
# SKIN DEEP

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The architect and engineer for Tower III of this Memphis office park had to design a building to meet current seismic requirements and to fit "inside" a stone curtain-wall "skin" fabricated a decade ago.

The office complex at the corner of Poplar Avenue and Massey, known as International Place, has been a Memphis, TN, icon for over ten years. The twin 10-story towers with their stone and glass façade resting behind their award-winning garden courtyard make a bold statement of progressive elegance and nature unmatched in the city's commercial real estate market.

The original plans for International Place called for three towers. Tower I was designed and constructed in 1986 and Tower II in 1987. Both structures have structural systems of reinforced concrete joists and post-tension concrete girders along with interior reinforced concrete shear walls. Tower III was originally designed at the same time as Towers I and II. All three of the original designs were "wind-only" lateral resisting systems, since Memphis/Shelby County had not yet adopted seismic criteria into the code.

Because the vein from which the exterior stone for the towers was quarried was expected to "run dry," stone for all three towers was purchased at the same time. The stone for Tower III was fabricated and crated for future use. This created a unique situation when it came time to design Tower III: the exterior dimensions of the façade had to match the old curtain wall system. Therefore, the existing stone set the exterior geometry and exterior column locations, as well as the typical floor-to-floor height of 12'-6".

## SEISMIC DESIGN

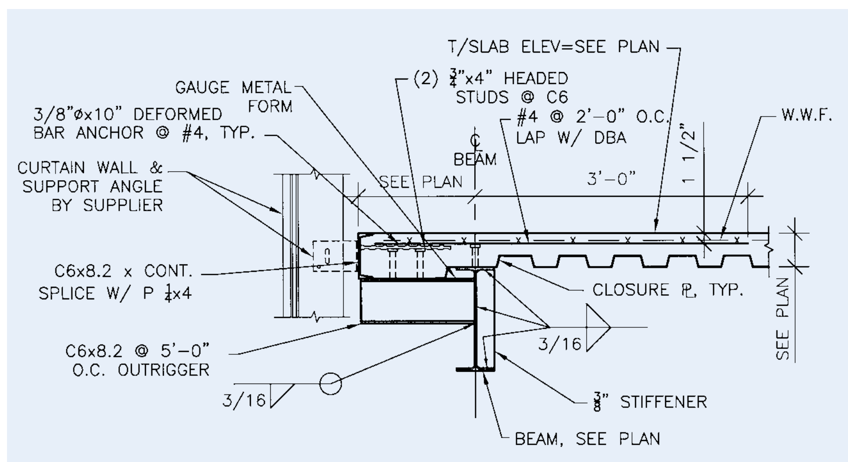
From the first meeting, everyone on the design team was ready to be challenged. First, the new design would have to be structurally revised to ac-

Typical floor framing consisted of composite castellated beams spaced at approximately 5' on center and spanning some 45'. This allowed the typical sprinkler piping to pass through special holes that aligned, but more importantly, it gave a full 15" structural depth with less steel weight.

commodate the current seismic criteria under the Standard Building Code, 1994 Edition, while maintaining the original exterior envelope for the warehoused stone. The seismic criteria for the Memphis, TN, site, according to the Standard Building Code, 1994 Edition, were Seismic Performance Category C with an Effective Peak Velocity Related Acceleration Coefficient ($A_v$) of approximately 0.19. A lateral analysis of the original concrete design revealed the core area would have to be increased dramatically to accommodate much longer shear walls. This would decrease the rentable square footage per floor plate by approximately 20 to 25%. An alternate solution had to be devised to keep the square footage similar to the original plan, accommodating the fixed vertical and horizontal geometry of the exterior curtain wall system.

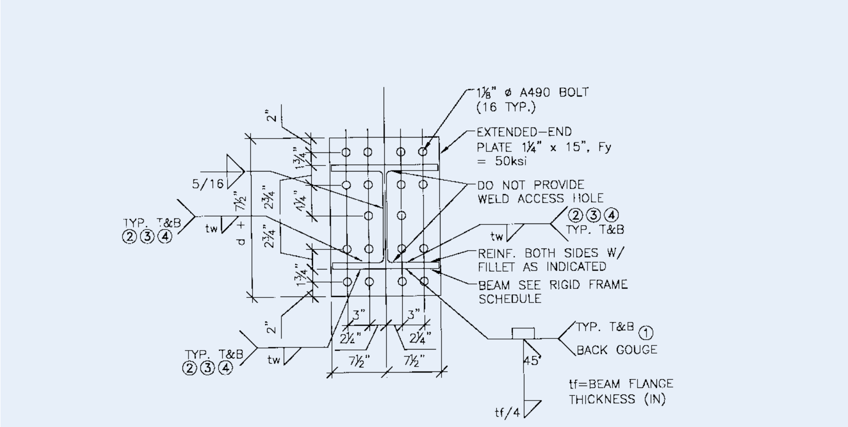
## STEEL SOLUTION

Several alternative structural systems were considered to reduce the structural impact of the seismic loads while keeping the cost within a reasonable budget. Fluid-viscous damping was investigated as a mechanism to reduce the seismic forces. Base isolation and non-linear dynamic analysis with special moment frames of both reinforced concrete and structural steel were reviewed. The results concluded a stocky, height-restricted structural steel design would reduce the total

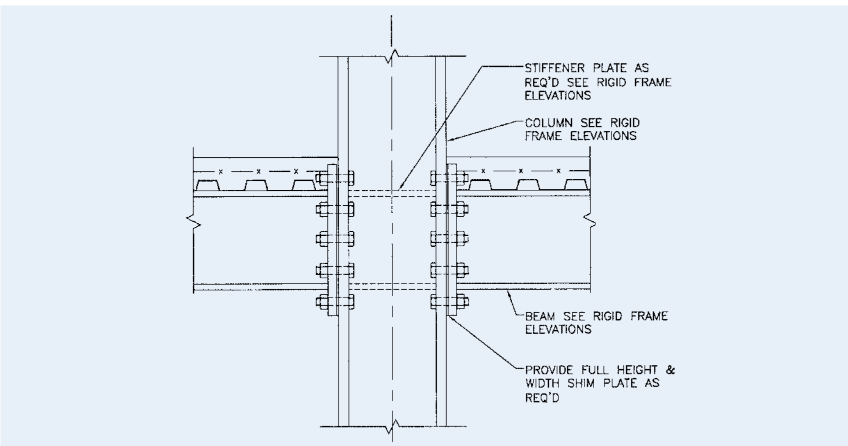



During the conversion from a concrete structure to a steel structure, the edge of slab condition had to be thickened to accommodate the curtainwall connection requirements. The continuous channel provided a good screed surface and a continuous steel face for mullion connections.

Erection of the fifth floor framing. Note the lack of column stiffeners in the run-out columns due to the extended end-plate bolted connections.




Typical section at the moment-resisting extended end-plate connection.




Typical side view of the moment-resisting extended end-plate connection.

weight of the structure by approximately 50% and therefore reduce the seismic forces by 50% or more. Structural steel could be erected faster than the cast-in-place concrete alternative, therefore meeting the tight schedule requirements for a successful lease agreement.

The design team met for extended sessions to define all of the systems that would be in the space above the ceiling. The mechanical system would fit under a 15″ structural steel depth envelope only if the sprinklers were located to pass through the structural steel at pre-defined locations. Composite structural steel girders were utilized with heavy W14 sections spanning over 33′ (W14x109, 119 studs, $1^{1}/_{4}$″ camber, $R$ = 52k). Typical floor framing consisted of composite castellated beams (Smartbeam by SMI) spaced at approximately 5′ and spanning some 45′ (CB15x45, 52 studs, 1″ camber, $R$ = 15k). This allowed the typical sprinkler piping to pass through holes that aligned, but more importantly, it gave a full 15″ depth with less steel. The large girder sections provided thick webs that virtually eliminated web hole reinforcing where the piping passed through the girder. The team mentality of the design process allowed the structural engineer to revise the fire protection design by locating the sprinkler piping based on minimum stress levels. The geometry was detailed on the structural documents so the fabricator and the general contractor could easily fabricate and align the piping holes.

The SMI Smartbeam provided two advantages over conventional structural steel. First, Smartbeam was cost effective over typical structural steel when accounting for the depth restriction and additional web hole fabrication and reinforcing. The Smartbeam comes with hexagon shaped holes at regular intervals that allowed smaller peripheral sprinkler piping to pass through without special hole fabrication. During the design, Billy Milligan, President of SMI, stated the project was the largest Smartbeam project in the country at that time. Second, the castellated beam design properties were recently added to the design tables of the RAM Analysis software for composite steel design. Sheridan Structural Solutions, Inc., used a Smartbeam definition in its framing model, and the software cranked through the laborious 100 calculations per castellated beam in minutes. Without this software, the Smartbeam option would not have been feasible.

In addition to the use of stocky gravity framing, the moderate seismic forces had to be resisted by a series of moment-resistant frames. Early in the design, welded moment connections were considered, but the post-Northridge criteria raised concerns. With the reduced seismic forces, the wind design in the north/south direction was comparable in magnitude to the seismic forces. Drift controlled the column and beam sizes for the depth-restricted frames, and a reduction in the Response Modification Factor ($R$) to a value of three ($R$ = 3) allowed the requirement for AISC *Seismic Provisions* (1997 yellow book) to be waived. With the large column sizes for beams (W14x120) and the large frame column sizes (W14x233), complete penetration flange welding in the field would be a very expensive venture. Therefore, with the *Seismic Provisions* no longer required, bolted extended end-plate moment connections were used with limited use of column stiffeners or web-doubler plates. An AISC quality-certified fabricator was specified to assure quality shop welding.

The general contractor brought his thorough computerized process of preconstruction value-analysis to bear on the project. A portion of the project cost was deleted through their unique process of vendor negotiation, redesign and scope elimination. One interesting scope change was to add approximately 1,000 sq. ft. of structural steel flooring in order to turn a two-story lobby into a one-story lobby. This change added approximately five tons of structural steel to the project but produced a savings of $12,000 by eliminating the expensive finishes of the second story lobby. This also adds 1,000 sq. ft. of rentable space to the building.

## CONCLUSION

The project was started under construction in early February 2001 with expected core and shell completion expected by April 2002 for $25 million. In just over four months, 2,011 tons of steel was erected in a "just-in-time" process with a very tight site. Both Sheridan Structural Solutions, Inc. with The Crump Firm, Inc. provided "out of the box" solutions in structural steel.

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## OWNER

Michael E. Harris of
Highwoods Properties

## STRUCTURAL ENGINEER

Sheridan Structural Solutions, Inc.,
Memphis, TN

## ARCHITECT

The Crump Firm, Inc., Memphis, TN

## STEEL FABRICATOR

Steel Service Corporation,
Jackson, MS (AISC member)

## STEEL DETAILER

Steel Service Corporation,
Jackson, MS (AISC member)

## GENERAL CONTRACTOR

Holder Construction Company,
Atlanta, GA

## SOFTWARE

RAM Structural System