ISTANBUL
Sabiha Gokcen AIRPORT, TURKEY
International Terminal Building

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A second airport has been constructed on the Anatolian side of Istanbul as a part of an ongoing "Advanced Technology and Industry Park" project. This new airport has been named after Sabiha Gokcen, the first female military pilot of the world. Among the various buildings of the Sabiha Gokcen Airport, the most fascinating one is the international airport terminal building.

The terminal building is 23,000m^2 (about 248,000 sq. ft.) in total and is equipped to handle 3.5 million passengers per year. Prime design objective was the direct visual interrelation between the apron and passenger halls. Special effort was put to allow utmost daylight inside, which created a spacious and comfortable environment for the passengers.

General Overview

The international airport terminal building consists of three main halls with dimensions of 67.35m (221.0′) in width and 58.80m (192.9′) in length each. The area covered by the whole structure is 83.23m x 207.18m (273.1′ x 679.7′). The elevation of the hall descends from the landside to the airside docking apron. The lower elevation of the roof descends from 13.42m (44.0′) on the landside to 8.60m (28.2′) on the airside.

On the landside, a 219m (719′) long, 15.10m (49.5′) wide and 6.85m (22.5′) high steel structure supported by reinforced concrete columns is designed to support the air conditioning unit (Figure 1).

(Top photo) Figure 1: Landside view of the terminal building.

Figure 3: Main steel structure of the roof.

Figure 2: Airside view of the terminal building.

On the airside, a steel canopy, 219m long x 9.40m wide (719′ long x 31′ wide), runs along the building (Figure 2).

Two mezzanine floors, inside the building, cover an area of 4,120m^2 (44,300 sq. ft.). These floors have been designed as composite floors supported by steel columns independent from the main structure. Bracing has been added at appropriate locations to take the lateral seismic loads.

Main Structure

The main structure is composed of a steel roof that rests on fixed supported reinforced concrete columns. The reinforced concrete columns have 80cm x 360cm (31″ x 142″) cross sectional areas. The columns are on a grid of approximately 8.4m x 67.50m (28′ x 221′). Columns are connected to each other by reinforced concrete beams spanning 8.40m (221′), forming a single-story seven bay frame. These beams are 190cm x 120cm (74.8″ x 47.2″) deep.

The main roof structure is composed of single span sim-

TABLE 1

MEMBER	PROFILE (mm x mm)
Upper chord members of the main trusses	Pipe: 406 x 9*
Lower chord members of the main trusses	Pipe: 406 x 9 Pipe: 406 x 16
Diagonal and vertical members in the plane of upper chord members of the main trusses	Pipe: 219 x 6 Pipe: 273 x 6
Side diagonals of the main trusses	Pipe: 324 x 7 Pipe: 355 x 8 Pipe: 406 x 16
Columns of the frames	Pipe: 406 x 9 Pipe: 406 x 16
Upper chord members of the longitudinal trusses	Pipe: 324 x 7
Lower chord members of the longitudinal trusses	Pipe: 355 x 8
Diagonals of the longitudinal trusses	Pipe: 324 x 7
Roof beams	Built-up I Profile: Flanges: Plate 200 x 12 Web: Plate 226 x 16
Eave purlins	Built-up I Profile: Flanges: Plate 200 x 30 Web: Plate 150 x 20

**roughly equivalent in size to Round HSS 16 x 3/8*

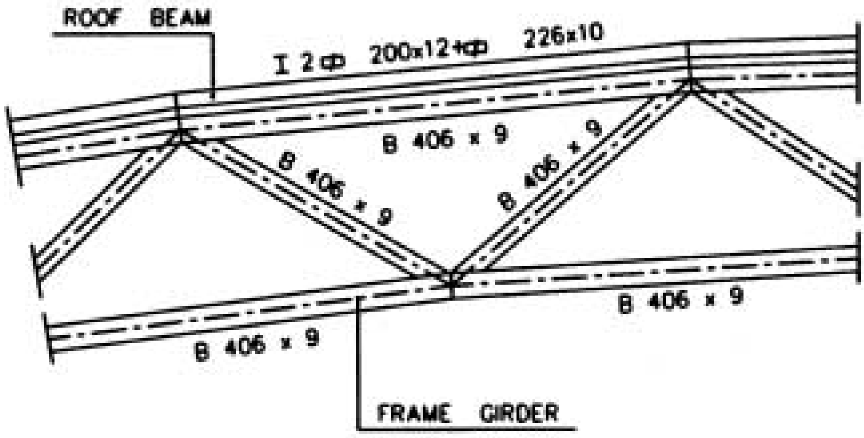

Figure 4: Detail of the truss members.

ply-supported arched beams that form a truss frame system. The frame span is 65.60m (215′) and the spacing between the frames is 8.40m (28′). The elevation of the frames decreases from grid C on the landside to grid K on the airside. The columns of the frames are supported by the reinforced concrete system at an elevation of +7.70m (+25′). The lower elevation of the beam is at +13.42m (+44.0′) on the highest roof frame and at +8.66m (+28.4′) on the lowest. This causes the column heights of the frames to vary between 5.72m (18.8′) maximum and 0.96m (3.15′) minimum (Figure 3).

The arched girders of the frames are in the form of triangular cross sectional space trusses. The members of the space trusses are made of pipes connected to each other by means of welds without any plates. Two parallel pipes spaced at 800mm (31.5″) are used on the lower chord members. Transverse secondary members are used in order to connect the two profiles to work together, as well as to take the shear forces. The main supporting structure of the roof is composed of three independent frames that lie next to each other on the transverse direction. In order to achieve the continuation of the roofing, these frames are connected to each other at the supporting regions of the upper chord members by means of secondary truss members using connections with slotted holes. Eight parallel frames span 65.60m (215′) each. These frames are then connected to each other on the longitudinal direction, perpendicular to the direction of the plane of the frames by means of longitudinal trusses formed at the end joints of the arched girders. This way, the stability along the longitudinal direction of the structure is achieved by means of a truss frame system with seven spans and hinged supports. The roofing is applied to the upper chord members of the frames by means of roof beams. Purlins of any other type are not used. The roof beams are assembled on the upper chord members as seen in Figure 4, in order to compensate for the discontinuation of the roofing. These members are supported by the truss joints of the upper chord members. As a result, the roof covering rests on those beams, and the upper chord members of the frames are prevented from bending stresses otherwise caused by the roofing material.

Roof eaves are supported by cantilever beams, which in turn are supported by the girders of the frames at grid C. In order to carry the heavy loading induced by the eaves, the frames of grid C are supported from the midpoint of their spans by means of outer wall columns, thus resulting in a two span space truss frame system.

The columns of the frames are hinge supported by the reinforced concrete system at elevation +7.70. The support detail is shown in Figure 5. Pins of 150

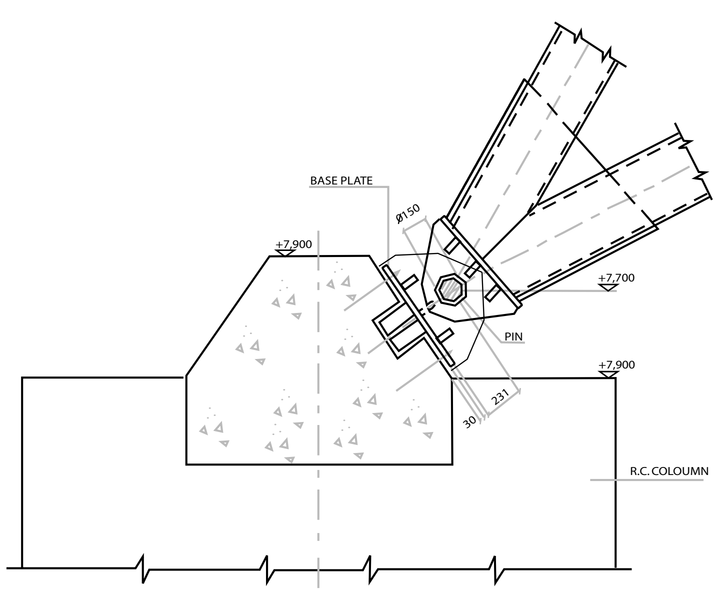

Figure 5: Pin connection detail.

Figure 6: View of trusses during fabrication.

m m (5.91″) diameter are used at the supports in order to provide free rotation of the frame columns. Bearing base plates are inclined so they are located perpendicular to the resulting component of the vertical and horizontal support reactions induced by the frame members. As a result, a considerable amount of the support reactions are compensated by the compression stresses of concrete under the base plates.

Engineering Analysis

A 3-D model was created in order to analyze the steel roof structure including the supporting reinforced concrete frames. The computer program, SAP 2000, was used for the structural analysis.

Two main types of steel are used in the design. For the round pipe shapes, the material type is A53 according to ASTM specifications. For the rest of the shapes, that material is "St 37.2" which is equivalent to ASTM A36. Their strengths are as follows:

Steel members that form the main steel structure are designed using the maximum forces obtained from the statical analysis. They are summarized in Table 1.

Fabrication and Transportation

Over 3,000 tons of steel has been manufactured for the steel structure of the terminal building. Single part drawings were produced using the computer program X Steel.

Piece cutting was performed using computer controlled CNC cutting machinery for the ends of the pipes that form the truss frames of the roof. After that, single parts were fitted up in the workshop using special templates and then welded to each other (Figure 6).

All shop-welds were inspected using either radiographic or ultrasonic test methods. 67.35m (221′) long truss girders are manufactured in five units for transporta tion purposes. The biggest unit transported has dimensions of 3.99m x 4.40m x 23.40m (13.1′ x 14.4′ x 76.8′).

Erection

The procedure applied during the erection of the roof structure is shown in Figure 7. As can be seen in the figure, frame members No. (1) and (5) are erected after the bearing plates No.(6) are fitted into place and grouted.

Frame members No 2, 3 and 4 are fitted together on the ground. Necessary welding for connections is completed, then the assembly is erected in one piece.

All welding, applied on site, has been inspected by ultrasonic testing.

Weight of Steel Construction

The total weight of the steel construction for the terminal building is 3,191 tons.

Construction Time

On April 6, 1999, the structural design process started. The construction of the terminal building was completed on October 25, 2000, and handed over to the administrative firm on January 8, 2001.

The selection of structural steel and outstanding work during the engineering design and construction of the project permits the structure to cover spans of 67.50m (221.5′) economically and aesthetically. The building was completed in a record-breaking 19 months including the structural design phase.

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LOCATION:
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STRUCTURAL ENGINEER:
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ARCHITECT:
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STEEL CONTRACTOR:
Alsim Alarko Contracting Group,
Istanbul, Turkey

DETAILER:
ARCE Engineering, Istanbul, Turkey
(AISC member)

SOFTWARE:
Sap2000, Xsteel

Winner of the ECCS Steel Design
Award—2001

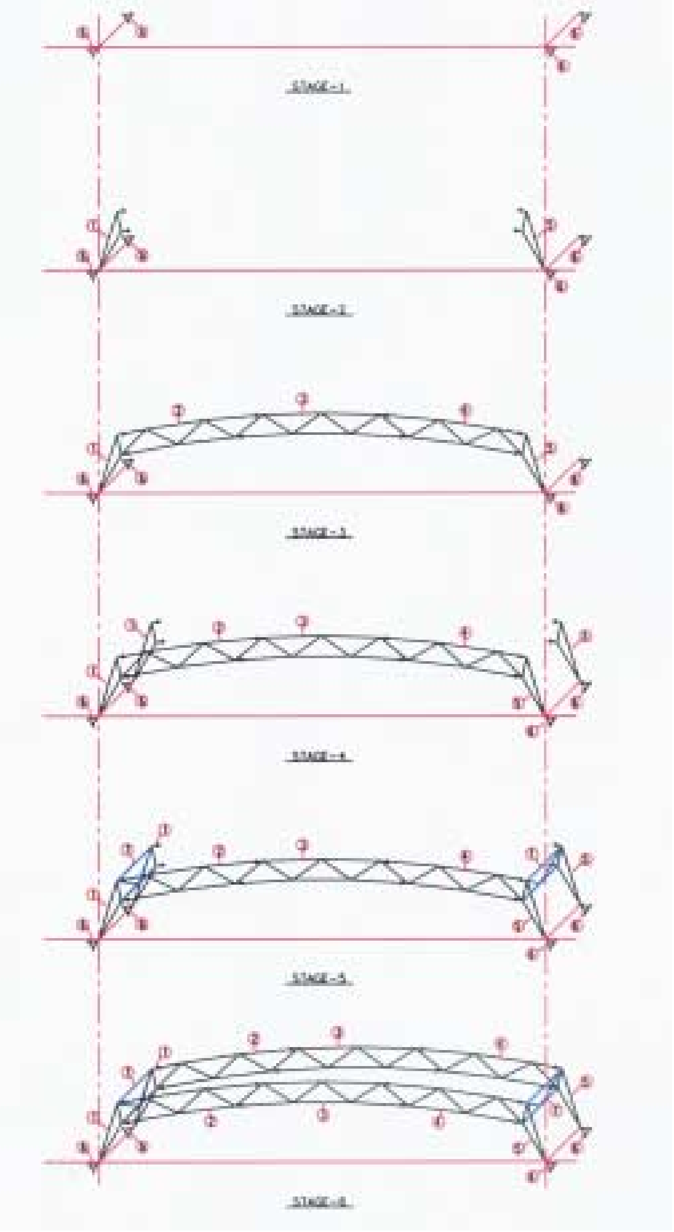

Figure 7: Erection procedure.