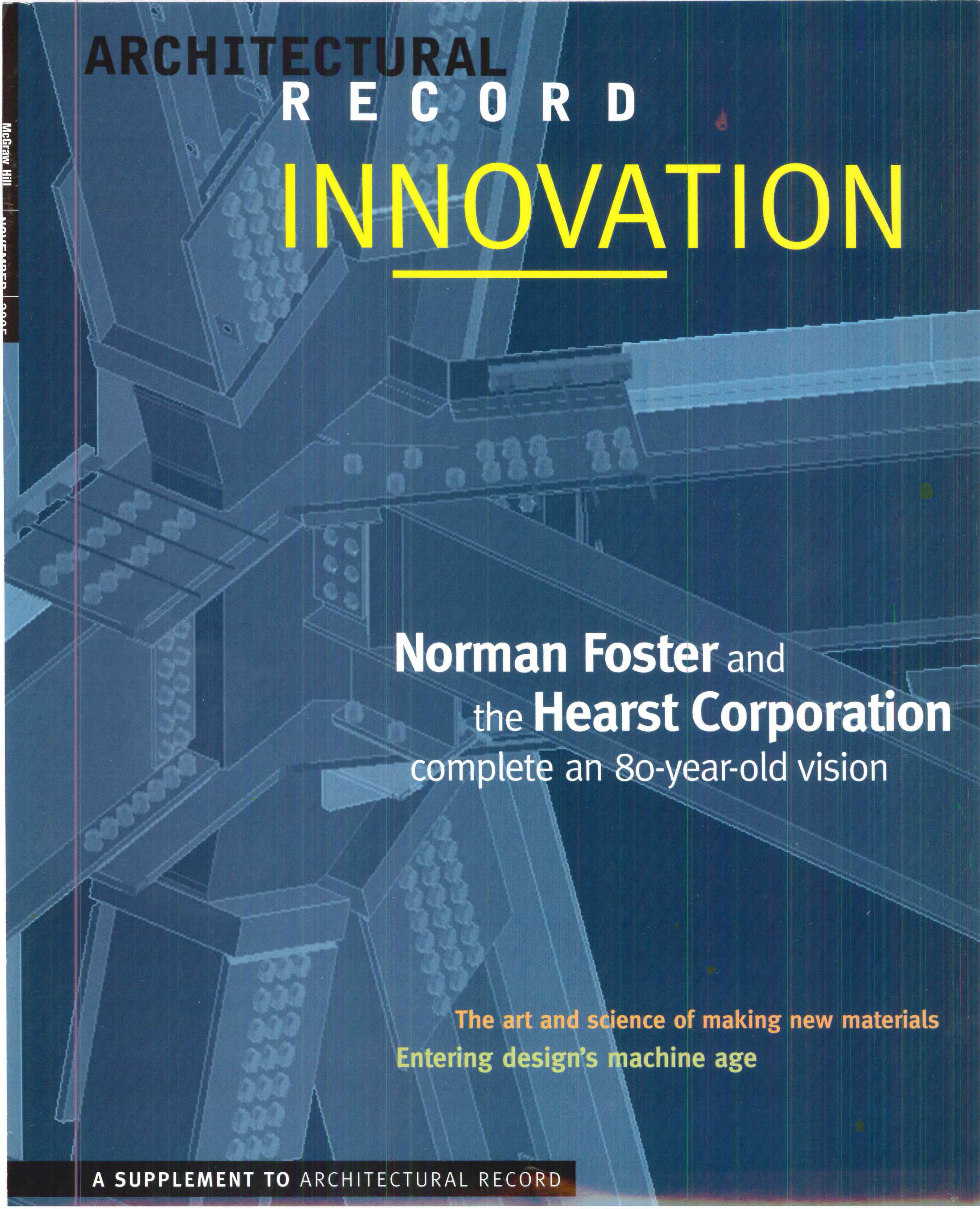

ARCHITECTURAL RECORD

INNOVATION

Norman Foster and the Hearst Corporation complete an 80-year-old vision

The art and science of making new materials

Entering design's machine age

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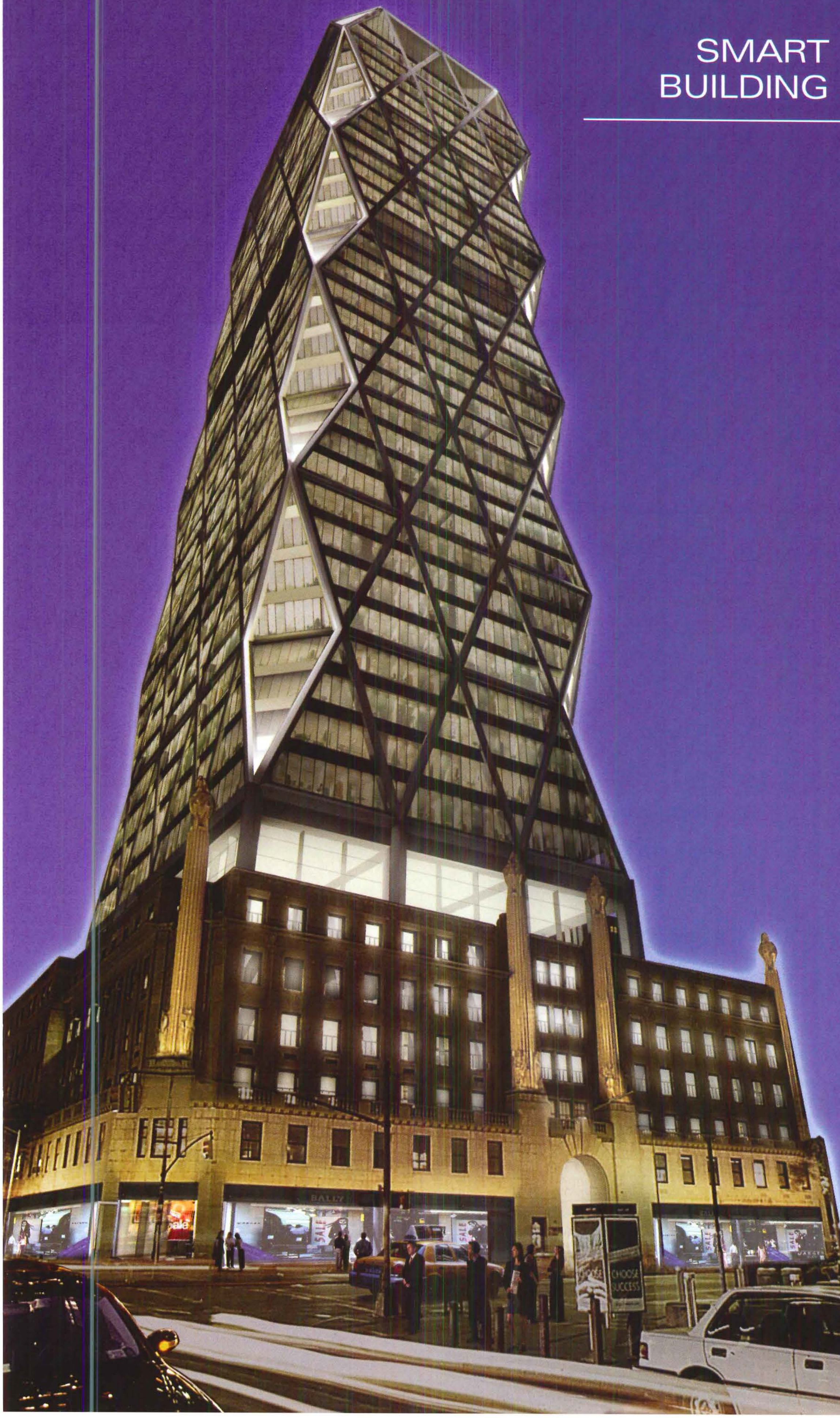

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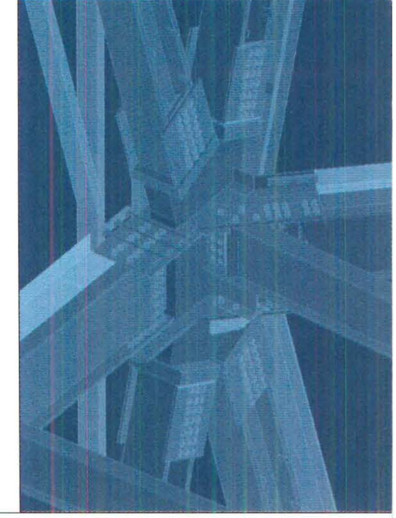
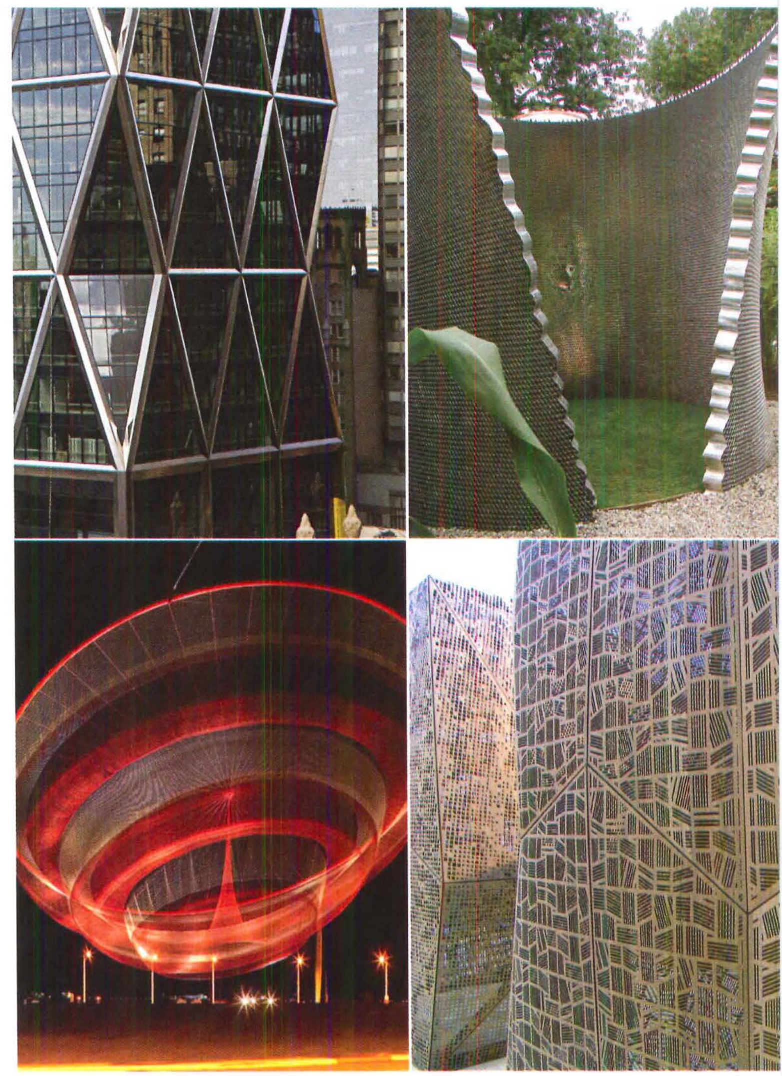


On the Cover: *Every steel member in the Hearst diagrid system was modeled in three dimensions to make coordination more efficient. Illustration courtesy Mountain Enterprises.*

NOVEMBER 2005



Above (clockwise from top left): *The Hearst Tower in New York, photograph by Foster and Partners; The Cornel West Pavilion in Princeton, New Jersey, photograph by John Nastasi; BL Special, a material designed by Steven Holl Architects, photograph by Steven Holl; "She Changes," a sculpture by Janet Echelman, photograph by Florence Lynch Gallery.*

INNOVATION is a special supplement to Architectural Record

Toward a better future

Editorial

By Robert Ivy, FAIA

At a time when the world has been besieged by natural calamities—earthquakes, hurricanes, and floods—as well as human-induced challenges, including global warming, war, and terrorism, it is easy to lose sight of our advances. Ironically, recent developments in technology point to enhanced capabilities for real improvements by architects and others who shape the built environment. At the same time that populations are devouring global resources, we are learning new methods of conserving energy, creating new categories of building materials, and discovering new means of construction.

In digital fabrication, for example, improved data-exchange standards and innovative technologies allow architects, fabricators, engineers, and researchers to find new manufacturing methods. Complex or compound forms can be described virtually in three dimensions, then translated into solid objects through a variant of robotics. In this growing field, the future has already arrived.

Contemporary structures often rely on materials to convey an important impression. Again, innovative results come when talented designers insist on products that must meet specific needs, for specific projects, functions, or for aesthetic effect. Increasingly we are witnessing the collaboration of the design and the research studio and the manufacturer, from Steven Holl and OMA to SensiTile. Together design and manufacturing are combining their resources to produce stunning new building products.

Innovation comes full circle at the new Hearst headquarters in New York City. Foster and Partners again has pulled off the nearly impossible: inserting a futuristic new structure within the Hearst Corporation's existing Art Deco landmark on Manhattan's west side. Salvaging the older building yielded a symbolic bonus, placing a contemporary statement within a familiar envelope. Yet the bold new structural system rising from the old represents strong, fresh thinking about business and its relationship to the contemporary city. The invisible supporting systems bear out the innovative philosophy.

As the Hearst headquarters demonstrates, we need to constantly devise new methods, new materials, and new places for our world. As our intellectual energies are pouring into improvements for the future, we are becoming better positioned to cope with and transcend the challenging present, including unexpected natural disasters. Ultimately, if we are smart, we can build a new world worth living in by enhancing the one we already have.

Robert Ivy

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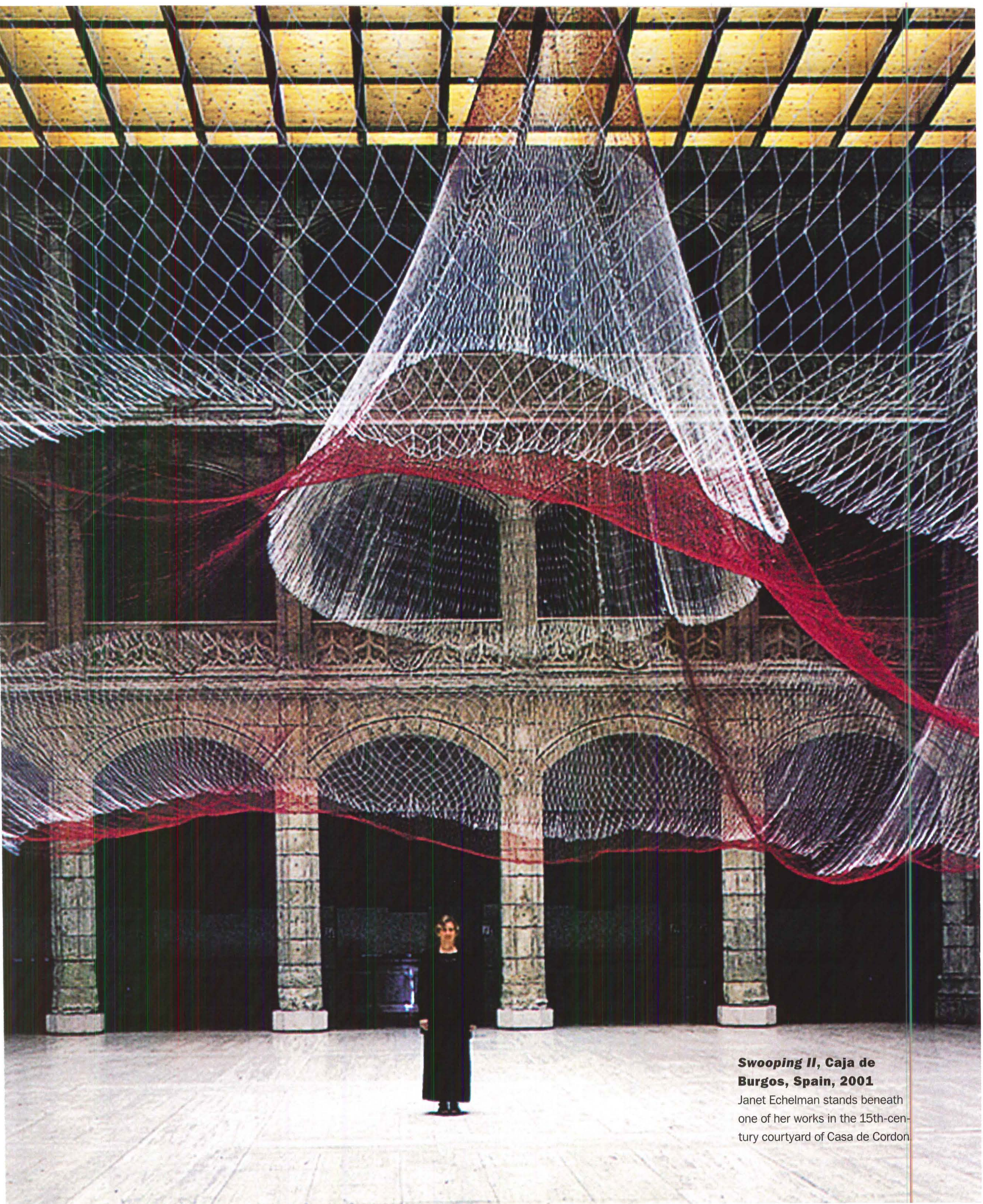


***Swooping II*, Caja de Burgos, Spain, 2001**

Janet Echelman stands beneath one of her works in the 15th-century courtyard of Casa de Cordon.

Matching artistic vision with technical innovation, **Janet Echelman** offers new ideas for public art

Catching Air

By Diana Lind

FEATURES

PHOTOGRAPHY: ©COURTESY FLORENCE LYNCH GALLERY, EXCEPT AS NOTED

***Eye of the Storm*, Cambridge, Mass., 1999**
A sculpture made of knitted stainless steel is suspended between buildings on Harvard's campus.

Janet Echelman's interdisciplinary art invites contradiction. Her body of work includes sculptural nets that dance whimsically in the air but whose choreography is the result of intense research and tedious calculations. Her projects, often large pieces of public art, have personal, human-scale titles such as *She Changes* or *Wide Hips*. Even her pedigree is not straightforward: Based in Boston and New York, she has a master's of fine arts from Bard College and has been duly awarded with prizes and fellowships, but she can also count a master's in psychology and two years as a concert pianist with the Florida Orchestra among her achievements.

But it's precisely this crosscurrent of education and influences that makes Echelman's art interesting. She first began using nets as a medium while in India on a Fulbright senior lectureship in 1997. She had planned to paint, but when the brushes and paints she'd sent separately never arrived, she took advantage of living in a seaside village. Walking along the shore at night, she noticed the fishing nets the area's fishermen rolled up at the end of the day. Soft but strong, the nets could be shaped but were easily transported—and thus a sculptural medium was born.

True to form, Echelman doesn't want to be perceived as limited to one type of project. In an interview with RECORD (see page 14), she was quick to assert that her repertoire extends beyond nets. "Collaborating with a site," she adds, is a central part of her approach to each project, as are the "animating forces" of wind and water.

In addition, she often has a range of collaborators: architects, engineers, and lighting designers. For a new project, she would like to explore the realm where art and architecture collide: "I would like to work with an architect where we collaborate to make a seamless transition between a solid structure and a fluid sculptural membrane—to where the boundary between the building and the wind sculpture is blurred entirely." If her past work is any indication, this collaboration will be anything but the expected.

She Changes, Porto, Portugal, 2005
Echelman's most recent work measures 164 feet high by 492 feet square and alludes to nearby smokestacks, fishing nets, and Portuguese lace.

Target swooping down...bullseye!
Madrid, Spain, 2001
Located in an office building, the hand-knotted nylon lace net can be seen from every floor.

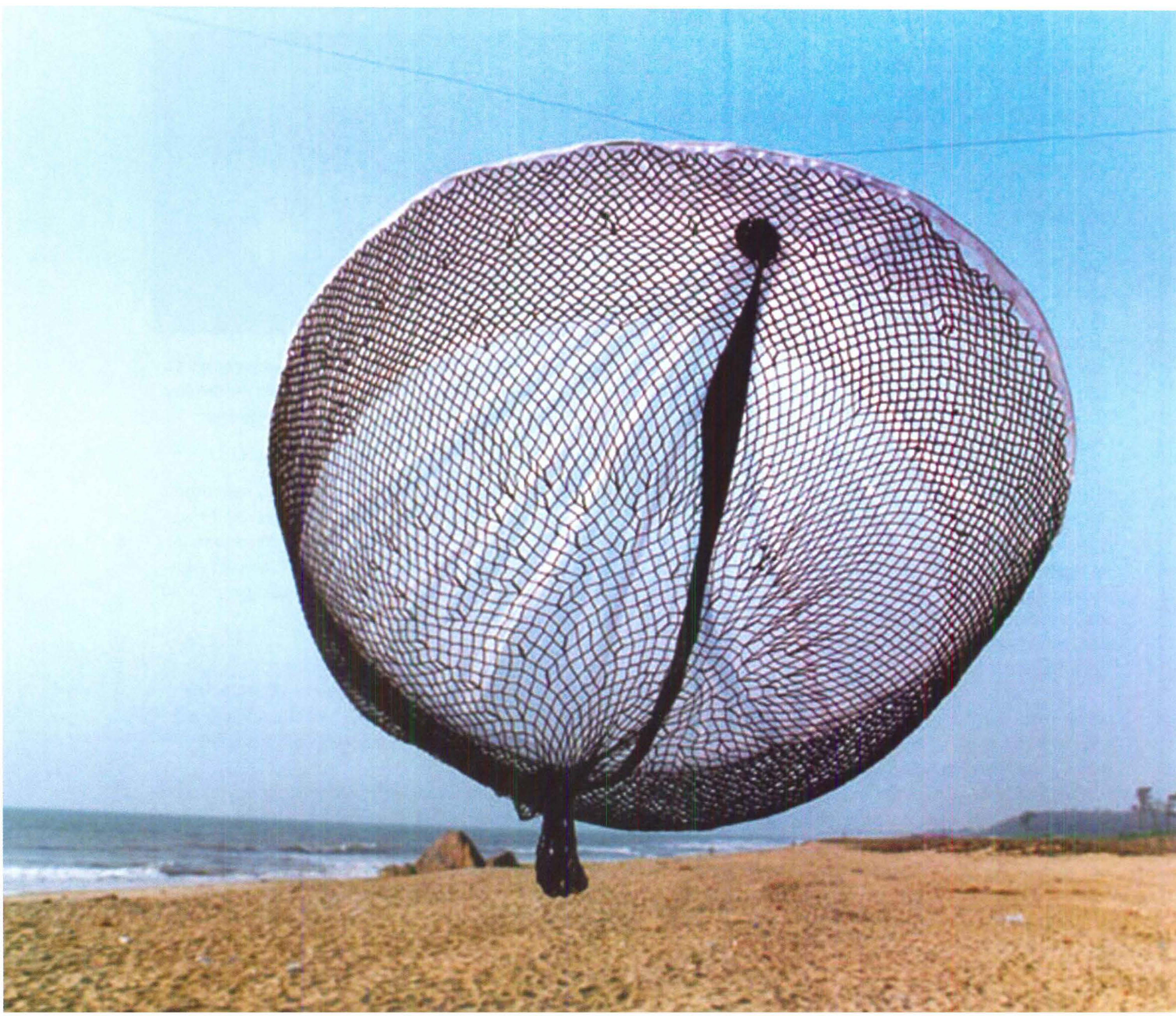
South India Project, Coimbatore, India, 1998
For this project, which includes brick, Echelman collaborated with Hindu temple masons.

***Roadside Shrine I: Cone Ridge*, Houston, 2000**

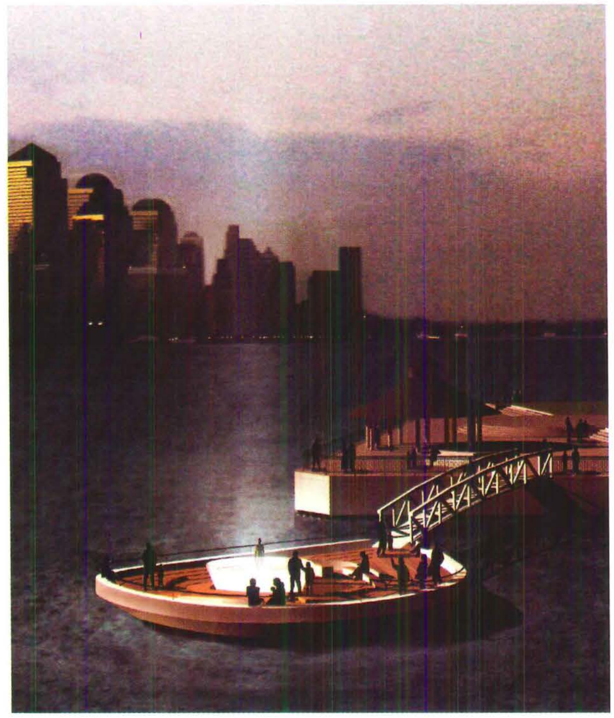
The sculpture was temporarily affixed to the underside of the interstate.

***Bellbottoms Series*, India, 1998**

The series of temporary structures was created from bronze, silk, cotton, and steel; it also formed a traveling exhibition.



An artist's mind at work



Janet Echelman (left) is currently working on a 9/11 memorial in Hoboken, N.J. (above) with Studio/Gang Architects, Thornton Tomasetti Group, Domingo Gonzalez Associates, and Thirst.

Architectural Record: *What attracted you to working on large-scale art and having your work in the public domain?*
Janet Echelman: Scale turns out to be central to my context. It's not that bigger is better, it's that my work is about creating an experiential interaction with the viewer. And because of that, [the art is] partly about letting we humans feel small in relation to a sculptural experience.

AR: *How were you introduced to Tenara [the main material used in* She Changes*]?*
JE: Once I had been hired for the commission in Portugal, I went in search of a material that would last in the elements, that would be colorfast, and that would not degrade when exposed to ultraviolet light. I wanted an adaptable, flexible material, because that's what my work is about—strength through adaptation, or strength through responsiveness. The manufacturer of Tenara, W.L. Gore, has been collaborating with me with custom colors, which are extruded into the fiber. I've been very pleased with how it's working.

AR: *How much of your creative process do you devote to research—say, doing modeling with computers or prototypes—and how much do you leave to chance?*
JE: Well, I try to leave *nothing* to chance, especially at this scale. We model and we find as many ways to double check as possible. For *She Changes*, we even created some proprietary computer software to model the net with its weight and shape in different wind directions and velocities to ensure that the sculpture would maintain its integrity in a hurricane, and also to ensure that we would get the kind of movement, the kind of wind choreography, that we want on an average day. I was hoping for a kind of gentle movement that was more like breathing, because I'm trying to make the nets almost like living, breathing structures.

AR: *How do you feel your collaborators change or influence your approach to your work?*
JE: In Portugal, the architect Eduardo Souto de Moura worked with me to design the ground plane that interacts with the piece. The concept was mine but he brought a lot to that process, including the lighting design. I think the outcome was better because of our collaboration.

I knew I wanted to put a team together for the 9/11 memorial in Hoboken, New Jersey, and working with such talented collaborators—in this case, Studio Gang—has really enriched the work. And engineers are as critical to me as they are to architects in terms of telling me what's possible. On a personal level, it's a lot more interesting to work with a team of smart people who bring different knowledge to a project.

AR: *What projects are you working on now?*
JE: I am working on a project for the city of Scottsdale, Arizona. They determined that they want landmark public art as opposed to many small pieces of integrated public sculpture.

At the same time we're working very actively now on the 9/11 memorial in Hoboken. I just participated in an event on the fourth anniversary of 9/11, in which we began gathering narratives from members of the community. I'm gathering them in handwriting because I want the actual personal qualities to become part of the memorial.

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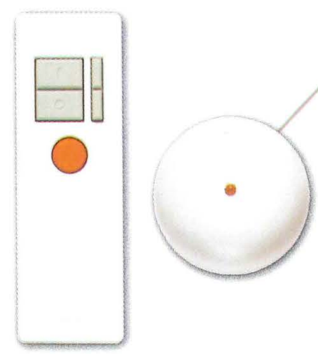

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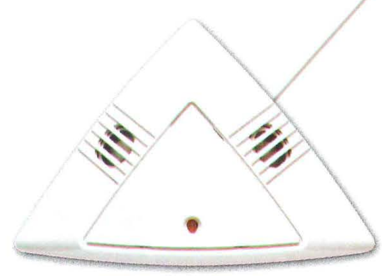

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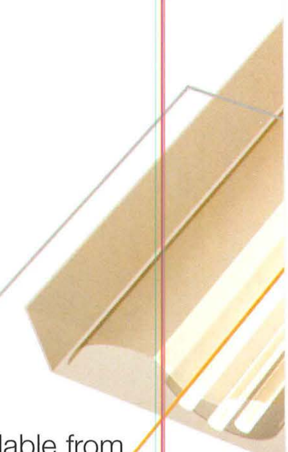

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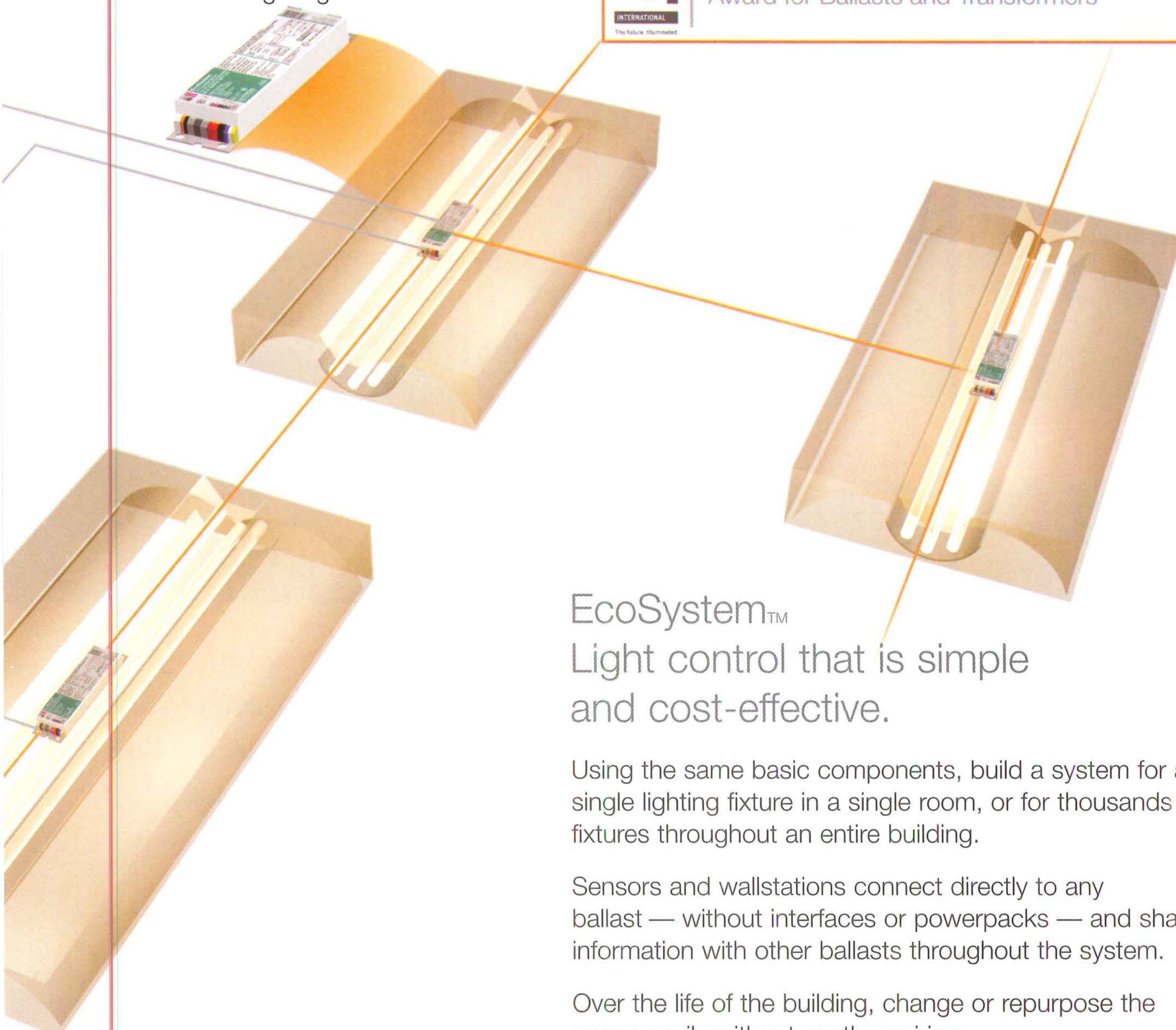

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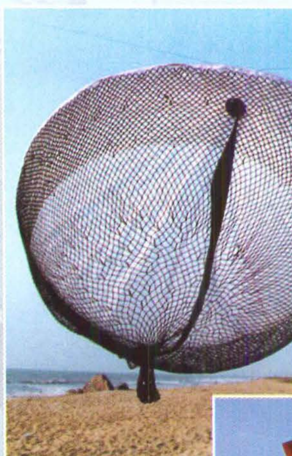
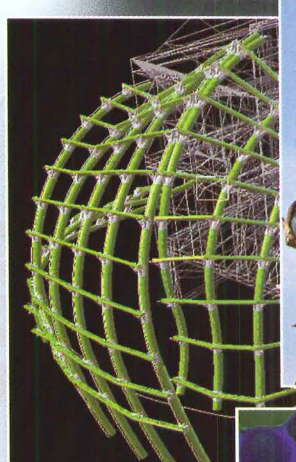
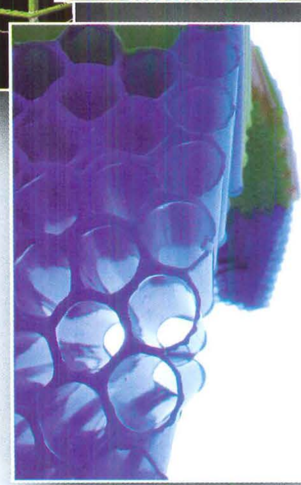
INNOVATION

By pioneering new materials, processes, and systems, architects and their collaborators are designing new worlds that stretch their limits and engage all their capabilities.

By Deborah Snoonian, P.E.







In 2003, when ARCHITECTURAL RECORD produced its first Innovations supplement and conference, Philadelphia architects Stephen Kieran, FAIA, and James Timberlake, FAIA, were finishing their seminal book, *Refabricating Architecture,* on how modern-day manufacturing methods are (and should be) changing the way buildings are designed and constructed. Within the text, a single phrase in boldface type neatly sums up the book's call to action. "Choose your world," they tell us.

Those powerful three words have galvanized us, for this third supplement, to find people in design who have chosen worlds that break new ground—worlds that inspire and inform us. To varying degrees, creating these worlds necessitated a departure from the norms of business as usual. In today's practice, it is not "normal" for an architect to become deeply involved with a product manufacturer to formulate the chemistry for a new building material. Likewise, not every architect would decide to learn a complex software program so that he could oversee and control the fabrication of his designs. Certainly not every firm is capable of working iteratively with engineers and other collaborators to derive the most efficient systems for a flagship building—one that will stand within the footprint of another flagship building, no less. These examples, which appear in the following pages, bring to light the reality that mere vision is not enough. Despite formidable odds and obstacles, these designers had the passion, intelligence, confidence, and energy to bring their worlds to life.

Whether we like it or not, our society today is characterized by unparalled choices and rapid-fire change. When faced with the uncertainties these realities create, many of us choose to retreat to our fiefdoms, cling fast to the status quo rather than risk navigating uncertain waters with new partners or processes. Such a reactive posture, however, does little to advance the case for good architecture. The best designers of the future will welcome the opportunity to act as change agents and assimilators—able to draw ideas, knowledge, resources, and inspiration from a variety of fields and distill them into cohesive concepts, whether they're working at the scale of a light fixture, a furniture assembly, a building, even an entire city. "Choose your world," Kieran and Timberlake tell us. What world will you choose? ■

Clockwise from top: Sculpture meets architecture in the air; innovative structural systems change form-making; architect-entrepreneurs create new materials; digital printers fabricate designs without drawings.

PHOTOGRAPHY: (CLOCKWISE FROM TOP) COURTESY FLORENCE LYNCH GALLERY; COURTESY FOSTER AND PARTNERS; COURTESY OF PADLAB; COURTESY JOHN NASTASI

FEATURES

Part I: Collaboration

An Icon is Completed After 80 Years

Foster and Partners connects **Hearst**'s past to its future.

By Sara Hart

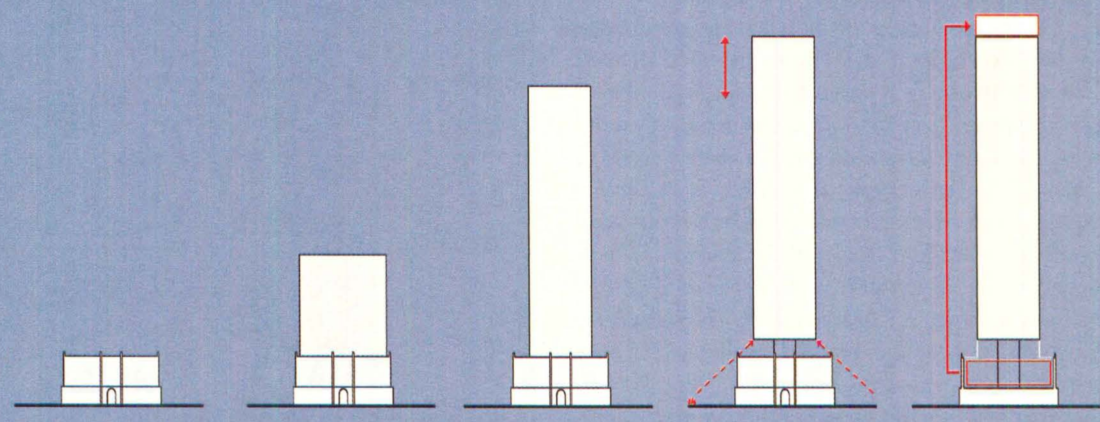
In architecture and engineering, coordination and collaboration are essential functions, but the terms are not interchangeable. Coordination is quantifiable and rational. Architects and engineers coordinate their drawings; contractors coordinate the trades. Collaboration, on the other hand, is creative and often daring. Collaborators are allies, committed to a single vision. Successful collaboration can raise a building's stature to that of icon, as the public will see next year, when media giant Hearst moves into its new 856,000-square-foot, $500 million headquarters in midtown Manhattan. The collaborative efforts of hundreds of people—the client's delegates, architects, consultants, contractors, and tradespeople—will be evident in the building's steel and glass exoskeleton, expansive interior piazza, and state-of-the-art environmental initiatives. (See Innovation supplement, November 2004, page 46.)

Foster and Partners' tower emerges from the existing 1928 precast-stone building by Joseph Urban with George P. Post & Sons.

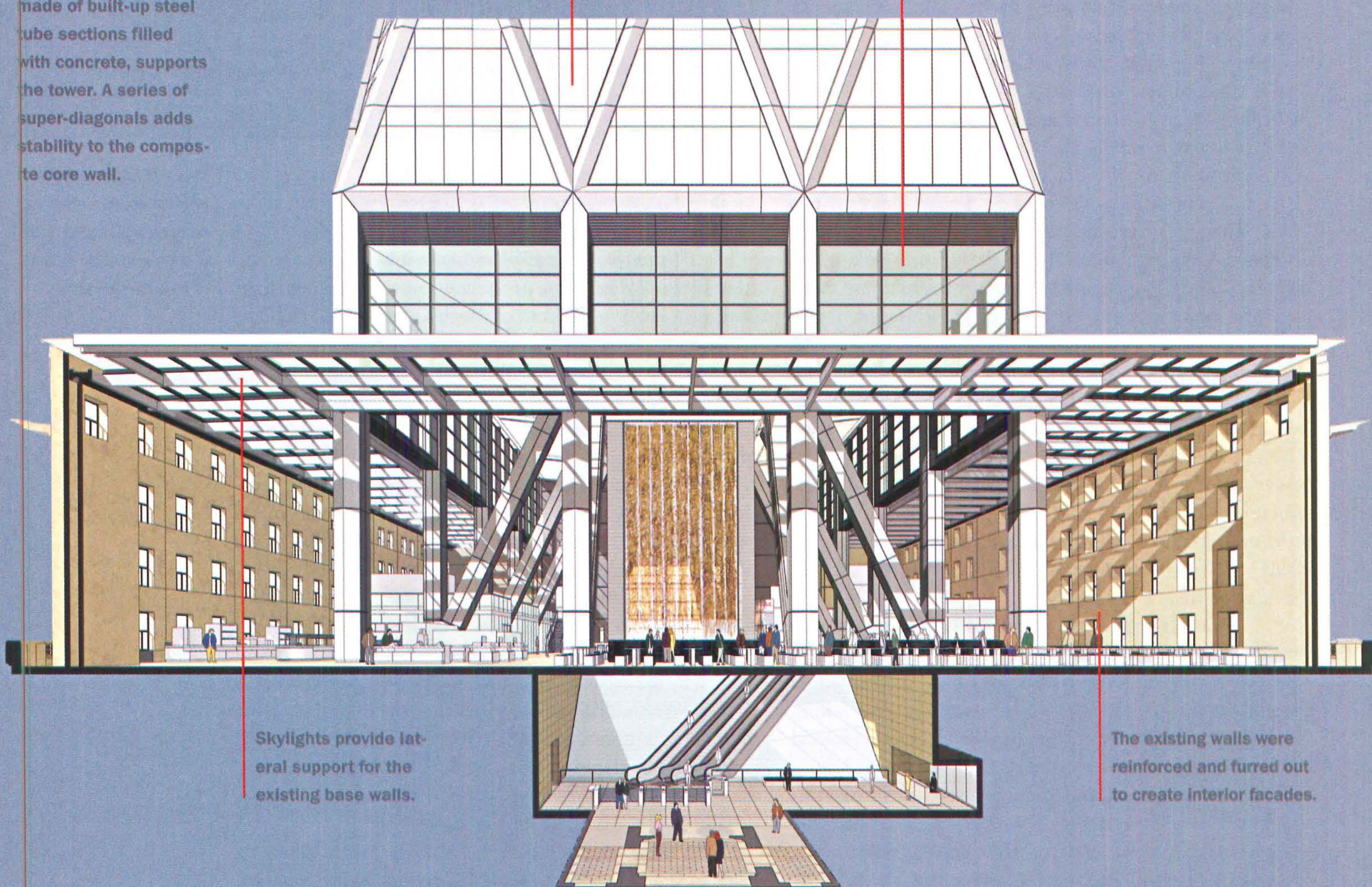
Collaboration was necessitated to a large degree by the extenuating circumstances of a corporate history layered with urban myth, a founder's ego, and no small amount of ambition. For nearly 80 years, the Hearst Corporation's official headquarters occupied a six-story building on Eighth Avenue, south of Columbus Circle, commissioned by founder William Randolph Hearst in the mid-1920s. Although only a fraction of Hearst's New York employees came to work at this location, the building remained the company's symbolic home. By 1999 the corporation had outgrown all its New York offices, so it retained development manager Tishman Speyer to investigate consolidating all of its operations into a single facility on the site of the original building. With Toronto-based architects Adamson Associates and other consultants, the developer determined that the project was feasible with the understanding that the building's shell, which received landmark status in 1988 from the New York Landmarks Preservation Commission, would have to be preserved. "It was our job to assemble the team, direct and manage the design process, shepherd the project through the arduous city approvals processes, then direct and manage the construction of the building," explains Bruce Phillips, Tishman Speyer's managing director.

This project was made more challenging by the site.

The fourth diagram in the evolutionary stages of the Hearst tower illustrates how the removal of floors 3 through 6 allowed their areas to be transferred to the top, increasing floor-to-ceiling height and thus providing better views.



The building's lobby is a grand piazza between the third and 10th floors, occupying about 85,000 square feet. A mega-column system, made of built-up steel tube sections filled with concrete, supports the tower. A series of super-diagonals adds stability to the composite core wall.



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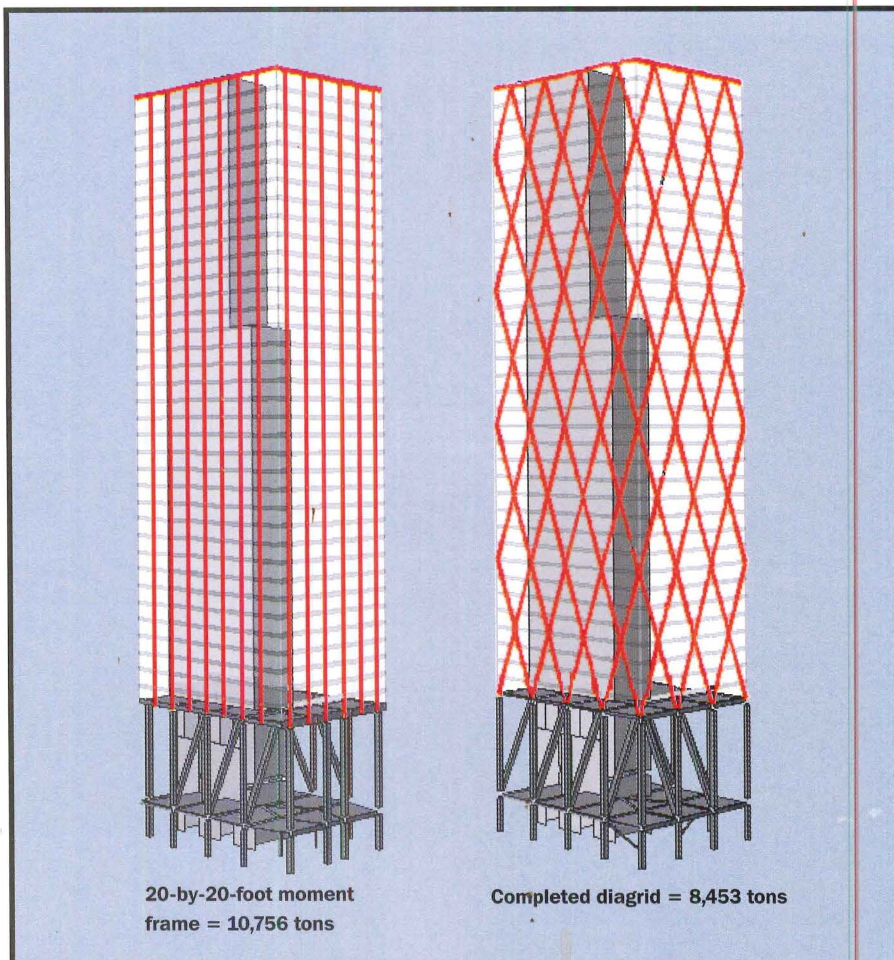
The International Magazine Company, as it was called at the time, was to be the anchor in founder Hearst's ambitious plan to develop Columbus Circle as the theatrical and commercial center of New York. In the mid-1920s, Hearst hired architect Joseph Urban (with George P. Post & Sons), known for his set designs for theater and opera, to design an arresting monument to his ambitions. Responding to his client's eccentric nature, Urban designed what was to be the base of a tower out of precast stone—an experimental material at the time—that defies stylistic classification. The facade is divided into two-stories of commercial space, a three-story shaft, and an attic separated from the shaft by a heavy cornice. The corners are chamfered to allow for columns rendered as allegorical figures and topped off with large urns. That was as far as Hearst's monument ever got with this project; as his dream to dominate Columbus Circle was lost to the vagaries of real estate speculation, his interests drifted elsewhere.

The search for an architect to build upon Hearst's incomplete vision, led by Tishman Speyer, began in earnest in 2000. An executive search committee eventually zeroed in on the British architecture firm Foster and Partners. While Pritzker Prize-winner Norman Foster has received international acclaim for his emblematic buildings, he has distinguished himself from many of his peers with his mastery of urban issues and his talent for seamlessly merging historic artifact with modernist intervention. To make its choice, the search committee needed only to observe Foster's transformative completion of the Queen Elizabeth II Great Court at the British Museum [RECORD, March 2001, page 114 and 149] and his brilliant reconstruction of and addition to the Reichstag in Berlin [RECORD, July 1999, page 102]. Both of these commissions were weighted with tremendous historical significance.

The challenges, it could be argued, involved two clients. Though Foster inherited Joseph Urban's precast stone artifice, his obligation was to Hearst, the forward-looking and diversified media empire, not to Hearst, the flamboyant patriarch who never finished his icon. Brian Schwagerl, senior real-estate official for the Hearst Corporation, is embedded in the project daily and has observed the meticulous restorations, innovative conversions, and bold architectural addition. He remains impressed by the collaborations that have resolved old and new. "Immediately after 9/11, new construction virtually stopped. After some design changes to harden the structure, we decided to go ahead with the project. We were fortunate enough to have access to an extraordinary pool of talent, and the commitment and collaboration will show in the final product," he says.

The architects began to look for a way to separate the new from the old by setting the tower back from the U-shaped base. Foster chose a design path in which the answer would come from studying the effects of numerous options within the site's surrounding urban context. The team used physical and computer-generated site models to determine the limitations created by light and air requirements. With the footprint established, the architects studied ways to separate visually the tower from the base. Foster partner Michael Wurzel acknowledges that "ultimately, placement was subjective. The only way to understand where to site the tower in relation to the base was to walk the streets until you can locate a point beyond the top of the base where the tower should begin." Those efforts produced a datum, articulated as a clerestory, 109 feet above grade from which the tower would rise.

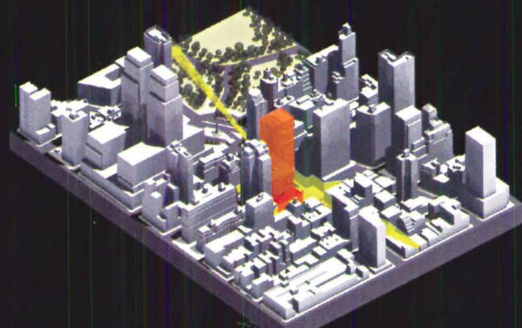


These diagrams show how much less steel is needed in the perimeter of a diagrid than in that of a moment frame.

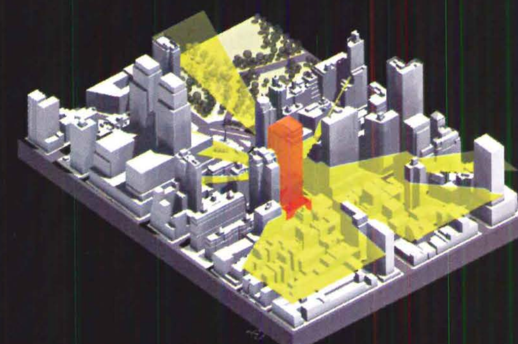
After separating old and new, it was time to reconnect them. Foster chose to hollow out the existing base, creating a vessel of sorts out of which a tower would rise. The structural challenges are outlined in the following article (page 24), but the challenge of sculpting a grand space in the remaining shell required constant collaborative problem-solving among all the consultants—preservationists, engineers, managers, contractors, interior designers, fabricators, and the client. This massive effort yielded more than a hundred iterations and thousands of drawings. Wurzel says the team was aware of the little-discussed fact that Urban's building had a raised interior courtyard at the third level, which was signaled by a balcony at the same level on the facade. "The balcony is such a strong datum, we chose to retain it as the level from which the new lobby would begin." The space then was defined by the existing precast-stone envelope, which soars to 85 feet. "We studied many options for how to articulate the interior as a grand piazza." It became necessary then to "invert" the envelope so that rather than looking at the back of the walls, they would be furred out and finished in limestone-colored stucco to become the piazza's facades.

While Foster's design embraces the memory of William Randolph Hearst's ambitions, it is an architectural benchmark that will have a place among New York's icons—Woolworth, Chrysler, Rockefeller, Lever, and Seagram. ■

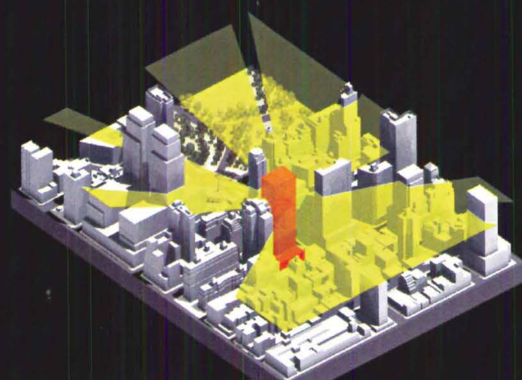
Numerous computer studies were conducted and massing models (below) built to determine the effect of different forms and setbacks on views, light, and shadow,



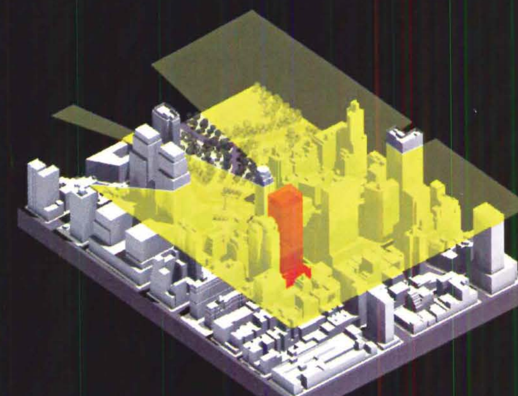
View from 10th floor



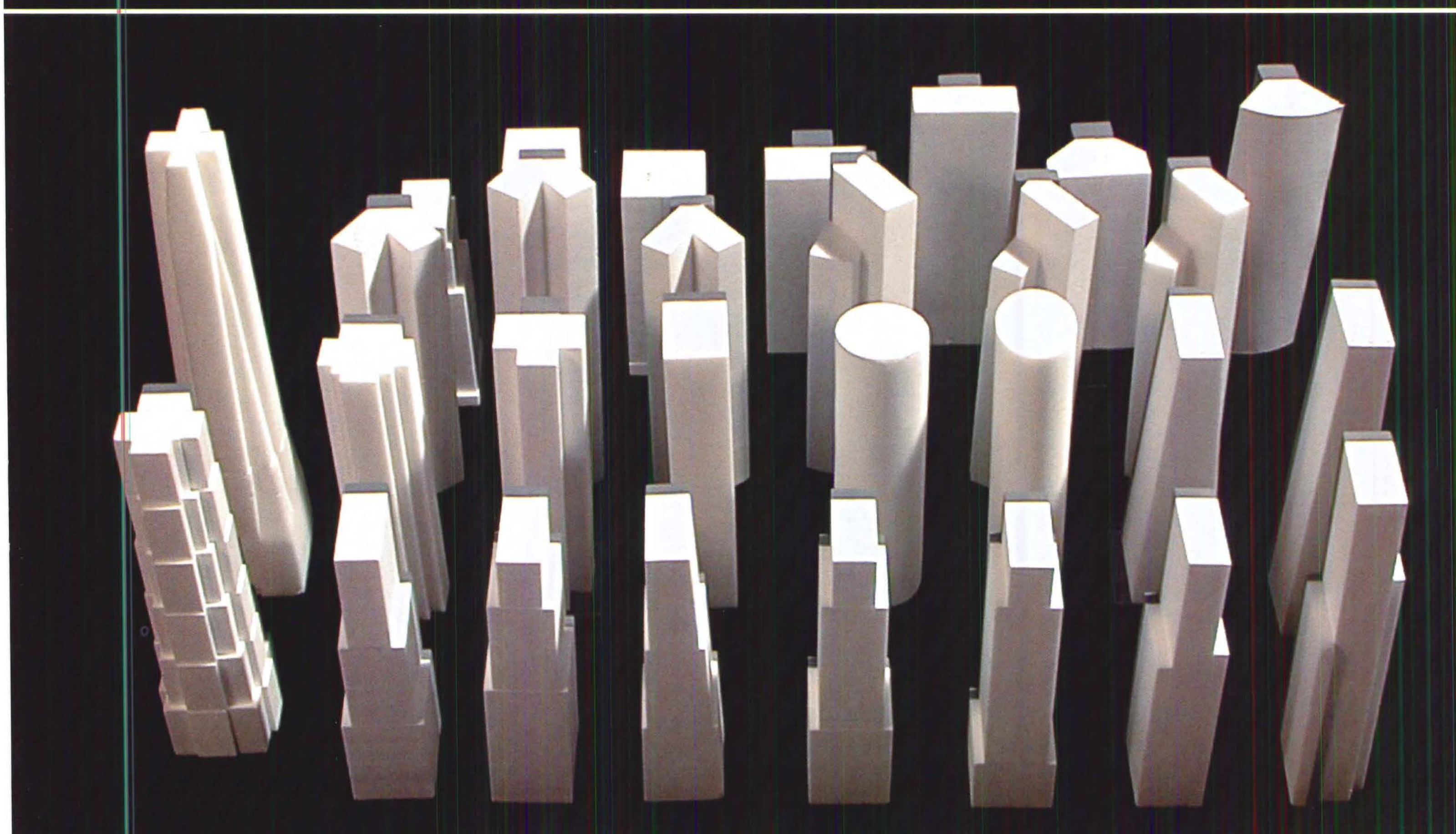
View from 21st floor



View from 30th floor



View from 41st floor



FEATURES

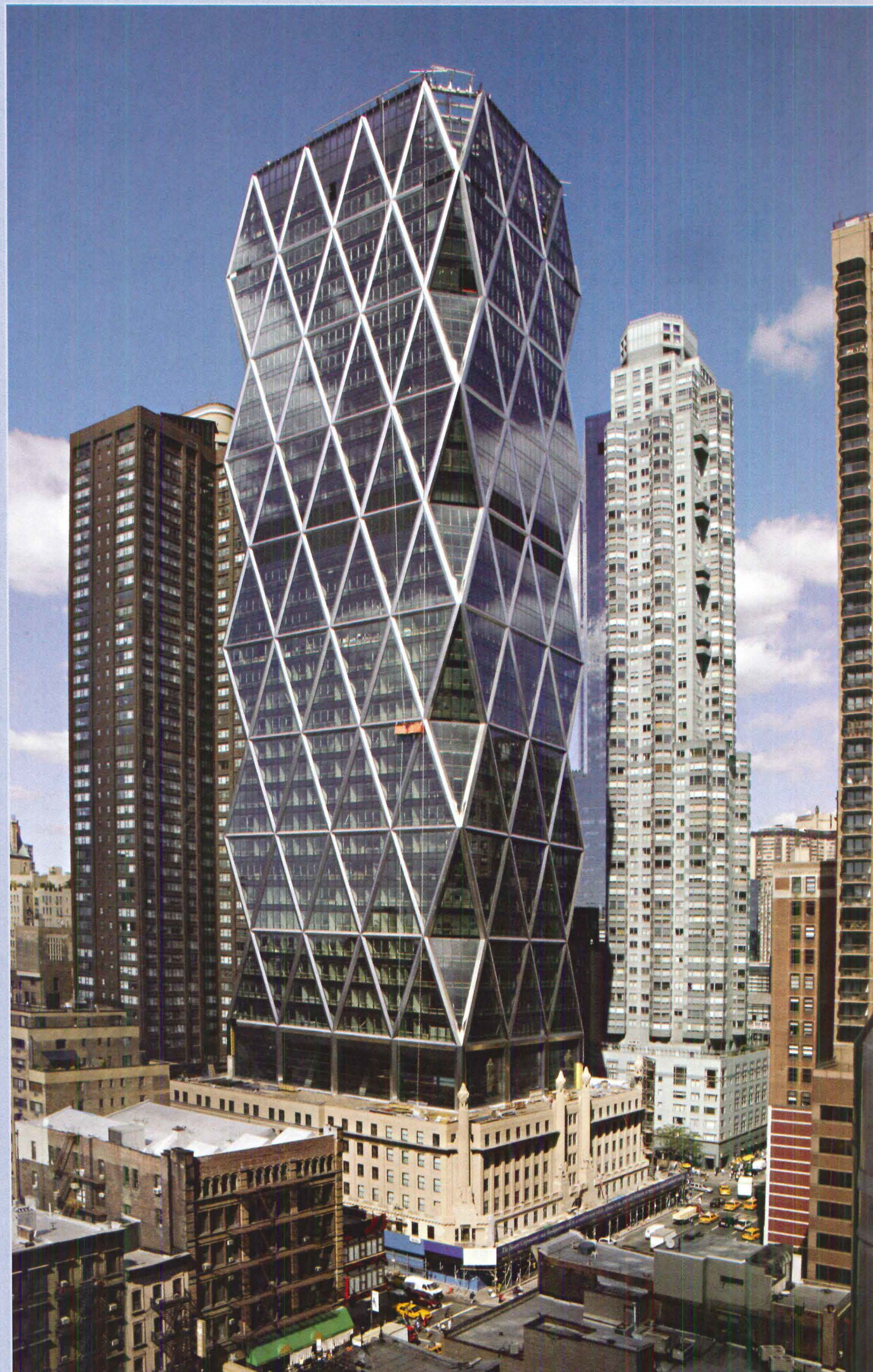
Part II: Innovation

Building a State-of-the Art Home

Engineering and architecture are fused by **logic, precision,** and **finesse.**

The new 42-story Hearst headquarters provides nearly one million square feet of office space. The building uses a composite steel and concrete floor with a 40-foot column-free interior span to allow for open office planning. The office zone starts at the 10th floor. At the seventh floor, the diagrid connects to the existing landmarked facade via a horizontal skylight system (right), which spans 40 feet between the old base and new tower. The "bird mouths" (opposite) at the corners provide some offices with "Zeppelin" views of Eighth Avenue.

COURTESY FOSTER AND PARTERS (EXCEPT AS NOTED)



By Sara Hart

The diagrid structural system, which is both a structural and architectural device in the Hearst Corporation's new tower, is familiar to its architect, Norman Foster. He first used it for the Hong Kong and Shanghai Bank in 1985. More recently, he used it to create the curvaceous forms of the Swiss Re headquarters in London [RECORD, June 2004, page 218] and the Greater London Authority [RECORD, February 2003, page 110].

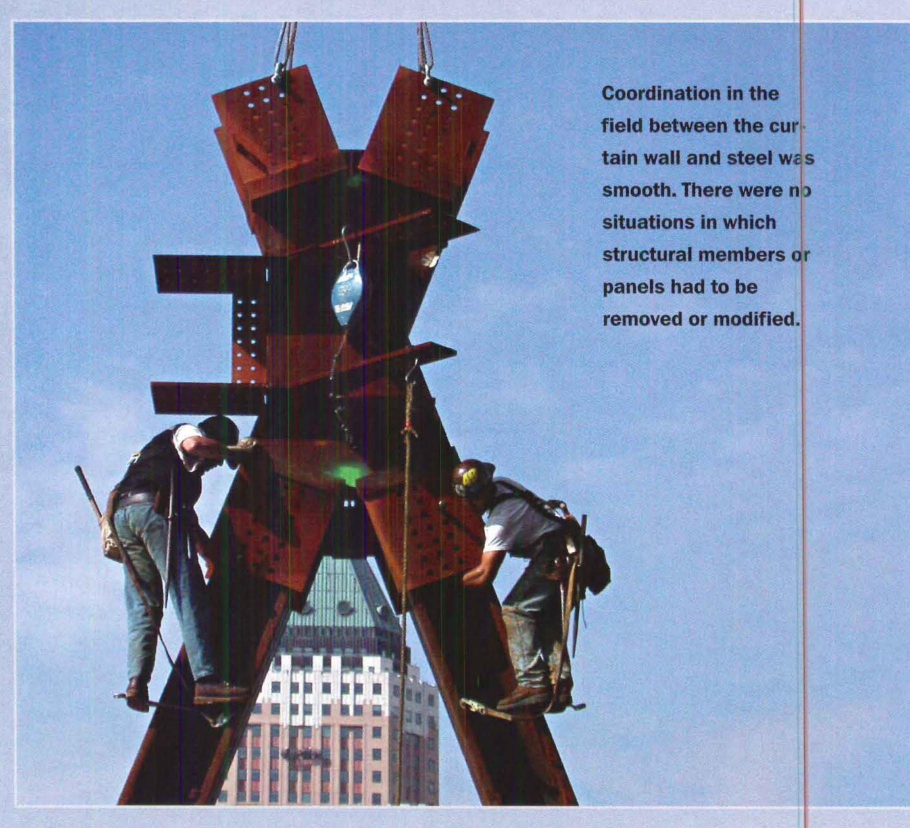
New York-based Cantor Seinuk, structural engineers for the Hearst tower, know the advantages and challenges of the diagrid as well. President Ahmad Rahimian and project manager Yoram Eilon have discussed the innovations demanded by this project in considerable detail. Rahimian notes, "We are all intuitively familiar with the inherent stability of triangular structures." Then he explains the mechanics: "A diagrid system is a diagonal arrangement of primary structural members to form a structural system made out of a network of triangles. Placement of diagonals, especially in steel structures to add stability and strength to building, has widespread applications and popularity among engineers, whether the bracings are placed around the perimeter of the building, such as the John Hancock Center in Chicago [Skidmore Owings & Merrill, 1969], or placed at interior of the building, disguised within finishes. However, in all these applications, the diagonals are placed within a primary orthogonal structural framework as elements providing stability under wind and seismic loads."

Foster and Partners' design for the Hearst tower called for gutting all the existing construction within the envelope, while preserving and restoring the landmarked facade. The footprint of the base is U-shaped in plan, covering the 200-by-200-foot site. The tower was to be built on a new foundation, creating a footprint 160 feet by 120 feet.

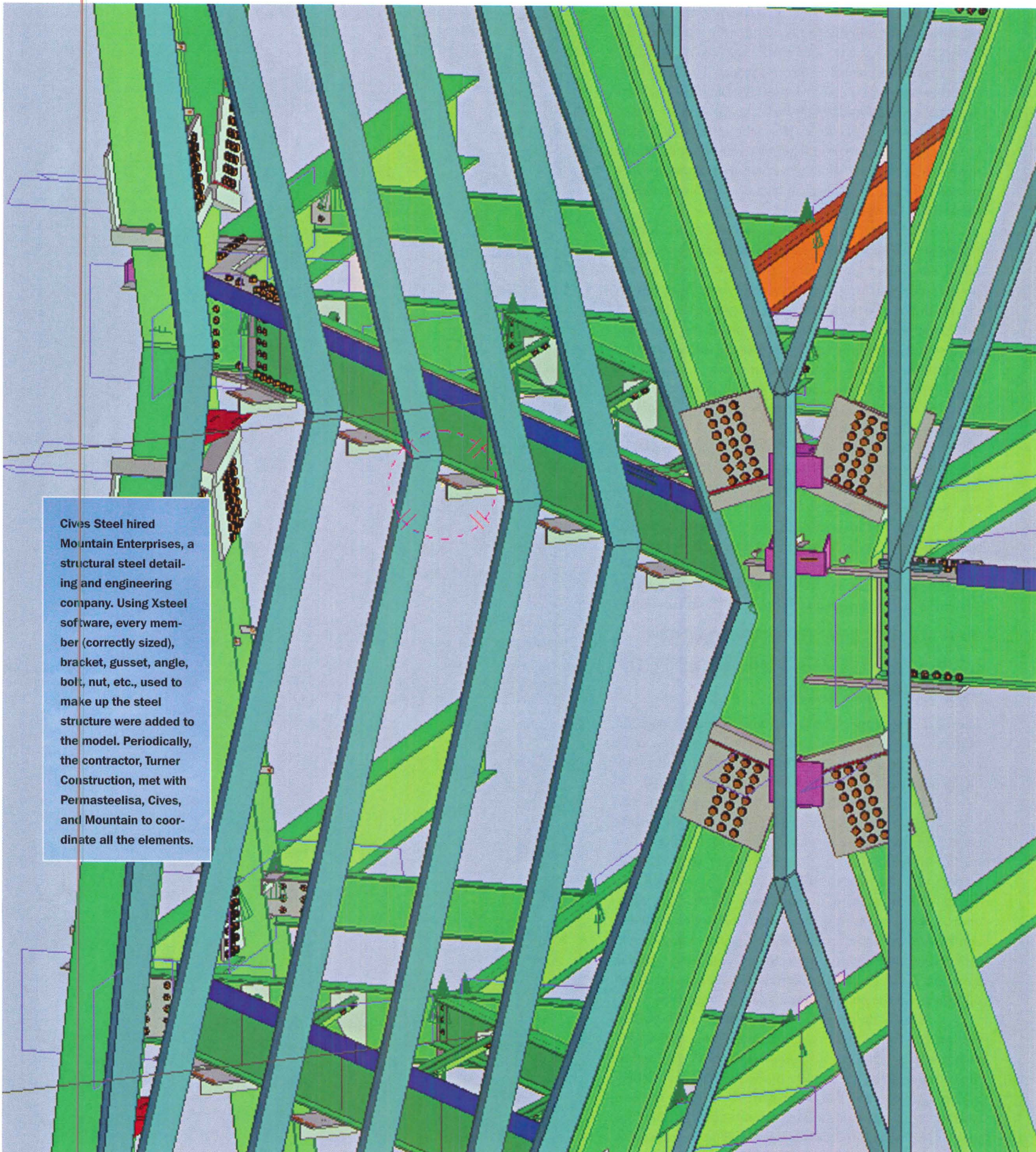
The first engineering challenge focused on the gutted structure. The shell was left unbraced to a height for which it was not originally designed. In response, the engineers devised a framing approach that would stabilize the remaining masonry walls. Whereas the existing supporting steel columns and spandrel beams maintained full vertical support for the facades, the engineers had to provide lateral stability and address new seismic requirements in the current New York City Building Code. They then designed an additional grid of vertical and horizontal framing behind the facades. In turn, both the existing and new grids are supported laterally by the new tower's third-floor framing system and the skylight framing system at the top of the seventh floor, which lines up with the top of the existing facade system.

The diagonals in the Hearst tower form pure triangles, which are the primary elements for gravity load as well as wind and seismic loads. This provides a highly efficient and redundant structure. As a matter of fact, the perimeter structure consumes 20 percent less steel than a conventional moment-frame structure. The contractor also saved the project millions of dollars by purchasing the bulk of the steel before the prices soared in 2003.

Despite all the computer software available to them, the engineers switched to model-making at one point. The key was to have a less labor-intensive design, even if it marginally increased the cost of materials.



Coordination in the field between the curtain wall and steel was smooth. There were no situations in which structural members or panels had to be removed or modified.



Cives Steel hired Mountain Enterprises, a structural steel detailing and engineering company. Using Xsteel software, every member (correctly sized), bracket, gusset, angle, bolt, nut, etc., used to make up the steel structure were added to the model. Periodically, the contractor, Turner Construction, met with Permasteelisa, Cives, and Mountain to coordinate all the elements.

The diagrid consists of triangular steel bracing beginning at the 10th floor and ending at the top. Triangular frames carry the gravity load while resisting lateral loads. Such an efficient system requires 20 percent less structural-steel than another type of structure. The diagrid also allows for large, open floor plates, in this case, offering an area of 22,000 square feet per floor. Here, the tower's diagonally braced structural envelope requires fewer columns on the floor plates and allows a fully glazed facade. It also eliminates corner columns, another advantage not usually offered in conventional moment-frame towers.

Although the diagrid was not reinvented for the Hearst tower, the team has experienced what one member called "continuous moments of innovation" throughout the project. For instance, Foster's design intention was to express the diagrid architecturally by cladding the triangles with stainless steel. "This added to the engineering challenge, because conventionally large gusset plates are used at the connections," explains Rahimian. "In this case, large plates would interfere with the cladding. "Simply put, the connection zone within the visible curtain wall zone could not be larger than the structural members."

Cantor Seinuk designed two types of nodes as substitutions for the gusset plates, a planar one for transferring loads in two-dimensional space and a more complicated corner node, which addressed the chamfered corners, called "bird mouths," for transferring loads in three-dimensional space. The nodes were created earlier during the conceptual design phase, rather than later, when detailing is usually undertaken, because the viability of the overall concept depended to a large degree on the feasibility of these nodes.

THE VIABILITY OF THE CONCEPT DEPENDED ON THE FEASIBILITY OF THE CORNER NODES.

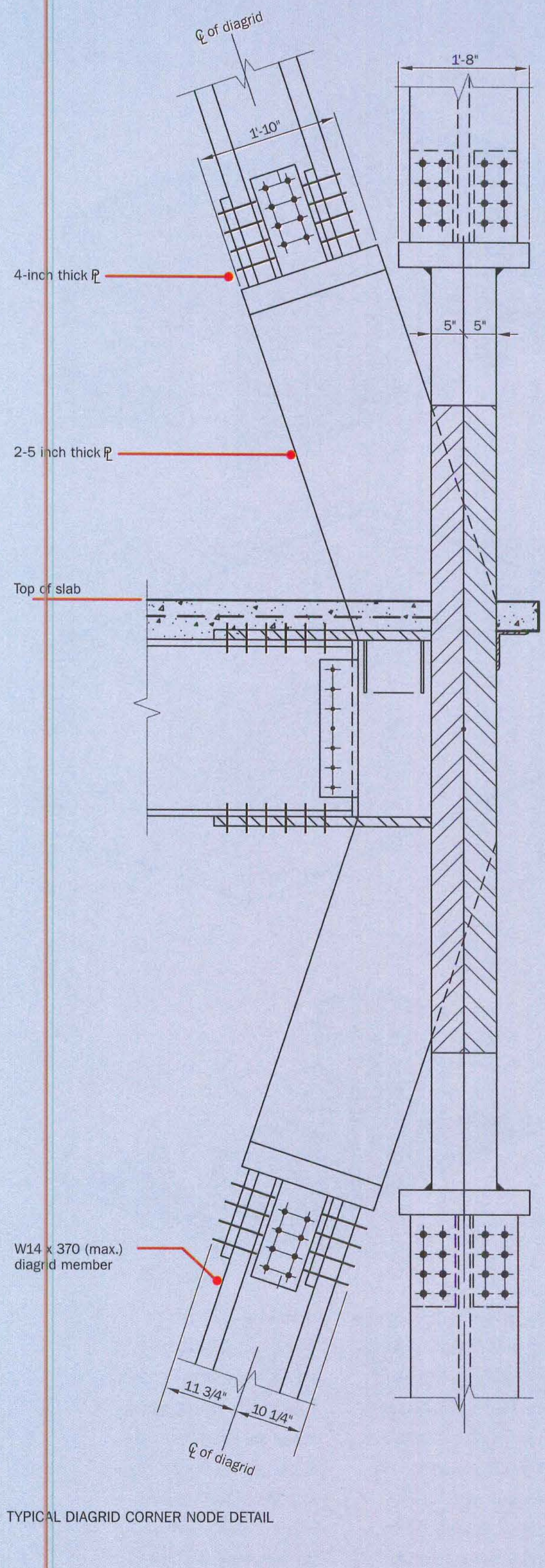
The final design met all the architectural and structural requirements, as well as those of the steel contractor, Cives Steel, which prefabricated the four-story, grade-65 steel triangles in its in its upstate New York and Virginia plants.

Nodes notwithstanding, the fabrication of the diagrid system had fewer complexities than a fully moment-connected frame. The repetitive nature of the node also further simplified the engineering of the shop-drawing preparation. The inherent stiffness of the diagrid requires a higher level of precision in fabrication and erection tolerances. It also provides a shorter window of opportunity for adjustment during erection. While diagrid systems have inherent strength and stiffness comparable to a triangulated structure, the diagonal elements must be braced between the nodel levels at the floors by a secondary lateral system.

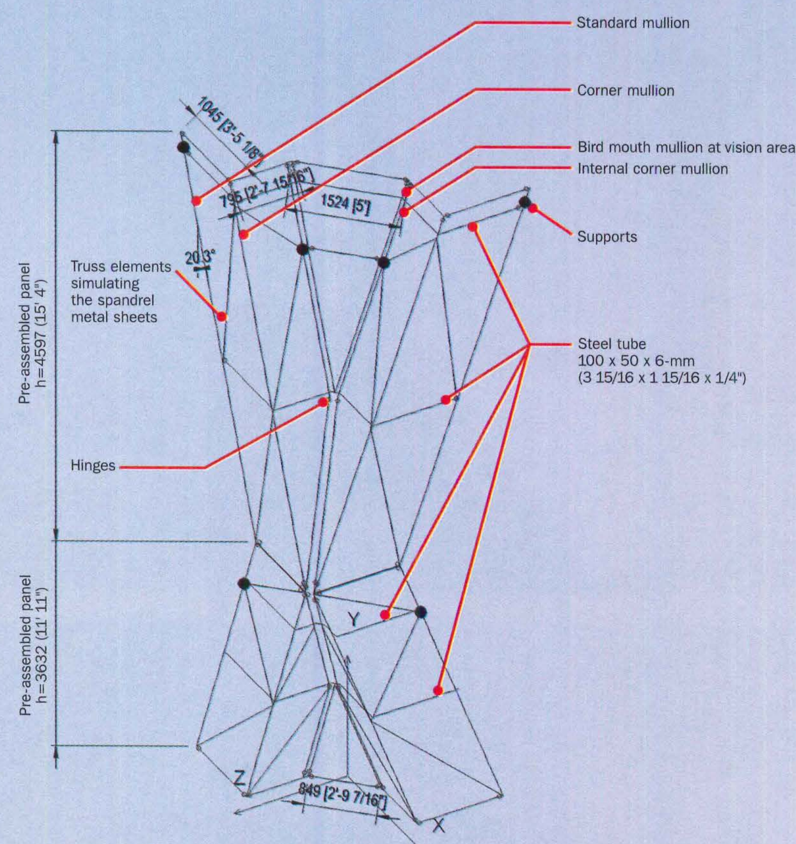
Finally, the diagrid's triangles will be infilled with a glass curtain-wall by Italian manufacturer, Permasteelisa. This intersection of plane and structure is perhaps the last layer of innovation needed to complete the architect's goal of combining figurative and literal transparency. It's also the one with which the occupants will interact most closely. While the memory of the past recedes for them as the tower rises, the views of the company's future are infinite looking out. ■

The large V-panels, which cover the steel diagrid (above), were assembled at Permasteelisa's Montreal facilities (below), and trucked to site. Most panels were fabricated, assembled, and shipped directly from Permasteelisa's plant in Italy.

COURTESY PERMASTEELISA (BOTTOM)

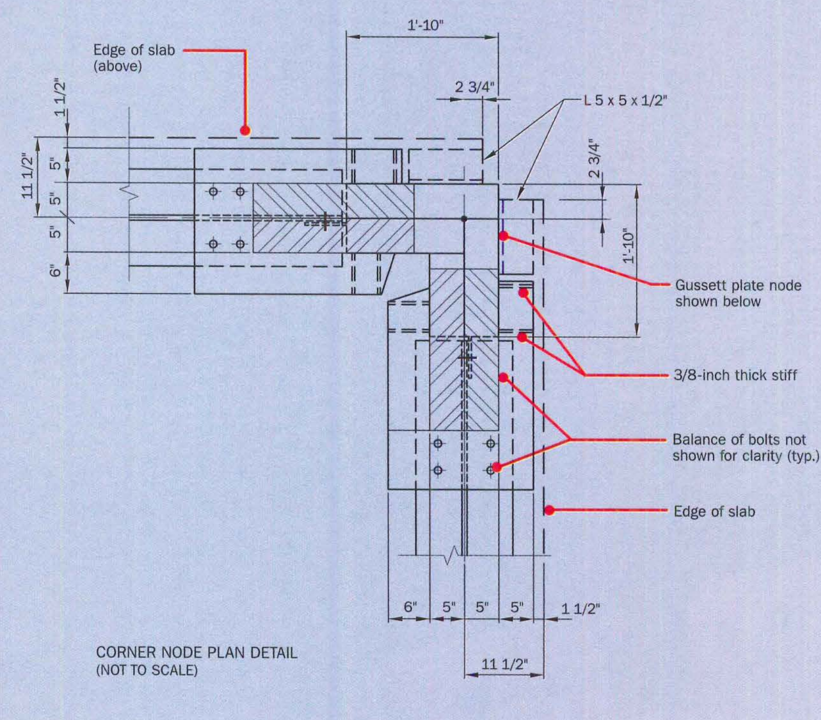


TYPICAL DIAGRID CORNER NODE DETAIL

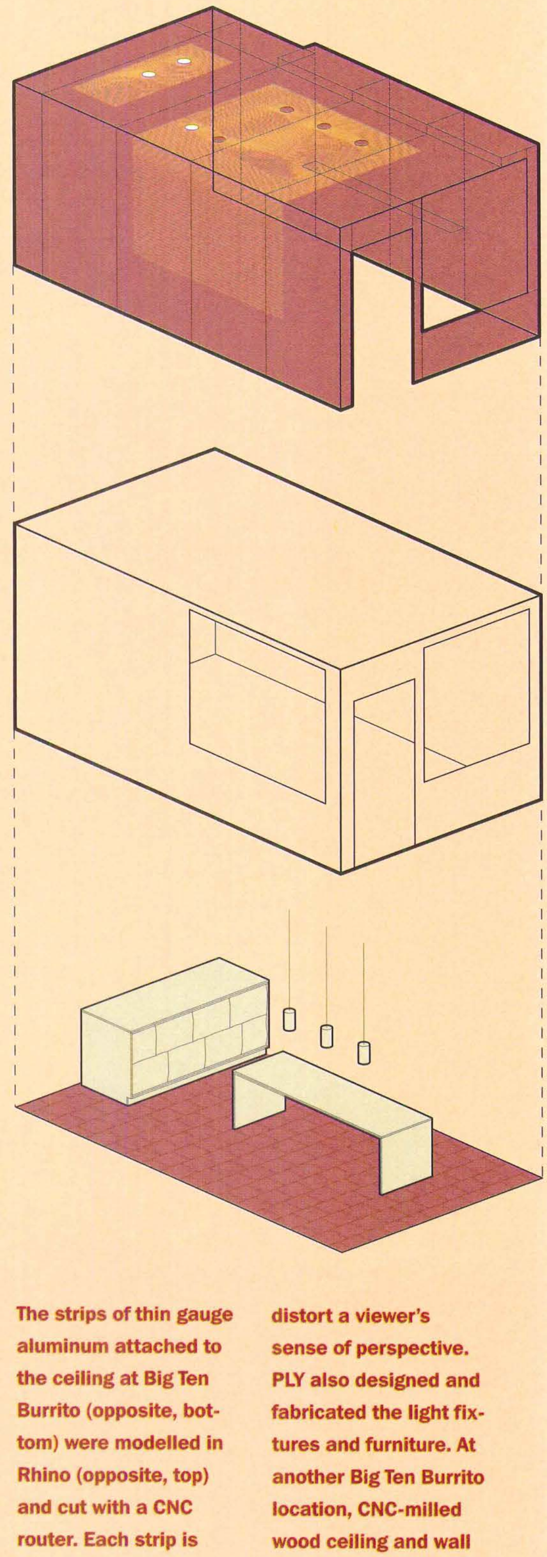


BIRDMOUTH STRUCTURAL DIAGRAM

The nodes are set on a 40-foot module, every four floors. This establishes the system's general parameters.



CORNER NODE PLAN DETAIL
(NOT TO SCALE)

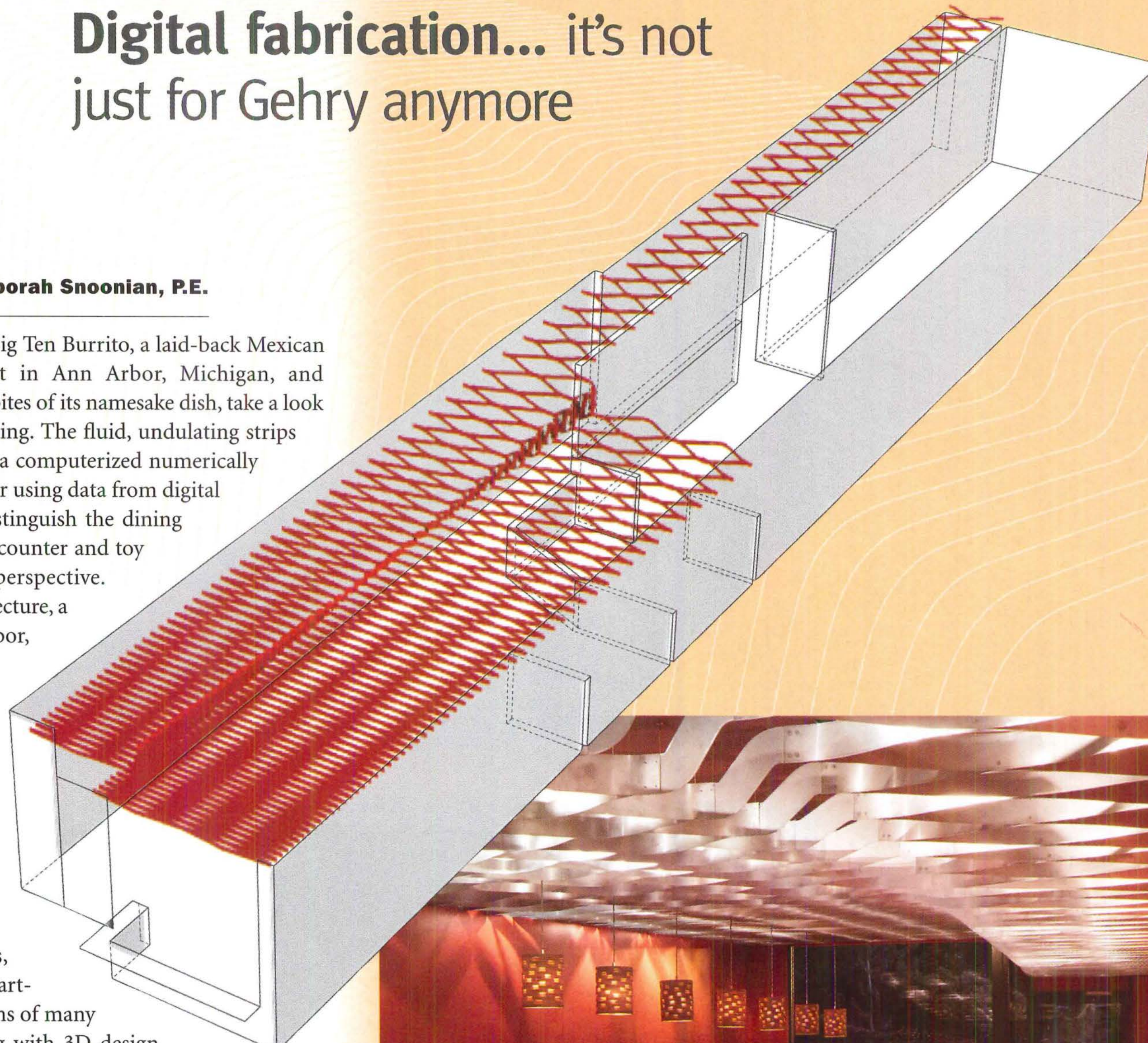


The strips of thin gauge aluminum attached to the ceiling at Big Ten Burrito (opposite, bottom) were modelled in Rhino (opposite, top) and cut with a CNC router. Each strip is unique in size and shape, and spaced to distort a viewer's sense of perspective. PLY also designed and fabricated the light fixtures and furniture. At another Big Ten Burrito location, CNC-milled wood ceiling and wall panels lend texture to a simple space.

Design Embraces the Machine Age

Digital fabrication... it's not just for Gehry anymore

By Alan Joch and Deborah Snoonian, P.E.

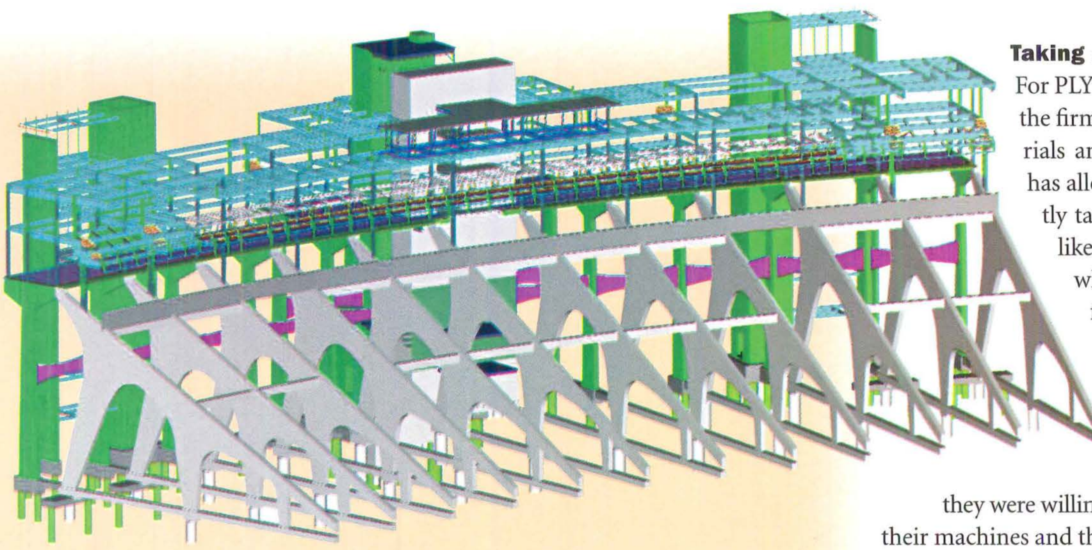


Walk into Big Ten Burrito, a laid-back Mexican restaurant in Ann Arbor, Michigan, and between bites of its namesake dish, take a look at the ceiling. The fluid, undulating strips of aluminum, cut with a computerized numerically controlled (CNC) router using data from digital design files, visually distinguish the dining area from the take-out counter and toy with your sense of perspective. Designed by PLY Architecture, a small firm in Ann Arbor, the distinctive ceiling at Big Ten Burrito is more than just an eye-catching touch by imaginative designers. It points the way to changes in how architects are working.

Despite hairy technical, legal, and cultural barriers, digital fabrication is starting to hit its stride. Firms of many sizes are experimenting with 3D design and manufacturing techniques that the automotive and aerospace industries adopted more than a decade ago. The shift has been motivated by many factors: aesthetic aspirations, a client's request, the desire to save time and money on projects. And the efforts of architects are being enabled by software companies eager to provide (and sell) feature-rich CAD programs that can translate 3D information into machinable components, along with engineers, contractors, and material suppliers who want to streamline design and construction.

Alan Joch is a business and technology writer based in New England. Contact him at ajoch@worldpath.net.

PHOTOGRAPHY: © CURT CLAYTON (THIS PAGE); HOWARD DOUGHTY (OPPOSITE); RENDERINGS: COURTESY PLY ARCHITECTURE

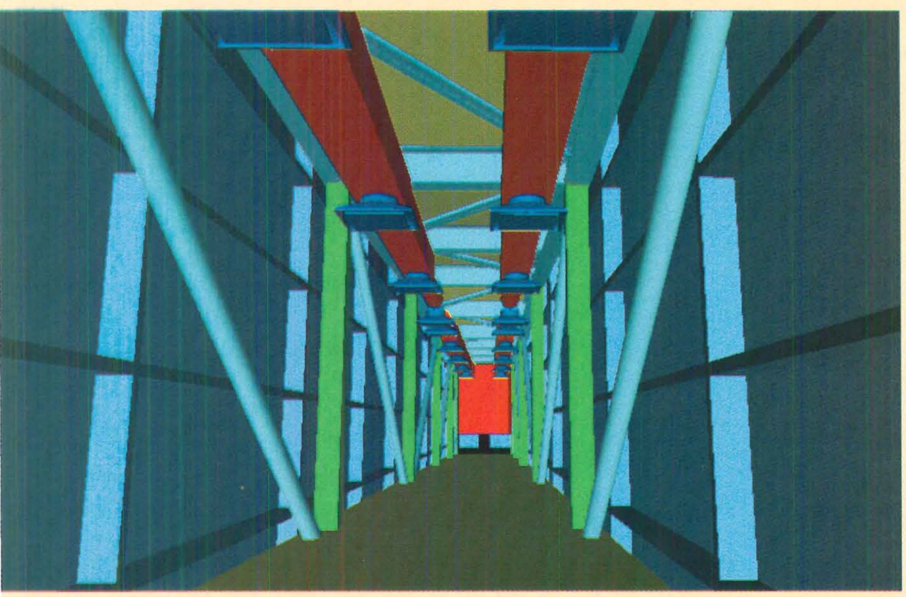


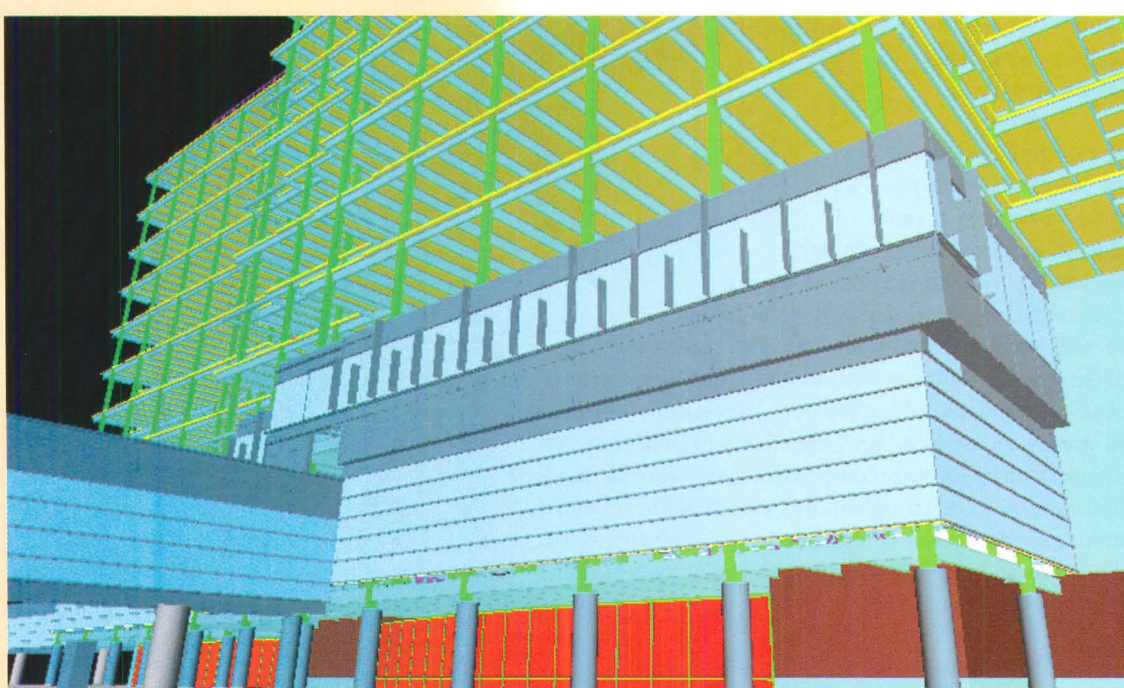
Taking a hands-on approach

For PLY Architecture, whose Web site describes the firm's "dedication to the synthesis of materials and craft," exploring digital fabrication has allowed them to create complex and subtly tactile forms in a cost-effective manner, like at their Big Ten Burrito projects, for which they also designed and made the furniture and light fixtures. "We found almost all the cabinet-makers in our area are now using CNC routers," says principal Craig Borum, AIA. "So we started having conversations with them to figure out what they were willing to do, and what the limitations are for their machines and their software."

Notably, PLY acts as the prime contractor on most of its projects, which lowers costs as well as risks because the firm doesn't have to hand off digital files to a third party. The aluminum ceiling at Big Ten, for instance, was made by the fabricator, pre-assembled in PLY's office, and installed onsite by three of their staff. "Overseeing fabrication gives us control through all the stages of production," Borum says. "Plus, we save a step by not having to produce a complete set of construction documents to explain to somebody else how to build our design."

Geography helps. PLY has access to an extensive network of fabricators that work mostly with the automotive industry in nearby Detroit. Borum and his PLY partner, Karl Daubmann, have forged budding relationships with a few fabricators who have been willing to halt their automotive production runs "to squeeze in some strange part on the side," says Borum. The firm is even commercializing a series of light fixtures, called PLY Lights, that feature shades made from scrap material left over from sheets of plywood cut with CNC routers, a material they acquire locally.





Fabricator Puma Steel is working with Kling and Fentress Bradburn Architects and contractor M.A. Mortenson on a 3D model for fabricating the steel structure of a 400,000-square-foot health sciences center at the University of Colorado in Aurora (right and above). For an earlier project, Sonny Lubick Field at Colorado State University (top), Puma used 3D models for sequencing and clash detection, but not fabrication.

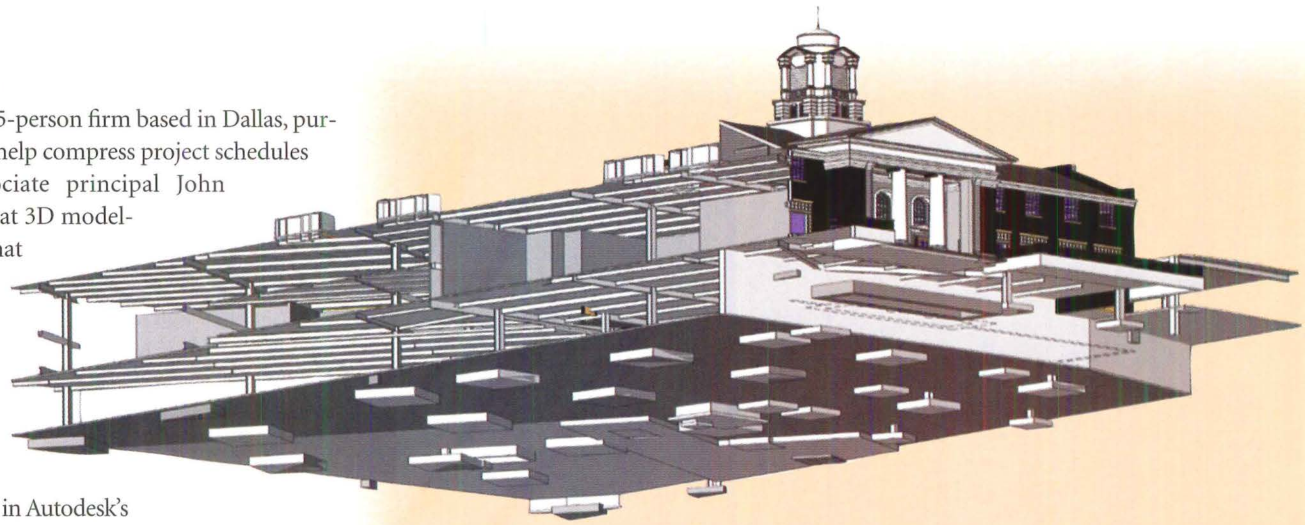
RENDERINGS: COURTESY MARTIN/MARTIN

The bottom-line effect

Good Fulton & Farrell, a 75-person firm based in Dallas, pursued digital fabrication to help compress project schedules for repeat clients. Associate principal John Moebes, AIA, estimates that 3D modeling enabled fabrication that shaved about a month's time off the recent design and construction of a national retail chain store originally slated to last eight months. Achieving that goal took serious preparation: first, investing in Autodesk's ADT and training staff how to use it, and later hunting down fabricators and subcontractors who were willing to use the digital models his firm produced. "We did a lot of research on which technology platforms are used by steel fabricators, air-conditioning ductwork fabricators, pipe fitters," Moebes says. He found collaborators the hard way—surfing the Web, making cold calls—but was pleasantly surprised to find them receptive to sharing digital data.

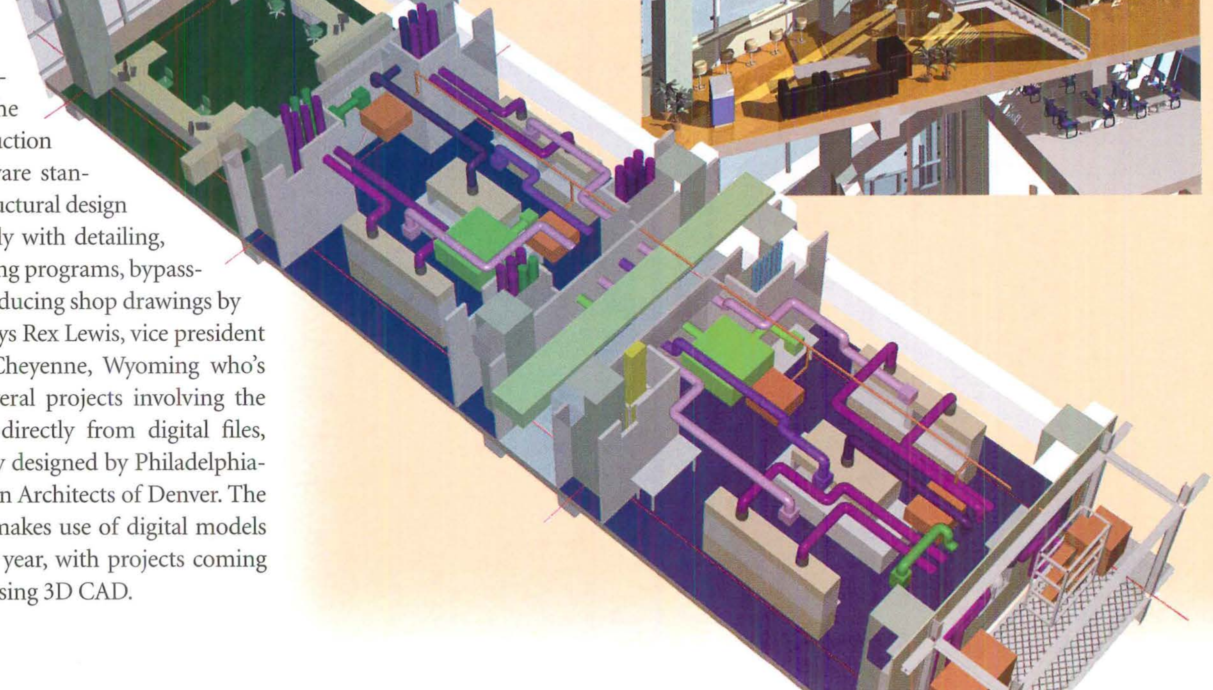
Of course, high-profile projects by signature architects are always ripe proving grounds for experimentation (and attempts to trim budgets). M.A. Mortenson, the contractor for Frank Gehry's Walt Disney Concert Hall in Los Angeles, is using what it learned there to build Daniel Libeskind's $62.5 million, 180,000-square-foot addition to the Denver Art Museum, slated for completion in 2006. Fabrication of the structural steel elements of Libeskind's angular addition took three months less than expected, says Derek Cunz, director of project development in Mortenson's Denver office. Field corrections fell "an order of magnitude," he adds, and reduced erection times resulted in savings valued at $400,000. Projects using 3D models and digitally-enabled fabrication represent about 20 percent of Mortenson's work, he says.

In truth, much of the push toward these work methods has come from experienced contractors such as Mortenson, as well as engineers and other groups who benefit from construction efficiencies. In 2000, the American Institute of Steel Construction (AISC) began promoting a software standard called CIS/2, which allows structural design programs to communicate directly with detailing, fabrication, and ordering and billing programs, bypassing the error-prone process of producing shop drawings by hand. "It's new territory for us," says Rex Lewis, vice president of Puma Steel, a fabricator in Cheyenne, Wyoming who's working with Mortenson on several projects involving the manufacture of structural steel directly from digital files, including a new healthcare facility designed by Philadelphia-based Kling and Fentress Bradburn Architects of Denver. The percentage of Puma's work that makes use of digital models has more than tripled in the last year, with projects coming from architects who have begun using 3D CAD.

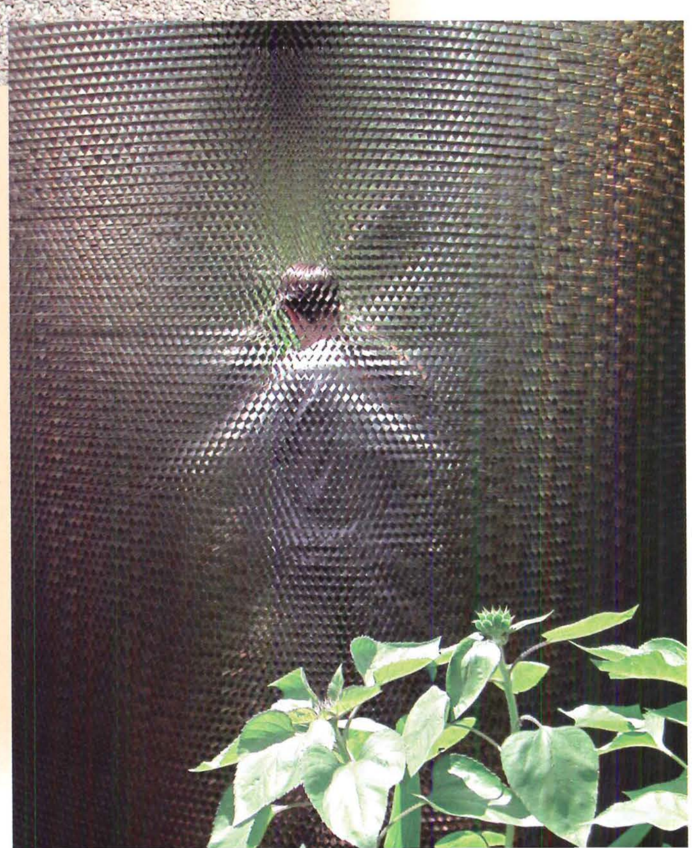


For a national retail chain, architects Good Fulton & Farrell created a 3D model used by fabricators to manufacture the building's structural steel, pipe, and ductwork.

The Maeda Corporation, one of Japan's largest civil engineering and contracting firms, used Bentley's MicroStation to create 3D models of a seven-story research lab in Tokyo. What once took eight months to complete drawings was shortened to two months, and the digital data were used by contractors to verify material quantities.



RENDERINGS: COURTESY GOOD FULTON + FARRELL (TOP); BENTLEY SYSTEMS (BOTTOM THREE)



Sharon McHugh and John Nastasi Architects built the Cornel West Pavilion in 2004 with Nastasi's graduate students at Stevens. This temporary, self-supporting structure on the campus of Princeton University is made from a honeycomb metal mesh used in the aerospace industry. Its geometry was derived from a digital study of the material's structural properties.

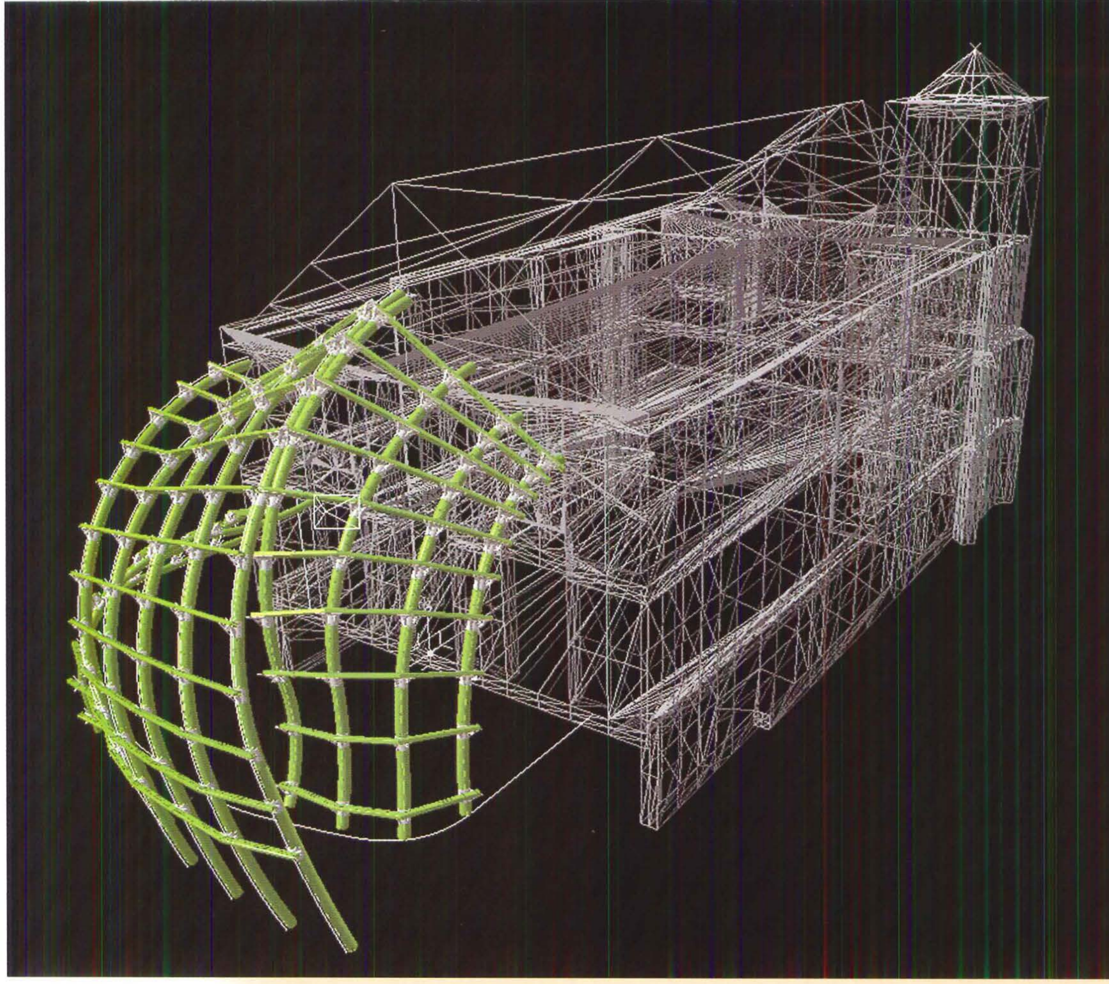
A new lesson plan

Fruitful partnerships are beginning to emerge between practitioners and universities that can afford to invest in equipment that's out of reach for most firms. While the 1990s were the era of the paperless studio at design schools, the past few years have seen the growth of the production studio, where students form interdisciplinary teams and learn advanced design and manufacturing techniques. PLY's Daubmann teaches a graduate-level seminar on digital fabrication at the University of Michigan's Taubman College of Architecture and Urban Planning. "The school has taken up this agenda to advance ideas about technology, construction, and fabrication, and allow them to affect the design process," says Borum, who is also on the faculty. Students from both architecture and engineering work with several software packages, including engineering and modeling software SolidWorks and Digital Project, the CATIA-based program developed by Gehry Technologies. "The college has invested in 3D printers and CNC routers because everyone senses these technologies are becoming more prevalent in the industry," Borum says.

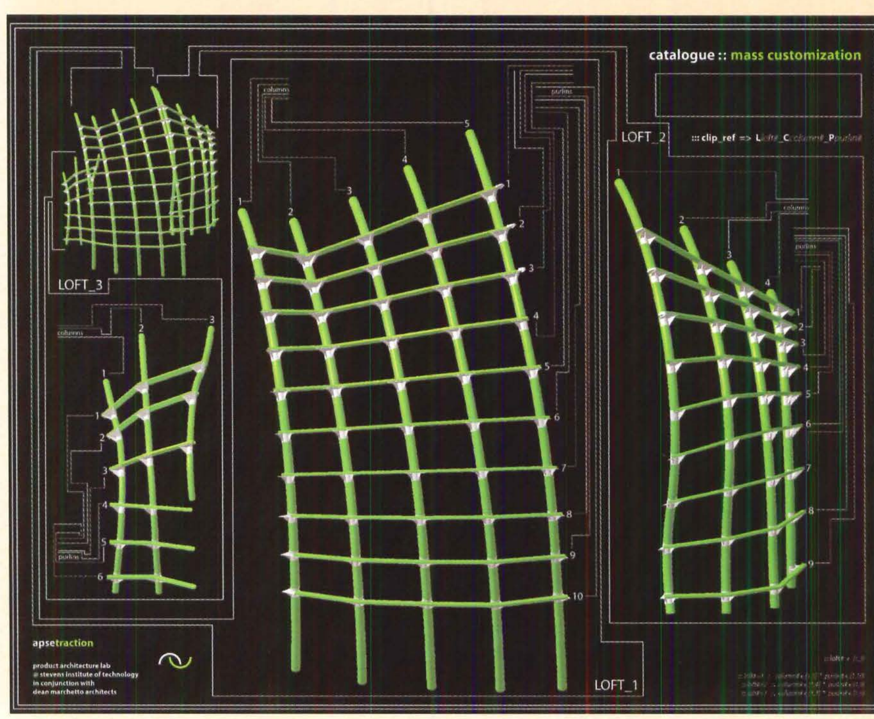
Apparently Yale's school of architecture hears the same muse. Dean Robert A.M. Stern focused on recent technology acquisitions in his annual letter to the school's alumni this fall. Scattered throughout Paul Rudolph's multileveled concrete building in New Haven are three laser cutters, a water jet cutter, 3D printers, CNC routers, a 3D laser scanner, and a foam cutter for large-scale models that's the size of a New York City studio apartment. "Not bad considering that five years ago nobody knew what a laser cutter was," says John Eberhart, director of digital media at Yale, who earned a master's in architecture from the university in 1998. He estimates that Yale has spent some $500,000 on rapid prototyping and digital fabrication equipment, not counting the extra computers and infrastructure upgrades their acquisitions entailed, which easily quadruples that figure. The equipment has drawn interest from other departments that want to collaborate with the architecture school to develop joint courses and research.

But the surest sign of transformation is the establishment of an interdisciplinary design master's program at an engineering school (RECORD, September 2004, page 187). At the Product-Architecture Lab at the Stevens Institute of Technology in Hoboken, New Jersey, a diverse student body of architects, engineers, and programmers study digital design and production using real-world case studies. Architect John Nastasi, who created the lab and graduate program in 2004, says collaborative work methods will be just as important to architects as technical know-how. "Digital fabrication allows architects to have more input on manufacturability, materials, costs—all the things we've handed over to construction managers for the past 20 years."

In just over a year, the lab has attracted an enviable roster of industry partners. Greg Otto, an engineer at Buro Happold whose career has focused on technology-enabled collaboration between engineers and architects, is on the faculty. The New York firm SHoP, one of the first to invest in its own rapid prototyping equipment, has sent one of its senior designers to study there; the students are also using SHoP projects as case studies, including an overhaul of New York's Fashion Institute of Technology. Front, a facade consultancy founded by architects and engineers who've worked for Norman Foster, Rem Koolhaas, and other top architects, contacted Nastasi recently to develop joint projects. "I call the Stevens program 'the digital Bauhaus,'" says architect David Serero, a principal of Brooklyn and Paris-based Iterae Architecture, an interdisciplinary firm that's used engineering software and digital fabrication on several projects in the U.S. and Europe.



Students at Stevens' Product-Architecture Lab are designing "Apse-straction," a 400-square-foot addition to a church in Hoboken, New Jersey, with Dean Marchetto Architects. The steel structure will be cut with a CNC router, and its connection brackets will be fabricated using a digital printer.



The tipping point?

Granted, for several years architects have championed building information modeling (BIM, the latter-day term for digital models embedded with design and construction data) and better data-exchange standards to enable digital fabrication, mass customization, and faster, cheaper construction. CIS/2, for instance, resolves one data-sharing challenge, and groups such as the International Alliance for Interoperability and FIATECH continue to define and refine existing standards. But industry leaders also recognize that technological advances alone won't define new business processes or transcend the uncertainties involved in digitally-based work methods. To that end, the AISC has developed model language for the use of 3D models as contract deliverables. And the next major update of AIA's contract documents, due in 2007, will also address digital work methods, says Phillip Bernstein, FAIA, a vice president of Autodesk and chair of the committee revising the standards.

Improved standards and processes help, but people are the real catalysts. Whether the impetus comes from an architect or academia, client or contractor, pursuing digital fabrication for buildings takes both vision and gumption. It's not a single-button push from modeled part to fabricated component, but the benefits of moving toward that goal have become clearer. "If I can say to a client 'you can open your store a month early,' that makes him happy," says Moebes. "Considering how important repeat business is to architects, anything we can do to improve service to existing clients is a mandate for us." ■

PHOTOGRAPHY AND RENDERINGS: COURTESY JOHN NASTASI

FEATURES

The leaders of the latest

Today's materials innovators are not only working for manufacturers or labs. Architects are also developing new materials in response to needs in the market, and the benefits extend far beyond their own projects.

By Blaine E. Brownell

By the time Modernism reached its apex, during the mid-20th century, many architects had proven the merits of self-initiated materials research and development. Fueled by a postwar economy and a society enthralled with technological potential, Buckminster Fuller, Charles and Ray Eames, and their contemporaries demonstrated an uncanny capacity for generating new products and technologies in their practices.

When the Modern project gave way to Postmodernism and Deconstructivism, technological advancement was eschewed in favor of the representation of abstract linguistic systems in architecture. Today, the focus on materials has returned. Renewed interest in technological innovation and sustainable practices characterizes our zeitgeist, and an explosion of new products has inspired a cottage industry of materials analysts from within the architecture and design professions. A veritable materials revolution is under way, and architects are once again contributing to the leading edge of product development.

What is driving this recent groundswell of materials innovation? A heightened awareness of the growing scarcity of raw material and energy resources, coupled with increased concern about greenhouse gas emissions and widespread pollutants, has spawned a passionate interest in ecologically responsible materials. The resulting drive to develop products that enhance performance while using fewer materials is analogous to the general trajectory of technology itself, which follows an accelerated curve toward increased power and miniaturization. It is also noteworthy that several decades-old NASA technologies, including products such as Aerogel and memory foam, have recently been adapted to the consumer market. Consequently, new materials have begun to capture popular attention as well as industry-specific interest.

Material programming

For the Office for Metropolitan Architecture's Chris van Duijn, the overall building concept drives materials innovation. Trained as an architect, and a longtime model maker, in

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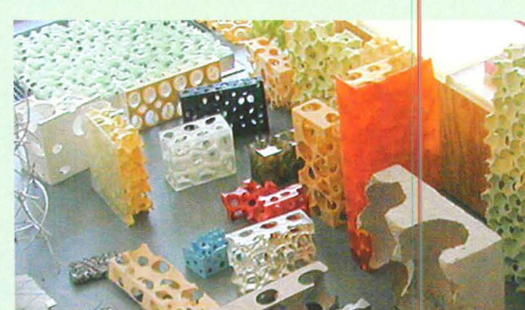
FOAM

FOAM was developed by OMA while working on several Prada epicenter stores simultaneously (the Los Angeles store is shown here). The sponge-like polyurethane material can be used to build furniture and partitions as well as entire spaces. Hundreds of prototypes of the material (below) were made to achieve the right balance of openness, translucency, depth, and color.



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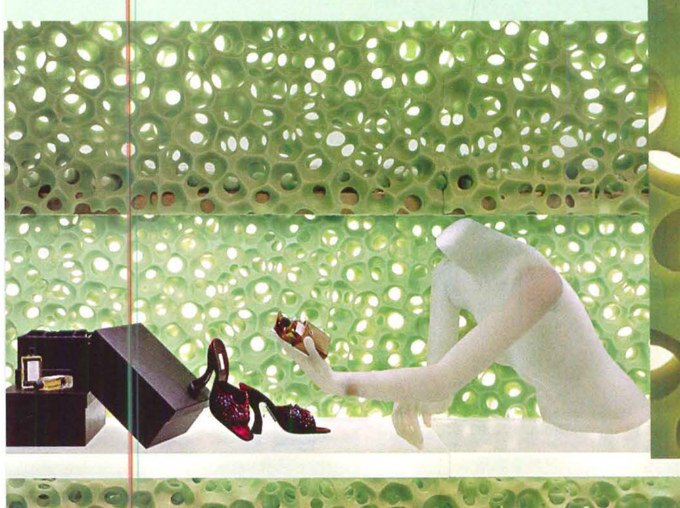
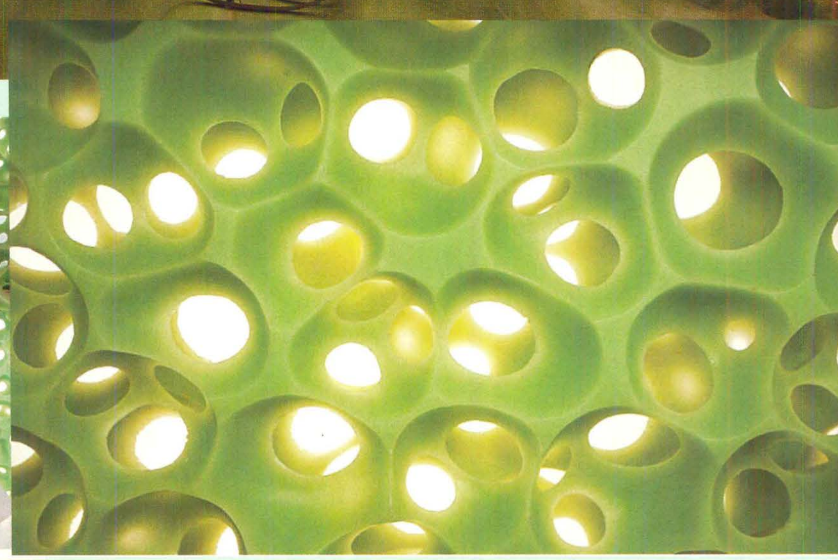
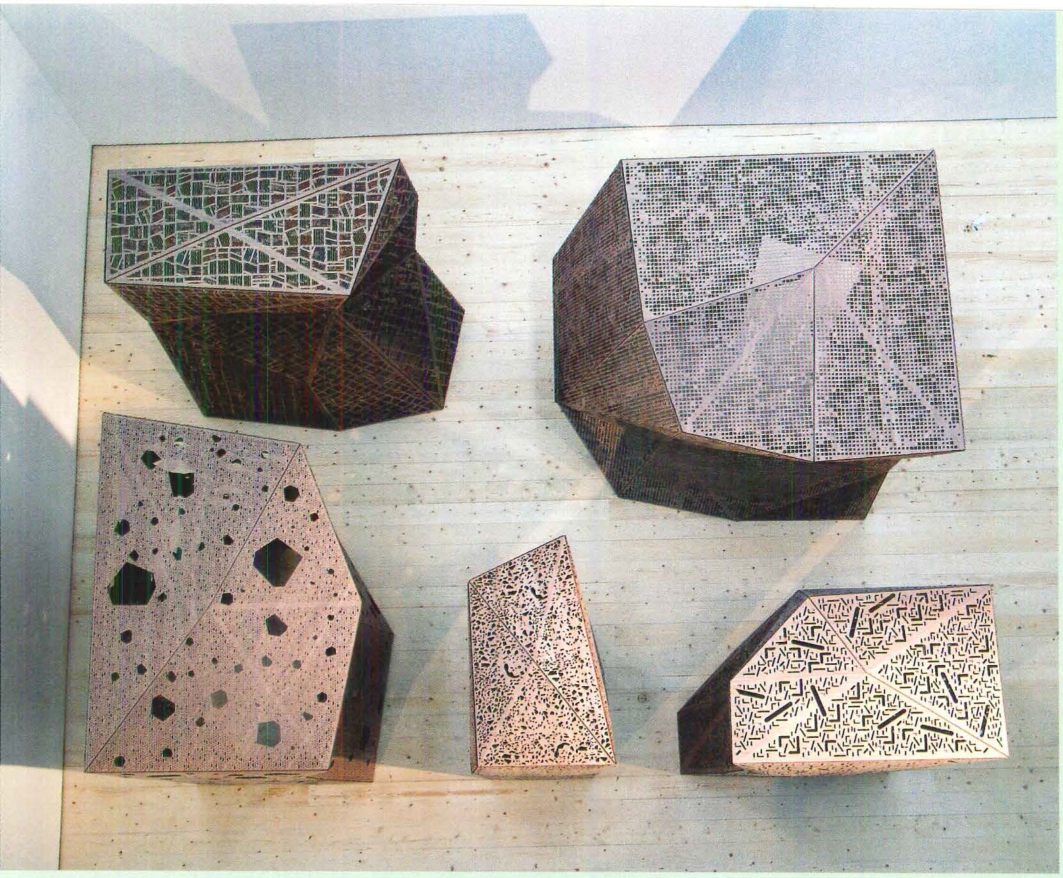
materials revolution

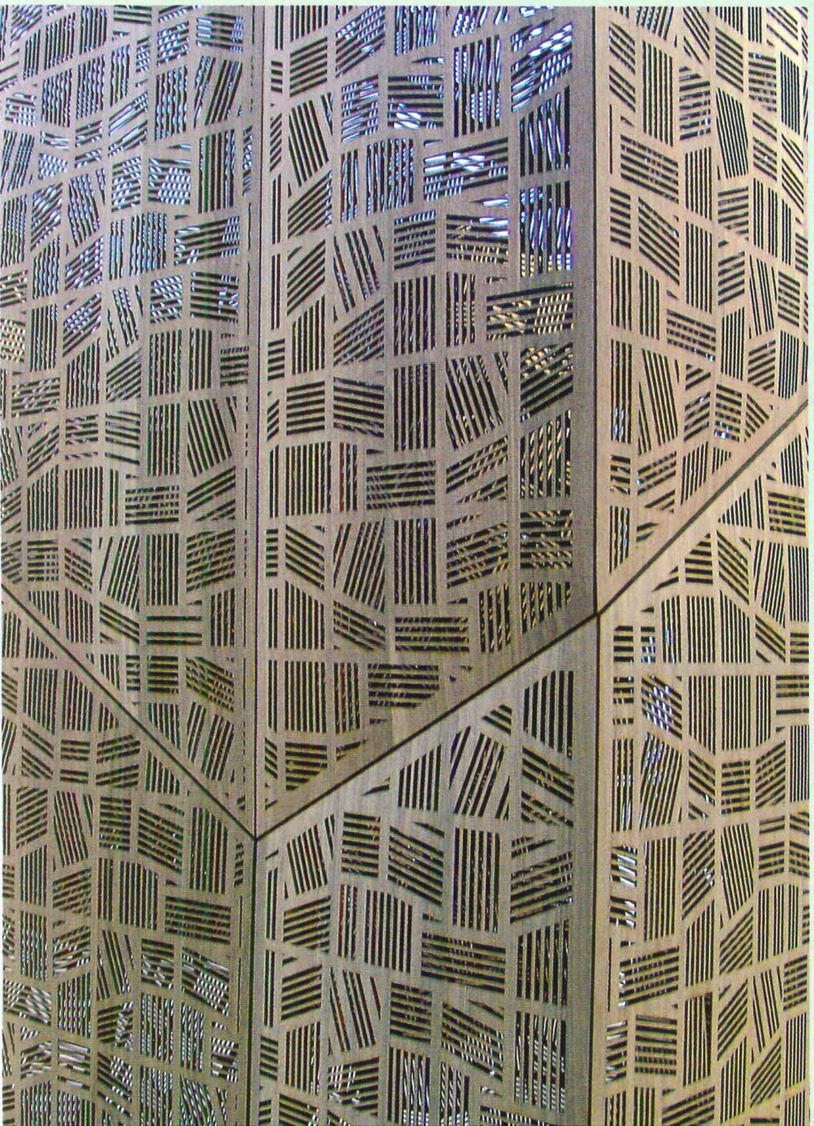


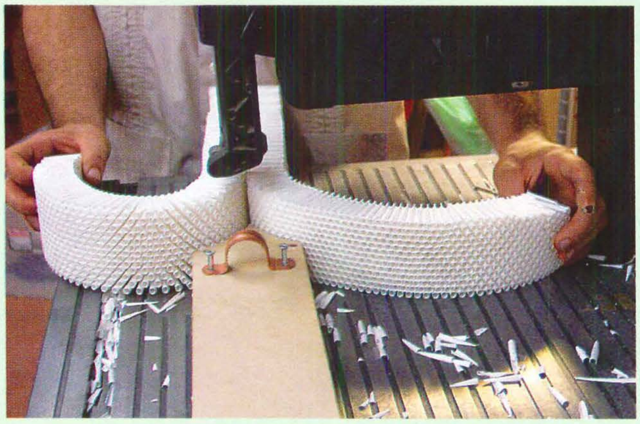




BL SPECIAL

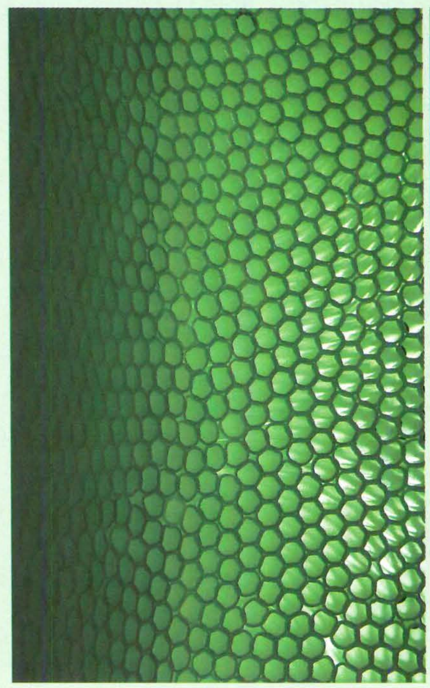
BL Special laminated panels were designed to be easily cut and modified by computer-driven processes. The lightweight panels are made of three core materials—ultrathin wood veneer, paper, and fabric—that are laminated together to allow them to remain rigid enough to produce partitions or enclosures.





FLEXICOMB

Flexicomb flexible polypropylene honeycomb panels have been developed by Los Angeles–based padLAb. Flexicomb can be bent, sprung, or compressed to form sculptural installations, lamps, desktop accessories, and furniture prototypes.



FLEXICOMB IMAGES COURTESY OF PADLAB; BL SPECIAL IMAGES COURTESY OF STEVEN HOLL

Rotterdam, van Duijn is OMA's materials guru; he was instrumental in developing the spongelike "Foam" product for use in OMA's Prada stores (RECORD, February 2002, page 84 [New York]; October 2003, page 92 [Tokyo]; February 2005, page 124 [Los Angeles]).

The development of new materials at OMA evolves naturally from its design process, in which representational models play a critical role. "Creating models for OMA projects is much more than just making a scale model of a building," says van Duijn. "The objective is for the model to reflect the concept of the project. It is therefore critical to think about the materials and techniques for building them. In most cases, more than 50 percent of the time spent on a model is experimenting—for instance, casting resin in combination with metal, testing new rubber types, developing casting techniques and molds in order to make the largest solid polyester casts, or thinking about lightweight and flexible systems that resulted in first designing our own 6.5' x 6.5' vacuum form machine."

This process of experimentation flows logically into the specification of materials for architecture. Once OMA has defined the desired qualities for various spaces within its buildings, it seeks to "materialize" the spaces. If the designers cannot find a suitable existing material, the team will not hesitate to develop something new, but it is critical that they know how the material needs to perform. In this way, new materials follow architectural concepts, instead of the other way around.

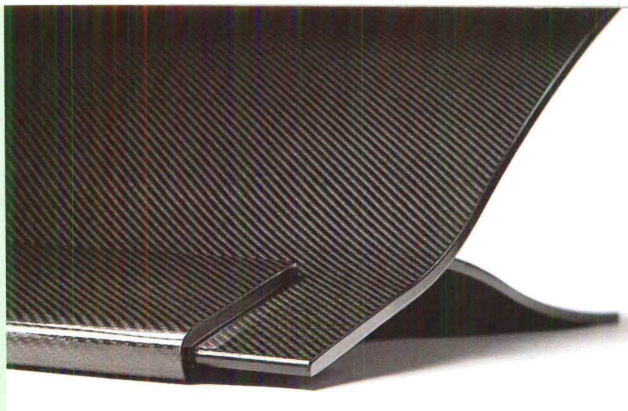
Chris van Duijn developed Foam while working on several Prada epicenter stores simultaneously. Because OMA sought a lexicon of interior organizing elements that could be applied to each store in a different way, van Duijn began experimenting with materials that could function as spatial dividers while preserving a certain degree of openness. "One of the concept models that we built was constructed with a kitchen sponge," says van Duijn. "The direct relation between the display system,

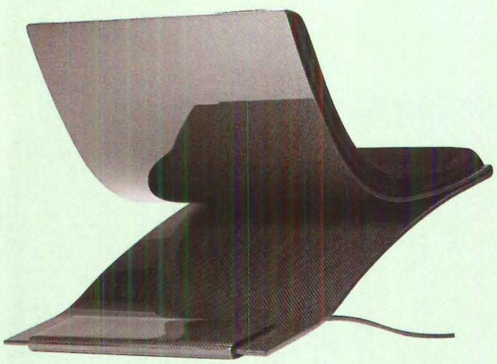
The development of new materials at OMA evolves naturally from its design process.

spatial concept, and material seemed immediately very interesting, and we decided to pick this up and develop it all the way."

In its final form, Foam is a polyurethane object cast of "an aggregate condition between solid and void." It is both a regular and an irregular structure of spongelike consistency that can be cast in stages from hard to soft, and from transparent to opaque. It forms a substance that can be used to build furniture and partitions as well as entire spaces (a further interpretation of solid and void).

In the end, van Duijn made hundreds of prototypes of Foam in order to test hole sizes, percentages of openness, translucencies, depths,





CARBON FIBER

Industrial designer/architect Giovanni Pagnotta's line of lightweight carbon fiber furnishings includes high and low tables, seating, and a rechargeable light. A rear-view and bottom detail of the collection's club chair is shown above.

LIVING SURFACES

Living Surfaces, developed by B.Lab from Gallarate, Italy, are tabletops (right) and floor tiles (below) comprised of layers of plastic sheets encapsulating nontoxic liquids. The liquids move and bubble in various ways depending on touch, depicting constantly changing patterns.

IMAGES COURTESY OF SENSITILE SYSTEMS

colors, etc. According to the architect, "Innovation, whether it is an architectural concept or a new material, is not just the ingenious idea of a genial person but much more a result of working hard and consistently on an idea. The most difficult phase in developing something innovative is not the creation of a concept, but developing and executing the concept without losing its original intention. Often this road will be blocked by all kinds of practical problems. Dealing with these problems often generates the invention."

Nick Gelpi, of Steven Holl Architects in New York City, endured a similarly challenging process developing BL Special, a laminated panel created for the assembly of complex interior fabrications. Designed to be easily cut and modified by computer-driven processes such as water jet, laser cutting, and computer numerical control (CNC) punching, BL Special is made of three core materials—ultrathin wood veneer, paper, and fabric—laminated together. The combination of these materials creates a lightweight structure that is also rigid. When bolted together, the self-supporting panels can be arranged to produce a complex partition or enclosure.

In addition to Holl and Gelpi, the BL Special team included Steven Holl project team member Alessandro Orsini, as well as Alberto Martinuzzo, who is the owner of Albeflex, a laminate producer in Treviso, Italy. The team's main objective was to devise a composite that would overcome limitations experienced with conventional composites, such as excess weight or expense.

From his experience developing BL Special, Gelpi says, "New technologies that indicate progress universally will always shape cultural practices. Architecture as a practice is necessarily a materially specific one, and materials as of yet are indistinguishable from technology, so as technology continues to advance, materials will index new possibilities cross-categorically."

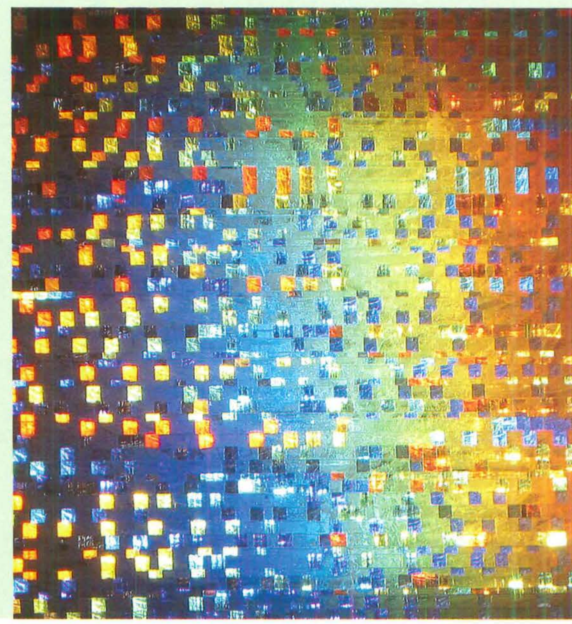
Materials first

When Los Angeles–based padLAb founders Dan Gottlieb and Penny Herscovitch were studying architecture at Yale, they had a desire to produce work at a 1:1 scale, and therefore bypassed the referential model as a design process tool. According to the architects, "We began to experiment with processes and explore specific material properties—tactility, recurring patterns, natural systems of organization—out of which we developed our own materials."

Their flexible polypropylene honeycomb panels, called Flexicomb, grew out of Gottlieb's research focus on structural honeycomb. "Commercial aerospace and transportation-grade honeycombs exceeded a student budget, so I decided to make my own out of a more economical raw material: drinking straws. I experimented with prototyping furniture

SENSITILE

SensiTile technology allows various materials to react to changes in light intensity and color. Using the same principle that makes fiber optics possible, the embedded light-conducting matrix in a SensiTile material either reconfigures the shadows that fall on it or redirects and scatters any oncoming light.



PHOTOGRAPHY: © ALLAN NEWMAN (LEFT TWO); COURTESY OF B.LAB ITALIA (RIGHT TWO)

out of straws that ranged from slim red coffee-stirrers to fat fluorescent super-straws." After the architects discovered the intriguing light-transmission qualities of the straw matrices, they began to design lamps with the material. Flexicomb can also be bent, sprung, or compressed to form sculptural installations, desktop accessories, and furniture prototypes.

Architect/industrial designer Giovanni Pagnotta's fascination with the high-performing alloys used in aircraft almost led him to join the Navy. His Prototype line of carbon fiber furniture demonstrates what can

Once you have defined the parameters of the materials, try to find partners in the industry who also share your belief.

happen when a material is taken to extreme limits of its strength-to-weight ratio. The Z5 chair, for example, is constructed entirely of carbon fiber, layered in plies to create an extremely thin profile. The Z5 weighs only 14 pounds, with a maximum thickness of half an inch, yet can carry 3,000 pounds with no indication of impending structural failure. Pagnotta has developed an entire line of furniture based on the same principles as the Z5 chair, including a high and low table, a lounge, and a light fixture. According to Pagnotta, when one tests limits with a high-performing material like carbon fiber, "the old rules become warped—design becomes gesture, calligraphic, reduced to its lowest common denominator."

Materials come alive

Founded by Gianfranco Barban and Gregg Brodarick, B.lab Italia in Gallarate, Italy, is driven by originality and, say the pair, "the desire to break the ordinary static aspect of our furnished environment." An Italian designer and American architect, respectively, Barban and Brodarick find that their different cultures, educational backgrounds, and work experiences create the right chemistry for generating new products.

Their Living Surfaces are the result of efforts to reproduce natural environments and sensations in design and architecture. The tabletops and floor tiles are comprised of layers of plastic sheets encapsulating nontoxic liquids, which move and bubble in various ways depending on touch, depicting constantly changing patterns. The bichromatic floor tiles generate colorful shapes in continuous transformation, and walking on them leaves a trail of footprints. They are made of two shock-resistant plastic layers, with the top layer treated with a non-slip surface. The team has also created a series of tabletops, panels, and floor tiles they call Living Glass that is created by sealing a sheet of tempered glass between layers of plastic, then shattering the glass to render an explosion of sparkling fragments.

Architects as entrepreneurs

Although architects often develop products for project-specific installations, many products are readily available to the consumer, and ship with reasonable lead times. As these examples show, creativity is just as necessary for funding as it is for product development. *B.E.B.*

BL SPECIAL (BELOW)
Funding: Steven Holl's office was invited to participate in a recent exhibition, and BL Special was funded by the exhibition's construction budget.
Ownership: Albeflex
Availability: BL Special is not currently for sale or license, although Albeflex is a fully functioning producer of laminate materials. www.albeflex.it
Cost: Prices range from $7–$12.50 for a 12.6"-square panel to $44–$77 for a 75.6" x 12.6" panel.
Lead time: 4 weeks for raw material plus 1 extra week for painting

FLEXICOMB
Funding: Initial development took place during architecture school. Subsequent product development was self-funded through padLAb's other projects.
Ownership: padLAb
Availability: Sculptural lights made from Flexicomb are for sale, and padLAb is pursuing licensing opportunities. (These sculptural lights are not yet UL-rated, and are only for use with low-heat compact fluorescent bulbs.) www.padlab.com
Cost: $395–$450 for a limited-edition sculptural Flexicomb light (plus S&H, and sales tax as applicable)
Lead time: 6 weeks

FOAM
Funding: OMA reserved a budget for material research & development.
Ownership: OMA and Prada
Availability: Foam was developed exclusively for Prada, and is not currently for sale. www.oma.nl
Cost: N/A
Lead time: N/A

LIVING SURFACES (RIGHT)
Funding: B.lab Italia used personal savings and profits from Brodarick's architectural studio and Barban's family custom carpentry business to develop the product. Further development has been funded by product sales.
Ownership: Barban and Brodarick, with Barban Arredamenti. B.lab Italia welcomes licensing of its technology for alternative applications.
Availability: Living Surfaces are for sale on B.lab Italia's website, www.blabitalia.com
Cost: Floor tiles are $65–$85 per square foot, tabletops are $400–$800 per unit. Living Glass panels are $100–$180 per square foot.
Lead time: 3 to 4 weeks, plus an additional 4 to 5 weeks for additional freight. B.lab Italia is opening a U.S. office in early 2006 to reduce delivery times.

SENSITILES
Funding: SensiTile products were funded by family and friends.
Ownership: Abhinand Lath. Licensure is a possibility.
Availability: SensiTiles are for sale on Lath's website, www.sensitile.com.
Cost: SensiTile Scintilla tiles are $140–$190 per square foot; SensiTile Terrazzo tiles are $60–$90 per square foot.
Lead time: 6 to 8 weeks. Certain sizes and color combinations are in stock now for immediate delivery.

Z5
Funding: The Z5 chair was self-funded.
Ownership: Giovanni Pagnotta
Availability: Pagnotta's furniture is for sale on his website, www.giovannipagnotta.com.
Cost: The Z5 currently sells for $3,800. Pagnotta is negotiating with a top distributor, which would result in a cost of $1,200.
Lead time: 8 weeks

Abhinand Lath, based in Detroit, developed the SensiTile surfacing system with a similar interest in bringing dynamic qualities to static environments. Trained as an electrical engineer as well as an architect, Lath reinforces the need for both an intuitive "hands-on" understanding of materials as well as a technical foundation in material processes. Comprised of a matrix of light-conducting acrylic polymers, SensiTiles move light between various points on the material's surface according to a principle Lath calls "total internal reflection," a process that also describes how fiber-optic cables transport light. When one places an object between SensiTiles and a light source, the tiles passively migrate light underneath the object's shadow, creating surprising dynamic effects. The tiles will even reflect an object's color from unexpected places within their surfaces, based on hidden relationships within the matrix.

Lath describes innovation as a transformational principle in his work: "It either combines the known into a new order, or it allows us to see something entirely fresh in what we already know—in both cases bringing into being that which did not previously exist."

Material possibilities

For the architects and designers described here, developing new products is a compelling part of the design process. Whether materials are shaped by architecture or vice versa, one may glean universal themes from the various methods employed to generate new materials. As we participate in a second machine age—a "neo-Modernism" defined by rapidly advancing technologies and creative material solutions—we are likely to see an increasing role for materials research and development within standard architectural practice. Chris van Duijn offers this advice for architects interested in developing their own products: "Create materials with substance, something that contributes to the overall quality of a project. Once you have defined the parameters of the material, try to find partners in the industry who also share your belief, and do not accept 'impossible' for an answer." ■

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1. What is your job function? (check one)
   - ❑ (1) Architect
   - ❑ (2) Engineer
   - ❑ (3) Designer
   - ❑ (4) Specification Writer
   - ❑ (5) Interior Designer
   - ❑ (6) Contractor or Builder
   - ❑ (7) Lighting Designer
   - ❑ (8) Other________________
2. In what type of organization do you work?
   - ❑ (9) Architectural or A/E Firm
   - ❑ (10) Commercial, Industrial or Institutional
   - ❑ (11) Contractor or Builder
   - ❑ (12) Government Agency
   - ❑ (13) Interior Design
   - ❑ (14) Lighting Design
   - ❑ (15) Other________________
3. Building Types you are currently working on?
   - ❑ (16) Commercial
   - ❑ (17) Educational
   - ❑ (18) Healthcare
   - ❑ (19) Industrial
   - ❑ (20) Multi-Family Residential
   - ❑ (21) Single-Family Residential
   - ❑ (22) Other ________________
4. Reason for Inquiry?
   - ❑ (23) Current Planning
   - ❑ (24) Future Planning
   - ❑ (25) Both
5. Are you currently a subscriber?
   - ❑ (26) Yes ❑ (27) No

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