Numerical Simulation of Lateral Loaded Pile Taking into Account the Shear Stress at the Sand Interface Layers

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ABSTRACT

Due to the recent research advances in understanding mechanisms which govern the deep behavior foundations, now the vertical piles can be used to support correctly lateral loads. The paper concerns the development of a computer program for studying non-linear behavior of lateral loaded piles taking into account the shear stress at the sand interface layers. Some examples issued from the use of the numerical code are compared with experimental results from centrifuge modelling loaded piles tests and, with other numerical results from a well-known code used in France.

KEY WORDS: Piles, Lateral loaded, Deep foundation, Shear stress, Numerical model, Centrifuge model-piles.

NOMENCLATURE

B : frontal width or diameter of the pile (m)
D : depth of penetration of the pile (m)
EI : pile rigidity (kN.m²)
E_s : subgrade reaction modulus (kPa)
G_s : shear stress modulus (kN/m²)
H : lateral loading (kN)
I_0 : density index
K_s : coefficient of subgrade reaction (kN/m²)
M : bending moment (kN.m)
p : lateral earth pressure (kN/m²)
P : lateral earth reaction (kN/m)
P_0 : atmospheric pressure (kPa)
T : shear force (kN)
y : pile deflection (m)
z : depth (m)

INTRODUCTION

Deep piles foundations, which are widely used in construction of coastal or offshore structures, are in a growing development. Improvements are made in the design and for technical innovations in construction piles. The weak performance of soils given to the constructors, and the importance of the construction dimensions, are at the origin of this development. Nowadays, the theoretical approaches are insufficient to take into account all the parameters of the soil-pile interaction. The design codes used do not take the shear stress at the soil interface layers into account. Moreover, the obtaining of experimental data on site is more difficult and more expensive. So, to study the influence of different parameters linked to the soil-pile interaction, led many researchers to use model-piles. Referred to the bibliography, only few non-linear design models relative to the behavior laterally piles are proposed to the case of that concern simple configurations. The paper concerns a design code, based on the matrix transfer method which is applied to the laterally loaded piles, taking into account the shear stress at the sand interface layers. Then, the performances of the developed design code is illustrated by some examples. The theoretical results are compared with the results given by the design code PILATE-LCPC (Frank and al., 1990), and with the experimental results obtained by tests on the models of piles in centrifuge.

NUMERICAL MODELLING

The interaction soil-layer model

Pasternak (1954) has proposed a behavior soil model taking in account the interaction of shear stress between the springs of the Winkler model (1867) (Figure 1). This is obtained by linking the springs to an incompressible layer that may support only tangential deformation caused by the shear stress. The shear stress layer is assumed isotropic depending on a shear stress modulus G_s.

The governing equation is given under the following relationship:

\[ p = K_s y + G_s \nabla^2 y \]  \hspace{1cm} (1)