Gearing Up for Green Growth

BY DAVID E. SCHROEDER, P.E., LEED AP

NREL's new research facility hopes to be as green and expandable as the renewable energy strategies that will be studied there.

JE Dunn Construction

THE FRONT END of renewable energy gets a lot of exposure—to the general public as well as the elements.

Wind turbines and solar arrays are the face of the industry, and their advocates tout the benefits of a greener grid. Of course, the grid itself is the part we don't actually see, and while harnessing the wind and sun (and other renewable energy resources) might seem like a fairly simple concept, distributing power from it is a different story.

That's where the Energy Systems Integration Facility (ESIF) comes in. The U.S. Department of Energy (DOE) facility, currently under construction at its National Renewable Energy Laboratory campus in Golden, Colo., will shed more light on this complex issue. Upon its completion, scheduled for this October, the ESIF will be the nation's only facility that can conduct integrated megawatt-scale

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A rendering of the completed project.

testing of all components and strategies critical to deploying renewable energy and other energy-efficient technologies to the nation's electrical grid at a utility scale.

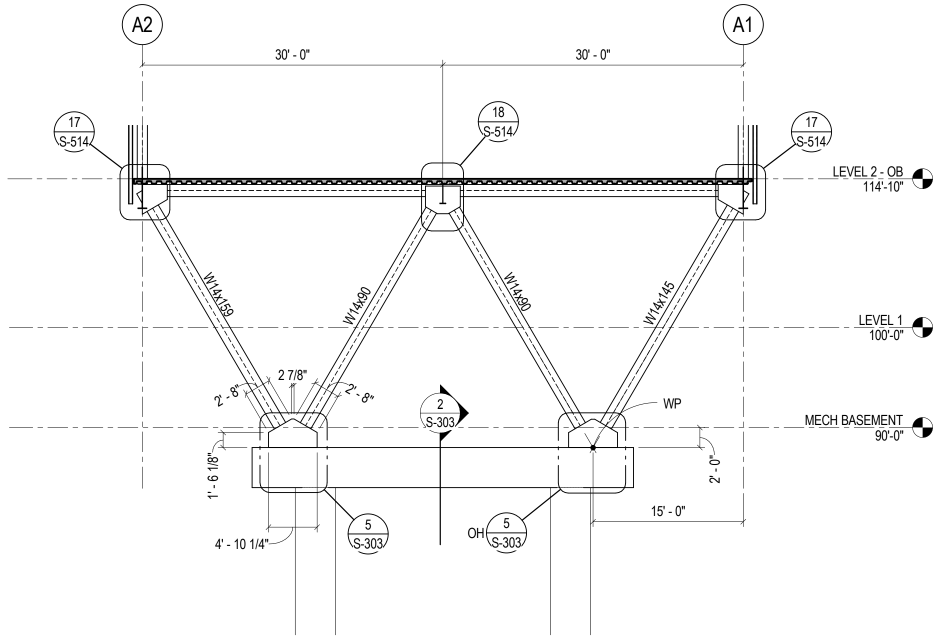
The 182,500-sq.-ft facility consists of three main components: 15 state-of-the-art laboratories, approximately 200 office and collaboration spaces and a high-performance computing data center. Designed by architect SmithGroupJJR and structural engineer Martin/Martin, the laboratory incorporates large propped cantilevers (W30×99) supported off of W14 inclined column assemblies at the office, cantilevered balconies at the office and data center, a mechanical strategy that uses a large under-floor plenum over the data center mechanical room and a ribbon window design for the office. The architectural design features, required flexibility for future expansion and team's decision to pursue LEED Platinum status (exceeding the DOE's LEED Gold requirement) made structural steel the ideal choice for the office and data center portions of the building.

Early Involvement

The preliminary design, completed in December 2010, included an early structural package that was used to competitively bid the structural steel scope. Steel fabricator Midwest Steel Works and erector Quality Steel Services were selected in early 2011, and the early procurement of the structural steel package allowed time to make changes to the design, providing cost and schedule benefits. For example, the ribbon window design for the office portion required structural steel elements to be interwoven with the window mullions, and the upfront coordination and planning between the window and steel subcontractors expedited this portion of the project, allowing the window frames to be installed without conflict. Quality Steel worked with Martin/Martin to revise a perimeter detail at the office building, resulting in a significant reduction in labor.

In addition to coordination with the curtain wall subcontractor and Martin/Martin, Quality Steel worked closely with the precast erector to coordinate the locations where their respective scopes interfaced. The laboratory portion of the building consists of precast double tees, inverted tees and columns with load-bearing

The propped cantilevers at the office have a 30-ft cantilever and a 30-ft back span and are supported on a W-shaped inclined column assembly.



"W" assembly design drawing.

Martin/Martin

insulated wall panels, facilitating a clear height of approximately 32 ft. However, there were ten structural steel beams required for the support of future bridge cranes in two of the laboratory spaces (the largest of which was a W36×231 spanning 44 ft) and a steel stair that serves the entire lab space. Quality Steel agreed to set the precast roof panels over the stair so that the stair could be fabricated in sections and dropped down from above rather than "stick built" from below. The precast erector agreed to set the steel beams with the concrete prior to setting the roof tees so that Quality Steel would not have to set the bridge crane beams inside of the precast structure. There were also architectural precast panels that sat below the cantilevering steel structure in the office and data center portion of the building. Quality Steel and the precast erector worked closely to agree upon an erection sequence that would work for both of them. In the case of the office, the precast panel box had to be set and temporarily braced before the structural steel was erected inside of the precast box. With the data center, approximately 30 structural steel pieces had to be constructed prior to erecting architectural precast wall panels around columns. After the precast was set around the columns, the remainder of the structural steel was able to be erected.

Zero Tolerance

The propped cantilevers at the office have a 30-ft cantilever and a 30-ft back span and are supported on a W-shaped inclined column assembly. There are double channel braces in the direction of the cantilevers on each end that carry both lateral and gravity load. The inclined column assembly also carries both lateral and gravity loads and is comprised of W14 inclined column shapes and a W14×109 web horizontal member at the floor line. The inclined columns bear on cast-in-place tie beams. The connections of the inclined columns to the web horizontal member at the floor line are zero-tolerance connections. Midwest Steel fabricated the individual elements of the assembly, assembled them in their shop to confirm fit-up, disassembled them and delivered them to the job site. The fabrication was perfect and there were no fit-up issues upon erection of the assemblies (three total).

The design includes a ribbon window on two floors of the office space on the north and south elevations. The window assembly has a consistent head elevation and a variable sill elevation. NREL/DOE has a goal to turn off the lights in the office space from 10:00 a.m. until 2:00 p.m. each day. This, in addition to the daylighting requirements for LEED, drove the design of the exterior window system. To facilitate the ribbon window system, vertical C5 channels are run from floor to floor inside vertical window mullions, and horizontal tube steel headers extend from channel to channel. To maintain a consistent mullion size, the C5 channels had to be fabricated and erected to a 3/32-in. tolerance. Through early input and coordination between Quality Steel and the curtain wall subcontractor, the connection details for the C5 channels and horizontal steel headers were completed such that Quality Steel could meet this tolerance requirement.

Balancing Function and Safety

A key component to the mechanical design in the High-Performance Computing Data Center was an open plenum for conditioning the data center space. Traditional under-floor air systems create a plenum space between access floor and a slab on metal deck over structural steel framing. The design of the ESIF data center created a plenum to the mechanical room 16 ft below the data center floor. To do this, the slab on metal deck was omitted, and the access floor pedestals are fastened directly to the top chord of the steel joists spaced at 2 ft on center. The diaphragm normally provided by the slab on metal deck was provided through horizontal flat plate bracing.

The data center was designed for future expansion, and omitting the slab on metal deck helped facilitate this goal. It also made it possible to install any required infrastructure for future expansion without interrupting function of the existing data center equipment.

Safety was considered in every decision throughout the design-build process. The use of an open plenum to the mechanical room floor 16 ft below created a possible safety issue if an NREL employee had to remove an access floor panel for any reason. The design team was tasked with providing a safety mechanism to prevent a fall hazard if an access floor panel was removed. It had to have the capacity to support a person falling through the opening but could not have a cross section that would inhibit airflow from the space below. The solution was to use flat sheets of welded wire fabric directly welded to the top of the steel joists. Considering that this was a non-typical use of welded wire fabric, the design-build team was required to load test a mockup of the safety mesh system to substantiate its use as fall protection. A mockup of the system was constructed at Quality Steel's shop. The welding of the mesh to the top chord of the steel joists was inspected by the DOE's third-party inspection agency. A specified load with a specified diameter was dropped from 42 in. onto the safety mesh assembly. After performing the load test two times, all welds and mesh material passed inspection. Upon completion of the test and inspection, the mesh sheets were purchased, delivered and erected.

Flexibility

As is typical to fast-track projects with early structural packages, design decisions continue to be made well after the structure is in place. The Power Systems Integration Laboratory (PSIL) is one of the largest laboratory spaces in ESIF and requires a control room that sits above the laboratory floor level. This room is supported on a structural steel mezzanine that is hung from the precast roof framing above. After the structural steel was erected but before the concrete slab on metal deck had been placed, the projection equipment within the PSIL control room was changed. The new equipment required that the PSIL control room become 9 ft larger in one direction. The flexibility of structural steel made it relatively easy to extend the mezzanine to accommodate the revised projection equipment.

Again, the ESIF will be the nation's only facility that can conduct energy distribution testing at such a large scale. It will provide the research, engineering, design, testing and analysis of components and systems to enable economic, reliable integration of renewable electricity generation, fuel production, storage and building efficiency technologies with the U.S. fuel and electricity delivery infrastructures. MSC

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U.S. Department of Energy

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Steel Team

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Erector
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