Passenger Terminal Building Wing Structure, Kansai International Airport, Japan

For:
Kansai International Airport Co Ltd

AWARD

Joint Venture Design Team:

Leader:
Renzo Piano Building Workshop

Architects & Engineers:
Nikken Sekkei

Engineer:
Ove Arup & Partners

Steelwork Contractors:
Watson Steel Ltd

General Contractors:
Obayashi Corporation and Takenaka Corporation

Kansai International Airport, Osaka Bay, is Japan's first 24-hour airport; an artificial island, 4.4 km x 1.25 km, built 5 km offshore and joined to the mainland by a double-deck road and rail bridge. On the island is the world's longest terminal building. The total project cost was 1.43 trillion yen (over £9 billion at current rates), with the Passenger Terminal Building alone accounting for 150 billion yen, or almost £1 billion.

The Passenger Terminal Building consists of a massive, clear span main hall, extending out from which are two "wings" over 1.6 km in length and curving in both width and height along their length. Responsibility for the manufacture and shipping to Japan of the 4000 tonne steel wing structure was entrusted to Watson Steel under a £13.0 m joint contract with two leading Japanese steel companies, Nippon Steel Corporation and Kawasaki Heavy Industries. This project can only be described as unique, not only for the complexity of its construction, with a constantly changing geometry curving in three dimensions, but also for the fact that this was the first ever contract awarded to supply fabricated steelwork into Japan by a foreign company.

Ove Arup's solution to the seemingly impossible form of the wings was highly innovative. Continuously varying geometry normally leads to high costs, however, this was solved by employing an inclined toroid as the basic shape model, giving continuous curvature but with the benefit of repeatable geometry throughout. A "light" appearance to the structure was achieved by utilising shell action with stiffening "diaphragms" being formed by the introduction of tie bar counterbracing on alternate "ribs".

Structural analysis was undertaken using a 3-D, non-linear program. The resulting structure is surprisingly slender given the severe design conditions of typhoon winds and earthquakes. The basic structural model is a series of curved ribs at 7.2 m centres supported on alternate twin and single "cigar" legs at the rear and interconnected by rails and bracings to form a shell structure. The ribs are of all-welded construction whilst the interconnecting members are joined by high strength, tension control bolts. Tie bars are solid steel rods in single or twin configuration. Whilst the mathematical model for the structure's shape allowed for repeatability of the basic geometry, the individual ribs were in themselves unique, having the same setting-out data but truncated at different positions.

The individual rib geometry is defined by four interconnected circular arcs. The normal method of cold bending used to curve sections proved unsatisfactory since it led to ovalling distortion of the cross section. Such ovality was undesirable, not only from a design aspect but also because of the difficulties it would have given in fabrication of the connections. To overcome this potential problem, Watson adopted the technique of induction bending by which the section is fed through an induction heating coil and gradually bent. This process produced the overall curvature, which incidentally was able to be varied along the length of section, and also left the basic cross section almost distortion free.

All of the steel used in the construction was supplied by British Steel and certified to Japanese standards. Circular hollow sections, 355 mm diameter, are used for the ribs and columns with other members being generally 250 x 250 mm RHS. From an order in December 1991, the fist shipment of steel arrived on site in April 1992. Shipments continued up to March 1993 and the final steel erection was made in early May 1993.

Judges' Comments:

Design, fabrication and erection to the highest world standards have combined to produce an exceptionally well engineered and aesthetically delightful structure.