Stansted Maintenance Facility - Stansted Airport

For: FFV Aerotech Stansted Limited

AWARD

Architects:
Faulks Perry Culley & Rech

Structural Engineers:
Burks Green & Partners and Sir Fredrick Snow & Partners Limited

Steelwork Contractor:
Hunt Steel & Cladding Limited

Main Contractor:
Costain Construction Limited

There are two basic geometric requirements for the main hangar building. Firstly, it was to be capable of housing for maintenance purposes, two Boeing 747 400 series aircraft under a single span roof without internal columns. Secondly, it was to impose the minimum possible visual intrusion on the Essex skyline.

Form

If two 747 400 series aircraft stand nose to nose and wing tip to wing tip, the plan perimeter produced is approximately a diamond shape. It was for this reason that the plan shape of the hangar comprised two equilateral triangles with 98m sides and a common base forming the centre line of the hangar. This arrangement gave clear roof spans of 98m between the obtuse corners and 170m between the acute corners.

Two doors 74m wide by 21m high are located at each side of one of the obtuse corners. These dimensions were dictated by the wing span and tail fin height of the 747 aircraft. Lattice girders 5.9m deep span 76m over each door opening.

Roof structure

The roof structure is a Cubic space frame comprising 1201 modules each of 4m depth and 2.0 x 3.5m on plan.

This space frame is essentially an orthogonal grid of Vierendeel girders. Each vertical member in the frame is therefore an integral part of two girders spanning at right angles to one another. Modular construction is made possible by the introduction of bolted splices in the chord members midway between adjacent verticals. Square hollow sections were used for the vertical members to provide the required bending capacity in the vertical direction. Universal beam or column sections were used for the top and bottom chord members.

It was assumed that splices between modules act as pinned joints. This assumption is justified because, even if the splices were capable of full moment transfer, their positions are always near to a point of contraflexure. In addition, the bolts are placed in clearance holes which, in combination with plastic embedment at the bolt/hole interface, permit rotation at the joints before any moment is transferred.

Moment continuity is required at the connection between the chords and the verticals. This was achieved by welding the chords to the wall of the square hollow section. In order to guard against local deformation of the SHS wall, cap plates are welded to the top and bottom of the SHS members. One flange of the incoming chord is welded to the cap plate and therefore does not apply load to the wall of the SHS. A stiffener is provided across the width of the SHS at the level of intersection with the other flange of the chord. This helps to transfer chord forces directly to the sides of the SHS.

An obvious advantage of the Cubic space frame roof is the omission of diagonal braces which greatly facilitates the installation of services. A further advantage became apparent at Stansted. Alternative forms of roof construction not only used more steel than the space frame but were 2m deeper giving a further advantage in an environmentally sensitive area of Essex. It also resulted in significant savings in cost. The one thousand, two hundred and one, 4m deep, modules forming the roof at Stansted weighed a total of 930 tonnes. Vertical posts varied between 200 x 200 x 6.3 SHS at the centre of the roof to 300 x 300 x 16 SHS at the perimeter. The chords varied between 203mm and 406mm deep sections.

Supporting columns

The roof is designed as simply supported at its perimeter. With the exception of the columns at the four corners of the building all supporting columns are assumed as pinned at top and bottom. Overall stability of the structure is therefore provided by the four sets of corner columns, which were designed as cantilevers from a fixed base. Under the application of wind loading, the space frame roof acts as a stiff plate to distribute the load between the four main sets of columns.

The four main columns were stressed to the piled foundations with 40mm diameter prestressed Macalloy bars. These ensure that, even with maximum uplift in any stanchion, there is residual compression at the underside of the baseplate. This eliminates elastic elongation of the bars under working load thereby ensuring the degree of fixity at the base necessary to avoid unacceptable horizontal displacements at eaves level.

Two obtuse corner sets of columns each comprise four 356 x 406 UC sections, positioned on plan at the corners of a square with 3m sides. 203 x 203 UC diagonal bracing is used between the main column sections.

The two acute corner columns each comprise three 356 x 406 UC sections, positioned on plan at the corners of an equilateral triangle with 2.5m sides and with 152 x 152 UC diagonal bracing.

The other perimeter columns, including those adjacent to the door openings were formed by two UB sections with channel bracing between them. In the case of the door columns (which support the lattice), two 838 x 292 UBs were positioned 1.2m apart and braced with channel sections. A vertical working load of 330 tonnes was to be carried by each of these columns under full dead and imposed loading. The total weight of the stanchions was 312 tonnes:

Lattice Girders

The lattice girders which spanned the door openings were 5.9m deep. The top and bottom chords were 356 x 406 column sections and the bracing was 254 x 254 column sections. There was a total weight of 90 tonnes to steel in each lattice girder.

Section sizes

In order to ease transportation, handling and erection problems the structural steelwork was fabricated and erected in manageable sections. Columns were spliced at mid-height with high strength friction grip bolts used at the column splices. This was to ensure that no slip occurred at the splice with stress reversal. This was particularly relevant to the four sets of main columns where a high degree of stress reversal, associated with wind loading, was expected. The 76m span lattice girders were split into 5 sections along their length and split again at mid depth. Each girder therefore arrived on site in 10 sections and was bolted together on the ground prior to lifting into place.

Judges' Comments:

A large industrial building, well planned, and providing good working conditions. The Vierendeel space frame roof makes good use of standard steel components to provide a very large column free space in an effective way.

The solution significantly reduced the overall height of the building, important to the Airport Authority, and despite initial erection difficulties the structure was completed on time and within budget.