Architect:	Foster and Partners
Structural Engineer:	Anthony Hunt Associates Ltd
Steelwork Contractor:	Watson Steel Ltd
Main Contractor:	Schal International
Owner:	National Botanic Garden of Wales

Great Glasshouse, National Botanic Garden of Wales

The National Botanic Garden of Wales is built on the site of Middleton Hall, an estate developed by William Paxton around 1800. The project has been funded by the Millennium Commission and many other public bodies as well as private finance.

The whole site has been landscaped and remodelled with many features, such as the existing lake system, restored to full working order. Anthony Hunt Associates have undertaken all the infrastructure design and detailing including roads, paths, car parking and drainage as well as the structural design of all the buildings.

The centrepiece of the development is the Great Glasshouse. Built on the crest of the hill on the site of the original hall, it houses a warm temperate environment to exhibit plants from Mediterranean regions. The substructure is a 100 x 55m oval ring, constructed in a combination of insitu and precast concrete, forming a raft foundation bearing on a boulder clay and containing two-storey plantrooms and escape tunnels.

The roof structure takes the form of a glazed dome, slightly tipped towards the southwest and oval in plan. It sits directly onto the insitu concrete ring beam that caps the substructure.

After an extensive study into various geometric forms which may have been suitable to achieve the doubly curved oval shape of the dome, a geometry based on a torus and the plane cuts of a torus was developed. By definition the torus is a tubular surface created by the rotation of a sphere (radius r) about an axis y with a radius R in an x, y, z- co-ordinate system.

The z-axis of the generating torus is tipped towards the southwest by approximately seven degrees. The size of the Glasshouse and the joint between the concrete ring beam and the steel glazed structure are determined by plane cuts of the torus.

The primary roof member takes the form of a single curved 323 diameter tubular hollow section arch up to 58m long, spanning across the toroid at four metre centres. The arches follow the precise geometry of the toroid, with a constant radius of curvature in every member.

Whilst simple in concept, the design of the arches required the most advanced non-linear buckling analysis to ensure an adequate factor of safety is maintained against global buckling. The tipping of the dome to one side also induces significant bending moments in the tubes and additional stiffness was gained by forming the 'T' section cladding supports and CHS into a composite section.

The secondary structure, which braces the arches against lateral buckling, is straight, 140 diameter CHS at 7.5m centres. The tubes run from the ring beam at either end of the roof, up towards to the centre line, where an expansion joint is incorporated to prevent the build up of excessive stresses under extremes of temperature.

The steelwork was erected from either end with the arches arriving on site in several pieces. Once erected on trestles they were site welded together. The end detail is a ball and socket connection machined from stainless steel, allowing the arches to drop into place regardless of the varying angle of incidence between the steel and the concrete ring beam. Under extreme wind loads the arches at the ends experience uplift forces which are resisted by an additional capping piece, bolted down to the socket/base plate.

The glazing system is aluminium and is free to move relative to the steelwork to accommodate differential expansion.

Judges' Comment:
The structural clarity of this beautiful steel building appears beguilingly simple; the design effort expended to deliver such a refined solution has been outstandingly successful.