Steel Showcase

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The ambitious design of the Science & Technology Museum in Shanghai, China sets a new standard.

With its sweeping form and massive scale, the 950,000-sq.-ft Shanghai Science and Technology Museum is a striking addition to the city's Century Boulevard. And to make the ambitious design work, the U.S.-based design team and China-based structural consultants relied on the strength and aesthetic of steel.

"Some of the critical architectural features of the building, such as the soaring roof with an overhang of more than 30′ and a 60′ span, simply proved to be feasible only with steel construction," said lead designer Xiaoguang Liu, of RTKL.

RTKL was awarded the $181.45-million project upon winning an international design competition sponsored by Shanghai ScienceLand Development Co., Ltd. The client challenged the designers to conceive a structure that would represent the City of Shanghai's emergence as a rising economic power and major contributor to the advancement of science and technology in China. At the same time, the two-building museum complex had to be highly functional, encompassing a multi-purpose hall, five galleries arrayed over four floors around a linear atrium, a theater complex with two large-format IMAX cinema venues and a 3-D dome, and permanent rainforest and stoneforest exhibits organized around an interior courtyard.

RTKL's asymmetrical design establishes a strong axis through the complex, which curves around the southern side of a civic plaza, and is located across from a government building, near Shanghai's Central Park. The use of exposed structural steel is significant to the building's final aesthetic, with its sweeping, reflective roof form and trademark egg-shaped dome.

Resisting the traditional Chinese architectural orthogonal order, the dynamic structure spirals from west to east, rising from a single level to four stories. Much of the exterior is clad in glass and steel curtain wall, offering a seamless transition from the museum's exhibits to the civic plaza located outside.

The museum's mass is broken into two structures. The main structure contains the five galleries, each organized by subject, while the annex houses support services and a research library. Upon entering the main building, visitors are enclosed in the glass elliptical space, which provides the access point for the museum's wings. The structure, composed of 2,628 triangular glass panels and an innovative steel strut-and-gusset framing system, is the world's largest clear-span ellipsoid. A floating sphere hangs in the center of the space, which is inspired by an egg and its yolk, the Chinese symbol for the origin of life.

In the four-story east wing, the gallery levels are pulled back from the front glass wall to create a linear atrium. The monolithic "flying roof" suggests the soaring technological advances of modern Shanghai and man's limitless quest for knowledge. Cascading escalators along the wall give visitors a chance to experience the roof's ascending dynamics. At the roof's tail end, the west wing houses permanent galleries, the theater complex, and an outdoor

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courtyard. Visitors can enter the galleries at any point, in any order. There is also space for temporary exhibits.

While reinforced concrete was used for above-grade and subterranean floors, steel was used for several other aspects critical to the function and form of the structure. It was chosen primarily for its long-span capabilities but also for its aesthetic, construction speed, design flexibility, light weight, and space efficiency. Several kinds of steel truss and space systems were employed to shape the vertical enclosures and the expansive spiral roof form, which is planned according to a 174.58-degree fan shape. The inside rim of this fan is 225 m (740′) long and the outer rim is 517 m (1696′) long.

"The project was actually quite challenging, especially given the fact that we had to work with local expertise and technologies in China," says Xiaoguang Liu. "China has a tradition of heavy industry but architectural applications for steel are only recent events."

RTKL was teamed with a local design institute to work on the museum. However, the institute's structural engineer was used to working with reinforced-concrete construction, and so was unable to meet RTKL's requirements for the structural steel design. Architectural steel was still new to local design professionals and contractors. Limited knowledge and primitive design methods translated from heavy industries often resulted in cumbersome shapes and sizes of otherwise delicate structures.

"We ended up using a local structure professor who did most of the work with a his own specially created 3D computer model," Liu says. The consultant, Professor Zhu Fu Hua, also designed the steel curtain wall system with a local manufacturer. He now has his own practice as an architectural steel consultant, something in great demand in China's booming construction industry.

Professor Zhu's solution incorporated steel into the roof structure, curtain wall, and a bridge within the spherical space that connects the main building to the annex. The roof employed a steel space frame that had a maximum span of 75 m (246′) and heights varying from 3 m to 4.5 m (10′ to 15′) along its radius. A shell of two-way steel trusses in the middle section has a maximum span of 85 m (279′). An oval roof opening of 50 m by 35 m (164′ by 115′) was reinforced with a planar ring truss, while a series of wing-shaped roof projections studded with skylights were shaped triangular steel trusses supported by box-type beams below.

The IMAX dome theater was shaped with a single-layer HSS network of 1.5 m (5′) grid. The spherical 3D theater inside the central space is supported by steel posts and connected to a curvilinear bridge made of a steel box beam spanning 51 m (167′) across the space.

A steel-concrete system seemed to be a natural choice for the construction of the science museum, based on RTKL's understanding of and experiences with the local construction industry. The early decision to employ this system was critical to keeping the architecture intact from concept to completion, while adhering to an extremely tight schedule and staying on budget.

The museum has been a tremendous success. In January 2003, it was awarded the 2002 Lu Ban Prize, the highest honor awarded in China's construction industry. The number of visitors has far exceeded expectations of 150,000 persons per month since the first phase of the project opened in April 2002. Further, the two IMAX and one Iwerks cinema venues were the first to be installed in China by the company, and their success has encouraged IMAX to make China its second-largest market after North America. The museum has become such a popular destination that the nearby subway station will soon be renamed after it.

Quality issues and the limited availability of architectural steel products could have discounted this and other prestigious design efforts in China. However, increased awareness within the industry and more emerging design professionals specialized in architectural applications of steel are changing the face of large-scale construction there. The Shanghai Science & Technology Museum is a tremendous example of this evolution.

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