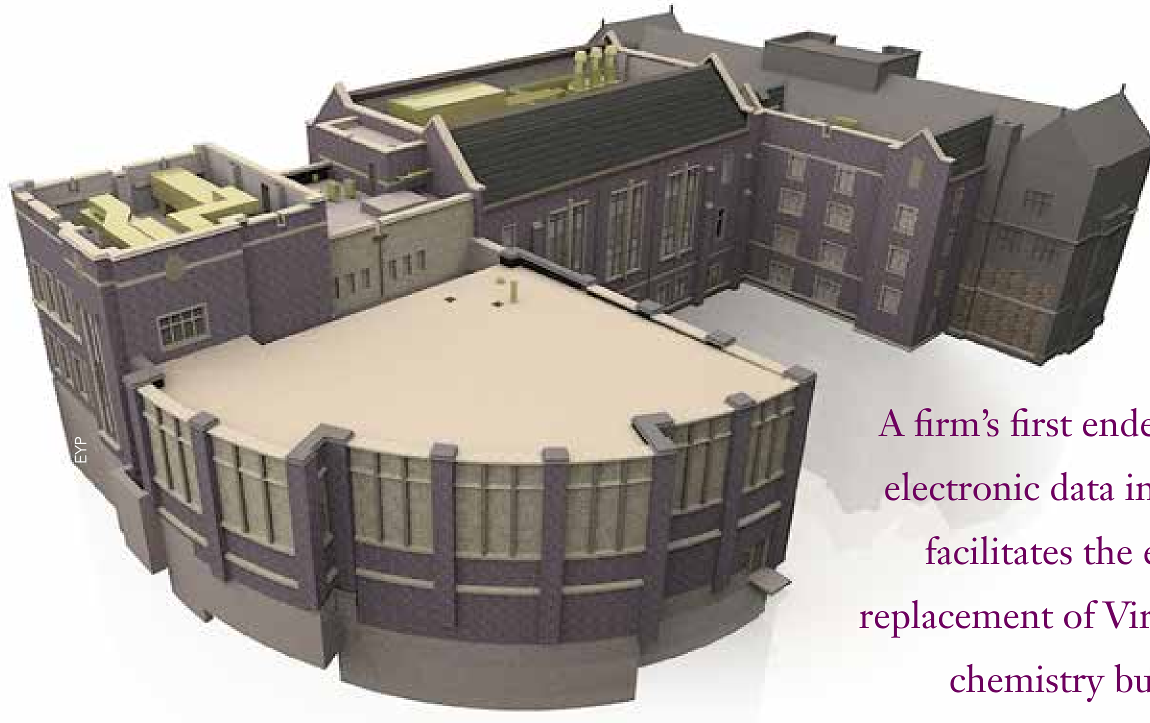
Chemistry Experiment

BY S. KEITH RITTENHOUSE, P.E.



EYP

A firm's first endeavor with electronic data interchange facilitates the efficient replacement of Virginia Tech's chemistry building.

DAVIDSON HALL did a lot of growing early in its life.

The building, home to the chemistry department at Virginia Polytechnic Institute and State University in Blacksburg—better known as Virginia Tech—began with a three-story front section and a rear two-story portion, both constructed in 1928. The front section received a fourth story and the two-story section was expanded in 1933; a subsequent project in 1938 added a three-story section north of the 1933 two-story expansion.

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More than seven decades later, in 2008, Virginia Tech was ready to upgrade the facility and retained EYP Architecture and Engineering for the project, which encompassed demolishing the building except for the four-story front section. The replacement building was constructed on the footprint of the demolished portion and joins the remaining front section at its north wall. The new 51,000-sq.-ft addition houses state-of-the-art flexible laboratories, classrooms, faculty offices and a lecture hall.

Footfalls and Foundations

The original building's lateral load resisting system is not clearly defined on the 1927 construction drawings, and planned demolition of the rear section raised concern for the north-south lateral stability of the rectangular front section of existing Davidson Hall to remain. Research laboratories in the new building meant that footfall vibrations would be an issue for the instrumentation and equipment areas, lab spaces and adjacent corridors. The Virginia Tech campus is located in an area of karst topography that invites consideration of deep foundation systems and while a heavier building would add damping mass, it would also generate both higher design gravity loads and seismic design

◄ A rendering of the new building, with the Davidson Hall front section to remain.

▲ Steel erection at the north end.

forces at this seismic site class C location. The relationship between structural system and speed of construction was also a consideration. Construction schedules for higher education buildings are typically set to have the building ready for occupancy at the beginning of a semester, and the effect of winter weather in southwest Virginia had to be taken into consideration.

The following gravity load structural systems were considered during the project schematic design phase:

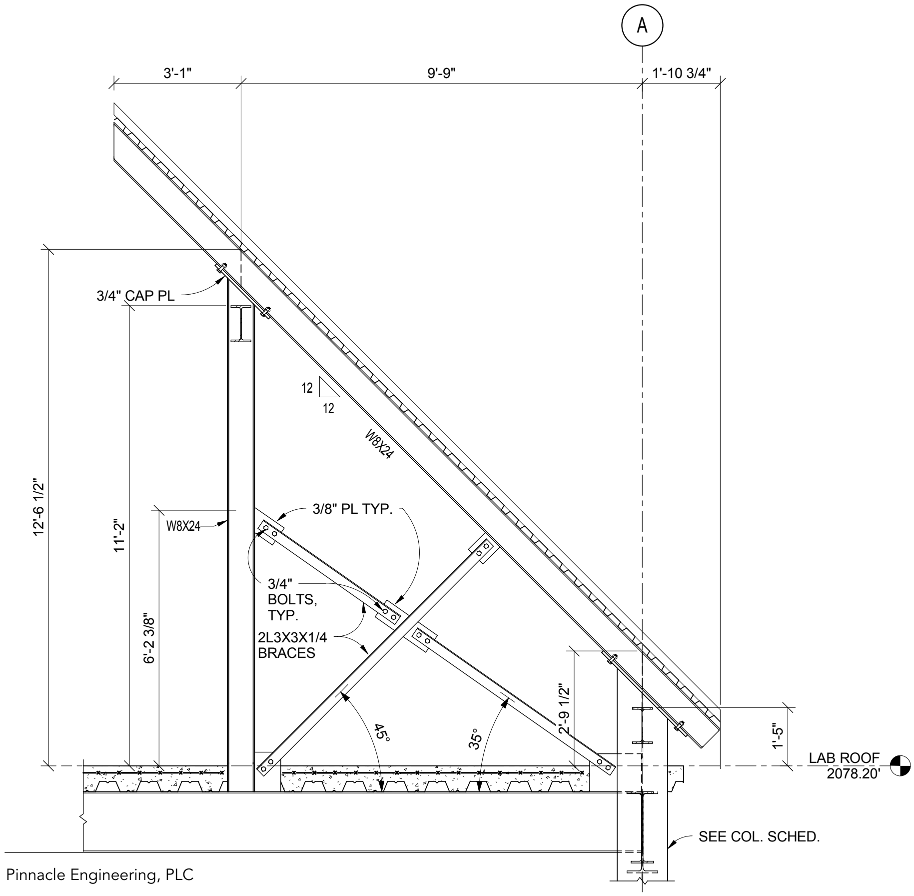
1. Structural steel beams and girders acting compositely with cast-in-place concrete slabs on composite steel deck
2. Cast-in-place concrete two-way flat slabs
3. Cast-in-place one-way concrete joists and beams

The composite structural steel option was chosen for a number of reasons. This selection was based in part upon consultation with the project construction manager, Barton Malow, and considered factors that included competitive cost advantage in the geographic area, enhanced field quality control and predictable speed of construction—advantages all offered by composite structural steel construction. The typical floor slab section is composed of 4½-in. normal weight concrete on 3-in., 18-gage composite steel deck (7½ in. total thickness), and the slab spans 10 ft, 6 in. between W16 composite floor beams at the laboratory areas. Ordinary steel moment frames laterally stabilize the new building in both orthogonal plan directions. A series of ordinary steel moment frames also provides north-south lateral stability for the original 1928 front section. Studies of potential locations for stabilizing frames within the original section footprint found this option to be expensive, in part because of limitations on column locations to avoid adversely affecting future use of the existing space, and also due to the need for new frame column foundations within the constraints of the existing structure. These stabilizing north-south frames were instead located in spaces created for them adjacent to the north wall of the remaining original building section and were laterally loaded through connections to the existing building floor diaphragms.

An EDI Opportunity

Building design team members EYP (architectural and MEP) and Pinnacle Engineering (structural) typically employ BIM in the preparation of construction documents and regularly shared and coordinated our Autodesk Revit models throughout the design process for Davidson Hall. During the construction documents phase—and thinking ahead to the traditionally time-consuming process of structural steel shop drawing preparation and review and its effect on the early construction schedule—Pinnacle developed an idea to improve that process. If we could somehow move our Revit Structure model through the traditional interface associated with the transfer of two-dimensional construction documents from the A/E to the construction manager, then provide it directly to the structural steel fabricator for shop drawing preparation, we might achieve measurable benefits for the university and every member of the team. Specifically, we might:

- ➤ Enable the detailer to create its detailing software model based directly upon our 3D Revit model rather than on an interpretation of 2D structural drawings
- ➤ Dramatically reduce the number of (or possibly even eliminate) requests for information associated with the preparation of shop drawings and the time associated with processing those RFIs
- ➤ Receive, review and process the structural steel shop drawings electronically



Pinnacle Engineering, PLC

TYPICAL SLOPED ROOF X-BRACING DETAIL

NOTE: DESIGN BRACE CONNECTIONS FOR 10 KIPS AXIAL LOAD IN EITHER DIRECTION

➤ A section at the roof mansard.

➤ The west elevation of the building in Revit, Tekla and structural steel.

- ➤ Substantially reduce the time to shop drawing approval, structural steel acquisition and fabrication and start of building structure erection
- ➤ Increase the quality of the in-place structural steel
- ➤ Reduce the number of field changes and potential change orders associated with the building framework
- ➤ Accelerate the early stage of the construction schedule associated with getting the structural framework and floor structures in place

In order to accomplish this, the support and commitment of the full team would be needed, and it was clear there could be no "working it out" at the beginning of construction when there is no spare schedule time. That support and commitment were immediate and positive, starting with a conversation where EYP's project manager and its director of architecture endorsed the initiative for sharing the Revit model; Virginia Tech's project manager also committed his support during the construction documents phase. From there, Barton Malow facilitated early contact with the project structural steel fabricator, SteelFab, and the "Can you read this?" back-and-forth exchange with Revit and Tekla trial models began. To establish an accurate conversation between Revit and Tekla that could be applied to the Davidson Hall structural steel package, SteelFab handled the trial model translations at its Charlotte engineering office rather than delegate that activity to Prodraft, the steel detailer. After several cycles of debugging, we introduced the Davidson Hall Revit Structure model and were prepared to confidently move forward with an electronic data interchange (EDI) approach.

As 2D contract documents were issued by the A/E team, Barton Malow forwarded a release from liability for its use of the Revit Structure model for the intended purpose, and Pinnacle provided its Revit model for use by SteelFab in preparing shop drawings. SteelFab constructed a Tekla model based directly on the Revit model and provided the Tekla model to Prodraft for preparation of structural

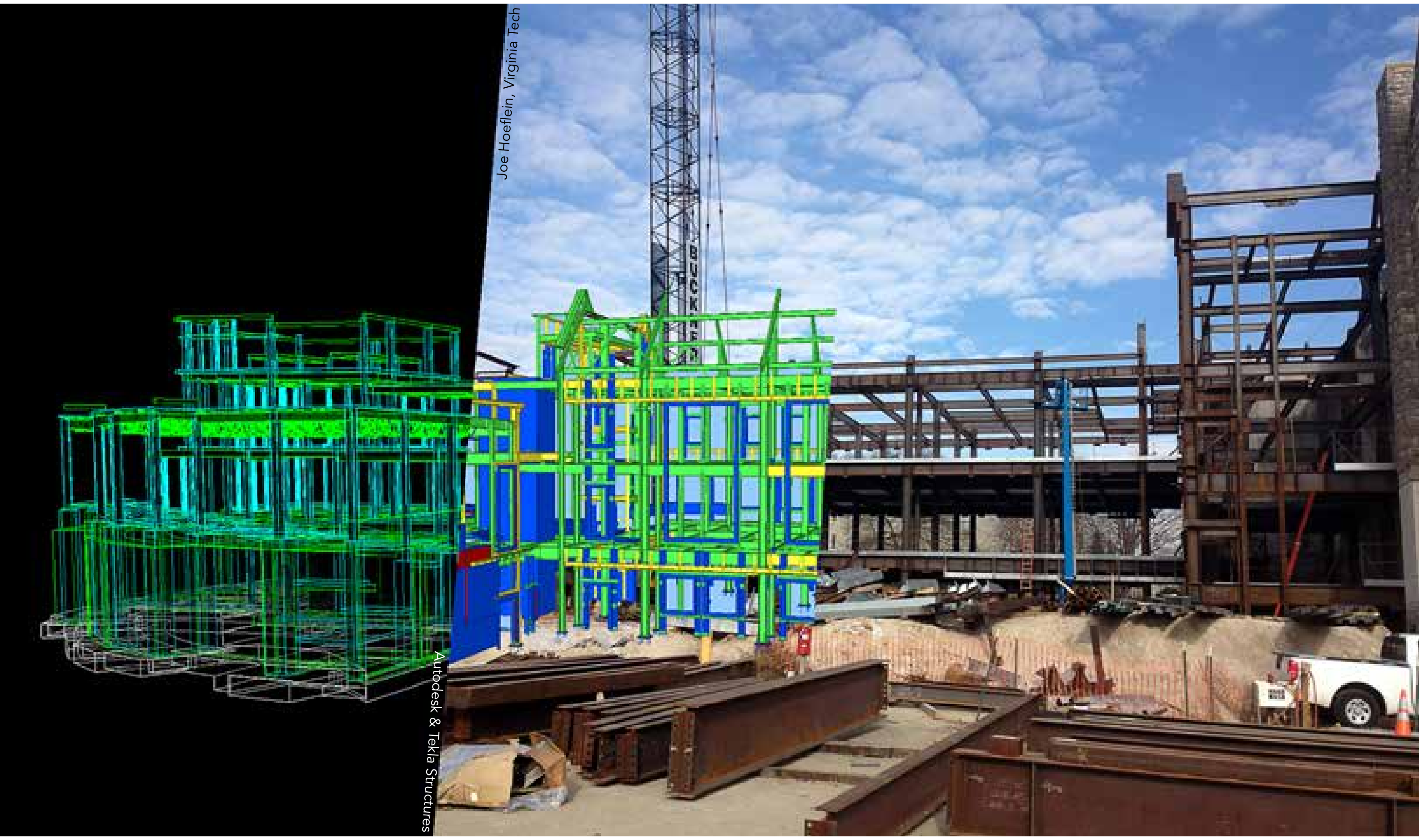
Word of Mouth

Various team members spoke to the benefits of the EDI process:

Barton Malow project manager, Jim Miller: "Because the steel shop drawing process was so smooth, we were able to reach out to the elevator manufacturer and take the range of shaft sizes that the A/E had proposed, identify the ideal dimensions specific to the selected elevator manufacturer and verify/adjust our steel to accommodate—without affecting the steel production stream or installation time table. Not a single piece of steel, including the complex radius at the auditorium, had to be sent back due to a fabrication error. Every piece fit perfectly on the first try."

SteelFab senior engineer, Mike Stewart, P.E.: "When we found out that the design team was interested in doing a paperless review and was interested in the recommendation we made to use our preferred detailing software, we were more than happy to invest in the process and purchase a temporary license (of Tekla's In-Model Review for Pinnacle Engineering) to make that happen. We feel our investment was well returned in the benefit of a streamlined approval review and minimal cost of scrubbing drawings prior to fabrication. Using the Revit model provided by the design team to generate our Tekla model for detailing helped limit the number of RFIs that had to be generated for our team to fully model and detail the structural steel components. This alone is a major benefit when working with an aggressive schedule. From our perspective as a fabricator, this type of project collaboration is a no-brainer. We find benefit at every level of our team—from detailing/engineering and project management to production and erection."

Virginia Tech project manager, Joe Hoeflein, P.E.: "The electronic data interchange worked so well that getting steel ordered was no longer on the critical path of our schedule. Our project benefitted from a two-month overall schedule reduction."


Joe Hoeflein, Virginia Tech
Autodesk & Tekla Structures

steel shop drawings that were subsequently submitted electronically for review; SteelFab also purchased and provided to Pinnacle a 24-month license of Tekla In-Model Review to facilitate the structural review. Two Pinnacle engineers reviewed the shop drawings that were submitted electronically in three sequences at two-week intervals. And the approach was immediately beneficial. Review of column locations in the lecture hall curved exterior wall revealed several instances where the rounded dimensions locating the columns on the construction documents differed slightly from the submitted model locations. EYP quickly affirmed Pinnacle's recommendation to direct Barton Malow and SteelFab to follow the precise model in lieu of the 2D construction documents in those particular instances. The few review comments were appended to the paperless submittals, and they were returned electronically to Barton Malow without requirement for resubmittal.

Documented Benefits

The last beam in the 497 tons of structural steel was set on December 19, 2012, and the team began a benefit assessment of the EDI process prior to the topping-out ceremony. With the last beam in place, the goals set by Pinnacle for use of its Revit Structure model in the construction phase had become reality. The 50% time reduction for shop drawing turnaround and the two-month construction schedule reduction, with an "every piece fitting perfectly, on the first try" level of quality, were significant accomplishments. But they couldn't have been realized without participation from the rest of the design and construction team. The combination of structural steel and EDI support from all of the players yielded great chemistry and eye-opening benefits. As a result, the EDI process is now an integral part of the design and construction administration on all of our structural steel projects. MSC

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