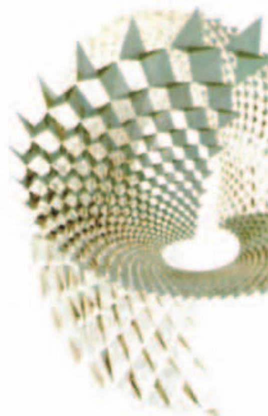
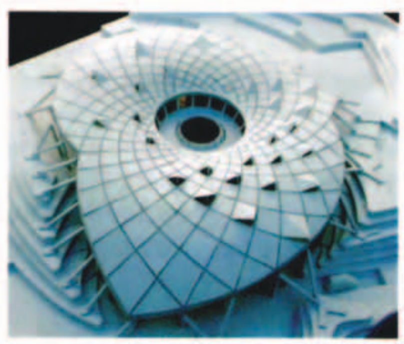
GREEN DESIGN: ALL SKIN AND NO BONES?

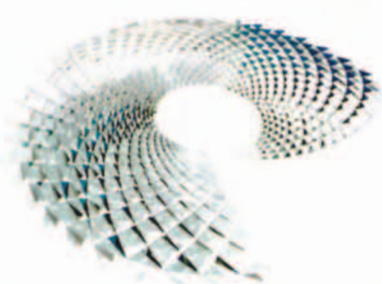
In the rush to sustainability, designers have ignored what holds it all together: *structure*. by Lance Hosey

The relationship between envelope and structure has informed every significant architectural development in every culture since the dawn of construction. Today, sustainable design has become a strong force in global architecture, but so far it has concentrated on only one of these systems and neglected the other. In the last decade, considerable progress has been made with façade technology: phototropic sunshades, energy-producing cladding, light-activated glass, thermally activated metals, and even pollution-absorbing paint. Skins can now react and adapt to changing climate conditions, while on the interior, environmental innovation has concentrated on M/E/P systems and material content, which mostly affect occupant health and comfort and energy performance, having little impact on visible architecture. But under the surface, structure has not changed much. By focusing almost exclusively on the skins of buildings, while virtually ignoring their bones, proponents of sustainable design have overlooked one of the most important determinants of architectural form.

Many very talented engineers have been silent on the topic of sustainable structural design, and the U.S. Green Building Council (USGBC) is not particularly vocal either—its LEED rating system treats structure only indirectly, through guidelines for material use. Not surprisingly, projects certified through LEED rarely show much structural innovation; likewise buildings honored by the AIA's Committee on the Environment (COTE) are typically built around conventional structural frames.







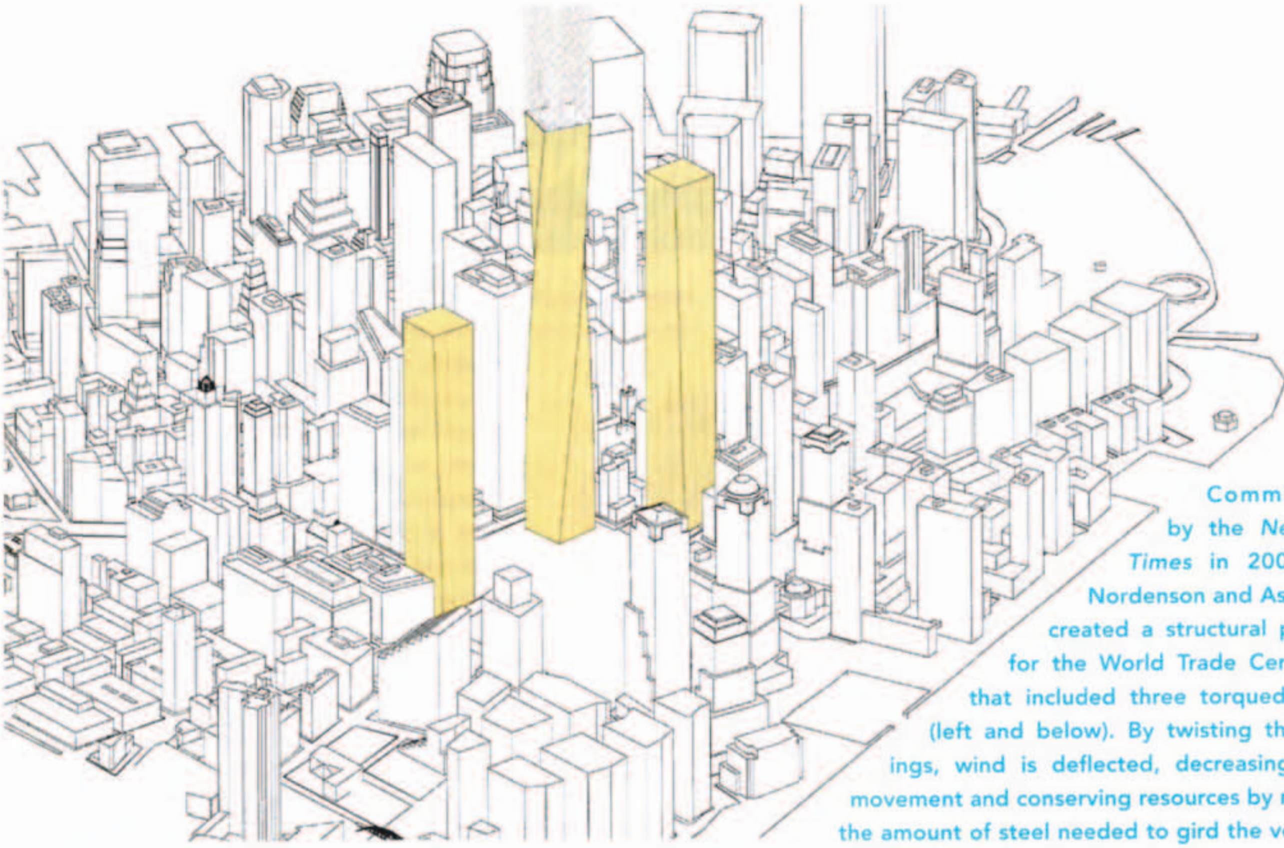
Designed by Grimshaw Architects, this education center now under construction is part of the Eden Project, a high-tech botanical garden in England. The wooden structure gains dynamic stability through its swirling lattice, echoing the morphology of the very plants in Eden's biomes.

SUSTAINABILITY TRUMPS DESIGN

Portuguese engineer Fernando Branco, author of the article, "A Structural Engineer for the 21st Century," says that the primary goal of sustainable structures is to reduce the amount of new material used in buildings in order to avoid depleting resources unnecessarily. He argues for two strategies—increasing longevity by using durable materials and avoiding virgin harvesting by specifying recycled products. (A third approach, using demountable and reusable building elements, has also been practiced by architects like Australian Glenn Murcutt.) Yet these methods don't exactly inspire architects to think about form and space. In general, many designers remain indifferent to green building as most strategies do not represent an aesthetic agenda. In other words, sustainable design seems to be more about sustainability than design.

The structural potential of sustainability has yet to be explored fully. If a primary goal is to use fewer resources, one way to accomplish this is to rethink the relationships between material and form. Environmentalist and retailer Paul Hawken, author of *The Ecology of Commerce*, describes sustainability as "doing more with less," a statement not so different from Mies van der Rohe's mantra, "Less is more." The similarity is ironic, since many green designers see modern architecture's rejection of traditional passive design strategies as a fundamental source of the problems they are now trying to correct. However, like modernism, sustainability can transform new structural technologies into an architectural vocabulary.

In common practice, standard structural members (columns, beams, studs, and the like) are overdesigned, not just in size, but also in shape, to aid assembly. The rectangle, the most common shape in construction, is inherently inefficient for carrying loads. We build orthogonally not to enhance performance but because production techniques, such as metal extrusion, favor simple forms. The modernist fascination with simple geometry was not about efficient design—it was about efficient fabrication. As Mies himself wrote in his 1924 essay, "Industrialized Building," "the industrialization of buildings constitutes the core problem of our time." By embracing plate glass and steel sections, he glorified the production of materials. In this sense, the modernist edict should have been "form follows *industry*."



Commisioned by the *New York Times* in 2002, Guy Nordenson and Associates created a structural proposal for the World Trade Center site that included three torqued towers (left and below). By twisting the buildings, wind is deflected, decreasing lateral movement and conserving resources by reducing the amount of steel needed to gird the volumes.

A FABRIC-FORMED ALTERNATIVE

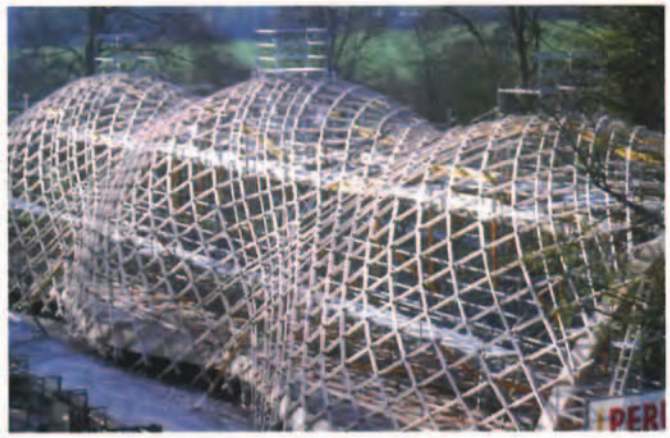
The machine aesthetic's forms do not match their functions. The stress and strain on a beam is not consistent along its length, so an extruded section is unnecessary and, from an environmentalist point of view, wasteful. Varying the beam's shape is more efficient for performance.

This is exactly what Mark West, director of the Centre for Architectural Structures and Technology at the University of Manitoba in Canada, is doing in his experiments with fabric-formed concrete. While concrete itself is capable of taking on virtually any shape, it is limited by conventional formwork, which is rigid and modular. However, textile molds can achieve forms that are at once more complex and cheaper and easier to assemble. For a typical beam, this technique uses up to 300 times less volume and weight in formwork material and half the concrete of an equivalent rectangular beam. The resulting fluid form, according to West, "places material only where it is needed and uses that material at optimum stress levels at every point along its span." With such methods, form finally does follow function.

The goal of such techniques is self-sustaining form—geometry that enhances structural and material integrity through the conservation of resources. The idea in itself is not new: Nearly two centuries ago at the University of Virginia, Thomas Jefferson used form to reduce material and increase strength in his famous serpentine brick garden walls, whose undulating shapes required only one layer of brick instead of two. And while conventional wisdom holds that the architecture of Antonio Gaudí was merely expressive skin wrapping simplistic bones, in actuality his understanding of geometry was visionary. The twisted columns of the Sagrada Familia, for example, are a tour de force of structure and material. Yet, these examples from history seem to have escaped the notice of most green designers. This is curious, given that many environmentally minded architects are influenced by R. Buckminster Fuller, whose concept of "ephemeralization" called for the minimizing of materials.

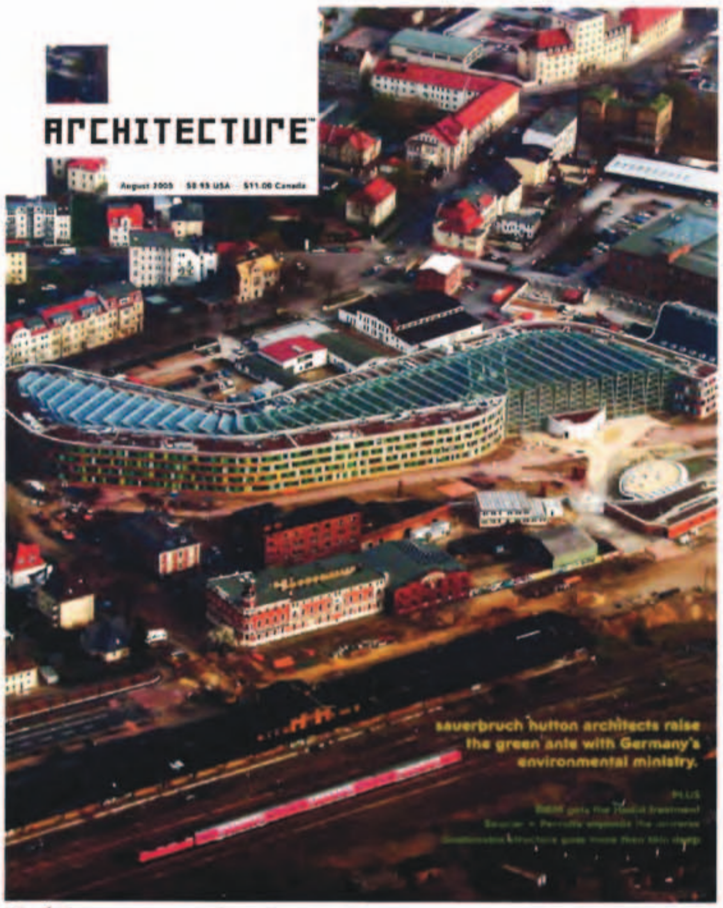
ENGINEERING NEW FORMS

Examples of these strategies among contemporary designers are rare but compelling and mostly come from engineers, not architects. New York structural engineer Guy Nordenson has combined vertical and lateral load systems by experimenting with torqued forms not unlike Gaudí's. In his projects with Nicholas Grimshaw, Richard Rogers, and Shigeru Ban, Craig Schwitter of Buro Happold's New York City office has explored ways to optimize volume through alternative materials like the timber thinnings he used in the Weald & Downland Museum in Sussex, England. Grimshaw's Eden Project, a state-of-the-art botanical garden in Cornwall, England, is a recent example of these new forms. In the first



In a University of Manitoba project, a lightweight, ribbed T-beam (left) is cast from fabric, using considerably less concrete than a rectangular beam designed for equivalent strength. For the Weald & Downland Museum in England, designers used simple bent oak laths to efficiently span a large workshop area (right).

LEFT: MARK WEST



Architecture magazine, August 2005

phase, eight interwoven domes built of steel icosahedral space frames and clad in a lightweight ETFE polymer foil rely on one another's "shell action" for strength. The vast structures pick up where Fuller's geodesics left off. An even more visually striking building is currently being constructed at Eden; developed along with engineers from Buro Happold and SKM Anthony Hunts, Grimshaw's education center achieves dynamic stability through novel form, a swirling lattice emulating spiral plant morphology. The architect's reference to the project as "an exercise in efficiency" is modest, for the project represents the future of architecture.

But sustainability may never realize its full potential as an architectural agenda until it addresses the question of structure. By inventing ways to optimize the relationship between form and material, designers can both respect natural resources and create novel geometries that could revolutionize architecture.