ISA
Istituto di storia e teoria dell'arte e dell'architettura
collana diretta da
Christoph Frank, Sonja Hildebrand, Daniela Mondini

Questo libro trae origine dal SNSF-International Exploratory Workshop *Form-Finding, Form-Shaping, Designing Architecture. Experimental, Aesthetical, and Ethical Approaches to Form in Recent and Postwar Architecture* (Mendrisio, 10-11 ottobre 2013).

Coordinamento editoriale
Tiziano Casartelli

Cura redazionale
Elisabeth Bergmann

Redazione
Michael Robertson (testi in inglese)
Gabriele Neri (testi in italiano)

Progetto grafico
Andrea Lancellotti

Impaginazione
Florentin Duelli, Alberto Canepa

In copertina
Elaborazione grafica da *Seifenblasen / Forming Bubbles* (Mitteilungen des Instituts für Leichte Flächentragwerke, Universität Stuttgart 18 / IL 18), Stuttgart 1987.

La pubblicazione ha avuto il sostegno
del Fondo Nazionale Svizzero per la Ricerca Scientifica

FNSNF

e della Boner Stiftung für Kunst und Kultur.

Form-Finding, Form-Shaping, Designing Architecture

Experimental, Aesthetical, and Ethical Approaches to Form in Recent and Postwar Architecture
Approcci sperimentali, estetici ed etici alla forma in architettura, dal dopoguerra ad oggi

a cura di / edited by
Sonja Hildebrand, Elisabeth Bergmann

Mendrisio Academy Press / Silvana Editoriale

Quando Elisabeth Bergmann e Sonja Hildebrand ci hanno comunicato l'idea di promuovere in Accademia un seminario internazionale sul tema delle relazioni tra questioni estetiche ed etiche in architettura, un progetto maturato grazie anche a un loro lavoro di ricerca sulle visioni di Frei Otto del periodo postbellico, siamo stati immediatamente catturati dalle loro intenzioni e abbiamo dunque incoraggiato l'iniziativa.

Nel 1996, proprio agli inizi delle attività della nostra giovanissima facoltà, nel vecchio mercato coperto, progettato a suo tempo dall'architetto futurista Mario Chiattone, la nostra scuola organizzò una bella mostra dedicata al lavoro di due grandi architetti: Eladio Dieste e Frei Otto. Quell'evento fu il primo di una lunga stagione di importanti esposizioni promosse dall'Accademia di architettura, Università della Svizzera italiana, che allora pubblicò, in occasione della mostra, il primo catalogo di Mendrisio Academy Press.

Molti di noi hanno senz'altro ancora impresse nella memoria le immagini delle Olimpiadi di Monaco del 1972, che avevano per sfondo quelle incredibili strutture progettate da Frei Otto e Günter Behnisch per l'Olympiastadion. Alcuni anni più tardi la lettura del volume *Natürliche Konstruktionen. Formen und Konstruktionen in Natur und Technik und Prozesse ihrer Entstehung*, pubblicato nel 1982, permise a un pubblico attento di avvicinarsi con maggior consapevolezza al lavoro dell'architetto di Stoccarda.

Che a diciassette anni dalla sua fondazione l'Accademia di architettura abbia ospitato un simposio sull'idea di *Form-Finding* sviluppata da Frei Otto, di cui questo volume rappresenta un esito duraturo, è per noi un segnale sicuramente positivo per la continuità nella ricerca dei valori in cui la nostra scuola vuole continuare a credere. Scorrendo la lista degli eminenti professori che sono stati coinvolti a Mendrisio durante le due giornate del seminario, e che qui pubblicano le loro riflessioni, siamo certi che per la nostra comunità questo evento abbia rappresentato di nuovo una buona occasione per incontrare personalità di differenti culture, provenienti da contesti diversi e dunque un'opportunità per scambiare opinioni differenti all'interno di uno spazio di dialogo.

Vogliamo esprimere dunque la nostra gratitudine a Sonja Hildebrand e a Elisabeth Bergmann dell'Istituto di storia e teoria dell'arte e dell'architettura della nostra facoltà e alla cattedra di Strutture del professor Joseph Schwartz e di Toni Kotnik dell'ETH di Zurigo, per i loro sforzi e per aver donato alla nostra scuola, ai nostri studenti e ai nostri professori questa grande opportunità d'incontro grazie anche al sostegno finanziario del Fondo Nazionale Svizzero per la Ricerca Scientifica.

Marc Collomb
Direttore
Accademia di architettura, Mendrisio

Marco Della Torre
Coordinatore di Direzione
Accademia di architettura, Mendrisio

Sommario
Table of contents

Sonja Hildebrand, Elisabeth Bergmann

Pathways to Form

Frei Otto and Beyond

During the last 20 years, the topic of architectural form has become one of the most controversial problem areas in public and professional discussions about architecture. Initially, the topic was closely linked to debates about architectural "icons" – the "Bilbao effect" and its consequences. Following the Digital Turn,[1] the issue became exacerbated and at the same time generalized, since with the computer-aided design and production processes that are customary today it is possible to create "extraordinary", emblematic buildings with apparently ever-greater rapidity and effortlessness.[2] Existing material conditions and technical requirements appear to be acting less and less as restrictive factors. But there are also severe problems associated with the feasibility and ubiquity of icons. These affect the cultural embeddedness of buildings and the associated semantic potential they hold. Icons are now so frequent that they are threatening to become banal; and the formally extremely complex products of computational design in particular often "speak" mainly about their own form.[3] However, the problems also affect aspects of authorship and the way in which architecture is embedded in the sphere of human production.

This problem area is reflected in architectural practice from various points of view. In his concept for the 14th Venice Architecture Biennial (7 June-23 November 2014), Rem Koolhaas chose an approach aimed at the "fundamentals" of architecture. In the face of a phenomenon described by Oliver Domeisen as "endless circularity and stasis of insular parametric iterations", Koolhaas has undertaken to provide a basis for an alternative discourse, favouring "a more pluralistic, evolutionary and historically aware understanding of contemporary architecture".[4] In preparing for the exhibition, Koolhaas has been conducting a research project focused on "histories – on the inevitable elements of all architecture used by any architect, anytime (the door, the floor, the ceiling, etc.)".[5] Koolhaas's argumentation is based on the enduring recognizability of essential components of buildings, which are inscribed in collective awareness through

the everyday usage of architecture. These offer a generally applicable interpretative pattern that can also be applied to formally extravagant buildings. In order to examine the tools and methods used in design and the products of computational design, a conference organized at RWTH Aachen University in April 2014 inquired into the epistemic objects that are involved in the design process. The conference was based on the diagnosis that "in the world designed by architects, designers and engineers … the protracted process of planning and production often remains barely visible. It disappears behind the usually perfect-looking surfaces of the objects, which suggest that the way they actually exist is the only way they could possibly exist".[6] Still more far-reaching is the hypothesis proposed by a conference announced for July 2014 at the University of Innsbruck on *The Disappearance of Architects. Architectural Practice in Precarious Design Conditions*:

> A drawing still allowed design steps to be examined and checked so that they could be further developed or abandoned – and it was thus [since the time of Alberti] constitutive for the idea of the author, for the idea of the architect as an autonomous creator of designs; by contrast, algorithmic, rule-based or self-generating production procedures of the sort that are now increasingly being used have proved to be indifferent to the concept of authorship.[7]

Jörg H. Gleiter, Professor of Architectural Theory at the Technical University of Berlin, has discussed this problem area in relation to perception. A large number of the products of computational design, he argues, are today characterized by an "overwhelming effect". According to Gleiter, this effect is closely linked to the hypercomplexity of the rational basis for the buildings – i.e., computational mathematics. Because of their high degree of mathematical complexity, the buildings tend to be inaccessible to any form of rational analysis, or even to appear irrational – and this is what makes them overwhelming. Whereas architectural language is traditionally based on constructional logic, the amorphous forms that result from computational design elude this type of articulation. They tend to remain silent about the way in which they are made and the structural scheme underlying them. Material constraints have apparently been overcome. Buildings such as Zaha Hadid's Guangzhou Opera House and Frank Gehry's Disney Concert Hall in Los Angeles appear to have been built by mysterious agencies. To counter this diagnosis, Gleiter suggests that "digital-formal and analogue-constructive rationality" should be allowed to interpenetrate each other. In this way, the products of computational design could preserve a residue of constructional legibility and could be perceived positively, as "digitally sublime".[8] What for Koolhaas is achieved by the fundamental elements of architecture is carried out for Gleiter by architectural-structural form.

Hardly anyone has reflected on the problem area involving architectural– structural form as intensively as Frei Otto – an innovative explorer on the boundary between architecture and civil engineering. His concept of "form-finding" is aimed at preventing any processes of designing and shaping – which in his view represent "distortion". Instead, form has to be found, "peeled out" and optimized.[9] This view raises fundamental questions that go beyond Otto's own architectural practices and are related to current debates: how much freedom of design do architects have? Do they need to abandon their view of themselves as "masters of form"? What does this imply for the work of the engineer? The pathways to architectural form that were theoretically reflected on and experimentally investigated by Frei Otto in the field of lightweight construction touch not only on problems of interdisciplinary teamwork, but also on more abstract questions of the aesthetics and semantics of form.

The concept of form-finding is being used increasingly often today in connection with the new opportunities provided by computer science and construction technology. At the same time, architectural and civil-engineering buildings have shown an increasing number of apparently arbitrary structural systems in recent decades that often no longer have any connection with constructional or functional principles – a situation that demands a critical analysis of the dynamics, changes and possible prospects for the future for architectural structures. All the more so since similar discrepancies are also noticeable in the current theoretical discourse.

Theoretical studies on the topic of generating architectural form often focus on the concept of form-finding, not infrequently with direct reference to Frei Otto. This group includes Ralf Höller's principles of form-finding for membranes and cable mesh, as well as the anthology on form-finding in shell constructions and lattice shells edited by Sigrid Adriaenssens, Philippe Block, Diederik Veenendaal and Chris Williams.[10] This group of engineers – only Block is also an architect – focuses on the technical, mathematical and applied aspects of the topic. The prefaces by Jörg Schlaich and Shigeru Ban emphasize the rapprochement between the spheres of the engineer and the architect. In his summary, Patrik Schumacher even mentions the "congeniality of architecture and engineering" (but not the congeniality of the architect and the engineer).[11] Works by Frei Otto, which are investigated in this context, include above all the Mannheim Multihalle and its prototype: the wooden lattice shell in Essen. In their essay on *Computational Form-Finding and Optimization*, Kai-Uwe Bletzinger and Ekkehard Ramm point out the advantages of Otto's suspended models, which result in clearly defined doubly curved surfaces, whereas hanging cloths generate shapes with wrinkles and negative curves at the edges. The catalogue of works at the end of the book also includes the domes of St Paul's Cathedral, St Peter's in Rome, and the Temple of Mercury from the first century B.C. as well. They are listed in alphabetical order along with contemporary shells and compared using their numerical parameters (area, span, thickness).

However, the way in which the term form-finding is used is often arbitrary, with any type of approach to form being described as a form-finding process in a generalizing way. This is true, for example, of Kari Jormakka's 2008 book *Methoden der Formfindung*, which offers a sketch of a wide variety of approaches to design, starting with nature and geometry and passing via music and mathematics, chance and the subconscious to generative processes such as morphing, datascape and parametric design.[12]

In *The Autopoiesis of Architecture*, Patrik Schumacher claims to have developed a new theoretical approach in architecture,[13] which he has described as a "comprehensive discourse analysis and sociological justification for architecture".[14] According to Schumacher, a new and sustainable constructive trend has now emerged after a long period of arbitrariness, and it requires a different discursive culture. In order to find the anchorage in history that he nevertheless seeks for this, he turns

to Frei Otto, whom he describes as "the only true precursor of Parametricism";[15] in another context, he also turns to engineers such as Heinz Isler. At the Architecture Biennial in Venice in 2012, Zaha Hadid and Patrik Schumacher exhibited shell models from Heinz Isler's estate that are held in the gta Archive at the Swiss Federal Institute of Technology (ETH) in Zurich, placed side by side with models from their own design courses – but without even starting to address the topic out of the fundamental differences between the paths to form taken in each case.

Appropriations such as this exemplify the need for a precise definition of the processes of form-finding and form-shaping in the intricate balance between constructional and technical parameters, design procedures, and architectural, aesthetic and semantic-cultural aspects. Beyond simplifications and misinterpretations, there is a need for careful analysis of the formal characteristics of architecture and its production in the computer-aided design processes that are practised throughout the world today. Because these are not only raising questions of the possible semantics and cultural identity of the resulting formal structures; they are also generally blurring the disciplinary boundaries established in the nineteenth century between architecture and civil engineering – but without at the same time overcoming the disciplinary barriers to mutual understanding.

These observations and considerations gave rise to the idea of re-examining the issue of form-shaping, or form-finding, in the tension between architecture and civil engineering on the basis of the outstanding example case of Frei Otto, by bringing together expertise on architectural history, architectural theory and technology and construction. For this purpose, the editors of the present volume organized an interdisciplinary workshop in October 2013 on *Form-Finding, Form-Shaping, Designing Architecture. Experimental, Aesthetical, and Ethical Approaches to Form in Recent and Postwar Architecture*, funded by the Swiss National Science Foundation (SNSF). This volume reflects on the workshop's findings and seeks to contextualize them.

In the discussions held during the meeting, Frei Otto was the most important reference point, and one on which critical reflection took place. He also continues to be an important point of anchorage in the essays presented here. However, the content also extends beyond the example of Frei Otto and his attempt to derive structural and architectural form from phenomena in nature. This opening up of the content also takes account of the continuing expansion of the range of technological and material options for form-generation in contemporary architecture, which can by no means be assessed solely by the standards of "natural design".[16]

No claim can be made, of course, that valid solutions are suggested here for the problems that have been outlined above. Instead, it was a matter of exploring the cultural and semantic potential of architectural form in the context of its material and technological production, in an exchange between the disciplinary fields of the history of art, history of architecture and history of technology and of architecture and civil engineering studies – in a dialogue between individuals working in the field of history and theory and those working on a practical basis. The boundaries of what is feasible here became clear in the process. The bridge that was built during the conference discussions between the different ways of thinking and communicating in the two disciplines remained a fragile, temporary structure that it has also not been possible to fully consolidate during the process of recording it in writing. The different conventions and "styles of thought"[17] used in the disciplines are still recognizable in the essays. This starts with the way of working with groups of authors (or with a compilation by one main author of passages written by different authors) that is customary in the field of engineering; but it also particularly affects aspects of content and methodology. There is a very wide span between the assumption-rich mathematical form of argumentation used on the engineering side (Neuhäuser et al.) and the use of the term calculation in the sense of a philosophical concept in the field of art history (Fabricius). Despite this – and precisely because of the breadth of this span – interdisciplinary discussion is important, as it sharpens our critical awareness of disciplinary conventions and habits.

The essays presented in this book cover a period of a good 100 years, although most focus on the second half of the twentieth century. Those essays that range further back investigate fundamental questions of the origins of aesthetic patterns of experience on the basis of lightweight "mobility machines" such as the bicycle and small car around 1900 (Möser) and the potential range of form theories, based on the example of Gottfried Semper (Hildebrand). The subject of form-shaping or form-finding is also approached from varyingly wide perspectives, ranging from concrete pathways to form in engineering research (Neuhäuser et al., Bergmann on Weinand) and in (experimental) model-making (Neri, Fabricius) to the ideology-critical reflections on form by Oswald Mathias Ungers and Rem Koolhaas (Schrijver). In addition to the producer side, consideration is also given to the way in which (everyday) objects are perceived and to the emergence of aesthetic patterns that art and architecture can connect with (Möser).

The referential fields of architectural form that are investigated in the essays are not limited to the natural laws investigated by Frei Otto and adapted in his buildings, nor to the social and technological dynamics and momentum acting in this context (Fabricius, Keller). They also investigate influencing factors such as early regulations on the multilayered structure of facades in Swiss-German architecture during the 1970s and 1980s; architects responded to these by developing a strategy in which they interpreted the skin of the building not merely as an air-conditioning shell, but rather as a form-shaping element that was increasingly regarded as a tectonic structure (Grignolo).

However, the fundamental question is also addressed of whether form-finding and form-shaping do in fact need to be mutually exclusive approaches, or whether they can also be regarded as the two ends of a continuum of scholarly and artistic aspects that need to be balanced off against each other. The approach used in the *Stuttgart SmartShell* creates a continuing process of form-finding. This adaptive structural shell was developed at the Institute for Lightweight Structures and Conceptual Design (ILEK), the successor to Frei Otto's Institute for Lightweight Structures. With a thickness of only four centimetres, the shell would be far too thin over a span of more than ten metres to be able to absorb wind and snow loads. However, active and targeted shifting of three of its four points of support distorts the wooden shell when necessary in such a way that tensions and distortions can be sufficiently reduced (Neuhäuser et al.). The experimental finding of form is continually repeated, so to speak, in order to approach the optimal form in each case for various

different load situations. At the same time, the active altering of the support points and the resulting continuous alteration in the shape of the *SmartShell* can also be interpreted as form-shaping. The *SmartShell* implicitly demonstrates that technological developments by no means necessarily lead to new architectural forms. Unusual new architectural forms in wood are now also being produced at the IBOIS Laboratory for Timber Construction at the Swiss Federal Institute of Technology (EPFL) in Lausanne (Bergmann on Weinand).

Frei Otto's philosophy of architecture revolves around the three key concepts of form(-finding), aesthetics and ethics (Bergmann on Otto). He regarded his lightweight constructions as counterexamples opposed to Nazi monumentalism. The architect's attempt to find an inherently democratic approach to form became problematic precisely when – as in the tent construction for the German Pavilion at Expo '67 in Montreal – the aim was to express weightiness in content and impressiveness in size, but without falling into nationalist rhetoric or oppressive monumentality (Keller). Oswald Mathias Ungers and Rem Koolhaas attempted to avoid the dangers of ideologically motivated shortcuts between form and content by denying the political semantics of form. On the basis of this critique, Ungers argued in favour of a form-shaping procedure based on morphological analogies that would link content to psychologically and culturally shaped visual habits, rather than ideologies (Schrijver).

The conference and subsequent discussions during work on the publication have shown how important it is to deploy larger-scale interpretative structures in the context of interdisciplinary dialogue – and also how important it is to have as precise as possible a definition of the specific subject concerned. The variety of disciplinary, methodological and theoretical approaches that were presented prompts reflection on one's own approach and leads to greater sharpness of focus in concepts and arguments. The present volume may thus be regarded as a model study, offering approaches that can be pursued further. It provides a set of tools – which should be further expanded – for considering the fundamental issues involved in architectural form and ways of creating it, along with the associated semantic, ethical and aesthetic aspects.

For invaluable advice and support given, we wish to thank:
Frei Otto and Ingrid Otto,
Riccardo Blumer, Elena Chestnova, Max Collomb, Marco Della Torre, Christoph Frank, Matthew Howell, Pimipat Hongdulaya, Fulvio Irace, Toni Kotnik, Rosalba Maruca, Daniela Mondini, Garbriele Neri, Andrea Netzer, Andrea Nicoli, Joseph Schwartz, Vincenza Sutter, Matteo Trentini, Leonardo Vinti.

(Translation by Michael Robertson).

Notes

_1. B. Junge et al. (eds.), *The Digital Turn. Design in the Era of Interactive Technologies*, Park Books, Zürich 2012; M. Carpo (ed.), *The Digital Turn in Architecture 1992-2010*, Wiley, Chichester 2013.

_2. A. LeCuyer, *Stahl & Co. Neue Strategien für Metalle in der Architektur*, Birkhäuser, Basel-Boston-Berlin 2003; and, more recently, F. Gramazio, M. Kohler, *The Robotic Touch – How Robots Change Architecture*, Park Books, Zürich 2014; F. Gramazio, M. Kohler, S. Langenberg (eds.), *Fabricate. Negotiating Design & Making*, gta Verlag, Zürich 2014.

_3. This risk has already been debated for several years, for example: *Urgency. Rem Koolhaas and Peter Eisenman in Conversation at the Canadian Centre for Architecture*, Montreal, 8 June 2007 (video, available at vimeo.com/2711744); B. Cache, *Projectiles*, AA Publications, London 2011.

_4. O. Domeisen, *Back to the Future. The Rewriting of History in Architecture*, "archithese", 43, 2013, n. 4, pp. 58-65, p. 58.

_5. R. Koolhaas, *La Biennale di Venezia. 14th International Architecture Exhibition/Fundamentals* (Statement) [press release], January 2013, cited after Domeisen 2013 (see footnote 4).

_6. Conference *Manifestationen im Entwurf* (Aachen, 10-12 April 2014), "H-ArtHist", 27 March 2014 (http://arthist.net/archive/7320, accessed 30 May 2014).

_7. Conference *Das Verschwinden der Architekten. Architektonische Praxis innerhalb prekärer Entwurfsverhältnisse* (Innsbruck, 3-4 July 2014), "H-ArtHist", 5 Feb 2014 (http://arthist.net/archive/6921, accessed 30 May 2014). A related approach with a positive evaluation is represented by G. Franck, D. Franck, *Architektonische Qualität*, Carl Hanser, Munich 2008, esp. chapter 6, pp. 169-196: *Kreativität: Fortsetzung der Evolution mit kulturellen Mitteln?* See also – following on from his studies of historical aspects of the graphic representation of architecture – M. Carpo, *The Alphabet and the Algorithm*, MIT Press, Cambridge MA-London 2011, esp. pp. 20-48.

_8. J.H. Gleiter, *Das Digital-Erhabene. Wie mit dem Computational Design eine vergessene ästhetische Kategorie in die Architektur zurückkehrt*, "Neue Zürcher Zeitung", 1 June 2013, p. 64.

_9. *Form. Form Kraft Masse 2 / Basics: Form Force Mass 2* (Mitteilungen des Instituts für Leichte Flächentragwerke, Universität Stuttgart / IL 22), Stuttgart 1988; F. Otto, B. Rasch, *Gestalt finden. Auf dem Weg zu einer Baukunst des Minimalen*, Edition Axel Menges, Fellbach 1995; F. Otto, *Architektur Natur*, Christian-Wagner-Gesellschaft, Warmbronn 1996, p. 3. On Frei Otto in general: W. Nerdinger (ed.), *Frei Otto. Das Gesamtwerk. Leicht bauen, natürlich gestalten*, Birkhäuser, Basel-Boston-Berlin 2005.

_10. R. Höller, *FormFindung. Architektonische Grundlagen für den Entwurf von mechanisch vorgespannten Membranen und Seilnetzen*, Balistier, Mähringen 1999; S. Adriaenssens et al. (eds.), *Shell Structures for Architecture – Form Finding and Optimization*, Routledge, Abingdon 2014.

_11. P. Schumacher, *The congeniality of architecture and engineering – the future potential and relevance of shell structures in architecture*, *ibidem*, pp. 271-273, p. 271.

_12. K. Jormakka, *Methoden der Formfindung*, Birkhäuser, Basel-Boston-Berlin 2008 (English edition: *Design Methods*, Birkhäuser, Basel-Boston-Berlin 2008).

_13. P. Schumacher, *The Autopoiesis of Architecture*, 2 vols., John Wiley & Sons, Chichester 2011-2012.

_14. Interview *"The Autopoiesis of Architecture". Ralf Ferdinand Broekman und Olaf Winkler im Gespräch mit Patrik Schumacher*, "build. – Das Architekten-Magazin", 2, 2011 (available at: http://www.build-magazin.com/index.php/themenfull/items/the-autopoiesis-of-architecture.html, accessed 30 May 2014).

_15. Schumacher 2012 (see footnote 13), p. 680.

_16. F. Otto et al., *Natürliche Konstruktionen. Formen und Prozesse in Natur und Technik und Prozesse ihrer Entstehung*, Deutsche Verlags-Anstalt, Stuttgart 1982.

_17. Borrowing the concept formulated by Ludwik Fleck around 1930; cf. L. Fleck, *Denkstile und Tatsachen. Gesammelte Schriften und Zeugnisse*, ed. S. Werner, C. Zittel and F. Stahnisch, Suhrkamp, Frankfurt am Main 2011, pp. 41-259.