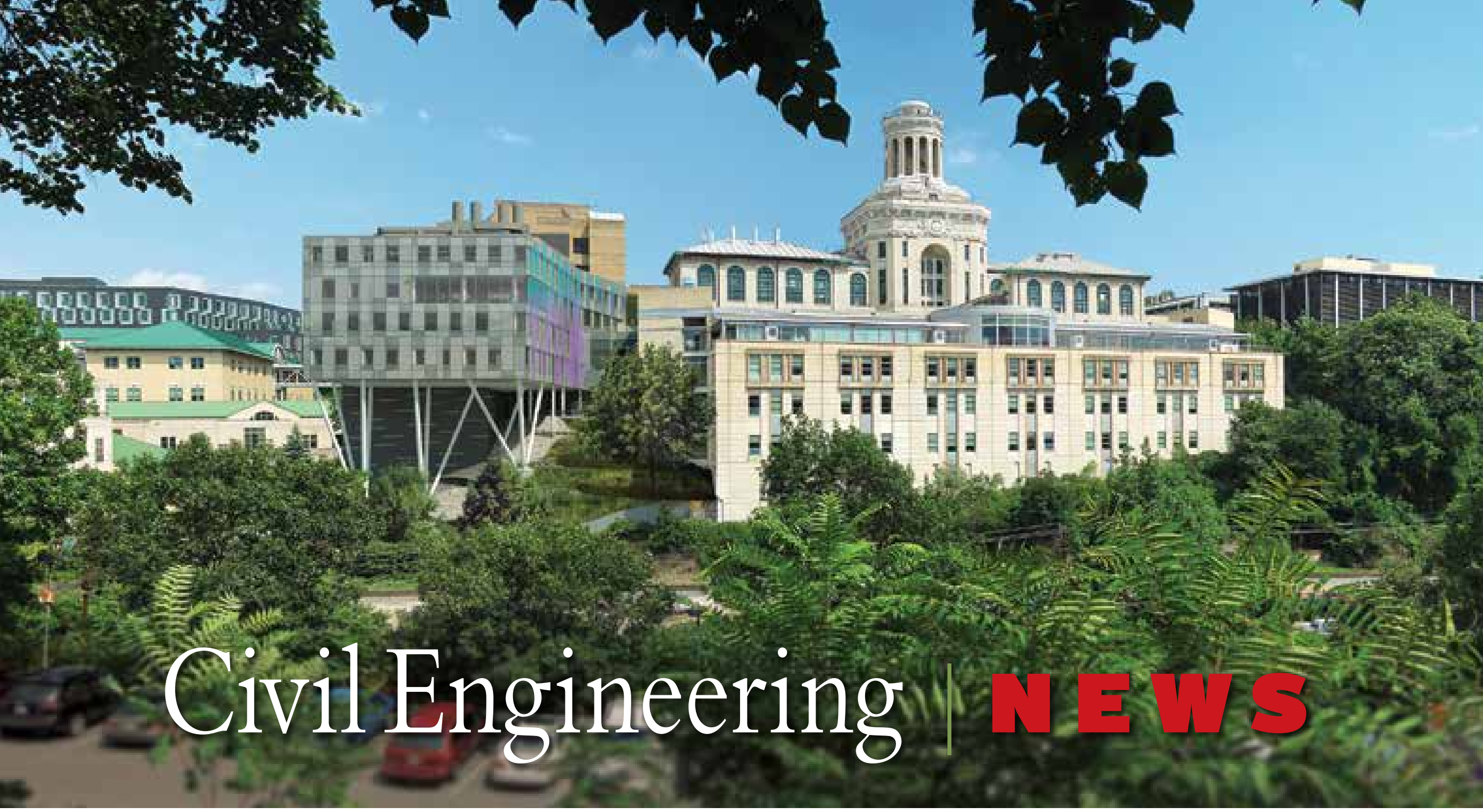


Civil Engineering | NEWS

STRUCTURAL ENGINEERING

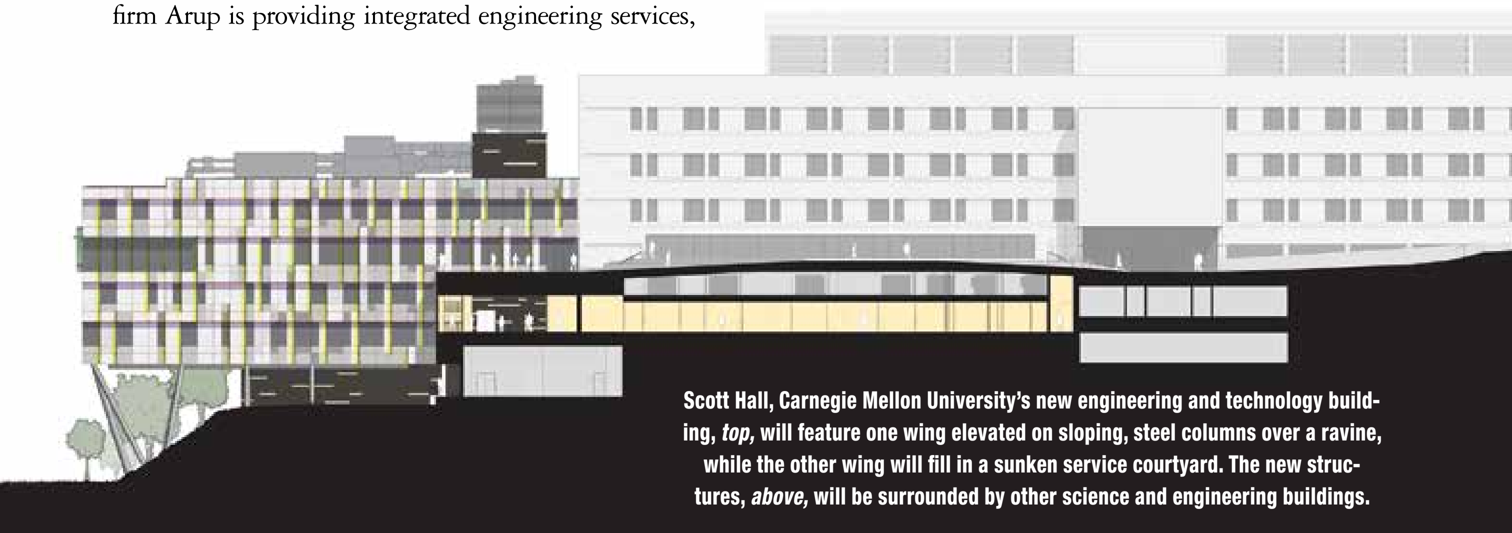
Difficult Site Leads To 'Split' Decision at Carnegie Mellon

THE SOLUTION to a challenging site for a new engineering and technology building at Carnegie Mellon University involved essentially splitting the new program space into two structurally separate wings. One will be elevated on sloping, steel columns over a ravine, while the other will fill in an existing sunken service courtyard surrounded by other science and engineering buildings. Together, the two wings will form the Sherman and Joyce Bowie Scott Hall (Scott Hall), now under construction on the Carnegie Mellon campus and expected to open in 2015.

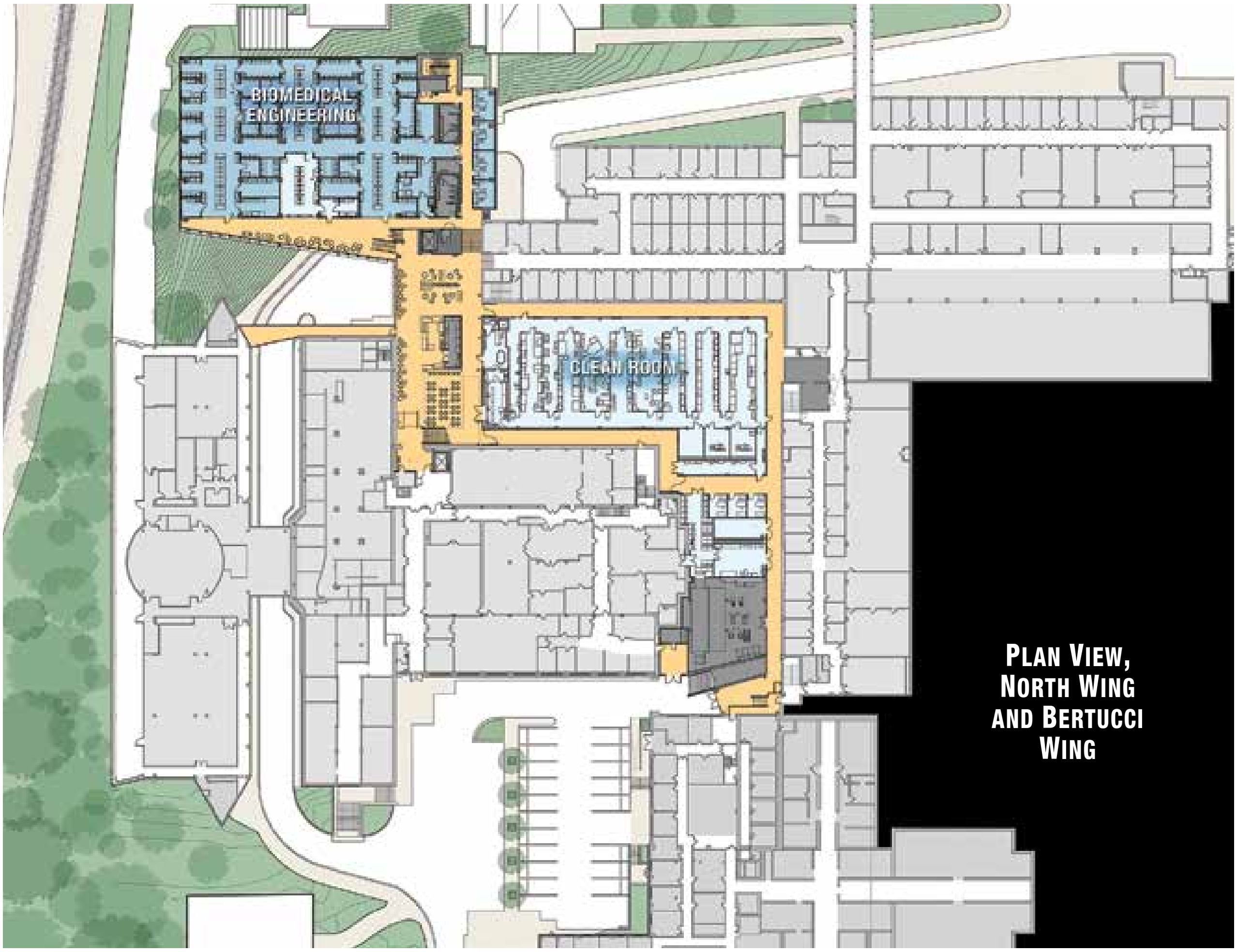
The competition to design Scott Hall was won by OFFICE 52, of Portland, Oregon, the project's design architect. Stantec, of Butler, Pennsylvania, is the architect of record. The New York City office of the international engineering firm Arup is providing integrated engineering services, especially structural engineering and the acoustical surveys used to determine the potential vibration issues associated with the site. Two divisions of Jacobs Engineering—Jacobs Consultancy, Inc., of Tarrytown, New York, and Jacobs Engineering Group, of Lake Oswego, Oregon—are responsible for respectively the design of the laboratories within Scott Hall and a special research-grade clean room with extremely stringent vibration requirements. Pittsburgh-based Jendoco Construction Corporation is the project's construction manager.

Scott Hall was designed to create an interdisciplinary hub for the university's College of Engineering and to house the clean room for collaborative research in biomedical engineering, energy, and nanotechnology. The building will also

OFFICE 52 ARCHITECTURE, *ALL THREE*



Scott Hall, Carnegie Mellon University's new engineering and technology building, *top,* will feature one wing elevated on sloping, steel columns over a ravine, while the other wing will fill in a sunken service courtyard. The new structures, *above,* will be surrounded by other science and engineering buildings.



PLAN VIEW, NORTH WING AND BERTUCCI WING

house the university's biomedical engineering department and provide space for the new, interdisciplinary Wilton E. Scott Institute for Energy Innovation. The clean room is being constructed in a concrete-framed space within the volume of the former sunken service courtyard at the western end of the campus's Hornbostel Mall; this portion of the building will be known as the Claire and John Bertucci Wing. The elevated portion over the ravine, known as the North Wing, will be a glazed, steel-framed structure supported on sloping, sculptural steel columns that were positioned carefully to avoid interfering with both the existing underground utilities and a service road and fire lane that passes beneath the elevated wing and had to be maintained.

Initially, a planning study conducted by the university prior to the design competition envisioned a single structure. This seven-story, roughly 80,000 sq ft building would have been located entirely in the space overlooking the ravine known as Junction Hollow, just west of Hornbostel Mall, explains Isaac Campbell, an OFFICE 52 principal. But a set of railroad tracks at the base of the ravine presented potential vibration problems for the planned clean room for work in biomedical engineering, energy, and nanotechnology, which was to be located within the elevated wing. What is more, the lower floors of the building were quite small and isolated from the neighboring facilities, Campbell says. So the architecture firm's solution involved essentially "breaking the parameters of the competition," notes Michelle LaFoe, an OFFICE 52 principal, by splitting the program into two structures and locating the clean room within the infilled courtyard, where it could be supported at grade, far from the track vibrations. Having shifted the most vibration-sensitive program to the infilled courtyard, the architects significantly reduced the structural requirements of the North Wing and thus were able to design it as a four-story structure that would be supported on the array of sloping steel columns, says Campbell.

The infilled courtyard will feature a single level of laboratory and office space, the floor-to-ceiling height being approximately 20 ft, beneath a vegetated roof that will extend the green spaces of the mall above. The Bertucci Wing will be created by enclosing the open courtyard on either side of the stairs that lead up to the entrance of Hamerschlag Hall, the home of the electrical and computer engineering departments. The eastern end of the space will be adjacent to an underground portion of Wean Hall (currently exposed on the courtyard side), which houses space for computer science, physics, and mathematics. Pedestrian access connections also will be created to link the Bertucci Wing and the North Wing to other academic buildings, although the two wings will be structurally separate from the surrounding buildings and also separate from each other, explains Dan Brodkin, P.E., an Arup principal and a 1986 graduate of Carnegie Mellon's civil engineering program.

The interconnectivity of the new spaces with the existing buildings was critical to the university's goals, Campbell says. "The university consciously made the decision to build on this site, which they knew would be harder, and to make the capital investment to do that because it would locate these [new] research facilities in close proximity to all of the other people, researchers, and programs that are in the adjacent buildings. The university understood that this would increase collaboration and innovation across disciplines," Campbell explains.

Although the new wings are being constructed in proximity to the existing university buildings, the new structures have been kept far enough away from the existing buildings so that little or no underpinning of the original foundations has been required, explain Campbell and Matt Larson, P.E., an Arup senior engineer. Moreover, because of the rigidity in both the new and the existing buildings, very little differential movement is expected, Campbell adds.

Because the location of rock varies beneath the infilled wing, the design team chose to use a raft foundation there. This 16 in. thick reinforced-concrete raft will have 4 in. of additional thickness beneath the columns that accommodate the structure's gravity loads, notes Larson. Shear walls resist the lateral loads of the cast-in-place Bertucci Wing, he adds. The folded flat plate roof is topped by an estimated 10 in. of soil, greatly assisting the university's efforts to control storm-water runoff, notes Campbell. In contrast to the current service courtyard, which is all concrete and asphalt, "the green roof with that thickness will actually absorb most of the water that falls on it; very little water will come out of the drains at the bottom of the green roof and go into the storm sewer," Campbell explains.

The clean room for collaborative work in biomedical engineering, energy, and nanotechnology occupies most of the Bertucci Wing. By locating this room in the sunken courtyard, the major vibration issues were resolved, Brodkin says, although some vibration-damping tables also were installed, and certain pieces of equipment that require an even finer degree of vibration control were locally isolated. But the clean room also has extremely strict air-handling requirements that must be maintained at all times, notes Greg Owen, P.E., Jacobs's manager of mechanical clean room technology. "These air-handling units run constantly—you can't shut them down or else you'll have problems with particulates and infiltration of ambient molecular contamination," Owen says, "so you don't ever shut down the air management system, even at night when you leave the building."

ALTHOUGH the high ceilings of the infill wing for the most part provided sufficient space for the inclusion of the equipment for the clean room systems, the design team did have to accommodate a ramp in the roof that would lead down from the mall area to a lower elevation entrance to the wing.

Although the high ceilings of the infill wing for the most part provided sufficient space for the inclusion of the equipment for the clean room systems, the design team did have to accommodate a ramp in the roof that would lead down from the mall area to a lower elevation entrance to the wing. "We had to massage the location of the units a little bit," says Owen, who describes the effort as "a geometric exercise to make things fit."

A glazed pavilion close to the lower end of the descending ramp forms one of several entrances to the Bertucci Wing. In the North Wing, a multilevel space on the south side of the building marks the point at which the elevated structure meets the infill space. This public space, the "collaboratory," is designed as a setting in which "all the different disciplines—all the different scientists, researchers, staff, and students—can mingle and talk about ideas in a more informal social setting," says LaFoe.

The North Wing is essentially perched atop a podium and in front of a tower that house respectively the mechanical systems and the riser shafts for ductwork and piping, as well as the vertical circulation within the wing's core. To accommodate the wing's lateral loads, these spaces are supported via a series of concentrically braced steel frames that include both inverted V-shaped frames and single diagonal type frames, notes Larson. Many of these frames are expressed in the public spaces of the building, Campbell adds. A permanent retaining wall also was constructed between the North Wing and the service road that passes beneath the new structure; this wall utilizes steel H-piles, precast concrete, and steel tieback rods set into the surrounding rock to relieve the wing's frames of the high out-of-balance soil pressures that result from the steep slope of the ravine, explains Larson.

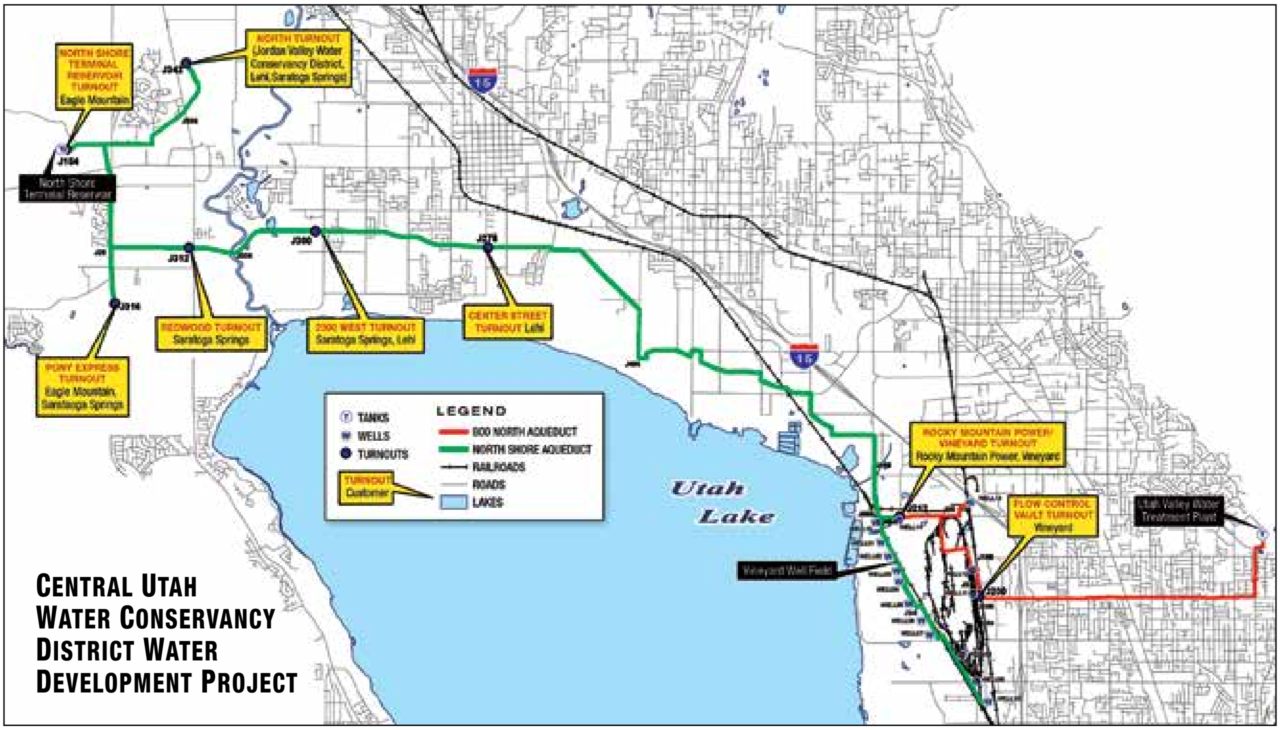
The steel-framed North Wing features composite deck floors and extensive glazing to provide the researchers with panoramic views of the city, says Campbell. The North Wing is shaded by "a complex pattern of ceramic frit that draws from the science taking place in the building and the proportions of the neighboring buildings," says Campbell. The south side of the North Wing also is shaded by a series of laminated glass fins made with dichroic film, a nanotechnology-based product that provides varying qualities of reflected and transmitted light, "which we thought was absolutely apropos for the building," says LaFoe, in reference to the nanotechnology research that will be conducted within.

Because the North Wing bracing is concentrated at the east end, adjacent to Wean Hall, the building is not very restrained in the north–south direction, notes Brodkin. To resolve that issue, the lowest floor level of the North Wing "has some unusual responsibilities compared to a regular floor," he says. In particular, this level must resist the horizontal forces of the sloping columns and take those forces back to the braced frames. Thus, this level features both a composite slab similar to the other floors but also some additional steel framing configured along the diagonal "so it sort of behaves like a triangulated truss on its side," says Brodkin.

The columns themselves are steel structures roughly 2 ft in diameter that taper at the bottom and are pinned to the heavy concrete piers set into the hillside. The augered concrete piles extend down as much as 50 to 60 ft to reach bedrock to control vibration and because of the difficult soil conditions, notes Campbell. The foundation system also features a series of ground beams that slant down the hillside, connecting the piles and pile caps together so they all participate as a group in resisting the horizontal forces, says Brodkin.

Because the university had not expected to construct a building on the North Wing site, the underground utilities are scattered throughout the area rather than, say, arranged along the perimeter, notes Brodkin. Thus, while the columns attach to the underside of the North Wing on a regular grid pattern, they slant to the ground at varying angles to accommodate the location of different pile caps and piles that have to avoid the underground utilities. Thus, whereas some projects "have miles of the same everywhere," in terms of the size and arrangement of structural elements, the Scott Hall project involves a fairly complicated foundation plan in which the slopes of the columns all differ, and "each pile cap is different from its neighbor," says Brodkin.

A pedestrian bridge also is planned for the site that will eventually extend from the North Wing across the ravine to land on the other side that the university hopes to develop someday. Although the location of the bridge was shown in OFFICE 52's design, there are no definite plans to construct it at this time, Campbell adds. —ROBERT L. REID



CENTRAL UTAH WATER CONSERVANCY DISTRICT WATER DEVELOPMENT PROJECT

PRODUCED BY MWH GLOBAL FOR THE CENTRAL UTAH WATER CONSERVANCY DISTRICT

DRINKING WATER

Major Utah Groundwater Project Features State's Deepest Wells

A MAJOR WELL FIELD being developed by the Central Utah Water Conservancy District promises to boost water supplies to communities in southern Salt Lake County and northern Utah County. Groundwater from the well field is eventually expected to account for roughly 80 percent of the drinking water provided by a $325-million project that the district plans to begin operating this summer. To access the groundwater, the district has had to construct what are believed to be among the deepest wells ever drilled in Utah for the purposes of providing drinking water.

Nearly 10 years ago the district bought the rights to approximately 43,400 acre-ft of water from the Geneva Steel Company, which previously operated a steel mill in Vineyard, Utah. In combination with other water rights that had been acquired, the purchase enabled the district to pursue a long-term project that will ultimately provide approximately 53,300 acre-ft of drinking water per year from groundwater