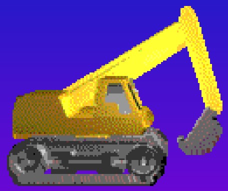
Geotechnical Slideshows

Turn the speakers on

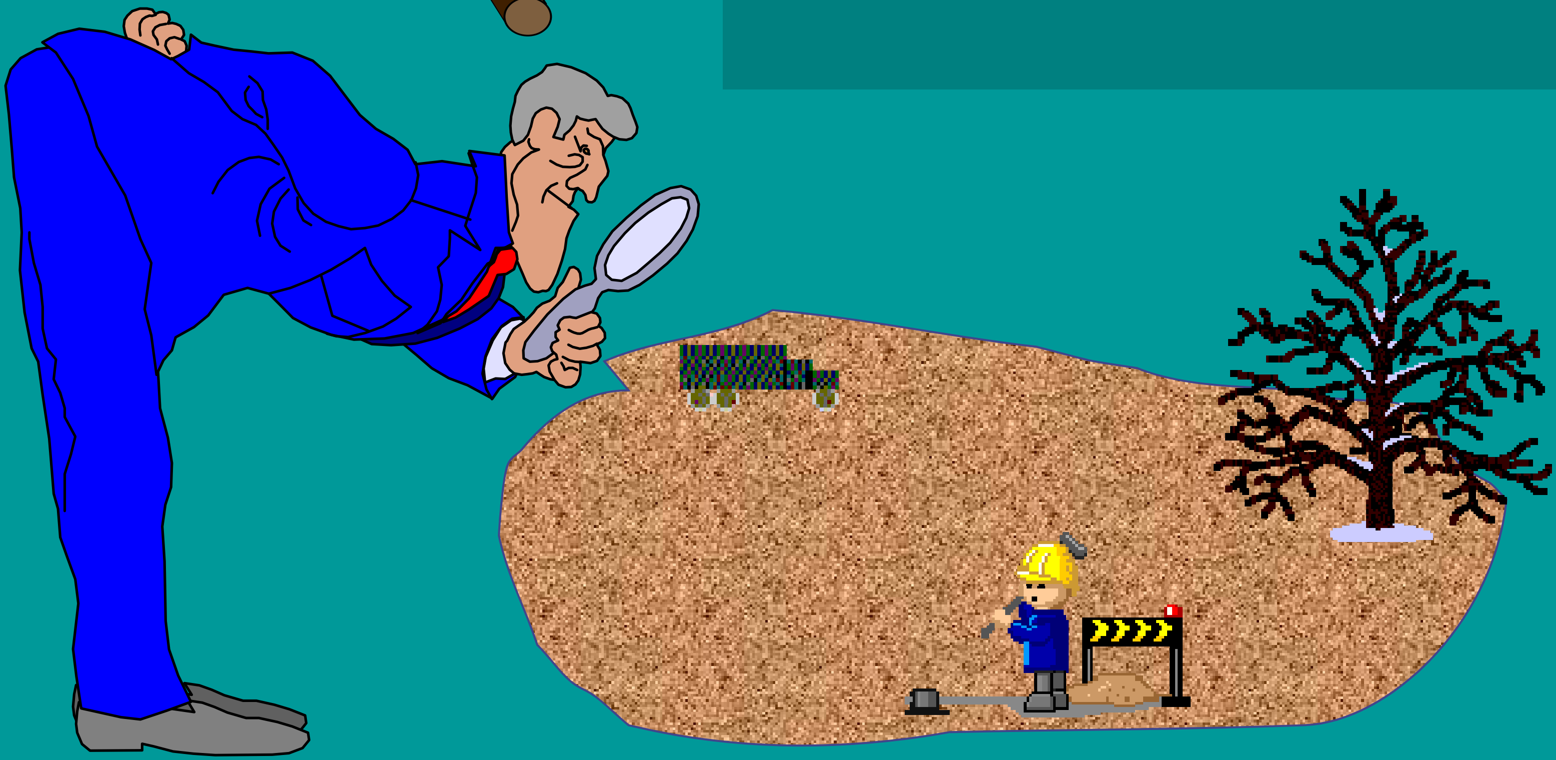
- A quick & dirty way to learn

This is an attempt to create a stand alone self learning module on **site investigation**. Fasten your seat belts. Sit back, relax and enjoy.

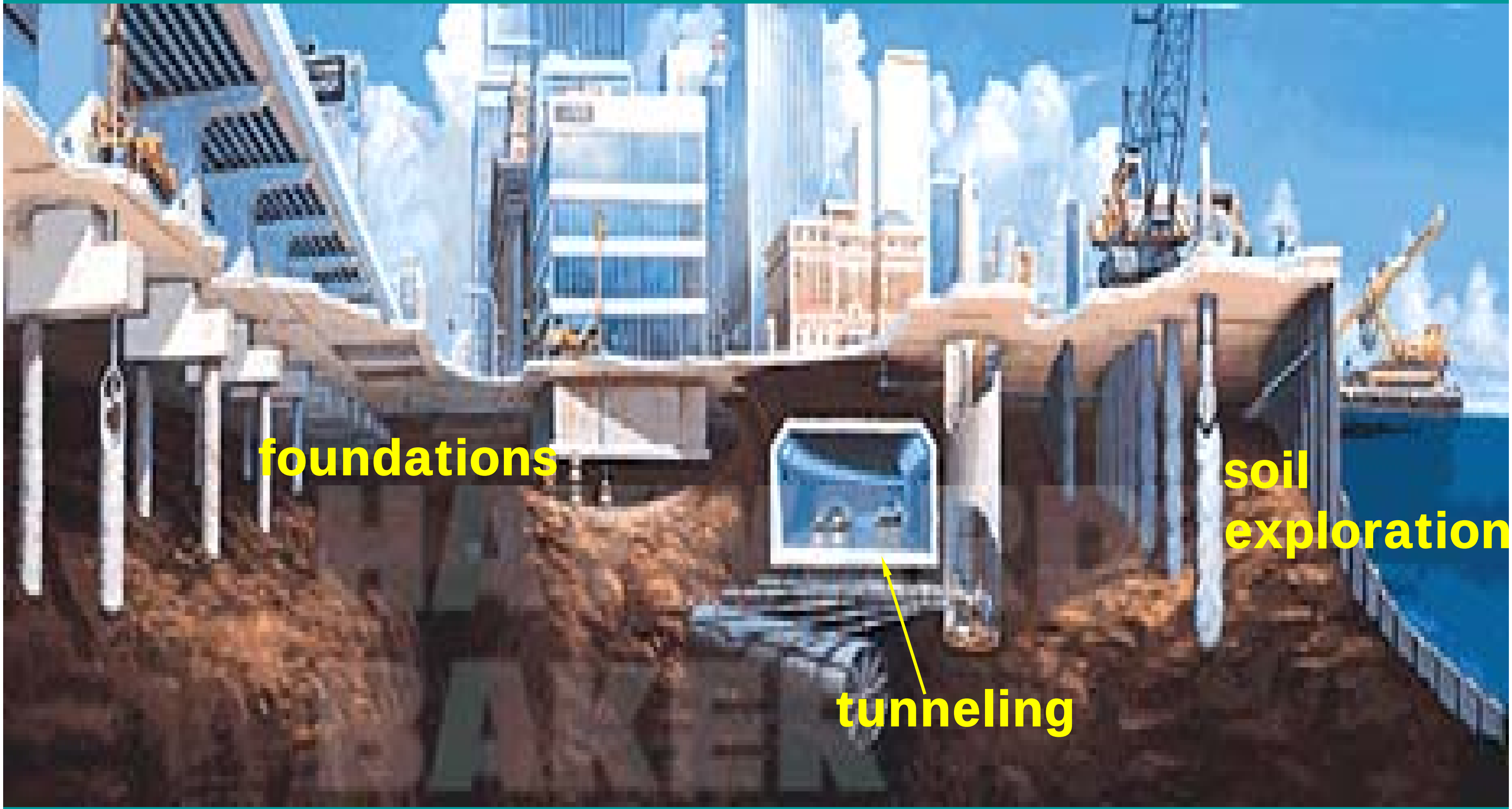


Site Investigation

Narrated by:

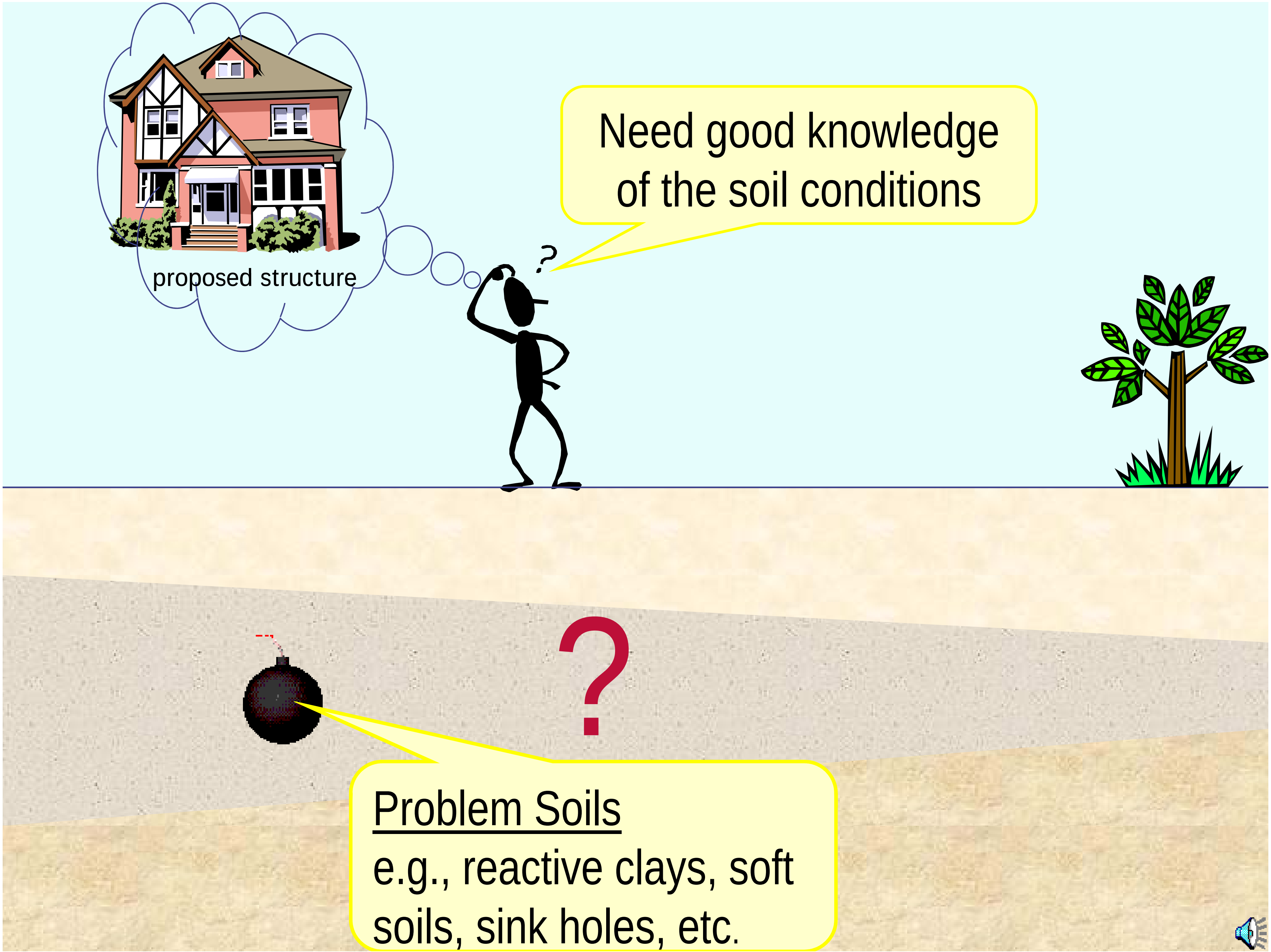


Some unsung heroes of Civil Engineering...



... buried right under your feet.

A good site investigation is a prerequisite.


proposed structure
Need good knowledge of the soil conditions
?
Problem Soils
e.g., reactive clays, soft soils, sink holes, etc.

Soil data required:

- Soil profile
  - layer thickness and soil identification
- Index properties
  - water content, Atterberg limits, etc.
- Strength & compressibility characteristics
  - c', c_u, ϕ', C_c, C_r, OCR, E, ...
- Others (e.g., water table depth)

Desk Study

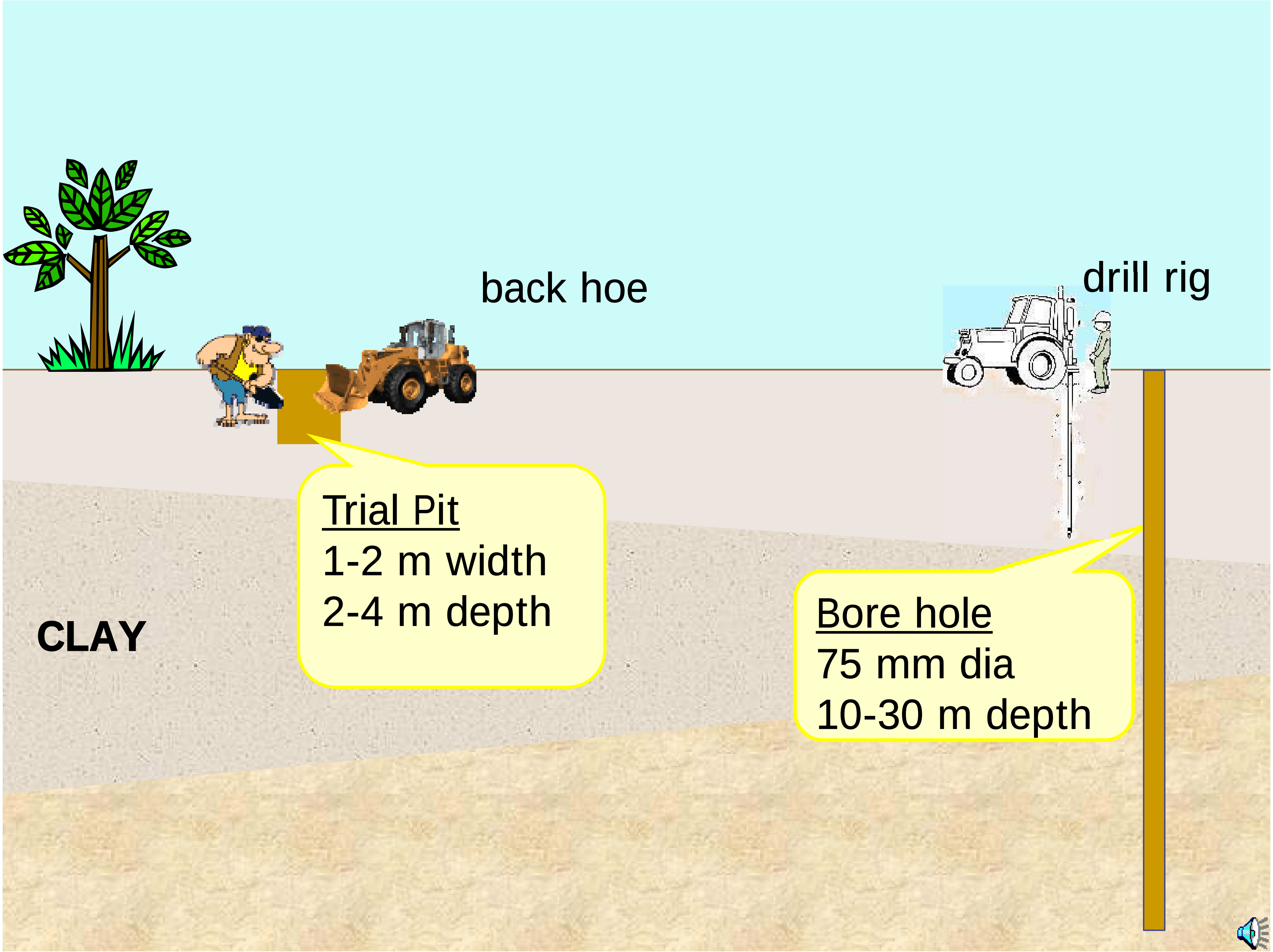
First stage of site investigation. Negligible cost. Look for any freebies (i.e., info available currently)

- ✓ Aerial photographs
- ✓ Topographical maps
- ✓ Existing site investigation reports (for nearby sites)
- ✓ Other info. from local councils, literature

Site Reconnaissance

A site visit and chat with locals.

- ✓ Site access
- ✓ Topography
- ✓ Site geology
- ✓ Conditions of adjacent structures
- ✓ Any obvious problems foreseen?

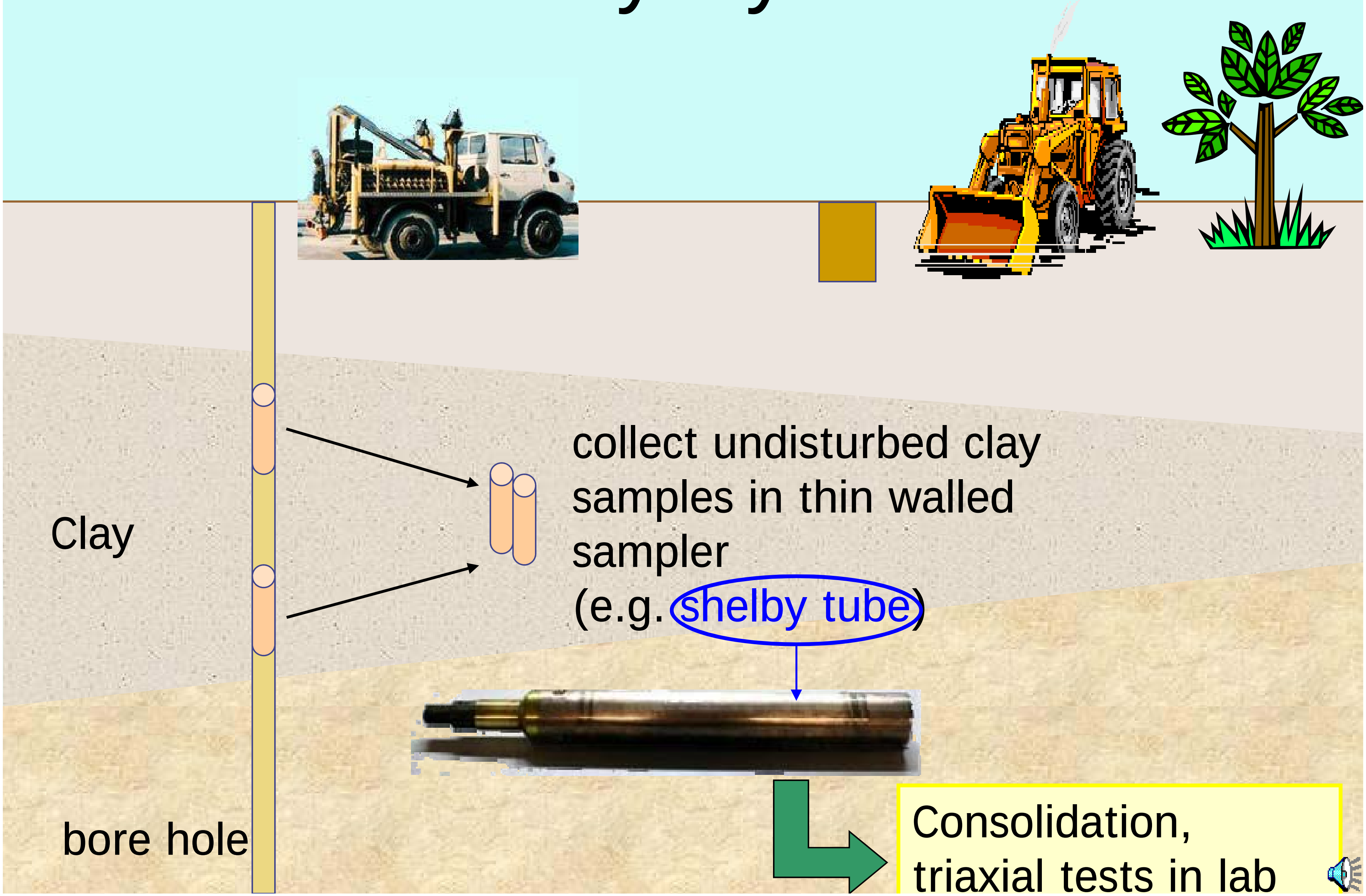

back hoe
drill rig
Trial Pit
1-2 m width
2-4 m depth
Bore hole
75 mm dia
10-30 m depth
CLAY

Trial Pit

Enables visual inspection, locating strata boundaries, and access for undisturbed block samples.

A Very Large Trial Pit

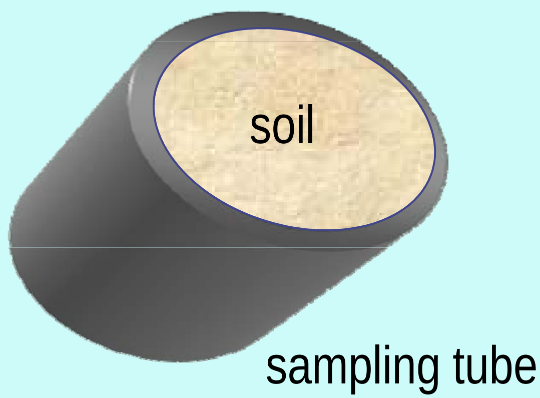
In clay layers...



Undisturbed Clay Samples

- Required for triaxial, consolidation tests in the lab.
- Good quality samples necessary.

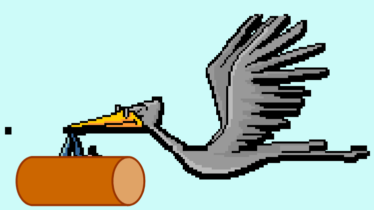
A_R<10%



$$A_R = \frac{O.D.^2 - I.D.^2}{I.D.^2} \times 100\,(\%)$$

area ratio

- Thicker the wall, greater the disturbance.



- Take good care in transport and handling.

In Granular Soils ...

Very difficult to get undisturbed samples.

∴ Go for in situ tests.

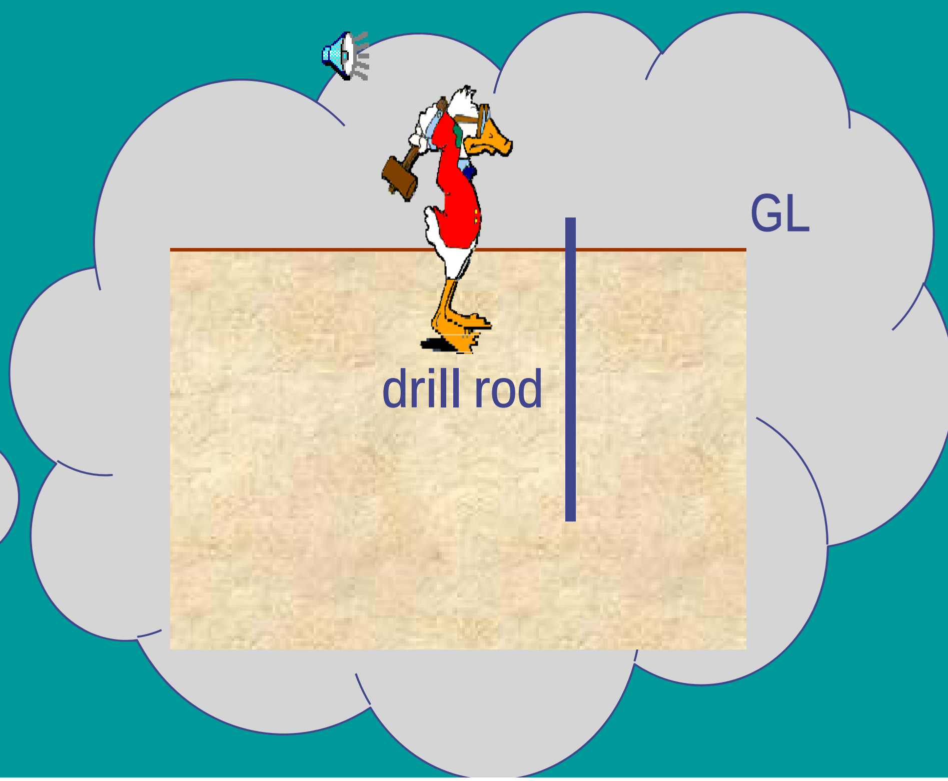
e.g., penetration tests

80-90% of foundation designs
are based on penetration tests

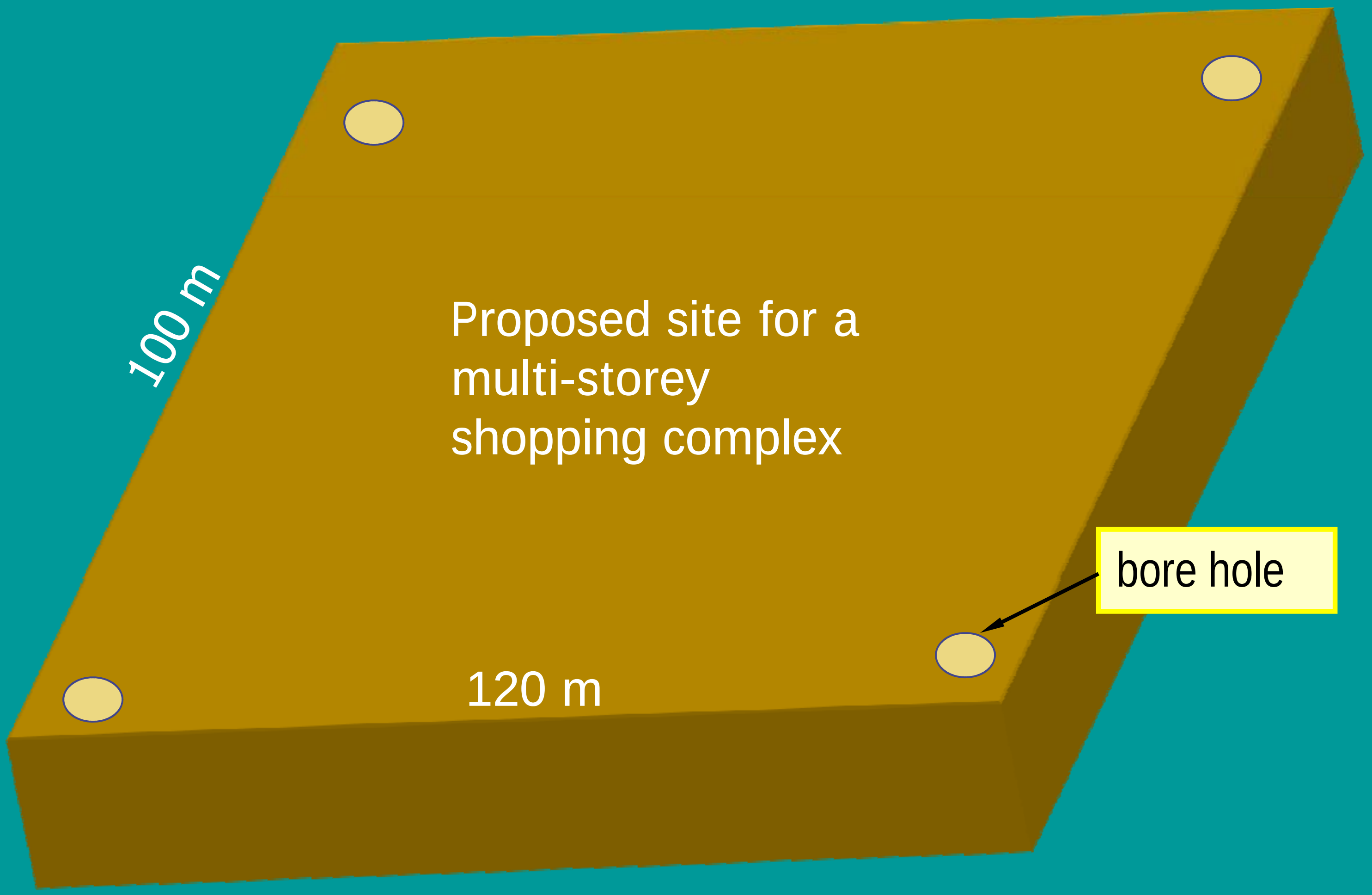
Penetration Tests

Measuring the soil resistance to penetration by a probe.

ϕ', E ...

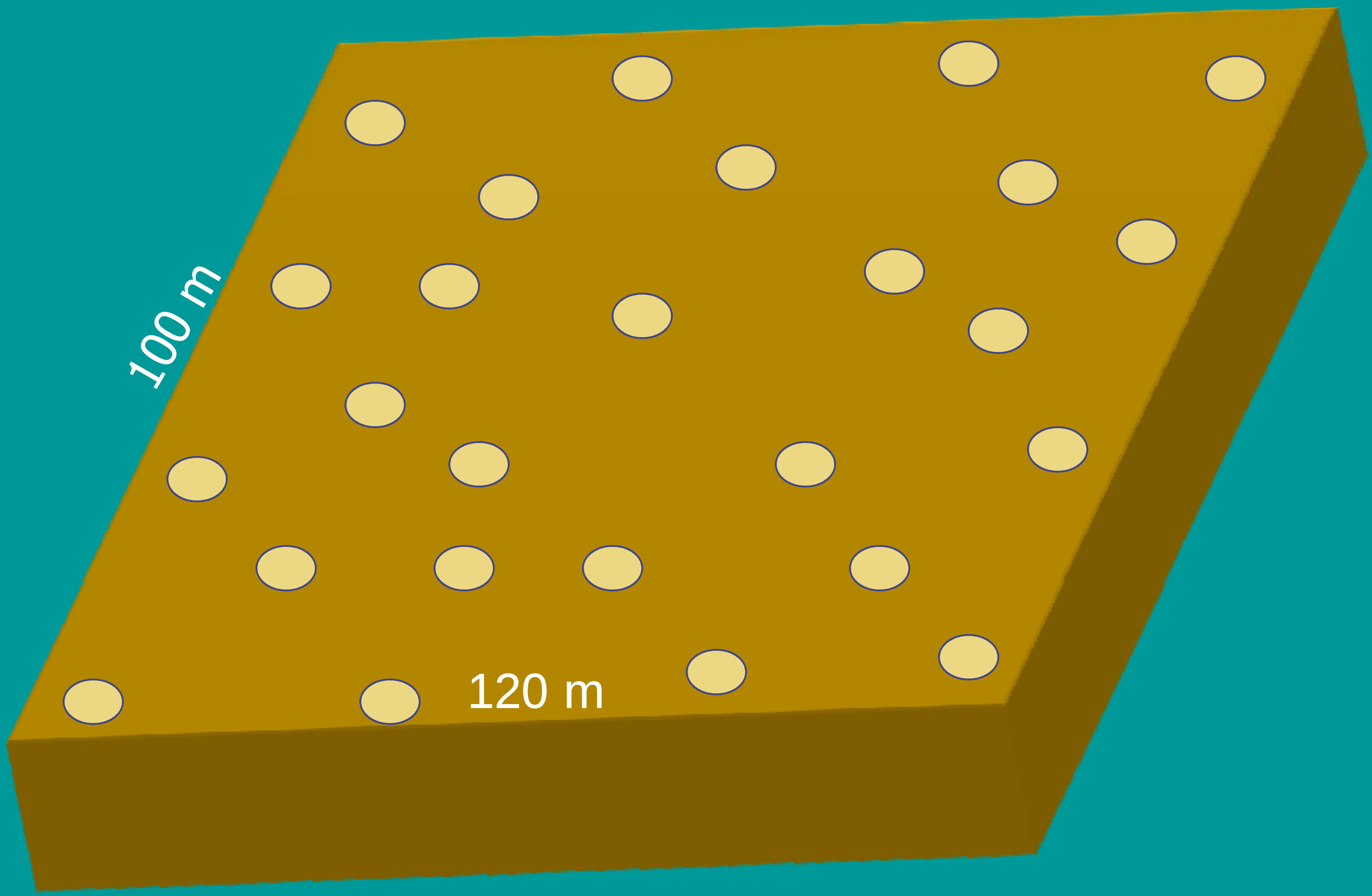


How many bore holes?



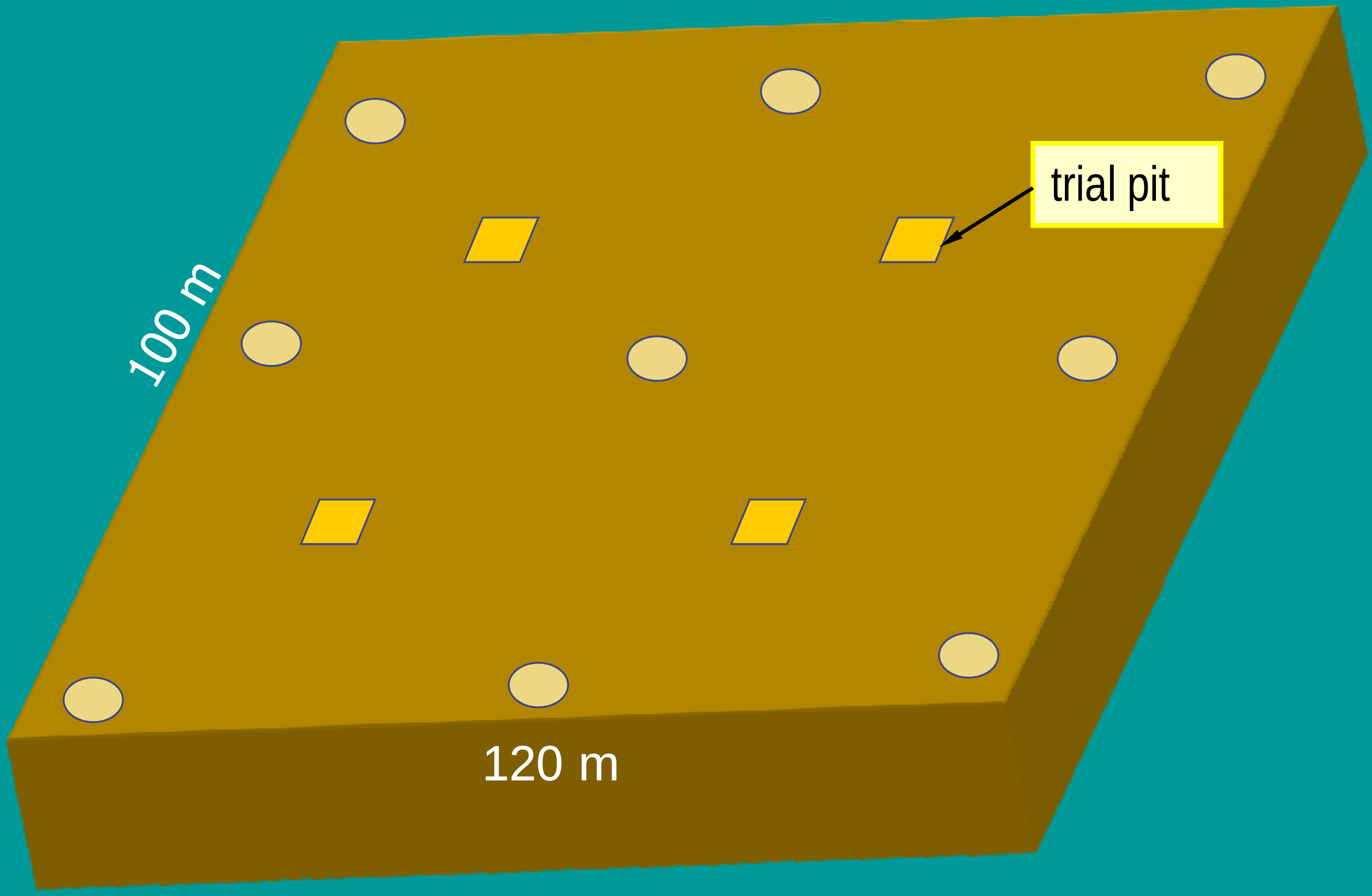
Not enough bore holes; soil profile and properties not well defined..

How many bore holes?



Too many bore holes and blows the budget.

How many bore holes?



About right?

SIVA

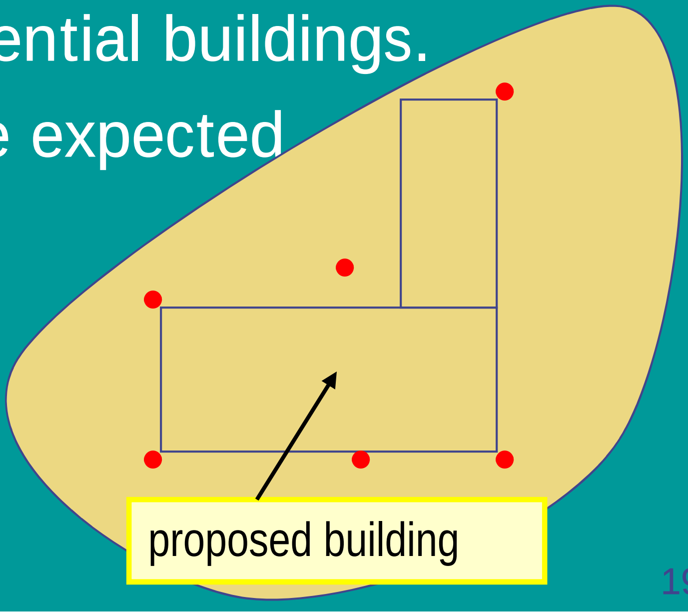
How many bore holes?

The number of bore holes depends on:

- type and size of the project
- budget for site investigation
- soil variability

Typically spaced at 20-40 m for non-residential buildings.

Locate the bore holes where the loads are expected



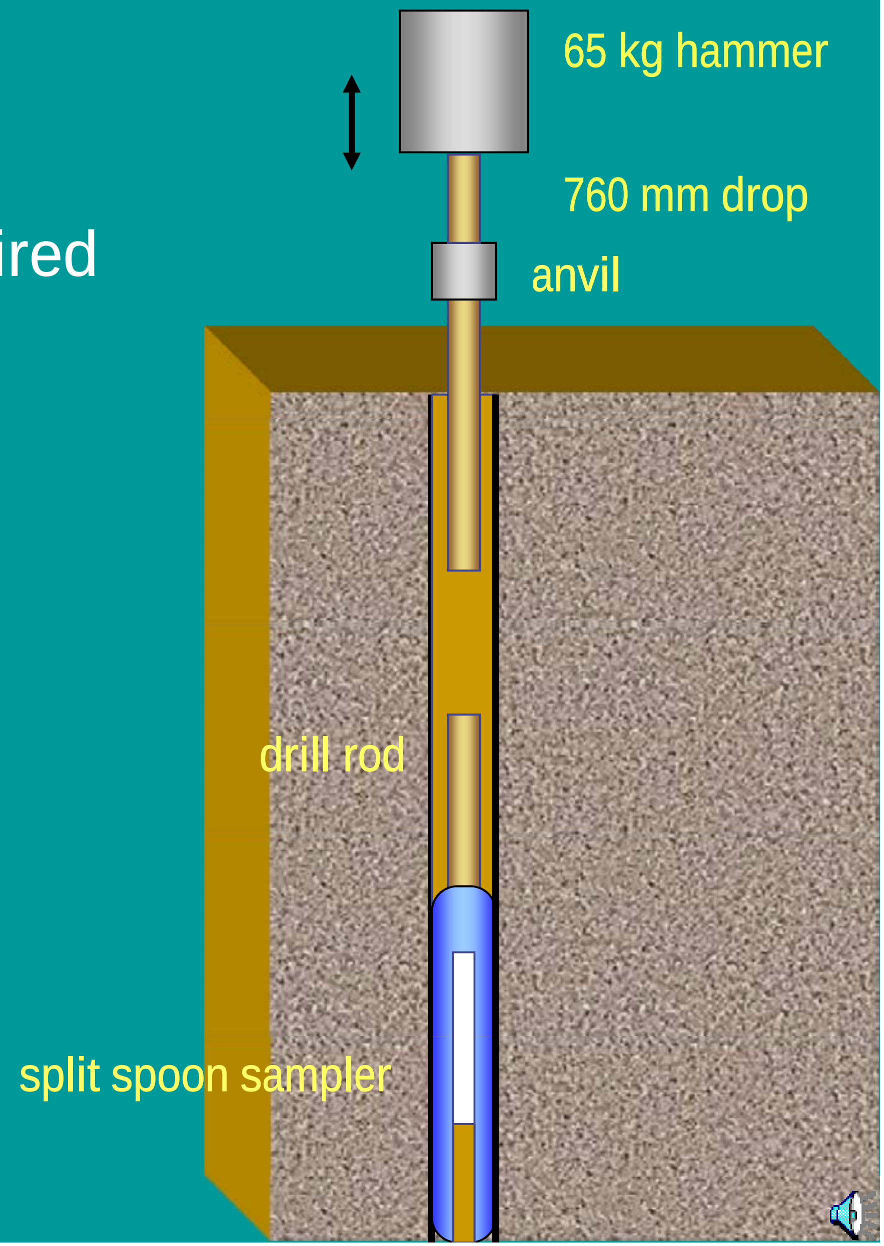
How deep to explore?

Explore the soil to a depth where the stress changes become insignificant

Standard Penetration Test (SPT)

<u>Count</u> the number of blows required for 300 mm penetration

Blow count
or
N-Value

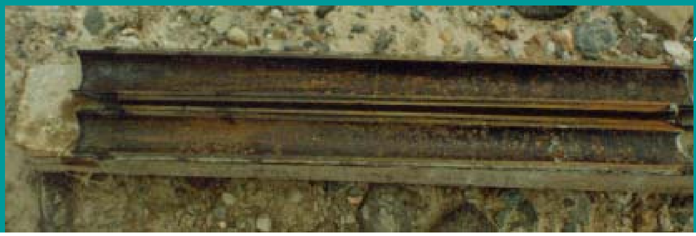


Standard Penetration Test

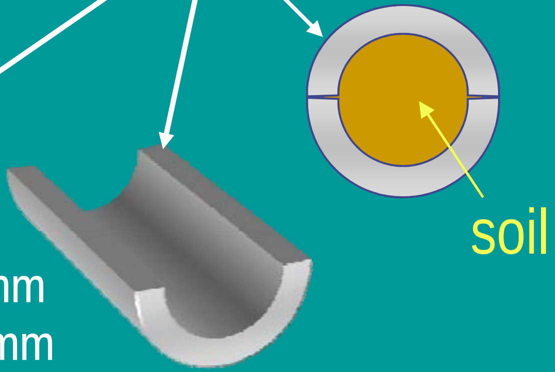
still has some value

- mainly for granular soils; unreliable in clays
- N-value correlated to ϕ', **E ...**
- done within bore holes at 1.5 m depth intervals
- samples (disturbed) collected in split-spoon sampler

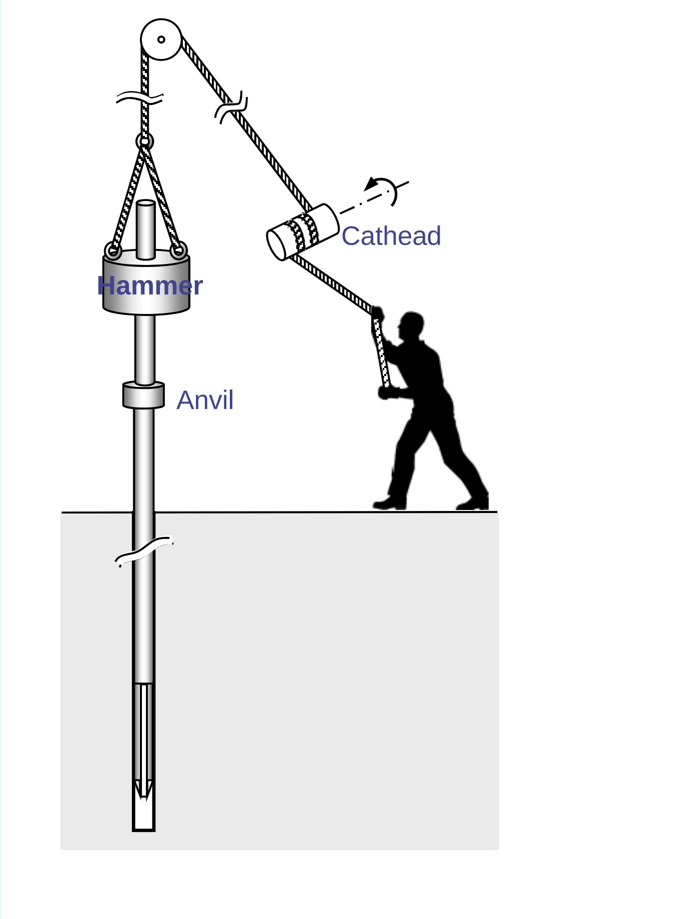
A_R = 112%; use for classification



I.D. = 35 mm
O.D.= 51 mm



Standard Penetration Test



Hammer with rotating cathead

Automatic trip hammer

SPT Hammer

SPT Corrections

$$(N_1)_{60} = C_{ER}\, C_N\, N$$

Corrected blow count

Energy correction

Overburden correction

Measured blow count

SPT Correlations in Clays

not corrected
for overburden

N_{60}	c_u (kPa)	consistency	visual identification
0-2	0 - 12	very soft	Thumb can penetrate > 25 mm
2-4	12-25	soft	Thumb can penetrate 25 mm
4-8	25-50	medium	Thumb penetrates with moderate effort
8-15	50-100	stiff	Thumb will indent 8 mm
15-30	100-200	very stiff	Can indent with thumb nail; not thumb
>30	>200	hard	Cannot indent even with thumb nail

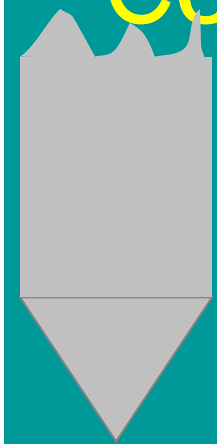
Use with caution; unreliable.

SPT Correlations in Granular Soils

not corrected for overburden → $(N)_{60}$

$(N)_{60}$	D_r (%)	consistency
0-4	0-15	very loose
4-10	15-35	loose
10-30	35-65	medium
30-50	65-85	dense
>50	85-100	very dense

Cone Penetration Test (CPT)



Dynamic cone penetration test (DCPT)

- similar to SPT; hammer driven
- using cone instead of split spoon

closed end;
no samples

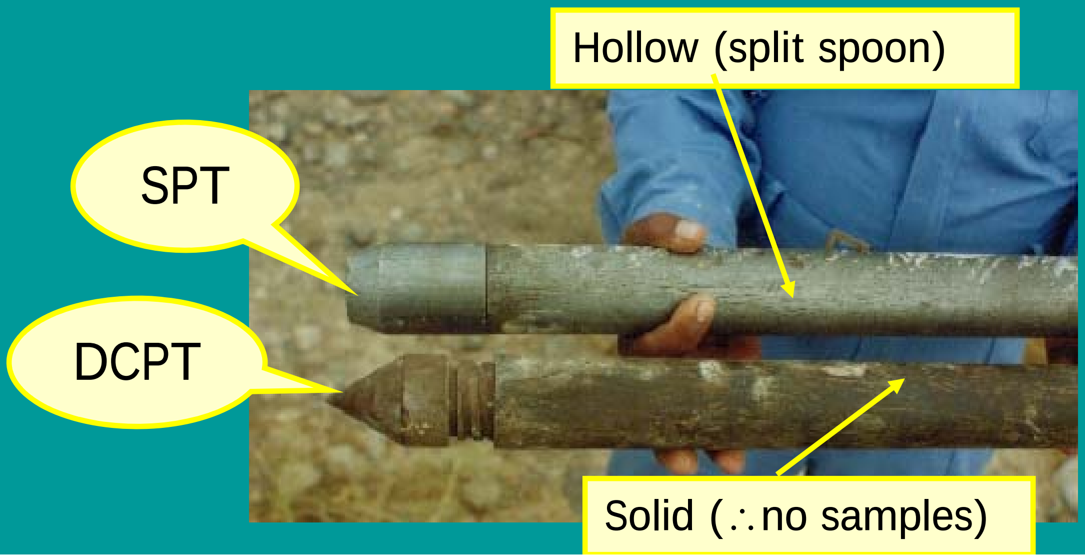
- gives blow counts @ 1.5 m depth intervals

Static cone penetration test (SCPT)

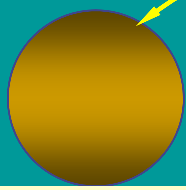
- pushed into the ground @ 2 cm/s
- gives continuous measurements

Dynamic Cone Penetration Test

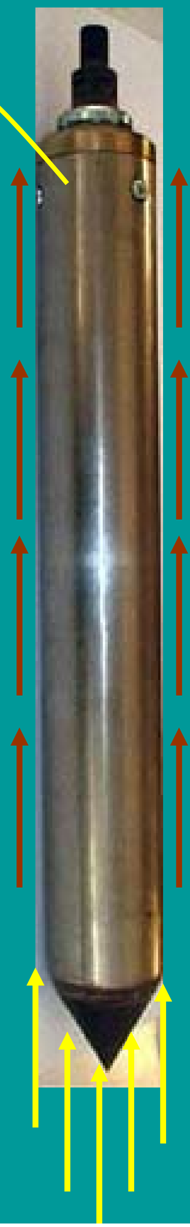
- Simple and rugged.
- Better than SPT or SCPT in hard soils such as dense gravels
- As crude as SPT; relies on correlations based on blow counts



Static Cone Penetration Test



10 cm^2 cross section



sleeve friction (f_s)

cone resistance (q_c)
or tip resistance (q_T)

$$\text{friction ratio, } f_R = \frac{f_s}{q_c} \times 100\ \%$$

Typically 0 ——— 10%.

granular | cohesive

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Piezocone (CPTU)

A modern static cone; measures pore water pressure also.

Pushed into the ground

Piezocone with the pore pressure measurement

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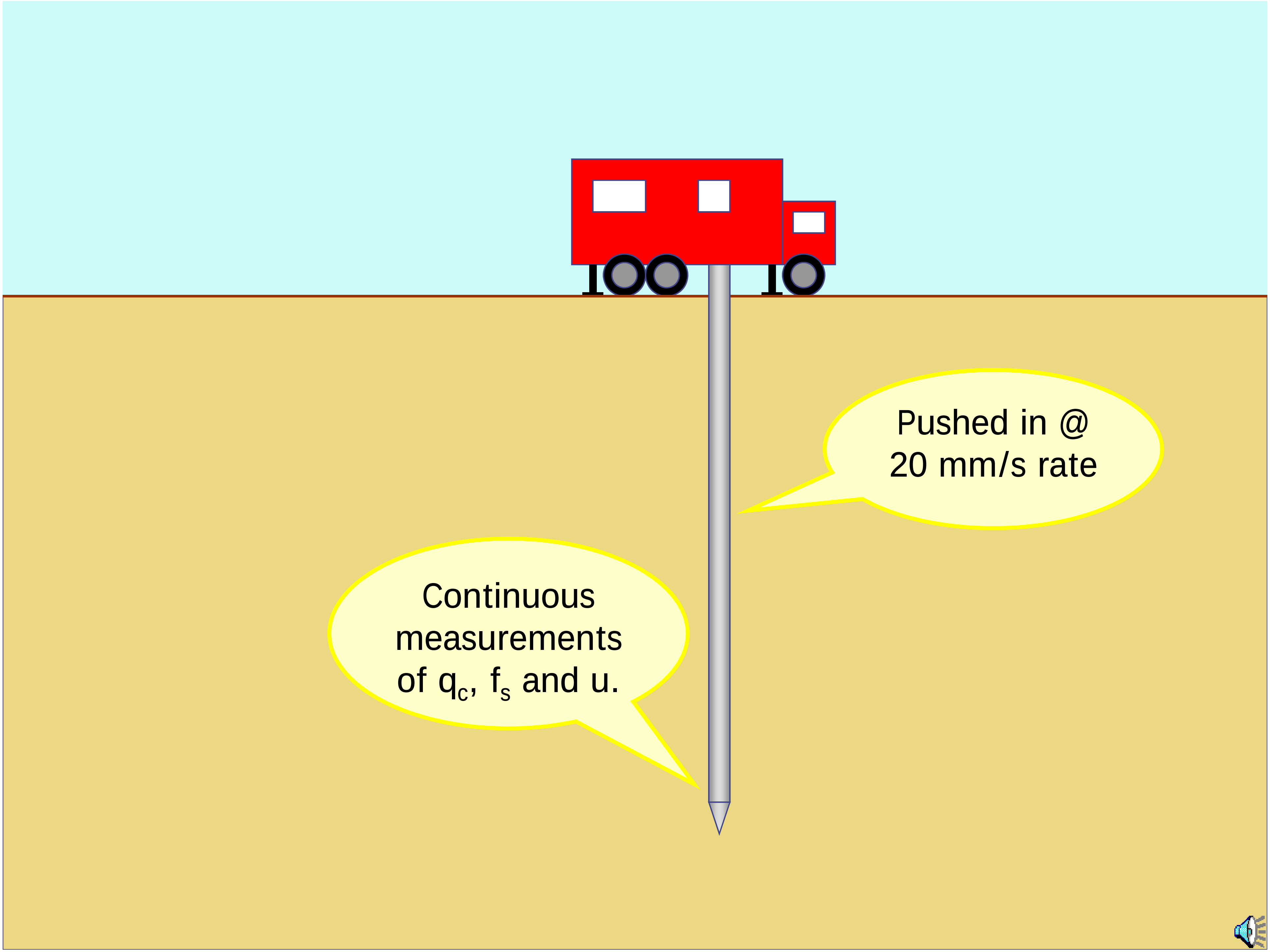
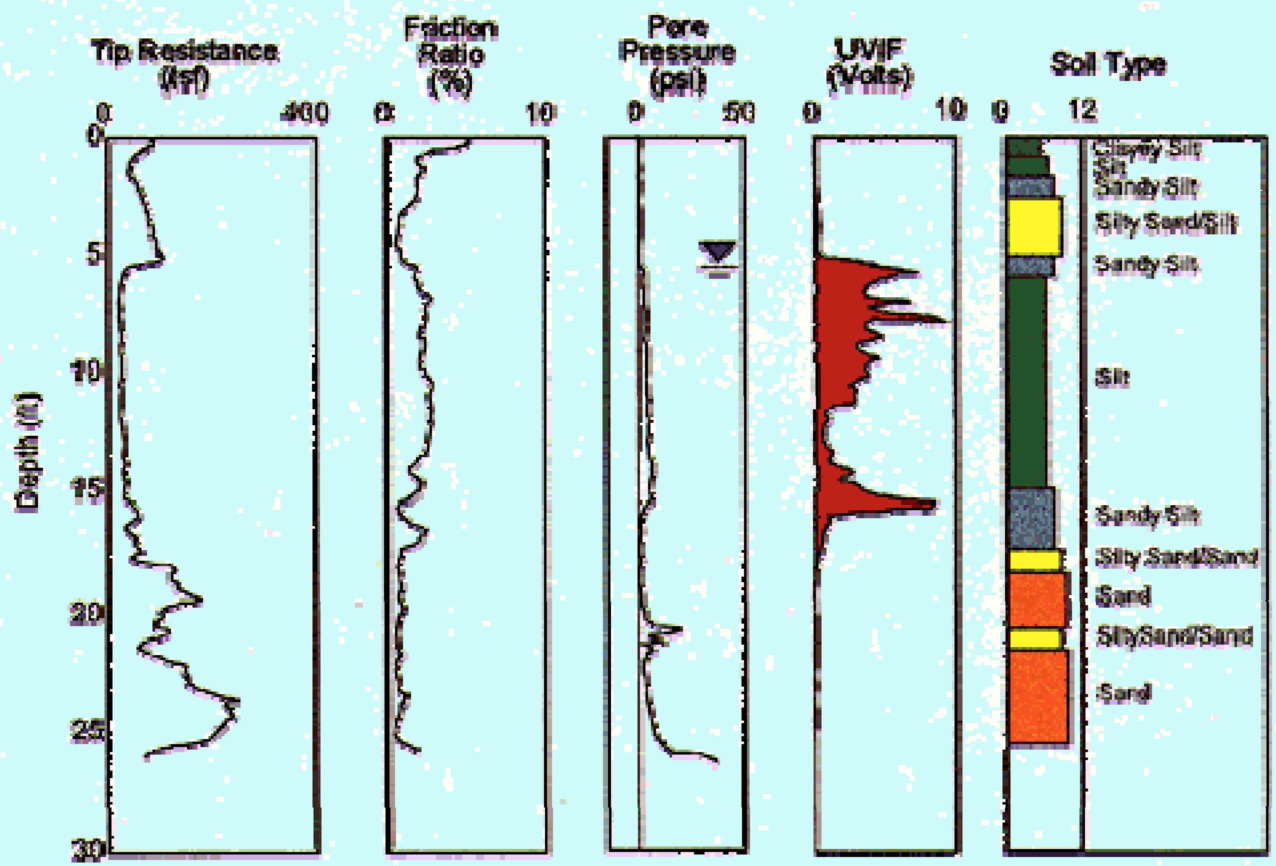
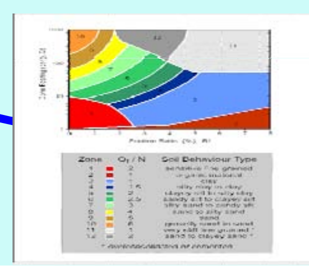

Pushed in @ 20 mm/s rate
Continuous measurements of q_c, f_s and u.

Interpreting SCPT Data





See next slide

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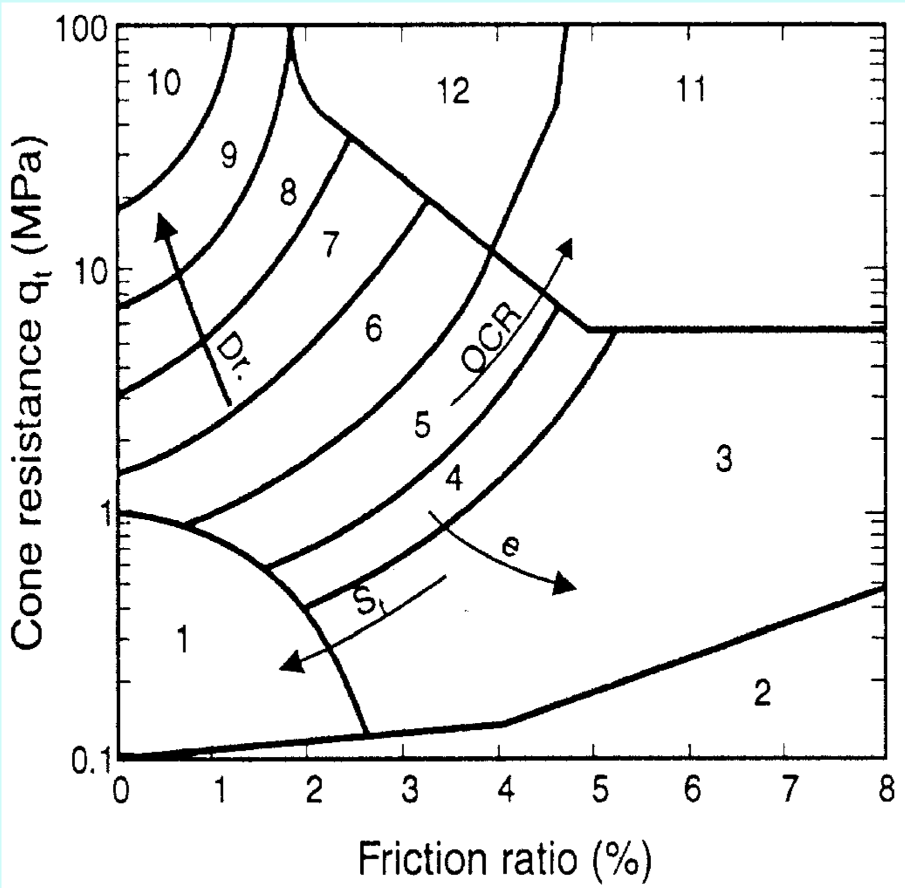
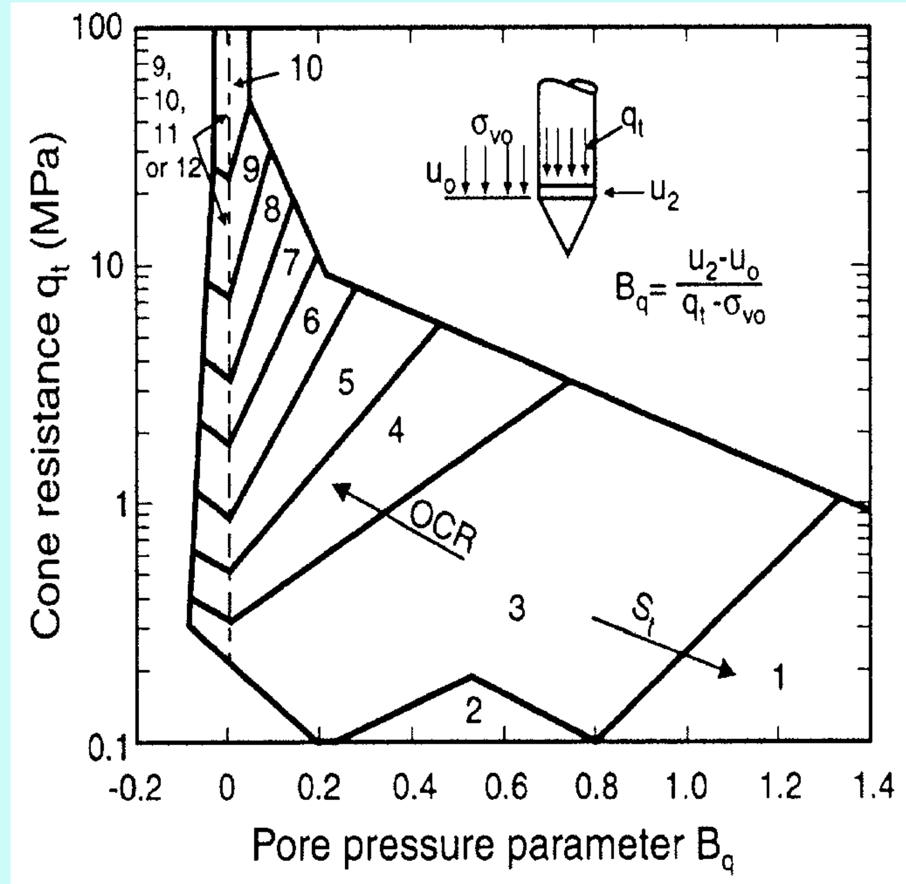
Interpreting SCPT (Piezocone) Data



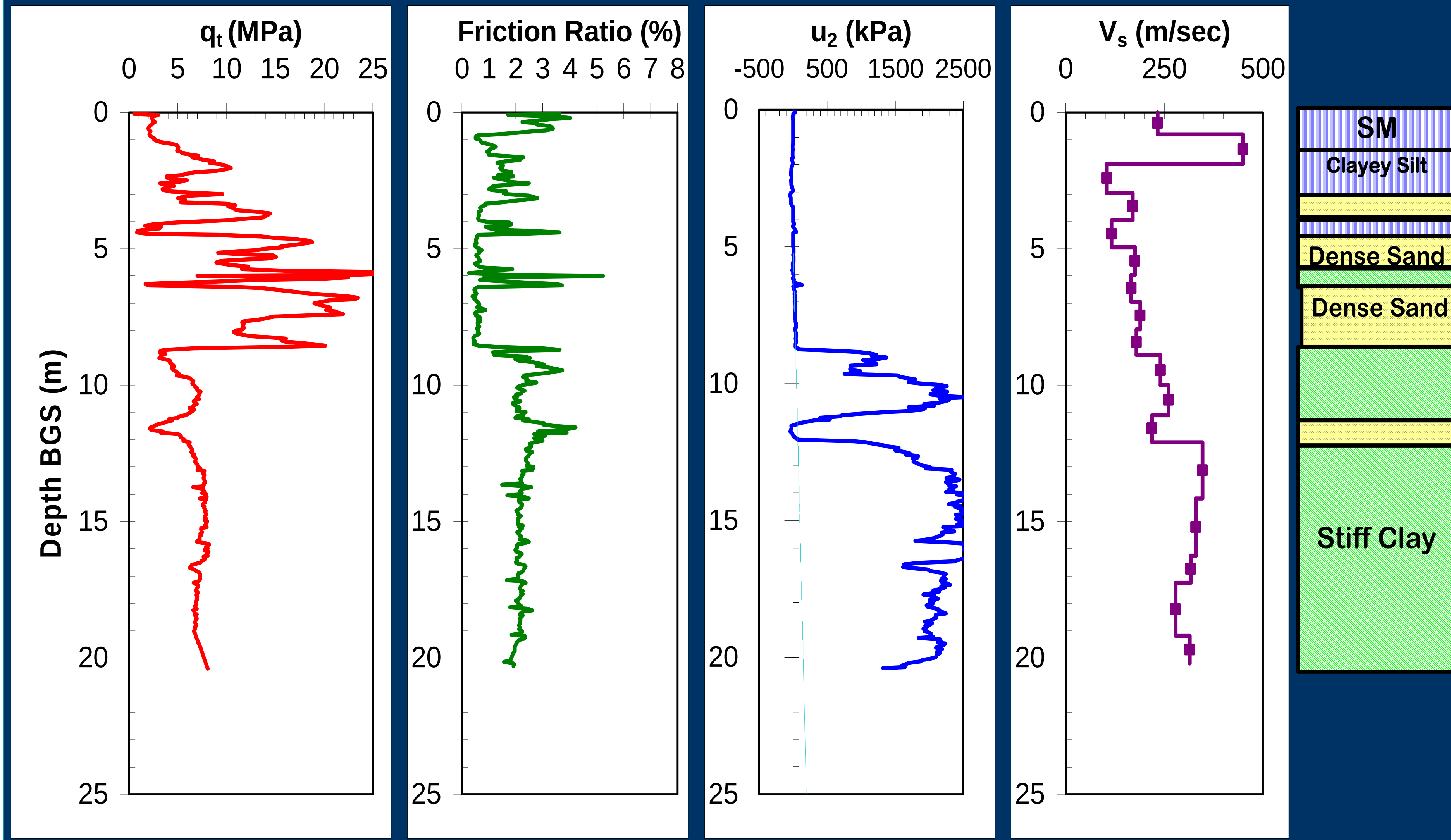


Soil Behavior Type (Robertson et al., 1986; Robertson & Campanella, 1988)

1 – Sensitive fine grained	**5 – Clayey silt to silty clay**	**9 – sand**
2 – Organic material	**6 – Sandy silt to silty sand**	**10 – Gravelly sand to sand**
3 – Clay	**7 – Silty sand to sandy silt**	**11 – Very stiff fine grained***
4 – Silty clay to clay	**8 – Sand to silty sand**	**12 – Sand to clayey sand***

Note: Overconsolidated or cemented

Sounding - Shelby County, TN (U.S.A)



Courtesy: Professor. P.W. Mayne, Georgia Inst. of Technology

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SCPT Correlations

In Clays,

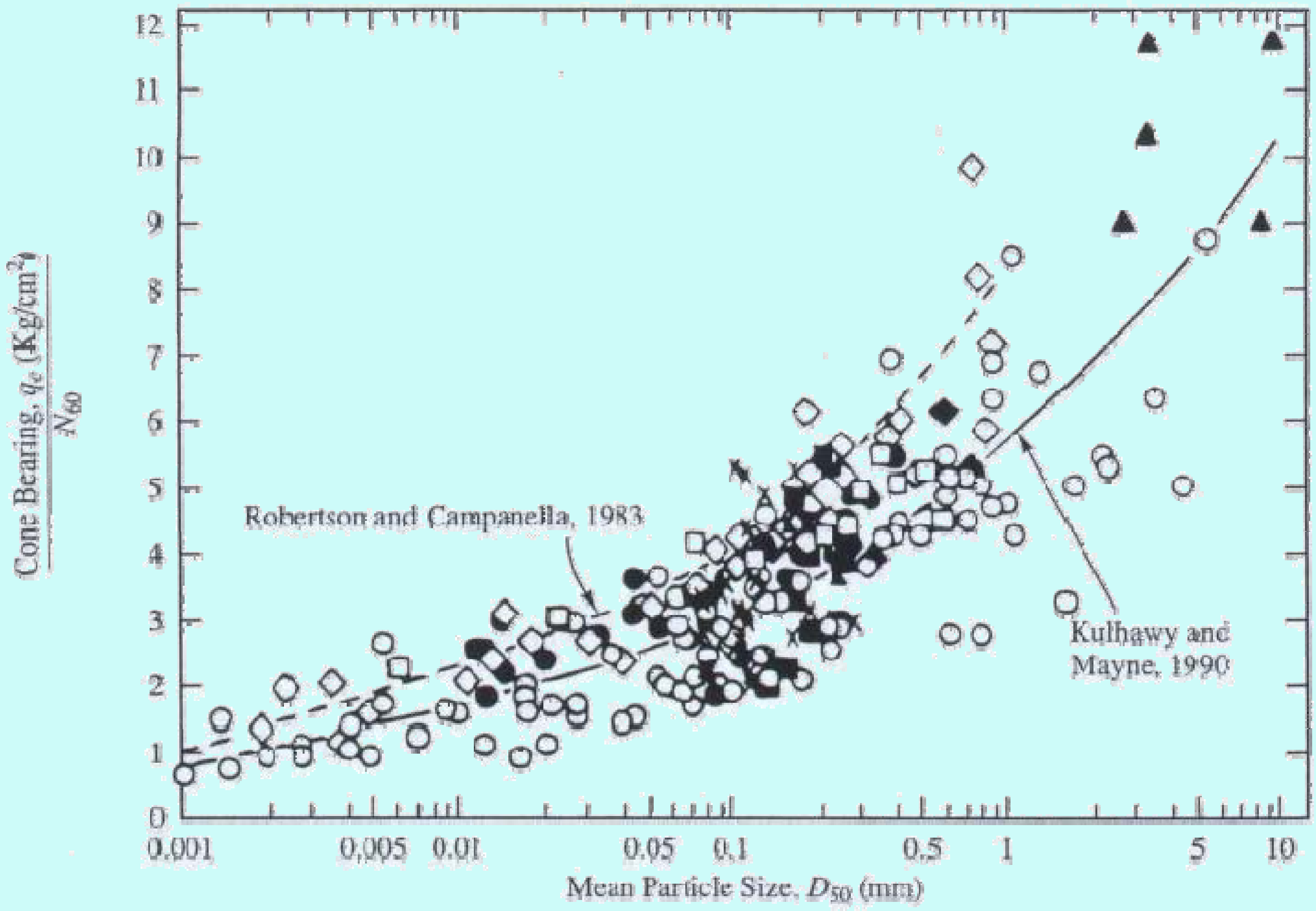
$$c_u = \frac{q_c - \sigma_{vo}}{N_k}$$

N_k → cone factor (15-20); varies with cone

In Sands,

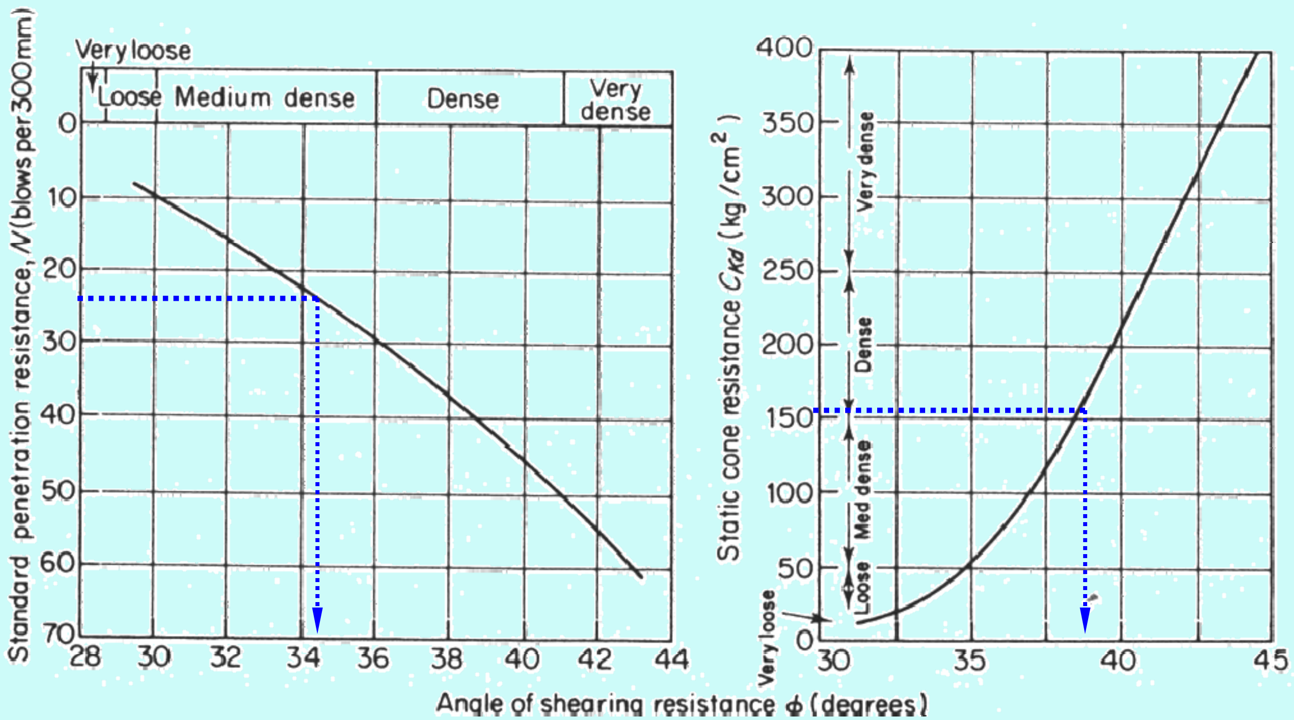
E = 2.5-3.5 q_c (for young normally consolidated sands)

q_c/N Relation in Granular Soils



q_c in kg/cm^2 (1 kg/cm^2 = 98.07 kPa)

φ' from SPT/CPT in Granular Soils

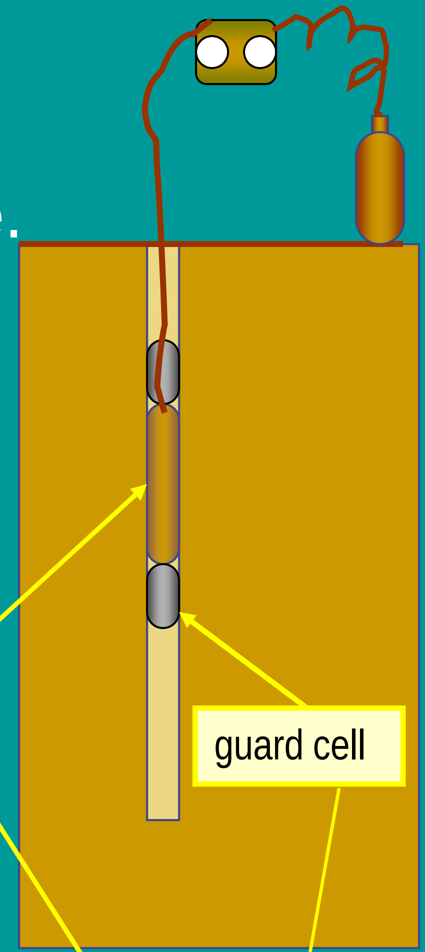


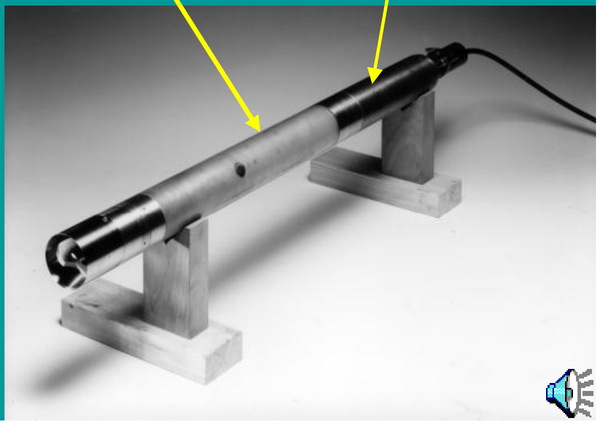
After Peck et al. (1974)

After Meyerhof (1976)

Pressuremeter Test

- Expand a cylindrical probe inside a bore hole.
- Most rational of all in situ tests
- Gives strength, modulus, K_0, c_v...
- For all soils

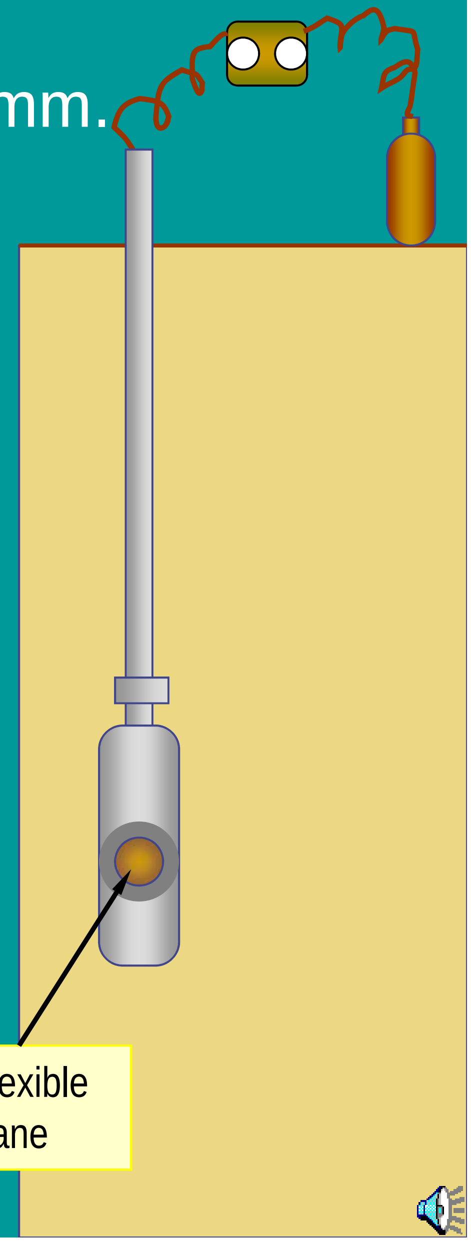




Dilatometer Test

- Advance @ 20 mm/s. Test every 200-300 mm.
- Nitrogen tank for inflating the membrane.
- Gives c_u, K_0, OCR, c_v, k, soil stiffness .
- Can identify soil (from a chart).

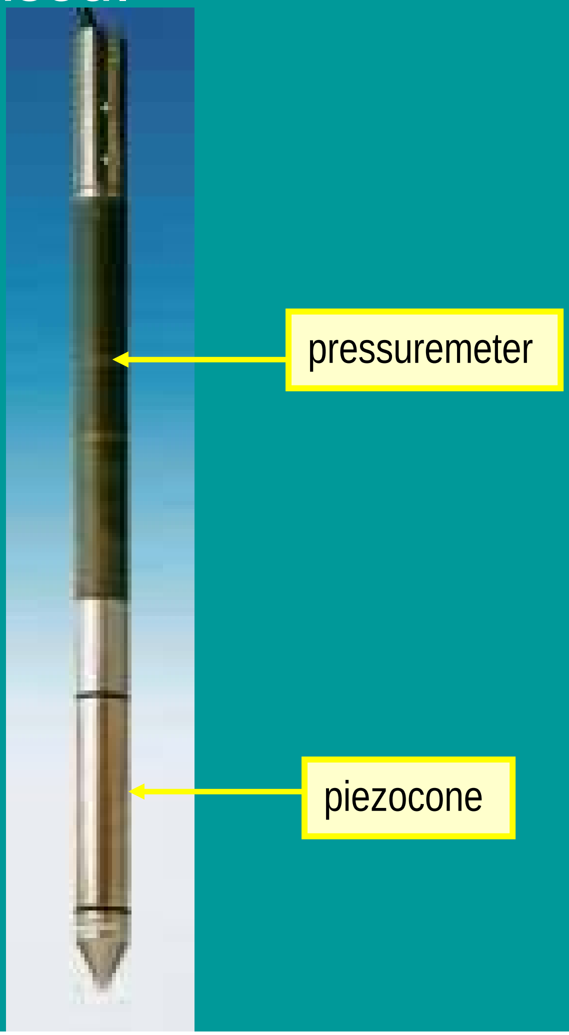
Similar to the cone



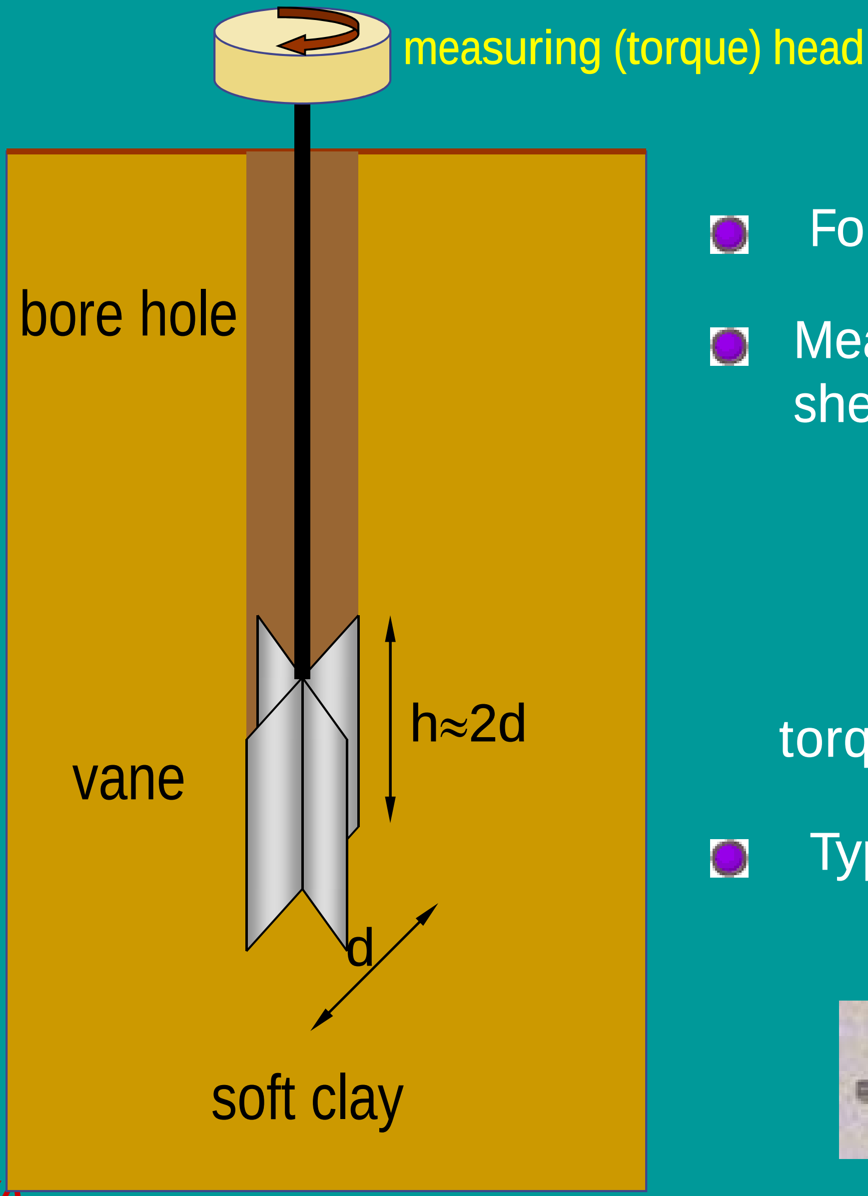
60 mm dia. flexible steel membrane

Cone Pressuremeter

- Combines piezocone and pressuremeter.
- Uncommon; specialised.



Vane Shear Test

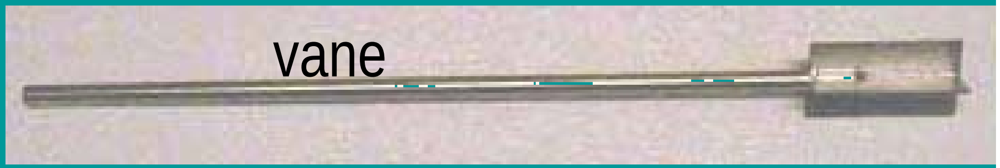


- For clays, and mainly for soft clays.
- Measure torque required to quickly shear the vane pushed into soft clay.

∴ undrained

torque → undrained shear strength c_u

- Typical d = 20-100 mm.



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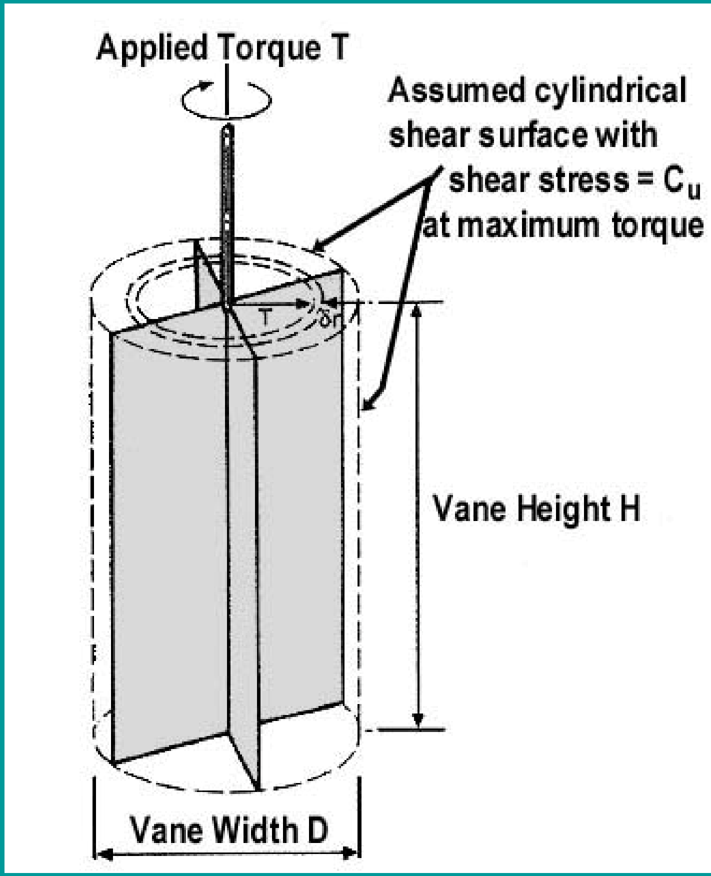
Vane Shear Test

Test in Progress

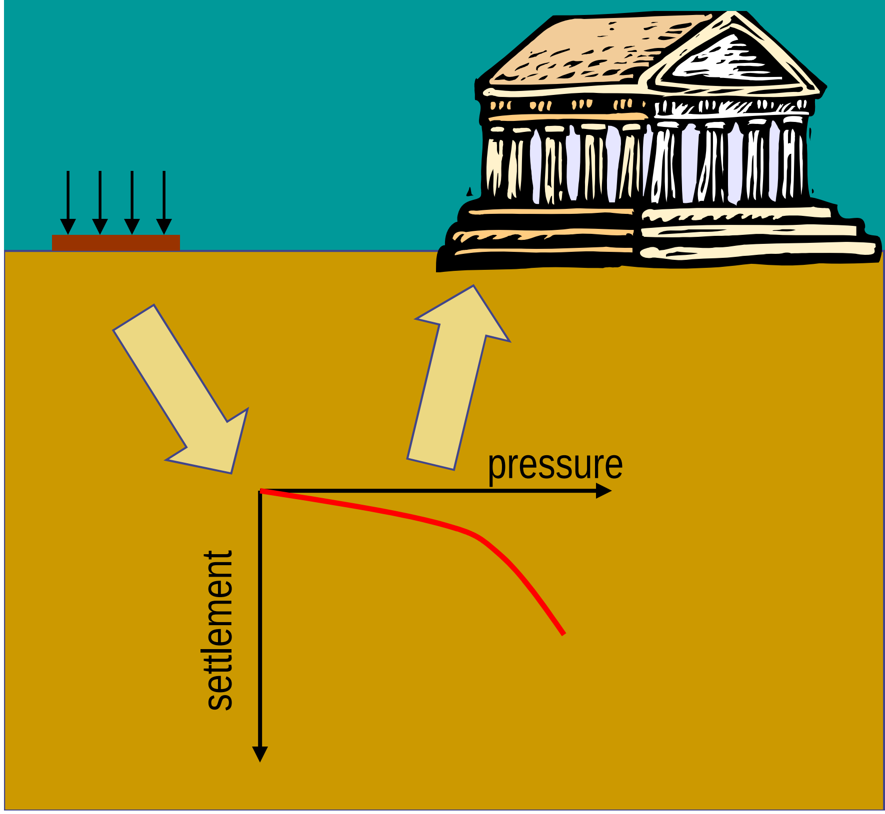


Failure surface

Plate Loading Test

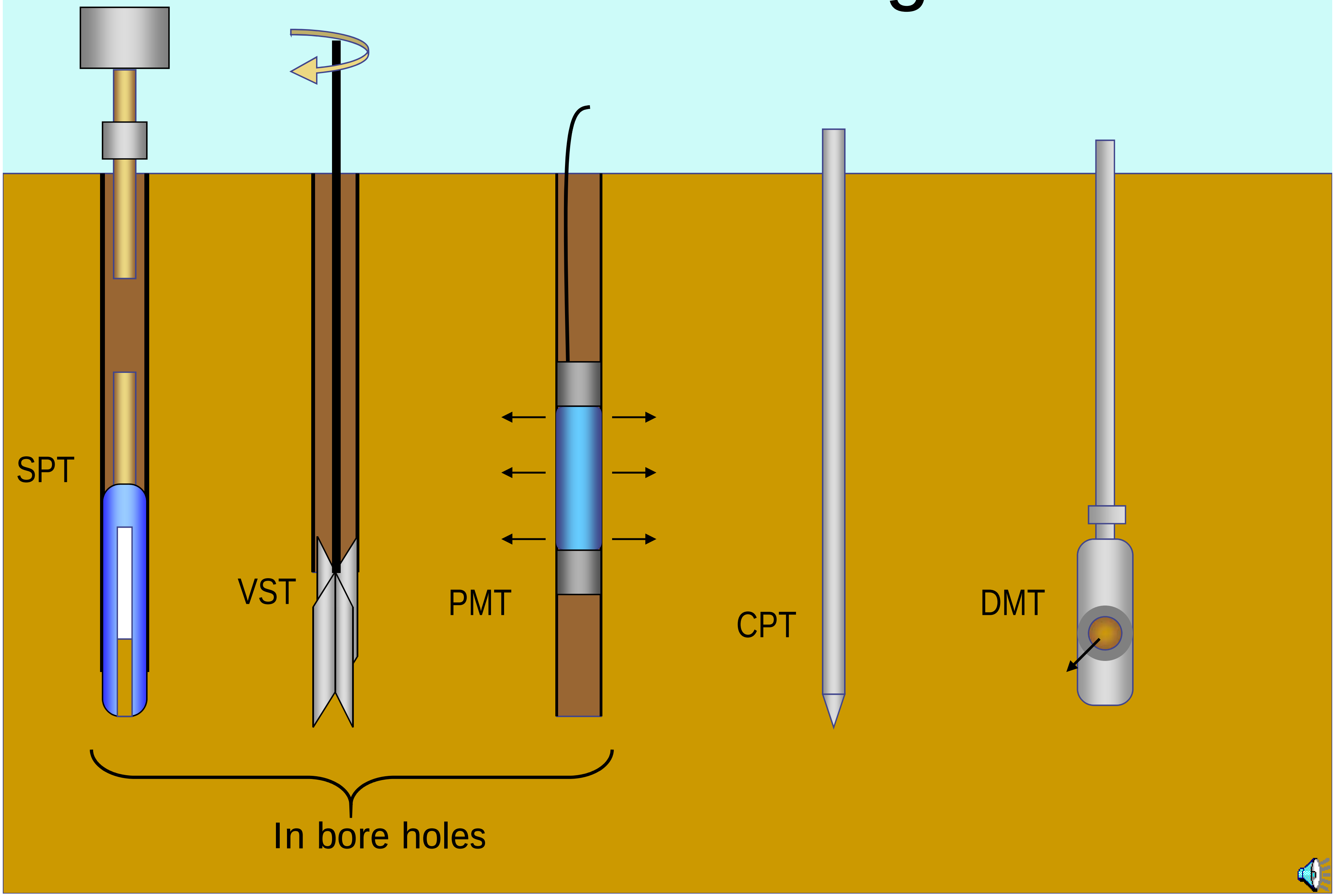
- Load a square plate (300 mm x 300 mm) to failure.

  Plot pressure vs. settlement. Extrapolate to prototype.
- Loading arrangement makes it expensive.
- Good on random fills; indicateses an average behaviour.



Doing it in Sri Lankan style.

Common In Situ Testing Devices

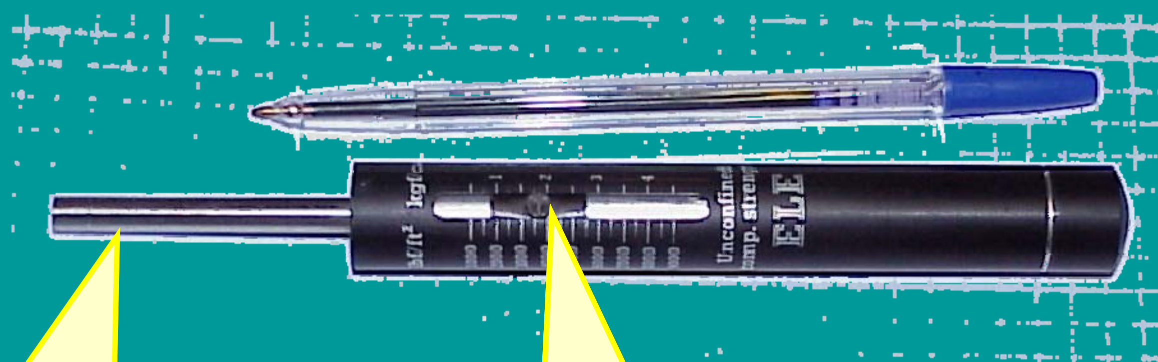


Pocket penetrometer

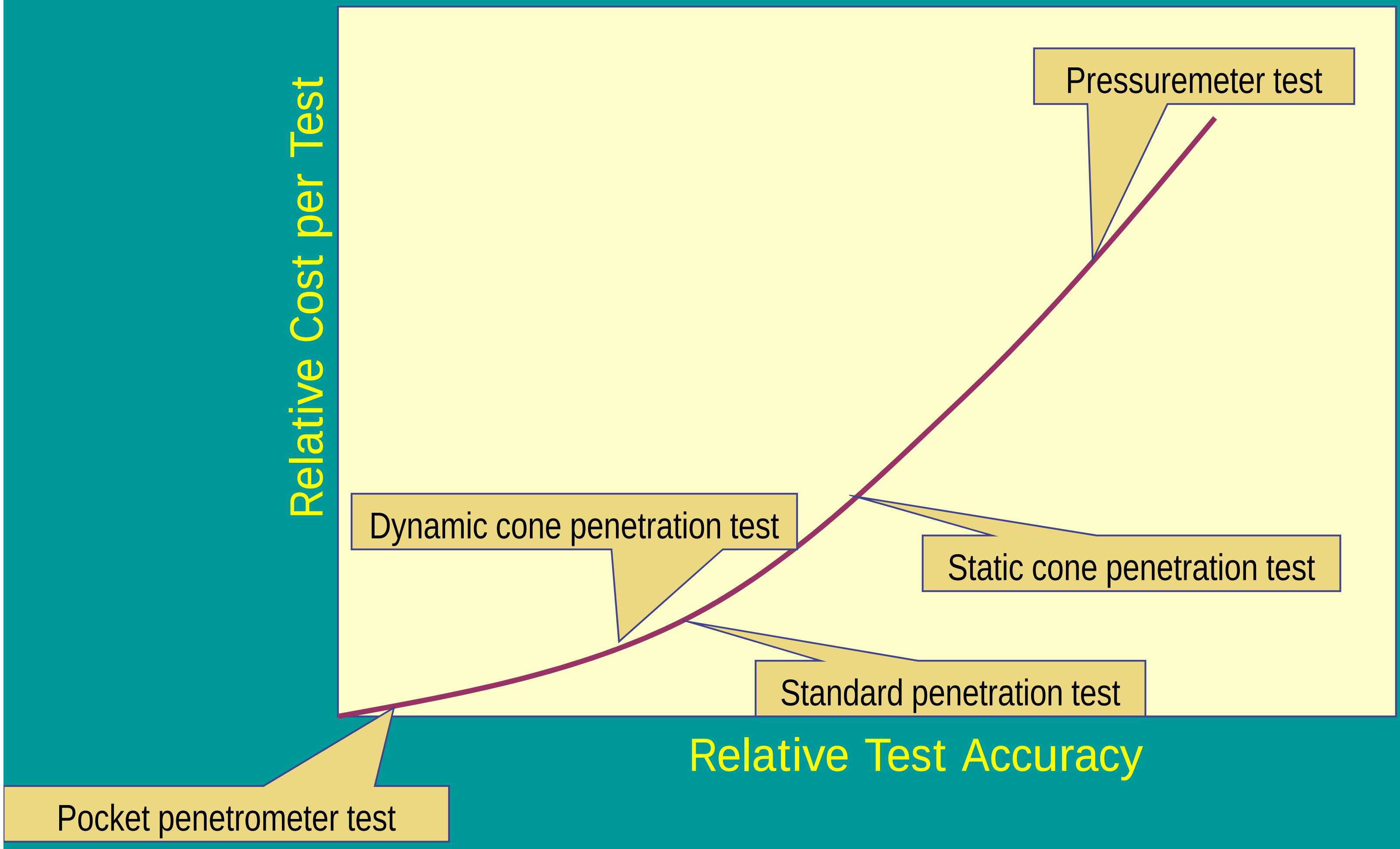
- A simple hand-held device for measuring unconfined compressive strength ($q_u = 2\ c_u$) of a clay.

very rough

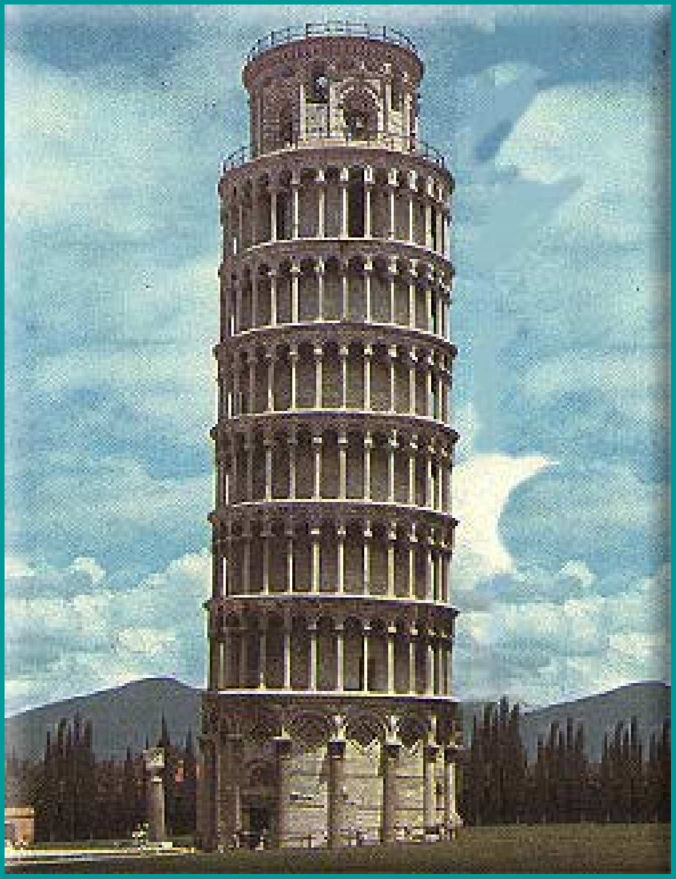
- Used in trial pits and samples.
- Must for every practicing geotechnical engineer.



Cost versus Accuracy



If only they had proper site investigation...



...Tower of Pisa will not be leaning today!

Hypertext References:

www.fugro.nl Fugro International-

www.ce.gatech.edu Georgia Institute of Technology

www.pagani-geotechnical.com Pagani Geotechnical Equipment