Direction de la Géotechnique
ir Ph. WELTER

Les forages de reconnaissance et la Géotechnique

Terminologie

- forages de reconnaissance = trou pour identifier (caractériser)

- géotechnique = art d'utiliser le sol pour réaliser une infrastructure naturelle (talus, pente, remblais) ou artificielle (fondations, injections, soutènements,……)

E

in the field of bridge foundations. Before construction of the bridges at Toulouse began, the master builders to whom the contract had been awarded undertook a form of ground investigation by probing with a 7 m-long iron bar, given the name 'espreuve', to determine the thickness of the alluvium above the marl.

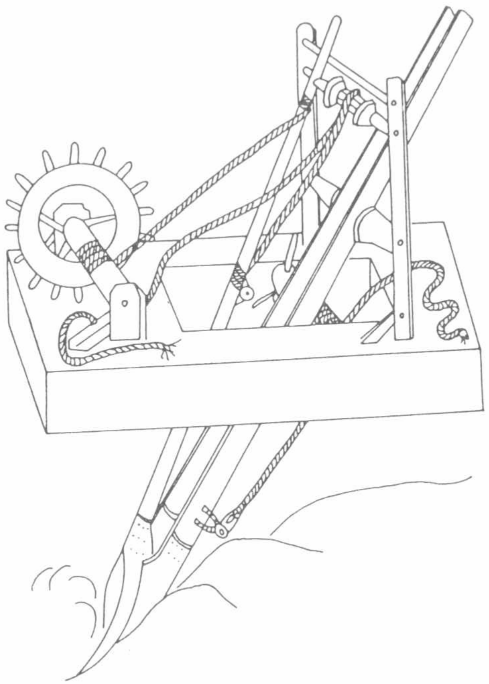


Fig. 75 - Machine for breaking up hard material underwater, invented by Fontana (1540-1614).

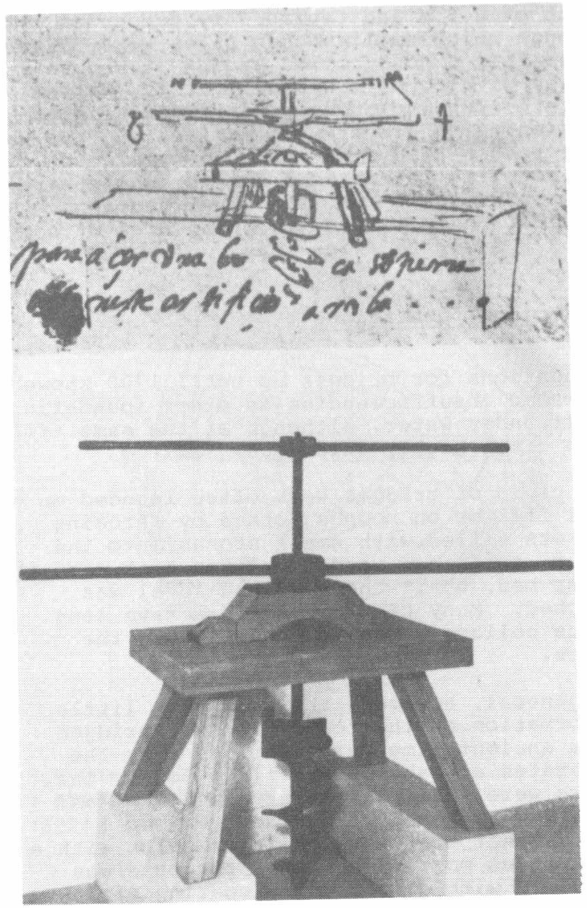


Fig. 76 - Leonardo da Vinci's design for an auger-boring device for soil, with below a model built in Italy based on the sketch.(1)

Fig
per

Stone slabs

g. 69 - The zarbiyyeh, or Egyptian self-sinking caisson (interpretation of the description).

ıammer piling rig designed by
ɛsco di Giorgio (around 1450),

Aspects abordés

- Echantillonnage
- Essais pressiométriques
- Essais scissométriques
- Essais dilatométriques
- Mesures des mouvements
- Mesures des contraintes
- Essais géohydrauliques
- Autres essais : …………….

Essais géotechniques en forages – état des documents normatifs

ISO work item number	CEN work item number	WG of CEN/ TC 341	Short title	Resolutions CEN/TC 341	Accepted by CEN 10.99	Stage 20.60 CD	Stage 30.99 ENQ draft DIS	Stage 45.99 FV final draft FDIS	Publication ISO Availability CEN (DAV)	Remarks
22476-1	00341042	2	Electrical cone penetration tests	31, 41, 61, (76), (77), 86, 87	2003-03	2003-11	2005-01			Reactivation is pending – ISO/CEN new WI number is expected
22476-9	00341021	2	Field vane test	23, 99	2002-03	2003-09	*2004-12*			Reactivation is pending, Res. 99 - ISO/CEN new WI number is expected
22476-12	00341054	2	Mechanical cone penetration test	31, 41, 69, 100	2003-05 2005-11	2003-11 2006-04	2006-04	*2008-03*	*2008-11*	Sent for FV on 2008-05
22476-2	00341004	3	Dynamic probing	37	2001-09				**2005-01**	EN ISO: 2005
22476-3	00341005	3	Standard penetration test	37	2001-09				**2005-01**	EN ISO: 2005
22476-4	00341016	5	Menard pressuremeter test	22, 64,88	2002-03	2003-09	2005-04 2007-09	*2008-12*	*2009-05*	END of 2nd pENQ:**2008-03-06** Comments of 2nd p Enquiry sent to Convenor on 2008-03-13
22476-5	00341017	5	Flexible dilatometer test	22, 64, 95	2002-03	2003-09	2005-06 2008-02	*2008-12*	*2009-06*	END of 2nd pENQ:**2008-05-14** Comments of 2nd p Enquiry sent to Convenor on 2008-06-05
22476-6	00341057	5	Self-boring pressuremeter test	22, 59, 73, 89	2002-03 2006-08	2003-09 *2007-03*	*2007-08*	*2008-12*	*2009-08*	Circulation of 1st CD from WG5 is pending
22476-7	00341019	5	Borehole jack test	22, 64. 95	2002-03	2003-09	2005-06 2008-02	*2008-12*	*2009-06*	END of 2nd pENQ:**2008-05-14** Comments of 2nd p Enquiry sent to Convenor on 2008-06-05
22476-8	00341058	5	Full displacement pressuremeter	22, 59, 74, 89	2002-03 2006-08	2004-08 *2007-03*	*2007-08*	*2008-12*	*2009-08*	Circulation of 1st CD from WG5 is pending
22476-X	?	5	Phicometer shearing test	75						TS, WI number pending
22476-10	00341022		Weight sounding test	24	2002-10				**2005-05**	TS: 2005 *under review*
22476-11	00341023		Flat dilatometer test	24	2002-10				**2005-05**	TS: 2005 *under review*
22282-1	00341060	1	Geohydraulic testing - General rules	56, 93	2004-05 2007-07	2008-01	2008-07	*2009-11*	*2010-07*	draft, sent for //ENQ to ISO/CS on 2008-01 (closing date 08-09-17)
22282-2	00341061	1	Permeability tests using open systems	30, 41, 55, 93	2003-05 2007-07	2008-01	2008-07	*2009-11*	*2010-07*	draft, sent for //ENQ to ISO/CS on 2008-01 (closing date 08-09-17)
22282-3	00341062	1	Water pressure test	30, 41, 55, 78 , 85	2003-05 2007-07	2007-09	2007-11	*2009-11*	*2010-07*	Comments of p Enquiry sent to Convenor on 2008-06-05
22282-4	00341063	1	Pumping tests	30, 41, 55, 79 , 85	2003-05 2007-07	2007-09	2007-12	*2009-11*	*2010-07*	Comments of p Enquiry sent to Convenor on 2008-06-20
22282-5	00341064	1	Infiltrometer tests	56, 80 , 85	2004-05 2007-07	2007-09	2007-12	*2009-11*	*2010-07*	Comments of p Enquiry sent to Convenor on 2008-06-20
22282-6	00341065	1	Permeability tests using closed systems	56, 81 , 85	2004-05 2007-07	2007-09	2008-07	*2009-11*	*2010-07*	draft, sent for //ENQ to ISO/CS on 2008-01 (closing date 08-08-27)

Echantillons remaniés ou non remaniés :

Table 3.1 — Quality classes of soil samples for laboratory testing and sampling categories to be used

Soil properties / quality class	1	2	3	4	5
Unchanged soil properties					
particle size	*	*	*	*	
water content	*	*	*		
density, density index, permeability	*	*			
compressibility, shear strength	*				
Properties that can be determined					
sequence of layers	*	*	*	*	*
boundaries of strata – broad	*	*	*	*	
boundaries of strata – fine	*	*			
Atterberg limits, particle density, organic content	*	*	*	*	
water content	*	*	*		
density, density index, porosity, permeability	*	*			
compressibility, shear strength	*				
Sampling category according to EN ISO 22475-1	A				
			B		
					C

Echantillons remaniés ou non remaniés :

- category A sampling methods: samples of quality class 1 to 5 can be obtained;
- category B sampling methods: samples of quality class 3 to 5 can be obtained;
- category C sampling methods: only samples of quality class 5.

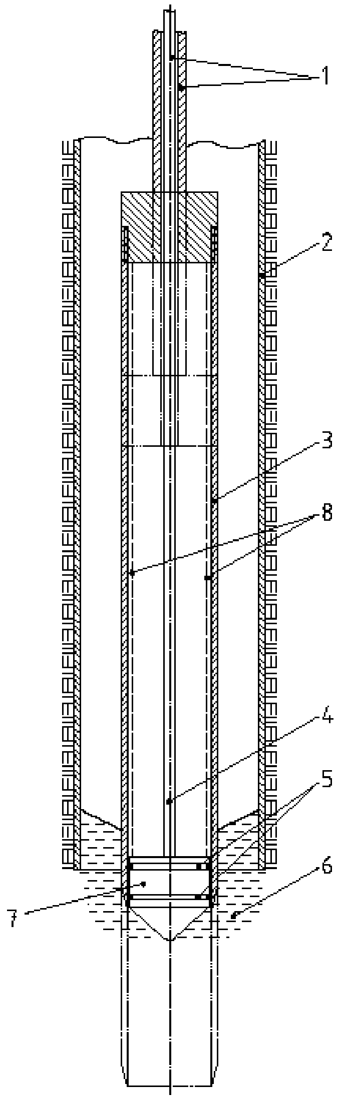
6.2.2 Samples of quality class 1 or 2 can only be obtained by using category A sampling methods. The intention is to obtain samples in which no or only slight disturbance of the soil structure has occurred during the sampling procedure or in handling of the samples. The water content and the void ratio of the soil correspond to that in-situ. No change in constituents or in chemical composition of the soil has occurred. Certain unforeseen circumstances such as varying of geological strata may lead to lower sample quality classes being obtained.

6.2.3 By using category B sampling methods, this will preclude achieving sampling quality class better than 3. The intention is to obtain samples containing all the constituents of the in-situ soil in their original proportions and the soil has retained its natural water content. The general arrangement of the different soil layers or components can be identified. The structure of the soil has been disturbed. Certain unforeseen circumstances such as varying of geological strata may lead to lower sample quality classes being obtained.

6.2.4 By using category C sampling methods, this will preclude achieving sampling quality class better than 5. The soil's structure in the sample has been totally changed. The general arrangement of the different soil layers or components has been changed so that the in-situ layers cannot be identified accurately. The water content of the sample may not represent the natural water content of the soil layer sampled.

Table 1 — Quality classes of soil samples for laboratory testing and sampling categories to be used

	Quality classes of soil samples for laboratory testing according to prEN 1997-2				
	1	2	3	4	5
Sampling categories	A	A	A	A	A
			B	B	B
					C



Key

1	drill rod locking device above ground	5	sealing ring
2	casing	6	disturbed soil
3	sample tube	7	piston
4	vent	8	liner (optional)

Figure 5 — Schematic thin-walled stationary piston sampler (PS) for sampling from borehole bottom

Table 4 — Examples on sampling methods with respect to the sampling category in different soils

Soil type	Suitability depends on e.g.	Sampling method		
		Category A	Category B	Category C
Clay	Stiffness or strength sensitivity plasticity	PS-PU OS-T/W-PU [b] OS-T/W-PE [a] OS-TK/W-PE [a, b] CS-DT, CS-TT LS, S-TP, S-BB	OS-T/W-PE OS-TK/W-PE CS-ST HSAS AS [a]	AS
Silt	Stiffness or strength sensitivity groundwater surface	PS OS-T/W-PU[b] OS-TK/W-PE [a- b] LS, S-TP	CS-DT, CS-TT OS-TK/W-PE HSAS	AS CS-ST
Sand	sizes of the particles density groundwater surface	S-TP OS-T/W-PU [b]	OS-TK/W-PE [b] CS-DT, CS-TT HSAS	AS CS-ST
Gravel	size of the particles density groundwater surface	S-TP	OS-TK/W-PE [a,b] HSAS	AS CS-ST
Organic soil	state of decay	PS OS-T/W-PU [b] S-TP	CS-ST HSAS AS [a]	AS

[a] Can be used only in favourable conditions.

[b] See also 6.4.2.3 for the detailed geometry.

Key

OS-T/W-PU	Open-tube samplers, thin-walled/pushed	CS-ST	Rotary core drilling, single tube
OS-T/W-PE	Open-tube samplers, thin-walled/percussion	CS-DT, CS-TT	Rotary core drilling, double or triple tube
OS-TK/W-PE	Open-tube samplers, thick-walled/percussion	AS	Augering
PS	Piston samplers	HSAS	Hollow stem augering
PS-PU	Piston samplers, pushed	S-TP	Sampling from trial pit
LS	Large samplers	S-BB	Sampling from borehole bottom

Echantilloneur à piston stationnaire

Dimensions in millimetres

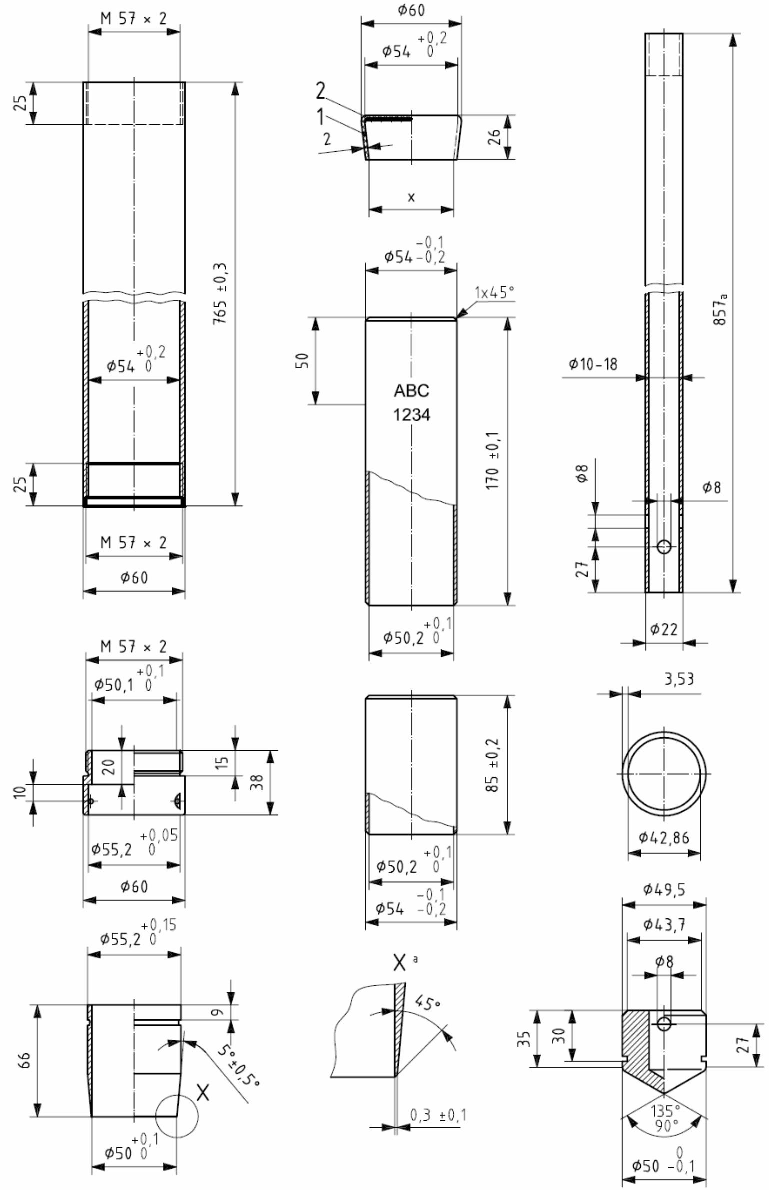
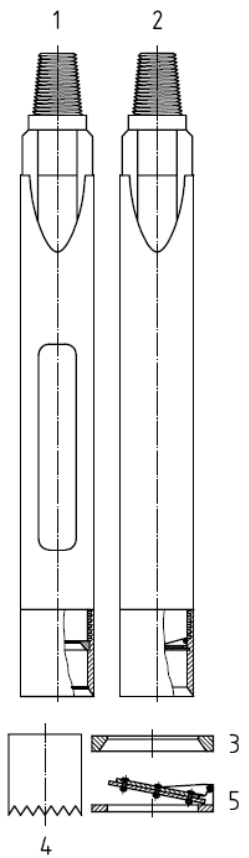


Figure C.18 — Stationary piston sampler with a 50-mm liner — Parts

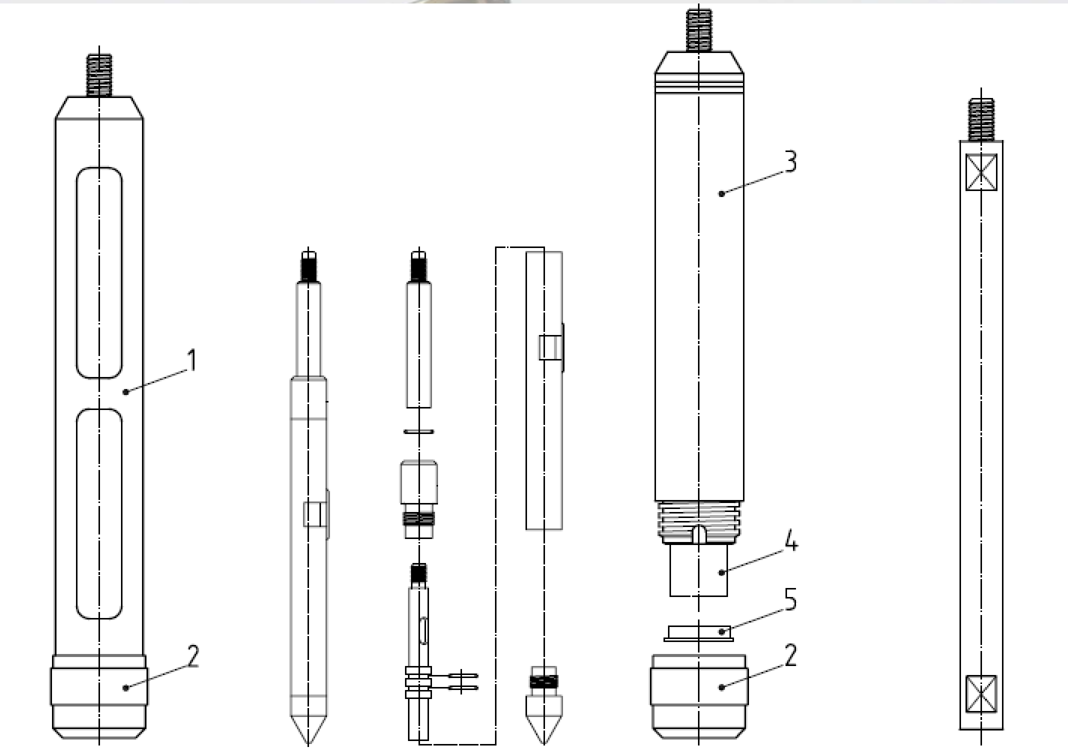
C.12.4 Clay cutter and shell (bailer)

See Figure C.24.



Key
1 clay cutter
2 shell or bailer
3 clay cutter ring
4 serrated tool shoe
5 leather clack

Figure C.24 — Clay cutter and shell (bailer)

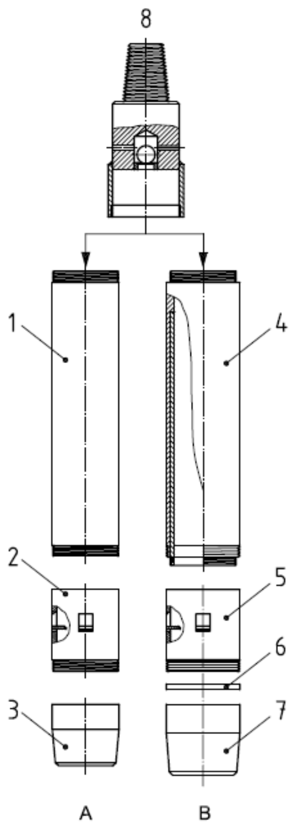


Key
1 sample tube-window
2 shoe
3 sample tube
4 plastic liner
5 retainer

Figure C.23 — Window and windowless samplers

C.11.4 U100 Sampler

See Figure C.20.



A) **Standard system** B) **Plastic liner system**

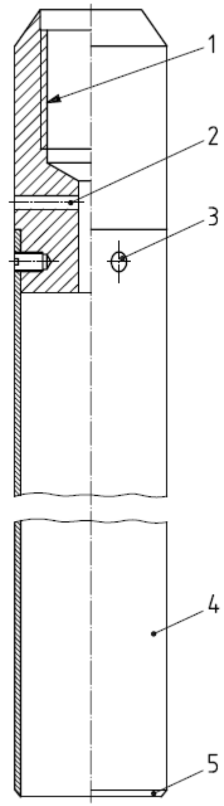
Key

1 sample tube (cadmium-plated steel or aluminium)
2 core catcher (optional)
3 cutting shoe (plain or serrated edge)
4 steel body tube (enclosing plastic liner)
5 core catcher (optional)
6 spacing ring
7 cutting shoe (plain or serrated edge)
8 U100 drive head (bell housing)

Figure C.20 — U100 Sampler

C.11.1 Thin wall sampler (Shelby tube)

See Figure C.15.



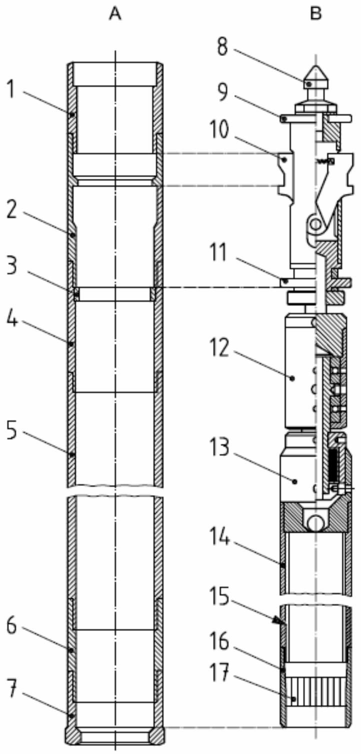
Key

1 sampler head with drill rod box connection
2 air relief port
3 grub screws (3) secure sample tube to head
4 thin wall Shelby tube
5 chamfered cutting edge

Figure C.15 — Thin wall sampler (Shelby tube)

C.5.2 Geotechnical wireline corebarrel

See Figure C.8 and Tables C.12 and C.13.



a) **Outer tube assembly**

b) **Inner tube assembly**

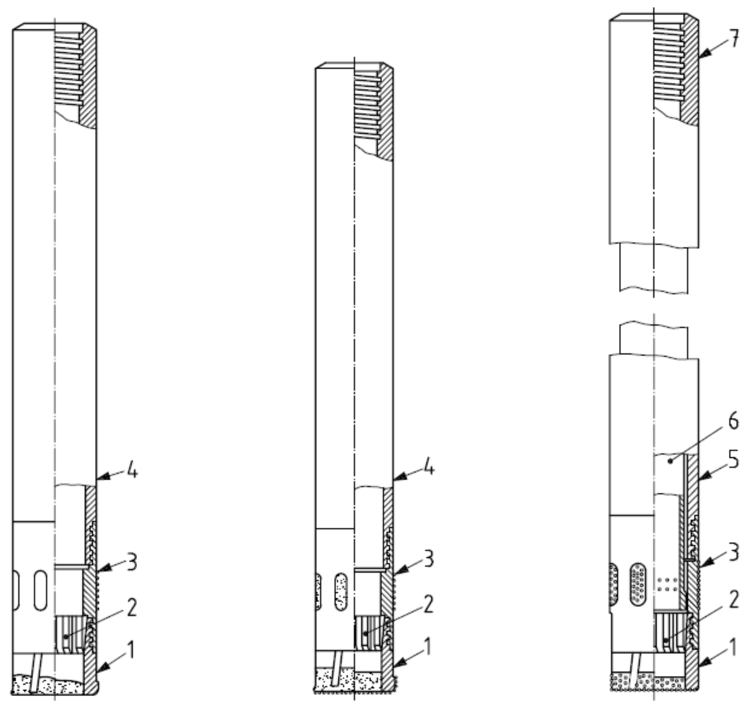
Key

1 drill and coupling
2 locking coupling
3 landing ring
4 adapter coupling
5 outer tube
6 blank reaming shell
7 core bit (not included)
8 lifting spear
9 upper stabiliser
10 latches
11 lower stabiliser
12 bearing assembly
13 inner tube bung
14 outer tube
15 plastic coreliner
16 core-lifter case
17 core lifter

Figure C.8 — Geotechnical wireline corebarrel (inner and outer tube assembly)

C.4.2 Corebarrels "W" series, according to ISO 3551-1

See Figure C.5 and Figure C.6.



a) **"WG" design single-tube corebarrel - Assembly [a]**

b) **"WT" design single-tube corebarrel - Assembly [a]**

c) **"WG" design double-tube corebarrel - Assembly [b]**

Key

1 core bit
2 core lifter
3 reaming shell
4 tube
5 outer tube
6 inner tube
7 head (rigid or swivel)

[a] Bits and core springs are interchangeable with double-tube barrels.

[b] Bits and core springs are interchangeable with single-tube barrels.

Figure C.5 — Corebarrels "W" series, according to ISO 3551-1

Dossier : A605-151-Z348	LIAISON CEREXHE-HEUSEUX-BEAUFAYS	F.36

Dossier : A605-151-Z348	LIAISON CEREXHE-HEUSEUX-BEAUFAYS	F.36

X Lambert : 245 094.77 Y Lambert : 148 048.34 Z : + 259.83	Société : MOORS ECOFORAGE Machine : Atlas Mustang 66	Commune : EVEGNEE-TIGNEE (Soumagne)	Feuille N° 1 de 1

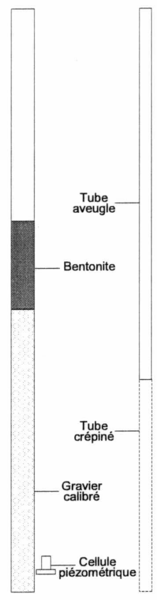
Date	Equip. Piézo.	Mode d'exécution – Forage – Diam. (mm)	Forage – Outil	Tubage – Diam. (mm)	Passe (m)	E. N.R.	E.R. – B	E.R. – C	E.R. – S	Récup. (%)	Log. Litho.	Cote	Description lithologique (F. de VILLE de GOYET)	RQD (%)	Strati-graphie	Cote
2008					1.50			1		27		+258.33	Limon argileux, finement sableux, brun foncé-noir. Contient des scories plurimillimétriques, noires.		X	
					7.25		18									
13/03/2008					7.50		19								Sx	
					7.75		20									
					8.00		21									
					8.25		22									
					8.50		23									
					8.75		24									
					9.00		25									
					9.25		26									
					9.50		27									
					9.75		28					+250.08				+ 250.00
					10.00		29						Argile brun clair, plastique. Contient une quantité importante de débris de silex.			
					10.25		30									
					10.50		31									
					10.75		32					+249.08	Argile très légèrement et très finement sableuse, brune, plastique. Contient de rares débris de silex.			
		254	ROCK.-B		11.00		33					+248.83				
					11.35		34						Silex pluricentimétriques et argile brun clair. Echantillon fortement lessivé.			
					11.50			2		50		+248.33				
					12.00			2		56		+247.83	Argile grossièrement sableuse, carbonatée, brun foncé et argile très légèrement et très finement sableuse, brun clair. Contiennent des débris de silex plurimillimétriques.			
					12.50	2						+247.33	Echantillon non remanié.			
					13.50			2		46		+246.33	Argile carbonatée, brun clair à brun-gris foncé et craie blanc-gris localement altérée.			
					15.00			3		82		+244.83	Craie blanche, altérée. Contient des débris centimétriques à pluricentimétriques de craie moins altérée et des passes pluricentimétriques à pluridécimétriques d'argile brune.			+ 245.00
					15.50							+244.33	Echantillon non remanié.			
					16.50			3		90		+243.33	Craie blanche, altérée. Contient des débris centimétriques à pluricentimétriques de craie moins altérée et des passes centimétriques d'argile brune.			
					17.00	4						+242.83	Echantillon non remanié.			
					18.00			4		88			Craie blanche, altérée. Contient des débris centimétriques à pluricentimétriques de craie moins altérée et des passes centimétriques d'argile brune.		GUL	
14/03/2008					19.50			4		92		+240.33				+ 240.00
					20.00	5						+239.83	Echantillon non remanié.			
					21.00			5		100		+238.83	Craie blanche, altérée. Contient des débris centimétriques à pluricentimétriques de craie moins altérée.			
					21.50	6						+238.33	Echantillon non remanié.			
					22.50			5		80		+237.33	Craie blanche, altérée. Contient des débris centimétriques à pluricentimétriques de craie moins altérée.			
					23.00							+236.83	Echantillon non remanié.			
					24.00			6		58		+235.83	Craie blanche et sable glauconifère vert à la base. Transition craie - marne.			
												+235.53	Marne brun-vert, plastique (= Smectite de Herve).		VAA	
		142	TRC-E		25.00			6		100		+234.83	Marne gris foncé, plastique (= Smectite de Herve).			+ 235.00

ssance

S.P.W. - Direction de la Géotechnique

Dossier : A605-151-Z348 — **LEGENDE DES SYMBOLES**

Equipement piézométrique



Outils de forage

- CH : Chape
- DC : Double carottier
- M.F.T. : Marteau fond de trou
- M.H.T. : Marteau hors trou
- ROCK. : Rockbit
- SC : Simple carottier
- SPC : Soupape à clapet
- TC : Tarrière à cuiller
- TP : Tarrière pleine
- TR : Tarrière à vrille
- TRC : Triple carottier
- TRIL. : Trilame

Niveaux d'eau

- 1 : Mesure du matin
- 2 : Mesure avant la pause de midi
- 3 : Mesure après la pause de midi
- 4 : Mesure en fin de journée
- a : L'eau a apparu
- b : L'eau a disparu
- c : L'eau a réapparu
- d : Pas d'eau parue
- e : Pas de mesure du niveau d'eau

Echantillons non remaniés

- 1 (case noire) Réussi
- (case vide) Non réussi

Echantillons remaniés

- B : Bocal
- C : Caisse
- S : Sac

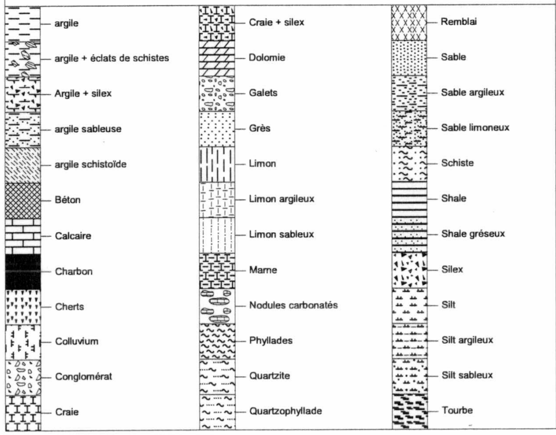
Fluides de forage

- S : Sec
- E : Eau
- P : Polymère
- B : Boue
- A : Air comprimé

Interprétations géologiques

- X : Remblais
- AMO : Alluvions modernes
- Q : Quaternaire
- SBL : Dépôts sableux et argileux
- Sx : Argile à silex
- GUL : Formation de Gulpen
- VAA : Formation de Vaals
- HOU : Groupe houiller
- JUS : Groupe de Juslenville
- BBN : Groupe de Bay-Bonnet
- BIL : Groupe de Bilstain
- ME : Formations de Montfort et d'Evieux
- LAM : Formation de Lambermont
- AIS : Formation d'Aisemont
- LUS : Formation de Lustin
- NEV : Formation de Nevremont
- PER : Formation de Pepinster
- VIC : Formation de Vicht
- ACO : Formation d'Acoz

Lithologies

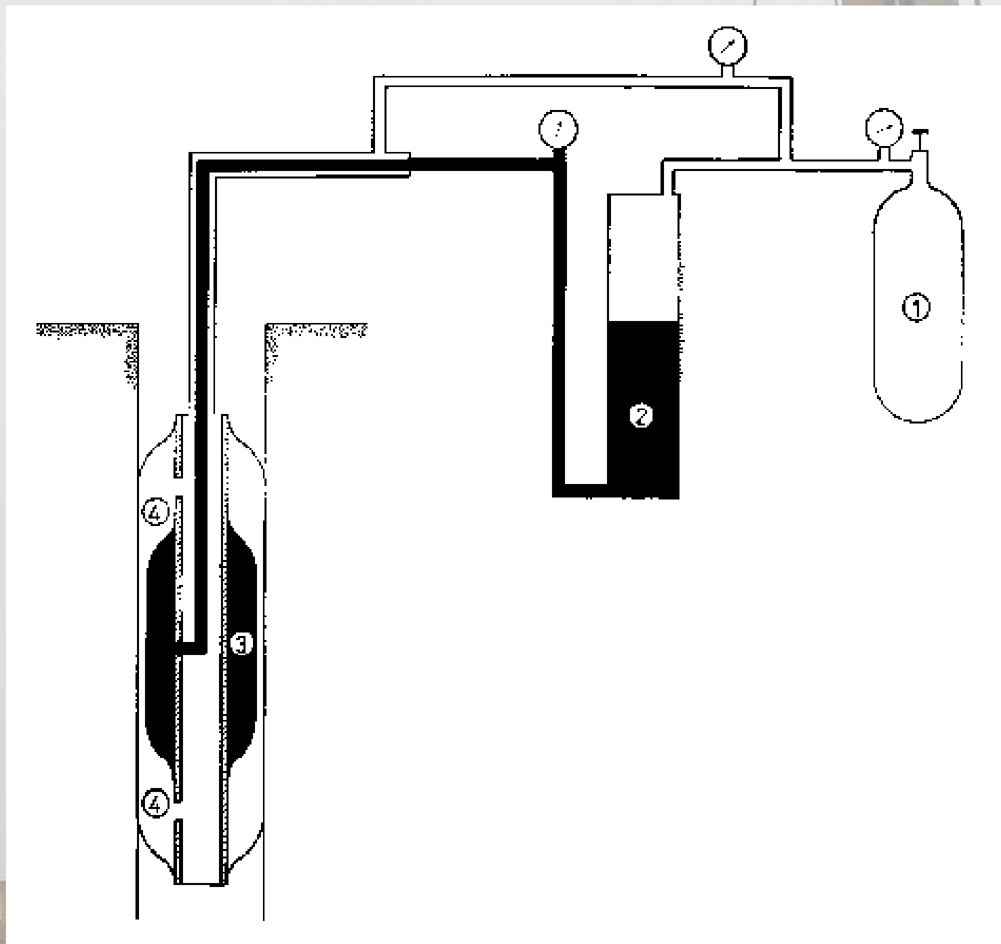


Rapport : A605-151-Z348/LOT1/A

SPW	DGO1	Département des Expertises techniques	
		Direction de la Géotechnique	Annexe 2/0

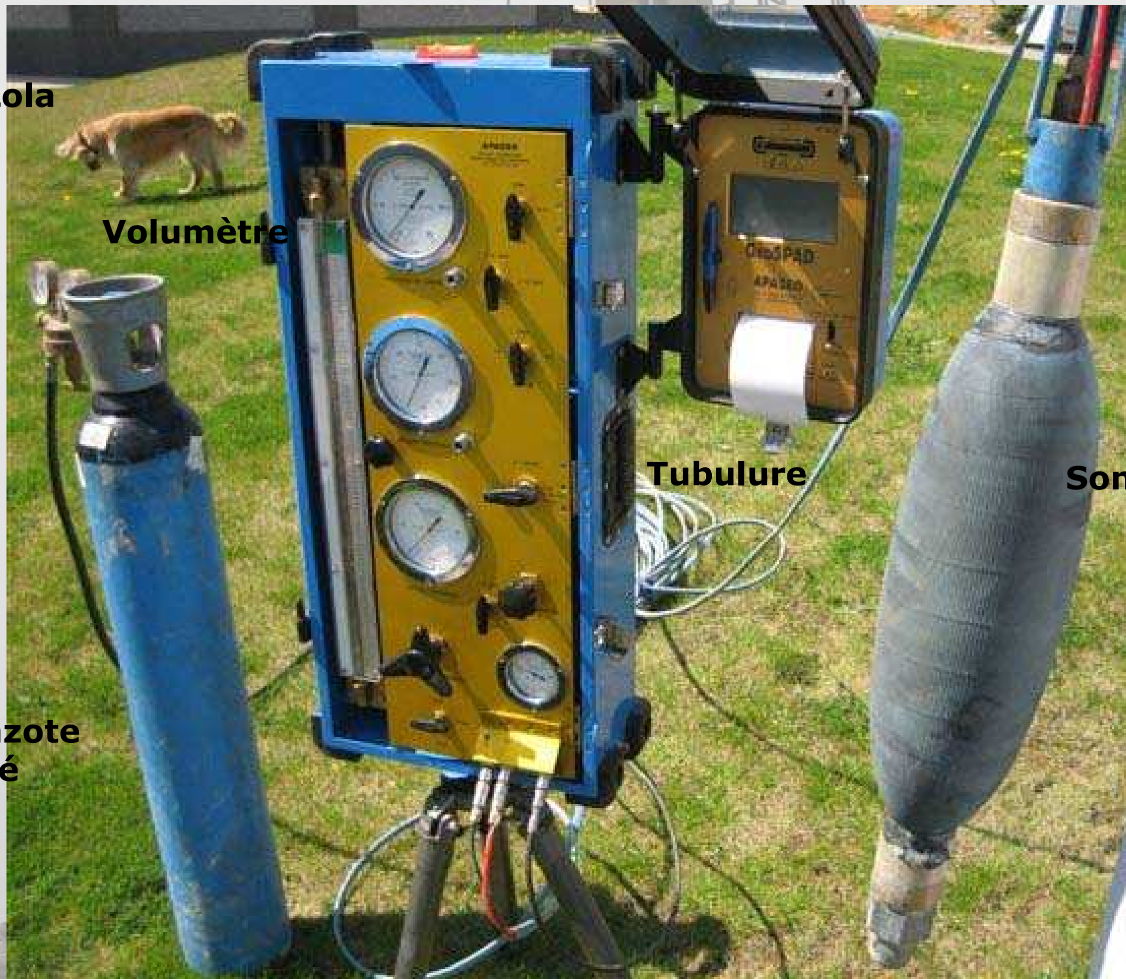
onnaissance

L’essai pressiométrique (extrait d’une présentation du Prof. J. NUYENS – SC OREX) formation GBMS (15/06/2006)



1. **Bouteille d’azote pour la mise en pression**
2. **Tube gradué permettant la mesure de l’augmentation de volume de la cellule centrale (volumètre).**
3. **Cellule centrale**
4. **Cellules de garde**

L’appareillage actuel



Le SPAD

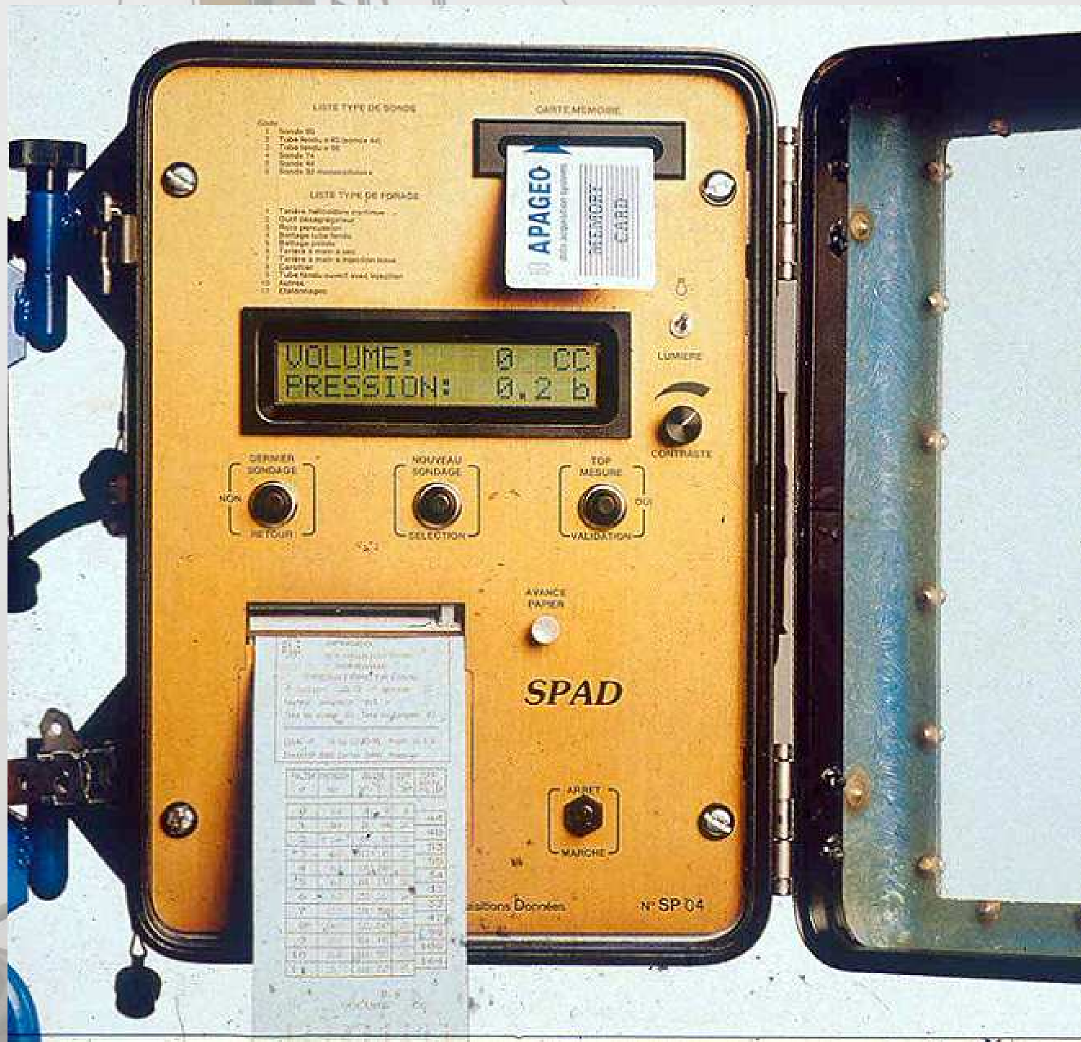
Le SPAD : enregistreur de données imposé par la norme NF P 94-110-1 pour empêcher la fraude.

Les résultats sont fournis dans un fichier qui NE peut PAS être modifié.

Garantie que les essais ont bien été exécutés.

Résultats bruts imprimés en cours d'exécution

Contrôle possible en cours d'exécution.



Forage pressiométrique

- *forage pressiométrique* : exécution du trou de forage.

- Contrairement aux forages d'exploration, priorité :
  - qualité
  - précision du diamètre du trou de forage
  - NON la qualité des échantillons prélevés

Les normes

- NF P 94-110-1

Norme encore en vigueur en France aujourd'hui (15 juin 2006) . Elle rend obligatoire l'utilisation du SPAD

- EN_ISO_22476_4

Projet de Norme européenne actuellement soumis à enquête. L'utilisation du SPAD est facultative (procédure B).

Passes de forage

Table C.1 — Maximum continuous drilling or driving stage length before testing

Soil type	Maximum continuous drilling stage length (m)		
	Rotary drilling	Rotary percussion	Pushing, driving and vibrodriving[b]
Sludge and soft clay, soft clayey soil	1[a]	—	1[a]
Medium stiff clayey soils	2	2	3
Stiff clayey soils	5	4	4
Silty soils:			
- above ground water table	4	3	3
- below water table	2[a]	1[a]	—
Loose sandy soils:			
- above ground water table	3	2	—
- below water table	1[a]	1[a]	—
Medium dense and dense sandy soils	5	5	4
Coarse soils: gravels, cobbles	3	5	3
Coarse soils with cohesion	4	5	3
Loose non homogeneous soils, non text book soils	2	3	2
Weathered rock, soft rock	4	5	3
Solid rock	c	c	—

[a] Or the required interval between two successive tests.

[b] Not applicable to STDTM technique.

[c] Maximum length is a function of the number of tests in a working shift.

Qualité du trou de forage :

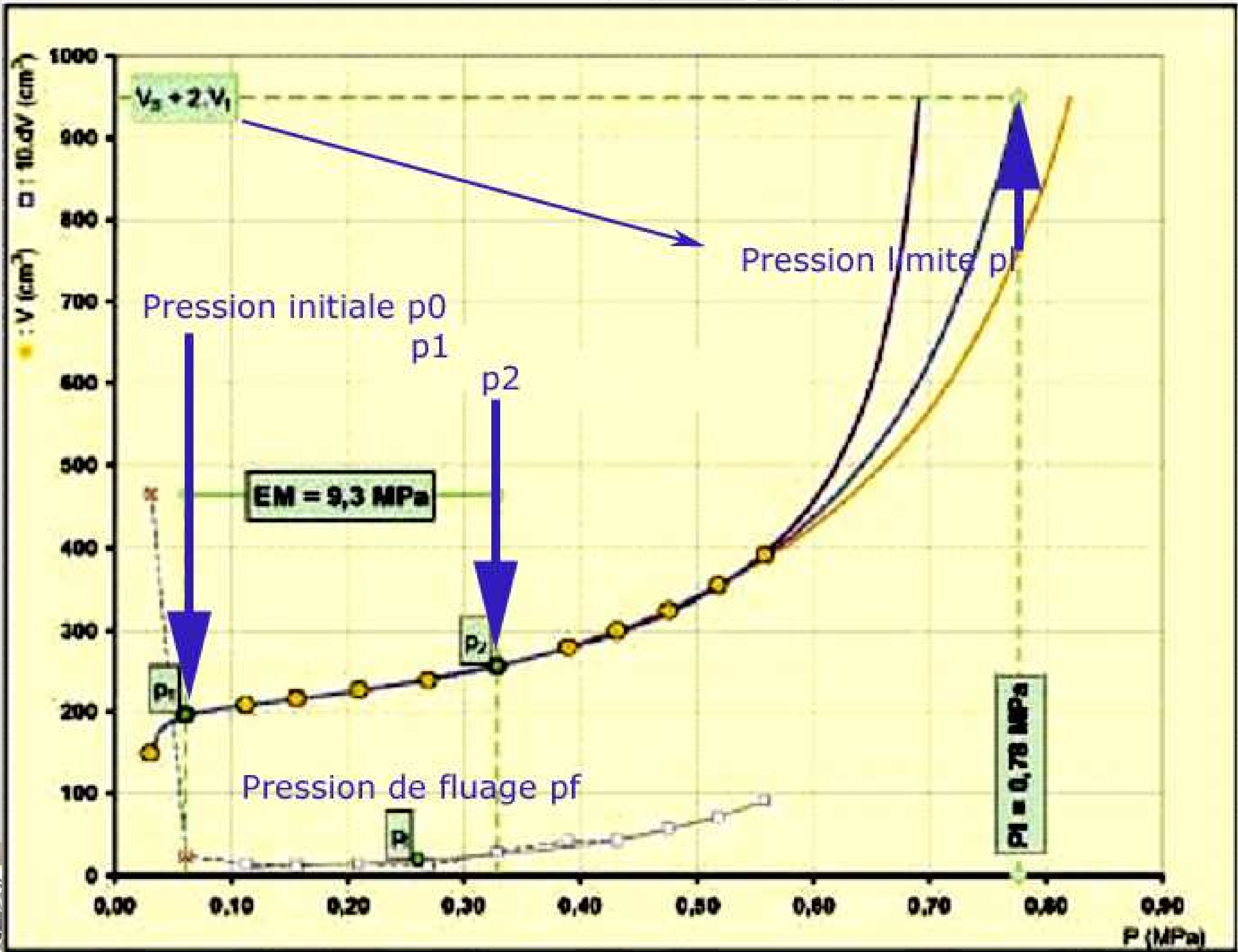
$1 < d_t/d_c < 1,15$

d_t diamètre de l'outil de forage
d_c diamètre extérieur de la sonde.

Passes de forage trop longues détériorent les parois du trou de forage:

- **flexion des tiges de forage,**
- **flambage des tiges de forage**
- **pression d'injection.**

Résultats



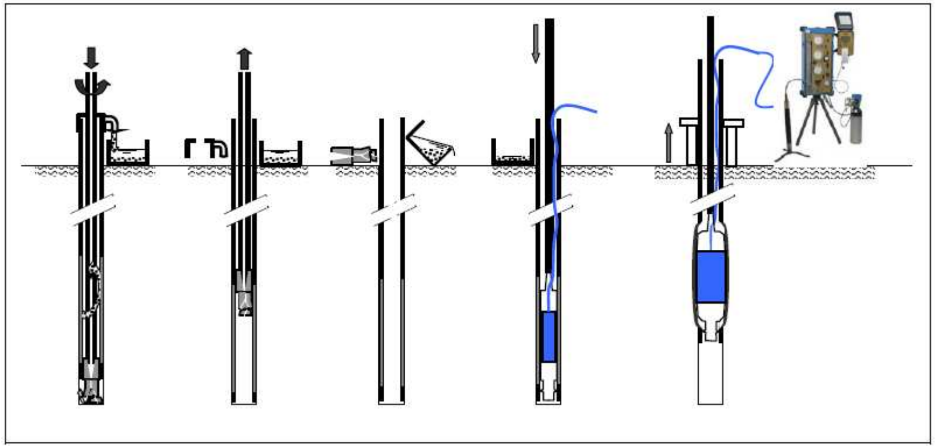
V (cm³) 10.dV (cm³)
1000
900
800
700
600
500
400
300
200
100
0
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
P (MPa)
$V_s + 2.V_1$
Pression limite pl
Pression initiale p0
p1
p2
EM = 9,3 MPa
Pression de fluage pf
Pl = 0,78 MPa

LE STAF®

Système de Tubage Auto-Foreur pour Pressiomètre®

Outil STAF®, porte outil, tige, tube fendu
Positionneur de sonde et sonde 44 Ménard

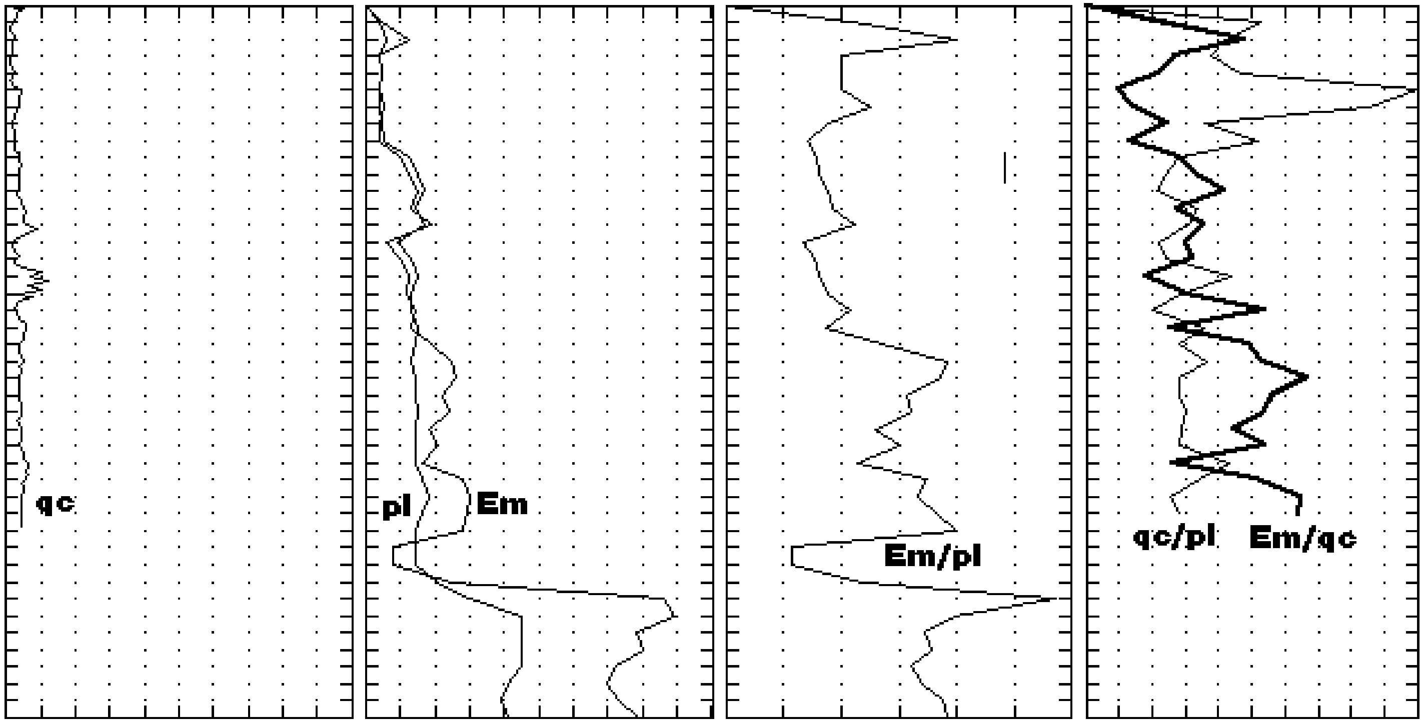
MISE EN ŒUVRE DU STAF ET REALISATION DES ESSAIS :



1. Forage roto-percuté avec l'outil STAF® et mise en place simultanée du tube fendu ouvert selon la méthode de forage pressiométrique "TFEM" (Tube Fendu ouvert avec Enlèvement simultané des Matériaux). Récupération des boues de forage dans un bac à sédiments pour effectuer la coupe de terrain
2. Enlèvement de l'outil STAF® et du train de tiges sans altération des parois du forage pressiométrique
3. Le forage est tubé. Le tube fendu est prêt à recevoir la sonde pressiométrique et le bac à sédiments décanté pour économiser le fluide de forage
4. A l'aide du positionneur de sonde, l'opérateur positionne la sonde pressiométrique à l'intérieur du tube fendu déjà en place dans le forage. La sonde est parfaitement centrée à l'endroit des fentes du tube fendu. Les essais pressiométriques peuvent commencer. La tubulure coaxiale ou jumelée est protégée par la colonne du tube STAF ® sans risque de pincement.
5. Les essais pressiométriques sont effectués en remontant, grâce à un système d'extraction prévu à cet effet. L'acquisition des données pressiométriques est assurée par le GEOSPAD® qui équipe le Pressiomètre®, selon la norme NFP 94-110-1.

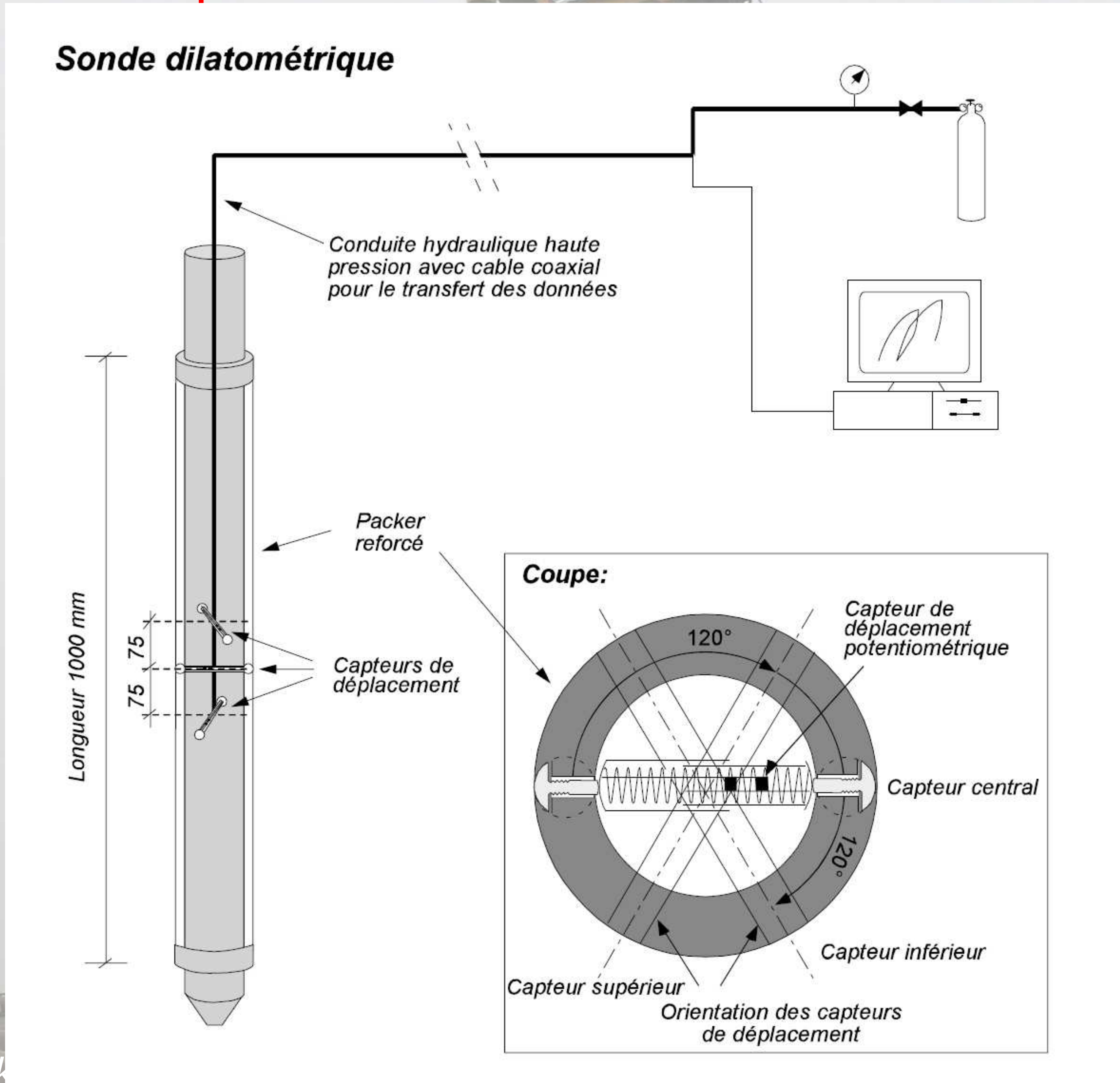
Un descriptif de la réalisation d'essais pressiométriques par autoforage d'un tube fendu peut être trouvé dans le Vol. 1 des actes du Symposium ISP₅ PRESSIO 2005 : *Réalisation d'essais pressiométriques par autoforage d'un tube fendu* - G. Arsonnet, J.P Baud, M. Gambin . Le tiré à part peut également être téléchargé sur notre site www.apageo.com.

Site de l'Hôpital Erasme



Diag.	Code	Description	Niveaux		Valeurs min. & max.		Unit V & H	
73	725	Résistance au cône C	0.0	42.0	0.00	100.00	1.0	1.0
73	730	Press limite (pressi	0.0	42.0	0.00	10.00	1.0	1.0
73	802	Module Pressiométriq	0.0	42.0	0.00	100.00	1.0	1.0
73	1104	**Em/pl**	0.0	42.0	0.00	30.00	1.0	1.0
73	1105	**qc/pl**	0.0	42.0	0.00	10.00	1.0	1.0
73	1106	**Em/qc**	0.0	42.0	0.00	10.00	1.0	1.0

Essais dilatométriques




ROCTEST

BOREHOLE DILATOMETER

Model DMP-95

GENERAL

Foundation studies in hard rock differ from the ones in soft soils by the fact that the bearing capacity is determined by the rock structure more than by its strength.

Rock mass is usually much weaker than the intact rock it contains. This is due to the presence of discontinuities such as joints, faults, shears and bedding planes.

Comprehensive in situ tests in mass rock must be performed on a large scale (2 to 3 m^3 of material) in order to measure rock deformation and crack squeezing. These tests can be done with a DMP-95 dilatometer.

DESCRIPTION

Probe

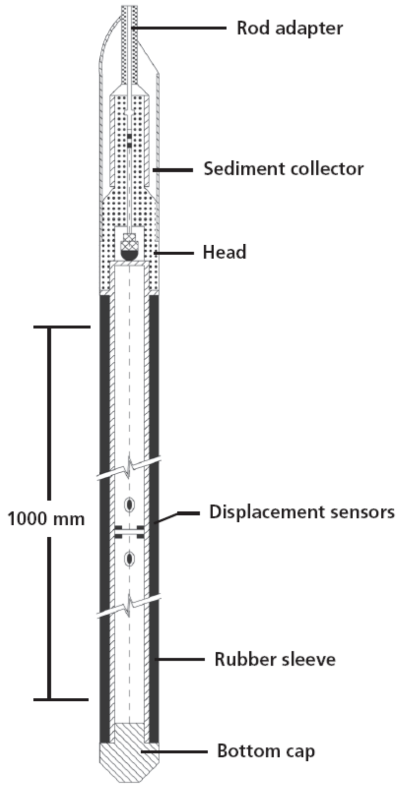
The DMP-95 Dilatometer consits of a probe with an aluminium alloy central body. The probe includes:

- An inflatable membrane (rubber sleeve) equipped with three pairs of metallic inserts spaced at 120° intervals
- A split spring-ring and double cone membrane retaining system
- Three inductive displacement sensors
- A pressure sensor
- A sediment collector

The dilatometer probe is designed to be lowered down into the borehole using a string of rods. The sediment collector placed on top of the probe is equipped with a threaded end.

Standard connection: CRAELIUS 50 or 60

The probe is usually inflated with compressed dry gas (nitrogen or air).



FEATURES

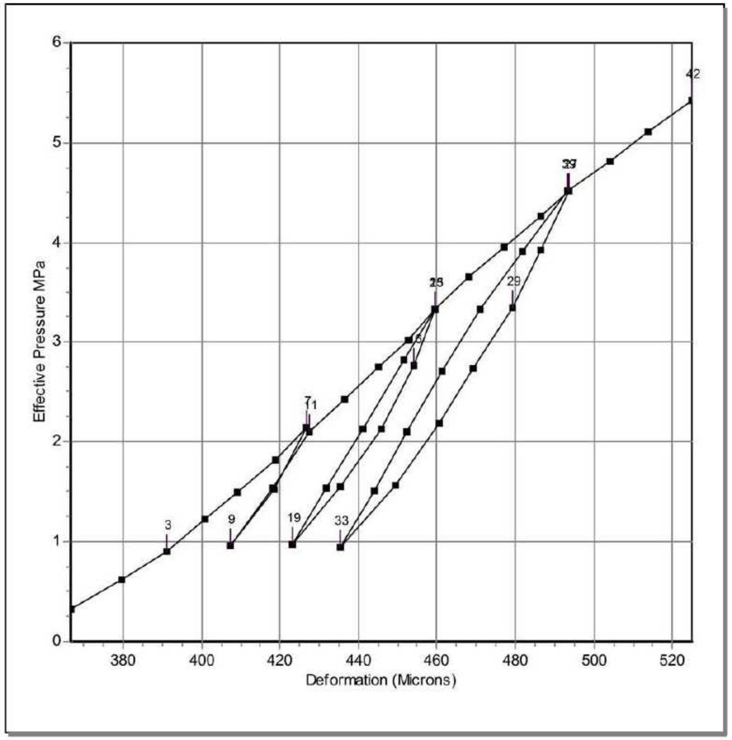
- Allows measurement of rock anistropy
- May be used in deep boreholes
- Test in 101-mm size boreholes

4. Evaluation des données et calcul des modules

Project: Liège	ANALYSIS RESULTS	Borehole: F*W 7
Test Date: 14.03.2008 11:48:00		Test Depth (m): 5.9

(TCB)/3 Extensometer

Step Nr.	Range Start-End	Fit Type	E-Modulus MPa	Step Nr.	Range Start-End	Fit Type	E-Modulus MPa
1	3 - 7	R	4420	2	7 - 9	S	7850
3	9 - 11	R	7300	4	11 - 15	R	4860
5	15 - 16	S	12800	6	15 - 19	S	8270
7	19 - 23	R	8300	8	23 - 27	R	4410
9	27 - 29	S	10300	10	27 - 33	S	7870
11	33 - 39	R	8010	12	39 - 42	R	3670



Le module d'élasticité est calculé en appliquant la formule de Lamé [4], spécifique à un cylindre infini à parois épaisses:

$$E = (1+v) * d * \Delta p / \Delta d$$

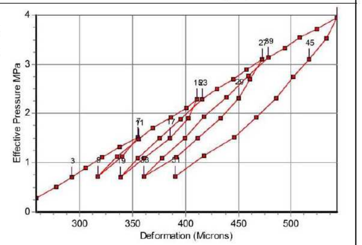
avec : Δp: *différence de pression*
d : diamètre du forage
Δd: *variation de diamètre*
v : coefficient de poisson

La valeur du coefficient de poisson choisi est v =0.33 s'il n'existe aucune mesure de laboratoire (comme proposé dans la norme AFNOR 2002)[2,3].

Project: Liège	ANALYSIS RESULTS	Borehole: F*W 7
Test Date: 17.03.2008 11:58:00		Test Depth (m): 7.3

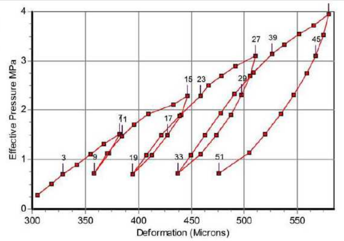
Top Extensometer

Range Start - End	Fit Type	E-Modulus MPa
3 - 7	R	1670
7 - 9	S	2720
9 - 11	R	2550
11 - 15	R	1820
15 - 17	S	3940
15 - 19	S	2800
19 - 23	R	2620
23 - 27	R	1800
27 - 29	S	4600
27 - 33	S	2690
33 - 39	R	2620
39 - 43	R	1590
43 - 45	S	4100
43 - 51	R	2700



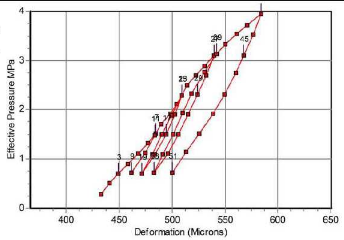
Central Extensometer

Range Start - End	Fit Type	E-Modulus MPa
3 - 7	R	1980
7 - 9	S	4360
9 - 11	R	3850
11 - 15	R	1610
15 - 17	S	5300
15 - 19	S	3920
19 - 23	R	3210
23 - 27	R	1970
27 - 29	S	7580
27 - 33	S	4110
33 - 39	R	3530
39 - 43	R	3530
43 - 45		8860
43 - 51	R	4140



Bottom Extensometer

Range Start - End	Fit Type	E-Modulus MPa
3 - 7	R	2930
7 - 9	S	4570
9 - 11	R	4520
11 - 15	R	3890
15 - 17	S	6650
15 - 19	S	5380
19 - 23	R	5460
23 - 27	R	3290
27 - 29	S	6270
27 - 33	S	5320
33 - 39	R	5340
39 - 43	R	2450
43 - 45	S	6680
43 - 51	R	4880



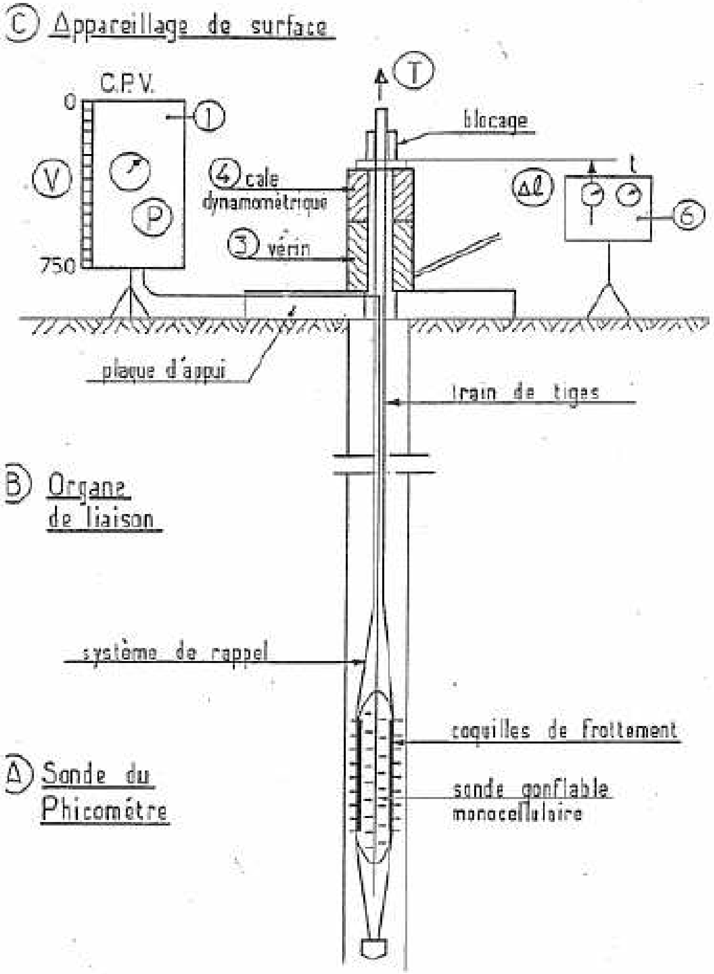
Program: Dilato2
Solexperts AG [JH]

Essai au phicomètre

1. Caractérisation du phicomètre

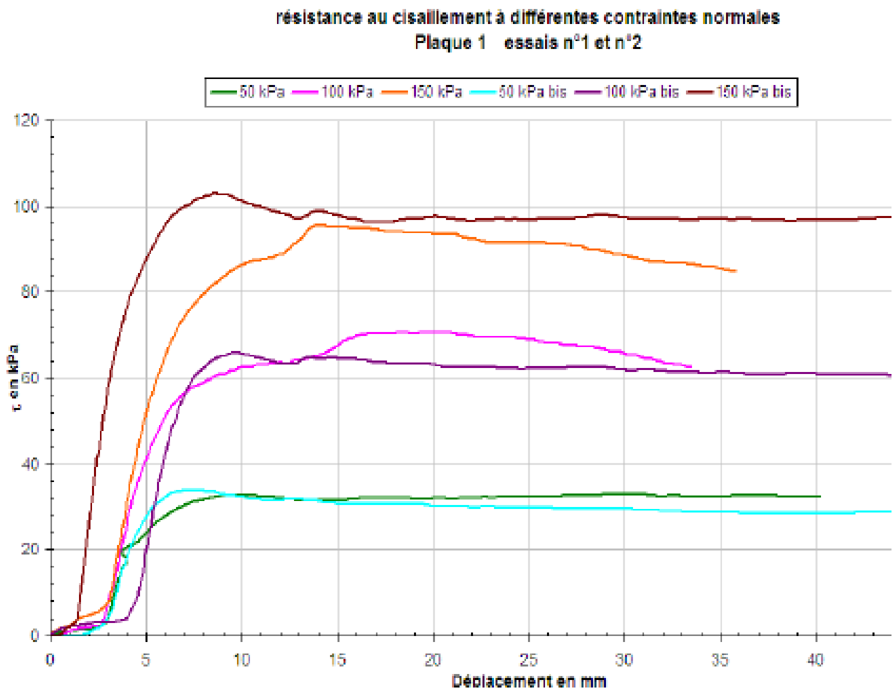
– Outil de mesure du cisaillement in situ normalisé (XP P 94-120)

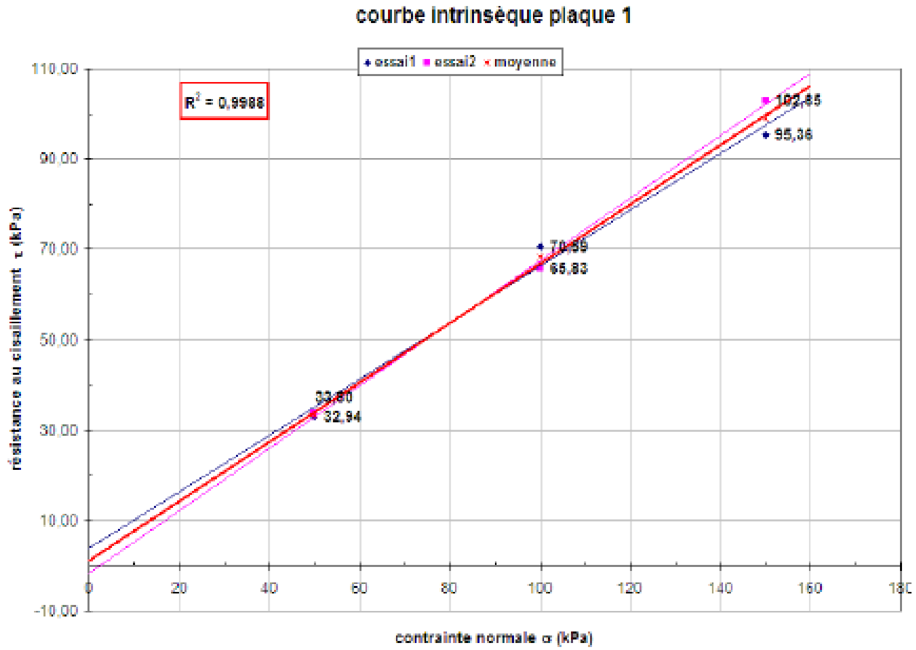
– Essai réalisable dans des sols grossiers



- **Principe de l'essai**
  - Forage préalable
  - Dilatation préliminaire de la sonde
  - Essai de cisaillement par arrachement (vitesse constante) par paliers de pression successifs

• Résultat d'essai : plaque n°1





– c = 1,2 kPa

– Φ = 33,3 °

Essai scissométrique

adapté aux terrains « faibles »

DESCRIPTION

Le scissomètre est un appareil de mesure in situ précis qui comporte :

- une tête enregistreuse de couple;
- une tige d'enfoncement (20 mm de diamètre);
- une palette de scissométrie;
- un joint coulissant.

Le système est installé soit sur :

- un bâti d'enfoncement (service léger ou dur);
- un adaptateur de tubage pour tête enregistreuse de couple.

Tête enregistreuse de couple

La tête enregistreuse est à la fois un appareil de chargement et d'enregistrement. Elle contient un mécanisme de chargement actionné par une manivelle qui permet la rotation des tiges d'enfoncement à l'une ou l'autre des deux vitesses. Un relevé précis est enregistré en permanence sur un disque de papier ciré au moyen d'une pointe en acier. La force de couple est enregistrée radialement alors que l'angle de rotation est enregistré de façon tangentielle. Un couvercle transparent protège la carte d'enregistrement. Un exemple d'enregistrement est illustré à l'endos.

Tête enregistreuse et adaptateur de tubage

Scissomètre modèle M-1000 et bâti d'enfoncement service dur

AVANTAGES

- **Mesure et enregistre : résistance de la palette, friction de la tige et angle de rotation**
- **Conçu pour fonctionner sans tubage de protection ou à l'intérieur d'un forage tubé**

Palette et joint coulissant

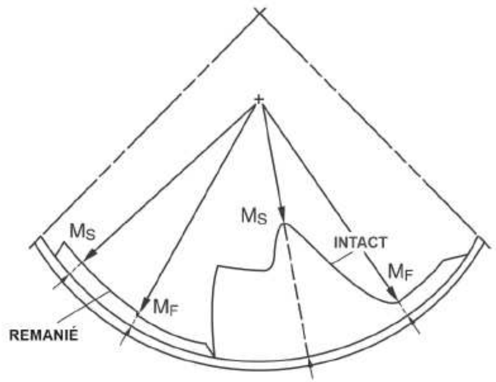
Les palettes sont fabriquées en acier trempé au chrome-nickel à haute résistance mécanique (1 700 000 kPa).

Un joint coulissant permet l'utilisation d'un seul ensemble de tiges. Un roulement à billes à friction minimum dans un accouplement scellé permet un jeu libre approximatif de 15° entre les tiges et la palette. Durant l'essai, la tige seule tourne d'abord jusqu'à la limite du jeu, après quoi les deux pièces tournent ensemble. Sur l'enregistrement de l'essai illustré à droite, M_F est le couple nécessaire pour faire tourner les tiges seulement. Le couple maximal nécessaire pour faire tourner l'ensemble des tiges et de la palette est M_S. La différence (M_S–M_F) détermine la résistance au cisaillement du sol. Il est à noter que la réduction dans la résistance au cisaillement après rupture est facilement déterminée par un essai en sol remanié effectué à la même profondeur.

Bâti d'enfoncement

Le bâti d'enfoncement est portable et peut offrir une force d'entraînement de une ou deux tonnes. L'appareil est ancré par quatre tarières et rondelles de retenue. La palette est enfoncée en utilisant un système d'engrenage manuel. Le bâti peut être assemblé et utilisé par une seule personne.

Palettes avec joint coulissant



Exemple d'enregistrement d'un essai

CARACTÉRISTIQUES

DESCRIPTION	DIMENSIONS	MASSE	CAPACITÉ	SENSIBILITÉ
Enregistreur de couple	38 cm × 38 cm × 25 cm	25 kg	1150 kg-cm	—
Bâti d'enfoncement	155 cm × 35 cm	35 kg	1 tonne	—
	155 cm × 45 cm	100 kg	2 tonnes	—
Palette	5 cm × 11 cm	0.3 kg	2,2 kg/cm²	0,60 (kg/cm² / po radial du papier d'enreg.)
	6,5 cm × 13 cm	0,5 kg	1,1 kg/cm²	0,30 (kg/cm² / po radial du papier d'enreg.)
	8 cm × 17,2 cm	0,8 kg	0,6 kg/cm²	0,15 (kg/cm² / po radial du papier d'enreg.)
Tige (dia. 20 mm)	1 m	2 kg	—	—

The Memova
high becaus
the rods. Th

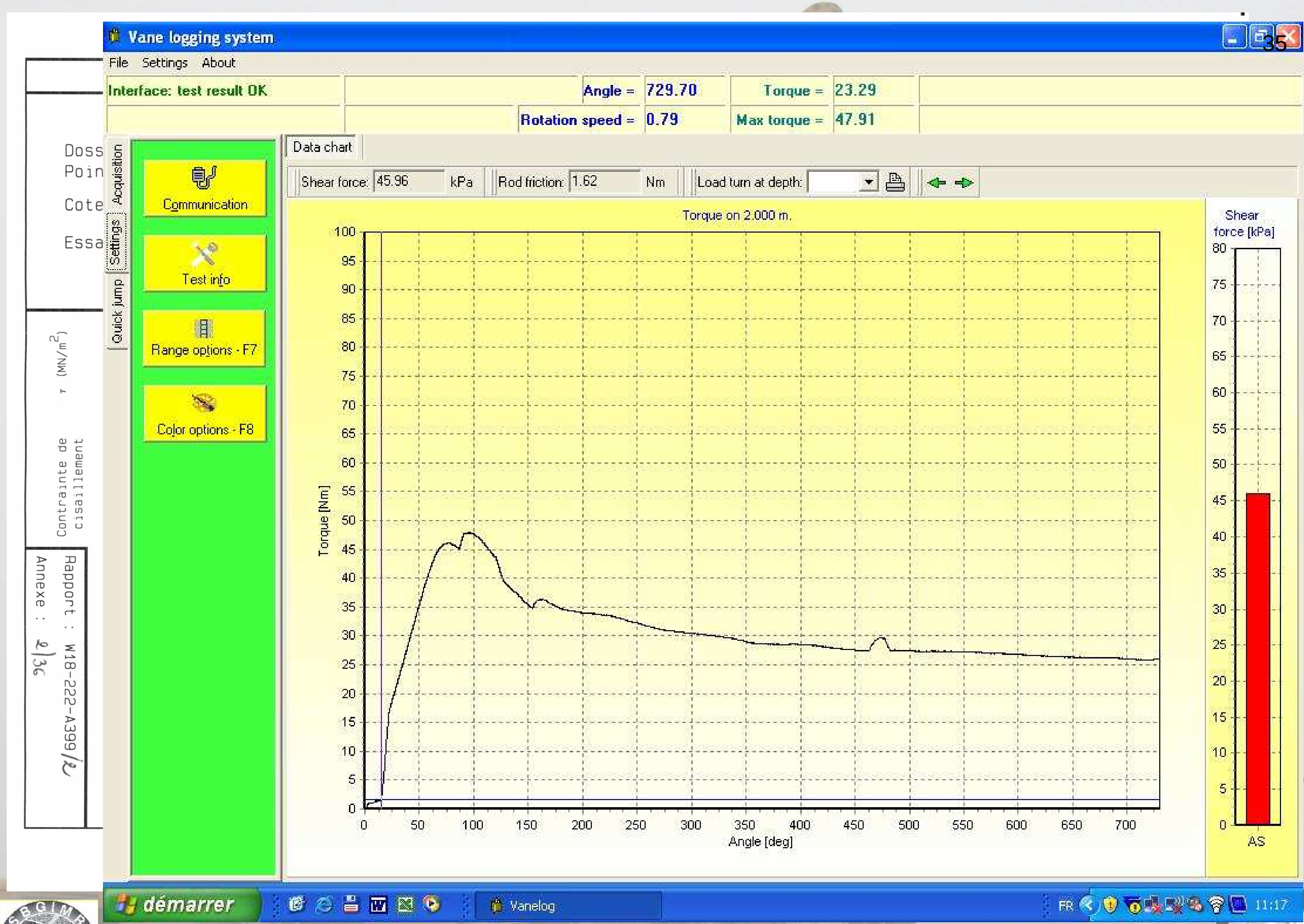
The vane an
for the insta
depth minus

The Memova
between 5 a
torque take

After the fa

Vhen the last vane test has been performed, the string is retracted.The Memovane is connected to the PC and all data s downloaded. The time from start is entered for each level and the PC extracts the corresponding vane data and nakes a diagram of each. Data files are produced at the same time.

Technical Specifications:	
Full range:	100 kPa (Vane size=55x110)
Resolution:	0.01 Nm
Accuracy:	0.3 Nm
Sampling rate:	1 per second


Vane logging system
File Settings About
Interface: test result OK
Angle = 729.70
Torque = 23.29
Rotation speed = 0.79
Max torque = 47.91
Acquisition
Settings
Quick jump
Communication
Test info
Range options - F7
Color options - F8
Data chart
Shear force: 45.96 kPa
Rod friction: 1.62 Nm
Load turn at depth:
Torque on 2.000 m.
Torque [Nm]
Angle [deg]
Shear force [kPa]
AS
démarrer
Vanelog
FR
11:17
Rapport : W18-222-A399/2
Annexe : 2/36
Contrainte de cisaillement

4 Equipment

4.1 Drilling equipment

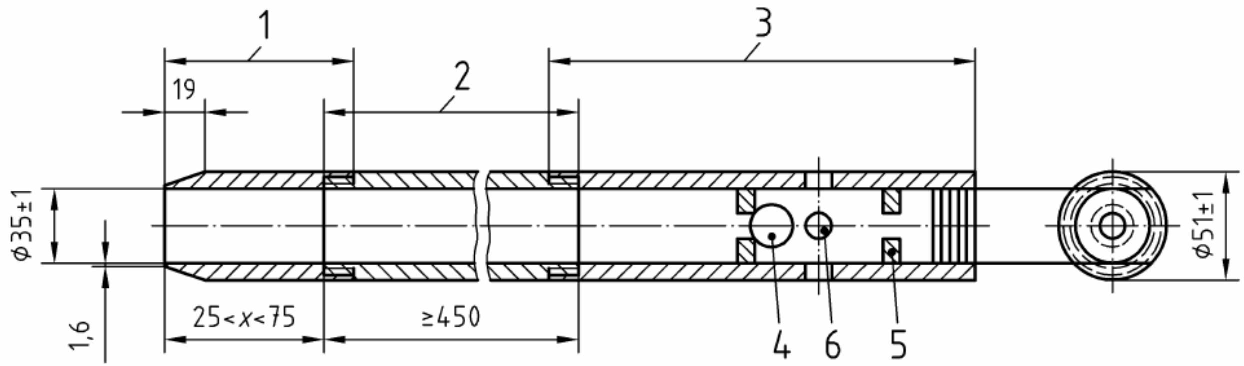
The drilling equipment shall be capable of providing a clean hole to ensure that the penetration test is performed on essentially undisturbed soil.

The area that is exposed in the base of the borehole prior to testing can influence the results and consequently the bor … iameter is 1

4.2

The … a non-retu

The … gravelly sar … (C).



Key

1 Drive shoe

2 Split barrel

3 Coupling

4 Non return valve (ball diameter: recommended 25 mm; ball seating: recommended 22 mm)

5 Ball retaining pins

6 Four vent holes (min diameter 12 mm)

x Length of the drive shoe

Figure 1 — Longitudinal cross section of an SPT sampler without a provision for a liner (dimensions in mm)

5.2 Preparation of the borehole

The borehole shall be prepared for the specified test depth. The base of the borehole shall be clean and essentially undisturbed at the test elevation and without an upward water pressure gradient.

When drilling bits are used, they shall be provided with side discharge and not with bottom discharge, from a safe distance of the test elevation.

When testing below the groundwater table, particular care shall be taken to avoid any entry of water through the bottom of the borehole, as this will tend to loosen the soil or even lead to piping. For this purpose, the level of the water or drilling fluid in the borehole shall be maintained at a sufficient level above the groundwater level in the layer with the highest pressure (potential) at all times, even during withdrawal of the boring tools. Withdrawal shall be performed slowly and with drilling tools providing enough clearance to prevent suction effects at the bottom.

When a casing is used, it shall not be driven below the level at which the test will start.

5.3 Test execution

The sampler and the drive rods shall be lowered to the bottom of the borehole and then the hammer assembly added. The initial penetration shall be recorded. The sampler shall be penetrated over an initial or seating drive of 150 mm applying the 63,5 kg hammer free falling 760 mm and the number of blows N_0 shall be recorded. Then the sampler in the same manner shall be driven over a test drive of 300 mm in at least 2 increments of 150 mm. The number of blows needed, shall be recorded during each of these increments (N_n). If a total of 50 blows for the test drive is reached, the test may be finished (N = 50); in soft rocks it can be increased to 100 blows (N = 100). The total number of blows required for the 300 mm penetration after the seating drive is termed the penetration resistance of that soil layer ($N = N_n + N_{n+1}$).

In hard soils or in soft rocks where the penetration resistance is very high, the penetration for a certain number of blows may be recorded.

A.1 Energy delivered to the drive rods

Energy losses are induced by the hammer assembly due to frictional and other parasitic effects, which cause the hammer velocity at impact to be less than the free fall velocity. Further losses of energy are originated by the impact on the anvil, depending on its mass and other characteristics. The type of machine, skill of the operator and other factors can also influence the energy delivered to the drive rods.

The value of the blow count, N, in sands is inversely proportional to the energy ratio E_r so that:

$$N_a \times E_{r,a} = N_b \times E_{r,b}$$

A.5 Use of the correction factors

Several correction factors have been mentioned in the previous paragraphs. As the existing design methods of foundations based on the SPT are of an empirical nature, only the corresponding correction factors should be used, unless duly justified.

If all the correction factors corresponding to this test procedure are applied for a design method based on an energy ratio of 60 %, the following value for the final blow count would be obtained (without including the one mentioned in A.3):

$$N_{60} = \frac{E_r}{60} \times \lambda \times C_N \times N \qquad \text{(A.5)}$$

where

λ is the correction factor for energy losses due to the rod length in sand;

C_N is the correction factor for vertical stress due to overburden of the soil in sand.

Dilatomètre plat (flat dilatometer)

The soil pressure p_1 against the flat dilatometer membrane when its centre is expanded 1,10 mm should be determined using the following relationship:

$$p_1 = p_B - \Delta P_{B;avg} - Z_m.$$

The soil pressure p_0 against the flat dilatometer membrane when its centre is flush with the blade should be determined with a linear backextrapolation from the soil pressure against the membrane at the two preset deflections, 0,05 mm and 1,10 mm, hence using the following relationship:

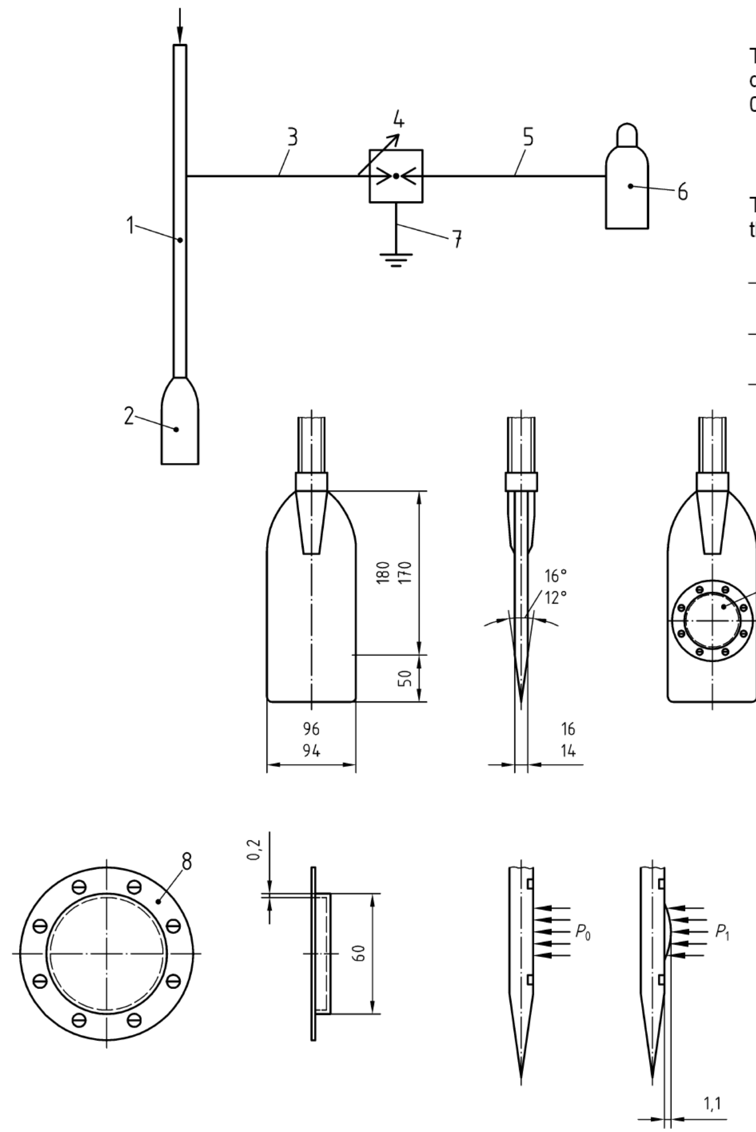
$$p_0 = 1{,}05\ (P_A + \Delta P_{A;avg} - Z_m) - 0{,}05\ p_1.$$

The material index I_{DMT}, the horizontal stress index K_{DMT} and the dilatometer modulus E_{DMT} should be calculated using the following relationships:

— $I_{DMT} = (p_1 - p_0) / (p_0 - u_0)$

— $K_{DMT} = (p_0 - u_0) / \sigma'_{v0}$

— $E_{DMT} = 34{,}7\ (p_1 - p_0)$

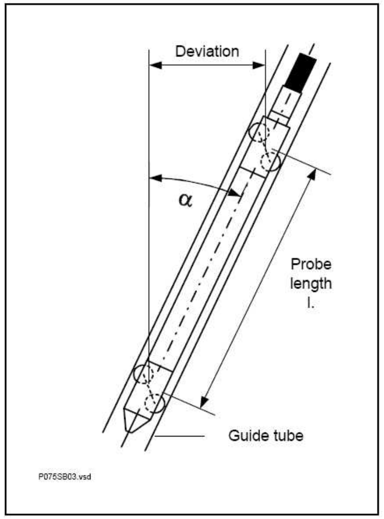


Mesures inclinométriques

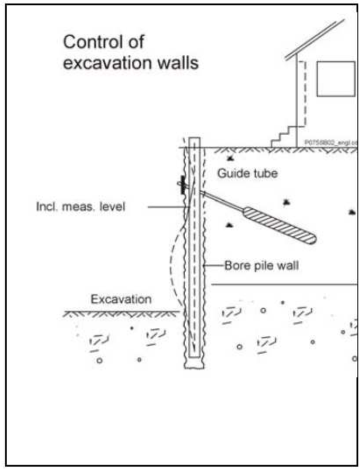
DIGITAL - VERTICAL - INCLINOMETER

Type: NMGD
Art. No: 75.02.01

Digital Probe - NMGD
- Latest technology with micro-controlling
- Approved and robust mechanics
- Installed controller/AD-converter with 16-Bit resolution ± 32.000
- Digital data transfer without disturbances via serial interface 1 mA
- Reliable measured data transfer for 1.000 m
- Real-value measuring data by correction and calculation of raw values in the controller
- Measured values registration with each PC-Laptop, notebock a.s.o.
- Simple calibration of probe, probe history stored in EEProm
- Low costs for standard model
- Probe secured against foreign use by pass-code, also in case of loss



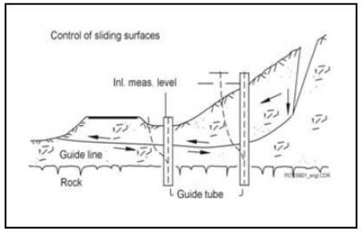
Application Ranges
- Stability control of skid-endangered slopes, constructions, retaining dams and embankments
- Deformation measurements at excavation walls, besides tunnel tubes, in bore piles
- Borehole measurements
- Verticality proof of diaphragm walls
- Stationary inclinometer chains

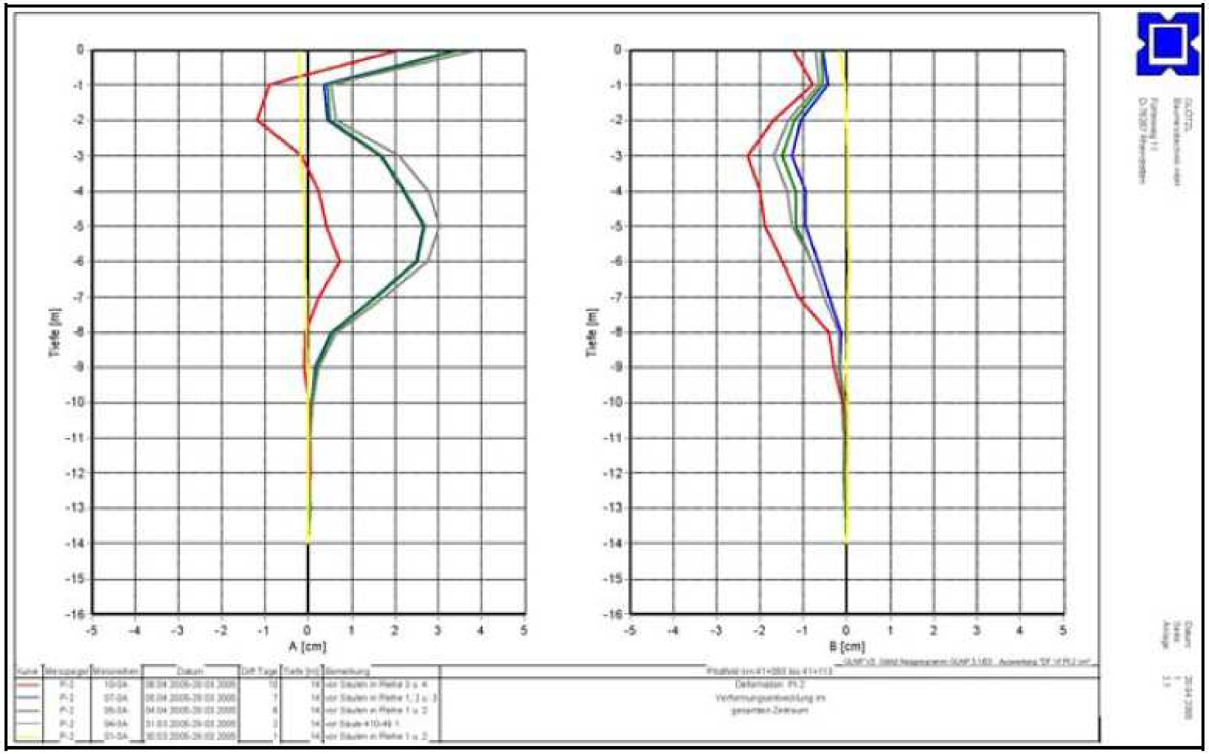


Measuring Principle

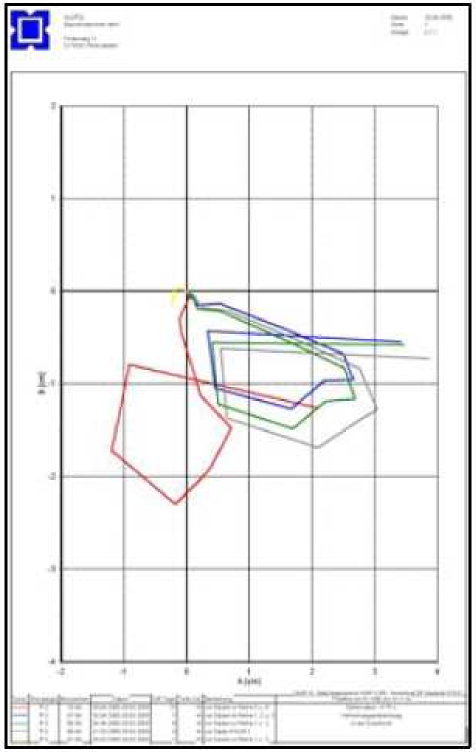
The analog measuring values of sensors are digitally converted, calculated and balanced in the probe by controller. Incorrect transfers are immediately recognized and definitely identified.

With the probe, the guide tube is passed through step by step from the bottom to the top. In each measuring step the probe is recording the inclination angle between vertical and probe position in one or two measuring levels (A- resp. A+B-axes). The output at the readout unit is either done as sine of the inclination angle or as horizontal deviation (mm/step). For a higher measuring accuracy and to avoid measuring errors, an additional turnover measurement should be carried out with probe turned by 180°.

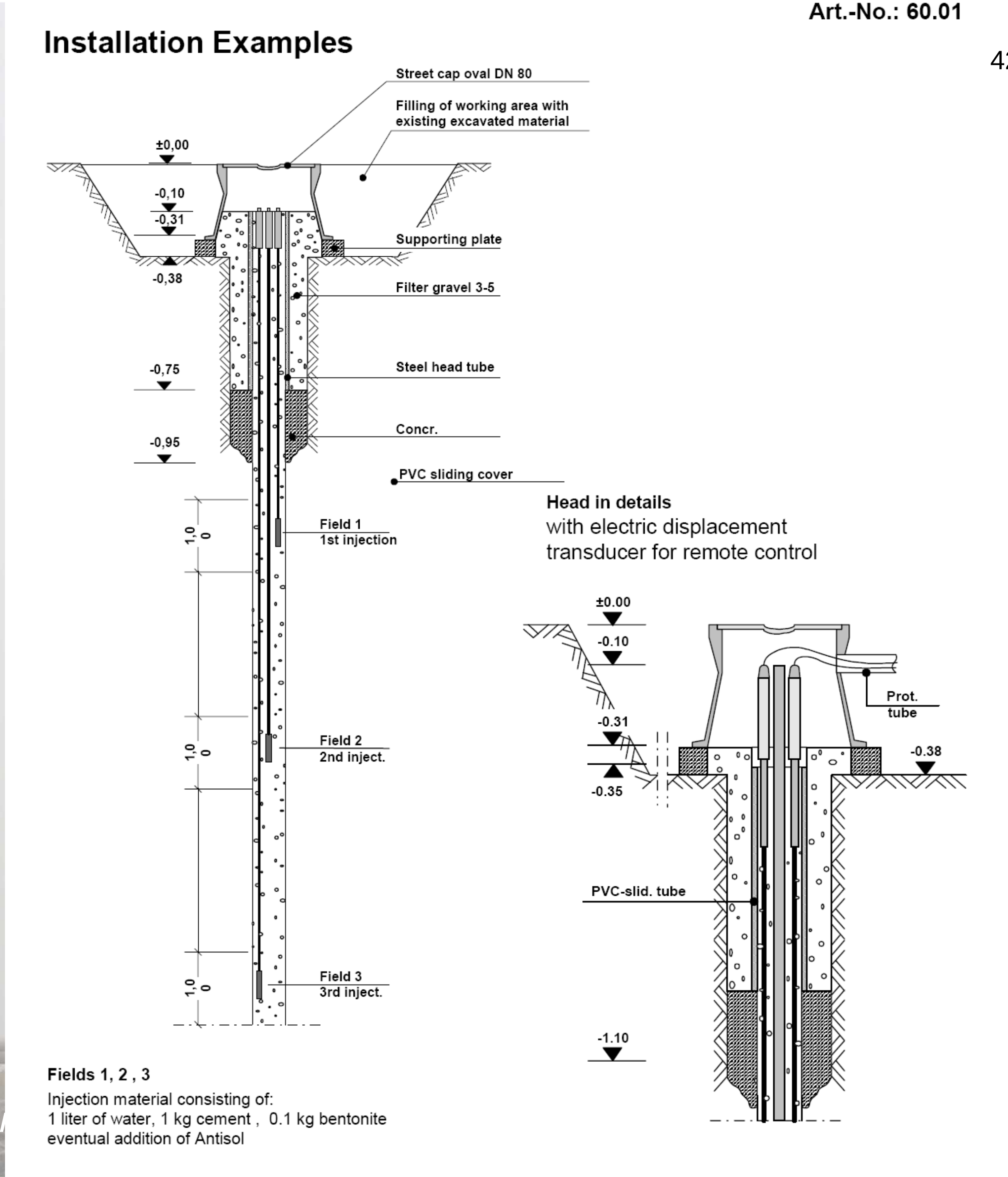




Tiefe [m]
A [cm]
B [cm]



Mesures extensométriques



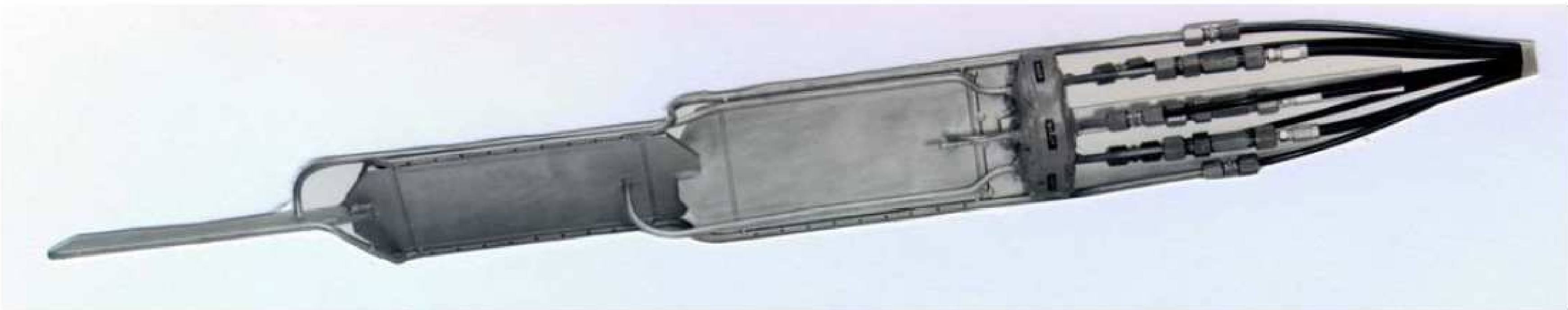
MULTIPLE EXTENSOMETER All extensometers are delivered completely assembled. In case of multiple extensometers, several single extensometers are fixed at the assembly plate by means of a counter nut. The measuring heads are mostly submerged in the borehole, so that a damage during on-site construction is nearly impossible. The insertion of a borehole can be determined short-term as no expensive multiple heads must be planned in advance.

Figure: 6-fold extensometer GKSE 6/16, consisting of
6 single extensometers with assembly plate
Installation is done by placing each extensometer into the borehole which is then fixed at the assembly plate.
A further possibility is the bunching of several extensometers outside of the borehole or on a ground-level for which the plastic holders can be used.

BORE HOLE CELL

Type: BB . . .

Art. No.: 03. . .



The bore hole cells or stress monitoring systems (SMS) are a suggestion for determination of the principle component of stress in size and direction.

The stress is a tensorial size which is determined by 9 resp. 6 directed sizes.

The installation of such a measuring equipment is an essential problem. Normally, this equipment is installed in a bore hole.

The deepening of the boring causes a stress transposition and thus a disturbance which seems to be unavoidable.

To solve this problem, it is our suggestion to install the measuring equipment in the bore hole and then to grout the annulus with injection material.

The basis for this idea is the

effect of hard inclusion.

This means that the injection material should have a higher stiffness as the surrounding rock.

The thus effected stress concentration is acting contrary to the stress transposition by the deepening of the boring.

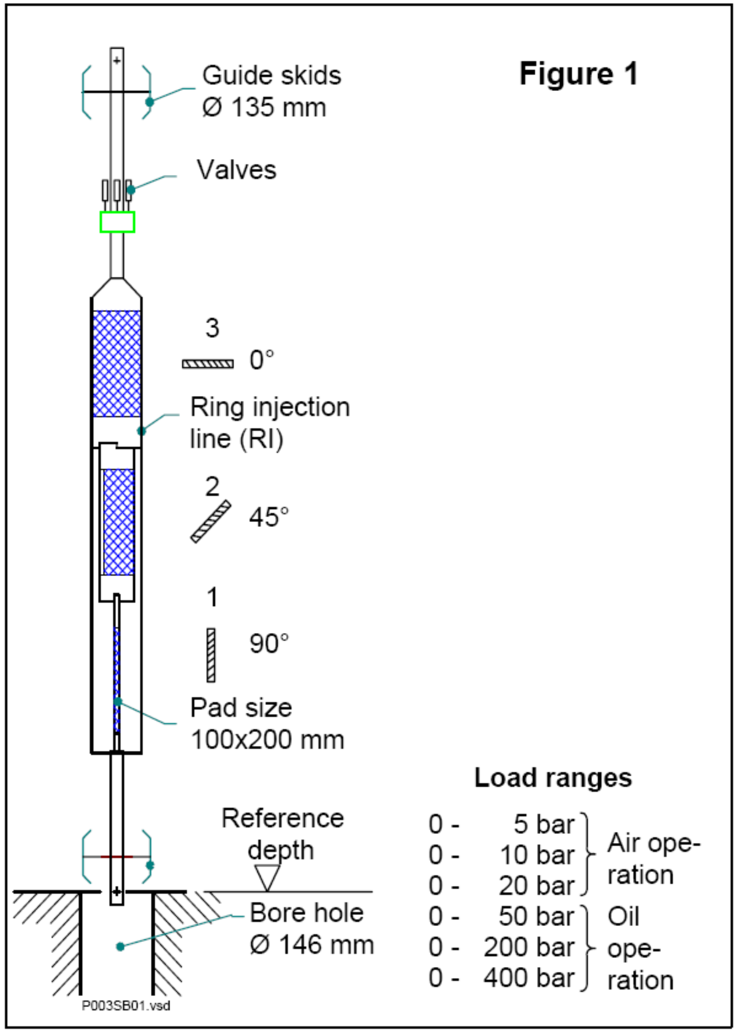


Figure 1 shows the assemblage of three cells which absorb the components. This enables the observation of the two-dimensional portion of the main stress.

Type: BB

Art. No.: 03. . .

Investigation of the Rock

- TV probe
- Consideration of boring cores
- Selection of a suitable drift

Test Implementation and Technics

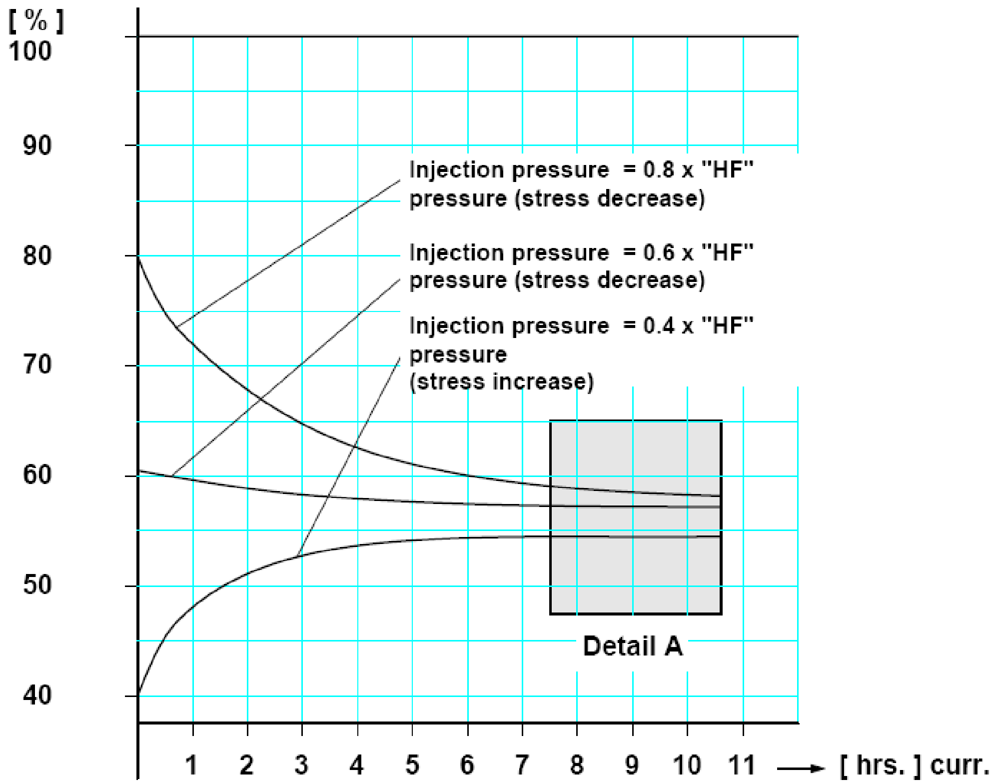
- Determination of the „hydraulic fracturing“ pressure
  (pressure for opening resp. keeping open of fissures)
  This value is limiting the max. possible primary stress condition of the rock.
- Placing of bore hole probe with 3 cells oriented in one level
  - a - by means of settlement rods in case of small depths up to approx. 30 m
  - b - by means of drill-rods

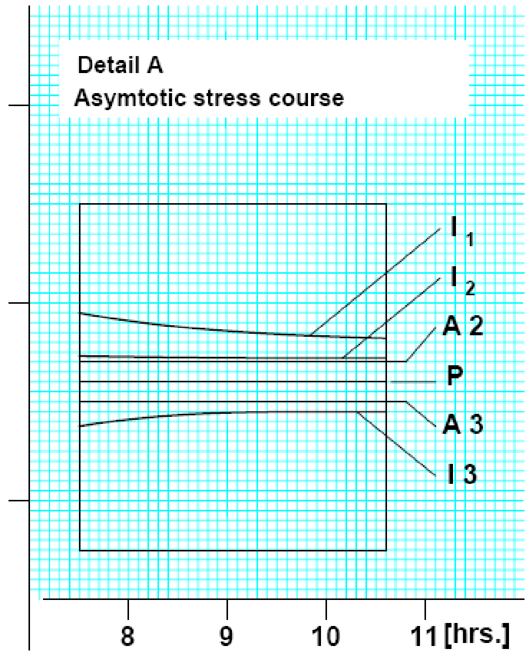
    Determination of orientation by means of a compass with remote control;
    Position or twisting angle of probe must not specifically be achieved,
    the determination of the actual status is sufficient.
- Closing of the drift by means of packers
- Injection of annulus between bore hole wall and bore hole probe body with a pressure
  0.8 x “hydraulic fracturing“ pressure
- E-modulus of injection material   E-modulus of surrounding rock
- Measurement of injection pressure with single cells
- Measurement of stress decrease or stress increase after hardening of injection material

Case A Decrease of Measured Pressure

Drop of stress by means of stress transposition
The injected pressure is higher than the primary stress. The measured pressure in the cells is approaching the primary stress asymptotically.
Placing of a second bore hole probe
Injection of the annulus with a pressure of 0.6 x “hydraulic fracturing“ pressure
When the injected pressure is reduced, placing of a third probe

Stress Time Diagram Case A





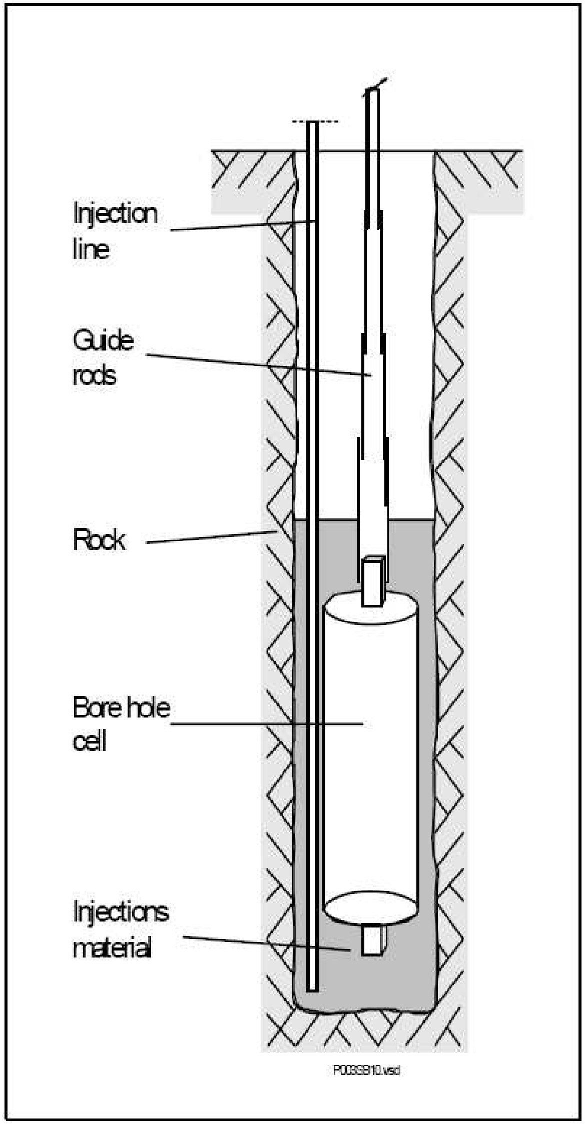
I_1 Injection pressure = 0.8 x „HF“ pressure

I_2 Injection pressure = 0.6 x „HF“ pressure

A_2 Asymptote to I_2

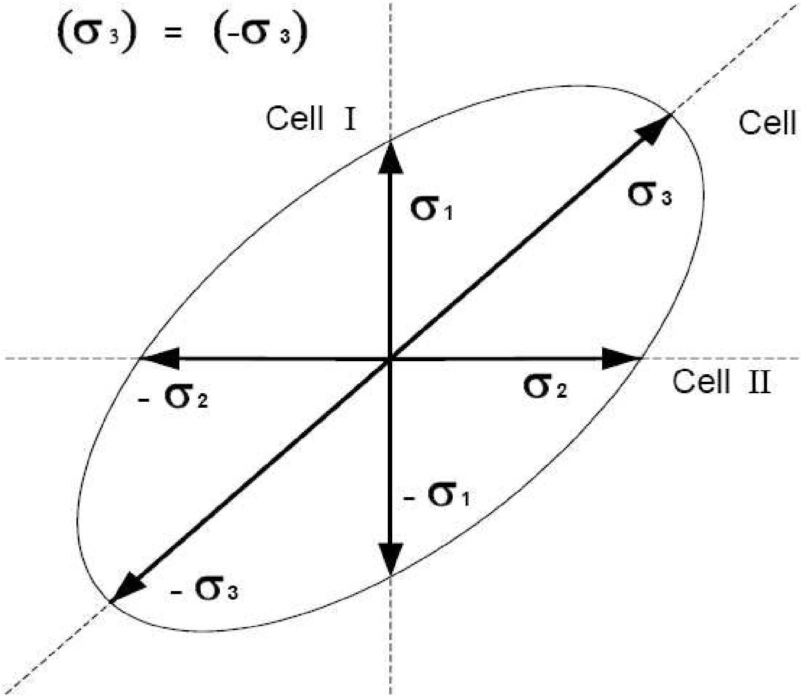
P Primary stress = $\frac{A_2 + A_3}{2} \pm \frac{A_2 - A_3}{2}$

Installation in Bore Hole



- By means of guide rods for directionally oriented installation
- Injection of bore hole cell by means of concrete with expanding addition
- Measurement of horizontal main stress in size and direction

Stress ellipse
Main stress



Geotechnical investigation and testing — Geohydraulic testing — Part 1: General rules

1 Scope

This ~~document~~ part of ISO 22282 deals with the general rules and principles for geohydraulic testing in soil and rock as part of the geotechnical investigation services in accordance with EN 1997-1 and ~~pr~~EN 1997-2. It defines concepts and specifies requirements relating to permeability measurement in soil and rock.

The different purposes of geohydraulic testing are to obtain information on the permeability of soil or rock in natural or treated states, transmissivity and storage coefficient, and hydrodynamic parameters of aquifers.

Geohydraulic testing is used for many purposes, such as:

a) absorption capacity and effectiveness of grouting in rock mass;

b) assessment of seepage and drainage;

c) assessment of groundwater lowering work;

d) effect of cut-offs for dams;

e) effect of tunnels and shaft sinking;

f) checking fill or cover tightness

g) assessment of the flow of fluids and suspensions in the ground

h) planning of remedial measures.

NOTE 1 Geohydraulic testing for water supply is covered by ISO 14686.

NOTE 2 For most type of ground, field permeability tests yield more reliable data than those carried out in the laboratory, because a larger volume of material is tested, and because the ground is tested in situ, thereby including effects resulting from the structure of the ground mass but avoiding the disturbance associated with sampling.

Th~~e~~is ~~document~~ part of ISO 22282 deals with the execution of tests with groundwater and does not explicitly consider other fluids and suspensions. The flow of other fluids and suspensions can be considered by applying the different viscosities and relations between transmissivity, permeability coefficient~~(hydraulic conductivity)~~ and ~~absolute~~ intrinsic permeability.

Essais géohydrauliques : série – en-iso-22282-1à 6

Geotechnical investigation and testing — Geohydraulic testing — Part 1: General rules

Geotechnical investigation and testing — Geohydraulic testing — Part 2: Water permeability tests in a borehole using open systems

Geotechnical investigation and testing — Geohydraulic testing — Part 3: Water pressure tests in rock

Geotechnical investigation and testing — Geohydraulic testing — Part 4: Pumping tests

Geotechnical investigation and testing — Geohydraulic testing — Part 5: Infiltrometer tests

Geotechnical investigation and testing — Geohydraulic testing — Part 6: Water permeability tests in a borehole using closed systems

Je vous remercie de votre attention