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Design Considerations for Seaberth with Relation to Construction Technique

Dimensionnement des postes d'amarrage en considération des techniques de construction

Überlegungen beim Entwurf von Landungsanlagen im Meer in Abhängigkeit der Konstruktionsmethoden

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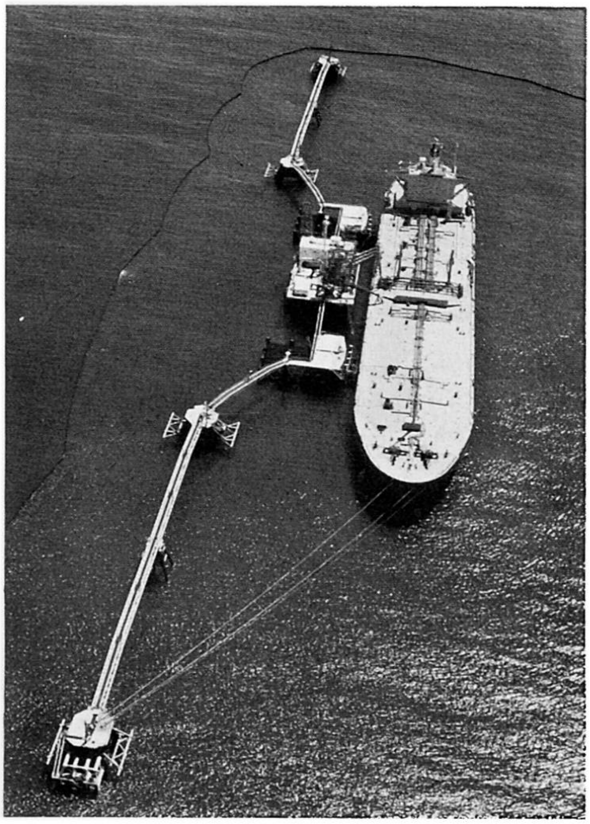
Introduction

Offshore structures are exposed to hostile environments not only during the entire service life but also during the construction period. Since the construction works are possible only under limited environmental conditions, the structures must be designed with due consideration given to the method of construction. Facilities constructed by different methods should have different design, even though constructed for the same objective at the same site. Consequently close cooperation between designer and construction engineer is required from the early basic design stage.



This Paper presents the design considerations for offshore structures, with relation to the construction techniques employed in constructing three fixed berth structures in Japan, as examples of the offshore structures.

Before the advent of the seaberth, crude oil and ore carried by ocean going vessels not exceeding 150,000-dwt having a 15m full draught had been unloaded at the terminals located in harbours. After the advent of the 200,000-dwt tankers having a 16.5m full draught, the seaberths have come to be constructed offshore to secure the depth and the area capable of maneuvering such tankers. The feature of an oil tanker seaberth generally consists of platforms carrying crude oil unloading facilities, breasting dolphins with fender systems and mooring dolphins for anchoring hawsers.

In the design of offshore structures, designing the structure which is capable of obtaining greater and greater stability step by step with the progress of works and simplicity of constructing are essential points to assure success.

1. Keiyo Seaberth

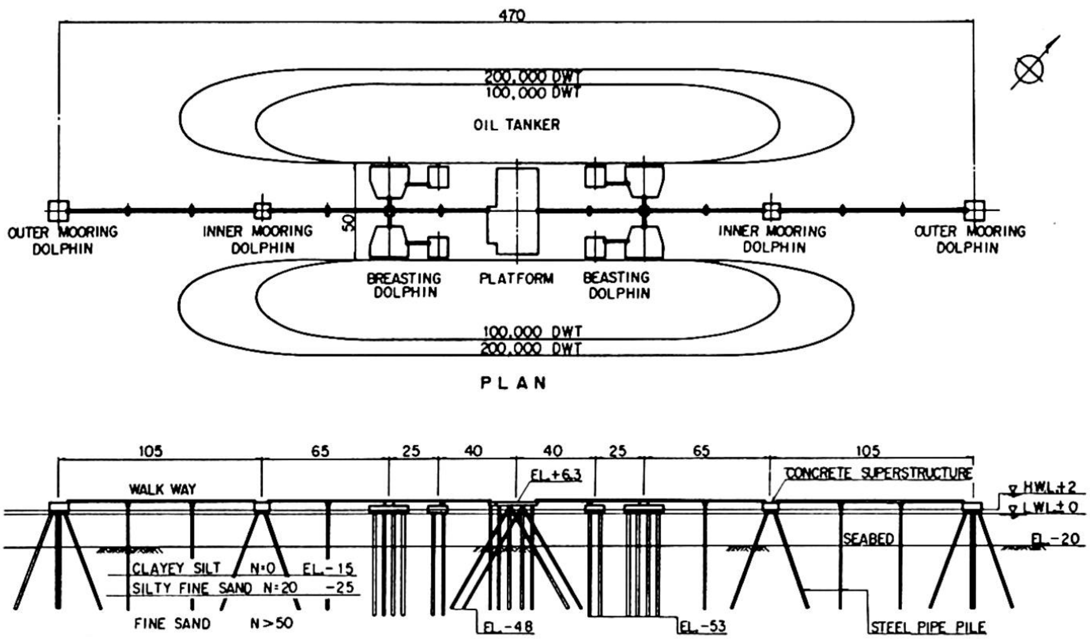
This was constructed in 1968 and is the first seaberth in Japan. It is situated in lat. 35°31'N. and long. 139°56'E. in Tokyo Bay. The works at the site 8 km offshore presented many problems to the engineers who had construction experiences only in the gentle sea protected by breakwaters. It is, however, possible to apply the design expertise having been formerly acquired in 100,000-dwt class tanker terminals to this project.

The tanker terminals were conventionally and economically constructed by following procedures with rather small scale equipments:

1) to drive piles using a floating barge equipped with a diesel pile hammer with rated energy less than 10 tm;
2) temporarily to interconnect pile heads;
3) to place concrete for superstructures in situ.

If the traditional procedures were to be employed in this project, three main difficulties were considered unavoidable at the performance:

1) Works carried out with floating barges would require environmental condition of not greater than 0.5m in wave height and within 7 m/sec in wind speed, and therefore the available working days would be only 40%;
2) Taking refuge in harbour from adverse sea conditions would produce one day loss of workable time until the works were resumed;
3) Accuracy in positioning and in maintaining the desired degrees of piling inclination would be inadequate.



ELEVATION

A SEP (Self-Elevating Platform) was considered to be able to overcome the difficulties. The SEP introduced in this project had a hull 50m x 24.4m x 4.3m with four legs in dia. 1.8m x 57m and equipped with an air pile hammer with rated energy 12.5 tm and two crawler cranes. Using the SEP, it was expected that the available working days would be 70%. The piles would then be driven with fair accuracy in positioning and degrees of inclinations; taking refuge in harbour would not be required in the environmental conditions of not more than 5m in wave height and 50 m/sec in wind speed.

The following considerations were introduced in the design to simplify the troublesome offshore works:

1) to fabricate each pile in entire length at the yard;
2) to precast superstructures.

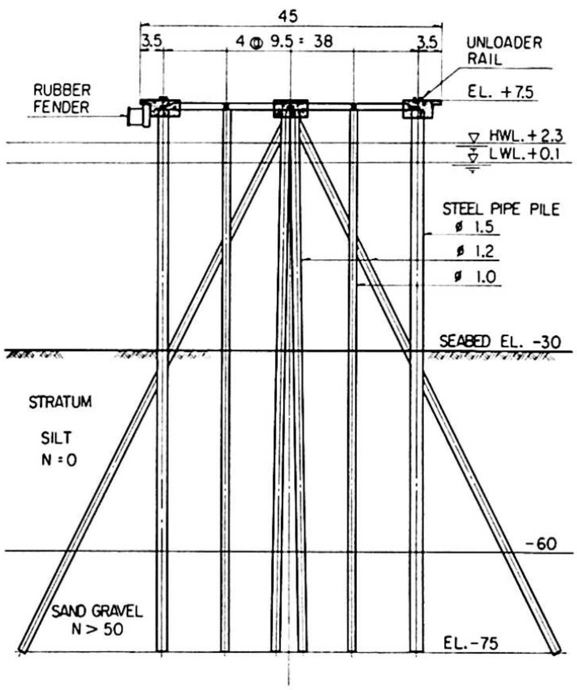
The precast superstructures were installed by the floating crane over the tops of the driven piles.

As a result of the performance, interconnecting of pile heads was found to be very difficult due to their swaying at all times by wave action. Several piles had been broken off at seabed before they were interconnected temporarily. Occurance of similar troubles at the oil tanker terminal in Bantry Bay, Ireland which was also under construction about the same time as this project, was reported on CE, ASCE June 1970.

2. Oita Seaberth

Oita Seaberth was constructed in 1971 and is situated in lat. 33°16'N. and long. 131°38'E. in Beppu Bay. The salient features of this project are as given below:

1) The largest seaberth built in Japan capable of mooring three 300,000-dwt class ore carriers simultaneously;
2) 738 piles 31,000 tons in total weight were driven;
3) Constructed on very poor sub-bottom strata as shown in Fig-3;
4) A large number of batter piles driven in reasonable accuracy within a short period of time by employing a unique method.



A batter pile structure was adopted in the design to enable the seaberth to withstand horizontal earthquake load, which is a design controlling factor without the neccessity of considering lateral resistance of piles penetrated into the poor soil seabed. Batter piles were designed to have great inclinations of max. 27.5° to plumb and to be so located on the centre row of the seaberth that they could be driven by the unique method. The above design concept made it possible to develop the following construction procedures:

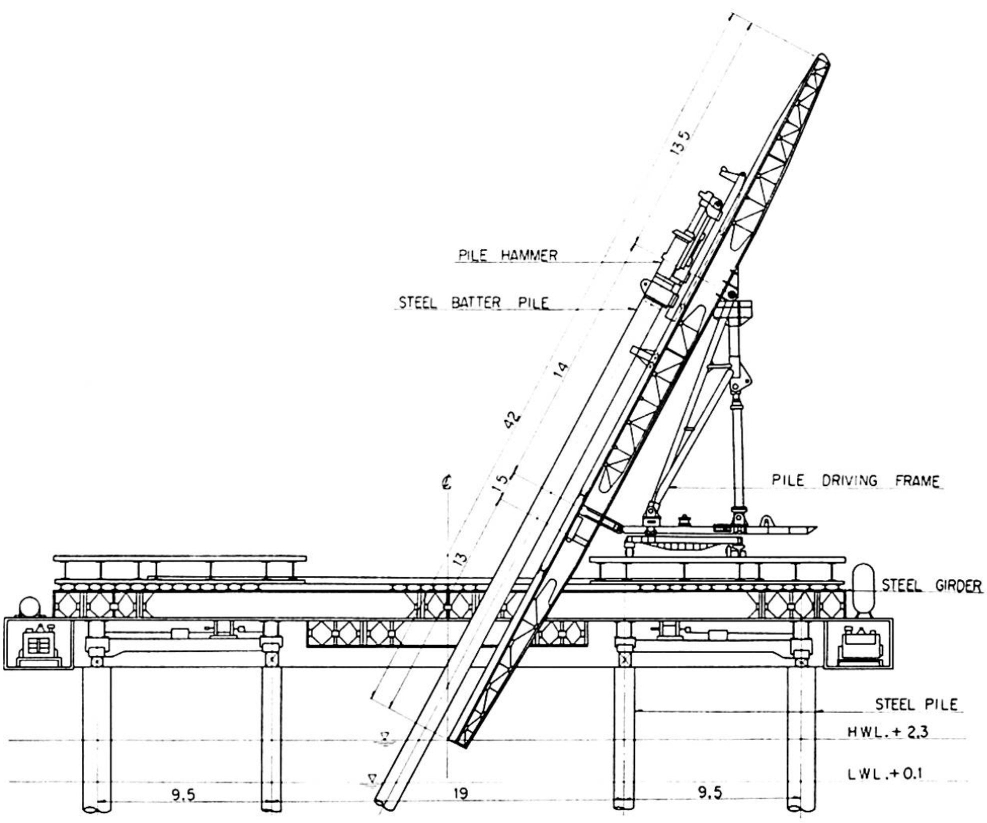
1) The vertical piles were driven using a floating barge equipped with an air pile hammer with rated energy 18.7 tm;
2) The prefabricated girders were installed on the pile heads;
3) The batter piles were driven with an air pile hammer equipped on the lead which is installed on a temporary truss girder capable of travelling along the jetty (Fig-4).

This design has been found to be sound in dealing with horizontal load at the site with a very poor soil condition. It also has proved advisable as a construction procedure.

3. Tomakomai Seaberth

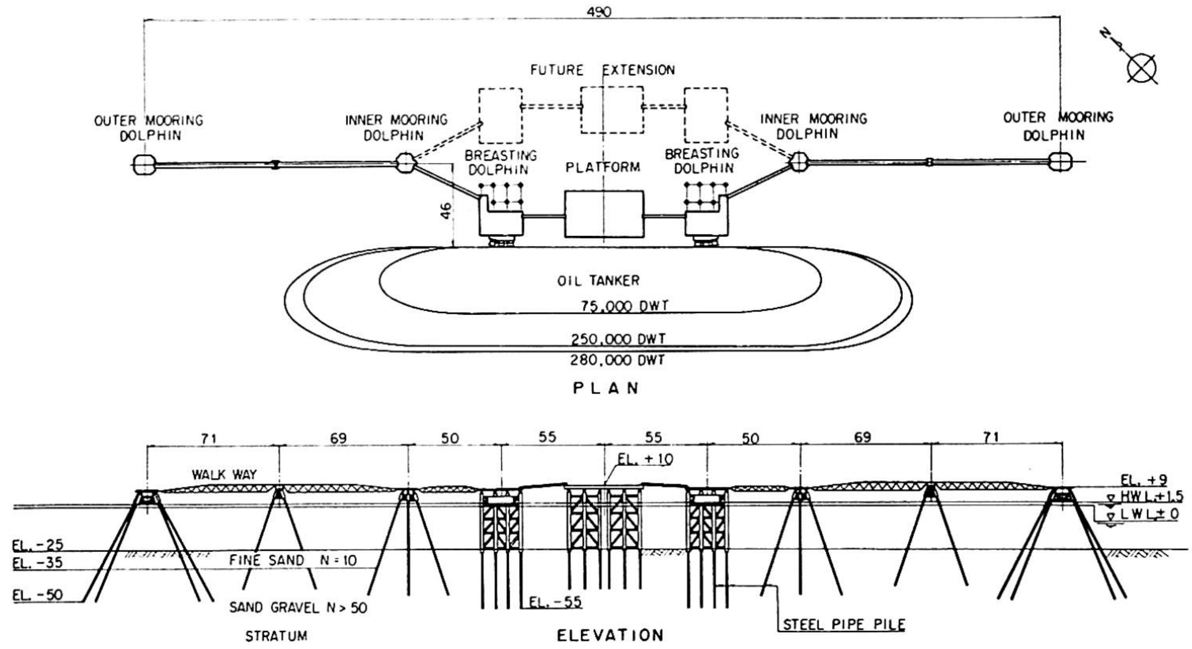
Tomakomai Seaberth was constructed in 1973 and is situated in lat. 40°36'N. and long. 141°39'E. in the open sea 3 km off the coast of Tomakomai.

The environmental conditions were far severer than those in Tokyo Bay or Beppu Bay. Therefore it was assumed that only two days out of ten would be workable when used a piling barge and that the lowest atmospheric temperature would be -20°C. But the soil condition was fairly satisfactory as



shown in Fig-5.

From the precious experience learned in Keiyo Project, such as the difficulty in interconnecting driven piles even though in rather gentle sea of Tokyo Bay, because of enduring sway of pile heads by wave action, it was deeply felt necessary to develop design and construction techniques in order to maintain the driven piles in place during construction period. And also to simplify the marine works was necessary. The socalled jacket concept which is in use for both drilling and production platforms for oil exploitation is a

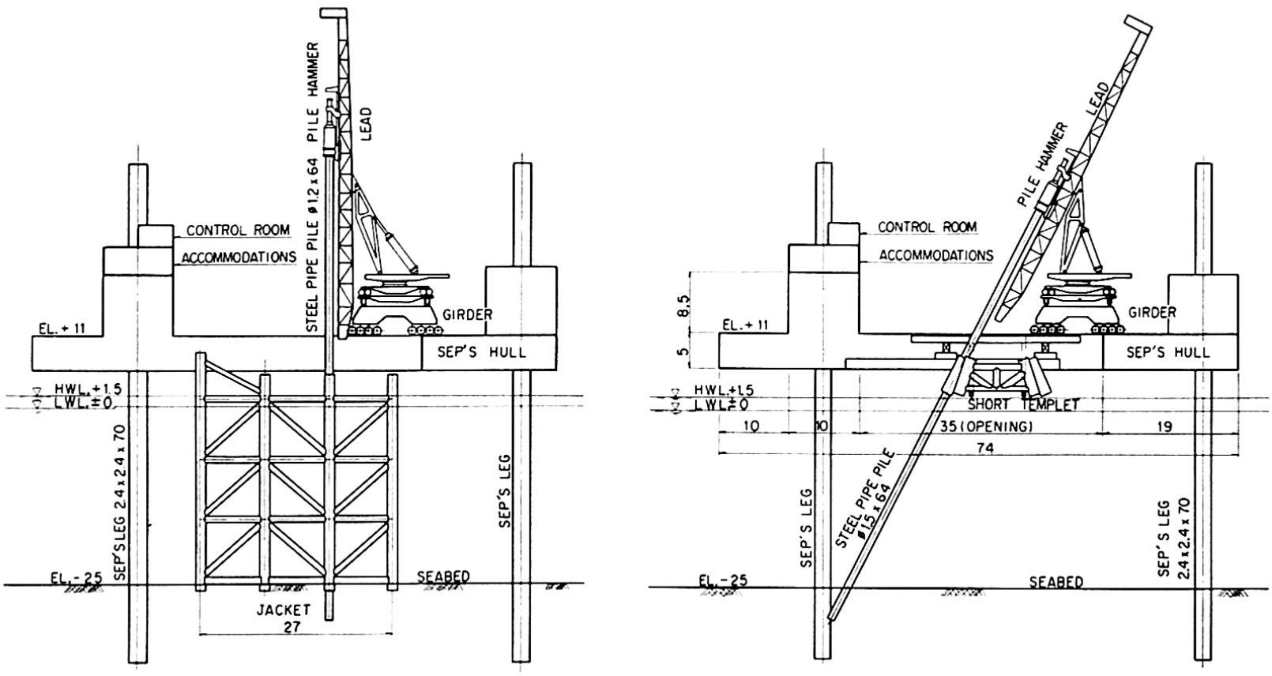


good solution for such purpose.

Applying jackets to all structures forming seaberth would, however, be uneconomical. For this reason, unique short templets having frameworks only above sea-water level were developed for the construction of piers and mooring dolphins. To allow piling in rough sea and to make the short templet concept practicable, a new type SEP in spacial shape and with a larger capacity than that used in Keiyo Project was required. The piling technique employed in Oita Project was introduced in the SEP, i. e. to handle piles by a jib-crane and to drive by a hammer attached to lead both equipped on a travelling girder. Then SEP "KAJIMA" having a U-shaped hull 74m x 45m x 5m in outside dimensions with a 35m x 30m inside well and with four 2. 4m x 2. 4m x 70m legs was developed for the performance of this project.

Piles were driven through jackets and short templets held in the well of the SEP (Fig-6 & 7). When piling and welding of the four corners was completed, the structure could self-stand against waves of 6m in height.

The marine works of the seaberth, including the entire facilities for mooring of vessels and unloading of crude oil, was started in October 1972 and successfully finished in August 1973.



SUMMARY

Offshore structures are required to be constructed under hostile environmental conditions. Therefore the structural design giving due consideration to the construction methods and procedures will assure success in operation of challenging offshore projects.

RESUME

Les constructions en pleine mer sont toujours construites dans des conditions très sévères d'environnement. Par conséquent, les projets doivent tenir compte des méthodes et procédés d'exécution pour assurer le succès dans l'exécution de constructions audacieuses.

ZUSAMMENFASSUNG

Bauten im offenen Meer werden oft unter schwierigen Umgebungsbedingungen erstellt. Um mit Erfolg schwierige Seebauten zu erstellen, müssen schon beim Entwurf im Projektstadium die Probleme der Ausführung beachtet werden.