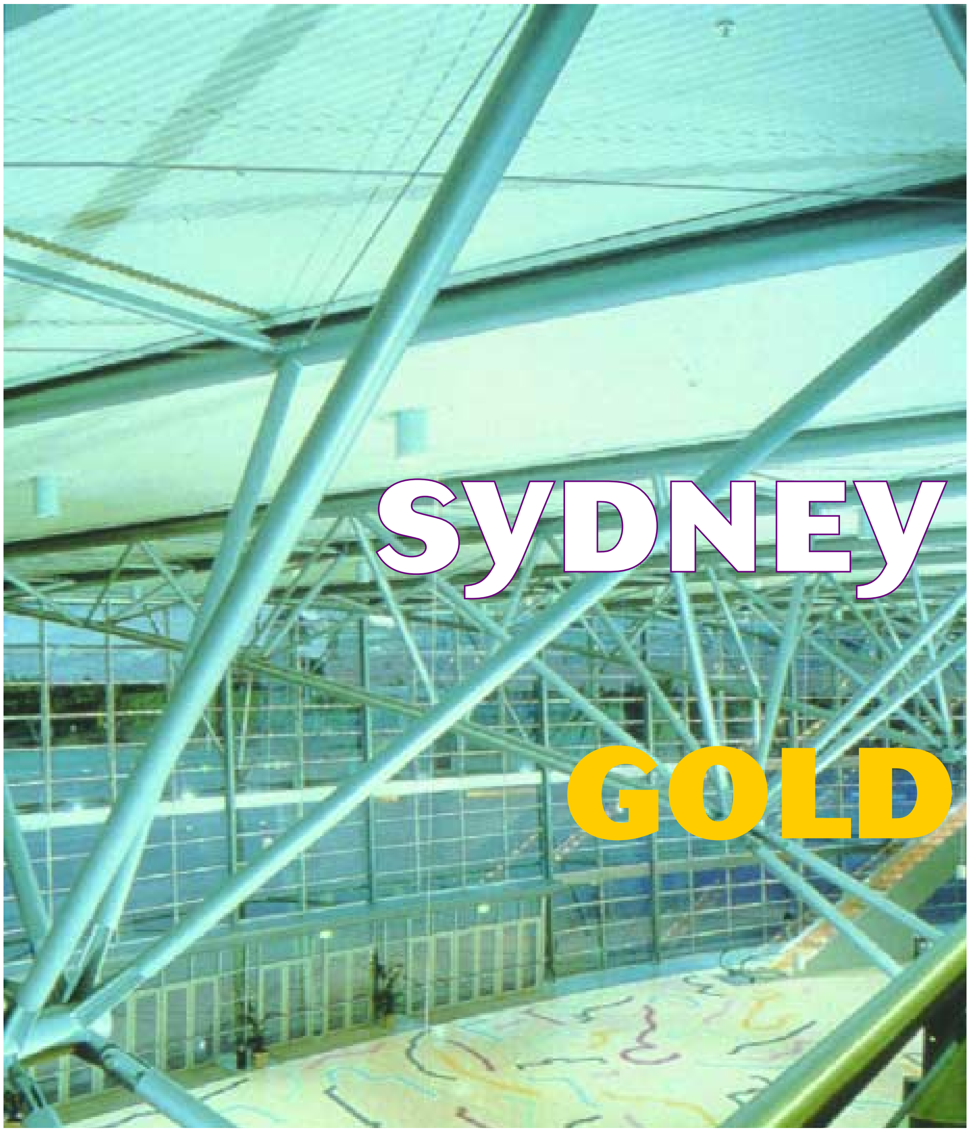

Sydney Arena Wins GOLD Medal

by Carl Yaeger

The world's greatest athletes, many of who spent a lifetime preparing for the moment, gathered last fall in Sydney, Australia for the Olympic Games. The Sydney Olympic Committee wanted nothing less than a world-class facility to serve as the stage for this athletic and cultural spectacle.

The result was the $200 million Sydney SuperDome, built for the games but destined to be a key element of Sydney's cultural fabric for decades to come. The grand arena, seating 15,000 for gymnastics and 18,000 for basketball, was designed by an international consortium led by Devine deFlon Yaeger, a Kansas City based architectural and engineering firm.

The challenges were many and varied. The Sydney Olympic Committee set high environmental standards for the building's construction and operation. Accessibility considerations were paramount because the SuperDome was also used for international Paralympic events for the disabled, which took place only weeks after the Olympics ended.

Construction of major projects also pose a unique challenge on the island continent, which has no glass manufacturing capability and is home to only two construction cranes capable of handling such a project.

The goal was to create a new benchmark in the design of accessible and "green" public assembly facilities. To meet that goal and deliver the building on time and on budget, the planners decided early in the process to depend heavily on structural steel. Steel is the dominant material in the SuperDome's construction and plays the key role in achieving the character envisioned by the designers. Steel's versatility has been demonstrated by the design of this unique structure.

Various simple and complex arch structures and folded plate structures were investigated early on but discarded in favor of a truss system. During the concept design a number of alternative truss systems were examined, including a fully trussed roof, a braced arch roof and a roof with and without the stepped center hub. The alternatives included investigation of both wood and steel truss systems. The final design evolved in response to the weight of the structure, erection requirements and environmental analysis.

Devine deFlon Yaeger employed sustainable design techniques throughout the project and performed in-depth analysis of selected building materials, looking at the ecology rating of each. For every decision, the questions asked were: "Is it recyclable? Is it local? Is it transferable? Is it cost-efficient?" The goal was nothing less than to create the "greenest" arena facility in the world.

The building boasts a self-contained system to maximize the use of recycled water. With this "gray" water system, roof runoff and hand water are then used for toilets, etc. The SuperDome also incorporates the country's grandest solar structure and energy-efficient lighting system and largely used local labor and indigenous materials.

One percent of total seating capacity was designated for spectators with disabilities and their companions. Patrons with disabilities benefit from enhanced sight lines and easy access to everything from concessions to telephones. Transmitter headphones are available for the hearing impaired. The most difficult accessibility issue is moving vertically with elevators, so more handicapped parking was allowed for on each garage level.

But the SuperDome is more than just a functional triumph. It is a stunning addition to the Sydney skyline, with its distinctive "crown" appearance created by 18 roof-support masts and their associated cables projecting into the air above the roofline.

During construction, managers needed to carefully analyze and monitor the erection sequence of the roof, because the forces generated by the method of construction can significantly affect the final design forces in the members.

The span of the main roof is 140 m by 100 m, with an area of 12,500 sq. m. There are 18 perimeter 600 by 400 steel box columns at about 20 m centers but this spacing increases to 32 m around the corners of the roof. The columns extend 12 m above the roof level, allowing the roof to be supported by cables that are tied back to the perimeter columns.

In the center of the main roof is a raised section measuring 40 by 70 m, which consists of trussed space frames about 5 m deep. These frames consist mainly of 250 and 310 universal column sections.

Radiating from the raised space frame in the center are 36 trusses at 20 m centers that span 30 m to the perimeter of the building. These trusses typically consist of 219 by 6.4 CHS (G350) bottom chords and 250 UC 73 and 250 UC 89 top chords. The top and bottom chords were bent to the radius. Between the radiating trusses is a parallel beam (250 UB 25), which is supported on ring trusses spanning between the radiating trusses, allowing for the purlin spacing to be cut down to 10 m.

Around the perimeter of the roof is a horizontal truss that distributes the thrust from the radial trusses into the bases of the columns. These forces are generated by a combination of arching action of the roof and the horizontal components of the restraining cable forces. These forces are then resisted by ring action in a reinforced concrete plant room slab.

The roof has strict acoustical requirements and was constructed with a layering of elements. This consisted of a top metal deck, two levels of purlins, insulation and plywood. In all, the weight of the roof system is 55 kg per sq. m.

The main roof weight, including the masts, columns, cables and the 800 deep steel rakers, is 880 tons. This does not include the 25 km of steel purlins in the roof. More than 26,000 sq. m of steel roof sheeting was used.

The outer "donut" section of the roof was partially constructed in pie-shaped segments on the ground, which included the roof sheeting system. These were then lifted into place on six temporary towers. The infill sections beside these elements were then completed in the air. The raised center roof was placed in erected position. When all the framing elements were in position, including the cables, jacking down the outer cables tensioned the structure. Finally, the temporary towers were lowered, allowing the roof structure to take all the dead loads.

Exterior of Sydney SuperDome.

The structure has been designed to support substantial rigging loads of up to 70 tons, in addition to self weight, live and wind loads. A 30-ton gondola is suspended from the center of the roof, supporting an array of large video screens and scoreboards, giving the operators great versatility for setting up various show configurations.

There is a wide veranda and colonnade wrapped around the building that, together with the extensive use of steel, echoes Australian vernacular traditions. The elliptical dome over the building footprint is extended by the varying veranda depth, with a maximum of 30 m, giving added interest to the façade.

The roof of the foyer structure consists of triangular trusses, spanning up to 30 m, strutted off the main concrete structure. Two plane trusses were joined together to form the triangular trusses.

The columns supporting the foyer trusses are linked with the colonnade columns into a triangular vertical truss. These vertical trusses are extended into a tree structure to support the edge of the veranda roof. The façade system is completed by horizontal trusses at each floor level, which turn the veranda colonnade into a large space frame.

The result is a network of highly inter-related lightweight members, each serving several functions, producing the appearance of a lacy veil of fine steelwork. The web wraps around the façade, creating a spider-web effect from the inside.

Carl Yaeger, AIA, is a principal of Kansas City, MO-based Devine deFlon Yaeger, and served as the firm's principal-in-charge on the Sydney SuperDome.

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AbiGroup

Structural engineer:
Taylor Thomson and Whiting

Architect:
Devine deFlon Yaeger

Associate Architect:
Cox Richardson

Construction:
AbiGroup

Environmental Consultant:
Manidis Roberts

Software:
AutoCAD; *Spacegass* for structural analysis.