Steel framing designed with a “missing floor” will accommodate future interior modifications for this North Carolina State University science center.

Designing for the Future

BY ASHLEY G. PARKER, P.E.

Mitch Fluhrer

WHEN REAL ESTATE DEVELOPMENT FIRM Keystone Corporation and North Carolina State University entered into a public/private partnership to create a new Science Center, they realized it was imperative to design the facility to accommodate future expansion. But in this case, that expansion meant the capability of adding an interior floor to the high-bay, 72,000-sq.-ft facility.

To meet the needs of its main tenant, the building is designed with 30-ft-tall ceilings in the central lab area. However, it is anticipated that future tenants won't require such high ceilings so the structural system was designed to easily accommodate adding a second interior floor.

"The owner wanted a building that was flexible enough to accommodate the needs of its current tenant, yet also allowed for adjustment should a tenant's needs differ years down the road," said Banning Reed, principal of Fluhrer Reed, the Raleigh, N.C., structural engineering firm hired for the job. "That's where the idea of designing the building for a missing floor came into play."

Adding to the challenge, the building's roof needed to be designed to support 268 solar panels.

Now You See It… Now You Don't

It was imperative for the building to have large, open floors to accommodate potential tenants with a wide variety of commercial space needs. When a top researcher in the integration of alternate energy technology and the nation's power grid showed interest in leasing a large portion of the building, the developer and the university jumped. However, the lab space required a 30-ft-tall, two-story "high bay" volume.

"We looked at the high bay area two ways," Reed said. "That gave the current tenant the space they needed but allowed the developer to accommodate future leasable options."

First, the steel in the lab area was analyzed to take the full out-of-plane wind loads imposed on the members without an intermediate floor being present. Second, the area was analyzed to take gravity loads as if an elevated floor would be added in the space at a later date.

To account for the absence of the second floor, W10 columns were designed as completely unbraced by an interstitial floor for their entire 30-ft height. The perimeter spandrel beams were designed to also take the full out-of-plane bending loads from the wind that would need to be resisted by the beams when no floor is present. These beams were designed as unbraced by other beams or decking. Engineers used wide-flange beams to frame these areas rather than HSS members which typically are better at handling out-of-plane loading. The engineers recognized that if a future floor was added, connecting the new floor beams to wide-flange beams would be much easier than making connections with HSS tubes as spandrel beams. "We had to think 10 to 20 years down the road and what the potential needs of the tenants of the space would be at that time," said Reed. W14 and W18 sections were used for the perimeter beams with flanges that were wide enough to give the beams resistance to out-of-plane loads without bracing them.

After designing the high-bay area without the intermediate floor, the engineers added the potential second floor framing into their models with loads equal to that of a typical composite steel office floor. That allowed them to verify that the beams, columns

Viewing the Keystone Science Center from the outside, one would not know it was designed with a "missing floor" to accommodate the need for a high-bay lab.

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The new facility opened in July 2010 and includes 268 rooftop solar panels, concealed by screens along with the other rooftop equipment.

The front entry of the Keystone Science Center, located on North Carolina State University's Centennial Campus.

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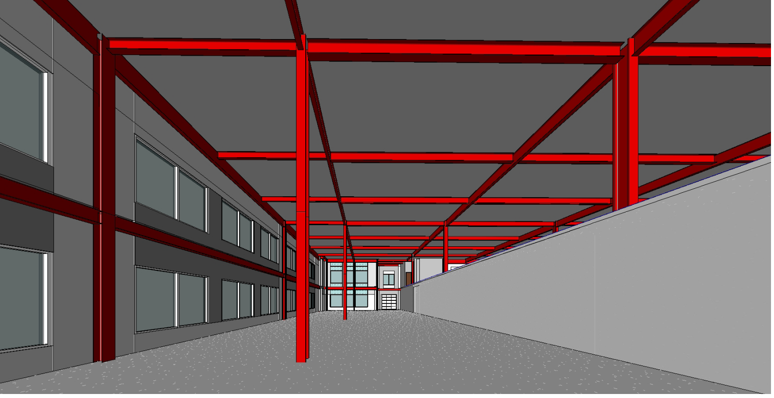

The new Keystone Science Center's lab area features a 30-ft-tall high bay.

and foundations would be adequate if an interstitial floor was added at a later date.

Fluhrer Reed also designed and detailed the exterior wall studs to bypass the spandrel beams, yet the connections bracing the components to the beams were designed to withstand the vertical deflection if a floor was added in the future.

Here Comes the Sun

Another challenging design component of the project was designing the support of 268 solar panels that were required by occupants of the science center. Fluhrer Reed's engineers worked with the solar panel provider to design suitable support framing for the panels. In particular, engineers used special wind tunnel testing data, supplied by the manufacturer, to account for wind loads that would be imposed on the panels.

The project included a 12-ft-tall rooftop mechanical enclosure at its completion. Designed to conceal large mechanical units necessary for operations in the center, the 14,300-sq.-ft, L-shaped enclosure was created by extending the building's interior columns through the roof level to form the supports for the mechanical area. HSS beams were framed between the extended columns and filled in with cold-formed metal wall studs to form the enclosure's screen wall. Metal panel was specified to clad the exterior of the wall.

After completing the construction of the enclosure, it was determined that an extensive solar panel system would be added to the roof of the building. The solar panel provider specified that the panels were to be mounted to a support frame at a 45° angle to optimize their sun exposure. However, potential damage to the existing roofing membrane when constructing the solar panel support frame had to be taken into account.

"We approached the design of the solar panel support framing as a kit of parts," Reed said. "We asked ourselves, how can we design a structure that is easily constructed and will not damage the parts of the building that are already in place?" Field welding of connections and general erection techniques had the potential of burning or tearing the waterproof roof membrane, and adding columns to support the proposed frame was not an option. Engineers ultimately designed a solution that included connecting the panel support frames to the existing rooftop mechanical screen wall.

Constructed of HSS 8×8 members that span between the existing mechanical screen columns, strut channel infill and smaller HSS braces to resist lateral loads, all of the steel members in the panel support structure were designed to be shop welded together and then bolted to the existing mechanical screen columns in the field. The strut channels, to which the solar panels were mounted, were also bolted to the steel frame in the field. This allowed the pieces of the solar panel support structure to fit together quickly and easily without field welding connections, thus minimizing the risk of damage to the roof.

The Keystone of Success

Keeping in mind the needs of its current users and the potential needs of its future occupants, the Keystone Science Center proved to be a practical and cost-effective project for N.C. State and Keystone Corporation during one of the most difficult economic situations in many years.

The structure required just 250 tons of structural steel—less than seven lb per sq. ft—which allowed engineers to use a foundation of shallow spread footings. By utilizing the flexibility of steel, Fluhrer Reed's structural engineers were able to design a building that meets the wide ranging needs of researchers, businesses and university students while also offering desirable, leasable space for the owner today and in the future. MSC

An Adaptable Structure in a Good Location

The Keystone Science Center was born in the midst of the "Great Recession" and is the product of collaboration between the university and real estate development firm Keystone Corporation. As things turned out, it was the only office building to break ground in 2009 in North Carolina's Triangle area, which in recent years had been growing rapidly.

The new structure is located on North Carolina State University's Centennial Campus, a 1,314-acre tract of land located south of the main campus created in 1984 and devoted to a partnership between the university and private corporations. In order to call Centennial Campus home, a private company must have a programmatic connection to N.C. State through collaborative research, student internships or other avenues. Currently, more than 60 corporations, government offices and nonprofit organizations are located on Centennial Campus and an estimated six million sq. ft of space is yet to be developed on the campus.

As a forward-looking project, developing the Keystone Science Center as a building that would be practical and economical for current and future tenants was vital. The building design required meeting the needs of the university along with creating highly desirable, leasable office space for private corporations and researchers. Those needs, coupled with the proposed fast-paced 14-month design and construction schedule made structural steel an ideal choice for the center.

At its grand opening in July, 2010, the building was 98% leased; an impressive accomplishment for a multi-tenant commercial office building during such trying economic times.

Developer
Keystone Corporation, Raleigh, N.C.

Architect
HagerSmith Design, PA, Raleigh, N.C.

Structural Engineer
Fluhrer Reed, PA, Raleigh, N.C.

Steel Fabricator
McCombs Steel, Statesville, N.C.
(AISC Member)

General Contractor
Shelco Corporation, Raleigh, N.C.

Structural Software
RAM Structural System, Revit Structure