14

COMPUTING THE PERFORMATIVE

BRANKO KOLAREVIC

14.1
The Dynaform BMW Pavilion at the IAA'01 Auto Show in Frankfurt, Germany (2000–01), architects Bernhard Franken and ABB Architekten.

In avant-garde contemporary architectural design, various digital generative and production processes are opening up new territories for conceptual, formal and tectonic exploration, articulating an architectural morphology focused on the emergent and adaptive properties of form.[1] In a radical departure from centuries-old traditions and norms of architectural design, digitally-generated forms are not designed or drawn as the conventional understanding of these terms would have it, but they are calculated by the chosen generative computational method. Instead of working on a *parti*, the designer constructs a *generative system* of formal production, controls its behavior over time, and selects forms that emerge from its operation. The emphasis shifts from the "making of form" to the "finding of form," which various digitally-based generative techniques seem to bring about intentionally.

The new, speculative design work of the digital avant-garde, enabled by time-based modeling techniques, is provoking an interesting debate about the possibilities and challenges of the digital generation of form (i.e. the *digital morphogenesis*).[2] There is an aspiration to manifest formally the invisible dynamic processes that are shaping the physical context of architecture (figure 14.1), which, in turn, are driven by the socio-economic and cultural forces within a larger context. According to Greg Lynn, "the context of design becomes an active abstract space that directs from within a current of forces that can be stored as information in the shape of the form."[3] Formal complexity is often intentionally sought out, and this morphological intentionality is what motivates the processes of construction, operation and selection.

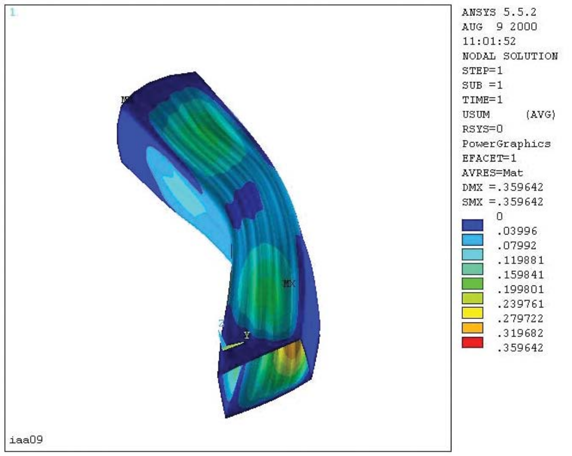
This dynamic, time-driven shift in conceptualization techniques, however, should not be limited to the issues of representation, i.e. formal appearance, only. While we now have the means to visualize the dynamic forces that affect architecture by introducing the dimension of time into the processes of conceptualization, we can begin to qualify their effects and, in the case of certain technical aspects, begin to quantify them too. There is a range of digital analytical tools that can help designers assess certain *performative* aspects of their projects, but none of them provide dynamic generative capabilities yet.

PERFORMANCE-BASED DESIGN

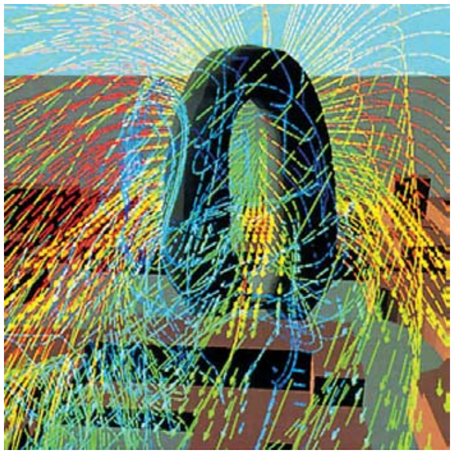
The aesthetics of many projects of the digital avant-garde, however, are often sidetracking the critical discourse into the more immediate territory of formal expression and away from more fundamental possibilities that are opening up. Such possibilities include the emergence of *performance-based design*, in which building performance becomes a guiding design principle, considered on a par with or above form-making.

The current interest in building performance as a design paradigm is largely due to the emergence of sustainability as a defining socio-economic issue and to the recent developments in technology and cultural theory. Within such an expansive context, building performance can be defined very broadly, across multiple realms, from financial, spatial, social and cultural to purely technical (structural, thermal, acoustical, etc.). The issues of performance (in all its multiple manifestations) are considered not in isolation or in some kind of linear progression but *simultaneously*, and are engaged early on in the conceptual stages of the project, by relying on close collaboration between the many parties involved in the design of a building. In such a highly "networked" design context, digital quantitative and qualitative performance-based simulations are used as a technological foundation for a comprehensive new approach to the design of the built environment.

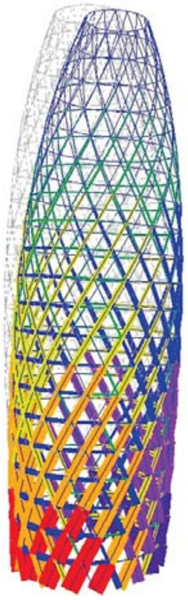
It is important to note that performance-based design should not be seen as simply a way of devising a set of practical solutions to a set of largely practical problems, i.e. it should not be reduced to some kind of neo-functionalist approach to architecture. The emphasis shifts to the processes of form generation based on performative strategies of design that are grounded, at one end, in intangibilities such as cultural performance and, at the other, in quantifiable and qualifiable performative aspects of building design, such as structure, acoustics or environmental design. Determining the different performative aspects in a particular project and reconciling often conflicting performance goals in a creative and effective way are some of the key challenges in performance-based design.



14.2
Finite-element analysis (FEA) stress analyses of the Dynaform BMW Pavilion for the 2001 Auto Show in Frankfurt, Germany, by Bollinger + Grohman Consulting Engineers, architects Bernhard Franken and ABB Architekten.



14.4
The CFD analysis of wind flows for Project ZED in London (1995) by Arup, architect Future Systems.



14.3
The FEA analysis of stresses for the Swiss Re building, London (1997–2004), by Arup, architect Foster and Partners.

CALCULATING PERFORMANCE THEN

The performative design thinking, framed by a broadly defined performance agenda and supported by a range of digital performance analysis and simulation tools, as outlined briefly above, was envisioned decades ago. Back in the late 1960s and early 1970s, a group of researchers led by Thomas Maver at ABACUS (Architecture and Building Aids Computer Unit Strathclyde) at the University of Strathclyde's Department of Architecture and Building Science, proposed that the building design be directly driven and actively supported by a range of integrated "performance appraisal aids" running on computer systems.[4]

Digital building performance "appraisal aids" and performance-based design were at the center of computer-aided building design research for more than three decades — many of the essential concepts and techniques were pioneered in the late 1960s and early 1970s. For example, the first use of computer graphics for building appraisal was in 1966, the first integrated package for building performance appraisal appeared in 1972, the first computer-generated perspective drawings appeared in 1973, etc.[5] The 1970s resulted in the "generation of a battery of computer aids for providing the designer with evaluative feedback on his design proposals," enabling architects to "obtain highly accurate predictions of such building performance measures as heat loss, daylight contours, shadow projections and acoustic performance."[6]

One of the first digital performance analysis tools to emerge was PACE (Package for Architectural Computer Evaluation), developed at ABACUS and introduced in 1970 as a "computer-aided appraisal facility for use at strategic stages in architectural design," which, unlike many of the efforts at the time, aimed "not on optimization of a single parameter but on production of a comprehensive and integrated set of appraisal measures."[7] PACE was written in FORTRAN and run on a time-sharing system; the "conversational interaction" was through a teletypewriter terminal. The program measured costs, "spatial," environmental and "activity" performance. The "spatial performance" component measured site utilization (plot ratio) and plan and mass compactness. Computing the environmental performance resulted in "plant sizes which [would] give adequate environmental conditions," while taking into account the heat gain and loss. The "activity performance" module measured "the degree to which the relationships input under activity information are satisfied by the proposed scheme."

The program would instruct the designer how to change geometrical or constructional information, i.e. how to modify the design concept to improve performance and then submit the modified design for "re-appraisal." In the end, the "repetitive man/machine interaction" would lead to "convergence of an 'optimum' design solution." A particularly interesting aspect of the program was its built-in capacity to "learn:" if the designer was satisfied with the scheme, the program would update the stored mean values used in assessments.[8]

As is often the case with visionary ideas, much of the early work in digitally-driven performance-based design was far ahead of its time both conceptually and technologically. But its time has now come, as performance-based design is slowly but steadily coming to the forefront of architectural discourse.

14.5
An early computer rendering of the structural system for Kunsthaus Graz, Austria (2000–03), architects Peter Cook and Colin Fournier (spacelab.uk).

SIMULATING PERFORMANCE NOW

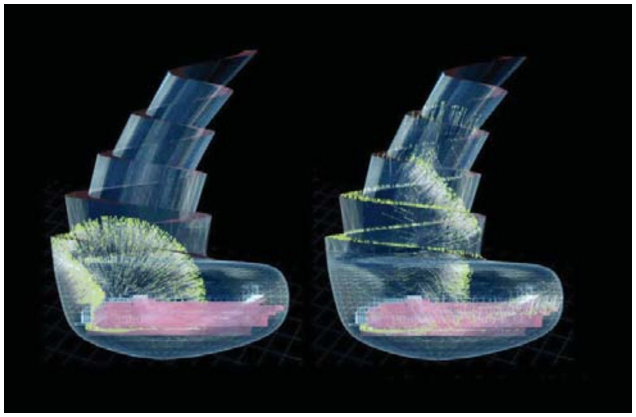
Today, digital quantitative and qualitative performance-based simulation represents the technological foundation of the emerging performative architecture described earlier. Analytical computational techniques based on the finite-element method (FEM), in which the geometric model is divided into small, interconnected mesh elements, are used to accurately perform structural, energy and fluid dynamics analyses for buildings of any formal complexity. These quantitative evaluations of specific design propositions can be qualitatively assessed today thanks to improvements in graphic output and visualization techniques (figures 14.2–14.6). By superposing various analytical evaluations, design alternatives could be compared with relative simplicity to select a solution that offers desired performance.

Future Systems, a design firm from London, used computational fluid dynamics (CFD) analysis in a particularly interesting fashion in its Project ZED, the design of a multiple-use building in London (1995; figure 14.4). The building was meant to be self-sufficient in terms of its energy needs by incorporating photovoltaic cells in the louvers and a giant wind turbine placed in a huge hole in its center. The curved form of the façade was thus designed to minimize the impact of the wind at the building's perimeter and to channel it towards the turbine at the center. The CFD analysis was essential in improving the aerodynamic performance of the building envelope.

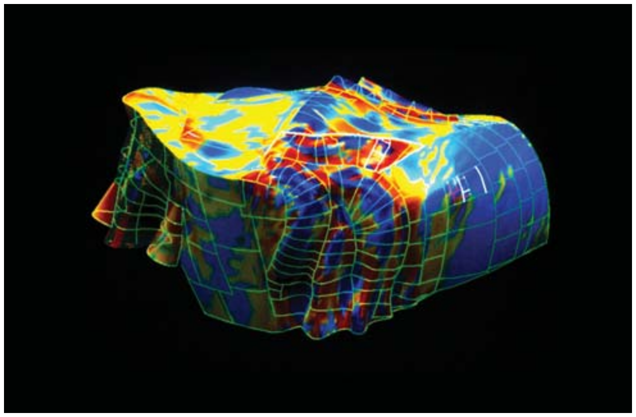
The original blobby shape of Peter Cook and Colin Fournier's competition winning entry for the Kunsthaus Graz, Austria (figure 14.5), was altered somewhat after the digital structural analysis by consulting engineers Bollinger + Grohmann from Frankfurt revealed that its structural performance could be improved with minor adjustments in the overall form, by extracting the isoparametric curves for the envelope definition not from the underlying NURBS geometry but from the structural analysis. Likewise, Foster and Partners' design for the main chamber of the London City Hall (figure 14.6) had to undergo several significant changes after engineers from Arup analyzed its acoustical performance using in-house developed acoustic wave propagation simulation software.

In Gehry's office, Gaussian analysis is used to determine the extent of curvature of different areas on the surface of the building (figure 14.7). That way the designers can quickly assess the material performance, i.e. whether the material can be curved as intended, as there are limits to how much a particular material with a particular thickness can be deformed. More importantly, the curvature analysis provides quick, visual feedback about the overall cost of the building's "skin," as doubly-curved areas (shown in red) are much more expensive to manufacture than the single-curved sections (shown in green and blue tones).

14.6
The acoustical analysis of the debating chamber in the City Hall, London (1998–2002) by Arup, architect Foster and Partners.



14.7
Gaussian analysis, Experience Music Project, Seattle (1999–2000), architect Gehry Partners.



As these examples demonstrate, the feedback provided by visualization techniques in the current building performance simulation software can be very effective in design development. The software, however, operates at the systemic level in the same *passive* fashion as two or three decades ago. "Computer-aided appraisal" now and back in 1980, as described by Thomas Maver, has consisted of four main elements: representation, measurement, evaluation and modification:

> The designer generates a design hypothesis which is input into the computer (representation); the computer software models the behaviour of the hypothesized design and outputs measures of cost and performance on a number of relevant criteria (measurements); the designer (perhaps in conjunction with the client body) exercises his (or their) value judgement (evaluation) and decides on appropriate changes to the design hypothesis (modification).[9]

As noted by Maver, "if the representation and measurement modules of the design system can be set up and made available, the processes of evaluation and modification take place dynamically within the design activity as determinants of, and in response to, the pattern of explorative search," which is a fairly accurate description of how performance analysis ("appraisal") software is being used today.

CHALLENGES

Designing buildings that perform (i.e. "which work — economically, socially and technically") is a central challenge for architects, as observed by Thomas Maver back in 1988.[10] He called for the development of "software tools for the evaluation of the technical issues which are relevant at the conceptual stages, as opposed to the detailed stages, of design decision-making."[11]

The challenges of developing such software, however, are far from trivial. Most of the commercially available building performance simulation software, whether for structural, lighting, acoustical, thermal or air-flow analysis, requires high-resolution, i.e. detailed, modeling, which means that it is rarely used in conceptual design development. This shortcoming, and the lack of usable "low-resolution" tools, is further compounded by the expected degree of the user's domain knowledge and skills. Another frequently encountered problem is that certain performance aspects can be analyzed in one environment while other performative analyses must be performed in some other software, often resulting in substantial and redundant remodeling. Providing a certain degree of *representational integration* across a range of "low-resolution" performance simulation tools is a necessary step for their more effective use in conceptual design.

Assuming that analytical and representational integration can be achieved, and that intuitive "low-resolution" performance simulation tools can be developed, additional challenges are presented by the need for *active* design space exploration. Instead of being used in a passive, "after-the-fact" fashion, i.e. after the building form has already been articulated, as is currently the case, analytical computation could be used to actively shape the buildings in a dynamic fashion, in a way similar to how animation software is used in contemporary architecture.[12] In other words, the performance assessment has to be *generative* and not only *evaluative*. For that to happen, however, a fundamental rethinking of how the digital performance simulation tools are conceptualized is required.

Ulrich Flemming and Ardeshir Mahdavi argued in 1993 for the close "coupling" of form generation and performance evaluation for use in conceptual design.[13] Mahdavi developed an "open" simulation environment called SEMPER, with a "multidirectional" approach to simulation-based performance evaluation.[14] According to Mahdavi, SEMPER provides comprehensive performance modeling based on first principles, "seamless and dynamic communication between the simulation models and an object-oriented space-based design environment using the structural homology of various domain representations," and bi-directional inference through "preference-based performance-to-design mapping technology."

PERFORMANCE-BASED GENERATIVE DESIGN

As Kristina Shea observed, "generating new forms while also having instantaneous feedback on their performance from different perspectives (space usage, structural, thermal, lighting, fabrication, etc.) would not only spark the imagination in terms of deriving new forms, but guide it towards forms that reflect rather than contradict real design constraints."[15] As a structural engineer, she cites the form-finding techniques used in the design of tensile membrane structures (pioneered by Frei Otto) as the nearest example of performance-driven architectural form generation, in which the form of the membrane is dynamically affected by changing the forces that act on the model. She notes that the form-finding techniques in structural engineering are generally limited to either pure tensile or pure compression structures, and she promotes the need for developing digital tools that can generate mixed-mode structural forms.[16]

According to Kristina Shea, a generative approach to structural design requires a design representation of form *and* structure that encodes not only (parametric) geometry but also a design *topology* based on the connectivity of primitives.[17] The experimental software she developed, called *eifForm*, is based on a structural shape grammar that can generate design topology and geometry, enabling the transformation of form while *simultaneously* maintaining a meaningful structural system. Primitives and their connectivity are added, removed and modified with a built-in *randomness* in design generation, directed by a *non-deterministic*, *non-monotonic* search algorithm based on an optimization technique called "simulated annealing," analogous to the "crystallization processes in the treatment of metals."[18] The software develops the overall form of a structure dynamically, in a time-based fashion, "by repeatedly modifying an initial design with the aim of improving a predefined measure of performance, which can take into account many different factors, such as structural efficiency, economy of materials, member uniformity and even aesthetics, while at the same time attempting to satisfy structural feasibility constrains." The end product is a triangulated pattern of individually-sized structural elements and joints (figures 14.8 and 14.9).

In a similar vein, I have proposed in a recent paper[19] the development of generative tools based on performance evaluation in which, for example, an already structured building topology, with a generic form, could be subjected to dynamic, metamorphic transformation resulting from the computation of performance targets set at the outset. Such a dynamic range of performative possibilities would contain at its one end an unoptimized solution and at the other an optimized condition (if it is computable), which might not be an acceptable proposition from an aesthetic or some other point of view. In that case, a suboptimal

14.8
Canopy design developed using *eifForm* for the courtyard of the Academie van Bouwkunst in Amsterdam (2002), designed by Neal Leach, Spela Videcnik (OFIS Architects), Jaroen van Mechelen and Kristina Shea.

14.9
eifForm: progressive generation of the canopy design.

solution could be selected from the in-between performative range, one that could potentially satisfy other non-quantifiable performative criteria.

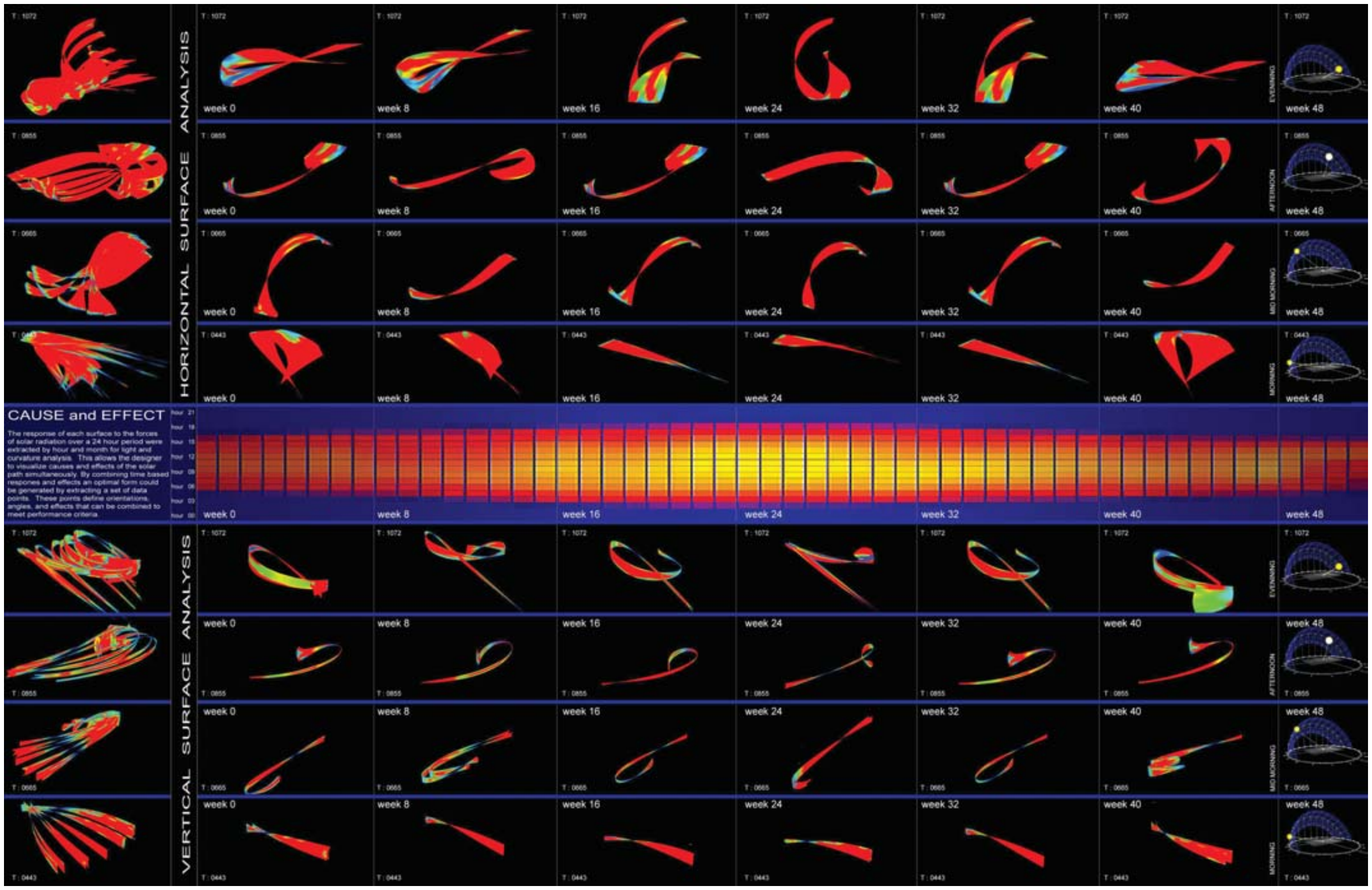
This new kind of analytical software will preserve the topology of the proposed schematic design but will alter the geometry in response to optimizing a particular performance criteria (acoustic, thermal, etc.). For example, if there is a particular geometric configuration comprised of polygonal surfaces, the number of faces, edges and vertices would remain unchanged (i.e. the topology does not change), but the shapes (i.e. the geometry) will be adjusted (and some limits could be imposed in certain areas). The process of change could be animated, i.e. from the given condition to the optimal condition, with the assumption that the designer could find one of the in-between conditions interesting and worth pursuing, even though it may not be the most optimal solution (figure 14.10).

In this scenario, the designer becomes an "editor" of the morphogenetic potentiality of the designed system, where the choice of emergent forms is driven largely by the project's quantifiable performance objectives and the designer's aesthetic and plastic sensibilities. The capacity to generate "new" designs becomes highly dependent on the designer's perceptual and cognitive abilities, as continuous, dynamic processes ground the emergent form, i.e. its discovery, in qualitative cognition. Even though the technological context of design is thoroughly externalized, its arresting capacity remains internalized. The generative role of the proposed digital techniques is accomplished through the designer's simultaneous interpretation and manipulation of a computational construct (topological configuration subjected to particular performance optimizations) in a complex discourse that is continuously reconstituting itself — a "self-reflexive" discourse in which graphics actively shape the designer's thinking process.

CONCLUSION

In conclusion, the new "performative" approach to design requires, at a purely instrumental level, yet-to-be-made digital design tools that can provide dynamic processes of formation based on specific performative aspects of design. There is currently an abundance of digital analytical tools that can help designers assess certain performative aspects of their projects *post-facto*, i.e. after an initial design is developed, but none of them provide dynamic generative capabilities that could open up new territories for conceptual exploration in architectural design. More importantly, the emergence of performance-based generative design tools would lead to new *synergies* between architecture and engineering in a collaborative quest to produce unimaginable built forms that are *multiply performative*.

14.10
An analysis of surface curvature across a range of formal alternatives extrapolated from a computer animation by Matthew Herman (graduate student at the University of Pennsylvania).



NOTES

1 Branko Kolarevic, Chapter 2 "Digital Morphogenesis" in B. Kolarevic (ed.), *Architecture in the Digital Age: Design and Manufacturing*, London: Spon Press, 2003, pp. 11–28.
2 Ibid.
3 Greg Lynn, *Animate Form*, New York: Princeton Architectural Press, 1999.
4 Thomas W. Maver, "PACE 1: Computer Aided Design Appraisal" in *Architects Journal*, July, 1971, pp. 207–214.
5 Thomas W. Maver, "Predicting the Past, Remembering the Future" in *Proceedings of the SIGraDi 2002 Conference*, Caracas, Venezuela: SIGraDi, 2002, pp. 2–3.
6 Nigel Cross and Thomas W. Maver, "Computer Aids for Design Participation" in *Architectural Design*, 53(5), 1973, p. 274.
7 Maver, "PACE 1," op. cit.
8 The program also offered eight perspective views of the scheme, which were drawn on a "graph plotter" driven by the paper tape produced by the program. That was a "revolutionary" technological development back in 1970s!
9 Thomas W. Maver, "Appraisal in Design" in *Design Studies*, 1(3), 1980, pp. 160–165.
10 Thomas W. Maver, "Software Tools for the Technical Evaluation of Design Alternatives" in *Proceedings of CAAD Futures '87*, Eindhoven, Netherlands, 1988, pp. 47–58.
11 *Ibid.*
12 Kolarevic, op.cit.
13 Ulrich Flemming and Ardeshir Mahdavi, "Simultaneous Form Generation and Performance Evaluation: A 'Two-Way' Inference Approach" in *Proceedings of CAAD Futures '93*, Pittsburgh, USA, 1993, pp. 161–173.
14 A. Mahdavi, P. Mathew, S. Lee, R. Brahme, S. Kumar, G. Liu, R. Ries, and N. H. Wong, "On the Structure and Elements of SEMPER, Design Computation: Collaboration, Reasoning, Pedagogy" in *ACADIA 1996 Conference Proceedings*, Tucson, USA, 1996, pp. 71–84.
15 Kristina Shea, "Directed Randomness" in N. Leach, D. Turnbull and C. Williams (eds), *Digital Tectonics*, London: Wiley-Academy, 2004, pp. 89–101.
16 Ibid, p. 89.
17 Ibid, p. 93.
18 Ibid. Simulating annealing is described by Shea as "a stochastic optimisation technique that tests a batch of semi-random changes generated by the structural shape grammar, measures their performance and then chooses one that is near the best. The amount of deviation from the best is gradually reduced throughout the process, but not necessarily from one design to the next."
19 Branko Kolarevic, "Computing the Performative in Architecture" in W. Dokonal (ed.), *Digital Design, Proceedings of the ECAADE 2003 Conference,* Graz, Austria, 2003.

15

TOWARDS THE PERFORMATIVE IN ARCHITECTURE

BRANKO KOLAREVIC

We might distinguish between two kinds of spatial disposition, effective and affective. In the first, one tries to insert movements, figures, stories, activities into some larger organization that predates and survives them; the second, by contrast, seeks to release figures or movements from any such organization, allowing them to go off on unexpected paths or relate to one another in undetermined ways.

John Rajchman[1]

In the late 1950s, performance emerged in humanities — in linguistics and cultural anthropology in particular — and in other research fields as a fundamental concept of wide impact. It shifted the perception of culture as a static collection of artifacts to a web of interactions, a dynamic network of intertwined, multilayered processes that contest fixity of form, structure, value or meaning. Social and cultural phenomena were seen as being constituted, shaped and transformed by continuous, temporal processes defined by fluidity and mediation; thus a *performative* approach to contemporary culture emerged.

As a paradigm in architecture, performance can be understood in those terms as well; its origins can be also traced to the social, technological and cultural milieu of the mid-twentieth century. The utopian designs of the architectural avant-garde of the 1960s and early 1970s, such as Archigram's "soft cities," robotic metaphors and quasi-organic urban landscapes, offered images of fantasies based on mechanics and pop culture; they have particular resonance today, as cultural identity and spatial practice are being rethought through performative acts that recode, shift and transform meanings in a true, semiotic sense.

In this spirit, performative architecture can be described as having a capacity to respond to changing social, cultural and technological conditions by perpetually reformatting itself as an *index*, as well as a mediator of (or an interface to) emerging cultural patterns.[2] Its spatial program is not singular, fixed or static, but multiple, fluid and ambiguous, driven by temporal dynamics of socio-economic, cultural and technological shifts. In performative architecture, culture, technology and space form a complex, *active* web of connections, a network of interrelated constructs that affect each other simultaneously and continually. In performative architecture, space unfolds in *indeterminate* ways, in contrast to the fixity of predetermined, programmed actions, events and effects.

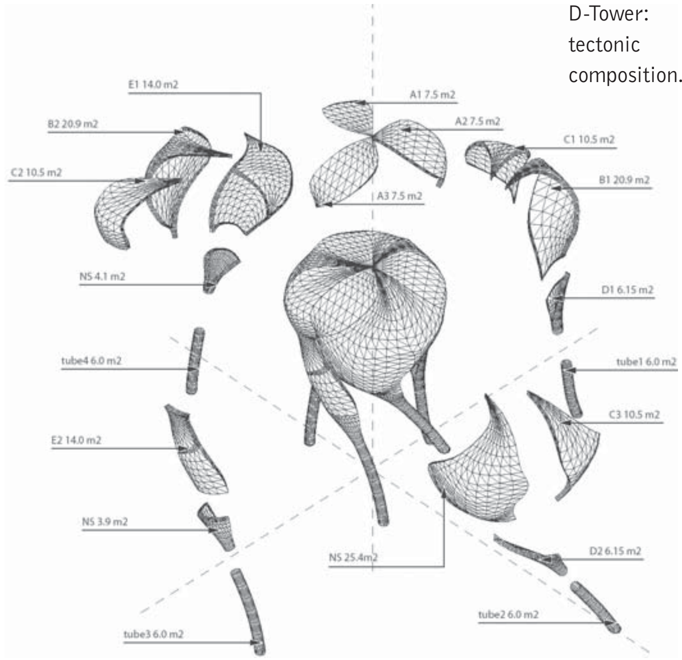
The description of performative architecture given above is one of many — its paradigmatic appeal lies precisely in the multiplicity of meanings associated with the performative in architecture.[3] The increasing interest in performance as a design paradigm is largely due to the recent developments in technology and cultural theory and the emergence of sustainability as a defining socio-economic issue. Framed within such expansive context, the performative architecture can indeed be defined very broadly — its meaning spans multiple realms, from financial, spatial, social and cultural to purely technical (structural, thermal, acoustical, etc.). In other words, the performative in architecture is operative on many levels, beyond just the aesthetic or the utilitarian.

ARCHITECTURE AS PERFORMANCE

At the urban scale, architecture operates between the opposing poles of "smooth" urban space (by blending in) and urban landmarks (that stand out). Contemporary avant-garde architecture advances the latter towards architecture as performance art, which takes the urban setting as a stage on which it literally and actively *performs*.

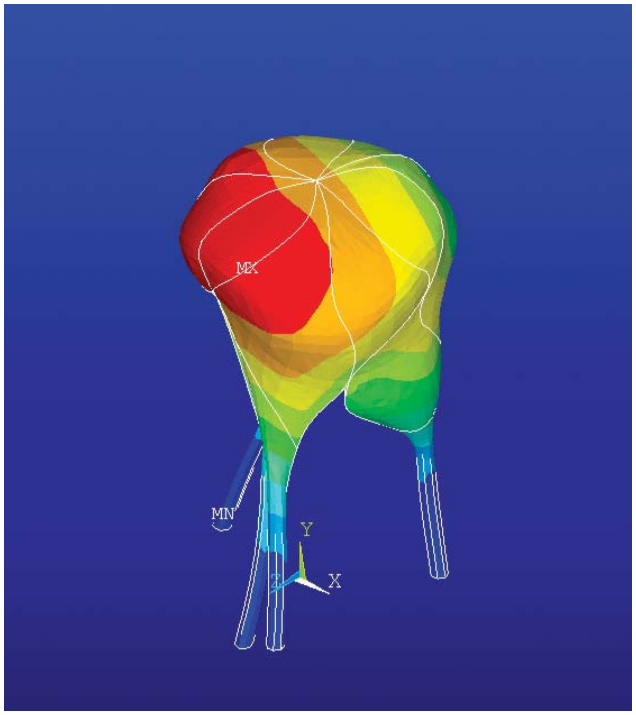
Some of the recent projects by Lars Spuybroek (NOX), such as the D-Tower[4] in Doetinchem, the Netherlands (1998–2003), and Maison Folie[5] in Lille, France (2001–04), can literally be seen as architectural performance pieces. D-Tower is a hybrid digital and material construct (figure 15.1), which consists of a biomorphic built structure (the tower), a website and a questionnaire that form an interactive system of relationships in which "the intensive (feelings, qualities) and the extensive (space, quantities) start exchanging roles, where human action, color, money, value, feelings all become networked entities."[6] The complex surface of

15.1
D-Tower, Doetinchem, Netherlands (1998–2003), architect NOX/Lars Spuybroek.



15.2
D-Tower: tectonic composition.

15.3
D-Tower: structural analysis of stresses.



the 12 m tower is made of epoxy panels shaped over CNC (computer numeric control)-milled molds (figure 15.2). The epoxy monocoque shell is both the structure and the skin, and thus simultaneously multi-performative from the tectonic and building physics perspectives (figure 15.3). The tower changes its color depending on the prevailing emotional state of the city's residents, which is computed from responses of the city's inhabitants to an online questionnaire[7] about their daily emotions — hate, love, happiness and fear — and these are mapped into four colors (green, red, blue and yellow), with a corresponding light illuminating the biomorphic surfaces of the tower. The city's "state of mind" is also accessible through the website, which also shows the "emotional landscape" of the city's neighborhoods. So, either by looking at the tower or the corresponding website, one can tell the dominant emotion of the day.[8] The tower also features a capsule in which the city's inhabitants could leave love letters, flowers, etc. To motivate participation in this socially and culturally performative urban and architectural experiment, a monetary prize of 10,000 euros is to be awarded to the "address with highest emotions."

15.4
Maison Folie, Lille, France (2001–04), architect NOX/Lars Spuybroek.

15.5
Kunsthaus Graz, Austria (1999–2003), architects Peter Cook and Colin Fournier (spacelab.uk).

15.6
BIX, the "communicative membrane" for Kunsthaus Graz, designers realities:united.

In Maison Folie in Lille (figure 15.4), an old textile factory that has been transformed into a new urban art center,[9] the added multi-purpose hall (a black box) features an external, partially transparent skin, whose intricate tectonic composition of metallic grilles produces varying moiré patterns as one moves along it. Spuybroek refers to this dynamic effect as a "static" movement, "an animation of the vertical tectonics of the façade, … bending vertical lines in a complex pattern that produce a whole range of changes when walking or driving by, enhanced by the position of the sun."[10] There is also the literal movement of changing lights placed behind the metallic grille of the façade, adding another layer of intricacy to the building's urban performance.

Dynamic display of light, i.e. changing light patterns, is a primary performative dimension in Peter Cook and Colin Fournier's Kunsthaus Graz, Austria (1999–2003; figure 15.5). BIX, the light and media installation designed by realities:united from Berlin, is inserted behind the acrylic glass layer to create a "communicative membrane" — a low-resolution computer-controlled skin, a "media façade" that, through the display of signs, announcements and images, hints at the activities within the building (figure 15.6). The performative aspects of the building are all geared towards an "urban communication strategy."

The BIX light installation blurs the boundaries between the architecture and the performance medium; in the Kunsthaus Graz "the medium is the message."[11] Extending McLuhan's ideas to performative architecture,[12] one could argue that mediated, animated architectural skins have the potential to change how we relate to the built environment and, reciprocally, how the built environment relates to us, as manifested in Mark Goulthorpe's *Aegis Hyposurface* project, described below.

Movement and performance

It is often the movement of people around and through a building that gives architecture its performative capacity, as Maison Folie demonstrates. It is the experience of architecture's spatial presence and materiality — the engagement of the eye and the body — that makes architecture performative.

15.8
The Millennium Bridge: the bridge's arches in the tilted position.

15.7
The Millennium Bridge in Gateshead, UK (1997–2001), architects Wilkinson Eyre Architects, engineers Gifford and Partners.

15.9
The Milwaukee Art Museum, USA (1994–2001), architect and engineer Santiago Calatrava.

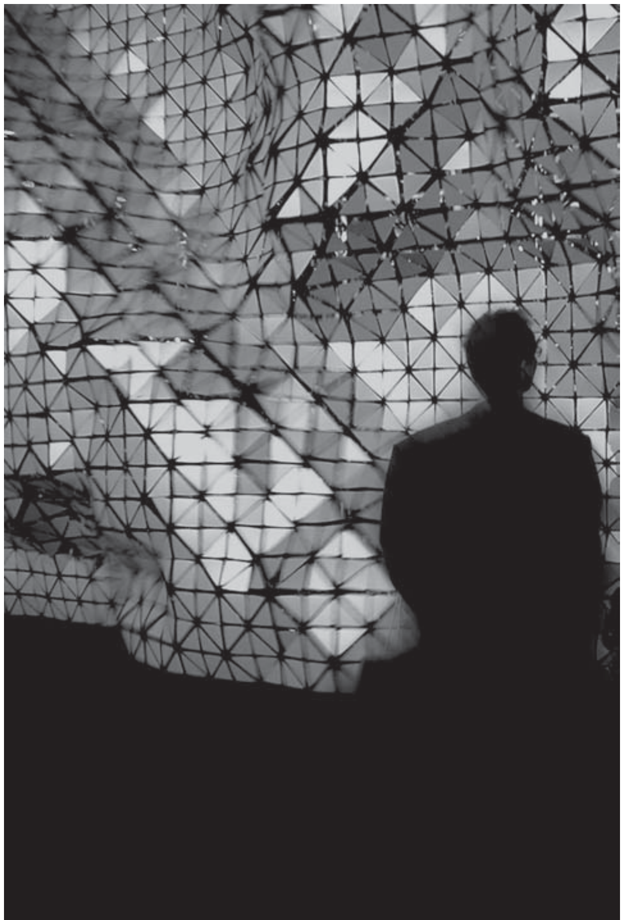
15.10
The Milwaukee Art Museum: the kinetic operation of the wing-like *brise soleil*.

In some recent projects, such as the Millennium Bridge in Gateshead, UK (1997–2001; figures 15.7 and 15.8), designed by Wilkinson Eyre Architects, and the Milwaukee Art Museum (1994–2001; figures 15.9 and 15.10), designed by Santiago Calatrava, the performative is in the kinetic effects of architecture — it is not the subject that moves but the object itself, creating an architecture of spectacle, an architecture of performance.

The Millennium Bridge in Gateshead — the "blinking eye" bridge, as it is popularly called — is the world's first rotating bridge; the entire bridge rotates around pivots on both sides of the river so that its tilt creates sufficient clearance for the ships to pass underneath (figure 15.9). The bridge's elegant arches appear to trap movement even when static; their dynamic metamorphosis has been described as resembling the slow opening of a giant eyelid — hence the "blinking eye" moniker.

For the museum building in Milwaukee, Santiago Calatrava designed a giant, movable wing-like sunscreen, a *brise soleil*, over a glass-enclosed reception hall. Made from fins ranging from 26 to 105 feet in length, the operable *brise soleil* is raised and lowered to control the amount of light (and heat) that enters into the reception area (figure 15.10). Calatrava clearly designed the operable *brise soleil* as an event, an urban performance on Milwaukee's waterfront. The performative, however, is not limited to the kinetics of the sunscreen; there are many "performances in geometry and engineering"[13] in this building, as is the case with almost all of Calatrava's projects.

In addition to kinetic effects, a building's skin can also dynamically alter its shape in response to various environmental influences, as the *Aegis Hyposurface* project by Mark Goulthorpe shows. Developed initially as a competition entry for an interactive art piece to be exhibited in the Birmingham Hippodrome Theatre foyer, the *Aegis Hyposurface* is a digitally controlled, pneumatically driven, deformable rubber membrane covered with metal shingles (figure 15.11) that can change its shape in response to electronic stimuli resulting from movement and changes in sound and light levels in its environment, or through parametrically-generated patterns. The dynamic performance of the building's skin can be either pre-programmed (determined) or in response to environmental changes (indeterminate, interactive).



15.11
Aegis Hyposurface, architect Mark Goulthorpe/ dECOi.

The Bilbao effect

In these and previously discussed projects, architecture's urban performances aim beyond the spectacle of the kinetic structures, dynamic skins and the changing light patterns. From the stakeholders' perspective (owners, municipal and regional governments, etc.), the intended performance of those buildings is primarily socio-economic; as urban landmarks, those buildings are meant to energize the urban contexts in which they are situated. By attracting the attention of local city dwellers and global cultural tourists, they are seen as the sparks of urban and economic renewal. The performances (and oftentimes forms) of these buildings become highly politicized.

This political, socio-economic and cultural performative potential of architecture is being rediscovered due, in large part, to what is nowadays called the "Bilbao effect," after the socio-economic and cultural transformation of a sleepy provincial town in northeastern Spain into a cosmopolitan cultural magnet as a result of a bold architectural and cultural strategy — the synergy of the global cultural brand of the Guggenheim Museum and the exuberance and expressiveness of Frank Gehry's architecture.[14] Not surprisingly, by reaching out for out-of-the-ordinary architectural tactics, cities increasingly expect miracles — hence, the curvaceous, light-animated forms of Kunsthaus Graz, the "blinking eye" bridge in Gateshead, and the wing-like museum in Milwaukee.

THE AESTHETICS AND ETHICS OF THE PERFORMATIVE

Admittedly, there is a considerable degree of novelty in complex, curvilinear forms (in spite of numerous precedents) pursued with fervor by the contemporary architectural avant-garde. The strong visual and formal juxtapositions created between "blobs" and "boxes" in traditional urban contexts, as is often the case, add to their "iconic" status and their perception of being exceptional and marvelous. The expressive form of the Kunsthaus Graz (figure 15.5), for example, is not accidental — its performative intent is aimed at the socio-economic: by attracting people to the area, this "Friendly Alien," as the building is curiously named by its architects, with its strange, mediated skin, will act as a development catalyst (aiming for the "Bilbao effect").

Appearance and performance

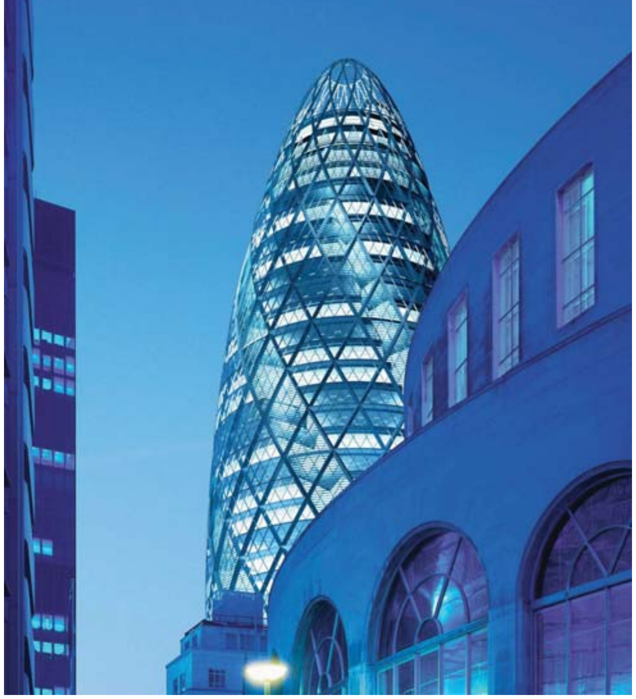
Interestingly, it is the surface — the building's skin — and its complex morphology and tectonics, and not necessarily the structure, that preoccupies the work of the contemporary (digital) avant-garde in its exploration of new formal territories enabled by the latest digital modeling software.[15] On the other hand, Santiago Calatrava appears to reject the skin in many of his projects and instead seeks to harness the expressive powers of exposed structure for its performative potential, both literally, in the engineering sense, and morphologically, for the beauty of force-driven formal articulation. Another strategy is to avoid the binary choices of skin or structure and to reunify the two by embedding or subsuming the structure into the skin, as in *semi-monocoque* and *monocoque* structures. The principal idea is to conflate the structure and the skin into one element.

This search for performance in geometry and engineering, in turn, prompted a search for different tectonics and "new" materials, such as high-temperature foams, rubbers, plastics and composites, which were, until recently, rarely used in the building industry.[16] For example, the *functionally gradient* polymer composite materials offer a promise of enclosures in which material variables can be optimized for local performance criteria, opening up entirely new material and tectonic possibilities in architecture. For example, transparency can be modulated in a single surface, and structural performance can be modulated by varying the quantity and pattern of reinforcement fibers, etc.[17]

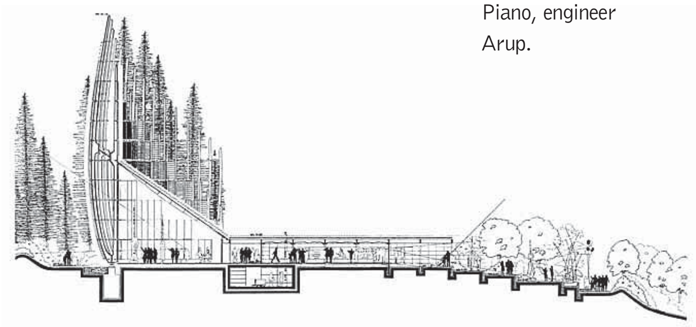
From a historic perspective, balancing performances in geometry and material is a continuously present theme in architecture. Geometry was often imposed onto the material, as manifested by various proportioning and other ordering systems. A different approach was to let the geometry *emerge* from the material and its capacity to deal with compression and tension (i.e. the material's structural performance). Gilles Deleuze and Felix Guattari illustrate these two different approaches with a brief reference to Romanesque and Gothic architecture, where the latter represents a qualitative shift from the former, from the "static relation, form-matter" (Romanesque) to a "dynamic relation, material-forces" (Gothic).[18] As Deleuze and Guattari note, "it is the cutting of the stone that turns it into material capable of holding and coordinating forces of thrust, and of constructing higher and longer vaults."[19] The forms "are 'generated' as 'forces of thrust' (*poussées*) by the material, in a qualitative calculus of the optimum." Such "Gothic" computation of form through a material was a method, most famously, behind Antonio Gaudí's work (his inverted chain-link models) and projects by Frei Otto (the use of soap bubbles, for example). In a contemporary architectural scene, Lars Spuybroek's "analog computing" of form, accomplished through the use of threads dipped into liquids, is a direct antecedent of such a performative, materially-driven line of design thinking.[20] For many designers in the contemporary architectural avant-garde, such as Mark Goulthorpe, Lars Spuybroek, Bernhard Franken and others, the fluid synergies of form and material, appearance and performance, architecture and engineering, are intrinsically embedded into the conceptual origins of their work.

Environmental performance

Addressing the building's appearance ("how it looks") and its performance ("what it does") increasingly requires creating environmentally attuned buildings, whose physical forms are shaped by environmental performances in respect to light, heat, energy, movement or sound. There is currently an interesting gap in the aesthetics (and ethics) between form-oriented or cultural performance-oriented designers (Frank Gehry, Greg Lynn, etc.) and those whose work aims at environmental performance (Thomas Herzog, Glenn Murcutt, etc.). On the other hand, there is another group of designers — the ones whose work is neither too formalist or environmentalist (Foster, Grimshaw, Piano, Sauerbruch and Hutton, Jourda and Perraudin, etc.). The design strategies in the projects of the latter group vary considerably as they respond to different cultural and environmental contexts. In many of their projects, formal and environmental performative agendas were successfully

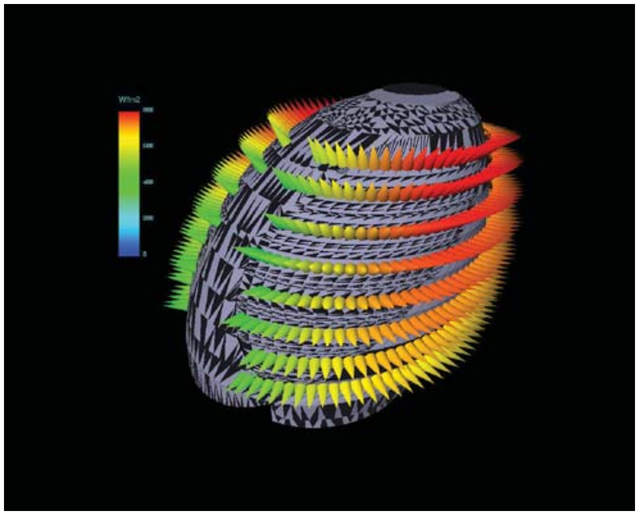


15.12
The Swiss Re building in London (1997–2004), architect Foster and Partners, engineer Arup.



15.13
Section drawing of the Tjibaou Cultural Center in Noumea, New Caledonia (1991–98), architect Renzo Piano, engineer Arup.

15.14
The City Hall in London (1998–2002), architect Foster and Partners, engineer Arup.



15.15
The solar diagram for the City Hall building.

pursued in parallel. In the Swiss Re project in London (1997–2004) by Foster and Partners (figure 15.12), the design aims at maximizing the daylight and natural ventilation in order to substantially reduce (by half) the amount of energy the building needs for its operation. The spiraling form of the atria at the perimeter, which runs the entire height of the building, is designed to generate pressure differentials that greatly assist the natural flow of air. The aerodynamic, curvilinear form, besides affording a commanding, iconic presence, enables wind to flow smoothly around this high-rise building, minimizing wind loads on the structure and cladding, and enabling the use of a more efficient structure. In addition, the wind is not deflected to the ground, as is common with rectilinear buildings, helping to maintain pedestrian comfort at the base of the building.

It is interesting to note that many of the designers mentioned earlier — notably Norman Foster and Nicholas Grimshaw, once labeled High-Tech and renamed Eco-Tech by Catherine Slessor[21] — have explicitly stated their intentions to improve the environmental performance of their often highly visible buildings (figure 15.12). While one could question the methodological consistency in their projects and whether certain performative aspects, such as energy efficiency, were indeed maximized, these architects did manage to consistently push the technological envelope of environmental performance in their buildings.

An interesting example of a recent project that seems to capture the broad agenda of performative architecture, from cultural to environmental performance, is Renzo Piano's Tjibaou Cultural Center for the Kanak population of New Caledonia (1991–98; figure 15.13). The "cases" that dominate the design, and that formally reference (but do not imitate) Kanaks' huts with their cone-like shapes, were conceived with a particular cultural performance in mind. The cones of the "cases" were truncated for a more efficient environmental performance. The natural air flow within the building is then further enhanced using a system of computer-controlled louvers on the inner skin in "cases," which was designed and developed through wind-tunnel testing and computer simulations by engineers at Arup and the *Centre Scientifique et Technique du Batiment* in France.

The performative design strategies can vary considerably as they respond to different contexts. Peter Cook and Colin Fournier's Kunsthaus Graz (figure 15.5), which was discussed previously, features an expressive, biomorphic blobby form, and an acrylic glass "skin" whose primary function is to be a "communicative membrane" — a low-resolution computer-controlled skin, a "media façade." Interestingly enough, there is not a hint of environmental performance in the Kunsthaus Graz project, as if to suggest that the formal and environmental agendas are often incompatible — which cannot be farther from the truth. Foster and Partners' City Hall in London (figure 15.14; 1998–2002), imbues an iconic, biomorphic form with a logic of environmental performance that calls for such a form in the first place. (The origin of the project was purely formal — it attained its environmental logic later in the development.) The "pebble-like" form of the building in the end resulted from optimization of its energy performance by minimizing the surface area exposed to direct sunlight. The building's form is a deformed sphere, which has a 25% smaller surface area than a cube of identical volume, resulting in reduced solar heat gain and heat loss through the building's skin (figure 15.15).

Foster's performative approach to the design of the City Hall building, for example, could imply a significant shift in how "blobby" forms are perceived. The sinuous, highly curvilinear forms could become not only an expression of new aesthetics, or a particular cultural and socio-economic moment born out of the digital revolution, but also an optimal formal expression for the new ecological consciousness that calls for sustainable building.

CONCLUSIONS

Performative architecture is not a way of devising a set of practical solutions to a set of largely practical problems. It is a "meta-narrative" with universal aims that are dependent on particular performance-related aspects of each project. Determining the different performative aspects in a particular project and reconciling often conflicting performance goals in a creative and effective way are some of the key challenges in this approach to architecture.

In performative architecture, the emphasis shifts from building's appearances to processes of formation grounded in imagined performances, indeterminate patterns and dynamics of use, and poetics of spatial and temporal change. The role of architects and engineers is less to predict, pre-program or represent the building's performances than it is to instigate, embed, diversify and multiply their effects *in material* and *in time*.

The development of more performative techniques of design is essential to this task. It necessitates a shift from scenographic appearances to pragmatist imagination of how buildings work, what they do, and what actions, events and effects they might engender in time.

NOTES

1 John Rajchman, *Constructions*, Cambridge, MA: The MIT Press, 1998, p. 92.

2 Performative architecture can also be seen as a *generator* of new cultural patterns. For example, organizers of a recently held symposium on performative architecture in Delft, the Netherlands (March 11, 2004), state that "instead of describing the architectural object, performative architecture focuses on how the architectural object and its process of production perform by producing new effects that transform culture." For more details, see http://www.x-m-l.org/ and also http://www.lab-au.com/files/doc/performative_architecture.htm

3 Performance is one of the most used (oftentimes misused and abused) but least defined concepts in architecture. As can be gleaned from the chapters in this book, the ways in which performance is understood in architecture are often contradictory; the meanings associated with it are often articulated as opposites.

4 NOX (Lars Spuybroek with Pitupong Chaowakul, Chris Seung-woo Yoo and Norbert Palz) and Q. S. Serafijn, artist, and the V2_Lab (Simon de Bakker, Artem Baguinski), 1998–2003, an interactive tower, a questionnaire and a website, for the city of Doetinchem.

5 NOX (Lars Spuybroek with Florent Rougemont, Chris Seung-Woo Yoo and Kris Mun), 2001, for the city of Lille — invited competition (first prize). Model: Ouafa Messaoudi and Estelle Depaepe.

6 From the NOX Architekten website: http://www.noxarch.com

7 The questionnaire was written by the Rotterdam-based artist Q. S. Serafijn.

8 Lars Spuybroek expressed his concern that the tower could easily end up showing only one color, presumably blue (for happiness), given that Doetinchem is a Dutch city. He remarked that they may have to tweak the formula that computes the "total" emotion, so that the output is more varied. (The issue of finding appropriate "yardsticks" to measure qualitative properties that often defy quantification equally perplexes all performative domains associated with the built environment, from social dynamics to environmental comfort.)

9 The complex of buildings contains exhibition spaces, artist-in-residence homes, clubs, Turkish baths, restaurants and sound studios.

10 NOX website, http://www.noxarch.com

11 Marshall H. McLuhan, *Understanding Media: The Extensions of Man*, New York: McGraw-Hill, 1965.

12 According to McLuhan, technology effectively interferes with our senses and, in turn, affects the sensibilities of societies in which we live. That process, McLuhan argues, was and is still the cause of major cultural shifts. For more information see Eric McLuhan and Frank Zingrone (eds), *Essential McLuhan*, New York: BasicBooks, 1995.

13 Rowan Moore, "INgeniUS" in *Metropolis* magazine, June 2001.

14 According to the *Financial Times*, in the first three years since its opening in 1997, the Guggenheim Museum in Bilbao has helped to generate about $500 million in new economic activity, and about $100 million in new taxes, as reported by Witold Rybzynski in "The Bilbao Effect," *The Atlantic Monthly*, September 2002.

15 For more details, see Branko Kolarevic (ed.), "Digital Morphogenesis" in *Architecture in the Digital Age: Design and Manufacturing*, London: Spon Press, 2003, pp. 11–28.

16 For more details, see Branko Kolarevic (ed.), "Digital Production" in *Architecture in the Digital Age: Design and Manufacturing*, London: Spon Press, 2003, pp. 29–54.

17 See Johan Bettum. "Skin Deep: Polymer Composite Materials in Architecture" in Ali Rahim (ed.), *AD Profile 155: Contemporary Techniques in Architecture.* London: Wiley Academy Editions, 2002, pp. 72–76.

18 Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, translated by Brian Massumi, Minneapolis, MN: University of Minnesota Press, 1987, p. 364.

19 Ibid.

20 For more details, please refer to Lars Spuybroek's chapter in this volume (Chapter 12).

21 Catherine Slessor, *Eco-Tech: Sustainable Architecture and High Technology*, London: Thames and Hudson, 1998.