AWARD WINNING PROJECTS

The Lancaster Center was presented a Merit Award (Building Projects $5M to $25M in construction value) in the NCSEA Fifth Annual Excellence in Structural Engineering Awards program.

Lancaster Center

Award Winning Addition to Houston's First Presbyterian Church

By: Peter "Chip" Hurley, PE

In this, the second in a year long series of "Award Winning Projects", we provide some additional structural detail on the project. A tight location, a generous space program, and an earnest desire to respect the scale of the existing campus culminated in a need for an extraordinary solution for the new Lancaster Center. Structural engineers developed conventional and unconventional solutions for the unique requirements and constraints presented by this project.

Challenges

As engineers, we all claim that we want challenging projects. We glean satisfaction from accomplishing the unusual or the extreme. But by definition, anything that is unusual is unique. And something that is unique is seldom, if ever, efficient to engineer. At Matrix Structural Engineers, we consciously avoid the kinds of projects and clients that lead to "commodity" work. We seek the unique and the challenging. On more than one occasion, I have felt over-challenged by architects that dream the impossible dream. However, my most satisfying work has been on projects that can best be characterized by realizing the "barely possible dream".

Lancaster Center is such a project. While it is very unusual to see an entire second floor suspended from the roof above, it is relatively common to see a balcony or mezzanine suspended from above. Except for size, there is no difference between suspending an entire floor and suspending a balcony or mezzanine.

In 1996, our office worked on the restoration of a 100 year old church in Huntsville, Texas. A large portion of the balcony and second floor were suspended from large wooden roof trusses above. Below the second floor, there were an abundance of partitions within which to hide columns, but we could not find a trace of a column. The steel columns above the second floor were readily visible. After concluding that the "columns" might be in tension, Dr. Moyeen Haque,PE, a partner at MATRIX, and I made our way to the appropriate spot in the attic and found that the columns had no cap plate, but instead the "columns" extended through the bottom chord of the roof trusses. A large bearing plate sat atop the bottom chord at a panel point. The so called "column" extended through the plate and was threaded. It was tensioned with a pair of giant double nuts.

We used a lesson learned from a very old building to a help a client solve a problem in a new building.

Structural Solutions

The first problem in need of a solution: In order to maintain the sense of scale at the site, and to accommodate the three stories required to enclose all of the space required, the architects wanted to use a basement to recess the building one floor into the ground and keep the roof eave height at the level of the existing buildings. A basement would require the use of a retention system. Drilled concrete soldier piles were chosen to retain the earth around the perimeter of the basement. In addition, extensive waterproofing and dewatering was required. The stiff clay at the site is easy to excavate but it is watertight… it just does not drain well. The water table is high, and local basements often leak.

Problem Number 2: The multi-purpose room was going to require a clear span of at least 88.5 feet, and would need to be two stories in height. If located above the classrooms, the roof could be easily framed with conventional trusses. However, this would place the classrooms in the basement. The challenge: Could the classrooms be located above the multi-purpose room? There could be no columns supporting the floor of the classrooms. The clear span would remain 88.5 feet, and in order to match the existing eave heights, the structural depth of the floor was limited to 24 inches. Such loads, spans, and depths proved to be incompatible for conventional steel framing. Final solution: suspend the second floor from trusses located within the roof above. An unusual but not unheard of solution, it appeared feasible because the interstitial space between the roof and the second floor ceiling varied from 11.0 ft. to 12.0 ft. However, the architectural drawings called for the ceiling height to be several feet higher than the eave height. This would lead to trusses that required the top diagonal chord to "cantilever" outwards several feet in order to bear on the columns, since the bottom truss chord would not be able to extend to the column.

A computer model was created using Risa-3D, resulting in an unusual but reasonably efficient truss. Mechanical mezzanines were added in the interstitial space between the roof and the second floor ceiling. The mezzanines are 3 inches of normal weight concrete on 26 gauge deck supported by steel bar joists that bear on the top flange of the bottom chord. As the eave line is below the second floor ceiling, the bottom chord could not attach to the end diagonal chord at the end of the truss. This put a high bending moment in the end diagonal chord, resulting in the selection of deep stiff wide-flange section (W 21x122).

Problem Number 3: It became evident that several columns along the east side would have to be omitted because the room requirements had expanded to allow space for the theatre seating to retract. Omitting the columns created an enhanced view of the stage from the entry area and upper deck, which were located at ground level. However, leaving out several columns in a row presented a problem since the second floor envelope was limited to 24 inches.

Matrix solved this problem by creating a super truss, dubbed "Truss X", to be located in the east wall. The bottom chord was buried in the second floor of the structure. The ends of the roof trusses connected to the top chord of "Truss X" instead of a column. The second floor and part of the lower roof were to bear directly on the bottom chord.

Conclusion

The individual engineering concepts employed were not out of the ordinary, but the method and combination of the concepts were certainly unusual. The structural steel tonnage worked out to 432 tons (9.75 psf), which is not much more than a typical composite office building and only slightly higher than a similarly framed composite steel structure with more typical spans.

The role of the structural engineer was very crucial to the success of this structure. The building functions extremely well, it respects the existing scale of the campus, it was completed in a timely fashion and, despite the exotic structure, the cost was within the budget.

In 1993, Peter "Chip" Hurley, PE founded Matrix Structural Engineers, Inc., Houston, Texas. Matrix is a 17 person firm that exclusively provides structural consulting services for buildings.

Project Credits

Owner – First Presbyterian Church of Houston
Structural Engineer – Matrix Structural Engineers, Inc.
Architect – Merriman Holt Architects
Contractor – W.S. Bellows Construction Corporation
Fabricator – Western Steel, Inc.
Erector - Metro Erectors, Inc.