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Construction of new runway from pier-type jacket structures with large-diameter long steel pipe piles

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Abstract

A new runway (named 'D-runway') for Tokyo Haneda International Airport was constructed offshore in Tokyo Bay to accommodate the recent increase in overseas and domestic flights to and from Tokyo. One of the most outstanding characteristics of the new runway is that it stands on two types of different structures: steel-jacket-platforms forming a pier-type structure and a reclaimed soil structure. The pier-type structure minimizes disturbance of water flow at the nearby Tama river mouth due to the presence of the new runway. This paper relates to the design and construction of the steel-jacket platforms for the pier structure. The main focus is on the results of pile load tests carried out to confirm the pile design, and the actual construction of the jacket structures. Through the construction of this pier-type structure, it has been possible to confirm the applicability of rapid load tests for large-diameter long steel pipe piles, the validity of the assumed pile tip plugging ratio used for design, and the applicability of a simple method for controlling the end of pile driving. Further, the effectiveness of joint-less work piles, the pile-keeper system, and GPS monitoring in the rapid and accurate construction of pier-type jacket structures was demonstrated.

Keywords: Haneda; Steel pipe pile; Case study; Bearing capacity; Pile load test; Rapid load test; Dynamic load test; Tip plugging; Construction; Jacket; Hammer; (IGC: E04/H01/K07)

1. Introduction

Tokyo Haneda International Airport has been one of Japan's most important airports since its official opening in the year 1931, as described by Suzuki (2010). As demand for rapid transportation between domestic and international locations has risen, the airport has been expanded several times, as described by Noguchi (2010) and Watabe and Noguchi (2010). Since the airport is located offshore in Tokyo Bay (see Fig. 1) where there are soft thick clay layers, geotechnical issues have always been raised in the process of design and construction.

In 2001, a decision was made by the Japanese government to construct a new runway (named D-runway, since it was to be the fourth runway at the airport). An overview of the new runway is shown in Fig. 2. As this figure makes clear, a unique characteristic of the new runway is that it

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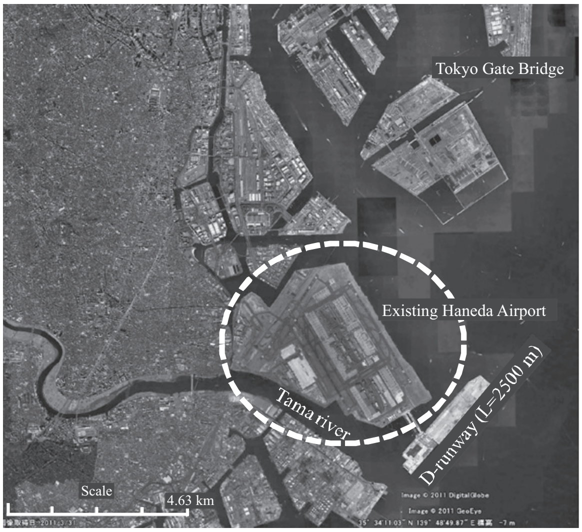

Fig. 1. Aerial photograph of the new runway for the Tokyo Haneda International Airport (after Google maps).

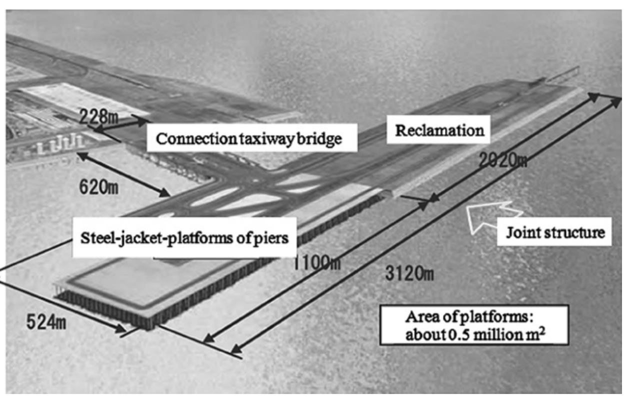

Fig. 2. Overview of new runway structure for Haneda International Airport.

was constructed on two types of different structures, one being a pier-type structure of steel-jacket platforms and the other a reclaimed soil structure. This pier-type structure was chosen so as to facilitate the flow function of the adjacent Tama river mouth (see Fig. 1) by minimizing possible disruption of river flow by the new runway.

This paper relates to the design and the construction of the pier-type jacket structures supported on long steel pipe piles, with particular focus on the results of the pile load tests conducted to confirm the pile designs and the actual construction of the pier structure.

The area to be constructed with the pier-type jacket structures was about 500,000 m^2, using 198 jackets in total with a typical length of 63 m and a width of 45 m. The ground at the construction site consists of thick soft clayey layers underlain by stiff bearing strata. Each jacket was supported on long steel pipe piles.

Fig. 3 outlines the construction procedure used for the pier-type structure. Steel pipe piles were first driven into the bearing stratum, then prefabricated jacket structures were lowered over the piles. Connection grouting was then carried out to fix the piles and the jacket legs. Once the jacket structure was in place, upper slabs and the pavement were constructed.

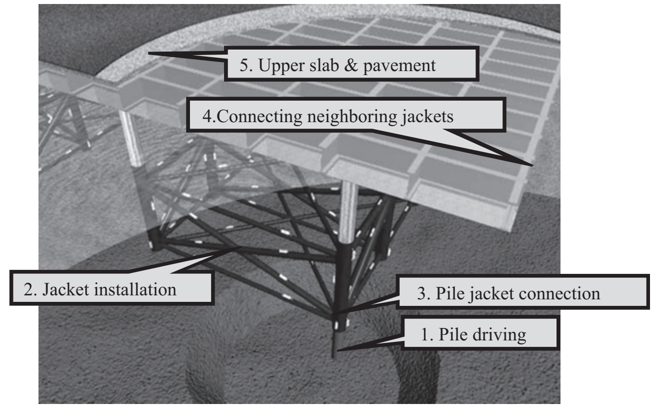

Fig. 3. Overall structure of the jacket and its construction procedure.

This is the first use in the world of such a pier structure for an airport runway and it is therefore considered important to provide details of the construction procedure, with special focus on the design and installation of long, driven pipe piles of large diameter. Specifically, the following points are addressed:

(1) From the designing point of view, it is important to confirm whether the pier-type structure satisfies the required performance as a runway. Due to the soft soil ground conditions at the site, 1849 driven steel pipe piles with a diameter ranging from 0.9 m to 1.6 m and a length exceeding 70 m are required to support the jacket structures. To confirm the performance of these piles, rapid load tests and dynamic load tests were conducted on two test piles. This paper describes the results of these pile load tests.
(2) As a quality control method for the piles, criteria for when pile driving should stop were determined prior to the actual pile driving stage. These criteria were based on the results of the pile load tests. This paper explains these criteria applied for pile driving control.
(3) Each jacket structure needed to be placed on six pre-installed piles with high accuracy. Details of the construction procedures used to achieve such accuracy are presented.

2. Ground conditions

Details of ground conditions at the site were described by Tanaka et al. (2007). Prior to construction, additional soil investigations were conducted at the site to verify the ground conditions in detail. Fig. 4 shows the points at which soil investigations were carried out after Nagaya et al. (2007) and Table 1 gives details of the type of investigations carried out (correspondingly labeled E, F, G, I, K in Fig. 4). The construction area is divided into two sections, consisting of the runway section and a connection taxiway bridge section. Points marked ‘F-1’ and ‘F-2’ in the figure correspond to where pile load tests were conducted.