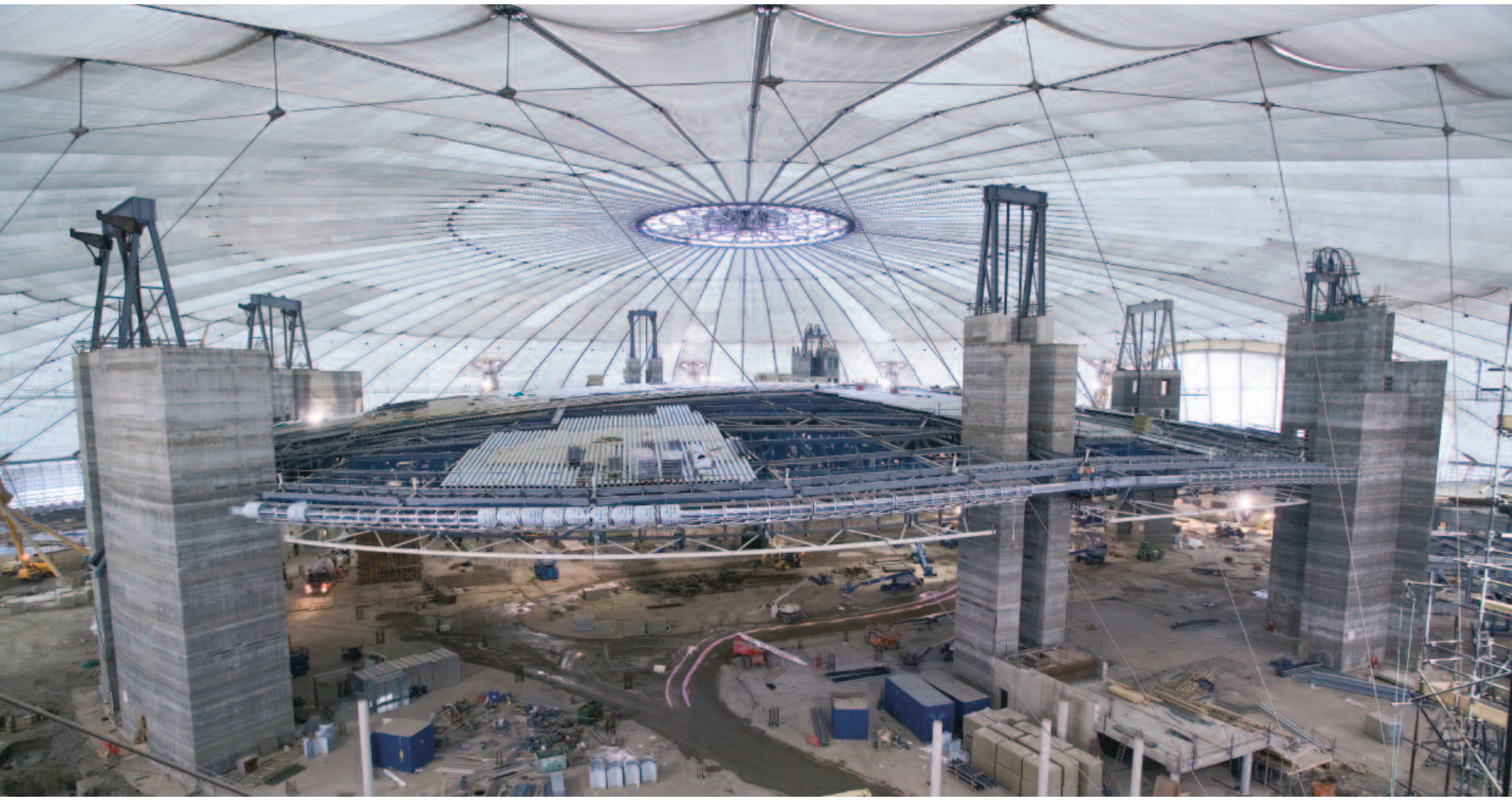
AWARD
THE O_2 ARENA, NORTH GREENWICH

steelwork by integrated team working

ARCHITECT - HOK SPORT ARCHITECTURE
STRUCTURAL ENGINEER - BURO HAPPOLD LTD
STEELWORK CONTRACTOR - WATSON STEEL STRUCTURES LTD
MAIN CONTRACTOR - SIR ROBERT MCALPINE LTD
CLIENT - ANSCHUTZ ENTERTAINMENT GROUP



Situated inside the original Millennium Dome structure, the O_2 is a 22,000 seat state-of-the-art multi-purpose venue, including 96 corporate suites. It is designed to be the most technically and acoustically advanced concert arena in Europe.

Built on time and within budget the O_2 Arena meets the client brief in every way. The construction programme took two years from first pile to first full capacity concert, as contractually agreed, and was achieved through careful design and teamwork in a well integrated design and build team.

Successful construction was partly due to the engineering design that considered buildability from the outset, including the constraint of being positioned within the existing O_2 (Millennium Dome) structure.

The complete roof system, including cladding, catwalks, ductwork and other building services, was completed at ground level and then lifted into place in one piece. Not only was this the safest strategy, but also the most cost effective. Safe erection of the roof was enabled by the use of strand jacking. The unique and innovative lifting process, including all of the method statements and safety check hold points, was agreed between the design-build team and lift specialist PSC-Fagioli.

A detailed 3D coordination process undertaken between Buro Happold, WSSL and HOK, also involved other parties, such as M-E Engineers (for ductwork layouts), to ensure the design was properly communicated to the steelwork contractor.

Combined teamwork was also adopted for the design of the temporary works required to lift the roof. Buro Happold and WSSL worked on different aspects of the lifting frames and slender cores in their temporary

judges' comment

This is a complex and substantial building in its own right, but made more so by its location within the Millennium Dome, presenting huge challenges. The chosen solution involved raising the 4,000 tonne steel structure, with its cladding, in one lift of more than 40m high to within 2m of the Dome's roof.

This is a triumph of planning, design and engineering, and a fine example of integrated team working.

Image courtesy of Buro Happold/Adam Wilson

condition. The whole team participated in a series of risk workshops to review the methodology, agree hold points and incorporate engineering design constraints to achieve a smooth, risk-free lift process.

Construction of the roof on temporary supports was unusual. It assumed its deflected shape at 'lift-off' using the innovative strand jacking lift process. To achieve this, a series of steelwork connections was configured to allow structural movement, aided by the cladding movement joints, and installed prior to the lift. All these aspects were monitored and the roof behaved as predicted.

The roof lift included geometric constraints of local points on the roof, as well as the global positioning of the structure relative to the concrete cores. This demanded very close monitoring, and the development of corrective measures should the constraints be reached. It was essential that the lifting strands remained within 25mm of vertical, and that the roof remained within a 30mm band of true horizontal, consequently interdisciplinary teamwork was crucial.

Bespoke brackets were used for each purlin pick-up connection to account for the spherical geometry of the roof with standard detail brackets used on the main trusses to reduce complexity.

Considerable skill and workmanship was also required to achieve the construction of some elements to within 2m of the dome fabric, without a single perforation to the existing structure.

Corrosion protection was arranged by dividing the steelwork into five distinct areas, and defining the performance criteria and environment for each. This led to an efficient corrosion protection scheme for the overall roof. Fire protection to the roof was not required.

The positioning of the 4,000 tonne roof in a single lift involved the use of multiple capacity strand jacks that were monitored by both position and load. A bespoke computerised surveying technique was used, which allowed designated positions to be observed in real time.

The design and construction sequence of the core structures allowed this to happen. The quadruped structures were fixed to the roof prior to its lift and then positioned to full height with the main roof inside the core walls. The bearing allowed these quadrupeds to be rotated into their final position.

In two of the cores, structural floors and walls were only constructed once the roof was in position to enable a vertical route for the roof lift. The design and construction of the concrete cores also had to accommodate the temporary lifting frames. The combined steel and concrete structures were assessed for stability and buckling behaviour and monitored during the lift. 'Stressed skin' diaphragm action in the deep profile cladding was utilised to gain maximum efficiency in the steel components.

The positioning of the temporary supports was coordinated and analysed from fully supported to lift conditions, to avoid over-stress at all times.

The 2,700 tonne roof structure has a design life of 60 years. The design of the structure allows for the possibility of the enveloping main dome structure being removed. It allows for easy replacement of the main bearings at the eight support positions using temporary jacking points, facilitating efficient, effective and safe maintenance. Also, a variety of paint systems were designed to suit the different exposure conditions throughout, and the design incorporates full external snow and wind load allowances.