



Cockrell Butterfly Center

Houston Museum of Natural Science



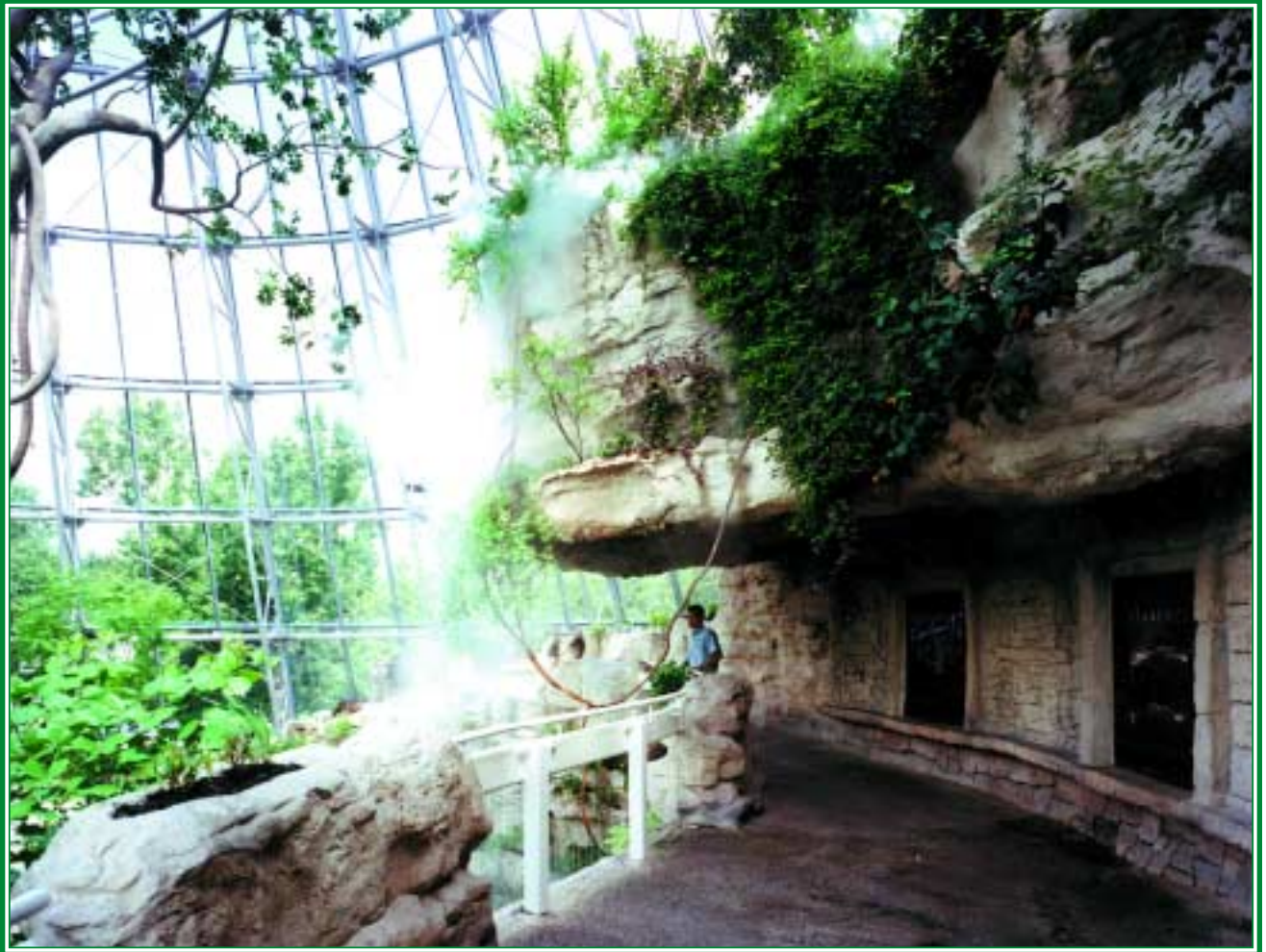
Engineering Awards
of Excellence

Regional Winner

Few creatures evoke more wonder and delight than the butterfly. Beautiful in their incredible variety of vivid colors and shapes, yet fragile as tissue, these amazing insects have an average life span of only two weeks—even under ideal conditions of tropical temperatures, high humidity and brilliant sunlight.

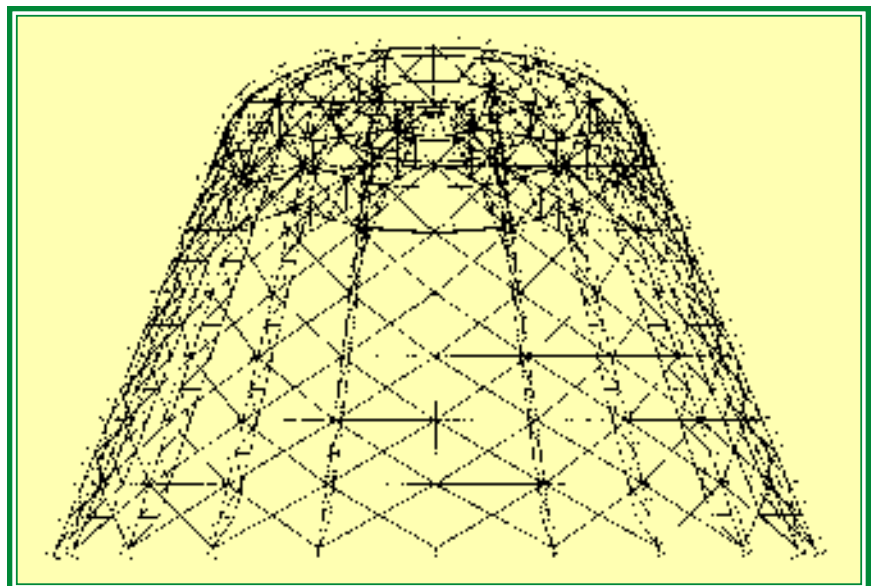
When the Houston Museum of Natural Science enlarged their facilities with a \$19 million expansion program called “Face of the Future: Phase II,” the centerpiece was a giant butterfly

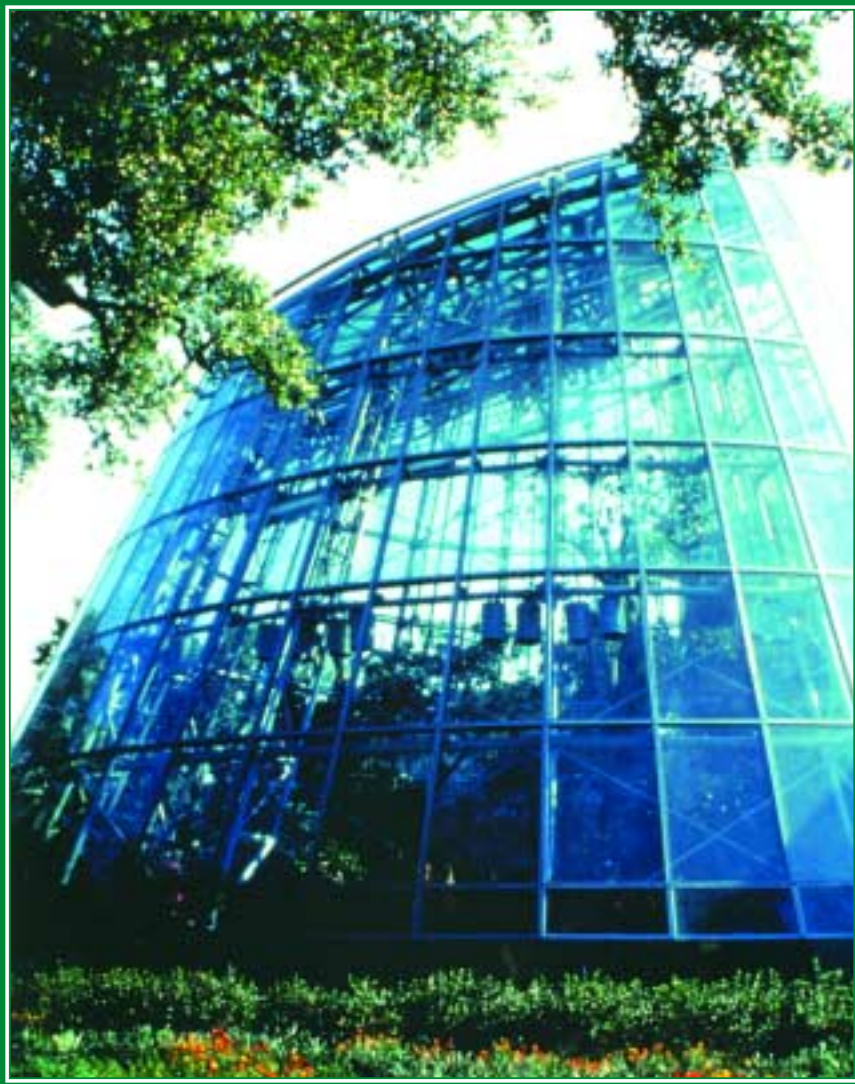
exhibit. As design began on the Cockrell Butterfly Center, it was clear that in addition to meeting the demands of the client, it was crucial that the center meet the needs of the butterflies. Each butterfly is purchased as a chrysalis at an average cost of \$6 and raised by the Museum. The butterfly is a delicate species, surviving best in a lush tropical environment with an abundance of flowering plants, minimum temperatures of 80 degrees F and relative humidity of at least 70%. Because both butterfly flight activity and plant growth are



directly proportional to sunlight, careful selection of materials and shapes were crucial: An abundance of glass was necessary and projecting elements and sharp edges had to be avoided.

The center's exhibit space is a soaring, 75'-high truncated glass cone with a distinctive sloping glass roof. Chief among the structural challenges was to create a system that could withstand the Class 5 hurricane winds of the Texas gulf coast while not blocking sunlight or endangering butterfly flight patterns. The solution is an elegant system of vertical





trusses arranged radially around the perimeter of the glass enclosure. All truss chord and web elements were designed using shop-welded pipe members to improve reflectivity of sunlight, minimize maintenance requirements, and eliminate the sharp edges so dangerous to butterflies. The slender perimeter trusses, which are spaced on 16' centers at the exhibit base, utilize 4"-diameter pipes for the vertical chords and 2"-diameter pipes for the web members.

With the external chords connect-

ed just inside the glass with a graceful system of small tie rods, the truss system efficiently supports the weight of the exhibit and provides a stiff superstructure to resist hurricane winds.

An additional refinement makes the superstructure even more attractive and even safer for the butterflies. With the 3'-deep trusses arranged perpendicular to the glass enclosure, the inboard vertical chord members were unbraced. A more conventional engineering design would require supplemental intermittent bracing (in this case, at 9' centers vertically) to prevent lateral buckling of

the chords, which are primarily compression members. However, such bracing, even if comprised of small diameter tie rods, would have created a dangerous maze of structure for the butterflies to negotiate in their natural flight paths.

Judges Comments

The building is an elegant and efficient design with a unique architectural shape and function. The exposed tension chord bracing not only is visually attractive, but also adds to the overall lightness of the framing. Also, despite the project's complexity, it came in under the original budget.

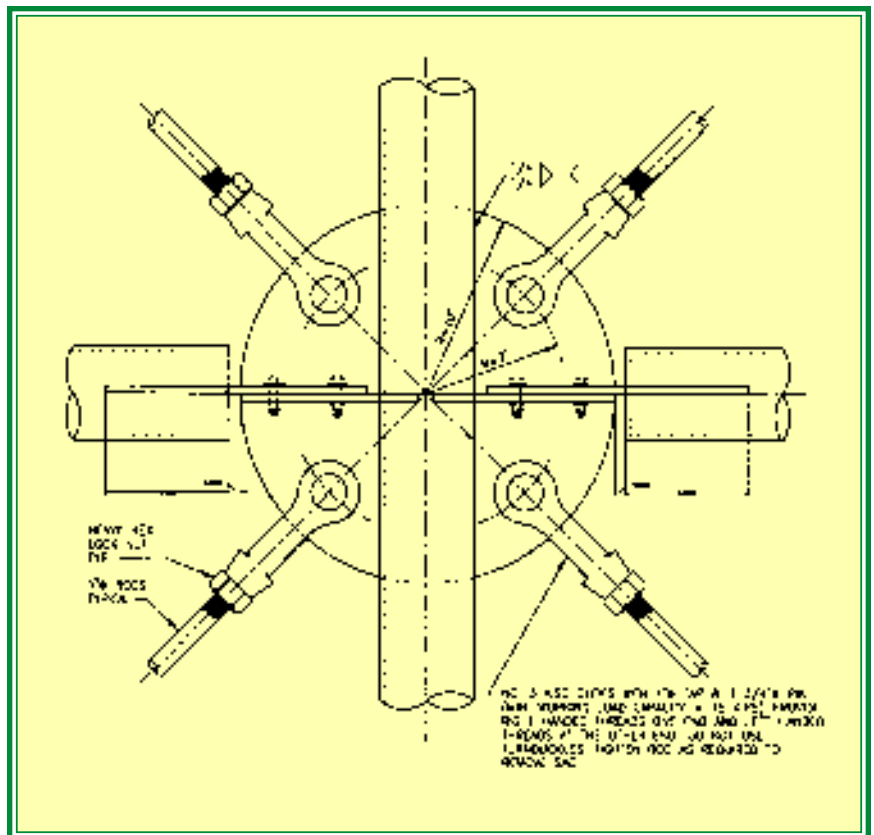
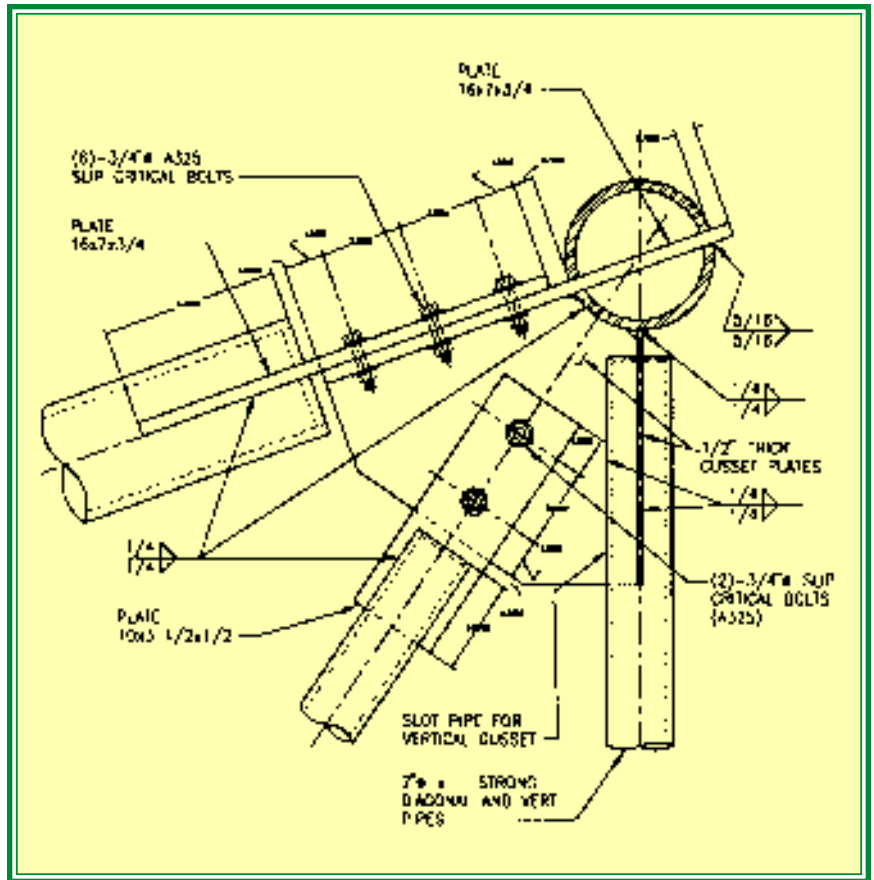
Instead, the structural engineer solved the problem by utilizing a structural bracing analysis technique more typically used in plate girder bridges. By stiffening the connections of the trusses along the perimeter glass, the designer created a tension chord bracing system that effectively braced the inboard truss chords. As a result, all supplemental lateral bracing of the inboard chord members was eliminated and the butterfly flight

paths were kept uncluttered.

Because the structure supporting the slanted oval glass roof is integral with the overall exhibit superstructure, it also required engineering creativity. Sloping roof pipe trusses are arranged radially to connect with the perimeter wall truss system. To minimize the depth, weight and cost of the roof, a central 10'-diameter compression ring efficiently carries the roof loads and simultaneously provides an elegant roof pattern. The pipe sections used throughout the superstructure are highly efficient, resulting in an economical and graceful framework. In addition, their rounded edges are highly reflective and of minimal danger to flying butterflies.

All structural connections were carefully designed and detailed to satisfy all loads in an aesthetic way. The connections feature circular gusset plates, clevises, turnbuckles and high-strength bolts. Connections sizes were minimized to reduce shading.

The tropical humidity needed to extend butterfly life presented an additional structural design challenge. Because of the constantly muggy 80 degrees F air in the exhibit, long-term corrosion of the superstructure was a serious concern and special steel preparation and painting procedures were specified to extend the life of the structure and minimize maintenance. After fabrication, the structure was abrasive blasted, coated with inorganic zinc primer, and then painted with a coat of high-build epoxy paint



and two coats of architectural finish paint. To speed erection and maintain the integrity of the shop finishes, the design call for all field connections to be bolted. As a final precaution against corrosion, all bolts, clevises, pins and turnbuckles were hot-dip galvanized prior to field painting.

The Center opened on schedule in July, 1994. Despite its complexity, it was completed for \$5,847,710—more than 6% under the original budget. Since its opening, more than 350,000 visitors have toured the centers winding paths.

Project Team

Engineer:

Walter P. Moore and
Associates, Inc. Houston

Architect:

Hoover Architects, a 3D/I
Company, Houston

Contractor:

S A E / S p a w - G l a s s
Construction, Houston

Project Manager:

Century Development,
Houston