



Developing confidence in critical state soil mechanics

11. Determining ψ insitu – the CPT

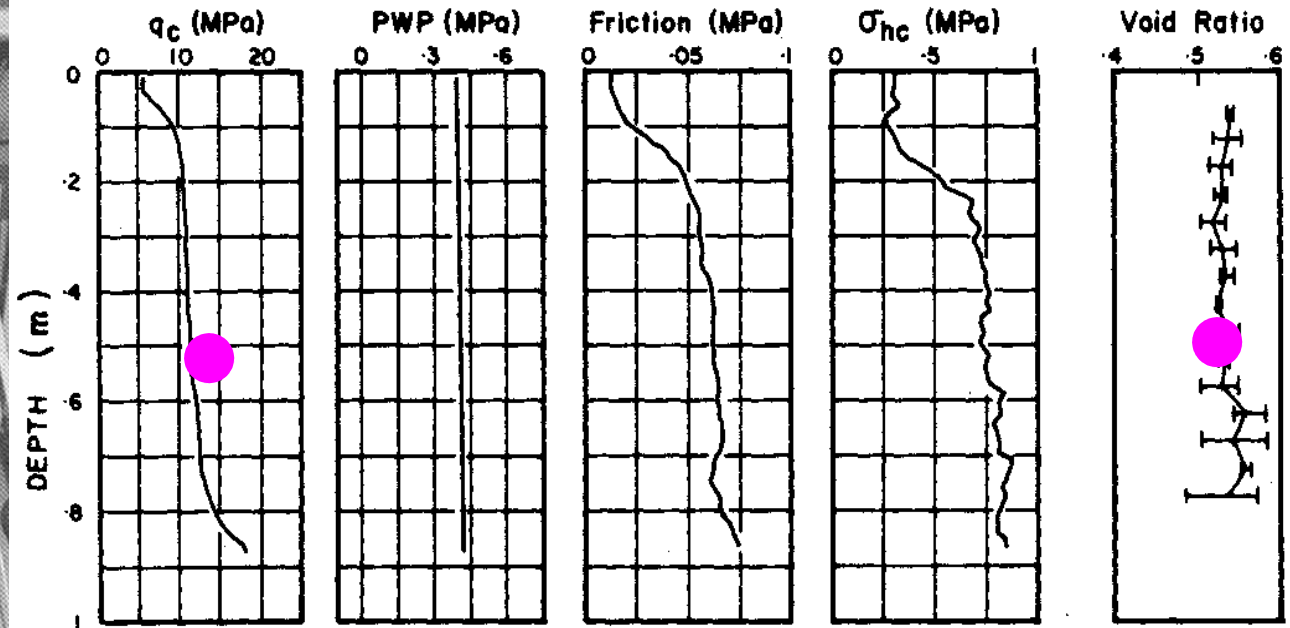
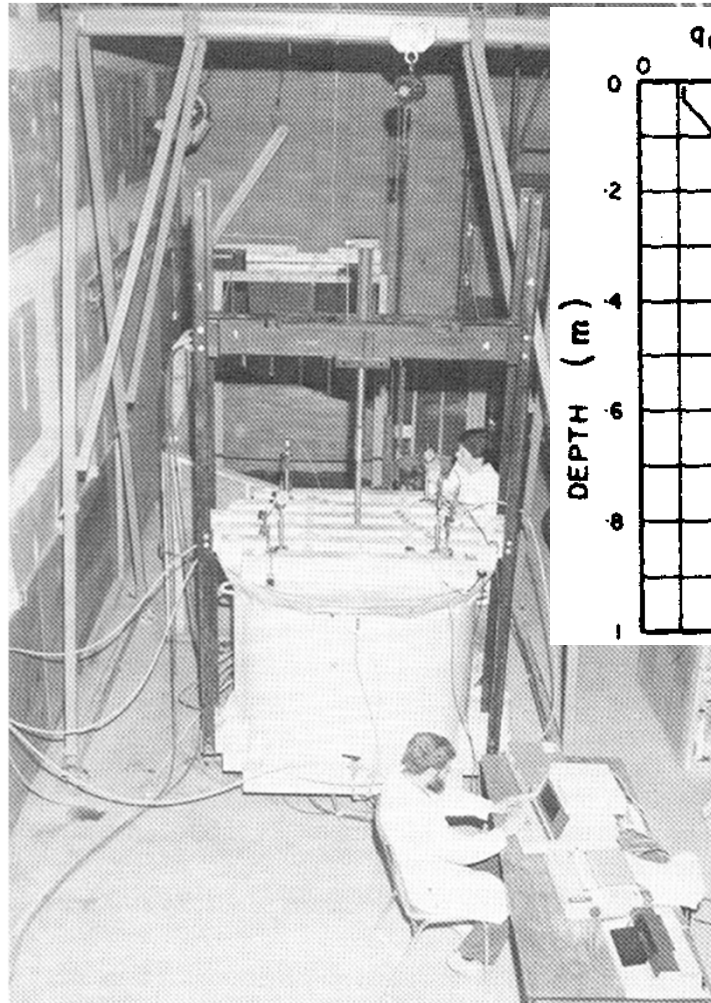
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Calibration chamber for the CPT

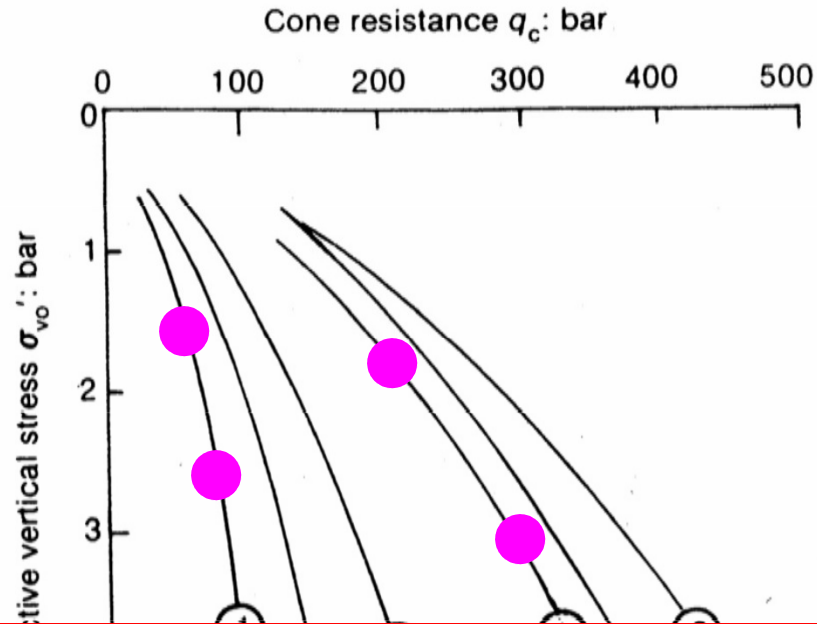
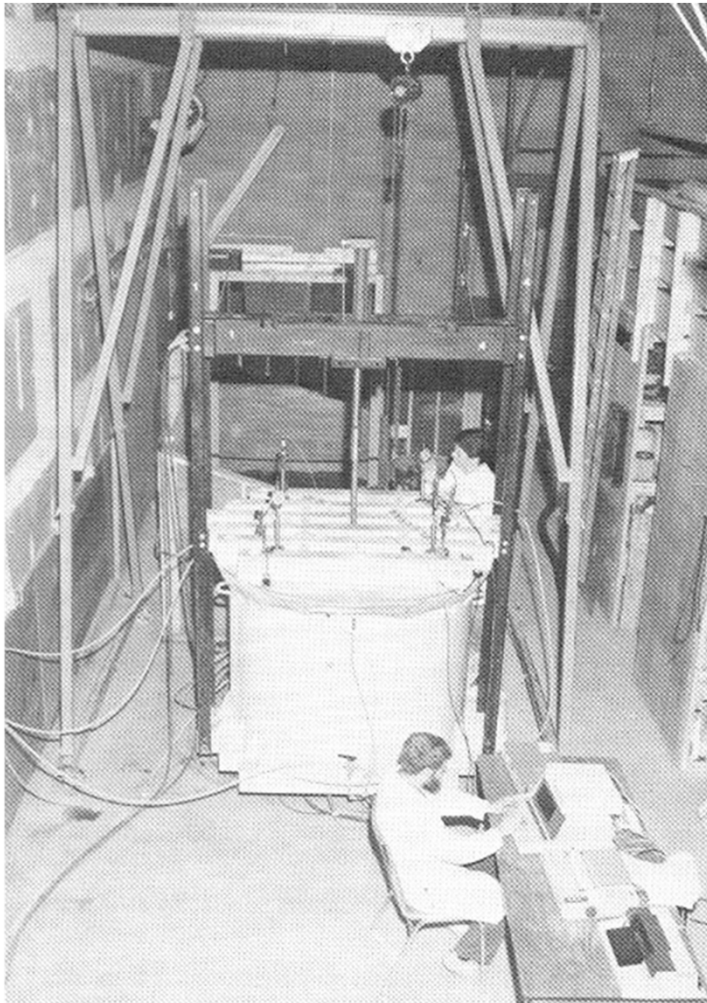


...see Book for complete set of world's calibration chamber data

Esso Resources Canada, Dome Petroleum, Gulf Canada Resources



Sorting out CPT “interpretation”



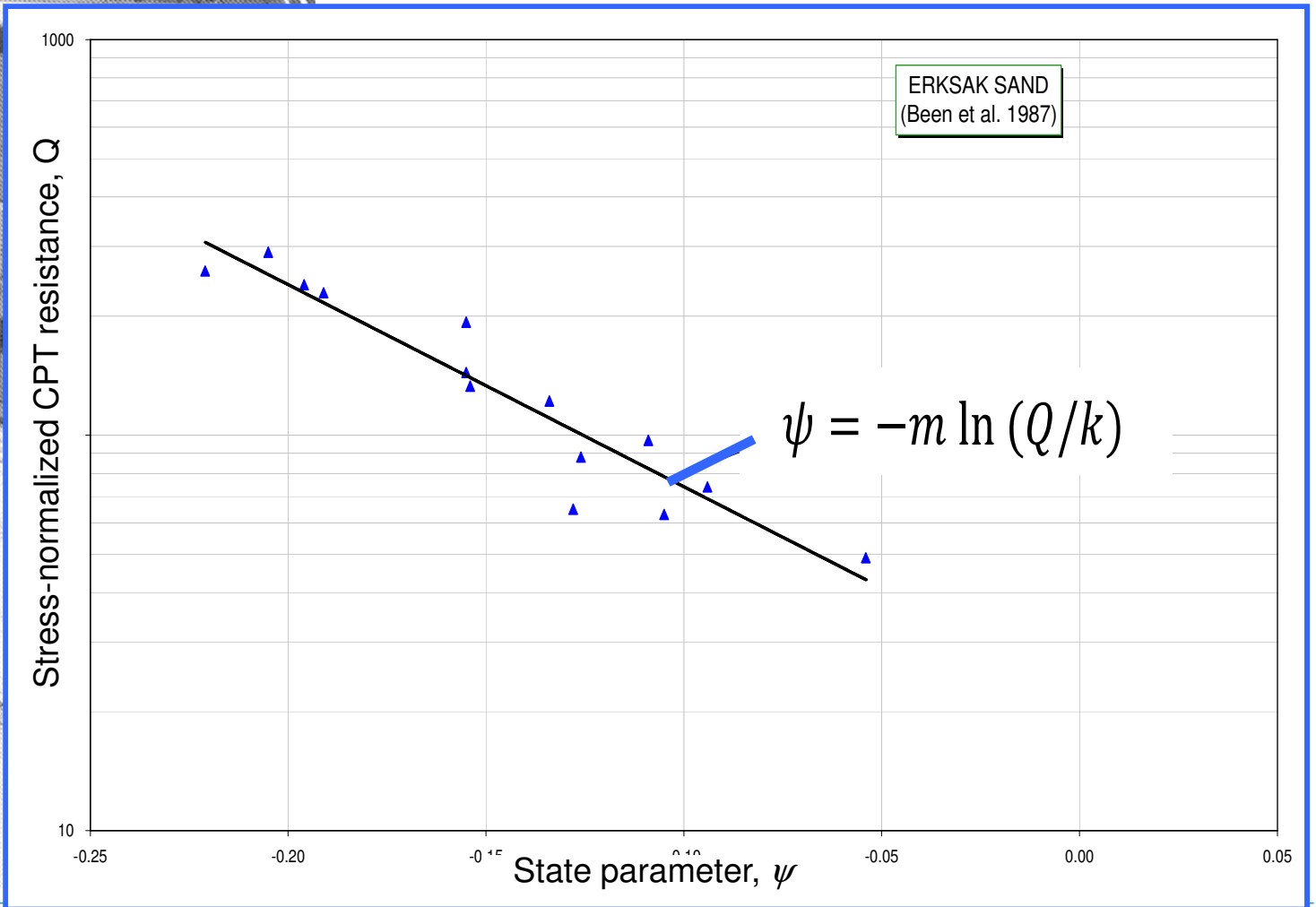
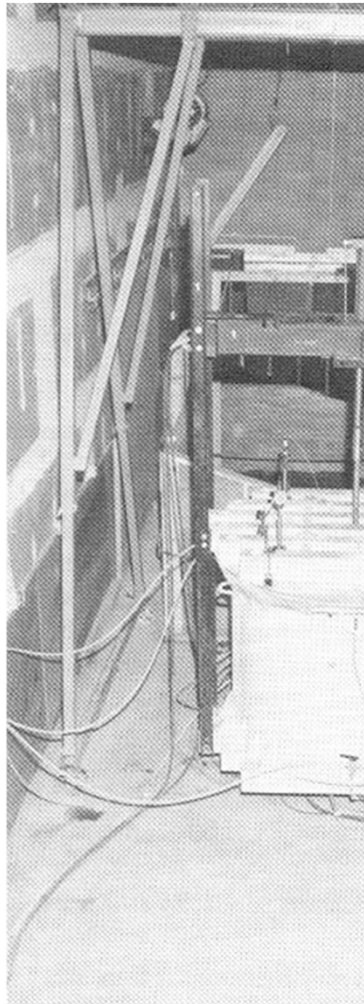
BASIC ISSUES

- 1) How stress level affects q_c - D_r
- 2) How soil properties affect q_c - D_r
- 3) And what about silts ?



Getting ψ from the CPT

Been et al (1987)

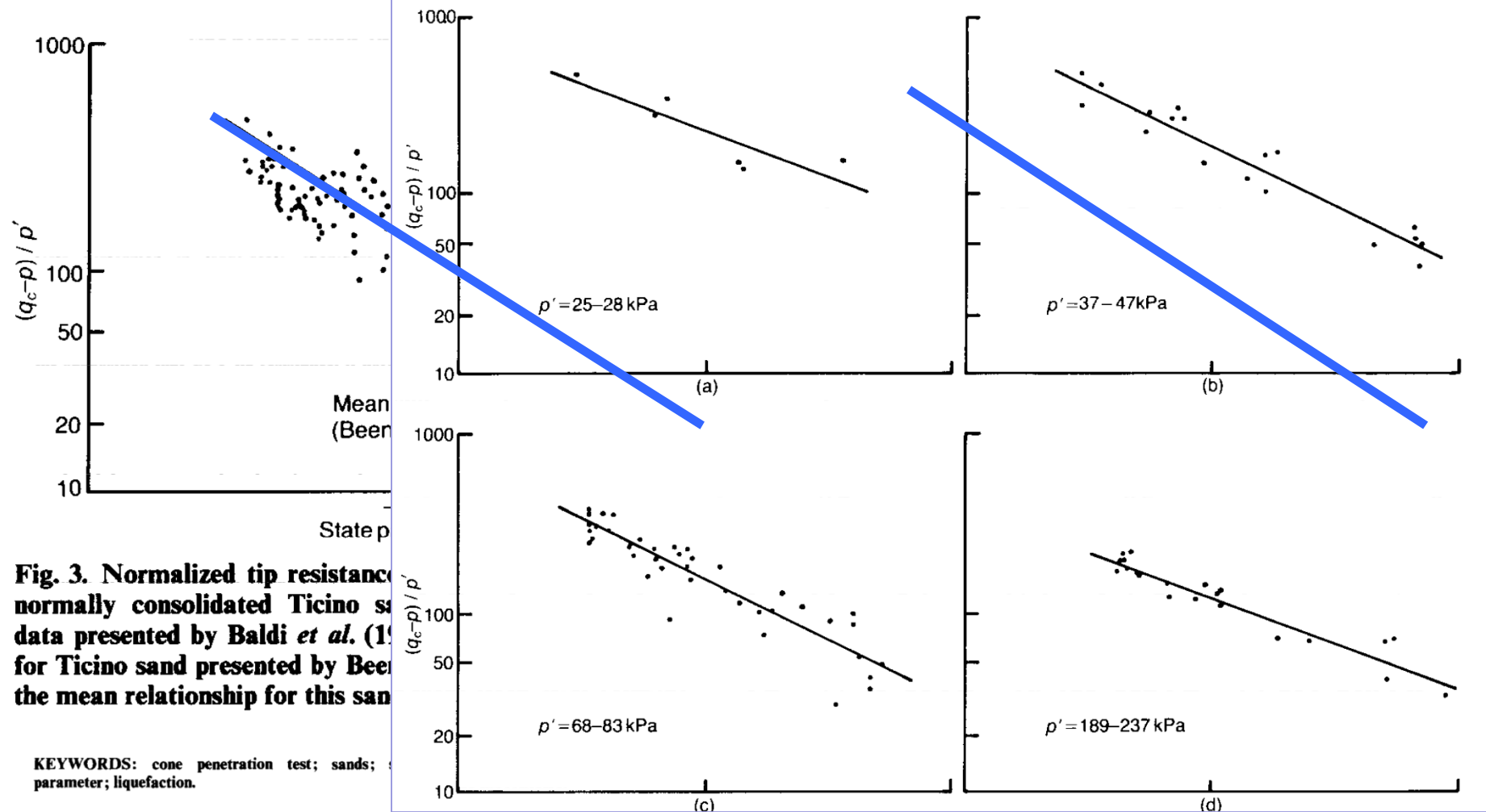


Esso Resources Canada, Dome Petroleum, Gulf Canada Resources



Sladen's intervention...

Sladen, J. A. (1989). *Géotechnique* 39, No. 2, 323-332





At some point you have to do “the math”

- Need large displacement computations
 - ‘moving mesh’ convects work and this needs including in solution
 - convection also depends on dilation
 - Appears simple, but actually rather sophisticated numerics
- Approach
 - Verify numerical implementation against constant friction, constant dilation soil for which “semi” closed-form solutions exist
 - Verify numerical implementation of NorSand against direct integration for laboratory element tests
 - Combine two verified modules to compute CPT behaviour



Time to "fess up" ...

INTERNATIONAL JOURNAL F

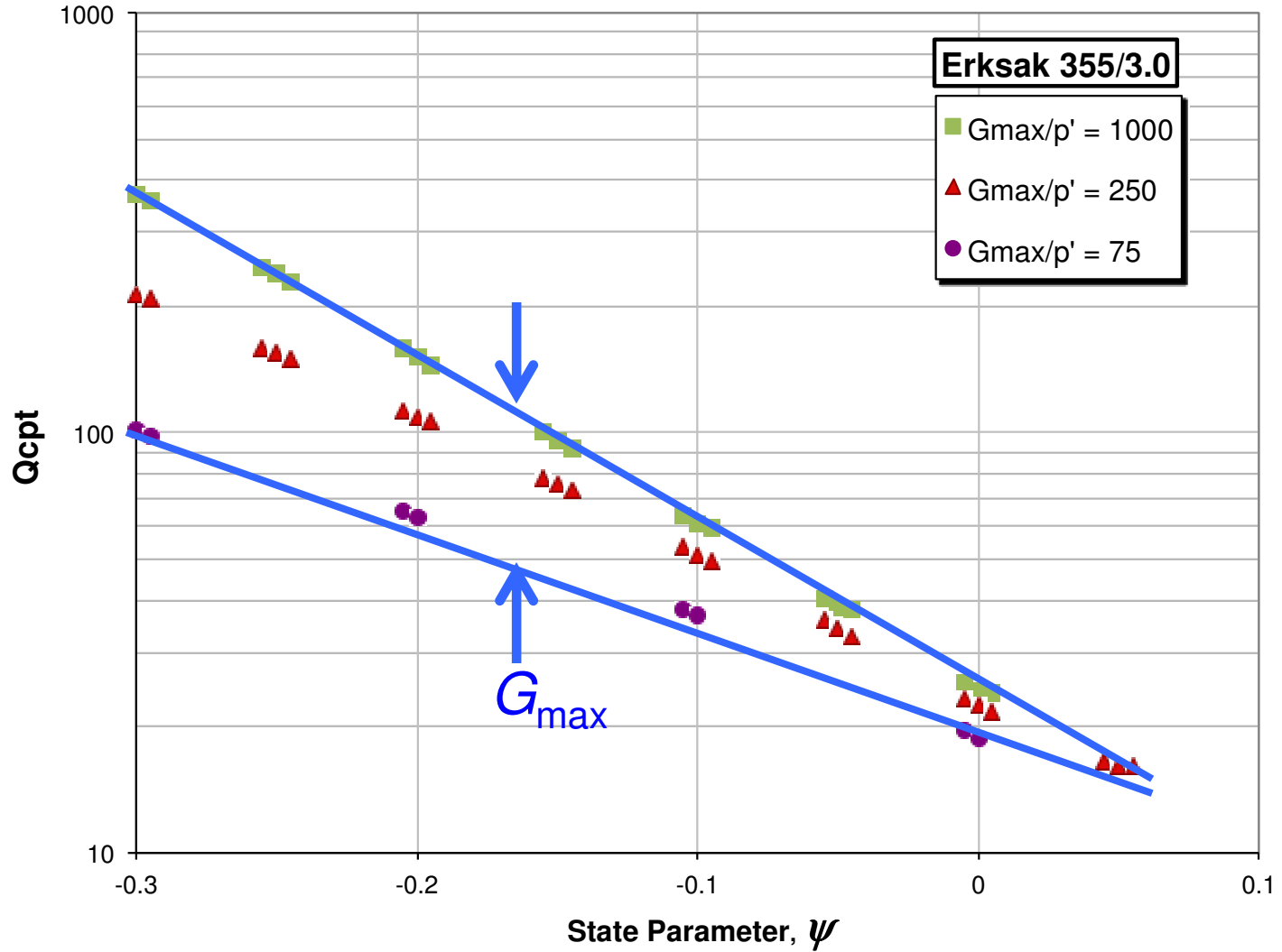
DIMENSION

² Golder As

The cone penetration test (CPT) is a tool that has gained widespread use in geotechnical engineering. It provides a rapid and repeatable method for measuring the resistance of soil and rock to penetration. A continuing difficulty, however, is the interpretation of the CPT response for different soil types and conditions. To date, most research has been carried out in large scale tests, which are often expensive and difficult to carry out. The use of small scale tests (such as the CPT) is therefore of great interest, particularly for the design of foundations and other structures. However, the use of small scale tests is often speculative because the results can be affected by a number of factors, such as the cavity expansion analog used to interpret the data. One of the issues that has caused concern is the effect of the cavity expansion on the CPT response. It is generally assumed that the cavity expansion in sand is analogous to the expansion of a cavity in a fluid, but this is not necessarily true. In fact, the cavity expansion in sand is a complex process that involves the formation of a shear zone and the expansion of the sand particles. This can lead to a non-linear relationship between the CPT resistance and the state parameter, which is not captured by the current models. Therefore, extreme care is required when interpreting CPT data, and particular care should be taken when using small scale tests.

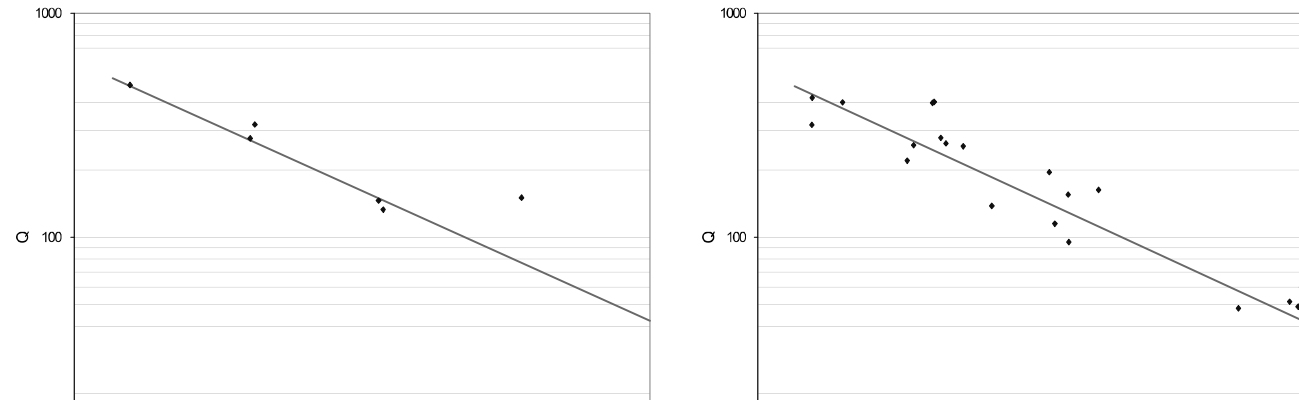
Int. J. Numer. Anal. Meth

Key words: cone penet



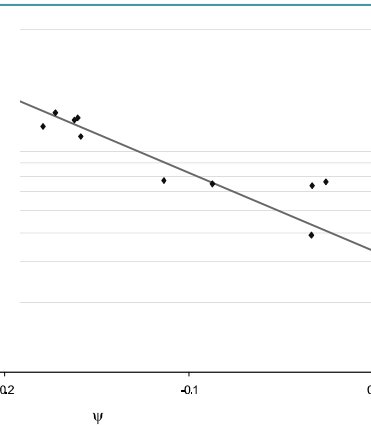


Effect of G_{\max} on Ticino CPT calibration



“Variable exponent” normalizations of CPT data are attempting to approximate the effect of G_{\max} on the penetration resistance *(and doing so badly)*

$$f\left(G_{\max} / p'\right)$$



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(c) $65 < p' < 85$ kPa

(d) $185 < p' < 240$ kPa



Site-specific CPT calibration

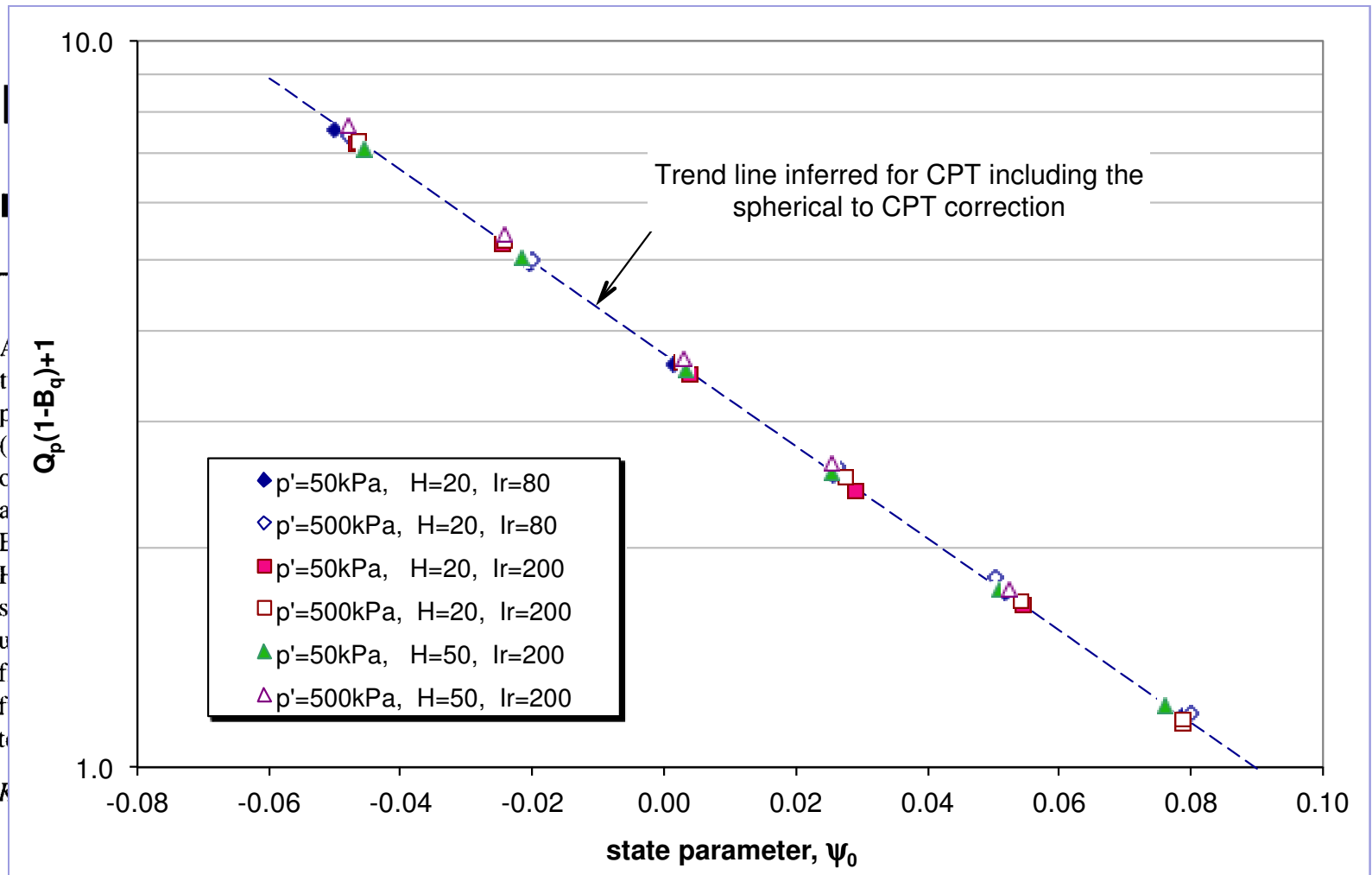
- Cavity expansion of NorSand is a pretty good analogue to CPT penetration resistance in calibration chambers
- Determine soil properties
 - $M, N, \lambda_{10}, \chi, H$... reconstituted samples
 - Measure G_{\max} insitu
 - And then there is K_0 ... 0.7 in alluvial deposits ?
- Use numerical method
 - Trend-fits for parametric simulations... in hand out
 - Use “widget”



What about variable geology ?

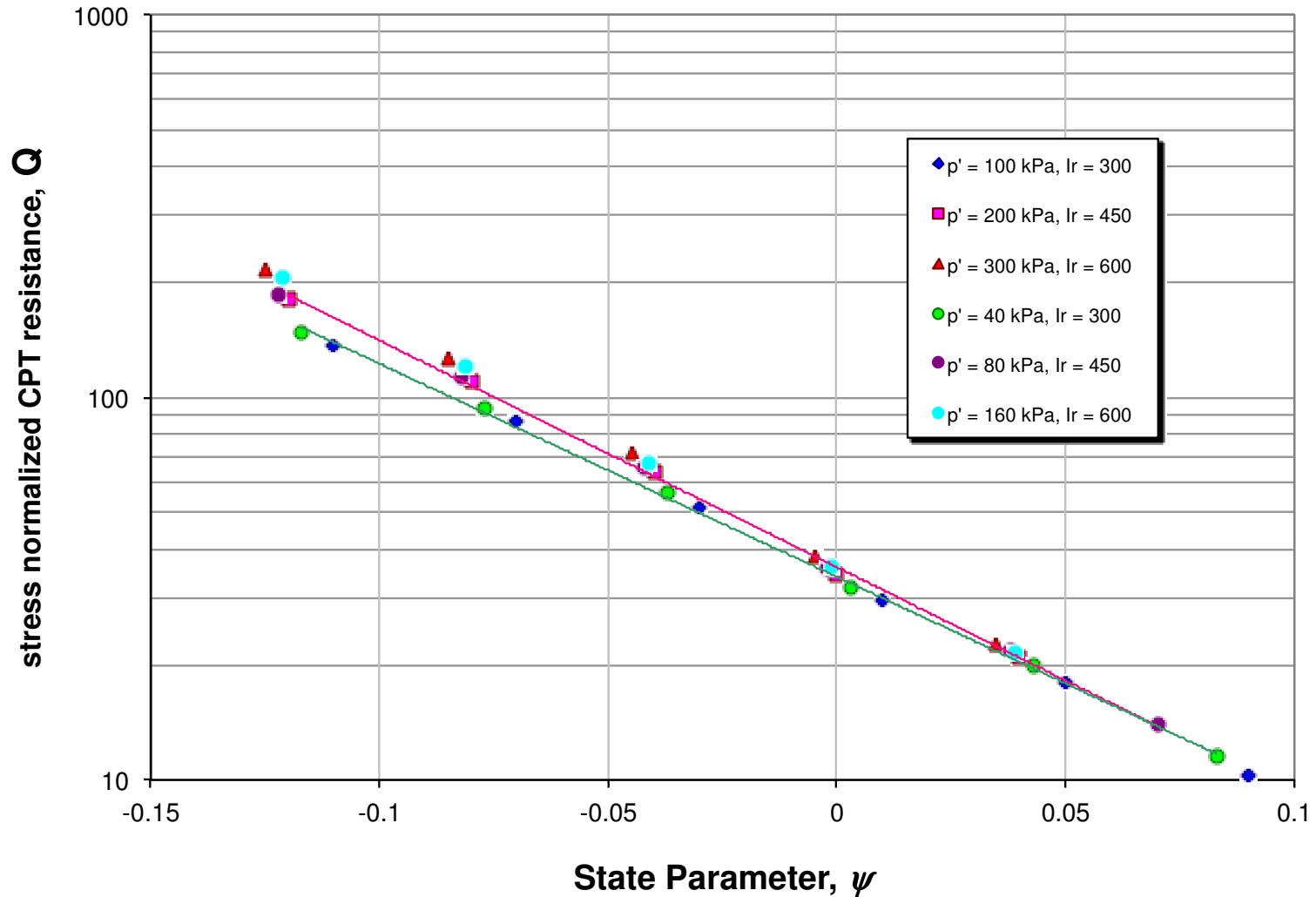


Moving from sands to silts: $Q(1-B_q) + 1$





Understanding CPT via numerics...



$$Q_p = \frac{q_t - p}{\bar{p}} = k \exp(-m\psi)$$