

Dredging Processes

Dr.ir. Sape A. Miedema

2. Soil Mechanics





[1]

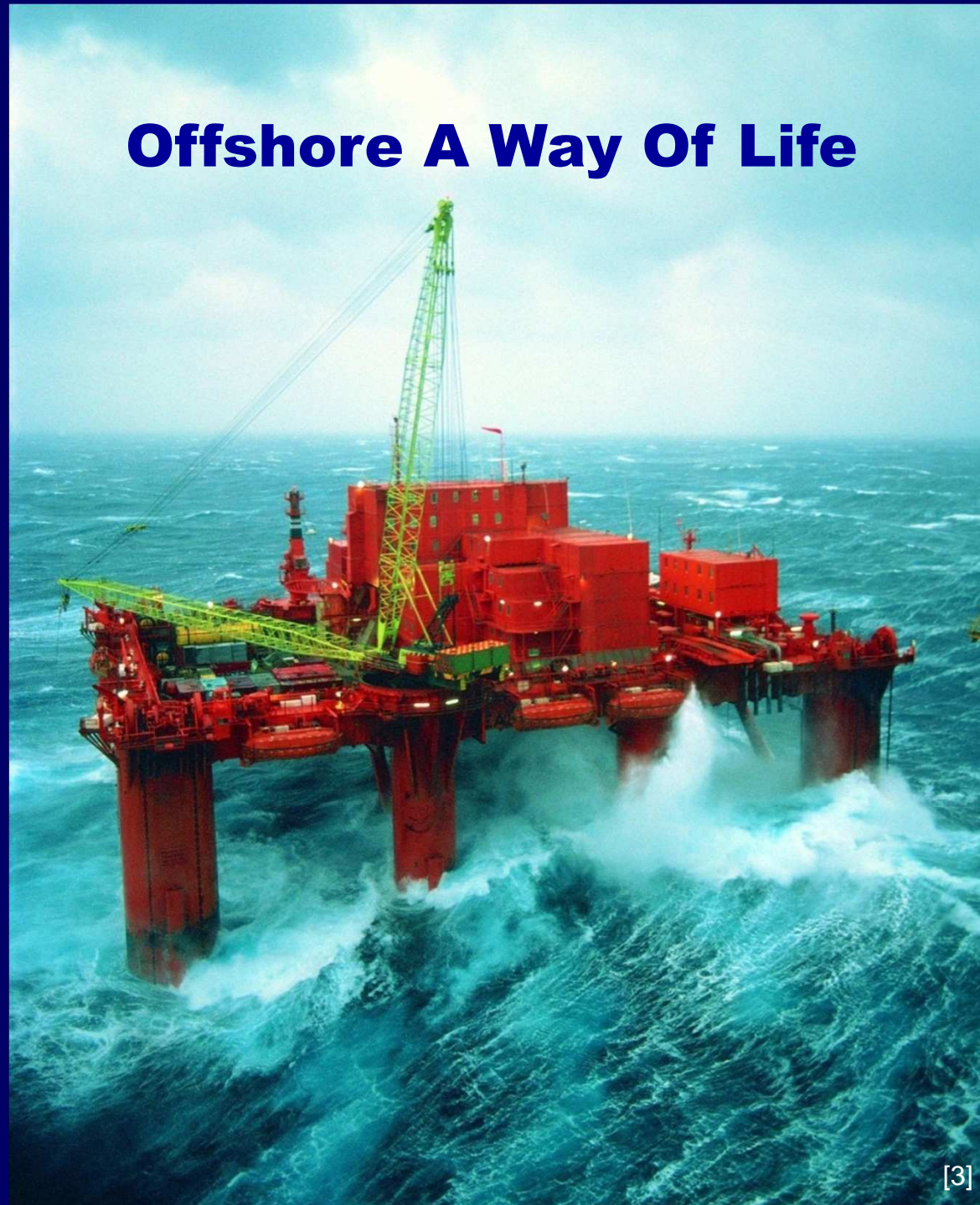
Dredging A Way Of Life





[2]

Offshore A Way Of Life



[3]

Offshore & Dredging Engineering

Dr.ir. Sape A. Miedema
Educational Director





Soils

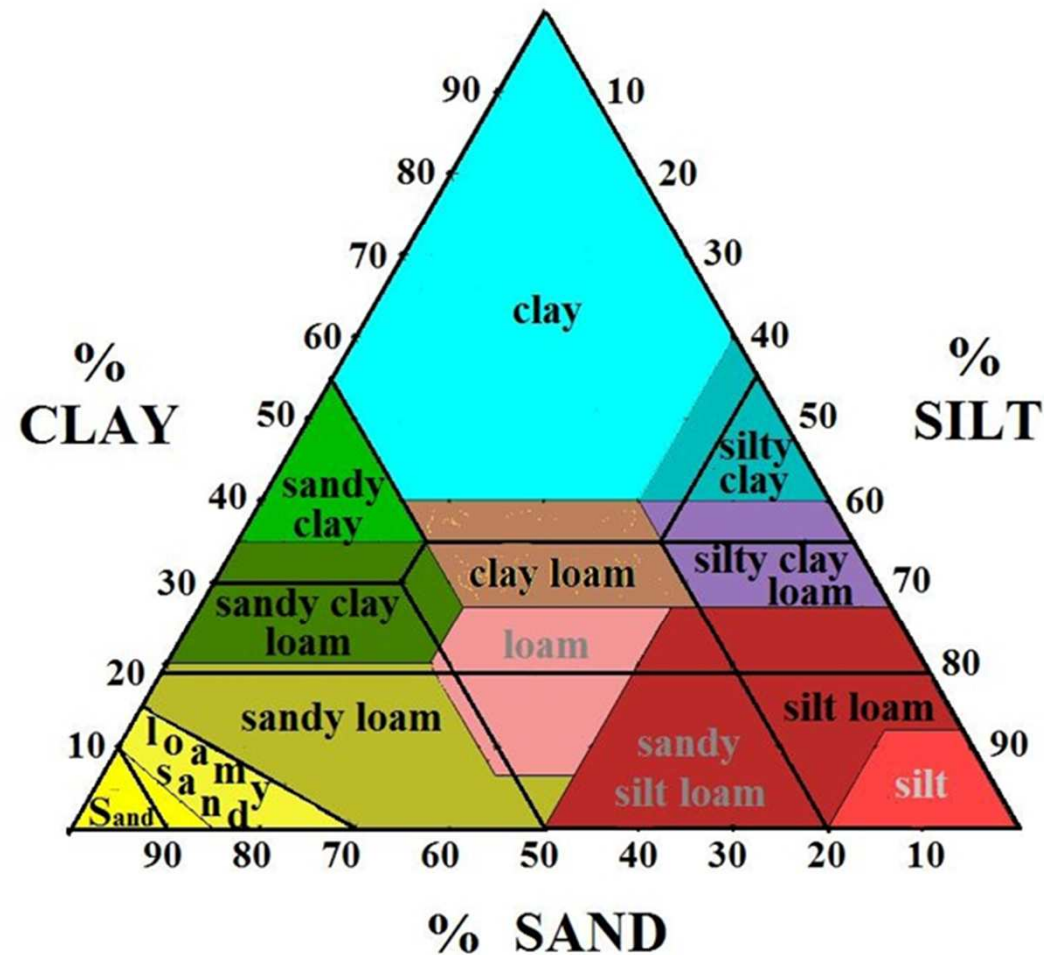
Soil Creation



[4]

Soil Classification

A soil textural triangle showing the subtle differences between the USDA (colours) and UK- ADAS (black lines) soil classes



[5]

Soil Classification

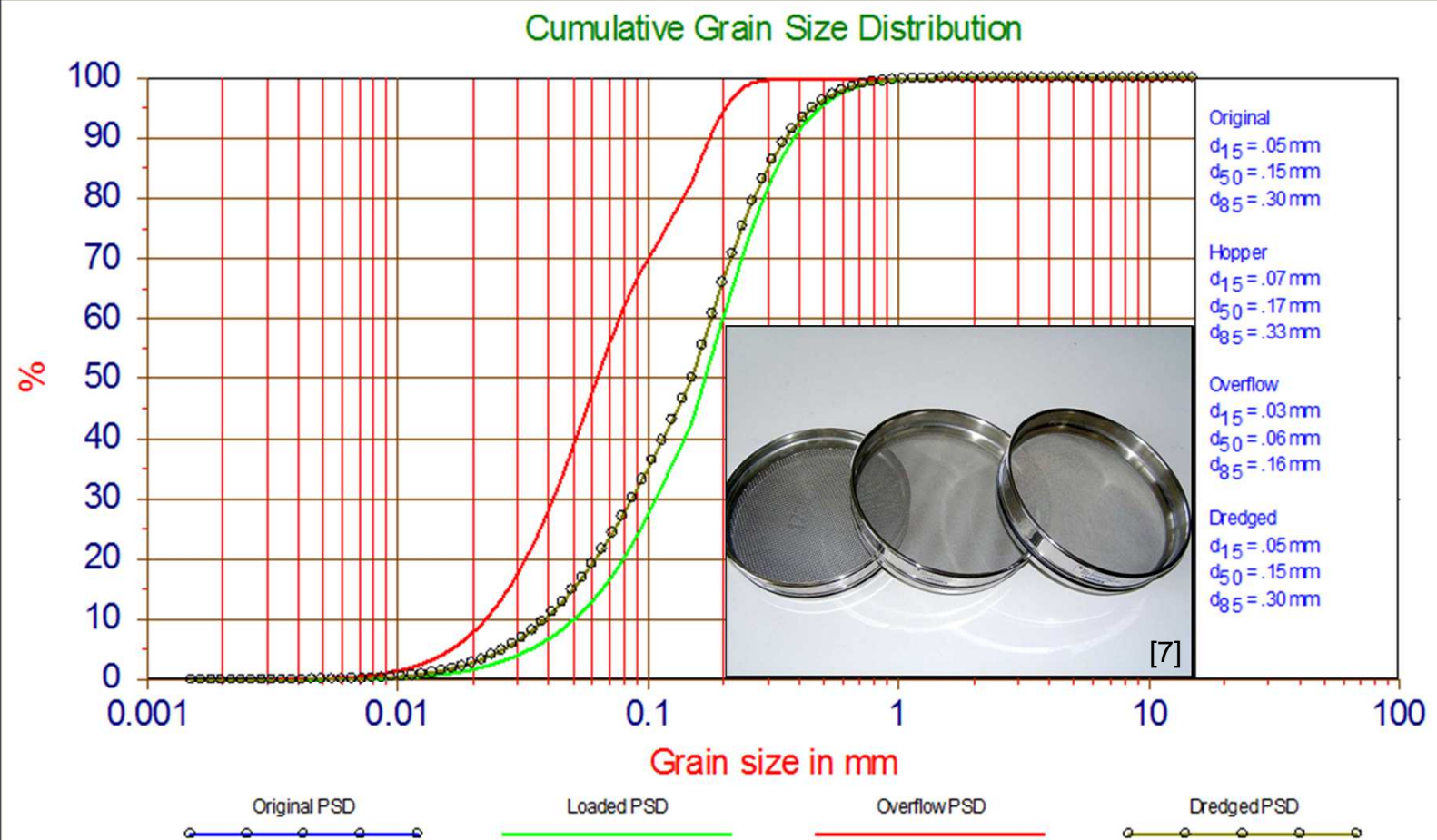
Name of soil separate	Diameter limits (mm) (<u>USDA</u> classification)
Clay	less than 0.002
Silt	0.002–0.05
Very fine sand	0.05–0.10
Fine sand	0.10–0.25
Medium sand	0.25–0.50
Coarse sand	0.50–1.00
Very coarse sand	1.00–2.00



Rock Classification

GRAIN SIZE (mm)	Bedded rocks SEDIMENTARY					Foliated rocks METAMORPHIC		Massive and crystalline rocks IGNEOUS				GRAIN SIZE (mm)
Coarse 2	RUDACEOUS CONGLOMERATE (rounded particles in a finer matrix) BRECCIA (angular particles in a finer matrix)	calcarudite	conglomerate limestone	Dolomite	Halite, gypsum, anhydrite	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands MIGMATITE mixture of gneiss and veins of igneous rock	Sometimes massive	GRANITE (1,2)	DIORITE (1,2)	GABBRO (1,3)	PERIDOTITE	Coarse 2
Medium 0.6 - 0.2 - 0.06	ARENACEOUS SANDSTONES (Quartz) ARENITE Quartz grains and siliceous cement (Quartz) ARKOSE Many feldspar grains usually with some mica (Quartz)(grey) WACKE Many rock chips CEMENTED VOLCANICASH	calcarearenite	CLASTIC LIMESTONE detrital limestone	CRYSTALLINE LIMESTONE & Dolomite	Halite, gypsum, anhydrite	SCHIST Well developed foliation generally much mica	METAMORPHOSED LIMESTONE (Marble)	MICRO-GRANITE (1,2) (Porphyry)*	MICRO-DIORITE (1,2) (Porphyry)*	DOLERITE (3) (Porphyry)*		Medium 0.06
Fine 0.002	ARGILLACEOUS SILTSTONE Mostly silt CLAYSTONE Mostly clay (massive texture) SHALES (fissile texture)	calcareous calcisiltite	fine grained limestone	COAL & LIGNITE	EVAPORITES	PHYLLITE Closely spaced foliation, mica luster, but crystals not visible with hand lens SLATE narrow spaced well developed plane of foliation, (mica is absent)	SERPENTINITE AMPHIBOLITE HORNFELLS QUARTZITE	RHYOLITE (3,4)	ANDESITE (3,4)	BASALT (3,4)		Fine 0.002
Amorphous	Flint, Chert	weak ROCK	strong ROCK			Mylonite		Obsidian				Amorphous
CLASTIC		CRYSTALLINE		Organic	CRYSTALLINE							
SILICEOUS		CALCAREOUS		Carbonaceous	Foliated rocks may be layered or banded. This banding may be undulating or contorted, except in the case of slates where it may be exactly parallel. Metamorphic rocks often split easily along foliation planes.							
GENERAL NOTES: Bedding in sedimentary rocks may not, because of its spacing, be seen in hand specimen but only in outcrop. Fossils may be found in sedimentary rocks. The mineral calcite, in calcareous rocks, may be scratched with a knife, and will react with dilute hydrochloric acid. Quartz scratches steel. Broken crystals in crystalline rocks reflect light. * siliceous and calcareous components are present (e.g. siliceous fine grained limestone)					MODE OF OCCURRENCE OF IGNEOUS ROCKS: 1. Batholiths 2. Stocks 3. Sills and dykes 4. Lava flows * Porphyries are rocks in which some mineral grains are very much larger than the surrounding matrix. All igneous rocks can be "porphyritic".							

Particle Size Distribution



Trailing Suction Hopper Dredge V1.4.3, August 02, 2011, 14:58:35
 Manhattan Island (C:\ProgramFiles\Trailing Suction Hopper Dredge\TSHDGLDD\Manhattan Island.Inp)
 Excercise (C:\ProgramFiles\Trailing Suction Hopper Dredge\SandNagsHead 0.413(0.712).Inp)
 Optimum production: 2493 TDS, loaded in: 30.5 min, overflow losses: 542 TDS





Parameters

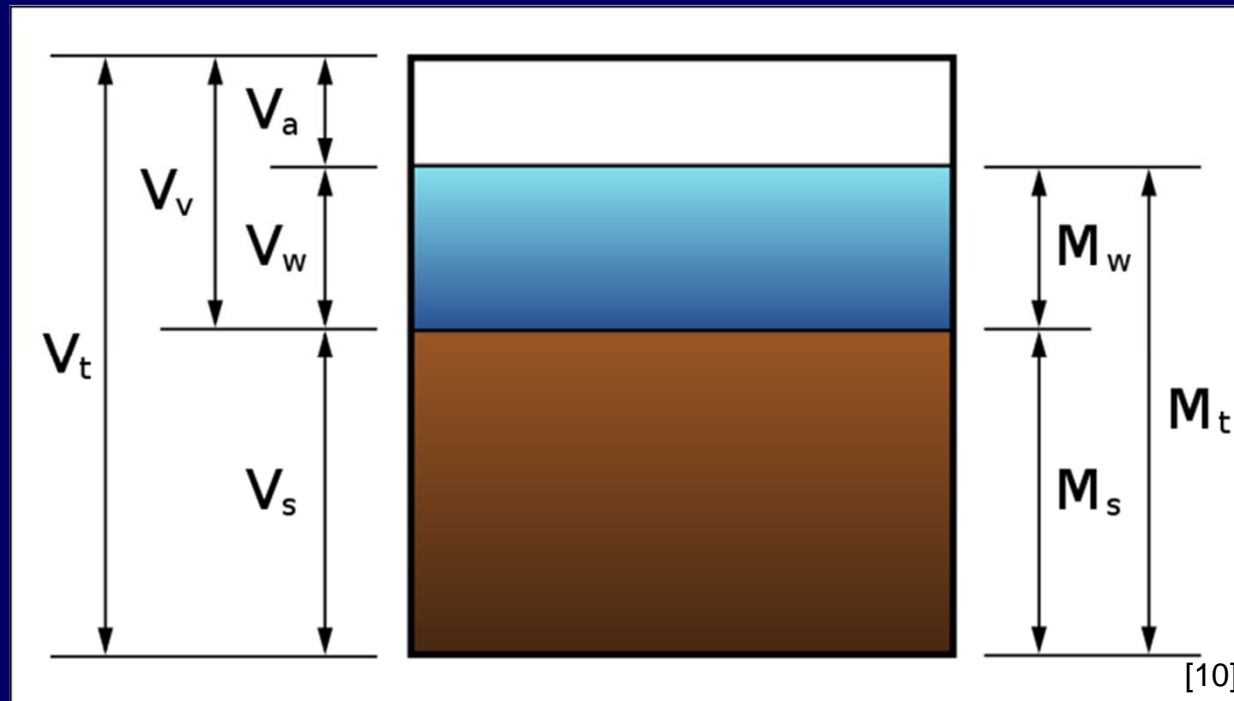
Atterberg Limits



Plastic Limit
Liquid Limit

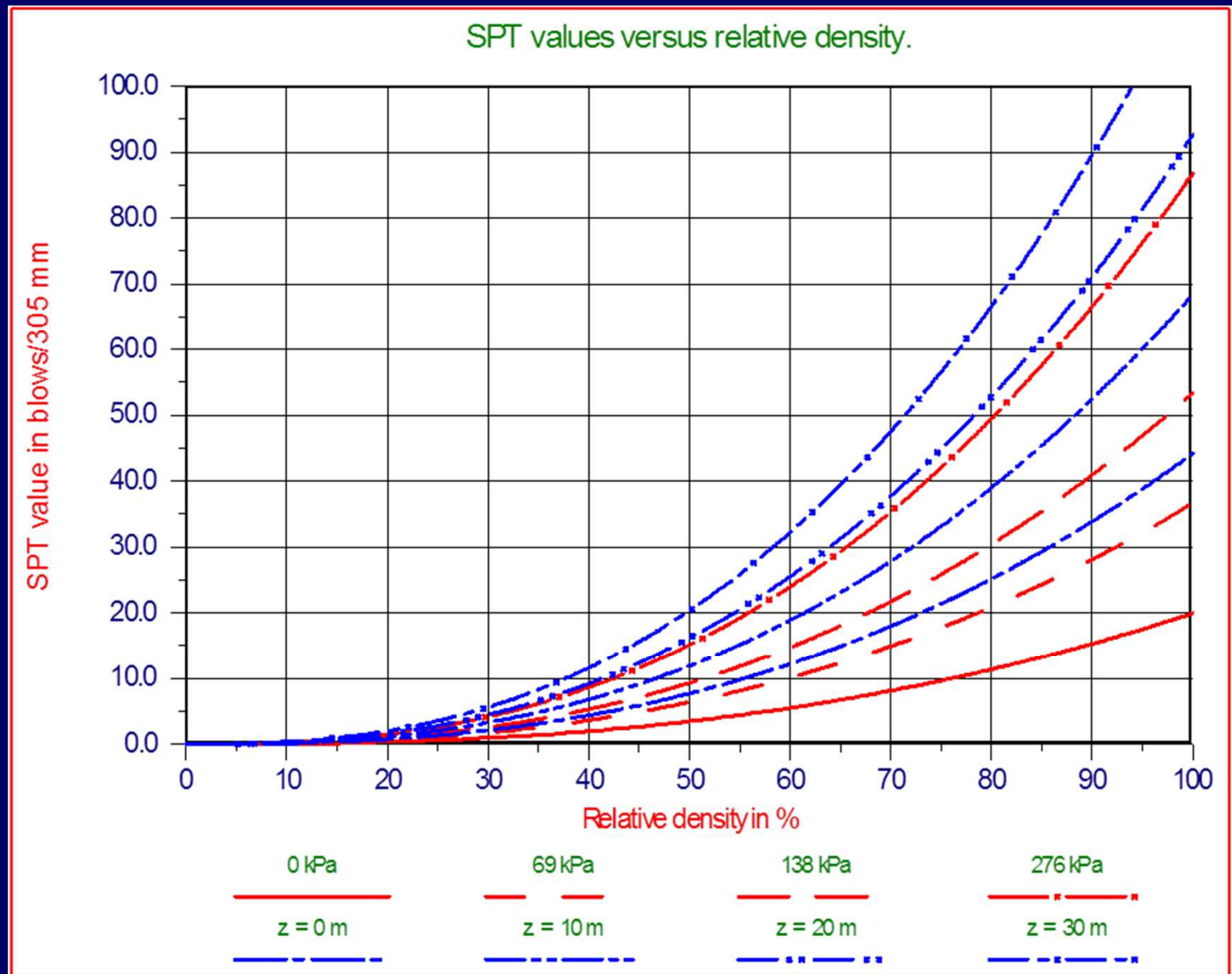


Mass Volume Relations



Density
Specific Gravity
Relative Density
Porosity – Void Ratio

Relative Density vs SPT Value



Permeability

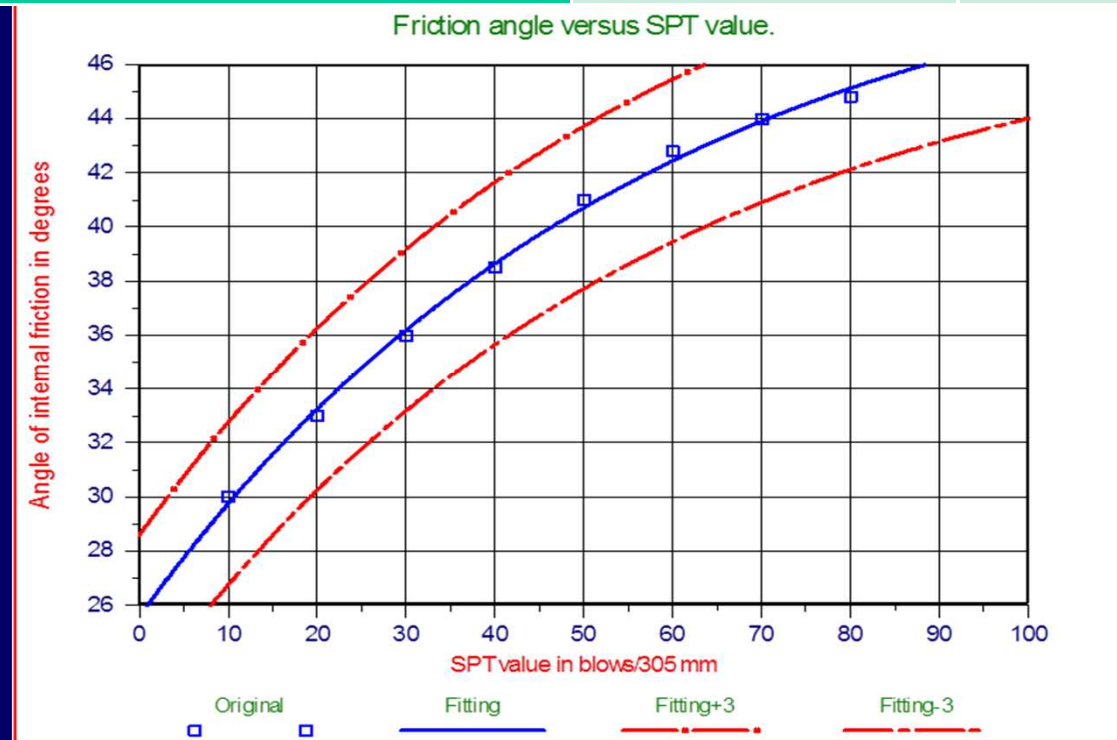
k (cm/s)	10 ²	10 ¹	10 ⁰ =1	10 ⁻¹	10 ⁻²	10 ⁻³	10 ⁻⁴	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸	10 ⁻⁹	10 ⁻¹⁰
k (ft/day)	10 ⁵	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷
Relative Permeability	Pervious				Semi-Pervious				Impervious				
Aquifer	Good				Poor				None				
Unconsolidated Sand & Gravel	Well Sorted Gravel	Well Sorted Sand or Sand & Gravel			Very Fine Sand, Silt, Loess, Loam								
Unconsolidated Clay & Organic					Peat		Layered Clay		Fat / Unweathered Clay				
Consolidated Rocks	Highly Fractured Rocks				Oil Reservoir Rocks		Fresh Sandstone		Fresh Limestone, Dolomite		Fresh Granite		

Permeability	Pervious				Semi-Pervious				Impervious				
Unconsolidated Sand & Gravel	Well Sorted Gravel	Well Sorted Sand or Sand & Gravel			Very Fine Sand, Silt, Loess, Loam								
Unconsolidated Clay & Organic					Peat		Layered Clay		Unweathered Clay				
Consolidated Rocks	Highly Fractured Rocks				Oil Reservoir Rocks			Fresh Sandstone		Fresh Limestone, Dolomite		Fresh Granite	
K (cm ²)	0.001	0.0001	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸	10 ⁻⁹	10 ⁻¹⁰	10 ⁻¹¹	10 ⁻¹²	10 ⁻¹³	10 ⁻¹⁴	10 ⁻¹⁵
K (millidarcy)	10 ⁺⁸	10 ⁺⁷	10 ⁺⁶	10 ⁺⁵	10,000	1,000	100	10	1	0.1	0.01	0.001	0.0001

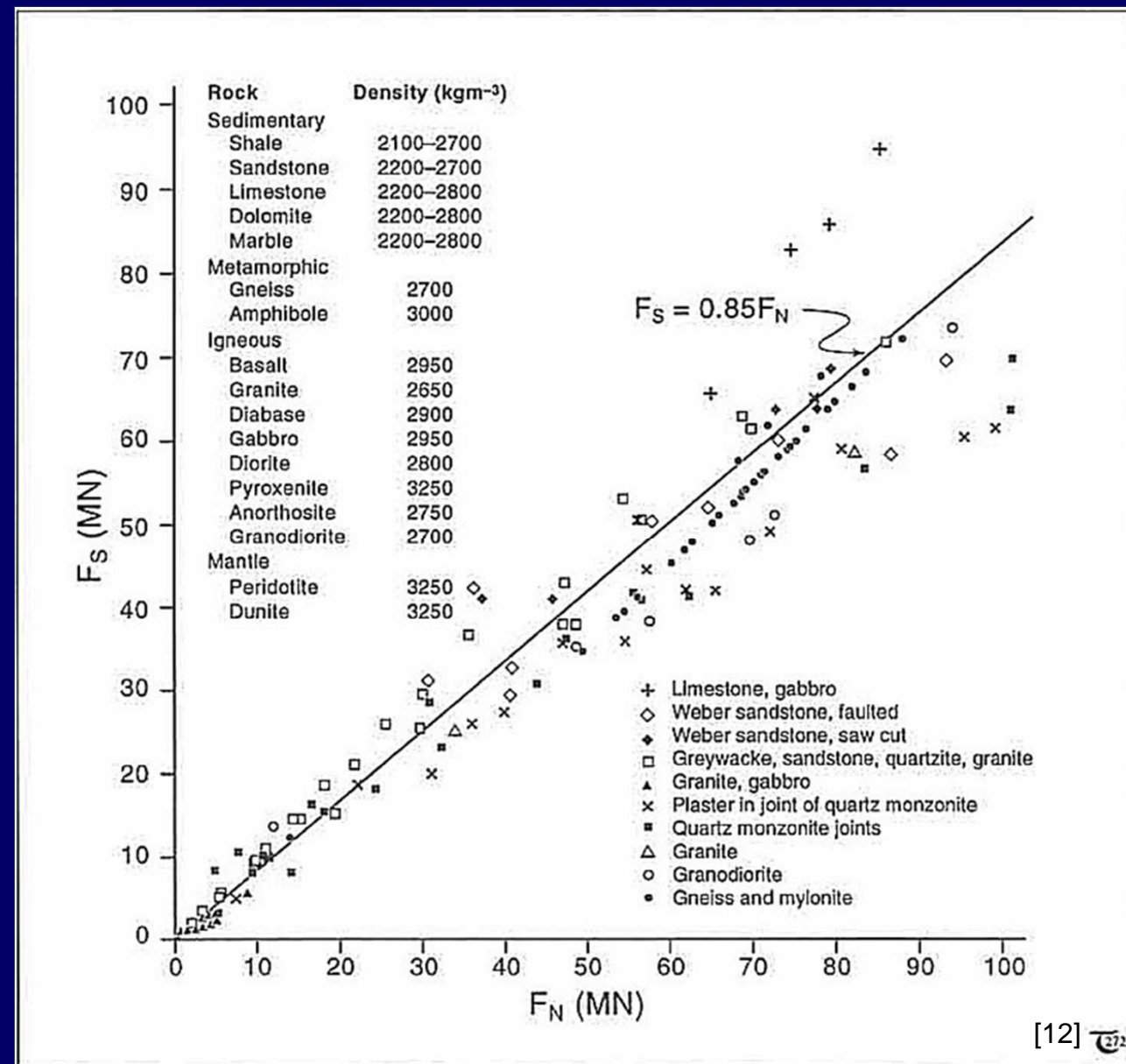
[11]

Angle of Internal Friction

SPT Penetration, N-Value (blows/foot)	Density of Sand	ϕ (degrees)
<4	Very loose	<29
4 - 10	Loose	29 - 30
10 - 30	Medium	30 - 36
30 - 50	Dense	36 - 41
>50	Very dense	>41



Angle of Internal Friction Rock



Angle of External Friction

20°	steel piles (NAVFAC)
$0.67 \cdot \varphi - 0.83 \cdot \varphi$	USACE
20°	steel (Broms)
$\frac{3}{4} \cdot \varphi$	concrete (Broms)
$\frac{2}{3} \cdot \varphi$	timber (Broms)
$0.67 \cdot \varphi$	Lindeburg
$\frac{2}{3} \cdot \varphi$	for concrete walls (Coulomb)

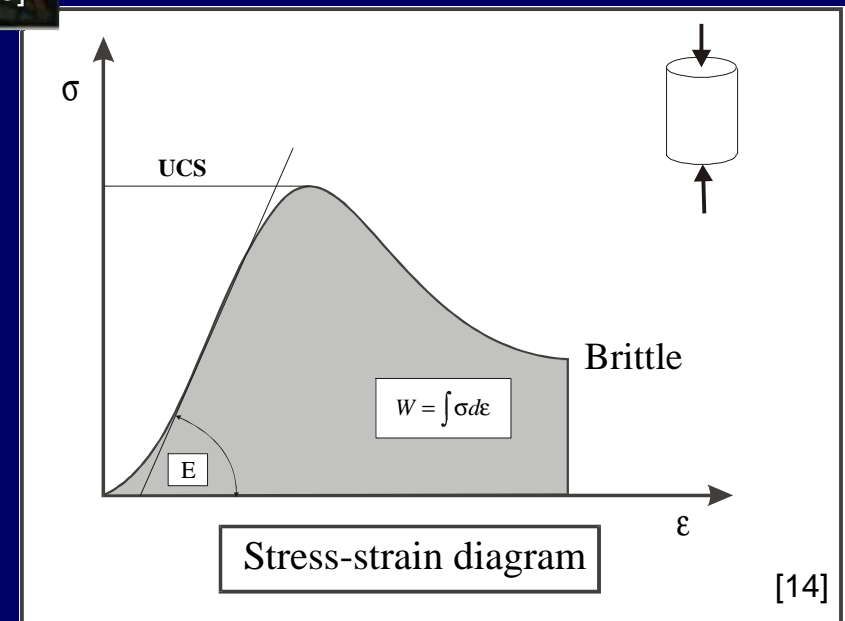


Cohesion/Adhesion

SPT Penetration (blows/ foot)	Estimated Consistency	U.C.S.(kPa)
<2	Very Soft	<24
2 - 4	Soft	24 - 48
4 - 8	Medium	48 - 96
8 - 15	Stiff	96 – 192
15 - 30	Very Stiff	192 – 388
>30	Hard	>388

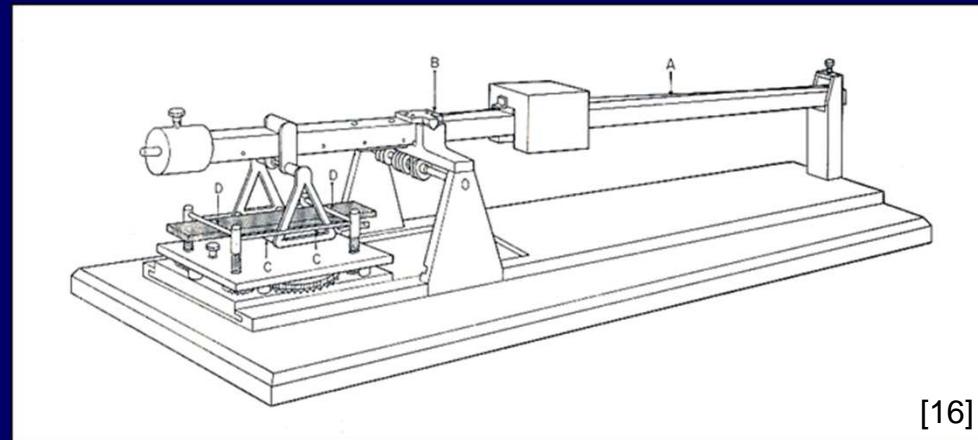
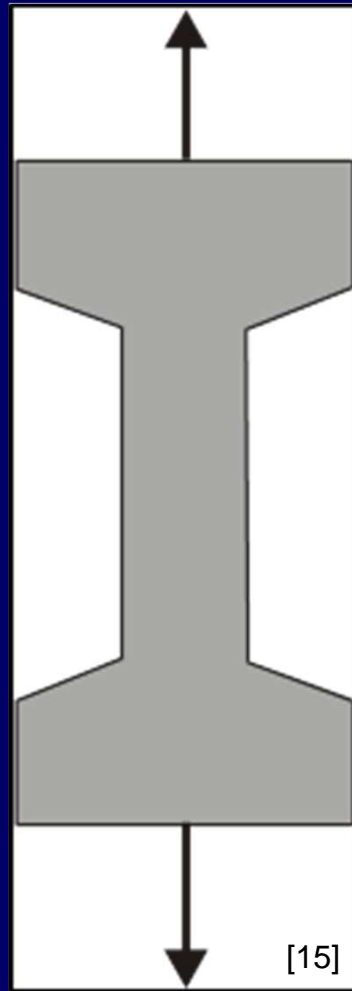


Unconfined Compressive Stress

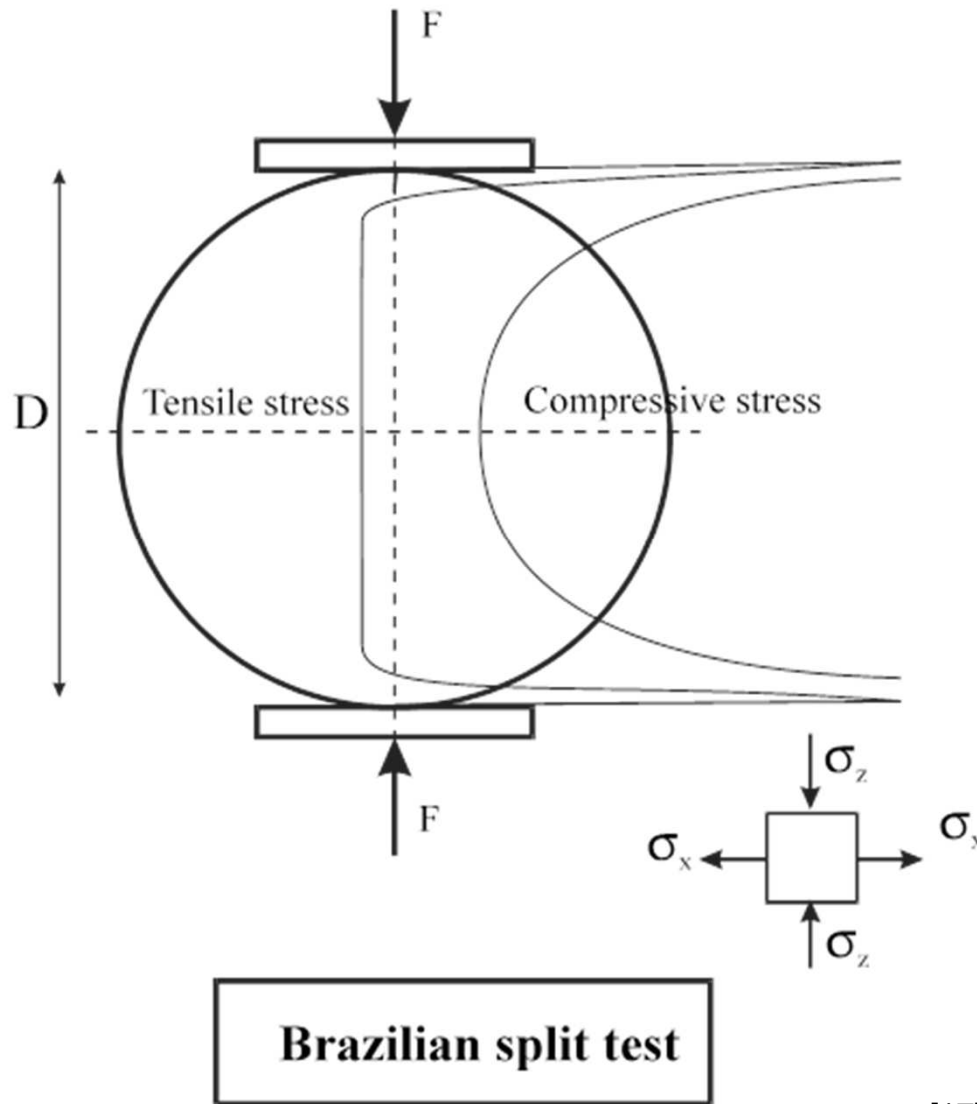


Faculty of 3mE - Dredging Engineering

Unconfined Tensile Strength

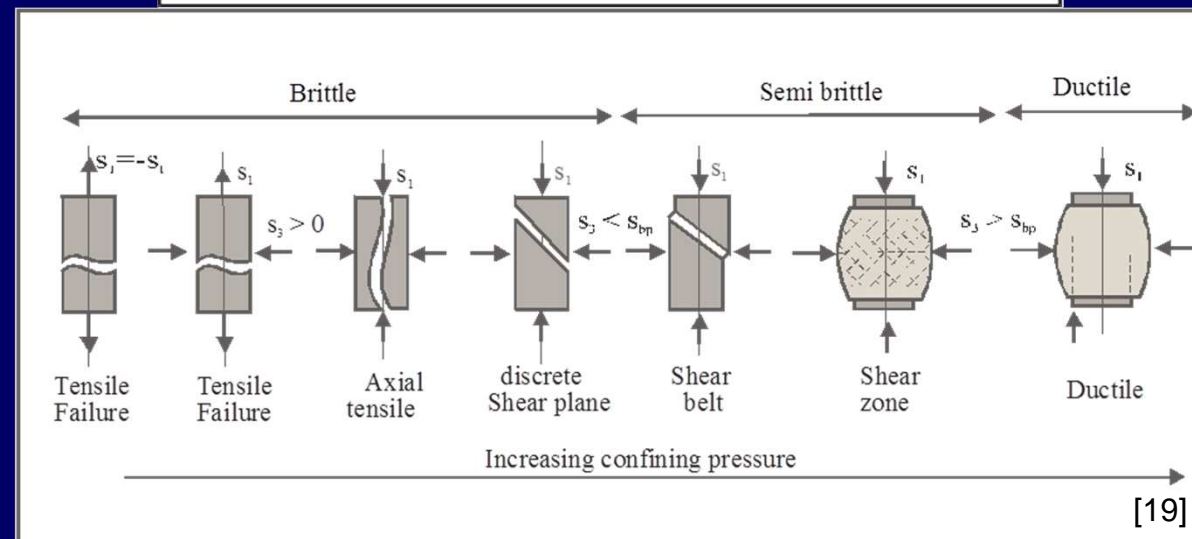
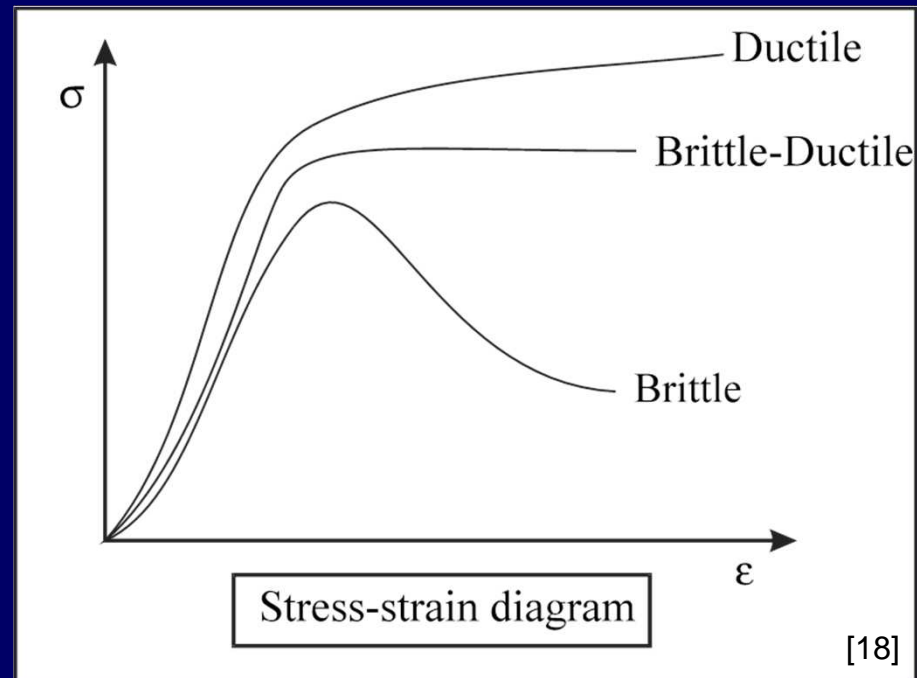


Brazilian Tensile Strength



[17]

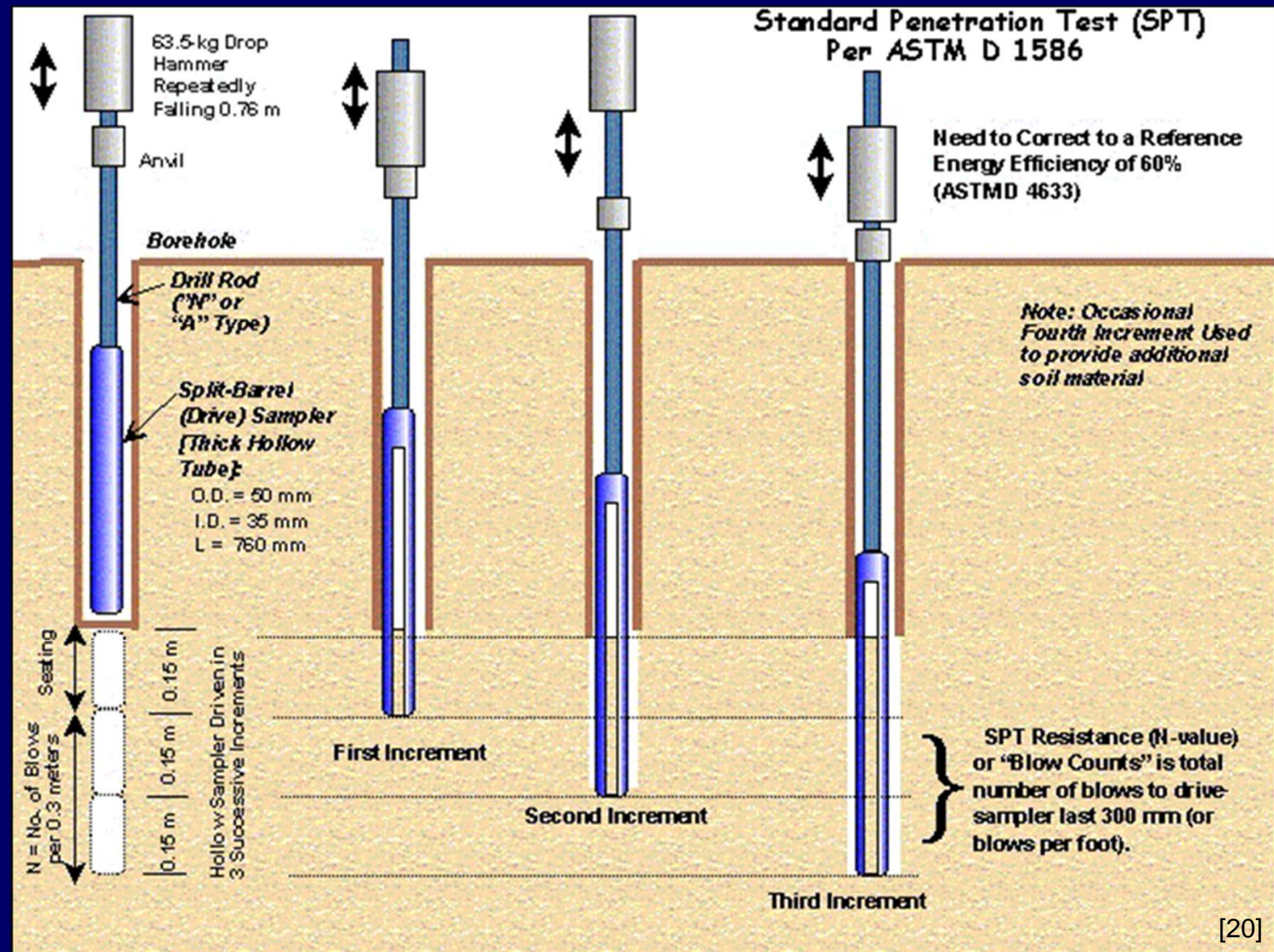
Brittle vs Ductile





Testing

Standard Penetration Test

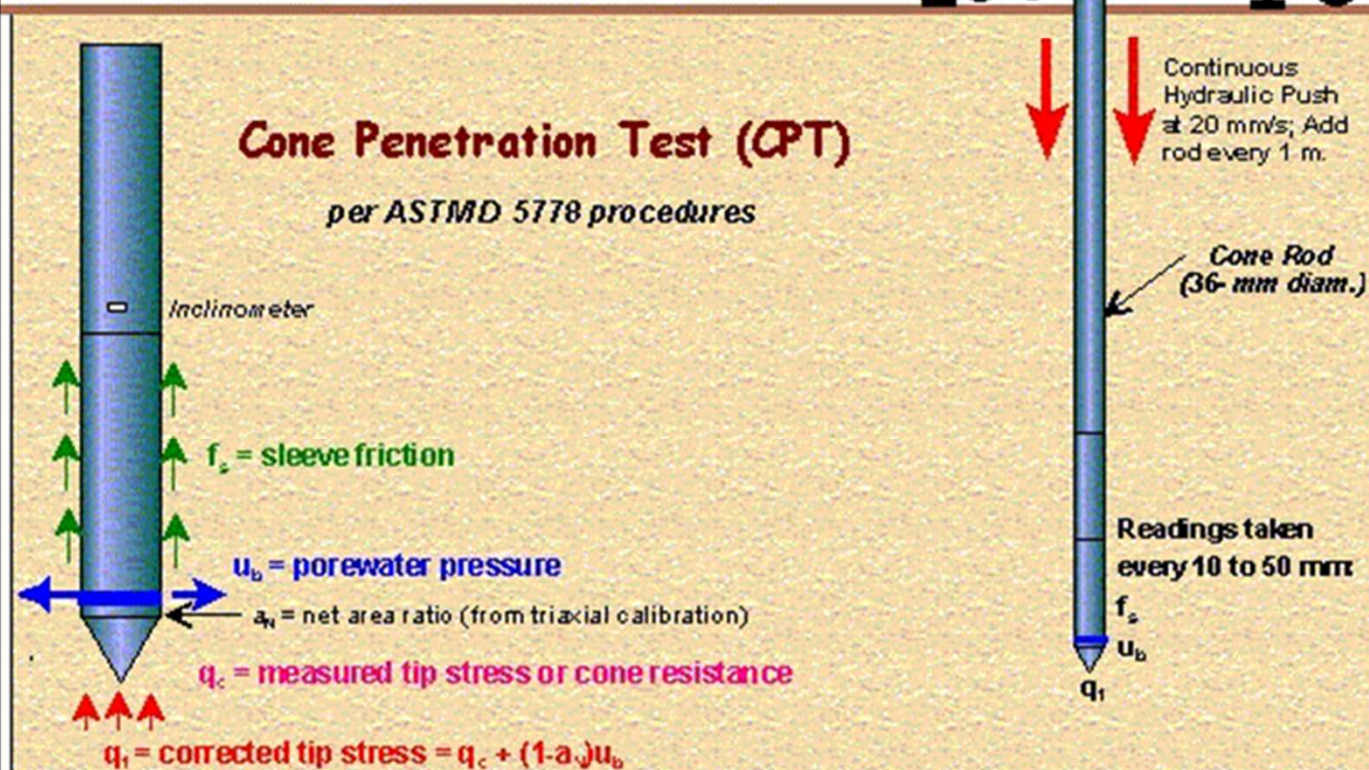


Cone Penetration Test

Electric Cone Penetrometer with 60° Apex:
 $d = 36 \text{ mm}$ (10 cm^2)
 or
 $d = 44 \text{ mm}$ (15 cm^2)

1. Saturation of Cone Tip Cavities and Placement of Pre-Saturated Porous Filter Element.
 2. Obtain Baseline Readings for Tip, Sleeve, Porewater Transducer, & Inclinometer Channels

Cable to Computer



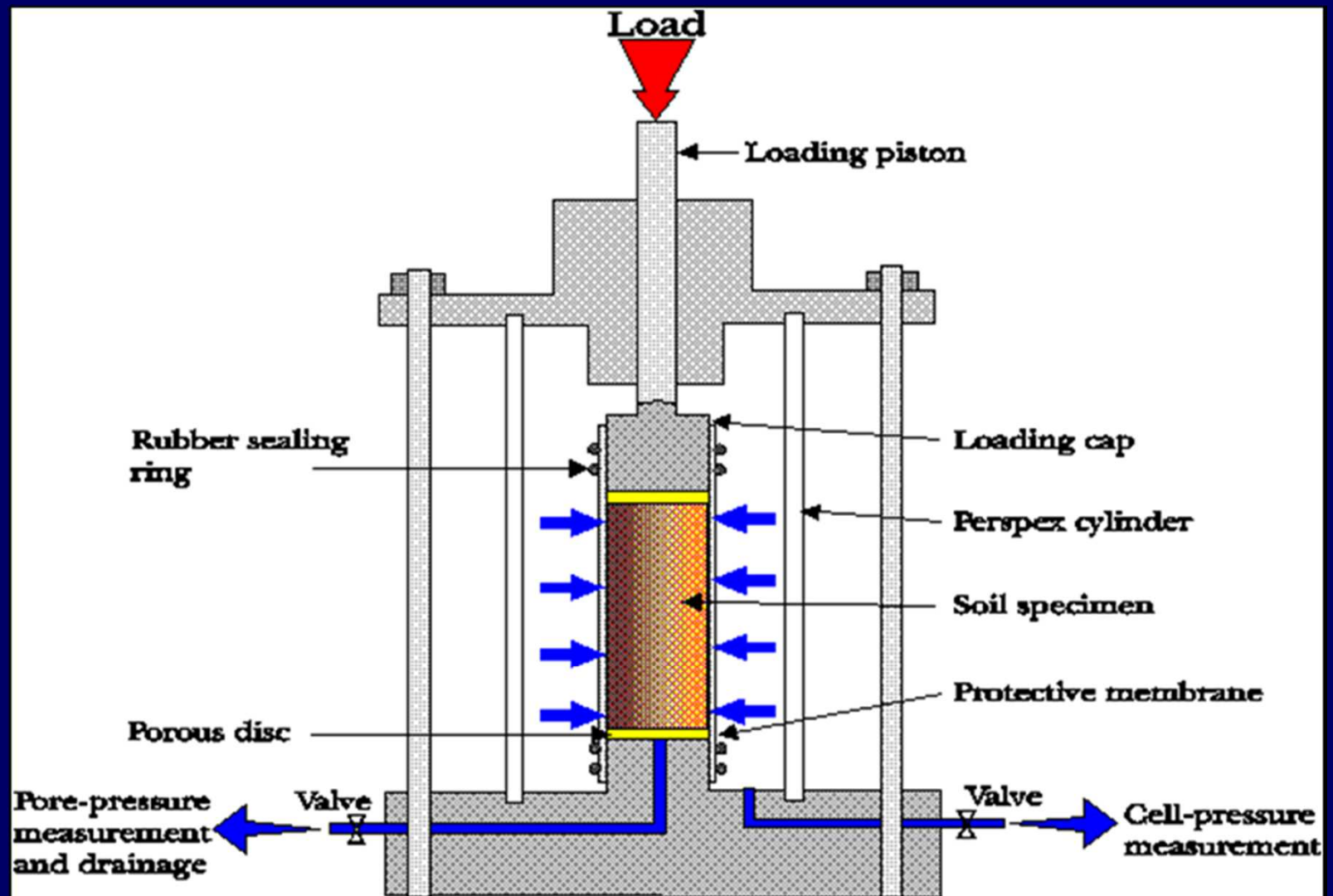
[21]

Cones



[22]

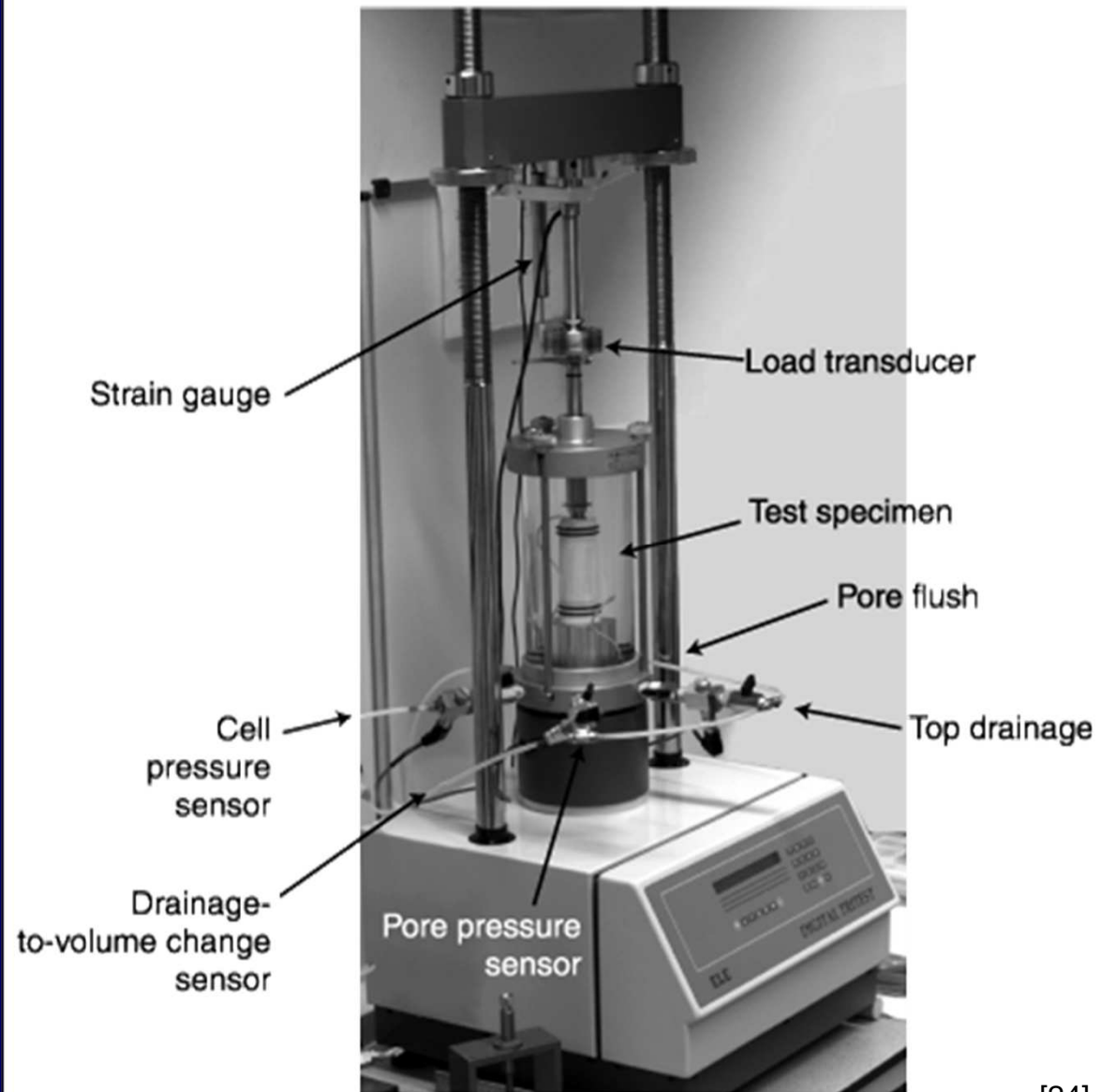
Tri-axial Test



Triaxial apparatus

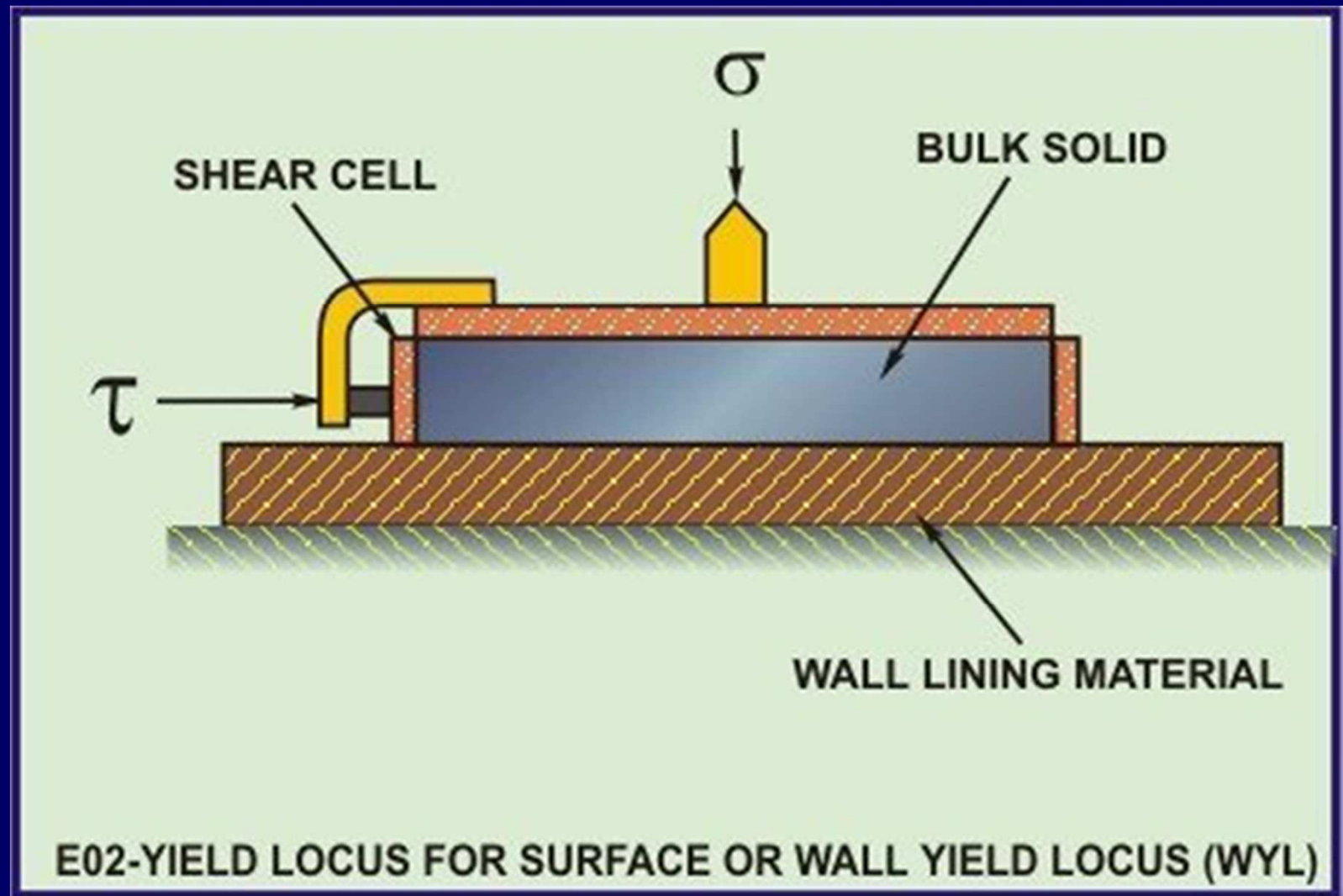
[23]

Tri-axial Test



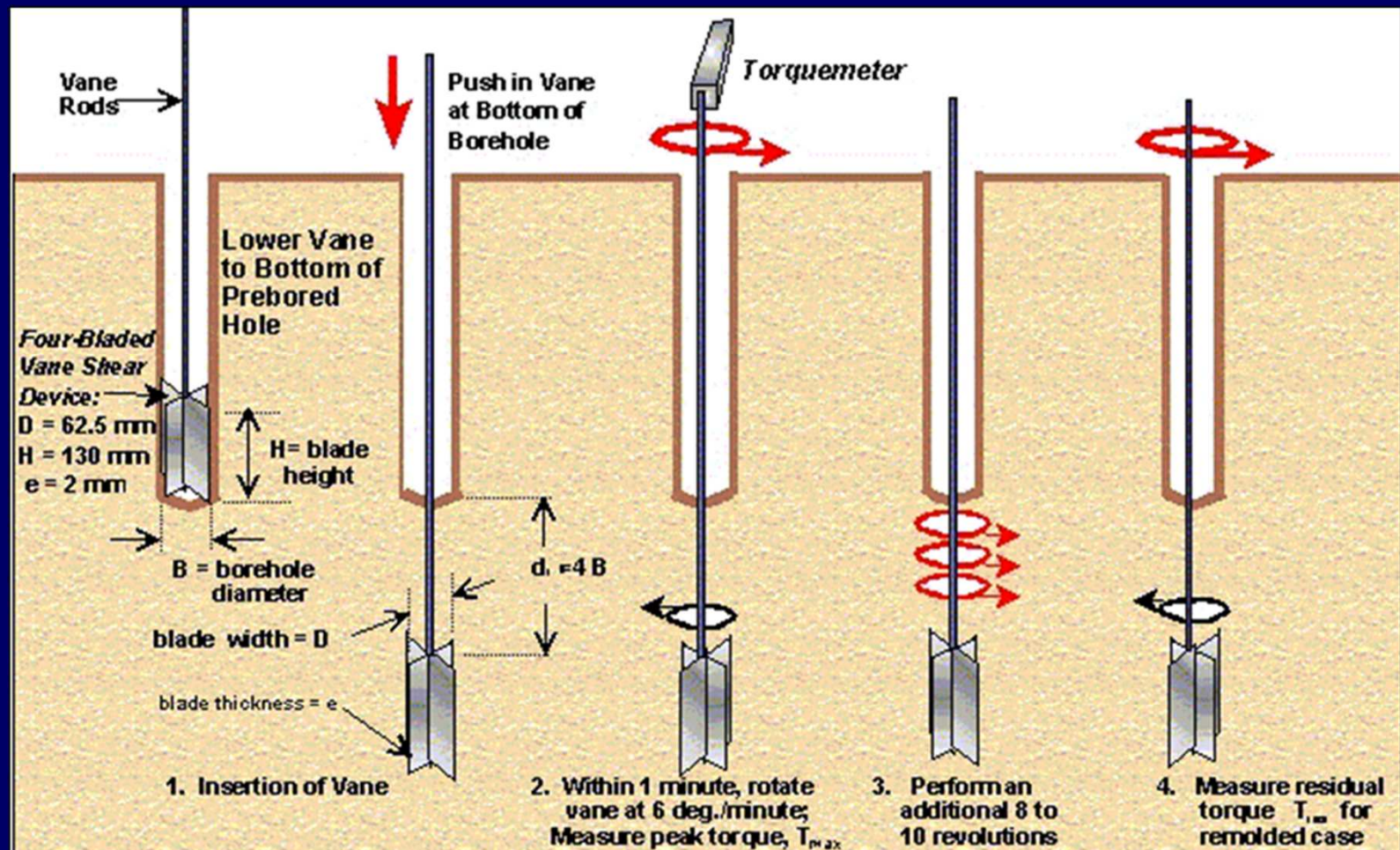
[24]

Direct Shear Test



[25]

Vane Shear Test



Vane Shear Test (VST) per ASTM D 2573:

Undrained Shear Strength: $S_{uv} = 6 T / (7 \pi D^3)$ For $H/D = 2$

In-Situ Sensitivity: $S_t = S_{uv} (\text{peak}) / S_{uv} (\text{remolded})$

[26]



Questions?

Sources images

1. A model cutter head, source: Delft University of Technology.
2. Off shore platform, source: Castrol (Switzerland) AG
3. Off shore platform, source: <http://www.wireropetraining.com>
4. Fox Glacier, New Zealand (1986), source: Wikimedia Commons/Ot
5. Soil textural triangle, source: Creative Commons/Greenman-23
6. Aid to identification of rock for engineering purposes, source: After BS 5930:1981.
7. Laboratory sieves; 1700 μm , 500 μm , 250 μm (from left), author: BMK/Wikipedia, source: http://commons.wikimedia.org/wiki/File:Laboratory_sieves_BMK.jpg
8. Liquid limit device, source: Wikimedia Commons/E smith2000
9. Soil Composition Cassagrande device, source: geomlab.com
10. Soil phase diagram, source: Wikimedia Commons/Sjhan81
11. Source: unknown.
12. Coefficients of internal friction for a variety of rock types, source: Wijermars (1997-2011).
13. A UCS test facility, source: Colorado School of Mines.
14. The stress strain relation during a UCS test, source: Vlasblom (2003-2007).
15. Unconfined, source: own work.
16. Bending, source: Vlasblom (2003-2007).
17. The Brazilian split test, source: Vlasblom (2003-2007).
18. Failure diagrams ductile-brittle, source: Vlasblom (2003-2007).
19. Brittle failure types, source: Vlasblom (2003-2007).
20. The Standard Penetration Test, source: <http://geosystems.ce.gatech.edu>.
21. A typical CPT test setup, source: <http://geosystems.ce.gatech.edu>.
22. Several cone configurations, source: <http://geosystems.ce.gatech.edu>.
23. The Triaxial apparatus cross-section, source: <http://environment.uwe.ac.uk>.
24. The Triaxial apparatus, source: <http://www-odp.tamu.edu>.
25. The direct shear test, source: A.W. Roberts et al, The University of Newcastle, Australia.
26. The vane shear test, source: <http://geosystems.ce.gatech.edu>.