Generative Design

ASTERIOS AGKATHIDIS

form + technique

Copyright @ 2015. Laurence King Publishing
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

GENERATIVE DESIGN:
FORM-FINDING TECHNIQUES IN ARCHITECTURE

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

LAURENCE KING

Published in 2015 by
Laurence King Publishing Ltd
361–373 City Road
London EC1V 1LR
United Kingdom
enquiries@laurenceking.com
www.laurenceking.com

© Text 2015 Asterios Agkathidis

Asterios Agkathidis has asserted his rights under the Copyright, Designs and Patents Act 1988 to be identified as the author of this work.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage or retrieval system, without permission from the publisher.

A catalogue record for this book is available from the British Library

ISBN: 978 1 78067 691 3

Cover Design by Pentagram
Design by & SMITH

Printed in China

Asterios Agkathidis is Lecturer in Digital Design at the Liverpool School of Architecture. He is the author of numerous publications, including *Modular Structures* (2009) and *Computational Architecture* (2012).

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Generative Design

ASTERIOS AGKATHIDIS

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

LAURENCE KING PUBLISHING

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

CONTENTS

1.0

INTRODUCTION TO GENERATIVE DESIGN > 6

1.1 Design methods in architecture: A brief review > 8
1.2 Generative form-finding processes > 14
1.3 The approach of this book > 19

2.0

CONTINUOUS SURFACES > 22

2.1 Soft mesh > 25
2.2 Double-curved shells > 30
2.3 Hyper paraboloids > 38

3.0

MODULARITY AND ACCUMULATION > 46

3.1 Interlocking units > 49
3.2 Irregular units > 58

4.0

DEFORMATION AND SUBTRACTION > 70

4.1 Twisted block > 72
4.2 Porous space > 80

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

5.0

ALGORITHMIC PATTERNS > 90

5.1 Tessellated planes > 93
5.2 Voronoi surface > 100

6.0

TRIANGULATION > 116

6.1 3D Penrose pattern > 118
6.2 Faceted loft > 129

7.0

CONCLUSION: THE DIGITAL VS PHYSICAL DEBATE > 146

BIBLIOGRAPHY > 154

INDEX > 155

PICTURE CREDITS > 158

ACKNOWLEDGEMENTS > 159

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

INTRODUCTION TO GENERATIVE DESIGN

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

1

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

1.1 / DESIGN METHODS IN ARCHITECTURE: A BRIEF REVIEW

Generating form poses one of the fundamental questions in architectural education and practice. Architectural production is frequently accompanied by debates about the legitimacy of its design approach, questioning the relationship between function and form, aesthetics and construction systems, context and structure, user needs and construction costs, in all possible configurations.

In recent years, computational tools have introduced innovative form-finding techniques, revolutionizing architectural design and production. These techniques are often described by terms such as 'generative design', 'parametric design' or 'algorithmic design', to name but a few. These offer new design paths to architects by breaking with predictable relationships between form and representation in favour of computationally generated complexities, thus enabling the development of new topologies. They shift the emphasis from 'form making' to 'form finding' (Kolarevic 2003).

The critics of such design approaches claim that they disconnect architectural output from its context and its users, and lead to a decrease in spatial quality and a building's integration within the urban environment. Furthermore, some argue that a totally computerized approach leads to disconnection from physical modelling

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

and drafting techniques – once essential foundations of architectural education – and so risks the loss of material qualities, effects and properties.

Yet various generative form-finding techniques existed in architecture long before the digital revolution. At the start of the twentieth century, many visionary architects, engineers and designers, such as Frederick Kiesler and Frei Otto, were applying design methods that were very similar to today's computational approach. It seems that today's new computational design techniques are not as new as they seem, nor impossible to practise without the use of computational tools. So is it the tools or the design method that should be targeted by critics of so-called digital architecture? The following will try to cast light on that perpetual conflict.

Why, though, should anyone follow a method for designing architecture in the first place? Can architects not simply rely on personal inspiration or their own sense of beauty? Throughout the evolution of architectural design there have certainly always been schools of thought that have encouraged a design process based on inspiration or an initial stimulus. However, others have promoted adherence to a specific design method, based on rules rather than intuition, and many now argue that design methods are necessary in order for architects to deal with today's hyper-complex design briefs, or to prevent self-indulgence and stylistically driven formal language. Others affirm that emerging computational design and fabrication tools are changing the architect's role, making design methods a necessity. In order to gain a better understanding of this debate it is worth briefly reviewing the various form-finding philosophies that have dominated architectural design over the past century and are still being widely used today.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Design processes driven by nature

Looking back at pre-computational times, around the end of the nineteenth century, avant-garde architects and thinkers were starting to question the historicist architecture of their time, which they felt was immoral and anachronistic because it failed to reflect both technological evolution and social structure; it did not correspond to the zeitgeist. They started to urge for universal design principles that would replace individual taste and the mere reproduction of historical styles. In their attempt to do so, their attention turned to precedents from nature and science instead. German biologist Ernst Haeckel's book *Kunstformen der Natur* (1904) was a profound influence on many architects and designers. Projects such as Hendrik Petrus Berlage's Jellyfish chandelier, the Paris Métro station entrances by Hector Guimard (figure 01) and many others within the Art Deco and Art Nouveau movements were greatly inspired by it. Much of this so-called nature-inspired architecture emerged continuously from the 1920s until the '60s and '70s, including examples such as Rudolf Steiner's Haus Duldeck (1916), Frederick Kiesler's Endless House (1950) and Eero Saarinen's TWA Terminal (1962). Nature-driven architecture still occurs today, too, with works like Santiago Calatrava's City of Arts and Sciences in Valencia (1998) and Achim Mengese's web-like ICD/ITKE Research Pavilion in Stuttgart (2012). Although each of these projects employed different tools, they all mimicked the intelligent processes of living organisms, translating them into architecture rather than simply using them as inspiration for form and appearance.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Figure 01 (left)
Paris Métro entrance,
by Hector Guimard

Figure 02 (right)
Notre Dame
du Haut Chapel
in Ronchamp,
by Le Corbusier

Design processes driven by geometry

Geometric rules and proportions have been the main driver for other important architects. Louis Sullivan, one of the most significant architects of the modern movement, used techniques such as quadrature and triangulation to design decorative patterns (Menocal and Twombly 2000), while Frank Lloyd Wright applied geometrical rules and proportions to the design of his Unity Temple in Chicago (1908). Wright's design was based on a 2 metre (7 foot) grid, enhanced with dimensions that derived from quadrature and were not compatible with the grid (Jormakka 2007). Later, Le Corbusier tried to systematize his own proportional design methods in the book *Modulor* (1948), praising the golden section as the gateway to beauty. He also applied his famous Modulor proportional diagram to two of his masterpieces, the Notre Dame du Haut Chapel in Ronchamp (1954; figure 02) and the Philips Pavilion in Brussels (1958). Both are among his most geometrically advanced projects, proving that the Modulor proportion rules could function as a toolbox offering unpredictable outputs.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Design processes driven by context

Other architects have used their response to the site and the use of morphological and typological elements as their design approach, forming the design movement known as postmodernism. Aldo Rossi, for example, used basic types often common in the historical context of Italian cities (the octagon, colonnade, arch and so on) in very pure shapes, regardless of function or scale. The octagonal tower shape, for instance, was used in his designs for a secondary school in Broni, Italy (1971), as well as the Teatro del Mondo in Venice (1979) and La Conica, the coffee pot he designed for Alessi (1983; Jormakka 2007).

For Oswald Mathias Ungers, responding to the site involved defining common silhouettes and morphological characteristics, such as materiality, texture, arches, symmetry, roofs and angles, then trying to reproduce these in a new composition. His housing complex at Lützowplatz, Berlin (built in 1979 but demolished in 2013) is a typical example of this approach (Ungers 2011). Mario Botta, on the other hand, uses simple, often symmetrical, modernist forms in combination with site-inspired materials, colours and traditional building techniques. His single-family house in Ligornetto, Switzerland (1976), for example, bears the characteristic stripes often found in the region (Cappellato 2004).

Design processes driven by performance

In contrast to the above, a number of architects and engineers have practised a completely different form-finding method. They have focused on the minimal possible form, deriving from structural performance and material properties. The building's relationship with its context plays only a minor role. Vladimir Shukhov's steel tower, built for an industrial exhibition

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

in Nizhny Novgorod in 1896, was the world's first ever hyperboloid diagrid structure. This structure was then duplicated in much of Shukhov's later work, including the telecommunication tower (Shukhov Tower) that he built in Moscow, which still stands today (figure 03). This structure achieves a perfect combination of mathematical shape, optimized structure and material performance (Khan-Magomedov 1987). Heinz Isler's concrete shell structure for the Wyss Garden Centre in Solothurn, Switzerland, built in 1962, assumes similar hyperboloid shapes, covering a span of 650 square meters (7,000 square feet), with a shell thickness of just 60 mm (2½ inches) (Chilton 2000). Finally, Frei Otto, investigating tensile membrane structures, developed the Munich Olympic Stadium in 1972 (figure 04) – a definite highlight of his career (Otto and Rasch 1996). Although developed at a time when computers where not used in architecture at all, the design approach adopted by Shukhov, Isler and Otto is strongly linked to contemporary performative design techniques.

Figure 03 (left)
Diagrid on Shukhov Tower in Moscow, by Vladimir Shukhov

Figure 04 (right)
Munich Olympic Stadium, by Frei Otto and Günther Behnisch

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

1.2 / GENERATIVE FORM-FINDING PROCESSES

So what is 'generative design' exactly? There is no single definition of the term, but many complementary definitions with common characteristics, which vary according to different architectural theorists. Overall it can be described as a design method where generation of form is based on rules or algorithms, often deriving from computational tools, such as Processing, Rhinoceros, Grasshopper and other scripting platforms. During the late 1980s and early '90s, just before the boom of computational architecture, Peter Eisenman started applying a set of design techniques, such as scaling, fractals, overlay and superposition, influenced by Jacques Derrida's Deconstruction theory. Eisenman applied these techniques in relation to rules of order, developing several projects on this basis, such as the Biocentrum in Frankfurt (1987) and the Nunotani Corporation headquarters in Tokyo (1992; figure 05) (Eisenman 2004). One could claim that his design method was the first contemporary generative design attempt. As software started to offer new possibilities, Eisenman introduced other techniques to his approach, such as morphing images, which was soon followed by UNstudio and their concept of the 'Manimal', a computer-generated icon that merges a lion, snake and human to represent the hybrid building (Van Berkel and Bos 1999).

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

The technique of folding appeared in Eisenman's Rebstockbad in 1991 (Eisenman 2004) and, as computational tools advanced further, Greg Lynn started applying new tools such as animation, splines, NURBS (non-uniform rational basis splines) and isomorphic polysurfaces, influencing a whole wave of architectural production, often described as 'blob architecture' (Lynn 1999). As algorithms and scripting become more accessible to architects and designers, and digital fabrication more affordable, parametric and panelization tools, simulation software, optimization and generative algorithms are dominating generative design techniques.

Figure 05
Nunotani Corporation headquarters in Tokyo, by Peter Eisenman

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

In their book *Generative Gestaltung* (Lazzeroni, Bohnacker, Groß and Laub 2009), the authors define generative design as a cyclical process based on a simple abstracted idea, which is applied to a rule or algorithm (figure 06). It then translates into a source code, which produces serial output via a computer. The outputs return through a feedback loop, enabling the designer to reinform the algorithm and the source code. It is an iterative operation, relying on the feedback exchange between the designer and the design system.

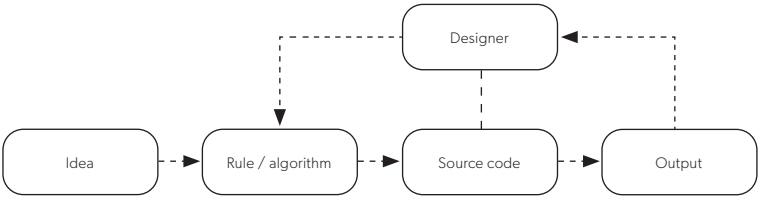


Figure 06
Generative design process diagram, by Lazzeroni, Bohnacker, Groß and Laub

Celestino Soddu (1994) defines generative design as 'a morphogenetic process using algorithms structured as nonlinear systems for endless unique and unrepeatable results performed by an idea-code, as in nature'. Indeed, the notions of generative design and digital morphogenesis are strongly associated. The term 'morphogenesis' derives from the Greek words *morphe* (μορφή, meaning 'form') and *genesis* (γένεσις, meaning 'birth'), so could be literally translated as 'birth of form'. As with the term 'generative design', there is no unique definition for morphogenesis, and it seems that the terminology is changing in relation to emerging technologies and techniques.

Branko Kolarevic (2003) describes digital morphogenesis as follows: 'The predictable relationships between design

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

and representations are abandoned in favour of computationally generated complexities. Models of design capable of consistent, continual and dynamic transformation are replacing the static norms of conventional processes. Complex curvilinear geometries are produced with the same ease as Euclidean geometries of planar shapes and cylindrical, spherical or conical forms. The plan no longer "generates" the design; sections attain a purely analytical role. Grids, repetitions and symmetries lose their past raison d'être, as infinite variability becomes as feasible as modularity, and as mass-customization presents alternatives to mass-production.' In addition, he sees such methods as unpredictable mechanisms of creation, relying on digital tools, where traditional architectural values are replaced by complexity, asymmetry, curvilinearity, infinite variability and mass customization. Architectural morphology is focusing on the emergent and adaptable qualities of form. Form is no longer being made, but found, based on a set of rules or algorithms, in association with mainly digital, but also physical, tools and techniques. They imply the rules; the entire process follows.

Michael Hensel describes digital morphogenesis as a 'self-organization process, underlying the growth of living organisms, from which architects can learn' (Hensel, Menges and Weinstock 2006). In their latest book, Rivka and Robert Oxman (2013) categorize form generation into six dominant models in relation to its main driver: mathematical, tectonic, material, natural, fabricational and performative. They see digital morphogenesis as 'the exploitation of generative media for the derivation of material form and its evolutionary mutation'. Its key concepts include topological geometries, genetic algorithms, parametric design and performance analysis.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Figure 07
Serpentine Gallery Pavilion in London, by Toyo Ito

Finally, Toyo Ito compares 'generative order' to the growth mechanism of trees, whose form derives from the repetition of simple rules, creating a very complex order (Turnbull 2012). A tree's shape responds to its surroundings, blurring the boundaries of interior and exterior spaces – qualities that are easy to recognize in Ito's Serpentine Gallery Pavilion in London (2002; figure 07).

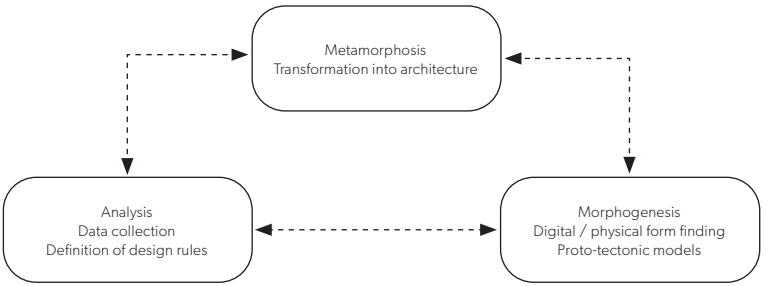
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

1.3 / THE APPROACH OF THIS BOOK

This book presents a series of undergraduate student projects that emerged from Studio 04, a research-led design unit headed by the author at the University of Liverpool's School of Architecture. A modified generative method was applied to each of these projects in order to assess its potential for developing innovative architectural solutions, incorporating contextual, performative, structural, material and typological parameters. The programme was also designed to satisfy learning outcomes specified by the Royal Institute of British Architects for an accredited Part 1 degree in architecture. The form-generation method applied was based on three main phases – Analysis, Morphogenesis and Metamorphosis (figure 08) – with the aim of producing complete architectural proposals in an educational framework. This was a non-linear design approach, operating as a continuous loop, which allowed all design phases to reinform each other.

Figure 08
Generative design method, by Asterios Agkathidis



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Analysis focused on data collection for various aspects, such as context, programme, material, structure and performance. Morphogenesis, digital or physical, then targeted the generation of abstract prototypes, based on spatial and organizational principles, including unit accumulation, surface continuity, faceting, volume deformation or subtraction, and algorithmic patterning. After undergoing a phase of iterations, the resultant not-to-scale 'proto-tectonic' structures (Frampton 2001) were then 'transformed' into building proposals, including floor plans, sections and elevations, as well as physical and digital models and all their derivatives (atmospheric images, visualizations, etc.). The metamorphosis of an abstract prototype into a building proposal could occur in two different ways. It could either be literal (a direct transformation into a building envelope and structure) or operational (functioning as an apparatus, which could generate design solutions in various scales and arrangements).

The design studio unit consisted of 60 students (part of a cohort of 240 in that year), tutored by five tutors, and the programme took place within a 12-week semester. Students worked collaboratively for the first four weeks (Analysis and Morphogenesis) and developed their individual projects during the remaining eight. Final submissions were then marked by all studio tutors, and moderated and tested by external examiners. The students had never followed a design approach like this before, and had to be trained in computer-based design techniques during the semester. They were encouraged to use both physical and digital techniques, and to use their findings from one to inform processes in the other. Surveys were also conducted in order to gauge student opinion. The whole programme aimed to answer following questions:

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

– How can generative design methodology be integrated in an undergraduate design studio module?

– What are its strengths and weaknesses?

– Does the applied design methodology produce innovative design solutions, and does it enhance students' design skills and future employability?

– Does the integration of generative design methodology at undergraduate level seem appropriate?

In combination with the preceding pages' discussion of generative design techniques and their implementation in architecture, the projects selected for this book offer a useful collection of illustrated design studies. Together they present a handbook of ideas, suitable as both an educational textbook and an inspirational research handbook for design scholars and practitioners.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

CONTINUOUS SURFACES

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

2.1 / SOFT MESH

Analysis: Properties of curved timber in relation to variable spatial qualities, such as high and low, wide and narrow, open and enclosed; precedent studies of Shigeru Ban's Centre Pompidou-Metz.

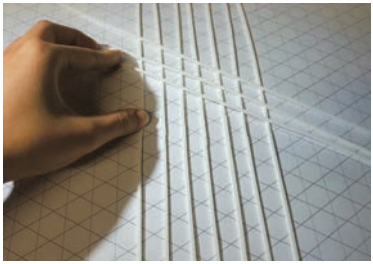
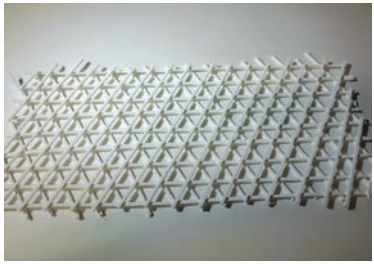
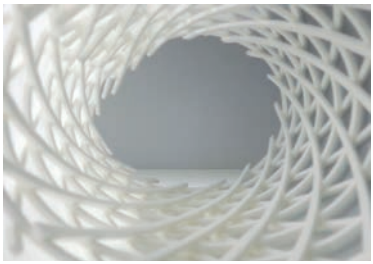
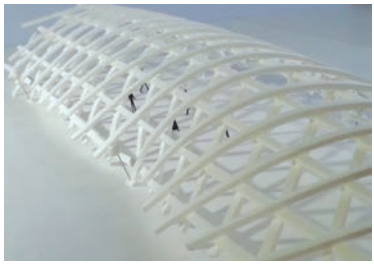
Morphogenesis: This project developed out of exploration with a bendable timber mesh and its material properties. It was constructed as a plain surface made from linear elements, exploring different weaving techniques in relation to the geometries and spatial typologies they were able to host (see pages 26–27). Physical working models were constructed out of balsa wood and foam board, generating a set of iterations. Digital models followed, exploring the possibilities offered by NURBS as design surfaces.

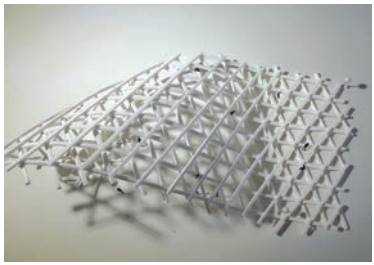
Metamorphosis: As a second step, contextual, structural and programmatic parameters were defined and applied to the design process. The proposal was for a food market hall in a dense urban context. It evolved as a continuous timber mesh structure, covered with PTFE foil, defining both roof and columns (see pages 28–29) and allowing a smooth transition between indoor and outdoor spaces. The switch from physical to digital models was essential in order to control the geometry of the roof structure.

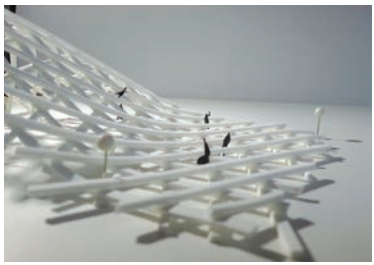
Design study
by Jianxuan Chen

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

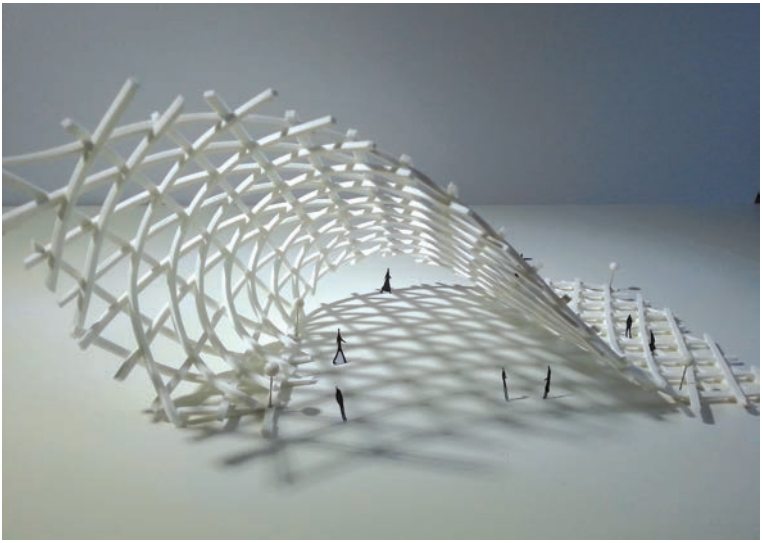





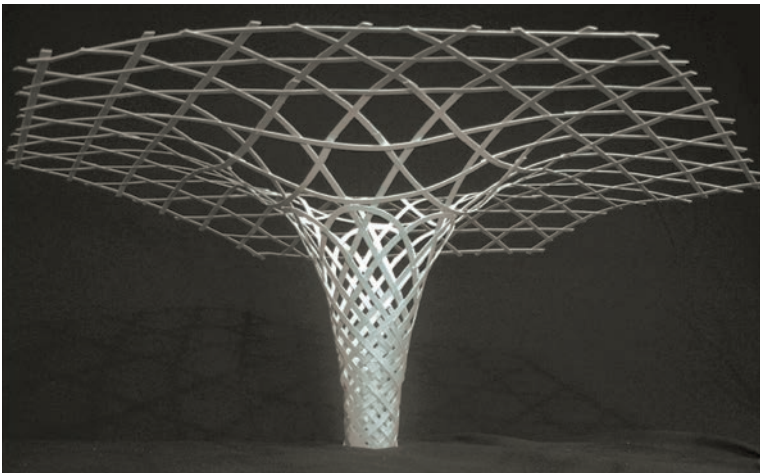




Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

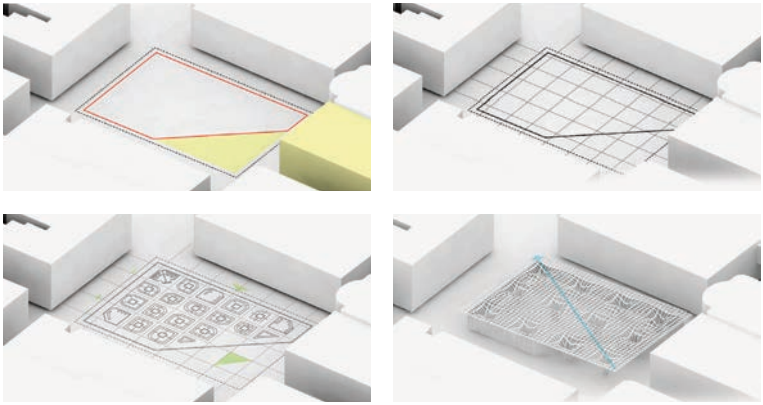




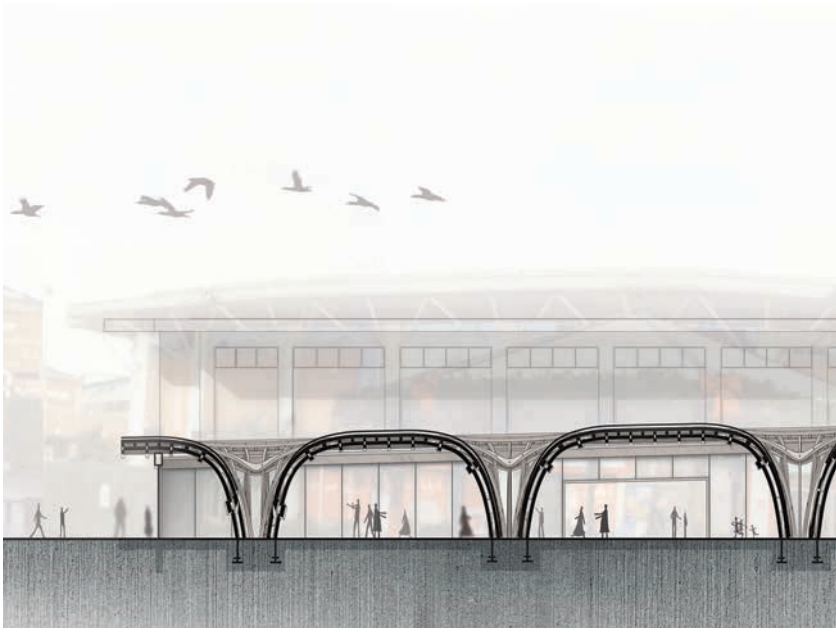
Structural–spatial iterations
of the timber mesh surface

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Site analysis and design parameter definition

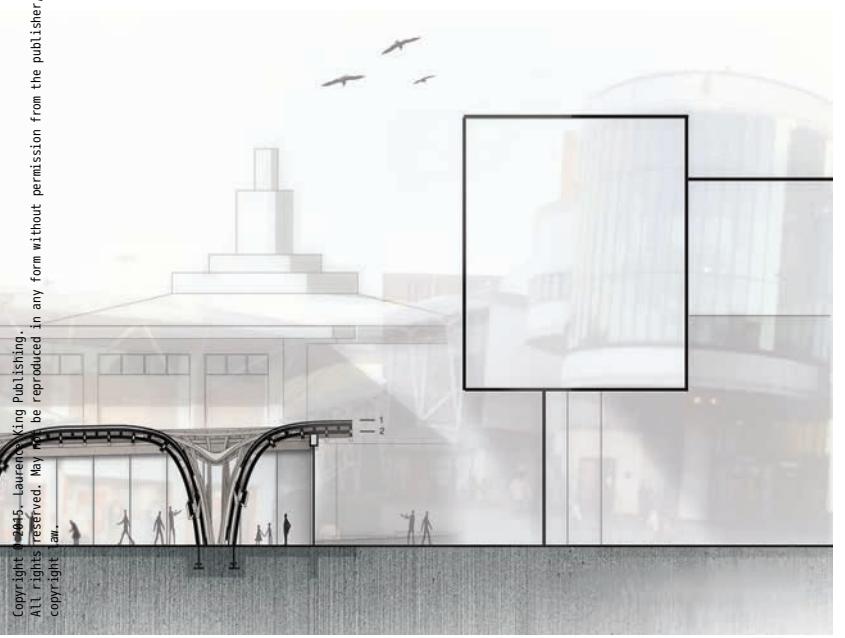


Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Left: Interior view of the market hall

Below: Longitudinal section through the canopy structure



Copyright ©2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

2.2 / DOUBLE-CURVED SHELLS

Analysis: Concrete shells; precedent studies of Félix Candela's Lomas de Cuernavaca Chapel and Toyo Ito's Kakamigahara Crematorium.

Morphogenesis: This project investigated concrete shell primitives and their structural performance. Simple, primitive shapes were first modelled and analysed (see pages 32–33), then combined in large-scale continuous surfaces, exploring regular and irregular iterations, as well as different degrees of curvature.

Metamorphosis: Site and programmatic parameters were used to define the footprint of the intended design – a market hall – preserving the existing trees on the site. The final roof proposal constituted a double-curved surface, covering a floor plan that was based on a Voronoi pattern. The concrete roof–column shell structure was perforated with a circular pattern to allow variable lighting conditions in the market hall's interior spaces (see page 35).

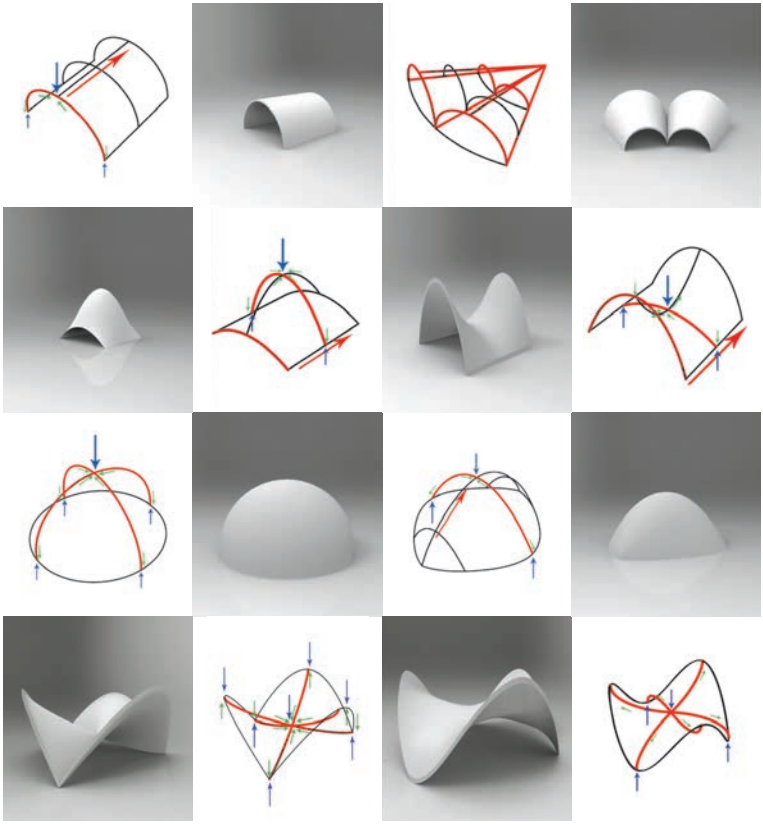
Design study by Xu Chen, Yuhui Qi, Peiyu Yang, Ruinan Zhang and Yuan Zhai

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

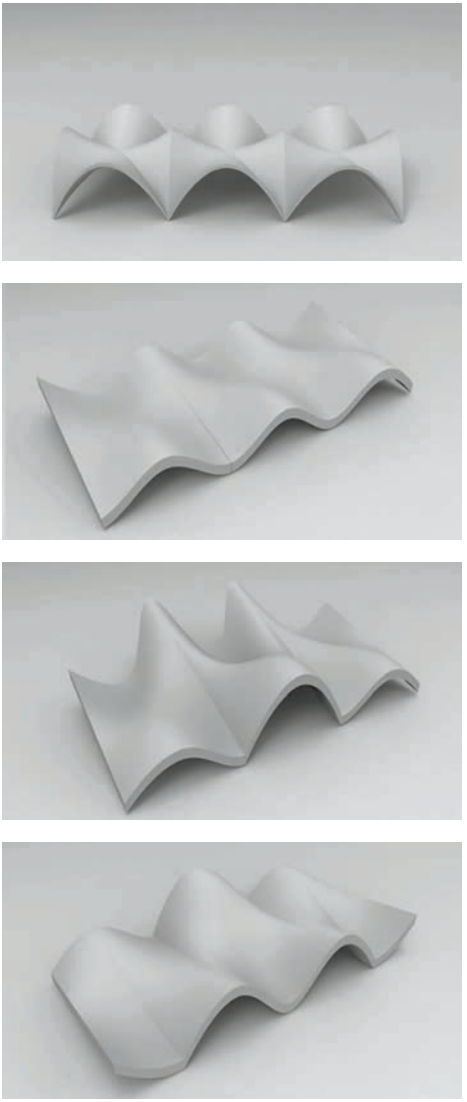


Iterations of concrete shell primitives, in relation to forces of tension and compression

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

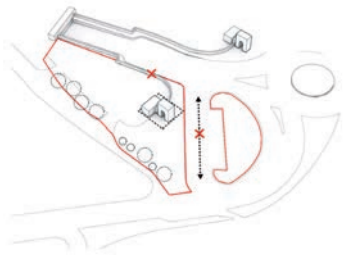
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Accumulation of shell units
into continuous surfaces

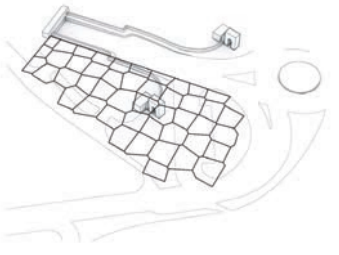


Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

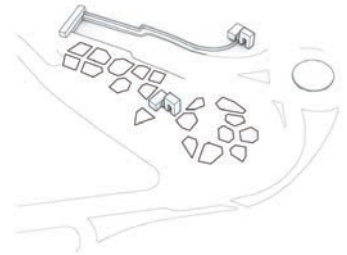
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



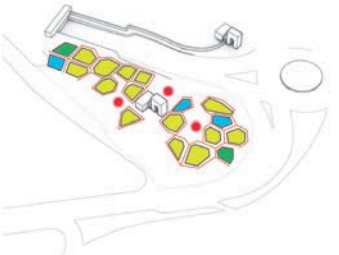
The site's two parts are unified



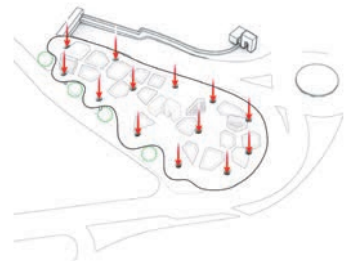
A Voronoi grid is applied to the site



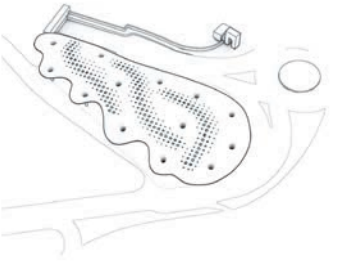
The Voronoi grid forms circulation and plan organization



Areas occupied by the schedule of accommodation



Position of columns is determined



Canopy structure emerges

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Floor plan

Interior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Exterior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

2.3 / HYPER PARABOLOIDS

Analysis: Paraboloid steel structures; precedent studies of Vladimir Shukhov's telecommunication tower.

Morphogenesis: This project evolved as a continuous hyper paraboloid surface, which derived from joining an array of inverted polygonal profiles of 'hills and valleys'. The resultant double-curved surface was constructed from planar linear beams. Iterations of the inverted hill-and-valley system, in relation to span and angle of the polyline, were explored in various prototypes (see pages 40–43).

Metamorphosis: In this case, the translation from prototype to architecture was almost literal. Iterations of span, beam thickness and height in relation to programme, scale and context were adjusted and optimized for the site – the extension of a historical harbourside building in order to shelter a ferry terminal, with retail and gastronomic facilities (see pages 44–45). The proposed roofscape evolved out of the roof of the existing building. It stretches as a lace surface above the threshold between the square and the floating platform, providing the terminal's interiors with optimum daylight conditions.

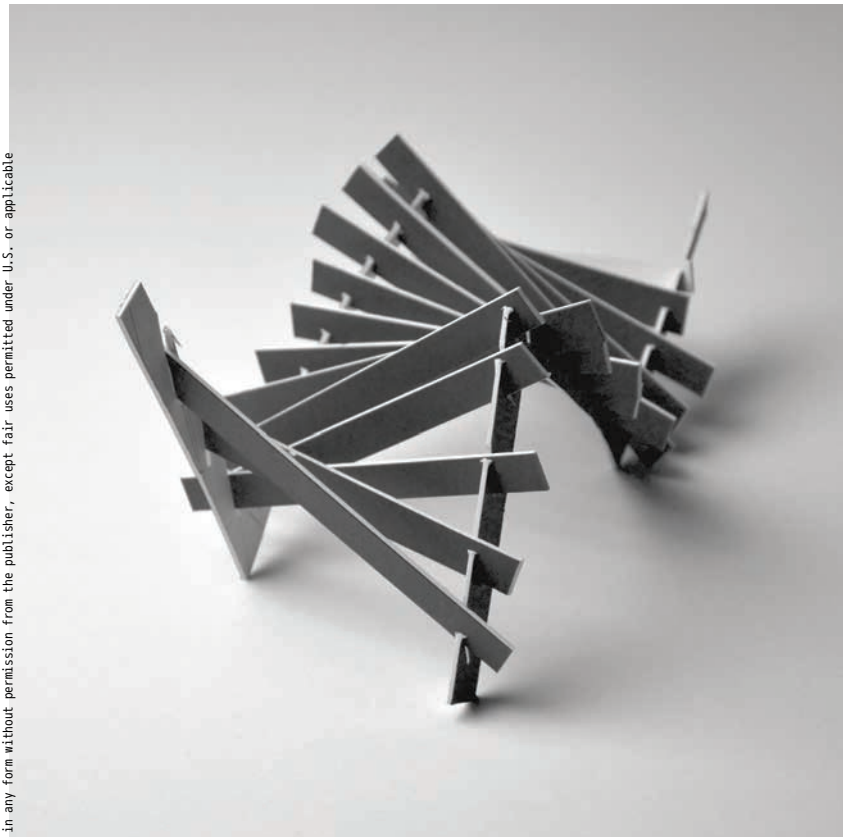
Design study by Jinglei Fu, Xiao Qi, Aqsa Imtiaz, Nadezda Kazakova, Xuerui Lu and Amy Whitmore

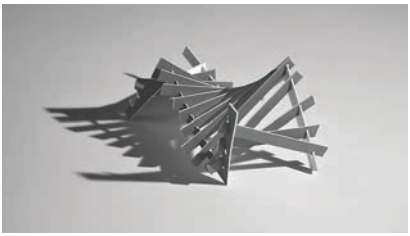
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

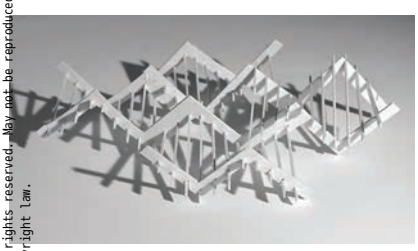




Double-curved surface iterative models

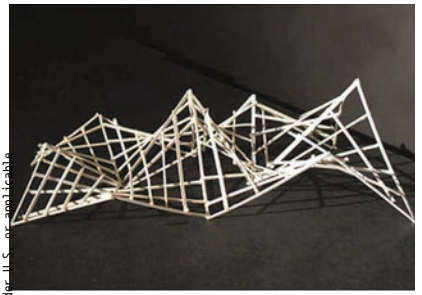
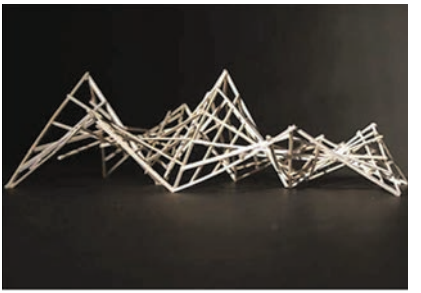
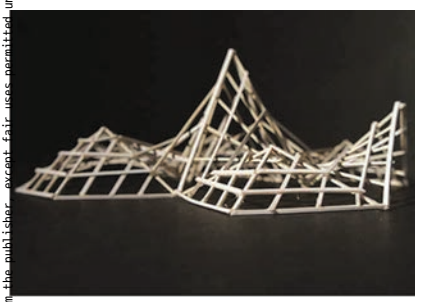
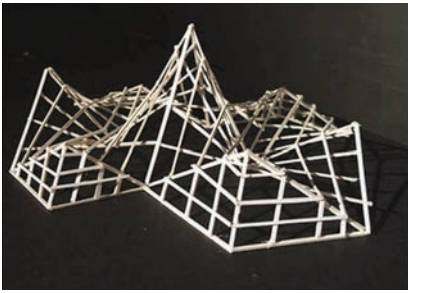
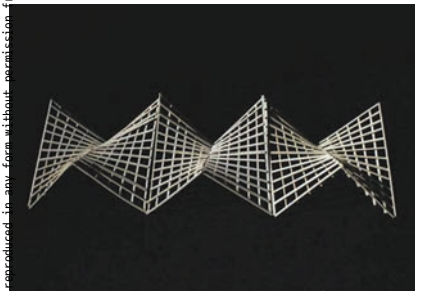
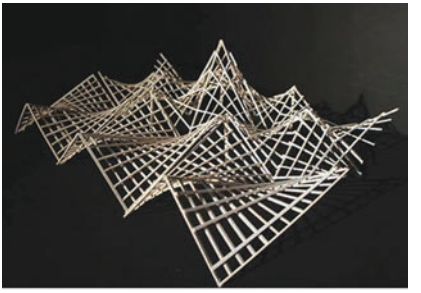
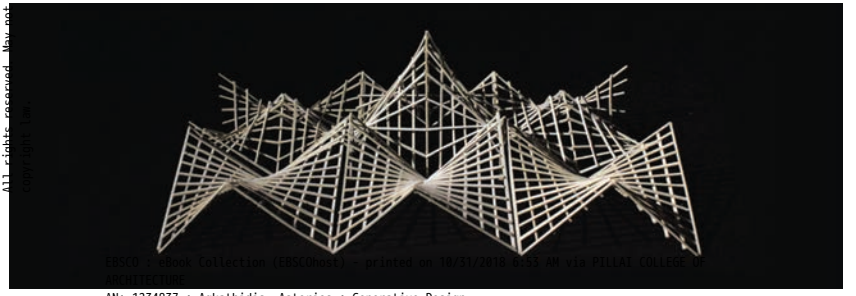
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



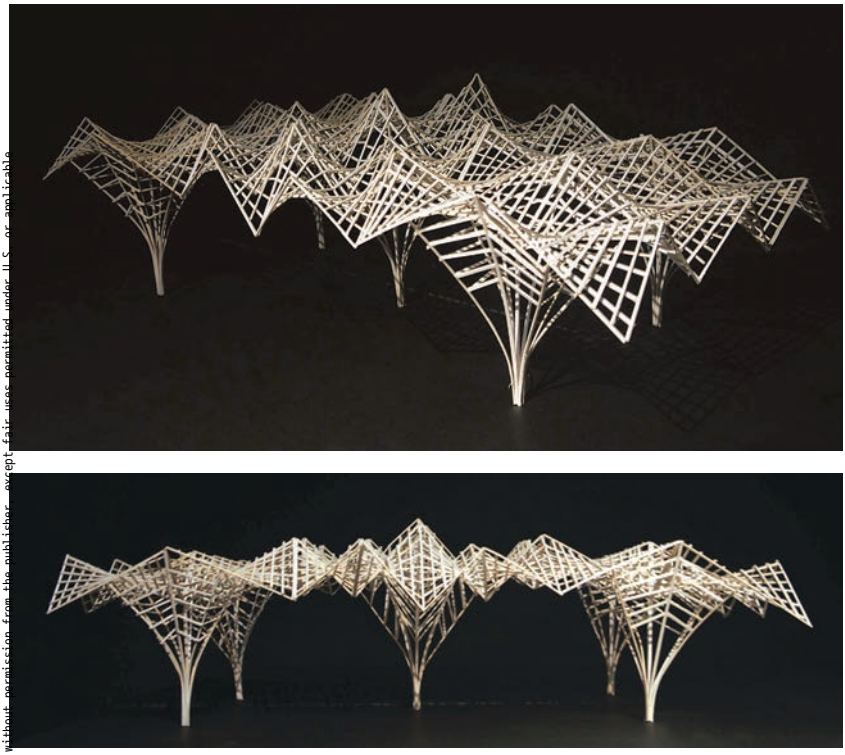
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable
Copyright Law

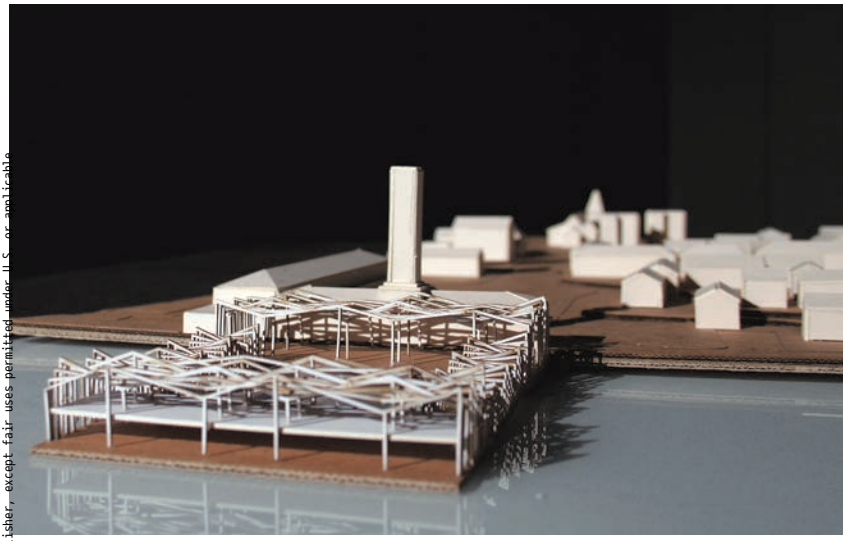
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:55 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

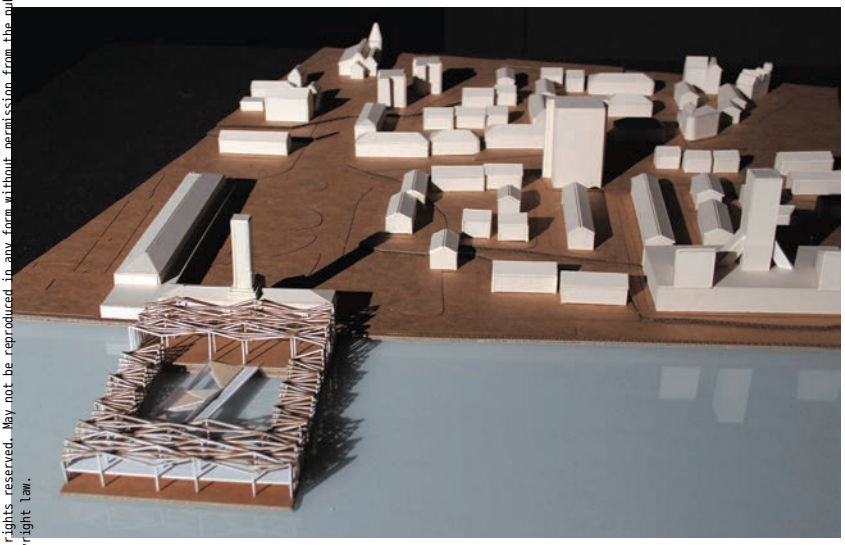


Iterations in span and mesh density, and arrangement of double-curved surface models

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

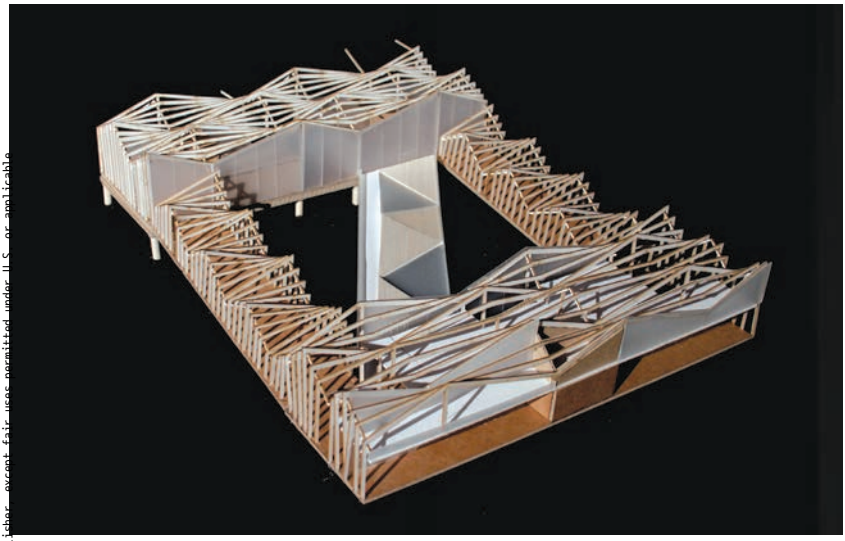




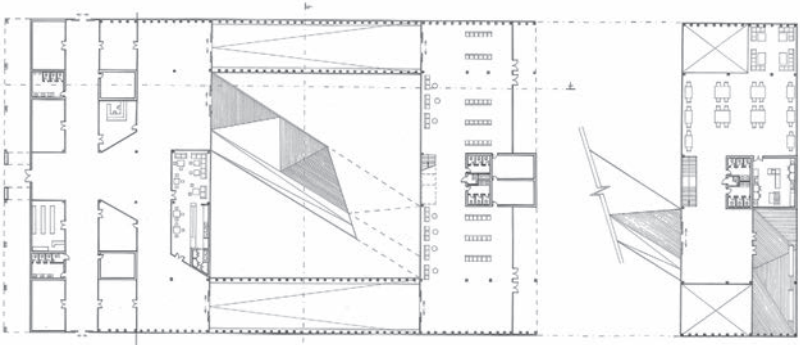
Ferry terminal arrangement in context

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Perspective view



Floor plan

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

MODULARITY AND ACCUMULATION

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

3.1 / INTERLOCKING UNITS

Analysis: Modular accumulation of space units; precedent studies of Le Corbusier's Unité d'Habitation and Charles Correa's Kanchanjunga apartment tower.

Morphogenesis: This series of prototypes derived from a rectangular block, which formed units in various combinations (see page 50). These enabled the design of various clusters, which aimed for balanced layouts of void and solid, interior and exterior, covered and uncovered space, orientation and height (see pages 51–53). The cluster prototypes offered an almost infinite number of iterations.

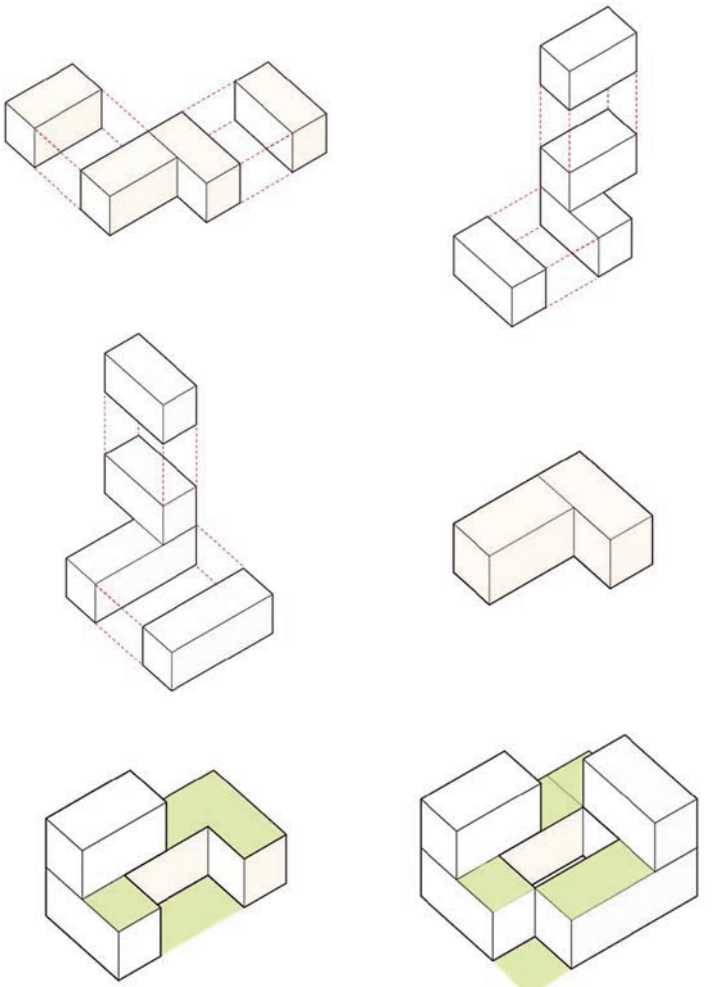
Metamorphosis: The size of the units was modified to accommodate one-, two- or three-bedroom apartments, and the building envelope was created to respond to the conditions of the site, embedding parameters such as optimal circulation, lighting and ventilation, as well as a harmonious relationship between public and private zones (see page 54). The final building proposal was developed around a courtyard typology, offering a variety of single- or double-height spaces and generous outdoor areas. Despite the simple, toolbox-based generative system, the final output achieves a high degree of complexity.

Design study by Xiao Gu, Yuedi Liu, Yangting Yang, Jinglei Fu and Wenxuan Zhang

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

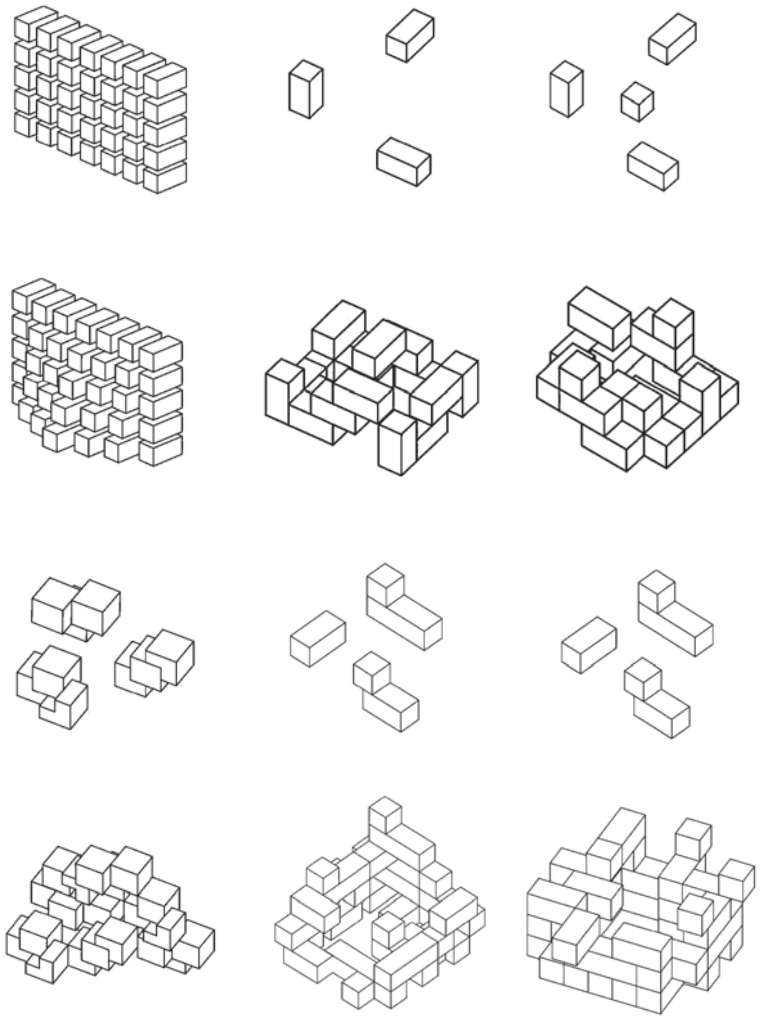
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.



Unit formation diagrams

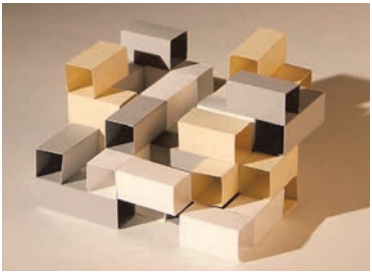
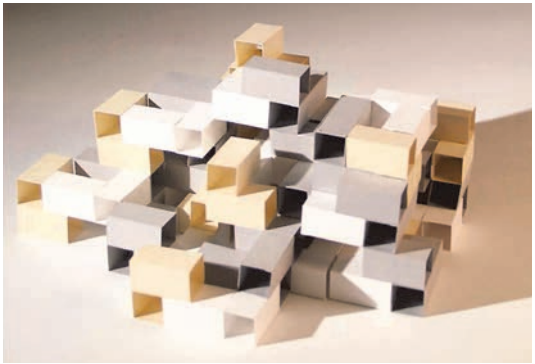
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.



Cluster formation of modular unit iterations

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Cluster formation: iterative models

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

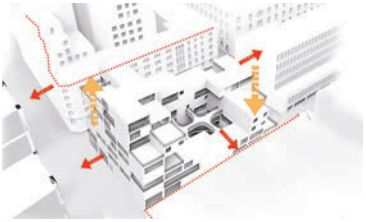
Massing is adjusted around the courtyard

Rear side is adjusted to natural light conditions

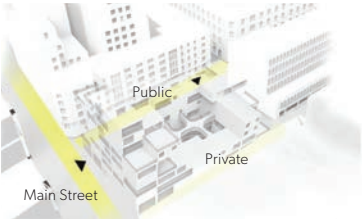
Units are adjusted into massing

Circulation and community spaces are embedded

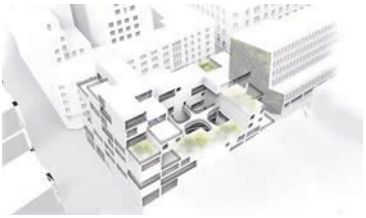
Transparent and opaque areas are defined



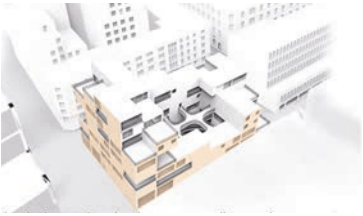
Building's height is adjusted to the context



Building's access is arranged according to privacy levels



Green areas are distributed on terraces and roofs



Building openings are matched to functions

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Seventh floor

Sixth floor

Fifth floor

Fourth floor

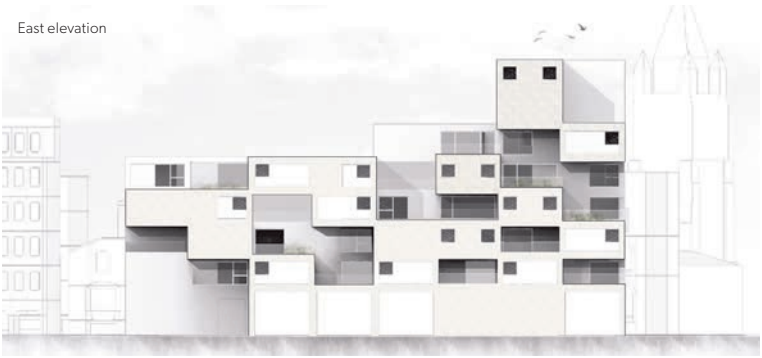
Third floor

Second floor

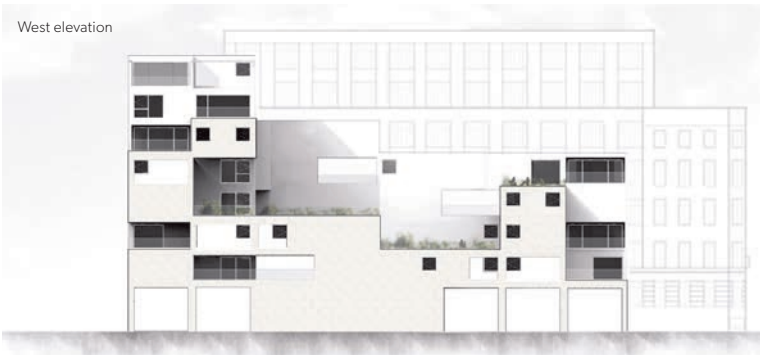
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

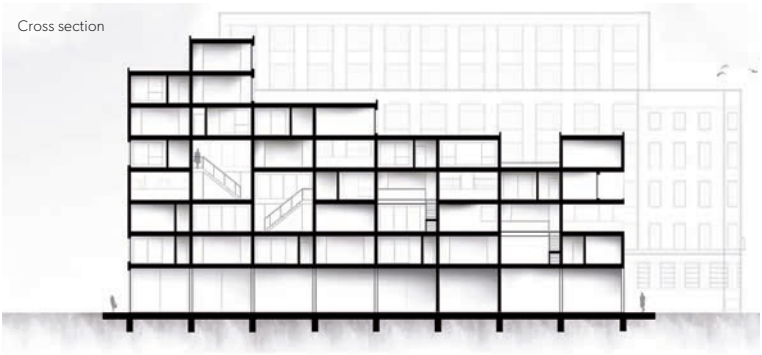
East elevation



West elevation



Cross section



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Perspective exterior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

3.2 / IRREGULAR UNITS

Analysis: Accumulation of irregular units; precedent studies of Kisho Kurokawa's Metabolist projects.

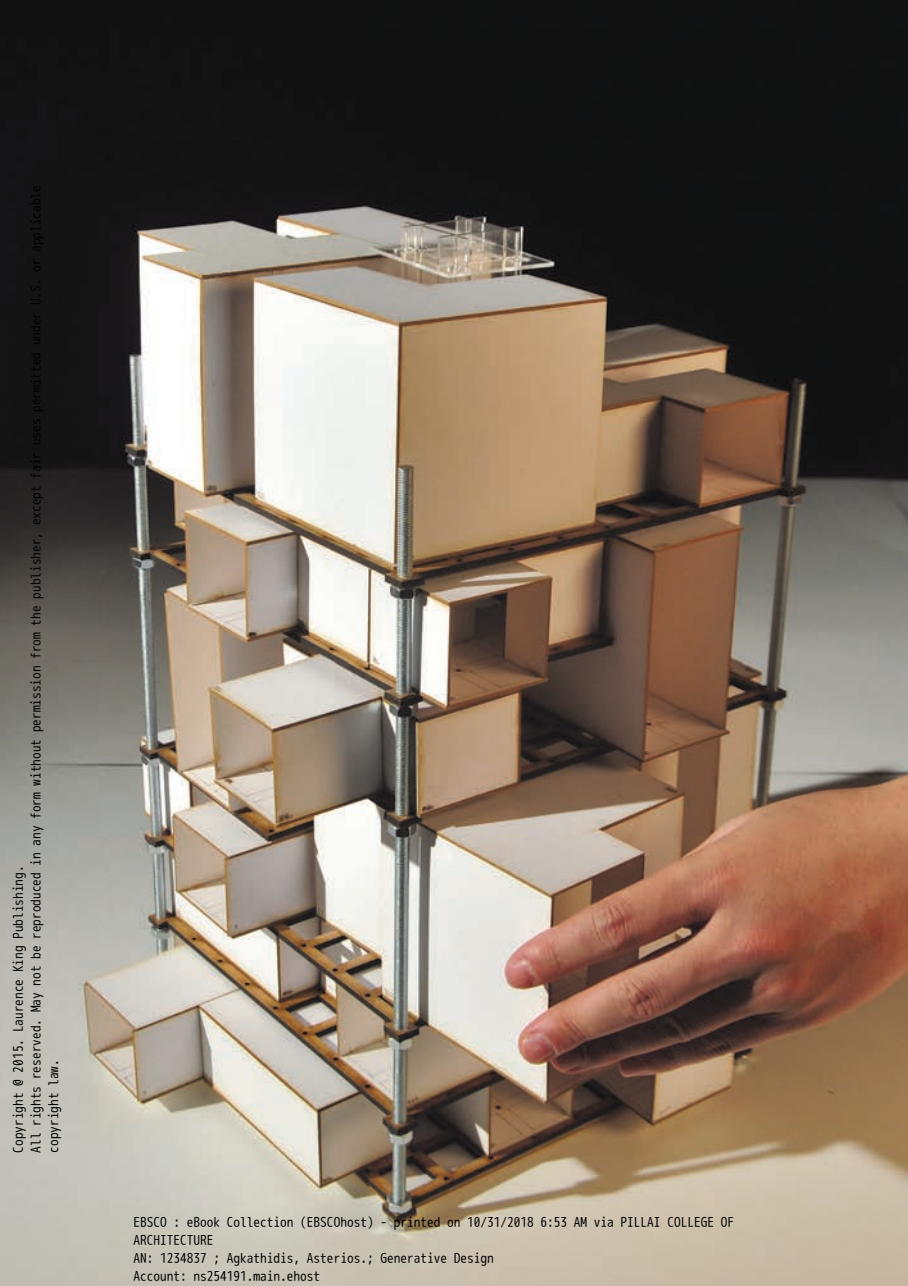
Morphogenesis: This design study evolved as a set of units that were irregular in layout and height. They were assembled on a vertical shelving system and a horizontal grid, which defined slabs and enclosed space. Clusters were composed according to spatial criteria, such as relationships between solid and void, open and enclosed, indoor and outdoor. The generative system allowed a vast number of iterations to emerge, all of which offered a high degree of plasticity and a range of spatial qualities (see pages 60–63).

Metamorphosis: The building developed in response to its context, in terms of circulatory, programmatic and typological requirements (see page 64). However, in contrast to the other design studies in this book, this project adopted mainly the prototype's design logic, rather than its form. The different apartment types were developed with the addition of bedrooms, living/dining areas and services units (see page 65). These in turn operated as modules, accumulated within a predetermined massing that was then remodelled to offer spacious public areas. A similar method was used to design the building's facade. A modular system evolved along a structural grid, and various cladding materials (e.g., glass, opaque panels and photovoltaic cells) were distributed along the east, west and south elevations (see pages 66–67). The final proposal is a residential apartment block, including two storeys of retail and a rooftop restaurant.

Design study by Charlotte Brookshouse, Shimou Chen, James Crookston, Minhui Huang, Lazaros Kyratsous, Longfei Wang, Nan Yang and Yuan Zhai

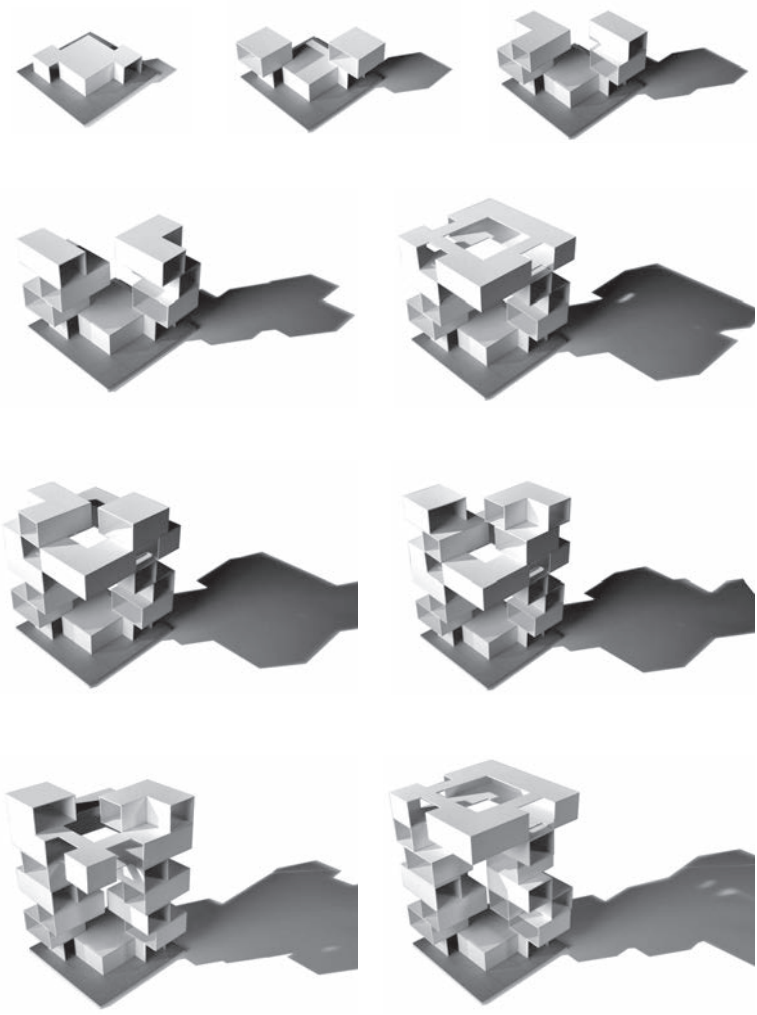
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

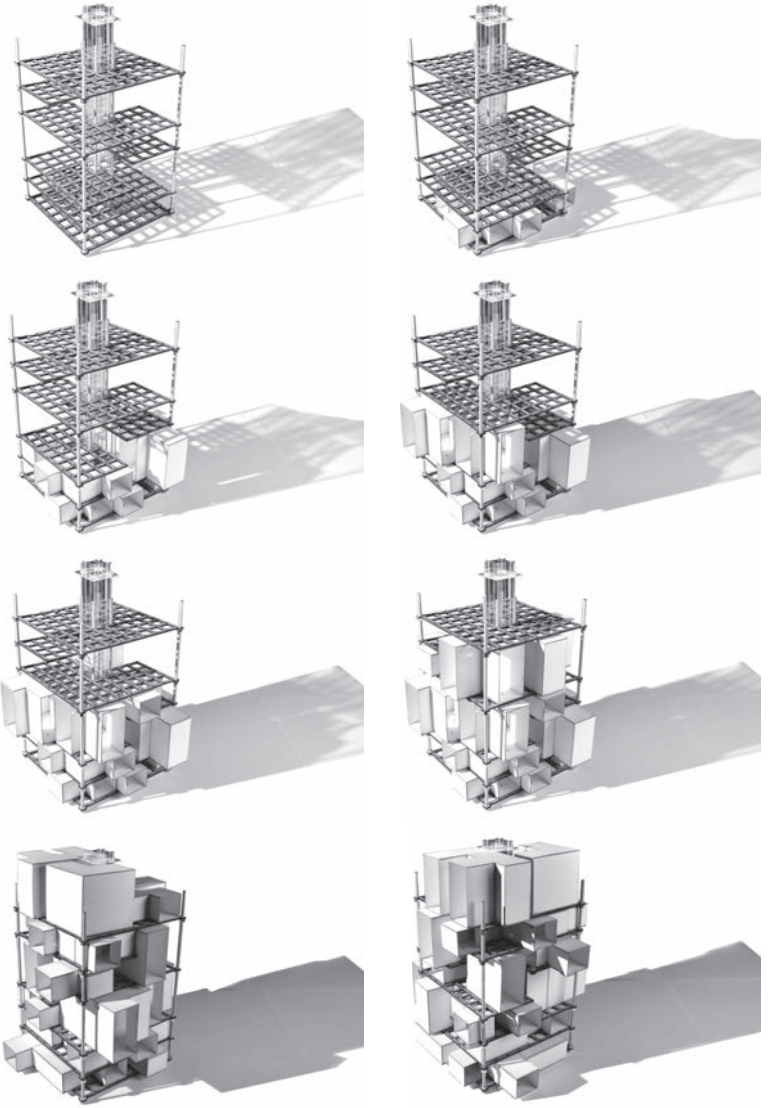
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Shelving system: iterative models

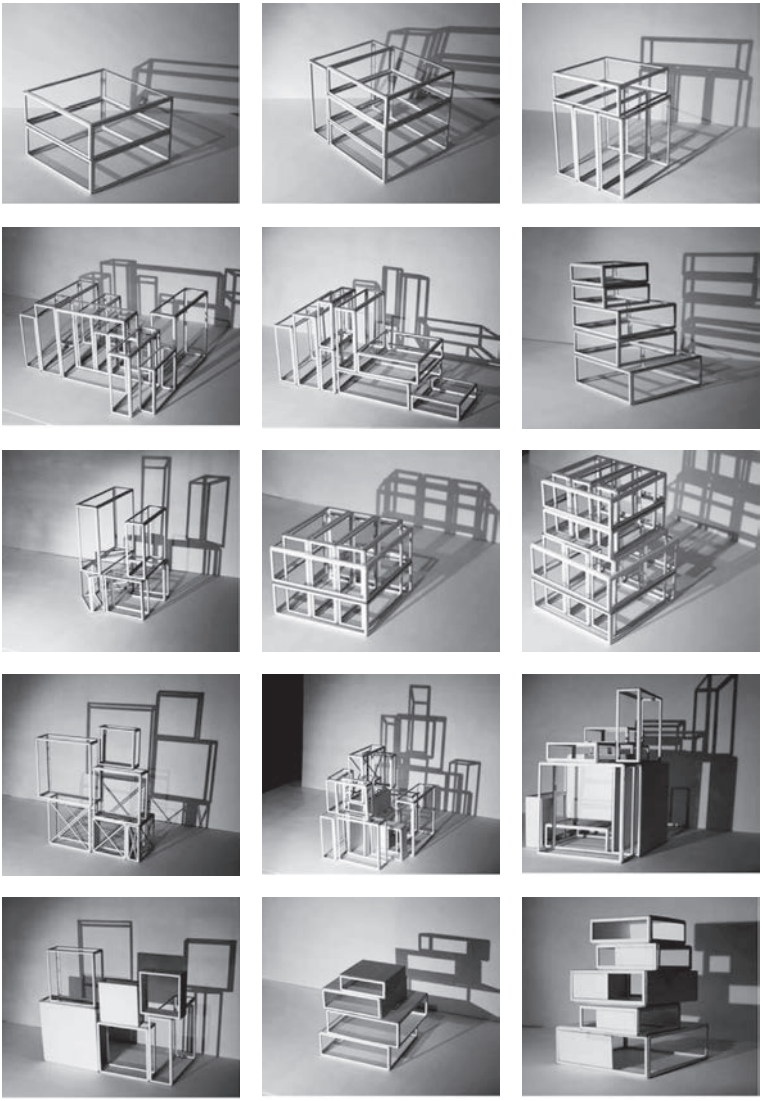
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



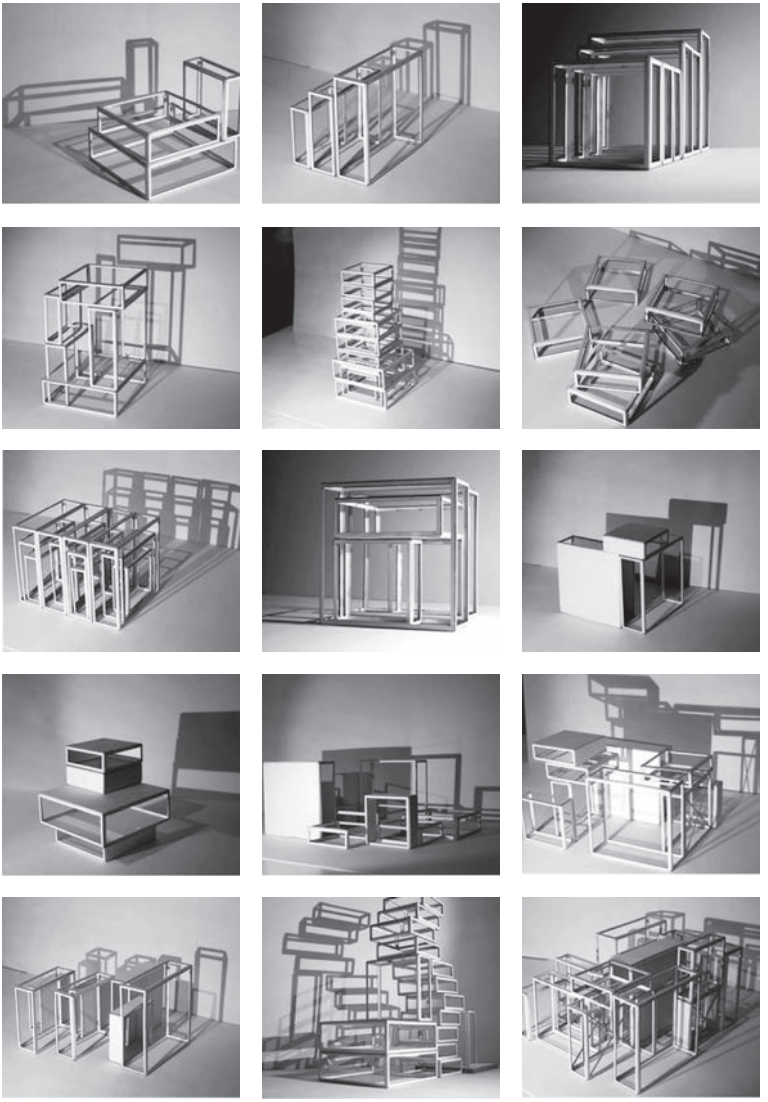
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



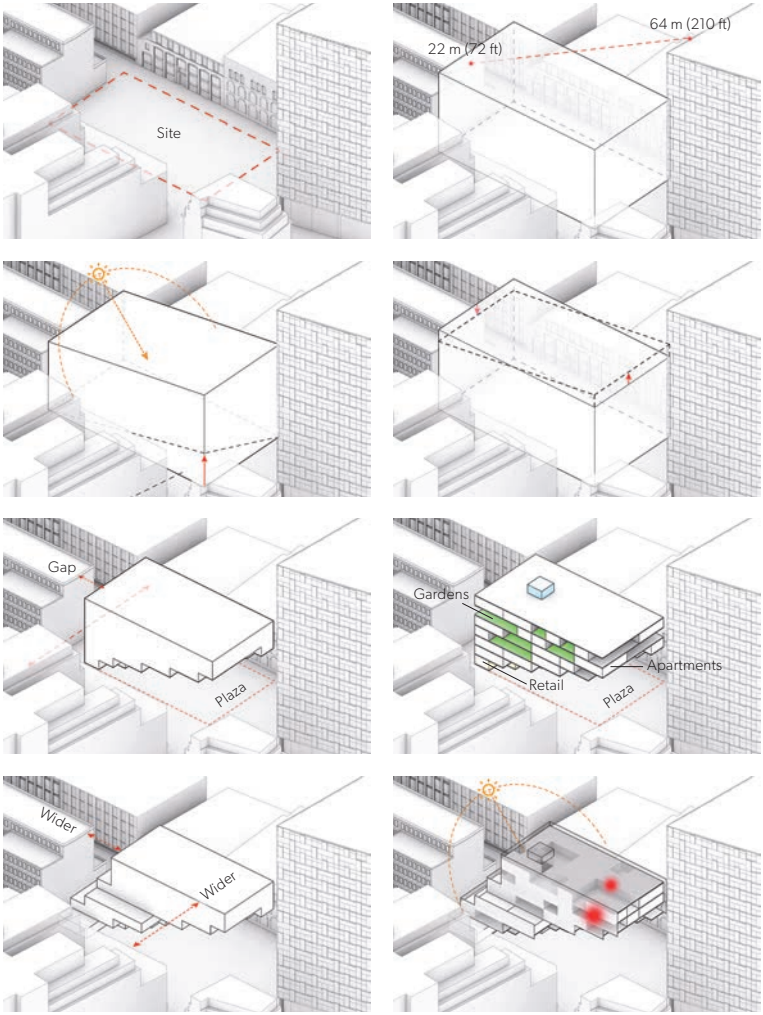
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Massing evolves as a set of contextual, programmatic and environmental parameters

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

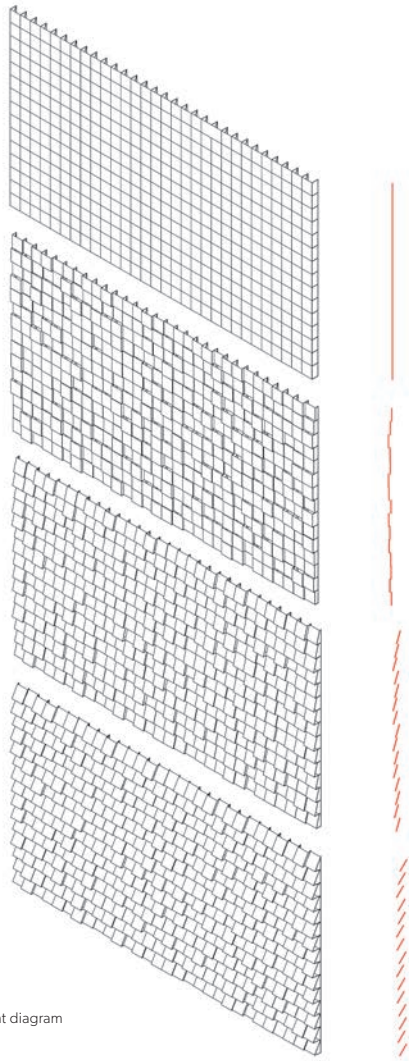
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Typical floor plan

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

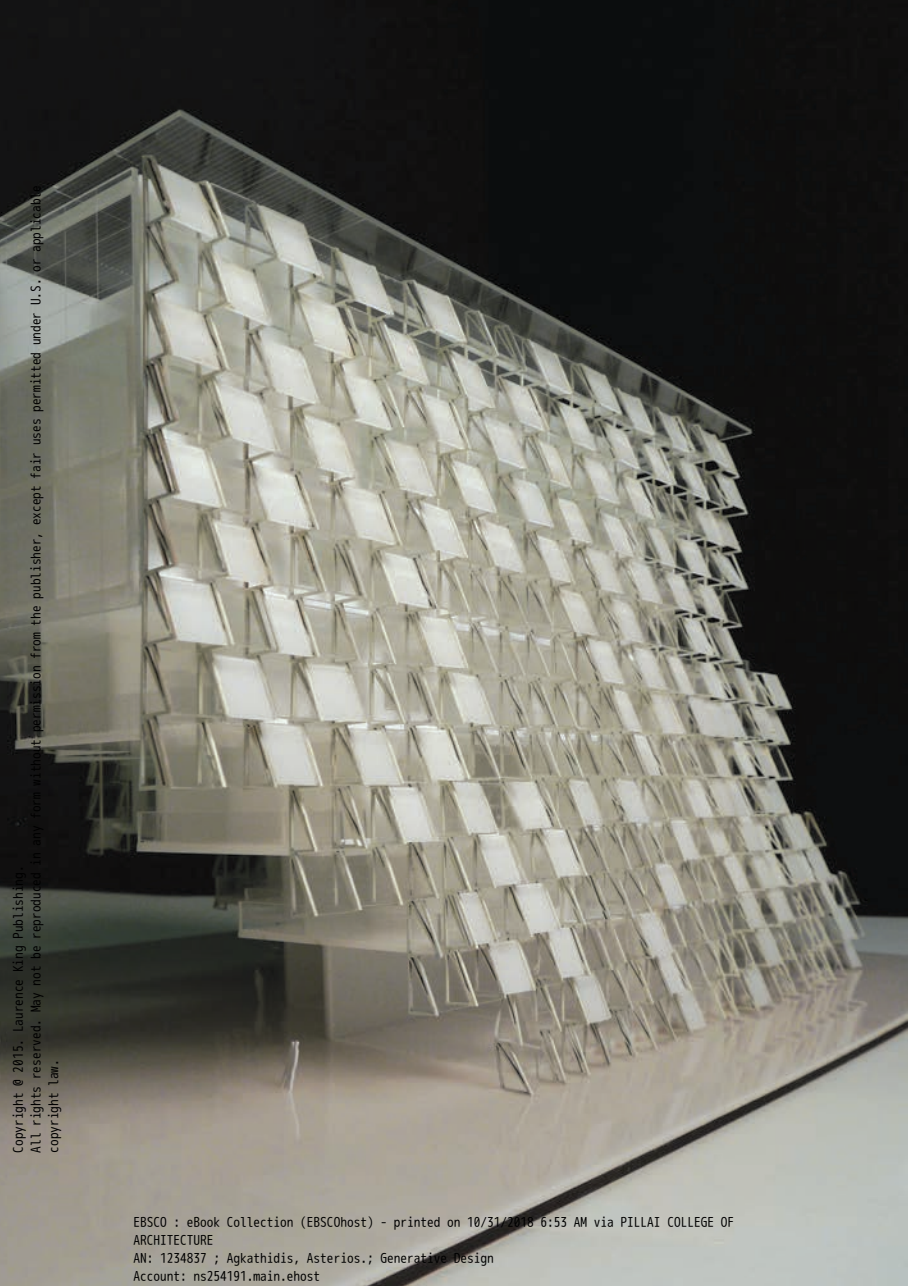


Above: Facade development diagram

Opposite: Facade model

Overleaf: Exterior view

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

DEFORMATION AND SUBTRACTION

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

4

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

4.1 / TWISTED BLOCK

Analysis: Load-bearing stone structures; precedent studies of Wandel Hoefer Lorch & Hirsch's New Synagogue, Dresden.

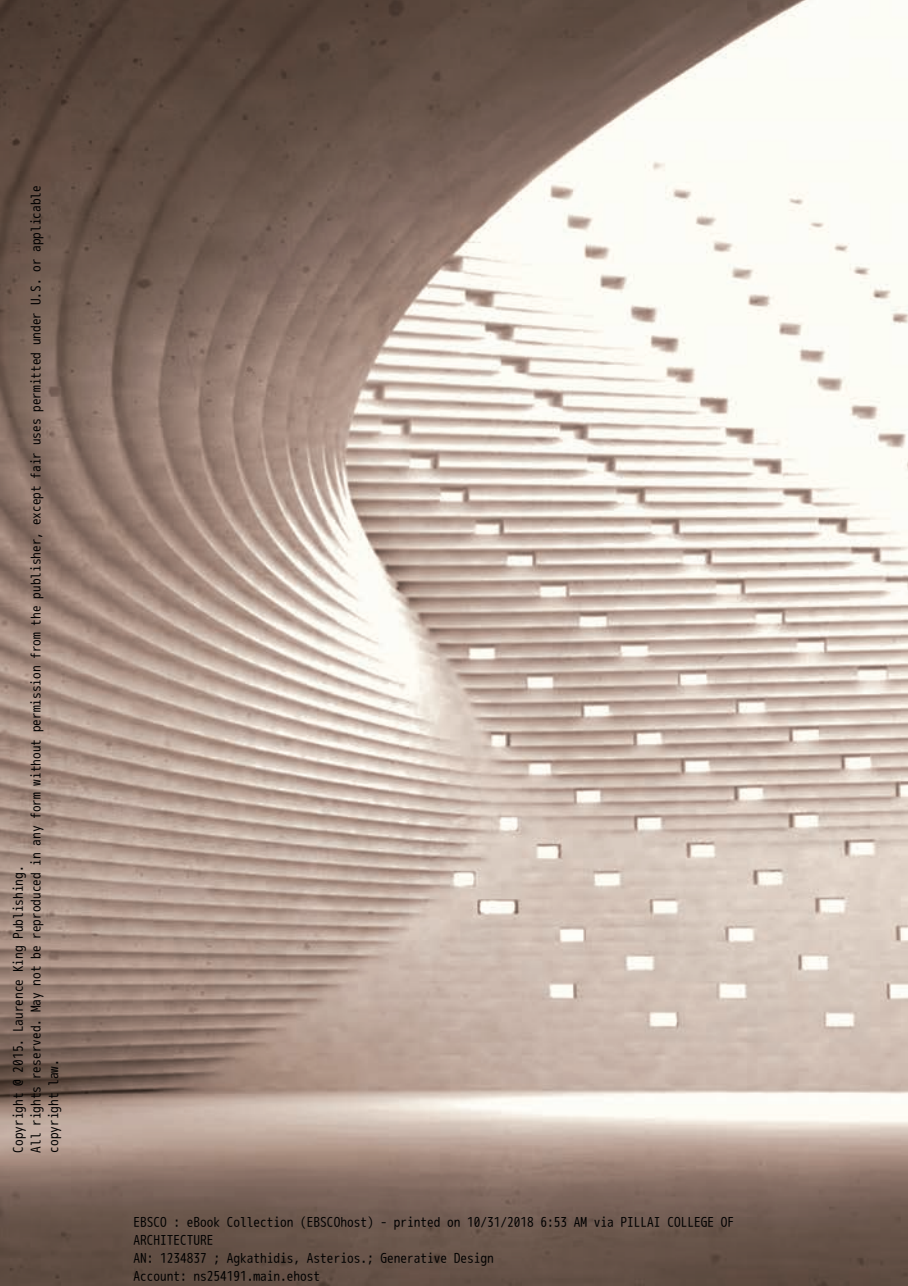
Morphogenesis: This project evolved as a twisted rectangular volume, examining the application of both physical and digital twisting techniques. Physical twisting was achieved by applying gradual pressure to timber frames arranged around an axis (see page 74). Digital twisting was applied to a block, which was then contoured, laser-cut and assembled (see page 75). By introducing small gaps in the timber frames, various lighting possibilities were explored.

Metamorphosis: The design proposal was to offer shelter to a market hall neighbouring a busy traffic junction. After analysing the site and the required schedule of accommodation, the twisting technique was applied digitally to an initial 3D massing model. The final building envelope was then deformed to the degree required by its integration into the site. The market hall offers spectacular interior spaces as well as usable terraced exterior areas (see pages 76–79). It is a load-bearing, stone structural skin, reinforced with a steel frame.

Design study by Sean Bailey and David Barker

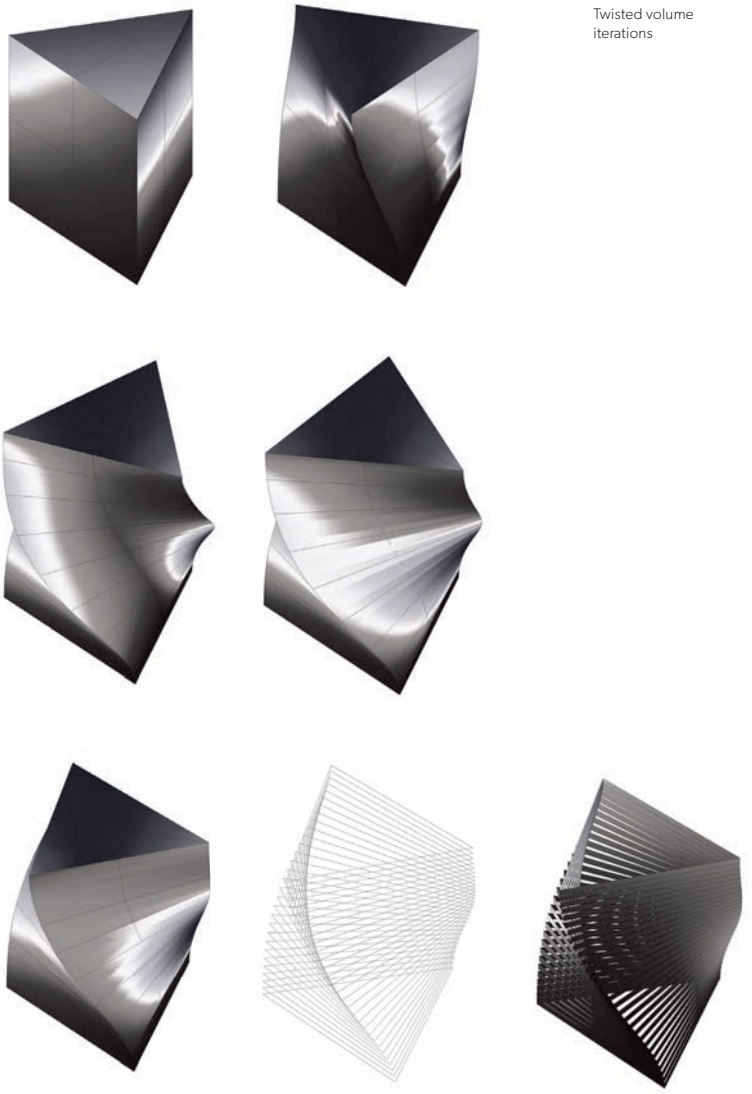
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

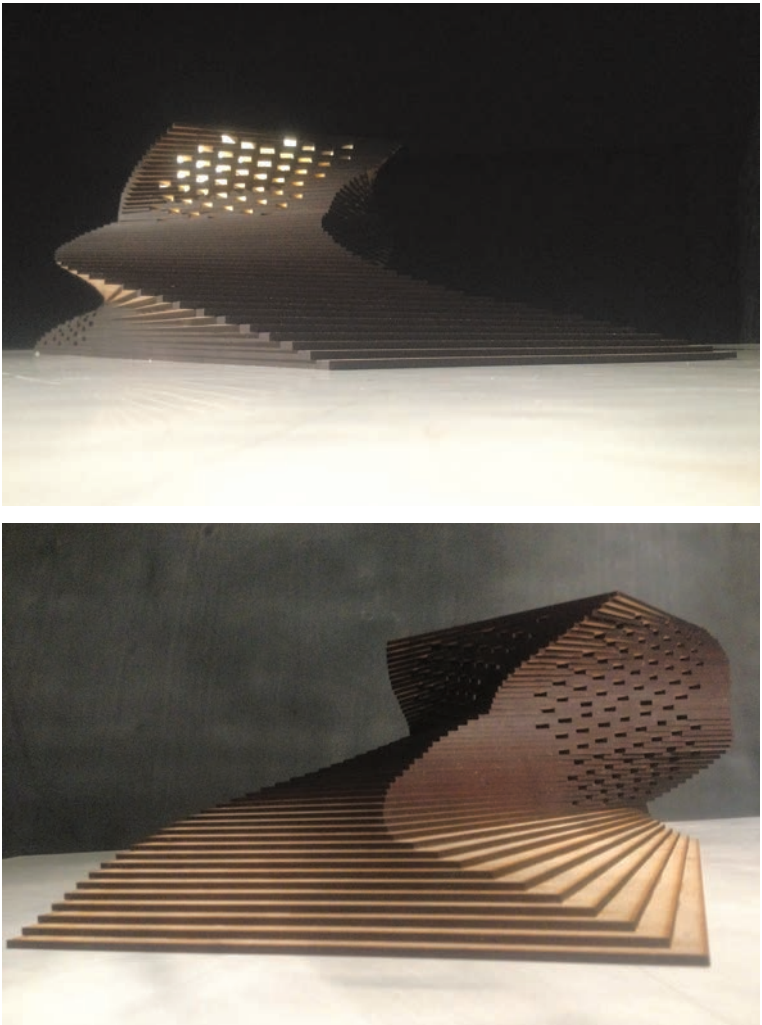
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Twisted volume
iterations

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable
copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

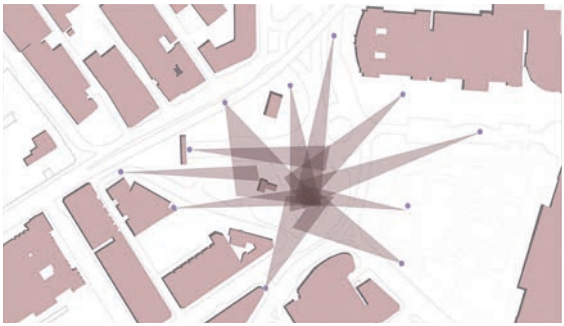


Digitally produced twisted models,
materialized using laser-cut MDF frames

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Defining circulation paths and access

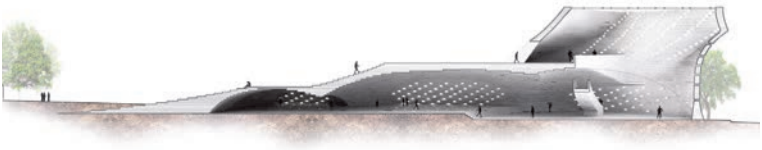


Defining views to the building

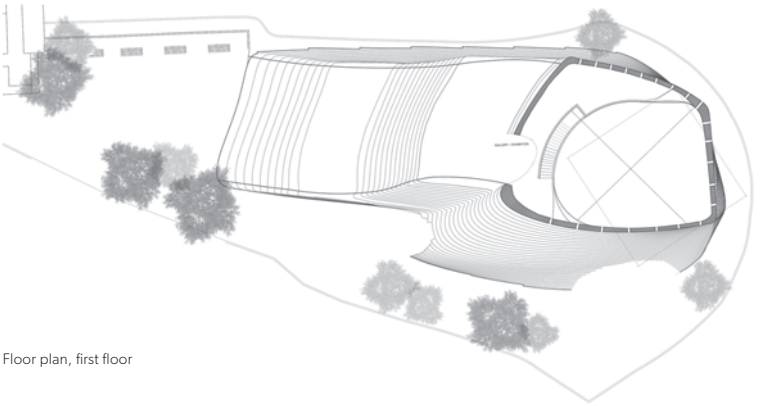
Aligning massing to the site

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

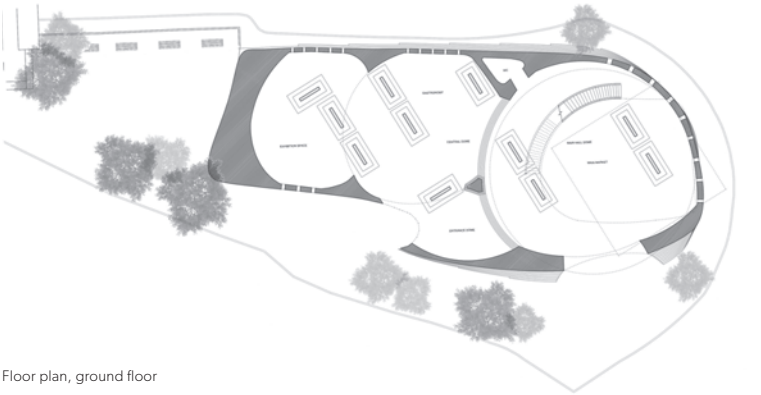
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Longitudinal section



Floor plan, first floor



Floor plan, ground floor

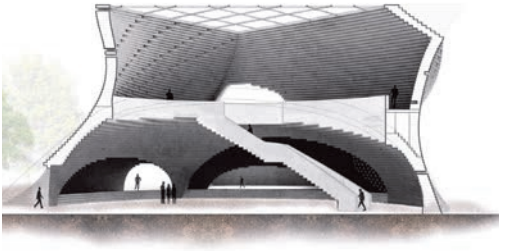
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Interior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Cross section

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

4.2 / POROUS SPACE

Analysis: Concrete casting and its properties; precedent studies of Frederick Kiesler's Endless House and Eero Saarinen's TWA Terminal.

Morphogenesis: This design study explored the notion of a porous space, inspired in particular by Kiesler's Endless House. It was a formal exploration using both physical and digital modelling tools. Balloons in three different sizes, filled with water, were used as forms for the plaster-casting stage. After the plaster had dried out and the balloons had been removed, a porous, 'Swiss cheese'-like structure remained (see pages 82–83). As a second step, the structure was analysed and then remodelled in a digital environment, using Rhinoceros and the T-Splines plug-in. The final output was a 3D-printed physical model (see pages 84–85).

Metamorphosis: This design was intended to host a market hall, including areas dedicated to gastronomy as well as public leisure spaces, located in a central urban environment. The building developed in response to issues of context, circulation, programme and typology discovered during development (see pages 86–87). It takes the form of a concrete structural shell, which allows the option of roof lights, and entrance and window openings. It embraces leisure zones and public outdoor areas, while also transforming the space from roof to wall and floor (see pages 88–89).

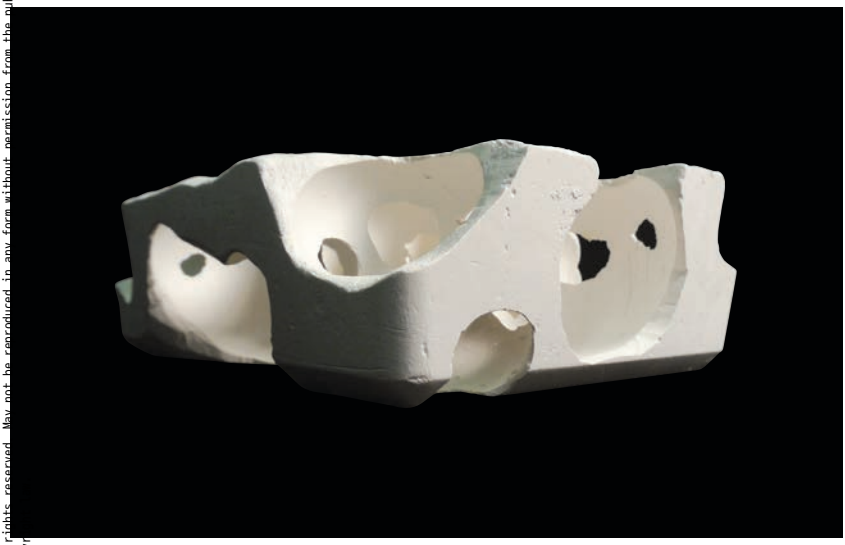
Design study by Nojan Adami, Yiqiang Zhao and Zhenyu Zhu

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234817 ; Agkathidis, Asterios.; Generative Design
Account: ns154191.main.ehost



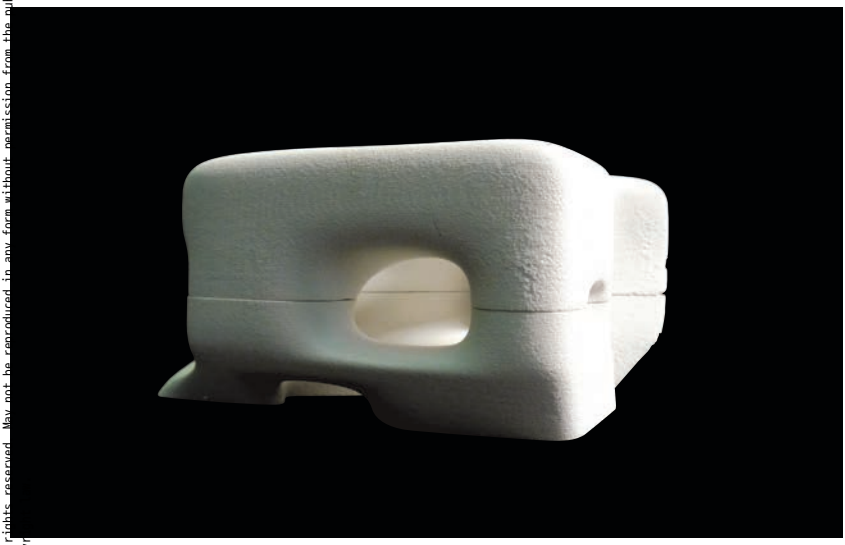
Porous shell: handmade plaster model

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

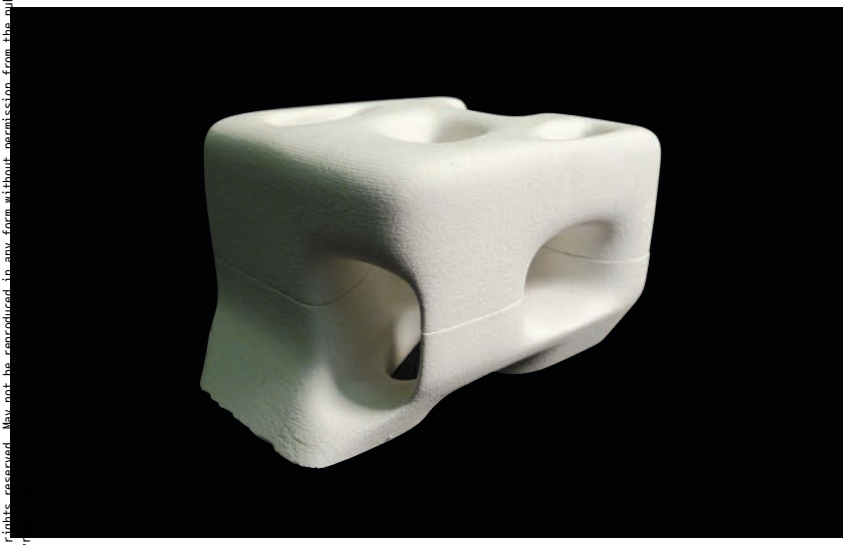
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Porous shell: 3D-printed model

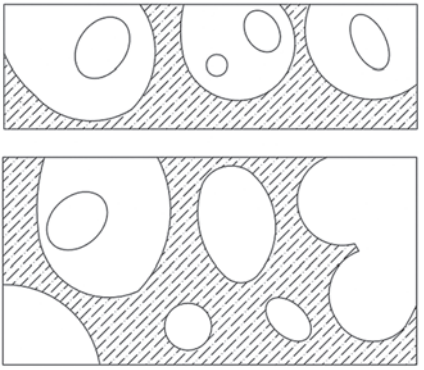
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyr

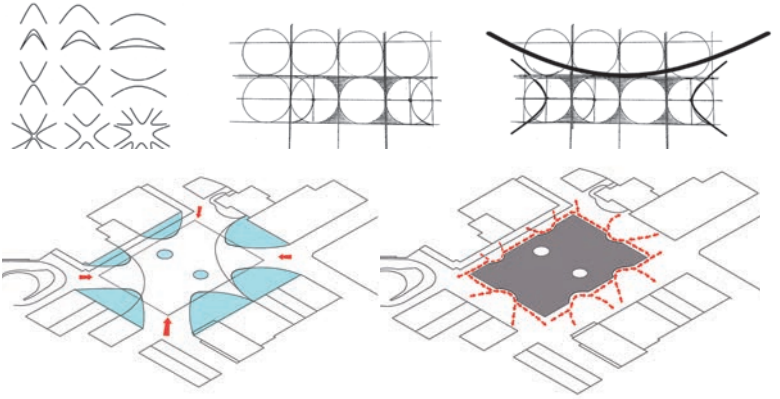
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

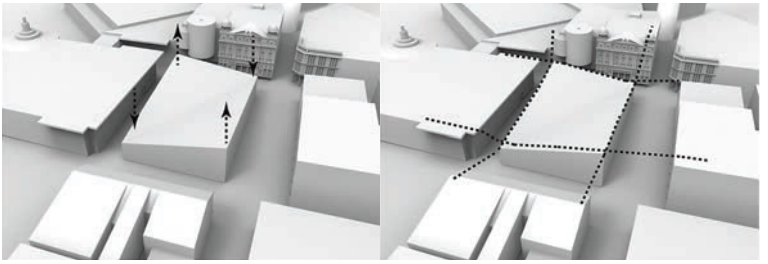


Left: Sectional diagrams of physical and digital models

Below: Forming the building's footprint from the circulation diagram and programmatic requirements

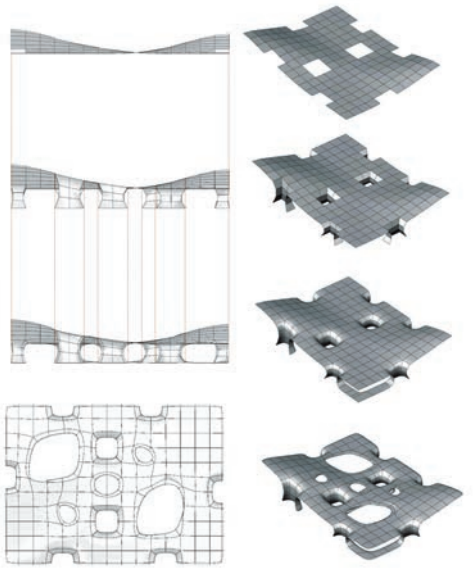
Bottom: Adjusting the massing to its context





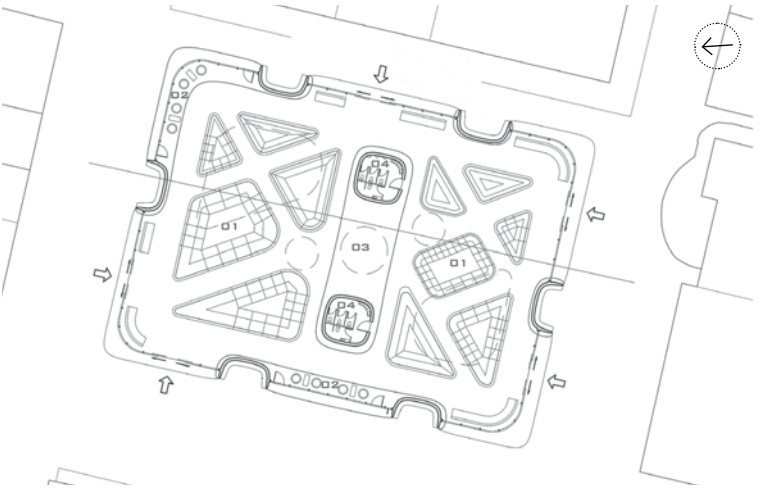
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



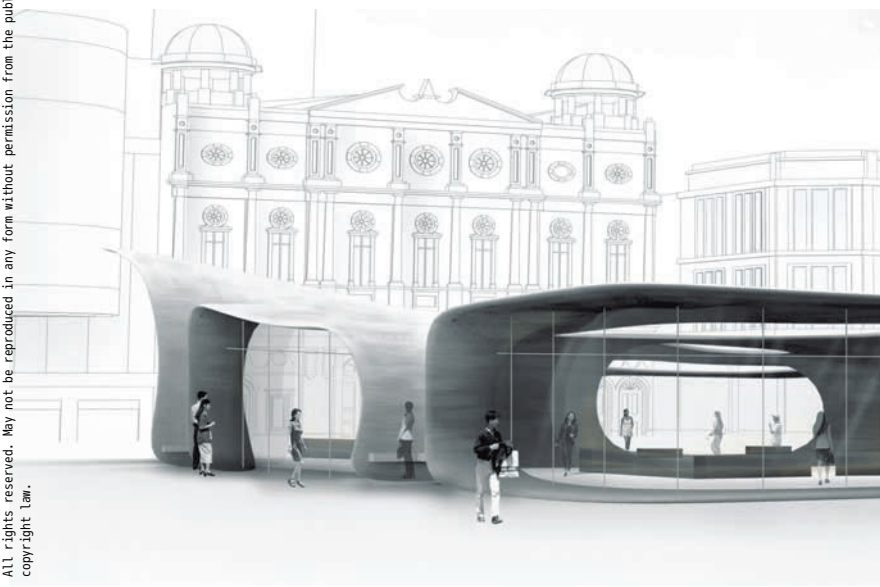
Left: Structural shell design process, using T-Splines

Below: Ground floor



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Perspective view in context

Copyright @ 2015, Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

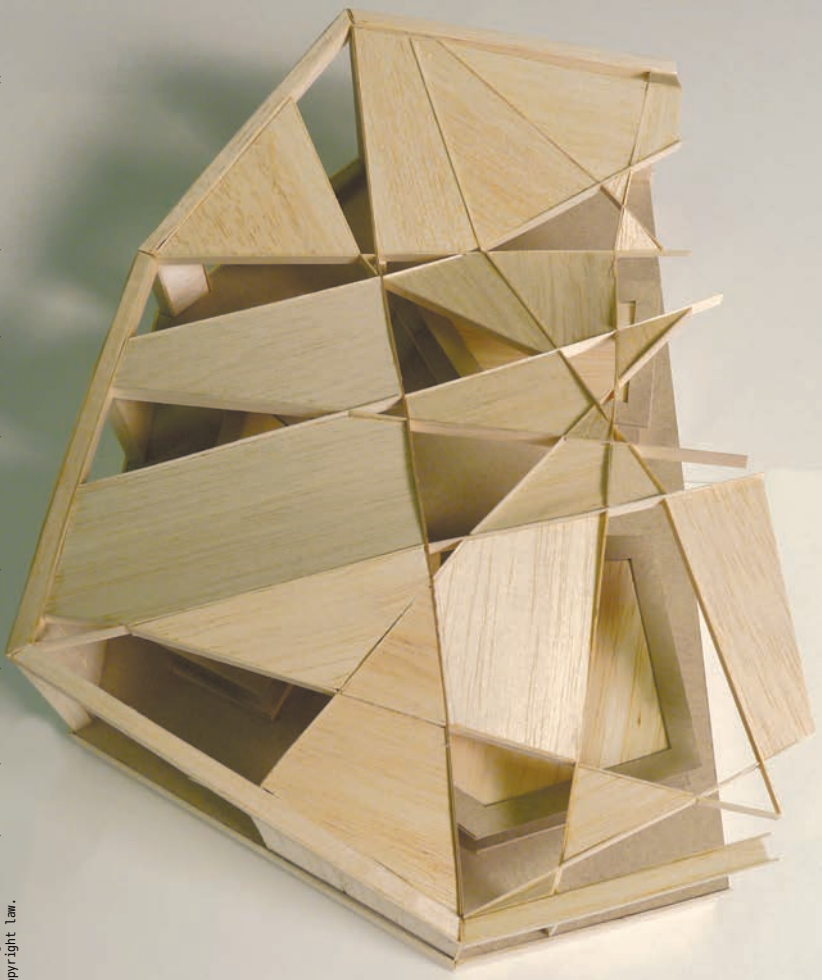
ALGORITHMIC PATTERNS

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

5.1 / TESSELLATED PLANES

Analysis: Steel structures; precedent studies of Toyo Ito's Serpentine Gallery Pavilion.

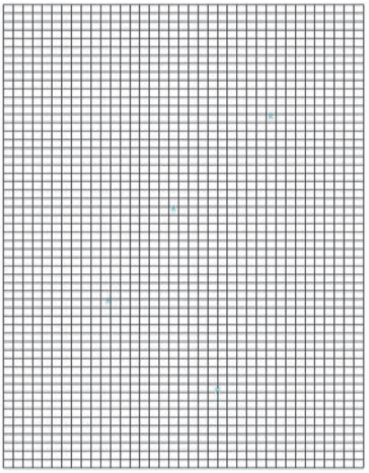
Morphogenesis: This project investigated three generative algorithms, using Rhinoceros 5 and Grasshopper, in search of possible structural patterns. The first pattern was based on attractor points and grid deformation, the second explored weaving patterns and techniques, while the third explored irregular tessellation of planar planes (see pages 94–95). After examining iterative models of all three algorithms, the last was chosen for further development.

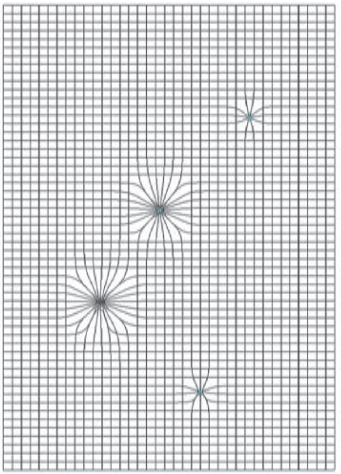
Metamorphosis: The footprint and massing of this central market hall was derived from contextual parameters, such as alignment with street views, and the heights and axes of neighbouring structures. The roof was then formed in various directions in order to allow views to the prestigious buildings around the site, such as a library and a train station. Finally, the tessellation algorithm was applied to the roof, defining the building structural system and envelope (see pages 96–97). As well as providing glazing, the aluminium panels give the hall a unique appearance (see pages 98–99).

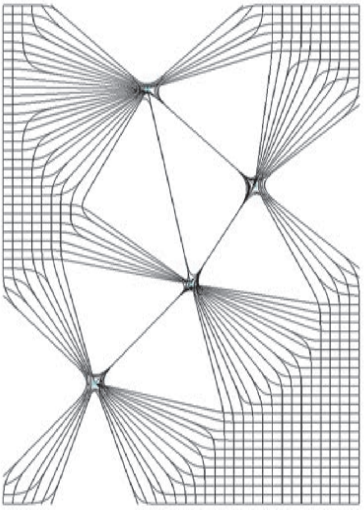
Design study
by Nojan Adami

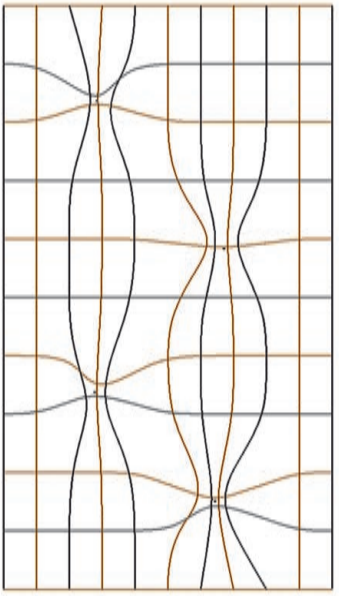
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost





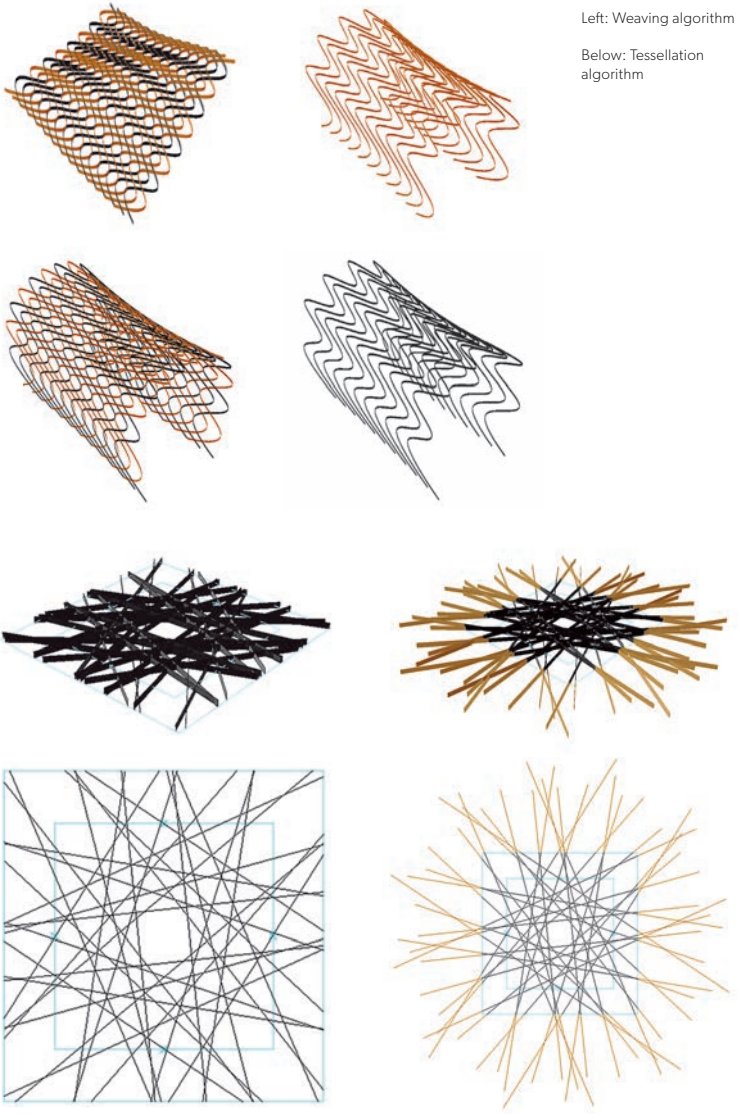




Point attractor and grid deformation algorithm

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

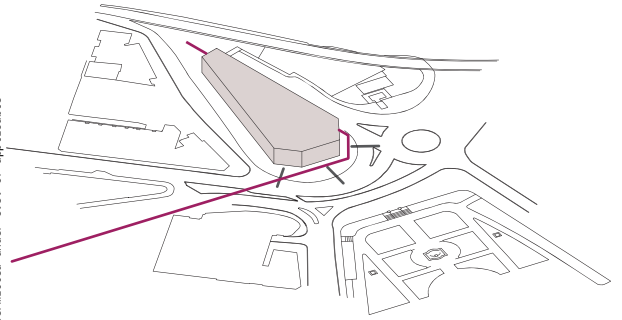


Left: Weaving algorithm

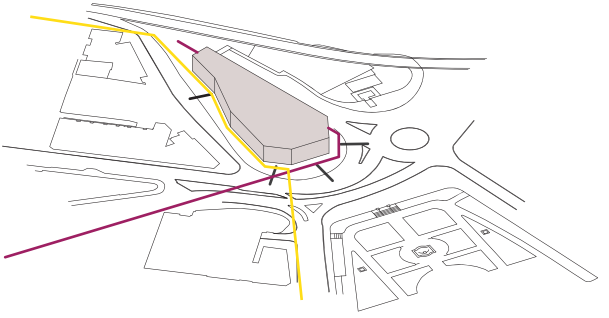
Below: Tessellation algorithm

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

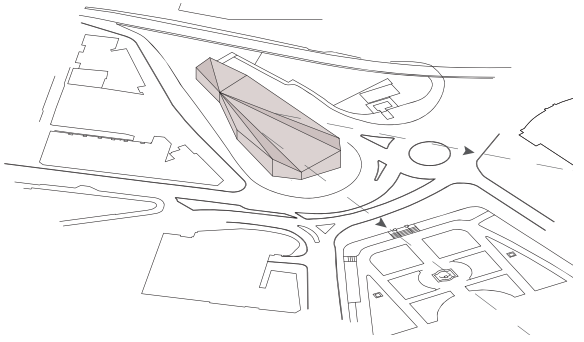
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Solar path analysis



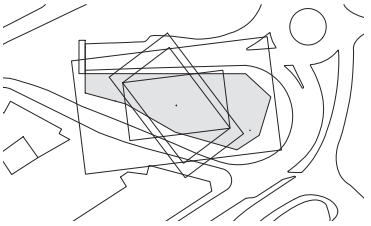
Building massing and main circulation axis on site

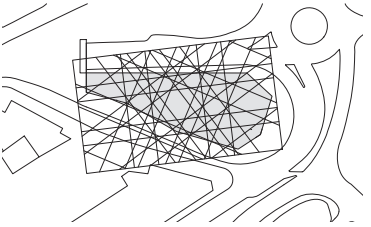


Building's roof is adjusted to accommodate views

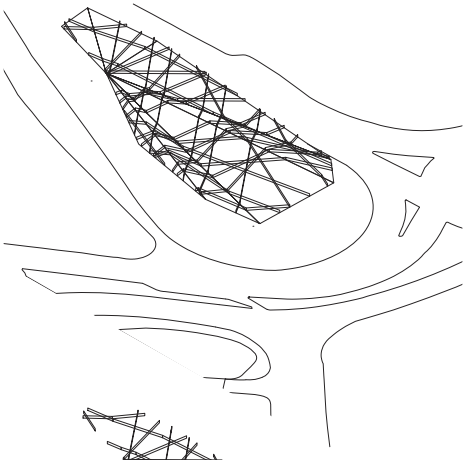
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

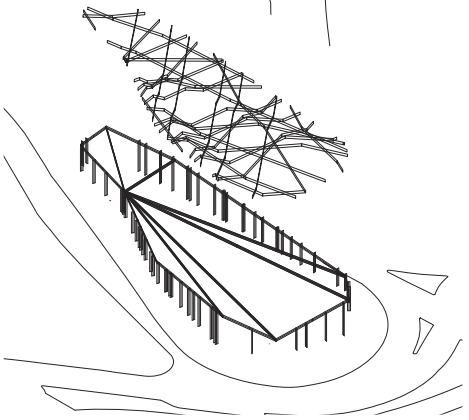
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost





Tessellation algorithm is applied to building envelope





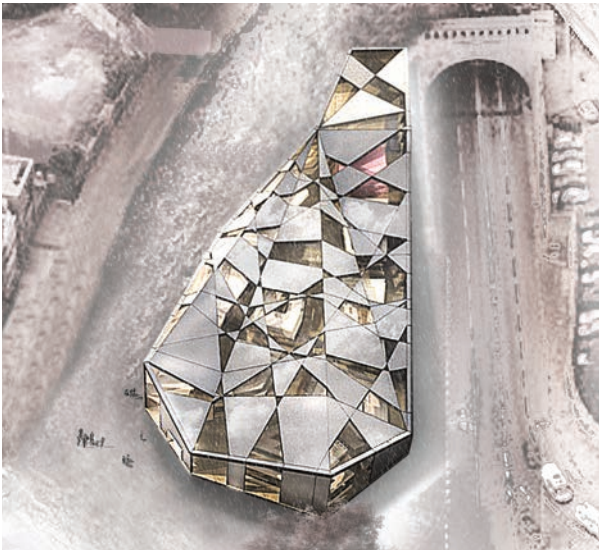
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Street view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Aerial view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 6:53 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

5.2 / VORONOI SURFACE

Analysis: Timber frame structures; precedent studies of Barkow Leibinger's Campus Restaurant.

Morphogenesis: This project experimented with a Voronoi pattern algorithm. For the first stage it used physical models to assess configurations of different shapes and sizes, as well as various degrees of extrusion (see pages 102–3). At the next stage it shifted to digital modelling, examining the Voronoi pattern parametrization and its application to three-dimensional and double-curved geometries (see pages 104–7).

Metamorphosis: This design was intended to provide shelter for a ferry terminal, incorporating retail and cultural spaces. During the final stage the Voronoi algorithm was applied to the site (see page 108), defining the main areas of accommodation as well as the position of the columns, and the landscape design of the neighbouring square. The final roof proposal is an irregular vault structure, with its laminated timber frame covered by PTFE foil, allowing continuity of natural light as well as variable degrees of transparency (see pages 112–13).

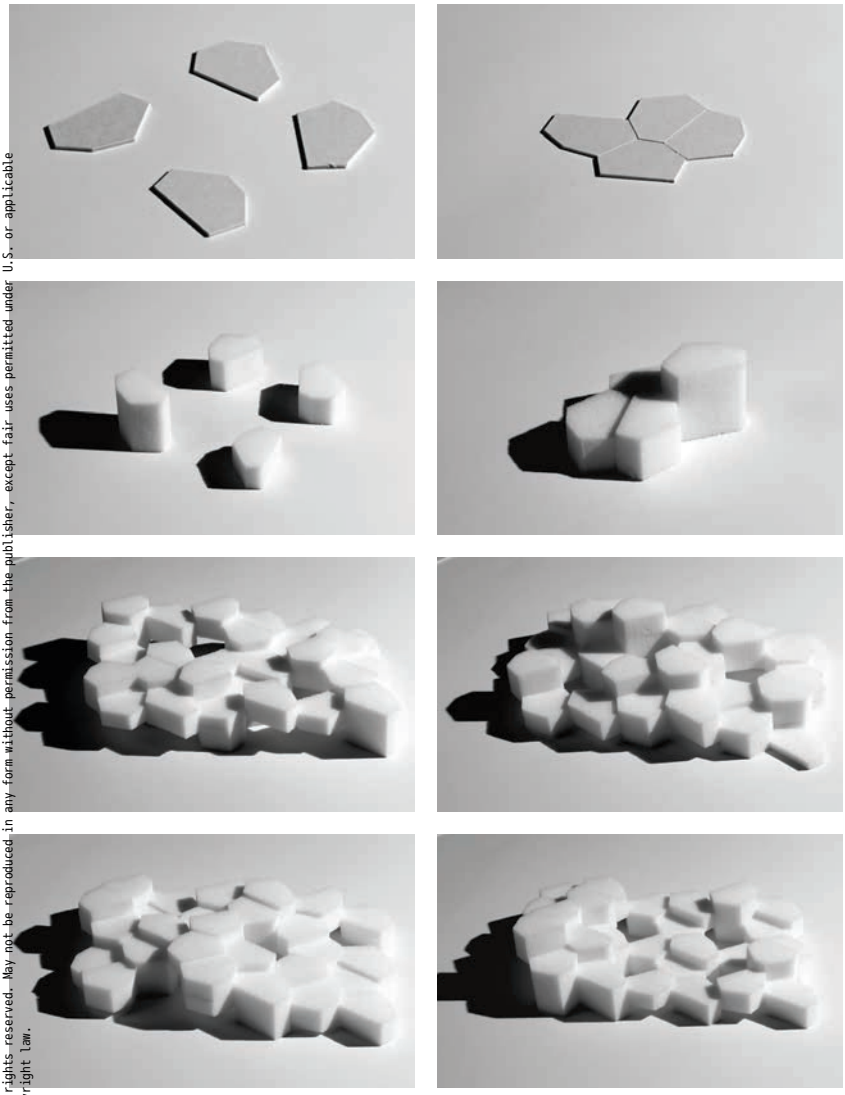
Design study by Liang Gao, Yiwei Gao, Man Jia, Jingchang Li, Xiao Lu and Yihan Zhang

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

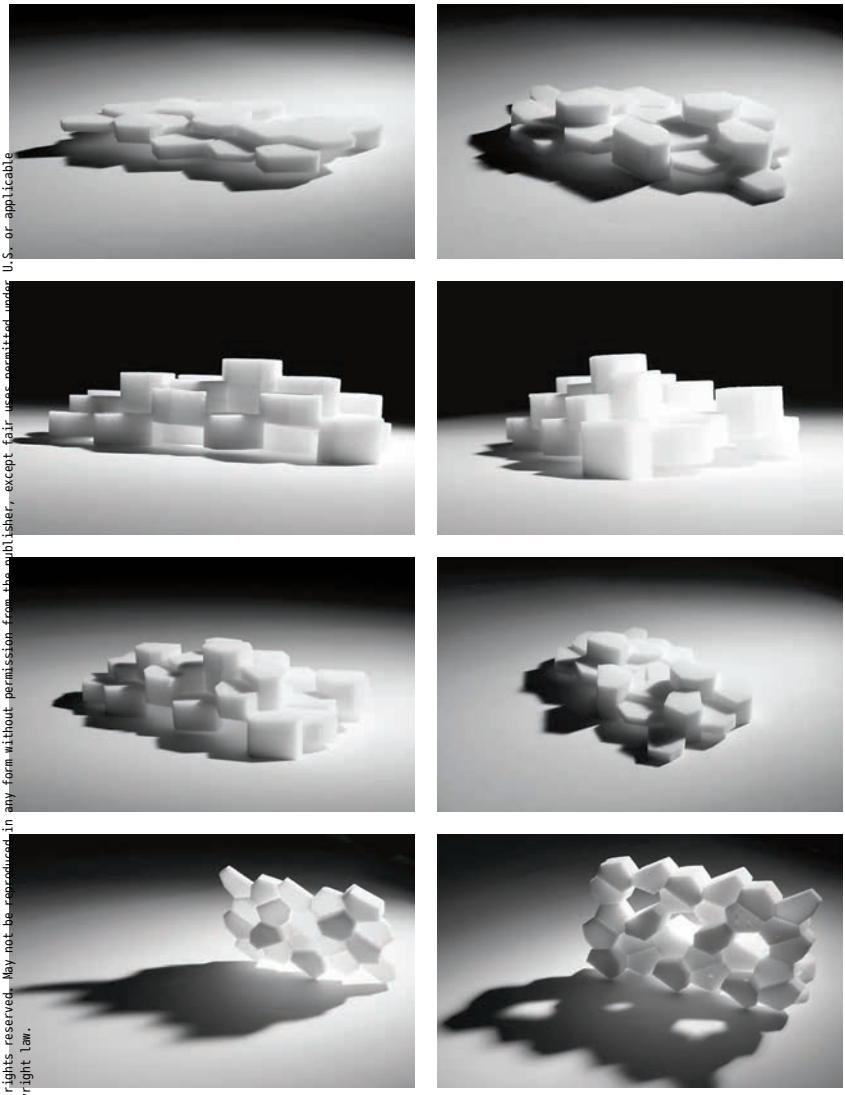
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Cluster models, Voronoi blocks

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

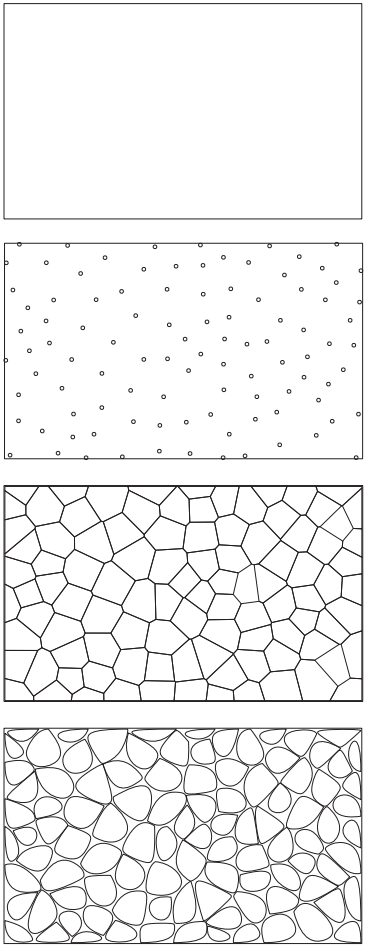
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

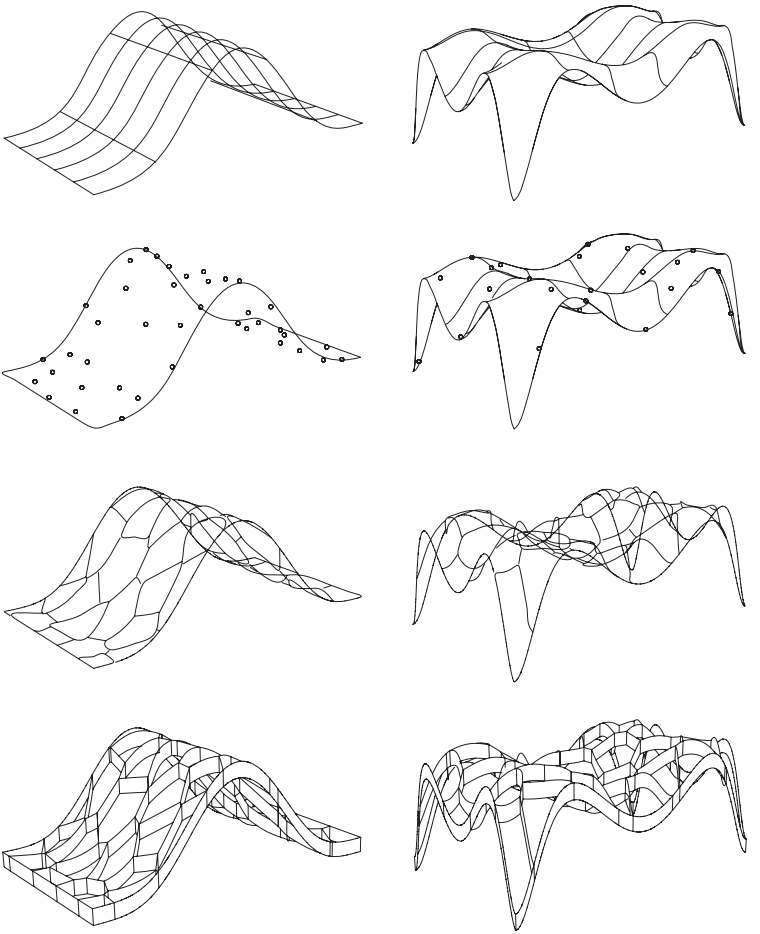
Voronoi pattern applied to rectangular planes and faceted surfaces



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

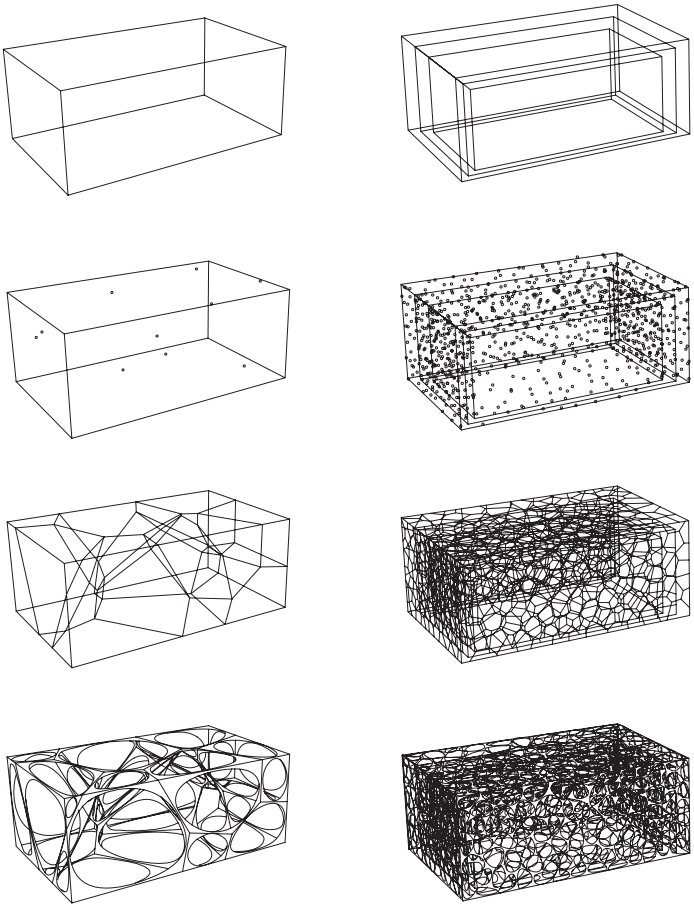
Voronoi pattern applied to
double-curved surfaces



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

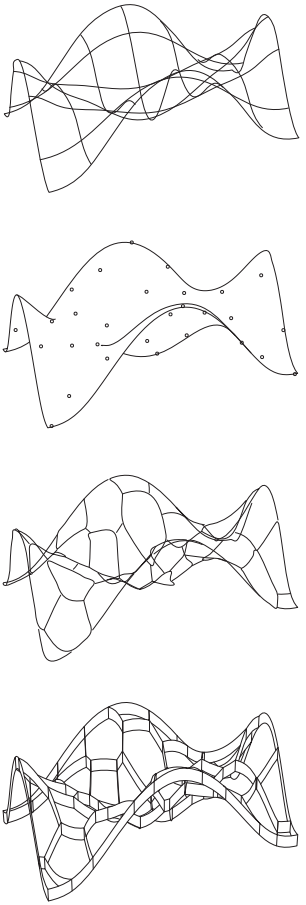
Voronoi pattern applied to solid blocks



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Voronoi pattern applied to paraboloid
and vault surfaces

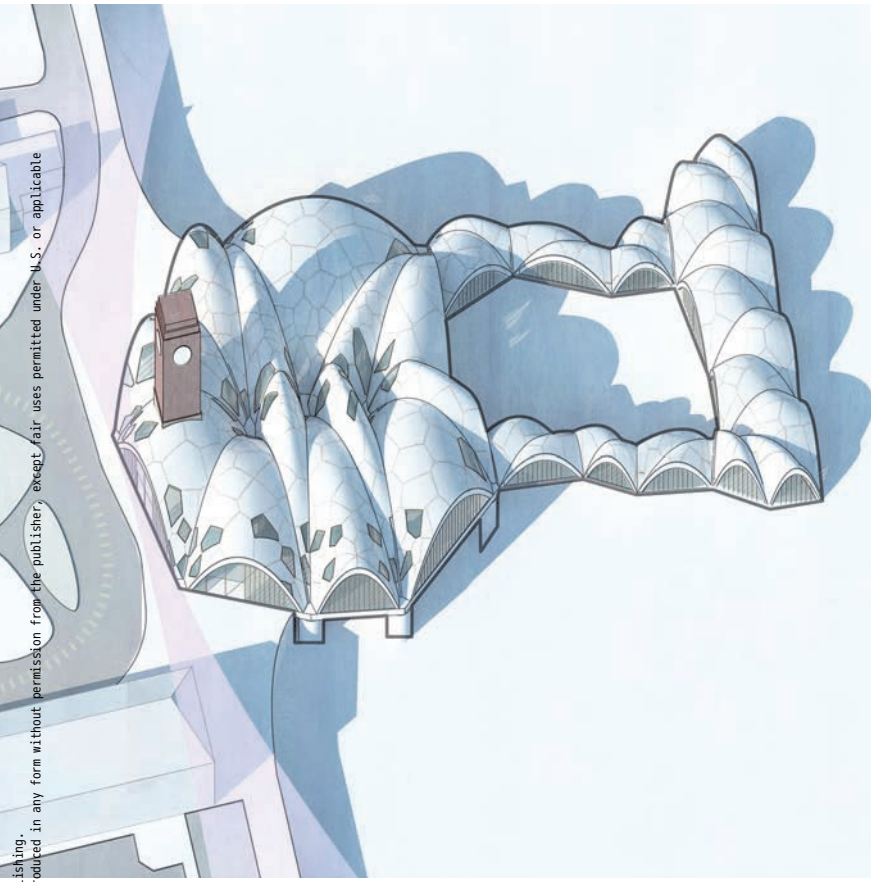


Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Left: Voronoi algorithm applied to the building site

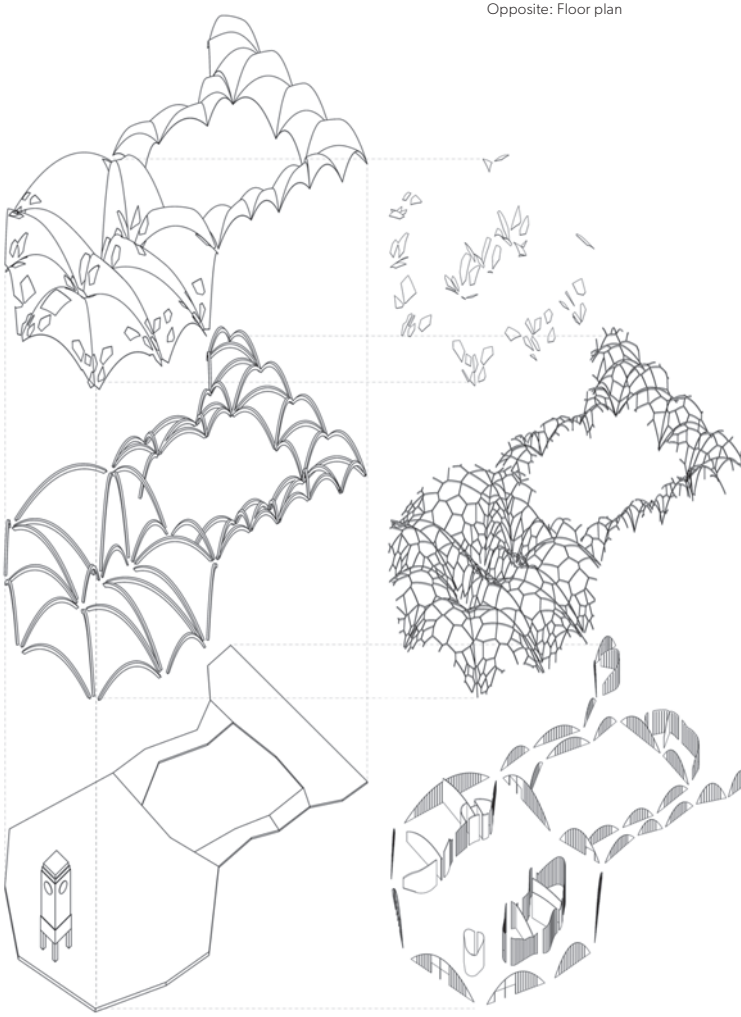
Above: Ferry terminal 3D model in context

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

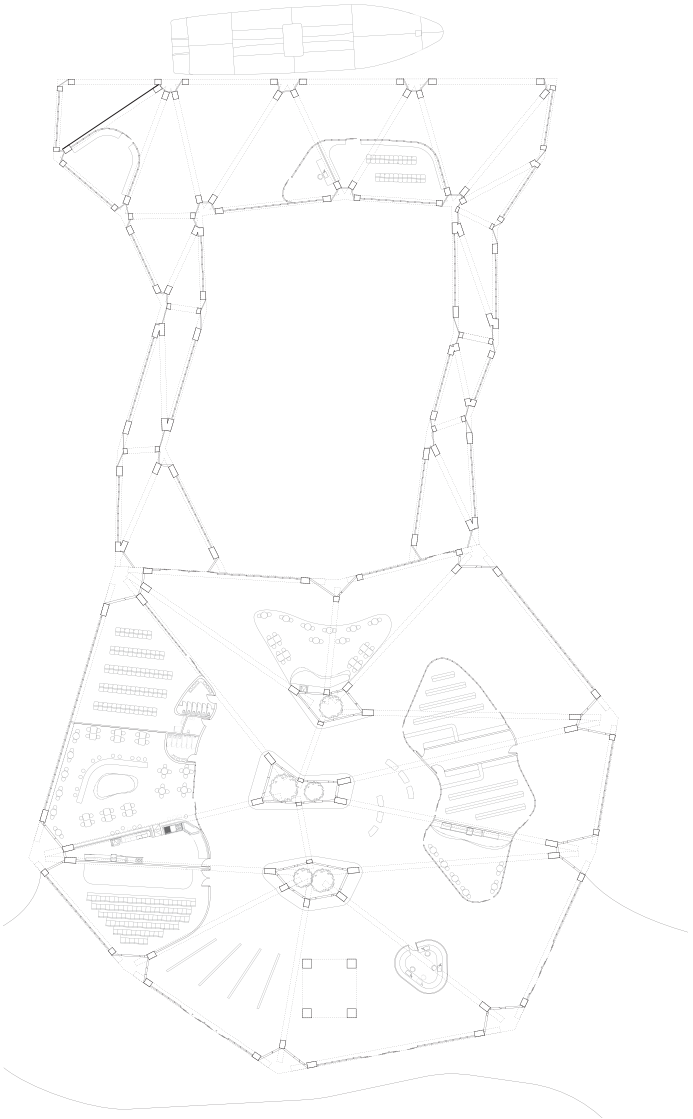
Below: Exploded axonometric drawing, demonstrating structure, skin and layout

Opposite: Floor plan



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



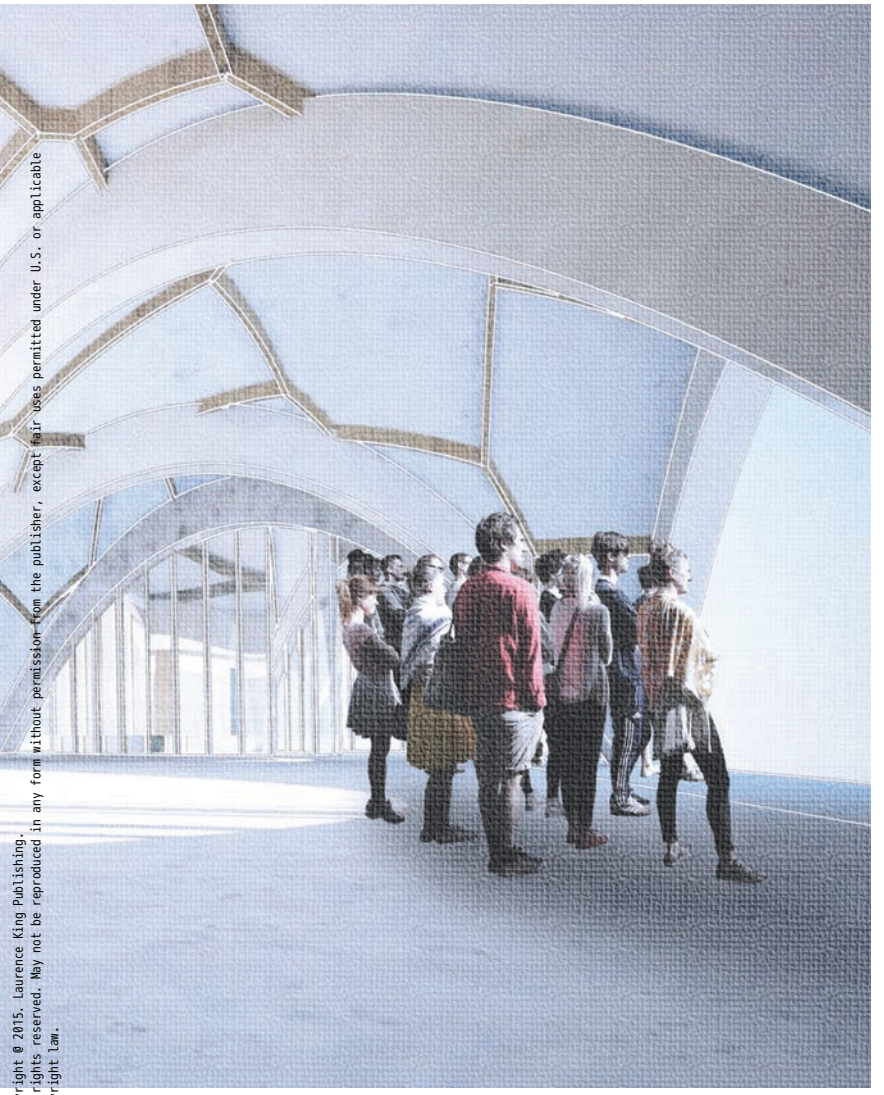
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Interior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Exterior view

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

TRIANGULATION

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

6.1 / 3D PENROSE PATTERN

Analysis: Steel frame structures and Penrose tiling.

Morphogenesis: This project employed a generative system comprising two different triangles and five joints (see page 120), inspired by the pattern of Penrose tiling. The combination of triangular components and joint types predetermined geometrical growth in three directions, allowing various spatial conditions to occur (e.g., hills and valleys, enclosures and surfaces). Variable opening types in relation to the heights of enclosed spaces were applied as an additional parameter, which allowed variable lighting conditions to occur.

Metamorphosis: As a second step, contextual, structural and programmatic parameters were applied to the emerging geometry. This was transformed into an envelope capable of having its footprint, height, section, structure, materiality and floor plan adjusted in order to accommodate a market hall in an urban square. Its irregular footprint allowed views to pathways around the building, while also directing visitors to usable outdoor spaces (see pages 122–23).

Design study by Yuedi Liu and Yaoting Yang

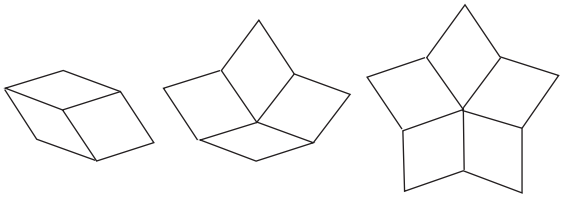
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

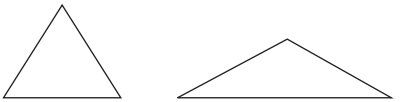
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Ackathinis, Asterios.; Generative Design
Account: ns254191.main.ehost

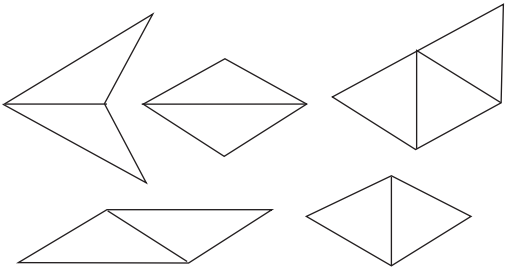
Generative system components:
two main units, five different joints



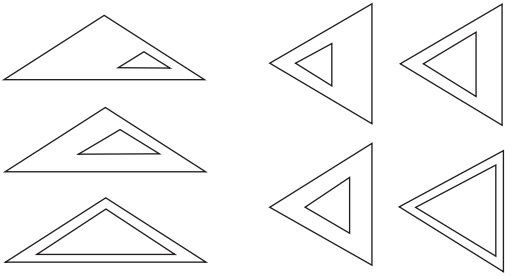
A. Typical Penrose tiling arrangements



B. The two main triangle components



C. Five different joint options

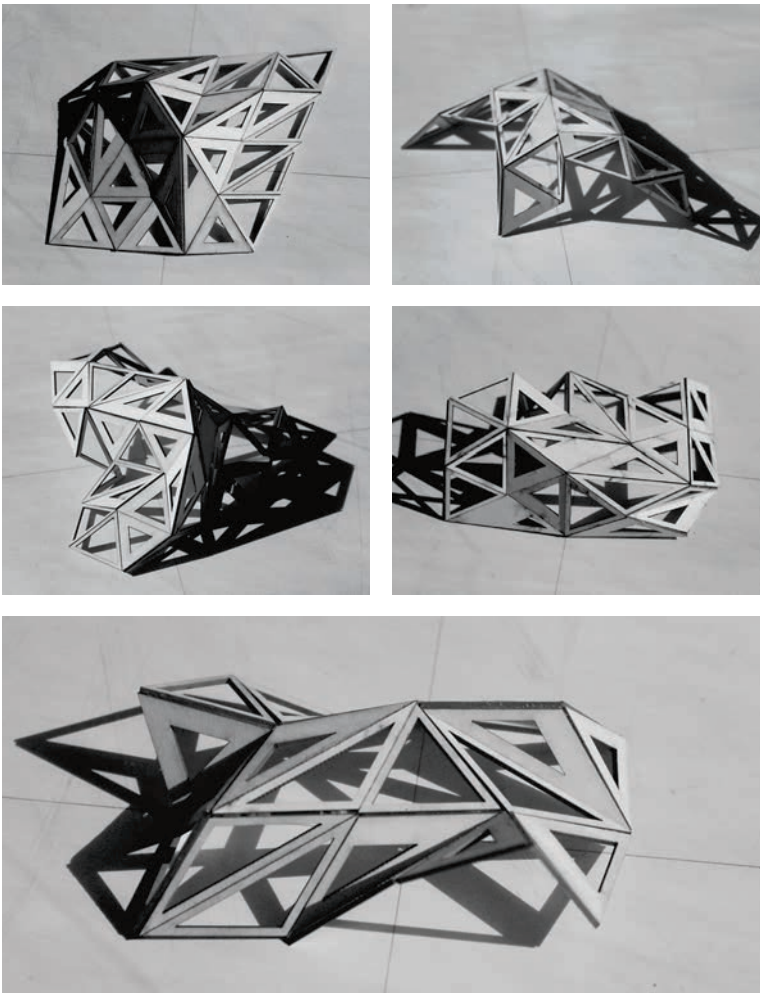


D. Seven different types of perforation

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

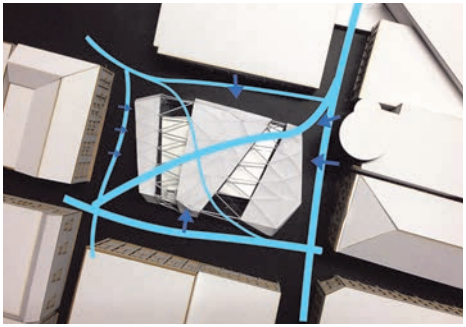
Morphogenesis: iterations of the generative system exploring different spatial conditions in relation to illumination intensity

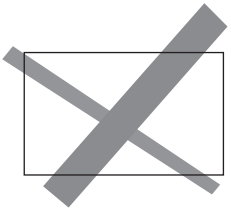


Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

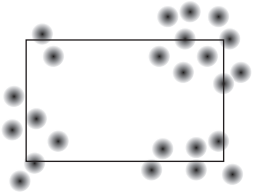
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Metamorphosis: adjusting geometry
to structural, programmatic
and contextual parameters

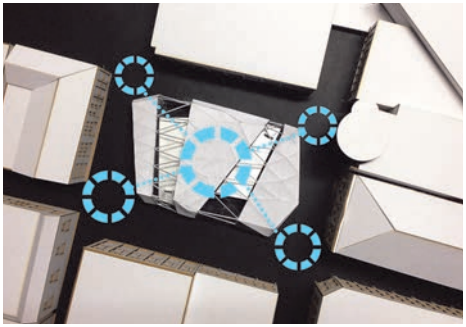


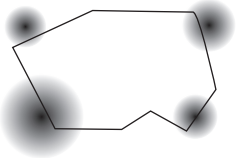


A. Introducing main and secondary circulation paths



B. Defining the entrances according to neighbouring functions

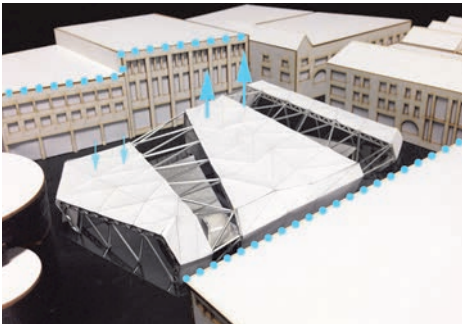


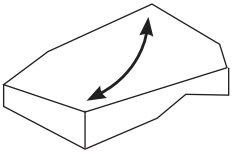


C. Defining the footprint in order to create usable public space and channel visitors' views

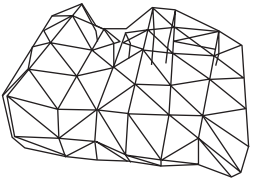
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

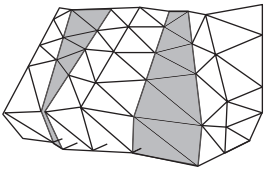




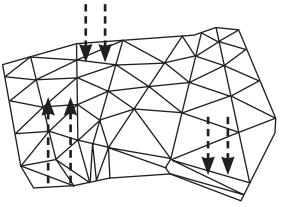
D. The building envelope is adjusted to the site



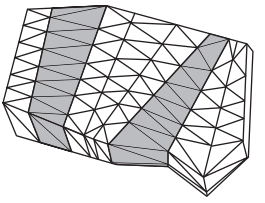
E. Geometry is translated into structure



F. Opaque and transparent materials are linked to different public and private zones



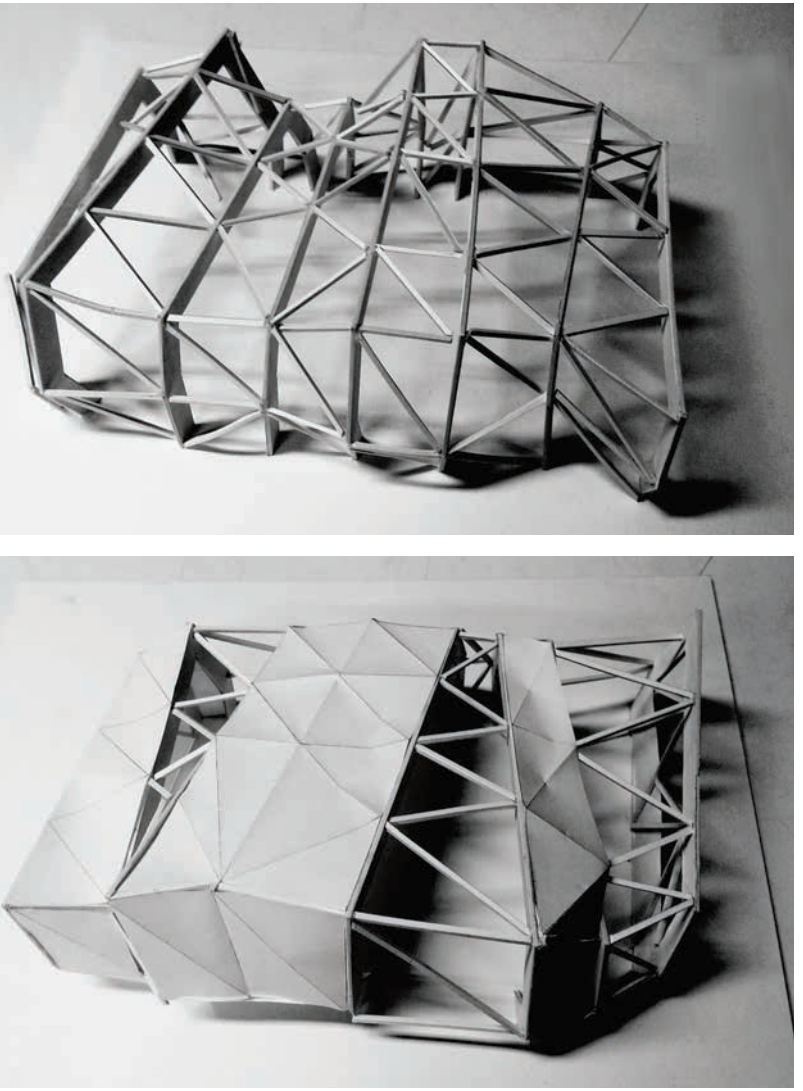
G. The building envelope's height is adjusted to those of neighbouring buildings



H. The building envelope is adjusted to programmatic requirements

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

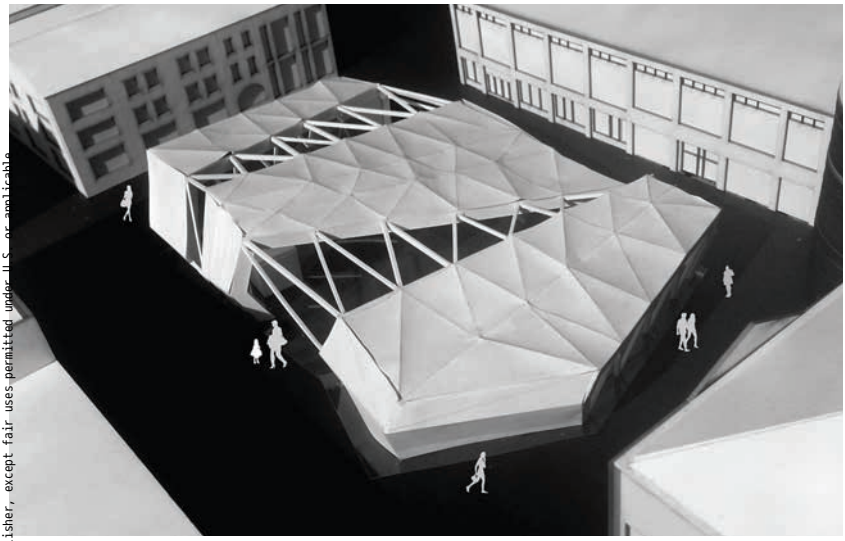
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

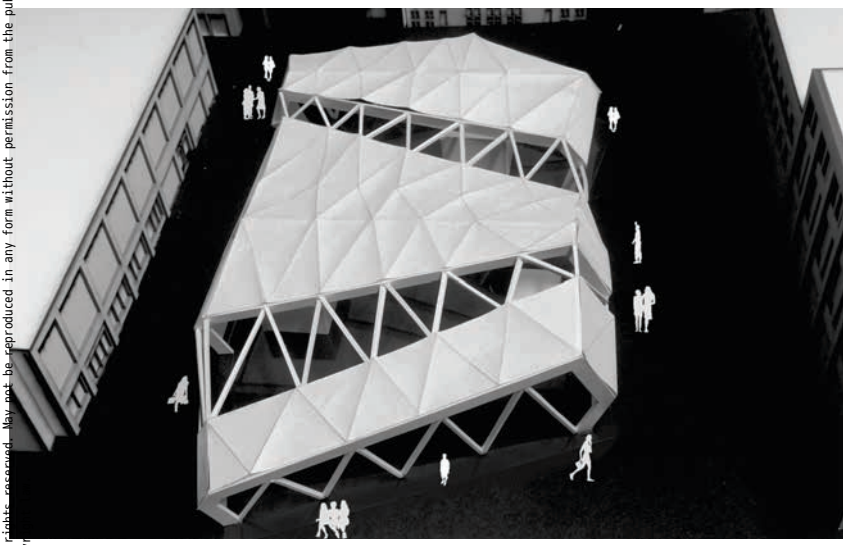


Massing model options in relation to context

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

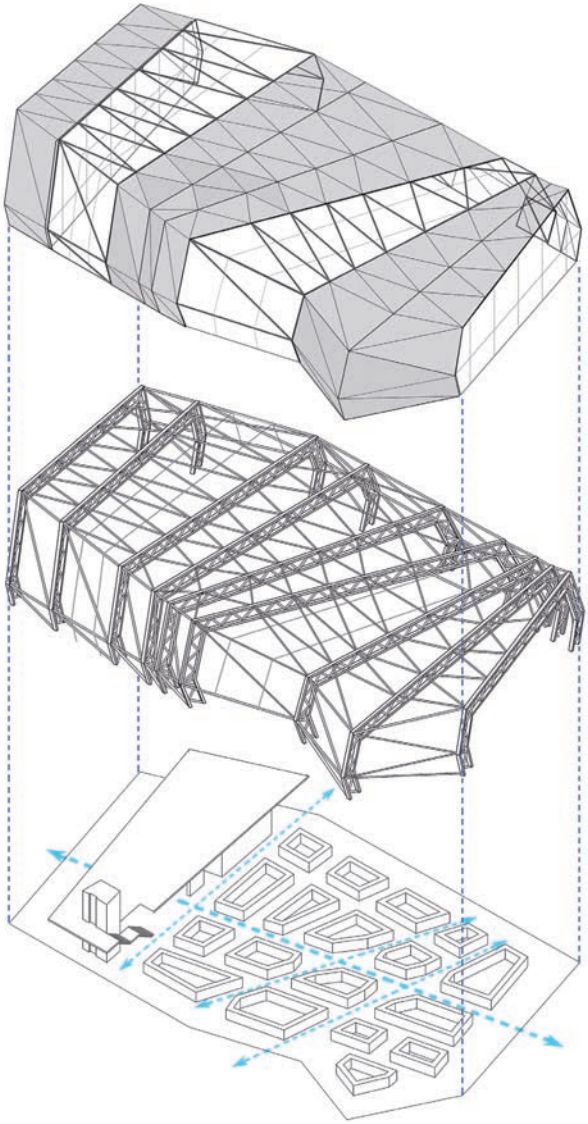
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost





Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



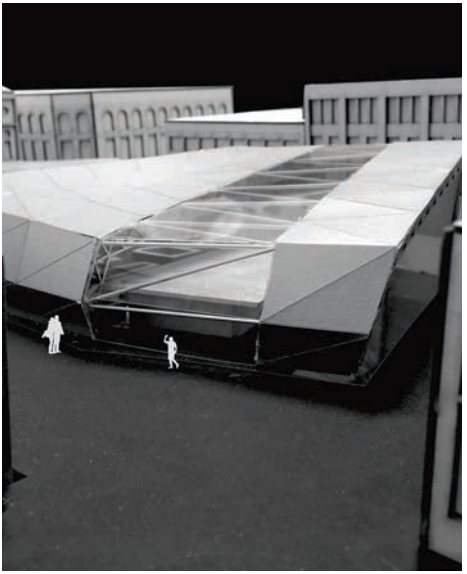
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

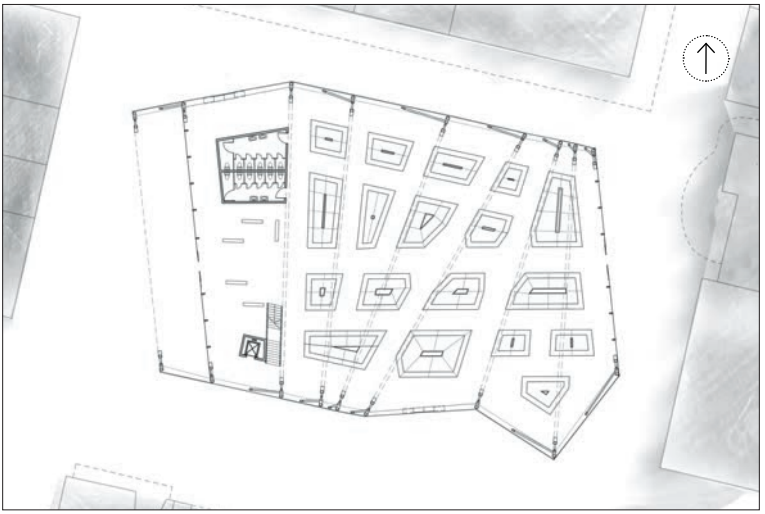
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Opposite: Exploded axonometric – skin, structure and organization

Right: Perspective view

Below: Floor plan, ground floor





Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2016 Laurence King Publishing. All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.: Generative Design
Account: ns254191.main.ehost

6.2 / FACETED LOFT

Analysis: Origami folding techniques; precedent studies of Sancho-Madridejos Architecture Office's Almadanejos Chapel.

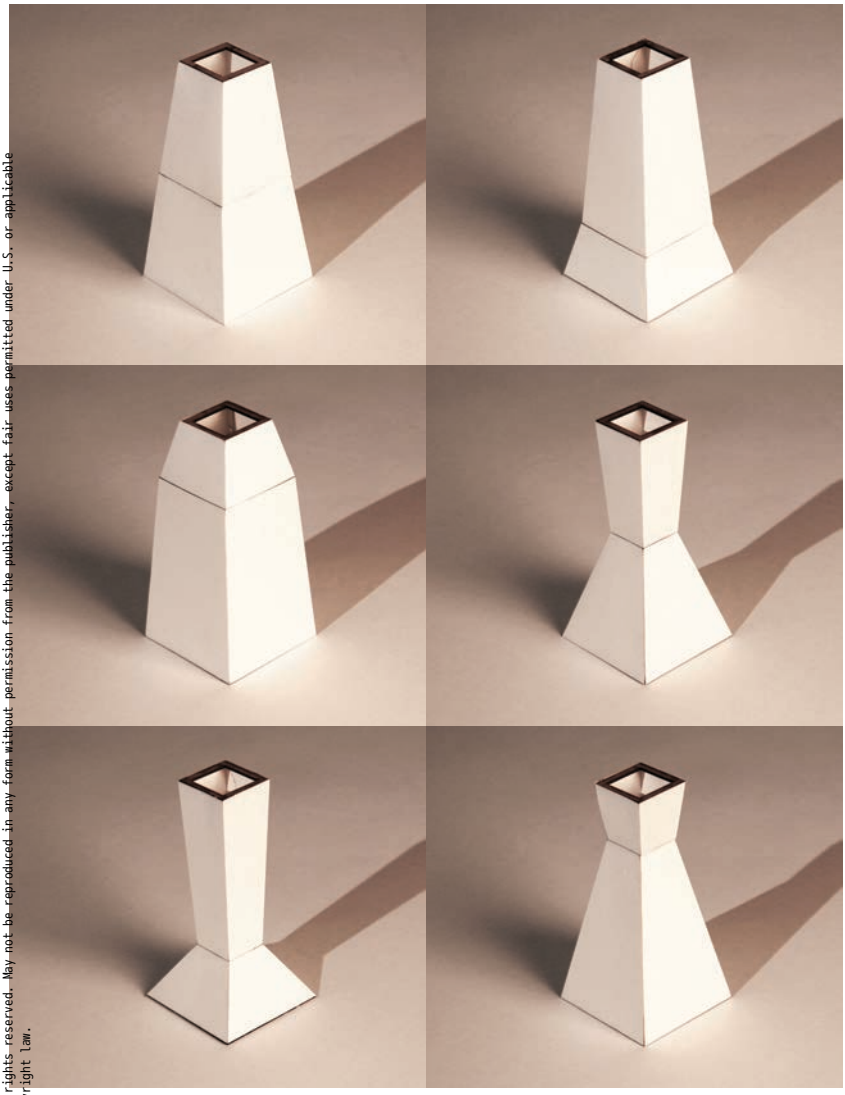
Morphogenesis: The generative system used for this project was composed using three different rectangular profiles, which were joined to create a faceted, 'lofted' surface. By modifying each profile's size and vertical arrangement, a set of iteration studies arose, exploring triangulated skin geometry, massing options and tectonics (see pages 130–39).

Metamorphosis: All the geometrical iterations explored in the first phase were then embedded in the design of an apartment block in the centre of Liverpool. Faceted, prismatic geometries shaped the block's massing, which was designed to provide optimal daylight conditions for all of the apartment units (see pages 140–41). In addition, faceted geometries were used to define the block's roofscape and associate it with its urban context. Finally, the building's envelope was transformed into a faceted skin, with extrusions or intrusions that enabled it to accommodate outdoor activities and terraces (see pages 142–43).

Design study by Yunxia Dai, Emily Gayer, Tobi Griffiths, Michael Hill, Haochen Jia, Sen Lin and Jinhui Zhu

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

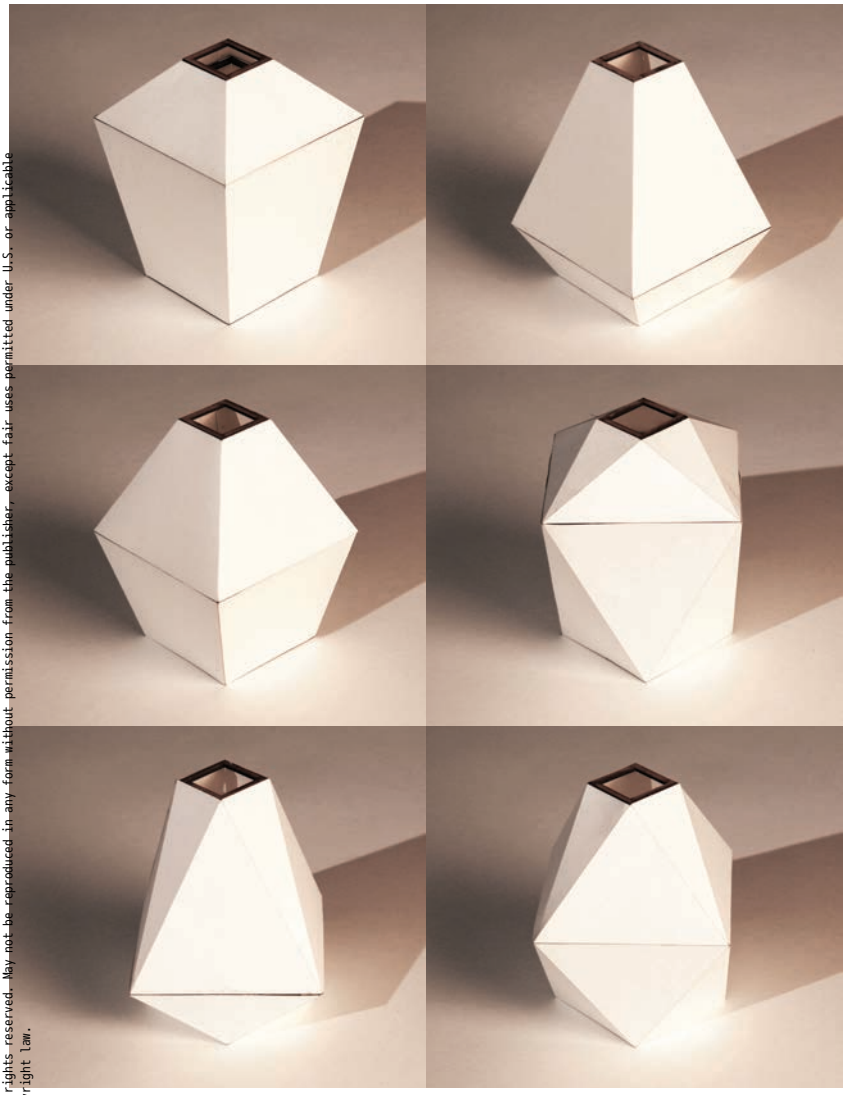
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Faceted, lofted surface iterations

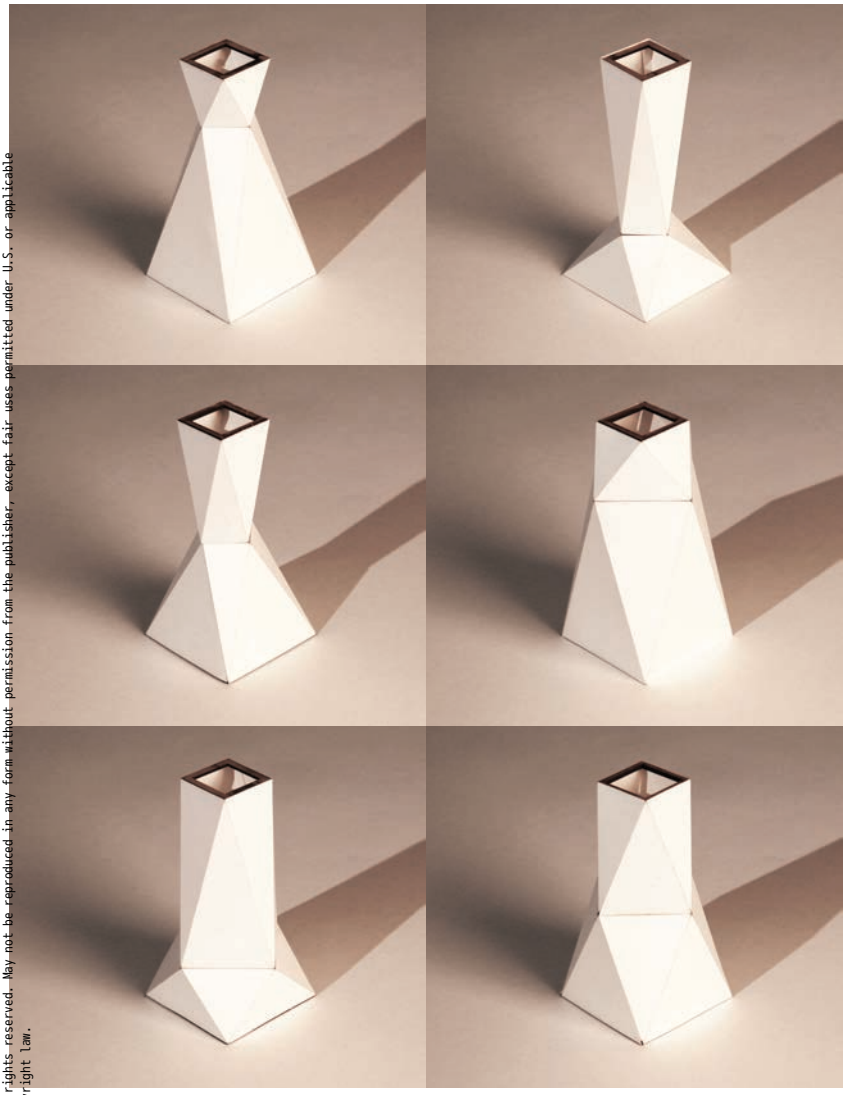
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

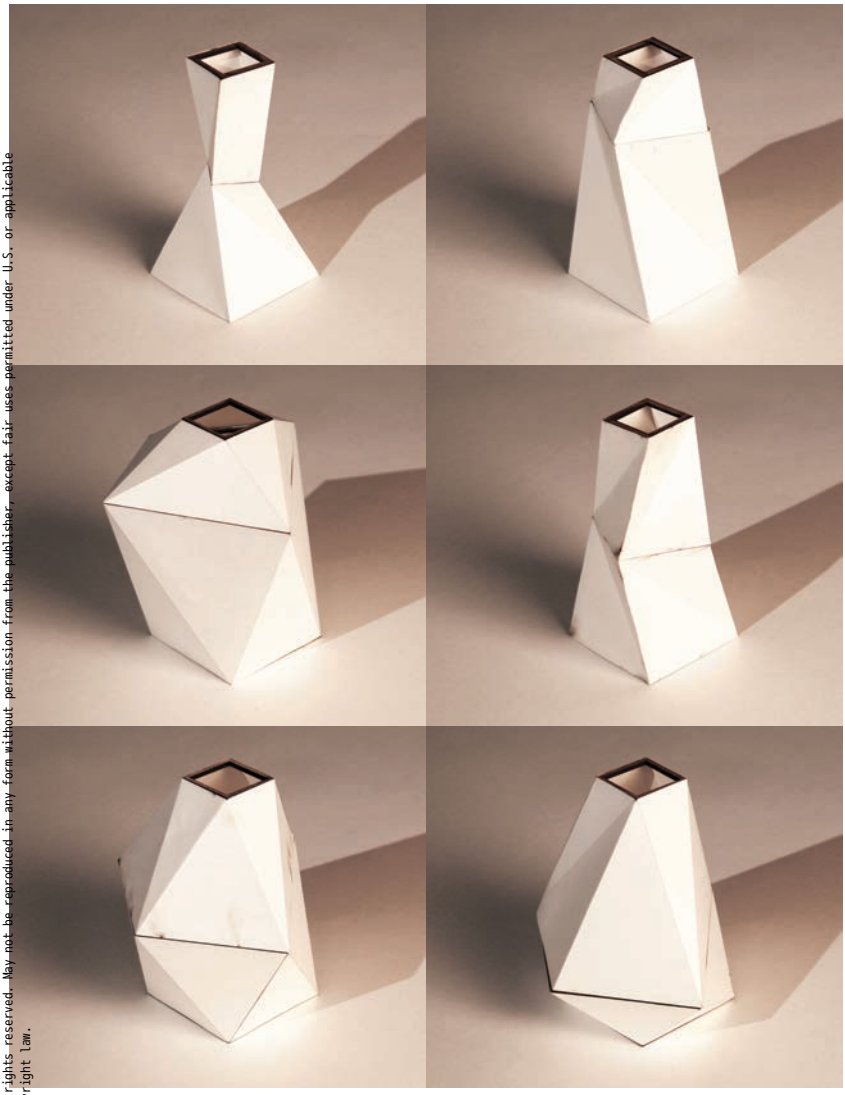
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Faceted, lofted surface iterations

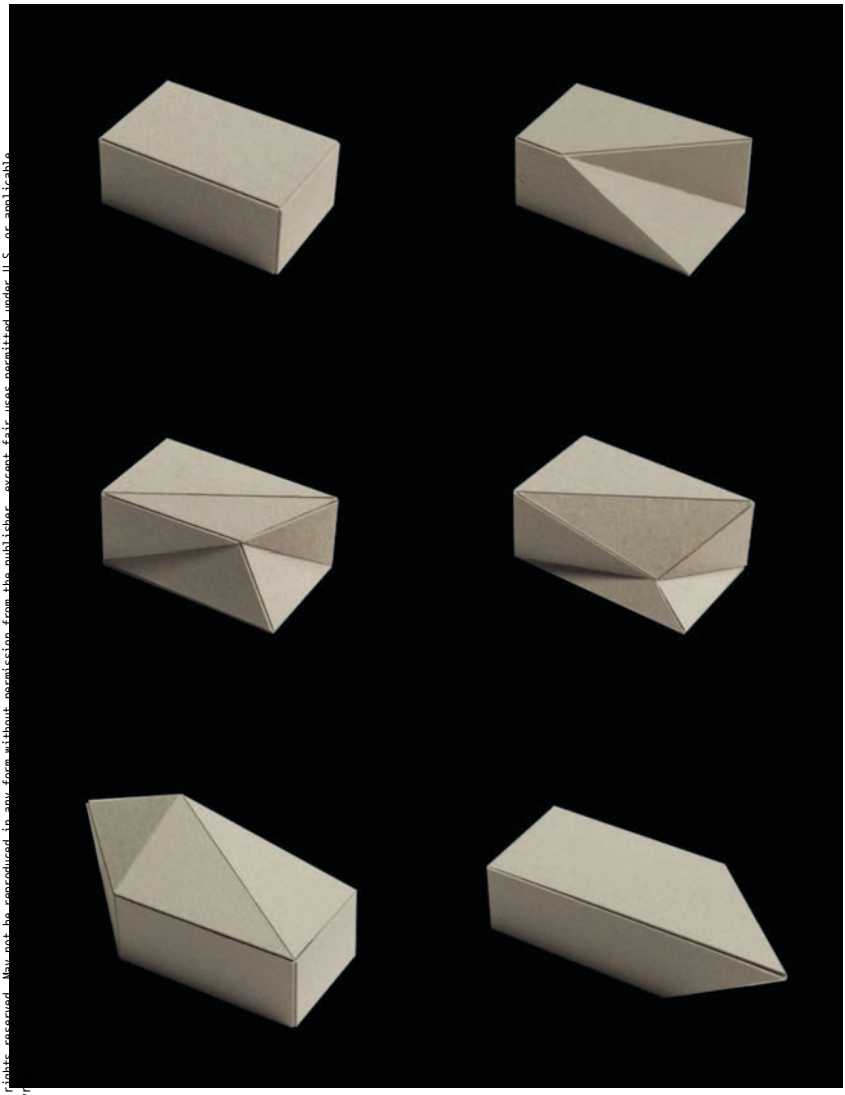
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

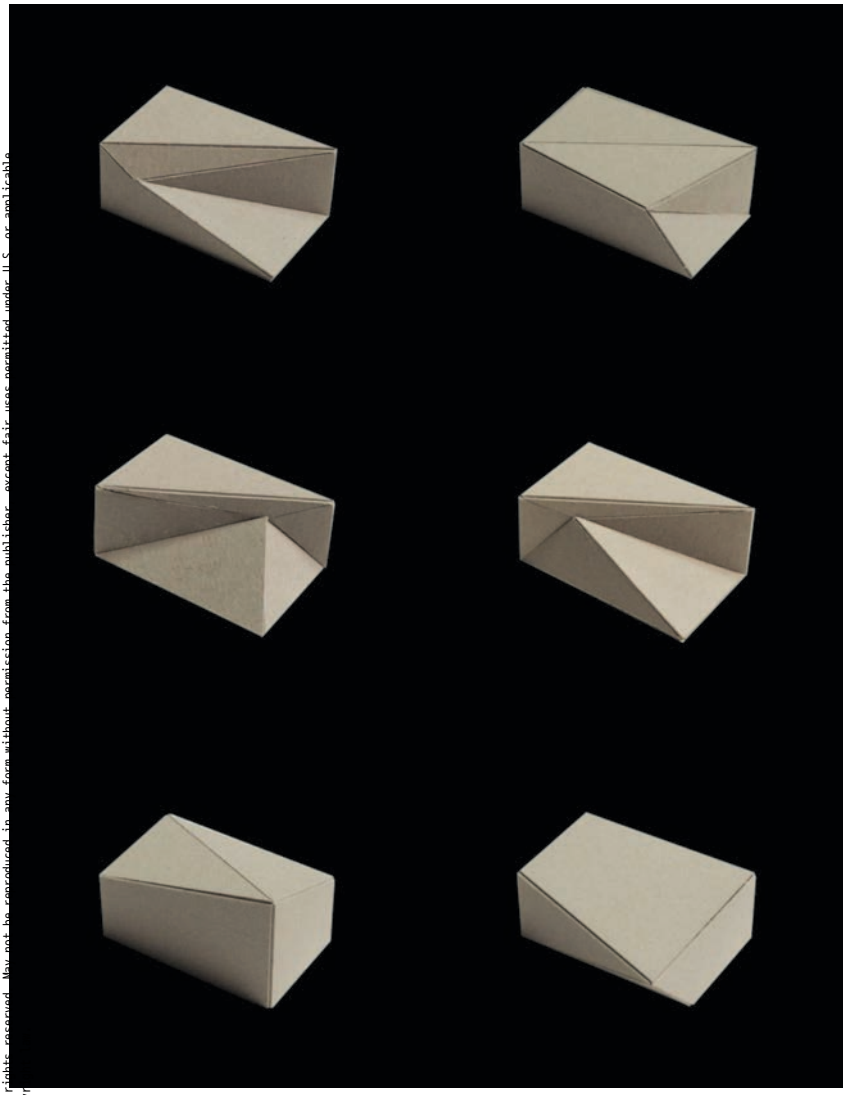
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Deformed box iterations

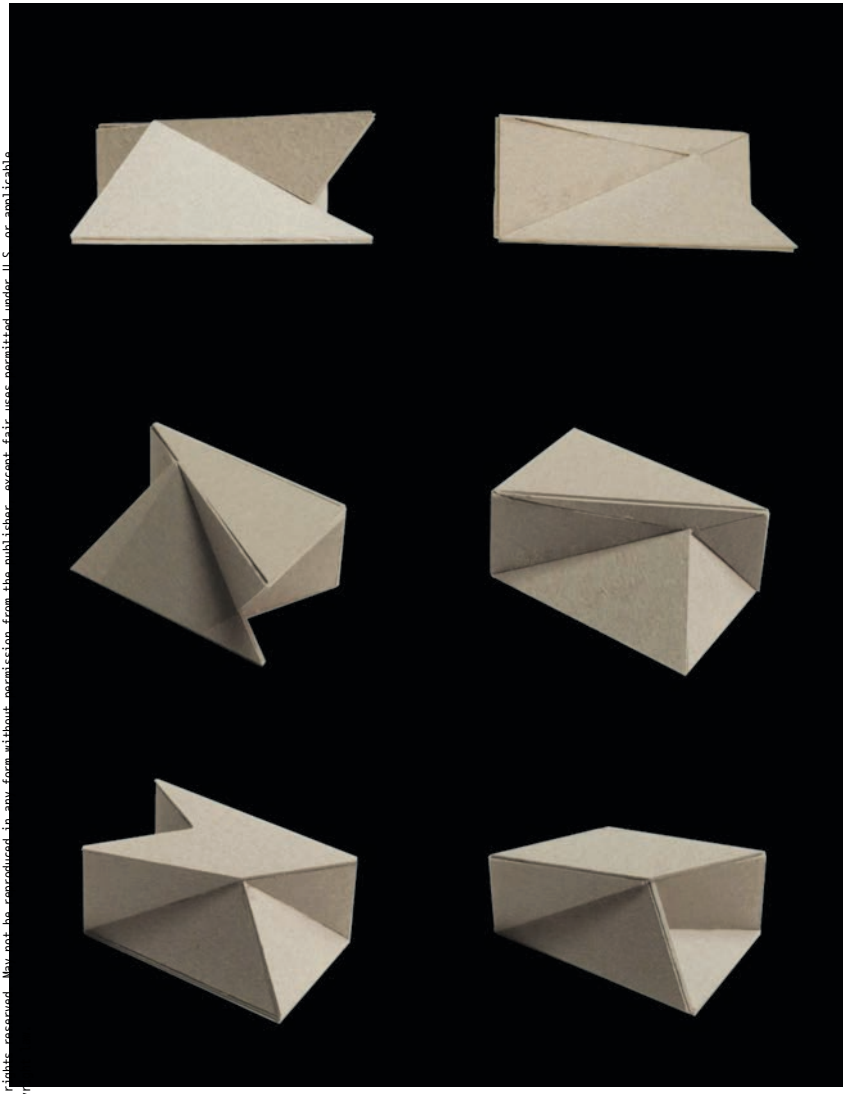
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

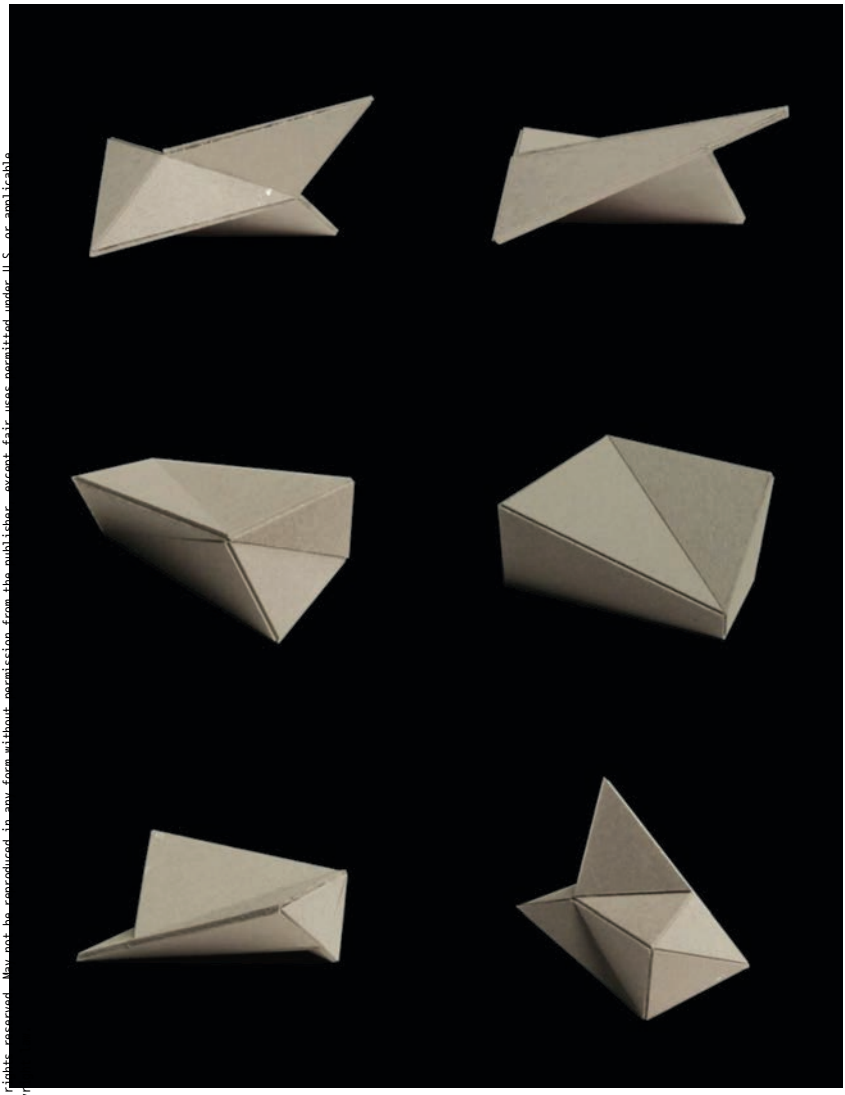
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Deformed box iterations

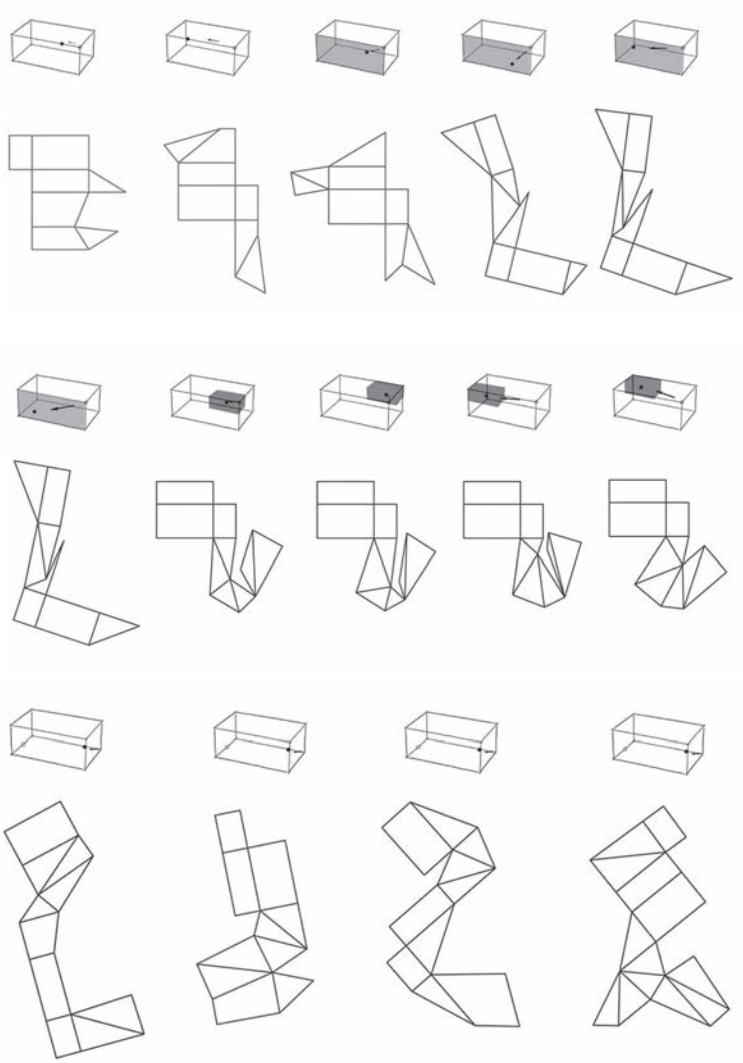
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyr

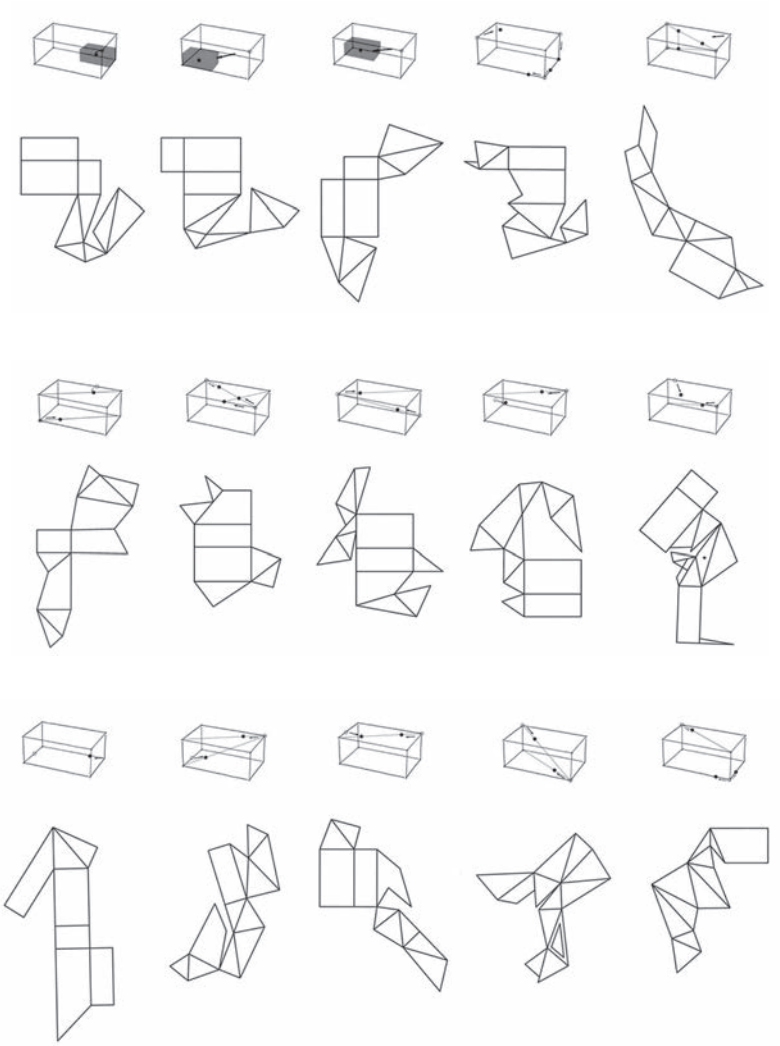
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Unfolded triangulated iterative models

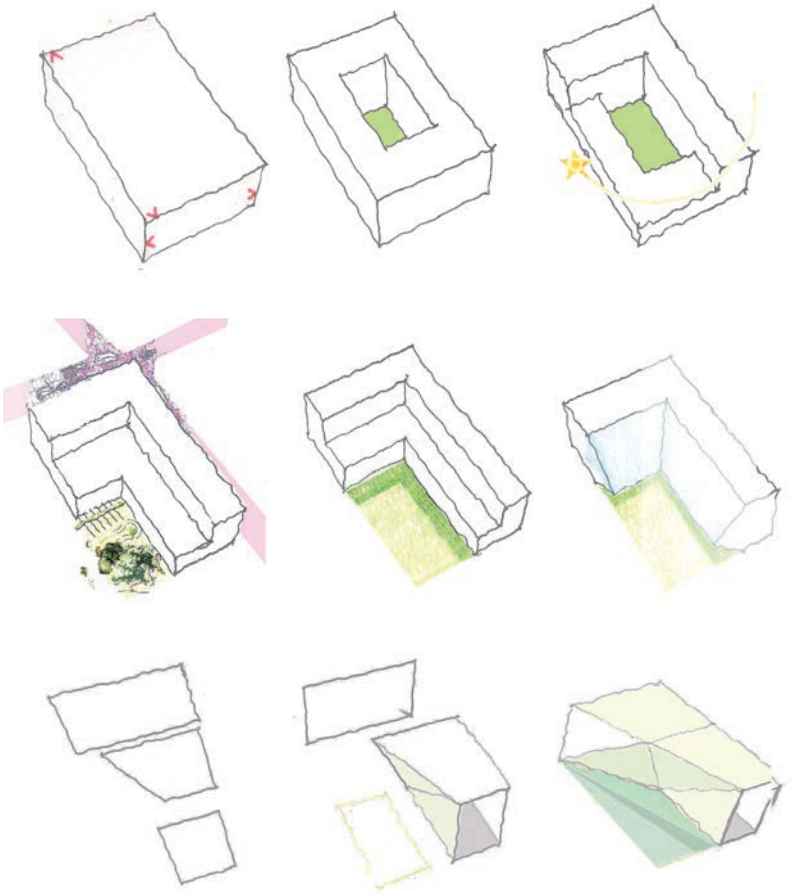
Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

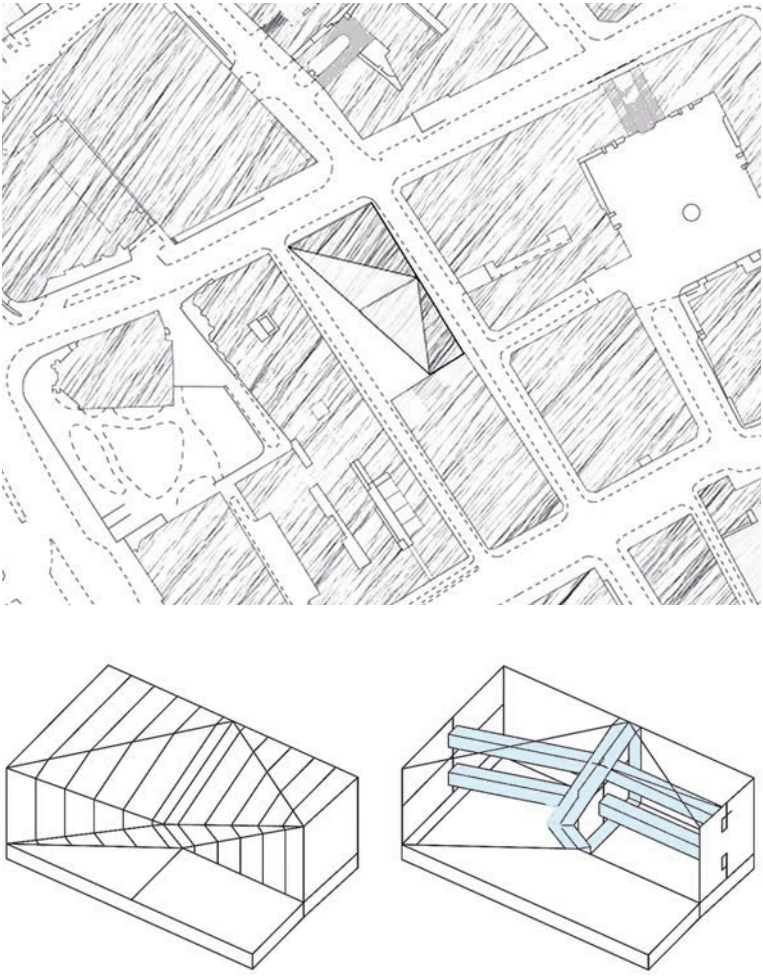
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Apartment block massing
and facetation studies

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

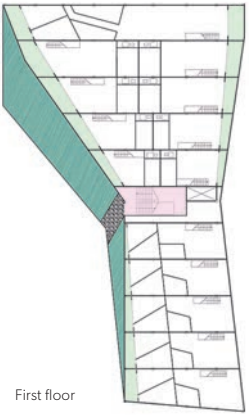


Top: Site plan

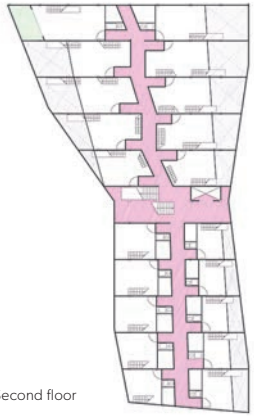
Bottom: Axonometric drawings of unit subdivision and circulation system

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

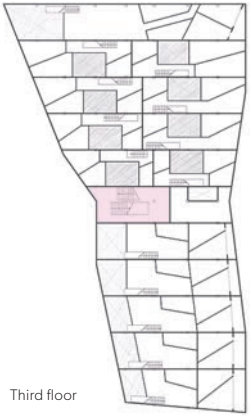
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



First floor



Second floor

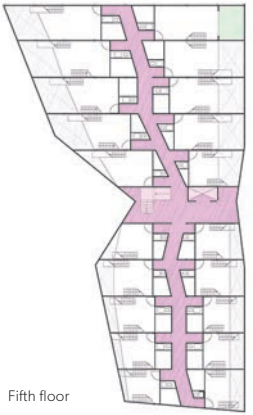


Third floor

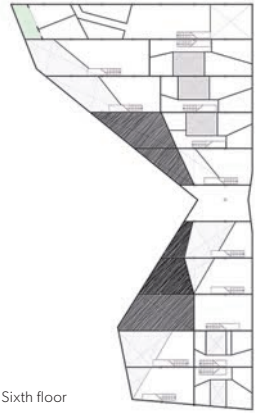
Fourth floor

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

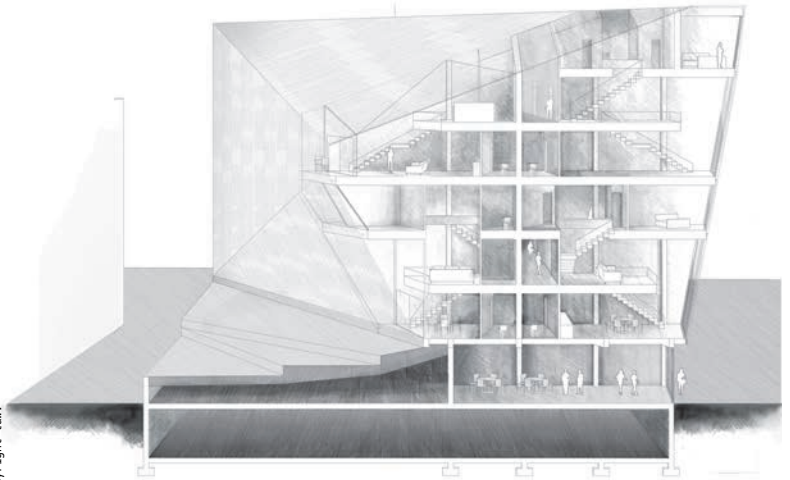
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Fifth floor



Sixth floor

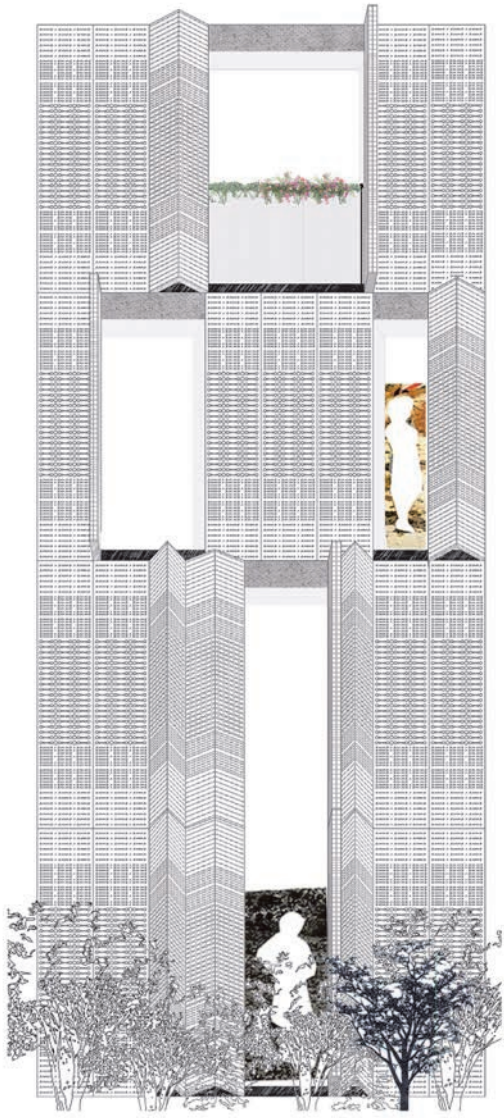


Cross section

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

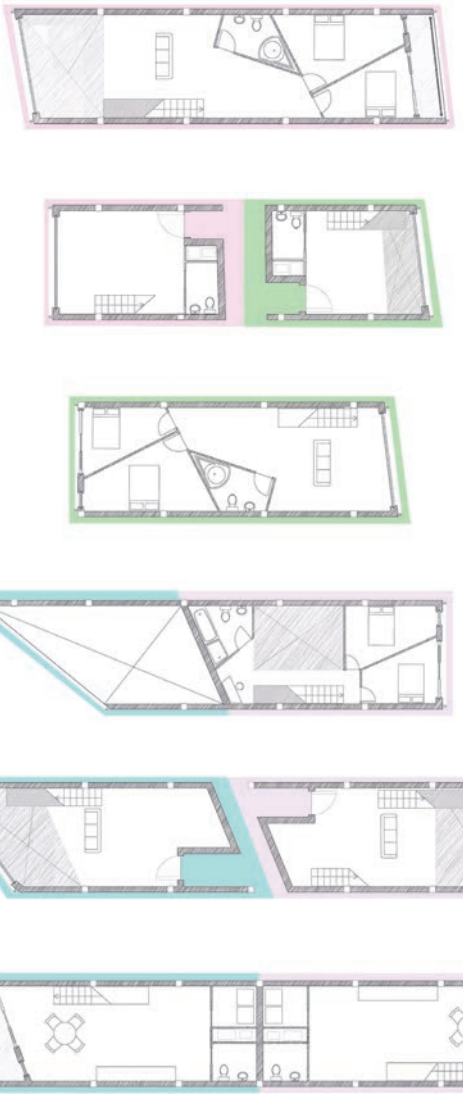
Cladding detail: perforated shading using aluminium skin panels



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Floor plans,
apartment units



Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

CONCLUSION: THE DIGITAL VS PHYSICAL DEBATE

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

7

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

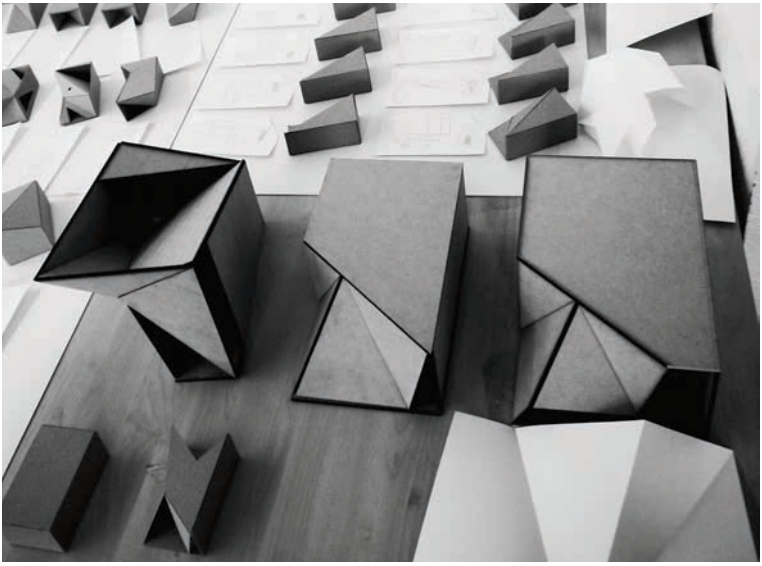
EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

By reviewing the design studies presented here, a set of conclusions and discussion points arises. Many architects and architectural educators are very sceptical about such unconventional design methods, fearing the loss of design control, materiality, craftsmanship, functionality and relationship to context. They tend to blame generative-based design for all the negative aspects of contemporary architecture. However, the design method applied here proves them wrong. It manages to support a high degree of differentiation between the schemes, despite the fact that many of the projects were developed using the same techniques (e.g., triangulation). It also inevitably supports creativity and innovation, which is why so many of the projects managed to move beyond standard building typologies and layouts (e.g., the Porous Space project, page 80). Innovation emerged not only in formal design aspects, but also in terms of building programme and spatial solutions, offering new building-type hybridizations, such as the ferry terminal proposal on pages 108–15. The mix of different design tools and techniques, switching from traditional physical modelling, such as plaster casting, to advanced 3D printing and CNC fabrication, proved to be of great educational value (see pages 82–85). It offered students the opportunity to test materials with their hands, and to experience the advantages, difficulties and opportunities advanced technology has to offer – a design path that is often excluded, due to dogmatism or ignorance of (or lack of respect for) either handcrafting or computerized techniques. Neither banning computers nor abandoning traditional craftsmanship offers a solution for the future of architectural education.

Digital tools can often be seductive for designers. However, while speeding up the design process,

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost



Generative model iterations, LSA final reviews

designing with digital tools makes gravity and materiality disappear. Physical modelling helps designers and students to reconnect with these two key elements, which are so important for architectural production. In addition, the switch between analogue and digital tools allows students to filter out excess complexity within a digitalized design process. By testing digital findings with physical prototypes, they can begin to assess whether a complex solution is really offering spatial, aesthetic or programmatic qualities to a project. The issue is not so much whether CAD and 3D modelling software should be banned or embraced in undergraduate architectural education, but rather to what extend they should be applied, in which educational year and for what purpose. The same principle applies for the use of digital fabrication.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright © 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Generative model iterations, LSA final reviews

It is indeed irrational to apply such techniques to cutting out rectangular panels, but they are more than appropriate for mastering fabrication of complex geometries.

Alongside the loss of materiality and craftsmanship, many critics of generative design methods argue that the resulting architectural proposals are totally detached from their context. This is a criticism often applied to modern architecture as well. During our programme, the degree of integration or non-integration within a context was up to the designer. Building up a relationship between a building and its context can be achieved in many different ways. It can rely on form, materiality or programme, or all of the above. One can choose to harmonize, ignore or break with a building's context, a decision that does not depend on the design approach but on the designer's attitude towards the site. Nevertheless, external examiners overviewing the projects expressed surprise at the high degree of site-specific proposals, despite the unconventional design approach.

All of the finalized projects managed to comply with standards and requirements defined by the accreditation body (RIBA) and the module descriptors, as evident in the drawing and modelling outputs. In that sense, the generative design method applied proved highly appropriate for design education, helping students to develop their skills and self-confidence, and enhancing their future employability.

Looking at the difficulties accompanying such an approach, findings varied. Scepticism from other colleagues and fellow educators was definitely among them. This included guidance from tutors involved in the process as well as criticism from others observing the approach. From a student's point of view, the shift away from

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

conventional design methods certainly appeared to be demanding. That became particularly evident after the completion of the form-finding phase; it was the Metamorphosis that presented the biggest challenges. As liberating and exciting as Morphogenesis might have been for some, abandoning the abstraction of the prototype and transforming it into a building proposal, overcoming obstacles of structure, urban context, planning and materiality seemed to be difficult. Many tended to start from scratch, leaving everything behind and following the conventional approach they were most familiar with. Some chose a brutal landing of their prototype into the site, without developing an attitude towards the context, while others failed to use their prototype for something more than simply trendy decoration.

Another issue that arose using this approach was having to manage the geometrical complexity that occurred. This was often a problem of representation. Complex geometries are easily produced in a digital environment, but controlling and representing their outputs often requires non-standardized methods as well. This can be a consequence of using software incorrectly, or of using inappropriate software for the task required. How can complex geometries be represented in floor plan, section and elevation? How can such geometries be built in a physical model?

This is when guidance is needed. Tutors play a critical role here. Educators need to guide students and enrich academic curricula with new design methods and tutored skills. But it is the student culture that plays an even more important role: the intercourse that occurs between students, either through daily procedures and presentations or through social media, websites and online forums. Today's young designers belong

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

to a generation that has grown up with smartphones and computer tablets instead of crayons and paper, granting them familiarity with digital technologies from an early age. These are designers, therefore, who are more than able to deal with unconventional design methods, and who will hopefully revolutionize architectural production in the future.

Generative model iterations, LSA final reviews

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

BIBLIOGRAPHY

Cappellato, G. *Mario Botta, Light and Gravity: Architecture 1993–2003*. Munich: Prestel, 2004.

Chilton, J. *Heinz Isler (Engineer's Contribution to Architecture)*. London: Thomas Telford, 2000.

Eisenman, P. *Eisenman Inside Out: Selected Writings 1963–1988 (Theoretical Perspectives in Architectural History & Criticism)*. New Haven: Yale University Press, 2004.

Frampton, K. *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*. Boston: MIT Press, 2001.

Haeckel, E. *Kunstformen der Natur*. 1904. Reprint, Wiesbaden: Marix Verlag, 2004.

Hensel, M., A. Menges and M. Weinstock. *Techniques and Technologies in Morphogenetic Design*. London: Wiley & Sons, 2006.

Jormakka, K. *Basics: Methoden der Formfindung*. Basel: Birkhäuser, 2007.

Khan-Magomedov, S. O. *Pioneers of Soviet Architecture: The Search for New Solutions in the 1920s and 1930s*. New York: Rizzoli, 1987.

Kolarevic, B. 'Digital Production.' In *Architecture in the Digital Age: Design and Manufacturing*, 46–48. London: Taylor & Francis, 2003.

Lazzeroni, C. (ed.), H. Bohnacker, B. Groß and J. Laub. *Generative Gestaltung: Entwerfen. Programmieren. Visualisieren. Mit internationalen Best-Practise-Beispielen, Grundlagen, Programmcodes und Ergebnissen*. Mainz: Schmidt Hermann, 2009.

Le Corbusier. *The Modulor*. 1948. Reprint, Basel: Birkhäuser, 2000.

Lynn, G. *Animate Form*. Princeton: Princeton Architectural Press, 1999.

Menocal, N. G., and R. Twombly. *Louis Sullivan: The Poetry of Architecture*. New York: W. W. Norton & Company, 2000.

Otto, F., and B. Rasch. *Finding Form: Towards an Architecture of the Minimal*. Stuttgart: Axel Menges, 1996.

Oxman, Rivka, and Richard Oxman. *Theories of the Digital in Architecture*. London: Routledge, 2013.

Soddu, C. 'The Design of Morphogenesis. An experimental research about the logical procedures in design processes.' *Demetra Magazine*, vol. 1, 1994.

Turnbull, J. *Toyo Ito: Generative Order (Kassler Lecturers)*. Princeton: Princeton Architectural Press, 2012.

Ungers, O. M. *O. M. Ungers: Morphologie/City Metaphors*. Manchester: Cornerhouse, 2011.

Van Berkel, B., and C. Bos (UNStudio). *Move: Imagination/Techniques/Effects*. 3-volume set. Amsterdam: Groose Press, 1999.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

INDEX

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

Page numbers in *italics* indicate illustrations

Adami, Nojan: design studies 80, *81–89*, *92*, 93, *94–99*
Agkathidis, Asterios: generative design method 19, *19*
algorithmic patterning 20
algorithms 8, 14, 15, 16, *16*, 20, 93
  genetic 17
  grid deformation 93, *94*
  point attractor 93, *94*
  tessellation 93, *95*, *97*
  Voronoi pattern 100, *101–15*
  weaving 93, *95*
Almadanejos Chapel, Spain (Sancho-Madridejos Architecture Office) 129
aluminium cladding *144*
analysis 19, *19*, 20
attractor points 93, *94*

Bailey, Sean: design study 72, *73–79*
Ban, Shigeru: Centre Pompidou-Metz, Metz 25
Barker, David: design study 72, *73–79*
Barkow (Frank) Leibinger (Regine): Campus Restaurant, Stuttgart 100
Behnisch, Günther *see* Otto, Frei
Berlage, Hendrik: Jellyfish chandelier 10
Berlin: Lützowplatz housing complex (Ungers) 12
Biocentrum, Frankfurt (Eisenman) 14
blob architecture 15
Botta, Mario 12
  house, Ligornetto 12
Broni, Italy: secondary school (Rossi) 12
Brookshouse, Charlotte: design study 58, *59–69*
Brussels: Philips Pavilion (Le Corbusier) 11

Calatrava, Santiago: City of Arts and Sciences, Valencia 10
Candela, Félix: Lomas de Cuernavaca Chapel, Mexico 30
Centre Pompidou-Metz, Metz, France (Ban) 25
Chen, Jianxuan: design study *24*, 25, *26–29*
Chen, Shimou: design study 58, *59–69*
Chen, Xu: design study 30, *31–37*
Chicago: Unity Temple (Wright) 11
cladding 58, *66*, *67*, *144*
concrete casting 80
concrete shells *see* Double-Curved Shells (project)
context-driven design processes 12
Corbusier, Le (Charles-Edouard Jeanneret-Gris)
  Modulor 11
  Notre Dame du Haut Chapel, Ronchamp 11, *11*
  Philips Pavilion, Brussels 11
  Unité d'Habitation, Marseilles 49
Correa, Charles: Kanchanjunga apartment tower 49
Crookston, James: design study 58, *59–69*
Cuernavaca, Mexico: Lomas de Cuernavaca Chapel (Candela) 30

Dai, Yunxia: design study *128*, 129, *130–45*
deformed box iterations *134–37*
Derrida, Jacques: Deconstruction theory 14
Double-Curved Shells (project) 30, *31–37*
double-curved surface iterative models 38, *40–41*
Dresden: New Synagogue (Wandel Hoefer Lorch & Hirsch) 72

Eisenman, Peter 14
  Biocentrum, Frankfurt 14
  Nunotani Corporation headquarters, Tokyo 14, *15*
  Rebstockbad, Frankfurt 15
Endless House (Kiesler) 10, 80

Faceted Loft (project) *128*, 129, *130–45*
faceting 20
form-finding techniques 8, 9
Frankfurt
  Biocentrum (Eisenman) 14
  Rebstockbad (Eisenman) 15
Fu, Jinglei: design studies 38, *39–45*, *48*, 49, *50–57*

Gao, Liant: design study 100, *101–15*
Gao, Yiwei: design study 100, *101–15*
Gayer, Emily: design study *128*, 129, *130–45*
generative design 8, 14–18
generative model iterations *149*, *150*, *153*
geometric design processes 11
geometries
  curvilinear 17
  topological 17
Grasshopper 14, 93
grid deformation algorithms 93, *94*
Griffiths, Tobi: design study *128*, 129, *130–45*
Gu, Xiao: design study *48*, 49, *50–57*
Guimard, Hector: Paris Métro entrances 10, *11*

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

INDEX

Haeckel, Ernst: *Kunstformen der Natur* 10
Haus Duldeck, Dornach, Switzerand (Steiner) 10
Hensel, Michael 17
Hill, Michael: design study *128*, 129, *130–45*
historicist architecture 10
Huang, Minhui: design study 58, *59–69*
Hyper Paraboloids (project) 38, *39–45*
hyperboloid diagrid structures 13

ICD/ITKE Research Pavilion, Stuttgart (Mengese) 10
Imtiaz, Aqsa: design study 38, *39–45*
Interlocking Units (project) *48*, 49, *50–57*
Irregular Units (project) 58, *59–69*
Isler, Heinz: Wyss Garden Centre, Solothurn, Switzerland 13
Ito, Toyo 18
  Kakamigahara Crematorium 30
  Serpentine Gallery Pavilion, London 18, *18*, 93

Jia, Haochen: design study *128*, 129, *130–45*
Jia, Man: design study 100, *101–15*

Kakamigahara, Japan: Crematorium (Ito) 30
Kanchanjunga apartment tower (Correa) 49
Kazakova, Nadezda: design study 38, *39–45*
Kiesler, Frederick 9
  Endless House 10, 80
Kolarevic, Branko 16–17
Kurokawa, Kisho: Metabolist projects 58
Kyratsous, Lazaros: design study 58, *59–69*

Lazzeroni, C., et al.: *Generative Gestaltung* 16
Li, Jingchang: design study 100, *101–15*
Ligornetto, Switzerland: house (Botta) 12
Lin, Sen: design study *128*, 129, *130–45*
Liu, Yuedi: design studies *48*, 49, *50–57*, *118*, *119–27*
Liverpool, University of: Studio 04 19–21
London: Serpentine Gallery Pavilion (Ito) 18, *18*, 93
Lu, Xiao: design study 100, *101–15*
Lu, Xuerui: design study 38, *39–45*
Lützowplatz housing complex, Berlin (Ungers) 12
Lynn, Greg 15

Marseilles: Unité d'Habitation (Le Corbusier) 49
massing *54*, 58, *64*, 72, *76*, *86*, 93, *96*, 129, *140*
Mengese, Achim: ICD/ITKE Research Pavilion, Stuttgart 10
mesh *see* Soft Mesh (project)
metamorphosis 19, *19*, 20, 152
Metz, France: Centre Pompidou-Metz (Ban) 25
modernism 11
Modulor (Le Corbusier) 11
morphing images 14
morphogenesis, digital 16–17, 19, *19*, 20, 152
morphology, architectural 12, 17
Moscow: Shukhov Tower (Shukhov) 13, *13*, 38
Munich Olympic Stadium (Otto and Behnisch) 13, *13*

nature-driven architecture 10
New York: TWA Terminal (Saarinen) 10, 80
Nizhny Novgorod: tower (Shukhov) 12–13
Notre Dame du Haut Chapel, Ronchamp (Le Corbusier) 11, *11*
Nunotani Corporation headquarters, Tokyo (Eisenman) 14, *15*
NURBS (non-uniform rational basis splines) 15, 25

origami folding techniques 129
Otto, Frei 9
  Munich Olympic Stadium (with Behnisch) 13, *13*
Oxman, Rivka and Robert 17

paraboloids *see* Hyper Paraboloids (project)
parametric design 8, 15, 17
Paris: Métro entrances (Guimard) 10, *11*
Penrose Pattern, 3D (project) 118, *119–27*
Penrose tiling 118, *120*
performance analysis 17
performance-driven design processes 12–13
Philips Pavilion, Brussels (Le Corbusier) 11
plaster models, using 80, *81–83*, 148
point attractor algorithms 93, *94*
Porous Space (project) 80, *81–89*, 148
postmodernism 12
Processing 14
proto-tectonic structures 20
PTFE foil 25, 100, *112–13*

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Qi, Xiao: design study 38, *39–45*
Qi, Yuhui: design study 30, *31–37*
quadrature 11

Rhinoceros 14, 80, 93
Ronchamp, France: Notre Dame du Haut Chapel (Le Corbusier) 11, *11*
Rossi, Aldo 12
  Broni secondary school 12
  La Conica coffee pot 12
  Teatro del Mondo, Venice 12

Saarinen, Eero: TWA Terminal 10, 80
Sancho-Madridejos Architecture Office: Almadanejos Chapel, Spain 129
scripting 14, 15
shells, concrete 13
  see Double-curved Shells (project)
Shukhov, Vladimir 13
  Shukhov Tower, Moscow 13, *13*, 38
  tower, Nizhny Novgorod 12–13
Soddu, Celestino 16
Soft Mesh (project) *24*, 25, *26–29*
Solothurn, Switzerland: Wyss Garden Centre (Isler) 13
splines 15
steel frame structures *see* 3D Penrose Pattern (project)
Steiner, Rudolf: Haus Duldeck, Dornach, Switzerland 10
Stuttgart
  Campus Restaurant (Barkow Leibinger) 100
  ICD/ITKE Research Pavilion (Mengese) 10
Sullivan, Louis 11
surface continuity 20

T-Splines 80, *87*
Tessellated Planes (project) *92*, 93, *94–99*
tessellation algorithms 93, *95*, *97*
3D Penrose Pattern (project) 118, *119–27*
3D-printed models 80, *84–85*, 148
timber frame structures *see* Voronoi Surface (project)
timber mesh *see* Soft Mesh (project)
Tokyo: Nunotani Corporation headquarters (Eisenman) 14, *15*
triangulation 11, 118, *120*, 129, *138–39*, 148
TWA Terminal, New York (Saarinen) 10, 80
Twisted Block (project) 72, *73–79*
twisting techniques 72, *74–75*
typological elements 12

Ungers, Oswald Mathias 12
  Lützowplatz housing complex, Berlin 12
unit accumulation 20
  Interlocking Units (project) *48*, 49, *50–57*
  Irregular Units (project) 58, *59–69*
Unité d'Habitation, Marseilles (Le Corbusier) 49
Unity Temple, Chicago (Wright) 11
UNstudio: 'Manimal' 14

Valencia: City of Arts and Sciences (Calatrava) 10
Venice: Teatro del Mondo (Rossi) 12
volume deformation 20
volume subtraction 20
Voronoi pattern 30, *34*, 100, *101–108*
Voronoi Surface (project) 100, *101–15*

Wandel Hoefer Lorch & Hirsch: New Synagogue, Dresden 72
Wang, Longfei: design study 58, *59–69*
weaving algorithms 93, *95*
Whitmore, Amy: design study 38, *39–45*
Wright, Frank Lloyd: Unity Temple, Chicago 11

Yang, Nan: design study 58, *59–69*
Yang, Peiyu: design study 30, *31–37*
Yang, Yangting: design study *48*, 49, *50–57*
Yang, Yaoting: design study 118, *119–27*

Zhai, Yuan: design studies 30, *31–37*, 58, *59–69*
Zhang, Ruinan: design study 30, *31–37*
Zhang, Wenxuan: design study *48*, 49, *50–57*
Zhang, Yihan: design study 100, *101–15*
Zhao, Yiqiang: design study 80, *81–89*
Zhu, Jinhui: design study *128*, 129, *130–45*
Zhu, Zhenyu: design study 80, *81–89*

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

PICTURE CREDITS

Except where otherwise noted, all photographs
© Liverpool School of Architecture, 2015.
All rights reserved.

Cover	Yiwei Gao, Man Jia, Xiao Lu, Yihan Zhang
6–7	Haoming Wang, Jingya Wu, Pengcheng Yao, Jiaxin Zhao
11	(Left) © Paul M.R. Maeyaert (Right) Asterios Agkathidis; © FLC / ADAGP, Paris and DACS, London 2015
13	(Left) © Heritage Image Partnership Ltd / Alamy (Right) Asterios Agkathidis
15	© Vito Arcomano / Alamy
18	© VIEW Pictures Ltd / Alamy
22–23	Asterios Agkathidis
24, 26–29	Jianxuan Chen
31	Yuan Zhai
32–33	Xu Chen, Yuhui Qi, Peiyu Yang, Ruinan Zhang
34–37	Yuan Zhai
39–41	Jinglei Fu, Xiao Qi
42–43	Aqsa Imtiaz, Nadezda Kazakova, Xuerui Lu, Amy Whitmore
44–45	Nadezda Kazakova
46–47	Shimou Chen, Minhui Huang, Longfei Wang, Nan Yang, Yuan Zhai
48, 50–53	Xiao Gu, Yuedi Liu, Yangting Yang, Jinglei Fu, Wenxuan Zhang
54–57	Yuedi Liu
59–61	Shimou Chen, Longfei Wang, Nan Yang, Yuan Zhai
62–63	Charlotte Brookshouse, James Crookston, Minhui Huang, Lazaros Kyratsous
64–69	Yuan Zhai
70–71	Asterios Agkathidis
73	Sean Bailey
74	Asterios Agkathidis
75	David Barker, Sean Bailey
76–79	Sean Bailey
81	Yiqiang Zhao
82–85	Asterios Agkathidis
86–89	Yiqiang Zhao
90–91	Andrew Kent, Jiawei Liu, Boya Zhang
92, 94–99	Nojan Adami
101	Yiwei Gao, Man Jia, Xiao Lu, Yihan Zhang
102–3	Liang Gao, Jingchang Li
104–7	Yiwei Gao, Man Jia, Xiao Lu, Yihan Zhang
108–15	Man Jia
116–17	Haoming Wang, Jingya Wu, Pengcheng Yao, Jiaxin Zhao
119–21	Yuedi Liu, Yaoting Yang
122–27	Yuedi Liu
128	Emily Gayer, Tobi Griffiths, Michael Hill
130–33	Emily Gayer, Tobi Griffiths, Michael Hill
134–39	Yunxia Dai, Haochen Jia, Sen Lin, Jinhui Zhu
140–45	Emily Gayer
146–47	Asterios Agkathidis
149–50	Asterios Agkathidis
153, 160	Asterios Agkathidis

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

ACKNOWLEDGEMENTS

My grateful acknowledgements go to the Studio 04 tutors Richard Dod, Joanne Hudson, Mathew Wells, Howard Miller and Jane Moscardini for their enthusiasm and hard work, as well as the workshop team of Stuart Carroll, Michael Baldwin, Stephen Bretland and Aleksandar Kokai at the Liverpool School of Architecture.

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost

Copyright @ 2015. Laurence King Publishing.
All rights reserved. May not be reproduced in any form without permission from the publisher, except fair uses permitted under U.S. or applicable copyright law.

EBSCO : eBook Collection (EBSCOhost) - printed on 10/31/2018 7:14 AM via PILLAI COLLEGE OF ARCHITECTURE
AN: 1234837 ; Agkathidis, Asterios.; Generative Design
Account: ns254191.main.ehost