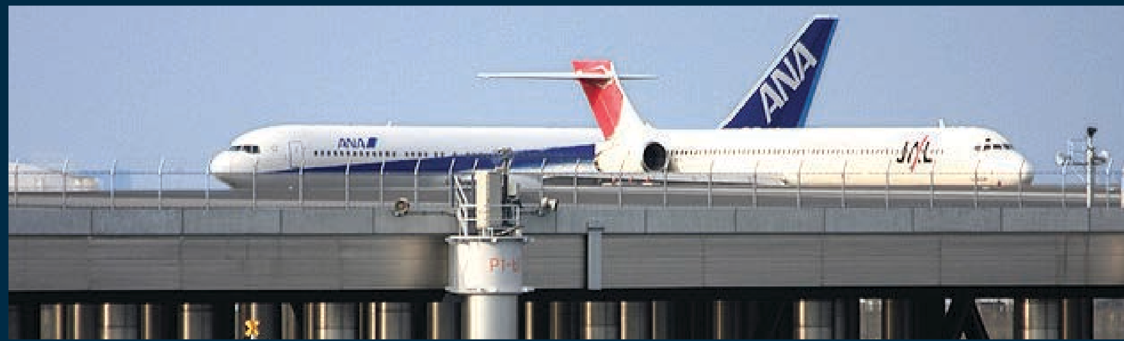
Bentley Sustaining Infrastructure

Be Inspired Awards 2012 Winner



Project Summary

Organization:
Nippon Steel & Sumikin Engineering Co., Ltd. (NSENGI)

Location:
Tokyo, Japan

Project Objective:

- Expand Tokyo International Airport capacity for annual arrivals and departures from 296,000 to 407,000.
- Design and build a fourth runway (D Runway) on a reclaimed island in the Bay of Tokyo without interrupting port shipping traffic.
- Maintain unimpeded flow at the mouth of the Tama River with a steel jacket-supported runway section.
- Design and build runway to last for 100 years with more than 10 million airplane take offs and landings.

Products used:
SACS

Fast Facts

- D Runway is the first instance of a jacket structure being used in offshore airport infrastructure.
- Using SACS for fatigue analysis, D Runway was designed to withstand a 400-ton airplane load applied 11.5 million times.
- The 100-year service life is 70-80 years longer than most offshore structures.

ROI

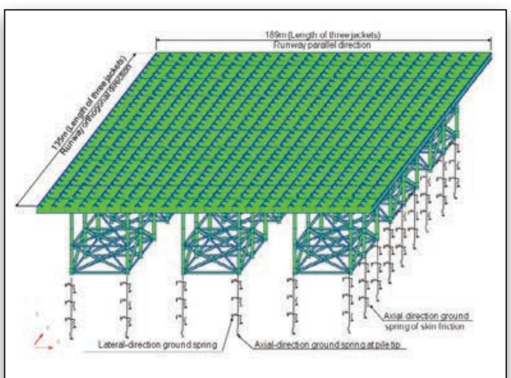
- NSENGI carried out detailed design of the jacket-type pier structure in just 18 months.
- SACS saved an estimated two months on the analysis, and an additional $52,000 compared to developing an in-house fatigue analysis application.
- The joint venture completed construction within 3.5 years of contract award, a short time period for this $6 billion project.

Nippon Steel & Sumikin Engineering Uses Bentley SACS Software to Design Innovative Offshore Runway in Tokyo

Achieves 100-year Service Life for Innovative Jacket-supported Pier Structure Using SACS for Efficient Fatigue Analysis

A First in Offshore Airport Infrastructure

Nippon Steel & Sumikin Engineering Co., Ltd. (NSENGI), a unit of Nippon Steel & Sumitomo Metal Corp. of Tokyo, Japan, participated in the 15-company joint venture (JV) that designed and built Tokyo International Airport's new D Runway. Located in the Bay of Tokyo, the USD 6 billion offshore runway is comprised of a 1,100-meter pier section and a 2,020-meter reclaimed section. NSENGI completed detailed design of the jacket-supported pier structure in just 18 months. This is the first application of a jacket structure for an offshore airport runway, and it could not have been designed in this timeframe without the use of Bentley's SACS software to perform fatigue analysis of the structure under the most severe of conditions. The pier's 100-year service life is 70-80 years longer than the standard for offshore structures.



The innovative design consisted of topside asphalt pavement and concrete floor slabs supported by the jacket structure.

Expanding into Tokyo Bay

Tokyo International Airport (Haneda Airport) is the second busiest airport in Asia and the fifth busiest in the world for passenger throughput. By 2022, it is estimated that more than 85 million passengers will use Haneda Airport annually. To accommodate the expected increase in travel demand, and limited by the constraint that adequate land was not available, the Ministry of Land, Infrastructure, Transport and Tourism prepared a design-build scheme for an offshore fourth runway. D Runway was designed to increase Haneda Airport's capacity from 296,000 to 407,000 arrivals and departures per year on existing routes, as well as routes to new destinations.

The airport is located in the Bay of Tokyo, which is also home to Japan's busiest ports. The new runway project could not interfere with the shipping traffic, so it was located just south of the existing airport island, at the mouth of the Tama River. In addition, to minimize ecological damage and avoid impeding the river's flow, the runway was designed to allow the river to flow through a pier section. This was the major engineering challenge of the project.

Innovative Hybrid Design Concept

The JV recommended an innovative hybrid design concept, which combined a pile-supported deck and a reclaimed island linked by flexible joints. The pile-supported section of the runway allowed the river to flow freely, while the reclaimed island – built from 38 million cubic meters of landfill – provided the foundation for the remainder of the runway. Structural analysis for the hybrid design was complex, needing to consider the vastly different dynamic responses of the pile-supported and reclaimed sections to seismic motion, earth subsidence and wind, wave, and current actions, as well as aircraft take off and landing loads.

NSENGI adopted a jacket-supported pier structure for the critical section of the runway located at the mouth of the Tama River. Jacket structures are routinely implemented in the construction of offshore energy facilities and port structures, but this was the first application of a jacket structure in airport infrastructure.

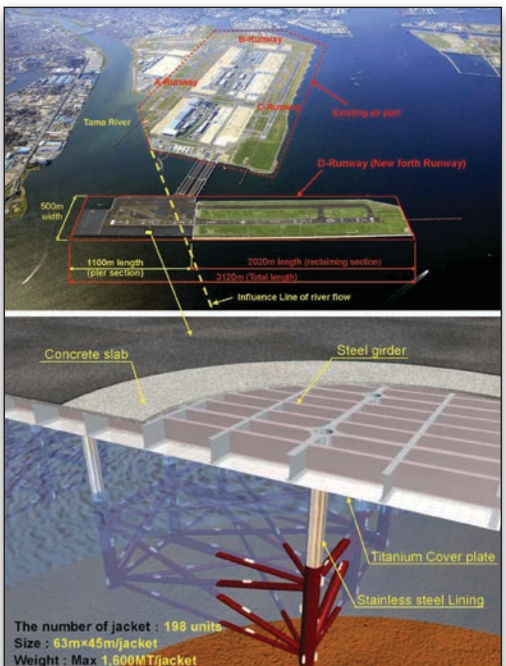
The innovative design consisted of topside asphalt pavement and concrete floor slabs supported by the jacket structure, which had a steel girder upper structure, a steel pipe truss lower structure, and foundation piles. The upper girder was arranged in a lattice pattern so that the girders joined with the jacket legs to support the floor slabs. Titanium cover plates were installed under the girders to withstand corrosion. The lower truss was designed without braces near the water surface for unimpeded flow. Structural members were sheathed with seawater-resistant stainless steel for corrosion protection.

"It was not realistic for us to handle such a large amount of data by manpower, in terms of time schedule and work quality. We would not have been able to carry out the complex analysis this project required manually – we had to use software. Using SACS rather than building our own solution saved us two months and about 5 million JPY, enabling us to deliver this complex, innovative project on time and on budget."

– Takenori Inuagi, Associate, Nippon Steel & Sumikin Engineering Co., Ltd.

SACS Aids Complex Fatigue Analysis

Taking advantage of its past experience in the design and construction of offshore structures using SACS, NSENGI implemented the integrated SACS software suite for analysis and design of the pier structure. SACS' ability to provide dynamic design iterations allowed the project team to perform specialized analyses including dynamic response, impact effect, and severe loadings. Fatigue analysis was critical to avoid progressive and localized structural damage due to cyclic loading. Unlike jacket structures for offshore oil and gas facilities, which are primarily subjected to cyclic loading by waves, a jacket structure for offshore airport infrastructure is subjected to cyclic loading by both waves and airplanes. Factors considered in the fatigue analysis included the location of loading on the runway, frequency of arrivals and departures, and the types of airplanes (10 total). To conduct the analysis, NSENGI created an analytical model and set up the fatigue loadings. After that, all operations were conducted automatically by SACS.



NSENGI built an offshore runway at Tokyo International Airport, using SACS to design the jacket-supported pier structure. Image courtesy of Joint Venture Group for D-Runway Construction in Tokyo International Airport (Haneda Airport) Re-expansion Project.

Minutes to Analyze 44,800 Points

The 520,000 square-meter pier section of the new runway was created by linking 198 jacket-supported units – each with a standard dimension of 63 meters wide, 45 meters deep, and 30 meters high – for a total weight of 260,000 metric tons of steel. SACS enabled NSENGI to carry out the fatigue design efficiently and rationally. This included SACS calculating fatigue damage at each of almost 10,000 tubular joints and 44,800 points.

NSENGI calculated that the pier had to withstand a maximum airplane load of 400 metric tons, repeated 11.5 million times across the 100-year life of the runway. The analysis model assumed that the stress variation applied by a running aircraft was influenced not only by the supporting jacket unit but also by eight adjacent jackets. SACS automatically calculated the Stress Concentration Factors, hotspot stress range, and number of cycles to failure.

Upon completion of the fatigue analysis, the analysis model was also used to tabulate material quantities and generate material take-offs in SACS.

Time Savings, Cost Avoidance

SACS enabled NSENGI to accomplish complex analyses within a short six-month time period. Without SACS, the team would have been unable to manage the extremely large volume of data required for modeling and design of the jacket structures. The alternative—developing an in-house application to perform the same functions as SACS—would have been impractical and time-consuming, and added two months to the schedule, while also costing an estimated additional $52,000.

NSENGI carried out detailed design of the jacket-supported pier structure in just 18 months. The JV completed construction of the entire D Runway project in October 2010 in approximately 3.5 years—well within the owner's timeframe and with no interference in the normal operation of the existing airport.

Unlike offshore structures typically designed to last 20 to 30 years, Haneda Airport's offshore jacket structure was built to serve for 100 years under extreme conditions with a 400 ton airplane load applied more than 11.5 million times. With a live load to dead load ratio exceeding that of general highway bridges, and advanced corrosion technology, such as titanium cover plates and stainless steel sheathing, D Runway is innovatively designed to outlast its onshore counterparts.

Find out about Bentley at: www.bentley.com

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