By Tudor Van Hampton

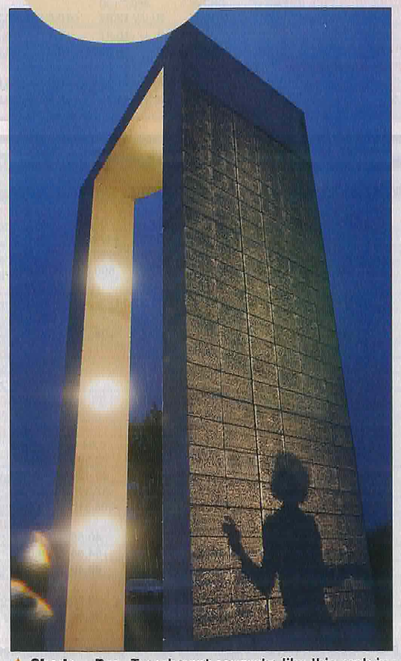
Research and Design Is Changing the

Shape of the Material World

An explosion of new materials, confusing and intriguing, lands on the designer's palette

Concrete—that gray, monolithic building material—is getting a face-lift. Inventors are reshaping it to do more, last longer and show off. A new kind of "translucent" concrete uses fiber optics to carry light and shadow. New light-sensitive terrazzo flooring can reflect a rainbow of colors. And high-strength concrete placed inside buildings and bridges can flex like hard rubber to dampen earthquake shocks. The possibilities seem endless.

Innovation is infusing other traditional building blocks, such as steel, glass and wood, with renewal, while nanotechnology and "green" building has brought a host of hybrid materials. A heightened interest in building smart, clean and fast is driving this rapid research across the material world.



▲ **Shadow Box.** Translucent concrete, like this arch in Hungary, sheds new light on traditional limitations.

Blaine Brownell, an architect and researcher at Seattle-based NBBJ, says he sees a "fascination with dynamically transforming, responsive materials, due to designer-led desires to enliven spaces and make them more intelligent."

Finding thousands of examples is easy, thanks to new resources. Bringing these products to market is another story, inventors say.

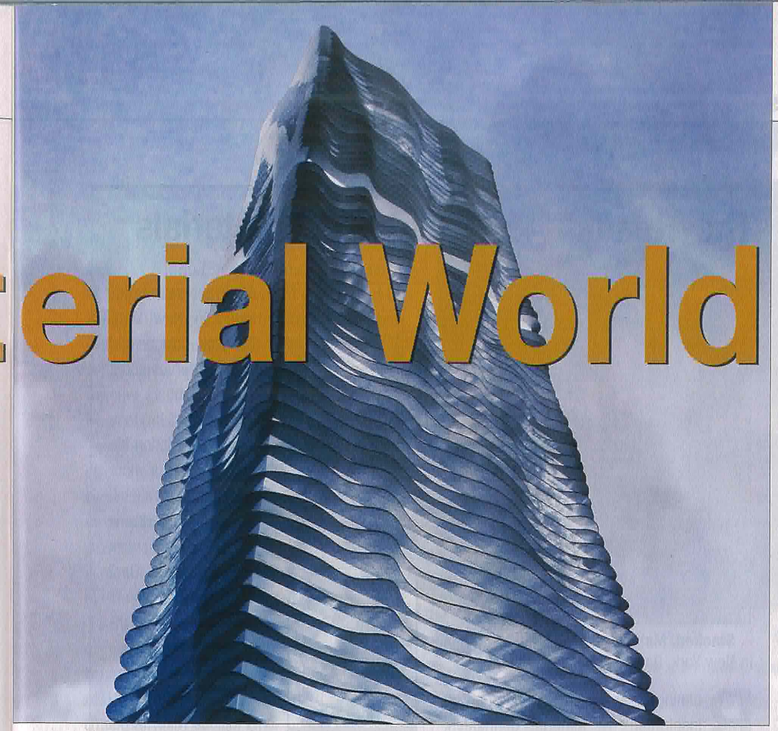
The ongoing quest for innovation has put some wild, new products on the designer's palette. Reflect for a moment on glass: It protects people from the elements, provides modest insulation and offers a nice view. But now it can do so much more. One type can clean itself using a catalytic film that uses sunlight and rain to break down and wash away dirt particles and smudges. U.K.-based Pilkington Group Ltd. is one vendor offering this product worldwide. Other suppliers are starting to experiment with similar substrates that help concrete buildings, bridges and highway barriers take pollutants out of the air. Even paint can clean itself. "We live in a time in which all material frontiers are being explored," Brownell says.

Steven Kosmatka, vice president of research for Skokie, Ill.-based Portland Cement Association, agrees, adding that designers wishing to use radically new concretes, "are sort of waiting for the critical mass." New materials are a tough sell. Some offer a long-term cost benefit at a short-term price premium; others simply have architectural appeal controlled by the whimsy of consumers. "The thing that baffles me are concrete countertops," Kosmatka says. "It's not something that [we] promoted. People just took a liking to it."

Fast computers, aeronautic inventions and environmental sensibilities have contributed to these recent material developments. The playing field is broad. If these innovative products have one thing in common, it is their ability to transcend expectations, often confusing the mind and engaging the eye.

One of the most striking examples is a new type of translucent concrete called "Litracon," developed by Áron Losonczi, a Hungarian architect. Inside Litracon's

PHOTO BY AP/WIDEWORLD



▲ **Ripples.** Chicago's "Aqua" is an example of how design is reshaping traditional materials.

precast blocks and panels are glass fibers, arranged in parallel like millions of tiny windows. They transmit light from one side of the concrete to the other. Tight manufacturing tolerances make production of this material a challenge, not to mention complicating on-site casting.

The end result, however, is illuminating. On his website, the inventor says he has inked agreements with "leading manufacturers" and hopes to offer it soon worldwide. Designers are fascinated because "by adding the glass fibers you're completely changing the whole way architects think about concrete," says Andrew Dent, vice president of Material ConneXion, a New York City-based library of 3,000 innovative materials. Its clients include architects, builders and large retailers. Memberships start at $200. It also offers private consulting that costs tens of thousands of dollars (see story, p. 24).

Kinetic and Mimetic

Innovative materials are finding new ways to interact within the natural world and reflect its beauty, both architecturally and structurally. A promising new technology is ultra-high-performance concrete, such as Lafarge's "Ductal" product. Introduced several years ago, it casts like concrete and feels like concrete. Once cured, it behaves more like a metal, using carbon fibers, polyvinyl-alcohol fibers and other embedded materials that bring compressive capacities up to 30,000 psi and flexural strengths to 6,000 psi (ENR 12/9/99 p. 24). Available in custom precast shapes, it costs somewhere "between" traditional concrete and steel, says the French producer. It is the featured material on a highway bridge completed this past spring in Wapello County, Iowa.

"Bendable" concrete is another material emerging in the fast-growing UHPC segment. It is similar to Ductal, resisting cracking 500 times more than traditional concrete, weighing 40% less and reducing the need for reinforcements and joints, especially in seismic zones. Under

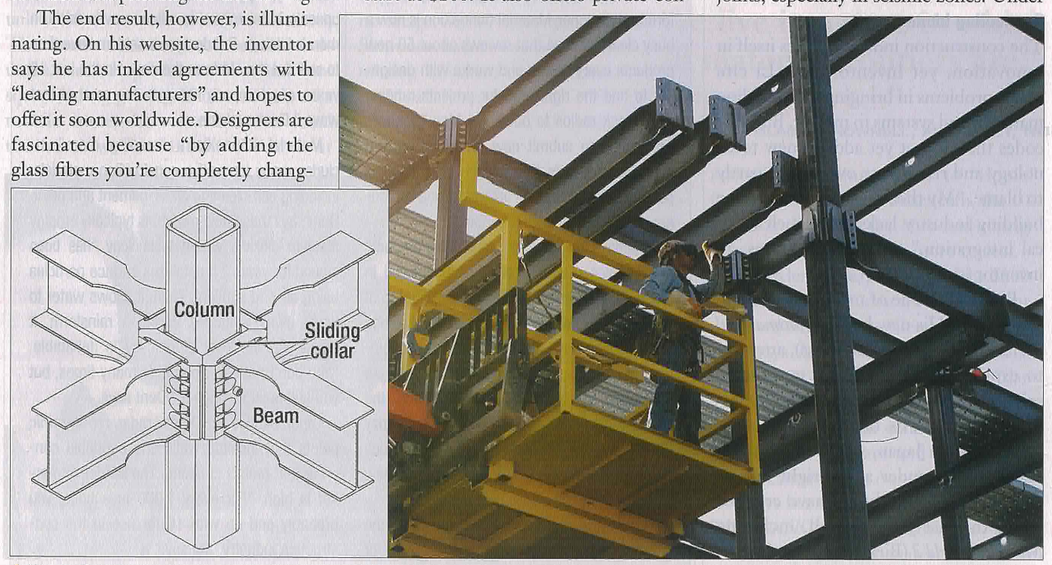


PHOTO TOP COURTESY OF STUDIO/GANG/ARCHITECTS; PHOTOS BOTTOM COURTESY OF CONXTECH INC.

▲ **Dovetailed.** New moment-resisting space frame (left) slides together quickly (right). Bolts are then added as trades rise through the building.

development at the University of Michigan, the combination of high strength and elasticity comes from synthetic fibers placed in the mix using traditional construction equipment and techniques.

Victor Li, a Michigan professor who invented the product, says it could soon bring roads and bridges that have no joints. "So far it works very well," he says, adding that it costs about three times more than typical concrete but can lower the cost of seismic engineering.

Not everyone is sold on the idea of super-performing concrete. Li says he is in talks with several companies to mass-produce it and is working with industry groups to develop design and testing criteria. So far, the material has appeared on a bridge in Michigan and two high-rise buildings in Tokyo, but little elsewhere.

Engineers also are experimenting with fiber-reinforced-polymer composites, such as glass-epoxy wraps, that can be applied to existing buildings and infrastructure to extend their life. "The greatest aspect of this material is the high strength-to-weight ratio," says Nicolas Saenz, a structural engineer in the Las Vegas office of Walter P. Moore.

Connecting Ideas

The construction industry prides itself in innovation, yet inventors like Li cite major problems in bringing new building materials and systems to market. Building codes that do not yet address new technology and risk-averse owners are partly to blame. "My theory on this [is that] the building industry lacks very much vertical integration," says Bob Simmons, an inventor in Hayward, Calif.

Brownell is one of many who are trying to help. His new book, *Transmaterial* (Princeton Architectural Press), attempts to explain the recent boom in material science and show off more than 200 far-out examples. His ongoing search has landed him in Japan, where he is studying materials under a Fulbright fellowship. Several other books have cropped up in the last year, as well, including *Material World 2* (Birkhauser), and *Material Architecture* (Elsevier).

The 'Reading Room' for New Materials

▲ **Stacked.** Material ConneXion has libraries in New York, Bangkok, Cologne and Milan.

DENT

Running late on a project and short on inspiration? At Material ConneXion, designers can jump onto the Internet or visit one of four international libraries showcasing 3,000 of the most intriguing substances on Earth. "People have been more interested in innovation," says Andrew Dent, who is the firm's vice president in charge of the "physical" library of materials.

Founded in 1997 by George M. Beylerian, a furniture designer, Material ConneXion is now a busy clearinghouse that reviews about 50 new products every month and works with designers to find the right stuff for projects ranging from clock radios to buildings. Manufacturers are invited to submit new products, but not every sample gets through the door. Each is scrutinized by a panel of architects and designers who judge its level of innovation.

Dent says the panelists "know a fair amount" about which materials should be featured in the company library. As chief coordinator of this effort, he has a Ph.D. in materials science from the University of Cambridge. Prior to joining the company in 2001, he provided private consulting to designers at Rolls Royce, the Defense Advanced Projects Research Agency (DARPA) and the National Aeronautics and Space Administration (NASA). "We know what's new and interesting," he says confidently.

The library, which can be accessed on the Internet at *www.materialconnexion.com* for $200 per year, is located in New York, Bangkok, Cologne and Milan. It serves about 2,000 members who pay at least $450 for a basic subscription fee and $15,000 or more for large corporations. Its staff also performs private consulting work for an extra fee. Dent won't disclose who in the construction industry uses the service but notes that some of the library's largest clients include Nike, Target and Aveda. "We haven't worked with a lot of construction companies," he says. "Mostly, it comes through the architect."

New research and development over the last 10 years has produced many dazzling products that have found their way into everyday life, from polypropylene-foam acoustical panels in upscale hotel rooms to silicone oven mitts in mom's kitchen. But designers seldom have time to sort out the old from the new. "In the last 10 years, our company has rode the crest of that wave," Dent explains.

Material ConneXion's "reading room" includes many innovative construction materials, including self-cleaning glass, cement and paint. Dent says these new materials typically employ titanium dioxide, whose technology "has been around for years." It catalyzes surface particles using air and sunlight. Then, it allows water to wash away smudges during a rainstorm. It works, but its level of efficacy is debatable. "You don't have to clean it so many times, but you still have to clean it," Dent says.

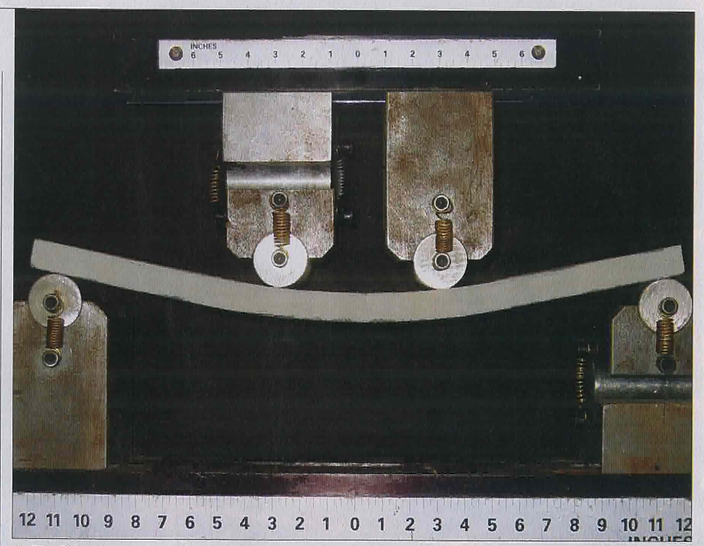
Other exotics on Dent's radar are ceramic paints that insulate walls and bendable concrete that resists cracking. The barrier to market is high. "For every 1,000 inventions, you probably end up with 10 for use in the construction industry," he says. ■

PHOTO TOP CENTER COURTESY OF MATERIAL CONNEXION

The conservation movement also has helped bring along some "green" materials, such as a new product called "Kirei Board." Made from sorghum and starting at $7 per sq ft, it behaves like plywood but is friendlier to the environment, the manufacturer claims.

Nearly 90% of the products catalogued in Brownell's 237-page book are being used in the field but few have "widespread deployment," he says. The construction process brings its own practical challenges. "Just because something is innovative…doesn't mean it is easy to produce on a work site," says Dent, who is the co-author of *Material ConneXion* (Wiley), another new book on materials.

Simmons is doing for steel what others are doing for concrete. The design-build contractor invented a moment-resisting space frame, called "ConXtech," that arrives on site and within minutes snaps together like a model airplane. But the building system is no toy, having solid roots in a seismic region and capable of rising to heights of up to 100 ft in about half the time of traditional frames. His patented "boltless" connectors, which robotic welding machines affix to the ends of 12-in.-deep beams, mate with dovetails welded on faces of hollow columns. The beams lock into the tubular columns, measuring between 4 in. and 8 in. square, using gravity. With the help of a mobile crane, the contractor can stand the frame without bolts. "We erect it from the top down," explains Simmons, "then we deck from the bottom up." Crews install bolts at each floor before pouring concrete slabs.



▲ **Flexible.** Concrete that bends is a material under development at the University of Michigan.

In the past two years, Simmons has designed, fabricated and built 12 buildings using this system and expects revenue this year to exceed $40 million. Getting his idea off the ground was no snap. On an early project, Simmons had to prove to permitting officials that the frame could satisfy seismic codes. "We just had to do a lot of arithmetic," he says.

> **"We live in a time in which all material frontiers are being explored."**
>
> — BLAINE BROWNELL, ARCHITECT, NBBJ

PHOTO TOP COURTESY OF UNIVERSITY OF MICHIGAN; BOTTOM COURTESY OF WALTER P. MOORE

▲ **Resin Bath.** Epoxy-coated materials help shore up old structures.

Owners have also had their hang-ups, the inventor adds. "As entrepreneurial and risk-taking as the development community wants to see itself, there is inherent conservatism in not wanting to take on new, unknown risk," he says. Eventually, a "trusting customer base" helped ConXtech materialize.

Amid the innovation, traditional materials still have their place, and can look just as cool. In Chicago, an 82-story rectangular, mixed-use tower called "Aqua," which begins construction this month, will have concrete balconies that cantilever as far out as 12 ft. Each slab has a unique shape in plan, with random undulation that will make the building appear to "ripple" from bottom to top. Underneath, the 10-in.-thick slabs and the core-and-outrigger structure couldn't be more typical.

Ron Klemencic, president of the $300-million tower's structural engineer, Seattle-based Magnusson Klemencic Associates, says Aqua's innovation is not so much about materials. Rather, the "daring" cantilevers are now possible using advanced design and construction tools, such as 3-D software and flying formwork. Jeanne Gang, Aqua's design architect, says her Chicago-based firm, STUDIO/GANG, can make advances "using some fairly standard materials that are now simply able to do more." ■