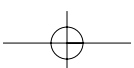
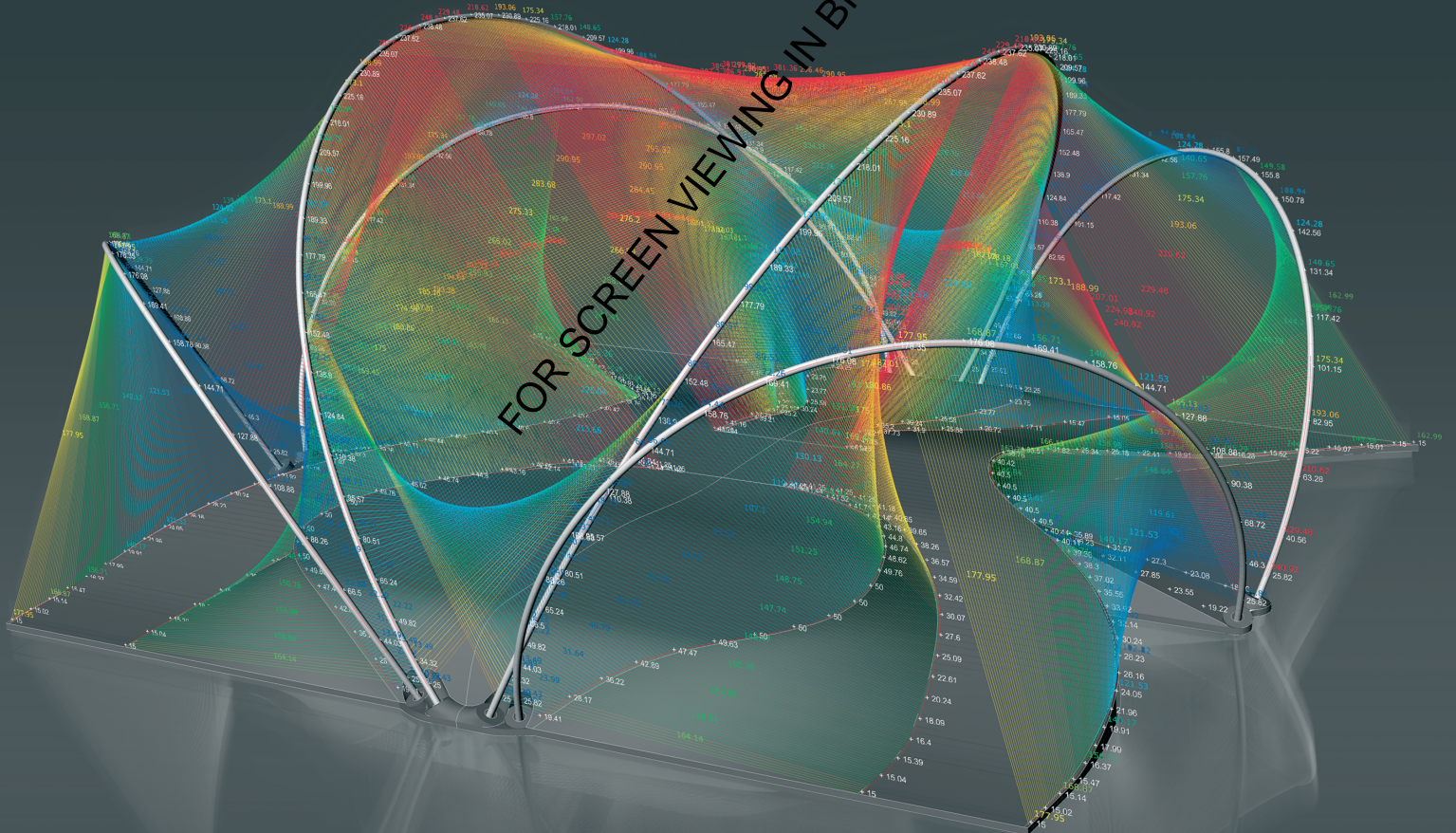


Introduction

# Versatility and Vicissitude

An Introduction to Performance in Morpho-Ecological Design

FOR SCREEN VIEWING IN BPA ONLY



The dictionary explanation of 'performance' is to 'carry out an action' or 'to fulfil a task'. Invariably, this definition seems to invoke a tired utilitarian debate on the correlation between form and function. Here, **Michael Hensel and Achim Menges** explain how in this issue of *AD* they aim to move the debate on entirely. In so doing, they redefine form not as the shape of a material object alone, but as the multitude of effects, the milieu of conditions, modulations and microclimates that emanate from the exchange of an object with its specific environment – a dynamic relationship that is both perceived and interacted with by a subject. Performance evolves from the synthesis of this dynamic, while morpho-ecological design concerns an instrumental approach, making form and function less of a dualism and more of a synergy that aspires to integral design solutions and an alternative model for sustainability.

**Versatile** *adj.* capable of or adapted for many different uses, skills  
**Vicissitude** *n.* variation or mutability in nature or life

Today, many make grand claims with regards to sustainability, but if one looks closely such claims all too often serve either mere public-relations and fund-raising purposes, or boil down to an ever greater division of exterior and interior space through ever thicker thermal insulation combined with reductions in energy use of electrical heating, cooling, ventilation and air-conditioning devices. When passive methods of environmental modulation are mentioned, it is often in an apologetic tone, assuring that the aim is not to promote a move back towards outmoded means that might sacrifice contemporary levels of comfort. Several questions arise from this. Can one offer alternatives to the currently prevailing approach to sustainability? Can passive means that utilise material and spatial strategies be updated so as to make redundant entire energy cycles currently involved in sustainable design? Can such an alternative approach evolve and carry its own beauty and aesthetic without devolving into superficial metaphors? Can such an approach promote a rethinking of currently prevailing modes of inhabiting space together with its related social formations, and thus become socially and culturally sustainable and robust?



Complex roof structure of the BMW Welt building in Munich by Coop Himmelb(l)au architects and Bollinger + Grohmann structural engineers. See 'Form, Force, Performance: Multi-Parametric Structural Design' on page 20.

The aim of this issue of *Architectural Design* is to let these questions remain implicit rather than explicit through the various investigations and discussions. We seek to encourage the rise of further questions, thoughts and approaches, instead of pretending that there already exists a fully developed paradigm. On the contrary, we wish to show some potential beginnings that might eventually lead to a fully developed paradigm that we generally refer to as performance-oriented design, the more specific basics of which we have attempted to outline in our book *Morpho-ecologies*.<sup>1</sup> This publication therefore aims to trace historical precursors and precedents and also to present the current state of the art of morpho-ecological design.

Within this context, 'versatility' entails the notion of the behaviour and performance of an organism or artefact within its specific context, while addressing both the object and the subject. 'Vicissitude' entails the differentiation of the object and the dynamic of the environment. The notion of 'ecology' addresses precisely this: the relationship between an organism and its environment. Ecology is in this way a central concept for morpho-ecological design. Thus this approach commences with a high degree of articulation of the built environment as a substrate and catalyst of motile, mutable and feedback-based relations between habitat and inhabitants that yield diverse and intense social interactions. Here, inhabitants' activities can be understood as emergent real-time matches between individual and collective itineraries, with provisions made and conditions yielded by highly differentiated spatial organisation and material systems. This notion of spontaneously emerging

The relationship between form, material and performance is the key driver in the design process of OCEAN's German Pavilion for the Prague Quadrennial International Exhibition of Scenography and Theatre Architecture 2007, as presented in 'Designing Morpho-Ecologies' on page 102.



Responsive surface structure that instrumentalises moisture-content activated shape changes of timber components. See 'Material Performance' on page 34.

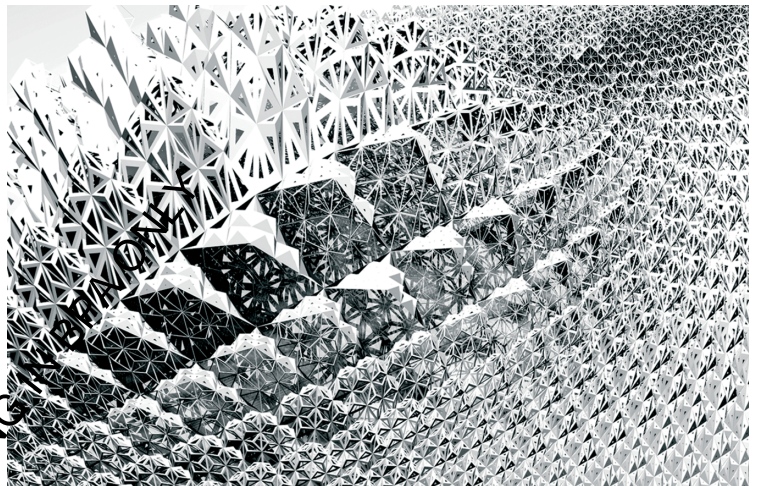
activities and their migration and mutation in relation to morpho-ecological dynamics can then serve to speculate about alternative notions of the social and cultural sustainability of the built environment.

Performance capacity of the synergy between spatial organisation and material assembly thus becomes a driver of morphogenesis. This marks a most significant shift in design approach and production towards levels of effects and performativity not previously considered. Bringing these concepts together has potentially tremendous consequences for the future of our human environment.

The first section of this issue outlines significant changes over the last century in the way performance has been understood and instrumentalised with regards to the correlation between stimulus or force, material response or form and the performative capacity that ensues from this dynamic relationship. This threefold correlation between force, form and performance is elaborated through a historical account, a contemporary approach and a visionary outlook in this section. The issue begins with Professor Remo Pedreschi's examination of the works of exceptional 20th-century structural engineers and their developments of form-active structures within the context of methodological and technological progress. The design approaches of Robert Maillart, Pier Luigi Nervi, Eduardo Torroja, Felix Candela, Eladio Dieste and Heinz Isler are presented as a multifaceted lineage, aiming for a more integral understanding of form, material, structure and the resultant structural behaviour. In the following article, Professor Klaus Bollinger, Professor Manfred Grohmann and Oliver Tessmann challenge the common classification of structural typologies that were central to 20th-century engineering design and the related ethically loaded concepts of 'building correctly'. Considering



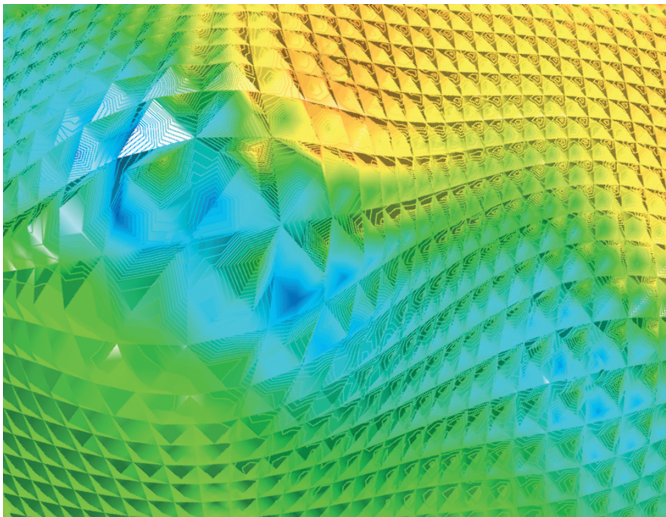
As part of the Freeform Construction research project at Loughborough University, the morphology of a *Macrotermes michaelseni* termite mound is scanned. See 'Manufacturing Performance' on page 42.



The transition from space-frame to surface morphology within one system offers a range of performative capacities through related changes of porosity. See 'Inclusive Performance: Efficiency Versus Effectiveness' on page 54.

each structure as an individual case with inherently complex behaviour, rather than a particular variant of an established archetype, they discuss their approach to design engineering, the relevant methods, generative techniques and the respective consequences of the relationship between force, form and structural performance along a number of their recently completed projects.

Michael Weinstock's article, entitled 'Metabolism and Morphology', then looks at an approach based on metabolism, highlighting the consequences for performance-oriented design. In the natural sciences, metabolism refers to all energy transformations, the sum of the complex chemical and physical changes that take place within an organism and promote growth, sustain life, and enable the processes of living organisms. Weinstock presents an account of the thermodynamics of mammalian, marine and plant metabolisms and their relationships to morphology and scale, to behaviour and to the environment. The relationships between living organisms and their environment are analysed in terms of the vectors of energy and material flows in populations, habitats and ecosystems. He also sets out a new model of metabolism for buildings



Computer fluid dynamics can be instrumentalised to explore and strategise the performative effects of material systems. See 'Inclusive Performance: Efficiency Versus Effectiveness' on page 54.

and cities that unfolds concepts, systems and relationships for groups of environmentally intelligent buildings, with interlinked systems of material and energy flows.

The second section presents changes in the way we may understand material performance and related manufacturing logics. In the first article, 'Material Performance', Michael Hensel and Defne Sunguroğlu ask why not all materials are considered 'smart' and test this label on wood to demonstrate that performance-oriented design would have a lot to gain from utilising the capacity of all materials, whether long in existence or new, to respond to extrinsic stimuli. Later in the same article, Achim Menges discusses a research project that demonstrates the potential consequences of this approach to material performance and the integral relationship between formation and materialisation processes.

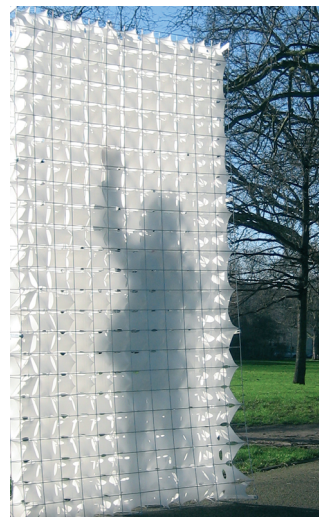


Digital form-finding of a complex membrane system. See 'Membrane Spaces' on page 74.

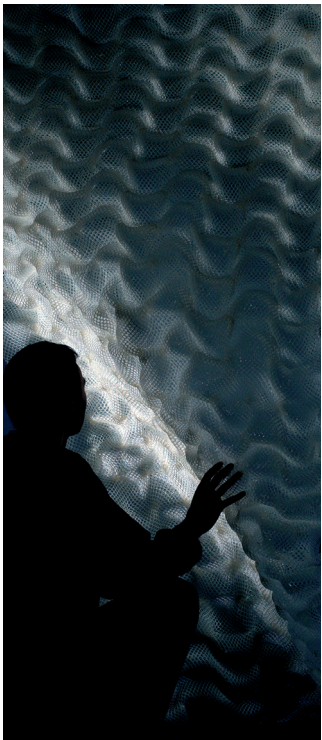
In the following article, 'Manufacturing Performance', Menges describes how advanced computer-controlled manufacturing processes can provide key design parameters for the development of performative structures. He investigates and explains the work of the Rapid Manufacturing Group at Loughborough University, which is at the forefront of developing rapid manufacturing technologies for various fields and is currently developing additive manufacturing processes at the construction scale. Aiming to instrumentalise so-called 'quasi composite material', that is, materials that can acquire a wide range of physical and mechanical properties through multiscale variations in the manufacturing process of a single material, the group not only focuses on the development of related manufacturing technologies, but also undertakes in-depth studies of the versatility and performance of natural, single material systems. Menges discusses this research as an example of an emerging kind of computer-controlled manufacturing technology that may fundamentally challenge not only the way we build, but also the way we envisage performative architectural design.

The final section leaps into a more inclusive understanding of performance-oriented design as outlined above. In 'Performance-Oriented Design: Precursors and Potentials', Michael Hensel examines and systematises selected historical precursors to performance-oriented design, with particular focus on passive means of environmental modulation and the opportunities that arise for inhabiting space and rethinking the strict division between exterior and interior, as well as the fear of loss of comfort that underlies current approaches to sustainable design.

In 'Efficiency Versus Effectiveness', Hensel and Menges elaborate their morpho-ecological design approach. Based on an understanding of material systems, not as derivatives of standardised building systems and elements, but rather as generative drivers in the design process, this approach seeks



Differentiated membrane component system. See 'Membrane Spaces' on page 74.



Full-scale prototype of a 3-D spacer-textile composite surface. See 'Environmental Intensifiers' on page 88.



Full-scale prototype of a glass-fibre band component surface. See 'Environmental Intensifiers' on page 88.

that instrumentalise multiparameter form-finding processes. A membrane is a thin, synthetic or natural pliable material that separates two environments and constitutes the lightest elements available for spatial organisation and environmental modulation in architectural design. The membrane expert Klaus-Michael Koch once posited that 'building with membranes is emerging from the shadow of the early pioneering achievements. Several decades of practical experience have led to a technology that is future oriented and that deserves to be more widely established.'<sup>2</sup> In this article the emphasis is on an understanding of membranes as inclusive systems that are form found as the equilibrium state of internal resistances and external forces, while at the same time anticipating a wide range of interactions with environmental influences.

An even more radical departure from established design and construction strategies is discussed, again by the guest-editors, in the article entitled 'Aggregates', which are loosely compacted masses of particles or granules. While an abundance of construction applications of bound aggregates exists (for example, concrete and asphalt), the authors argue that research on loose aggregates requires a fundamental rethinking of architectural design and its preoccupation with element assemblies as aggregates are formed not through the connection of elements by joints or a binding matrix, but

to develop and employ computational techniques and digital fabrication technologies to unfold innate material characteristics and specific latent performative capacities. Extending the concept of material systems by embedding their material characteristics, geometric behaviour, manufacturing constraints and assembly logic within a computational model, the systems manipulations can be recurrently evaluated in relation to structural and environmental performance. In doing so, the article focuses on the possibilities of rethinking the prevailing notion of efficiency through the effectiveness of material systems.

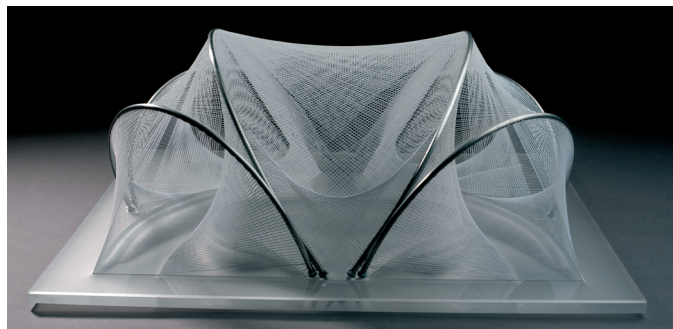
In order to further elaborate and exemplify the morpho-ecological design approach, a variety of projects and material systems are presented and discussed in greater detail in the following articles.

Defne Sunguroğlu introduces her approach to brick – one of the oldest building materials of humanity. Two aspects are of interest here: first, what are the innovations that one might wish to draw upon, and second, what are the unexplored possibilities of building with brick. The article offers a short historical inquiry into specific lineages of the innovative use of brick, with particular focus on the work of Rafael Guastavino and Eladio Dieste, as well as an introduction to Sunguroğlu's current research project entitled, like the article, 'Complex Brick Assemblies'.

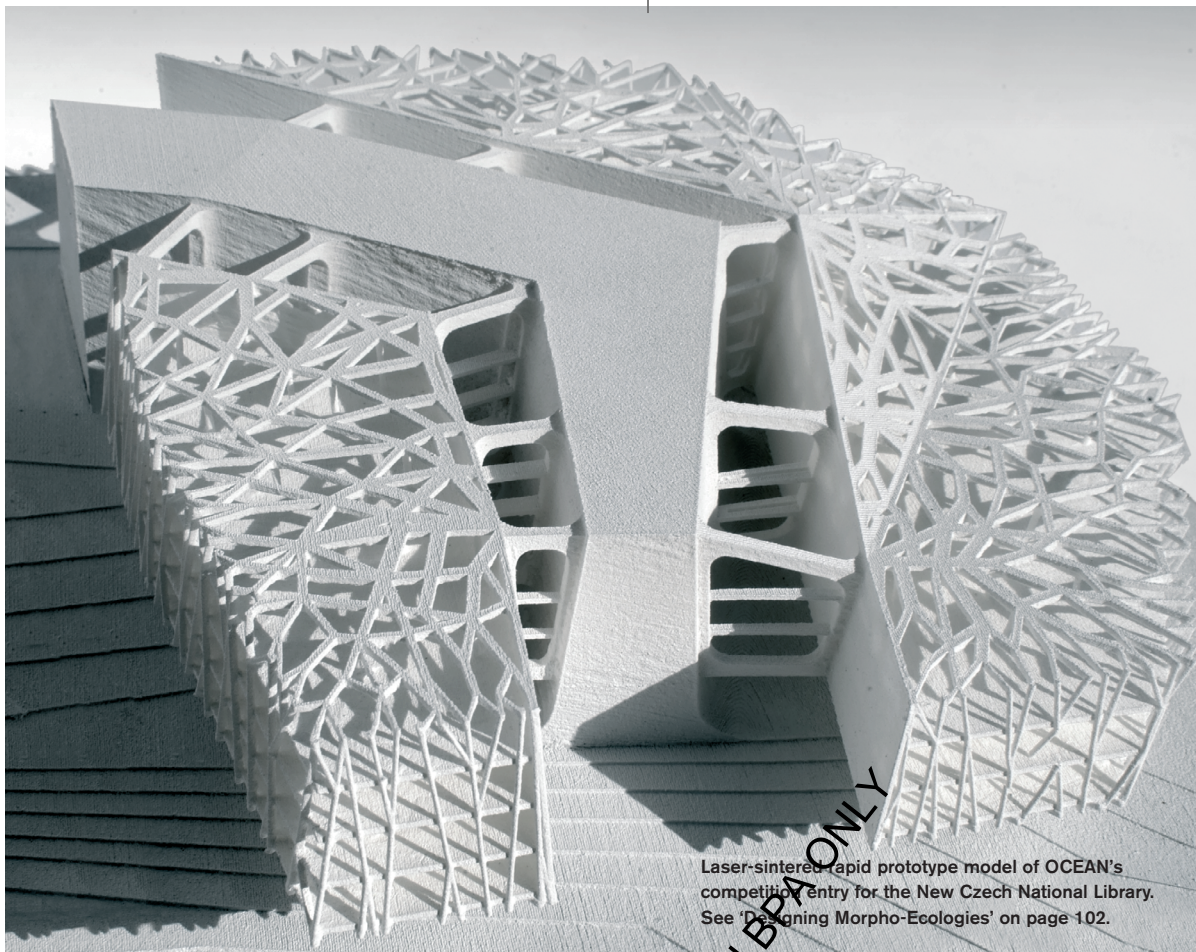
In 'Membrane Spaces', the guest-editors discuss recently developed approaches to designing with membrane systems



Cavernous spaces emerging from the self-stabilising process of aggregates. See 'Aggregates' on page 80.



A 1:20 scale model of OCEAN's German Pavilion for the Prague Quadrennial International Exhibition of Scenography and Theatre Architecture 2007 was employed to test different intensities of transparency, reflection and density that provide a space of various microconditions. See 'Designing Morpho-Ecologies' on page 102.



Laser-sintered rapid prototype model of OCEAN's competition entry for the New Czech National Library. See 'Designing Morpho-Ecologies' on page 102.

through the loose accumulation of discrete elements. This offers a different inroad to the design of performative structures, based on design understanding of the processes of self-organisation of systems interacting with the environment rather than the fully controlled, precise geometric definition of the still prevalent tectonic element assemblies. A number of related research projects are introduced alongside the article.

In 'Environmental Intensifiers', Aleksandra Jeschke examines the work undertaken by the Department of Form Generation and Materialisation at the Hochschule für Gestaltung (HfG) in Offenbach, Germany. The research projects presented here focus on design processes that instrumentalise the inherent possibility for differentiation in fibre composites. Driven by exploration and parameterisation of innate material constraints, elaborate morphologies with complex, internal fibre architectures can be articulated in response to structural forces and environmental influences. These projects are discussed as possible modes of integrating form-generation and materialisation processes in deep, performative skin structures that intensify the surface's interaction with the environment and the body of the user.

Peter Trummer speculates about the possibilities and potential repercussions of 'engineering ecologies' inherent to a change from physics to biology as the underlying paradigm of engineering, and eventually the discipline of architecture. Shifting from the micro-ecological scale of product design elaborated in the previous article to the macro-scale of landscape, he investigates a broader palette of disciplines with regards to design aiming for careful

modulations of environments and ecologies. Based on the introduced morpho-ecological design approach and the corresponding understanding of optimisation, efficiency and redundancy in relation to multiperformative material and construction systems may indicate a very different take on spatial organisation, environmental modulation and, ultimately, social formation.

In the final article, 'Designing Morpho-Ecologies', Michael Hensel and Achim Menges discuss a number of recent projects by OCEAN: the competition entry for the New Czech National Library and a design study of a pavilion in Prague. Set within considerably different contexts and with different scales, the projects explore a high degree of articulation of the material and tectonic systems that yield diverse and intensified spatial experiences and microclimatic conditions. Furthermore, they highlight the importance of the designer in an alternative role, one that is central to enabling, moderating and influencing integral performance-oriented design processes that require novel skills and methods to achieve synthesis of versatility and vicissitude. **Δ**

#### Notes

1. Michael Hensel and Achim Menges, *Morpho-ecologies*, AA Publications (London), 2006.
2. Klaus-Michael Koch, *Membrane Structures*, Prestel (Munich, Berlin, London and New York), 2004.

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