Coordinated Construction

John Cross, P.E.

The Girder-Slab™ System helped reduce construction time for a graduate student housing project at Princeton University.

In 2002, Princeton University authorized the design and construction of a seven-building graduate student housing complex adjacent to the existing Lawrence Apartments near the Princeton, NJ main campus. The goal of the project was to increase graduate student housing by the beginning of the 2003/2004 academic year.

The complex consists of two steel-framed five-story structures and one steel-framed six-story structure, totaling 131,000 sq. ft. Four three-story concrete block and plank structures comprise 81,000 sq. ft. The mid-rise steel-framed buildings are serviced by elevators, and the three-story concrete buildings are designed as walk-up structures with internal stair systems. In order to achieve fall occupancy for the steel structures, an aggressive construction schedule was required, including winter work.

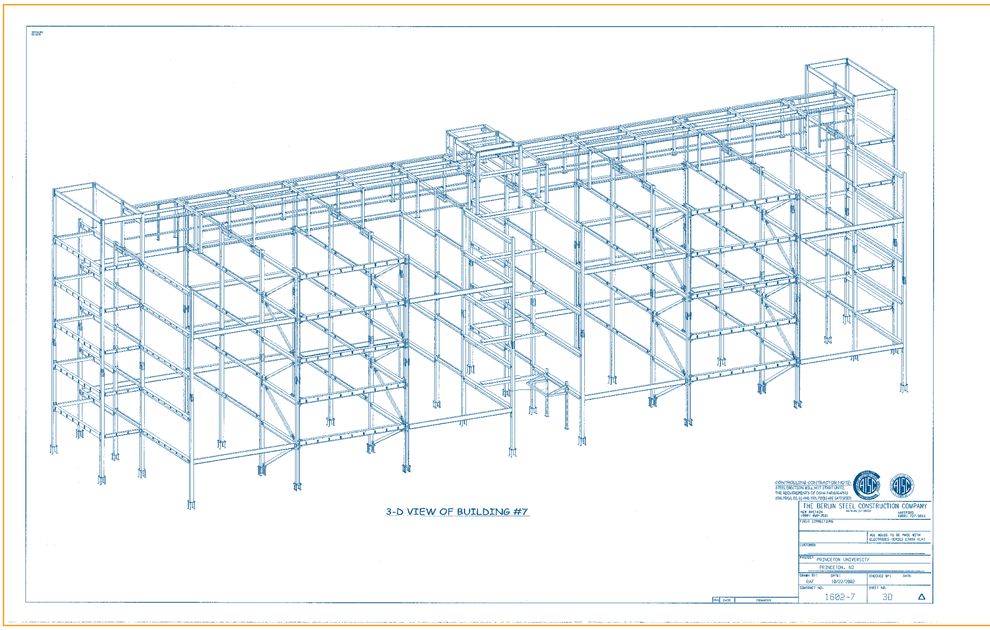
The selected designer and general contractor were sister companies, The Henderson Design Group and Henderson Corporation of Raritan, NJ. To meet the schedule, construction was phased, with the steel-framed mid-rise structures constructed in the winter months and the concrete low-rise structures in the spring and summer. The Girder-Slab™ System was chosen as the framing and floor system for the mid-rise structures. The combination of steel-frame erection with the setting of pre-cast hollow-core plank on the erected steel allowed for construction to conform to the desired schedule, even in the face of one of the most severe winters in recent New Jersey experience.

Developed by Girder-Slab Technologies, LLC, the Girder-Slab System is a steel-and-precast hybrid developed for use in mid- to high-rise residential construction. It utilizes precast hollow-core slabs with an integral steel girder to form a monolithic structural-slab assembly. The system uses a special steel beam as an interior girder supporting the precast slab on its bottom flange. This open-web dissymmetric beam, referred to as a D-Beam™, is assembled in-place. The precast slabs are scribed with 8″ knockouts at the end of each core. The knockouts are broken in the field with the concrete debris pushed back into the core to form a dam. Reinforcing bar is then run through the open web of the D-Beam into the hollow-core openings and grouted into place. This process results in a system that develops composite action, enabling it to support residential live loads.

The Girder-Slab System currently utilizes two basic D-Beam Girder sections for use with 8″ precast slab: the DB-8 and the DB-9. The DB-8 provides an 8″-thick slab assembly, and the DB-9 is designed for use with a 2″ concrete topping that results in a 10″-thick slab. Precast slab lengths can generally span as long as 28′.

The advantages of Girder-Slab for residential construction projects generally are seen as the opportunity to trim 25% off of the construction schedule and the ability to maintain equivalent floor-to-floor heights with cast-in-place concrete. "The project team and system delivered as advertised and allowed the project to continue even as the weather did not cooperate through the winter," said Andrew Balto, principal of The Henderson Design Group.

The new graduate housing utilizes DB-8 D-Beams with 8″ hollow-core plank spanning 24′-26′. The structural engineer worked closely with the plank manufacturer to incorporate a large



Building 7, whose 3-D erection drawing is shown here, was erected in three weeks.

Typical columns are W8×48. The lateral bracing system combines diagonal braces and moment frames.

D-Beams™, licensed from Girder Slab Technologies, LLC, are framed within the depth of the concrete plank. Their bottom flanges are nearly flush with the underside of the plank.

number of penetrations in the plank that supported a geothermal circulating water-heat-pump HVAC system. A ¾″ topping will level the cambered planks. This step has been avoided on similar projects by clamping the precast slabs prior to grouting.

Steel fabrication and detailing services were provided by AISC-member fabricator Berlin Steel of Malvern, PA. The steel contract included all structural steel for the three steel-framed buildings, penthouse structures for six of the seven structures, and all miscellaneous metals on the project. The structural portion consisted of 452 tons of structural steel, of which 32 tons were D-Beams.

Erection began on February 13, 2003, using a 150-ton hydraulic crane. Original plans had called for the use of two cranes, but site and weather conditions limited the operation to one. The two five-story buildings were hung, planked and grouted in a total combined time of four weeks. Included in that period were five days of downtime caused by severe winter snowstorms that inundated the Princeton area with 22.6″ of snow. The total number of working days to erect the two five-story buildings (96,000 sq. ft) was only 17 days, including plank and grouting. The plank supplier worked closely with the fabricator and erector to coordinate plank deliveries to the site.

The taller and more complex six-story building (35,000 sq. ft) began erection on March 24 and was completed three weeks later, including four days lost because of rain. During the erection sequence, the engineer of record determined that four floors of precast deck could be placed on the steel frame before grouting was required. Temporary erection beams were used to stabilize the frame prior to the placement of the plank, which, after grouting, functions as a spandrel beam in the structural system. The temporary erection beams are then worked up the structure in a series of steps as the plank is installed, and grouted to a point where they are left in place at the roof level as a wide-flange spandrel beam.

Two challenging aspects of the project for the fabricator were the coordination of the hip-and-valley penthouse steel with the architect and the aggressive erection schedule during difficult weather conditions. Both challenges were handled successfully.

The structural system utilizes W 8 × 48 as typical columns. Lateral loads were handled through a combination of diagonal bracing located unobtrusively between units and rigid frames along the exterior column lines. Wide-flange tree columns were utilized to extend the span of the D-Beams between column lines and simplify field erection. All of the connections were bolted using either standard Berlin Steel connections or connections specified in the Girder-Slab Design Guide. The fabricator selected connections that minimized the sharing of bolts to aid erection safety. Typically these consisted of column-web connections with a stiffened-seat and single-angle beam connections.

Spray-on fire protection was utilized on the building frames. The lower flange of the D-Beam was spray fire-protected according to the UL Floor-Ceiling Design K912 rating, classified for two- and three-hour assembly ratings. K912 allows fire protection methods that use either spray-applied fire protection or gypsum board.

Key to the success of the project was the teamwork that characterized the relationships between the designer, general contractor, steel fabricator, erector and plank supplier, and the effective utilization of an innovative steel framing system.

More information can be obtained on the Girder-Slab System by contacting Girder-Slab Technologies at 888.478.1100 or visiting their web site at www.girder-slab.com. ★

John Cross is National Project Director, AISC Marketing LLC, Chicago.

OWNER
Princeton University, Princeton

STRUCTURAL ENGINEER
O'Donnell & Naccarato, Princeton

ARCHITECT
The Henderson Design Group, Raritan, NJ

STEEL FABRICATOR/DETAILER
The Berlin Steel Construction Company, Malvern, PA (AISC member)

ERECTOR
JL Erectors, Blackwood, NJ

GENERAL CONTRACTOR
Henderson Corporation, Raritan, NJ