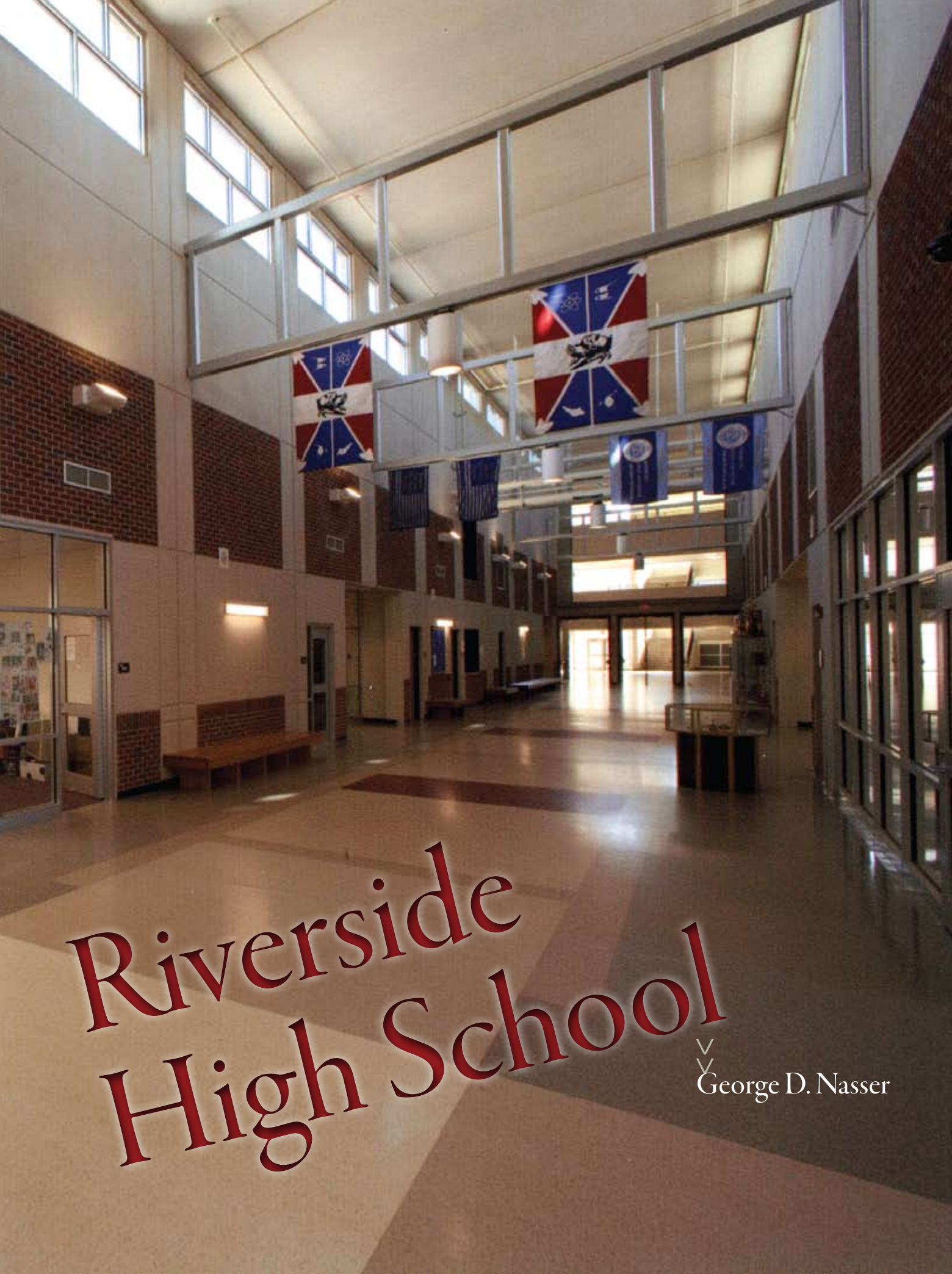

One of the first
schools in the
United States to
be LEED certified



Riverside High School

George D. Nasser

Previous page Pictured is Riverside High School's spacious interior. Photo courtesy of BRPH Cos. Inc. of Marietta, Ga. Graphic design by Paul Grigonis.

Above This drawing shows the architect's rendition of Riverside High School in Greer, S.C. Courtesy of BRPH Cos. Inc.

Greenville County Schools has for the past several years embarked on a billion-dollar rebuilding program of the schools and educational facilities in Greenville County, S.C.

A key element in this construction program is that the new buildings embrace energy efficiency and environmental conservation. The goal was that some of these schools would become Leadership in Energy and Environmental Design (LEED) certified.

Early in the design process, it was determined that sustainability goals would best be achieved using a precast/prestressed concrete system. Therefore, when the need in 2004 came to replace the Riverside High School in Greer, S.C., a sustainable design approach was the guiding principle for building the new structure.

Architect BRPH Cos. Inc., a firm with a solid reputation in urban and contemporary architectural design, was commissioned to plan and design the school. The engineer of record, Professional Engineering Associates Inc., assisted the architect. The engineer's main responsibility was the gravity and lateral load analysis and design of the building structure according to the 2000 *International Building Code* (IBC). The structure was designed to withstand wind speeds of 90 mph (145 km/hr).

The building contract was awarded to M. B. Kahn Construction in April 2005. Tindall Corp. played an important role in the project as the precaster, supplying and erecting the precast/prestressed concrete components. Tindall also provided several cost-saving ideas during the course of the project.

The final structure is a 268,000 ft^2 (24,920 m^2), three-story facility built with essentially a precast/prestressed concrete frame. The upper two elevated floor levels and roof level are 227,400 ft^2 (21,150 m^2).

A major structural feature of the building is that both the exterior and interior corridor walls are loadbearing, supporting the tee beams and double tees. The walls also act as shear

Team members

Owner:
Greenville County Schools of Greenville, S.C.

Architect:
BRPH Cos. Inc. of Marietta, Ga.

Engineer of record:
Professional Engineering Associates Inc. of Greenville

Contractor:
M. B. Kahn Construction of Greenville

Precaster:
Tindall Corp. of Spartanburg, S.C.

walls for lateral stability. For thermal efficiency, the exterior walls are insulated sandwich panels.

In turn, the double tees, with spans up to 60 ft (18.3 m), create large, column-free spaces. The floor double tees were field topped with 2½ in. (63 mm) of concrete, while the roof double tees were untopped.

The outside faces of the wall panels received an attractive architectural finish. A buff white concrete face mixture with medium sandblast and thin-brick veneer were used for the exterior panels.

Precast concrete components were also used to form the elevator shafts, stairs, and landings. Although the exterior and corridor walls provided the majority of the loadbearing support, in a few places of the building, reinforced precast concrete columns were used for support.

Altogether, 1611 precast/prestressed concrete components were used in this building. The table on the next page lists specific details of the individual components.

To ensure the highest possible quality control in the precast concrete products, the following PCI documents were strictly adhered to:

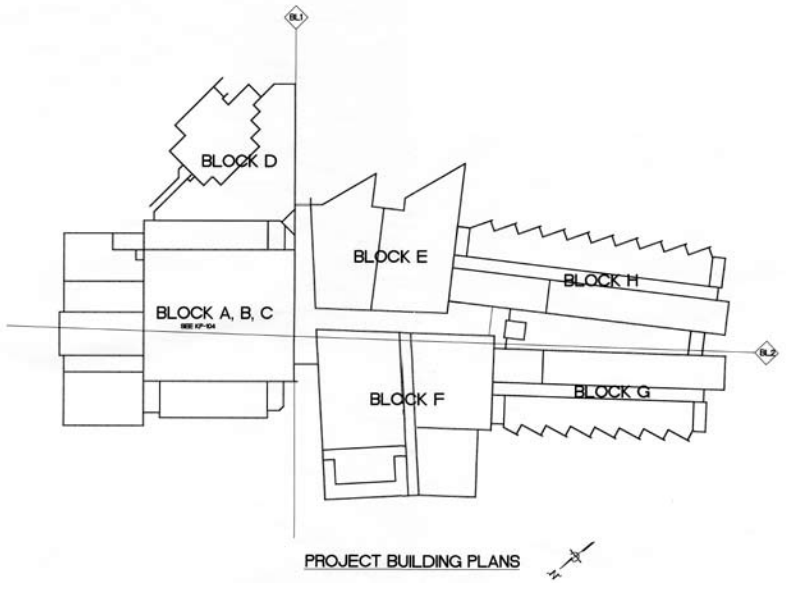
- *Quality Control for Plants and Production of Structural Precast and Prestressed Concrete Products*,[1]
- *Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products*,[2]
- *Architectural Precast Concrete Color and Texture Selection Guide*.[3]

This aerial photo shows the finished Riverside High School in Greer, S.C. Courtesy of BRPH Cos. Inc. of Marietta, Ga.

Project timeline

In early 2004, the Greenville County Schools decided that a new facility for the Riverside High School was urgently needed. By April 2005, the design team had prepared the bid package for early award of the precast concrete components. Within a month, the precast concrete package was released and the engineering design work began along with development of the construction documents for general contract bid.

In June 2005, Tindall Corp. began production of the precast concrete components at its plant in Spartanburg, S.C. The precast concrete products were transported to the project site by tractor trailer, a distance of about 30 miles (50 km). Tindall began erecting the



This picture shows the building plan for Riverside High School in Greer, S.C. Courtesy of BRPH Cos. Inc. of Marietta, Ga.

Number and dimensions of precast/prestressed concrete components used in Riverside High School

Number	Components	Dimensions
273	Wall panels	8 in. thick × 12 ft wide
506	Insulated wall panels	10.5 in. thick × 12 ft wide
12	Insulated wall panels	12.5 in. thick × 12 ft wide
155	Floor slabs	6 in. thick × various widths
53	Floor slabs	10 in. thick × various widths
400	Double tees	20-in.-deep double tees
26	Double tees	24-in.-deep double tees
111	Double tees	32-in.-deep double tees
13	Tee beams	24 in. wide × 36 in. deep
11	Rectangular beams	24 in. wide × 48 in. deep
25	Square columns	24 in. × 24 in.
26	Stair units	
Total: 1611		

Note: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

precast concrete components in October 2005, and the precast concrete work was completed in May of the following year, less than eight months later.

The school building was completed in fall 2006 in time for the beginning of the school year.

The total cost of the school project was $36 million.

From top This outside view of Riverside High School in Greer, S.C., shows the building's fenestration. Courtesy of BRPH Cos. Inc. of Marietta, Ga.

This outside view of Riverside High School shows the brick veneer panels. Courtesy of BRPH Cos. Inc.

Precast concrete ideal for energy efficiency

This project required energy efficiency and sustainable construction practices for LEED certification, speed of construction, and durability while being cost effective. All of these requirements were achieved efficiently with a precast/prestressed concrete system.

Energy efficiency The precast concrete wall panels were manufactured using a highly efficient insulation system. The inner and outer wythes of the sandwich panels are separated from each other with insulation, which results in no solid areas or cold spots.

LEED certification About 23 of the 26 required points for LEED certification were influenced by the precast/prestressed concrete components, which employ several innovative design elements, contributing to efficient recycling methods during construction and lessening the impact on the environment during and after construction.

Speed of construction No other construction material can reduce construction schedules for schools as much as precast concrete. The precast concrete construction went quickly while allowing other trades to begin work earlier and work under safer conditions.

Durability Precast concrete is well known for its long-term durability. In addition, it is tornado, hurricane, and fire resistant. It is also resistant to graffiti and other forms of vandalism.

Sustainable design leads to certification

This energy-efficient and environmentally responsible replacement school complex made of total precast/prestressed concrete framing presented a major challenge beyond that of a tight budget and strict construction schedule. It will be among the first schools in the United States to achieve LEED certification. This will likely be the first high school in the country to do so and at a value that will bring considerable energy savings to the facility.

The precast/prestressed concrete structure employed several innovative design features and contributed to meaningful recycling efforts during construction. The following features are noteworthy:

Clockwise from left **This vertical view of Riverside High School in Greer, S.C., shows the brick veneer.** Courtesy of BRPH Cos. Inc. of Marietta, Ga.

The exterior of Riverside High School gives an undulating effect. Courtesy of BRPH Cos. Inc.

Pictured is the inside of the Riverside High School auditorium. Courtesy of BRPH Cos. Inc.

- A trapezoidal classroom floor plan with windows on two sides provides more daylight per classroom and maximized floor space.
- The sun lights up to 90% of regularly occupied spaces. In the library, cafeteria, and gymnasium, daylight enters through roof monitors. Automatic lighting controls dim electric lights as the sunlight comes in and brightens lights when spaces become darker.
- Precast concrete's step-and-repeat units allowed for easy replication of classroom units and entire classroom wings, which are economically efficient for both the design and construction of the school.
- Long free spans created open, flexible interior spaces unmarred by traditional load-bearing columns.
- Quick, safe interior access was provided by precast concrete interior stairways' being erected along with the floors, eliminating the need for scaffolding and allowing mechanical, electrical, and interior-finish trades to begin work earlier and more safely.
- Loadbearing wall panels incorporated a highly efficient insulation system for limited heat loss and more energy-effective heating and cooling. The high-density precast

concrete panels have no cavities where moisture condensation and mold growth could occur.

- Radiant heat barriers in the roof reflect the sun's heat, reducing roof temperatures. Solar panels on the roof provide 550 gal. (2080 L) of preheated water storage for the kitchen's hot-water system.
- The low-maintenance exterior of sandblasted concrete with brick veneer reflects the look of traditional schools and eliminated six or seven trades as well as costly and time-consuming masonry.
- One unique feature of the replacement school is a 5000 ft^2 (465 m^2) rooftop garden, which is two floors high and accessible through the mezzanine level of the gymnasium. The garden contains a weather station, native plants, and a water garden for studying wetlands, climate, and plant life.
- Precast concrete's simultaneous foundation and production work, erection speed, just-in-time delivery of materials, and construction in limited work areas allowed the precast/prestressed concrete system to be completed in eight months. It also allowed the new facility to be constructed adjacent to the old school while school was in session.
- Materials from the demolished buildings were recycled. As asphalt was removed, it was ground up to use as a base course for new parking lots. Old concrete was broken up and used as backfill. About 70% of construction waste was taken to recycling centers.

The energy efficiency, low maintenance, and healthy environment made possible with precast concrete did more than add crucial points toward attaining LEED certification for the school; it ensured significant energy cost savings for the future.

School proves functional and economical

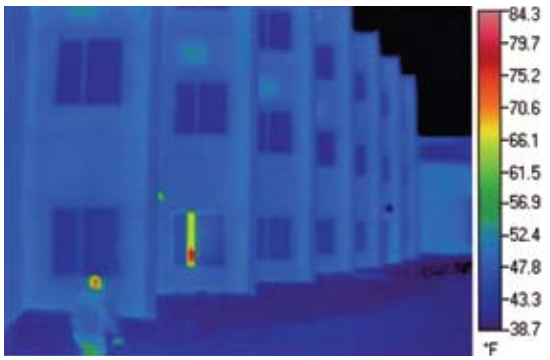
The new high school is unique in that functionality, aesthetics, and economy were important elements in the project, but energy efficiency and environmental concerns were also of paramount importance. This was achieved by employing sustainability principles made possible largely with a precast/prestressed concrete design.

The new school has now been operating for more than a year. So far, the energy and maintenance costs have been in line with the initial predictions. It is expected that the school will have a long life and will serve as a model for other schools to follow, not only in South Carolina, but also in other parts of the United States.

From top The Riverside High School library in Greer, S.C., has a spacious interior. Courtesy of BRPH Cos. Inc. of Marietta, Ga.

This photo shows the Riverside High School classroom workshop. Courtesy of BRPH Cos. Inc.

This thermographic image shows how the precast concrete wall panel insulation system eliminates any solid areas that lead to excessive heat loss from Riverside High School. The light-green areas are where the insulation was reduced for double-tee bearing details while still maintaining the minimum required R-value. Courtesy of BRPH Cos. Inc.



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1. PCI Plant Certification Committee. 1999. *Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*. MNL-116-99. 4th ed. Chicago, IL: PCI.

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3. PCI. 2003. *Architectural Precast Concrete Color and Texture Selection Guide*. MNL CTG-03. 2nd ed. Chicago, IL: PCI.

About the author

George Nasser is editor emeritus of the *PCI Journal*. Nasser has written multiple articles and technical papers for the precast, prestressed concrete industry. A well-respected expert in the precast concrete industry, he was editor-in-chief of the *PCI Journal* for over 30 years. He is a PCI Fellow and was named a Titan of the Industry in 2004.

Synopsis

Energy-efficient, environment-friendly, and sustainable design features were built into this all-precast concrete, three-story high school facility in the southeast United States. This project will be one of the first high schools in the country to be LEED (Leadership in Energy and Environmental Design) certified.

Keywords

All-precast concrete, architectural precast concrete, buildings, education, energy efficiency, LEED, sustainability.

Reader comments

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