Kansai International Airport (HKN047)

Soil:	Landfilled gravel, sand, mudstone
Method:	Deep dynamic compaction, SCP
Foundation:	Direct base (shallow)
PGA:	0.25g H
Damage:	Minor cracks

Site Description

Kansai International Airport in Izumi Sano City, Osaka, was built on a manmade island filled with approximately 180,000,000 m^3 of rock mixed soil during the late 1980's and 1990's. The area improved with heavy tamping and sand compaction piles includes roads, railroads, and runways. Improvement began in November of 1990 and ended in September of 1992. The site location is shown in Figure 1.

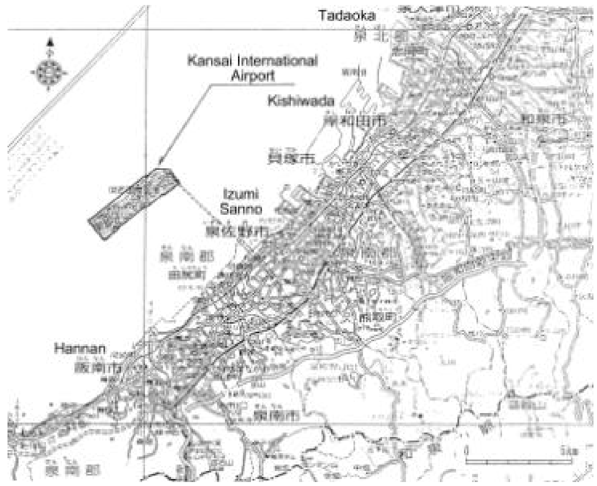

Figure 1. Site Location (Kaiyo Kogyo, 1995)

Initial Conditions and Liquefaction Potential

The airport is located on a manmade island consisting of gravel, sand, and mudstone with relatively large gravel and cobbles (smaller than 30 cm in diameter). The island was constructed using rapid deposition and as a result the soil profile was loose and nonuniform. The fill soil was obtained in equal amounts from three locations, including Awaji Island in Hyogo Prefecture, Hannan in Osaka Prefecture, and Kabuto in Wakayama Prefecture. The soil from North Awaji Island is masa soil (decomposed granite) and the soil from South Awaji Island, Hannan, and Kabuto is sandstone and earthen sand and rock from the Izumi Layer Group. The South Awaji Island sandstone from the Izumi Layer Group was crushed at the site and dropped in first, therefore about 20 m from the ground surface consists of sandy gravel. The gravel inclusion rate is about 90 %. The pre-improvement (uncorrected) SPT N value was about 10 and the density was highly variable throughout the profile.

Superstructure and Foundation

The Kansai Electric Energy Center substation, the toll house for the railroad and the roads department, the Hokunetsu sewage disposal facility, the airplane wastewater disposal facility, and the domestic and international freight distribution centers and terminals are built on improved ground. Most structures are supported on direct base (shallow) foundations. The site layout is shown in Figure 2. A summary of improved areas is included in Table 1.

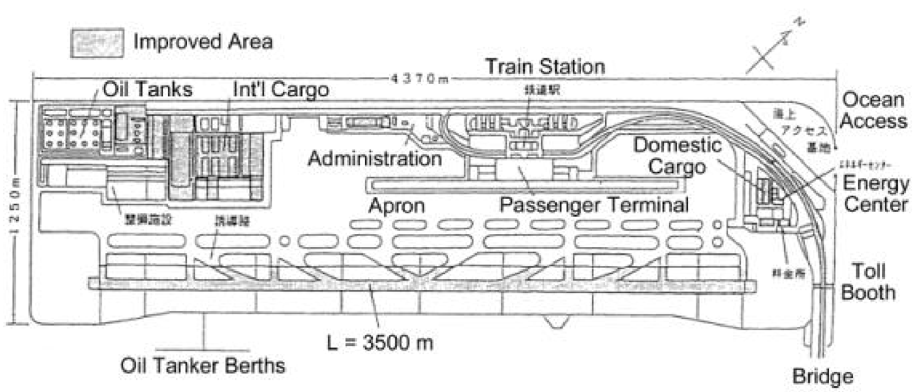

Figure 2. Site layout (Kaiyo Kogyo, 1995)

Table 1. Summary of Ground Improvement at Kansai International Airport

Facility Type	Facility Description	Improvement Method	Improved Depth (m)	Improved Strength	Construction Summary
Pavement-General	Taxiways, public roads, trackyard	MVT (dynamic compression)	5	N = 10	9m^2 tamper area, 180 kV vibration, 2 series
Pavement-Important	Runways	Dynamic compaction	10	N = 15	25 ton hammer, 25m drop, 11 hits/point, 5m square spacing
Building-General	Airline buildings, waste disposal	Dynamic compaction	10	N = 15	25 ton hammer, 25m drop, 11 hits/point, 5m square spacing
Building-General	Hangars, industrial waste disposal, airline food manufacturing	Sand compaction piles	15	N = 15	700mm diameter, 15m length, 2.8m square spacing, 5% replacement ratio
Building-Important	Terminal building, train station	Sand compaction piles	15	N > 15	700mm diameter, 15m length, 2.3m square spacing, 7% replacement ratio
Building-Important	Main terminal, control tower, highway	Sand compaction piles	20	N > 15	700mm diameter, 20m length, 2.5m square spacing, 6% replacement ratio

Ground Improvement Goals, Methods, and Construction Procedures

Ground improvement was performed because of the potential for harmful differential settlement. The goal SPT N value was set at approximately 15. The intended depth of improvement using heavy tamping was 10 to 15 m. The main tamping effort was aimed at compacting the deep and middle parts of the loose soil profile. Tamping points formed a square patter with 5 m point spacing. Three series of drops were made from a 25 m drop height with a 25 ton, 4 m^2 hammer. The energy imparted by the compaction effort was between 150 and 450 tf-m/m^2. The finishing tamping effort, aimed at compacting the surface area, consisted of tamping the entire area with a 12 ton, 3 m^2 hammer dropped from a 10 m height. The energy imparted by the finishing tamping effort was 80 tf-m/m^2. Ground settlement resulting from the dynamic compaction was on the order of 45 to 166 cm. The improvement SPT N value was greater than 20. Details about the areas improved with sand compaction piles have not been obtained.

The 1995 Hyogoken Nanbu Earthquake

The site is located approximately 29 km from the epicenter of the M_W=6.9 1995 Hyogoken Nanbu earthquake. The closest distance to the surface projection of the fault rupture zone is also 29 km. Several acceleration recordings were obtained at the site. An accelerometer near a runway reported peak ground acceleration of 0.25g. An accelerometer on a building located at the airport recorded a maximum acceleration of 0.45g.

According to Sitar (1995), free-field instruments located at the northern and southern ends of the runway recorded ground level maximum horizontal accelerations (MHA) of 0.15g and 0.09g, respectively. The terminal building has strong motion instruments located at its basement, fourth floor and roof levels. The MHA recorded at the basement level was relatively low at only 0.04g, whereas, at the fourth floor level, the recorded MHA increased to 0.10g. One of the piers of the bridge that connects Kansai Airport Island to the mainland has instruments located at its bottom and top, and these instruments recorded MHAs of 0.13g and 0.27g, respectively.

Performance of Improved Ground

Little damage was reported as a result of the 1995 Hyogoken-Nanbu earthquake. No damage was reported to buildings. In the runways, 10 or more cracks less than 3 mm wide were reported. The cracks, however, were inconsequential. Figure 3 shows the toll plaza and other facilities after the earthquake.

Figure 3. Toll plaza at Kansai International Airport (Kaiyo Kogyo, 1995)

Performance of Adjacent, Unimproved Ground

Settlement and other damage was observed in walkways that were unimproved, as shown in Figure 4.

Figure 4. Cracked area of walkway (Kaiyo Kogyo, 1995)

References

Editorial Committee, 1995. Report on Hanshin-Awaji Earthquake Disaster, Investigations of causes of damage to civil engineering structures: foundation ground and soil structures, port and coastal facilities, Editorial Committee for the Report on Hanshin-Awaji Earthquake Disaster, 104-127, (in Japanese).

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