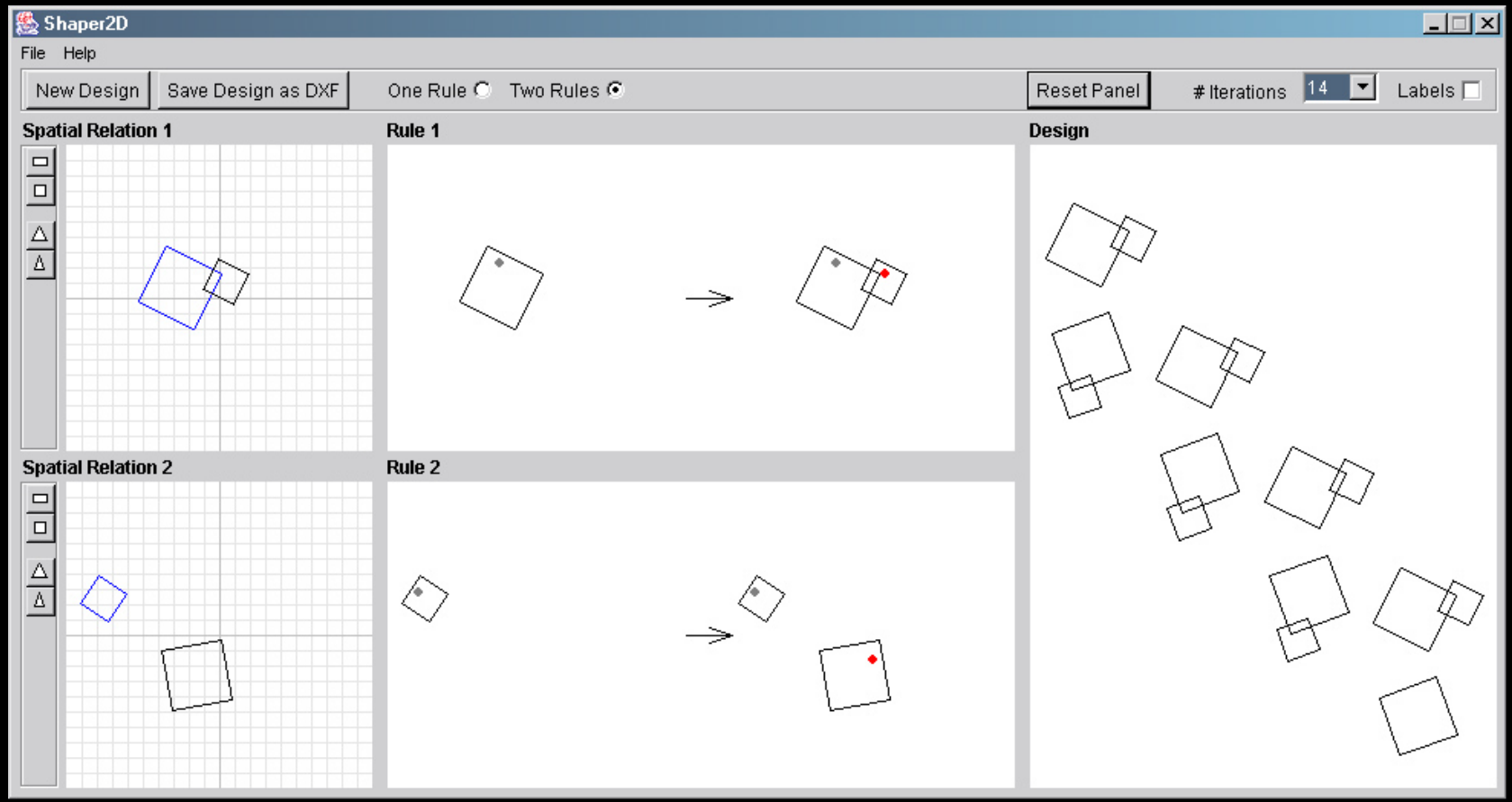


design

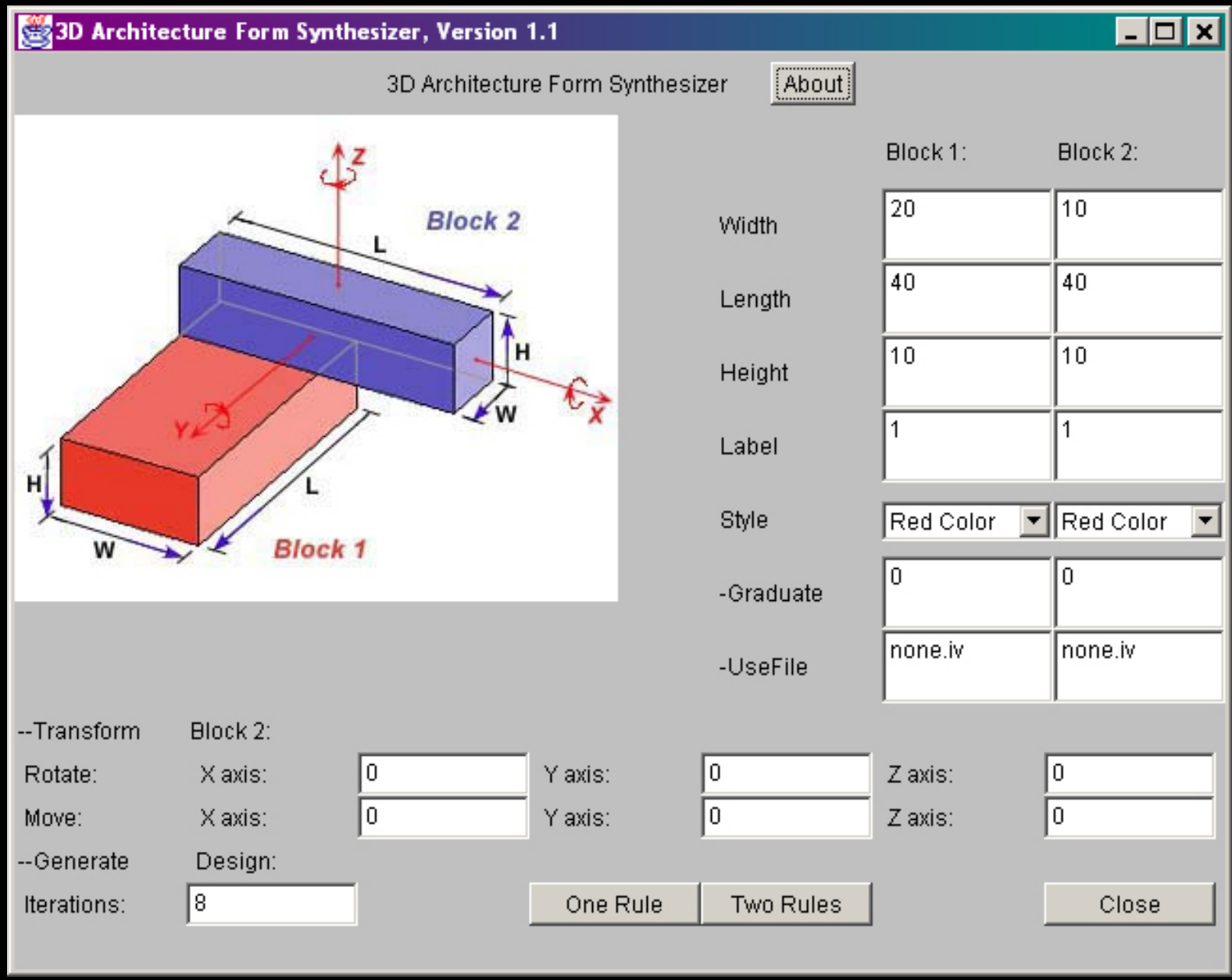


design

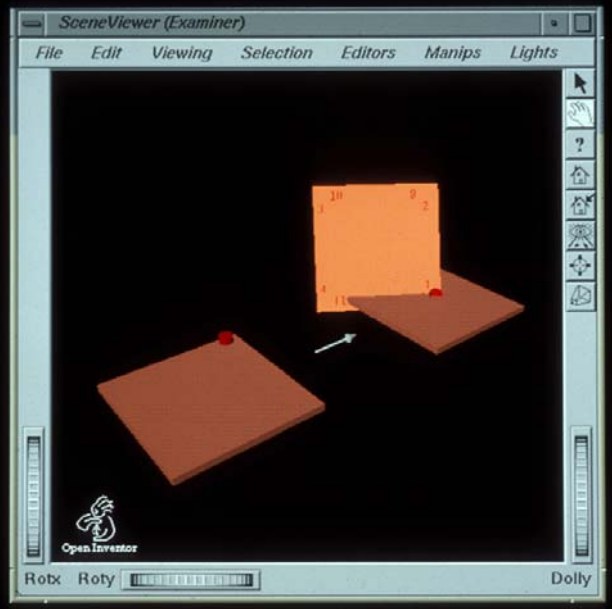
basic grammars



shaper2D (Miranda McGill)

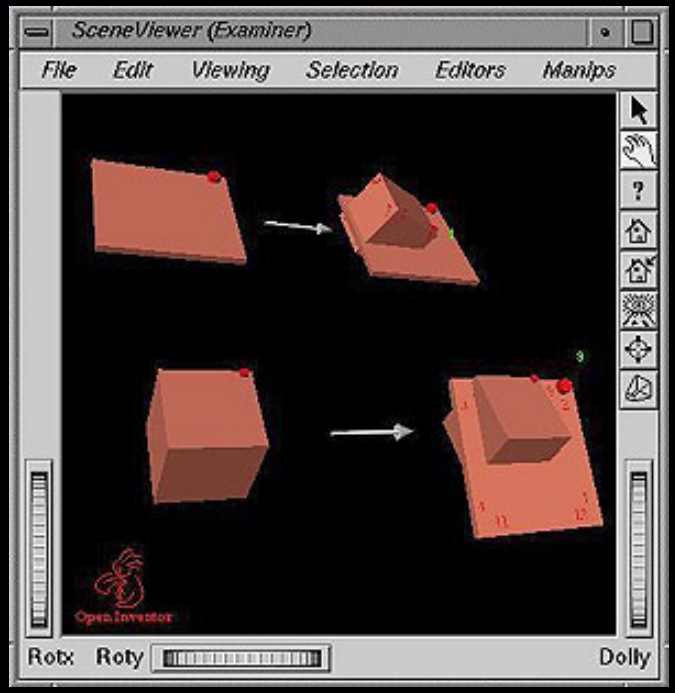


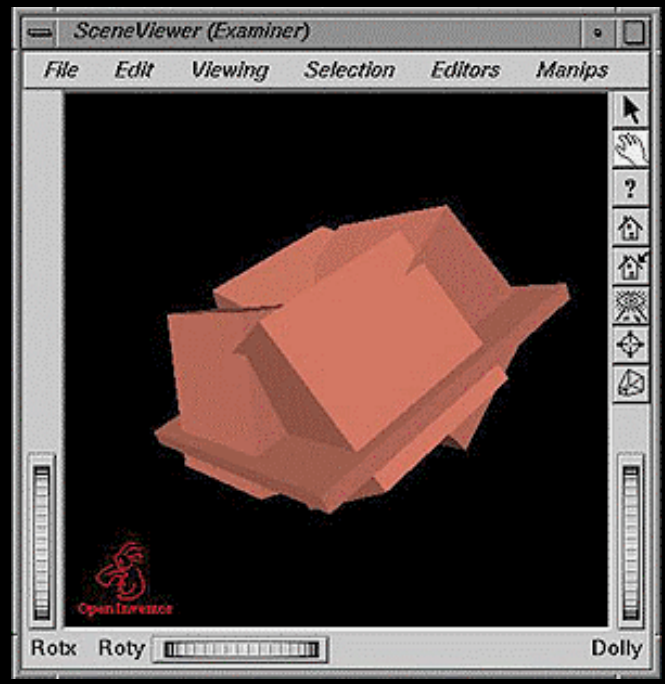
3D architecture form synthesizer (Yufei Wang)



rule

designs

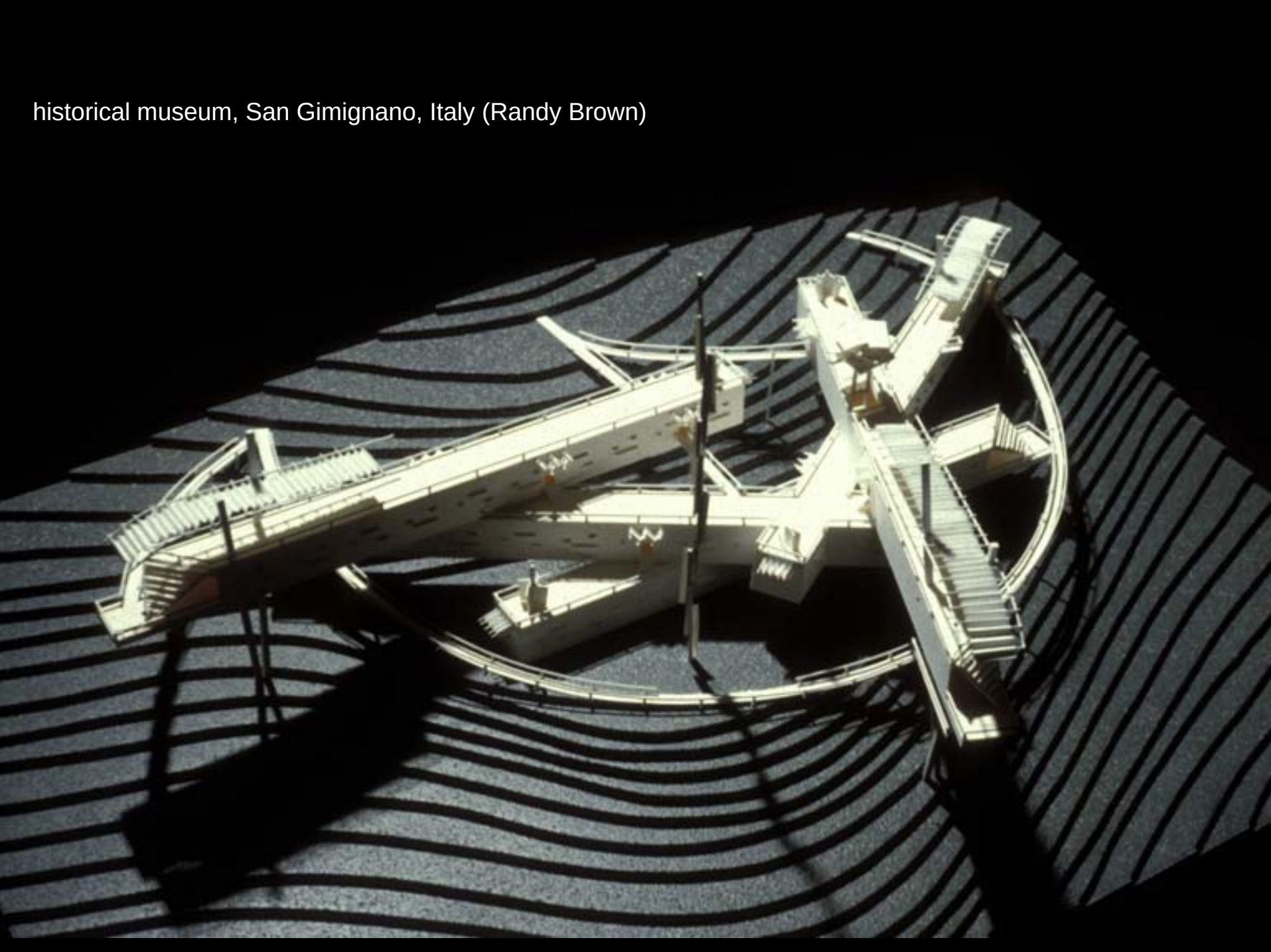


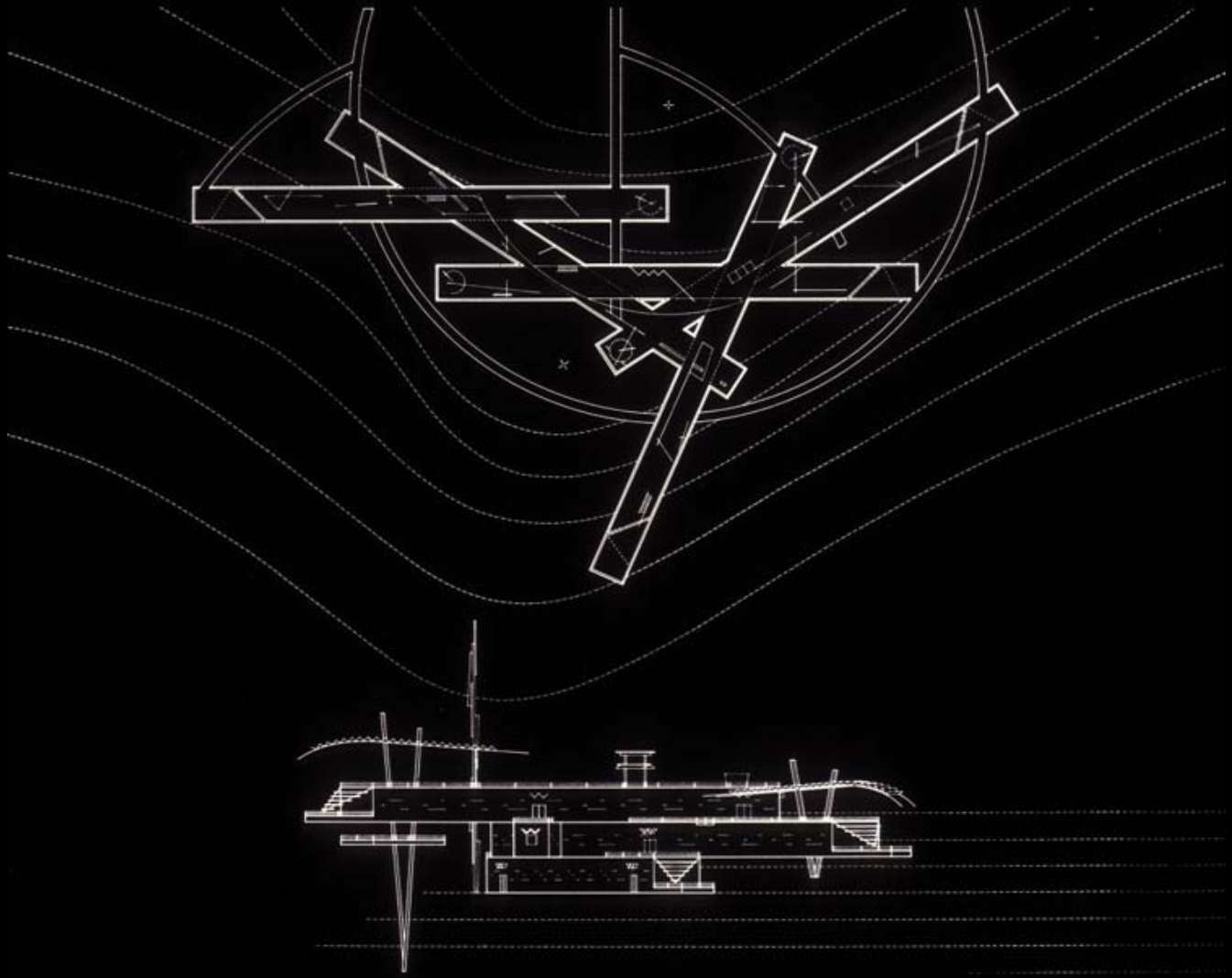


rule

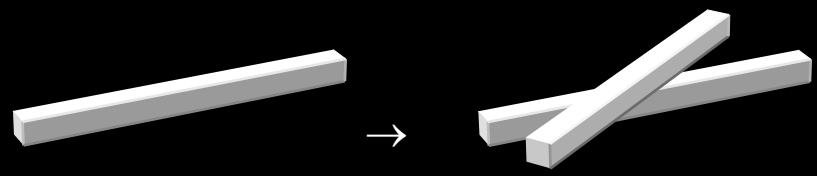
designs

historical museum, San Gimignano, Italy (Randy Brown)



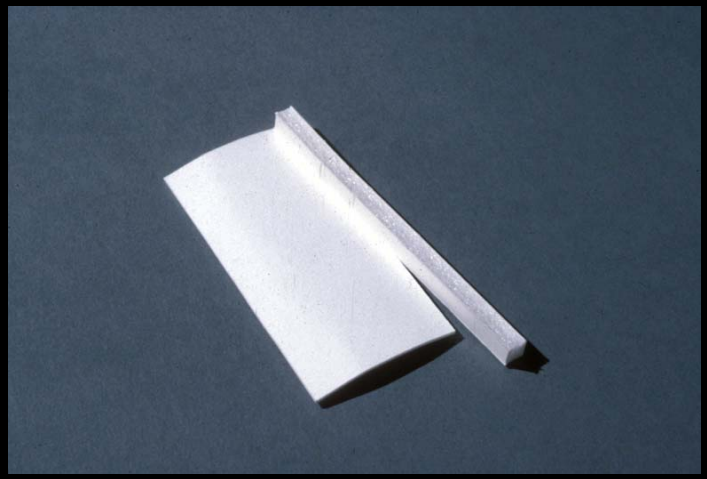


historical museum, San Gimignano, Italy (Randy Brown)

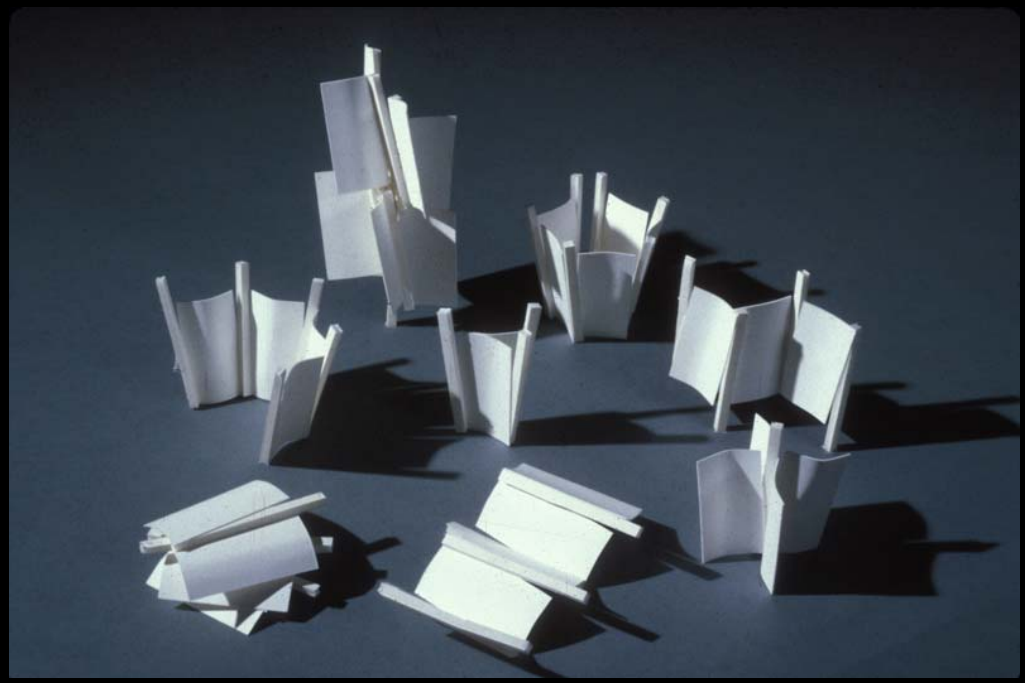


underlying rule

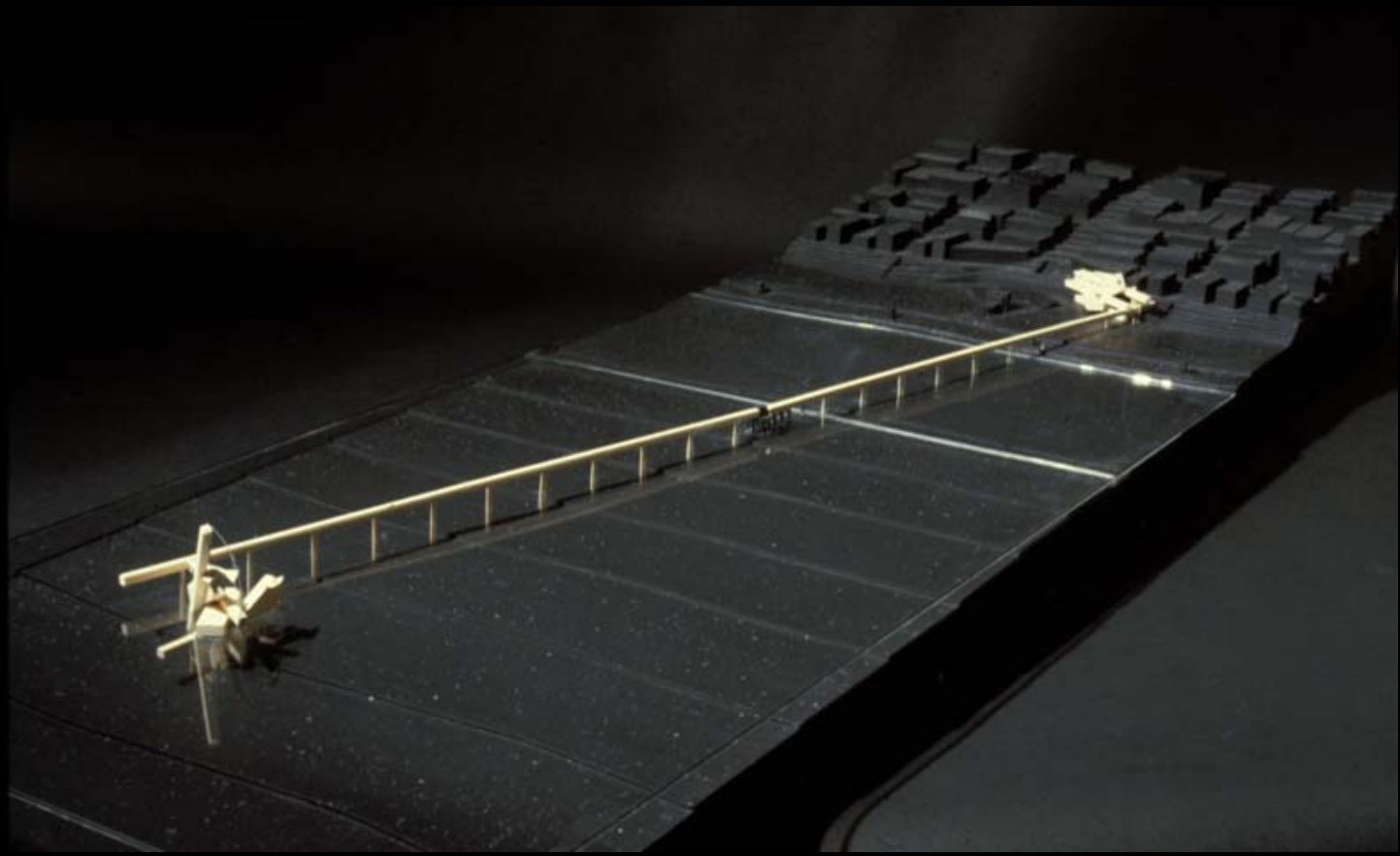
massing studies



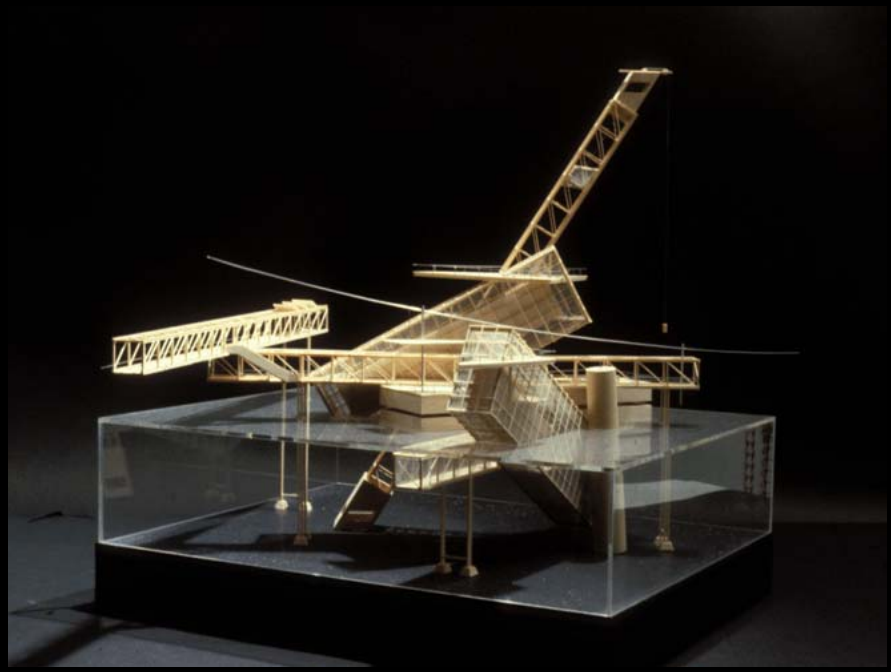
spatial relation

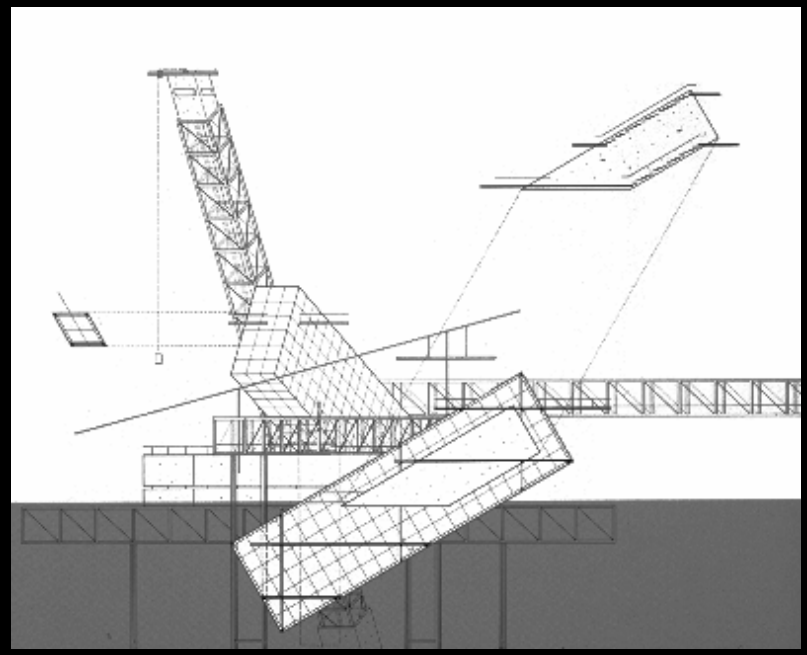


generated designs

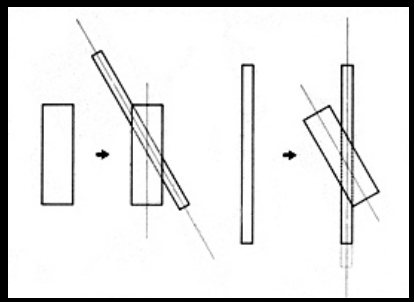


pier, ocean observatory and education facility, Manhattan Beach, CA
(Randy Brown)

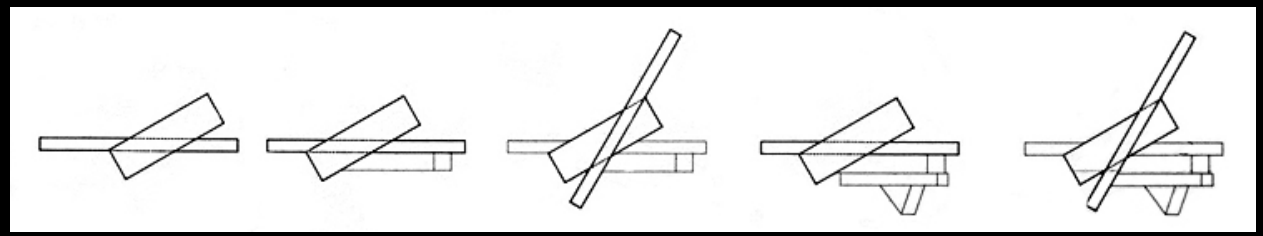




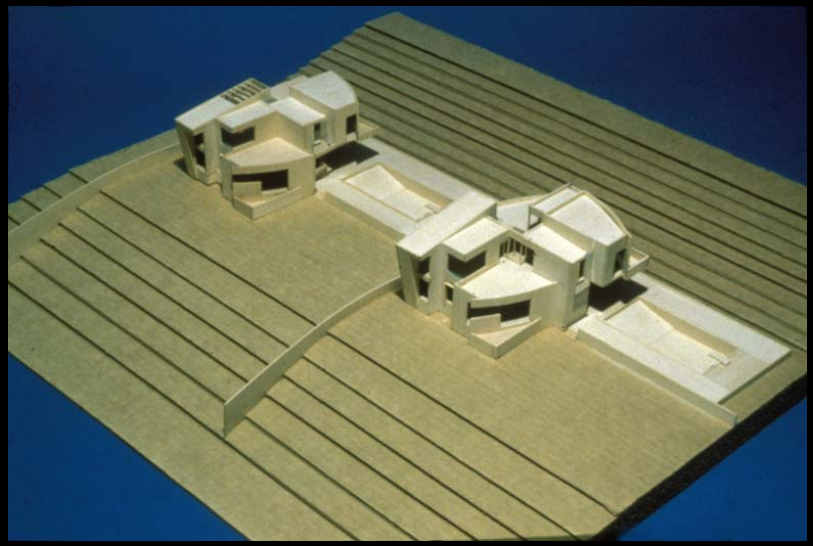
ocean building



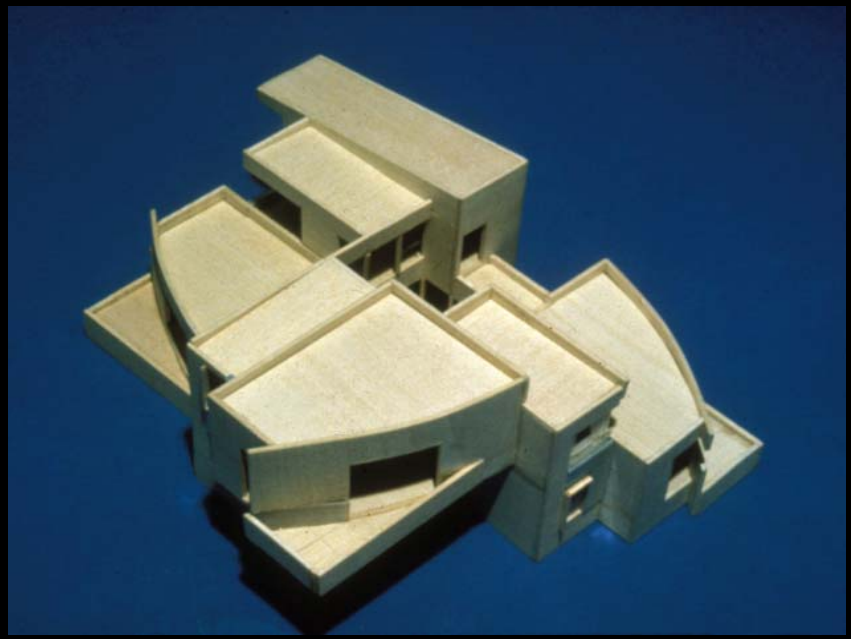
rules

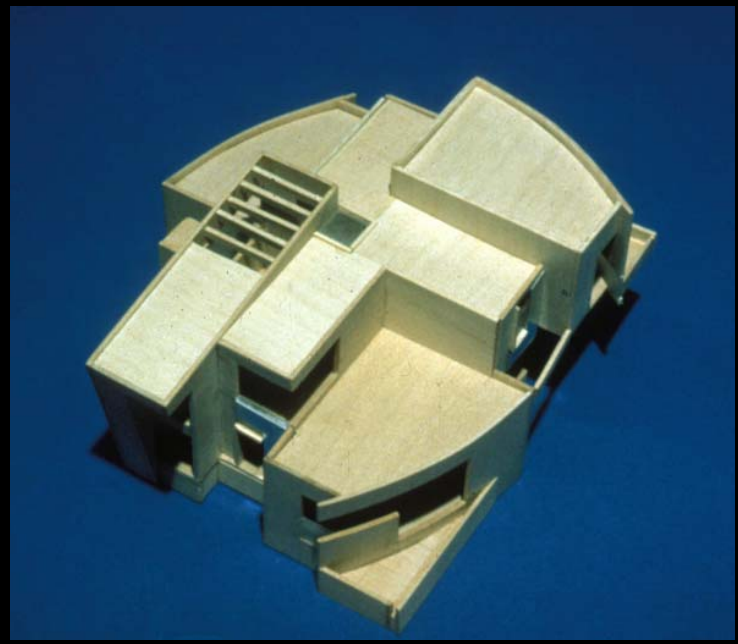


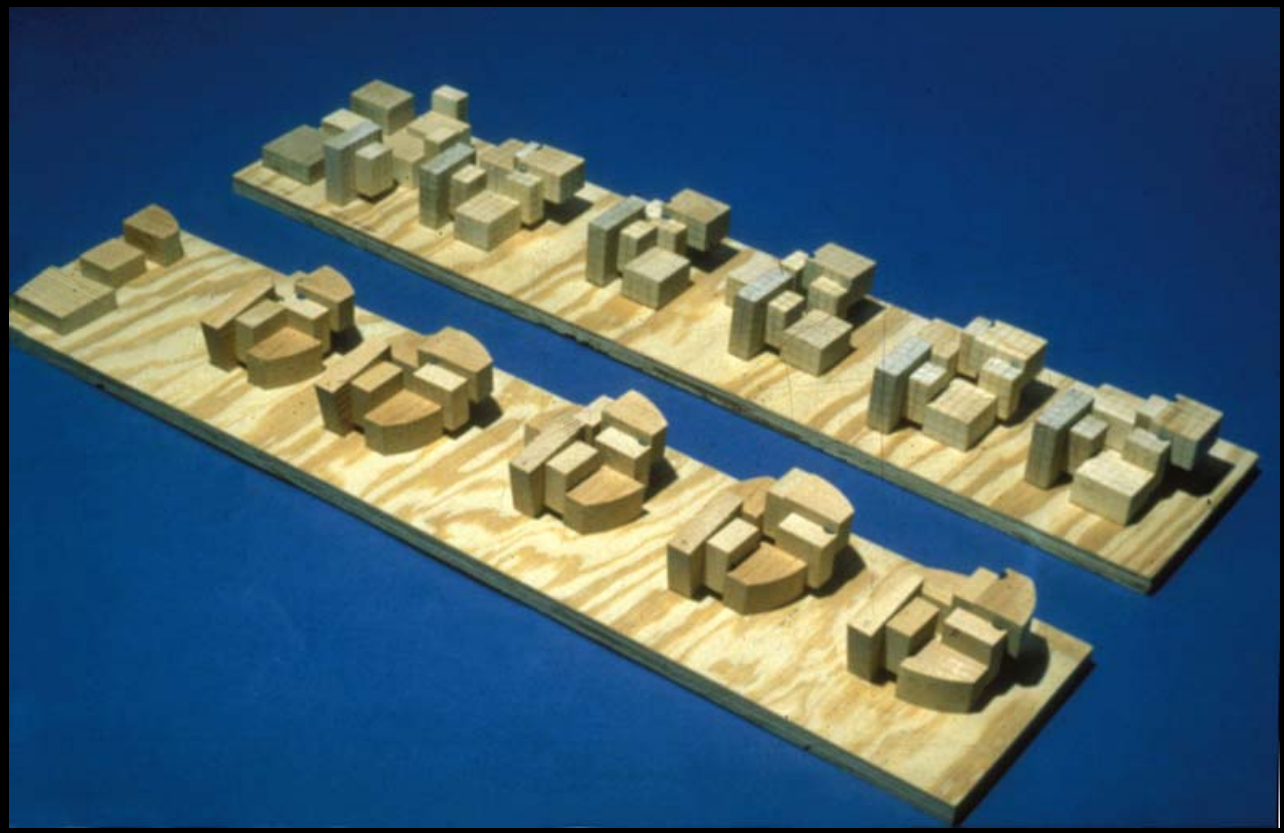
derivation



courtyard houses, Malibu, CA
(Jin-Ho Park)

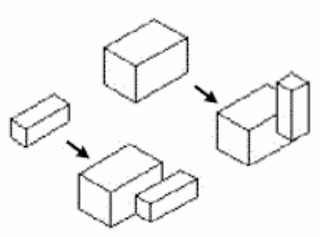




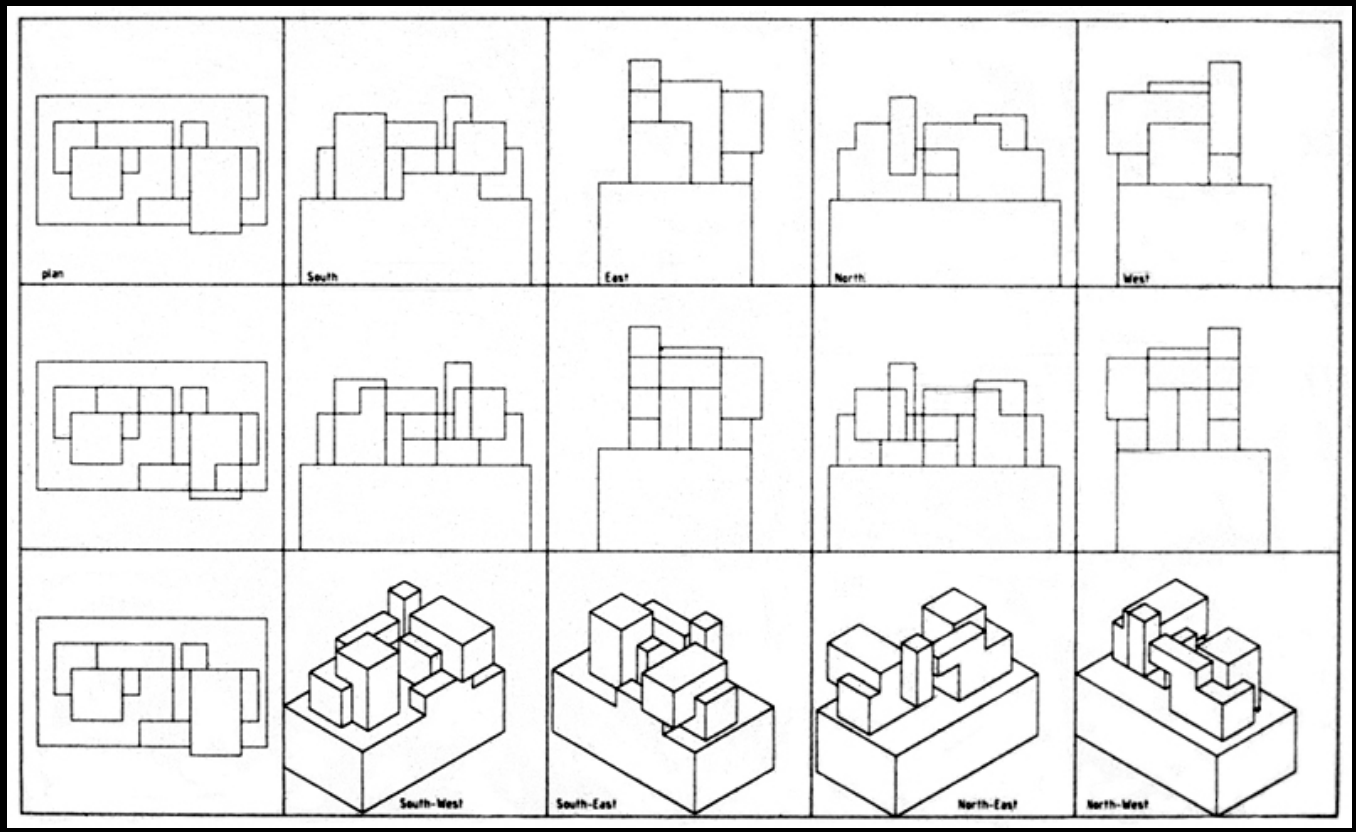


courtyard house possibilities

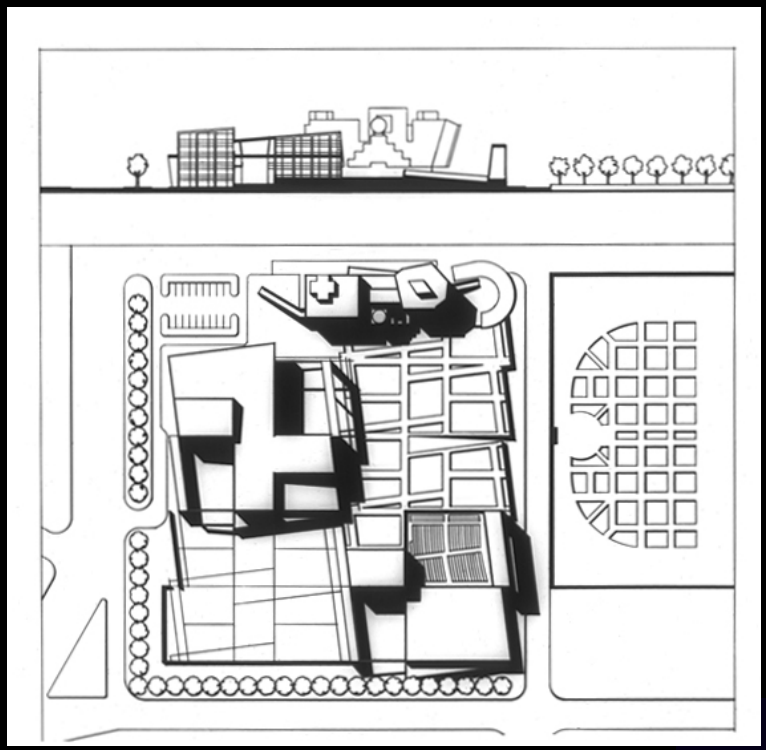
apartment house complex
(Murat Sanal)



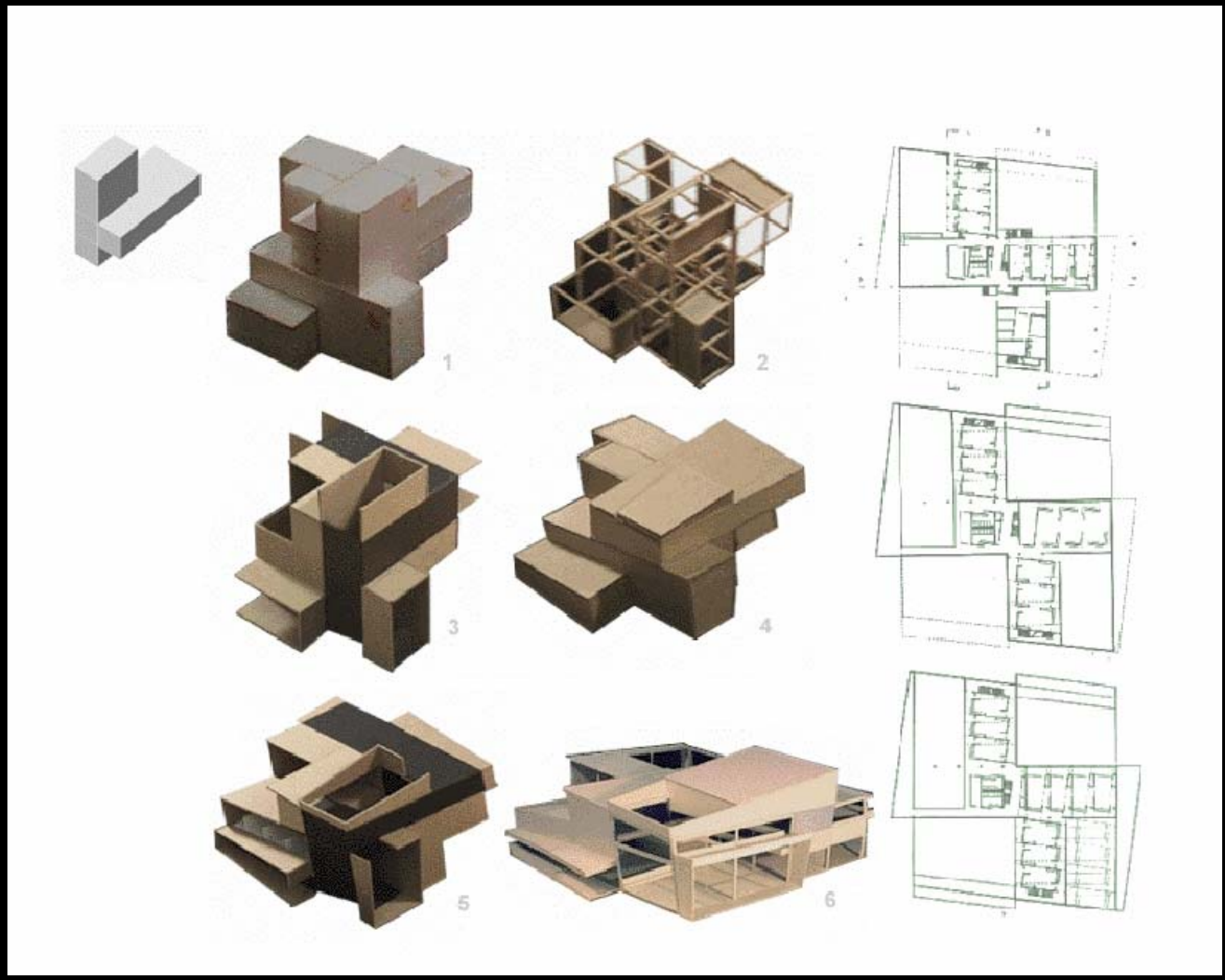
underlying shape rules


plan
South
East
North
West
South-West
South-East
North-East
North-West

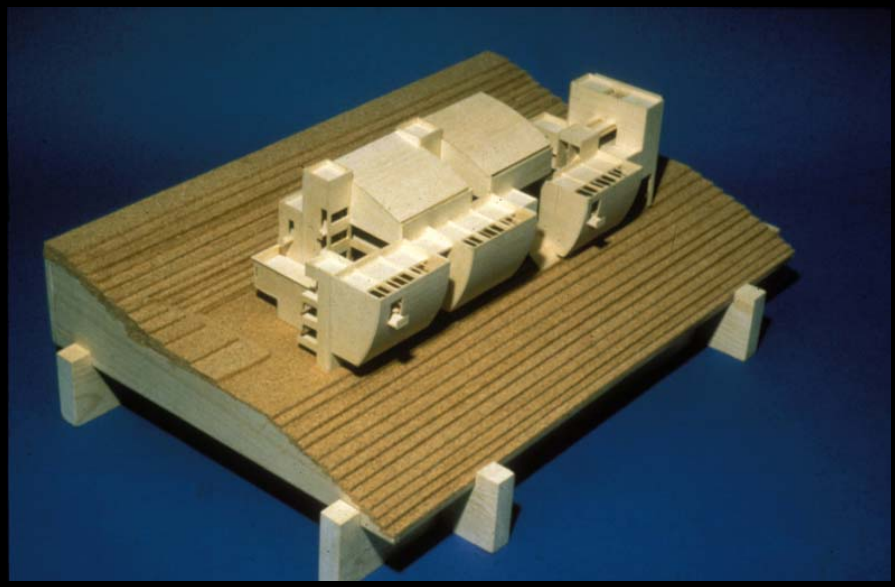
variations



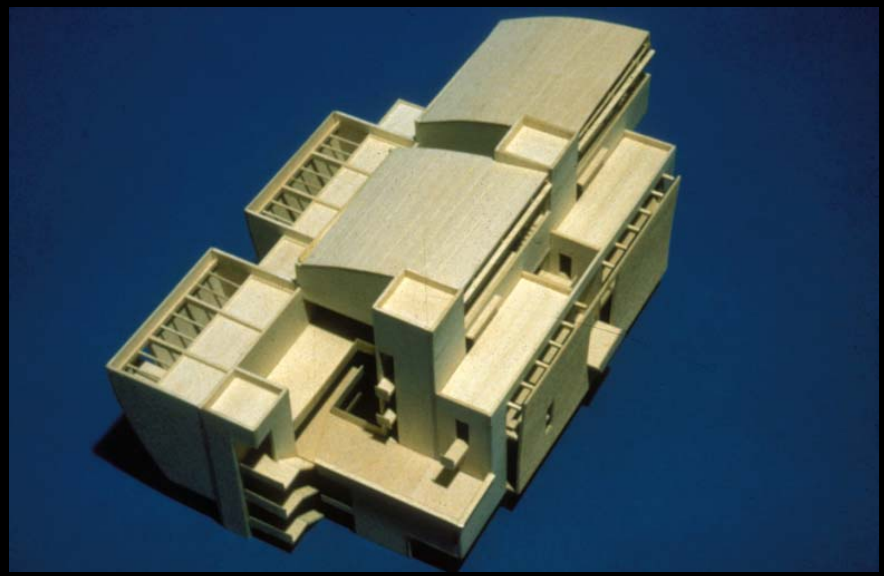
elementary school complex, Los Angeles
(Michael Brown)

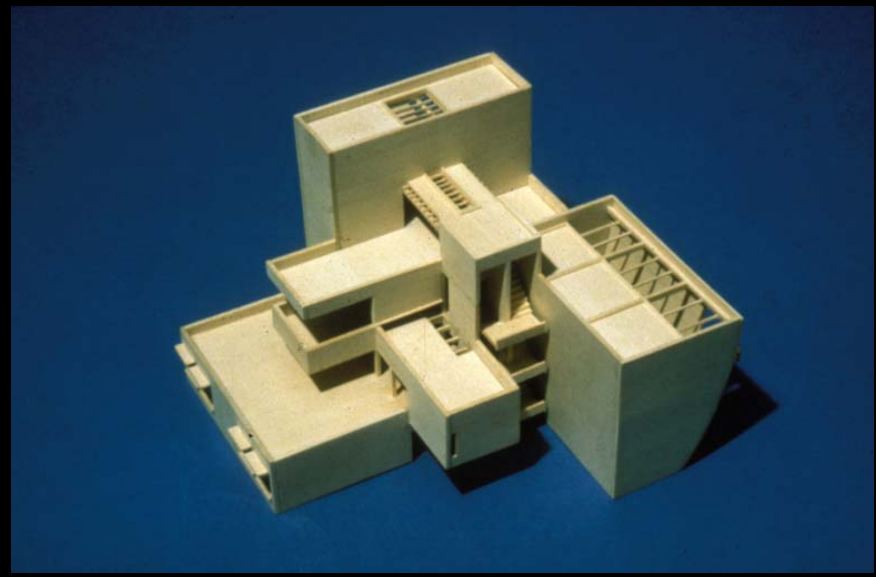


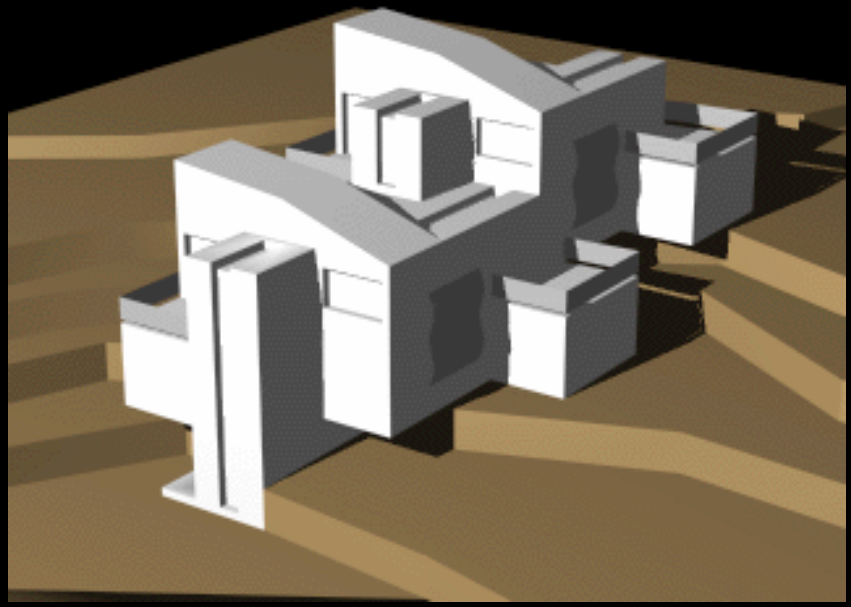
elementary school complex, Los Angeles (Michael Brown)

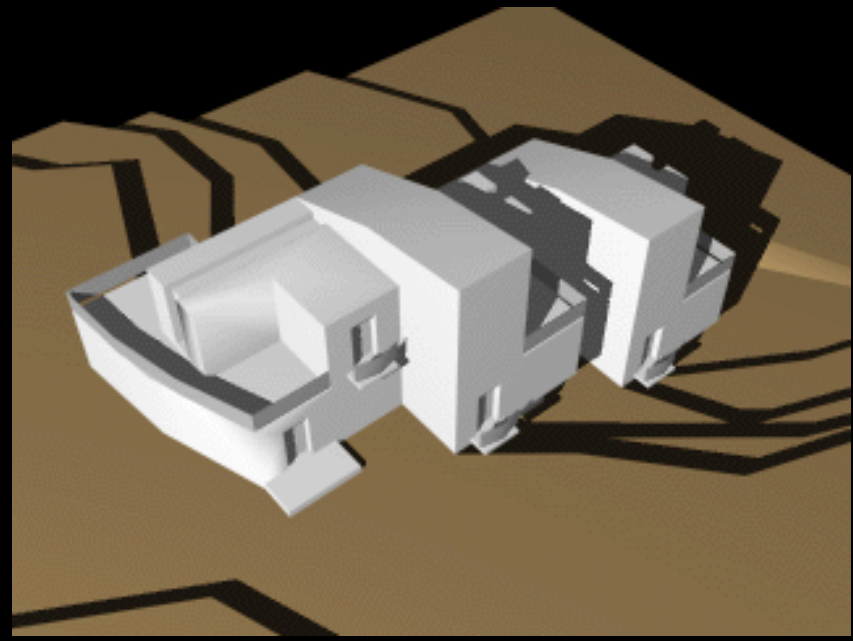


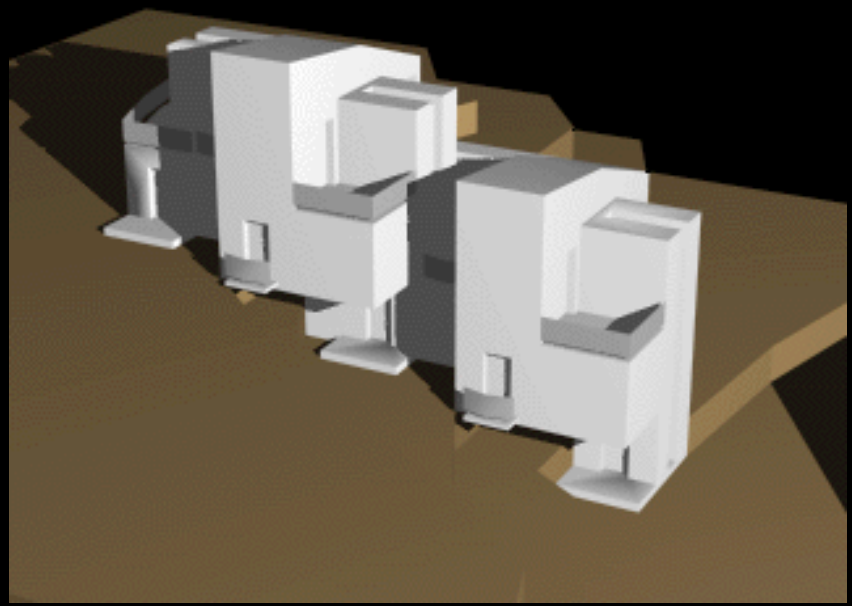
cultural history museum, Los Angeles
(Jin-Ho Park)

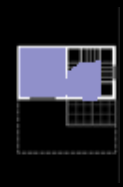






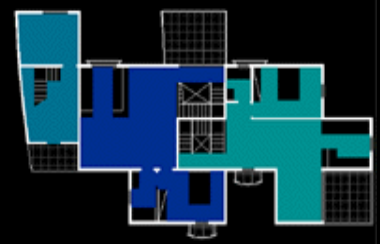




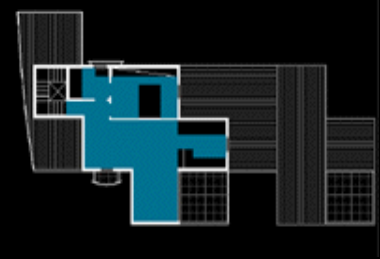


1st floor

2nd floor



3rd floor

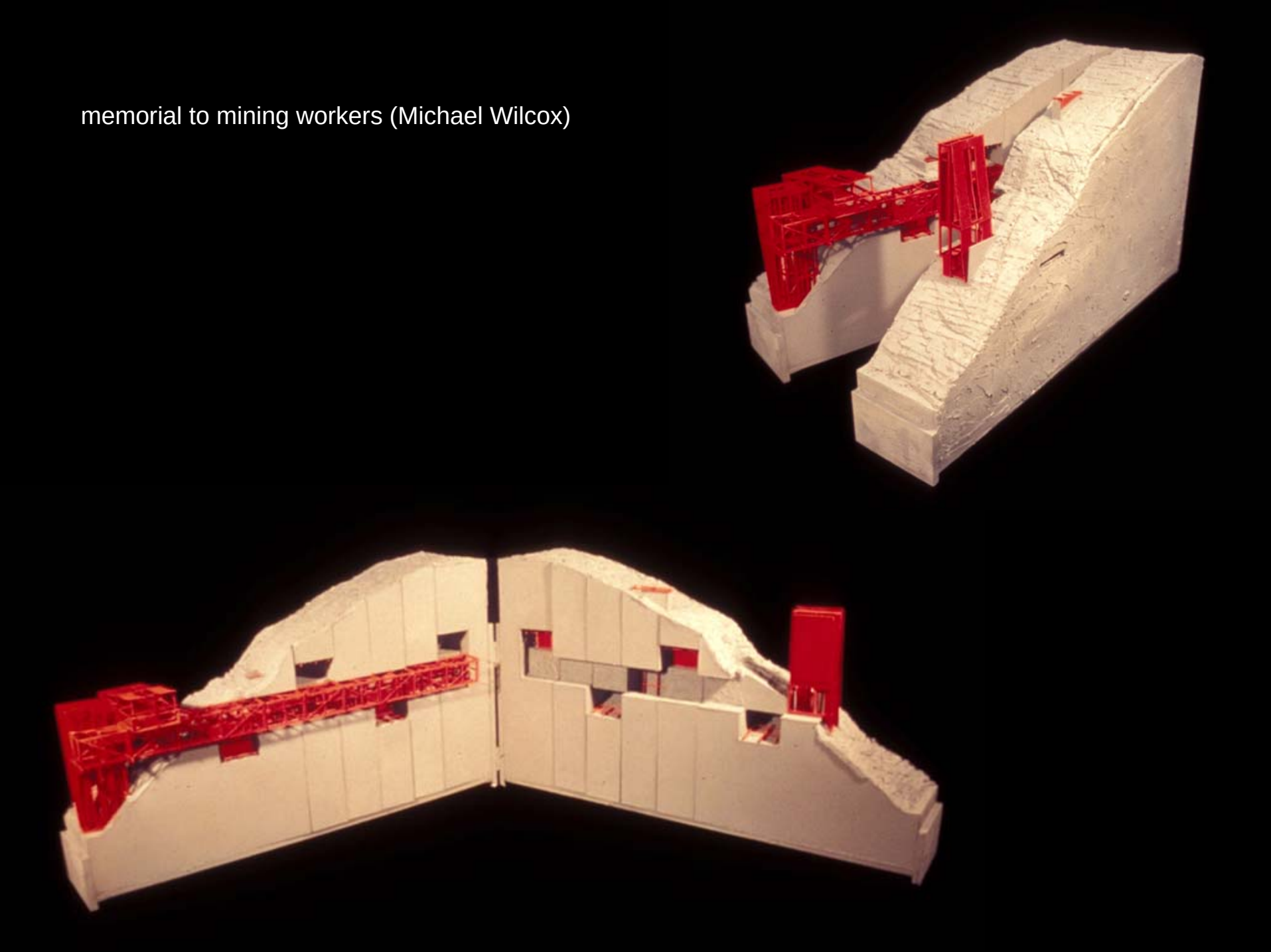


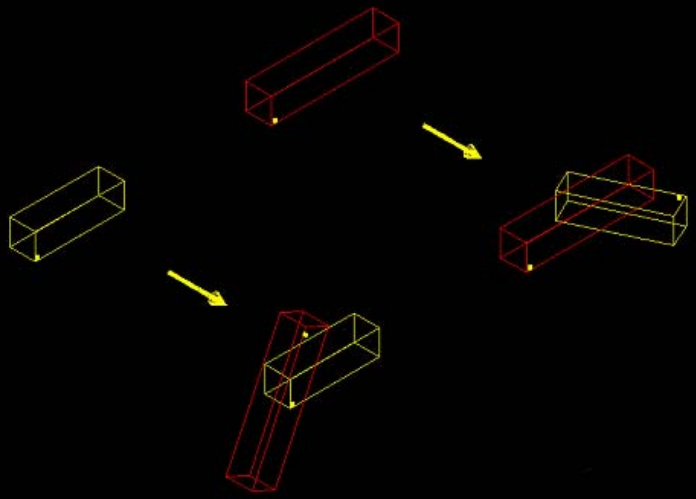
4th floor

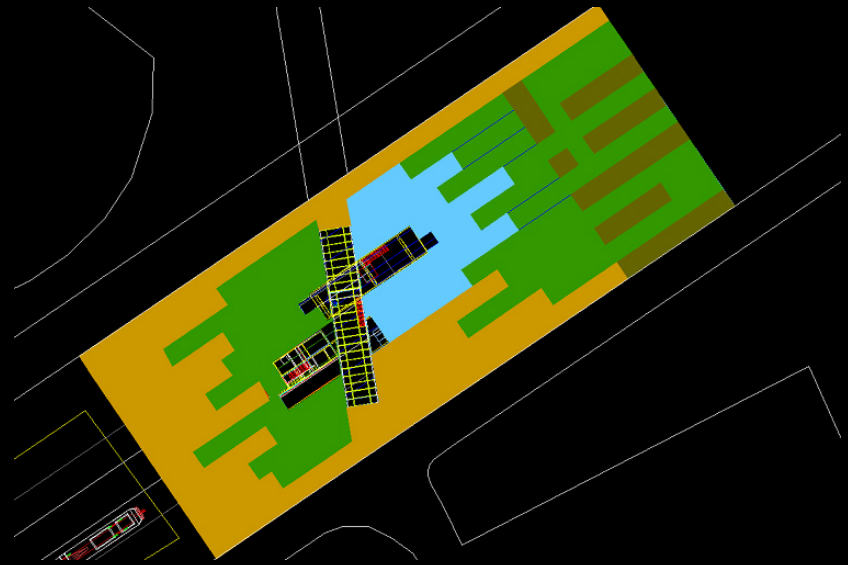
hillside townhouses (Gabriela Celani)

memorial to mining workers (Michael Wilcox)

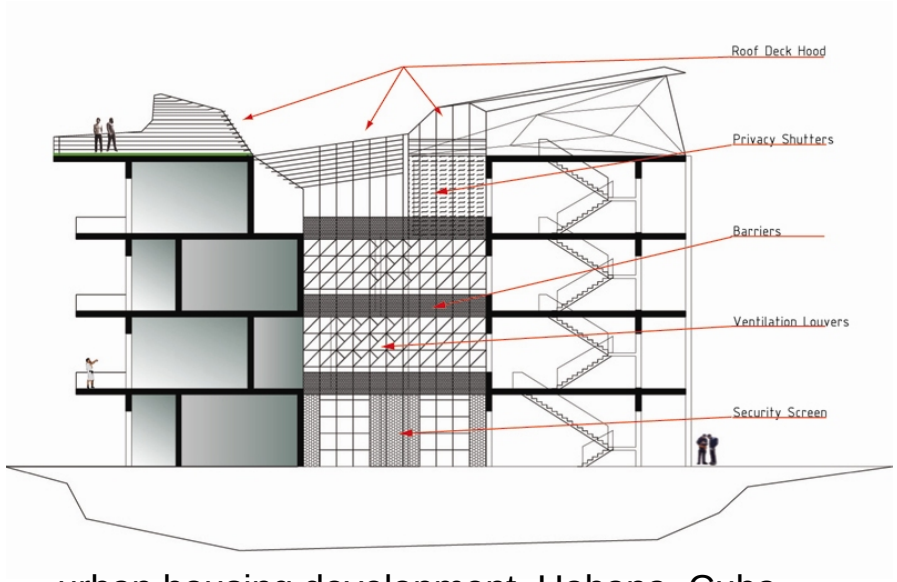
memorial to mining workers (Michael Wilcox)



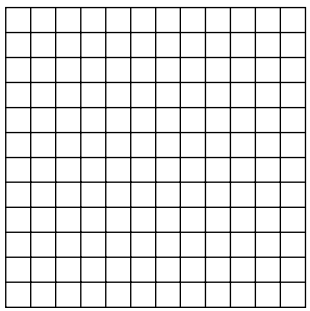




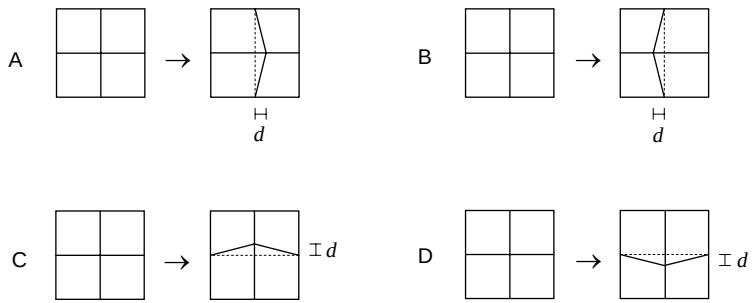
subway station, MIT campus (Gane, Gichuhi,Tian)



urban housing development, Habana, Cuba
(Daniel Bonham)

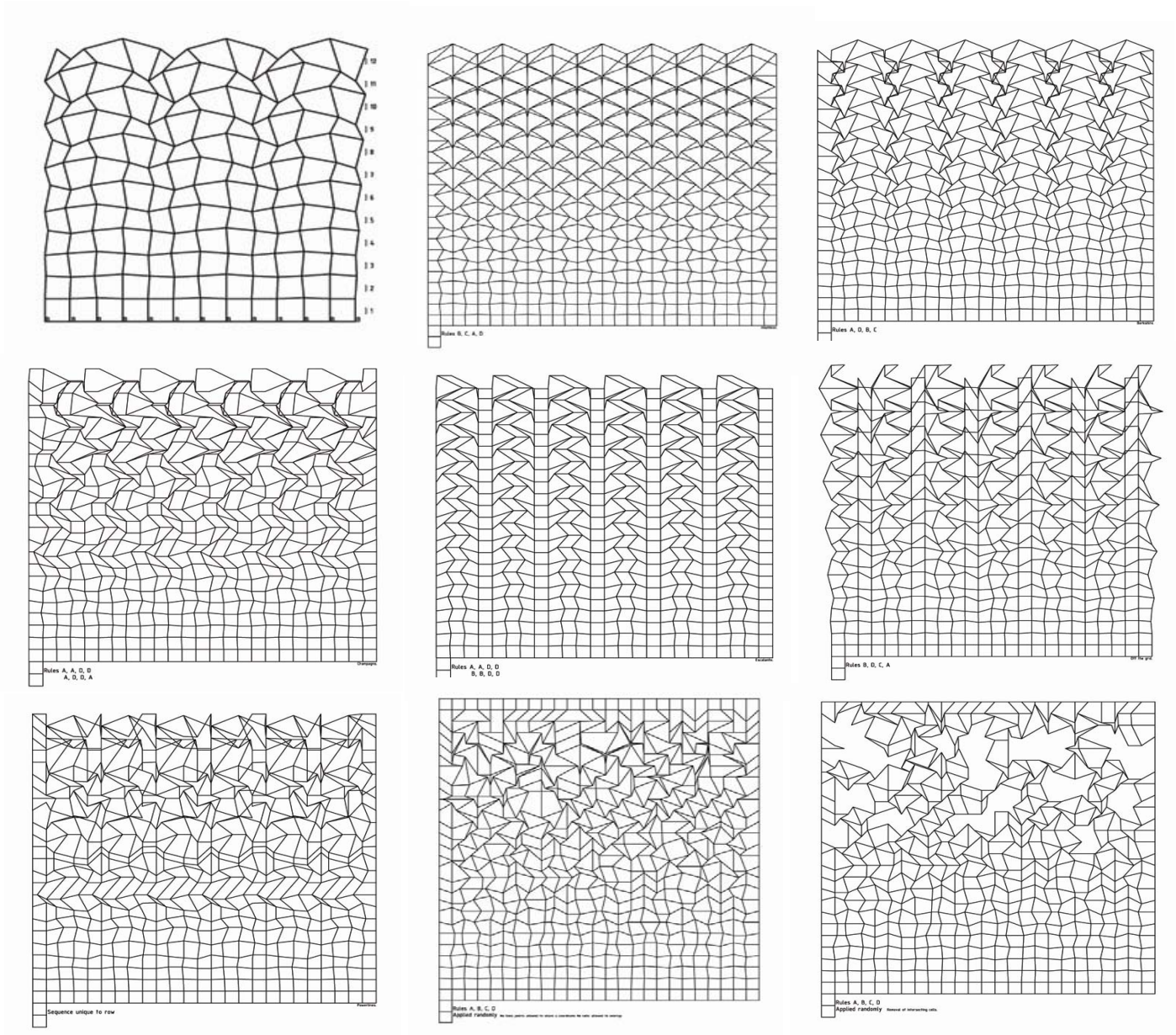


initial shape



rules

subtle grammar



subtle grammar: some generated designs