Overall View of Building.

New Brunswick Gateway Transit Village

Integration of Diverse Structural Systems and Design Delegation in a Mixed Use Space

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The New Brunswick Gateway Transit Village (NBGTV) is situated adjacent to the commuter rail train station in New Brunswick, NJ. At 300+ feet tall, NBGTV is currently the tallest building in the city. The building consists of 632,000 square feet of mixed used space which includes parking, retail, office and residential uses. The podium structure of the building consists of a precast parking garage, with areas of concrete and metal deck on structural steel framing wrapping around the garage. Rising above the ten story podium is a fourteen story precast plank on structural steel framed residential tower. All of this is supported by deep continuous cast-in-place concrete footings.

The Problem At Hand

The parking consultant required 24-foot and 36-foot spacing between the support walls of the garage to optimize the parking spaces and the available width of precast double tees. Upstairs in the residential tower, the architects demanded a grid that completely ignored the supporting grid below. Utilizing 10-inch thick pre-cast pre-stressed concrete plank as the floor slab system, Severud Associates, as the project's Structural Engineer of Record (SER), was able to span up to 36 feet between supports thereby aligning the column lines of the residential tower with the garage support walls below. As a clear drive aisle was required in the garage structure, a series of 9-foot deep steel transfer trusses were designed to transfer the loads from the residential tower's interior columns to the exterior columns and shear walls located between the parking spaces. As the majority of the steel residential tower rests above the precast garage, the precast garage walls provide support for both the gravity and the lateral forces from the steel framed tower above.

While it is standard practice for the precast fabricator to design all the precast structural elements themselves, with a complicated structure such as this, the division of design responsibilities needed to be set. Direction was requested from the construction manager to determine the elements whose design would be delegated to the precast manufacturer and the elements to be designed directly by the SER. It was Severud's preference to design the precast concrete support walls themselves and provide complete design documents for the precast concrete contractor to adhere to. The remainder of the elements (typically gravity walls and double tees) would then be in the domain of the precast contractor. However, the construction manager during the design development phase requested that the design be left completely open and flexible. It was their opinion that allowing the precast fabricator full flexibility in the design would result in a more economical bid. This, in effect, required that the gravity and lateral systems in the lower half of the building, a building that essentially was not only a structure unto itself but also supported the building above it, be done as a delegated design.

Deep Cast-In-Place Footings and Tie Beams to Resist Overturning at the Base of the Precast Walls.

Delegated Design

For the majority of the structural work on a given project, the structural design is fully specified directly in the construction documents. However, there are often portions of the project that are intended to be designed by other structural engineers. Typically, these other engineers are hired either by the general contractor, a fabricator or a sub-contractor. These delegated designs can include elements of the façade, steel connections, open web joists, precast elements and/or miscellaneous metals such as stairs. The main purpose of these delegated designs is to allow fabricators to utilize materials, member sizes and connection types that are most economical for their particular shop. It is important for the SER to properly define the parameters of the delegated design elements in the construction documents and supervise their design and construction throughout the project. In most projects, these delegated designs are done for supplementary items. However, what happens and where do the lines of responsibility lie when these elements play not just a primary role but a critical role in the overall structure? The NBGTV is a project that illustrates some of the challenges faced by Severud Associates in their capacity as the overall project's SER and design team when the delegated design items include critical elements of the lateral and gravity structural systems.

In order to maintain overall structural integrity for the entire building, Severud demanded and retained complete control of the overall design, the right to review, approve and/or reject any aspects of the garage design, and the right to modify component design and connections, all with the express understanding that the process was to be a collaborative effort with the engineers retained by the precast concrete manufacturer.

As the lateral elements in the garage would be designed by the precast fabricator's engineer, Severud prepared an early bid set of drawings and specifications for the precast concrete portion of the work. This would allow the chosen precast manufacturer to join the design team earlier in the design process and deliver the foundation loads necessary to allow for the design of the foundation system prior to the final bid. This time sequence required Severud to make certain base assumptions about the garage structure in the early stages to determine the support locations and approximate relative stiffnesses of the various structural elements. The bid documents would include information and the locations of all the load vectors from the structure above as applied to the top of the precast walls below. As the transfer trusses transfer both lateral and gravity loads, information about dead, live, wind and seismic forces, along with the required eccentricities for both wind and seismic load cases was placed on the bid documents. In addition to resisting the provided loading, deflection and rotational boundaries for the tops of the precast concrete walls were provided to ensure that the movements at the top of the tower would stay within acceptable serviceability levels.

All of these parameters forced the bidding fabricators to conduct a preliminary structural design during the bid phase and in effect helped 'weed out' precast contractors who lacked the engineering capabilities to complete the project. While the garage itself is only ten stories, the overall structure still stands at twenty four stories tall, requiring the precast walls to resist the forces for the full lateral and gravity loads of the twenty four story building.

Design and Coordination

The precast concrete portion of the building was awarded to High Concrete. Immediately after the contract award, weekly meetings were

Precast Garage Supports both Lateral and Gravity forces from the Steel Structure.

Steel Column and Brace Supported by Precast Garage Wall.

Erection of Steel Residential Tower over Precast Garage.

conducted with the entire design team which included members from the precast manufacturer's engineers, Severud, as the overall Structural Engineer of Record, the Building Architect, the Garage Designer, the Owner and the General Contractor. In addition, other trades including the steel fabricator, the steel detailer, and the erector would often attend the meetings. These meetings were very necessary since the design was an iterative process between the SER and the precast fabricator. Changes to the lateral walls in the garage below would result in changed stiffness values at the base of the residential tower, redistributing the loads within the steel tower structure above. At each step of the parking garage design, Severud would recheck the original base design to ensure that the load distribution in the residential tower structure did not change.

Connections between the steel tower and precast structure were developed by Severud, along with detailed drawings of the embedded connector elements. It was imperative to Severud that these connections provide a high level of detailing to ensure complete coordination between the steel and precast fabricators.

The final design by High Concrete relied on twenty four-inch thick shear walls constructed with 10,000 psi concrete and with up to forty four #11 reinforcing bars on each end. These high strength, densely reinforced walls reduced field labor by concentrating the load in a lesser number of walls instead of requiring additional field connections to engage additional structural elements, thereby yielding a more economical design for the precast concrete contractor. While these twenty four-inch thick shear walls were sufficient in most areas, there were areas where the initially assumed design could not be replicated. In these select areas, cast-in-place concrete placement strips were added to allow the precast concrete walls to engage the adjacent walls.

While the final design used different member sizes and materials than the starting assumptions made by Severud, the global load path and load distribution remained the same throughout the design process, since the locations of the load resisting elements, as coordinated by the design team prior to precast concrete bid, remained constant throughout the process.

Conclusion

It is a common misconception that delegated design is the 'easy way out' or an effort by the SER to pass the responsibility for a portion of the design onto the sub-contractors. Delegating that design can often be far more burdensome for the SER than designing the structural elements themselves. Preparing concise documents which fully explain the parameters of the overall design, the required constraints and the lower and upper performance boundaries of the elements can be challenging in even the most basic of designs. Trying to delegate essential elements of a lateral system can be even more onerous. At the end of the project, one can look back and see that the final product is due not only due to the ground work laid out by the SER, but by the efforts of all involved stake holders.▪

The author would like to note the contributions of Dr. Mohamed Arafa, P.E., Fianna Ouyang, P.E., Justin Lawson, Stephanie DeCruz, P.E. and Gustavo Amaris to this article.

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Project Team

Structural Engineer of Record: Severud Associates Consulting Engineers
Owners:
Somerset Development Partner
New Brunswick Development Corp. (DEVCO)
New Brunswick Parking Authority
Architect of Record: Meltzer Mandl Architects
Designer: EEKR
Parking Garage Consultant: Tim Haahs and Associates
General Contractor: AJD Construction, Leonardo, NJ
Precast Contractor and Designer: High Concrete Group, Denver, PA
Steel Fabricator: SteelFab, South Carolina, Georgia and North Carolina
Steel Erector: Shamrock, Keyport, NJ
Steel Detailer: Prodraft, Chesapeake, VA