Scientific Solutions

By Akbar Tamboli, P.E. and Cristina Martinez

A two-way steel truss floor system satisfies vibration criteria and provides space planning flexibility at the National Institute of Health's first steel-framed facility in Bethesda, MD.

The new John Edward Porter Neuroscience Research Center at the National Institutes of Health (NIH) campus in Bethesda, MD, is an impressive and unconventional research building with striking architecture and an innovative structural system.

Neuroscience research has made tremendous progress in recent years, with the potential for many more breakthroughs in the near future. The Porter Center offers an environment conducive to collaborative research among scientists from all clinical departments of neuroscience, as well as researchers from clinical departments of neurology, psychiatry, neurosurgery, medicine and anesthesiology. It houses approximately 100 principal investigators from various institutes working in an integrated environment, sharing space and ideas.

Sizeable Structure

The building's seven stories, including a basement, fit within an overall height of 37 m (121′). The 55,300 m^2 (596,000 sq. ft) facility was built in two phases. Phase 1 completed in spring 2004, while Phase 2 will not conclude until summer 2007. Phase 1 consisted of constructing 24,800 m^2 (267,000 sq. ft); Phase 2 will provide the remaining 30,500 m^2 (329,000 sq. ft).

The phased approach allows research to continue throughout construction, first at the existing building and then at the new facility. The goal of collaborative research required a building design that would provide space-planning flexibility. Labs are arranged by research focus, rather than by institute affiliation. They also allow for any reconfiguration necessary as research methods and the number of researchers change.

In April 2000, NIH launched a design competition to select the design team for the project. Rafael Viñoly Architects, PC, was selected to design the revolutionary new building. The challenge was to produce floor plans that could be reconfigured to accommodate research needs, to conform to the NIH campus master plan, and to create a beautiful space. The resulting design is based on square modules, each roughly 37 m by 37 m (121′ by 121′), which meet criteria such as comfortable walking distances and visual perception of space. The floor plan is comprised of six modules arranged in a nine-square grid. The modules rise vertically to become an array of cubes surrounding the central atrium (which forms the seventh module). The prominent five-story atrium serves as the building's main entrance and houses meeting and seminar rooms and a café. The transparent glass and steel atrium features an off-center monolithic tower that houses an elevator core and partially supports the faceted roof. Through peripheral ramps and transverse bridges, the atrium serves as a connector between the modules and a central gathering area for the scientists.

Vibration Control

For laboratory floor systems, strict vibration criteria often drive structural design. To maintain a high degree of accuracy, sensitive equipment requires minimal disturbances. A relatively stiff

Phase 1 of construction of the Porter Center during erection of the trusses.

and light floor is ideal to minimize the floor vibrations from footsteps. The criteria for the Porter Center was established according to the following area uses:

Office without lab
Velocity (µin./sec) = 8000

Laboratory area with bench microscopes
Velocity (µin./sec) = 2000

Electron microscope areas up to 30,000× magnification
Velocity (µin./sec) = 500

Layout Flexibility

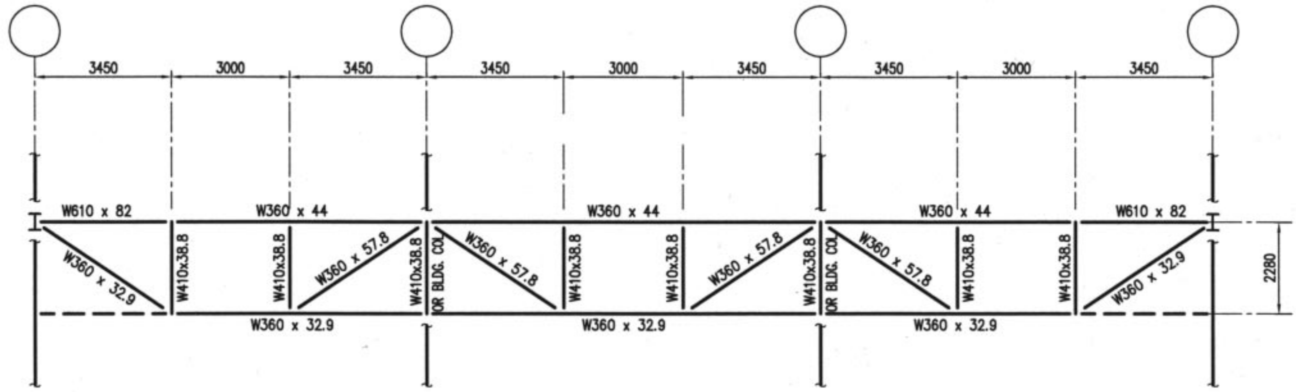
The pioneering research goals for the Porter Center only could be achieved in a building that provided maximum flexibility for future layout changes. As science evolves and research practices change, the laboratories will be rearranged accordingly. To accommodate a variety of layouts, the building structure allows for possible penetrations on the major and minor grid lines, following a 3.3 m grid (11′) aligned with the column layout.

Refining the Structure

A cast-in-place concrete waffle slab system was initially selected as the floor system for the building. However, in order to meet the most restrictive criteria of 10 µin./sec., the steel system was eventually identified as the most cost-effective option to control vibration and simultaneously allow for the needed space planning flexibility. The Porter Center is the first building on the NIH campus with a steel structural system. TTE subsequently revised its initial steel design to a two-way, 3-m deep (10′) Vierendeel truss floor system with 200 mm (8″) precast planks spanning between the trusses at 3.3 m (11′). The moment of inertia of the steel members influences the stiffness of the Vierendeel trusses, so deeper members are more efficient. This differs from conventional diagonal trusses that rely solely on the area of the members. To provide room for deeper members, the precast planks were recessed into the trusses to achieve maximum structural efficiency while satisfying the architectural requirements. For further flexibility, an eccentric beam-to-post configuration was developed to allow for penetrations and greatly simplified connections. Although this structural system satisfied all the requirements, further brainstorming produced a more refined version even better suited to the structure. During this process, the design team determined that not all Vierendeel bays had to remain open for proper laboratory function and flexibility.

Final Structure

The final structural steel floor system is a variation of the earlier two-way truss



Elevation of truss types 1, 2 and 3.

system. The trusses are hybrids of Vierendeel and Pratt-type trusses (otherwise known as inverted Queenpost trusses). This creative design, which utilizes trusses spanning 9.9 m (32′) and spaced at 3.3 m (11′), proved much more efficient than the previous truss system. Not only is it 35% lighter (steel tonnage without connections) while providing the same stiffness, it also allows for the slab system to rest above the top of the steel since the inherent behavior of these trusses lessens the need for deep members. Therefore, deck/plank supports are not necessary, , thus permitting typical concrete on metal deck construction to be used.

Cost Competitive

The use of structural steel successfully realized the project's objectives and produced a cost competitive alternative to the usual lab-floor construction methods. While the structural steel framework is very stiff, it is also lightweight and causes no obstruction to building functions. In addition, the truss floor system provides an ideal accommodation for the mechanical, electrical and plumbing systems.

Extensive coordination and collaboration among the members of the design team were critical to the progress and success of this project, as was the structural engineers' active involvement during the construction phase to ensure that the intricate structure was built according to plan. ★

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