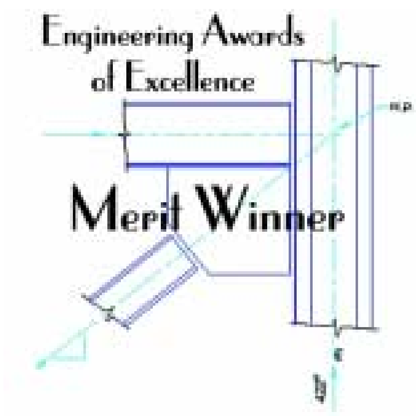

Sophia M. Sachs Butterfly House & Education Center

Faust County Park, Chesterfield, Missouri

Sunlight is an essential source of energy on which butterflies rely for survival. So with this in mind, building transparency was the key design issue of the Butterfly House and Education Center in Faust County Park in St. Louis. The $3.4 million new construction consists of an exhibit hall, a gift shop, a theater, and an 8,000-sq.-ft. glass conservatory.

The conservatory houses 60 exotic species of living butterflies imported from four tropical countries. To compliment the home for the tropical butterflies, brightly-colored plants and flowers were transplanted from the southern Florida. A tropical ecosystem was called for with constant air temperature of 82

Jurors' Comments

"An impressive and innovative structural design that maximized structural efficiency. It was a simple solution that saved significant costs."

"This design solved owner requirements with design techniques that lowered costs dramatically."

"Building aesthetics were critically important and this efficient structural system met that need."

degrees, 74% humidity, and sufficient sun light. The requirements for constant air temperature and humidity were met by using underground HVAC system and laminated insulating glass panels. However, the need for natural sunlight demanded a creative structural system with minimum shadow-casting effect so as to collect as much solar energy as possible to maintain plant growth for the butterflies to thrive.

A five-span vaulted skylight structure was conceived for the conservatory to evoke and resemble the curved shape of butterfly wings. The skylight system covers a 107' by 72' footprint with a 37' high center vault. Four steel truss frames are the main gravity load-carrying elements supporting five vaults of aluminum skylight rafters. The narrow curved rafters serve as secondary load-carrying members, as well as glass mullions in order to minimize shadow-casting effects. Vertical truss columns have rigid

connections with horizontal truss girders to form moment frames. This provides the conservatory with a lateral force resisting system in the truss frame direction. The combination of lateral bracing for the truss chords, unbalanced horizontal forces from the skylights due to gravity loads, and the wind and seismic forces called for a special structural system in the direction perpendicular to the trusses. The conventional solution was a compression bracing system with curved steel trusses parallel with vaulted skylights. However, the compression thrust caused lateral stability problems for curved truss members. The connections between curved and horizontal trusses became extremely difficult due to stringent requirements for the butterflies to have natural flight paths.

A multi-span tension rod tie-down system with elastic supports was proposed for the required lateral bracing system. The new system replaced conventional curved trusses with 1½" diameter tension rods and reduced bracing steel from 27 tons to only 2 tons. All curved steel members and their expensive fabricating process were completely eliminated. The new design saved construction cost of $11.50 per sq. ft. Since the tie-rods provided compression thrust, the aluminum-arched rafters were able to be designed for minimum sections and were able to span up to 30'. A bright open space was created and the project benefited from simpler construction with a shorter schedule. Truss columns were designed to have certain fixity at base so that progressive collapse is minimized should tension rods suffer severe damage for any reason. This design consideration also eliminated temporary bracing for the truss frames during erection.

Tension rods are large deformation members. Conventional linear elastic analysis does not apply to the structural analysis. A special computer program was developed to model the true curved rod length at each loading stage. The challenge the structural engineer faced was that the tension rod tie-down system is not as stable as tension rod suspension system as used in cable-stayed bridge. Due to the unique geometric setting, many factors tended to reduce the rod tightness. Among these factors were rod elastic elongation due to axial load increase and rod relaxation due to steel support vertical deflections. Extreme care was used to make this delicate structure strong and stable by optimizing and balancing the stiffness between tension rods and supporting steel frames. ASTM A449, 90-ksi high strength steel was specified for the rods so that inelastic deformation will not occur even under factored load condition. The design also ensured that steel frame deflections were within strict skylight tolerances. ASTM A519, 90-ksi high strength steel pipe was used for turnbuckles to keep the size to a minimum and to provide a clean look. Rod installation and setup were assisted with a torque wrench calibrated with strain gauges.

In order to reduce field welds, truss members were fabricated in the shop to a maximum extent. A special retractable backing tube detail was developed for full penetration welds at main truss chords. All welds were ground smooth after welding and received special inspections which included ultrasonic and magnetic field tests. The structure and connection details were designed simple, practicable and thoughtful, construction process was smooth and straightforward. No change orders were issued for the structure.

This new facility, which opened on September 18, 1998, presents an unparalleled opportunity to foster a better understanding of butterflies, to increase public awareness of our natural world, and to provide family recreation. The creative structural design made the Butterfly House simultaneously strong and elegant. Coupled with excellent architectural, landscaping design and quality field execution, it placed the Butterfly House among the most notable landmarks in the St. Louis area.

Project Team

Owner:
The Butterfly House
St. Louis

Structural Engineer:
Ibrahim Engineering Corp.
St. Louis

Architect:
Christner Inc.,
St. Louis

General Contractor:
BSI Constructors Inc., St. Louis