The design of this tower was inspired by a biomimetic study of the Cactaceae family. The plant's self-shading logic was then combined with a camera diaphragm mechanism. This drove the form-finding logic for a double skin, which was populated on the facade through scripting according to an analysis of sun exposure during different times of the day and seasons of the year.
Within contemporary architectural design, a significant shift in emphasis can be detected – a move away from an architecture based purely on visual concerns towards an architecture justified by its performance. Structural, constructive, economic, environmental and other parameters that were once secondary concerns have become primary, are now being embraced as positive inputs within the design process from the outset. Architecture, it would seem, is no longer so preoccupied with style and appearance. It is as though a new paradigm has emerged. This new paradigm can be understood as an attempt to overcome the hegemony of Postmodernism. It aims to locate architectural discourse within a more objective framework where efficient use of resources supersedes the aesthetic indulgences of works that previously came under the broad heading of Postmodernism, which might include not only the somewhat conservative movement noted for its decoration and superficial appearance, but also the more progressive movements such as Deconstructivism, all of which privilege appearance over performance. This development is by no means universal. Many areas of architectural production remain deeply rooted in Postmodern concerns for appearance, and no doubt architectural culture would be poorer if all architects were to subscribe to the same approach. However, it does represent a significant shift not only in the various ‘hot spots’ of architectural production – cities such as London, New York, Rotterdam and Los Angeles – but also in other cities where the designs of various progressive architects from around the world are now being built. The structural engineer is no longer simply the master architect, as close as possible to his or her initial design. The role of the structural engineer is to make possible the fabrication of the designs of the master architect, as close as possible to his or her initial poetic expression. Meanwhile, the more contemporary architects operating within the new paradigmatic context can be seen more as the controllers of processes, who facilitate the emergence of bottom-up form-finding processes that generate structural formations. The difference, then, lies in the emphasis on form-finding over form-making, on bottom-up over top-down processes, and on formation rather than form. Indeed the term ‘form’ should be relegated to a subsidiary position to the term ‘formation’. Meanwhile, ‘formation’ must be recognised as being linked to the terms ‘information’ and ‘performance’. When architecture is ‘informed’ by performative considerations it becomes less a consideration of form in and of itself, and more a discourse of material formations. In other words, ‘form’ must be ‘informed’ by considerations of ‘performative’ principles to subscribe to a logic of material ‘formation’. However, the logic of morphogenesis in architecture is not limited to questions of design methodology: it also extends into the ethical arena.

If we can find forms that operate more efficiently from a structural point of view, then we can use fewer materials. Equally, if we can devise forms that perform more efficiently, then we can consume less energy in heating or cooling our buildings. In either case morphogenetic design will help to preserve the world’s resources. As such it can be taken not only as a critique of the scenography of Postmodernism, but also as an ethical argument in terms of the environment.

**Material Computation**

Biotechnology provides one of the major sources of inspiration for research into morphogenesis in architecture. Nature operates largely through a logic of optimisation, and can therefore offer important lessons for architects. Biomimetics – the study of what we can learn by replicating the mechanisms of nature – has therefore emerged as an important field of research. It is not simply that nature describes products such as Velcro or recent fabrics used in the manufacture of swimwear that are based on the hydrodynamic properties of shark’s skin; rather, nature itself can teach us important lessons about the efficiency of certain structural organisations. Following on from the early experimentation of Gaudi, Frei Otto has become a champion of observing the behaviour of certain structures in nature, and reapplying their principles through analogue modelling. Thus spiders’ webs and soap bubbles can provide deep insights into the behaviour of form-finding lightweight structures. These observations come under the heading of ‘material computation’. They offer us analogue forms of computation, which – despite the apparent crudeness of computational models – are actually highly sophisticated mechanisms for the optimisation of structural performance. To describe them as a form of computation is not to undermine the role of digital computation; rather it is to recognise that computation is everywhere in nature. ‘Computation’ – a term derived from the Latin ‘componere’ (to ‘think together’) – refers to any system where individual components are working together. But it is equally important to recognise that digital computation has its limitations. It necessarily involves the reduction of the world to a limited set of data that can be simulated digitally, but it can never replicate the complexity of a system such as a soap bubble whose internal structural computation involves an intricate balance between highly complex surface material organisations and differential atmospheric pressures. A number of contemporary architects have re-examined the works of Gaudi and Otto, and found in them sources of inspiration for the new morphogenetic generation of form-finding research, often coupling the lessons of their analogue experimentation with more contemporary digital techniques. Mark Goulthorpe of d’Eci Architects describes his work as a form of ‘post-Gaudí praxis’, while Mark Burry, as architectural consultant for the completion of Santiago Calatrava’s Santiago railway station in Barcelona, has been exploring digital techniques for understanding the logic of Gaudi’s own highly sophisticated understanding of natural forces. Meanwhile, Lars Spuybroek of NOX has performed a number of imaginative experiments inspired by the work of Frei Otto as a point of departure for some innovative design work, which also depends on more recent software developments within the digital realm. This work points towards a new ‘performative turn’ in architecture, a renewed interest in the principles of structural performance, and in collaborating more technically with certain progressive structural engineers. However, this concern for performance may extend beyond structural engineering to embrace other constructional discourses, such as environmental, economic, landscaping or indeed programmatic concerns. In short, what it amounts to is a ‘folding’ of architecture into the other discourses that define the building industry.

**Digital Computation**

Not surprisingly in an age dominated by the computer, this interest in material computation has been matched by an interest in digital computation. Increasingly the performative turn that we have witnessed within architectural design culture is being explored through new digital techniques. These extend from the manipulation and use of form-generating programs from L-Systems to cellular automata, genetic algorithms and multi-agent systems that have been used by progressive designers to breed a new generation of forms, to the use of the computer to understand, test out and evaluate already designed structures. The seemingly paradoxical use of the immaterial domain of the computer to understand the material properties of architecture has spawned a new term in architecture: ‘digital tectonics’. In other words, the digital paradigm means that the material and the immaterial world of the digital has broken down. What we have instead is a new tectonics of the digital or ‘digital tectonics’. A certain genealogy can be detected in the use of the computer in architecture. What distinguishes this new digital paradigm from early uses of the computer in the architectural arena is that it reinterprets the computer not simply as a sophisticated drafting tool – an extension, in other words, of the possibilities of the previous paradigm of ink on tracing paper – but also as a device that might become part of the design process itself. With this we see a development in the very nature of the architect from the demiurge ‘form giver’ to the architect as the controller of generative processes, where the final appearance is a product not of the architect’s imagination alone, but of the generative capacities of computer programs. It is not that the architect here is any less imaginative; rather, the architectural imagination has been displaced into a different arena – into the imaginative use of various processes.

But even within the logic of digital tectonics there is a certain genealogy of development. Computational methodology had first been
used as a means of testing and thereby verifying and supporting the initial designs of the architect. The objective here was simply to use the computer to make the designs of the architect realisable. The only significant contribution to the design process occurred when findings of this process influenced the original design and forced minor amendments to it. Examples here would include the use of software to test out the design by Foster + Partners. Occasionally, also, a more precise structural definition of a loosely formulated building by Foster + Partners. It is programs such as this that reveal the true potential of the digital realm in influencing the process of design itself, by opening up fields of possibilities. The computer, then, emerges not only as a prosthetic device that extends the range of the architectural imagination, but also – much like a calculator – as a tool of optimisation that offers a more rigorous means of searching out possible options than what could be described as the pseudo-computational logic that often dominates contemporary practice.

New Theoretical Paradigms

This interest in digital production has also prompted a broad shift in architectural theory and philosophical matters, and an increase in interest in scientific thinking and in philosophies informed by scientific thinking and an understanding of material processes. It is thus simply to the recognition of Jacques Derrida that is fading in popularity, that of Gilles Deleuze is becoming increasingly popular. Indeed it has been through the work of secondary commentators on Deleuze, such as Manuel DeLanda, that the relevance of Deleuze’s material philosophies has been championed within architectural circles.

DeLanda coined a new term for this emerging theoretical paradigm: ‘New Materialism’. This should be distinguished from Marx’s ‘Dialectical Materialism’ in that the model is extended beyond mere economic considerations to embrace the whole of culture, and yet the principle behind Marx’s thinking – what we see on the surface is the product of deeper underlying forces – remains the same. Here we might understand cultural production not in symbolic terms, but in terms of material expressions. It is not a question of what a cultural object might ‘symbolise’ – the dominant concern in the Postmodernist quest for interpretation and meaning – but rather what it ‘expresses’. The concern, then, is to understand culture in terms of material processes – in terms of the actual ‘architecture’ of culture itself. Within this new configuration the economist, the scientist and the engineer are among the reassessed heroes of our cultural horizon, and figures such as Cecíl Balmont have become the new ‘material philosophers’ – to use another term adopted by DeLanda – of New Materialism.

To some extent this can be read as a highly positive development within architectural circles in that the domains of science and technology, for so long neglected at the expense of history and theory and practiced as largely posthistorical domains, have now been reappropriated and recognised as offering a highly relevant and rich domain of intellectual enquiry.

It is not just materialist philosophies that have seized the imagination of architectural theorists. So, too, has scientific thinking itself begun to find its place in the architectural curriculum, from the early observations of D’Arcy Thompson on growth and form to more recent theories – such as ‘emergence’, popularised by Steven Johnson, and Stephen Wolfram’s discourse of ‘A New Kind of Science’, both of which deal with complexity emerging from a simple set of initial rules.12

If we add to these the developing interest in computational methodology – the possibility of scripting, parametric modelling and performance-based generative techniques such as multi-agent systems or genetic algorithms – we can begin to define a broad shift that has already appeared in certain progressive schools of architecture and that is beginning to spread into mainstream architectural culture.

Notes

1. Morphogenesis is derived from the Greek terms, ‘morphé’ (shape/form) and ‘genesis’ (creation).
2. See Michael Hensel, Achim Menges and Michael Weinstock’s issues of AD: Emergence: Morphogenetic Design Strategies (July/August 2004) and Technologies and Technologemes in Morphogenetic Design (March/April 2006).
4. A Alejandro Zaera-Polo and Farshad Moussavi comment, their interest is to recognise the other disciplines in the building industry not simply as offering a service that should be treated as an afterthought in the design process, but rather as an important range of design considerations that should be embraced and incorporated into the early stages of the design process itself. Farshad Moussavi and Alejandro Zaera Polo (Foreign Office Architects), ‘Rollenrecker construction’, in Neil Leach (ed), Designing for a Digital World, John Wiley & Sons (London), 2002, pp 117–20.

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