TWINSTAR DOME FOR LA PLATA

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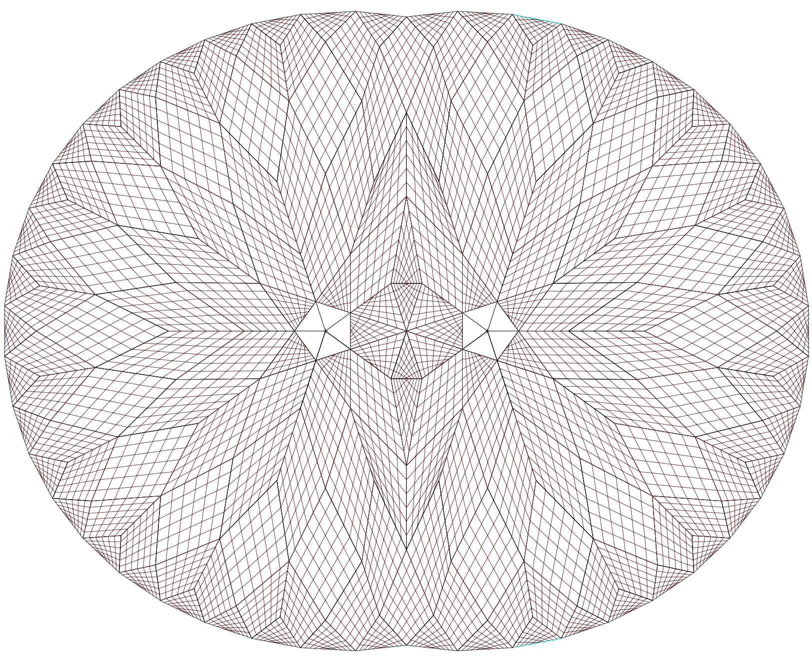
Introduction

A new 45,000 seat soccer stadium under construction in La Plata, Argentina features a unique twin-peaked Tenstar Dome™. The plan of the dome has been uniquely shaped by the arquitect, Roberto Ferreira, to provide an individual identity to each of the two soccer clubs scheduled to share the use of the facility. The resulting image is that of a Mastercard symbol.

In order to adapt to the non-monotonic hoops, an arch has been introduced across the pinched waist centerline of the stadium to resist the outward thrust. This arch required the introduction of rigid ribs instead of all cables that would have been the case if the kink were not present. Another distinguishing characteristic of this roof structure is the method of support. A triangulated perimeter truss resting directly on the top of the seating berm provides resistance both against horizontal forces and gravity loads. Since this truss is about 13m high, boxes have been introduced that are hung from its top chord.



2. Project Description.

The plan is derived from the intersection of two circles with radii of 85m and with centers 48m apart.

Along the perimeter of the dome is a triangular steel trussed compression ring about 9m wide and 13m high, with a gutter along the outer top chord and louvered sides for ventilation. The vertical posts of this compression truss form a colonnaded gallery at the back of the stands.

This ring truss sits at the top of a berm that forms the seating bowl for the stadium. In cross-section, the stadium is therefore seen as a low profile structure with a berm rising from a moat somewhat below natural grade toward a seating bowl with a playing field also below natural grade. This profile was determined to balance the cut and fill on the site to the greatest possible extent.

At the top of the posts of the compression ring is an inner top chord that forms the spring line for the dome which consists of a triangulated ridgenet of cables, characteristic of a Tenstar Dome. A series of three tension hoops step inward and upward from this inner top chord. The first of these hoops is held by radial cables (rather than the triangulated cables in previous Tenstar Domes), sloping down from the inner top chord. From the node at the intersection of the radial cables and the hoop, rigid vertical posts rise to top ridgenet nodes. Diagonal cables angle down from these nodes to pick up the next tension hoop which, in turn, supports the second set of posts. This sequence is repeated until reaching the top of the third ring. A diamond-like array of radial cables springs from the third ring to form the tent-like cupola of each peak. These cupolas actually consist of two overlapping surfaces that provide a weather-protected monitor, which lets air to flow freely through 15m diameter openings in the lower level roof surface of each of the two peaks. A jewel-like skylight crowns each peak accentuating the identity of the two ball clubs.

Catwalks are placed along the tension hoops to permit the installation of lights, speakers, and rigging for special events. Bridges span between the hoops, linking the catwalks and providing support for power and communication cables.

Skyboxes and control booths are placed on the two sides of the stadium within the space of the compression ring.

3. Structural Concept.

The Tenstar Dome is a tensegrity system that is defined as a ‘spatial network in a state of self stress’. The system consists of four elements: triangulated ridgenet, triangulated diagonal cables, hoop cables, and rigid vertical posts. The system works like a truss in which the bottom chord is interrupted and then follows the line of hoop cables around to the opposite side of the arena. The system is truly three dimensional rather than planar and therefore benefits from the triangularization of structural elements. This improves load-carrying capability and permits non-conventional geometry, such as the intersecting circles of the La Plata Dome. In order to prevent cables from becoming slack under load, the system needs to be prestressed. The level of such prestressing is established based on the load combination acting on the roof that would cause a cable to go slack. Prestressing satisfies the criterion for a tensegrity system and also produces a reduction of deformation of the system. As a consequence, the roof is extremely rigid, comparable to a tightly held drum.

The triangulated compression ring supporting the dome is designed to carry gravity loads from the dome as well as wind loads acting against the roof surfaces. A certain level of lateral resistance is therefore required between the ring and the foundation. At the same time, the roof structure is subject to expansion and contraction due to temperature variations. Internal stresses in the ring due to restrained temperature deformations were evaluated and found to be acceptable if only one support on each side of the kink was radially released. This was accomplished by providing sliding teflon bearings in a guideway that permit radial movements but restrain circumferential displacements. All other ring truss supports are fixed to the foundation.

The ring truss is supported on pile caps at the top of the berm, with piles that extend down to virgin soil. Grade beams tie the pile caps together and act essentially as the bottom chord of the trussed compression ring.

4. Connections.

The design of the Tenstar Dome assumes that no adjustment will be required in the specified lengths for the cables. This implies that all cables will be fixed at nodes, either by dead ending with a socket joint or firmly anchoring continuous cables with a friction clamp. Top chord connectors in the ridgenet are designed to have continuous cables along the intersecting diagonal lines. Fixed connectors are used at the top of the roof around the two center openings and at the inner top chord of the compression ring.

Bottom connectors are designed to permit the hoop cables to be continuous and therefore are clamped. The diagonal cables ending at the hoop connector are the fixed socket types. All connectors are assembled and welded together out of steel plates. The principle that is followed in the assembly procedure is to avoid subjecting welds to tension.

5. Covering.

The roof is covered with a teflon coated fiberglass fabric in panels that are fixed to the cables. Since the aim of the facility is to have a natural grass field, it was necessary to find a fabric that possessed the characteristics of high translucency. Previously available PTFE-glass fabrics had at most a 16% translucency, which is not sufficient to insure the survival of grass. A new fabric, UltraLUX, with more open weave and a resulting translucency of over 24% was developed by Chemfab and is being used for the first time in this dome. This fabric has a tensile strength of 171 kg/cm, less than 5% weaker than the more commonly used Teflon/glass fabric with greater opacity.

It is a characteristic of the Tenstar Dome that the cable structure is totally stable and does not rely on the fabric for stability. The fabric is therefore merely a roofing material. The roof will be covered in two stages. Initially, only the outer two rings of the roof will be covered with a closure cable in a scalloped configuration at the second ring. In the second stage, the inner rings will be covered and the cupolas installed. The final decision on proceeding with the full cover rests on the issue of the viability of a new system for growing and maintaining grass.

A unique study is currently under way to test new varieties of grass and methods of treating the field. This study is being carried out by a joint venture between the University of La Plata and Michigan University. A test greenhouse covered with the same fabric planned for the dome was erected in the summer of 1997 in La Plata. Plats of different varieties of grasses are being grown under this roof and subject to a variety of tests for toughness, durability, endurance etc. These tests will result in a grass being chosen for the dome which, if found to be sufficiently rugged, will lead to the complete covering of the dome. This clearly has profound implications for the future proliferation of covered stadiums.

6. Construction.

The typical method of erecting a Tenstar Dome by first hanging the ridgenet from the perimeter truss may not be practical in the case of the Twinstar Dome. The rigid elements that make up the arch section at the pinched waist centerline of the dome augur against this method. Undoubtedly, before the cable dome can be assembled, the arch section must first be erected. To accomplish this, it is contemplated that erection towers will have to be installed at the panel points. These towers have the function of supporting the arch during assembly and until the cable dome is attached thus rendering the arch stable. We envision that a maximum of seven trussed towers will be required. These will be braced laterally by cables anchored with deadmen in the ground.

Following the assembly of the arch, the balance of the erection procedure will essentially follow the typical Tenstar erection methodology with the difference that the attachment to the arch is treated similarly to the attachment to the compression ring. It is anticipated that the two sides of the cable dome will be raised simultaneously to avoid unsymmetrical loads on the arch. Once the ridgenet is hung, the first row of posts will be hung and the first hoop attached. Following this, the diagonal cables from the compression ring will be connected to the first hoop nodes. The second and third hoops will be erected in a similar fashion. A detailed procedure will be coordinated with the roof contractor. Completion of the project that will provide La Plata a premiere venue for soccer and other events is expected before the new millenium.