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World's Largest Earthquake-Safe Building

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The world's largest seismically isolated building, the new international terminal at Istanbul's Sabiha Gökçen Airport, is now complete and open for business.

Stretching across more than 2 million square feet, the terminal doesn't sit directly on the soil, but rather on more than 300 isolators, bearings that can move side-to-side during an earthquake. The whole building moves as a single unit, which prevents damage from uneven forces acting on the structure.

"What an isolation system does is that it enables the building to move through large displacements in unison, and in doing that, you absorb earthquake energy," said Atila Zekioglu, the engineer at the firm Arup, who designed the building.

Earthquakes accelerate buildings laterally, whipping them back and forth. Isolators (see photo below) slow down the motion of the building. In the case of the new terminal, the building will only have to withstand one-fifth of the acceleration that it would have had to without the earthquake proofing.

A devastating magnitude 7.4 earthquake struck Istanbul on August 17, 1999 killing 17,000 people and causing billions of dollars in property damage. Scientists estimate it's more likely than not that the city will be hit by another large quake in the next 30 years. Istanbul is located near the confluence of the Arabian, African, and Eurasian plates. The North Anatolian Fault runs less than 15 miles south of the city. So, like Los Angeles, San Francisco, and a host of other Pacific Rim cities, Istanbul's builders and planners have to take major earthquake precautions.

Luckily, designing structures for that kind of performance has become cheaper and easier. Increased computing enables better simulations of how buildings will act when an earthquake hits.

Zekioglu and his team ran their building designs through 14 different simulations of earthquakes.

"What we have done over the years is that there are many tests going around the globe in terms of shake tables, testing labs, and what we do is we take that data… test the ability of our seismic simulation software," he said.

This software, called Dyna, was originally developed at Lawrence Livermore National Laboratory in the 1970s. It can be used to model what will happen to materials under all kinds of conditions from car crashes to earthquakes to bomb blasts.

The software has allowed engineers like Zekioglu to go beyond simply satisfying the building codes to designing buildings that will really meet the objectives of the structure's owners. You don't just want an airport (or a hospital) to stay standing after an earthquake, you want it to be functional.

The Istanbul project is quite similar to what was done with the San Francisco Airport's international terminal, said Michael Constantinou, a seismic isolation expert at State University of New York at Buffalo, but it uses a newer kind of seismic isolation device.

"This is one of the first projects, at the time they started this thing, to use this

advancement," Constantinou said.

The new type, triple friction pendulum isolators manufactured by Earthquake Protection Systems in Vallejo, are more compact and can reduce the cost of constructing a building, he said. Many buildings, including three new hospitals in the San Francisco Bay Area, are now incorporating the new isolators.

Constantinou also highlighted a more general advantage that seismically isolated buildings have: They are actually easier to design because it's very difficult to quantify how and why a structure will collapse.

"You are designing so that the structure will remain undamaged, and that's much easier to understand," he said.

The new terminal is designed to withstand an earthquake as strong as 8.0.

Images: 1) The new terminal/ARUP. 2) Seismic situation near Istanbul/USGS. 3) The triple pendulum slider/ARUP.

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