Above Recladding the Marshak building will increase its energy efficiency and prevent further deterioration of its 40-year-old lightweight concrete facade.

CCNY Marshak Science Building

Ahuja Partnership Architects

One of the university's largest buildings finds new life with a steel-reinforced re-skinning of its deteriorating concrete facade.

AS THE CITY COLLEGE OF NEW York's largest graduate science teaching and research facility, the 13-story, 600,000-square-foot Marshak Science Building is the most visible structure on campus, standing out from the surrounding Gothic buildings completed more than 100 years earlier.

Designed by Skidmore, Owings & Merrill in 1971, the building's facade was built with lightweight concrete, an innovative material at the time that was intended to lighten the weight of the building since it rests on a complicated system of transfer girders above the plaza level. However, as with many structures of that period where lightweight concrete was used in an exposed condition, the diffusion of water through the porous aggregate together with chloride accelerators used in the mix proved to be the building's own worst enemy. Within ten years of the building's completion the exterior concrete had begun to spall and crack revealing extensive reinforcement corrosion. As the exterior conditions worsened and the corrosion became more widespread, the college sought to determine the causes of the deterioration. After an initial assessment by engineering consultant Stone & Webster (now Shaw Consultants International), New York-based Ahuja Partnership Architects (previously APA Architects) and structural engineer RSD Engineering PC, were called in to analyze the problem, determine its causes, and develop design alternatives for a permanent solution.

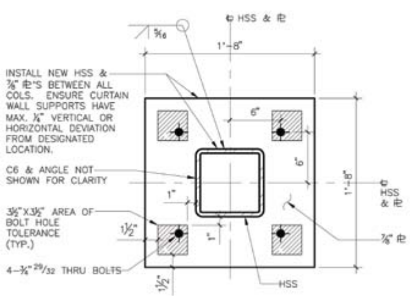
The team had an extensive series of tests of the concrete conducted by an independent lab. These revealed that not only was the aggregate highly porous, but also that carbonation and high chloride concentrations were present throughout the concrete structure. Carbonation is a corrosion-enhancing process whereby dissolved atmospheric carbon dioxide in the pore water reacts with the cement paste to increase the concrete's acidity. When this is combined with the chloride ion's mobility in solution, which further promotes acidity, a particularly aggressive corrosion environment exists. In the absence of water neither process can occur, explaining why no interior deterioration or corrosion occurred. To worsen matters, 3-foot-wide perimeter gutters at each level, originally designed to act as sun shades over the building's recessed windows, had no slope and essentially acted as bathtubs for collecting snow and rain, further deteriorating the concrete.

Structural engineer RSD Engineering concluded that the condition had to be dealt with immediately because the exterior slabs were so damaged that they could not be relied on to adequately brace the columns. To stabilize the columns until a permanent solution was found, RSD designed exterior, story-high steel trusses and beams, which were installed in 2000. "As the exterior columns and gutters were structural in nature and there was no permanent way to arrest the concrete deterioration and solve the drainage issues resulting from the 'bathtubs,' repairing the exterior structural frame and encapsulating the building with a new curtain wall was found to be the only economical and practical solution," says APA founding principal Raj Ahuja. The design team advised the school to install an exterior glass and aluminum curtain wall to protect the concrete members from natural elements, a solution which permitted the building to remain fully occupied. APA's design for the exterior of the building would not only create a more fitting architectural expression for this imposing structure, but also provide for an energy efficient building envelop using tinted insulated glass with low-e coating.

Execution of APA's proposed design presented some challenges, as testing had established that the concrete deterioration was so extensive at the exterior slabs that the building's new curtain wall could not be supported on the slab edges. Instead, 8-by-8-inch HSS box sections were installed spanning between columns, which were designed to transfer the load

Above HSS box sections spanning between columns will transfer the curtain wall load directly to the existing columns without transferring any new load to the slab edges.

Below A diagram detailing the new curtain wall's HSS support installation.



of the curtain wall directly to the existing columns without transferring any new load to the slab edges.

The box sections also fulfill the function of bracing the existing concrete columns. They are connected to each column by means of 24-inch-square by ⅞-inch-thick end plates sized to achieve high fixity, thereby reducing deflections and economizing on HSS size. Controlling deflections was critical in ensuring serviceability of the curtain wall. Plates on opposite sides of the columns are bolted together with high-strength, corrosion-resistant A588 through-bolts torqued to 130 foot-pounds. Locations for the through-bolting were first established by pachometer to minimize cutting the column reinforcement.

At the parapet level, new HSS trusses provide additional bracing for deteriorated concrete columns in addition to adding a decorative architectural feature to the building. APA chose coloration for the modern building's new glass and aluminum components that would complement the terra cotta and New York schist stone facades of the neighboring historic Sheppard Hall.

To minimize construction time, the glass and aluminum curtain wall was designed as a unitized panel system, factory assembled and glazed spanning the nearly 11-foot floor heights and supported on outriggers attached to the HSS. Vertical mullion spacing within the curtain wall was designed to align with the existing window mullions. As part of the future renovation, the owners plan to remove the old windows altogether, freeing up space for new HVAC units. Though not required at this point, the curtain wall is also designed to receive fire stopping at the floor lines and vertical jamb of each window bay and at each floor level once the interior windows are removed.

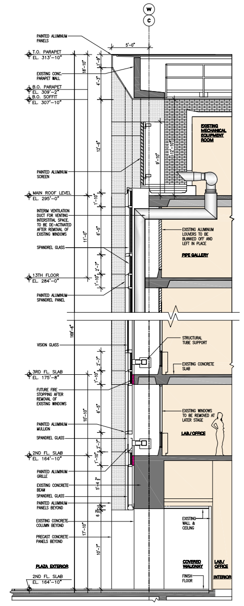
Along the north and south elevations, the existing solid wall sections at the four corners of the building are designed to be clad in aluminum panels, which continue horizontally at the roof level to create a portal-like expression along the east and west facades. As of June 2011, construction was largely complete, with most work carried out while the science center's computer, medical, and laser labs, in addition to more than two hundred teaching and research labs, remained fully operational.

The carefully designed details for permanently repairing the existing exposed building structure and a new curtain wall envelope will result in a fresh architectural identity for the dated building. A structure that was at one time facing demolition has been given a new life ahead of it as the City University of New York undertakes its "Decade of Science," with renewed attention and funding to research in math and science.

"Steel saved the day by allowing us to brace the building and save the curtain wall," says RSD founder Richard Donald. "We saved the concrete using steel."

This page: RSD Engineering

Clockwise from top: RSD Engineering; Ahuja Partnership Architects; Ahuja Partnership Architects



Above left A typical curtain wall section.

Above Existing solid wall sections at the four corners of the north and south elevations will be clad in aluminum panels.

CCNY MARSHAK SCIENCE BUILDING

Location: **137th Street and Convent Avenue, New York, NY**
Owner: **Dormitory Authority of the State of New York (DASNY)**, *New York, NY*; **The City University of New York (CUNY) Department of Design, Construction and Management (DDCM)**, *New York, NY*
Architect: **Ahuja Partnership Architects**, *New York, NY*
Structural Engineer: **RSD Engineering**, *New York, NY*
Mechanical Engineer: **Genesys Engineering**, *Pelham, NY*
General Contractor: **Whitestone Construction Corp.**, *Woodside, NY*
Construction Manager: **URS Corp.**, *New York, NY*
Miscellaneous Iron Erectors: **Whitestone Construction Corp.**, *Woodside, NY*; **Metro-Tech Erectors Corp.**, *Glendale, NY*
Architectural Metal Erector: **Whitestone Construction Corp.**, *Woodside, NY*
Curtain Wall Erector: **Whitestone Construction Corp.**, *Woodside, NY*