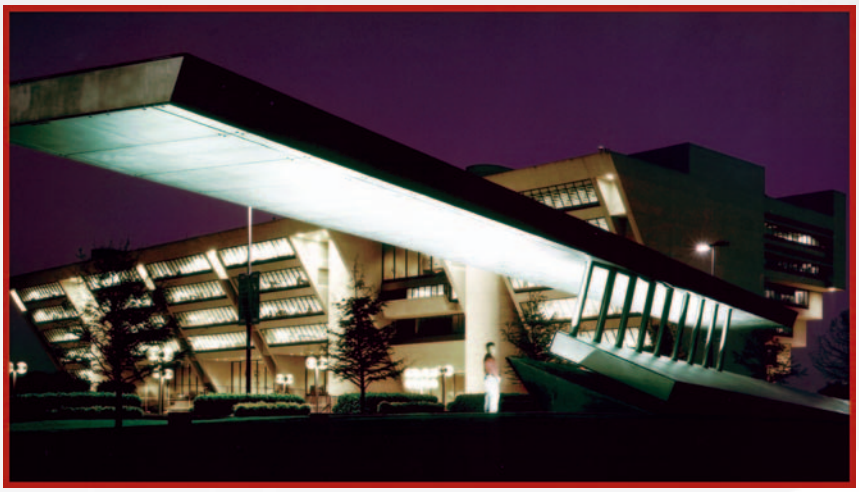
AWARD WINNING PROJECTS

The Dallas Police Memorial was presented a Merit Award (Building Projects under $5M in construction value) on the NCSEA Fifth Annual Excellence in Structural Engineering Awards program.

Dallas Police Memorial

Striking Structural Tribute

D. Martin Sloan, P.E.



Dallas Police Memorial at night with City Hall beyond (Charles Davis Smith, Photographer)

The Dallas Police Memorial employs a dramatic stainless steel cantilevering table to "project" a striking tribute to officers of the Dallas Police Department slain in the line of duty since the establishment of the force in the late 19th century. This highly visible landmark, commissioned by the Dallas Police Foundation, occupies a prominent site on parkland adjacent to the City Hall in downtown Dallas.

The primary feature of the memorial is a level, 93' long by 10' wide by 20"deep, elevated table cantilevered 39 feet at one end and 21 feet at the other. It is supported along a portion of one edge by a single line of progressively skewed stainless steel columns mounted on a canted base structure which appears to rest on the undulating contours of the site. The entire structure bears on drilled piers or caissons.

The long cantilevers, eccentric loading, and shallow depth requirements of this structure created great concern about stability and deflection. The structural designer modeled the entire steel structure in RISA-3D. Because of the exposed, linear nature of the Memorial, any variation in the straightness and levelness of the elevated table would be apparent. With this in mind, the designers rigorously calculated cambers for the cantilever ends and applied them in both the vertical and horizontal directions, since the non-symmetric nature of the structure resulted in significant deflections in both of these planes. The longer cantilevered end required 4"of vertical camber and 1½" of horizontal camber. In addition, the plans provided dimensional information for both the unloaded and loaded conditions of the structure to assist in the shop layout of the elements.

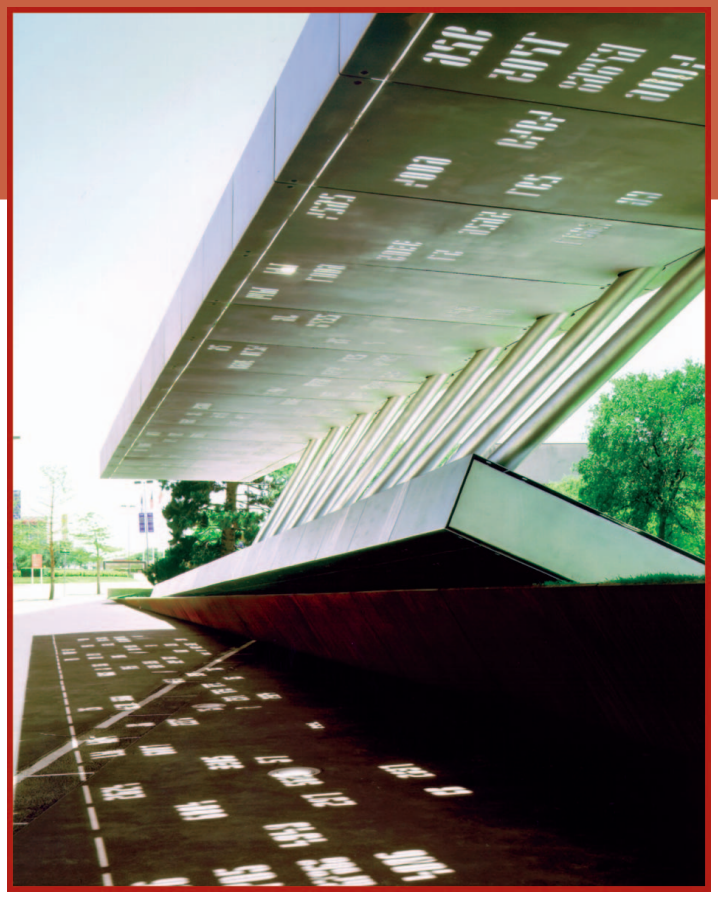
The plans also provided an implicit camber for the column elements whose deformation contributed significantly to the upper table deflection because of their severe tilt and resulting large bending moments. Finally, a cable post-tensioning system was integrated into the box section spine to allow for variable correction of the deflection needed to accommodate construction tolerances and material variations not known during the design phase. Twelve ½-inch diameter 270 ksi seven-strand prestressing tendons, each capable of imparting ¼" of upward deflection, were threaded, in two bundles, through precisely located holes in each of the internal bulkhead stiffeners and through twelve separate holes in each recessed end bulkhead during shop fabrication. After the assembly was erected on site and mostly clad, the contractor stressed a number of strands in a pre-determined sequence until a straight and level structure was achieved. Final measurements on the completed structure showed a total variation in the vertical position of the elevated table structure of 0.20 inches over the entire 93 foot length.

To accommodate the large torsional forces generated by the eccentric support configuration, the elevated table structure is fabricated with an 18" deep, closed rhomboidal-section spine built from 1" and 1½" thick A572 steel plate and stiffened internally by 1" thick transverse bulkheads at 4' 0" on center, supporting cable-stayed, 3" deep, Type 304 stainless steel tee purlins projecting horizontally at right angles to the long axis of the spine.

The braided stainless steel cables have counter-threaded couplers at each end to function as turnbuckles for pre-tensioning the cables for accommodation of compressive forces due to wind uplift and for making final vertical adjustments in the elevated structure. Together with the tee purlins, they form a truss-like structure to stiffen the table against variable winds which would otherwise result in significant and disturbing flutter. ASTM A 500 steel tubes form the perimeter framing of the remaining three sides. Although much of the table structure is clad with a brushed stainless steel skin, two-thirds of the cable-stayed purlins are exposed from above and visible from adjacent building. The very light structure used to frame the bulk of the table was designed to afford optimum solar exposure of the horizontal steel plates on the underside, which bear the badge numbers of the fallen officers, cut into the plate and arranged so that the sun will shine through and project them onto the asphalt paving below. Portions of this asphalt paving have been cut from prominent streets in Dallas to represent police beats in the city.

The elevated table is cantilevered in three directions from a single line of exposed, 7" diameter, solid Type 316L stainless steel columns. These columns penetrate the bottom and top sides of the rhomboidal box spine, and are welded continuously to the edges of each of those holes in order to create the necessary moment connection to the solid round section. The closed box spine provides a stiff torsional element to collect the eccentric load of the purlin/cable assemblies and deliver it to the edge mounted columns. The columns are connected, at the bottom, to another rectangular box spine of steel plates in a manner similar to the upper connection. Each of the nine columns is canted at a progressively larger angle from vertical, both in line with the table long axis and perpendicular to it, as they approach the longer cantilevered end. This skewed arrangement of columns prevented the upper box spine from slipping down over the column tops simultaneously. Instead, the columns had to remain loose in the lower box spine and roughly parallel to each other until the upper ends of the columns were inserted into the upper box spine. All of this fit-up was accomplished in the fabricator's shop, and the columns, with their top and bottom spines, were shipped about 35 miles to the site in one piece.

Background photo: Structure cantilevers 39 feet from 7" diameter solid stainless steel columns (Edward Baum, FAIA)



Pictured Right: Sunlight projects through badge number cutouts onto pavement below (Edward Baum, FAIA)

Once the column/spine assembly was on site, the contractor placed it in its final position, partially supported on falsework, while the lower box spine was full moment welded to a series of parallel W18x50 steel beams already bolted to the lower cast-in-place concrete table structure. The space between the W18x50's was then filled with concrete to further stabilize the beams, and the entire lower table was clad in stainless steel plate to match the upper table. Unlike the upper table, this lower table is canted 22.5 degrees along its short axis and 1.7 degrees along its long axis. In addition, its long axis is 2.2 degrees out of alignment, in plan, with the upper table. The visual result is a very level and regular suspended slab supported by a base in upheaval. To control the complex dimensional calculations needed to assure the proper fit of these skewed planes and line segments, a highly interdependent and complex spreadsheet template was developed to provide redundant checks of the geometry and eliminate calculation errors. The interdependencies were designed to maintain appropriate geometric relationships even when the controlling parameters were modified during development of the design. The spreadsheet enabled the designer to issue a coherent set of dimensions which the fabricator used to produce an accurately fabricated assembly.

Extreme care in the dimensional control of the project was essential to the project's constructability and to the realization of the designers' vision. With the in-place deflection adjustment capability and the care and dedication of the entire project team, the erection of this very complex and challenging structure was relatively trouble-free and resulted in a powerful and effective example of structure as art.

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Project Credits

Structural Designer
Datum Engineers, Inc., Austin, TX
Designers
Edward Baum, FAIA and John Maruszczak, Dallas, TX
Architect-of-Record
Oglesby-Greene, Dallas, TX
Contractor
Austin Commercial, Dallas, TX
Fabricator
Big D Steel, Dallas, TX
Erector
Azteca Enterprises, Dallas, TX