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.

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 exemplars 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 materials 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 concrete, "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 whims of consumers. "The thing that baffles me are concrete counterparts," Kosmatka says. "It's not something that we promoted. People just took a liking to it."

Fast computers, aeronautical 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 "Lighten," developed by Áron Losonczi, a Hungarian architect. Inside Lighten's 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 ConnectXon, a New York City-based library of 3,000 innovative materials. Its clients include architects, builders and large retailers. Memberships start at $290. 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 earns 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 129/999 p. 24). Available in custom precise 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 UHPF segments. 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
The ‘Reading Room’ for New Materials

The conservation movement also has helped bring along some “green” materials, such as a new product called “Kered 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 cataloged in Brownell’s 237-page book are being used in the field but few have “widespread deployment,” he says. The construction process brings into 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 Connection (Wiley), another new book on materials. Simonds is doing for steel what others are doing for concrete. The designer-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 room 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 “bolbos” connectors, which are robotically welded machine-affix to the ends of 12-in.-deep beams, mate with dovetails welded on faces of hollow columns. The beams lock into the tabular column intersections, starting between 4 in. and 6 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 Simonds, “when we dock from the bottom up.” Crows install bolts at each floor before pouring concrete slabs.

In the past two years, Simonds has designed, fabricated and built 12 buildings using this system and expects revenue this year to exceed $400 million. Getting his idea off the ground was no snap. On an early project, Simonds had to prove to permitting officials that the structure could satisfy seismic codes. “We just had to do a lot of arithmetical,” he says.

Owners have also had their hang-ups, the inventor adds. “As entrepreneurs and risk-taking as the developer 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 far Out 12 ft. Each slab has a unique shape in plan, with random undulation that will

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