BRITE Innovation Case Study No. 9

TELSTRA Stadium (formerly Stadium Australia) was reconfigured in 2003 to remove the temporary seating in the north and south terraces, which had been used for the 2000 Olympic Games and Paralympic Games.

Two new 3,500sq m roofs for all-weather accommodation were constructed over the stadium ends. The seating stands on the east and west sides of the playing field were placed on moving frames so that the arena could be quickly adjusted for rectangular and oval settings.

The reconfiguration cost $80 million, with the roofing component being around $10 million, and was completed without disruption to the scheduled events at the stadium. A post-tensioned roof was adopted to avoid problems that were likely to be encountered with a more conventional steel roof, including the need for every connection node to be propped until the roof was completed.

The principles of post-tensioning have long been understood by structural designers, but they have not often been applied to steel frame structures. The behaviour of a structure can be predicted by applying loads to a theoretical 'string line' - compression domes have been designed this way for centuries. Traditionally, loads simulating the self-weight of the dome were hung from a string. The shape taken up by the string was plotted and inverted to form the design of the dome. The tension in the string line was measured and this determined the thickness of the dome structure.

A similar process was used for the stadium roof, using 3D computer modelling instead of the physical string line. In this case, the string line shape was not inverted but accepted as the form of the main catenary trusses. There was no need for inversion because the tension and compression properties of steel are strong enough to support the load (unlike a masonry dome, which has very little tensile strength).

The string line approach does not, however, deal with deflection, so sophisticated software was used to model the loads in the members, and deflections in the structure. The string line is represented by the post-tensioned cables in the truss bottom chords. These cables are loaded by hydraulic stressing to resist the external forces acting on the structure.

All the prefabricated members which make up the trusses are straight lines or simple curves, so that while a very large truss is produced, the components are easily transported and lifted into place. Once assembled, the truss was in effect proof-tested by the stressing process. The approximately six kilometres of stressing cables in the bottom chords of the trusses were stressed by hydraulic jacks, then fixed in place with high-strength grout once they were in position.

The connecting joints for the post-tensioned roof structure are all simple 'butterfly', 'half moon' and 'end plate' connections, so the truss sections can be quickly and easily bolted together on-site. The trusses were assembled in two relatively small areas on the concourse outside the stadium. A 400-tonne and an 800t crane on the concourse were used in tandem to lift the main trusses into place. Smaller cranes with long reach capacity completed the assembly, also from outside the stadium. This included the secondary trusses and the 10m x 10m framed polycarbonate panels that finished the roof.

The stored energy in the stressed cables reduces deflection under load. This allowed the main trusses to span the 114m between the existing roofs without any intermediate support or propping during construction, leaving the seating under the roofs available for scheduled events.