Staggered Truss System Earns an A+

by Matthys P. Levy, P.E.

The administration saw the Baruch College Academic Center as an excellent opportunity to obtain a variety of needed facilities. Sited on a midtown Manhattan block, the Center is an urban campus in three dimensions. The building is organized around an atrium that extends upward, fifteen stories from the ground level, changing shape as it rises. Below grade rests a world-class athletic facility with two gymnasiums, a pool and racquetball courts. Also located below grade are a performing arts center with an auditorium, a theater and a student center. The academic spaces reside on the upper floors and include classrooms, computer labs, lecture halls, faculty offices and lounge. Elevators located on one end of the atrium and a multitude of stairways provide vertical transportation for the three thousand students that will pass through the building every day. The academic spaces are arranged so that students will use the elevators only when arriving and generally be able to use the stairs, climbing or descending no more than two stories between their classes and offices during the day.

The atrium looks as if it had followed the path of a lightning bolt that cut through the building. It penetrates the south façade of the building on the upper floors and extends down to the ground floor on the north side, allowing daylight to flood the center of the 200' by 330' building. Both the north and south sides of the building have vertically curved facades that not only add to the structural complexity of the building but introduce visual excitement as well.

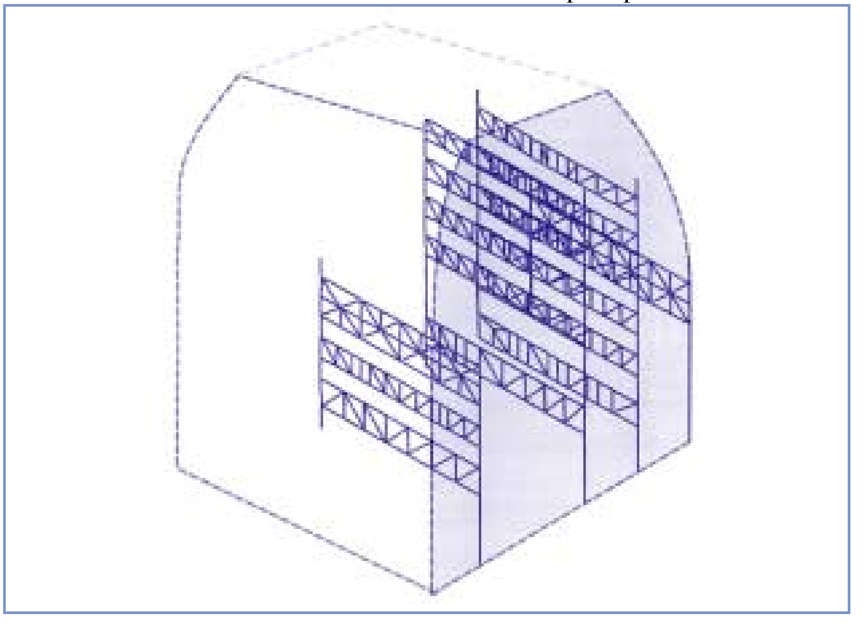
Foundation

The site occupies a 197' blockfront on Lexington Avenue between 23rd Street and 24th Street and extends 336' east toward Third Avenue. The western end of the site is excavated 42' down to provide three levels below grade. An Olympic size swimming pool in the central part of the site extends a further nine feet below the lowest basement. The eastern end of the site, only excavated for two basement levels, avoids heavy rock excavation in the vicinity of an existing residential building. In general, all footings are on rock with a 40-ton capacity except in the eastern end of the site where the bearing capacity equals 20 tons per sq. ft. Recognizing the sensitivity of the neighbors, vibration monitoring of the adjacent properties was instituted during the rock excavation phase of the project. Ground water is located about 45' below grade, which places it below the lowest basement but above the bottom of the pool. To counter the resulting uplift forces on the pool slab, rock anchors spaced eight feet on center in each direction were provided. The lowest basement level, except for the pool area, contains an underdrain system to catch any stray water that may seep through the rock. Sheeting with a temporary tie back system builds the basement slabs and walls without the encumbrance of internal bracing.

Staggered Truss Superstructure

To accommodate the various aspects of the program, structural spans varied from 30' to 120' and were distributed both in plan and vertically throughout the building. Given that steel would provide the only solution for this problem, a conventional approach would have been to design girders or trusses above the longest span spaces. Such a solution was explored in the preliminary design phase of the project and showed a severe penalty in tonnage of steel, therefore increasing the cost. Since the $168 million budget for the project was fixed and very tight for an academic building of 785,000-sq. ft., another approach was needed. Weidlinger Associates proposed reorganizing the building to achieve an efficient structure that included staggered trusses to accommodate the longest span spaces. With only minor revisions to the original layout, the architects, KPF, placed the longest span spaces on the east side of the building. The relatively smaller theatre and auditorium were placed on the west side, which has a typical steel beam and concrete slab on metal deck framing system. Classrooms and offices, positioned throughout the building, shifted as needed to accommodate the new plan.

To develop a space and cost-efficient frame for the long span side of the structure, Weidlinger engineers used the staggered truss concept very efficiently. Originally developed for apartment buildings in the 1970s by MIT engineers, the concept introduces story deep, long span trusses arranged in a staggered pattern vertically. In this way, floors only have to span from the top chord of one truss to the bottom chord of the next one, while the open space on each floor is



Perspective view of staggered trusses within building envelope.

Vierendeel openings in story-high truss.

double the floor span. Viewed three dimensionally, the whole system provides rigidity in the direction of the long span trusses with the floors acting as diaphragms, transferring loads from one truss to the next as lateral forces descend to the ground.

Open Floor Plan

The principal advantage of using a staggered truss system lies in the ability to create wide-open spaces within a restricted floor-to-floor height. The disadvantage is the existence of diagonal members crossing the space along the truss lines. To overcome this problem, Vierendeel panels allowed corridors to pass through. Since such Vierendeel panels introduce bending in the truss members, a penalty of increased steel weight occurs. To minimize this effect, the Vierendeel panels were positioned as close to the center of the truss as possible where the bending effect is the least. In addition to the staggered trusses on the east end of the building, numerous other isolated trusses satisfy specific planning requirements. For instance, a two-story high truss between the fourth and sixth floors carries the loads of the two floors below it with a hanger system and also supports the floors up to the penthouse above. Since this truss is on the curved façade of the building, it is sloped to match the façade contours. There are other trusses at the ground floor over the pool, the gym and the theatre. In all, the project includes twenty trusses, most of which are a story high and 120' long.

Lateral System

Since the building's structural grid is so irregular, providing lateral force resistance against wind and seismic forces proved to be a challenge. In the east-west direction, the staggered trusses provided a substantial portion of the lateral force resistance. In the north-south direction, vertical braced frames were introduced for lateral stiffness. But, as nothing in this structure is straightforward, the position of the atrium that virtually cuts the building in half required the interaction through the floor diaphragms to distribute the lateral force around the atrium.

Circular stair on north side of building.

Finally, the sloped faces of the north and south facades above the sixth and eighth floors respectively, introduced horizontal forces that had to be resisted by the vertical bracing system.

Cladding

To support the façade of the building that includes masonry and metal panels, girts were placed outside the columns at a vertical spacing dictated by the requirements of the panels. This material was included in the 6600 tons of steel provided by the fabricator.

Conclusion

The imaginative application of the staggered-truss framing system to this structure allowed the owners to combine their varied program needs into a mixed-use structure, maximizing their investment.

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