Validation of In-Situ Probes by Calibration Chamber Tests

Sergio Airoldi[1], Alberto Bretschneider[1], Vincenzo Fioravante[2], and Daniela Giretti[1](✉)

[1] ISMGEO Srl, Seriate, BG, Italy
giretti@ismgeo.it
[2] University of Ferrara, Ferrara, Italy

Abstract. This paper describes the ISMGEO Large Calibration Chamber and its application for the validation of in-situ testing probes such as Cone Penetration, Nuclear Cone Penetration, geophones for seismic wave propagation. The calibration chamber is active since the 1980s, during this period thousands of tests have been carried out demonstrating the effectiveness of such experimental facility.

Keywords: Calibration chamber · CPT · Nuclear cone

1 Introduction

The development of new technologies for in-situ geotechnical testing requires a strong calibration based on the comparison with the existing methods. The measure of in-situ physical and mechanical parameters by classical geotechnical field methods can found strong benefit from laboratory tests. Large scale laboratory tests are useful to reproduce real-like stress conditions for soils. In this frame the use of calibration chambers is an outstanding method to reproduce site conditions.

The geotechnical calibration chamber is a test system capable of providing the environmental necessary to simulate full scale in situ tests in the laboratory. The dimensions of the soil specimen and the boundary conditions are such that experimental data can be readily interpreted and applied to in situ conditions. The purposes for which the calibration chamber apparatus was developed include the following:

(a) establishment of a wide range of correlations between test result and geotechnical parameters of the soil, to better understand the typically empirical in situ geotechnical tests; further, given the controlled conditions in the chamber, it is possible to check the correlations currently suggested for the interpretation of in situ test results;
(b) verification of the mechanical operation of in situ geotechnical instrumentation;
(c) development of new in situ geotechnical instrumentation;
(d) testing of model piles, tie rods, etc.

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2 ISMGEO Geotechnical Calibration Chamber

The ISMGEO calibration chamber (Fig. 1) has been in operation since the 1980s [1] and since then it has been extensively used to test and calibrate geotechnical field probes. It houses a 1.42 m high by 1.2 m diameter specimen. The equipment consists of a flexible wall chamber, a loading frame, the apparatus for sand deposition and the saturation system.

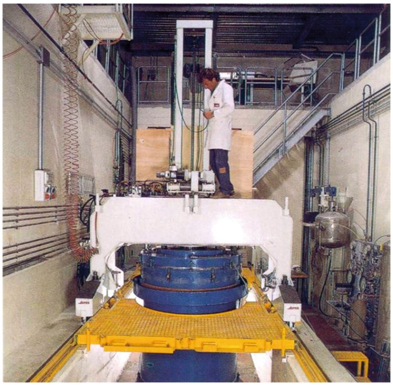

Fig. 1. The ISMGEO geotechnical calibration chamber

Vertical and horizontal stresses can be independently applied in a controlled manner to the boundaries of the sample. Vertical stresses are applied to the specimen through a piston (positioned at the bottom of the chamber), the horizontal stresses are applied by the pressure of water surrounding the specimen. The cylindrical specimen is enclosed at the sides and base by a membrane; the top of the membrane is sealed around an aluminium plate which confines the specimen at the top and transfers the thrust of the chamber piston from the specimen to a top lid and loading frame to counteract the piston force and to hold the hydro-mechanical press which pushes the probe into the chamber.

To control both the stresses and the strains during the saturation and consolidation phase, the following parameters are measured by the data acquisition system: vertical stress, pore pressure within the sample, water pressure in the inner cell (i.e. horizontal stress on the sample), vertical displacement of the chamber piston, horizontal displacements of the specimen (measured by 7 LVDTs placed at seven different heights of the samples) and specimen volume change.

Soil samples are prepared by air pluviation and can be reconstituted at the desired relative density values. Internal and external sensors can be installed on soil specimen to measure soil and water pressure, waves propagation, specimen deformation.

3 Testing Examples

A classic approach is the use of calibration chamber testing for Cone Penetration Test data interpretation to evaluate the mechanical properties of sand deposits (relative density, shear strength). An example of Relative density of NC and OC siliceous sands is reported in Fig. 2, from [2].

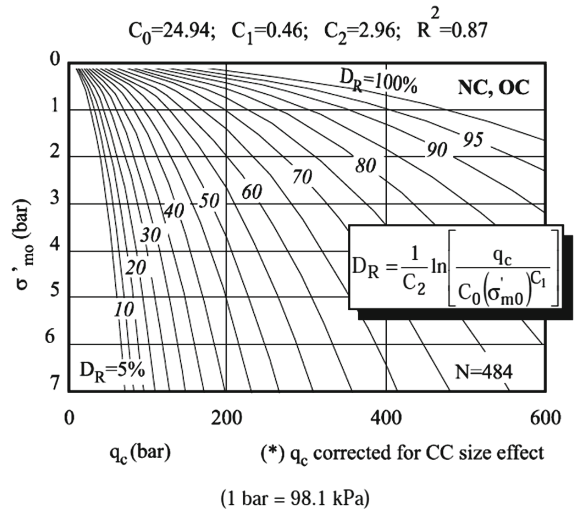

Fig. 2. Relative density of NC and OC siliceous sands from [2]

Another application of calibration chamber was the validation of nuclear CPT probes to measure soil density by gamma-ray. This method can be used to obtain a continuous measure of density with depth in penetrometer tests. Even if the method is known since some decades [3], it is not yet largely applied in common practice.

CPTs on carbonate sands have also been extensively studied. Carbonate sands have crushable grains and can be significantly more compressible than silica sands, so CPT-based correlations for silica sands are not applicable and a soil-specific calibration are needed for density, shear strength and compressibility parameters evaluation [4].

The propagation of seismic waves has been also studied on silica and carbonate sands. As an example seismic wave propagation tests have been performed on dry carbonate oolitic sand from Kenya [5]. Sand specimen were reconstructed at relative densities of 30% and 85%. Geophones were embedded during the specimen preparation and were used as source and receiver of seismic waves (Fig. 3).

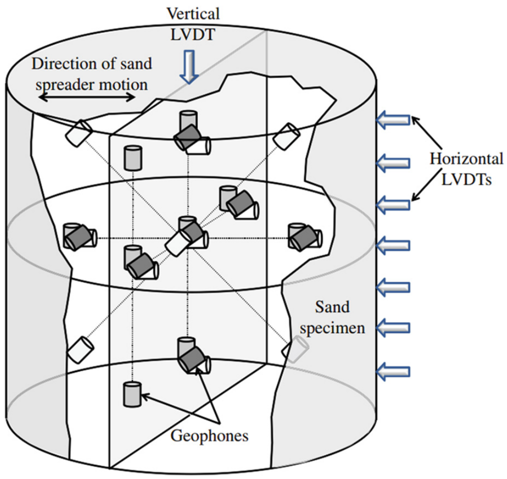

Fig. 3. Propagation of seismic waves, experimental setup.

Propagation of compression and shear waves were measured along the vertical, horizontal and inclined planes. The tests allowed to quantify and describe the effects of the fabric, of the stress induced anisotropy as well as the stress history on the velocity of propagated seismic waves and to calibrate semi-empirical correlations useful to analyze body wave velocity profiles measured in situ and to evaluate the state parameters and anisotropy properties of carbonate sand deposits.

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