Design of Unique Structural Systems for the Corning Museum of Glass Expansion

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Summary

This paper discusses the combination of steel, cast-in-place, and precast concrete structural systems developed and implemented in the design of the 9500 m^2 Corning Museum of Glass North Wing Expansion project in Corning, New York, USA. The structural system for the Museum building consists of a series of 6 m tall cast-in-place concrete serpentine cavity walls that act in tandem with a system of wide, shallow concrete band beams within the gallery level slab. Together they span as deep beams between concrete walls and columns below. The gallery building roof structure consists of closely spaced exposed precast concrete joists that are 122 cm deep and 9 cm thick which span up to 17 m between the serpentine concrete walls and a steel perimeter structure. These three unique structural elements were combined to form a structural system that is integral to the architectural form and performance and that is expressed throughout the minimalist interior spaces.

Keywords: precast concrete; cast-in-place concrete; deep concrete beams; lateral torsional buckling; curved concrete walls

1. Introduction

The Corning Museum of Glass North Wing addition project by architect Thomas Phifer and Partners (TPP) is the largest space dedicated to the display of contemporary art glass in the world. Built in Corning, New York, USA, the new museum building features 9500 m^2 of program area, including 2500 m^2 of gallery space on the upper floor. The architectural concept called for a series of curved interior walls throughout the gallery level, separating the various gallery spaces. The roof framing system was required to span between irregular curved gallery walls, provide support to the continuous roof skylight system, and serve as baffles for the overhead natural light. Structural engineers Guy Nordenson and Associates (GNA), working with the architect, developed a structural framing system consisting of several unique structural elements that were fully integrated with the architecture in order to support a design concept that called for absolute simplicity, with all structural elements exposed and expressed throughout the primary gallery spaces.

2. Structural System Overview

The primary building structural system at the North Wing (Fig. 1) consists of a ground-level slab on grade, cast-in-place concrete columns and shear walls from the ground-level to the second floor, and a series of cast-in-place concrete slabs and wide, shallow “band beams” at the second floor. At the second floor gallery level, the building extents are defined by a perimeter steel frame including multiple braced frames, and the building interior is defined by 6m tall cast-in-place concrete curved gallery walls. A series of thin, deep, closely spaced precast concrete roof joists span north-south between perimeter steel and interior concrete wall elements (Fig. 2), and a system of thin steel purlins runs east-west over the top of the precast roof joists to provide lateral bracing to the joists.

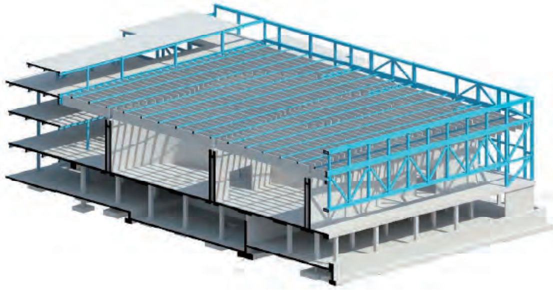

Fig. 1: Section Perspective of the North Wing Building Structure

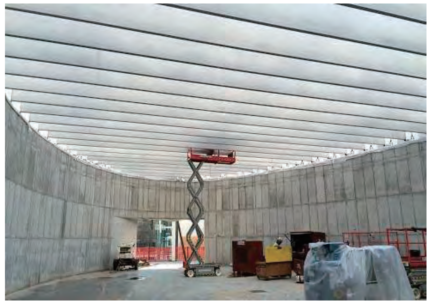

Fig. 2: Precast Roof Joists Spanning Between Cast-in-Place Curved Walls
(Photo credit: Guy Nordenson and Associates)

3. Gallery Walls and Band Beams

The 6 m tall cast-in-place concrete gallery walls which are curved in plan, define five fluid gallery spaces inside the rectangular "box" plan at the main gallery level of the North Wing. In addition to being the expression of a deliberate architectural gesture, the gallery walls are an essential structural element for resisting both gravity and lateral loads. They also integrate the air supply and return systems for all of the gallery spaces by serving as the cavity space through which air is distributed via a carefully arranged network of ducts and plenums.

4. Roof System

A series of over 200 closely spaced high strength precast concrete beams—almost all of which have unique geometry or loading configurations— is the primary element of the museum roof framing system, functioning as joists supporting the glass and steel skylight. While all beams share the same cross-section (9 cm by 122 cm), the spans vary between 2,0 m and 17,0 m. Each joists is pinned at both ends and is braced at 2,9 m by roof purlins running in the perpendicular direction. Given the extremely slender geometry of the beams, calculating their buckling resistance presented a major analysis challenge, as the standard methods for calculating the resistance of steel, aluminium, and timber structural elements do not extend to concrete beams. Providing the necessary lateral bracing to prevent joist buckling in a way that was not detrimental to the architectural design intent was an additional challenge. Special care was given to the detailing the roof connections since most of them are exposed to view in the galleries. As the joists are braced only along their top surface, it was essential to prevent any negative bending from occurring. Therefore, all joist connections utilized solid stainless steel pins placed horizontally through stainless steel pipe sleeves cast into the ends of the precast joists, with extensive local reinforcing to prevent concrete breakout.

5. Conclusion

The structural concept and design for this project required an acute sensitivity to the architectural intent and unusual approaches to the design development, analysis, and detailing of each of the three unique primary structural elements—the concrete band beams, the curved gallery walls, and the thin precast roof joists. Employing parametric analysis methods allowed for the efficient design of the highly varied roof joist geometries and the associated connection conditions and details. Resolving the gravity and lateral load paths through this composition of roof framing and gallery wall structural elements provided for a clear, direct expression and produced an elegant interplay between light, structure, and architecture.

6. Acknowledgements

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