DESIGNED TO EFFECTIVELY WITHSTAND SHOCKWAVES, SABIHA GÖKÇEN INTERNATIONAL AIRPORT IS AN ANATOLIAN PRIDE

Istanbul that straddles Europe and Asia across the Bosphorus Strait; the commercial hub and largest city of the transcontinental country, Turkey boasts the remarkable, monumental and a wonder of the human mind – the Sabiha Gökçen International Airport. The airport was developed as a Greenfield project and named after the Turkey's first woman combat pilot.

It is one of two international airports serving the city, offering a whopping total area of more than 3,20,000 sq. m and is comprised of an integrated domestic and international terminal building, a hotel, a new VIP terminal and a multitude of other airport facilities.

With 28,285,578 passengers and 206,180 aircraft movements in 2015, Sabiha Gökçen International Airport is the third busiest single-runway airport in the world, after Mumbai and London Gatwick.

Since Istanbul is located at the confluence of 3 tectonic plates close to the North Anatolian Fault, which runs for 1,500 km between the African and Eurasian tectonic plates, it experiences large earthquakes because of its geographical positioning. The tragic 1999 Kocaeli earthquake killed 17,000, injured 43,000 and forced 250,000 people to relocate. An estimated property loss ranged from $3 to $6.5 billion, along with the overall economic loss to the country as the earthquake hit a heavily industrialized area of Turkey. This led to the adoption of more and more earthquake-resilient structures to minimize loss of lives and damage to assets.

The is credited to the fine sense of engineering of Arup's Istanbul and Los Angeles teams offices, who worked together to design and deliver the project in just 18 months – record time for a project of such scale and ambition.

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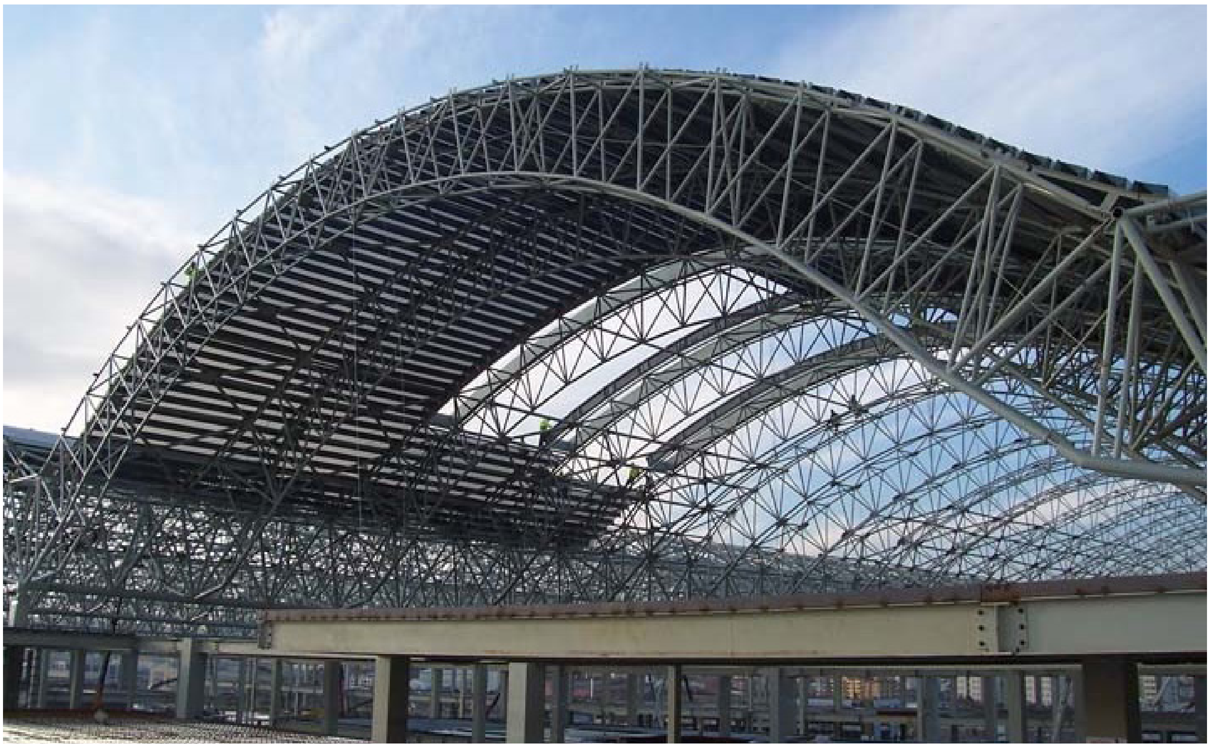
STRUCTURAL SYSTEM

The new SGIA Terminal building is a steel structure with a plan dimension of 160 m by 272 m with a total building height of approximately 32.5 m. The building consists of four storeys above and a basement floor below the isolation plane.



The gravity system of the superstructure is composed of concrete filled steel decks, composite steel beams, and composite steel columns. The superstructure resists lateral loads by a system of steel moment frames through rigid horizontal diaphragms. The clear span length supported by the columns is 16 m in both directions.

All structural members, such as columns and beams, are built-up members. Plates were cut in appropriate shapes and were connected via welding in order to constitute the required structural sections. Floor rib beams are made of grade S235 steel plates and columns and main beams are made of grade S355 steel plates.

Rib beam layout orientations are changed in every main cell (16m x 16 m), so that all the main beams are loaded with the same gravity loads. The framing for the stairs and elevators below the isolation plane is suspended from and braced by the isolated super structure above. The concrete compressive strength is 35 MPa for composite columns.

The roof system consists of light steel space purlin systems running longitudinally and located at every 8 m and braced in the transverse direction. The purlin has a parabolic curve form with a depth of 12 m and 6 m placed evenly next to each other. They are pin-supported by the top of the columns at every 32 m and 48 m. Purlins consist of pipe members which are in grade S355. Considering the shape of the roof, unbalanced snow drift load was taken into consideration in the analysis.

“The roof system consists of light steel space purlin systems running longitudinally and located at every 8 m and braced in the transverse direction.”

SEISMIC DESIGN

As per the client’s requirements, two performance levels were defined for seismic analysis of the terminal building, numerated as follows:

• The building was designed for Operational Level. i.e. no structural and no non-structural damage for an earthquake hazard with a uniform 10% probability of exceedance in 50 years, which is equivalent to a hazard with a return period of 475 years. This earthquake hazard is commonly known as Design Basis Earthquake (DBE) or design earthquake in practice.

- The building was designed for Structural Immediate Occupancy for an earthquake hazard with a uniform 2% probability of exceedance in 50 years, which is equivalent to a hazard with a return period of 2475 years. This earthquake hazard is known as Maximum Considered Earthquake (MCE).

Contrary to the conventional seismic detailing which are generally adopted, base isolation was implemented to achieve the desired seismic performance.

Isolator-column-beam connection

Placement of a typical isolator

To determine the amount of movement it could withstand, Arup used real-time earthquake simulation modelling and LS-DYNA specialist software to test the building's integrity at 100th of second intervals. The results of 14 potential earthquake scenario tests showed that it could withstand an earthquake of magnitude 7.5-8.0, as measured on the Richter scale.

Triple friction pendulum devices were used to build the world's largest seismically isolated building. There are 300 triple-friction pendulum isolators that are distributed over the entire plan. The triple-friction pendulum bearings, with a conceptual period of 3 seconds and displacement limit of 345 mm, were selected owing to performance and cost. The effective damping provided by the isolators is 38% and 30% at DBE and MCE events, respectively.

> **Triple friction pendulum devices were used to build the world's largest seismically isolated building.**

Structure	The terminal comprises four storeys above and a basement floor below the isolation plane. It has a steel superstructure, with plan dimensions of 160 x 272 ^{m}, without floor joints and a total building height of approximately 32.5 m.
Area of Terminal	200,000 m^2
Passenger Capacity	22 million
Opening	31st October, 2009
Architect	Tekeli-Sisa Architecture Partnership
Master Planning, Structural Design, Seismic Simulation and Design	Arup
Triple Friction Pendulum Isolators	Earthquake Protection Systems, Vallejo, California
Simulation Software	LS-DYNA, developed by Livermore Software Technology Corporation

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