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COMITÉ FRANÇAIS DE MÉCANIQUE
DES SOLS ET DE GÉOTECHNIQUE

« Regards croisés sur la pratique de la géotechnique entre la Roumanie et la France »

Le pressiomètre : une méthode directe pour caractériser le terrain et dimensionner les fondations

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The pressuremeter: principle and main features

A cavity expansion test

- Cylindrical probe inserted in the ground
- Measurements: volumetric expansion and pressure applied at the cavity
- Various testing procedures available

Result: cavity expansion curve

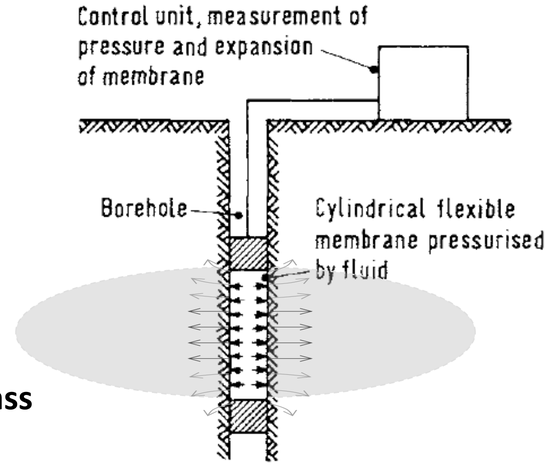
- Accounts for the strength and the stiffness of the surrounding ground mass

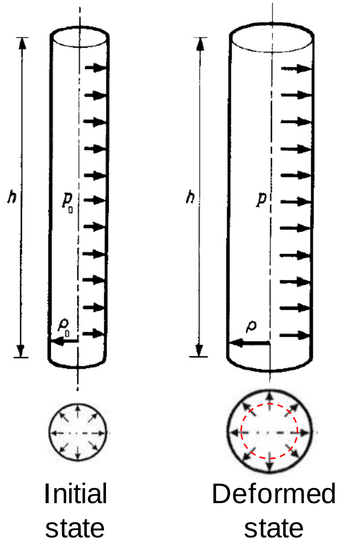
Tested volume of ground mass around the cavity

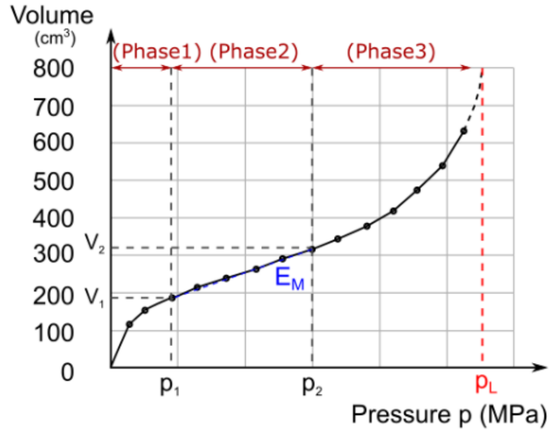
- Significant in comparison to laboratory tests,
- Allows a representative characterization of the ground mass

Enables the determination of

- The initial stress state (the initial earth pressure coefficient at rest)
- The elastic components of the ground behaviour (stiffness)
- The plastic components of the ground behaviour (strength)





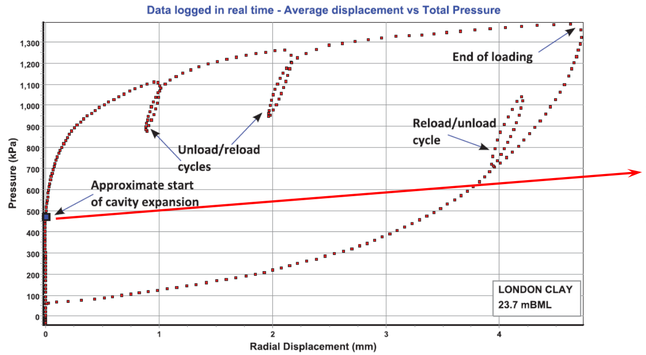


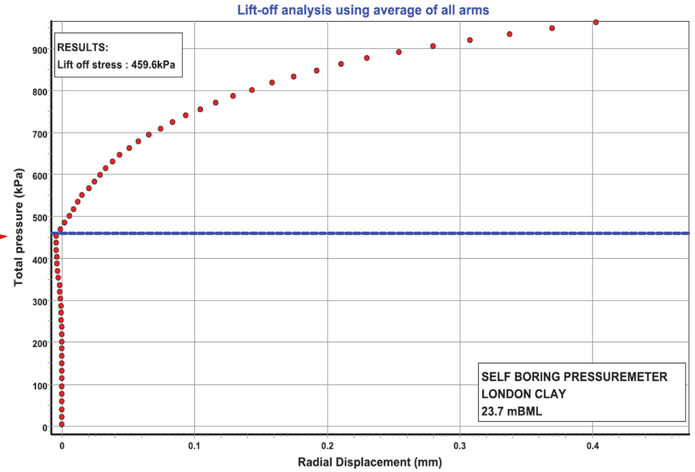
The pressuremeter: the intial earth pressure coefficient at rest

Recovering the initial horizontal stress state after the probe is inserted in the ground

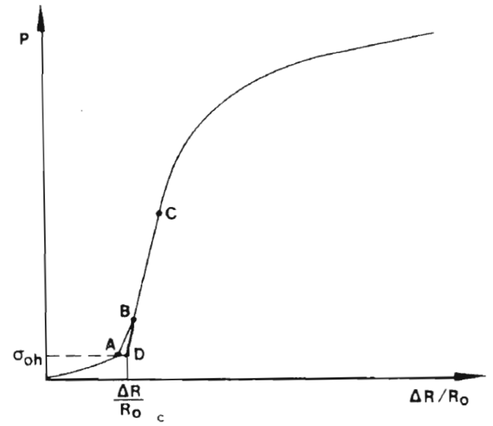
In self-bored tests: Lift-off method

In pre-bored tests: after recompression, additional loop during unload

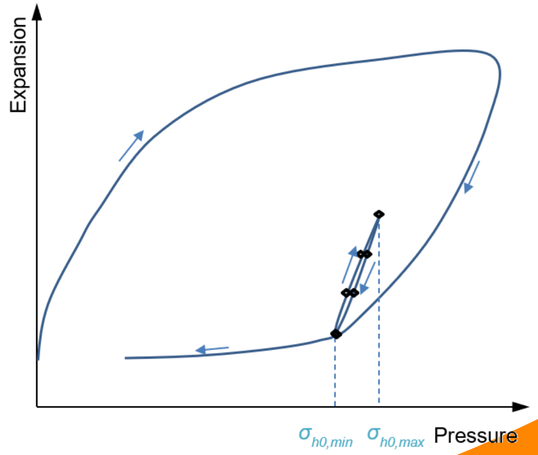




(Cambridge InSitu)



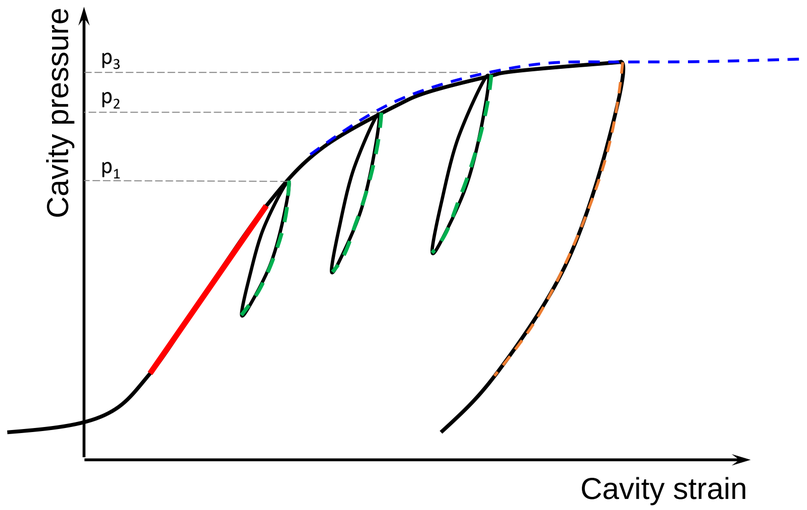
(Briaud, 1992, Reiffsteck et al, 2018)

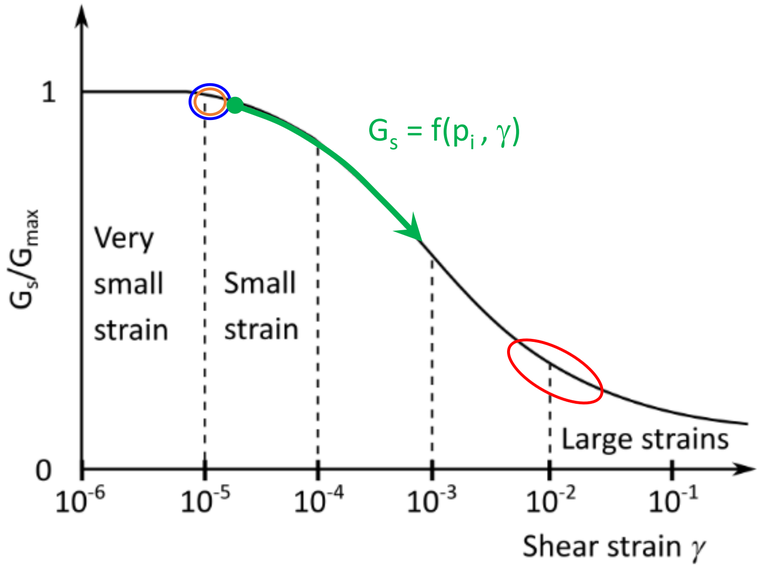


(ARSCOP)

The pressuremeter: the elastic components of the ground behaviour

Specific testing procedures and specific interpretation methods to assess ground stiffness at different strain levels





Ménard Modulus
Curve fitting considering hyperbolic constitutive behaviour (loading)
Curve fitting considering hyperbolic constitutive behaviour (unloading)
Secant apparent modulus and strain and stress transformation (loops)

NF EN ISO 22476-4
Habert and Burlon (2020)
Ferreira and Robertson (1992)
Lopes (2020), Jardine (1992), Bellotti et al (1989)

The pressuremeter: the plastic components of the ground behaviour

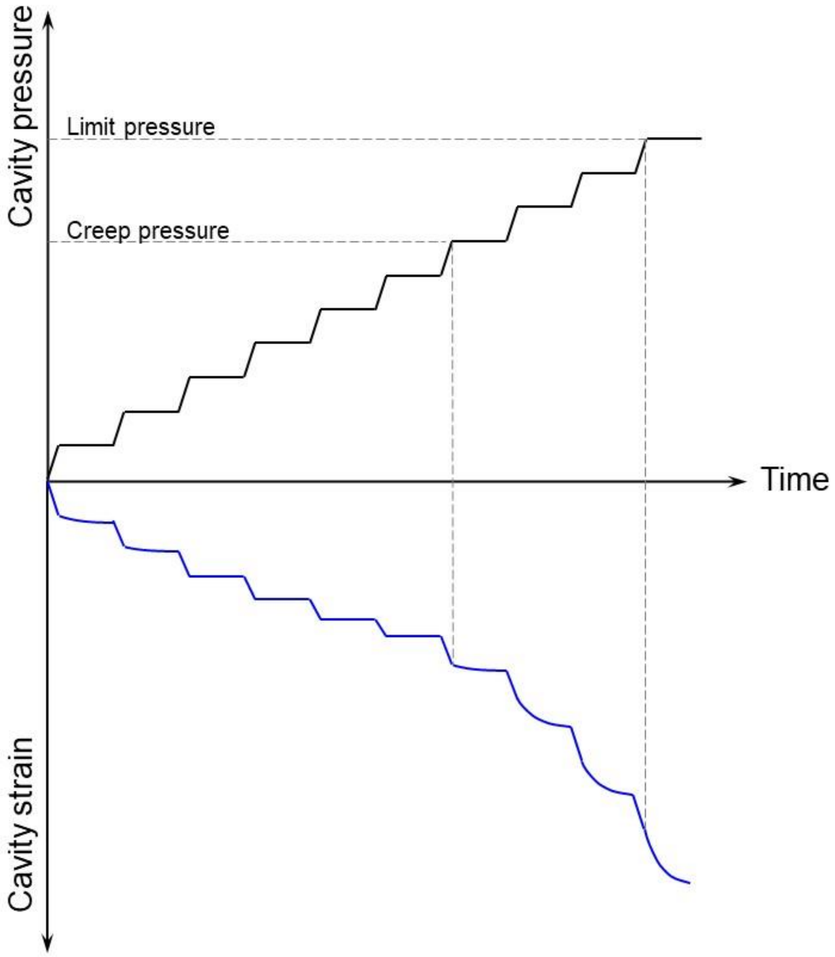
As the cavity pressure increases, the ground response becomes highly non-linear

- From a given yielding pressure, plastic strains start to appear
- Cavity response becomes time dependent
- Cavity response tends to an asymptotic value from which the ground cannot support any additional load

The pressuremeter creep pressure: beginning of time-dependent strain accumulation

The pressuremeter limit pressure: the maximum pressure that can be supported

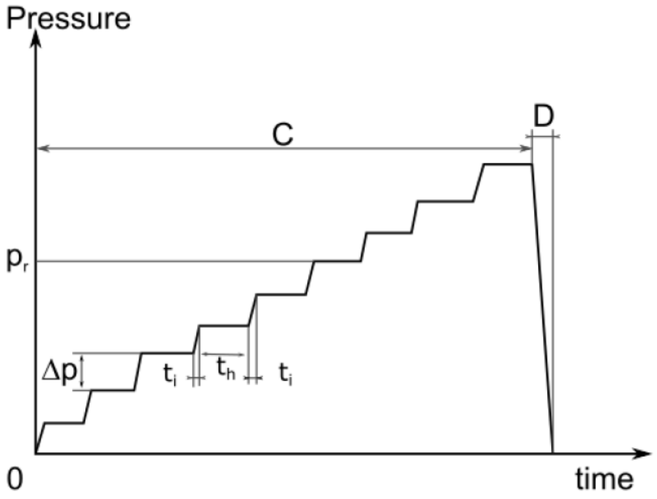
- Can be correlated to the strength properties: c_u, c', φ'



The pressuremeter: the Ménard procedure

Most commonly used procedure in French practice

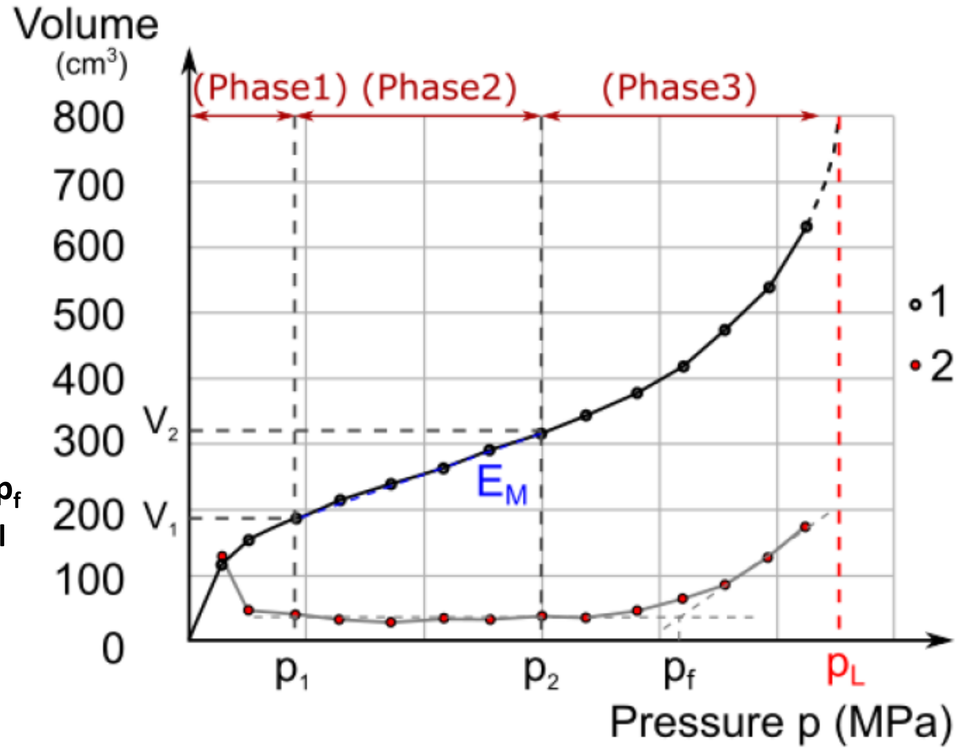
- Constant pressure load steps of 60s
- Usually 7 to 10 measuring points



Norme européenne
EN ISO 22476-4

Derived parameters

- Ménard Modulus E_M
- Pressuremeter creep pressure p_f
- Pressuremeter limit pressure pl



- Limit pressure is conventionally defined as the pressure for doubling the initial cavity volume

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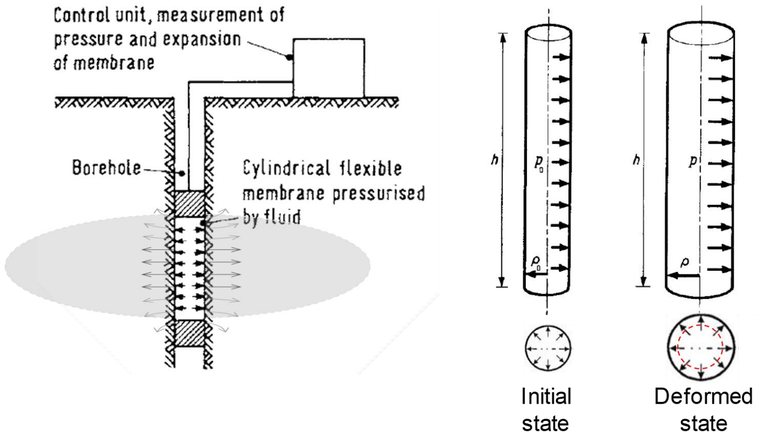
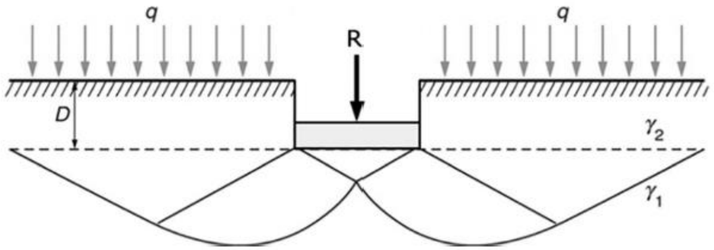
The pressuremeter: design of shallow foundation

The use of the Ménard pressuremeter tests for the design of foundation is direct since the strain and failure mechanisms around the probe and beneath a footing are very similar.

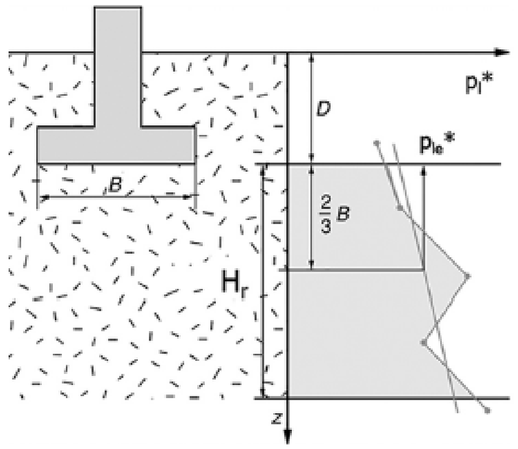
The bearing pressure of a shallow foundation is very close to the net limit pressure.
Many experimental tests on different French sites have allowed to improve the analogy or the correlation taking into account the type of soil, the embedment (the eccentricity and the inclination factors are similar to the other methods).

The Ménard modulus is used to develop a direct method for the settlement calculation of rigid footing. The method is similar to the Schmertmann's method used with CPT parameters as they both include a vertical stress diffusion derived from the theory of elasticity.





The pressuremeter: design of shallow foundation



Bearing capacity

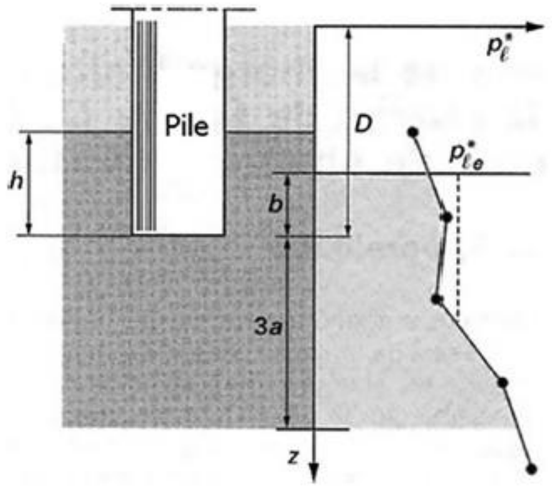
$$R_c = A i_e i_\delta i_\beta k_p p_{le}^*$$

Settlement
Ménard method
with E_M

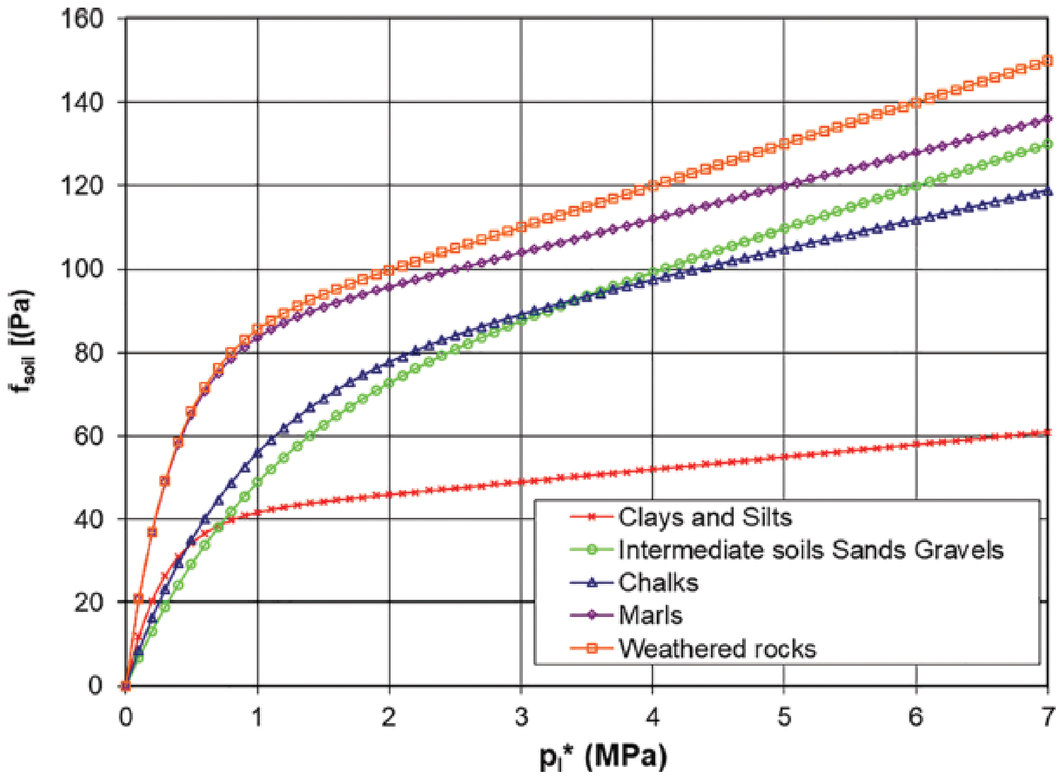
The pressuremeter: design of deep foundation
The bearing capacity

As for bearing pressure of footings, the net limit pressure can be used for the assessment of pile base resistance by the means of the bearing factor taking into account the pile technique and the ground type.

The relationship between the net limit pressure and unit shaft friction is not so direct but the objective is to establish a correlation taking into account the ground strength, the type of soil and the type of pile.



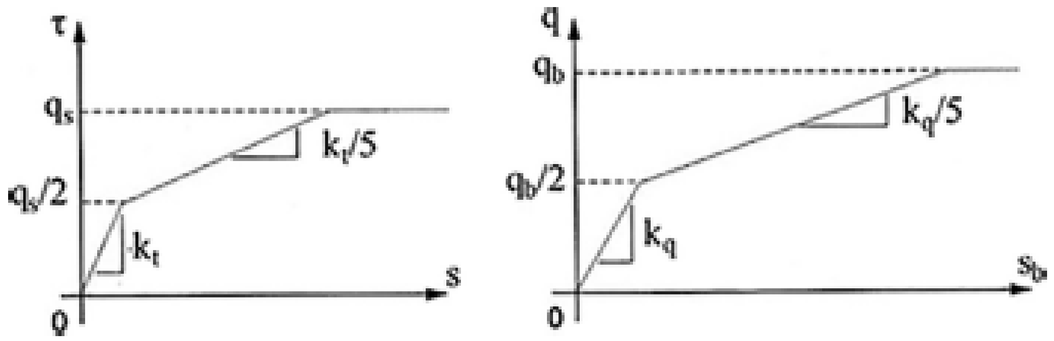
$$R_b = A k_p p_{le}^*$$



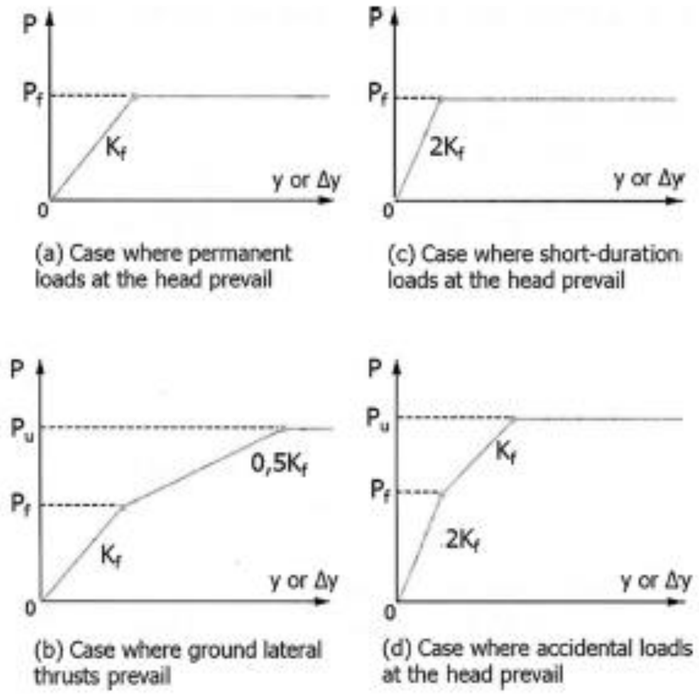
$$R_s = \Sigma P_i h_i f_{soil,i} \alpha_{ps,i}$$

The pressuremeter: development of t-z and p-y curves

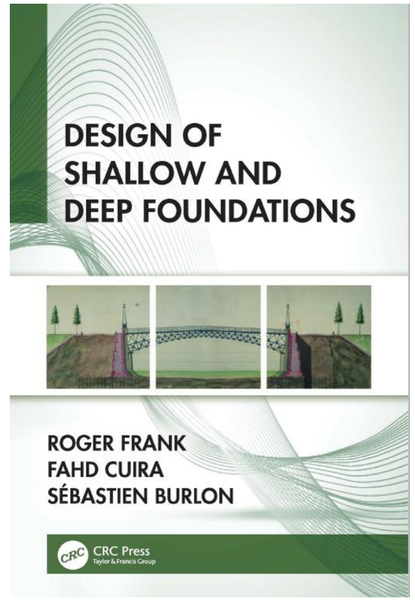
Development of t-z and p-y curves for piles



t-z curves (Frank and Zhao, 1982)



p-y curves



Use of subgrade reaction curves for retaining walls

The pressuremeter: conclusion

An original and versatile ground investigation method due to the volume of ground involved and the several possibilities loading procedures

The possibility of deriving moduli at different strain levels

An analogy with foundation failure mechanisms

Very useful for the design of foundations and other geotechnical structures despite of its sensitive use

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