

SpringerBriefs in Applied Sciences and Technology

PoliMI SpringerBriefs

Editorial Board

Barbara Pernici, Milano, Italy

Stefano Della Torre, Milano, Italy

Bianca M. Colosimo, Milano, Italy

Tiziano Faravelli, Milano, Italy

Roberto Paolucci, Milano, Italy

Silvia Piardi, Milano, Italy

More information about this series at <http://www.springer.com/series/11159>
<http://www.polimi.it>

Roberto Naboni · Ingrid Paoletti

Advanced Customization in Architectural Design and Construction



POLITECNICO
DI MILANO

 Springer

Roberto Naboni
Ingrid Paoletti
ABC - Department of Architecture, Built
Environment and Construction
Engineering
Polytechnic University of Milan
Milan
Italy

ISSN 2282-2577

ISSN 2282-2585 (electronic)

ISBN 978-3-319-04422-4

ISBN 978-3-319-04423-1 (eBook)

DOI 10.1007/978-3-319-04423-1

Library of Congress Control Number: 2014953239

Springer Cham Heidelberg New York Dordrecht London

© The Author(s) 2015

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Acknowledgments

We would like to express our gratitude to all the people who provided support, valuable suggestions and constructive critiques, to all those who assisted in the writing, proofreading and editing of this book.

Above all we want to thank Maia Zheliazkova and Mariela Tsopanova for the generous help and fundamental contribution in each aspect of this publication, and their full involvement, which made this work possible.

We express our appreciation to Beatrice Buffa and Valeria Marsaglia for the help provided in the process of selection, organization, and analysis of the case studies.

Special thanks to Michael Iannaco for his support in proofreading the book.

We are grateful to all the people, companies, and research institutions who provided us with valuable information and enriched the contents listed in the Illustration Index. In particular to: Arup, Crawford Architects, dECOi, Enrico Dini, DUS Architects, Jelle Feringa, Fletcher Priest Architects, Massimiliano and Doriana Fuksas, Gehry Partners, Gramazio & Kohler, Michael Hansmeyer & Benjamin Dillenburger, Institute for Advanced Architecture of Catalonia (IAAC), Institute of Computational Design (ICD), Institute for Building Construction and Structural Design (ITKE), Amar Kalo, Berok Khoshnevis, Joris Laarman Lab, Parke MacDowell, Matter Design, Nemesi & Partners, Permasteelisa Group, Brian Peters, PROJECTiONE, Rojkind Arquitectos, RVTR, Asbjørn Søndergaard, Styl-Comp Group, Trahan Architects.

We would like to acknowledge the support of Department of Architecture, Built Environment and Construction Engineering of Politecnico di Milano, and particularly to the colleagues and students collaborating in our research unit, ACT Lab, who inspired the ideas of this books with daily stimulations.

Last but not the least, we want to dedicate this book to our families, that have been a constant source of unconditional love and care, support and strength.

Contents

1	Introduction	1
1.1	General	1
1.2	Towards an Intelligent Industrial Prefabrication	2
1.3	Shifting to a Process Strategy	3
1.4	New Methods of Collaboration	4
	References	5
2	The Third Industrial Revolution	7
2.1	Digital Fabrication in Architecture	7
2.2	From Numeric Control to Connecting Bits and Atoms	9
2.3	How to Make (Almost) Anything in a Fab Lab	11
2.4	Peer Production and Fabrication Democracy	14
2.5	The Third Industrial Revolution	16
2.6	Building with Fab Lab	18
2.7	A Network of Production—Fab City Barcelona	19
2.8	Open-Source Architecture	21
2.9	WikiHouse Project	23
	References	25
3	Advanced Machinery	29
3.1	General	29
3.2	CNC Machinery	31
3.2.1	Origins of CNC	31
3.2.2	Computer Aided Manufacturing	32
3.2.3	Subtractive Processes	34
3.2.4	Formative Processes	37

3.3	Robotic Fabrication	40
3.3.1	Evolution of Robotic Arms	40
3.3.2	Robotic Fabrication in Architecture	42
3.3.3	From Component Customization to Tailored Fabrication	43
3.3.4	Robotic Assembly	44
3.3.5	Robotic Formative Processes	48
3.3.6	Robotic Subtractive Processes	51
3.3.7	Outlook on Robotics in Constructions.	59
3.4	Additive Manufacturing	59
3.4.1	Principles of AM	59
3.4.2	Evolution of 3D Printing.	60
3.4.3	3D Printing in Architecture and Construction.	61
3.4.4	Large-Scale 3D Printing	62
3.4.5	Manufacturing Building Components	66
3.4.6	Perspectives in AEC.	73
	References	74
4	How to Build (Almost) Anything Customized	77
4.1	How to Build (Almost) Anything Customized	77
4.2	Skin Systems.	78
4.2.1	Casting Aggregate Structures.	79
4.2.2	Robotically Fabricated Brick Façade.	84
4.2.3	Digital Design with Local Manufacturer	88
4.2.4	Web-Based Platform for a Complex Façade.	91
4.2.5	BIM Platform to Tailored Skin Production	94
4.2.6	Material Customization	98
4.3	Structural Applications	103
4.3.1	3D Printed Nodes Shroud	103
4.3.2	Bespoke In-house Optimization Tools.	106
4.3.3	Non-standard 3D Printed Bricks.	112
4.3.4	3D Printing Research-by-Doing	116
4.4	Interior Interfaces	120
4.4.1	Stone Fluidity with Design Interoperability	120
4.4.2	Wooden Parametric Inflections.	125
4.4.3	Printing Unlimited Complexity.	129
4.4.4	Kinetic Electroacoustic Ceiling.	134
4.4.5	Interactive Wall	140
	Projects Credits	143
	References	150

- 5 Towards a 100 % Customized Architecture.** 153
 - 5.1 The Role of Information-Driven Design 153
 - 5.2 A New Material Awareness 155
 - 5.3 Evolution of the Professional Competences 157
 - 5.4 Towards a 100 % Customized Architecture 158
 - References 159

- Glossary** 161

- Index** 167