The Suite Life

BY ERIC ROTH, P.E.

An innovative steel system is seeing increased use in university residence halls, as illustrated by a current dorm project in Pennsylvania.

IN LATE 2005, A RESIDENCE HALL PROJECT AT KUTZTOWN UNIVERSITY WAS IN THE MARKET FOR A STRUCTURAL SYSTEM. As the design team, we were determined to employ a system that would not only be cost-effective, but would also exceed expectations for speed and possible winter construction.

We ultimately chose the Girder-Slab System. Often schedule-driven, with the need to meet occupancy requirements for incoming students, the student housing market has increasingly turned to this system. To date, it has been utilized on nine student housing projects at colleges and universities throughout the U.S. It will also be used for a project at the University of North Florida, currently in design, and was recently chosen for a 200,000-sq.-ft mixed-use North Quad student housing facility at the University of Michigan.

Why Girder-Slab?

The new steel and precast composite 258,000-sq.-ft residence hall at Kutztown U. (in Kutztown, Pa.) is scheduled for occupancy by August 2008. It will include retail space and meeting rooms in addition to providing 856 beds and several apartment-style units.

When the project was awarded to our firm, I immediately knew what system we should use (see the sidebar "Discovering D-Beams"). The challenge was convincing our chief structural engineer, the project manager, and the client that Girder-Slab was the way to go, given that we had no track record with this system. What finally convinced everyone was the erection speed. Girder-Slab indicated that with sufficient erection forces and completed foundations, the building frame, with floors in place, could be erected in 40 days. In the student housing market, if the building isn't in place at the start of the school year, a school can suffer huge revenue losses.

Getting to Know the System

The Girder-Slab System, like any other steel frame, can use several different lateral load resisting systems, but of course some work better than others. Moment frames can be used, but D-Beams—the heart of the Girder-Slab System—are very shallow, only 8

or 9.645 in. deep, and therefore do not have very high moment capacities. Columns in moment frames often are required to be deeper, making it more difficult to bury them in the walls of a housing unit. Shear walls can be used for lateral loads, but bringing another trade on board only slows down the erection.

We found that the Girder-Slab System works best with braced frames; the issue is finding places within a housing unit to place bracing. Due to the short column-to-column distances, the braces tend to be steeper than optimum, and brace forces in mid-rise structures can be very large. Bracing locations need to be addressed early in the project since they often require thicker walls to conceal the bracing, which needs to be worked into the overall architectural floor plan.

The Girder-Slab web site (**www.girder-slab.com**) offers several different types of typical connections of D-Beams to columns, including shear tabs, end plates, and column trees. Our drawings were set up to allow the fabricator a choice of connection types. The fabricator opted for end plate connections. The Girder-Slab standard details we used show a typical end plate connection with bolts to the column outside of the beam flanges.

In retrospect I would opt for end plate connections with the bolts inside the beam flanges. Having the bolts outside the beam flanges brought up the questions of whether this was truly a pinned connection and whether we were introducing unintended moments into the column. Also, since the end plates and the bolts on the top side of the connection extend above the precast plank and topping, we have had unanticipated issues with the plates and bolts being in the way of wall framing. Moving the bolts inside the beam flanges on end plate connections avoids these issues. Using the 9.645-in. D-Beam, there is room to tighten the bolts. The FAQ technical section of the Girder-Slab web site suggests two bolts above and two bolts below the bottom flange. Girder-Slab's new design guide will also suggest this.

Finding a Way

Several places in the building required spans that were larger than the 15-ft column bays typically used with Girder-Slab System. One of these was a lower level vehicle pass-through. In this case we were able to use the column tree-style connection. Each column branch was extended 3½ ft, allowing us to increase the span at this one location to 22 ft. Column branches were used on each side of the columns in question in order to balance the loads into the column and reduce the amount of moment introduced into the column. As with all longer spans the engineer must be aware of the amount of dead load deflec-

Steel erection at Kutztown University occurred this summer. Lateral bracing is provided by chevron braces strategically located to avoid window locations.

Discovering D-Beams

The main structural elements for the Kutztown University project are D-Beams, the heart of the Girder-Slab System. Our choice to go this route was actually due to our experience on a project prior to the Kutztown building. This first project was a seven-story housing unit for another university, and the owner had requested a block-and-plank building. During the gravity portion of the design, as our engineer's design reached the bottom floor for the bearing walls, he found that he simply could not get the block to take the dead and live loads from the floors above.

As in many housing units, there were numerous doors along the center hallway bearing walls. Thicker walls or multiple widths were not an option, as reduction in room size or expansion of the building width was deemed unacceptable. Going to a conventional steel frame system would have increased the building's floor-to-floor height and its overall height of the building—another unacceptable scenario. At this point, the design ground to a stop, as we had no solution for bearing walls given the constraints on the project. Unfortunately, our structural group was removed from the project, and we were made aware that an outside engineering firm had come up with a solution.

Professional curiosity being what it is, we inquired which system and engineer were completing the project. The engineering firm, O'Donnell & Naccarato, Inc., Philadelphia, was actually the engineering consultant hired by Girder-Slab Technologies to oversee the original laboratory and full-scale testing program.

Through further research we discovered D-Beams, which were used for this project. A D-Beam is a castellated tee beam with a flat bar welded to the web to form the upper flange. The D-Beam initially supported the plank weight and construction loads—on its bottom flange—and then was doweled and grouted to form a composite section for post-erection loads. I was left thinking, "We could have done that if we had only known." Lesson learned!

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tion in the system. This is especially true with the shallow D-Beam members. Even in lightly loaded members, deflections can become excessive.

A typical detail for attaching the plank to the framing is to use weld plates in the bottom of the plank to connect it to exterior spandrel beams. Attaching the D-Beams to the plank is typically accomplished by running reinforcement through the beam castellation and grouting the gap to make the beam composite with the plank. During erection, multiple floors of plank may be set before grouting the plank. The erector will often plumb the structure using cables and come-alongs. We soon found that as the cables were tightened during the plumbing operation, the columns were being pulled closer together since there is no physical attachment of plank to the D-Beams prior to grouting. Angles and shims had to be added between the plank and the columns to prevent the plank from any movement on the bottom flange of the D-Beam. In the future I would require planks bearing on D-Beams that are adjacent to the columns to have weld plates installed, thus preventing movement.

The Right Choice

Was Girder-Slab the right system for this project? Absolutely! While the Girder-Slab System has span limitations and requires numerous columns, its speed of erection and clear underside of structure are big pluses when dealing with housing units or hotels and low floor-to-floor heights. There are some detailing items that must be addressed during the design as mentioned above, and as with any new system there's a bit of a learning curve. But the system itself can be analyzed just like any other steel frame system. MSC

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