Merit Award—Less than $15 Million

STORAGE BARN – WASHINGTON, CONN.

Photos by Bo Crockett/Gray Organschi Architecture

For this structure, the architect envisioned a vertical and orderly method for storing landscape materials with minimal impact to the pondside site. The project design goals included electricity generation via a photovoltaic array on the roof, and a translucent skin to allow natural daylighting through the walls and roof. The 28 ft by 20 ft translucent structure also glows at night when interior lights are on.

The daylighting is accomplished with translucent insulated polycarbonate panels on the walls and transparent photovoltaic panels on the roof set atop light cowls. The basement contains mechanical, electrical and plumbing equipment for the solar array and for a geothermal heating system. The garage stores the forklift and other equipment.

As many as 114 custom steel pallets can be placed on the walls to hold stone tile, stone pavers, field stone, or firewood. The pallets reside on six tiers of steel brackets that cantilever from HSS steel columns.

The foundation and ground floor of the enclosed structure are, respectively, conventional cast-in-place concrete walls and a concrete slab on metal deck. The large and variable pallet loads and their large eccentricities created significant building torsional and sway forces as well as significant out-of-plane bending forces. The forces are resisted by the floor, roof, and four walls all structurally integrated into a rigid six-sided box.

The garage floor slab serves as the base of the box. The other five sides of the box are steel framed with moment frames along the four perimeter walls and a steel space frame roof. The moment frames are assembled from 16-ft-tall HSS6x6 columns and a wide-flange beam at the roof level. Diagonal braces were not used in the plane of the walls because they would obstruct the polycarbonate wall panels.

The lack of columns in the wall containing the full width door resulted in insufficient in-plane stiffness. Rather than increase column and roof beam sizes to compensate, additional stiffness was provided with vertical trusses, one on each side of the building. The trusses allow the columns elsewhere to remain small and consistent in size. The horizontal members of the vertical trusses also perform as a bracket for the pallets at each tier.

A designed and manufactured steel space frame was selected for the roof framing to satisfy three criteria. First, an eye-pleasing roof system was desired because it would be exposed to view. Second, in-plane strength and stiffness were necessary to resolve the building torsional forces and sway forces. And third, it does not obstruct light transmitting through the translucent roof surface.

The space frame was assembled on the ground into two pieces and then bolted to the perimeter roof beams to complete the rigid six-sided box. All structural steel was hot dipped galvanized. Slender steel outriggers were bolted to the top of the first bay along the perimeter of the space frame to support the very thin wood framed roof overhang. Wood 2x nailers were bolted to the top of the space frame at the nodes to fasten the plywood roof sheathing and the wood cowls that support the photovoltaic panels.

With 114 pallets, each potentially supporting stone material, there is seemingly an infinite number of possible pallet load arrangements to consider. Unbalanced loading can result in unusually large sway forces and large building torsional forces. The many possible pallet load arrangements were distilled down to those that would maximize building sway and torsion:

- A full complement of fully loaded pallets
- Load combinations with and without wind forces and snow loads
- An impact load due to the forklift dropping and lifting pallets

A 3D analysis model was created to test the strength and performance of the steel framed superstructure due to the various load combinations. The space frame roof was modeled as a rigid diaphragm with rigid links where it engages the roof beams. Then the output shear forces in the rigid links were transmitted to the space frame manufacturer for each load case use in designing the space frame and its connections.

The structural system derives its success from the use of simple components and its careful integration with the architectural design.

Architect
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Fabricator
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General Contractor
Catalpa Management, Morris, Conn.

Structural Analysis Software
RISA-3D, Revit