

THE CONSTRUCTION OF THE KANSAI AIRPORT, JAPAN

The world's first international airport on the sea "Kansai International Airport" was built on a man-made island on the sea, about five kilometers off the coast of Senshu in Osaka Bay. It opened on September 4, 1994. The huge, long building stretching 1.7 kilometers alongside the 3,500-meter runway is the passenger terminal building.

This airport on the sea is most appropriate to the image of a place where huge man-made birds crossing the seas can rest their wings. Its construction and subsequent problems highlight the marvels that the different modern soil and site improvement techniques can achieve. This summary highlights some aspects of the construction, monitoring, and of the problems.



In the mid-1980's Osaka's Itami Airport was woefully inadequate for the needs of the Kansai region of Japan. The Kansai region includes not only Osaka, the second largest city of Japan and a major commercial center, but also the major cities of Kyoto and Kobe. The old airport was hemmed in by urban development in more ways than one. The urban development prevented any spatial expansion, but it also restricted the hours of use because of the aircraft noise in the late hours of the night would disturb the sleep of the residents in the vicinity of the airport.

The limitation of the old airport was forcing the exporters of the Kansai region to ship their air cargo to Tokyo for shipment abroad. This inconvenience was probably limiting those exports.

The airport authorities considered finding a land site for a new airport, but they looked at the experience of Tokyo in building the Narita Airport. The protests of the farmers to the forced sale of their land mobilized a movement that delayed the completion of the airport for years. It is little appreciated outside of Japan that there is a substantial group of violent radical activists in Japan who will flock to any public protest movement and turn it into vicious showdown of force. In the Narita Airport construction these radicals fire bombed the heavy earth-moving equipment and endangered the lives of the equipment operators. There were several deaths in the Narita Airport protests and three thousand radical activists were arrested.

It is quite possible that the radical activists could prevent a new, land-based airport for the Kansai region from ever being built. That motivated the consideration of a water-based airport. An airport operating from an island in Osaka Bay could operate 24 hours per day. Radical activists could be prevented from getting access to the construction site.

Since there is no island in Osaka Bay where the airport is needed, one would have to be built. That would be costly be not impossible. There are several factors that have to be considered. The Kansai region is subject to severe earthquakes and earthquakes can liquefy the sort of land-fill that might be used to construct such an island. Also Japan is subject to typhoons (hurricanes in the Pacific). A typhoon in 1934 created a surge that raised water levels ten feet in the Osaka area for several hours. An island airport would have to be high enough to withstand severe typhoon water surges.

When serious design work started on the island airport the authorities headed off a potential protest from Osaka Bay fishermen who would have their livelihood disturbed by the construction. A generous payment was offered by the airport authorities and accepted by the fishermen.

The designers envisioned an airport 2.5 miles long and 4000 feet wide. The site selected was three miles from land and there the water depth was 60 feet. The water depth was not a serious impediment. The problem was the condition of the soil under the water. Soil immediately under the water was a soft clay called *alluvial clay*. This alluvial clay went down 100 meters. Japanese engineers had solved the problem of building in this soil. They would drive down pipes which would be then packed with sand. The pipes would then be pulled up leaving columns of sand in place to absorb the moisture in the alluvial clay. The uncertainty for the construction came from the layer of clay lying below the alluvial clay. This clay was called *dialluvial clay* and extended about one thousand feet down. The compressibility of this clay was uncertain and because of its depth nothing could be done to modify that compressibility.

The airport authorities had a number of experts estimate how much the airport island would sink as a result of the weight of its weight. The estimates ranged from 19 feet to 25 feet.

The official looked at the estimates of the degree of sinking and did what now seems to have been the worse possible thing. They accepted the smallest estimate, 19 feet, in what appears to have been wishful thinking. The design of the airport was then based upon a sinking of 19 feet.

The construction started in 1987. The alluvial clay was stabilized with sand columns as described above. The perimeter of the island was defined by means of 69 steel chambers which were sunk to the bay floor. These chambers were 75 feet in height and 75 feet in diameter. They weighed 200 tons each. The spaces between the chambers were filled with 48,000 specially shaped concrete blocks. Irregular stones weighing one to two tons were added to the walls.

The cavity within the walls was filled with rocks and coarse gravel to avoid the danger of liquefaction of earth-fill during an earthquake. The fill came two mountains which were leveled in the process.

The radicals, not to be denied their opportunity to commit violence, attacked the quarries where the fill material for the island was being excavated. Altogether there were about two dozen attacks.

The island airport had to be linked to the land. That part of the project was started in 1987 and by March of 1990 the bridge link was completed, at a cost of \$1 billion. The trussed bridge framework carried a railway on its lower level and a motor vehicle highway of the upper level.

By 1990 the island and its link to the land had been completed. Ten thousand people had worked on the project. The trouble was that the airport island was sinking more than the design provided for. The maximum estimate was 25 feet. The airport authorities took the minimum estimate of 19 feet. The actual sinkage by 1990 was 27 feet and the island was still sinking at a rate of about per feet per year at that time.

The authorities added another 11.5 feet of fill at a cost of \$150 million. The runway was covered with asphalt rather than concrete to avoid cracking.

The terminal facilities constructed and completed in 1994.

SINKING FEELING: (2000)

Aviation Week & Space Technology. New York: May 14, 2001. Vol. 154, Iss. 20; p. 21

O.K., it's official: After years of denial, Japanese officials have finally admitted that the engineering heavyweight Kansai International Airport-just six years after its completion to designs by Italian architect Renzo Piano-is settling at an faster-than-expected rate.

Of course designers and engineers anticipated some settling: The entire 294,000-square-meter complex sits atop a 1,263-acre, completely man-made island in Osaka Bay.

Unfortunately though, their settlement estimates fell short. Recent reports indicate that the airport has subsided 3.4 feet ahead of schedule. While builders planned for the complex to meander down to 11.5 feet over mean sea level over a decade, it is now expected to reach just 8 feet above sea level.

As a result, the airport has deployed a sophisticated pump system to reduce rising seawater levels. Future repairs may include a dike-like structure to maintain constant water heights. But officials are confident of having full buoyancy: Construction is currently under way on a neighboring man-made island to support additional facilities.

AIRPORT IN FULL SERVICE (2006)

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Osaka Kansai International Airport this winter will see the most scheduled flights since the island airfield opened more than 12 years ago, and with the opening of a second runway now planned for Aug. 2, 2007, the airport believes it is positioned to become a large Asia/Pacific hub.

Kansai got worldwide attention when it first opened in September 2004 because it was built in Osaka Bay on reclaimed land, with the construction project taking about seven years to complete. The airport has a single terminal and a 3,500-meter (11,500 feet) runway, which was enough to handle the traffic in the past decade, but executives see significant growth potential for the airport and the Kansai region.

The airport in 1994 had about 400 weekly flights in the winter and about 450 in the summer, most of which carried passengers. The airport weathered the Sept. 11, 2001, attack and the SARS pneumonia epidemic, and executives reported that the airport will see a record 733 weekly flights this winter, including 167 cargo services. As expected, much of the growth is to China, which the airport is scheduled to serve with 201 weekly flights to 15 Chinese cities this winter.

KIX is also growing its domestic service, as carriers move flights from Itami Airport, the only airport in the city before KIX opened. Japanese carriers serve 15 cities in Japan with 55 flights per day, most going to Tokyo, Sapporo, Fukuoka and Naha. With international and domestic service on the rise, the Kansai International Airport Co. persuaded the government to move ahead with the construction of a second runway and more cargo facilities.

Because the airport is an island, the decision to build the second runway required another seawall and more reclaimed land to build an adjoining island. The second island -- of about 545 hectares -- was finished two years ago and the second 4,000-meter (13,000 feet) runway and connecting taxiways will be finished next year, in time for an August opening. One of the initial benefits to the second runway will let KIX lay claim to being

the "only true 24-hour airport with multiple runways," said Atsushi Murayama, president of the airport company.

With only one runway, KIX has to close overnight several days per week for maintenance; however, the second runway means no closures and no slot restrictions. Murayama said in Osaka recently that many carriers like to operate late-night flights to resort destinations. Off-hour operations also allow for easier connections to and from Tokyo, and the carrier finds that 40% of cargo flights to KIX operate from 10 p.m. to 6 a.m., so a 24-hour operation will likely attract more cargo service.

Murayama said the airport company will offer landing charge discounts on flights operating during off-peak hours. While the carrier may not become a major passenger hub in the near term, executives are working to attract more cargo service. The Kansai region has the seventh-largest gross domestic product in the world with more than \$750 billion, more than Canada, Spain and Mexico. "We will market KIX as an international cargo hub," Murayama said.

The airport has already seen cargo growth and there have been eight warehouses and processing facilities built since 2004 and a ninth is set to open in May. All of the growth has been on the first island and there is a new cargo area already outlined for the second island. Executives have not decided when to start construction on the second cargo area as it is subject to demand and growth rates.

Additional Source:

<http://www.sjsu.edu/faculty/watkins/kansaiairport.htm>