Evaluation of bearing capacity of cast in place piles from in situ tests based methods

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Abstract

Many in situ based methods are used to determine the bearing capacity of piles. This paper aims to deal with the evaluation of bearing capacity of cast in place piles, by using various methods based on Standard Penetration Test (SPT), Cone Penetration Test (CPT) and Dilatometer Marchetti Test (DMT) data. The tests are not only used to identify the soil profile, but also to characterize the strength parameters of the soils, which are further used to estimate the bearing capacity. The tests are carried out in Albania. The soil profile identified in all the sites is non homogeneous compounded by sandy and clayey layers, locally organics. The considered cast in place pile diameters, in this paper, range from 0.5 m to 2.0 m and embedment lengths considered are 10 m, 20 m and 32 m. At the end, the results of bearing capacities obtained by different methods used are compared and an attempt to study load - displacement curve by numerical simulation using MEF is presented and compared with the results of static loading test carried out in site. Some conclusions are highlight related to the use of in situ tests during the pile foundation design.

INTRODUCTION

The allowable axial load capacity of piles is calculated based on SPT, CPT and DMT, as a complement of static and dynamic loading tests and analysis. In this paper, the comparison of results obtained by different methods of calculations of pile bearing capacity and an attempt to study load - displacement curve by numerical simulation using MEF is presented.

The results of the tests carried out in 3 sites in Albania are used to calculate axial bearing capacity of cast in place piles. SPT and CPTU tests results are considered from the 1st site, where the piles depths of 20.0 m are related to the piles diameters, which vary from 0.50 m to 2.00 m. CPTU and DMT tests results from the 2nd site are used to calculate the bearing capacity of piles with depths of 10.0 m and diameters from 0.50 m to 2.00 m. In the 3rd site SPTs data are considered, from which re derived also the CPT parameters used. Part of the investigation program was static loading testing, carried out at 32.0 m cast in place pile with diameter 1.20 m. The pile is designed for 3330 kN. The loading – displacement curve from the test in site is compared with the curve obtained by the Finite Element Model of the same pile, in same conditions.

FINITE ELEMENTS MODEL CONSIDERATIONS

The pile: D = 1.2 m and L = 32.0 m;

Soil profile: 1st, 2nd, 3rd layers are sandy silts to silty sands, 4th layer is silty clay, 5th layer is fine sand and 6th is silty clay to clayey silt. (Underground water level - 1.00 m);

Boundary conditions: Standard fixities;

Soils conditions/ model: Undrained/ (HSM)

Soil-structure interaction/behavior of interfaces:
R = 0.90/elastic– plastic;

Pile Model/ Elements/ Properties:
Axisymmetric/ Triangular with 15 nodes, linear – elastic, non porous/ γ=25 kN/m3, M=3.0x107 kPa.

Load application:
12 phases (same as in site during the static loading test);

Used criteria: PL/AE + D/120 + 4 (mm);

Settlements calculation (150% of working load):
2% D+0,5 PL / EA;

RESULTS

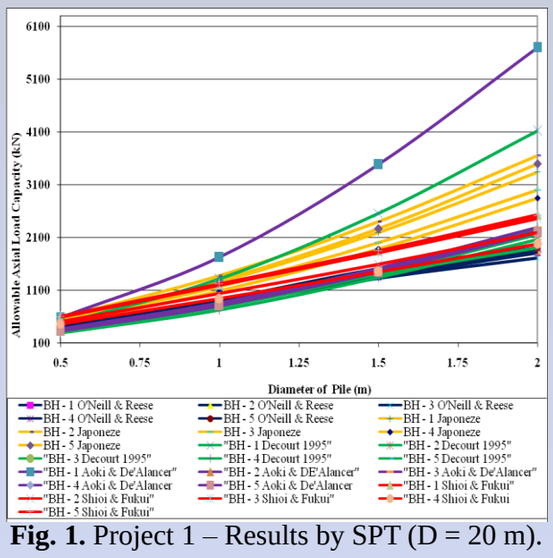

Fig. 1. Project 1 – Results by SPT (D = 20 m).

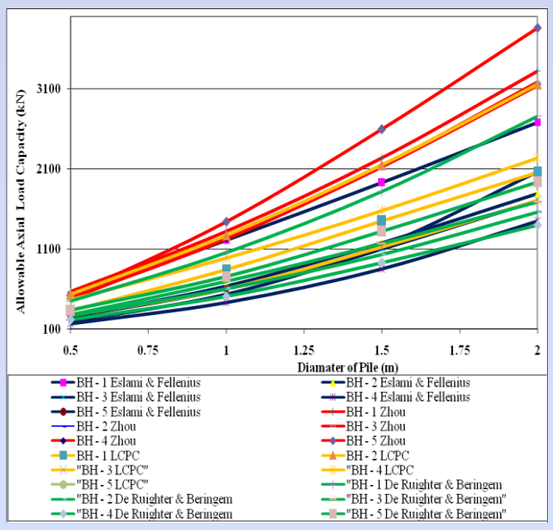

Fig. 2. Project 1 – Results by CPT (D = 20 m).

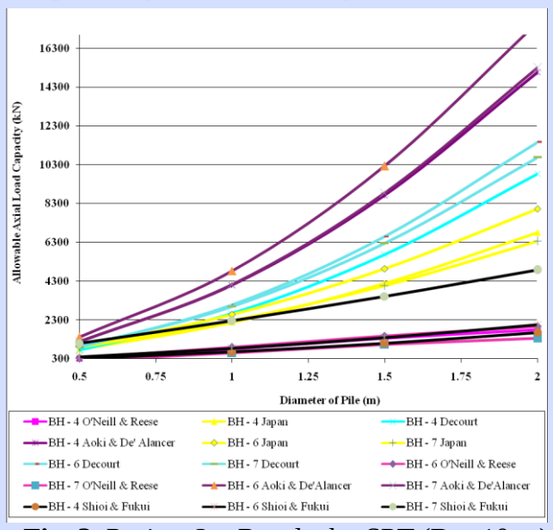

Fig. 3. Project 2 – Results by SPT (D = 10 m).

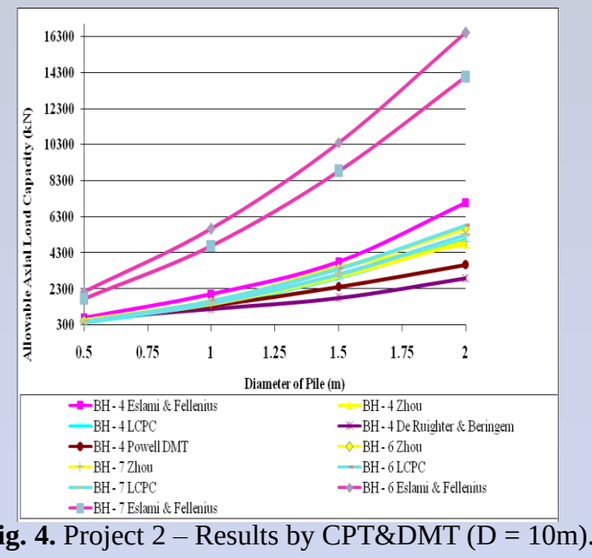

Fig. 4. Project 2 – Results by CPT&DMT (D = 10m).

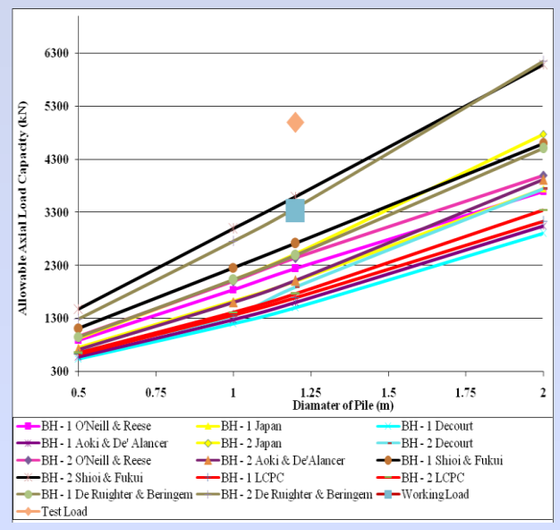

Fig. 6. Project 3 – Results by SPT & CPT (D = 32m).

Fig. 3. Project 2 – Results by SPT (D = 10 m).

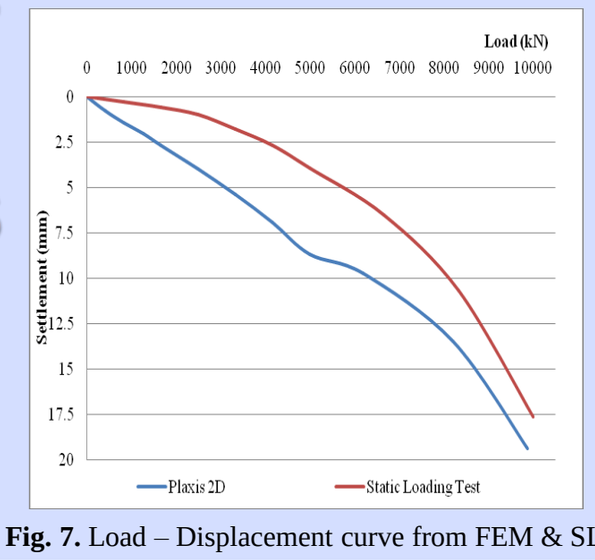

Fig. 7. Load – Displacement curve from FEM & SLT

SUMMARY OF THE RESULTS

Project 1 –Bearing capacity from **SPT** based methods: **292 kN - 5696 kN**;
from **CPT** based methods: **168 kN - 3862 kN**.

Project 2 –Bearing capacity from **SPT** based methods: **197 kN - 17614 kN**;
from **CPT** based methods: **437 kN - 16521 kN**;
from **DMT** based method : **538 kN - 3619 kN**.

Project 3 –Bearing capacity from **SPT** based methods: **542 kN - 6095 kN**;
from **CPT** based methods: **635 kN - 6153 kN**.

Static Loading Test **Axial load = 5000 kN, Settlement = 3.933 mm**.

FEM Analysis **Axial load = 5000 kN; Settlement = 8.670 mm.**

CONCULSIONS

1. *SPT based methods are widely used for axial bearing capacity of piles calculations, but deficiencies still exist.*
2. *To overcome the accuracy problems, CPT based methods are developed. Bustamante & Gianiselli is one of the most accurate methods to use in clayey soils, whereas de Ruitter & Beringen and Eslami & Fellenius are very efficient approaches to predict the axial bearing capacity of piles in sandy soils.*
3. *Although big similarity between piles and cones, many factors may affect the accuracy of CPT based methods, e.g. considerations of soil behavior in the method, differences of pile & cone diameters, the pile - soil and cone - soil interfaces.*
4. *A good method for axial bearing capacity evaluations of piles is the load-displacement curve, from SLT in site or FEM analyze, which shows good agreement of the results if the pile and the soil are modeled correctly in the software used.*