Mooring of Floating Structures by Expanded End Bearing Pile

Tomiya Takatani
Maizuru National College of Technology, Kyoto, Japan
Yoshi-hiko Maeno
Nihon University, Tokyo, Japan
Hirosuke Kodama
Kodama Concrete Co., Ltd., Saitama, Japan

ABSTRACT
The response of a bearing pile with an expanding end plate to tide level change was evaluated by FEM analysis in order to investigate the feasibility of a pre-cast concrete pile anchor with an end bearing plate as a floating structure foundation. The pile anchor was assumed to be a linear and elastic solid, and the soil was assumed to be a fluid saturated elastic medium for several seabed types such as sand, silt and clay. The size effect of an end bearing plate at the tip of a pile anchor on the response of seabed was numerically estimated for various seabed materials. Simulation results imply that such an end bearing pile disturbs the dissipation of excess pore water pressure around a pile anchor.

KEY WORDS: Floating structure, bearing pile with expanding base, tide level change, FEM analysis, excess pore water pressure

INTRODUCTION
Floating structures such as pontoons are applied to coastal structures in tranquil inner bays. For example, the Saltus bridge in Norway is well-known as a floating bridge, which utilizes the arch effect under unidirectional current. Floating structures are not only pontoons but also an extra-large floating body such as the mega-boat, which is used at the garrison base of helicopters in Okinawa, Japan. In using such a floating structure for the severe sea conditions, considerable attention has to be paid on the responsibility of mooring system as well as the structural resistance against waves and currents. It is rare to observe floating structures in the open sea. To reduce the horizontal force due to wave attack, a piled jetty is popular. Even in a relative large waters, structures such as quay or pontoon are supported by steel pile piles.

In order to increase the structural resistance against wave attack, the anchorage of a pre-cast concrete pile with an expanding end is introduced for the mooring system of pontoon on soft mud. This pile anchor has both effects of holding power against the buoyancy of the pontoon during high tide level and the bearing power against the weight of pontoon during low tide level. Wherever the range of tide level change is large in an inner bay, the proposed pile anchor is considered to be more effective than other mooring structures. Both the steel pile anchor and the concrete pile anchor have the resistance against overturning or horizontal movement caused by wave attack, but the concrete pile anchor may be more economical than the steel pile.

The feasibility of a pre-cast concrete pile anchor with an end bearing plate is discussed in this paper.

ANALYTICAL METHOD
The response of pile anchor with an end bearing plate against the tide level change is analyzed by FEM, which takes into account the consolidation and elasto-plastic deformation in soft ground. Considering the application of pile anchor to various seabeds such as sand, silt and clay, the effects of the permeability of seabed and the diameter of end bearing plate on the seabed responses around a pile anchor are numerically investigated as well as a pile anchor itself. Both the linear elastic and non-linear FEM analysis are used in this paper. At first, the seabed response around a pile anchor embedded in some seabeds is numerically estimated by the linear elastic analysis, and then the non-linear response of seabed around a pile anchor is investigated by applying the Cam-clay model to the seabed ground.

The response of seabed around a pile anchor in the time domain is discussed for actual tide level change data observed in the bay area.

In order to apply a pre-cast concrete pile anchor with an expanded base to the mooring anchor system, a pile anchor with an end bearing plate is employed as an analytical model to simplify the mechanism of the bearing power of a pre-cast concrete pile anchor.

![Figure 1: Floating structure and pile anchor model with end bearing plate](image-url)