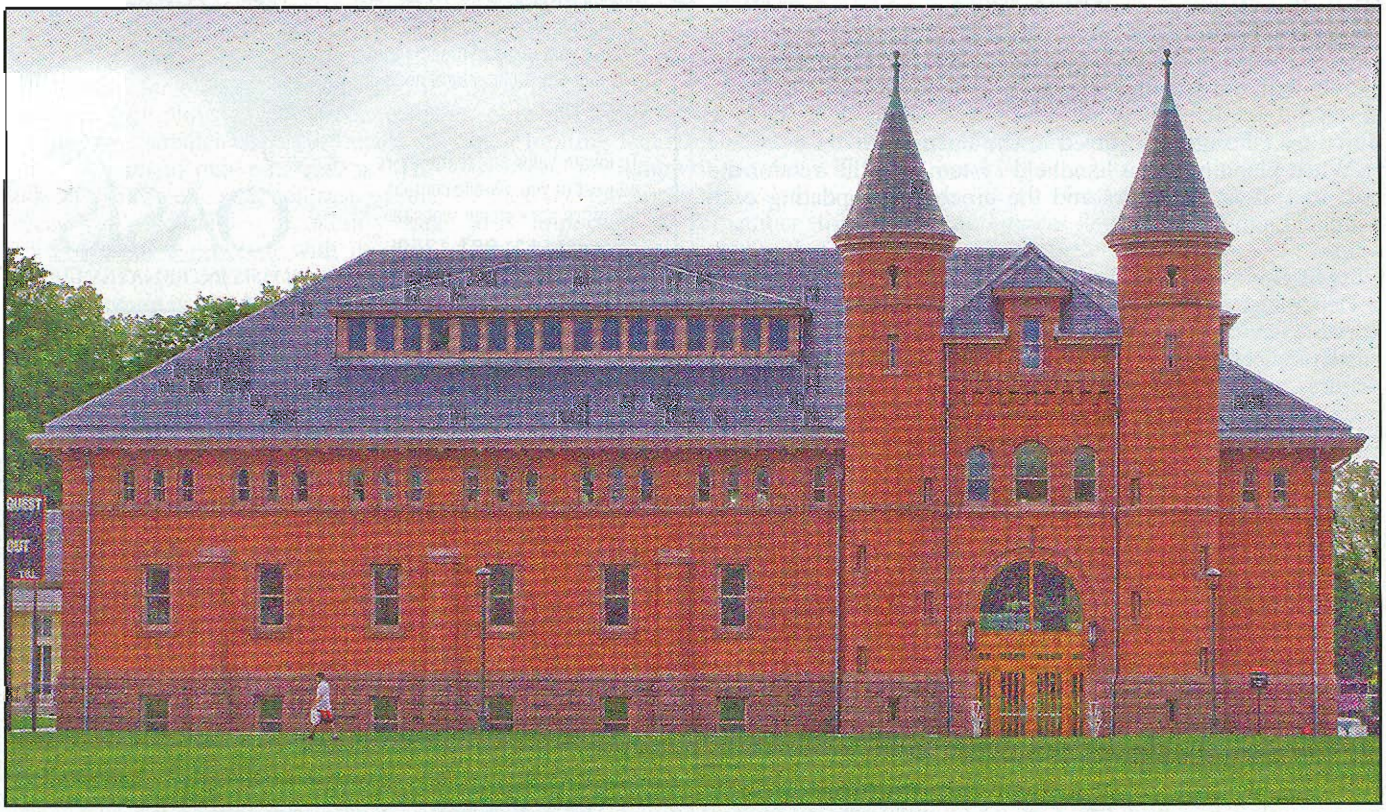
Reducing the Carbon Footprint

For reasons both aesthetic and pragmatic, masonry has long been a popular material choice for school and hospital construction. It is adaptable to either traditional or contemporary design, comes in a range of attractive colors, and its discrete units communicate a comfortable, human scale. Masonry is also strong enough to resist hard use, offers good sound-control properties, and can serve as both structure and finish.



Masonry has a strong history in school and hospital construction thanks to both its wide range of design options and durability. Photo courtesy of: Steven H. Miller

In the twenty-first century though, these desirable characteristics alone are not enough to recommend the use of a building product. We now have to consider a product's environmental impact, both short- and long-term, in order to make responsible choices. Furthermore, the decision to build green has become not only a matter of sound policy or economic advantage but in many instances, a legal mandate. Federal, state and local governments across the United States have begun requiring LEED Certification for publicly owned or subsidized building projects, including many schools and health care facilities.

Masonry's Environmental Attributes

Traditional masonry has a number of environmentally-friendly characteristics, such as durability and thermal mass. However, as our collective understanding of environmental science—and especially of climate change—advances, we have had to revise our definition of green building. The manufacturing of building materials (cement, brick, gypsum wallboard, steel, etc.) accounts for about 12% of all emissions of carbon dioxide (CO2)—a greenhouse gas with an immediate and direct impact on climate change. The EPA has plans to require audits of energy-intensive building material manufacturing, which will affect the building industry's views on what materials are most environmentally-friendly.

One increasingly useful way to measure a product's environmental impact is to audit its 'embodied energy' and 'embodied CO2' – the amount of energy consumed and CO2 released to extract, transport, and process raw materials and manufacture the finished product. One focus of materials research and development is finding ways to reduce those levels without sacrificing other product benefits.

Clay brick is fairly high in both measures. However, a new masonry material, fly-ash brick (FAB), has been developed to provide the traditional benefits of brick masonry while significantly reducing the energy consumed and CO2 emitted in brick production. FAB prototypes have achieved embodied energy and CO2 emission levels that are 85% less than those of clay brick.

Clay brick manufacturing is energy-intensive because clay requires firing for up to three days to become hard and durable. Brick kilns operate at about 2000°F and are generally kept hot even when not in use. The heat for most kilns is generated by burning natural gas, while some brick producers use fuels such as coal and petroleum coke that are not as clean-burning as gas. All of these fuel sources emit significant CO2 during combustion.

The National Institute for Standards and Technology (NIST) Building for Environmental and Economic Sustainability (BEES) database lists the average embodied energy for a common fired clay brick at about 8800 Btus. A state-of-the-art fired clay brick plant operating at optimal efficiency might reduce this figure to slightly below 5000 Btus. CO2 emission is often a by-product of energy consumption; each clay brick fired with fossil fuel releases about 1.3 lbs of carbon dioxide into the atmosphere.

How Fly Ash Brick is Different

Producing fly ash brick consumes less energy and emits less CO2 because it does not require firing to harden the masonry units. FAB also contains a high percentage of recycled material content – up to 40%. Its principal ingredient is fly ash, a pre-consumer by-product of coal-fired power generation.

As environmental consciousness has grown, the use of fly ash in construction has expanded rapidly; it is used for example, in concrete, for soil stabilization and as filler in paints and plastics. Fly ash is defined in ASTM C 618, *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*, as "the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gases." It is a powdery substance composed of glassy-smooth particles. Two classes of fly ash are defined by chemical composition. Class F generally contains less than 10% calcium oxide (lime) and is used as a pozzolanic additive to replace some portland cement in concrete. Class C can contain over 25% lime, giving it both cementitious and pozzolanic properties.

Prototype fly ash brick and pavers contain 40% recycled Class C fly ash, which is composed mainly of silicon dioxide, aluminum oxide, and calcium oxide—the same elements found in clay, though in different proportions. Other component materials include sand and iron oxide pigments produced from recycled steel. While the base elemental composition is more like clay, the addition of water and proprietary additives generates a chemical reaction between these compounds similar to cement hydration. The brick is compacted in molds and gains strength through this chemical reaction, without the need for firing. This is why FAB technology is truly a new, hybrid masonry category, distinct from both clay and concrete masonry but exhibiting elements of both.

FAB has been shown in tests to meet or exceed the performance standards in ASTM C 216 *Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)*, including the stringent dimensional tolerances for Type FBX architectural facing brick. FAB is also well below the allowable shrinkage limits for concrete brick in ASTM C 55, *Standard Specification for Concrete Building Brick.* This property allows architects to use conventional clay brick details when specifying FAB instead of the more complex and expensive details required for cement-based brick. In field trials, professional masons using conventional masonry techniques have found FAB to have good mortar adhesion, making the product easy to build with. FAB will be available in modular and utility sizes, a soft, smooth texture and features earth-tone colors using stable, colorfast mineral oxide pigments.

Environmental Benefits Now and Long-Term

The United States produces about 72 million tons of fly ash each year and more than half of it is now dumped in ponds and landfills. FAB production diverts fly ash from landfills or retention ponds and binds it into a safe product, thus transforming fly ash from an environmental burden into a useful material. With over 50% of electricity in the United States generated through burning coal, it may take many decades before energy sources with smaller carbon dioxide footprints can displace coal-fired generation. Until then, coal will be burned to generate electricity whether or not the fly ash serves any worthwhile purpose. The beneficial reuse of this industrial byproduct clearly contributes to sustainability now.

Clay brick manufacturers have suggested that the high embodied energy of their product should be viewed with clay brick's durability in mind, and "amortized" over the many decades of a building's expected service life. Durability is important of course, but embodied energy relates to CO2 emissions that are accelerating climate damage today. A hundred-year amortization of climate change is not an acceptable option.

Architects designing hospitals think about building envelopes that promote quality of life and patient well-being. The safety and protection values that supported the "pavilion plan" in hospital design, a style embraced by Henry Curry, are the same values that support a low carbon cladding specification.

Because they always represent substantial investment, schools and hospitals must be built to last. The choices we make during their design and construction will affect people's health and well-being for generations to come, so it is important to consider their environmental impact from both near- and long-term perspectives. Fly ash brick offers us access to brick masonry's many benefits without the energy and climate costs. +

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