Annual Report of E-learning project: Site Investigation Simulation Program Part II: Laboratory tests

Project number: 2011.211
01.01.2011 - 31.12.2011
Chien-Hsun Chen (Project Leader)
Department of Infrastructure
Devision of Geotechnical and Tunnel Engineering

January 19, 2012

Contents

1 Introduction

A good foundation ensures the stability of the structure standing above it. The proper design as well as the following construction of a good foundation rely on the good understanding/evaluation of in-situ underground conditions. Therefore, no good constructions/designs can flee from carrying out proper site investigations, as it is the key to the safe design of structures and the key to personnel safety during construction as well.

The aim of this program is to simulate the site investigation being carried out during design phase. By carrying out a site investigation plan, the underground conditions can be better understood and the required parameters for design or numerical analyses can be obtained through in-situ tests (e.g. dynamic probing in Austria, SPT in American and Italian, CPT in Netherlands) and by sending specimens retrieved from in-situ boreholes to laboratory for testing. The types of laboratory test required to be carried out are decided by the engineers based on the type and the function of the structure to be built (e.g., the type of foundations, the amount of loading), the geometrical conditions (e.g., on a slope, on a clip, flat land), the geological conditions (e.g., old riverbed, glacial area, alluvial area), and etc. Therefore, one needs some practice before being able to carry out proper or better site investigations. To achieve that, the program was designed to be able to carry out the Dynamic probing heavy being often used in the Austria and Germany (in-situ tests), as well as various laboratory tests.

This project “Site Investigation Simulation Program” consists of Part I and Part II. Part I was finished in the year of 2010. It focused on developing various 3D geological models and the graphical user interface (GUI) in Matlab. In addition, the in-situ test (SPT-N value) and in-situ sampling (engineering borings) can be carried out in the simulation. Three type of foundations combined with 4 different geological models provides 12 various tasks are provided. By involving a special random number technique, the program provides 10000 cases for students with varying underground conditions. That random number technique also promises an arbitrary case to be re-produced based on a case code, which could be used for the instructor to re-generate cases while discussing with the users. For details of the developed models and GUI in the project Part I, reader are referred to the annual report of the project Part I. As students who enrolled in the technical university at the University of Innsbruck have free assess to Matlab within the campus network or at home through VPN connections, they may run the program any time anywhere.

The features developed in project Part I made it possible to become a powerful tool to help students with learning site investigation by implementing laboratory tests. Implementation of laboratory tests is therefore the main task of the project Part II. The goal of project Part II has been reached in the end December 2011. In the simulation of site investigation, if the user carry out the in-site sampling (drilling boreholes), the specimen can be delivered to a laboratory for further test. Therefore, the project Part I and Part II make the program a great tool for student to get to know site investigation and can practice with it.

The achievement of the project part II and its usage in some of the courses are detailed in the coming sections.

2 Site Investigation Part II

2.1 The task

The main task of the site investigation project Part II, as also detailed in the proposal of the project part II, is to

1. create a database of laboratory tests;
2. make conducting laboratory tests in the simulation program possible.

The task has been fulfilled and is detailed in the following sub-sections.

2.2 Database and laboratory tests

The created database (which will be detailed in a later section) provides the information to produce the following laboratory tests as promised in the proposal (listed bilinqually: English — German):

1. Water content (w) — Wassergehalt (w)
2. Void ratio/Porosity (e/n) — Porenzahl/Porenanteil (e/n)
3. Degree of Saturation (S) — Sättigungsgrad (S)
4. Density of Solids — Korndichte
5. Natural density — natürlich Dichte
6. Dry density — Trockendichte
7. Max. and Min. e/n — Lockerste/dichste Lag (LD)
8. Atterberg limits (Ip) — Zustandsgrenzen (Ip)

9. Grain size distribution — Korngroß enverteilung
10. Permeability (k10) — Durchlässigkeit (k10)
11. Compression test (Oedometer) — Kommpressionsversuch
12. Direct shear test — Direktscherversuch
13. CD triaxial test — CD Triaxialversuch
14. Multi-stage triaxial CD test — Mehrstuf. Triaxialversuch
15. UU triaxial test — UU Triaxialversuch
16. Standard compaction test (Proctor) — Proctorversuch

The standard compaction test is provided herein as it is must-konw standard compaction test. The testing procedure for the standard and modified compaction test are identical, except that the later requires a heavier hammer in the test. The CU test are not provided herein as it makes more sense if excess pore water pressure during shear can be produced by a proper constitutive model. Professor Kolymbas and his colleagues have been working on developing a simple constitutive equations for cohesive soils. As lacking of CU affects the simulation program only very little, it is therefore suggested that CU test being included later on, using a meaningful constitutive model for cohesive soils if there is any.

Each laboratory test requires specific parameters to reproduce the laboratory test results. Those parameters and the corresponding explanations along with the reference sources are listed in Table 1. It is noted that there are four main types of soils in the program, they are:

1. Soil type 1: Gravel / Kries (denoted as yellow)
2. Soil type 2: Sand / Sand (denoted as orange)
3. Soil type 3: Silt / Schluff (denoted as oliv)
4. Soil type 4: Clay / Ton (denoted as violet)

These four type is the classification based on the size of soil grains in geotechnical engineering. The colors use herein are regulated in the germen regulation, DIN 4023. These colors are similar to the ones regulated in the austrian regulation, ÖNORM B 4400-1:2010. There are 8 typical types of soils implemented in this program. These 8 types of soils are somewhat combinations of the above four soil grain sizes. The created database of soil parameters listed in Table 2 are adopted based on the references listed in Table 1.

If a parameter does not apply to that soil, its value is set to be zero. This simulation program apply to granular geomaterials, therefore, no sample can be retrieved from bedrock (implying that no laboratory tests can be carried out in the bedrock in this program)

2.3 Formal reports: laboratory Tests and in-situ dynamic probing.

In order to bring a more realistic situation, the user will get a standard laboratory test results if they deliver specimens to laboratory for testing. The laboratory reports used by Division of Geotechnical and Tunnel Engineering, University of Innsbruck, are adopted herein. They are re-generated to give the user a realistic feeling of receiving a real laboratory test results. By doing this, the user can learn how to read a standard laboratory report and learn how to find out important information for a laboratory report. Besides, the graphical interface and all information are given in English, except for the laboratory test. In stead of considering it as a inconsistency in language, we believe that will help the student to start to get in touch with English technical terms used in geotechnical engineering. For example, Korverteilungsliene is grain size distribution, Rammsonder is called dynamic probing, Druchlässigkeitsversuch is called permeability test, and etc.

It is worth mentioning that the reports has been successfully created using Matlab alone, which means no extra software are required. The laboratory tests and corresponding report is detailed as follows:

- The laboratory report for water content, void raio/Porosity, degree of Saturation, natural density, . dry density, and Max. and Min. void ratio / porosity is shown Figure 1.
- The laboratory report for Atterberg limits and soil classification results is shown in Figure 2.
- The laboratory report for a grain size distribution analysis is shown in Figure 3.
- The laboratory report for a permeability test is shown in Figure 4.
- The laboratory report for a compression test (Oedometer test) is shown in Figure 5.
- The laboratory report for a direct shear test is shown in Figure 6.

	Parameters	Explanation	Reference
1	Index	Soil index, (numbering the soil data base.)	-
2	Soil type	Soil type, (denoted by integer 1, or 2, 3 ...)	the classification of soils, these soil type involve most of the range of the various grain size 0.001 mm 63 mm.
3	N_{10}	Number of drops of the insitu dynamic probing light, per 10 cm.	Presentation of Prof. Czurda and Partner mbH. Geologen und Ingenieure für Wasser und Boden.
4	cu	Undrained shear strength for UU test	IGT laboratory test results
5	c	Undrained test for CU test	IGT laboratory test results
6	ϕ	Undrained friction angle for CU test	IGT laboratory test results
7	c'	Drained cohesion for CD test,	IGT laboratory test results
8	ϕ'	Drained friction angle for CD test	IGT laboratory test results
9	k_{10}	Permeability at temperature of 10 degree	Kolymbas D. Geotechnik, 3rd print. Springer 2011.
10	w	Natural water content	Karl Josef Witt (Hrsg.) Grundbau-Taschenbuch. Tei1: Geotechnische Grundlagen. T. Auflage. Ernst and Sohn 2009. ISBN 972-3-433-01843-9.
11	ρ_s	Density of soilds	Karl Josef Witt (Hrsg.)
12	$e(insitu)$	Natural void radio	Karl Josef Witt (Hrsg.)
13	e_{min}	Mininum void ratio	Karl Josef Witt (Hrsg.)
14	e_{max}	Maximum void ratio	Karl Josef Witt (Hrsg.)
15	$\rho_{d,min}$	Mininum dry density	Karl Josef Witt (Hrsg.)
16	$\rho_{d,max}$	Maximum dry density	Karl Josef Witt (Hrsg.)
17	w	Coefficient grain size distribution curve	Karl Josef Witt (Hrsg.)
18	abi	Coefficient grain size distribution curve	Murray D. Fredlung, D.G. Fredlund, and G. Ward Wilson (2000) 'An equation to represent grain-size distribution' Can. Geotech. J., 37. 817-827.
19	nbi	Coefficient grain size distribution curve	Murray et al.
20	mbi	Coefficient grain size distribution curve	Murray et al.
21	drbi	Coefficient grain size distribution curve	Murray et al.
22	dm	Coefficient grain size distribution curve	Murray et al.
23	jbi	Coefficient grain size distribution curve	Murray et al.
24	kbi	Coefficient grain size distribution curve	Murray et al.
25	lbi	Coefficient grain size distribution curve	Murray et al.
26	Lower-bound	The lower-bound of the grain's diameters in mm	IGT laboratory test results
27	Upper-bound	The upper-bound of the grain's diameters in mm	IGT laboratory test results
28	Ip	Plastic index	Karl Josef Witt (Hrsg.) Grundbau-Taschenbuch. Tei1: Geotechnische Grundlagen. T. Auflage. Ernst and Sohn 2009. ISBN 972-3-433-01843-9.
29	w_L	Liquid limit	Karl Josef Witt (Hrsg.)
30	ρ_{pr}	Density at 100% compaction (proctor test)	Karl Josef Witt (Hrsg.)
31	w_{pr}	Water content at 100% compaction (proctor test)	Karl Josef Witt (Hrsg.)
32	Cc	Compression index Cc at stress state of 0.1 - 0.2 MN/m2	IGT laboratory test results; Holz R. and Kovascs K. An introduction to Geotechnical Engineering. Rainbow-Bridge Bok Co. Ltd.
33	Cs	Compression index Cs at first unloading	The same as above.

Table 1: List of soil parameters in the database for eight typical soils.

	Parameters	Gravel	Small gravel (Kies)	Dense sand	Loose sand	Silt (Schluff)	NC clay (Ton)	NC high Plastic clay	OC Clay	Bedrock
1	Index	1	2	3	4	5	6	7	8	9
2	Soil type	1	1	2	2	3	4	4	4	5
3	N_{10}	45	35	25	17	10	4	3	15	150
4	value cu	250	220	200	42	45	37	37	37	1000
5	c	0	0	2	2	3	1	1	0	1000
6	ϕ	25	24	23	18	16	11	15	16	80
7	c'	0	0	1	1	2	2	2	8	1000
8	ϕ'	45	42	39	28	27	20	30	17	80
9	K_{10}	5.2E-2	1.1E-3	1.7E-6	7.4E-4	4.8E-7	6.3E-8	1.4E-9	5.7E-9	8.6E-1
10	w	5.1	9.2	11.1	12.8	19.3	17.5	18.9	18.2	1.1
11	ρ_s	2.65	2.65	2.65	2.65	2.67	2.75	2.77	2.73	2.65
12	$e(insitu)$	0.52	0.55	0.53	0.74	0.52	1.7	1.21	0.89	0.1
13	e_{min}	0.3	0.33	0.5	0.56	0.39	0	0	0	0
14	e_{max}	0.69	0.67	0.71	0.75	0.67	0	0	0	0
15	$\rho_{d,min}$	1.6	1.6	1.5	1.5	1.6	0	0	0	0
16	$\rho_{d,max}$	1.9	2	1.8	1.7	1.9	0	0	0	0
17	w (grading)	1	1	1	1	0.1	1	1	1	1
18	abi	29.06	5.25	1.68	1.68	0.03	0.42	0.89	0.05	1
19	nbi	3.64	3.41	3.91	3.91	5.82	3.16	3.9	0.72	1
20	mbi	1.01	0.93	0.71	0.71	2722.79	0.04	0.01	0.26	1
21	drbi	100.02	100.17	101.05	101.05	-0.82	99.88	99.64	100	1
22	dm	0.4	0.03	0.03	0.03	0	0	0	0	1
23	jbi	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	1
24	kbi	1	1	1	1	1.59	1	1	1	1
25	lbi	0.3	0.3	0.3	0.3	1.53	0.3	0.3	0.3	1
26	lower-bound	0.08	0.01	0	0	0	0	0	0	1
27	upper-bound	1000	110	40	40	2	7	7	7	1
28	Ip	0	0	0	0	6.2	23.5	33.2	18.4	0
29	w_L	0	0	0	0	34.1	44.3	60.5	38.6	0
30	ρ_{pr}	1.9	2.21	1.95	2.1	1.7	1.65	1.51	1.72	0
31	w_{pr}	7.9	4.2	9.9	6.2	18.2	21.2	24.7	19.5	0
32	Cc	0	0.01	0.02	0.04	0.05	0.1	0.14	0.04	0
33	Cs	0	0	0	0	0.01	0.01	0.02	0	0

Table 2: List of soil parameters in the database for eight typical soils.

- The laboratory report for a triaxial CD test is shown in Figure 7.
- The laboratory report for a triaxial CD multi-state test is shown in Figure 8.
- The laboratory report for a triaxial UU test is shown in Figure 9.
- The laboratory report for a compaction test (Proctor test) is shown in Figure 10.

The formal report of the dynamic probing is also implemented, as shown in Figure 11.

2.3.1 Some remarks of reproducing the lab test reports

Compression tests (Oedometer test): This test requires only and Cc and Cs. It will generate the compression test results. This results holds only within the stress state of 0.4 MN/m^2.

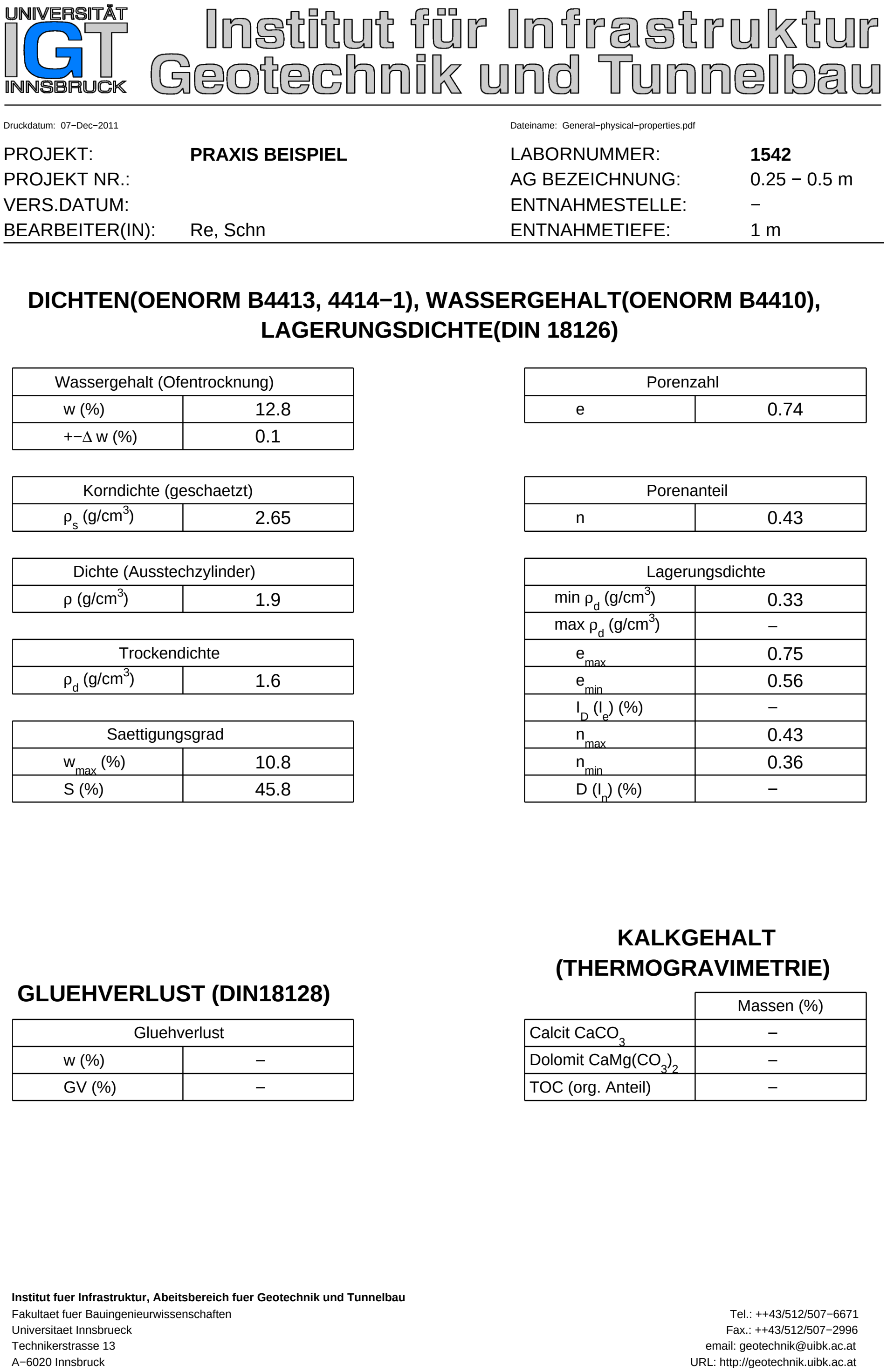
Grain size distribution analyses: The curve-fitting to the grain size distribution curve is carried out by using the model proposed by Murray et al.[1](see table 1). Then the index of curvature (Cc) and index of uniformity (Cu) are calculated from the model. Cc and Cu are then further used for soil naming and soil classification.

Soil naming and soil classification: A subroutine has been made to carry out the soil naming and soil classification based on ÖNORM B 4400-1:2010 and ÖNORM EN ISO 14688-1:2003. The percentage of grain sizes of fine contents, silt, sand, gravel, and stones, Cc, Cu, Ip and w_L are required. If any of the above parameters do not apply, their values will be set to zeros. Soil naming and soil classification are used in the report of grain size distribution analysis and in the report of Atterberg limits, respectively.

Triaxial tests: Triaxial test are reproduced based on the prescribed inertial friction angle and cohesion. The Mohr-circles plotted with most encountered stress states (with cell pressure of 100 kPa, 200 kPa and 300 kPa). Random numbers are added to the Mohr-circles to bring up more realistic uncertainty of the test results.

---

[1] Murray D. Fredlung, D.G. Fredlund, and G. Ward Wilson (2000) An equation to represent grain-size distribution Can. Geotech. J., 37. 817-827.



UNIVERSITÄT IGT INNSBRUCK

Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: General−physical−properties.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1542**
PROJEKT NR.:		AG BEZEICHNUNG:	0.25 − 0.5 m
VERS.DATUM:		ENTNAHMESTELLE:	−
BEARBEITER(IN):	Re, Schn	ENTNAHMETIEFE:	1 m

DICHTEN(OENORM B4413, 4414−1), WASSERGEHALT(OENORM B4410), LAGERUNGSDICHTE(DIN 18126)

Wassergehalt (Ofentrocknung)	
w (%)	12.8
$+-\Delta$ w (%)	0.1

Porenzahl	
e	0.74

Korndichte (geschaetzt)	
ρ_s (g/cm^3)	2.65

Porenanteil	
n	0.43

Dichte (Ausstechzylinder)	
ρ (g/cm^3)	1.9

Trockendichte	
ρ_d (g/cm^3)	1.6

Saettigungsgrad	
w_{max} (%)	10.8
S (%)	45.8

Lagerungsdichte	
min ρ_d (g/cm^3)	0.33
max ρ_d (g/cm^3)	−
e_{max}	0.75
e_{min}	0.56
I_D (I_e) (%)	−
n_{max}	0.43
n_{min}	0.36
D (I_n) (%)	−

KALKGEHALT (THERMOGRAVIMETRIE)

	Massen (%)
Calcit $CaCO_3$	−
Dolomit $CaMg(CO_3)_2$	−
TOC (org. Anteil)	−

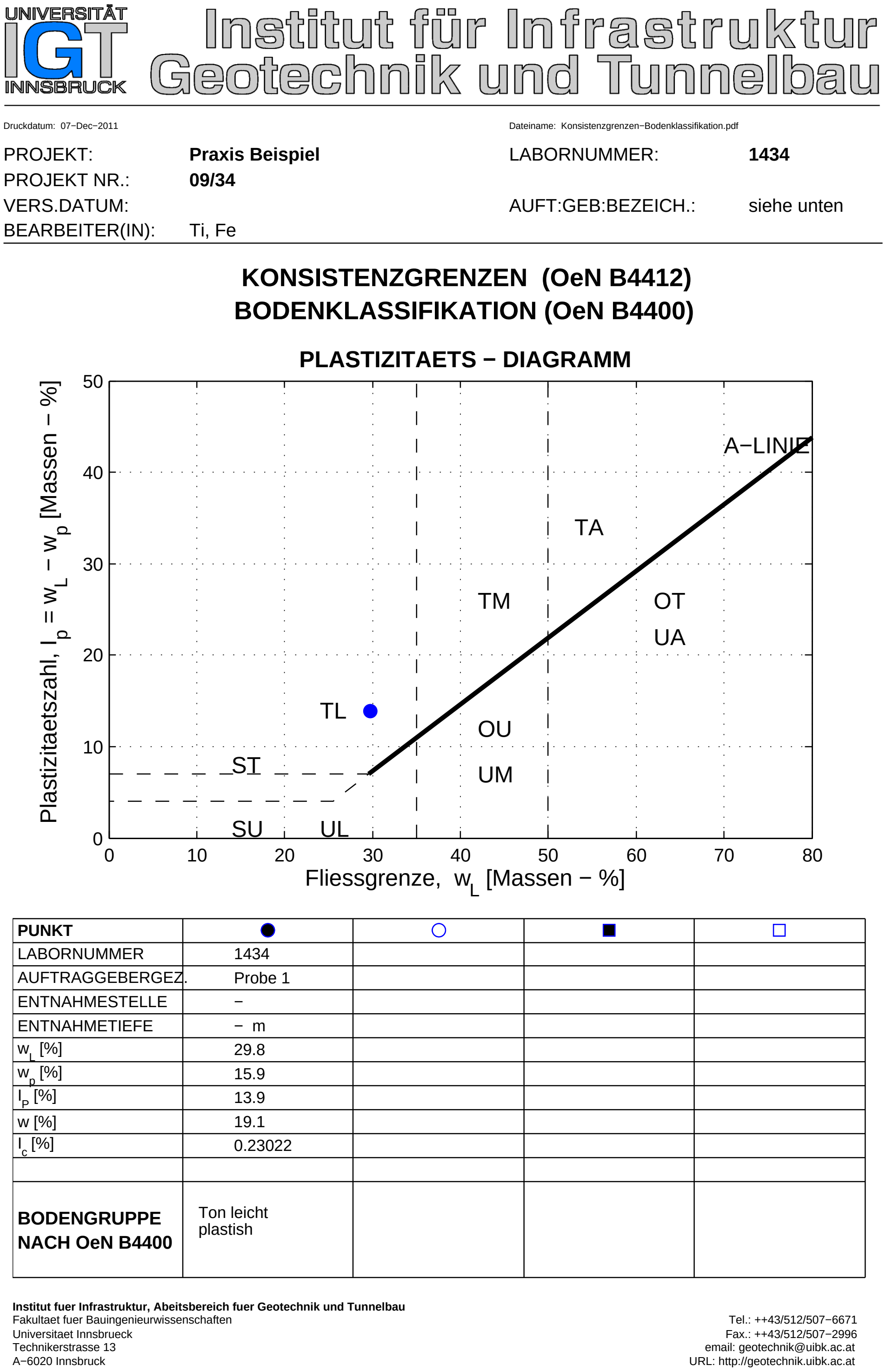
GLUEHVERLUST (DIN18128)

Gluehverlust	
w (%)	−
GV (%)	−

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 1: An example of reproduced laboratory report for water content, void raio/Porosity, degree of Saturation, natural density, dry density, and Max. and Min. void ratio / porosity.



UNIVERSITÄT IGT INNSBRUCK

Institut für Infrastruktur
Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: Konsistenzgrenzen−Bodenklassifikation.pdf

PROJEKT:	**Praxis Beispiel**	LABORNUMMER:	**1434**
PROJEKT NR.:	**09/34**		
VERS.DATUM:		AUFT:GEB:BEZEICH.:	siehe unten
BEARBEITER(IN):	Ti, Fe		

KONSISTENZGRENZEN (OeN B4412)
BODENKLASSIFIKATION (OeN B4400)

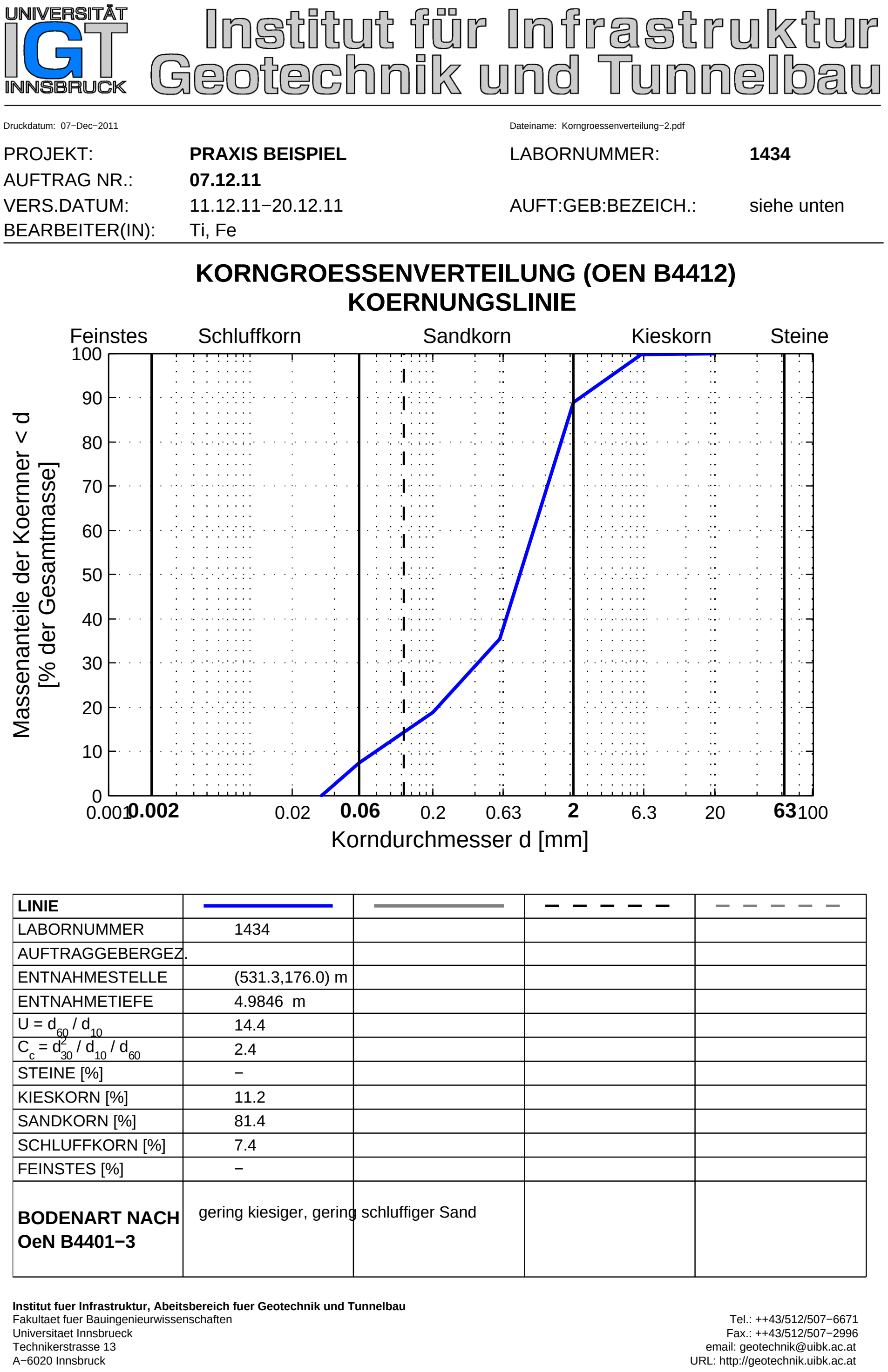
PLASTIZITAETS − DIAGRAMM

PUNKT	●	○	■	□
LABORNUMMER	1434			
AUFTRAGGEBERGEZ.	Probe 1			
ENTNAHMESTELLE	−			
ENTNAHMETIEFE	− m			
w_L [%]	29.8			
w_p [%]	15.9			
I_p [%]	13.9			
w [%]	19.1			
I_c [%]	0.23022			
BODENGRUPPE NACH OeN B4400	Ton leicht plastish			

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 2: An example of reproduced laboratory report for Atterberg limits and soil classification results.



UNIVERSITÄT IGT INNSBRUCK Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011 Dateiname: Korngroessenverteilung−2.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1434**
AUFTRAG NR.:	**07.12.11**		
VERS.DATUM:	11.12.11−20.12.11	AUFT:GEB:BEZEICH.:	siehe unten
BEARBEITER(IN):	Ti, Fe		

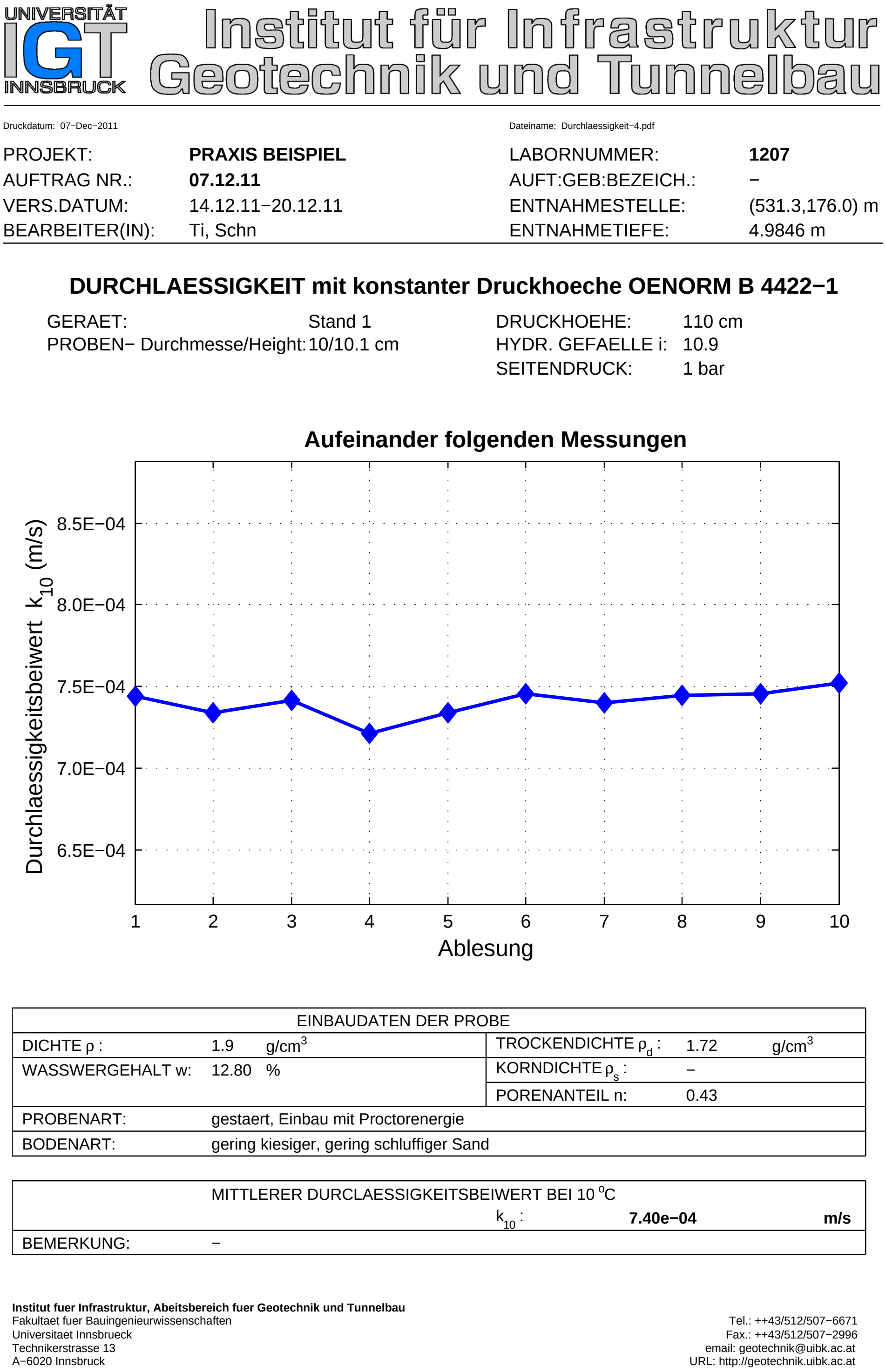
KORNGROESSENVERTEILUNG (OEN B4412)
KOERNUNGSLINIE

LINIE	━━━━	━━━━	— — — — —	– – – – –
LABORNUMMER	1434			
AUFTRAGGEBERGEZ.				
ENTNAHMESTELLE	(531.3,176.0) m			
ENTNAHMETIEFE	4.9846 m			
$U = d_{60} / d_{10}$	14.4			
$C_c = d_{30}^2 / d_{10} / d_{60}$	2.4			
STEINE [%]	−			
KIESKORN [%]	11.2			
SANDKORN [%]	81.4			
SCHLUFFKORN [%]	7.4			
FEINSTES [%]	−			
BODENART NACH OeN B4401−3	gering kiesiger, gering schluffiger Sand			

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 3: An example of reproduced laboratory report for the grain size distribution analysis.



Institut für Infrastruktur
Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011
Dateiname: Durchlaessigkeit−4.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	AUFT:GEB:BEZEICH.:	−
VERS.DATUM:	14.12.11−20.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Schn	ENTNAHMETIEFE:	4.9846 m

DURCHLAESSIGKEIT mit konstanter Druckhoeche OENORM B 4422−1

GERAET:	Stand 1	DRUCKHOEHE:	110 cm
PROBEN− Durchmesse/Height:	10/10.1 cm	HYDR. GEFAELLE i:	10.9
		SEITENDRUCK:	1 bar

Aufeinander folgenden Messungen

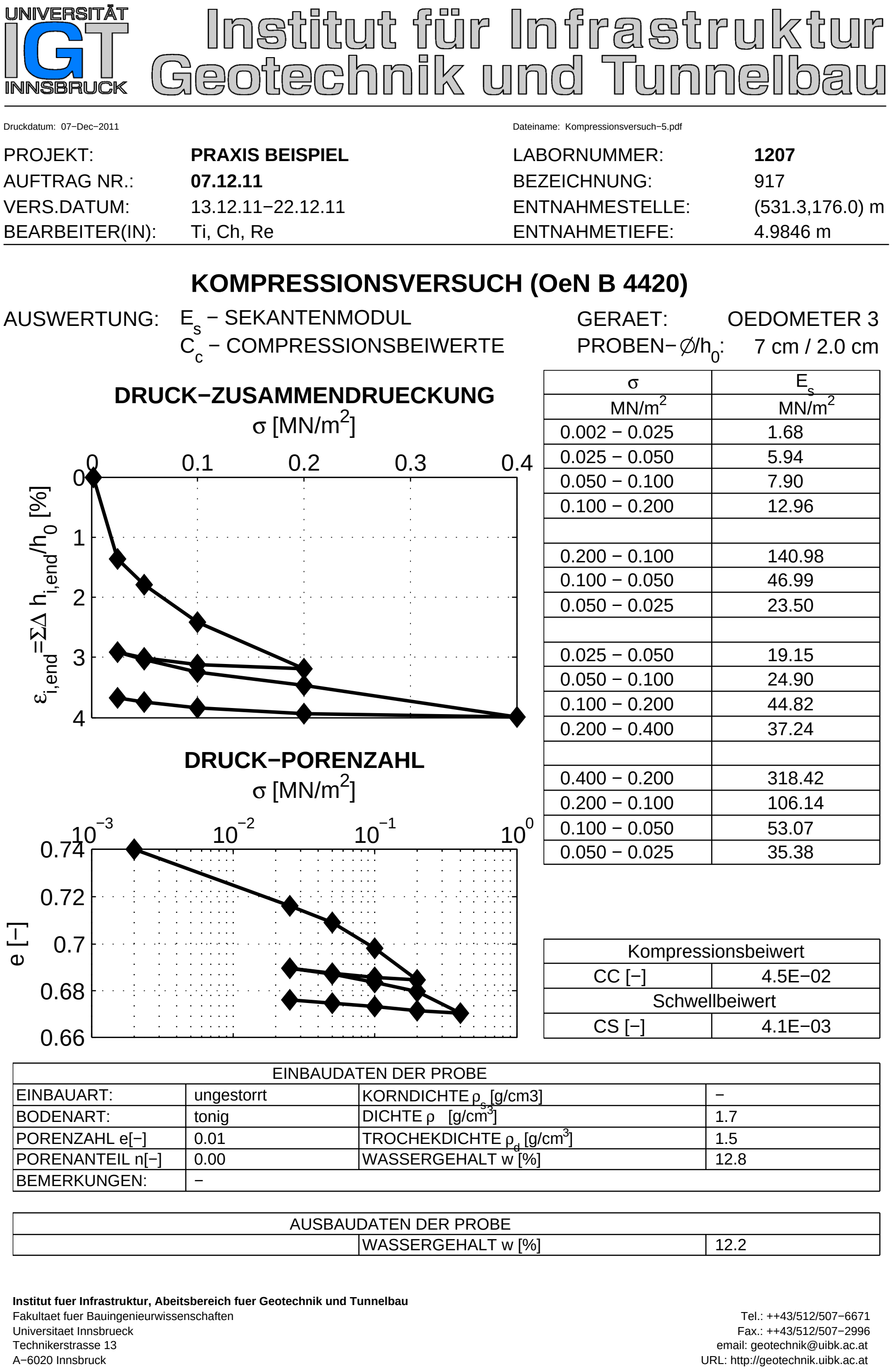
EINBAUDATEN DER PROBE						
DICHTE ρ :	1.9	g/cm^3	TROCKENDICHTE ρ_d :	1.72	g/cm^3
WASSWERGEHALT w:	12.80	%	KORNDICHTE ρ_s :	−	
			PORENANTEIL n:	0.43	
PROBENART:	gestaert, Einbau mit Proctorenergie				
BODENART:	gering kiesiger, gering schluffiger Sand				

MITTLERER DURCLAESSIGKEITSBEIWERT BEI 10 °C			
	k_{10} :	**7.40e−04**	**m/s**
BEMERKUNG:	−		

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 4: An example of reproduced laboratory report for the permeability test.



Institut für Infrastruktur
Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: Kompressionsversuch−5.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	BEZEICHNUNG:	917
VERS.DATUM:	13.12.11−22.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Ch, Re	ENTNAHMETIEFE:	4.9846 m

KOMPRESSIONSVERSUCH (OeN B 4420)

AUSWERTUNG: E_s − SEKANTENMODUL

C_c − COMPRESSIONSBEIWERTE

GERAET: OEDOMETER 3

PROBEN−∅/h_0: 7 cm / 2.0 cm

DRUCK−ZUSAMMENDRUECKUNG

σ [MN/m^2]

DRUCK−PORENZAHL

σ [MN/m^2]

σ	E_s
MN/m^2	MN/m^2
0.002 − 0.025	1.68
0.025 − 0.050	5.94
0.050 − 0.100	7.90
0.100 − 0.200	12.96
0.200 − 0.100	140.98
0.100 − 0.050	46.99
0.050 − 0.025	23.50
0.025 − 0.050	19.15
0.050 − 0.100	24.90
0.100 − 0.200	44.82
0.200 − 0.400	37.24
0.400 − 0.200	318.42
0.200 − 0.100	106.14
0.100 − 0.050	53.07
0.050 − 0.025	35.38

Kompressionsbeiwert	
CC [−]	4.5E−02
Schwellbeiwert	
CS [−]	4.1E−03

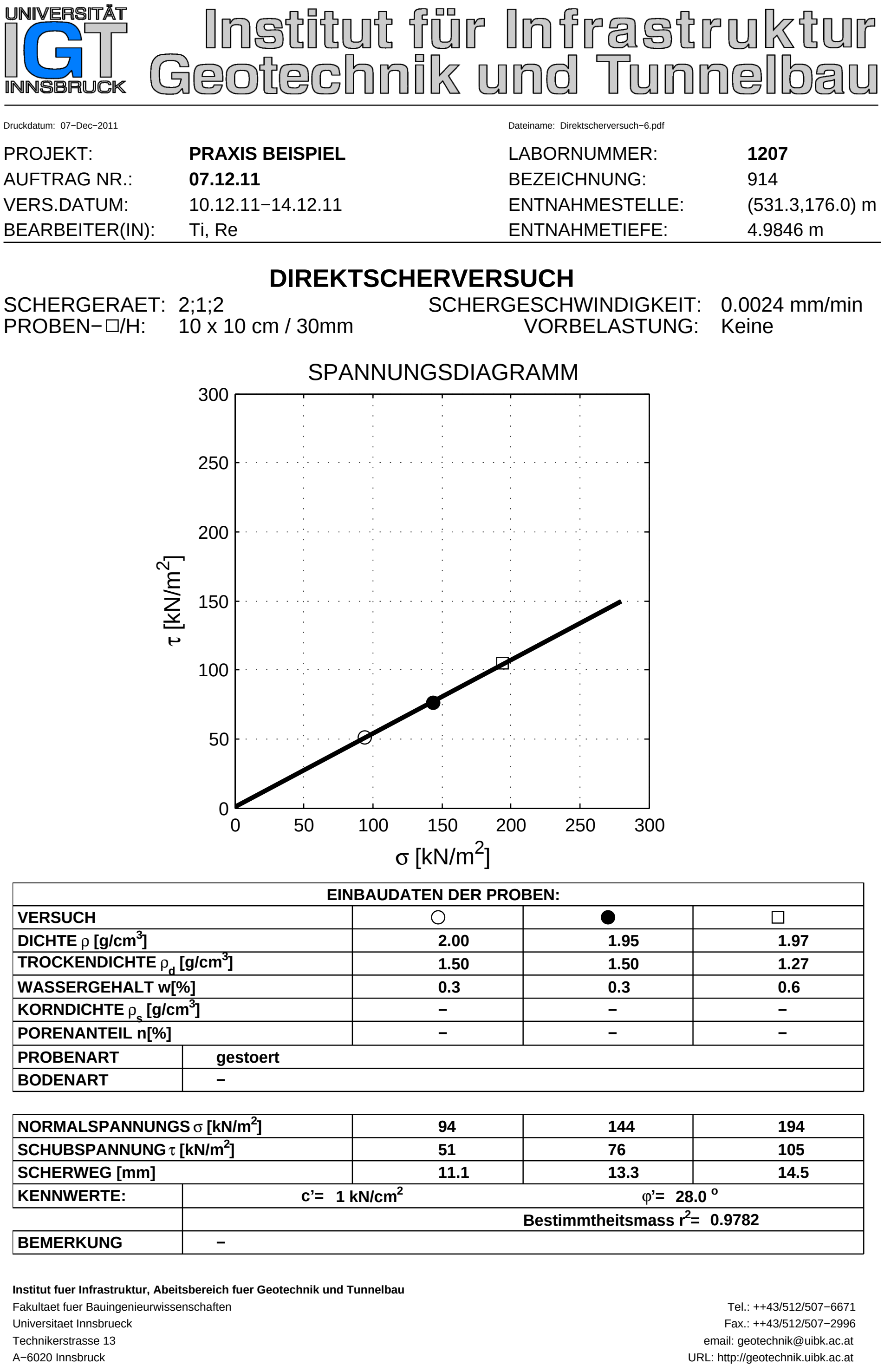
EINBAUDATEN DER PROBE			
EINBAUART:	ungestorrt	KORNDICHTE ρ_s [g/cm3]	−
BODENART:	tonig	DICHTE ρ [g/cm^3]	1.7
PORENZAHL e[−]	0.01	TROCHEKDICHTE ρ_d [g/cm^3]	1.5
PORENANTEIL n[−]	0.00	WASSERGEHALT w [%]	12.8
BEMERKUNGEN:	−		

AUSBAUDATEN DER PROBE			
		WASSERGEHALT w [%]	12.2

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 5: An example of reproduced laboratory report for a compression test (Oedometer test).



UNIVERSITÄT
IGT
INNSBRUCK
Institut für Infrastruktur
Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: Direktscherversuch−6.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	BEZEICHNUNG:	914
VERS.DATUM:	10.12.11−14.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Re	ENTNAHMETIEFE:	4.9846 m

DIREKTSCHERVERSUCH

SCHERGERAET:	2;1;2	SCHERGESCHWINDIGKEIT:	0.0024 mm/min
PROBEN−□/H:	10 x 10 cm / 30mm	VORBELASTUNG:	Keine

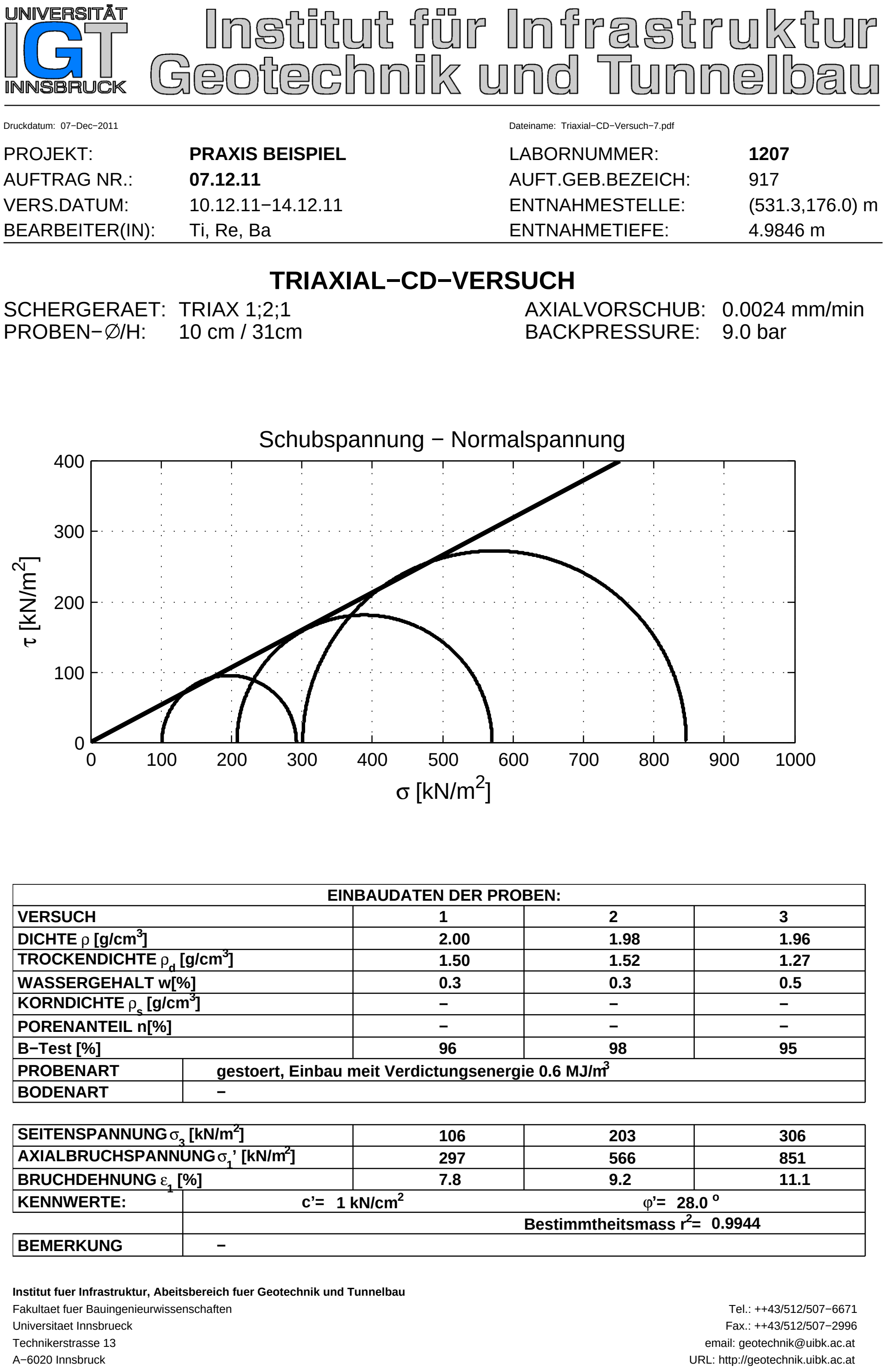
EINBAUDATEN DER PROBEN:				
VERSUCH		○	●	□
DICHTE ρ [g/cm^3]		2.00	1.95	1.97
TROCKENDICHTE ρ_d [g/cm^3]		1.50	1.50	1.27
WASSERGEHALT w[%]		0.3	0.3	0.6
KORNDICHTE ρ_s [g/cm^3]		–	–	–
PORENANTEIL n[%]		–	–	–
PROBENART	gestoert			
BODENART	–			

NORMALSPANNUNGS σ [kN/m^2]		94	144	194
SCHUBSPANNUNG τ [kN/m^2]		51	76	105
SCHERWEG [mm]		11.1	13.3	14.5
KENNWERTE:	c'= 1 kN/cm^2		φ'= 28.0 ^{o}	
			Bestimmtheitsmass r^2= 0.9782	
BEMERKUNG	–			

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 6: An example of reproduced laboratory report for a direct shear test.



UNIVERSITÄT IGT INNSBRUCK Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011 Dateiname: Triaxial−CD−Versuch−7.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	AUFT.GEB.BEZEICH:	917
VERS.DATUM:	10.12.11−14.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Re, Ba	ENTNAHMETIEFE:	4.9846 m

TRIAXIAL−CD−VERSUCH

SCHERGERAET:	TRIAX 1;2;1	AXIALVORSCHUB:	0.0024 mm/min
PROBEN−∅/H:	10 cm / 31cm	BACKPRESSURE:	9.0 bar

Schubspannung − Normalspannung

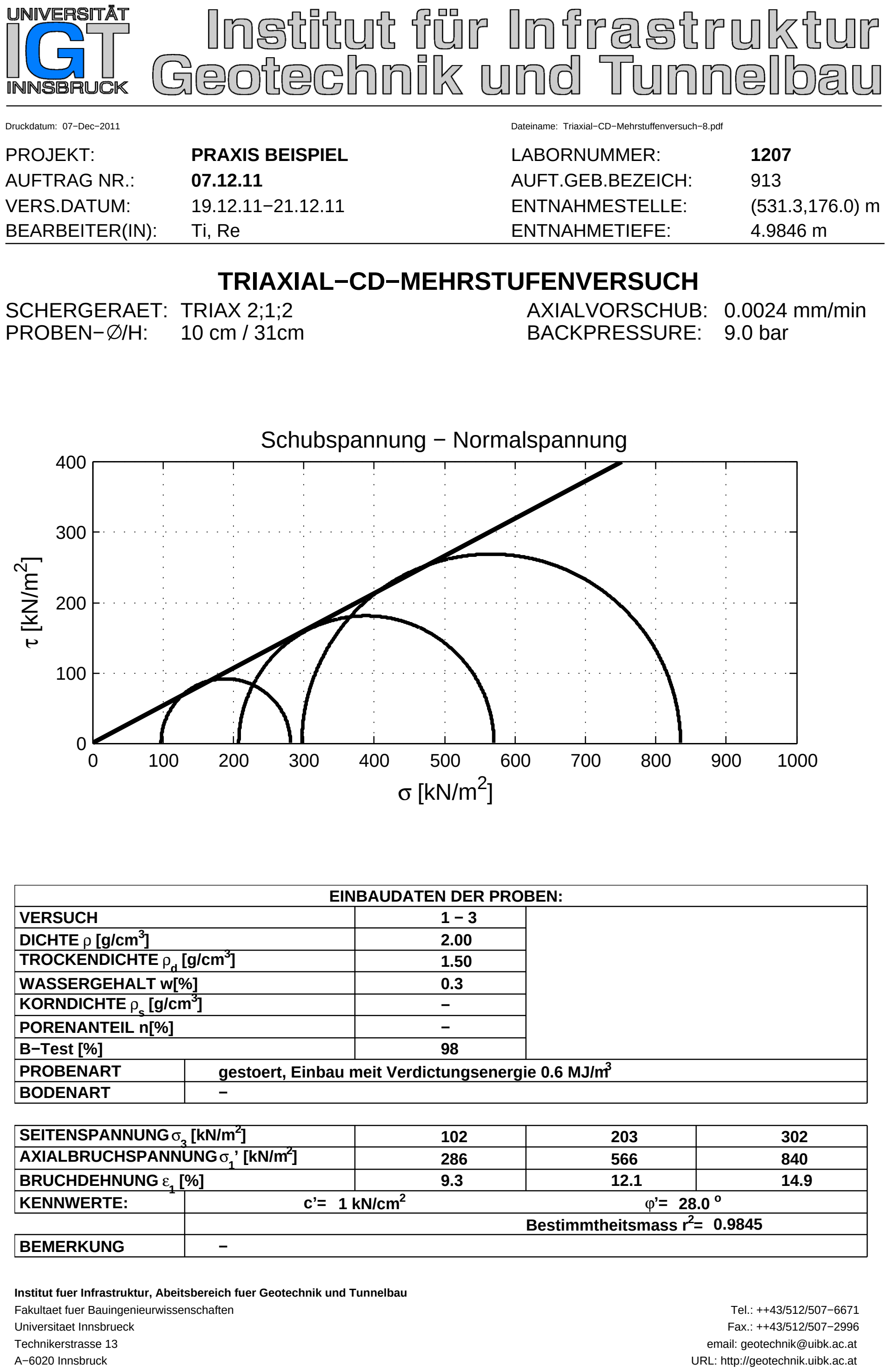
EINBAUDATEN DER PROBEN:			
VERSUCH	**1**	**2**	**3**
DICHTE ρ [g/cm^3]	**2.00**	**1.98**	**1.96**
TROCKENDICHTE ρ_d [g/cm^3]	**1.50**	**1.52**	**1.27**
WASSERGEHALT w[%]	**0.3**	**0.3**	**0.5**
KORNDICHTE ρ_s [g/cm^3]	**–**	**–**	**–**
PORENANTEIL n[%]	**–**	**–**	**–**
B−Test [%]	**96**	**98**	**95**
PROBENART	**gestoert, Einbau meit Verdictungsenergie 0.6 MJ/m^3**		
BODENART	**–**		

SEITENSPANNUNG σ_3 [kN/m^2]	**106**	**203**	**306**
AXIALBRUCHSPANNUNG σ_1' [kN/m^2]	**297**	**566**	**851**
BRUCHDEHNUNG ε_1 [%]	**7.8**	**9.2**	**11.1**
KENNWERTE:	**c'= 1 kN/cm^2**	**φ'= 28.0 °**	
		Bestimmtheitsmass r^2= 0.9944	
BEMERKUNG	**–**		

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 7: An example of reproduced laboratory report for a triaxial CD test.



Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: Triaxial−CD−Mehrstuffenversuch−8.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	AUFT.GEB.BEZEICH:	913
VERS.DATUM:	19.12.11−21.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Re	ENTNAHMETIEFE:	4.9846 m

TRIAXIAL−CD−MEHRSTUFENVERSUCH

SCHERGERAET:	TRIAX 2;1;2	AXIALVORSCHUB:	0.0024 mm/min
PROBEN−∅/H:	10 cm / 31cm	BACKPRESSURE:	9.0 bar

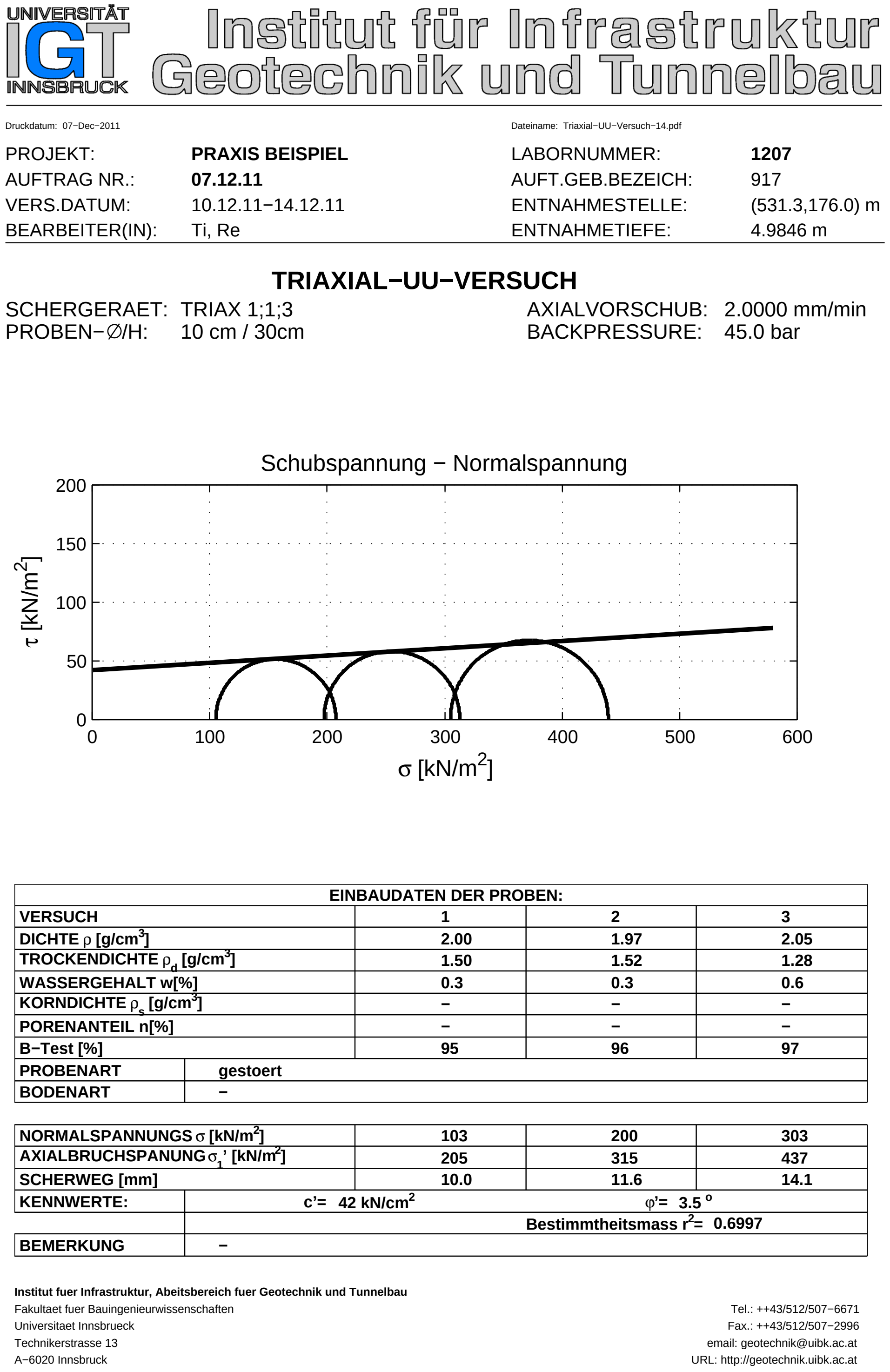
EINBAUDATEN DER PROBEN:		
VERSUCH	**1 − 3**	
DICHTE ρ [g/cm^3]	**2.00**	
TROCKENDICHTE ρ_d [g/cm^3]	**1.50**	
WASSERGEHALT w[%]	**0.3**	
KORNDICHTE ρ_s [g/cm^3]	**−**	
PORENANTEIL n[%]	**−**	
B−Test [%]	**98**	
PROBENART	**gestoert, Einbau meit Verdictungsenergie 0.6 MJ/m^3**	
BODENART	**−**	

SEITENSPANNUNG σ_3 [kN/m^2]	**102**	**203**	**302**
AXIALBRUCHSPANNUNG σ_1' [kN/m^2]	**286**	**566**	**840**
BRUCHDEHNUNG ε_1 [%]	**9.3**	**12.1**	**14.9**
KENNWERTE:	**c'= 1 kN/cm^2**	**φ'= 28.0 °**	
		Bestimmtheitsmass r^2= 0.9845	
BEMERKUNG	**−**		

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 8: An example of reproduced laboratory report for a triaxial CD multi-state test.



UNIVERSITÄT IGT INNSBRUCK **Institut für Infrastruktur Geotechnik und Tunnelbau**

Druckdatum: 07−Dec−2011 Dateiname: Triaxial−UU−Versuch−14.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	AUFT.GEB.BEZEICH:	917
VERS.DATUM:	10.12.11−14.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Re	ENTNAHMETIEFE:	4.9846 m

TRIAXIAL−UU−VERSUCH

SCHERGERAET:	TRIAX 1;1;3	AXIALVORSCHUB:	2.0000 mm/min
PROBEN−∅/H:	10 cm / 30cm	BACKPRESSURE:	45.0 bar

Schubspannung − Normalspannung

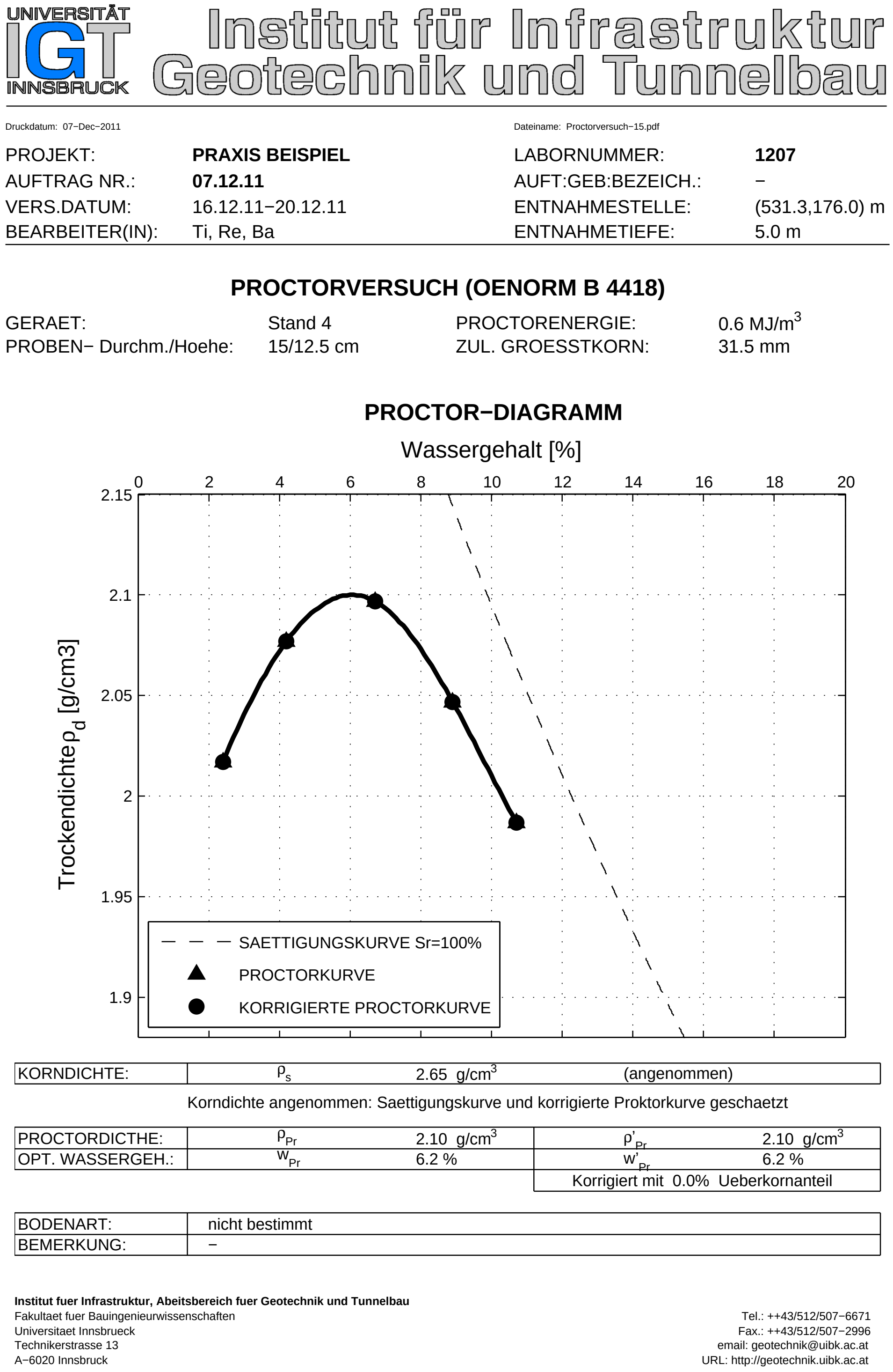
EINBAUDATEN DER PROBEN:			
VERSUCH	**1**	**2**	**3**
DICHTE ρ [g/cm^3]	**2.00**	**1.97**	**2.05**
TROCKENDICHTE ρ_d [g/cm^3]	**1.50**	**1.52**	**1.28**
WASSERGEHALT w[%]	**0.3**	**0.3**	**0.6**
KORNDICHTE ρ_s [g/cm^3]	**–**	**–**	**–**
PORENANTEIL n[%]	**–**	**–**	**–**
B−Test [%]	**95**	**96**	**97**
PROBENART	**gestoert**		
BODENART	**–**		

NORMALSPANNUNGS σ [kN/m^2]	**103**	**200**	**303**
AXIALBRUCHSPANUNG σ_1' [kN/m^2]	**205**	**315**	**437**
SCHERWEG [mm]	**10.0**	**11.6**	**14.1**
KENNWERTE:	**c'= 42 kN/cm^2**		**φ'= 3.5 °**
			Bestimmtheitsmass r^2= 0.6997
BEMERKUNG	**–**		

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 9: An example of reproduced laboratory report for a triaxial UU test.



UNIVERSITÄT IGT INNSBRUCK

Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011
Dateiname: Proctorversuch−15.pdf

PROJEKT:	**PRAXIS BEISPIEL**	LABORNUMMER:	**1207**
AUFTRAG NR.:	**07.12.11**	AUFT:GEB:BEZEICH.:	−
VERS.DATUM:	16.12.11−20.12.11	ENTNAHMESTELLE:	(531.3,176.0) m
BEARBEITER(IN):	Ti, Re, Ba	ENTNAHMETIEFE:	5.0 m

PROCTORVERSUCH (OENORM B 4418)

GERAET:	Stand 4	PROCTORENERGIE:	0.6 MJ/m^3
PROBEN− Durchm./Hoehe:	15/12.5 cm	ZUL. GROESSTKORN:	31.5 mm

PROCTOR−DIAGRAMM

KORNDICHTE:	ρ_s	2.65 g/cm^3	(angenommen)

Korndichte angenommen: Saettigungskurve und korrigierte Proktorkurve geschaetzt

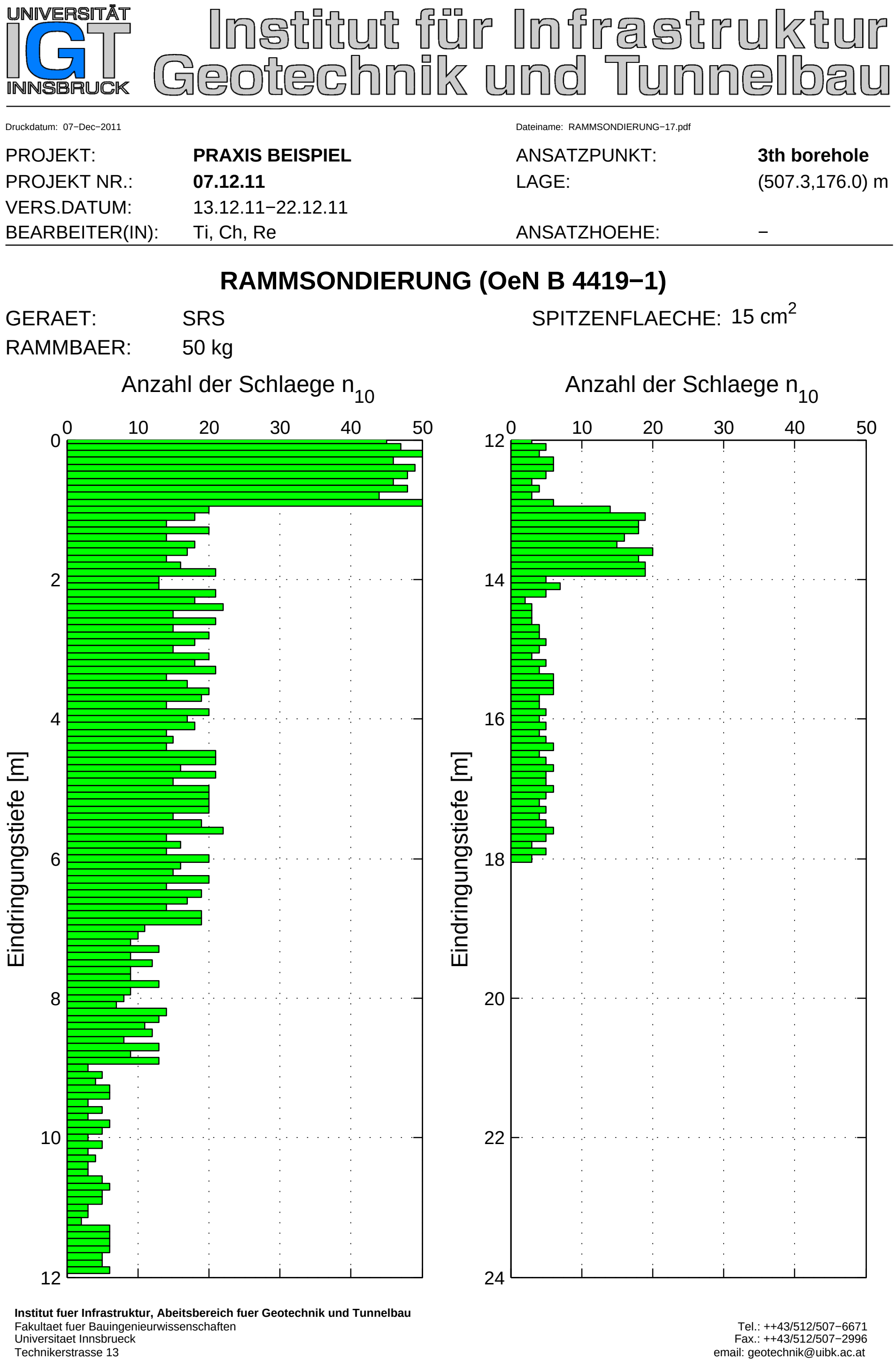
PROCTORDICTHE:	ρ_{Pr} 2.10 g/cm^3		ρ'_{Pr}	2.10 g/cm^3
OPT. WASSERGEH.:	w_{Pr} 6.2 %		w'_{Pr}	6.2 %
			Korrigiert mit 0.0% Ueberkornanteil	

BODENART:	nicht bestimmt
BEMERKUNG:	−

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 10: An example of reproduced laboratory report for a compaction test (Proctor test).



UNIVERSITÄT IGT INNSBRUCK Institut für Infrastruktur Geotechnik und Tunnelbau

Druckdatum: 07−Dec−2011

Dateiname: RAMMSONDIERUNG−17.pdf

PROJEKT:	**PRAXIS BEISPIEL**	ANSATZPUNKT:	**3th borehole**
PROJEKT NR.:	**07.12.11**	LAGE:	(507.3,176.0) m
VERS.DATUM:	13.12.11−22.12.11		
BEARBEITER(IN):	Ti, Ch, Re	ANSATZHOEHE:	−

RAMMSONDIERUNG (OeN B 4419−1)

GERAET: SRS

SPITZENFLAECHE: 15 cm^2

RAMMBAER: 50 kg

Institut fuer Infrastruktur, Abeitsbereich fuer Geotechnik und Tunnelbau
Fakultaet fuer Bauingenieurwissenschaften
Universitaet Innsbrueck
Technikerstrasse 13
A−6020 Innsbruck

Tel.: ++43/512/507−6671
Fax.: ++43/512/507−2996
email: geotechnik@uibk.ac.at
URL: http://geotechnik.uibk.ac.at

Figure 11: An example of reproduced formal report for the in-situ dynamic probing light.

Compaction test (Proctor test): Five different curves are implemented so that the user get different curve types. That makes the simulation more realistic. Those curves are shifted to match the report results. The correction of the over-size grains is carried out according to DIN 18127: 1997-11.

Permeability tests: This report is reproduced based on k_{10} which is the permeability at the temperature of 10 degree Celsius. The curve was added with random number to make look real. All other parameters are the in-situ parameters, as it is assumed that the in-situ permeability are interested and low-disturbed soil specimens are available. It should be noted that, for filter design, for example, the parameter from proctor test might be desired.

Direct shear test: Random numbers are implemented to make the test results look real.

In-situ dynamic probing (light): The in-situ dynamic probing light provides the number of drops in 10 cm. However, the test results are not quite accurate. Therefore, the random number implemented to make the results look real. For bedrock, the n_{10} value is set to a very large number as bedrock is considered as a very hard material herein.

2.4 Explanation and hint for each laboratory test

As this program is to help the student to learn site investigation, necessary explanations are shown when the user conduct a an insitu test or laboratory test, for example:

Dynamic probing light: If one or more boreholes for sampling have been drilled, one may take specimens and send them to the a geotechnical laboratory for further tests, such as triaxial tests, Oedometer tests, proctor tests, permeability analyses, water content, Atterberg limits, and etc. Only laboratory tests for granular geomaterial are available in this moment, i.e. bedrock can not be sampled in this simulation.

Grain size distribution analysis: By sending specimens to a lab for testing, the grain size distribution will be obtained through dry sieve analysis (0,06 mm ¡ d ¡ 31 mm) and wet sieve, and sedimentation analysis (0,001 mm ¡ d¡ 0,125 mm). It should be noted that the wet sieving removes fines from coarser grains (diameter greater then the #200 sieve), thus providing preciser estimation of grain size distribution curves. The sedimentation analysis can determine the grading down to diameter = 0.001 mm and it is required when percentage passing of diameter = 0.125 mm is more than 5%. It is noted that sedimentation analysis does not always required if it is sure that very little fine contents exists, e.g. sand-gravel mixtures.

Compression test: By sending specimens to a lab for carrying a Oedometer test, the compression index Cc and swell index Cs will be obtained. These parameters are required in the estimation of settlement due to the change in effective stress in the soil. As these parameters various with the state of stress, the state of stress for a Oedometer test needs to be specified according to the predicted changes in stress in soils (due to surcharge or change of ground water table, etc) while sending to a laboratory for testing. Herein, the stress state until 0.4 MN/m2 is carried out with 5 loading stages and 3 unloading stages. One may require more loading stages with higher stress state. Surcharge may be applied for more loading stages. The size of the specimen about 2 cm high with diameter = 7 cm. It is noted that larger size of tests are also available, e.g. Rowe Zelle, d = 7,5 / 16 / 25 cm.

Direct shear test: By sending specimens to a lab for carrying out direct shear tests, the shear parameters will be determined. Please note that the price for non-cohesive soil and cohesive soils varies.

Triaxial CD test: By sending specimens to a lab for carrying out consolidated drained (CD) triaxial tests, the shear parameters will be determined. As it is drained condition during shear, the effective shear parameters are obtained. CD tests with specimen diameter of 10 cm and height of 20 cm is provided herein. There are also specimens with diameter = 3.8 cm, 7 cm and 15 cm. Please note that the price may vary with size of the samples and with materials of the specimen, e.g. non-cohesive soil is cheaper than cohesive soils.

Multi-stage triaxial CD test: By sending a specimen to a lab for carrying out multi-stage consolidated, drained triaxial tests, the shear parameters will be determined. This test is necessary when there is only one undisturbed specimen at hand. This test costs also less than a normal triaxial test due to less work of preparing testing samples.

Triaxial UU test: By sending specimens to a lab for carrying out unconsolidated, drained triaxial tests, the shear parameters will be determined. This test provides undrained shear parameter cu, which is often used in evaluating initial stability of soils when ground water exists in cohesive soils. CD tests with specimen diameter of 10 cm and height of 20 cm is provided herein. There are also specimens with diameter = 3.8 cm, 7 cm and 15 cm. Please note that the price may vary with size of the samples.

Compaction test: By sending specimens to a lab for carrying out proctor tests, the optimized water content which gives maximum (100%) relative compaction is determined. The curve is corrected based on DIN 18127: 1997-11 if there exists grains with diameter larger than 31.5 mm. The sample has diameter = 15 cm and height =12.5 cm. A curve of water content vs. dry density after compaction will be provided, which helps to determine the required water content of a designated relative compaction. It should be noted that the price varies with the size of the sample. There are also other sample with diameter = 10 or 30 cm. If there are grain size > 31.5 mm, the curve will be corrected based on the mass percentage of those grains. There is the other "Modified Proctor test" which uses heavier hammer for testing.

Permeability test: By sending specimens to a lab for testing, the permeability of soils at the temperature of 10 degree Celsius will be determined. If you want to know the in-situ permeability, it is suggest to take low-disturbed samples, One may also use re-molded sample if the in-situ conditions (dry density for example) is known. If it is used for filter design, an arbitrary designed grain size distribution curve with specified dry density can be applied.

2.5 Prices of tests

The price for insitu test and laboratory test collected from reliable sources are listed in Table 3 and Table 4. Realistic prices make the training more meaningful. However, these sources are not provided in this report as the prices are confidential and the sources do not want to be cited.

2.6 Graphical User Interface

The graphical user interface has been improved. For more detail of the interface, please see the annual report of the project Part I. In Project Part II, two widgets have been added (Figure 12):

Ground surface profile: Most of the tasks in site investigation plans are the identification of the underground conditions, Thus, a widget that

Dynamic Probing Light	**Cost**
Initial setup of testing machine	58 Euro
$n_{10} \leq 50$	1.06 Euro/10 cm
$n_{10} > 50$	2.12 Euro/10 cm

Sampling Boreholes	**Cost (Initial setup cost included)**
$0 \leq Depth < 10$ m	195 Euro/meter
$10 \leq Depth < 20$ m	200 Euro/meter
$20 \leq Depth < 30$ m	240 Euro/meter
$Depth > 30$ m	300 Euro/meter

Table 3: Price list of laboratory tests.

	Laboratory test	Cost (Euro)
1	Water content	10
2	Porosity/Void ratio	80
3	Saturation	80
4	Grain density	50
5	Natural density	40
6	Dry density	30
7	Max./Min. Void ratio/Porosity	80
8	Atterberg limits	130
9	Grain size distribution	160
10	Coefficient of permeability	200
11	Oedometer test	170
12	Direct shear (Non-cohesive material)	180
13	Direct shear (cohesive material)	130
14	CD triaxial tests (Non-cohesive material)	530
15	CD triaxial tests (cohesive material)	850
16	CD triaxial tests - multi-stage (Non-cohesive)	265
17	CD triaxial tests - multi-stage (Cohesive)	425
18	UU triaxial test	850
19	Proctor test	180

Table 4: Price list of laboratory tests.

allows users to generate profiles at a specified coordinate on the x- and y-axis are provided.

LAB Tests: This is the core of the project Part II. All mentioned laboratory tests are able to be carried out by specifying a depth of the sample beeing sampled and select a laboratory test.

3 The target User

As aforementioned importance of site investigation, it is more or less involved in all courses of geotechnical engineering. With proper course design, this program are expected to help student connecting what they have learned in the class with what could be the real situation in engineering practice. The correlation of this site investigation simulation program to the following courses are explained in the following sections.

Instant Information
The snap shot of this program is generated.

Budget : 9999999959 EU

1) Get Coordinate X,Y,Z

2) Update X,Y with the cursor

Or manually input X,Y:

X: 513.3317 Y: 176.0254

3) Bore until 20 m

4) Select a Test

○ Dynamic probing light [marked as green]

● Boreholes (sampling) [marked as red]

5) Start an in-situ Test

To display nothing, use [ ].
To display multi-slices, e.g.
use [20, 60, 80].

x= []
y= [0, 100]
z= 0

X: 513.3317
Y: 176.0254
Z: 67.4846

1th In-situ test at
x= 513.3m, y= 176.0m, z= 67.5m
(In-situ Sampling)

Get a profile of ground surface at:
x= 100 m
y= 100 m

Show insitu test: 1

LAB Tests :
Take samples at elevation: 0 m
Select a lab test:
01-Water content (w)

Figure 12: Graphical interface of the site simulation program.

3.1 Soil mechanics and foundation engineering I (Bodenmechanik und Grundbau I: VL und UE)

In this beginning course, students learn basic knowledges of soil mechanics (soil classification, soil naming, evaluation of stress in granular geomaterial, seepage force, evaluation of settlements, filter design), laboratory experiments (Theory of Water content analysis, grain size distribution analysis, Atterberg limits, permeability test, shear parameters and etc). What an geotechnical engineer has to know is the underground conditions. Therefore the soil samples are retrieved and then sent to a lab for testing or insitu tests are carried out. All the parameters used in the course are determined in the laboratory. They somehow all link to each other as they are the properties of the soils. One of the questions has been also ask by students is that "*Why should I learn this?*" This program will be used in this bung as an extra help to explain students what it is important to learn these subjects. The students can play with the program and have an insight of what they can do with the samples got from a construction site. They might see may parameters they calculate in the course are listed in the report. They will experience the importance of what they are learning because what they learn in the course are actually used in the engineering practice. They might also have noticed that there are in-situ tests which they have not heard before or other thing in the site investigation program. The designed simple tasks and 3-D geological model will help them to realize the complication of the geotechnical problems. By playing with this program, without stress, the students will also have more chances to read and use the technical terms. That will help them to be familiar with the important parameters used in geotechnical engineering.

3.2 Soil mechanics and foundation engineering II (Bodenmechanik und Grundbau II: VL und UE)

In this course, students learn to evaluate the stability of various engineering problems. First of all, one needs to know the parameters for evaluating the stability. The question starts from *How can one know the underground conditions?* The answer is that "Site Investigation" needs to be planed and carried out. Then, *How many boreholes should be carried out? Where?* and *How deep?* Thereafter, *How to decide which sample need to be sent to lab? Which lab test needs to be carried out? What kind of parameters should I or will I get from the lab tests? What should I do with these parameters?* This site investigation program will be a great tool for students to practice how to solve the above questions; and it will be a great tool for the bung instructors to demonstrate and discuss with students about they questions. Student can repeatedly practice and get the hang of it. This program will be combined with questions and the calculation tasks through the bung course each week.

3.3 Advanced foundation engineering AK Grundbau (VL)

In this course, students learn the knowledge in the engineering practices. One of the topic is how to carry out the site investigation and how to interpret the obtained parameters through laboratory tests and in-situ tests. This program will be introduced to students and they will be be encouraged to solve the simple tasks provided in the program. Though these tasks, they will understand that the limitation of underground information makes solving the geotechnical problems more difficult and that why geostatistics such as kriging is important when limited data are available.

3.4 Laboratory tests of soil mechanics Bodenmechanisches Versuchswesen (SE)

In this course, students will learn standard procedures of laboratory experiments and conduct them. These experiments have been very often mentioned and used in the courses of soil mechanics I and II and Advance foundation engineering. In this course, this program can be a minor assistant to inspire students, linking each laboratory test to corresponding parameters of interested.

4 P-code

Students will get the student version consisting of p-codes, which can be executed with matlab. P-code is a encrypted functions. Using P-code can ensure that the users can use the program without access to the source code. In the student version, the task will be randomly assigned with limited budget. Beside, the function of looking into the ground does not work. Instructor version has unlimited budget and can select a specific case by input a case code, which allows instructors to repeat the randomly assigned task and discuss with the students. Instructors can also look into the ground and see the underground conditions.

Students who enrolled in the technical university at the University of Innsbruck have free assess to Matlab in the within the campus network or at home through VPN connections (Students can freely download Matlab and install in their own personal computers. While starting Matlab, Matlab will automatically get a license from University of Innsbruck through VNP connections). Therefore, they may run the program any time anywhere.

5 Program copy right

The copy right of the program belongs to the University of Innsbruck. All distributions will be encrypted as p-code files. Acquisition of the source code can only through the University Innsbruck. Division of Geotechnical and Tunnel Engineering, under Department of Civil Engineering at University of Innsbruck, will keep developing the this program to fit into our courses in geotechnical and tunnel engineering based on our goal of teaching.

6 Acknowledgment

The financial support of this project from the University of Innsbruck in 2010 (project Part I, project code 2010.164) and in 2011 (project Part II, project code 2011.211) are very much appreciated. In addition, many thanks to the colleagues, A. Kirsch, D. Renk, A. Bilioumi, B. M. Scheider-Muntau, G. Medicus, professor W. Fellin and professor D. Kolymbas at Division of Geotechnical and Tunnel Engineering, University of Innsbruck, for their professional suggestions, inspirations during the time of developing this program.