# A Capitol Idea

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The new State of Michigan House of Representatives fourteen-story complex, built at a cost of $40,000,000, brings State Legislators, their staff and the House support departments into one building centrally located in downtown Lansing across the street from the historic State Capitol. The location at the corner of Capitol Avenue and Ottawa Street presented a winning opportunity for relocating the 710 persons involved with the House of Representatives, who previously occupied several buildings dispersed around the city, into this class "A" environment with adjacency to the Capitol.

The House of Representatives building is comprised of three individual structures framed with a total of 2,540 tons of structural steel—new construction only. The project involved the redevelopment of two sites on either side of Ottawa Street and the connection of those two sites. The result presents two office towers with a third bridge building serving as the connection. This three-part frontage afforded the opportunity to develop identical office suites for all 110 Representatives, each facing the Capitol Building. Feature windows, located at each suite, provide views of the entire State of Michigan government complex. Also featured are hearing rooms, a committee center, conference and reception services, a lobby restaurant and underground parking.

The three major building components involved vertical expansion of the City of Lansing Board of Water and Light Building from a nine and five story to a fourteen-story tower, demolition of an existing eight-story building and replacement with a new eleven-story tower along with construction of a seven-story bridge building suspended 65' over Ottawa Street. At the onset of the project, the design and construction team was faced with a very aggressive schedule of 17 months from the inception through completion.

## Vertical Expansion

Most technically challenging was the existing Board of Water and Light Building expansion. A portion of the building had nine floors, while the remaining had five. The building program required addition of five and nine levels respectively, on top of the existing structural framework. It required considerable structural upgrading to receive additional floor loads and to resist lateral

wind and seismic loads. New columns were threaded through the existing floors to bear on mini-pile foundations drilled through the basement floor. During the construction, portions of the building were still occupied by the Board of Water and Light employees. This required new columns to be strategically located and installed without disturbing the tenant spaces. Columns with 2″-thick flanges were full penetration welded at the lower shaft splice points.

## Reinforcement of Existing Columns and Beams

A large number of existing beams and columns were reinforced to support additional loading. Many existing columns needed reinforcement in two or more adjacent levels. Desai/Nasr designed reinforcement to be continuous and to extend through new penetrations in the existing concrete floor. A typical configuration consisted of four plates each welded to one edge of column flanges. This allowed reinforcing plates to run through the floor without interference with the existing beam-to-column connections. This configuration also has the added advantage of reversing the residual stresses in the existing columns thus favorably tapping their reserve capacity. Several other reinforcement configurations were designed to accommodate various situations. Heavy WT-sections (e.g. WT9x71.5) were used to reinforce exterior columns carrying loads from nine additional stories. In all cases of column reinforcement, the effect of shift in column centroid on load eccentricity was taken into consideration.

Reinforcement of existing beams took several varied configurations using plates, angles and channels. In many cases, existing beams carrying concentrated loads from new columns were reinforced with a heavy WT- section welded to the bottom flange in conjunction with reinforcement of existing connections.

*East elevation. Board of Water and Light building and Ottawa Bridge Building under construction.*

## Lateral Load Resistance

The existing structure was designed with "type 2" connections to resist lateral loads. "Type 2 connections" are essentially simple connections whose inherent partially-restrained behavior is used to resist lateral loads. New braced bays were added to resist current code required lateral loads. The bracing connections needed to be custom fit to the existing beam connections. At many locations, due to space being occupied, permanent bracing could not be installed. Desai/Nasr designed temporary bracing within the existing structure to resist lateral loads so that precast panel erection could continue uninterrupted to maintain aggressive project schedule.

## Interior Column Removal

Besides requiring localized reinforcement of beams, columns and connections, it was discovered that in the newly planned hearing room on the 5th floor an existing column interfered with the Chairman's desk. This required removal of a column between the 5$^{th}$ and 6$^{th}$ floors. In order to move the interfering column, the adjacent existing columns were reinforced. New W36x280 transfer beams were threaded through one of the window openings, raised to their final supporting positions and attached to the existing column. After all the

*Closeup view of special v-shaped knee-bracing assembly to transfer forces from Vierendeel nodes to bridge support column.*

connections were made, the column was cut and removed. The beams were designed to deflect due to dead load no more than 1/4" to avoid cracking of four supported floors above.

## North Capitol Building

In the mean time, Desai/Nasr determined that it would be more cost effective to demolish the eight-story structure across the Ottawa street to accommodate the 11 floors needed to provide the required square footage. Desai/Nasr worked closely with the Project Architect, Hobbs & Black, to determine the column locations to avoid interference with the existing caisson foundations. All the exterior columns had to be located inbound by 8' from the exterior and resulted in cantilevering all 11 floors. Desai/Nasr and NuCon precast panel contractor designed panel connections to the structure to accommodate differential floor deflection at the cantilevered ends. Small building footprint (70' x 70') compared to the building height (154') presented a challenge to resist lateral loads. Rigid frames in combination with wide flange K-braces were designed with high-strength bolted connections to speed the erection of the frame.

## Ottawa Street Bridge Building

Desai/Nasr faced additional challenges in interfacing the two towers located across the four-lane Ottawa Street and designed three 30' deep Vierendeel trusses to support seven floors totaling 37,000-sq. ft. space over the street. The trusses were integrated into the three lower floors and were primarily framed with W14X398 sections. All the trusses were fabricated in "tree" shapes with full penetration welds and shipped from South Carolina and field connected with over 7,000 1 1/8" diameter A490 bolts. Five-story shoring towers were erected on mats beneath the tower to temporarily support trusses until assembly and splicing were complete. Desai/Nasr analyzed and designed the trusses to account for incremental construction loads to ensure level floor elevations in final use. The trusses were supported on 65' high composite columns consisting of W14x398 steel sections and 6000 psi concrete bearing on caisson foundations. Due to below grade interference, the columns could not be located to align with any of the nodes of the Vierendeel truss. A special V-shaped knee bracing assembly was designed at the top of the columns to transfer the forces from the Vierendeel nodes to these columns. The Mackinac Room located on the fifth floor of the bridge structure with a stunning seven-story stained glass window provides 5,000-sq. ft. of assembly space and features views of the State Governmental complex on the west and the Grand River and Lansing Convention Center on the east.

Due to the fast pace of construction on this complex structure, fabrication was being performed as the design was developing. Mill orders were placed based on initial design, with final design and detailing being completed as the raw material was arriving for fabrication. At times fabrication was completed prior to shop drawing approval with some modifications being made in the field. The required modifications could not have been achieved had the existing building been framed using reinforced concrete.

## Engineering Software

RAM Steel engineering software was used for the analysis and design of all steel members. In addition, STAAD Pro was used to verify the design of the Vierendeel trusses and to calculate the axial loads in the Vierendeel beams, which at that time could not be obtained from the RAM Steel program as it assigns the axial force to the rigid diaphragm. Other engineering software such as Enercalc and Ecom were used for foundation design and for analysis and design of individual steel and concrete members. In-house computer programs were developed and used to design and check column and beam reinforcement.

## Site Safety, Space Restrictions and Accessibility Problems

Initially, steel erection had to be scheduled during nights and weekends to assure the safety of the building occupants working just below the new levels of steel. Erection had to follow closely behind the surgical demolition and abatement of the occupied building. During periods of the project, steel was being erected during the day and precast during the night using the same crane. Erection of the North Capitol Building was delicate work as the new steel frame came within inches of a neighboring historic landmark building.

## Satisfying Owner's Program

Mr. Bill Frank of Granger Group said: "Desai/Nasr met and exceeded Owner/Client's needs by utilizing reserve capacity of the Board of Water and Light buildings—columns and foundations, strategically locating and designing new column locations so that the columns could be installed while the building was still occupied. Further, Desai/Nasr solved the problem of integrating the two office towers located on each side of Ottawa Street, by designing the 30' deep Vierendeel

Trusses, which allowed the owner to provide seven floors of the office/assembly function spaces over a roadway. The integrated 300,000-sq.ft structure provided a simple and seamless flow of traffic for the staff, and easy access for the visitors."

## Economic Impact

The House of Representatives building consolidated all house offices and functions at one location. The building also provided a permanent office for each district and saved the Michigan taxpayers the cost of moving expenses estimated to be several thousand dollars after each election year.

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**Structural Engineer:**
Desai/Nasr Consulting Engineers, Inc., West Bloomfield, MI

**Architect:**
Hobbs & Black Associates

**Owner/Developer:**
Capital Outlook L.L.C.

**Software:**
RAM Steel, STAAD Pro, Enercalc, Ecom