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# New correlations of penetration tests for design practice

M.Jamiolkowski, V.N.Ghionna, R.Lancellotta & E.Pasqualini
*Technological University, Torino, Italy*

**ABSTRACT:** A critical review of the significant progress and innovation in interpretation of in-situ penetration testing is presented. Emphasis is placed on the Standard Penetration Test (SPT), Cone Penetration Test (CPT) and Flat Dilatometer Test (DMT). Use of these test methods in geotechnical practice to evaluate the basic design parameters of initial state variables and stress-strain-strength characteristics of cohesive and cohesionless soils is presented.

**KEY WORDS:** In-Situ Testing, Standard Penetration Test, Flat Dilatometer Test, Cone Penetration Test, Calibration Chambers, Indirect Approach, Correlations, Cohesionless Soil, Cohesive Soil.

## 1 INTRODUCTION

The present lecture attempts to summarize the existing knowledge of Penetration Testing in Geotechnical Design Practice. The last fifteen years have been characterized by significant developments in the area of in-situ testing. These developments have resulted in the invention of new tests, and in the innovation, improvement and standardization of the existing ones. However, the most relevant feature of this period, is a better understanding of the relationships between the results of in-situ tests and basic soil behaviour.

This last fact has contributed to a remarkable rationalization of the interpretation of different kinds of in-situ tests and of the use of their results in design.

More detailed information concerning the role, advantages and limitations of the in-situ testing techniques as applied in Geotechnical Practice can be found in works by Ladd et al. (1977), Mori (1981), Robertson and Campanella (1982), Wroth (1984), Jamiolkowski et al. (1985) and Robertson (1986).

To avoid duplications with other lectures in the programme of ISOPT-I, the following discussion is limited to the Standard Penetration Test (SPT), Static Cone Penetration Test (CPT), and Flat Dilatometer Test (DMT) (Marchetti, 1975; 1980).

## 2 INNOVATION AND PROGRESS IN PENETRATION TESTING

The penetration test is an old and well established method of in-situ experimental soil engineering. At present, recent advances in electronic sensors and data acquisition systems have largely improved the capabilities of Penetration Tests to contribute in a cost-effective way to the solution of important design problems.

The most relevant innovations are:

a. Development of the static electric cone penetrometer which permits continuous measurements of cone resistance $q_c$, and local shaft friction $f_s$ as well as the monitoring of the deviation of the CPT tip from vertical (De Ruiter, 1971; 1981; 1982; Schaap and Zuidberg, 1982; Robertson and Campanella, 1984).



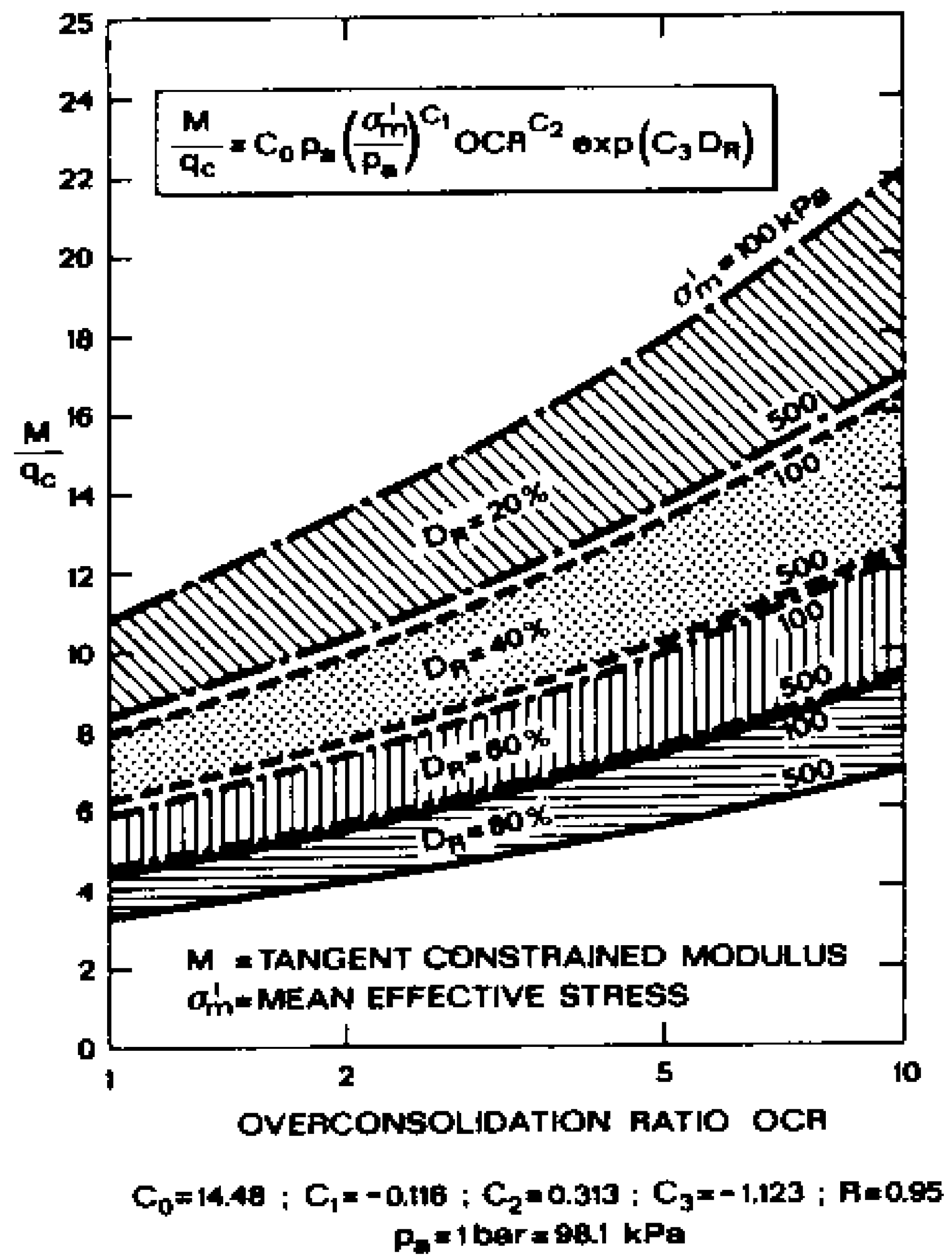


Fig.13 M versus $q_c$ correlation for Ticino sand (Jamiolkowski, 1986)

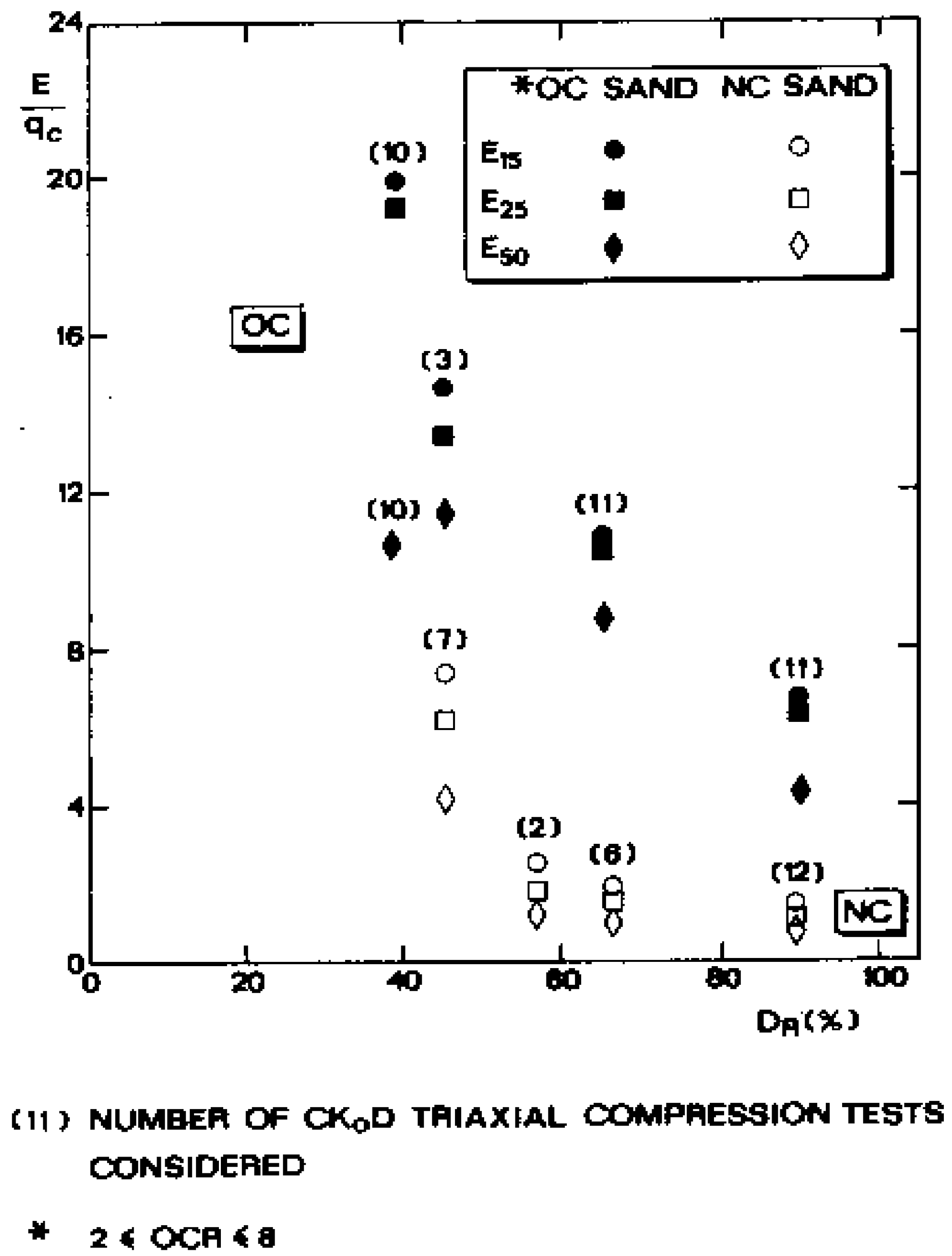


Fig.14 Young modulus vs cone resistance in Hokksund sand

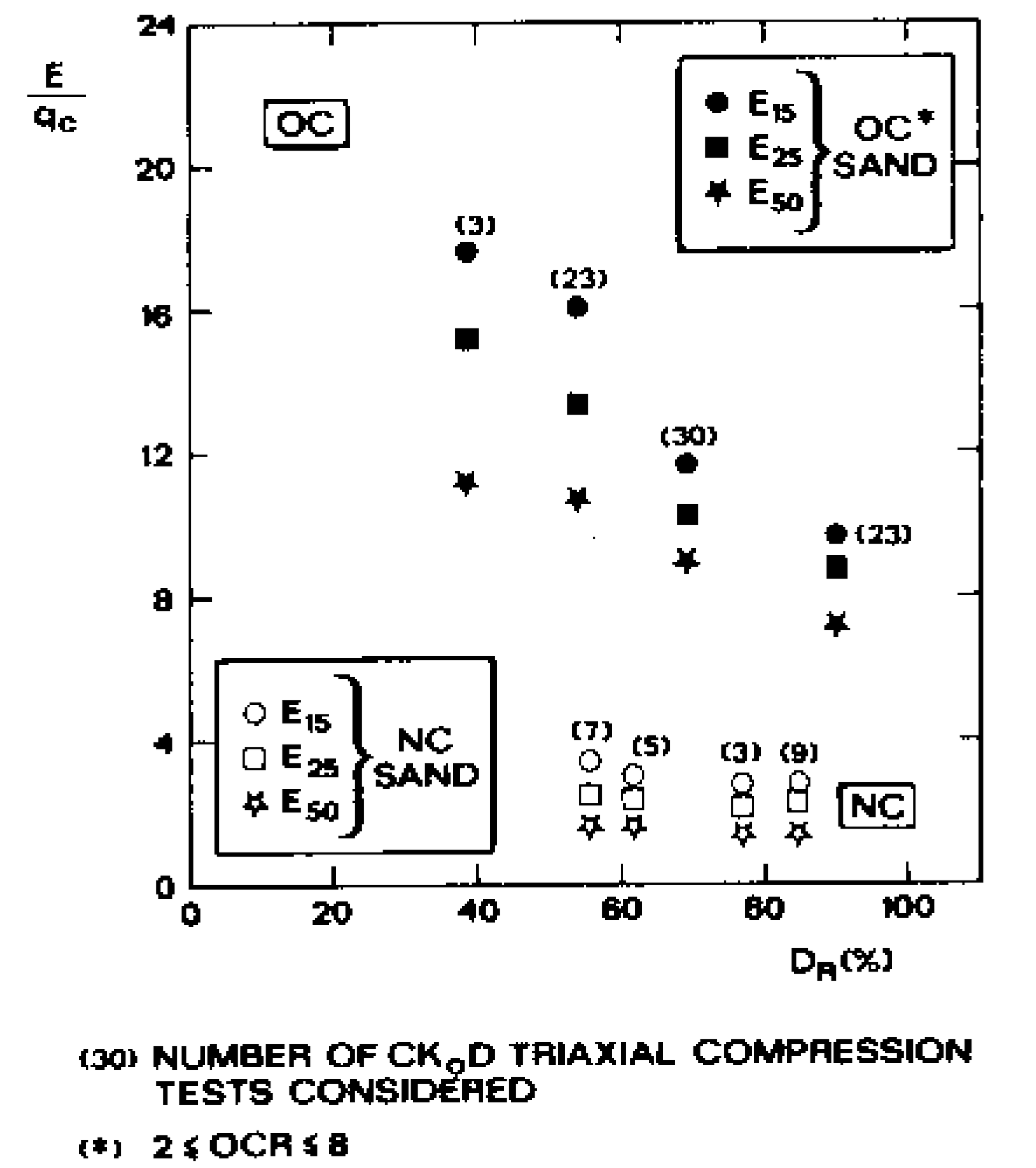


Fig.15 Young modulus vs cone resistance in Ticino sand

Table 5. Average Axial Strain corresponding to Young's Moduli in Figs.14 and 15.

| Sand | OCR | $(\epsilon_a)_{15}$ % | $(\epsilon_a)_{25}$ % | $(\epsilon_a)_{50}$ % |
|---|---|---|---|---|
| Ticino | 1 | 0.113 | 0.232 | 0.694 |
| Ticino | 2 to 8 | 0.039 | 0.069 | 0.159 |
| Hokksund | 1 | 0.152 | 0.316 | 0.939 |
| Hokksund | 2 to 8 | 0.036 | 0.060 | 0.215 |

Analysis of the $\epsilon_a$ values displayed in Table 5 suggests that $E_{15}$ and $E_{25}$ of OC test sands correspond to the "elastic" stiffness evaluated inside the current yield surface, while the $E_{50}$ of OC sands and obviously all the NC values of E reflect the elastic-plastic stiffness at the yield surface.

The results shown in Figs.13 through 15 indicate the following important trends in terms of the discussed correlations:

a. The ratios $M/q_c$ and $E/q_c$ are much higher for the mechanically OC sands than for the NC ones. This means that, without an "a priori" knowledge or assumption of the stress history of the deposit, it is impossible to select a reliable value of the design modulus.



**M from qc??**