CPT /CPTU

- What is a CPT/CPTU and what do we measure?
- Historical overview
- Role in todays soil investigations
  - *onshore*
  - *offshore*
- Equipments for testing
  - *Deployment systems*
  - *Various CPT/CPTU equipments available*
  - *Data aquisition*

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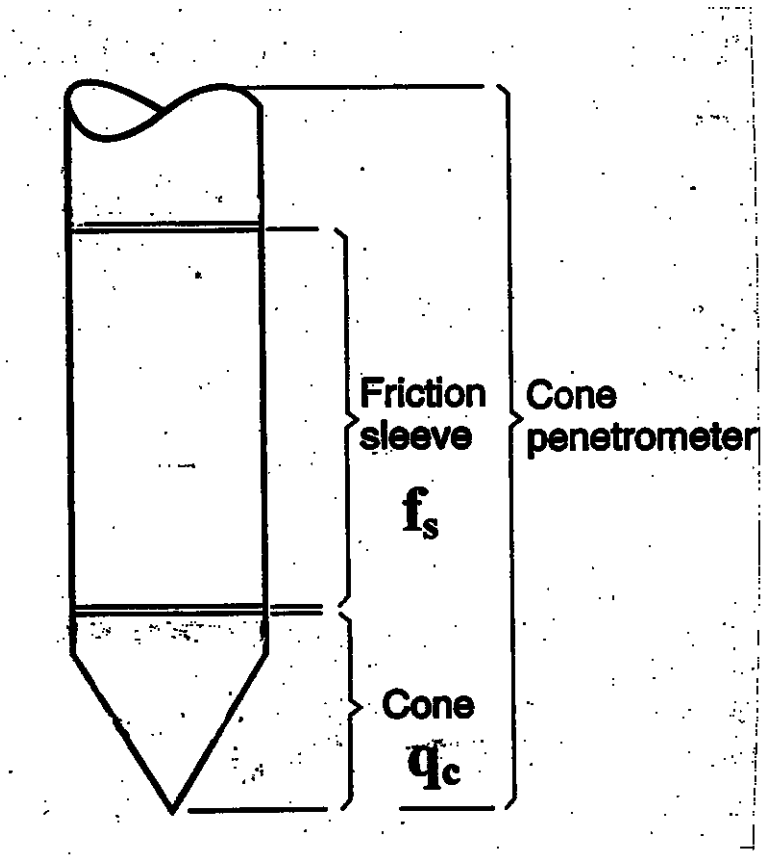
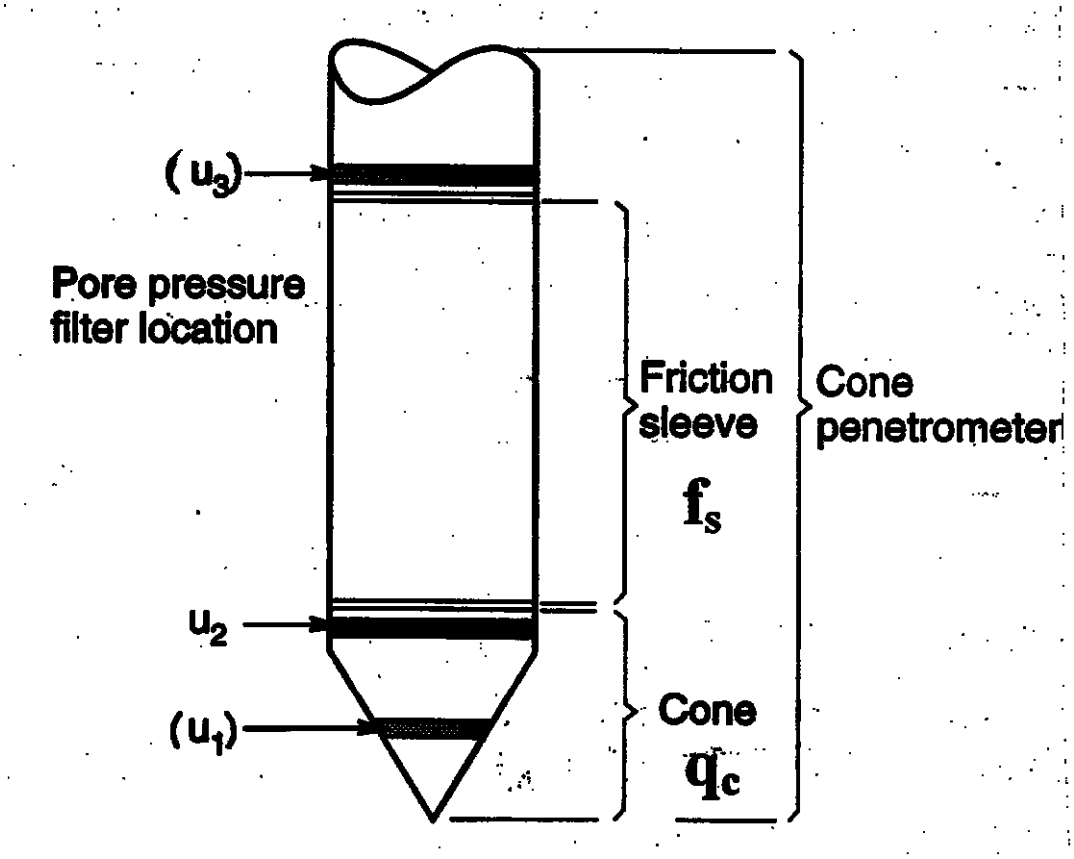
TERMINOLOGY FOR CPT

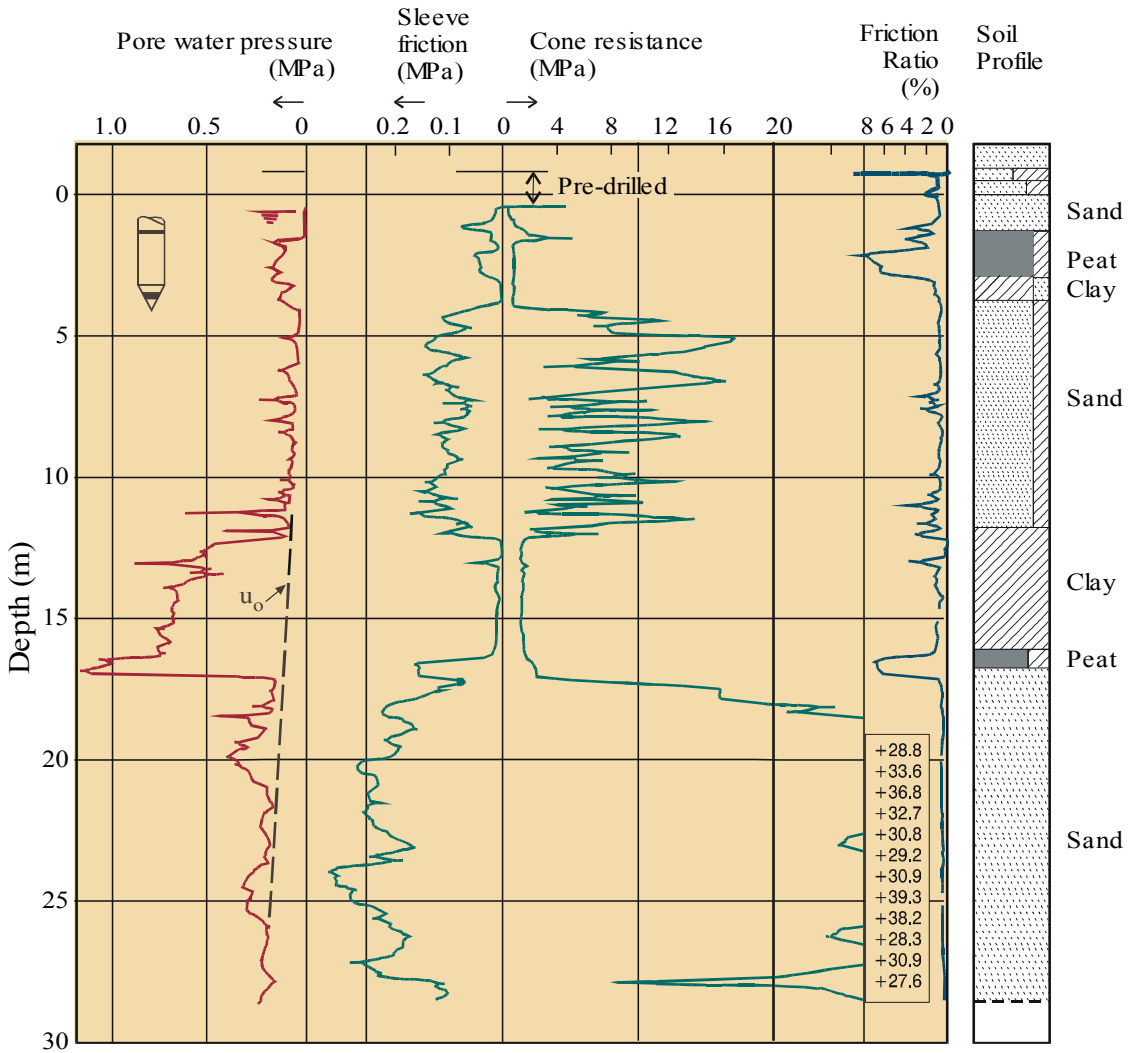


TERMINOLOGY FOR CPTU AND WHAT DO WE MEASURE



In addition frequently measure inclination, i

Example CPTU profile from Holland



HISTORICAL BACKGROUND CPT

- 1932 First Dutch cone penetration tests (by hand)
- 1935 Delft Soil Mechanics Laboratory (DSML) performs CPT with 10 t manually operated rig
- 1948 Improved design of Dutch cone including conical mantle
- 1953 Measurement of friction sleeve added to mechanical cone
- 1948 DSML develops first electrical cone
- 1965 Fugro develops electrical friction cone

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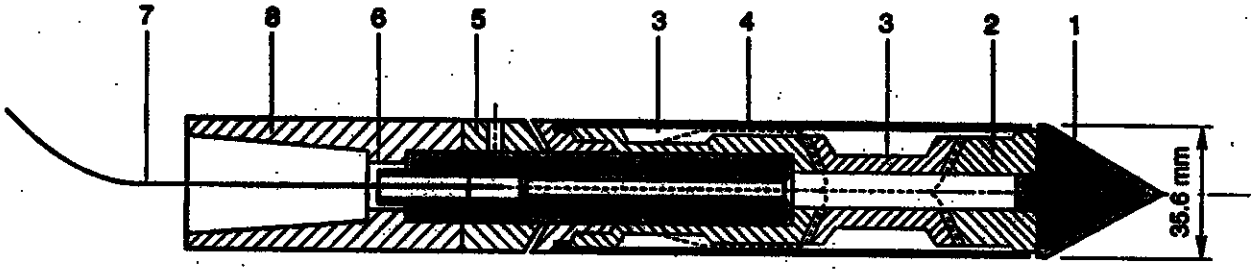
THE FUGRO ELECTRICAL FRICTION CONE (AFTER DE RUITER, 1971)



1 Conical point (10 cm²)
2 Load cell
3 Strain gauges
4 Friction sleeve
5 Adjustment ring
6 Waterproof bushing
7 Cable
8 Connection with rods

HISTORICAL BACKGROUND CPTU

- *1974* Janbu and Senneset (Norway) and Schmertmann (USA) penetrates conventional piezometer. Wissa et al. (USA) and Torstensson (Sweden) simultaneously piezoprobe

- *1980* Roy et al. (Canada) develops probe with combined measurement of cone resistance, sleeve friction and pore pressure

- *1986* Fugro (Holland) and McClelland (UK) simultaneously develop “triple element” piezocone. Campanella et al. (Canada) performs seismic piezocone tests

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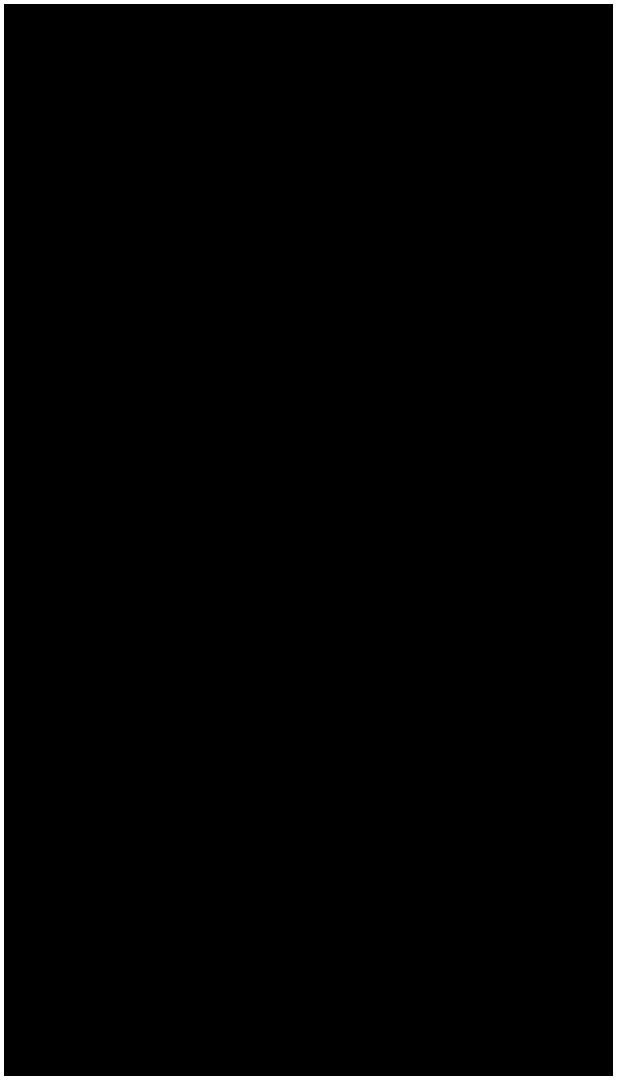
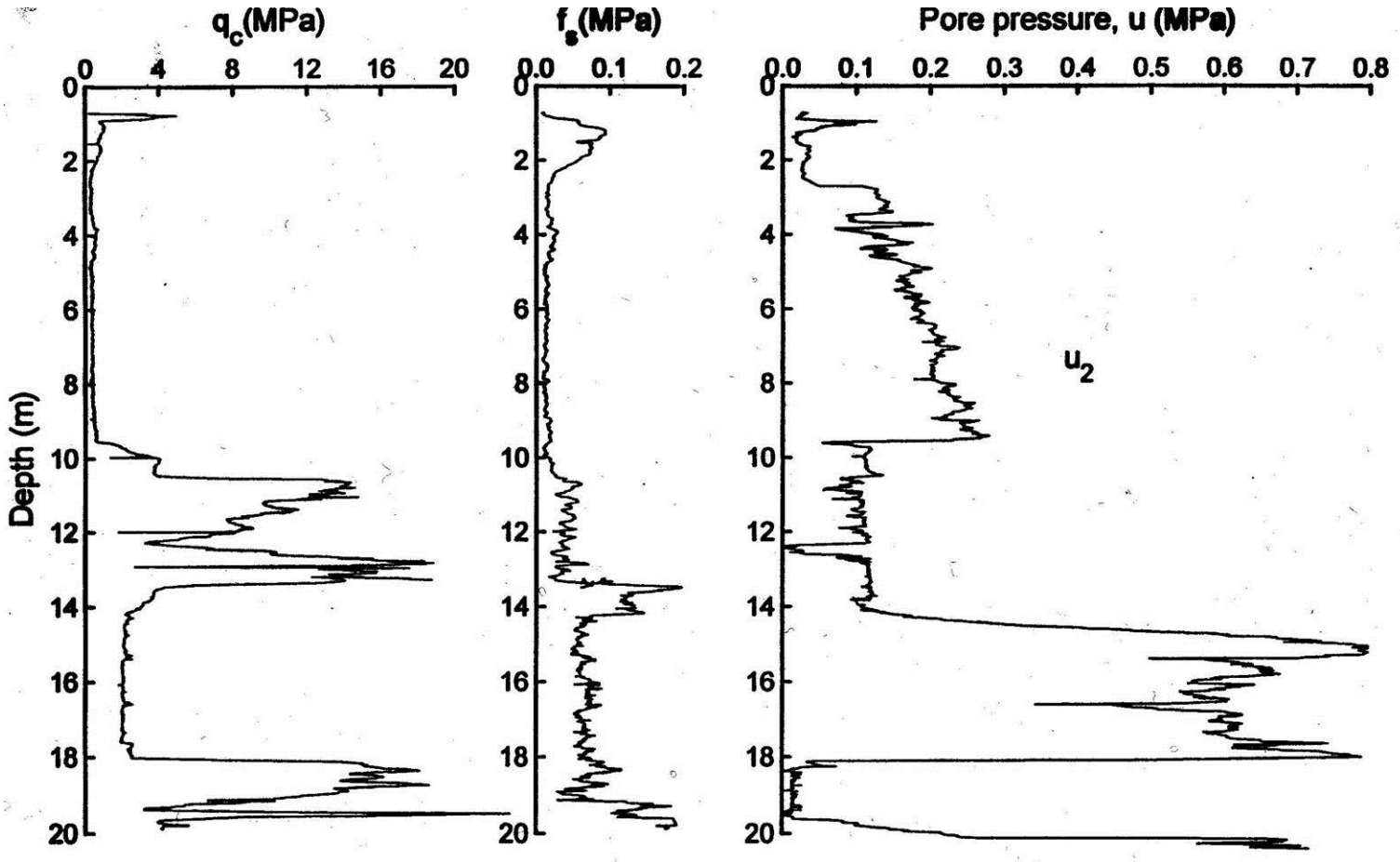
Example combined CPT and pore pressure probe Piezocone or CPTU



Examples measured CPTU parameters



Example: Measured CPTU Parameters

ROLE OF CPT/CPTU IN TODAYS SOIL INVESTIGATIONS

Onshore Scandinavia

- **Used in large projects by knowledgeable clients**
- **Gradually taking over after the vane tests; results used for soil profiling and also to define parameters for foundation design**
- **However, the full potential is not yet used. Not all clients and consultants are aware of the advantages of the test**

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ROLE OF CPT/CPTU IN TODAYS SOIL INVESTIGATIONS

Offshore North Sea

- Since 1972 has dominated offshore soil investigations (> 50%)
- Used in most projects
- In some cases investigation consists of only CPTUs

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Deployment of CPT/CPTU

Equipment now exists for pushing in cone penetrometers into soil for a large range of conditions

- **on land**
- **offshore**

Example CPT rigs

Geomil rig

Geotech simple rig

CPT/CPTU on land

Modern truck mounted system *(ConeTec/Gregg)*

CPT/CPTU on land

Track-mounted system

(ConeTec/Gregg)

Standard CPT Rigs

LANKELMA
CONE PENETRATION TESTING LTD.

20 Tonne Crawler

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Non-Standard CPT Rigs

15 Tonne Rail Crawler

- Rapid investigative technique. Minimal set-up and test time per locat
  No reinstatement required
- Optimises track possession time more effectively
- Mini-crawler with inclined rams for rail embankments
- No lifting required for mobilisation

Non-Standard CPT Rigs

LANKELMA
CONE PENETRATION TESTING LTD.

1.5 Tonne Mini Crawler

- Suitable for restricted access (rubber tracked, low ground bearing pressure)
- Thrust capacity 20 tonnes
- Reaction weight 1.5 tonnes (increased with ground anchors & water tanks)
- Suitable for Railway related work

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Pagani small trackmounted CPT rig

Versatile Mobile Rams

LANKELMA
CONE PENETRATION TESTING LTD.

Embankment CPT's

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CPT/CPTU on land

Drill-rig system

(ConeTec)

Low headroom CPT - Inside buildings

(ConeTec/Gregg)

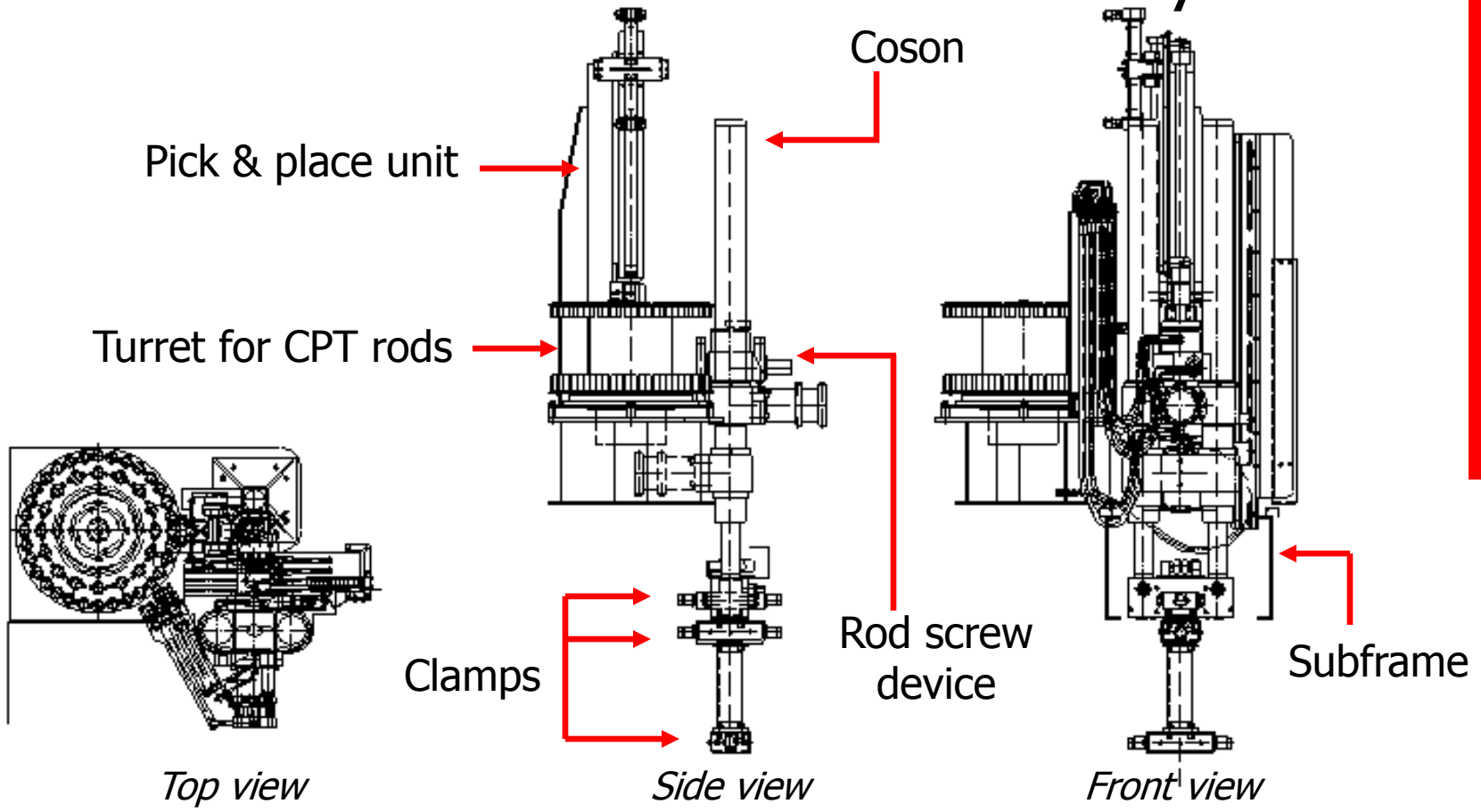
CPT in London Underground tunnel

Courtesy of Lankelma, UK

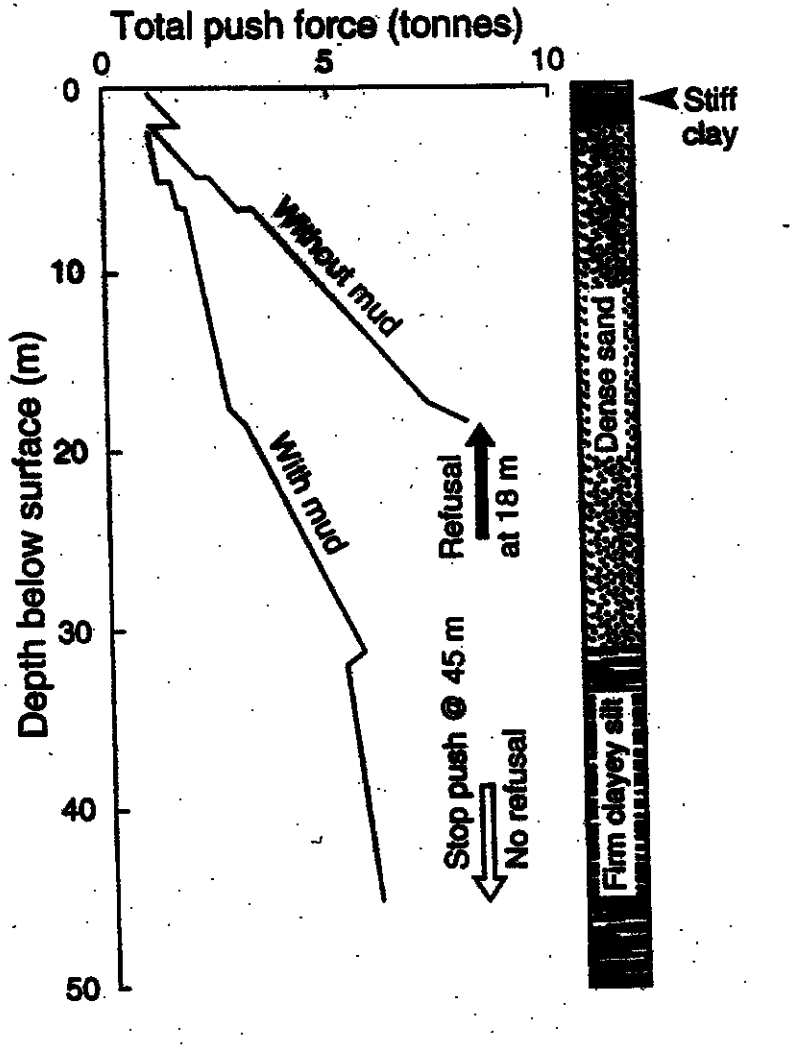
Coson® 200 kN

- Continuous Static cone penetrometer
- Take-over principle
- Time saving about 7 sec/m
- No loss of data at one meter intervals
- No dissipation effects interfering with pore water pressure measurements.

Schematic overview of Autocoson system



TOTAL CONE PUSH FORCES WITH AND WITHOUT MUD INJECTION (FROM JEFFERIES AND FUNEGÅRD, 1983)



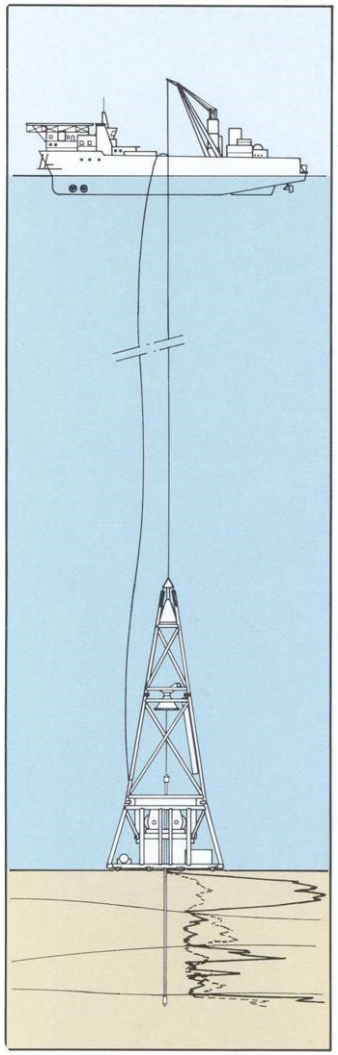
In situ testing in offshore geotechnical investigations

Deployment platforms

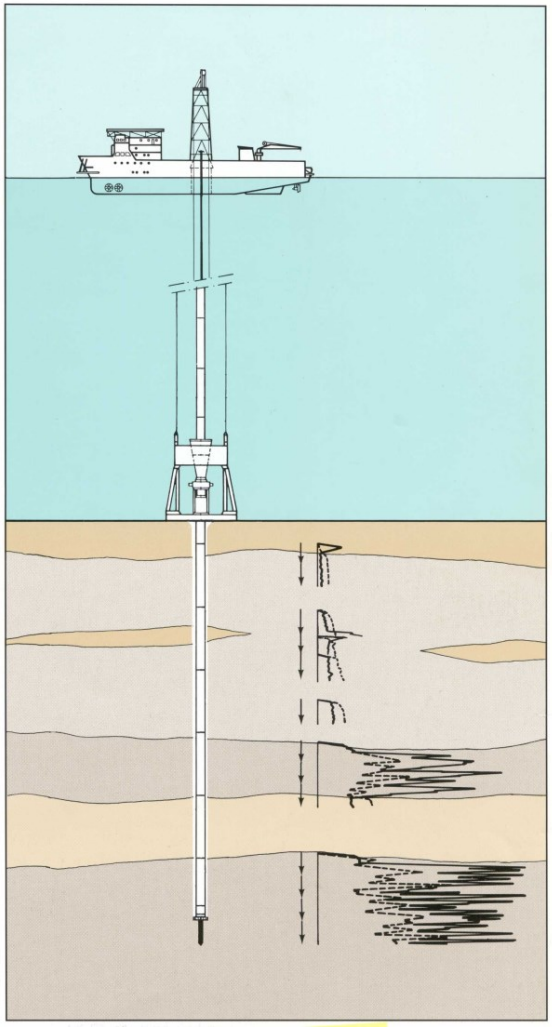
- Jack up rigs
- Barges
- Survey ships
- Special soil drilling vessels

Investigations from jack-up platform

Deployment from vessels



Over the side or stern



Through the moonpool

From Fugro brochure

In situ testing in offshore geotechnical investigations

Basically two modes of operation:

- Seabed mode
- Down-hole mode

In situ testing in offshore geotechnical investigations

Sea bottom rigs:

- Standard size rigs (e.g. 10 or 15 cm^2 cone penetrometers)
- Minirigs (1 to 5 cm^2 cone penetrometers)

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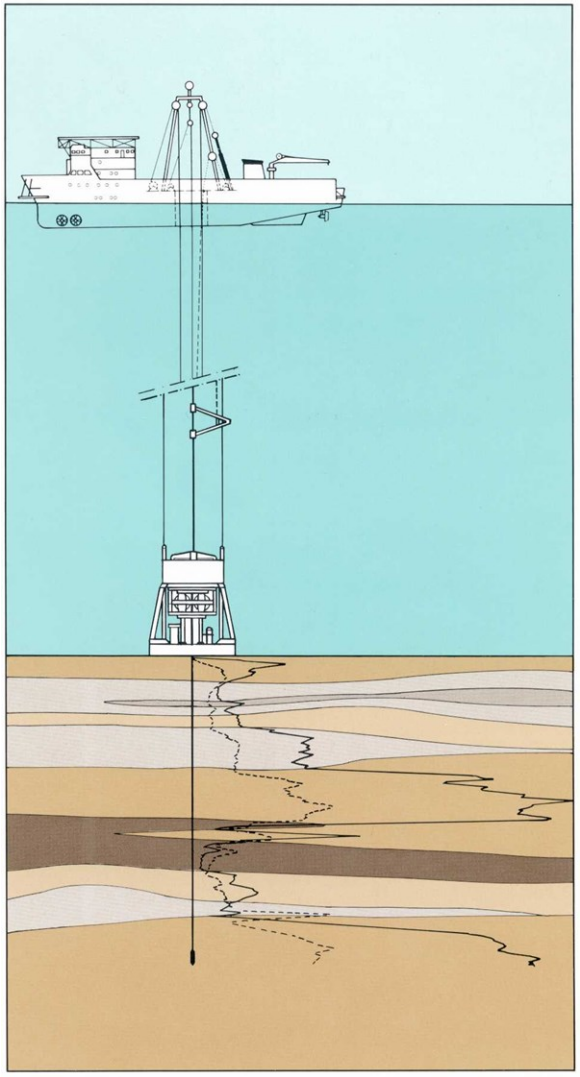
Fugro's wheeldrive CPT system



Heavy duty rig
20 t, profiling
to 45-50 m
penetration
possible

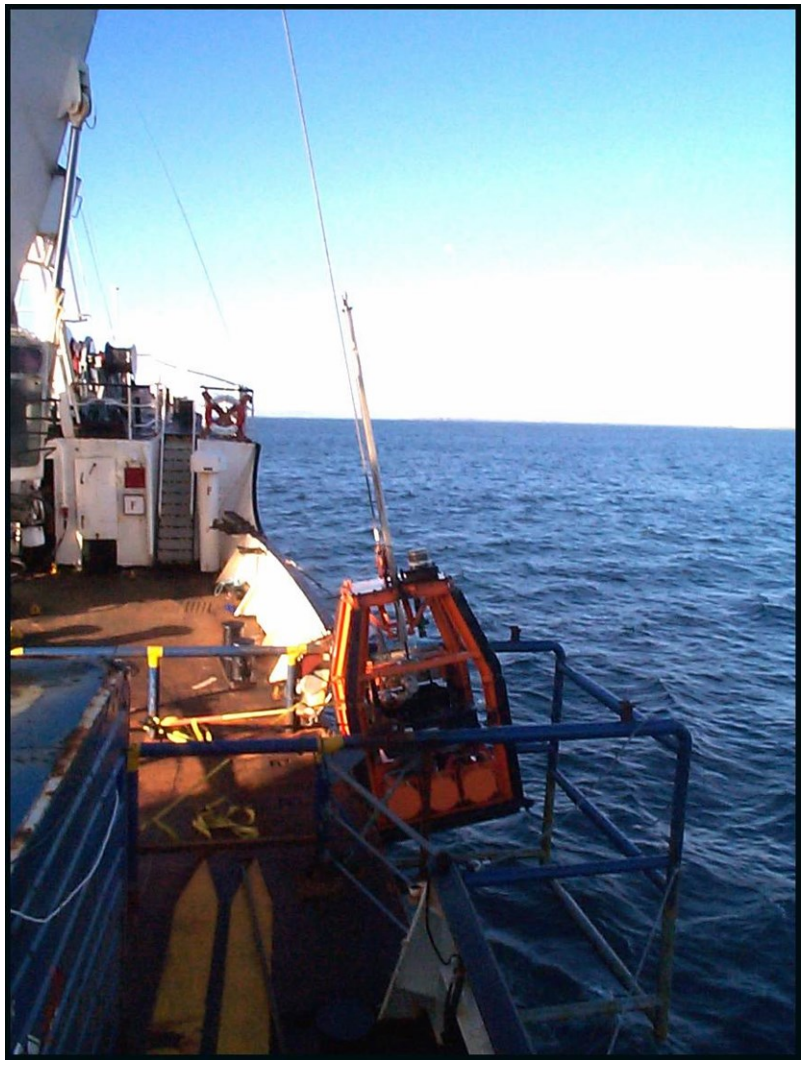
From brochure

Roson rig with one set of roller wheels

5 ton rig for pipeline investigations with standard size cones

From AP van den Berg brochure

CPT rig with acoustic telemetry



Light version:

-weight < 3 tons

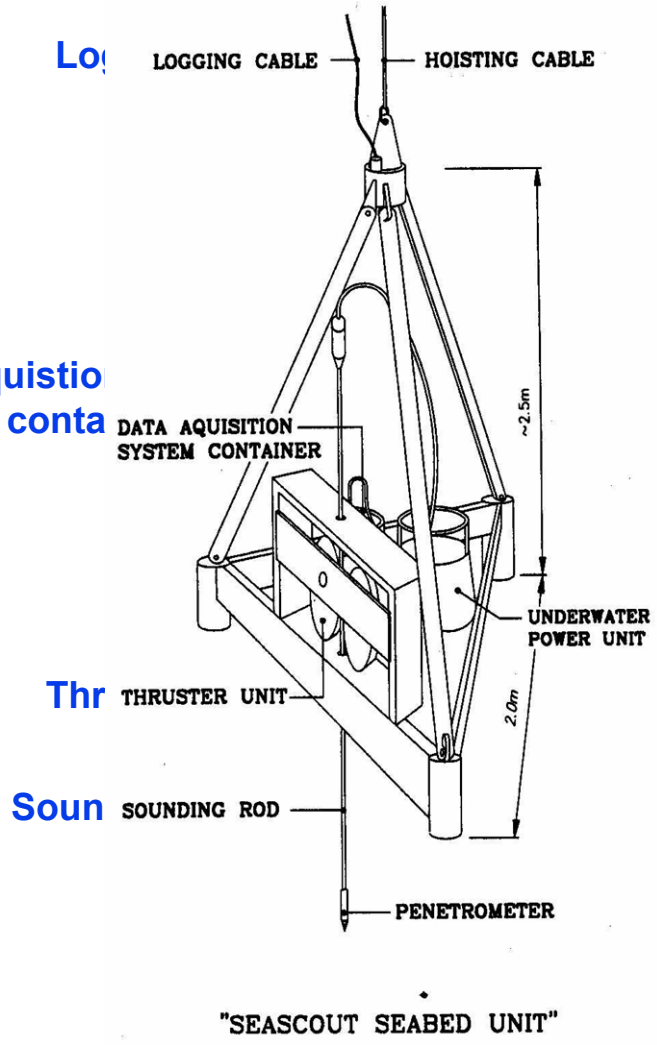
-thrust capacity 1 ton

-base area 2.25 m^2

-2 cm^2 - 5 cm^2 cones

From Gardline brochure

Fugro's Seascout minirig



- Weight = 2 ton
- Cone area= 5 cm^2
- Penetration : 6 m
- Water depth : 2000m

After Power and Geise,1994

Example of light mini-rig for use in deep waters

Global, UK

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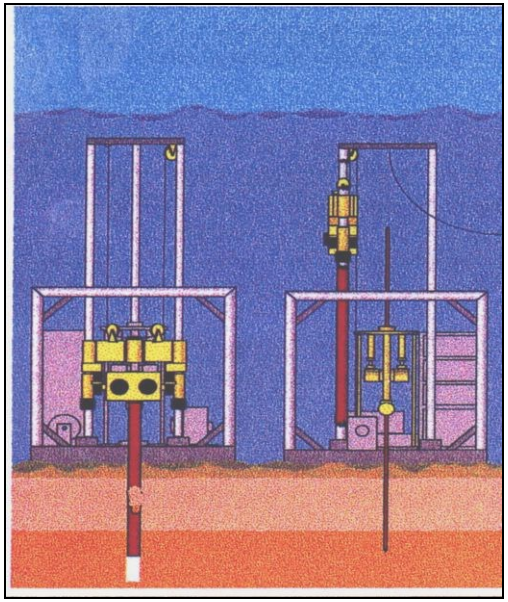
Geo's combined CPT and Vibrocore seabed rig "GeoCeptor"

- CPT and vibrocore in "one operation"
- CPT up to 10 m depth
- Soil sampling up to 6 m depth



GEO “CPT-ROV”

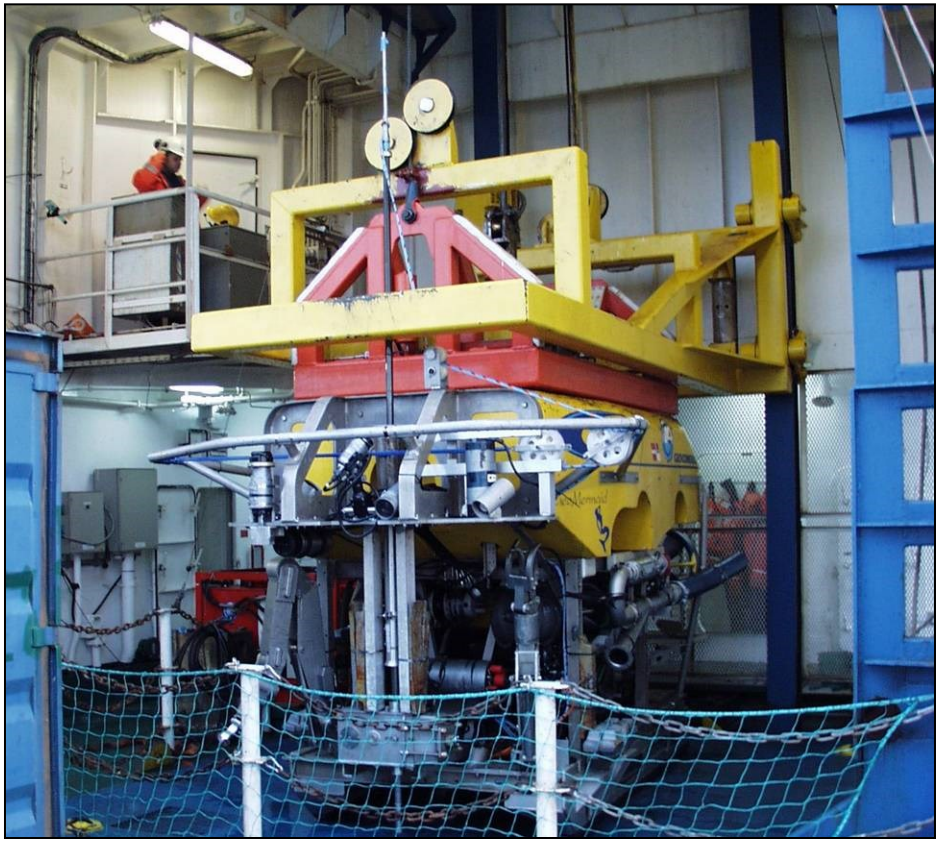
Weight: 200kg

Deployment depth: 3000m

Max penetration: 3 m

Cone dimensions:

$10cm^2$ $5cm^2$



Geo CPT-ROV

Mounting on ROV

- Power from ROV
- Interfaced to ROV. Using ROV umbilical cable for data transmission and control

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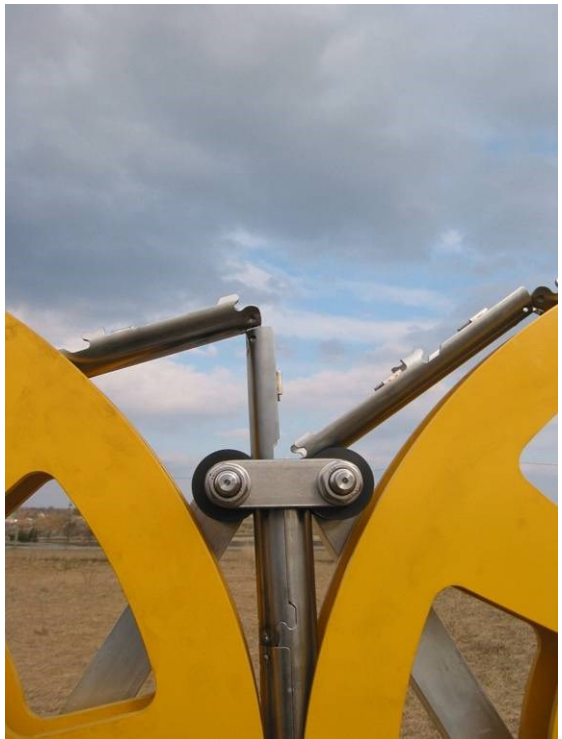
Soil stinger

Felttest Sola Golfbane

New Norwegian system that can potentially be used for tests deployed from ROV

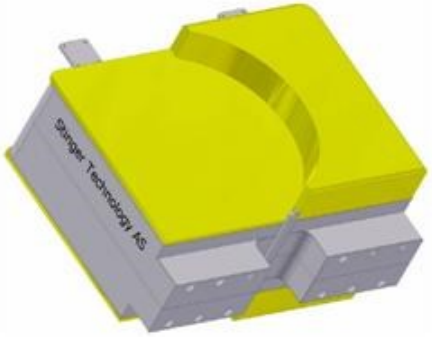
nt:



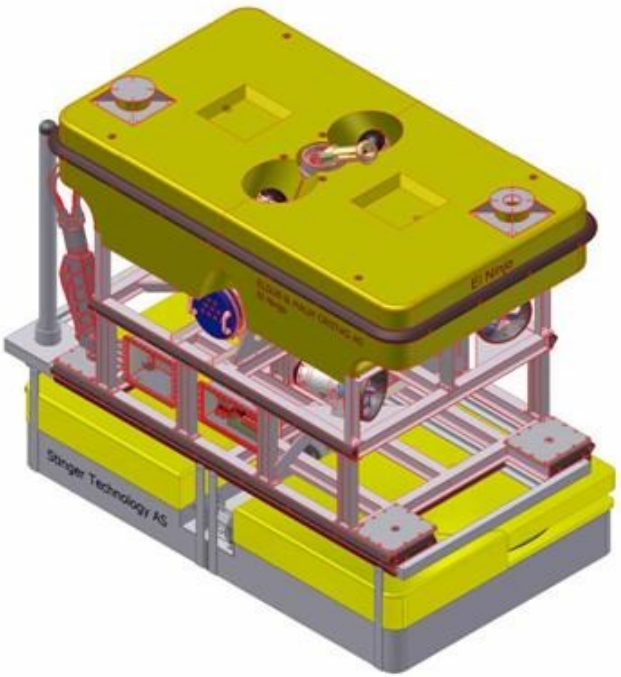
SOIL STINGER

Geotechnical rov tool

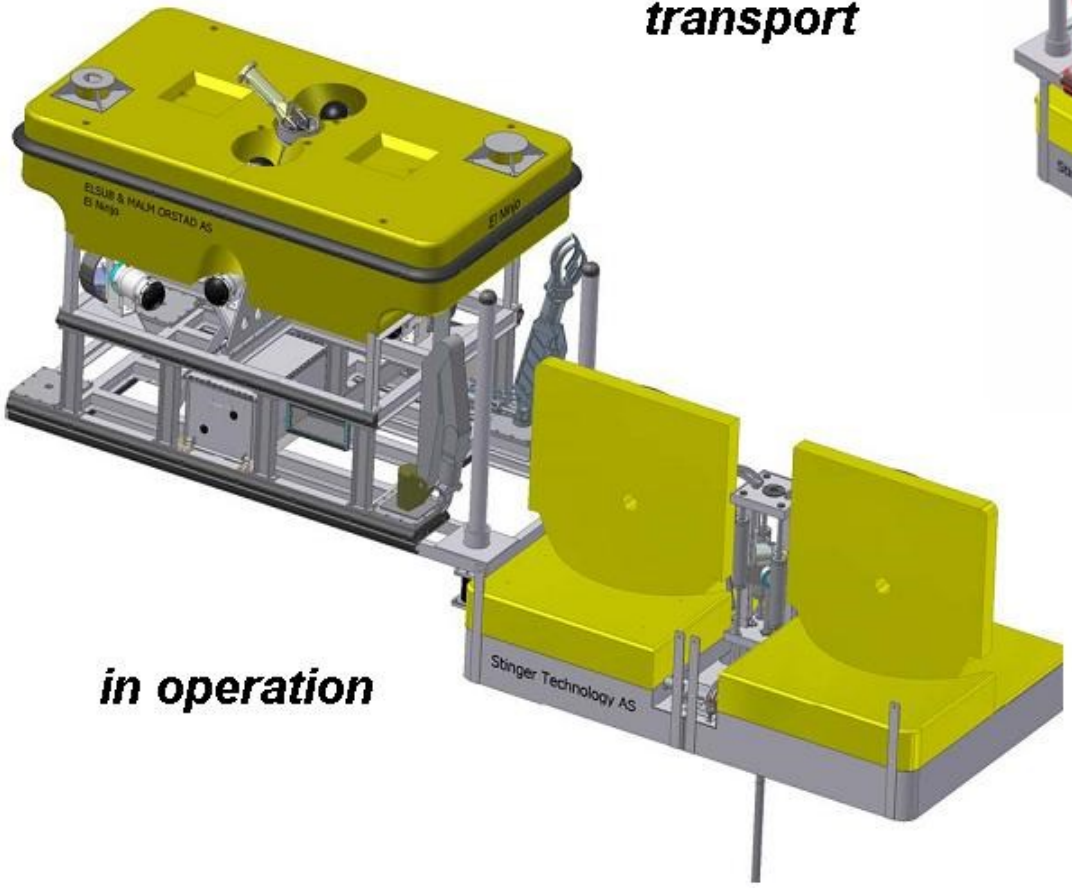
Transport dim: 1500 x 1800 x 1200 mm
Operating dim: 3000 x 1800 x 600 mm
Dry weight : 1000 kg
Wet weight : 50 kg



transport



free swimming



in operation

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Stinger Technology

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CONE PENETRATION TESTING LTD.

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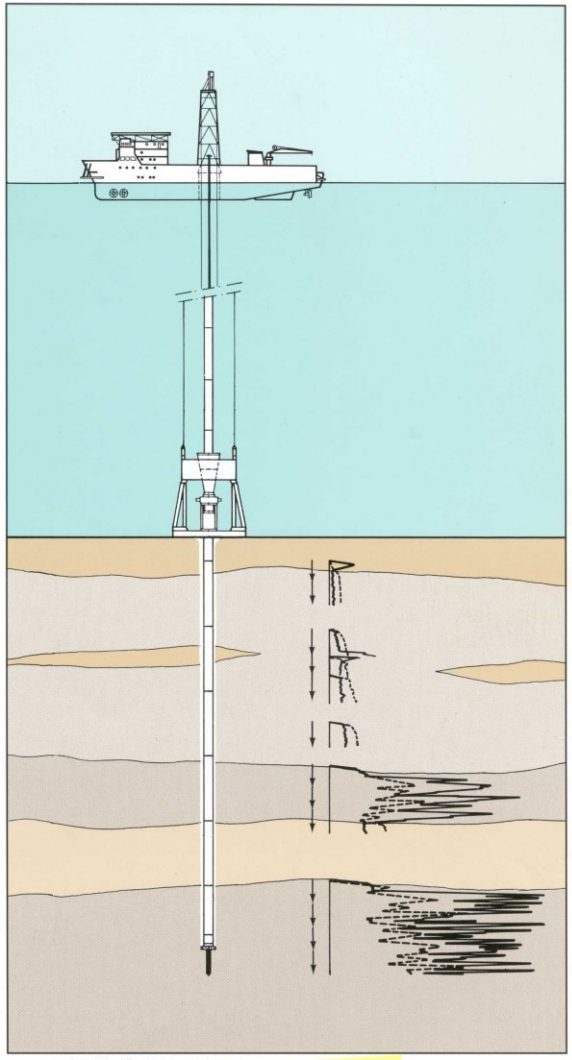
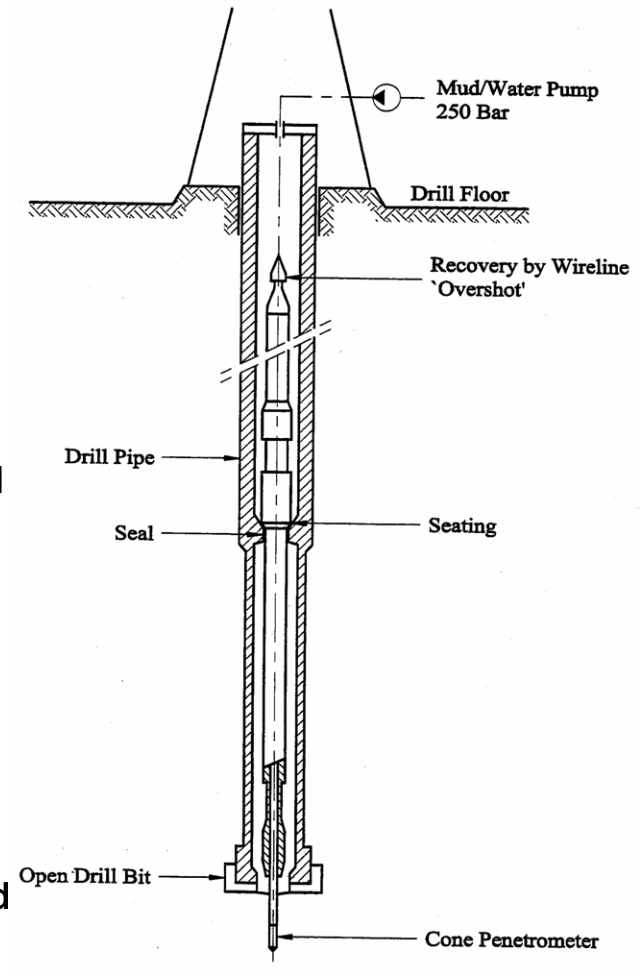
Down-hole insitu testing



Operation with umbilical, hydraulic cylinder pushes tool below bottom of borehole. Data aquisition through cable and real time display of test results. Depth limitation about 700 m.

From Fugro brochure

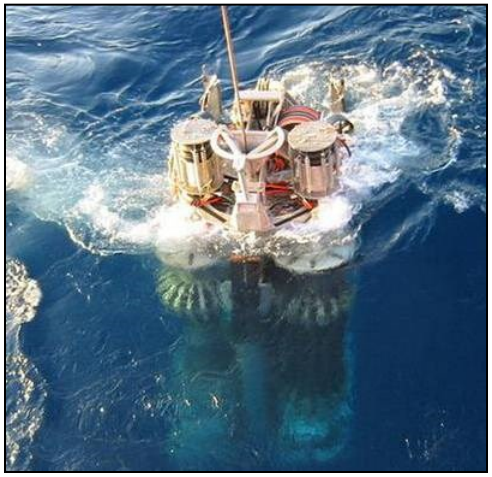
Fugro's downhole XP system



Mud pressure to penetrate in situ tool. Memory based data aquisition

From Hawkins and Marcus(1998)

PROD : Horizontal Launch & Recovery



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BENTHIC GEOTECH PTY LTD

260m of drill tools in two carousels

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BENTHIC GEOTECH PTY LTD

Penetrometer

- Standard 10cm^2 CPT
- Full piezocone capability
  - *Standard probing*
  - *Dissipation testing*
- Real time data
- Full seabed redundancy
- Full spares kit

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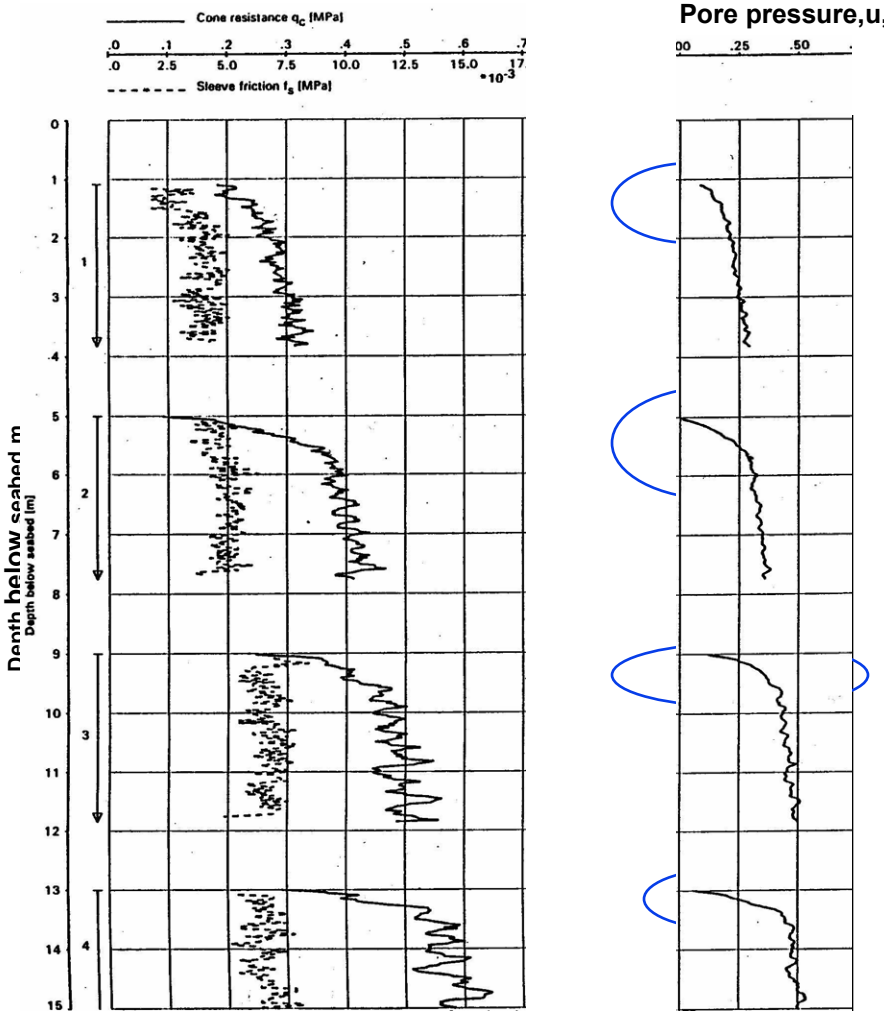
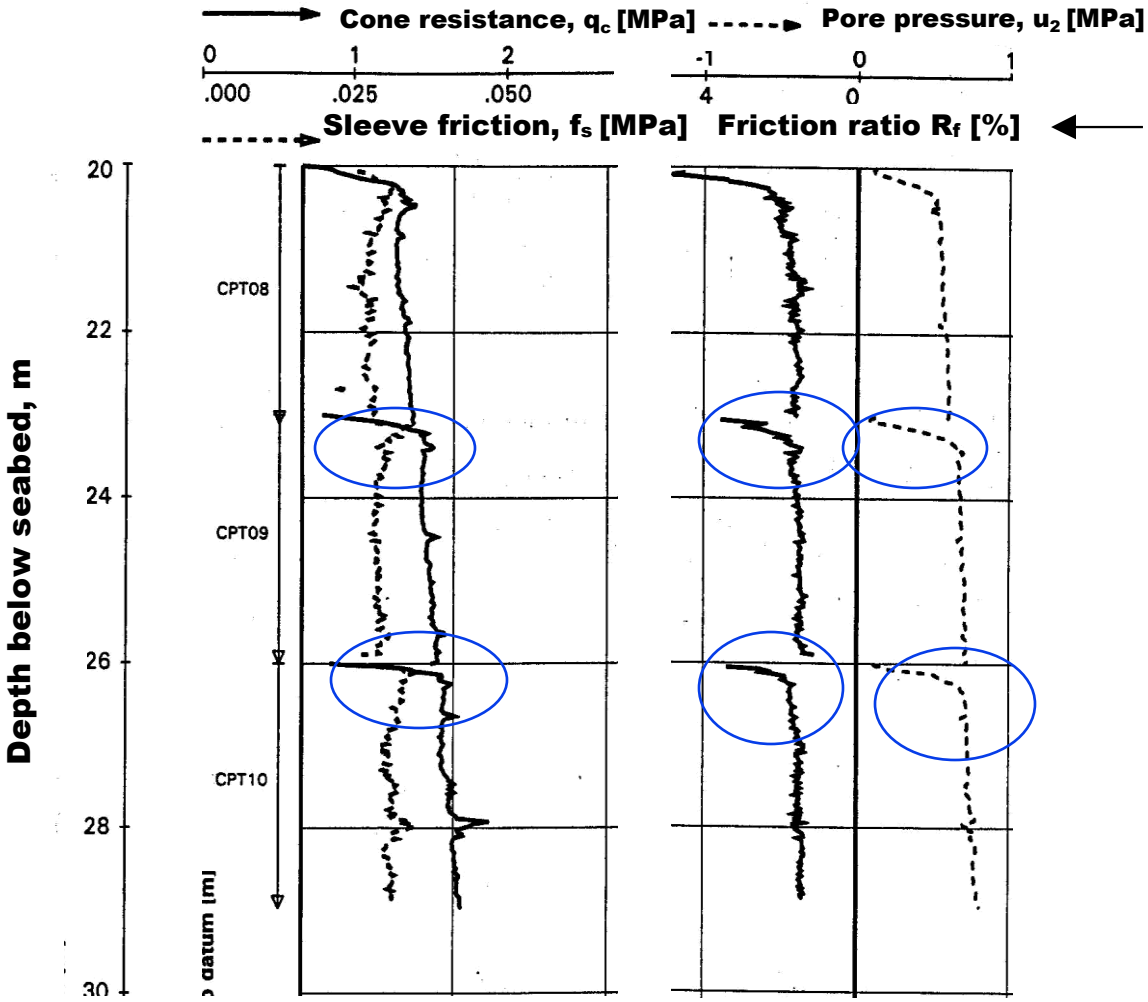
BENTHIC GEOTECH PTY LTD

Example of downhole CPT showing soil disturbance due to drilling



Example of downhole CPTU showing little drilling disturbance



Seabed or down-hole testing ?

Advantages of down-hole testing:

- **Penetrations to 150 m or more**
- **Hard layers can be penetrated**
- **Possible to do combination of different types of in situ tests and/or sampling**

Seabed or down-hole testing ?

Advantages of seabed testing:

- **Easier and quicker deployment**
- **Less expensive ships can be used**
- **Higher quality of tests due to no soil disturbance due to drilling**

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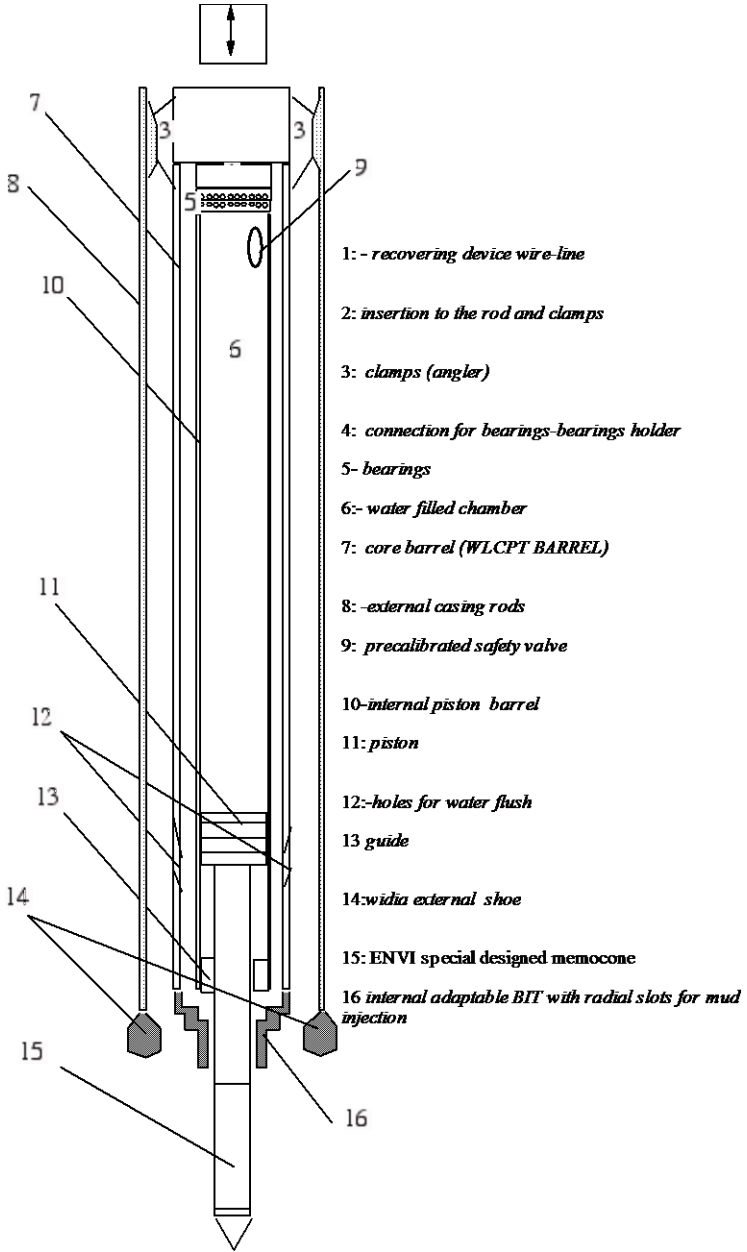
New alternative CPTU while drilling

Developed by Italian company SPG and Swedish company ENVI

- Cone penetrometer protrudes in front of drill bit while drilling in same way as a corer
- CPTU data stored in a memory unit
- Drilling parameters logged at same time

CPTU while drilling; principle



1: - *recovering device wire-line*

2: *insertion to the rod and clamps*

3: *clamps (angler)*

4: *connection for bearings-bearings holder*

5- *bearings*

6:- *water filled chamber*

7: *core barrel (WLCPT BARREL)*

8: -*external casing rods*

9: *precalibrated safety valve*

10-*internal piston barrel*

11: *piston*

12:-*holes for water flush*

13 *guide*

14:*widia external shoe*

15: ENVI special designed memocone

16 *internal adaptable BIT with radial slots for mud injection*

(From M.Sachetto,2001)

DETAIL OF MEMOCONE AND THE CPTwd-BARREL BIT

SLOTS FOR THE MUD INJECTION

ENVI MEMOCONE

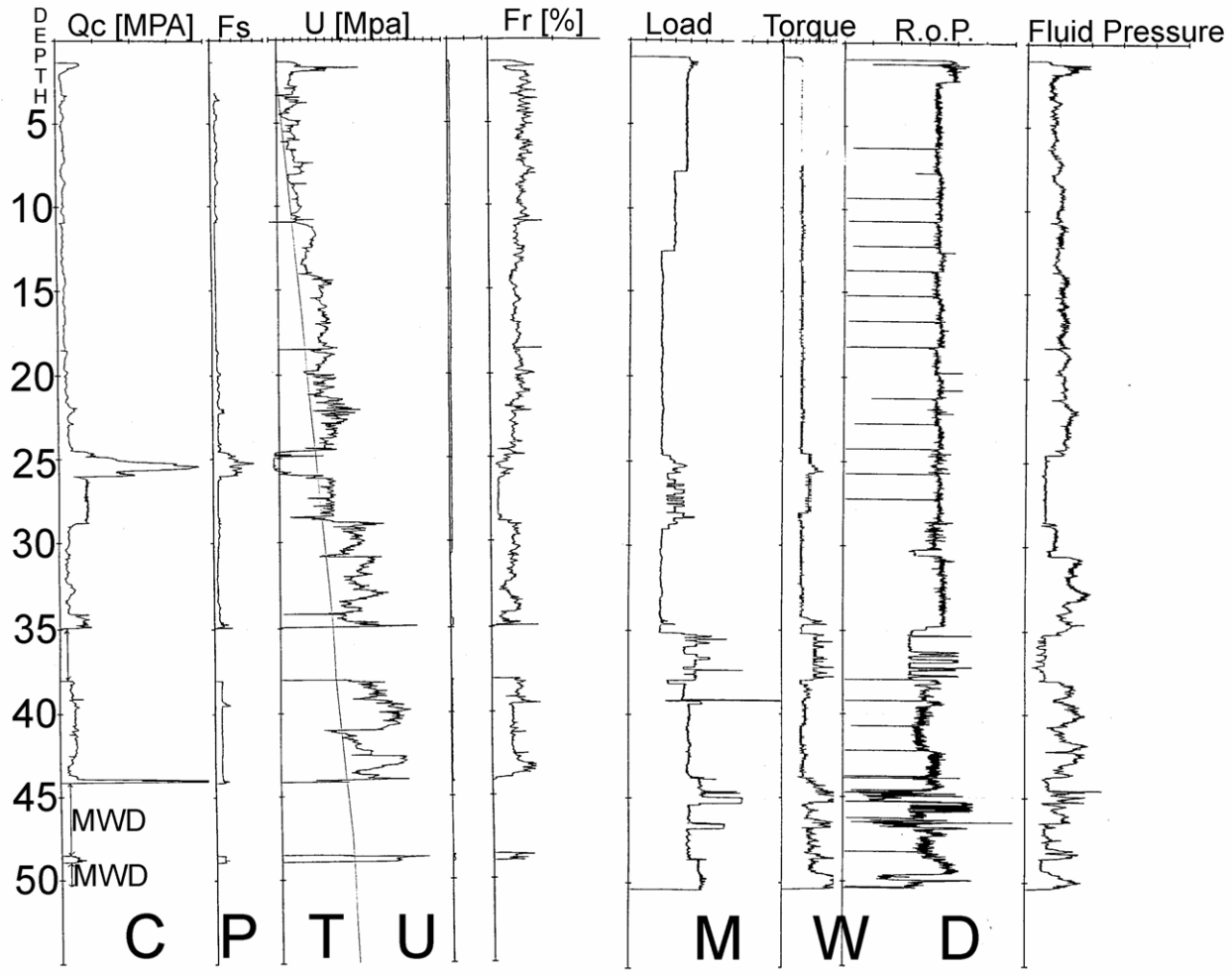
CPTwd-BARREL BIT (rotating part)

From M.Sachetto,2001

CPTU while drilling

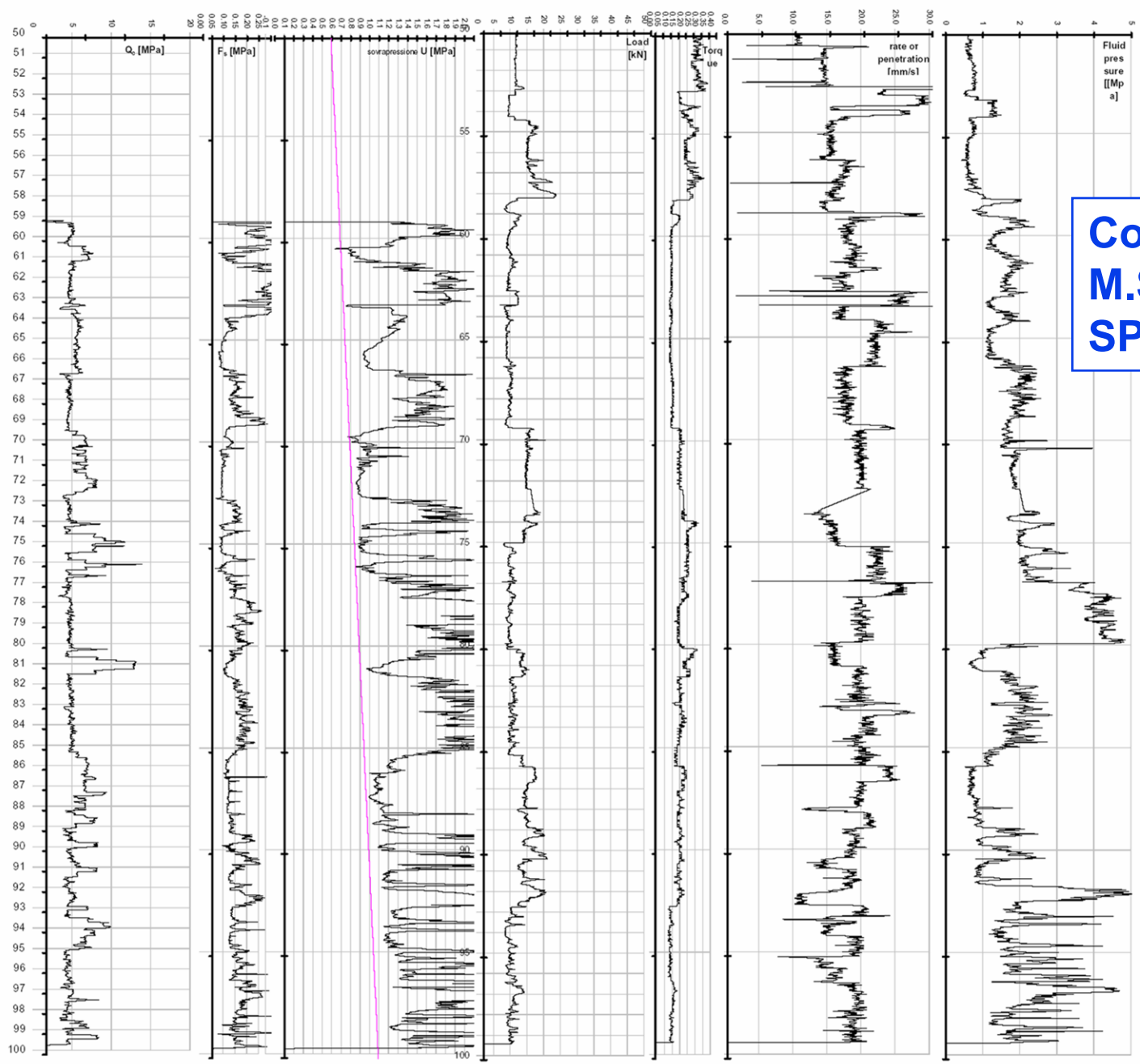
After M.Sachetto(2001)

Result from CPTU while drilling



From Sachetto(2001)

Result of CPTUWD – Bologna, Italy, 2005



Courtesy of M.Sachetto, SPG, Italy

CPT/CPTU MEASUREMENT SYSTEM

- Depth measurement
- Cone resistance/sleeve friction strain gauge load cells
- Pore pressure - pressure sensors
- Data acquisition

CPT/CPTU MEASUREMENT SYSTEM

- **Depth measurement**
- **Cone resistance/sleeve friction strain gauge load cells**
- **Pore pressure - pressure sensors**
- **Data acquisition**

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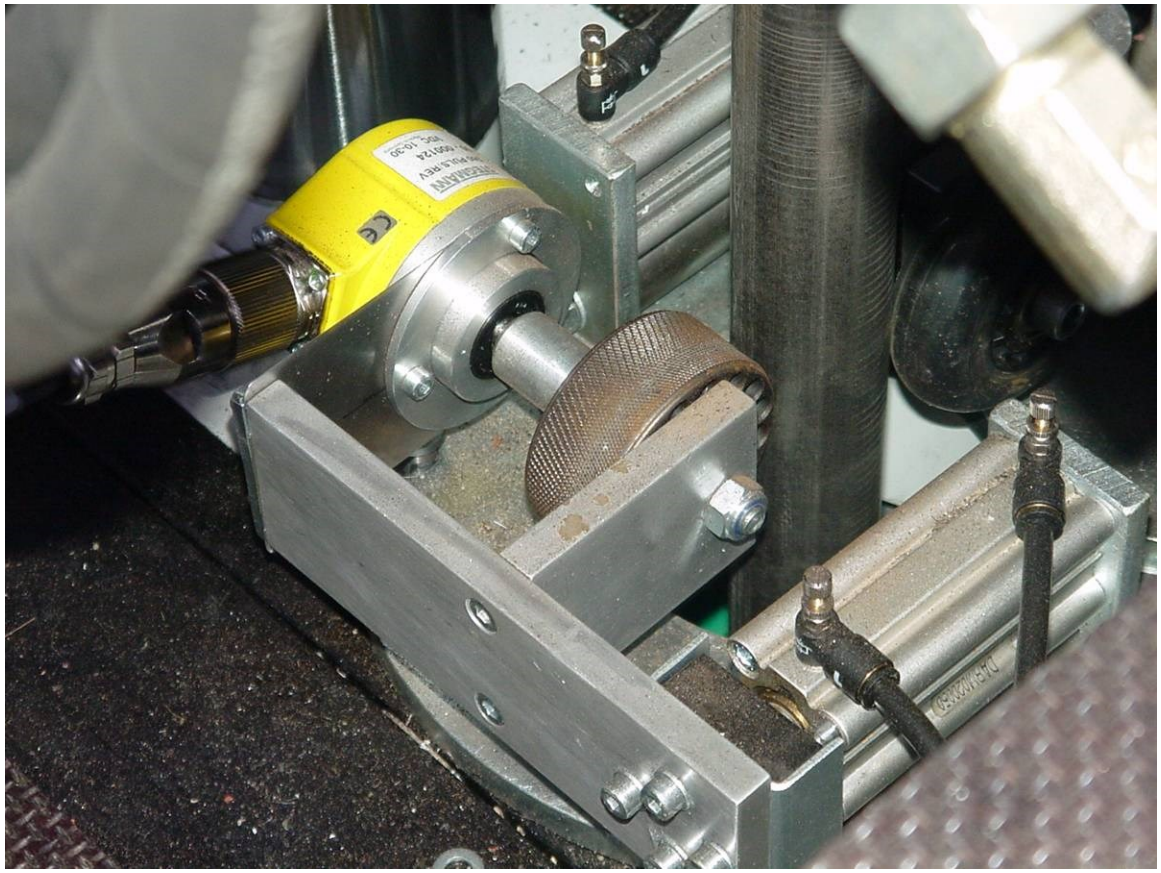
EXAMPLE OF DEPTH REGISTRATION SYSTEM

EXAMPLE OF DEPTH REGISTRATION SYSTEM

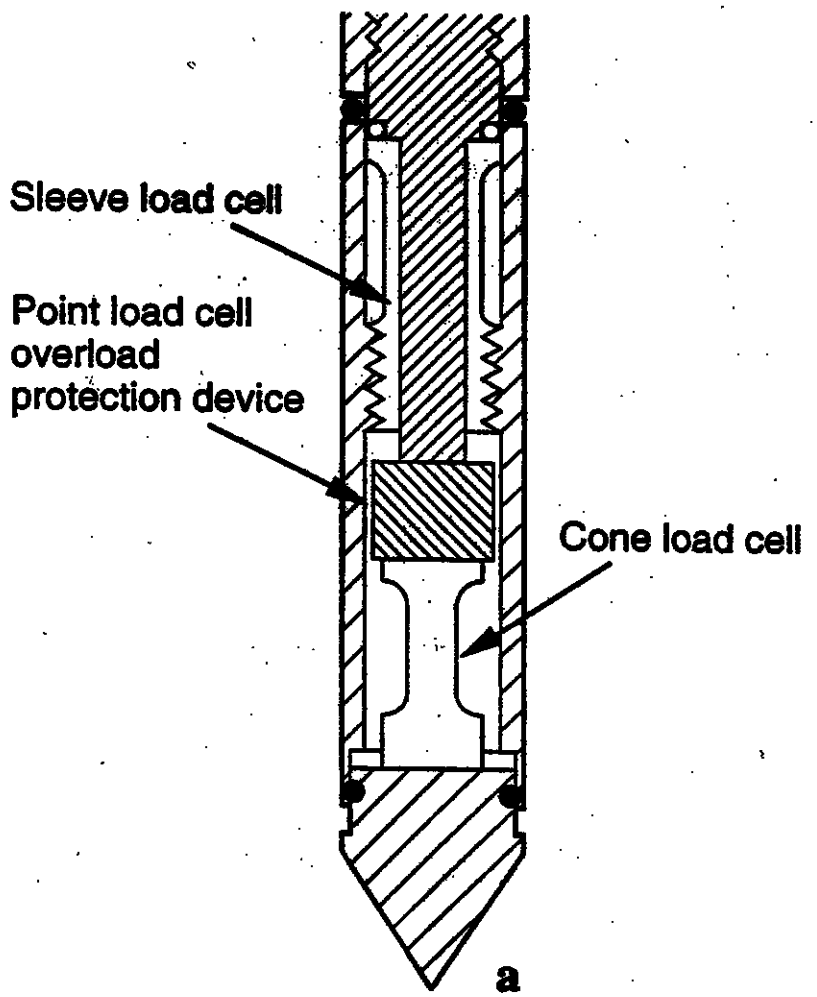


Courtesy of APvandenBerg

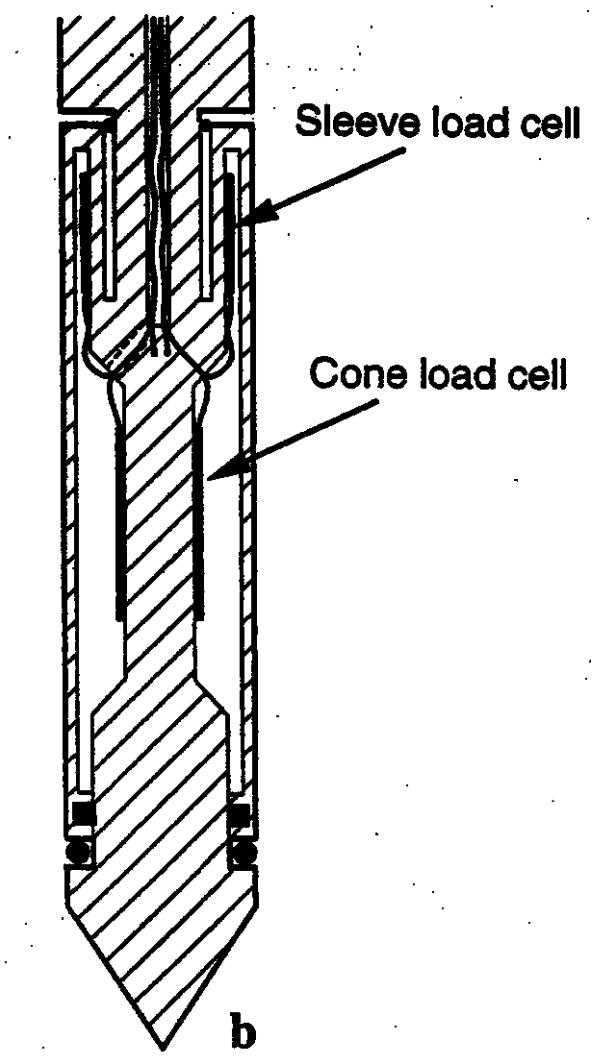
CPT/CPTU MEASUREMENT SYSTEM

- Depth measurement
- Cone resistance/sleeve friction strain gauge load cells
- Pore pressure - pressure sensors
- Data acquisition

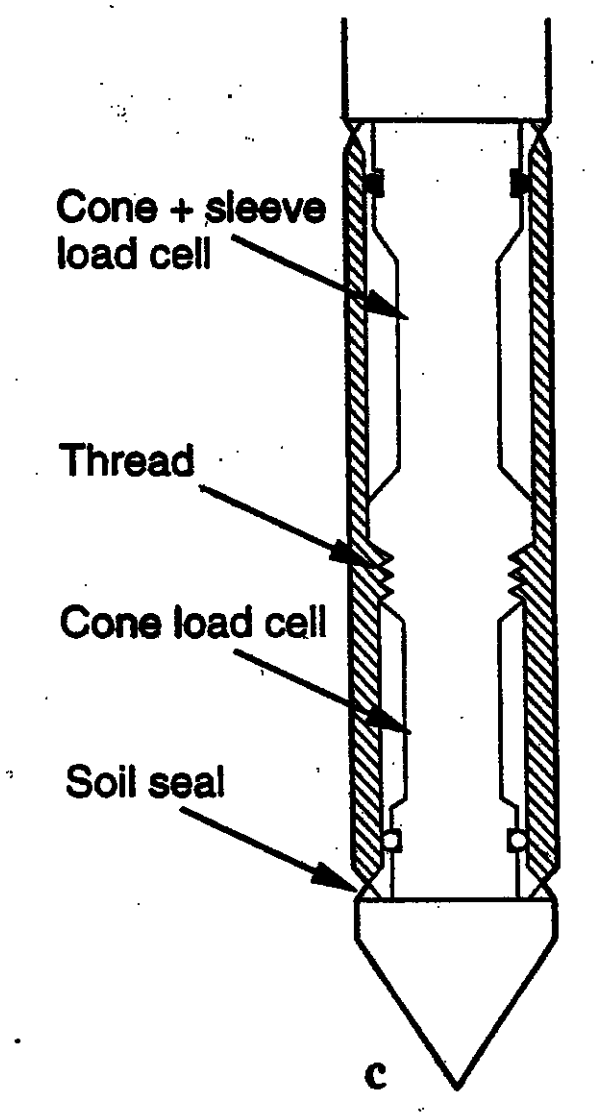
DESIGN OF CONE PENETROMETERS. (a) CONE RESISTANCE AND SLEEVE FRICTION LOAD CELLS IN COMPRESSION



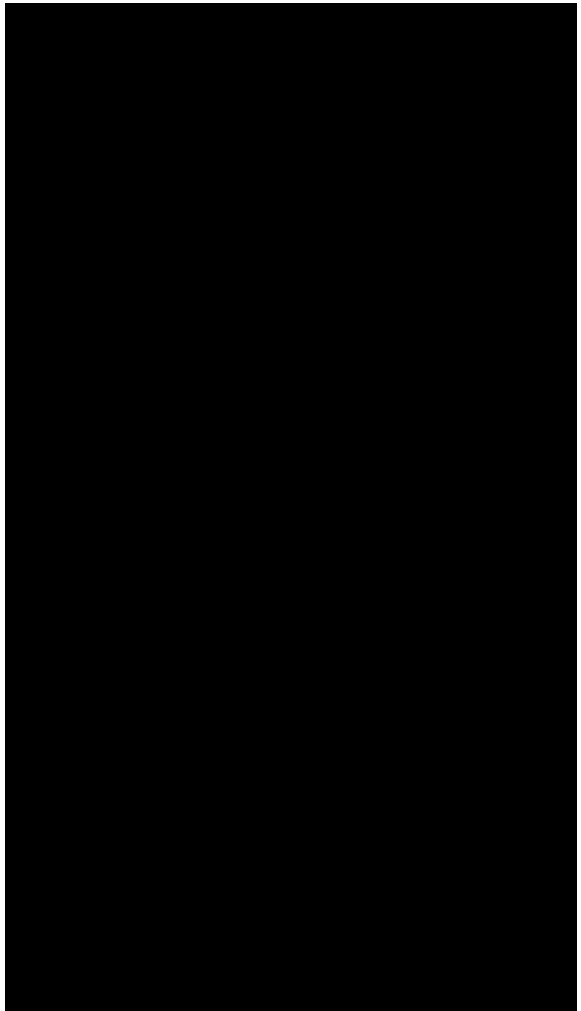
DESIGN OG CONE PENETROMETERS. (b) CONE RESISTANCE LOAD CELL IN COMPRESSION AND SLEEVE FRICTION LOAD CELL IN TENSION



DESIGN OF CONE PENETROMETERS. (c) SUBSTRACTION TYPE CONE PENETROMETER.



Typical piezocone with two separate load cells for cone resistance and sleeve friction and a pressure transducer for pore pressure measurements



CPT/CPTU MEASUREMENT SYSTEM

- **Cone resistance/sleeve friction strain gauge load cells**
- **Pore pressure - pressure sensors**
- **Data acquisition**
  - ***Transmission via cable***
  - ***Acoustic transmission***
  - ***Storing data in memory mode***

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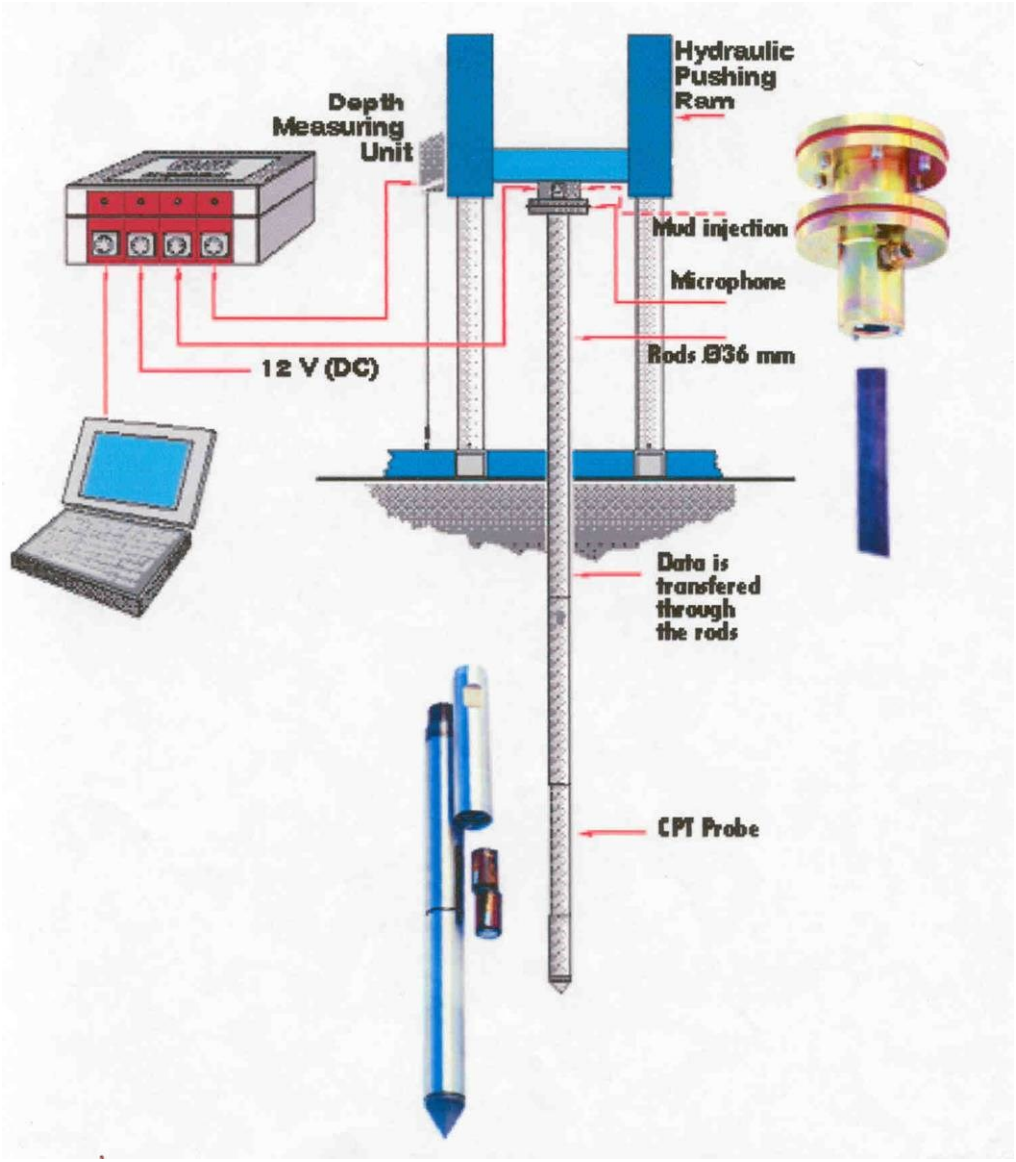
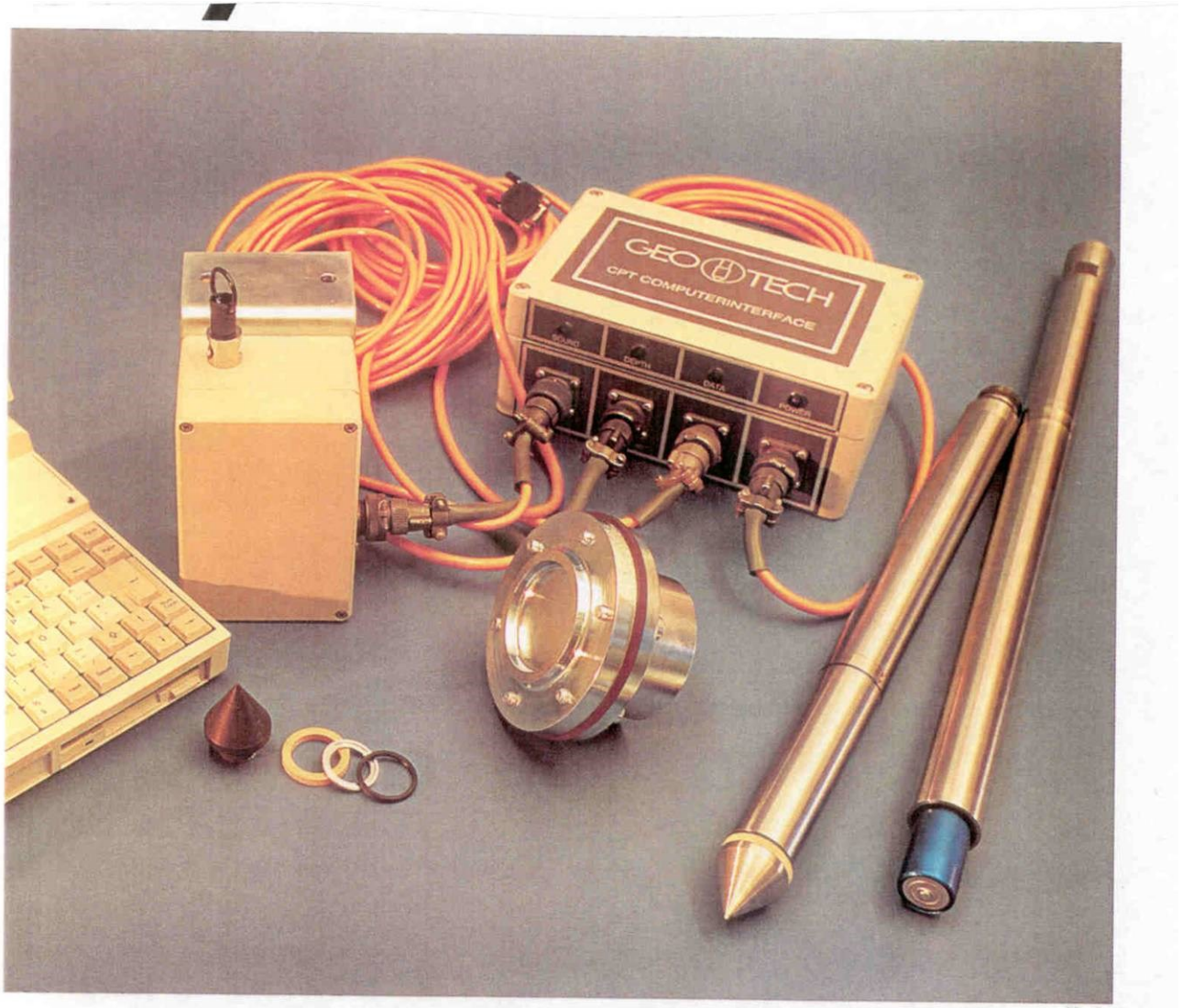
CPT/CPTU MEASUREMENT SYSTEM

GEOTECH'S SYSTEM WITH ACOUSTIC TRANSMISSION OF SIGNALS

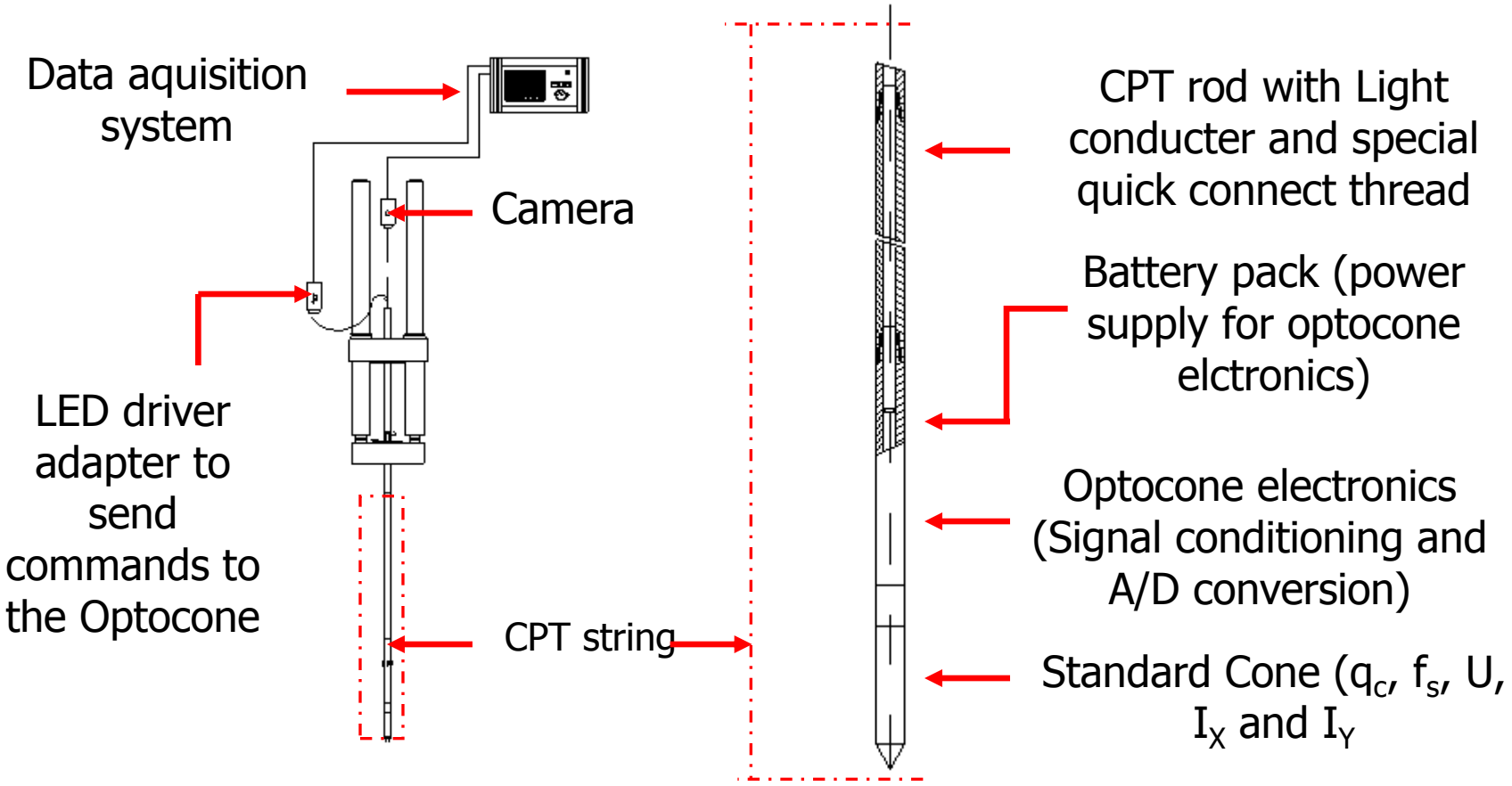


GEOTECH'S SYSTEM WITH ACOUSTIC TRANSMISSION OF SIGNALS



Geotech's wireless CPT-system,
a different solution

Schematic overview Optocone® System



ProductInfo

Envi™ Memocone II CPT Probe

- *Flexible - cordless or with cable*
- *Measuring point resistance, local sleeve friction and pore pressure*
- *Easy storage of data*
- *Easy calibration of probe*
- *Fulfils highest ISSMFE class*
- *Used world-wide*

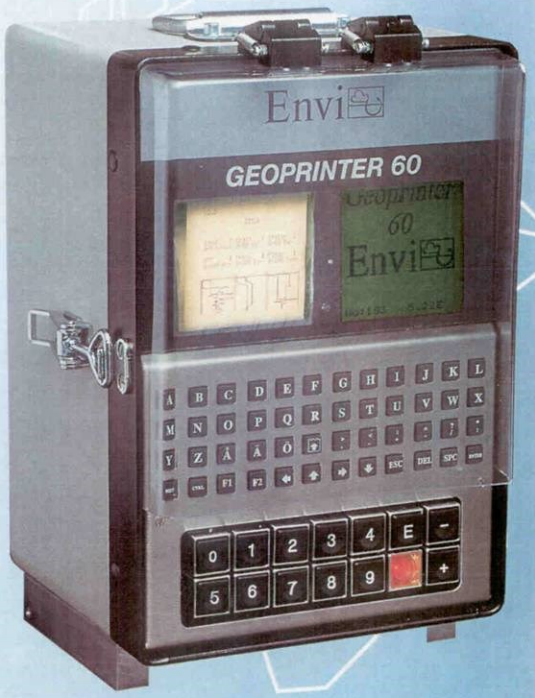
Envi Memocone II

ProductInfo

Envi™ Geoprinter 60
Drilling parameters, CPT data collector and printer 22 channels

Programmable for a number of methods:

- *CPTu sounding*
- *Tunnel grouthole probing*
- *Jet grouting*
- *Percussive drilling*
- *Penetration testing*
- *Diamond core drilling*
- *SPT Sounding*
- *Dynamic Testing DIN*
- *Quality Control of Lime Columns*
- *Ram sounding*



Wheather proof instrument

Easy to install on all drillrigs

Easy to adapt to all methods

Envi Geoprinter 60

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History,Equipment etc

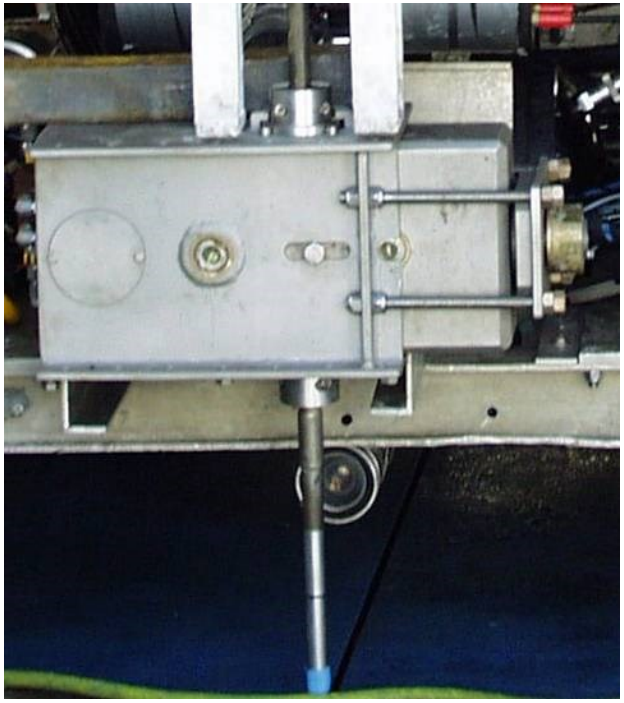
- Over last 50 years CPT/CPTU has developed into very efficient technology
- We now have very well developed equipment for testing onshore, nearshore, offshore

GEO "CPT-ROV"

CPT thrust unit

Weight: 110kg

Capacity: 15kN



Electronic unit

Weight: 30kg

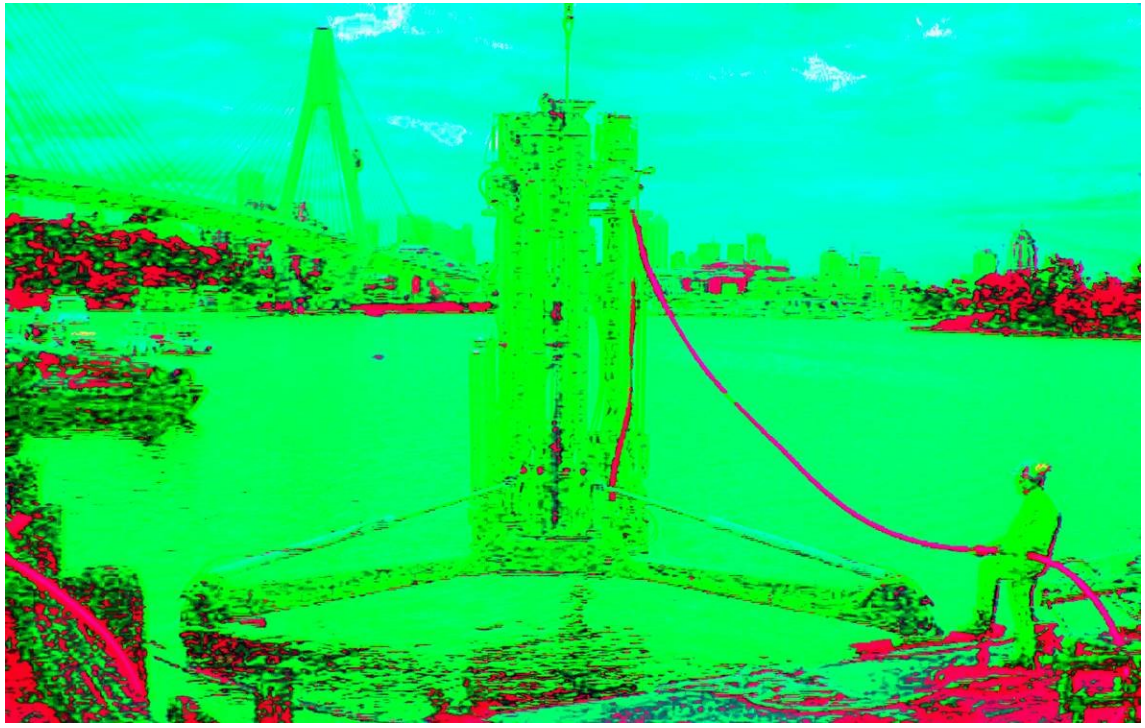
BENTHIC GEOTECH
PTY LTD

Portable

Remotely

Operated

Drill



NGI

EXAMPLE OF DEPTH REGISTRATION SYSTEM