ROCKALL STUDIES GROUP

REGIONAL GEOTECHNICAL CHARACTERISATION OF NEAR SURFACE SEDIMENTS

(PROJECT No. 98/20)

PRELIMINARY GEOTECHNICAL ASSESSMENT

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1 INTRODUCTION

The Rockall Trough deepwater environment is situated on the Irish continental slope, NW Europe. An innovative research programme, incorporating data acquisition and research projects in relation to the Rockall Trough and its immediate environs is currently being co-ordinated by the Rockall Studies Group (RSG), a joint venture between the Irish government, (specifically the Petroleum Affairs Division (PAD) of the Department of Marine and Natural Resources) and international hydrocarbon companies with exploration licence awards within Irish territorial waters in the area. Figure 1 shows the location of the Rockall Trough.

1.1 Scope of Work

A study team comprising representatives from John Barnett and Associates and the geotechnical sections of the Civil Engineering Departments of Trinity College Dublin and University College Dublin (JBA/TCD/UCD) was appointed by the Rockall Studies Group in December 1998 to carry out a regional geotechnical characterisation of near surface sediments, (Project Reference No. 98/20) under the technical direction of the RSG Seabed Technical Commitee. The scope of work comprises three main activities : laboratory testing, data interpretation and a comparison with near surface sediments from other relevant deepwater environments. The detailed scope of work agreed with representatives of the Rockall Studies Group and the study team is reproduced in Appendix 1.

1.2 Report Structure

This report provides a brief description of the offshore sampling of near surface sediments (carried out by BGS, under RSG project 97/50) in Section 2. Section 3 outlines the geotechnical test programme designed to determine the geotechnical characteristics of specimens from selected samples. The factual laboratory data obtained from the suite of geotechnical tests is presented in Section 4. An interpretation of the results and characterisation of the sediment encountered in the Rockall Trough Area is also provided in Section 4. Section 5 describes and compares the Rockall Trough data with geotechnical data collated for other comparable sites.

1.3 Acknowledgements

The study team would like to acknowledge the assistance and useful comments on draft report provided by Mr. Charles Keiller (Project Mentor) and Mr. Martin Davies (RSG Secretariat).

2 OFFSHORE SAMPLING OF NEAR SURFACE SEABED SEDIMENTS

2.1 Sampling Method

As part of the first data acquisition project undertaken by RSG, BGS Marine Operations carried out the shallow drilling programme site survey from 18th to 28th June 1998 onboard RRS Challenger. (Project Reference No. 97/50). The site survey included geophysical surveying and sampling of near surface seabed sediments at and between seven sites. The samples which were 87.5mm in diameter, were recovered with a 3m gravity core sampler. The respective sampling locations were recorded to DGPS accuracy. The schedule of gravity cores collected is included as Appendix II.

The sample recovery using the gravity core sampling technique was generally found to be good. It was not possible to recover samples from many locations at Sites 2 and 2A, due to the presence of pebbles at the sea-bed. In addition, there was poor recovery at one location at Site 4 where shells were encountered. Poor recovery at a number of locations at Site 1 was overcome by acquiring second samples immediately adjacent to the failed ones.

The sampling procedure and labelling was previously specified by and agreed with the JBA/TCD/UCD Study Group and BGS Marine Operations. The gravity cores were removed from the corer in a polycarbonate liner which was cut and curated into lengths not less than 0.75m and not exceeding 1.0m. After an initial examination of each end for a brief geological and geotechnical appraisal, the core sections were capped top and base. If a discrepancy between the size of the sample and liner tube existed, wax was placed to ensure minimal disturbance insofar as was practical.

2.2 Transportation and Storage of Samples

Once curated and described the cores were stored in labelled cardboard boxes for onward shipping. The gravity core samples were transported and stored horizontally (as BGS experience indicates vertical storage induces much more dewatering) at the CSA Group's core store in Dublin.

3 GEOTECHNICAL TESTING PROGRAMME

3.1 Sample Selection

Six gravity core samples recovered at five different borehole locations (shown on Figure 2) were selected from the gravity core schedule provided by BGS Marine Operations and reproduced herein as Appendix II. The initial criteria for sample selection pending RSG and geological confirmation were :

i) representative geographical coverage
ii) good core recovery

(5) Sample Selection Criteria

3.2 Geological Inspection

Prior to forwarding the selected samples to the respective laboratories for testing, a brief visual geological inspection of the cores in the plastic liners and an examination of shoe samples under binocular microscope was performed by Dr. Pat Shannon and Dr. Peter Haughton of UCD Department of Geology on 16 April 1999 at CSA Group Core Store. The objective of this geological inspection was to ensure that the samples selected for geotechnical testing were representative of the geological succession at each of their respective sampling locations. In light of their recommendations, the gravity core samples tabulated below were ultimately selected for geotechnical testing; see Table 1.

Two samples from the same borehole location (1A 83/20-SC003) were selected and tested at two different participating geotechnical laboratories in order to provide a quality assurance check. However subsequent testing indicated that the selected samples from this location were of different engineering classification and such a check was not possible.

Survey Site	Gravity Core Sample No.	Sample Depth (m)	Water Depth (m)	Latitude	Longitude
1	83/24-SC002 Box 2 of 3	0.65 to 1.55	1503	52°14'03.6"N	15°16'43.2"W
1A	83/20-SC003 Box 2 of 3	0.40 to 1.30	1032	52°26'39.0"N	15°06'51.6"W
1A	83/20-SC003 Box 3 of 3	1.40 to 2.30	1032	52°26'39.0"N	15°06'51.6"W
2	16/28-SC002 Box 2 of 2	0.40 to 1.30	1465	54°01'42.6"N	13°30'06.6"W
3A	11/20-SC002 Box 2 of 3	0.44 to 1.33	1007	55°25'39.0"N	10°00'42.6"W
4	78/28-SC007 Box 2 of 2	0.58 to 1.48	1296	56°02'03.6"N	14°26'16.2"W

Table 1 : Gravity Core Samples selected for Geotechnical Testing

The locations from whence the selected cores were sampled are shown in Figure 2.

(6) Sample Locations

3.3 Sample Preparation

The following procedure for opening the gravity core samples selected for geotechnical testing was discussed and agreed by RSG representatives, the study team and the participating geotechnical laboratory personnel.

i) Three core lengths were delivered to each of the geotechnical laboratories at TCD and UCD.
ii) A UCD geologist, Dr. Peter Haughton, was present for the splitting of each of the six samples.
iii) A 25mm wide slot was cut longitudinally along the top of the polycarbonate core liner using a hand held Stanley knife.
iv) The cut slot was lifted and removed to facilitate detailed geological inspection and description of any sedimentary structures, lateral variations, shells, rock clasts present in core by a UCD geologist.
v) Care was taken to minimise loss of soil particulates from the liner. Fluid draining from the split cores was collected and stored.
vi) Samples were photographed.
vii) Specimens were removed from each sample for geotechnical testing, as required.

On completion of testing, the disturbed material from each section of core opened was placed in a labelled plastic bag and sealed. The sample label identifies the depth to the top and bottom of the sample, thereby ensuring consistency with the core liner identification system. The original sample structure has effectively been destroyed by the geotechnical testing, particularly the compaction tests. All samples, including those disturbed by testing, have been returned to the CSA Group core store for long-term storage and inspection as required by RSG.

3.4 Preliminary Sedimentological Observations

UCD geologist, Dr. Peter Haughton carried out a detailed geological inspection on each of the selected samples during the opening of the core liners. The geological inspection was beyond the scope of this project and was performed at no cost to RSG. A summary of the preliminary sedimentological observations is included in Appendix III.

3.5 Geotechnical Testing Programme

A comprehensive programme of laboratory testing was developed to establish the geotechnical characteristics of the selected core samples. Laboratory testing of soils was generally carried out in accordance with BS 1377 (1990) – Methods of Test for Soils for Civil Engineering Purposes: Parts 1 to 9. Falling head triaxial permeability testing was undertaken in accordance with Head (1986). These standards are widely applied in geotechnical testing.

Evaluation of Mineralogical Properties of the Sediments : The following tests were performed to provide information on the mineralogical properties of specimens:

i) Petrographic Analysis
ii) X-Ray Diffraction (clayey soils)

Evaluation of Chemical Properties of the Sediments : The following tests were performed to provide information on the chemical properties of specimens:

i) Carbonate Content

Classification of Material Properties : The following tests were carried out to identify and categorise the material. These tests were valuable in assisting with the description and identification of the sampled materials in accordance with established soil classification schemes, and in establishing basic soil properties:

i) Moisture Content
ii) Atterberg Limits (Plastic and Liquid Limits)
iii) Particle Size Analyses
iv) Bulk Density and Specific Gravity
v) Minimum and Maximum Void Ratio

Evaluation of Geotechnical Properties : A detailed schedule of laboratory tests was specified in order to assess strength, compressibility and permeability characteristics of the material. Following assessment and interpretation of these soil properties, representative geotechnical parameters have been provided. To achieve these aims, the following laboratory tests were carried out:

i) Consolidated Drained Triaxial Compression Tests (granular materials)
ii) Consolidated Undrained Triaxial Compression Tests, with Pore Pressure Measurement (fine / cohesive materials)
iii) Drained Shearbox Tests
iv) Angle of Repose Test
v) One Dimensional Consolidation Tests
vi) Permeability vs. Void Ratio Relationship (5 points)
vii) Triaxial Permeability Test

On account of the nature of the selected core samples (i.e. large proportion of clay and silt size particles), the minimum and maximum void ratio and angle of repose were not determined for all test samples.

A summary of tests undertaken as part of this project is summarised in Table 2 below.

	NUMBER OF TESTS PERFORMED ON EACH SAMPLE					
SITE	**1**	**1A**	**1A**	**2**	**3A**	**4**
Sample	83/24-SC002 Box 2 of 3	83/20-SC003 Box 2 of 3	83/20-SC003 Box 3 of 3	16/28-SC002 Box 2 of 2	11/20-SC002 Box 2 of 3	78/28-SC007 Box 2 of 2
Depth (m)	0.65 – 1.55	0.40 – 1.30	1.40 – 2.30	0.40 – 1.30	0.44 – 1.33	0.58 – 1.48
Test Lab	UCD	TCD	UCD	TCD	UCD	TCD
TEST TYPE						
Soil Description	1	1	1	1	1	1
Mineralogy Tests : (undertaken by Conodate Ltd)						
Petrographic Analysis	1	1	1	1		1
X-Ray Diffraction					1	
Classification Tests :						
Moisture Content	5	6	6	6	3	6
Atterberg Limits	2	2	2	2	2	2
Specific Gravity	2	1	2	1	2	1
Min/Max Void Ratio	1	-	1	-	-	-
Carbonate Content	2	2	2	2	2	2
Particle Size Analysis : Sieve	2	2	2	2	2	2
Particle Size Analysis : Hydrometer	2	2	2	2	2	2
Strength :						
Shear Box	1	1	1	1	-	1
Angle of Repose Tests	1	-	1	-	1	-
Triaxial Tests	1	2	1	2	1	2
Compressibility :						
1-D Oedometer Test	1	1	1	1	1	1
Permeability :						
Permeability vs. Void Ratio Relationship	1	1	1	1	1	1
Falling Head Permeability Test	1	-	1	-	-	-
Triaxial Permeability Test	-	-	-	-	1	-

Table 2 : Summary of Geotechnical Tests

(7)

4 RESULTS OF GEOTECHNICAL TESTING PROGRAMME

The results from the suite of geotechnical tests performed on each of the six selected gravity core samples at the geotechnical laboratories at TCD and UCD (unless otherwise stated) in the period May to August 1999 are presented in this section. For each gravity core sample the geotechnical properties are described and discussed in the following sequence (where the available information allows):

- Sediment Mineralogy
- Sediment Chemistry
- Classification
- Strength
- Consolidation
- Permeability

An overall summary of the classification properties of the sediments recovered at all five core locations is presented. In addition, for each borehole location the site specific classification properties are described in detail.

The detailed laboratory results are included in Appendix IV for completeness and reference.

4.1 Sediment Mineralogy

A representative sample from each of the six gravity cores was examined to determine its petrography. After hand specimen description, it was decided that the five samples which were rich in foraminifera were suitable for thin section analysis after impregnation with epoxy resin. Due to the clayey nature of the sediment recovered at site location 3A sample 11/20-SC002 this sample was examined by x-ray diffraction (XRD) by Dr. David Doff at Geology Department, TCD.

The XRD examination performed on sediment from 1.1m to 1.3m depth in sample 11/20-SC002 (from site 3A) indicates plastic brown illite and kaolinite clay with minor quartz and calcite silt. The clay also contains dolomite and salt. The thin section petrography of five samples recovered from five sites is summarised in Table 3 over. A complete summary of the petrographic analysis carried out by Gareth Jones of Conodate including photographic plates is included in Appendix V.

Gravity Core	Sample Depth (m)	Thin Section Petrography	
1 83/24-SC002	0.8 – 0.9	*Muddy coarse foraminiferal and quartz sand.*	
		Uni- and plurilocular foraminifera	<30%
		other bioclasts – brachiopod, gastropod, echinoid spine, sponge spicule	<5%
		fine to coarse quartz sand	<50%
		other lithoclasts including chalcedony, chert, dolomite in a clay matrix	~15%
1A 83/20-SC003	1.3	*Very muddy brown clay with coarse bioclasts and quartz grains.*	
		Mostly uni- and plurilocular foraminiferal tests <0.2mm	<25%
		and fine to coarse angular to sub-angular quartz grains	<25%
		occasional lithoclasts including rounded 2mm fine-grained greywacke clast and very irregular and vesicular <1mm grains	<3%
		of opaque material in a clay matrix	~50%
1A 83/20-SC003	2.21 – 2.3	*Muddy coarse to very coarse-grained sand – loose sediment*	
		Coarse to very coarse bioclasts, uni- and plurilocular foraminifera	<20% and
		other bioclast debris	<0.5%
		fine to coarse sub-angular to sub-rounded quartz grains in brown clay matrix	<30% <45%
2 16/28-SC002	1.1	*Medium-grained argillaceous bioclastic and quartz sand.*	
		Grains consist of 0.1-0.3mm uni- and plurilocular foraminiferal tests	<40%
		<0.1mm sub-angular to sub-rounded quartz grains	<30%
		set in brown clay matrix	<30%
		occasional lithoclasts of reworked clay	
		occasional grit to pebble size bioclasts of brachiopod shells, etc	
4 78/28-SC007	1.18	*Muddy foraminiferal sand.*	
		0.1-0.3mm uni- and plurilocular foraminiferal tests	<70%
		silt-grit angular to sub-angular quartz grains	<20%
		in a clay matrix	~10%
		occasional gravel-grained lithoclasts of volcanic, angular, glass-rich tuff	
		occasional rounded clast of glass with large crystals of quartz after feldspar	

(Note : Geologists Descriptions)

Table 3 : Thin Section Petrography Summary

4.2 Sediment Chemistry

4.2.1 Carbonate Content

The carbonate content of representative samples from each of the six gravity cores were determined using rapid titration method described in BS1377 Part 3 (1990). The measured carbonate content (expressed as $\%CO_2$) of the material encountered at the 5 borehole sites is plotted against depth below seabed in Figure 3. The carbonate content ranges from 14% to 30% with the exception of sample 83/20-SC003 (from Site 1A) and sample 11/20-SC002 (from site 3A), where the measured carbonate content is relatively low at 1% and 6% respectively. Carbonate content (expressed as $\%CaCO_3$) is plotted in Figure 3A.

The lowest carbonate content (6%) was recorded on a sample from site 3A, which petrographic analysis indicated had the highest clay content. Otherwise, the higher carbonate content generally reflects increased presence of formaninifera in the analysed thin sections.

4.3 Classification

The classification properties of the sediments recovered at all five borehole locations are summarised in this section and are then individually described in detail in the following sub-sections.

The index properties (moisture content, plastic limit and liquid limit) of the material encountered at the 6 core sites are plotted against depth below seabed in Figure 4. As would be expected, the moisture content of the material is high ranging from 36% to 94%. Moisture content is very variable over the depth range of specimens tested (0 to 2.3m).

Atterberg Limit test results indicate that the material at the sites have plastic limits (PL) values ranging from PL = 23% to 30% and liquid limits (LL) ranging from LL = 39% to 74%. The corresponding plasticity index (PI) values vary from PI = 12% to 45%. Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered can generally be classified as inorganic clay of intermediate to very high plasticity (CI, CH and CV).

Particle size distribution (PSD) curves for soil samples recovered at the five core sites are re-plotted in Figure 6. The grading curves indicate that the material encountered at the five core sites is described as CLAY or SILT or sandy CLAY or SILT.

The activity (i.e. the ratio of plasticity index to clay fraction) of the sediment encountered at the five core sites ranged from 0.6 to 4.2 (inactive to active clays); see Figure 7.

Specific gravity tests undertaken on samples recovered at the five core locations indicate that their specific gravity values range from 2.41 to 2.70; see Figure 8.

The bulk density (based on the assumption that the samples were undisturbed) varied from 1.38Mg/m^3 to 1.97Mg/m^3, see Figure 9.

The maximum and minimum void ratio determined for samples from two core locations indicate e_{min} values of 0.652 and 0.817 and e_{max} values of 2.047 and 2.476 at sites 1 and 1A respectively.

4.3.1 Classification Results from Site 1

The index properties (moisture content, plastic limit and liquid limit) of the material encountered in sample 83/24-SCOO2 are plotted against depth below seabed in Figure 4. The moisture content of the material is high at 37% to 75%.

Atterberg Limit test results indicate that the material at 0.65m depth has a plastic limit (PL) value PL = 27% and liquid limit (LL) value LL = 39%; the moisture content (w) is close to and slightly dry of the liquid limit. The corresponding plasticity index (PI) value PI = 12%. Atterberg Limit test results indicate that the material at 1.4m depth is non-plastic and has liquid limit (LL) value LL = 60%; the moisture content is wet of the liquid limit. Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered at 0.65m depth in sample 83/24-SCOO2 may be classified as intermediate plasticity silt (ML).

Particle size distribution (PSD) curves for soil samples recovered at this borehole site are re-plotted in Figure 6. The grading curves for two samples recovered from 0.65m and 1.4m depth at core 83/24-SC002 indicate that the material is sandy CLAY or SILT.

The activity of a sediment sample encountered at 0.65m depth is 0.6, which reflects the presence of inactive clay minerals in the sample; see Figure 7. Specific gravity tests undertaken on samples recovered at this core location indicate that the specific gravity varies from 2.41 to 2.60; see Figure 8. The relatively low specific gravity (2.41) may reflect the presence of halite (2.16) or gypsum (2.32) minerals within the test sample.

The bulk density of the material encountered at 0.7m depth at this core location is 1.63Mg/m^3; see Figure 9. The maximum and minimum void ratio determined for a sample from this location was 0.817 and 2.476 respectively. The maximum void ratio of 2.476 is relatively high by comparison with most other soils.

4.3.2 Classification Results from Site 1A

The index properties (moisture content, plastic limit and liquid limit) of the material encountered in samples 83/20-SC003 are plotted against depth below seabed in Figure 4. The moisture content of the material is high ranging from 36% to 94%.

Atterberg Limit test results indicate that the material at this site has plastic limits (PL) values ranging from PL = 23% to 30% and liquid limits (LL) ranging from LL = 44% to 74%. The corresponding plasticity index (PI) values vary from PI = 21% to 45%. The moisture content of the material tested is approximately midway between the liquid and plastic limits at 0.9m and 1.1m depth and slightly wet of the liquid limit at 1.5m and 2.2m depth.

Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered at 0.9m and 1.1m depth is classified as very high plasticity clay (CV). However, at increased depth in this core the plasticity is reduced, material encountered at 1.5m and 2.2m depth is classified as high and intermediate plasticity clay (CH and CI) respectively.

Particle size distribution (PSD) curves for soil samples recovered at this core site are re-plotted in Figure 6. The grading curves for two samples recovered from 0.9m and 1.1m depth at core 83/20-SC003 indicate that the material has a high fines content (82% and 97% respectively) and is CLAY or SILT. The grading curves for two samples recovered from 1.5m and 1.6m depth at core 83/20-SC003 however indicate that the material is sandy CLAY or SILT.

The activity of the sediment samples encountered at 0.9m, 1.1m, 1.5m and 2.2m depth ranges from 0.8 to 1.5, which reflects the presence of normal to active clay minerals in the samples; see Figure 7. Specific gravity tests undertaken on samples recovered at this core location indicate that the specific gravity varies from 2.51 to 2.70; see Figure 8.

The bulk density of the material encountered at this core location varied from 1.38Mg/m^3 to 1.64Mg/m^3, with bulk density generally decreasing with depth; see Figure 9. The maximum and minimum void ratio determined for the sample were depth were 0.652 and 2.047 respectively. The maximum void ratio of 2.476 is relatively high by comparison with most other soils.

Although it had been hopedto compare test results from the two laboratories as a Quality Assurance check, subsequent testing indicated that the selected samples from this location were of different engineering classification and as such, this check was not possible.

4.3.3 Classification Results from Site 2

The index properties (moisture content, plastic limit and liquid limit) of the material encountered in sample 16/28-SC002 are plotted against depth below seabed in Figure 4. The moisture content of the material is moderately high at 48% to 71%.

Atterberg Limit test results indicate that the material at the site has plastic limit (PL) value PL = 26% and liquid limit (LL) value LL = 46%. The corresponding plasticity index (PI) value PI = 21%. The moisture contents are wet of the liquid limit. Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered at 0.5m and 0.9m depth in sample 16/28-SC002 is classified as intermediate plasticity clay (CI); the plasticity index and liquid limit are identical for the two samples tested.

Particle size distribution (PSD) curves for soil samples recovered at this core site are re-plotted in Figure 6. The grading curves for two samples recovered from 0.5m and 0.95m depth at core 16/28-SC002 indicate that the material is sandy CLAY or SILT. The activity of the sediment samples encountered at 0.5m and 0.9m depth are 1.2 and 4.2 respectively, which reflects the presence of normal to active clay minerals in the samples; see Figure 7.

A specific gravity test undertaken one sample recovered at this core location indicates that the specific gravity is 2.68; see Figure 8. The bulk density of the material encountered at this core location varied from 1.55Mg/m^3 to 1.67Mg/m^3; see Figure 9.

4.3.4 Classification Results from Site 3A

The index properties (moisture content, plastic limit and liquid limit) of the material encountered at core 11/20-SC002 are plotted against depth below seabed in Figure 4. The moisture content of the material is moderately high at 54% to 76%.

Atterberg Limit test results indicate that the material at this site have plastic limit (PL) value PL = 27% and liquid limit (LL) values within the narrow range from LL = 66% to 67%. The corresponding plasticity index (PI) values vary from PI = 38% to 40%. Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered at 0.4m and 1.1m depth is classified as high plasticity clay (CH).

Particle size distribution (PSD) curves for soil samples recovered at this core site are re-plotted in Figure 6. The grading curves for the two samples recovered from 0.4m and 1.1m depth at core 11/20-SC002 indicate that it is a purely fine material (i.e. fines content 100%); the composition of the material is almost identical.

The activity of the sediment samples encountered at both 0.4m and 1.1m depth is 0.6, which reflects the presence of inactive clay minerals in the samples; see Figure 7. This is consistent with the XRD test performed on a sample from 1.1m to 1.3m depth which indicated the presence of both illite (A=0.9) and kaolinite (A=0.38) minerals.

Specific gravity tests undertaken on two samples recovered at this core location indicate that the specific gravity is 2.50; see Figure 8. The bulk density of a sample from 0.4m depth at this core location is 1.54Mg/m^3; see Figure 9.

4.3.5 Classification Results for Site 4

The index properties (moisture content, plastic limit and liquid limit) of the material encountered in sample 78/28-SC007 are plotted against depth below seabed in Figure 4. The moisture content of the material is moderately high at 41% to 94%, and generally increases with depth below seabed.

Atterberg Limit test results indicate that the material at 0.8m depth has a plastic limit (PL) value PL = 25% and a liquid limit (LL) value LL = 47%. The corresponding plasticity index (PI) value PI = 22%. The moisture content is wet of the liquid limit. Atterberg Limit test results indicate that the material at 1.2m depth is non-plastic. Plotting these data on a Casagrande plasticity chart in Figure 5 indicates that the material encountered at 0.8m depth is classified as intermediate plasticity clay (CI).

Particle size distribution (PSD) curves for soil samples recovered at this core site are re-plotted in Figure 6. The grading curves for two samples recovered from 0.8m and 1.2m depth at core 78/28-SC007 indicate that the material is CLAY or SILT and sandy CLAY or SILT respectively. The activity of the sediment sample encountered at 0.8m depth is 1.0, which reflects the presence of normal clay minerals (e.g. illite) in the sample; see Figure 7.

A specific gravity test undertaken on one sample recovered at this core location indicates that the specific gravity is 2.49; see Figure 8. The bulk density of the material encountered at this core location varied from 1.67Mg/m^3 to 1.97Mg/m^3; see Figure 9.

4.4 Strength

4.4.1 Undrained Shear Strength

No unconsolidated undrained (UU) tests or vane tests were included in the scope of work of this study to determine the undrained shear strength.

The undrained strength (c_u) has been determined for the material encountered at the five core locations from isotropically consolidated undrained (CU) triaxial compression tests on 38mm diameter "undisturbed" samples. The samples were isotropically consolidated at pressures of 50kPa and 100kPa. However, the influence of the consolidation pressure (which is greater than the apparent preconsolidation pressure determined from the one dimensional oedometer test) and the rate of shearing is evident on the magnitude of the recorded undrained shear strengths at failure.

Assuming that the seabed sediment is normally consolidated, the following correlation between undrained shear strength, effective vertical stress (c_u/σ_v') and plasticity index (I_p) proposed by Skempton (1954) can be applied:

$$\frac{c_u}{\sigma_v'} = 0.11 + 0.0037 I_p$$

On the basis of the recorded saturated bulk densities and plasticity indices, the inferred undrained shear strengths generally increase with depth below seabed and range from approximately 1kPa at 0.5m depth to approximately 4.7kPa at 2.25m depth; see Figure 10.

The correlation between (undrained shear strength in triaxial compression) and effective vertical stress (c_u/σ_v') independent of the plasticity index proposed by Hight et al. (1987) can also be applied:

$$\frac{c_{u\,(\text{triaxial compression})}}{\sigma_v'} = 0.3$$

Assuming that the vertical effective stress increases linearly with depth and γ'=6kPa (on the basis of measured bulk densities), the inferred undrained shear strength ranges from 0.9kPa at 0.5m depth to 4.05kPa at 2.25m depth and correlates closely to the relationship derived by Skempton.

4.4.2 Effective Stress Strength

Effective stress strength parameters (effective cohesion, c', and angle of friction, ϕ') have been determined for the sediment encountered from isotropically consolidated undrained (CU) triaxial compression tests (with pore pressure measurement) on samples from each of the six selected gravity cores. Effective stress parameters have also been determined for the sediment encountered from drained shearbox tests carried out on reconstituted samples.

The values of t and s' measured at maximum deviator stress and the stress paths followed in the CU triaxial compression tests with pore pressure measurement for the gravity core samples are plotted in Figure 11. These data indicate that the peak effective stress strength parameters for the sediments range from c' = 4.5kN/m^2 and ϕ' = 28° to c' = 0kN/m^2 and ϕ' = 41°.

The results of shearbox tests undertaken on reconstituted samples are plotted in Figure 12. These data indicate that the peak effective stress strength parameters for the sediments range from c' = 0kN/m^2 and ϕ' = 35° to c' = 0kN/m^2 and ϕ' = 47°. The constant volume friction angle, ϕ_{cv}' typically ranges from 32° to 44°. In general the peak effective stress strength parameters determined from shearbox tests are higher than those determined in the CU triaxial compression tests.

The relationship between maximum angle of friction ϕ' and dry density obtained from the reconstituted shearbox samples tested is plotted for the five core locations in Figure 13. As would be expected, these test results generally indicate that the friction angle of the test samples reduces according as the dry density of the sample reduces.

Tests on three samples from gravity cores at Site 1, 1A and 3A indicate that the angle of repose ('i') varied from 30° to 40°. The angle of repose was determined by placing dry soil against a collapsible model retaining wall. The angle of repose is generally taken to approximate to the constant volume friction angle ϕ_{cv}'. As such, these test results are broadly consistent with those obtained by shearbox testing.

4.5 Compressibility

4.5.1 One-dimensional Consolidation Test

Oedometer tests were performed on sediment samples taken from each of the six selected gravity cores. The oedometer test curves obtained are plotted in Figure 14.

The compressibility parameter $C_c/(1+e_0)$, where Cc is the compression index and e_0 is the initial voids ratio, was determined from the oedometer tests. These tests indicated that the value of $C_c/(1+e_0)$ generally varied from 0.104 to 0.146 with the exception of two samples. The test results for the samples from 1.4m depth at 1 83/24-SC003 and 1.3m depth at 3A 11/20-SC002 yielded $C_c/(1+e_0)$ values of 0.042 and 0.195 respectively. The relationship between the compressibility parameter $C_c/(1+e_0)$ and moisture content is presented in Figure 15, along with the correlation for normally consolidated soils presented by Lambe and Whitman (1979). The test data suggest that the recovered sediments are less compressible than would have been anticipated were they normally consolidated.

The preconsolidation pressure was determined from the oedometer curves using the empirical construction method proposed by Casagrande. It should be noted that the Casagrande method relies to some extent on subjective analysis of oedometer test curves, which may in turn reflect influence of sample disturbance and plate embedment. Plotting these preconsolidation pressures as a function of depth below sea-bed, all six samples tested indicated varying degrees

of overconsolidation, see Figure 16. The overconsolidation ratio (OCR) is typically 3, however at site locations 2 and 4, the oedometer tests indicated OCR values of 13 and 8 respectively.

The apparent overconsolidation of the samples is consistent with the stress paths followed in the consolidated undrained (CU) triaxial tests which indicate that when isotropically consolidated at an effective consolidation stress of 40 - 50kPa the samples display a typical overconsolidated response, with the exception of a sample from site 1A. The normally consolidated response of the upper sample from site 1A indicates that the applied consolidation stress may have exceeded the in-situ preconsolidation pressure. This view is supported by the oedometer test response for the same sample that identified a low preconsolidation pressure of approximately 15kPa.

4.6 Sediment Permeability

The vertical permeability values of sediments encountered at the five sites was inferred on the basis of oedometer consolidation test data to vary within a relatively narrow range, from 1×10^{-10} m/sec to 2×10^{-8} m/sec.

The vertical permeability of the sediment encountered at site 1A (sample 83/20-SC003) and site 1 (sample 83/24-SC002) was recorded in the falling head test to range between 4×10^{-9} m/sec and 6×10^{-7} m/sec to 3×10^{-5} m/sec respectively.

The relationship between void ratio (e) and permeability obtained from the oedometer and falling head permeability tests is identified for samples from the five core locations in Figure 17. The permeability measured in the falling head tests is greater than that inferred for the respective samples from the consolidation test data.

The relatively low permeability (7×10^{-11}m/s) recorded by the triaxial permeability test on the sample from site 3A (sample 11/20-SC002) reflects the high clay content at this particular location.

5 COMPARSION WITH GEOTECHNICAL DATA FROM OTHER SITES

5.1 Selected Comparable Sites

Four deepwater sites in the North Atlantic Area have been chosen for the comparison study presented in this section. In addition to the availability of published geotechnical information, the sites also provide geotechnical information from a range of water depths. General site information for the selected comparable sites is tabulated in Table 4.

The comparable site locations are shown in Figure 18.

SITE	LOCATION	WATER DEPTH	REFERENCE
1. Faeroe-Shetland Channel	West of Shetland	900m – 1200m	Paul *et al.* (1993) Paul *et al.* (1998)
2. Foinaven	West of Shetland	~500m	Evans *et al.* (1998)
3. Vøring Basin	Norwegian Sea	850m – 1300m	NGI (1999)
4. NW Labrador Slope	Labrador Sea	2650m – 3030m	Morin & Dawe (1987)
Rockall Trough	***West of Ireland***	***1000m – 1500m***	

Table 4 : Selected Comparable Sites

A detailed description of the geological conditions, depositional processes and geotechnical properties at each of the four sites is contained in the relevant referenced paper. The comparable geotechnical properties for the top 2m of sediment at all four sites are described and discussed in this section (where available information allows) in a similar sequence to Section 4. The available geotechnical properties for each of the four sites are summarised and tabulated in Table 5, at the end of this chapter and compared to the range of results obtained for the Rockall Trough samples.

5.2 Sediment Mineralogy

Detail of sediment mineralogy was available for two of the four sites, Faeroe-Shetland Channel and NW Labrador Slope. No information regarding the mineralogy at Foinaven and the Vøring Basin was available. X-ray diffractometry revealed illite and chlorite (or kaolinite) as the dominant clay minerals at both sites. Quartz in the dominant mineral of the silt fraction with calcite, muscovite, chlorite, corundum and dolomite all present at the Faeroe-Shetland Channel site. It is considered that the presence of halite probably arises as a precipitate from saline pore water. Dolomite, hematite-calcite, felspar and quartz were all present at the NW Labrador Slope site. The mineralogy determined by XRD for the Rockall Trough Site 3A sediments revealed illite and kaolinite clay (with dolomite and salt) with minor quartz and calcite silt, which is consistent with the two comparison sites.

5.3 Sediment Chemistry

5.3.1 Carbonate Content

Information regarding sediment carbonate content was available for only one of the four sites, the NW Labrador Slope. The carbonate content was determined using a combustion method, which involved raising the temperature from 500°C to 800°C and measuring the amount of CO_2 burned between the two temperatures. The measured carbonate content (as CO_2) increased with depth, varying from 14% at 0.58m depth to 28.8% at 1.75m. The range of measured carbonate content at the NW Labrador Slope is consistent with the range of 14% to 30% measured for the Rockall Trough sediments.

5.4 Classification

The classification properties of the sediments at the four locations are summarised in this section and tabulated below in Table 5.

The moisture content of the material is generally very high at 20% to 90%, and generally increases with depth below seabed. At Foinaven and the Vøring Basin the moisture content only increases with depth in the top 0.3m and 1m respectively, decreasing with depth thereafter.

Atterberg Limit test results indicate that the material at the sites have plastic limits (PL) values ranging from PL = 15% to 30% and liquid limits (LL) ranging from LL = 25% to 95%. The corresponding plasticity index (PI) values vary from PI = 10% to 50%. Plotting these data on a Casagrande plasticity chart in Figure 19 indicates that the classification of the material encountered at these sites ranges from low to extremely high plasticity clays (CL, CI, CH, CV and CE), which is consistent with the Rockall sediments. The sediments encountered at the Faeroe-Shetland Channel and Foinaven are classified as low to intermediate plasticity clays (CL and CI). The sediments encountered at the Vøring Basin are classified as intermediate to extremely high plasticity clays (CI, CH, CV and CE). The sediments on the NW Labrador Slope are classified by the ASTM standard as high plasticity clays (percentage passing 75μm (No. 200) sieve > 50%, LL>50%). The range of plasticity of the materials encountered at the Rockall Trough and the Vøring Basin reflects the larger amount of available information for these locations while that available at the other sites is limited.

The composition of sediment encountered at the Faeroe-Shetland Channel, on the NW Labrador Slope and the Rockall Trough are plotted in Figure 20. No information regarding the sediment composition at Foinaven and the Vøring Basin was available. The relatively high percentage of sand and subsequent lower silt and clay proportions is noteworthy. The composition of sediments at the other two aforementioned sites is very similar.

The relationship between clay fraction and plasticity index (activity) of the sediment encountered at the Faeroe-Shetland Channel, on the NW Labrador Slope and the Rockall Trough is illustrated and compared in Figure 21. No information was available regarding the activity of the sediment at Foinaven and the Vøring Basin. The activity of the Faeroe-Shetland Channel sediments indicate the presence of inactive clay minerals, while that of the NW Labrador Slope sediments indicates normal to active clay minerals occur. As discussed previously in Section 4.3, the activity of the sediments encountered at the Rockall Trough core locations ranges from inactive to active clays and indicate variability at and between core locations.

5.5 Strength

5.5.1 Undrained Shear Strength

The undrained shear strength (c_u) has been determined for the material encountered at the four comparable sites from in-situ and laboratory fall-cone and / or vane tests. As expected the undrained shear strength increases generally with depth below seabed at each site. The measured undrained shear strength is typically less than 10kPa, over the depth range 0 to 2m below seabed at each of the four sites. The low measured undrained shear strength is consistent with the undrained shear strength inferred for the Rockall Trough sediments, which increased to 6.75kPa at 2.25m depth.

5.5.2 Effective Stress Strength

Information regarding effective stress strength parameters was available for only one of the four sites, the NW Labrador Slope. Effective stress strength parameters (effective cohesion, c', and angle of friction, ϕ') have been from direct shearbox tests. The results of direct shearbox tests indicate that the effective stress strength parameters for the sediments at this site are typically c' = 5kN/m^2 and ϕ' = 30° (it is not indicated whether the parameters are peak or constant volumes values), which are similar to the lower bound parameters determined for the Rockall Trough sediments.

5.6 Compressibility

5.6.1 Compressibility Parameter

Information regarding the compressibility parameter $C_c/(1+e_0)$ and moisture content relationship was available for the NW Labrador Slope site only. The compressibility parameter / moisture content relationship for samples is plotted in Figure 22. This plot indicates that the compressibility parameter ($C_c/(1+e_0)$) values determined for the Rockall trough sites are generally lower than that determined at the NW Labrador Slope site.

5.6.2 Overconsolidation Ratio

The sediments encountered at the Faeroe-Shetland Channel and on the NW Labrador Slope appear to be lightly overconsolidated (the preconsolidation pressure being evaluated as for the Rockall sediments using the Casagrande classical method). The degree of overconsolidation varied from 1 to 3 at the Faeroe-Shetland Channel and 4.5 on the NW Labrador Slope. Notwithstanding the fact that a small number of samples recovered from the Rockall Trough exhibit a relatively high degree of overconsolidation, the published data are generally consistent with the OCR of 3 inferred for (much of) the sediment in the Rockall Trough.

SITE	I Faeroe–Shetland Channel	II Foinaven	III Vøring Basin	IV NW Labrador Slope	**Rockall Trough**
Approx. Water Depth (m)	900-1200	500	850-1300	2650-3030	**1000-1500**
Sample Depth Range (m) (below Seabed)	0 – 4	0 – 2	0 – 3	0 – 1.6	**0 – 2.3**
Classification :					
Moisture Content (%)	20 –65	30 – 70	50 – 80	50 – 90	**36 – 94**
Atterberg Limits:					
Liquid Limit (%)	25 – 55	30 – 50	45 – 95	55 – 70	**39 – 74**
Plastic Limit (%)	15 – 25	19 – 21	20 – 30	19 – 21	**23 – 30**
Plasticity Index (%)	10 – 25	19 – 29	30 - 60	35 - 50	**12 - 45**
Liquidity Index	0.8 – 2.0	0.5 – 2.0	1 – 1.3	1.1 – 1.4	**0.5 – 2.1**
Carbonate Content (%CO_2)				14 – 28.8	**14 – 30**
Particle Size Analysis :					
Sand (%)	~0			5	**0 - 60**
Silt (%)	60			60	**15 - 93**
Clay (%)	40			35	**5 - 60**
Mineralogy:(Dominant Clay Mineral)	Illite			Illite	**Illite/Kaolinite**
Strength :					
Shear Box : c' (kPa)				5	**0 – 4.5**
ϕ' (°)				30	**28 – 41**
Undrained Strength : c_u (kPa)	$5 – 20^{?}$	$< 10^{+*}$	$2.5 – 10^{+*}$	$5 – 10^{+*}$	**1 – 4.7**
Compressibility :					
OCR	1 - 3			4.5 @1.6m	**3 (8-13)**

NOTE: i) $^{+}$ = fall-cone * = vane $^{?}$ = unknown

Table 5 : Typical Geotechnical Parameters for Four Comparable North Atlantic Sites versus Range of Geotechnical Parameters Obtained for Rockall Trough Sites

(16)

References:
Site I Paul *et al.* (1993) and Paul *et al.* (1998)
Site II Evans *et al.* (1998)
Site III NGI (1999)
Site IV Morin & Dawe (1987)

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A number of gravity core samples obtained as part of a data acquisition project undertaken by Rockall Studies Group in June 1998 were selected for a programme of limited geotechnical testing. Sample selection was influenced by quality of core recovery and need to maximise geographical coverage. A detailed geological inspection was undertaken on test samples immediately upon opening of the core liners in order to identify the nature and origin of the recovered sediments.

(i) The laboratory tests undertaken on sea-bed sediment samples recovered from a number of sites on the Rockall Trough indicate that the sediments are highly variable, varying from medium sands to inorganic clays of intermediate to very high plasticity. The samples exhibit significant variability at and between sample locations.

(ii) The carbonate content of selected test samples (measured as $\%CO_2$) was found to vary from 14% to 30% for all but for one clay-rich sample that contained a carbonate content of 6%.

(iii) Soil classification data indicates that the activity of clay sediments retrieved from the Rockall Trough is quite variable (from inactive to active). This in turn indicates that different clay minerals occur in these sediments. Given the limited scope of this study and the variability of the sediments recovered, x-ray diffraction (XRD) analysis was only undertaken on one sample. Consequently this study provides little conclusive data on clay mineralogy.

(iv) The measured specific gravity of test samples were variable. The relatively low value of specific gravity recorded in one instance could indicate the presence of halite (a precipitate of salt water) within the test sample. However, in the absence of thin section petrography on the sample, this cannot be verified.

(iv) No unconsolidated undrained tests or vane tests were undertaken on the test samples. If the seabed sediment is assumed to be normally consolidated, its undrained shear strength would be inferred on the basis of Hight (1987) and the recorded sample bulk densities to range from approximately 1kPa at 0.5m depth to 4kPa at 2.25m depth.

(v) Shearbox tests indicate strength parameters ranging from $c' = 0kN/m^2$ and $\phi' = 35°$ to $c' = 0kN/m^2$ and $\phi' = 47°$. The scatter in the data reflects the variation in sample dry density and in compactive effort in sample preparation.

(vi) The constant volume friction angle, ϕ_{cv}' determined from shearbox tests typically ranges from 32° to 44° (assuming no c' intercept). Although ϕ_{cv}' values of up to 39° have been recorded for

well graded calcareous sands, the ϕ_{cv}' value of 44° is considered unrealistic and possibly suggests that there is a c' intercept in a number of samples. Tests on other samples indicate that the angle of repose ('i') varied from 30° to 40°. The angle of repose is generally taken to approximate to the constant volume friction angle and, as such, these results are likely to be more realistic and credible.

(vii) Compressibility test data suggest that the recovered sediments are less compressible than would have been anticipated were they normally consolidated. Preconsolidation pressures determined from oedometer tests indicate varying degrees of overconsolidation. This may reflect the densifying effect of wave action or of some creep compaction or aging process.

(viii) In general, the range of geotechnical parameters obtained for Rockall sites by this study was broadly comparable to those obtained at other deep-sea environments in the North Atlantic. In the absence of detailed data from these other sites, the only notable difference appears to be in respect of sediment compressibility characteristics. The sediments recovered from the Rockall trough appear to be slightly less compressible than those recovered from the NW Labrador Slope.

6.2 Recommendations

(i) *Given the limited scope of the geotechnical testing of sediments from the Rockall Trough undertaken in this study and the limited amount of published geotechnical data for similar deep-water environments, the conclusions presented above should be treated with some caution and assumed to be indicative only.*

(ii) In light of the significant variation in the geotechnical properties of the sediments tested, more extensive geotechnical testing would be required to more fully appreciate the variation in composition and geotechnical behaviour of sediments at and between each of the sampling locations around the Rockall Trough.

(iii) Any additional work should focus in particular on identification of sediment mineralogy (thin section petrography and x-ray diffraction) and classification testing (Atterberg Limits, gradings, specific gravities). It should also provide for some vane testing and unconsolidated undrained triaxial testing of soft clay soils where appropriate and for further assessment of the effective stress strength of the sediments. This additional work could be undertaken on other undisturbed gravity core samples previously recovered which remain in storage and could be incorporated cost-effectively into existing geotechnical research programmes for Irish third level institutions. This would also eliminate the requirement to charter expensive marine drilling and sampling equipment.

(iv) Any subsequent drilling or sampling programme should investigate and provide, where possible, for in-situ field assessment of the geotechnical properties of sea-bed sediments (using static cone penetration test equipment / piezocones etc). Data obtained in this manner could then be compared with that derived by laboratory testing of sediments from the gravity core samples. It may also be worthwhile to use improved sampling techniques (eg vibrocoring) to recover higher quality sediment samples from the sea-bed.

REFERENCES

British Standards Institution (1990) 'BS 1377 – Methods of Test for Soils for Civil Engineering Purposes : Parts 1 to 9

Evans T.G., Clarke J., Hampson K.M., Price C.H., Ghorbani A., Andenaes E. and Shepherd C. (1998) 'Geotechnical Challenges West of Shetland', *New Frontiers : Offshore Site Investigation and Foundation Behaviour, SUT Conference, London*

Hampson K. and Power P. (1996) 'Geotechnical Investigations for the Foinaven and Schiehallion Developments, West of Shetland', *Towards 2000 Metres or Millenium?, SUT Conference, London*

Head (1982) 'Manual of Soil Laboratory Testing, Volume 2', Pentech Press, London

Head (1986) 'Manual of Soil Laboratory Testing : Effective Stress Tests, Volume 3', Pentech Press, London

Hight D.W., Jardine R.J. and Gens A. (1987) 'The Behaviour of Soft Clays' *Embankments on Soft Clays, Public Works Research Centre, Athens, Chapter 2, pp33-158*

Lambe T.W. and Whitman R.V. (1979) 'Soil Mechanics', SI Version, John Wiley & Sons

Morin P. and Dawe R. (1987) 'Geotechnical Properties of Two Deep-Sea Marine soils from the Labrador Sea', *Can. Geotech. J. Vol. 24, pp 536-548*

Norwegian Geotechnical Institute - NGI (1999) 'Private Communication'

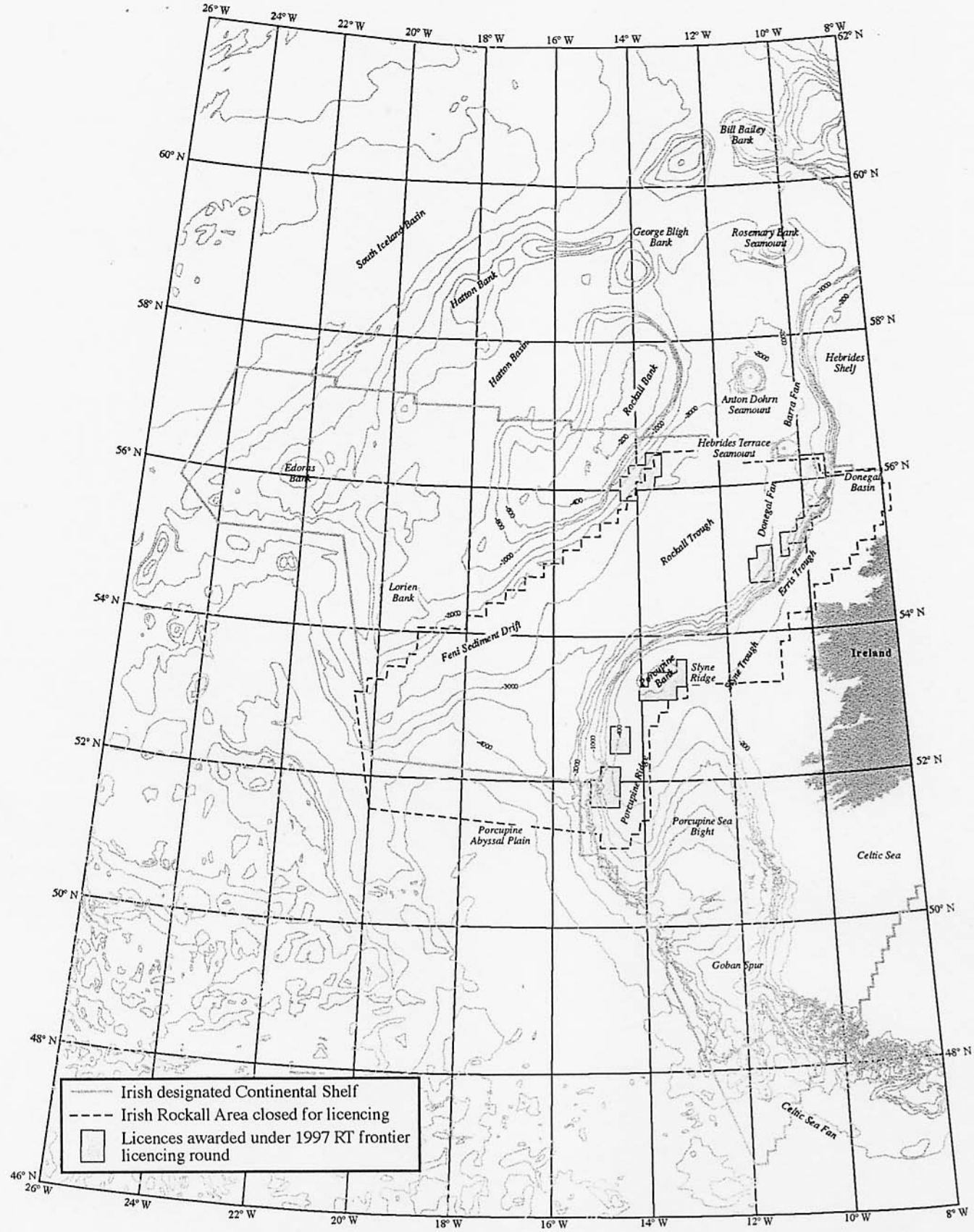
Paul M.A., Talbot L.A. and Stoker M.S. (1993) 'Geotechnical Properties of Sediments from the Continental Slope Northwest of the British Isles', *Volume 28 : Offshore Site Investigation and Foundation Behaviour, SUT Conference, London*

Paul M.A., Talbot L.A. and Stoker M.S. (1998) 'Shallow Geotechnical Profiles, Acoustic Character and Depositional History in Glacially Influenced Sediments from the Hebrides and West Shetland Slopes', *Geological Processes on Continental Margins: Sedimentation, Mass-Wasting and Stability. Geological Society, London, Special Publications, 129, pp 117-131*

Skempton A.W. (1954) 'The Pore Pressure Coefficients A and B', *Géotechnique, Vol. 4, No.4*

Tomlinson M.J. (1995) 'Foundation Design and Construction', 6th Edition, Longman Scientific & Technical

FIGURES



Projection: UTM Zone 28 (Central Meridian 15°W) System: ED50.
Bathymetry Source: GEBCO 97, water depths in metres.

JBA

PRELIMINARY GEOTECHNICAL ASSESSMENT

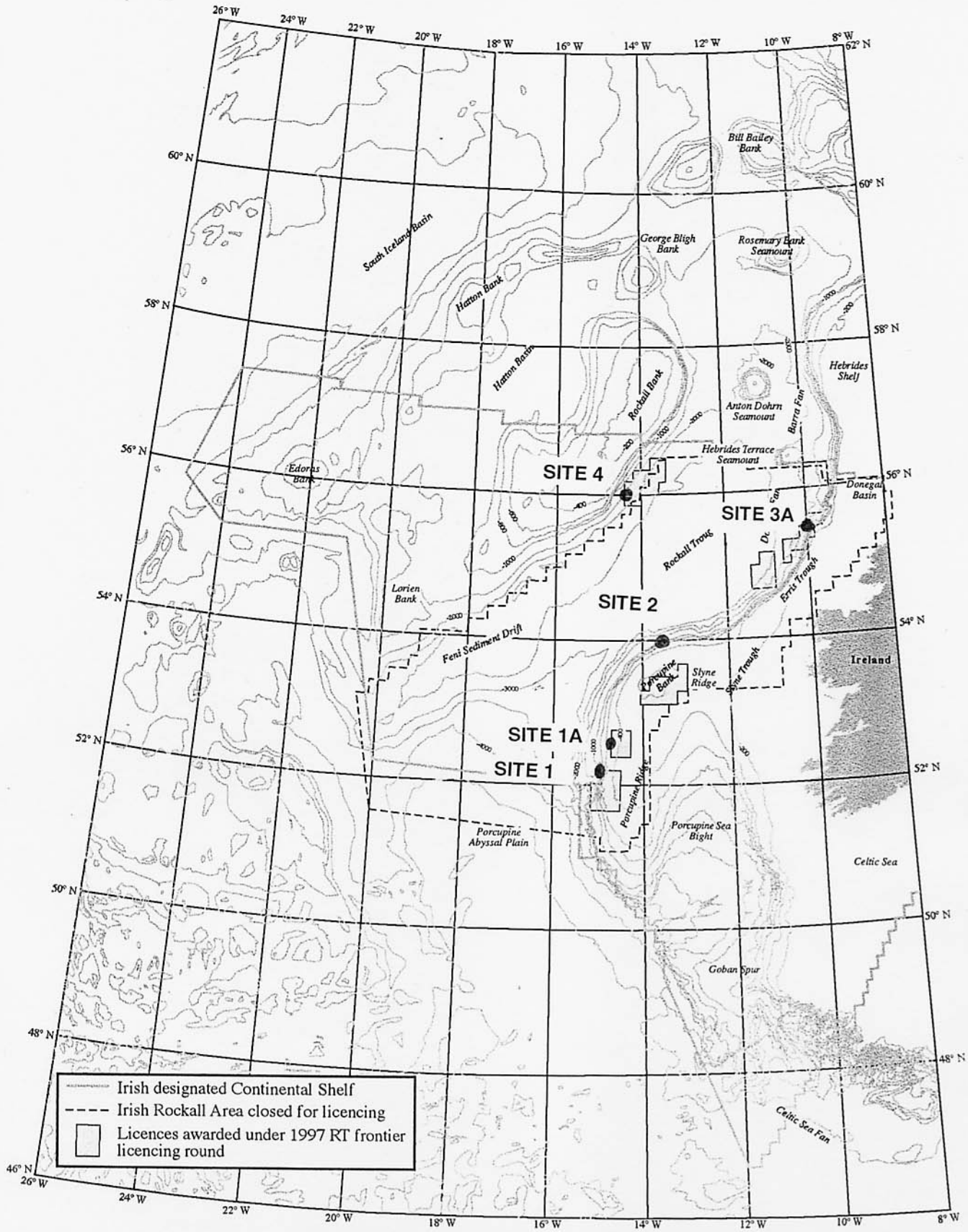
ROCKALL STUDIES GROUP

SITE LOCATION

Author: A.F.

Date: Sept '99

FIGURE 1



Projection: UTM Zone 28 (Central Meridian 15°W) System: ED50.
Bathymetry Source: GEBCO 97, water depths in metres.

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PRELIMINARY GEOTECHNICAL ASSESSMENT

ROCKALL STUDIES GROUP

BOREHOLE LOCATIONS

Author: A.F.

Date: Sept '99

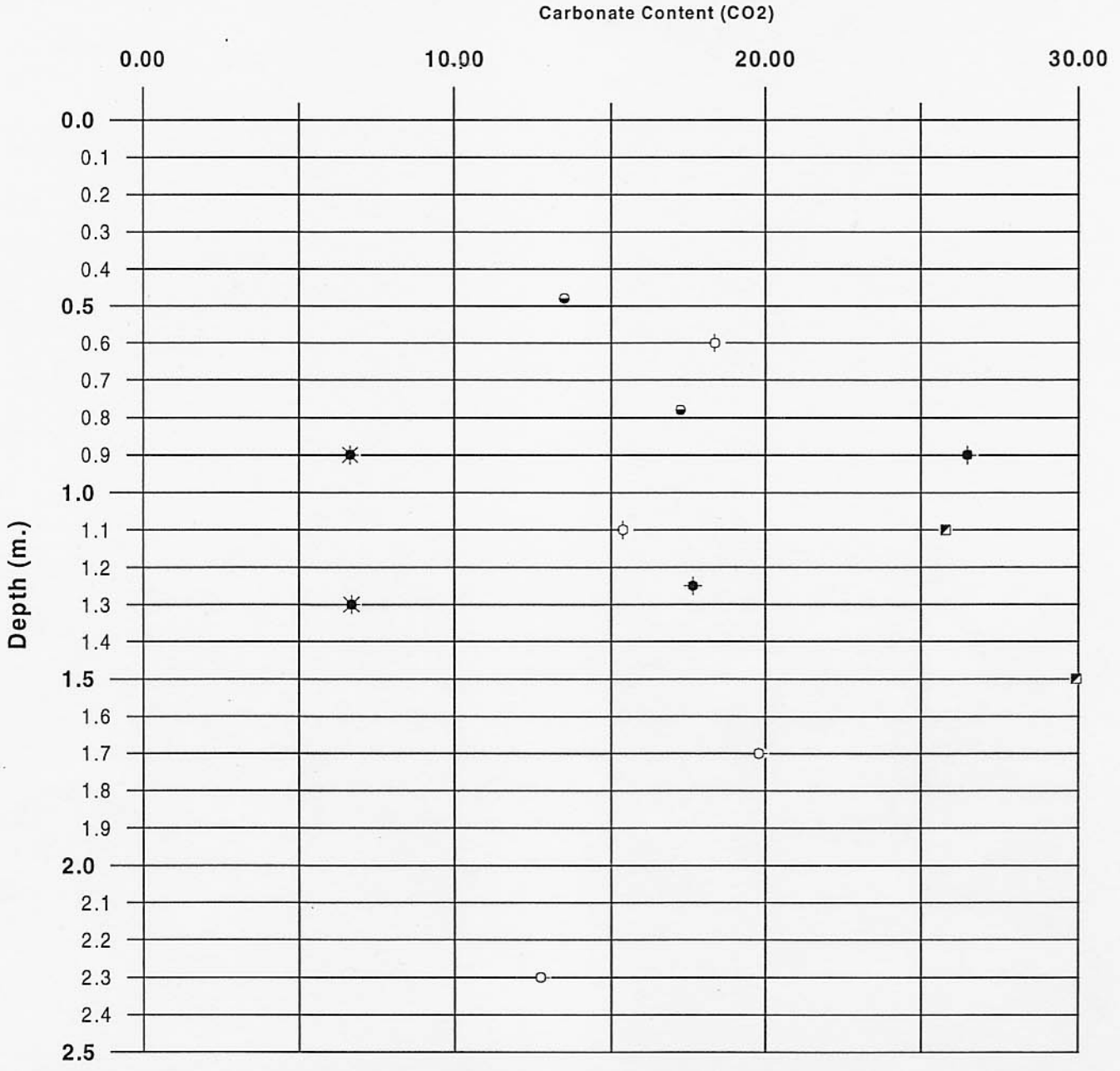
FIGURE 2

John Barnett & Associates

Carbonate Content -vs- Depth below GL

Job No.: JBA2107

Site Name: Rockall Trough



Bh_number

- 1A 83/20-SC003 Box 2
- 1A 83/20-SC003 Box 3
- 3A 11/20-SC002
- 1 83/24-SC002
- 2 16/28-SC002
- 4 78/28-SC007

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PRELIMINARY GEOTECHNICAL ASSESSMENT

ROCKALL STUDIES GROUP

CARBONATE CONTENT

Author: A.F.

Date: Sept '99

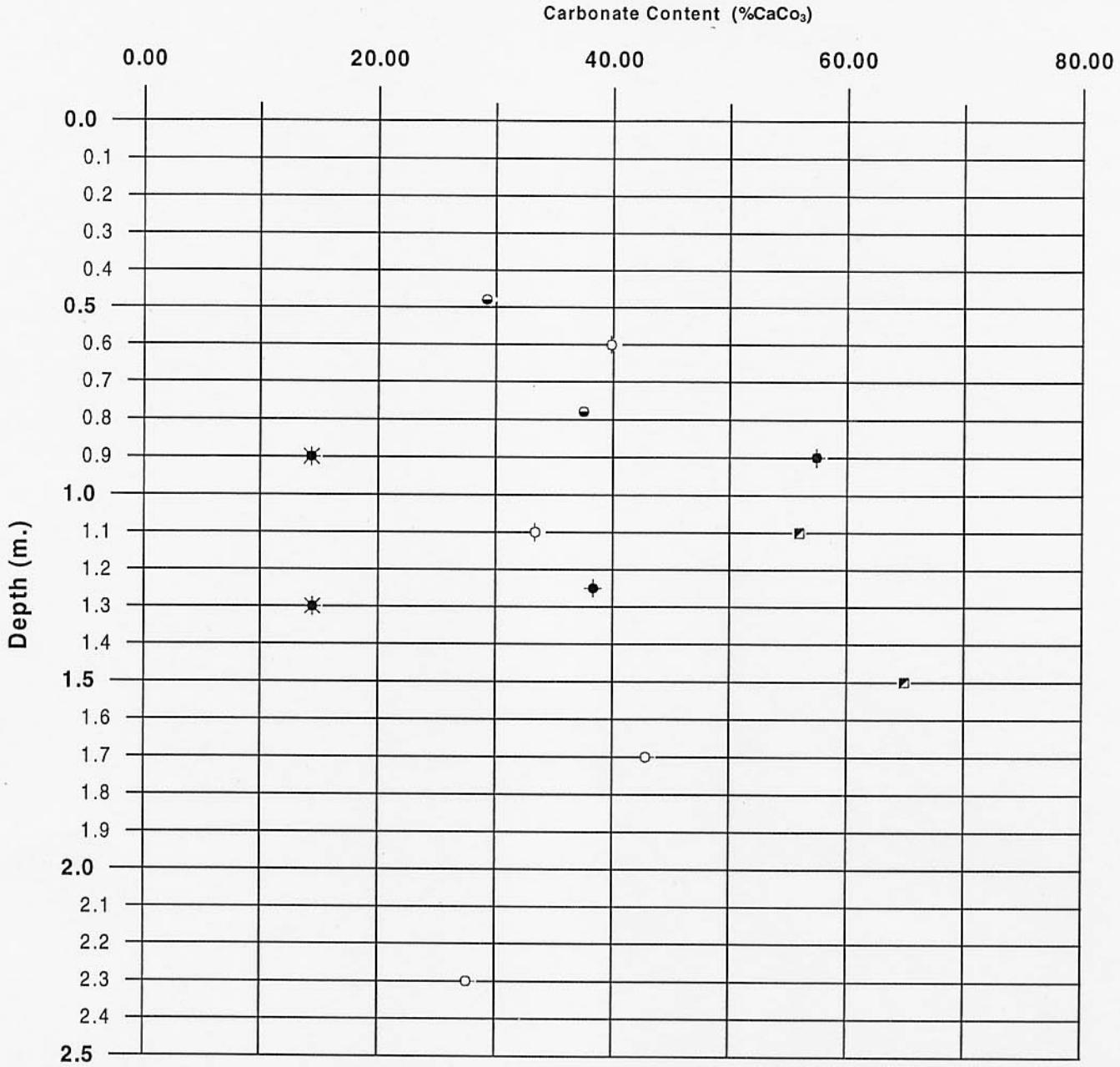
FIGURE 3

John Barnett & Associates

Carbonate Content -vs- Depth below GL

Job No.: JBA2107

Site Name: Rockall Trough



Bh_number

- 1A 83/20-SC003 Box 2
- 1A 83/20-SC003 Box 3
- 3A 11/20-SC002
- 1 83/24-SC002
- 2 16/28-SC002
- 4 78/28-SC007

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PRELIMINARY GEOTECHNICAL ASSESSMENT

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CARBONATE CONTENT

Author: A.F.

Date: Sept '99

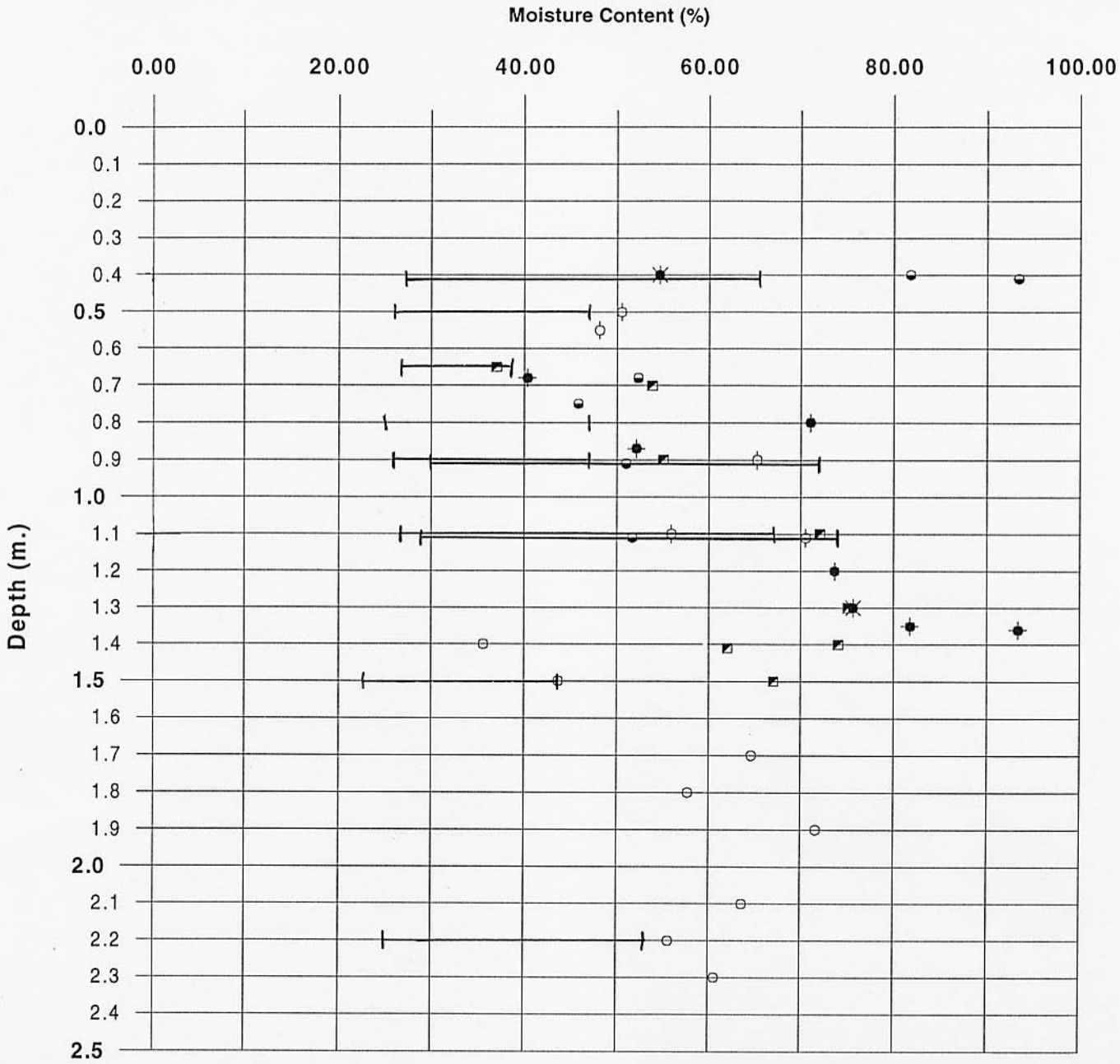
FIGURE 3A

John Barnett & Associates

Atterberg Limits -vs- Depth below GL

Job No.: JBA2107

Site Name: Rockall Trough



Bh_number

1A 83/20-SC003 Box 2
1A 83/20-SC003 Box 3
3A 11/20-SC002
1 83/24-SC002
2 16/28-SC002
4 78/28-SC007

Moisture contents are labelled

Bar plots from PL to LL

PL NMC LL

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ATTERBERG LIMITS

Author: A.F.

Date: Sept '99

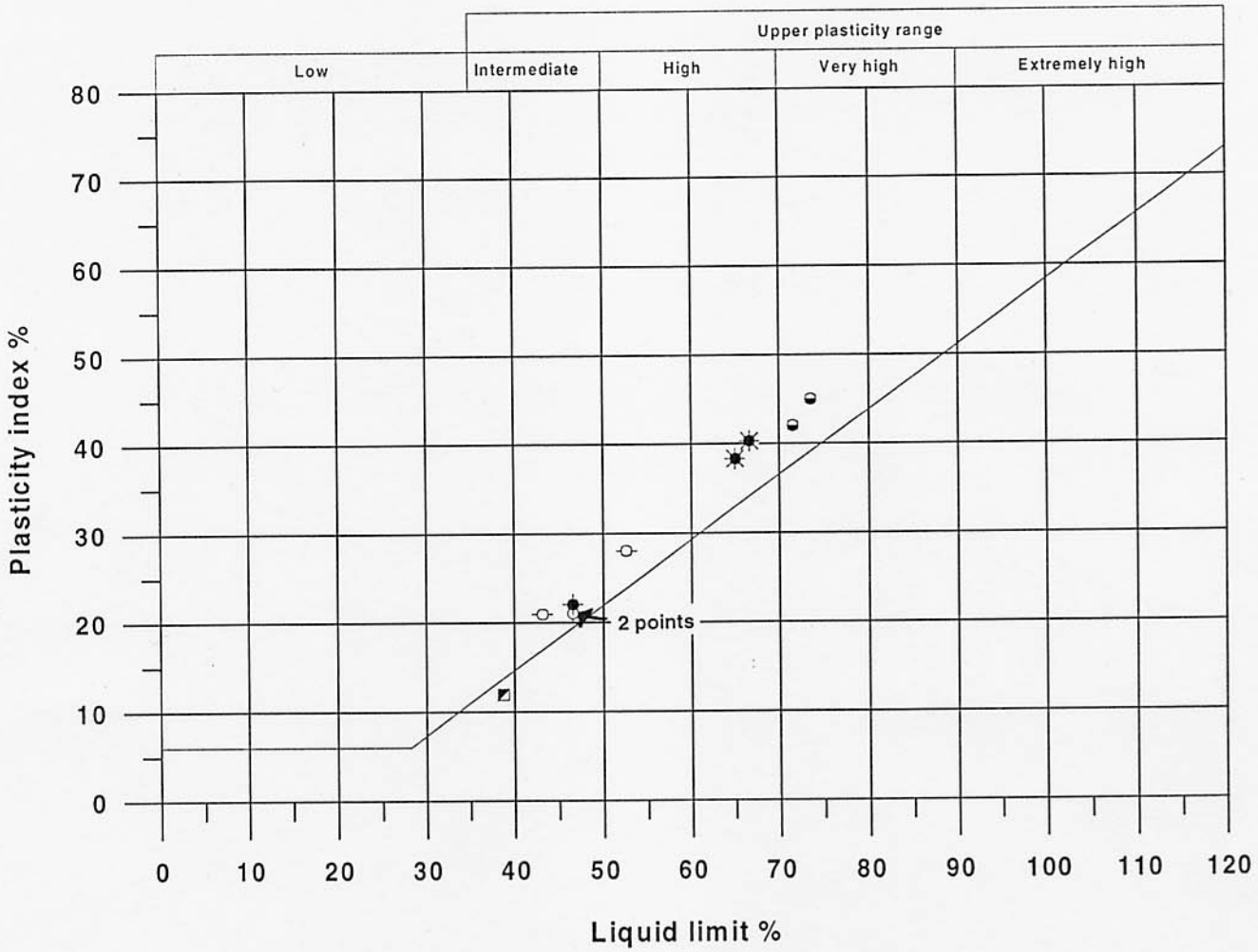
FIGURE 4

John Barnett & Associates

Plasticity Chart

Job No.: JBA2107

Site Name: Rockall Studies Group



Bh_number

- 1A 83/20-SC003 Box 2
- 1A 83/20-SC003 Box 3
- 3A 11/20-SC002
- 1 83/24-SC002
- 2 16/28-SC002
- 4 78/28-SC007

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PLASTICITY CHART

Author: A.F.

Date: Sept '99

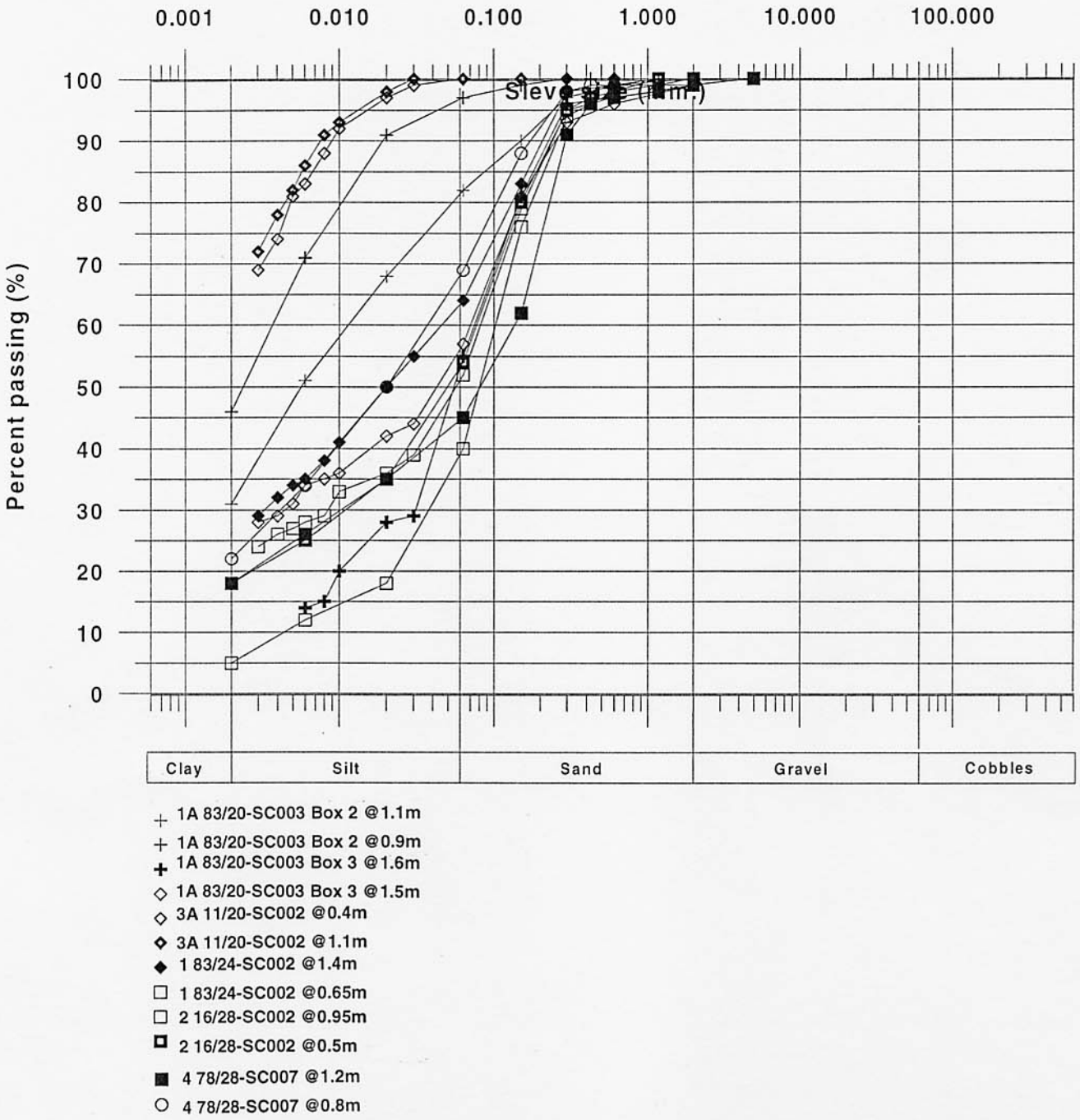
FIGURE 5

John Barnett & Associates

Job No.: JBA2107

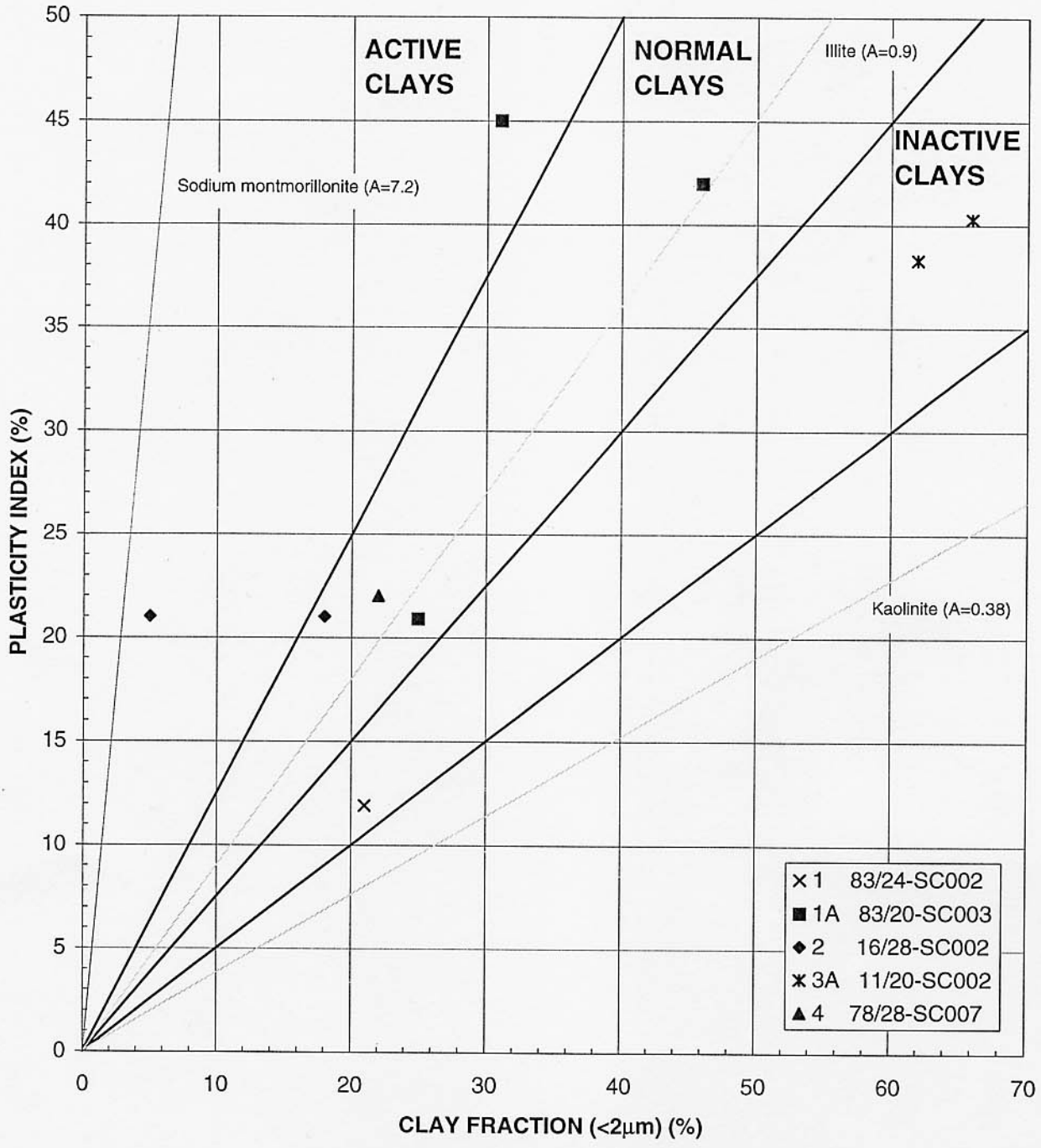
Site Name: Rockall Studies Group

Particle Size Distribution



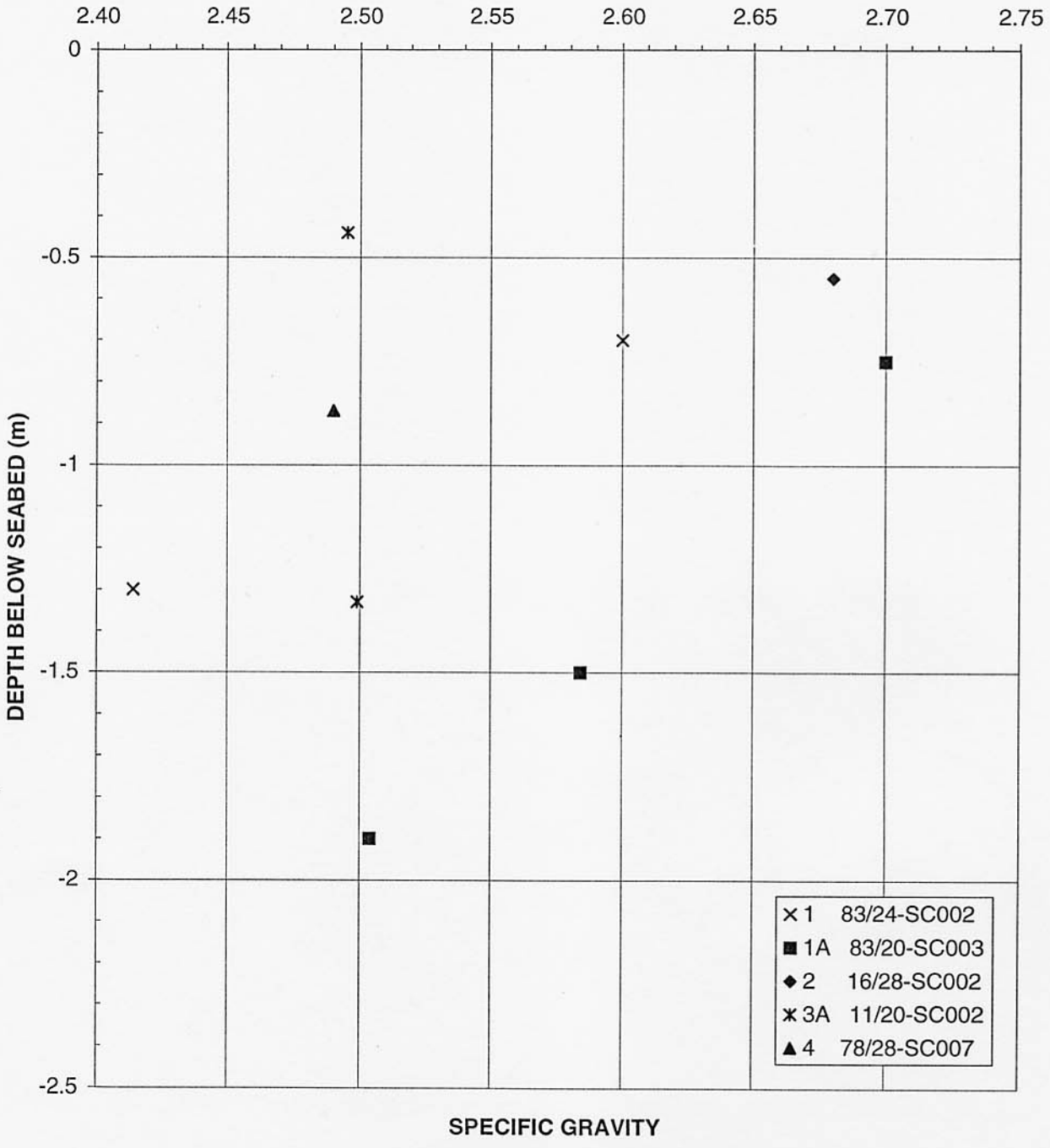
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP PARTICLE SIZE DISTRIBUTION	
	Author: A.F. Date: Sept '99	FIGURE 6

RELATIONSHIP BETWEEN CLAY FRACTION AND PLASTICITY INDEX



JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP CLAY FRACTION - PLASTICITY INDEX RELATIONSHIP
	Author: A.F. Date: Sept '99
	FIGURE 7

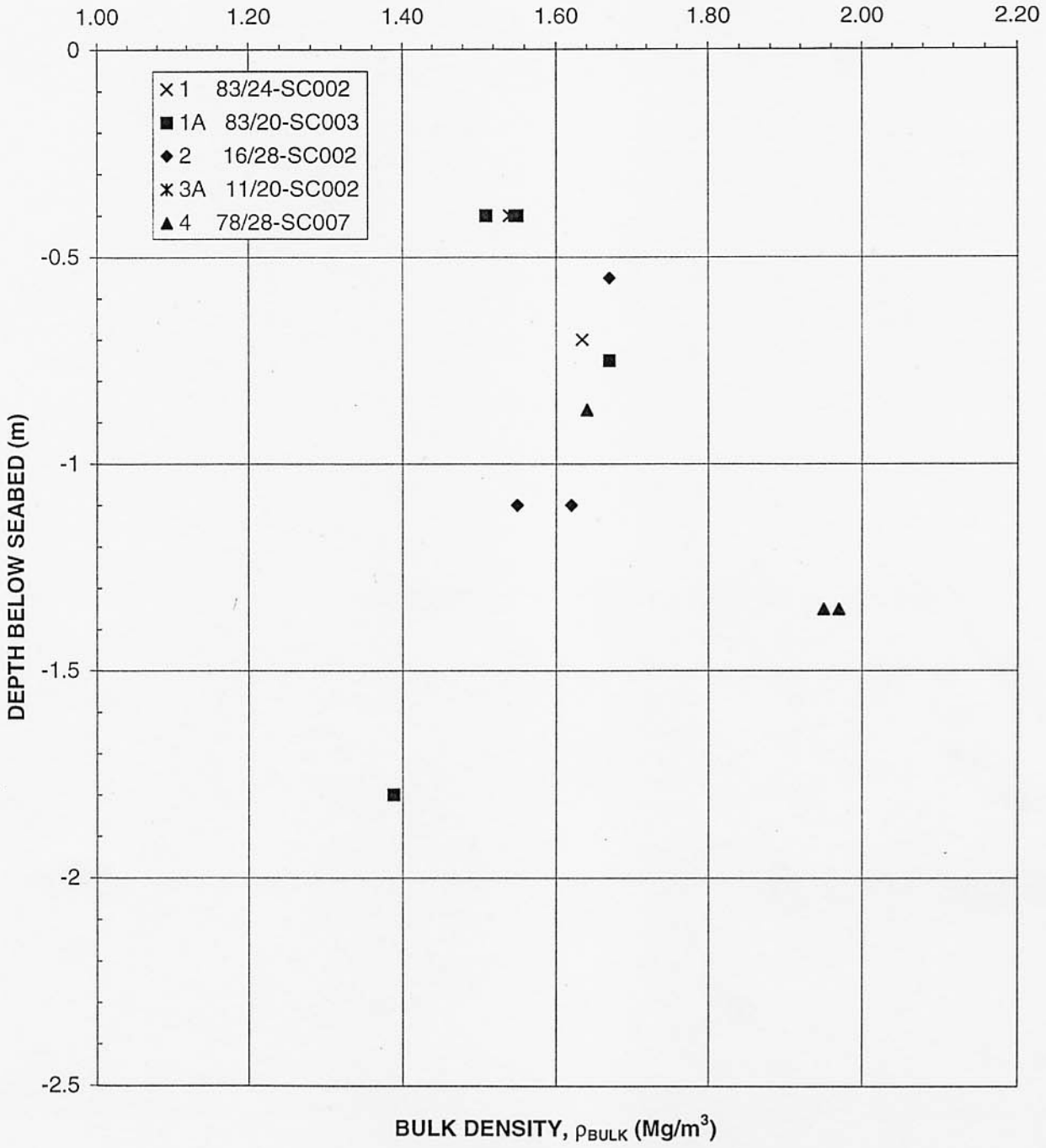
SPECIFIC GRAVITY



NOTE : Specific gravity of minerals -
quartz : 2.65
clay mineral (illite, kaolinite) : 2.5 -2.8
halite : 2.16
gypsum : 2.32

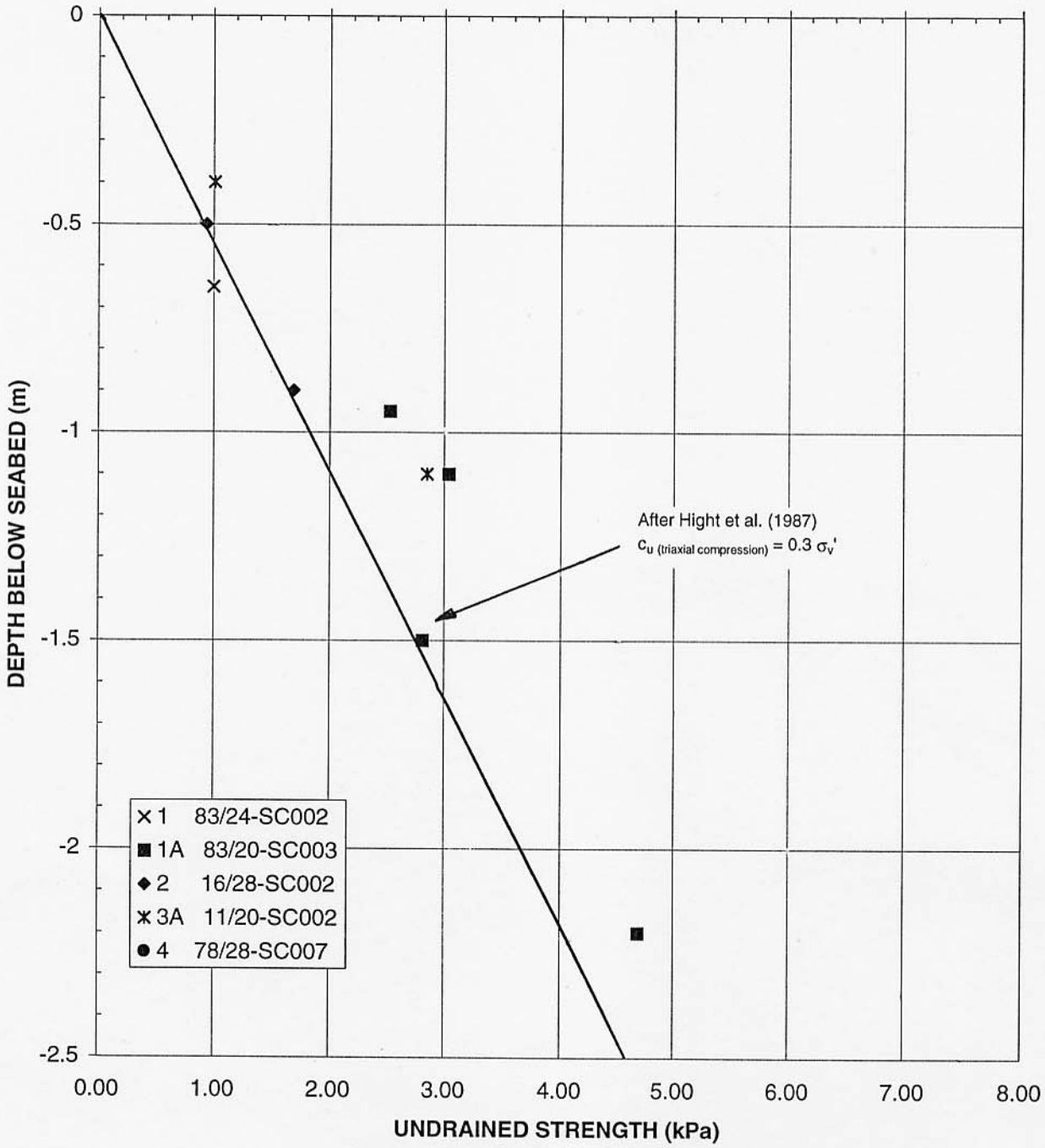
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP SPECIFIC GRAVITY	
	Author: A.F. Date: Sept '99	FIGURE 8

BULK DENSITY



JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP BULK DENSITY	
	Author: A.F. Date: Sept '99	FIGURE 9

UNDRAINED STRENGTH
(Estimated Using Correlation with σ_v' and PI)



After Skempton (1954) $c_u = (0.11 + 0.0037I_p)\sigma_v'$

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PRELIMINARY GEOTECHNICAL ASSESSMENT

ROCKALL STUDIES GROUP

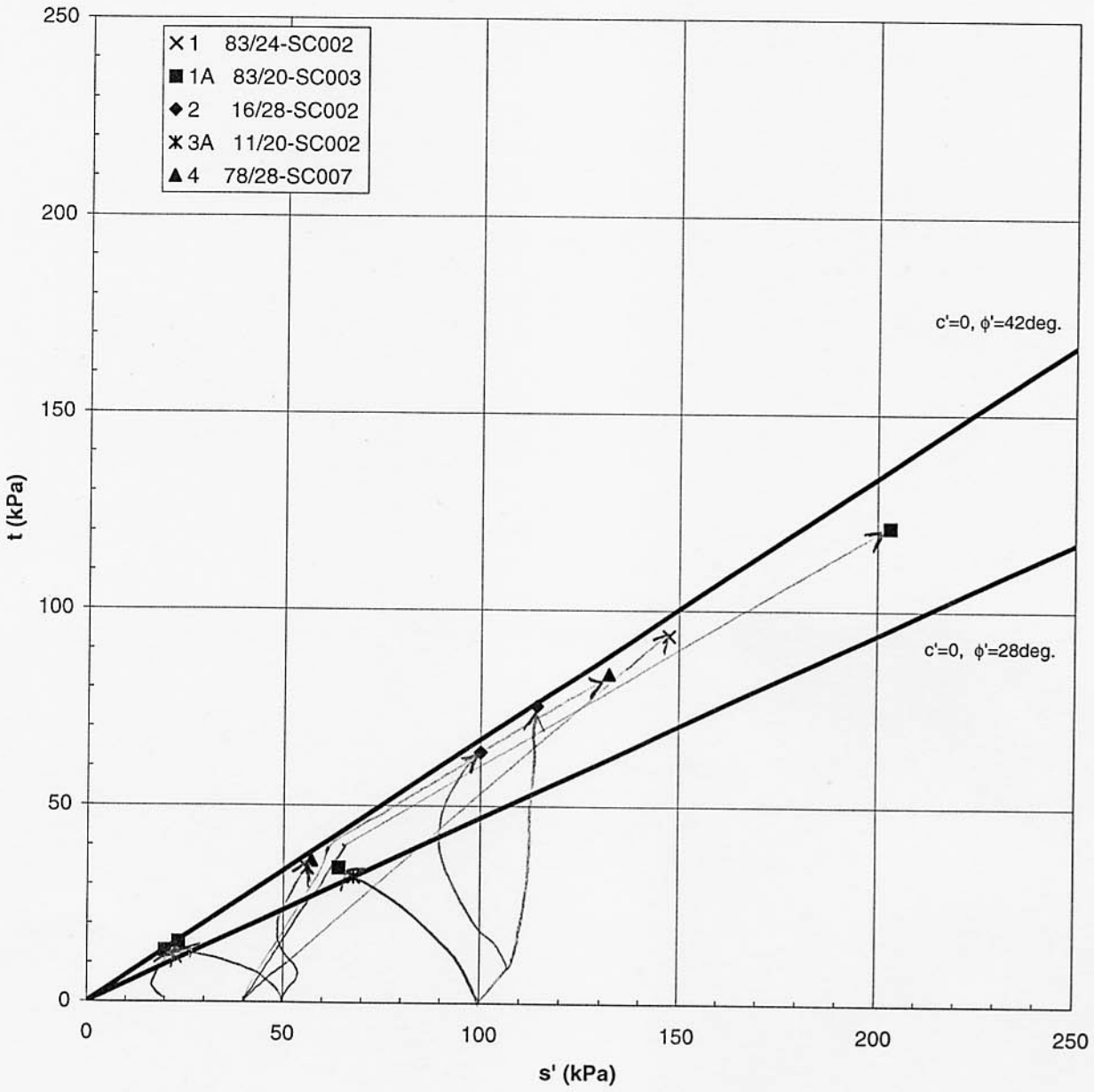
UNDRAINED STRENGTH

Author: A.F.

Date: Sept '99

FIGURE 10

CU TRIAXIAL TESTS
PEAK STRESS CONDITIONS

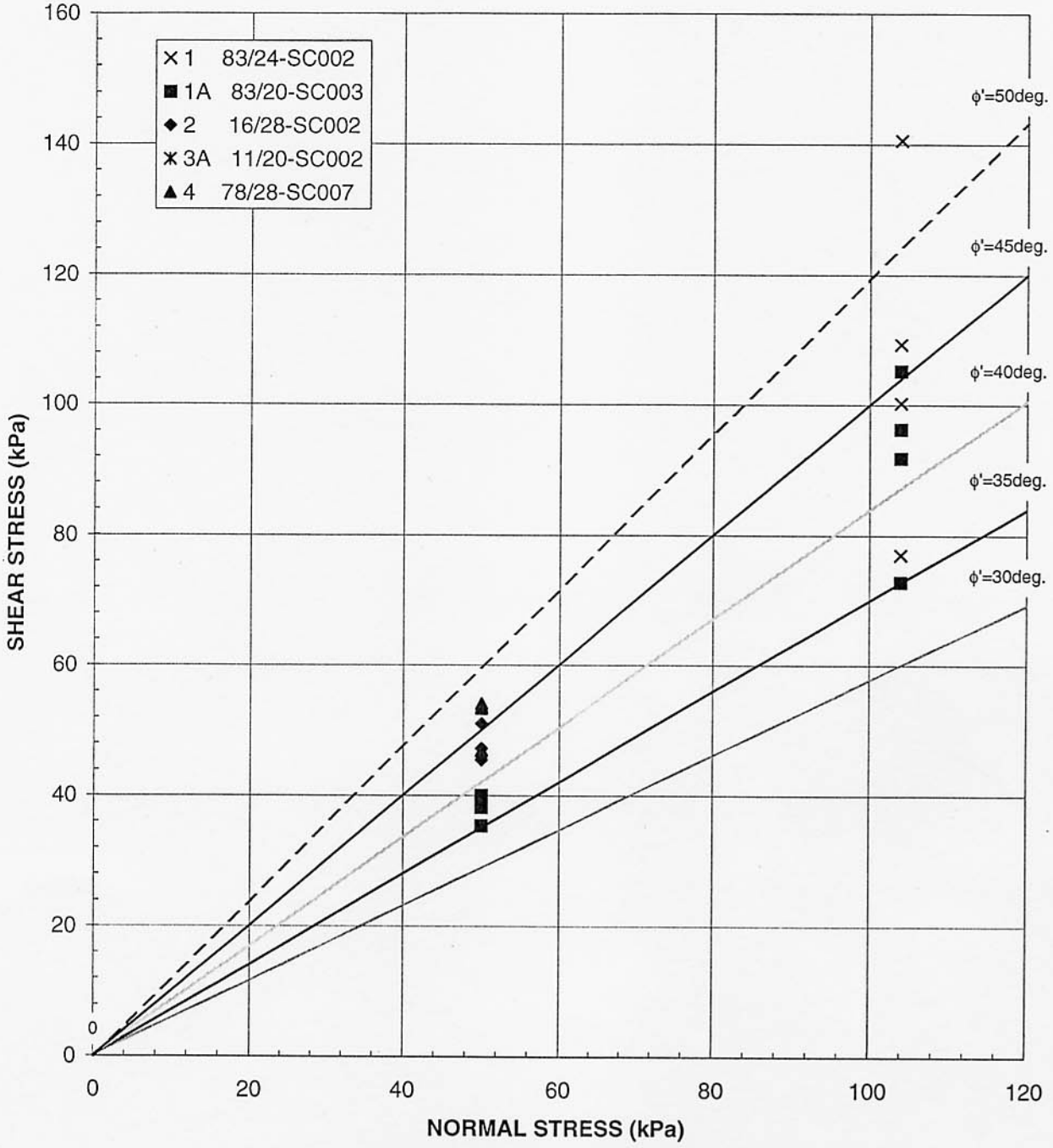


$s' = \frac{1}{2} (\sigma_{1f}' + \sigma_{3f}')$
$t = \frac{1}{2} (\sigma_{1f}' - \sigma_{3f}')$

σ_{1f}' = major effective stress at failure
σ_{3f}' = minor effective stress at failure

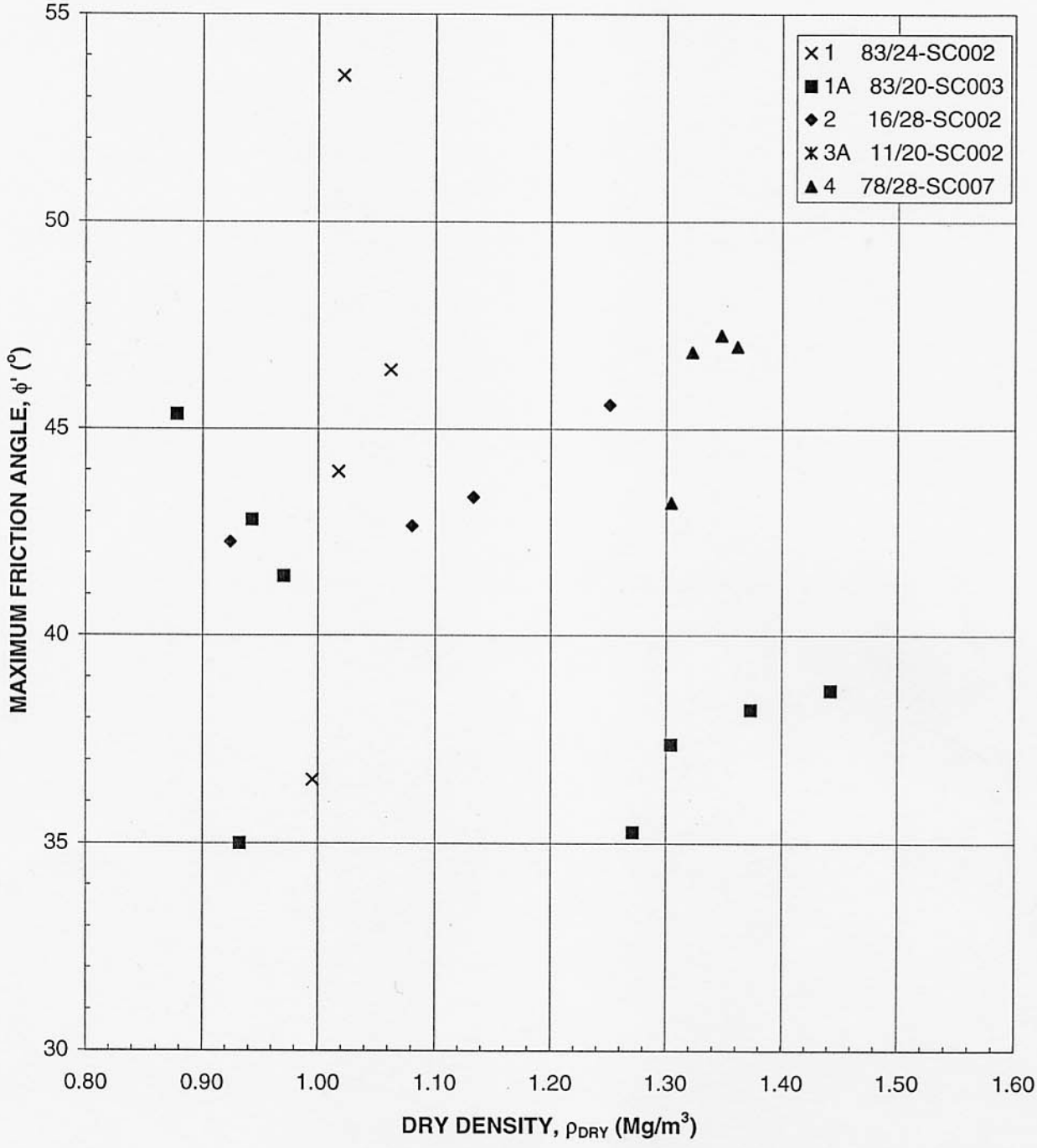
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP CU TRIAXIAL COMPRESSION TESTS	
	Author: A.F. Date: Sept '99	FIGURE 11

SHEAR STRESS - vs - NORMAL STRESS



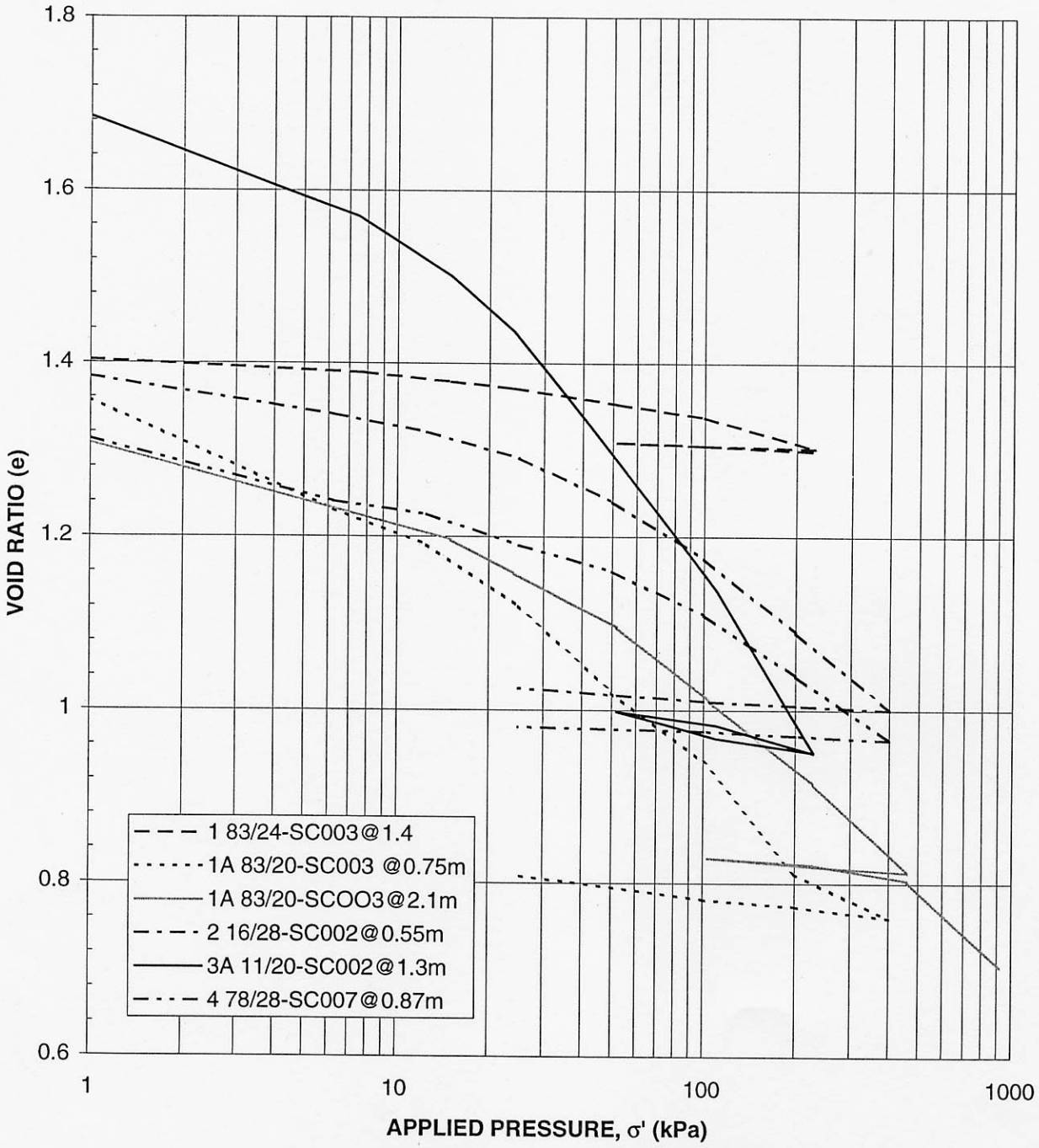
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP SHEARBOX TESTS	
	Author: A.F. Date: Sept '99	FIGURE 12

MAXIMUM FRICTION ANGLE -vs- DRY DENSITY



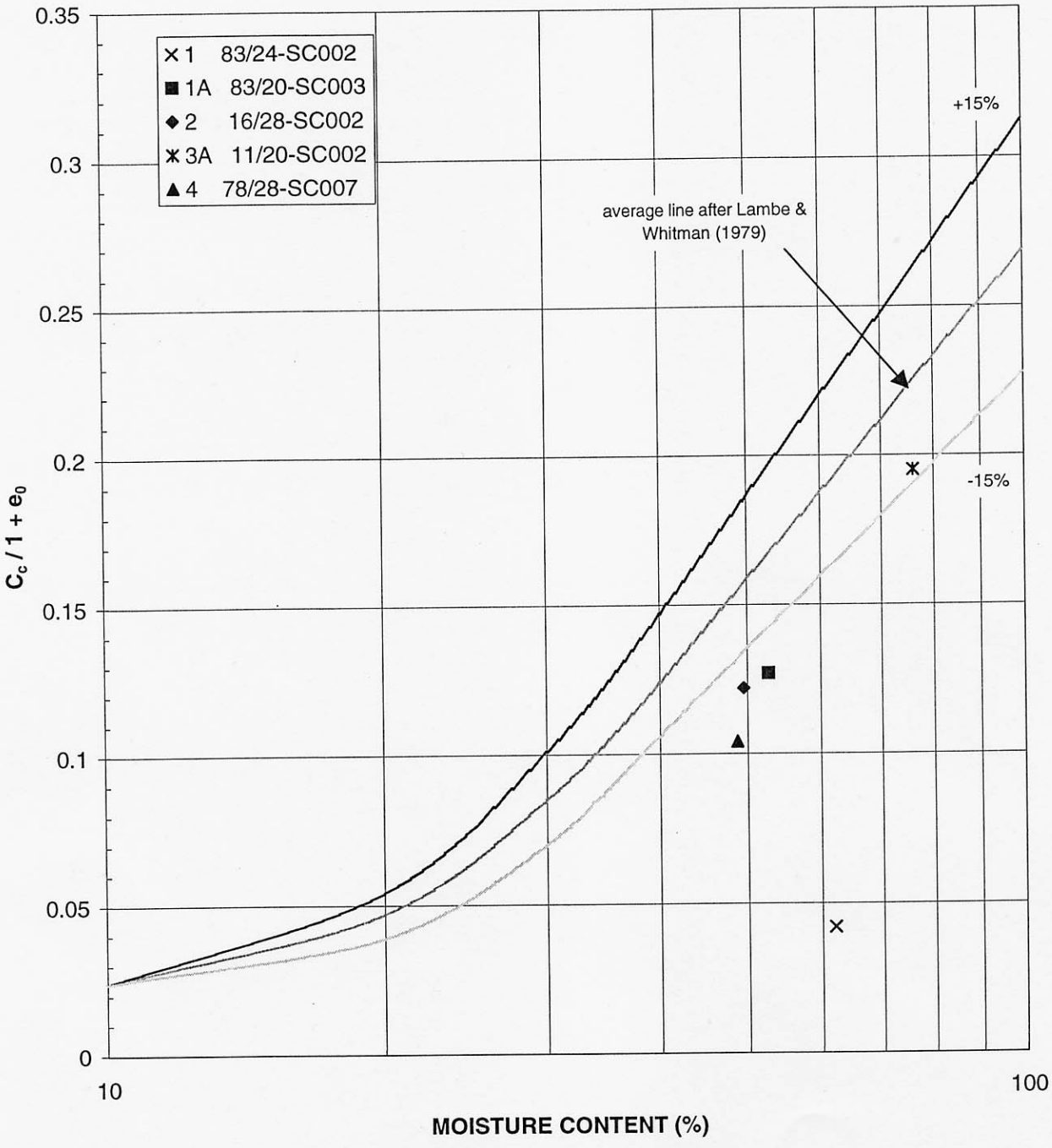
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP MAXIMUM FRICTION ANGLE - DRY DENSITY RELATIONSHIP	
	Author: A.F. *Date: Sept '99*	**FIGURE 13**

VOID RATIO - vs - APPLIED PRESSURE



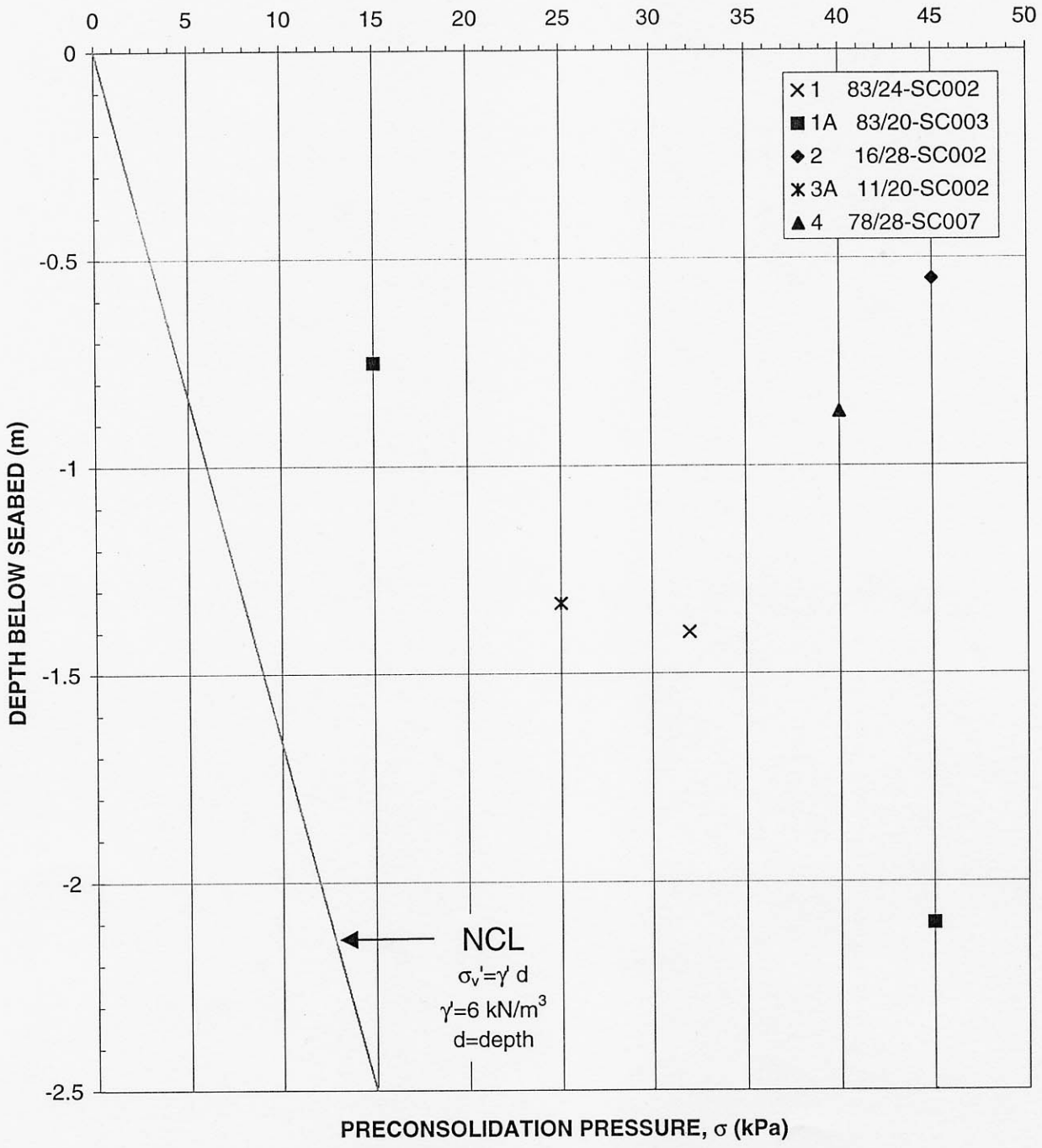
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP OEDOMETER TESTS	
	Author: A.F. Date: Sept '99	FIGURE 14

COMPRESSIBILITY PARAMETER - vs - MOISTURE CONTENT



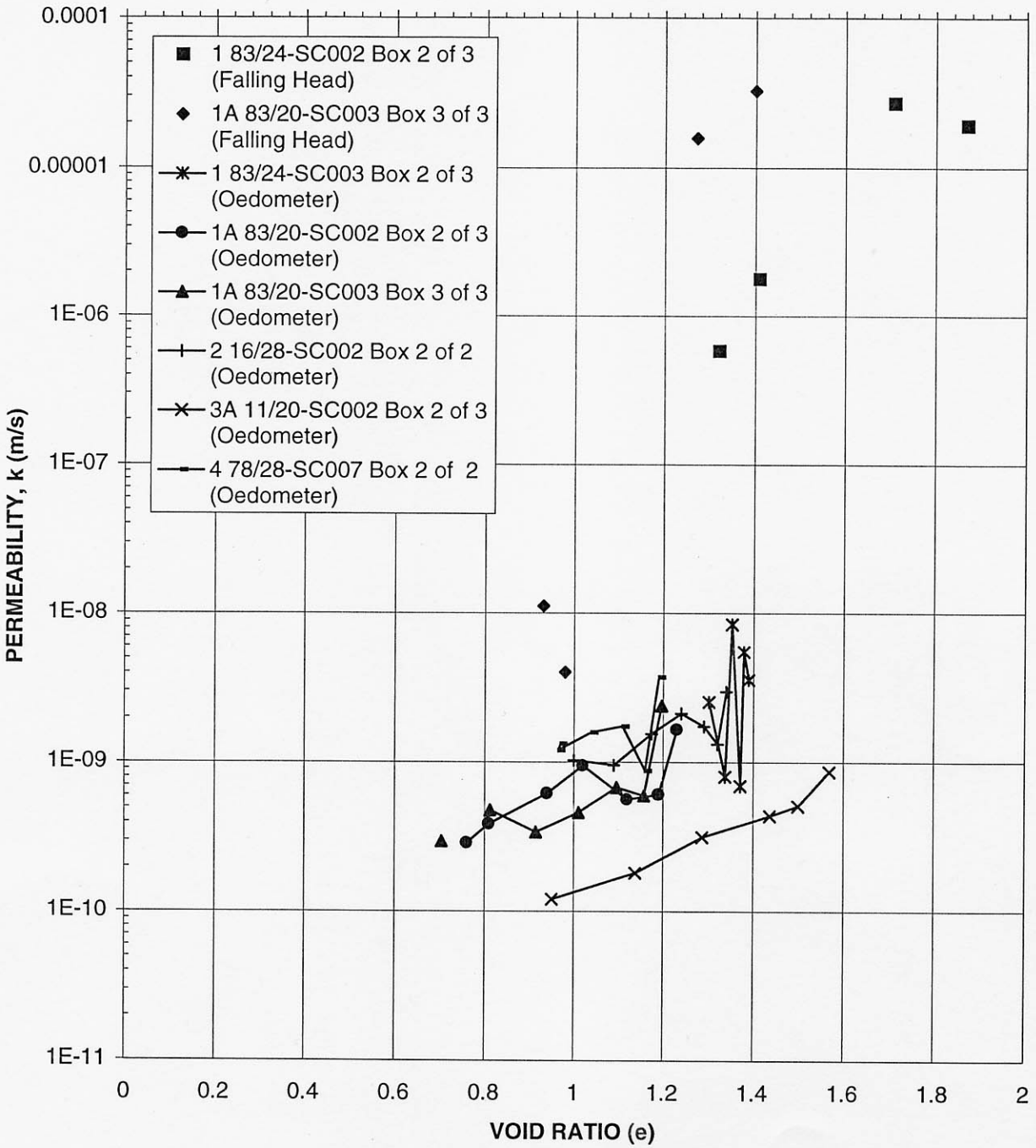
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP COMPRESSIBILITY PARAMETER - MOISTURE CONTENT RELATIONSHIP	
	Author: A.F. Date: Sept '99	FIGURE 15

PRECONSOLIDATION PRESSURE - vs - DEPTH BELOW SEABED



JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP PRECONSOLIDATION PRESSURE	
	Author: A.F. Date: Sept '99	FIGURE 16

VOID RATIO - vs - PERMEABILITY



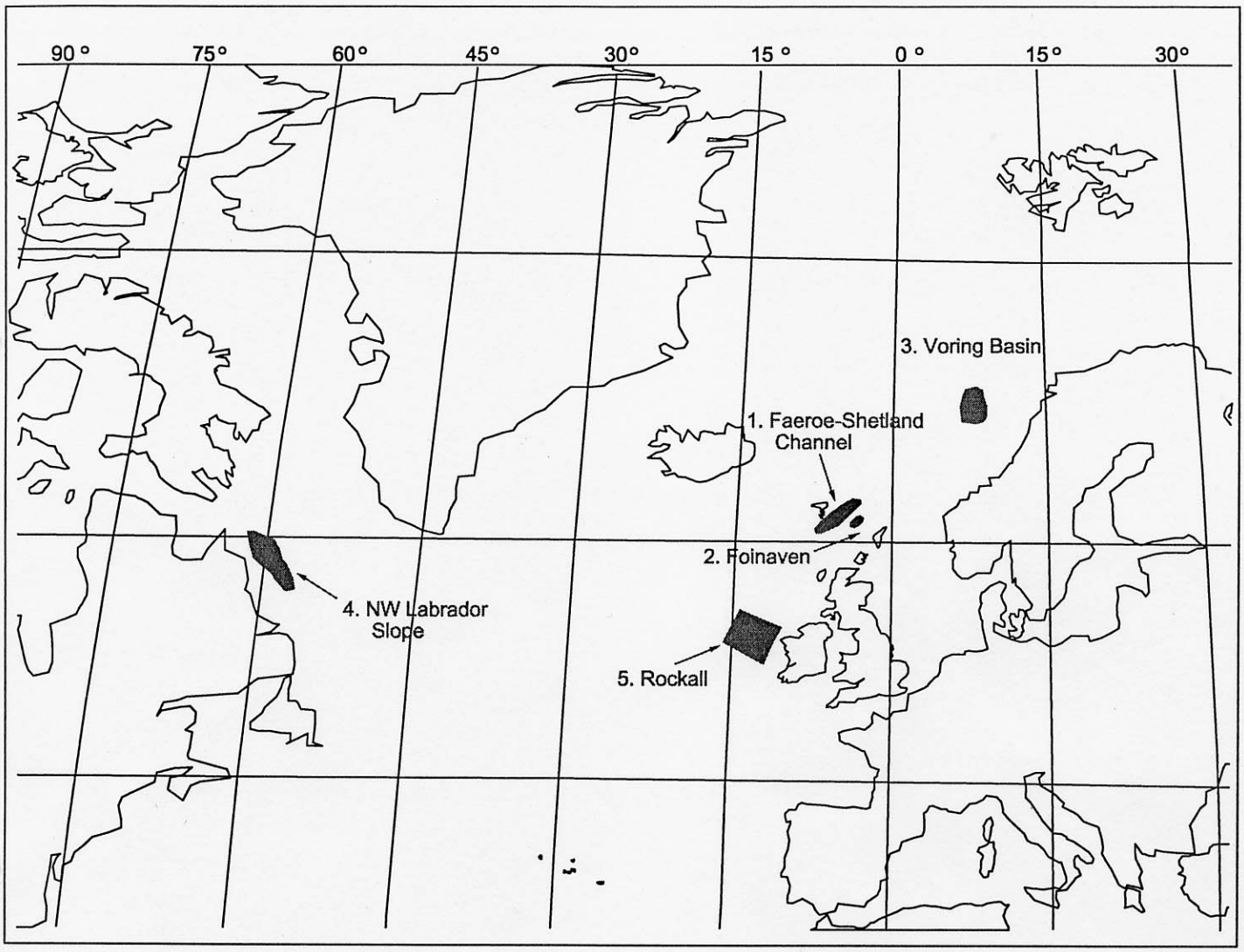
JBA

PRELIMINARY GEOTECHNICAL ASSESSMENT
ROCKALL STUDIES GROUP

VOID RATIO - PERMEABILITY RELATIONSHIP

Author: A.F.
Date: Sept '99

FIGURE 17



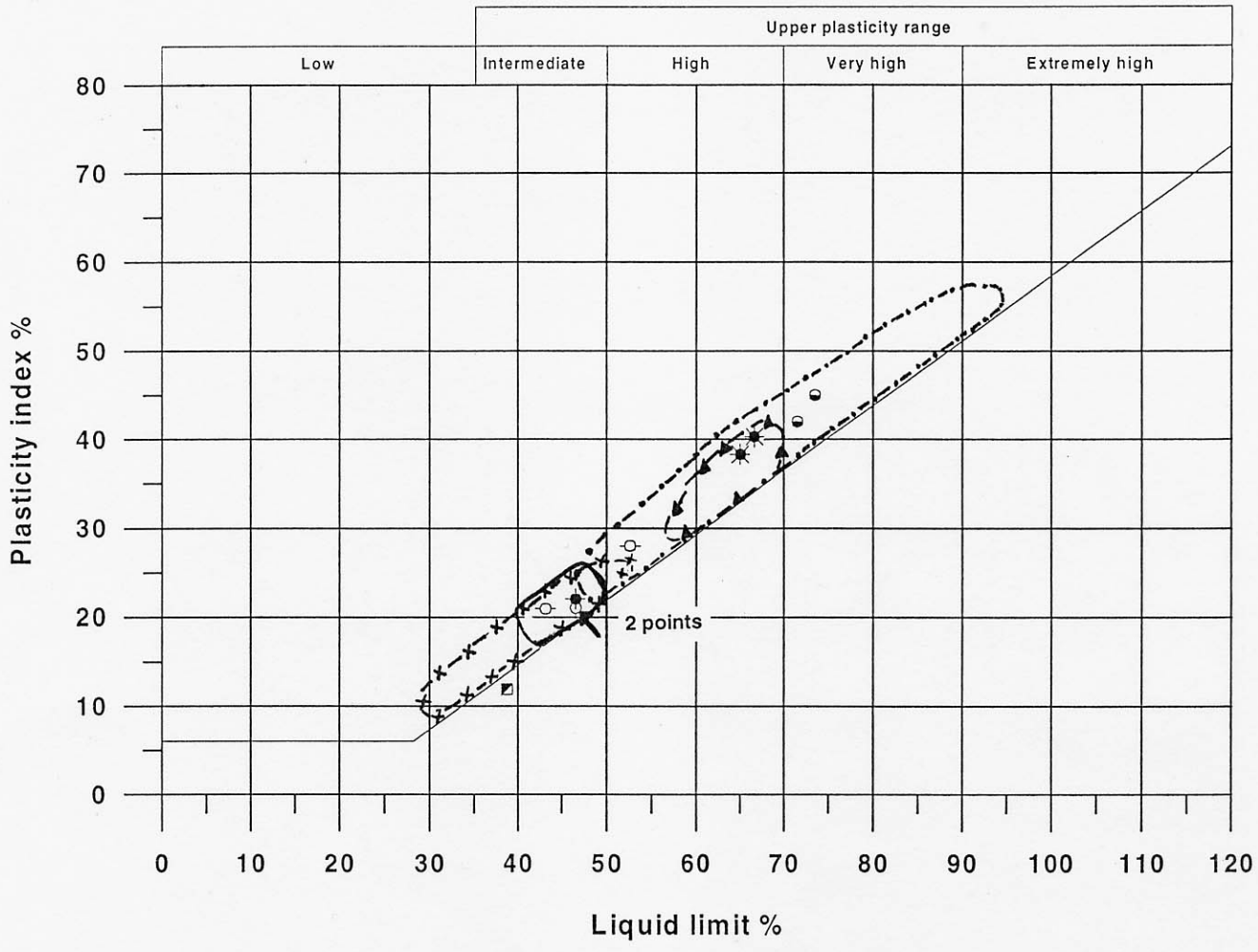
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP SITE LOCATIONS	
	Author: AF/TF Date: Dec '99	FIGURE 18

John Barnett & Associates

Job No.: JBA2107

Site Name: Rockall Studies Group

Plasticity Chart



Bh_number

- 1A 83/20-SC003 Box 2
- 1A 83/20-SC003 Box 3
- 3A 11/20-SC002
- 1 83/24-SC002
- 2 16/28-SC002
- 4 78/28-SC007

- Faeroe-Shetland Channel
- Foinaven
- Vøring Basin
- NW Labrador Slope

JBA

PRELIMINARY GEOTECHNICAL ASSESSMENT

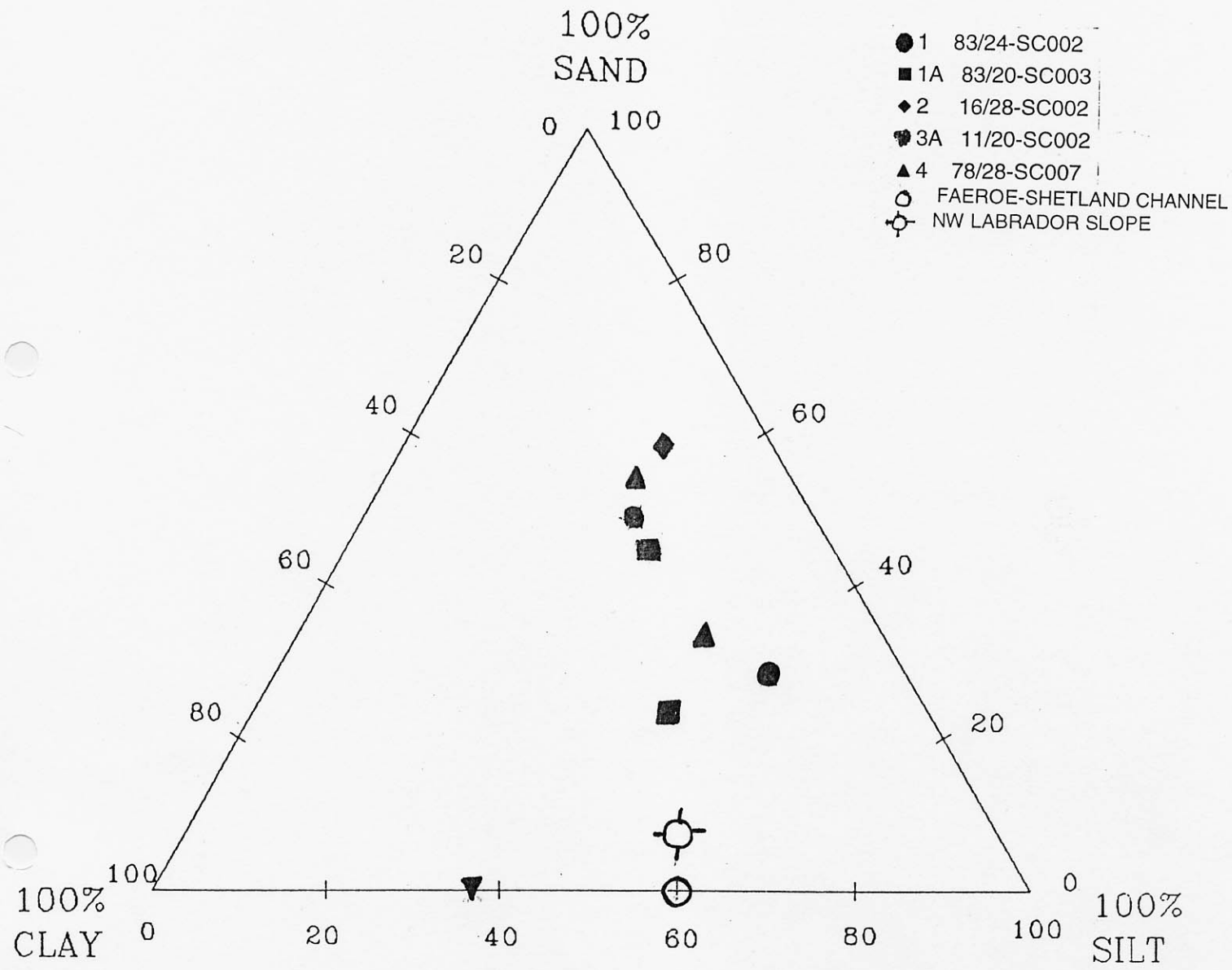
ROCKALL STUDIES GROUP

PLASTICITY CHART

Author: A.F.

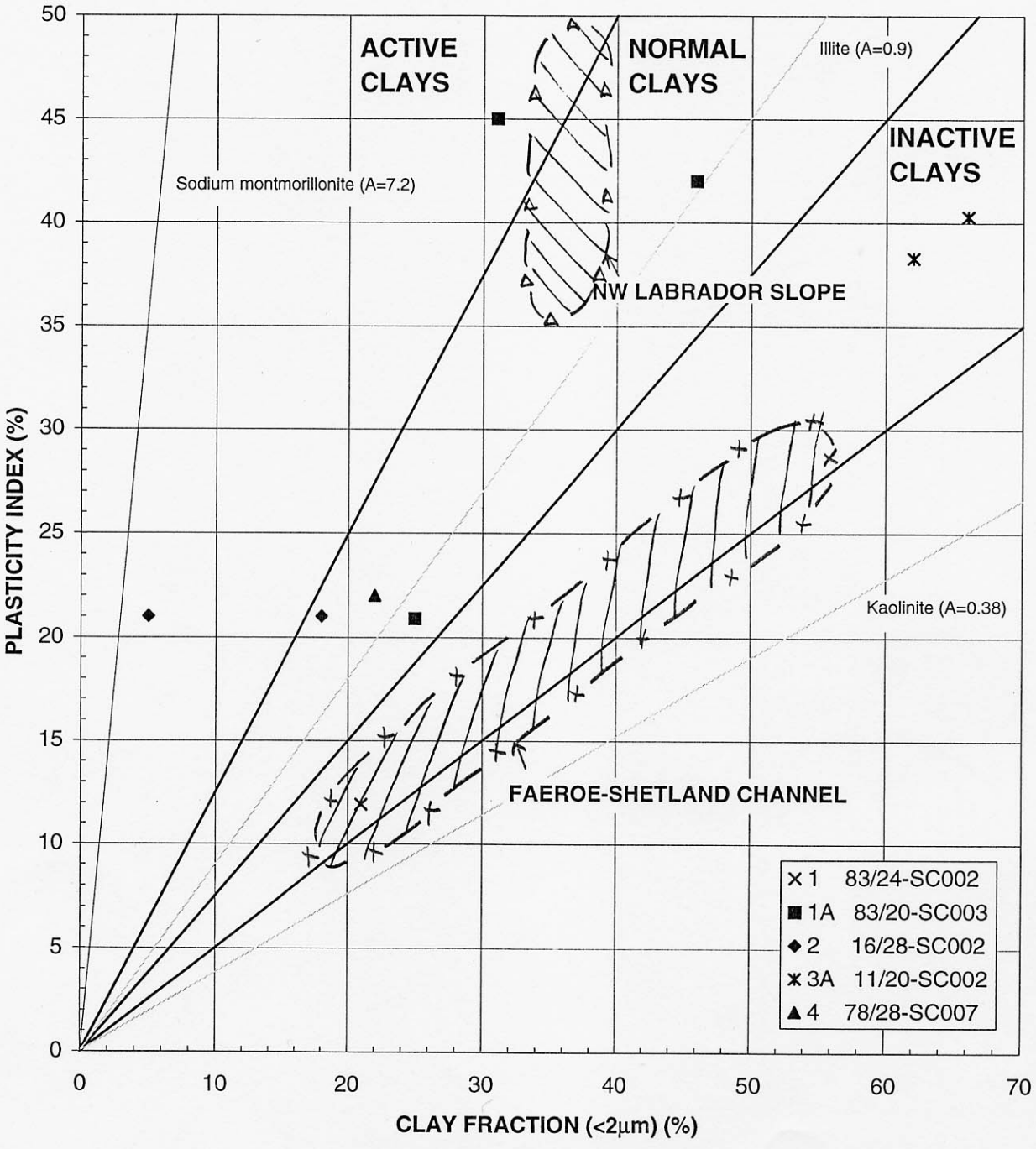
Date: Sept '99

FIGURE 19



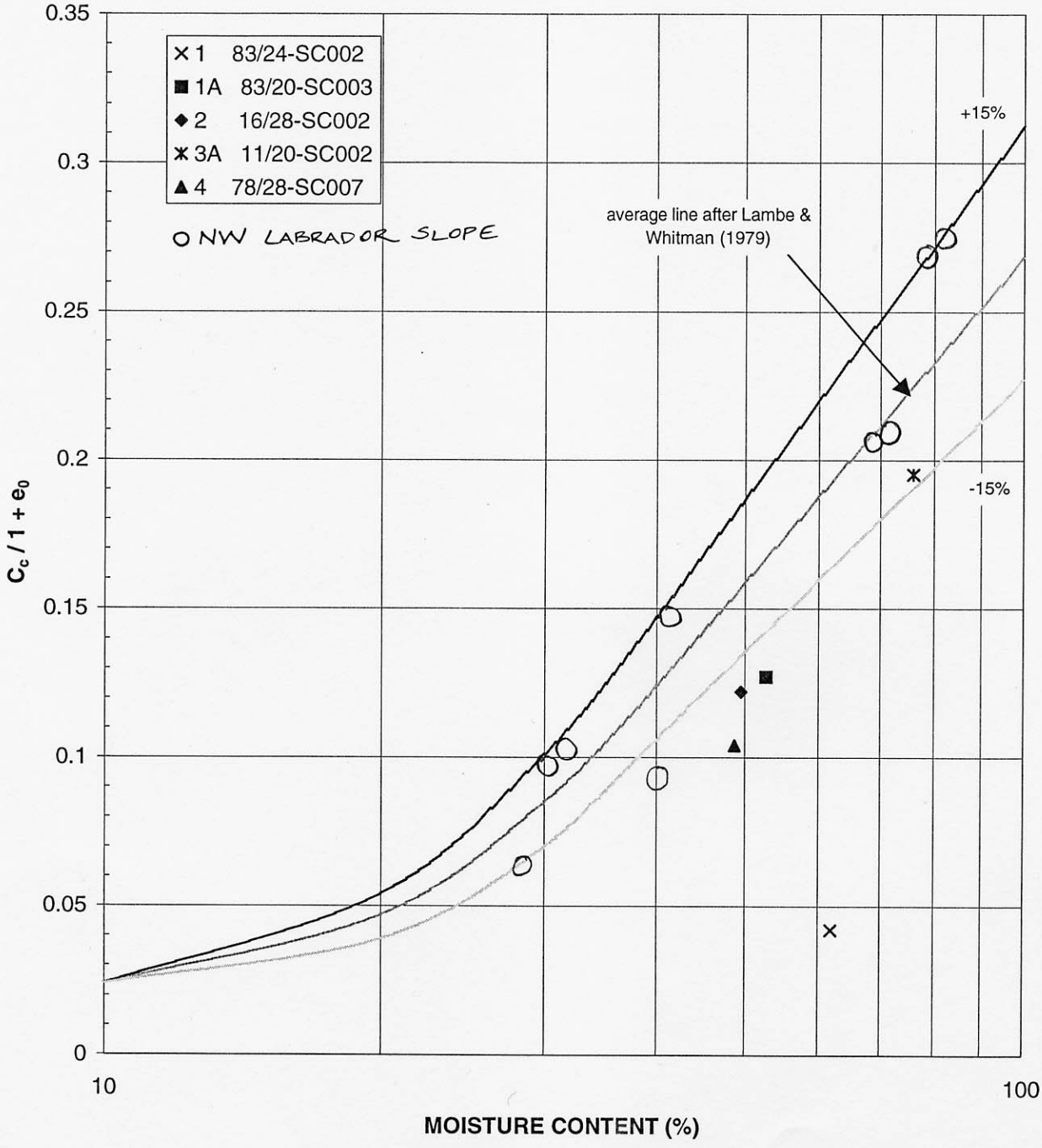
JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP **SEDIMENT COMPOSITION**	
	Author: A.F. *Date: Sept '99*	**FIGURE 20**

RELATIONSHIP BETWEEN CLAY FRACTION AND PLASTICITY INDEX



JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP CLAY FRACTION - PLASTICITY INDEX RELATIONSHIP	
	Author: A.F. Date: Sept '99	FIGURE 21

COMPRESSIBILITY PARAMETER - vs - MOISTURE CONTENT



JBA	PRELIMINARY GEOTECHNICAL ASSESSMENT ROCKALL STUDIES GROUP COMPRESSIBILITY PARAMETER - MOISTURE CONTENT RELATIONSHIP	
	Author: A.F. Date: Sept '99	FIGURE 22

ROCKALL STUDIES GROUP

REGIONAL GEOTECHNICAL CHARACTERISATION OF NEAR SURFACE SEDIMENTS IN THE ROCKALL TROUGH (PROJECT No. 98/20)

PRELIMINARY GEOTECHNICAL ASSESSMENT APPENDICES TO FINAL REPORT

DECEMBER 1999

Report No. JBA 2107 / RSG / 01

APPENDIX I

SCOPE OF WORK

ROCKALL STUDIES GROUP

REGIONAL GEOTECHNICAL CHARACTERISATION OF NEAR SURFACE SEDIMENTS IN THE ROCKALL TROUGH

PROPOSAL FOR A PRELIMINARY ASSESSMENT

Tim Paul

(John Barnett & Associates Ltd.)

Presentation to RSG Sub Committee – June 1998

1 PROJECT TEAM

Combines the geotechnical experience and expertise of two Irish Universities and an Irish Geotechnical Consultancy.

Key members of the Project Team are:

I) Mr. Tim Paul (John Barnett & Associates Ltd. – Geotechnical Consultants) : Project Manager

ii) Dr. Barry Lehane (Soil Mechanics Section, Dept. of Civil Engineering, TCD)

iii) Mr. Mike Long (Soil Mechanics Section, Dept. of Civil Engineering, UCD)

Facilities available include comprehensive state of the art soil testing laboratories for the full range of tests required for offshore engineering projects.

2 OBJECTIVES OF THE STUDY

i) Geotechnical testing of specimens from gravity core samples recovered from the 1998 RSG Sampling Programme

ii) Geotechnical characterisation of the materials recovered and a preliminary geotechnical assessment of the near surface sediments

iii) Comparison with published data and possibly data held by RSG Member Companies from other deep water environments

iv) Provide recommendations and guidelines for future regional and site specific geotechnical investigation work

v) Prepare a Geotechnical Assessment Report covering the issues listed above. This will assist complementary RSG studies particularly the interpretation of geophysical survey data and the regional assessment of marine slope stability

3 SCOPE OF WORK

I) Laboratory testing of soil samples recovered by others – refer to typical schedule of tests in the JBA/TCD/UCD proposal

ii) Data interpretation: use of the results of the laboratory testing programme to provide a geotechnical characterisation of the materials recovered

iii) Comparison with Materials from Other Deep Water Environments to provide a bench-mark against which to assess the geotechnical characteristics of the near-surface materials in the Rockall Trough

iv) Geotechnical Assessment Report

PRELIMINARY PROGRAMME

I)	Geotechnical Testing (20 samples)	2 months
ii)	Data Interpretation:	0.5 month
iii)	Comparison with other data:	0.5 month
iv)	Preparation of Report:	0.5 month

Draft Report would be presented to the RSG Project Co-Ordinator for review by RSG Member Companies approximately 3 months after receipt of the samples.

The report would be finalised within two weeks of comments on the draft.

TABLE 1: TYPICAL LAB TEST SCHEDULE FOR A GRAVITY CORE SAMPLE

Test Type	*No.*	*Cost / Test*	*Total Cost*
Description & Photographs:			
Detailed description and photograph of the core sample	1		
Classification Tests:			
Moisture Content / Atterberg Limits	2		
Specific Gravity	2		
Max / Min Void Ratio	2		
Carbonate Content	2		
Particle Size Analysis	2		
Petrographic Analysis	2		
Strength:			
Shear Box: Friction Angle vs. Density Relationship (4 points)	1		
Angle of Repose Tests	2		
Triaxial Tests: Peak & Constant Volume Friction Angle	2		
Compressibility:			
1 – D Oedometer Test	2		
Permeability:			
Permeability vs. Void Ratio Relationship (5 points)	1		

Notes:

All tests to be carried out in accordance with the relevant BS or ASTM standard
Exact schedule of tests will be dependent on sample material (predominately clay or

APPENDIX II

GRAVITY CORE SCHEDULE

BGS Marine Operations

Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
1	83/24-sc001	1	0 - 0.65 + shoe	1.7	0.65 - 0.75	1,468	52° 14' 33.0" N 15° 16' 21.0" W	Borehole location	Mud or sandy mud grading to sandy mud w/qtz grs lithic frags & forams	Close to minor Tertiary fault. Sea floor slope 3.5° BTU approx 130m BSB
		2	0.75 - 1.57 + 1.57 - 1.60		1.60 - 1.70					
1	83/24-sc002	1	0.0 - 0.65	2.65	none	1,503	52° 14' 03.6" N 15° 16' 43.2" W	Borehole site	Mud or sandy mud grading to sandy mud w/qtz grs, lithic frags & forams	No shoe sample
		2	0.65 - 1.55		1.55 - 1.65					
		3	1.65 - 2.55		2.55 - 2.65					
1	83/24-sc003	1	0.0 - 0.96	2.06	0.96 - 1.06	1,404	52° 14' 25.8" N 15° 15' 28.2" W	Borehole site	Mud or sandy mud grading to sandy mud w/qtz grs, lithic frags & forams	
		2	1.06 - 1.96 + shoe		1.96 - 2.06					
1	83/24-sc004	1	0.0 - 0.39	1.49	0.39 - 0.47	1,426	52° 15' 04.2" N 15° 16' 0.0" W	Borehole site	Mud or sandy mud grading to sandy mud w/qtz grs, lithic frags & forams	No shoe sample
		2	0.47 - 1.39		1.39 - 1.49					
1	83/24-sc005	1	0 - 0.44 + shoe	2.44	none	1,527	52° 14' 40.8" N 15° 17' 15.6" W	Borehole site	Mud or sandy mud grading to sandy mud w/qtz grs, lithic frags & forams	
		2	0.44 - 1.34		1.34 - 1.44					
		3	1.44 - 2.34		2.34 - 2.44					
1.2	83/29-sc001	1	0.0 - 0.71 + shoe	2.81	none	2,343	52° 00' 12.6" N 15° 13' 12.6" W	Canyon axis	Grey clay w/some forams	Sedimentological
		2	0.71 - 1.71		1.71 - 1.81					
		3	1.81 - 2.71		2.71 - 2.81					
1.3	83/30-sc001	1	0.0 - 0.77 + shoe	2.77	none	1,766	52° 04' 19.2" N 15° 02' 31.8" W	Canyon axis	Mud w/forams & lithics. Some sandy mud	Sedimentological
		2	0.77 - 1.67		1.67 - 1.77					
		3	1.77 - 2.67		2.67 - 2.77					
1.4	74/21-sc001		Seabed spl	poor		738	52° 13' 58.8" N 14° 54' 55.2" W	Carbonate mound (RT 39)	yel grey clay	Geotechnical. Rock bbl deployed.
1.4	74/21-sc002	1	0 - 0.69 + shoe + s/bed	0.79	0.69 - 0.79	746	52° 13' 55.8" N 14° 54' 55.8" W	Carbonate mound (RT 39)	Bryozoa & coral in grey clay matrix	Second attempt. No 'blank'
1.5	83/23-sc001		Seabed spl	poor		2,412	52° 19' 04.8" N 15° 26' 43.2" W	Spur	yel brn clay w/small to large pebbles	Sedimentological.
1.5	83/23-sc002	1	0.0 - 0.50 + shoe	1.61	0.50 - 0.60	2,418	52° 19' 01.2" N 15° 26' 47.4" W	Spur	Sand w/forams & pebbs on stiff white clay	Second attempt
		2	0.50 - 1.51		1.51 - 1.61					

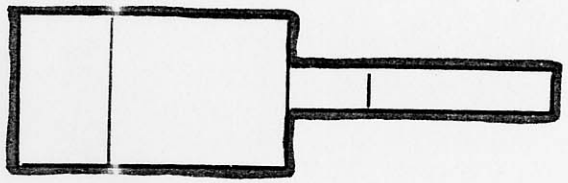
Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
1.6	83/5-sc002	1	0.0 - 0.20 + shoe	1.15	none	1,458	52° 56' 10.8" N 15° 03' 24.6" W	Slump body	Foram rich fine sand/mud, lithic clasts	Sedimentological
		2	0.20 - 1.05		1.05 - 1.15					
1.7	83/5-sc001	1	0.0 - 1.00	1.1	1.00 - 1.10	1,723	52° 56' 11.4" N 15° 07' 27.0" W	Slump body	Sandy mud, forams & lithic clasts	Sedimentological
1.8	83/3-sc001	1		Nil		2,800	52° 55' 10.8" N 15° 25' 19.2" W	Slump body		Sedimentological
1.8	83/3-sc002	1	0.0 - 0.82 + shoe	2.82	none	2,806	52° 55' 10.2" N 15° 25' 18.0" W	Slump body	Dom sandy mud, forams & lithics	Second attempt
		2	0.82 - 1.72		1.72 - 1.82					
		3	1.82 - 2.72		2.72 - 2.82					
1.9	75/18-sc001	1	0 - 0.58 +shoe	0.68	0.58 - 0.68	762	53° 26' 04.2" N 14° 27' 45.0" W	Carbonate mound (RT 23)	Coral frags on sandy mud w/shell debris & forams	Bent barrel
1.10	74/1-sc001	1	0.0 - 0.55	1.66	0.55 - 0.65	712	52° 57' 24.0" N 14° 49' 52.2" W	Carbonate mound (RT 51)	Live & dead coal on coral-rich mud	No shoe sample
		2	0.65 - 1.56		1.56 - 1.66					
1.11	74/1-sc002	1	0.0 - 0.35	0.35	none	700	52° 56' 53.4" N 14° 48' 39.6" W	Carbonate mound (RT 52)	Foram rich, f-m sand grad to mud; coal spots	Bent barrel. no shoe sample.
1.11	74/1-sc003	1	0.0 - 0.89 + shoe	1.01	0.89 - 0.99	700	52° 56' 54.0" N 14° 48' 39.0" W	Carbonate mound (RT 52)	Foram rich, f-m sand w/lithic frags	Second attempt. Bent barrel
1.12	74/6-sc001	1	0.0 - 0.97	2.09	0.97 - 1.07	978	52° 43' 10.8" N 14° 59' 35.4" W	Possible seep	Foram rich, f-m sand on clay on sand	No shoe sample
		2	1.07 - 1.99		1.99 - 2.09					
1A	83/20-sc001	1	0.0 - 0.71	1.81	0.71 - 0.81	1,060	52° 26' 46.2" N 15° 07' 43.2" W	Borehole site	Soft mud or sandy mud w/minor proportions of forams, shell debris & lithic frags	No shoe sample
		2	0.81 - 1.71		1.71 - 1.81					
1A	83/20-sc002	1	0.0 - 0.92	2.02	0.92 - 1.02	1,025	52° 27' 07.2" N 15° 06' 29.4" W	Borehole site	Soft mud or sandy mud w/minor proportions of forams, shell debris & lithic frags	No shoe sample
		2	1.02 - 1.92		1.92 - 2.02					
1A	83/20-sc003	1	0.0 - 0.40	2.4	none	1,032	52° 26' 39.0" N 15° 06' 51.6" W	Borehole location	Soft mud or sandy mud w/minor proportions of forams, shell debris & lithic frags	No shoe sample. Negligible sea floor slope. BTU approx 200m BSB
		2	0.40 - 1.30		1.30 - 1.40					
		3	1.40 - 2.30		2.30 - 2.40					

Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
1A	83/20-sc004	1	0.0 - 1.02	2.12	1.02 - 1.12	1,043	52° 26' 09.0" N 15° 07' 15.6" W	Borehole site	Soft mud or sandy mud w/minor proportions of forams, shell debris and lithic frags	
		2	1.12 - 2.02 + shoe		2.02 - 2.12					
1A	83/20-sc005	1	0 - 0.28 + shoe	2.16	none	1,007	52° 26' 27.0" N 15° 05' 58.8" W	Borehole site	Soft mud or sandy mud w/minor proportions of forams, shell debris and lithic frags	
		2	0.28 - 1.06		1.06 - 1.16					
		3	1.16 - 2.06		2.06 - 2.16					
2	16/28-sc001	1	0.0 - 0.57	1.17	none	1,486	54° 01' 52.2" N 13° 31' 10.8" W	Borehole site	Muddy sand, forams and small rounded lithics	
		2	0.57 - 1.17 + shoe		none					
2	16/28-sc002	1	0 - 0.40 + shoe	1.4	none	1,465	54° 01' 42.6" N 13° 30' 06.6" W	Borehole site	Muddy sand, forams and small rounded lithics	
		2	0.40 - 1.30		1.30 - 1.40					
2	16/28-sc003			Nil	none	1,465	54° 01' 20.4" N 13° 30' 51.0" W	Borehole location		Hard sea floor. Recent slumping. BTU 180m SSB
2	16/28-sc004	1	(shoe & s/bed samples)	poor	none	1,460	54° 00' 58.2" N 13° 31' 34.8" W	Borehole site	Few small pebbles	
2	16/28-sc005	1	(shoe & s/bed samples)	poor	none	1,446	54° 00' 49.2" N 13° 30' 28.8" W	Borehole site	Few larger pebbles	
2A	75/10-sc001	1	(shoe & s/bed samples)	poor	none	859	53° 42' 27.6" N 14° 08' 17.4" W	Borehole site	13 small pebbles	Poor weather conditions, damage to core barrels
2A	75/10-sc002			Nil	none	853	53° 42' 44.4" N 14° 07' 32.4" W	Borehole location.		Hard sea bed. Sea floor slope 3° - 3.5°. BTU 165m SSB
2A	75/10-sc003			Nil	none	910	53° 43' 10.2" N 14° 08' 13.2" W	Borehole site		
2A	75/10-sc004	1	(shoe & s/bed samples)	poor	none	861	53° 43' 07.2" N 14° 06' 54.0" W		10 small pebbles, few shells	
3	11/20-sc006	1	0 - 0.52 + shoe	2.52	none	1,496	55° 24' 37.2" N 10° 07' 50.4" W	Borehole site	Mud and sandy mud w/forams & volcanic lithics	
		2	0.52 - 1.42		1.42 - 1.52					
		3	1.52 - 2.42		2.42 - 2.52					

Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
3	11/20-sc007	1	0.0 - 1.01	2.11	1.01 - 1.11	1,365	55° 24' 49.8" N 10° 06' 50.4" W	Borehole site	Sandy mud, forams - less sand with depth	
		2	1.11 - 2.01 + shoe		2.01 - 2.11					
3	11/20-sc008	1	0 - 0.41 + shoe	2.41	none	1,463	55° 25' 00.6" N 10° 07' 13.2" W	Borehole location.	Mud/sandy mud, forams	Sea floor slope 7.5° - 8°. Poor BTU reflector
		2	0.41 - 1.31		1.31 - 1.41					
		3	1.41 - 2.31		2.31 - 2.41					
3	11/20-sc009	1	0.0 - 0.88	2.08	0.88 - 0.98	1,522	55° 25' 11.4" N 10° 07' 33.6" W	Borehole site	Sandy mud, lithics (some volcanic)	Shoe sample in separate box on Shelf 16-10
		2	0.98 - 1.98		1.98 - 2.08					
3	11/20-sc010	1	0.0 - 0.31	2.31	none	1,397	55° 25' 25.2" N 10° 06' 35.4" W	Borehole site	Sandy mud, lithics & forams	No shoe sample
		2	0.31 - 1.21		1.21 - 1.31					
		3	1.31 - 2.21		2.31 - 2.41					
3A	11/20-sc001	1	0.0 - 0.92	2.02	0.92 - 1.02	1,144	55° 25' 31.2" N 10° 01' 53.4" W	Borehole site	Muddy sand with forams	
		2	1.02 - 1.92 + shoe		1.92 - 2.02					
3A	11/20-sc002	1	0 - 0.44 + shoe	2.43	none	1,007	55° 25' 39.0" N 10° 00' 42.6" W	Borehole site	Foram rich grey clay	
		2	0.44 - 1.33		1.33 - 1.43					
		3	1.43 -2.33		2.33 - 2.43					
3A	11/20-sc003	1	0 - 0.48 + shoe	1.57	0.48 - 0.58	1,110	55° 25' 15.0" N 10° 01' 21.6" W	Borehole location.	Foram sand on dark grey clay	Recent slumping, sea floor slope 3.4°. BTU 70m BSB
		2	0.58 - 1.47		1.47 - 1.57					
3A	11/20-sc004	1	0 - 0.33 + shoe	2.22	none	1,025	55° 24' 50.4" N 10° 02' 00.6" W	Borehole site	Brown foram mud on grey mud	
		2	0.33 - 1.13		1.13 - 1.23					
		3	1.23 - 2.12		2.12 - 2.22					
3A	11/20-sc005	1	0.0 - 1.00	2.09	1.00 - 1.10	991	55° 24' 58.2" N 10° 00' 50.4" W	Borehole site	Grey mud with few forams	
		2	1.10 - 1.99		1.99 -2.09					
4	78/28-sc001					1,187	56° 01' 37.8" N 14° 25' 28.8" W			Shell site

Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
4	78/28-sc002					1,191	56° 01' 37.8" N 14° 25' 27.6" W			Shell site
4	78/28-sc003					1,190	56° 01' 37.8" N 14° 25' 26.4" W			Shell site
4	78/28-sc004	1	0.0 - 0.78	0.88	0.78 - 0.88	1,186	56° 01' 13.2" N 14° 26' 05.4" W	Borehole site	Muddy sand, forams, lithics & dead coral	No shoe sample
4	78/28-sc005	1	0 - 0.37 + shoe	1.47	0.37 - 0.47	1,306	56° 01' 16.2" N 14° 27' 33.6" W	Borehole site	Sandy mud, forams & lithics	
		2	0.47 - 1.37		1.37 - 1.47					
4	78/28-sc006	1	0.0 - 0.40	0.5	0.40 - 0.50	1,263	56° 02' 01.8" N 14° 27' 36.0" W	Borehole site	Muddy sand, forams & lithics	No shoe sample
4	78/28-sc007	1	0 - 0.48 + shoe	1.58	0.48 - 0.58	1,296	56° 02' 03.6" N 14° 26' 16.2" W	Borehole site	Muddy sand, forams & lithics	
		2	0.58 -1.48		1.48 - 1.58					
4	78/28-sc008	1	0.0 - 0.38	0.48	0.38 - 0.48	1,306	56° 01' 40.2" N 14° 26' 54.6" W	Borehole location	Foram sand	No shoe sample. Sea floor slope 2.5° - 3°. BTU unclear
4.2	77/9-sc001	1	0.20 - 1.16	1.26	0.10 - 0.20;	2,013	55° 49' 52.8" N 14° 22' 13.8" W	Sediment waves	Mud w/rare sand, forams & lithics	No shoe sample. 0.0 - 0.10m absent
4.3	78/30-sc001	1	0.0 - 0.60 + shoe	1.7	0.60 - 0.70	1,940	56° 04' 43.8" N 14° 06' 01.2" W	Carbonate mound (RT 3)	Mud/sandy mud w/forams	
		2	0.70 - 1.60		1.60 - 1.70					
4.4	8/1-sc001	1	0.0 - 0.78	1.88	0.78 - 0.88	2,290	55° 55' 18.0" N 13° 58' 22.8" W	Edge of debris flow deposit	Mud w/forams	No shoe sample
		2	0.88 - 1.78		1.78 - 1.88					
4.5	8/2-sc001	1	0.0 - 0.38	2.39	none	2,497	55° 53' 55.2" N 13° 45' 39.0" W	Debris flow deposit	Mud & sandy mud w/forams	No shoe sample
		2	0.38 - 1.32		1.32 - 1.42					
		3	1.42 - 2.32		2.29 - 2.39					
4.6	78/28-sc001			Nil		1,187	56° 01' 38.0" N 14° 25' 27.0" W	Basement ridge		Rock barrel. Shell site
4.6	78/28-sc002		Seabed spl	poor		1,191	56° 01' 38.0" N 14° 25' 27.0" W	Basement ridge	Lots of coral, some live	1.5m barrel. Fourth drop abandoned for
4.6	78/28-sc003		Seabed spl	poor		1,190	56° 01' 38.0" N 14° 25' 27.0" W	Basement ridge	some coral	enviromental reasons

Site	Core Number	Box No.	Box interval (m)	Recovery (m)	Geochem Spls (m)	Water Dph (m)	Position	Target	Lithology	Comments
4.7	8/9-sc001	1	0.0 - 0.49 + shoe	2.49	none	2,691	55° 49' 59.4" N 13° 15' 00.6" W	Debris flow deposit	Mud w/forams	
		2	0.49 - 1.39		1.39 - 1.49					
		3	1.49 - 2.39		2.39 - 2.49					
4.8	9/7-sc001	1	0.0 - 0.82	2.8	none	2,744	55° 46' 47.4" N 12° 43' 24.0" W	Debris flow deposit	Mud on sand on mud w/a few forams	No shoe sample
		2	0.82 - 1.72		1.72 - 1.82					
		3	1.82 - 2.72		2.70 - 2.80					



TEST SAMPLE

APPENDIX III

PRELIMINARY SEDIMENTOLOGICAL OBSERVATIONS

Dr Peter Haughton & Dr Pat Shannon

PILOT GRAVITY CORE SEDIMENTOLOGICAL STUDY

Peter Haughton & Pat Shannon, Department of Geology, UCD 11 June 1999

The following file note summarises the preliminary sedimentological observations made on six 0.9 m long gravity core lengths from five sites on the margins of the Irish Rockall Basin. A total of 45 gravity cores were collected to help assess the suitability of a number of sites for proposed deeper bedrock drilling in the area. The sections examined sedimentologically were from a subset of five representative cores selected for geotechnical testing (Cores 16/28-sc002, 83/24-sc002, 11/20-sc002, 83/20-sc003 and 78/28-sc007). The cores were sealed in water-tight perspex sleeves. These were opened along two cuts exposing a *c.* 30° sector along the core length. Fluid draining from the cores when opened was collected and archived. The sedimentological make-up of the cores was then documented by graphic logging, photography and sampling for microscopy before the geotechnical testing commenced. All the observations reported below are thus from a limited and peripheral part of the cores, but they serve to demonstrate the wider potential of the 45 core dataset in terms of further analysis. Hard copies of preliminary core sedimentology descriptions accompany this file note.

Highlights

Attention is drawn to the following general observations arising from the core documentation:

- the lithology of the opened cores is broadly consistent with what was anticipated on the basis of shoe samples and review of the cores when sealed in plastic sleeves. This confirms that that the cores selected for geotechnical testing (and the observations set out below) are broadly representative of the wider data set.
- the cores (with one exception - 11/20-sc002) preserve impressive internal detail in terms of compositional and textural variations, and physical and biogenic structures (laminations, sharp bed bases, variable bioturbation fabrics, shell lags). Beds down to several cm thick are well resolved, and even delicate mm-scale burrow networks are locally apparent. Despite the peripheral sections studied, disturbance appears minimal and this bodes well for detailed examination of deeper slices and the integrity of the core data set as a whole.
- 5 out of the six cores preserve evidence of multiple 'events' - stacked, discrete beds, grading, alternations of mud and sand, changes in colour, variable ichnofabrics and bioturbation intensity - suggesting the cores are an archive of significant periods of time and an important historical record of slope processes on the Rockall Basin margin (particularly when tied to shallow seismic and TOBI imagery, and if the core materials can be dated).
- angular pebbles were noted in 5 of the six core lengths. These are of diverse composition (limestone, red siltstone, ?arkose etc.) and there are important ramifications for provenance/supply/remobilisation. Black clasts of uncertain origin (?volcanic) are also locally important. The number and diversity of clast types is all the more significant, given the very limited volume of the core available for study at this stage.
- the opened cores are suprisingly sandy - only one of the core sticks (11/20-sc002) was mud-prone. The sand grains are of both siliciclastic and bioclastic origin, with the later locally dominant (*e.g.* 78/28-sc007). The proportion bioclastic/siliciclastic sand grains can vary between/within beds in the same core. Detailed grain compositional analysis will be important to assessing the external sand budget on the Rockall slopes.
- there are wide variations in mud colours/consistency between cores, ranging from tan brown, to olive green to medium grey particularly stiff clays, implying areal clay mineralogical changes and potential changes in bottom conditions/slope stability/geotechnical/ properties and degree of consolidation. Determining the clay mineralogy and source of the clays will be important.
- the 'grainy' sediments have a complex texture and were probably emplaced by a range of flow and settling mechanisms - some units appear to be well graded and may have laminations and sharp bases (=turbulent currents?); others are poorly graded,

contain clasts or are rich in foraminifera grains (=debrites remobilising glaciogenic sediment, current-winnowed sands?). Detailed textural analysis will be important to understanding transport mechanisms and potentially budgeting volumes of pelagic rainout *vs.* glaciogenic, along-slope or up-slope/externally-derived sediment.

- variable ichnofabrics are evident between cores, potentially relating to different bottom water conditions/substrate types/depth zonation.
- there is a rich macro- and microfauna, with abundant spines, small shells and foraminifera. Focused study of these components has the potential to further constrain bottom conditions, the degree of remobilisation/reworking and source(s) of some of the event beds.

Summary of specific core observations

The following notes should be read in conjunction with the preliminary core sedimentology logs. Note that the grain size curves await calibration using microscopy (in progress). Depths are measured from the sea bed.

Site: 1
Core No: 83/24-sc002
Box No. 2 of 3
Box interval: 0.65-1.55 m
Core details: This core is composed of two very different units separated by an abrupt contact at 1.02 m. The lower unit is characterised by a very uniform texture, a pale white/cream colour, a lack of internal structure and a dominance of foraminifera grains. It is capped by a thin pale brown clay with scattered small shells (1.06 - 1.02 m) beneath which the foraminifera sand has indistinct mottling which may represent bioturbation. The upper section of the core (above 1.02 m) is a poorly sorted, grey-brown granular clayey sand (both siliciclastic and foraminifera grains) with crude laminae at the base picked out by concentrations of dark coloured, coarse sand grains/granules. A large sub-angular pebble (35 mm across) of purple siltstone occurs at 0.85 m, but otherwise there are no obvious breaks/changes in texture.

Site: 1A
Core No: 83/20-sc003
Box No. 3 of 3
Box interval: 1.40-2.30 m
Core details: A heterogeneous interval containing three prominent normally graded, clayey sand beds (the upper one extending into Box 2 - see below), separated by distinct clay-prone intervals. The basal section of the core (below 2.23 m) is clay-prone with a stiff, grey-brown mud unit traversed by a dense network of pale, mm-scale inclined to sub-vertical, locally branching burrows, increasing in density upwards. The first sand bed is sharp based, weakly bioturbated, graded, relatively thin, unit with scattered black granules at the base, grading back vertically into the grey-brown sticky, densely bioturbated clay (at *c.* 2.16 m). A sub-angular ?arkosic pebble occurs at the top of the sand. A sharp contact at 2.085 m marks the base of the second clayey sand bed, again graded, grey-brown in colour (mixed siliciclastic/bioclastic provenance), with abundant broken shell fragments and foraminifera, and becoming progressively more clay prone upwards, grading into a stiff grey clay with a large angular dark limestone fragment (32 mm across). The clay-prone top (1.50-1.60 m) is rather churned and detail hard to discern at this level, but it is abruptly overlain by a third 'dirty' sand unit, extending to the top of the core (and into the overlying core stick - see below).

Site: 1A
Core No: 83/20-sc003
Box No. 2 of 3
Box interval: 0.40-1.30 m

Core details: This interval represents a continuation of the succession retrieved in Box 3 of 3 (see above) although the core depths imply 10 cm of no recovery between the two sticks. Box 2 of 3 cores a major upward transition (gradual) from clayey sand or sandy clay at the base to a homogenous clay at the top. Dark grey-brown clayey sand with shells extends up to *c.* 0.90 m, with a possible internal contact at 1.10 m (a concentration of black clasts up to 6 mm across). The upper section of the core gradually becomes less 'grainy' and grades into is a sticky grey-brown ?spinose clay with little obvious internal structure.

Site: 2
Core No: 16/28-sc002
Box No. 2 of 2
Box interval: 0.40-1.30m
Core details: The core is composed of clay-prone, brown 'dirty' sands of variable grain size locally with dark granules and occasional larger pebbles, arranged in cryptic to obvious beds. The sand grains appear to be of mixed provenance, with quartz, lithic and bioclastic components all important. There is a striking central finer grained unit (0.77-0.71 m) with a crude parallel lamination truncated by a sub-vertical burrow (cm-scale, piped down from overlying bed?). This sits transitionally on a coarser grained dirty sand with indistinct mottling and granule clusters at the top (also bioturbated?) passing downwards in to a structureless clayey sand unit. There is arguably a bed base at 1.04 m and almost certainly one at 1.20 m where there is a concentration of black granules sitting on disrupted (coring artefact?) finer grained more clay-prone sandy clay. The section above the central laminated/bioturbated division is composed of dirty fine grained clay-prone sand. A prominent shell lag at 0.60 m may mark an amalgamation plane, and there is potentially also a bed contact (defined by variable texture) at 0.48 m.

Site: 3A
Core No: 11/20-sc002
Box No. 2 of 3
Box interval: 0.44-1.33 m
Core details: Little sedimentological detail is evident in this core. The whole section comprises a uniform, plastic, medium grey, well (?over) consolidated clay with no obvious structure or vertical trends. The outside of the core is caked with a thin film of more sandy material, possibly dragged down from closer to the sea bed (potentially more sandy material was identified consistently in the uppermost sections of the 11/20 cores in the initial viewing of the sleeved material).

Site: 4
Core No: 78/28-sc007
Box No. 2 of 2
Box interval: 0.58-1.48 m
Core details: A heterogeneous section with at least 4 discrete beds and with evidence for compositional variation between beds. The lower section of the core is a grey-green, clayey sand with no obvious structure apart from possible bioturbation mottling at the top. This extends up to 1.265 m where there is an abrupt contact and colour change. A 'grainy' (bioclastic) cream coloured, thin sand bed extends up to 1.23 m where it progressively becomes clay-prone and grades into a sticky tan brown clay. At 1.21 m there is a second abrupt contact at the base of a thick graded, poorly sorted, muddying upwards, clayey sand (variegated white and pale brown reflecting composite beds/compositional variations?). This unit contains small lithic granules, abundant foraminifera grains, a large echinoderm spine and is capped by a second sticky, tan brown coloured clay (0.80-0.69 m). A third sharp base separates this clay from a dark grey-brown, very clay-prone sand which is traversed by pale brown, cm-scaled, inclined burrow fills. This upper unit seems intensely bioturbated.

(5) = small samples for microscopic exam

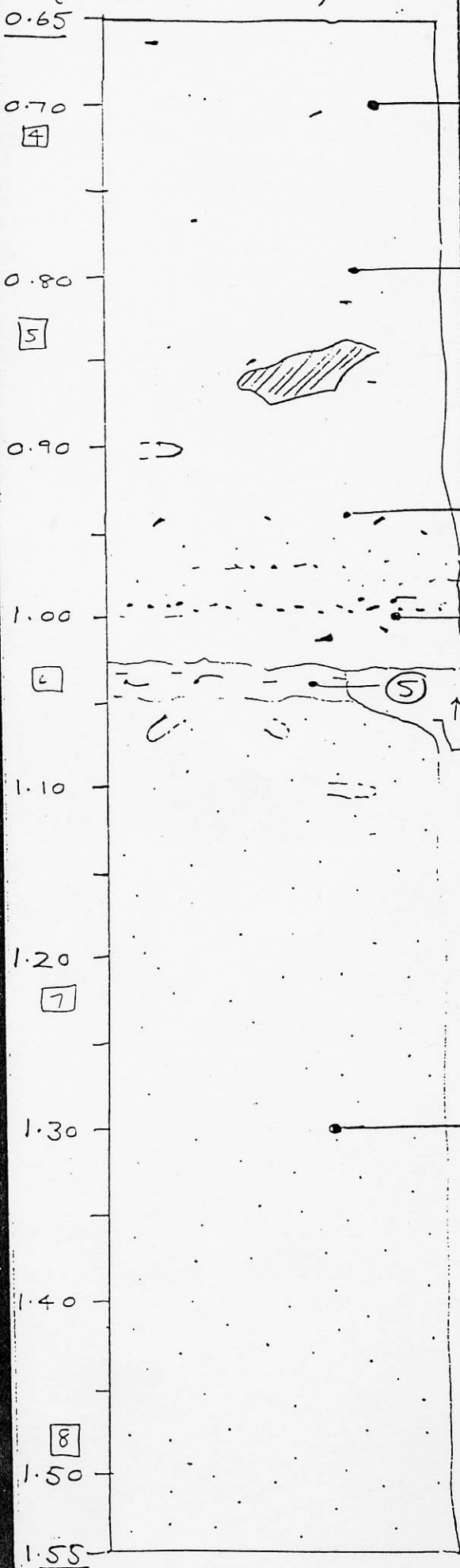
against microscopic observations.

Core opened 1/6/99 Earlsford Terrace

83/24 - SC002
(0.65 - 1.65m) Box 2 OF 3

overall - greater disturbance than 16/25-SC002; remainder did not adhere to perspex as well.

[3] = photographs



- relatively cohesive - significant mud content.
- grey-brown - in contrast to cream-white colour of underlying unit.

TEST

subangular red/pink pebble 35mm long!

- possible 'in' scale burrow with darker (muddier) fill?

scattered black grains rich in tram grains - how much true sand?

? red sand grain.

- laminae enriched in black coarse sand-grade grains.

abrupt contact; dark tan brown beneath - more mud-rich; small bivalve/gastropod shells.

- isolated brown patches - possible burrowing.

Unit characterised by:

- very uniform texture
- pale cream-white colour.
- no/v. small scattered black grains.
- no structure.
- appears to be foraminifera ooze?

TEST

nb. poor adhesion to barrel wall over this interval.

no obvious breaks in texture

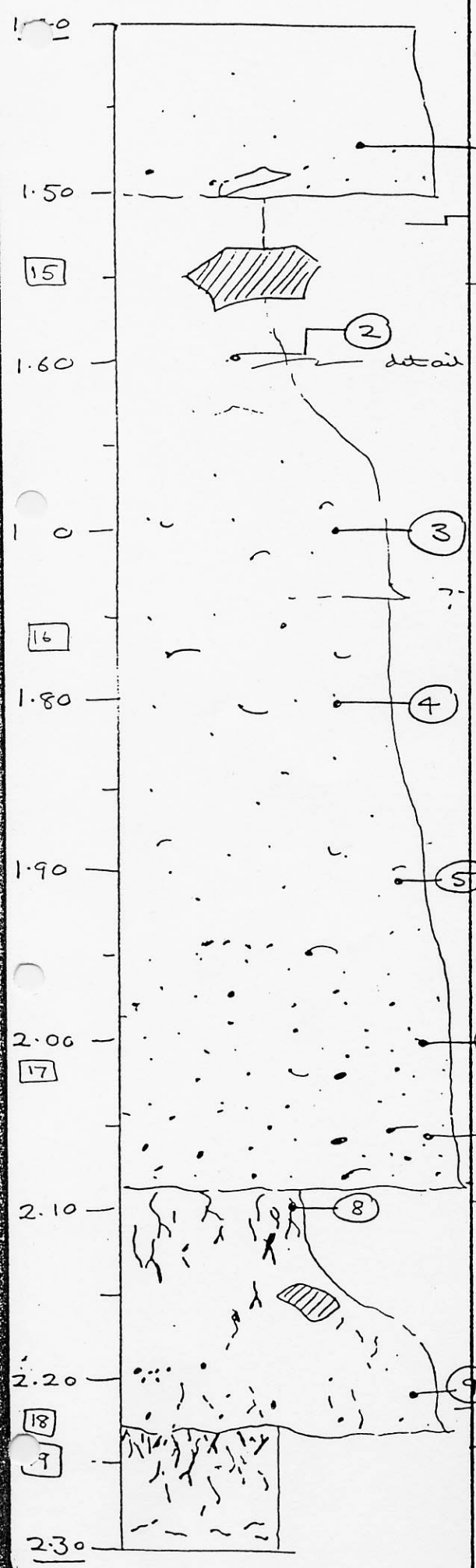
9 = gen. view.

10

1·33

83/20 - SC003 1.40 - 2.30m Box 3 of 3.

15 = photograph.



1.5 stiff grey mud.

v. weak normal grading?

could be mudclasts at this level.

- obscure bioturbation - content with below.

1.54 Angular dark limestone pebble (carb?) - 32mm across.

- seems to be embedded in fine mud-prone facies.

upward change to sticky mud-prone lithology.

broken/comminuted bioclasts - abundant trans.

grey-brown colour

graded upwards

common black fragments

2.085 grey brown. fining upwards.

bioturbation abruptly stops.

yellow-brown

- subangular pebble = red arkosic sandstone? (rounded)

scattered black grains - locally clustered?

2.23

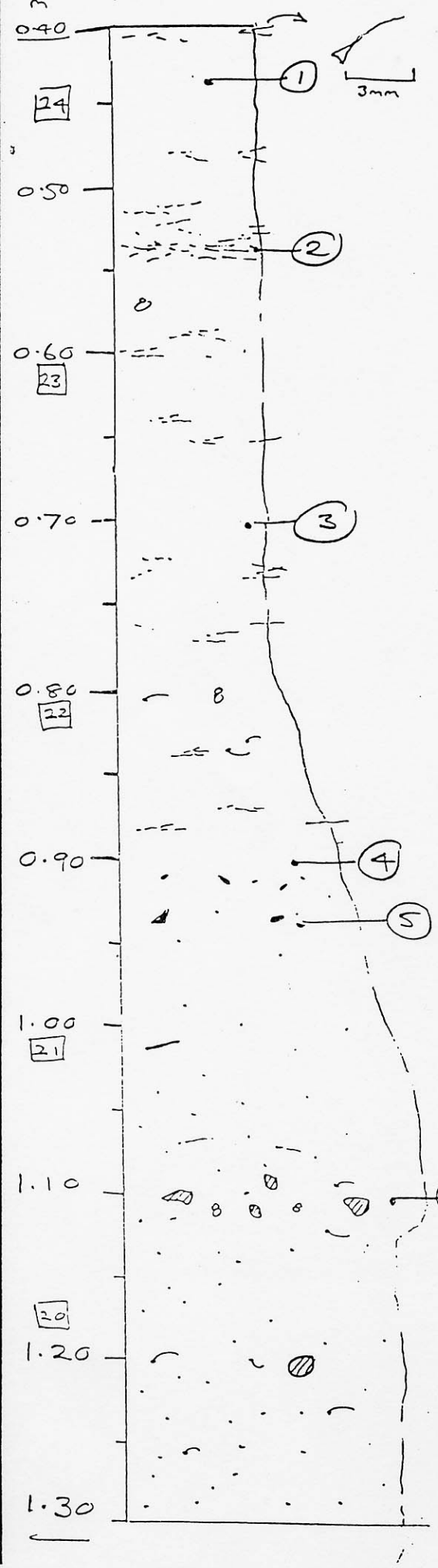
- only weakly burrowed.

many thread-like non-scale pale coloured burrows.

stiff grey brown mud - slightly gritty.

83/20 - SC 003

B/3 0.40 - 1.30m
Box 2 of 3



nb both grooves cut completely through - consequently detailed structure poorly preserved.

25 = good view.

dense concentration of 'hairs'

grey brown 'sticky' mud - with abundant hair-like particles - spines or contaminant? v. few admixed grains.

becomes less 'grainy' upwards - appears gradational

- carbonaceous fragment?

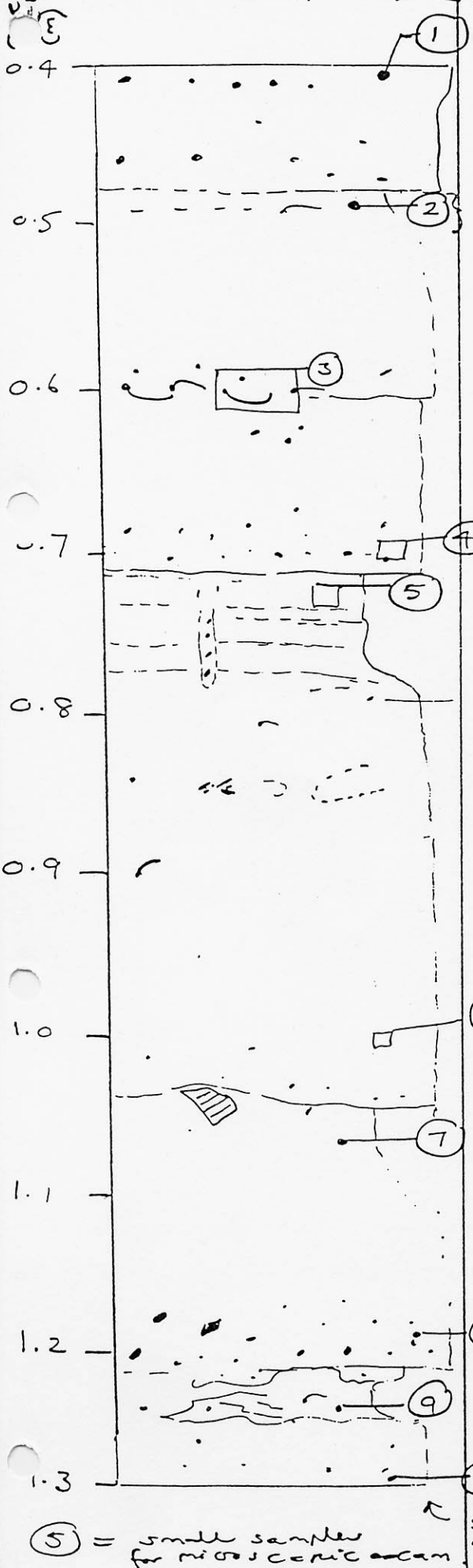
black clasts - up to c. 6mm across - non-carbonate. Appear to be concentrated at this level.

rare 'brachiopod'.

dull grey-brown colour - clot of inorganic mud/clay - but quite 'grainy' - mostly forams? relatively 'blocky'.

CORE OPENING - TCD
5-5-99

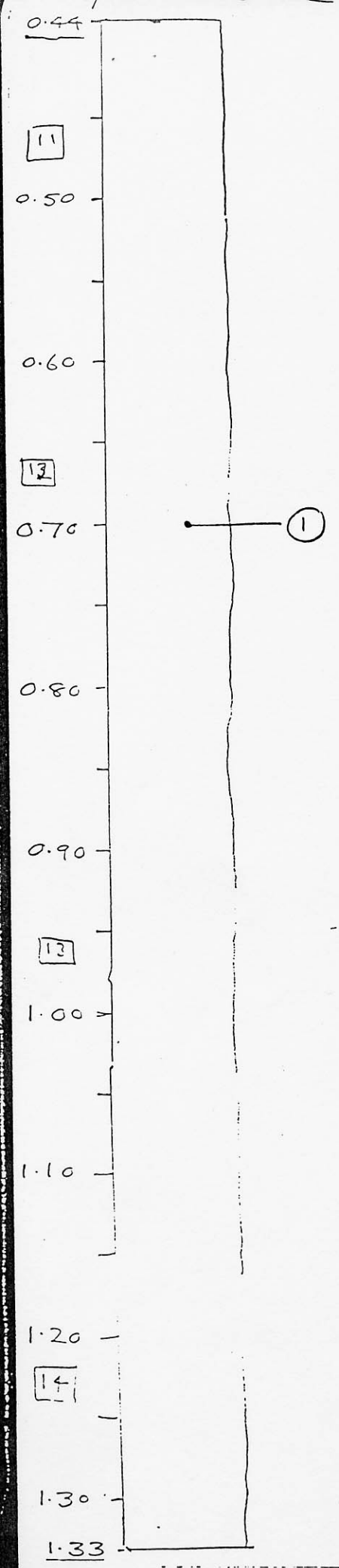
16/28 - SC002
0.40 - 1.30m Box 2 of 2.



- scattered coarse grains - bare or CU? disturbed by extrusion / core cut.
- darker more clay-prone colour brings out textural contrast.
- shell concentration - boundary?
- 0.71
- sand-filled burrow fill coarser grained than surrounding material.
- with shell.
- darker rounded structure - burrow? clusters of coarse fragments - also bioturbation.
- reddened fragment
- more grainy?
- about top - projecting dart?
- fine grained? - more clay-prone.
- 1.08 - 1.18 - structure unclear
- more 'cohesive' Here?
- SMEARED on this section.
- many black fragments.
- cryptic boundary?
- fine grained - biot./lam? disturbed. colour banding
- could be coring induced.

(5) = small sample for microscopic exam.

grain size to be calibrated against microscopic observations.

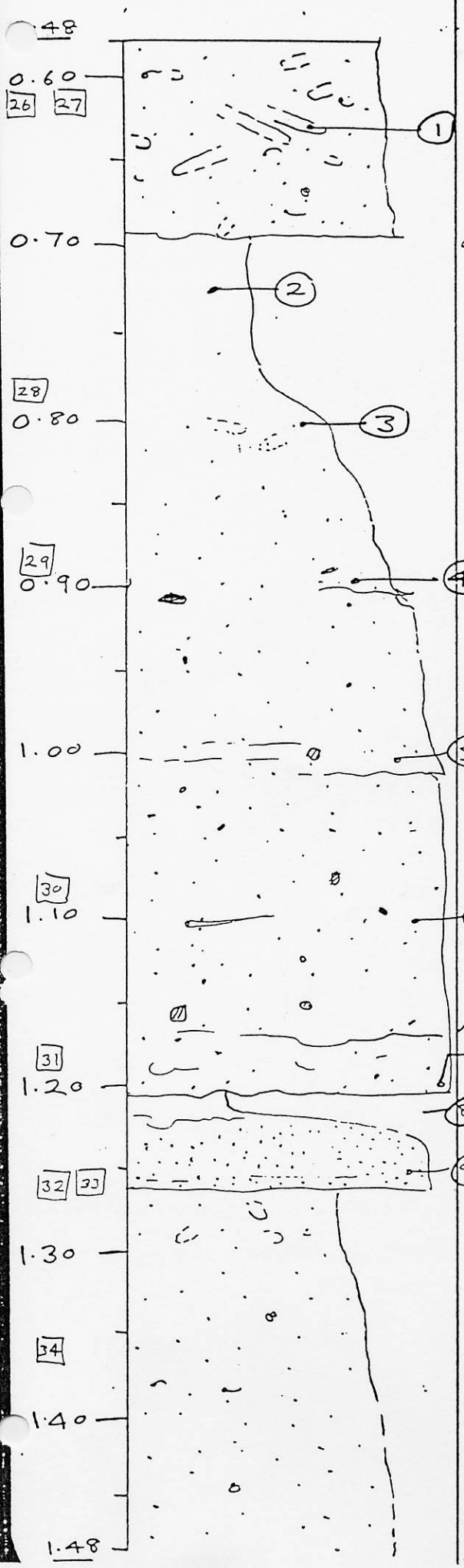


uniform medium grey, sticky, very fine grained mud – no obvious sedimentary structures/ beds/ bioturbation.

nb some sandy material plastered on inner coring tube – dragged down from higher up?

83/20 – SC003 1.40 – 2.30m Box 3 of 3.

78/28 - SC007 Box 2 of 2
0.58 – 1.48m



0.69

1.210

1.265

medium dark grey-brown clayey sand traversed by pale brown burrow fills.
Scattered broken shell material.

– sharp irregular contact.

sticky tan brown clay – very smooth – no coarse grains.

poss. bioturbation – very subtle mottling

gradually becoming darker and more clay-rich upwards.

– 10mm black clast.

slight colour change – brown → paler.
hint of structure – lamination?
poss. contact?

very rich in foram grains.

arching spine.

pale coloured – white – brown

change in colour – white beneath.
red-brown clasts – quartzose.

– mottled appearance.

– sticky tan brown clay.
– gradational. v. grainy

– hint of lamination? cream coloured.
– abrupt colour change

subtle bioturbation – 'arching' burrow mottling.

grey-green clayey sand – dirty. no obvious structure.

35 36 = general views

APPENDIX IV

LABORATORY TEST RESULTS

TCD & UCD

Job: Rockall Date 12.7.99

Liquid & Plastic Limit Tests and Natural Water Content Tests

Sample No.	Depth	Liquid Limit	Plastic Limit	Natural Water Content
16/28 SC002	0.5-0.55m.	47	26	50.9
16/28 SC002	0.9-0.95m.	47	26	65.6
83/20 SC003	0.9 - 0.95m	72	30	51.4
83/20 SC003	1.1 - 1.15m.	74	29	52.1
78/28 SC007	0.8 - 0.85m.	47	25	71.4
78/28 SC007	1.2 - 1.25m.		Non-Plastic	74.0

Geotechnical Laboratories,
Trinity College,
Dublin.2.

Job: Rockall

Date 12.7.99

Carbonate Tests (Test 6 B.S. 1377 part 3 1990)

Sample No.	Depth.	Percentage Carbonates (as CO_3)
16/28 SC002	0.6m.	18.5
16/28 SC002	1.1m.	15.5
83/20 SC003	0.48m.	13.6
83/20 SC003	0.78m.	17.4
78/28 SC007	0.90m.	26.6
78/28 SC007	1.25m.	17.8

Geotechnical Laboratories,
Trinity College,
Dublin.2.

PARTICLE SIZE DISTRIBUTION CHART

DATE 24.5.99
JOB Rockall
DESCRIPTION OF SOIL Beige very sandy Clay ?

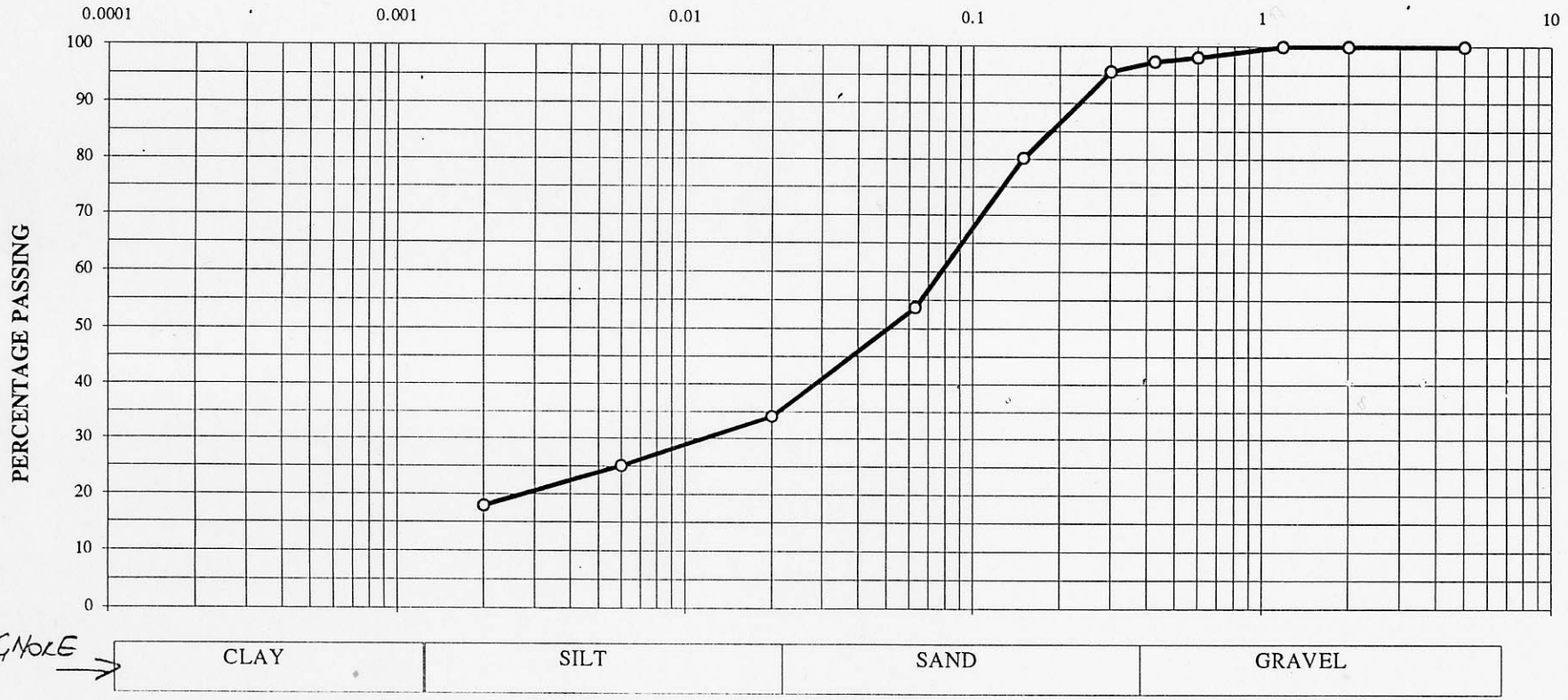
BOREHOLE NO.
SAMPLE NO. 16/28 SC002
DEPTH . 0.5 - 0.55m

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.

PARTICLE SIZE MM

SEDIMENTATION

BRITISH STANDARD TEST SIEVES



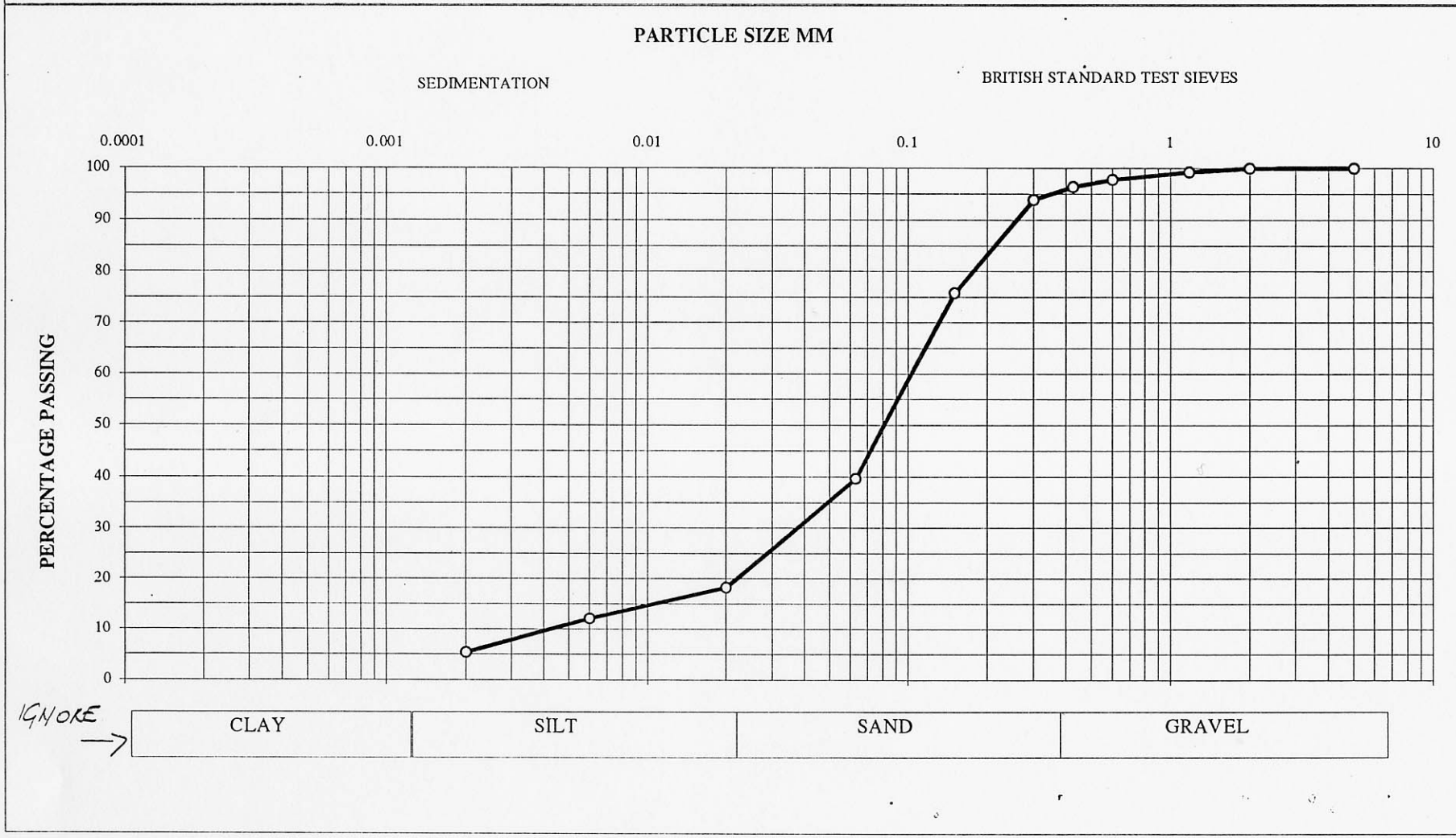
3

PARTICLE SIZE DISTRIBUTION CHART

DATE 24.5.99
JOB Rockall
DESCRIPTION OF SOIL Beige very Sandy Clay ?

BOREHOLE NO.
SAMPLE NO. 16/28 SC002
DEPTH . 0.95 - 1.0m

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.



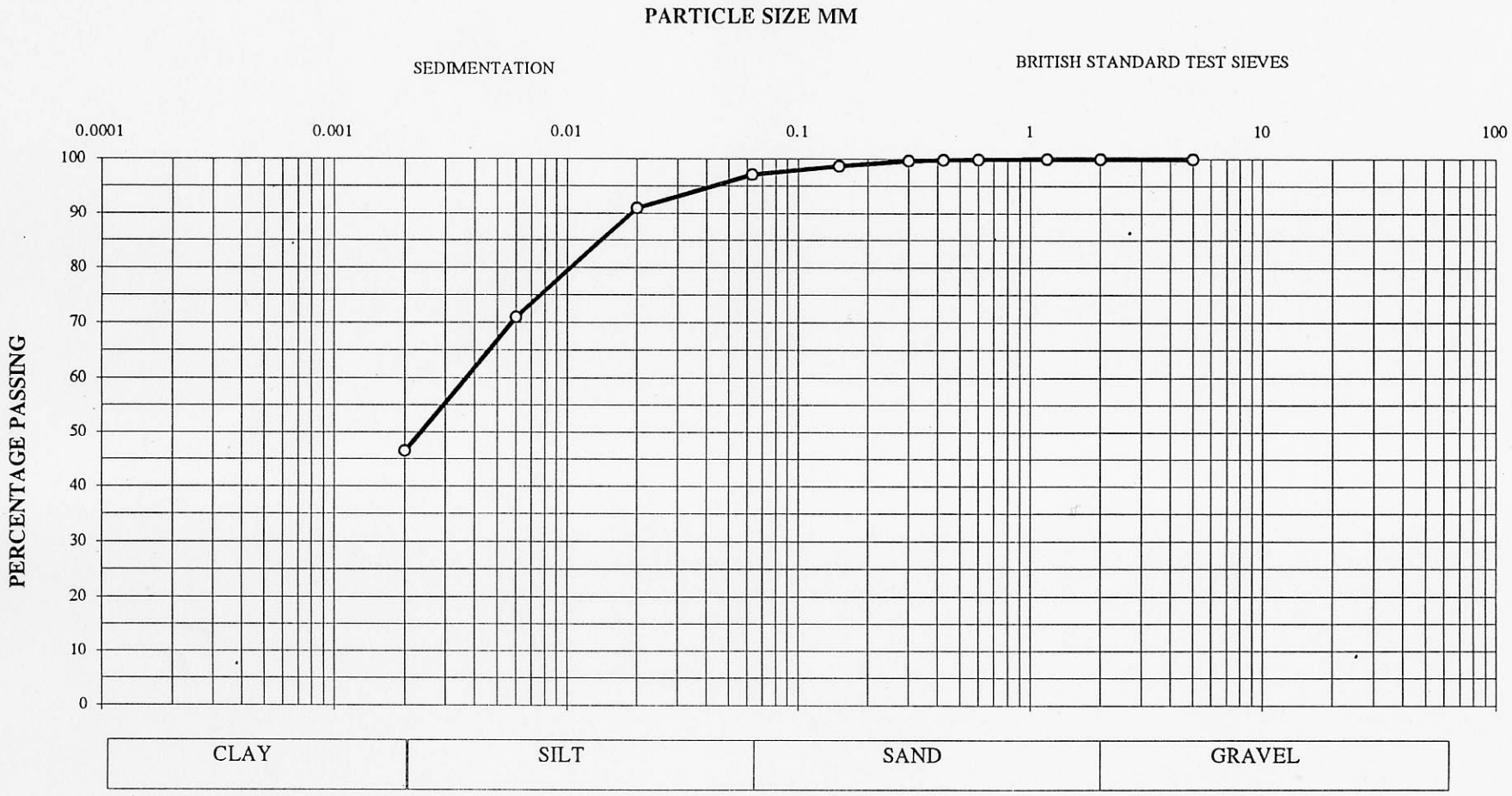
4

PARTICLE SIZE DISTRIBUTION CHART

DATE 11.6.99
JOB Rockall
DESCRIPTION OF SOIL Grey Clay

BOREHOLE NO.
SAMPLE NO. 83/20 - SC003
DEPTH 0.9m

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.



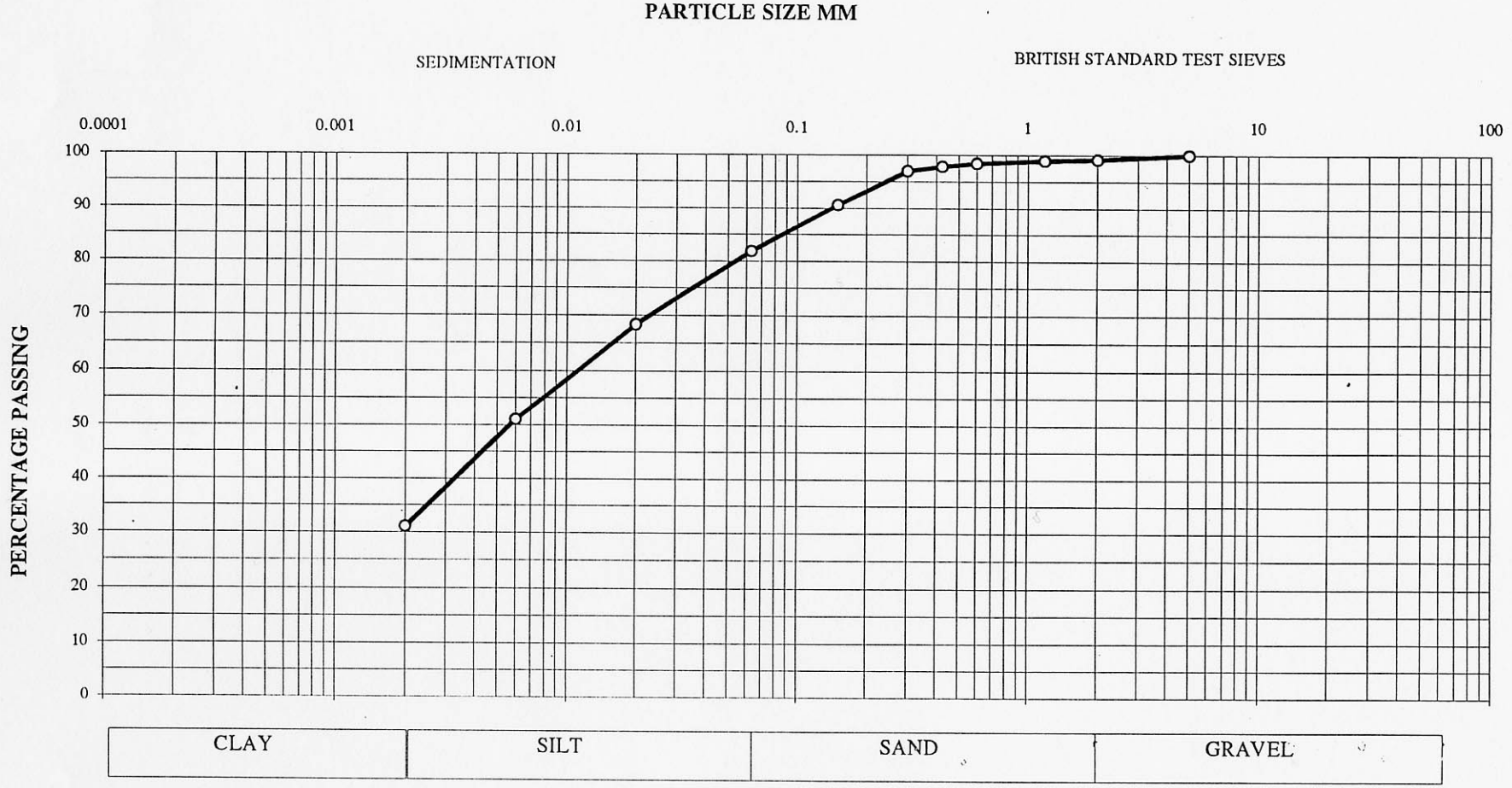
5

PARTICLE SIZE DISTRIBUTION CHART

DATE 11.6.99
JOB Rockall
DESCRIPTION OF SOIL Grey Clay

BOREHOLE NO.
SAMPLE NO. 83/20 - SC003
DEPTH 1.1 m.

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.

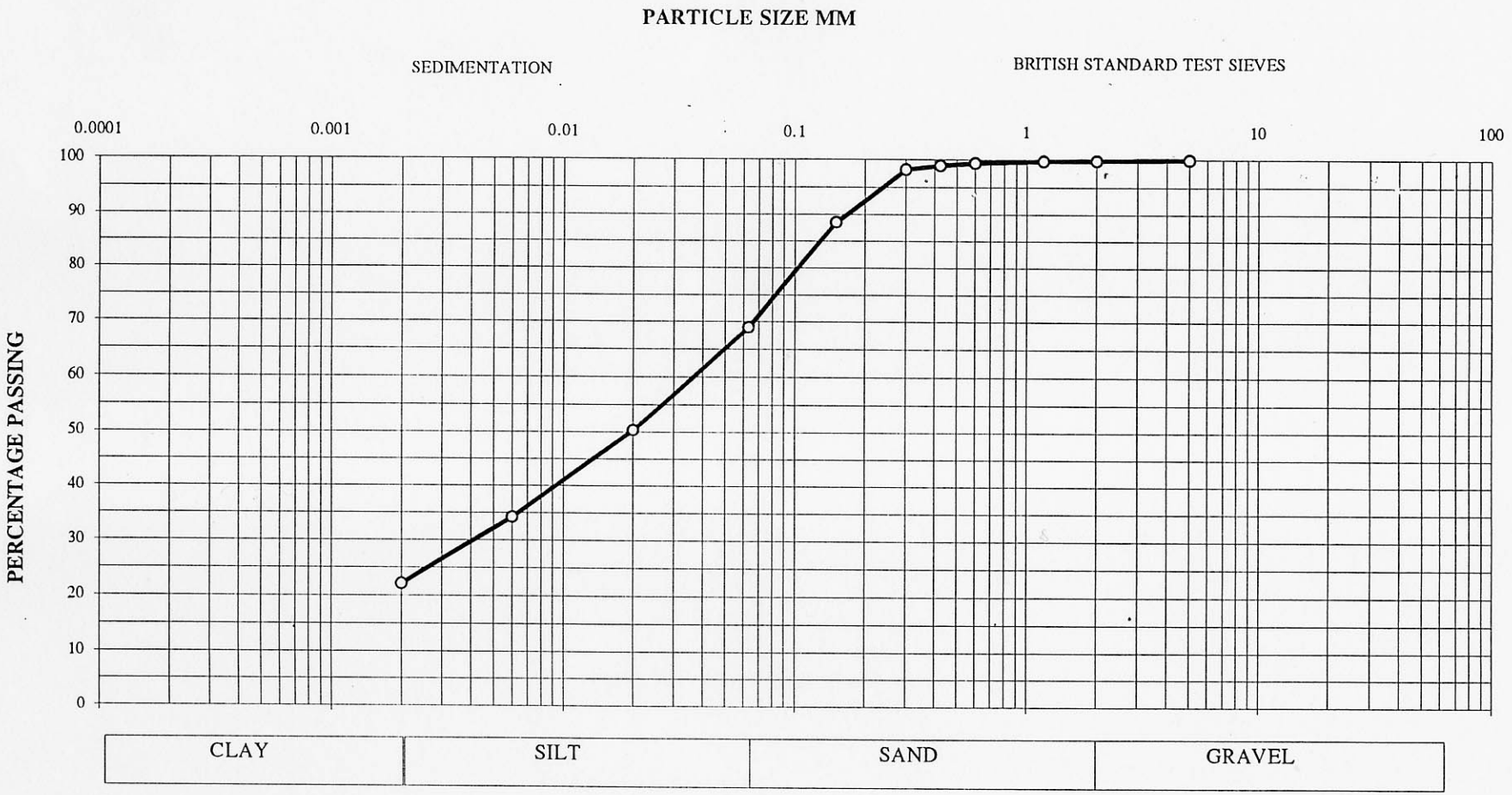


PARTICLE SIZE DISTRIBUTION CHART

DATE 11.6.99
JOB Rockall
DESCRIPTION OF SOIL Beige Clay

BOREHOLE NO.
SAMPLE NO. 78/28- SC007
DEPTH 0.8m

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.

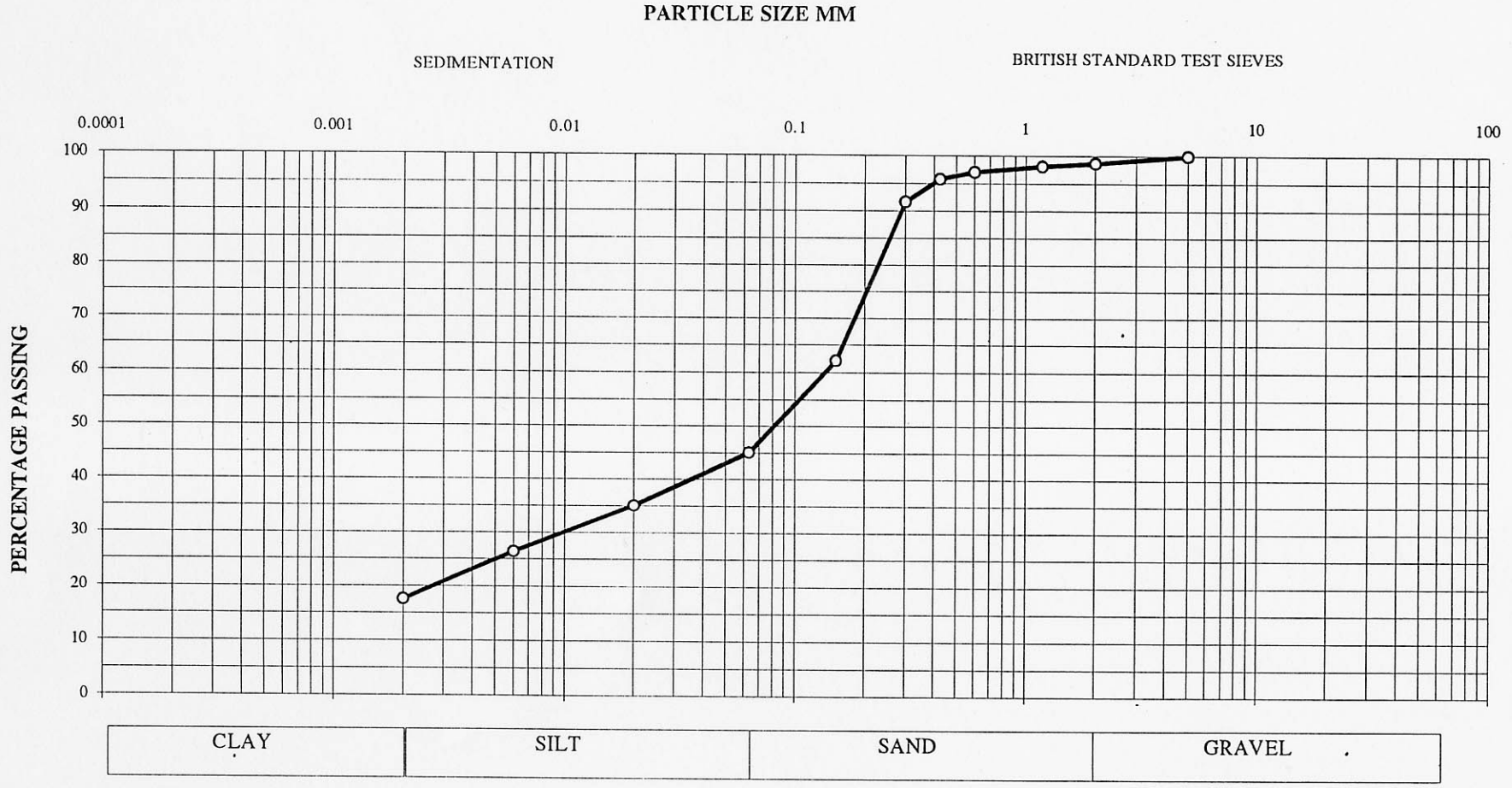


PARTICLE SIZE DISTRIBUTION CHART

DATE 11.6.99
JOB Rockall
DESCRIPTION OF SOIL Beige clayey very sandy silt

BOREHOLE NO.
SAMPLE NO. 78/28- SC007
DEPTH 1.2m

GEOTECHNICAL LABORATORIES,
TRINITY COLLEGE,
DUBLIN.2.



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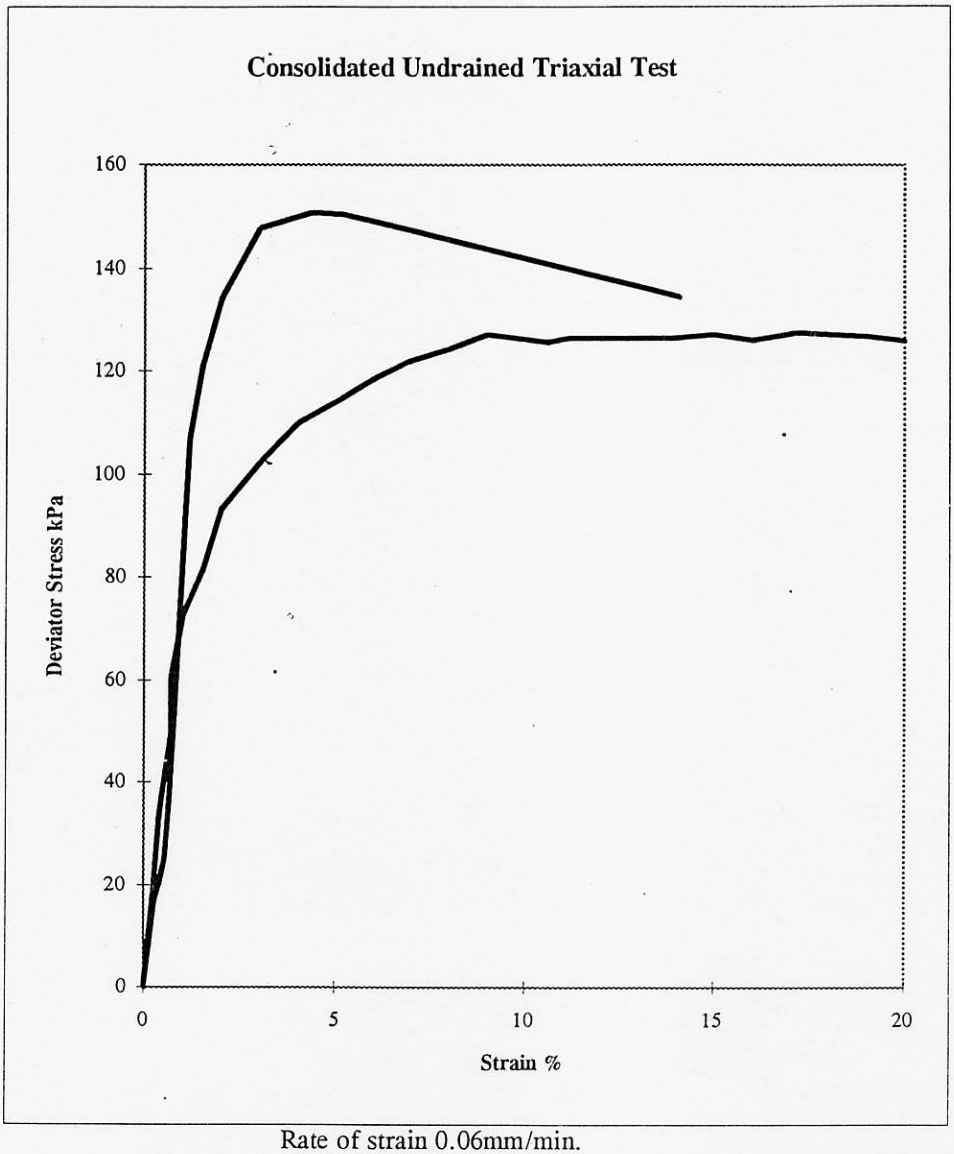

Rate of strain 0.06mm/min.

Cell Pressure kPa	250	300
Back Pressure kPa	200	200
Initial Bulk Density Mg/m^3	1.62	1.55
Initial Water Content %	56.30	70.90
Water Content after test %	55.10	67.60
Max. Deviator Stress kPa	127.1	150.8
Pore Pressure at Max. Stress	213.3	259.9
Strain at max. deviator Stress %	9.00	4.35

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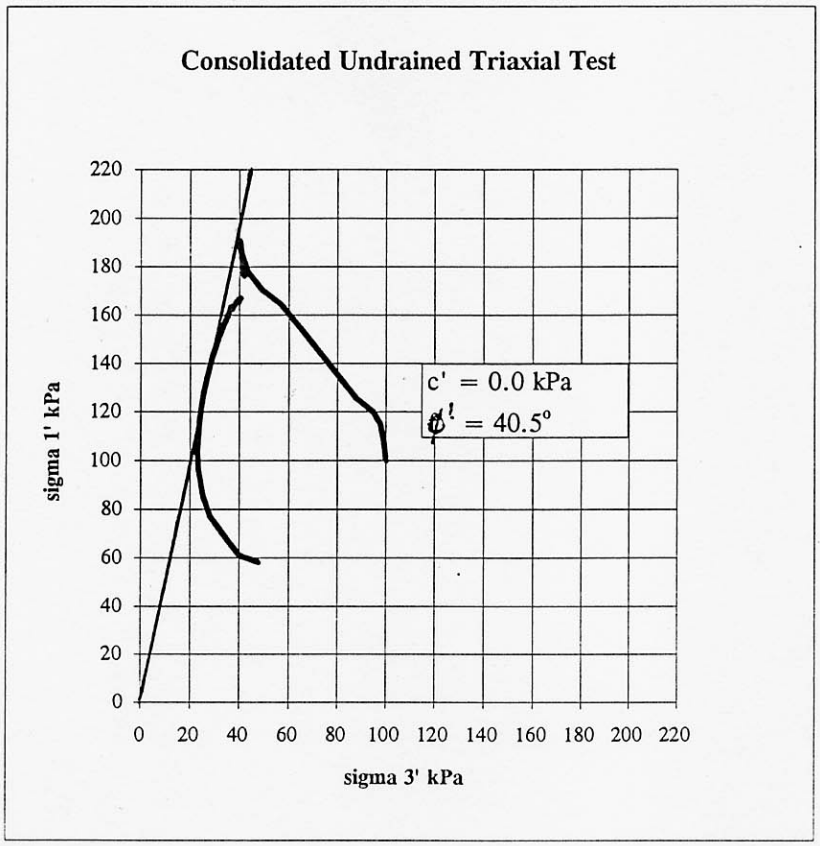
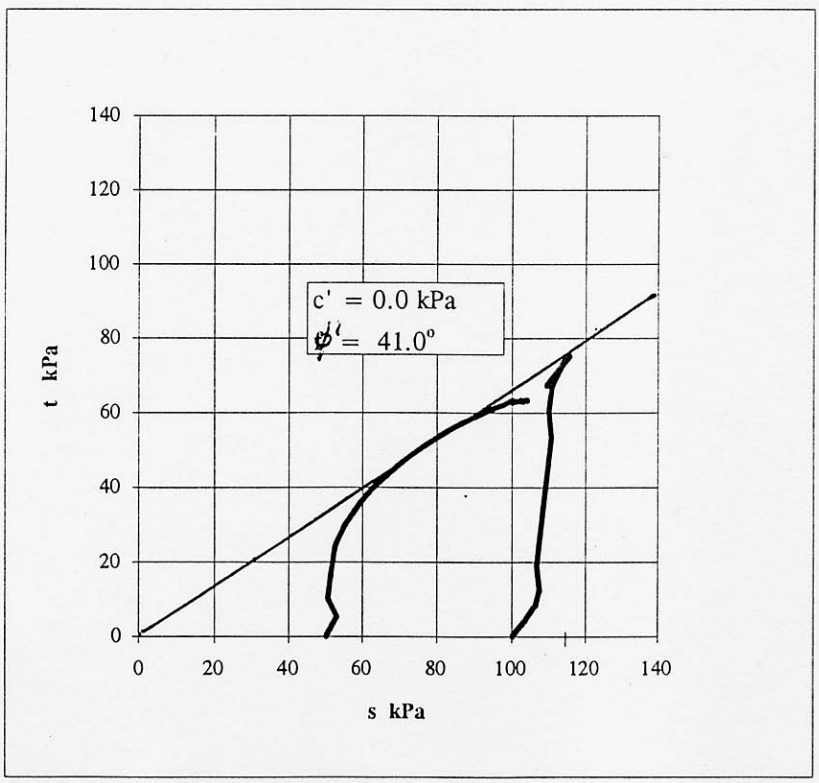
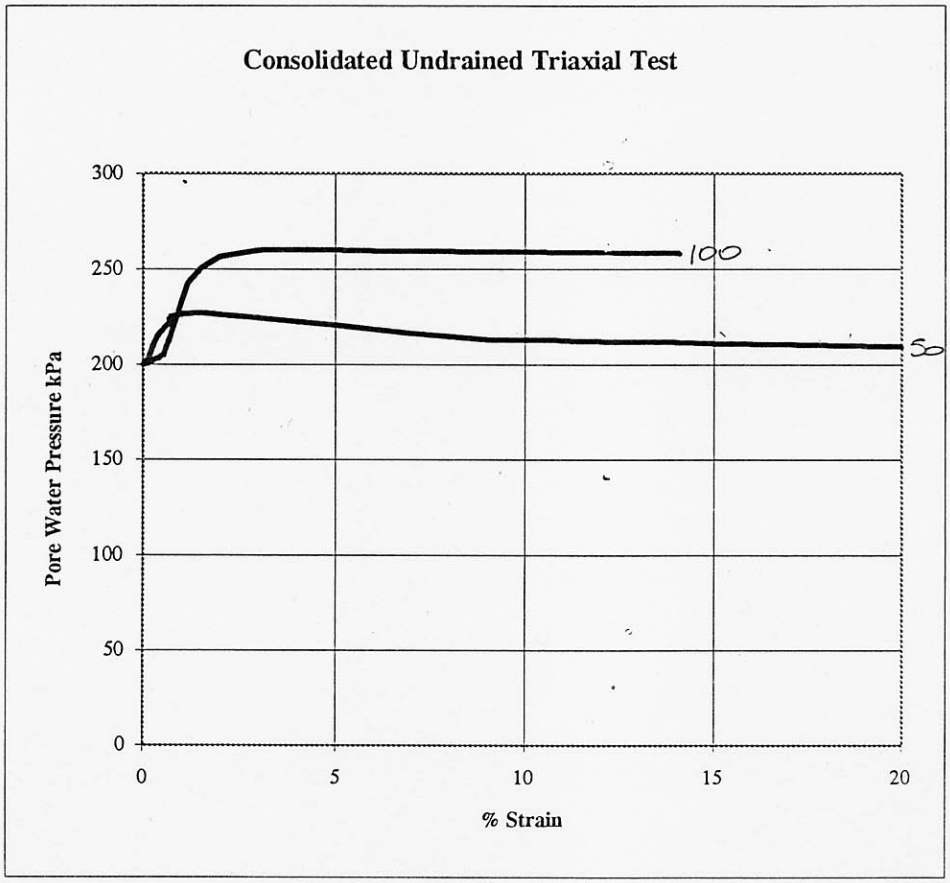
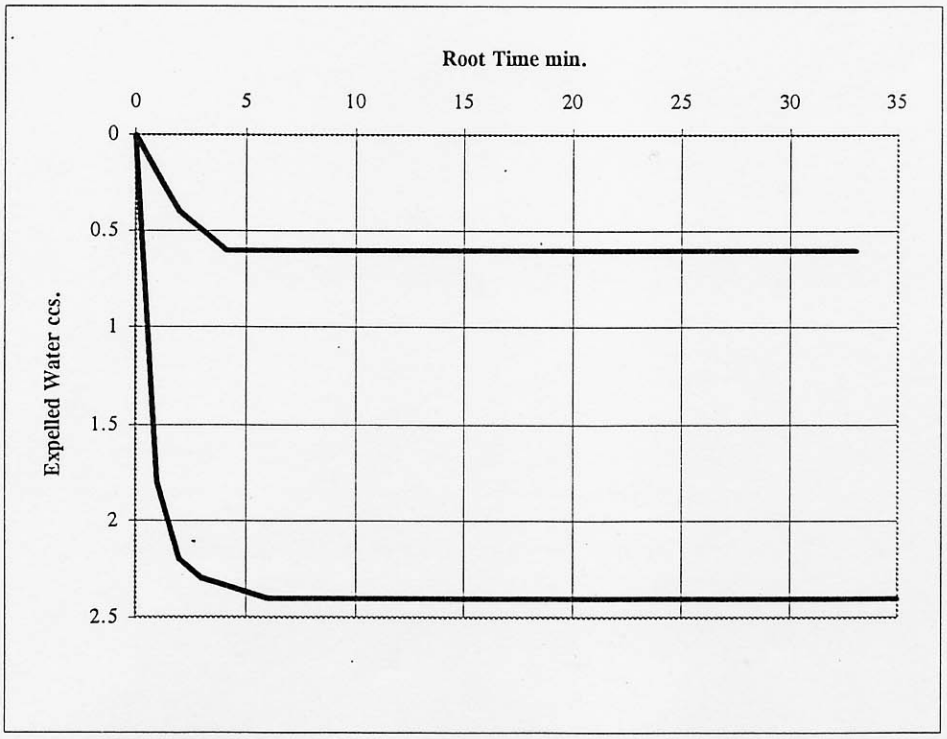
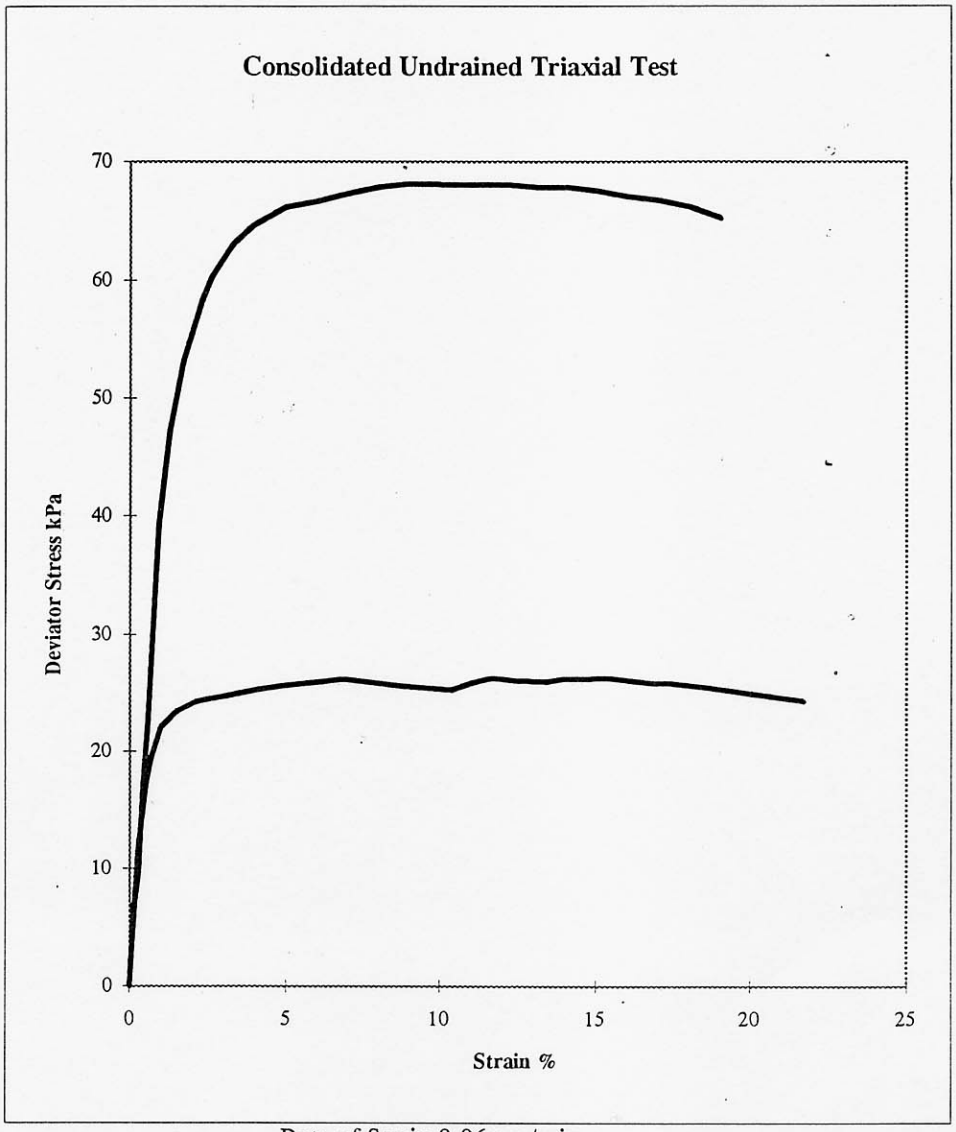
Sample no. SC002 1.1 - 1.2m.






Consolidated Undrained Triaxial Test
Pore Water Pressure kPa
300
250
200
150
100
50
0
0
5
10
15
20
% Strain
100
50


Root Time min.
0
5
10
15
20
25
30
35
Expelled Water ccs.
0
0.5
1
1.5
2
2.5



Rate of Strain 0.06mm/min.

Cell Pressure kPa	250	300
Back Pressure kPa	200	200
Initial Bulk Density Mg/m^3	1.55	1.51
Initial Water Content %	82.20	93.70
Water Content after test %	58.70	53.40
Max. Deviator Stress kPa	26.2	68.2
Pore Pressure at Max. Stress	236.9	272
Strain at Max. Deviator Stress %	6.83	9.01

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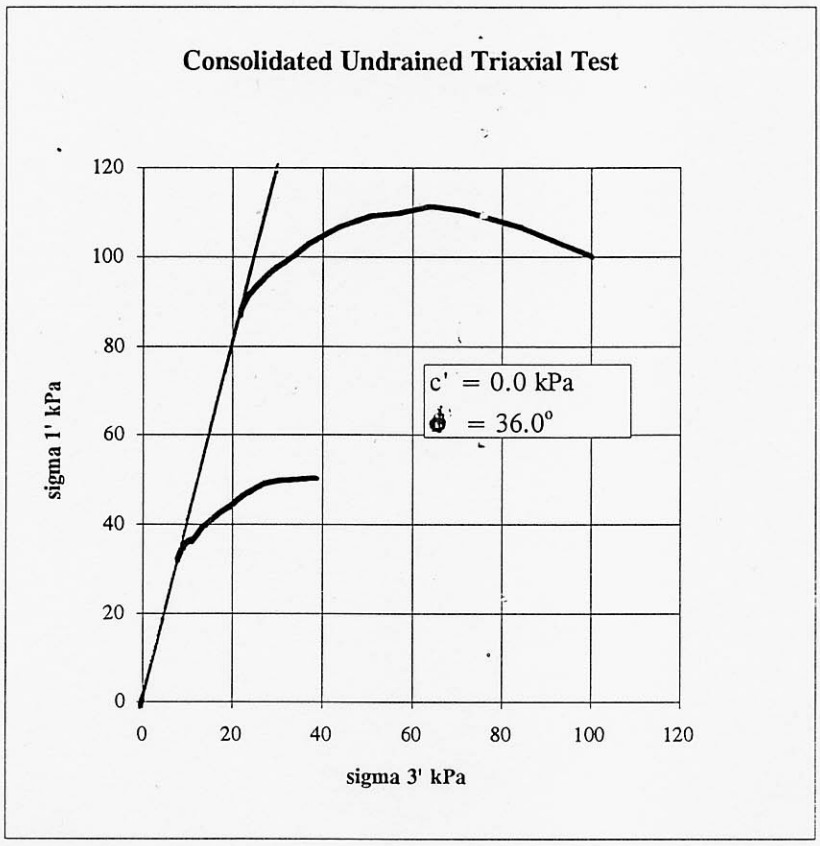
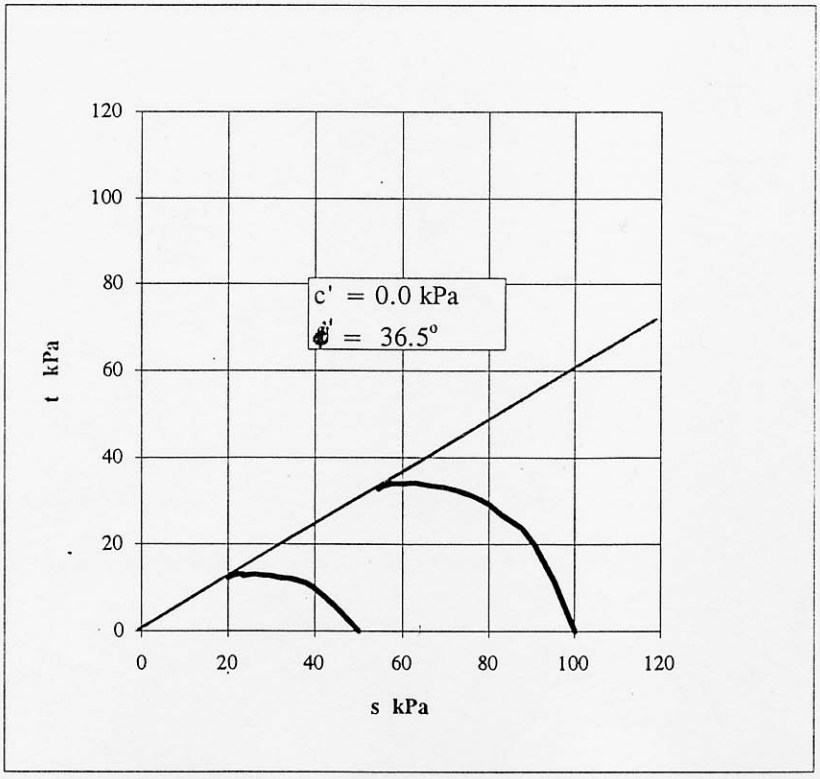
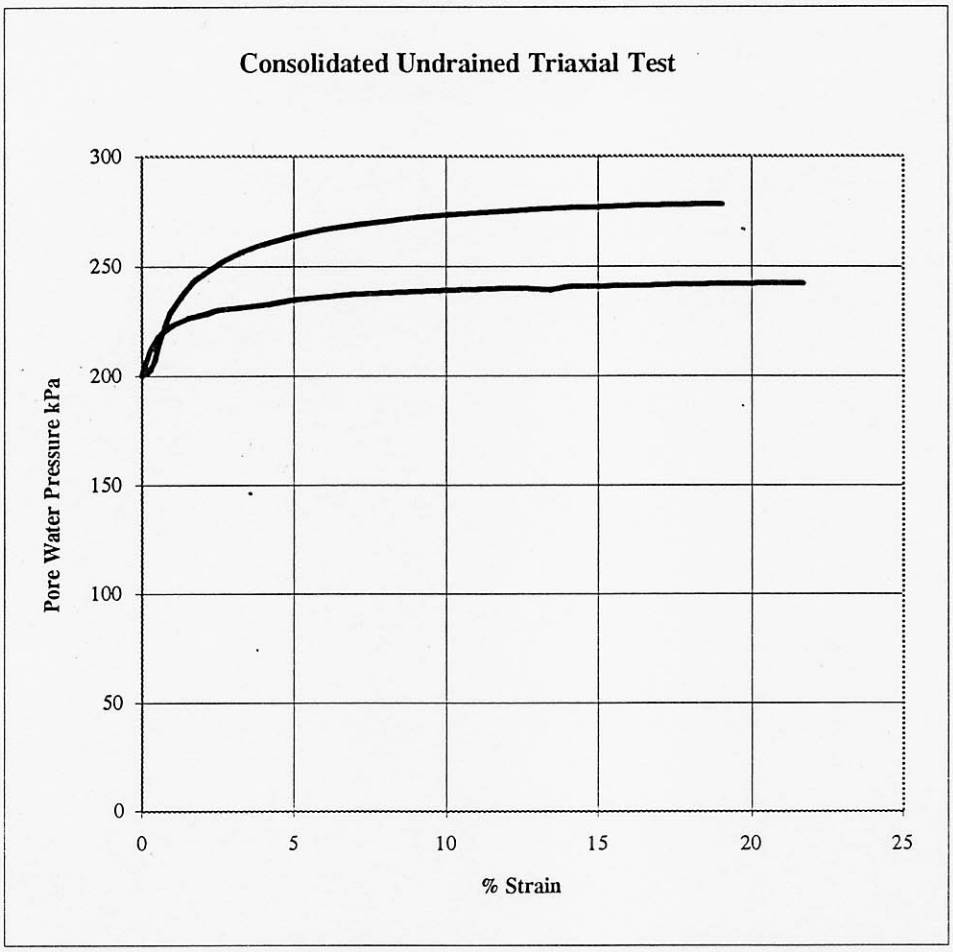
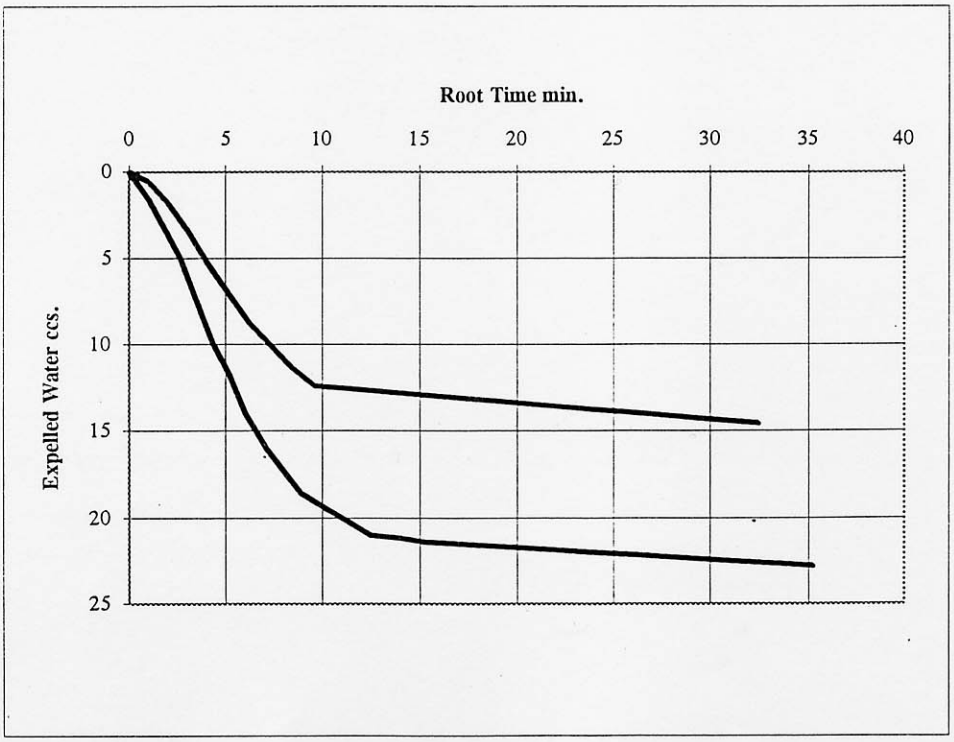
Sample no. SC003 0.4 - 0.48m.

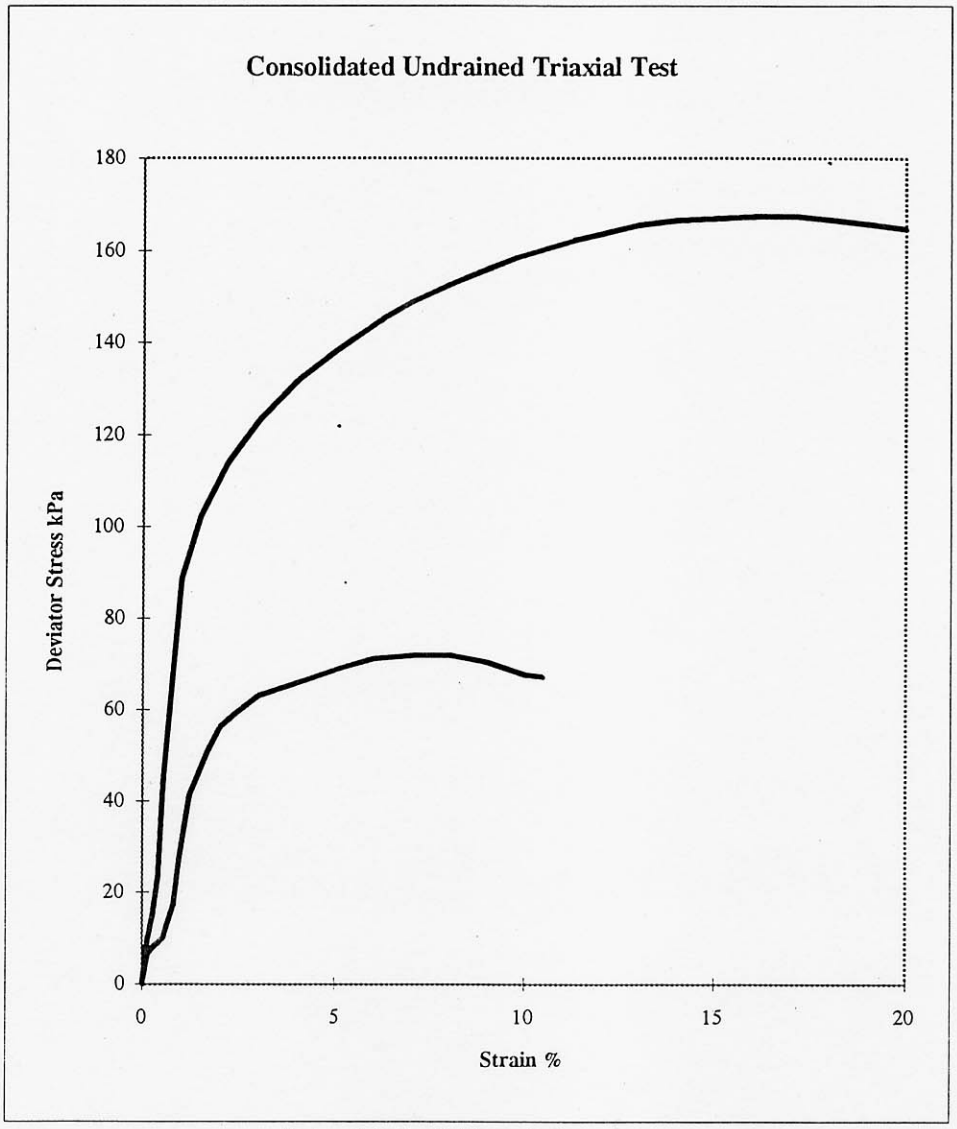





Consolidated Undrained Triaxial Test
Pore Water Pressure kPa
300
250
200
150
100
50
0
0
5
10
15
20
25
% Strain


Root Time min.
0
5
10
15
20
25
30
35
40
Expelled Water ccs.
0
5
10
15
20
25

Job: Rockall Sample No. 78/28 SC007 1.35-1.45m. Date 9.7.99



Rate of strain 0.06mm/min.

Cell Pressure kPa	250	300
Back Pressure kPa	200	200
Initial Bulk Density Mg/m^3	1.97	1.95
Initial Water Content %	28.55	28.56
Water Content after test %	27.05	25.72
Max. Deviator Stress kPa	72	167.5
Pore Pressure at Max. Stress	229.2	250.7
Strain at max. Deviator Stress %	8	17

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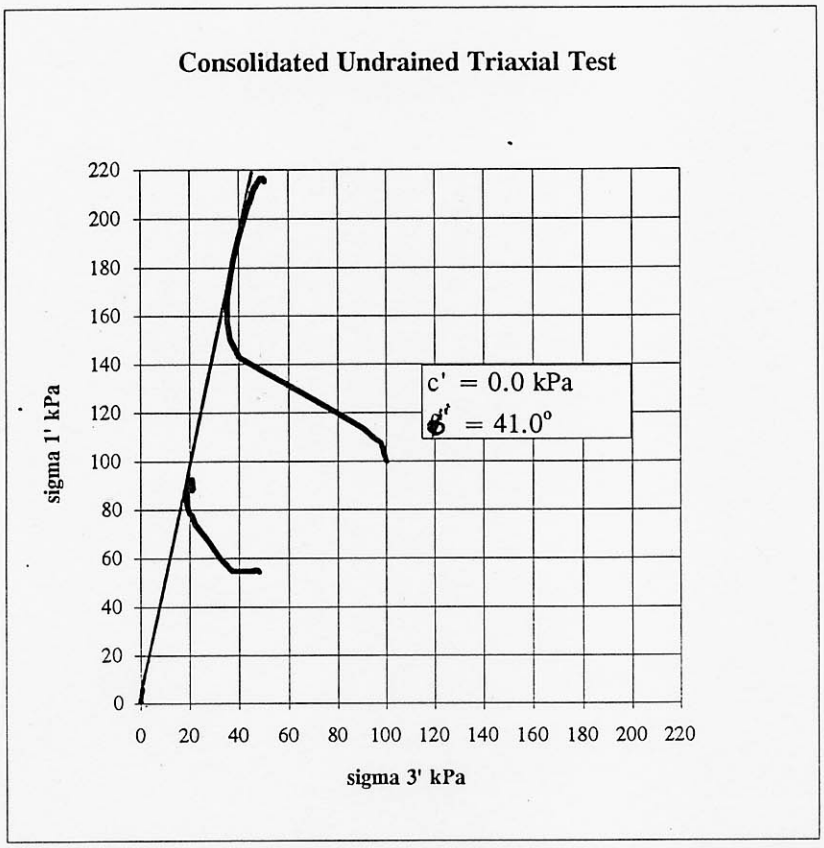
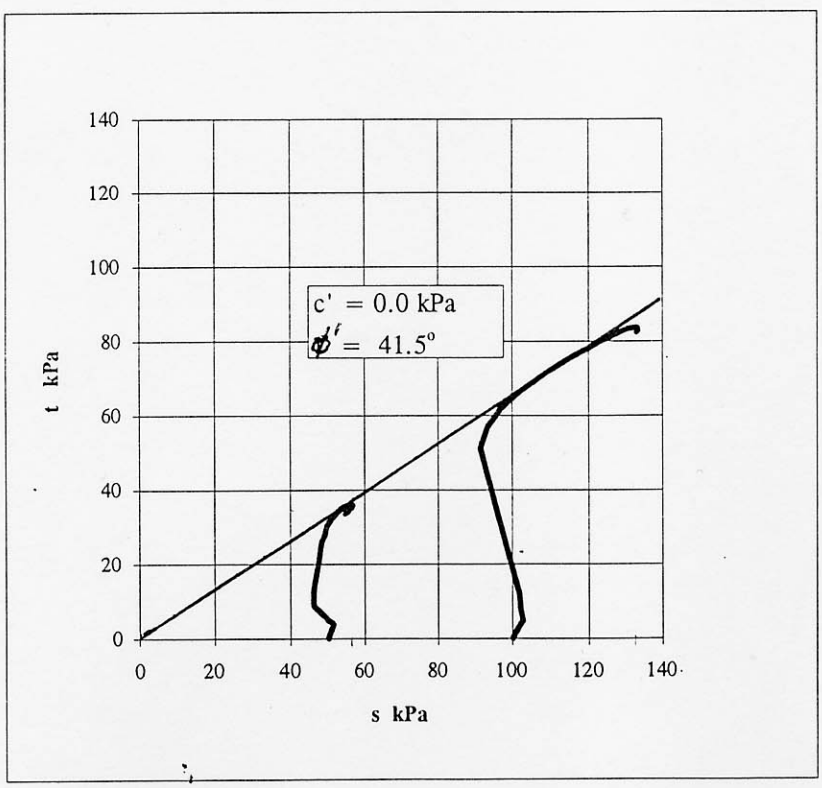
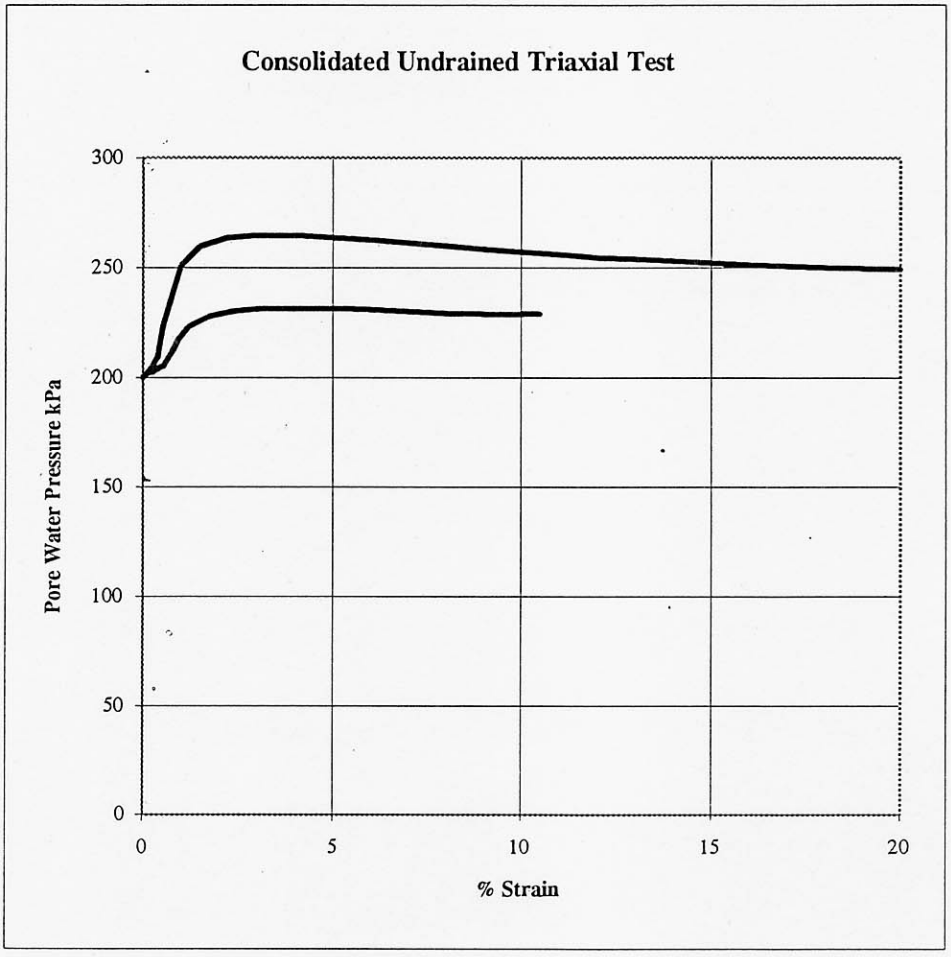
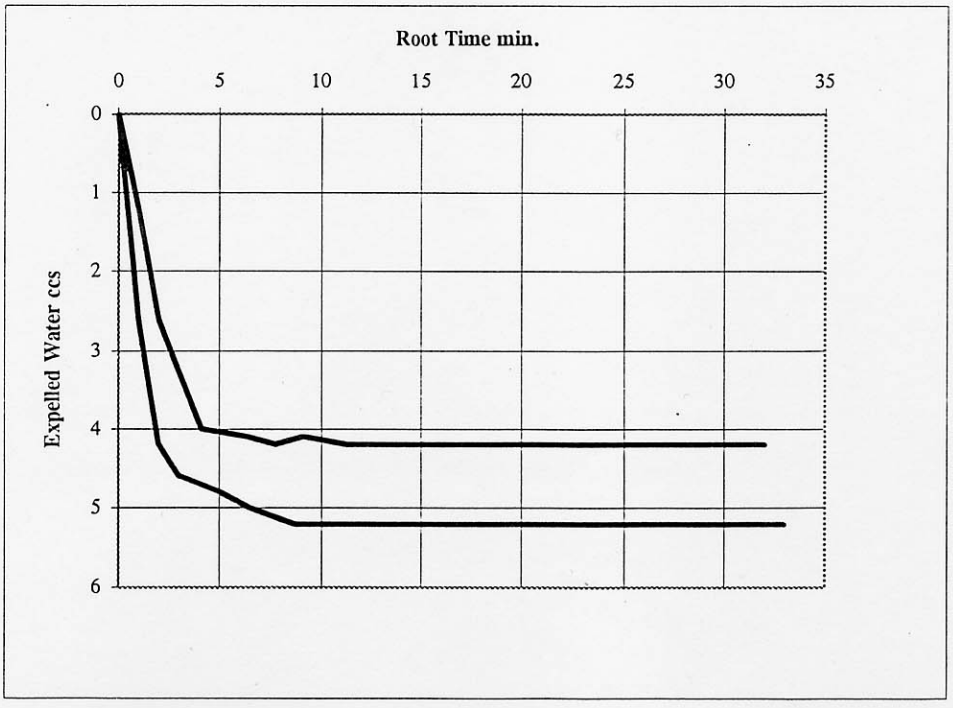
Sample no. SC007 1.35 - 1.45m.



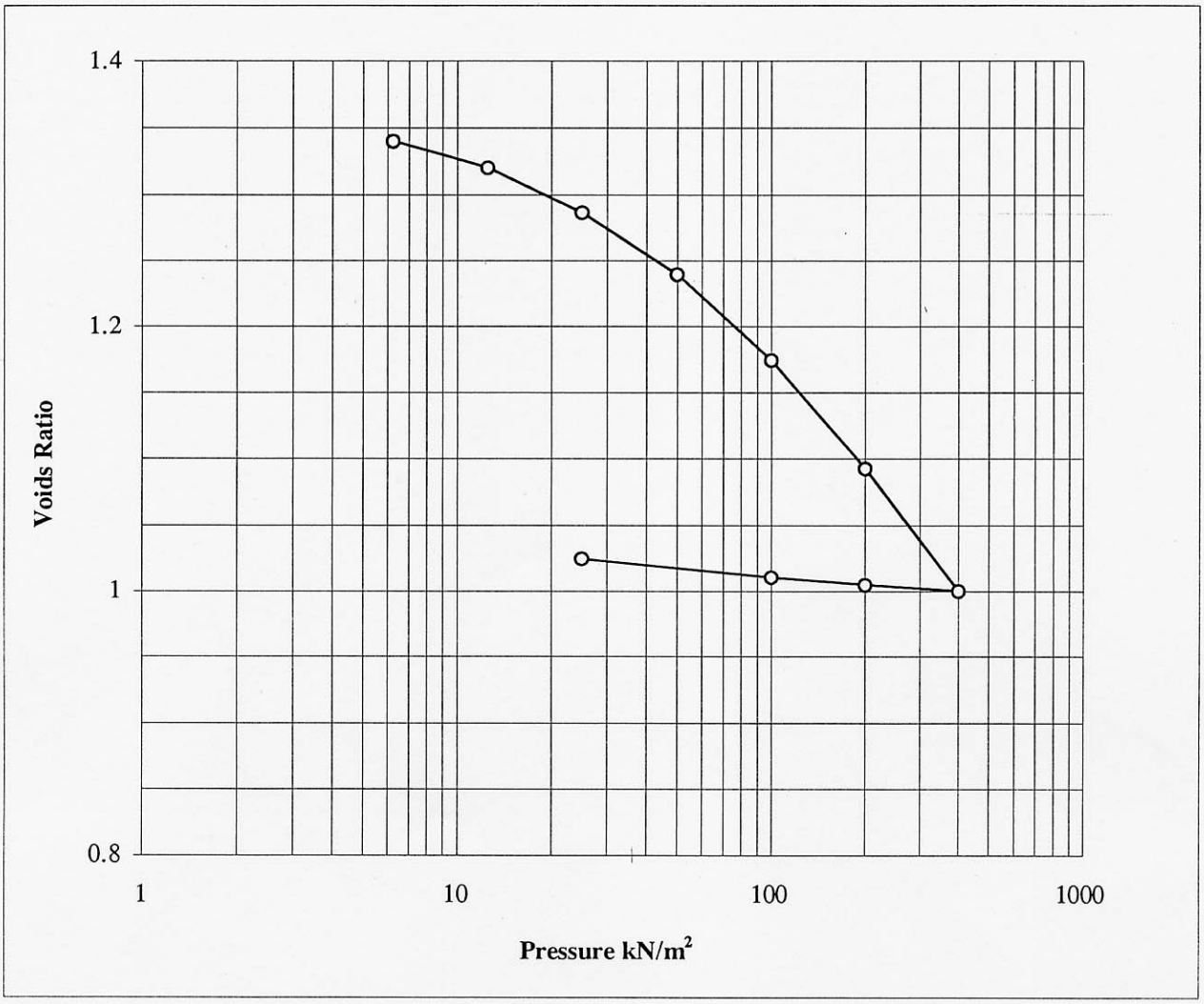



Consolidated Undrained Triaxial Test
Pore Water Pressure kPa
300
250
200
150
100
50
0
0
5
10
15
20
% Strain


Root Time min.
0
5
10
15
20
25
30
35
Expelled Water ccs
0
1
2
3
4
5
6

JOB: Rockall DATE: 24/06/99

SAMPLE 16/28 SC002
BOREHOLE NO:
DEPTH: 0.55- 0.58m.



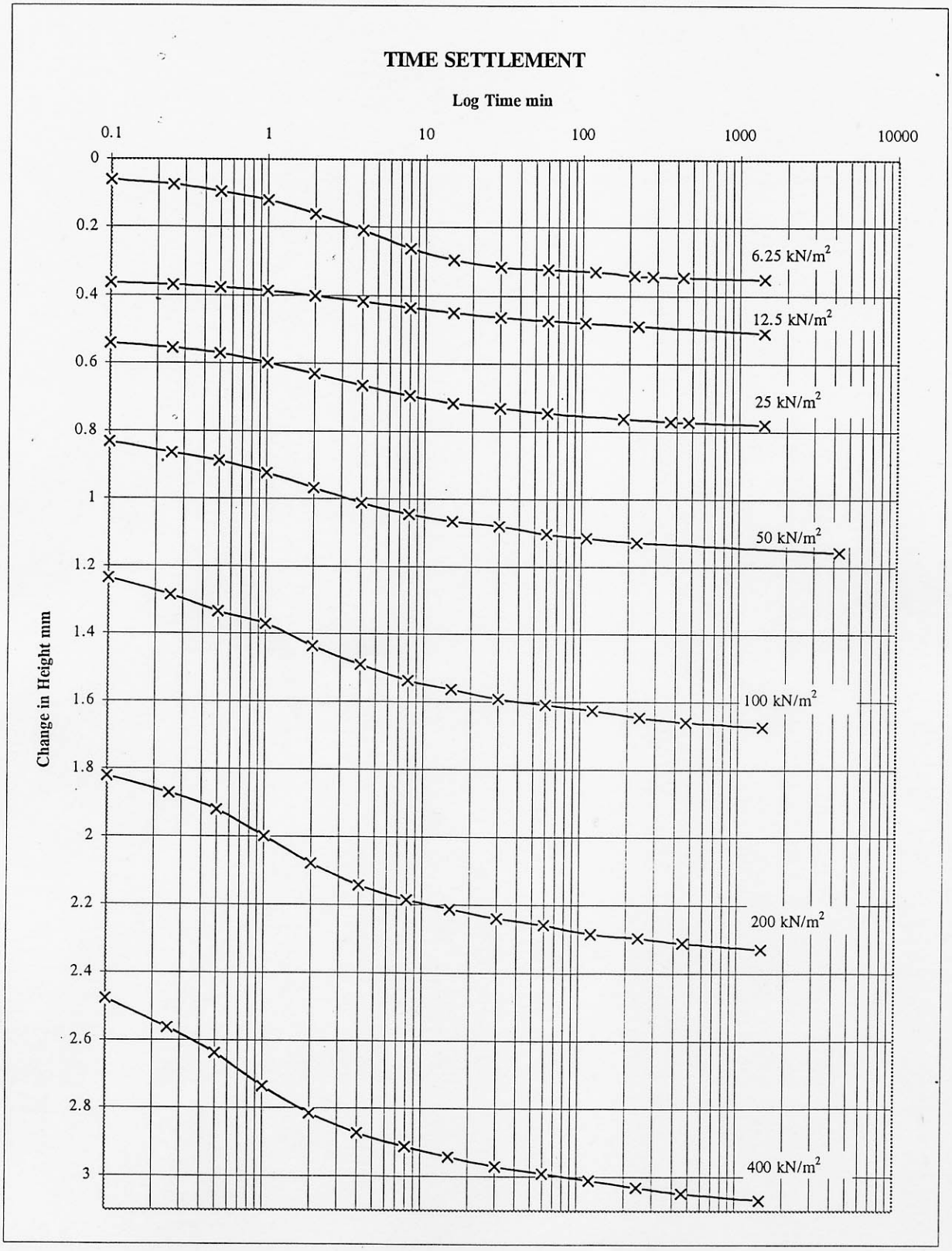
Visual Description : Soft beige clay

Specimen height mm	19.05		Bulk Density Mg/m3	1.67
Specimen diameter	76.2		Dry Density Mg/m3	1.12
Specific Gravity	2.68	(measured)	Degree of saturation	93.86
w% trimmings	49.53		Initial voids ratio	1.3840
w% specimen	48.47			

Pressure range kN/m²		m_v m²/MN	c_v (log) m²/yr	c_v (root) m²/yr
0	6.25	2.9564	3.0873	3.2279
6.25	12.5	1.3520	3.2191	3.1412
12.5	25	1.1650	4.4037	4.7960
25	50	0.8276	6.5385	8.2287
50	100	0.5768	6.7374	8.6291
100	200	0.3775	7.9542	8.0651
200	400	0.2213	13.1139	14.8364

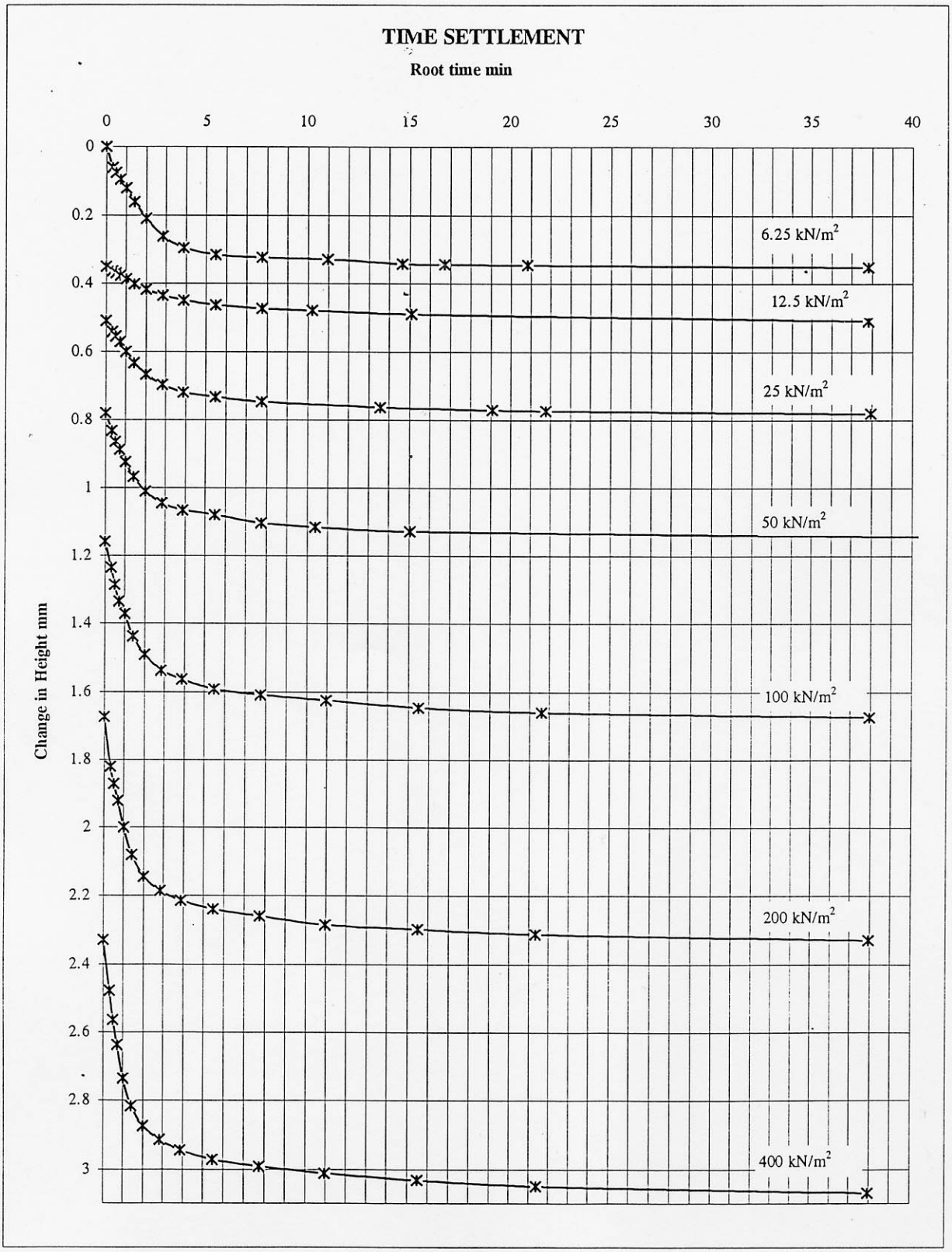
JOB:Rockall DATE: 24/06/99

SAMPLE NO: 16/28 SC002
BOREHOLE NO:
DEPTH: 0.55- 0.58m



JOB: Rockall DATE: 24/06/99

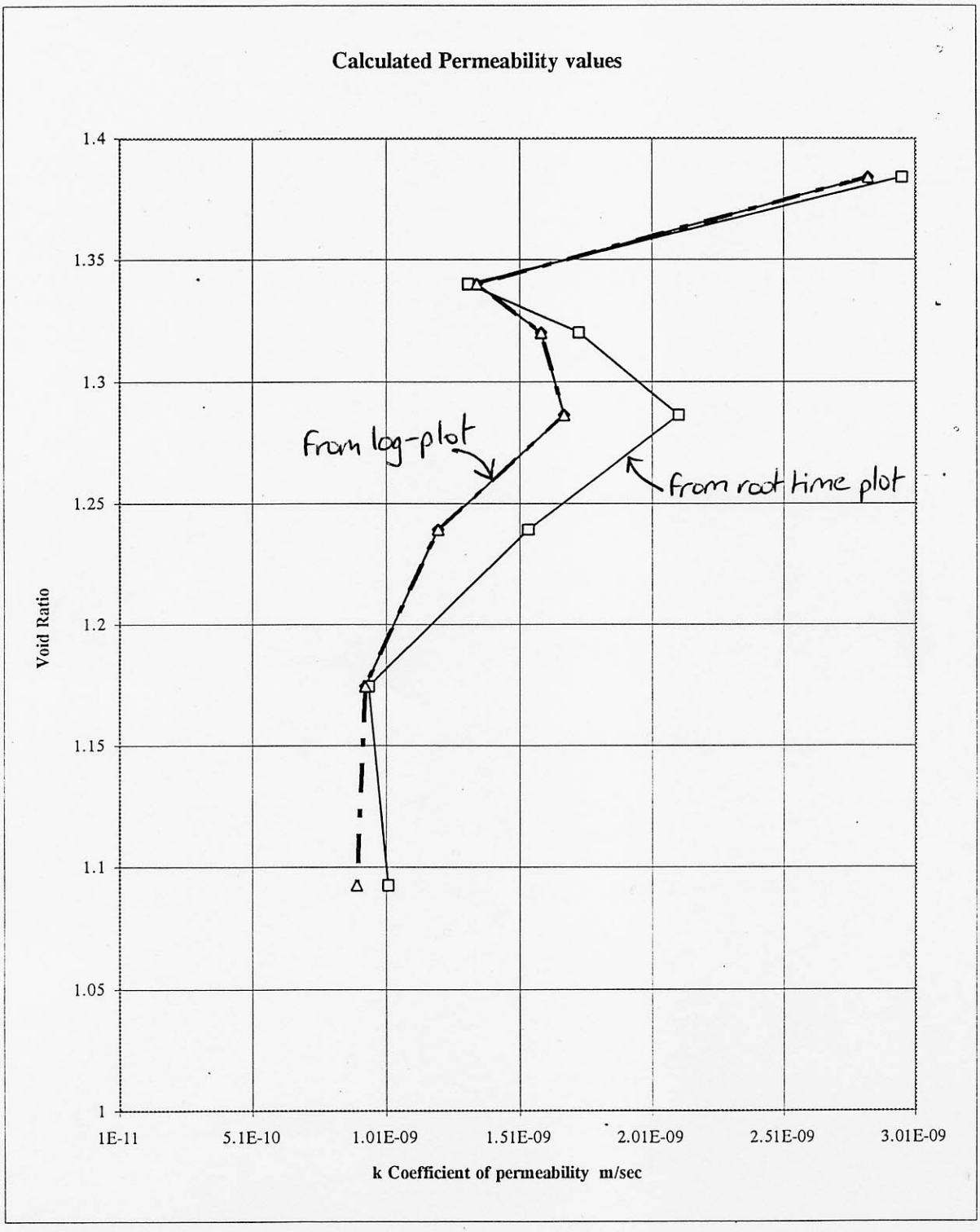
SAMPLE NO: 16/28 SC002
BOREHOLE NO:
DEPTH: 0.55- 0.58m.



Job: Rockall

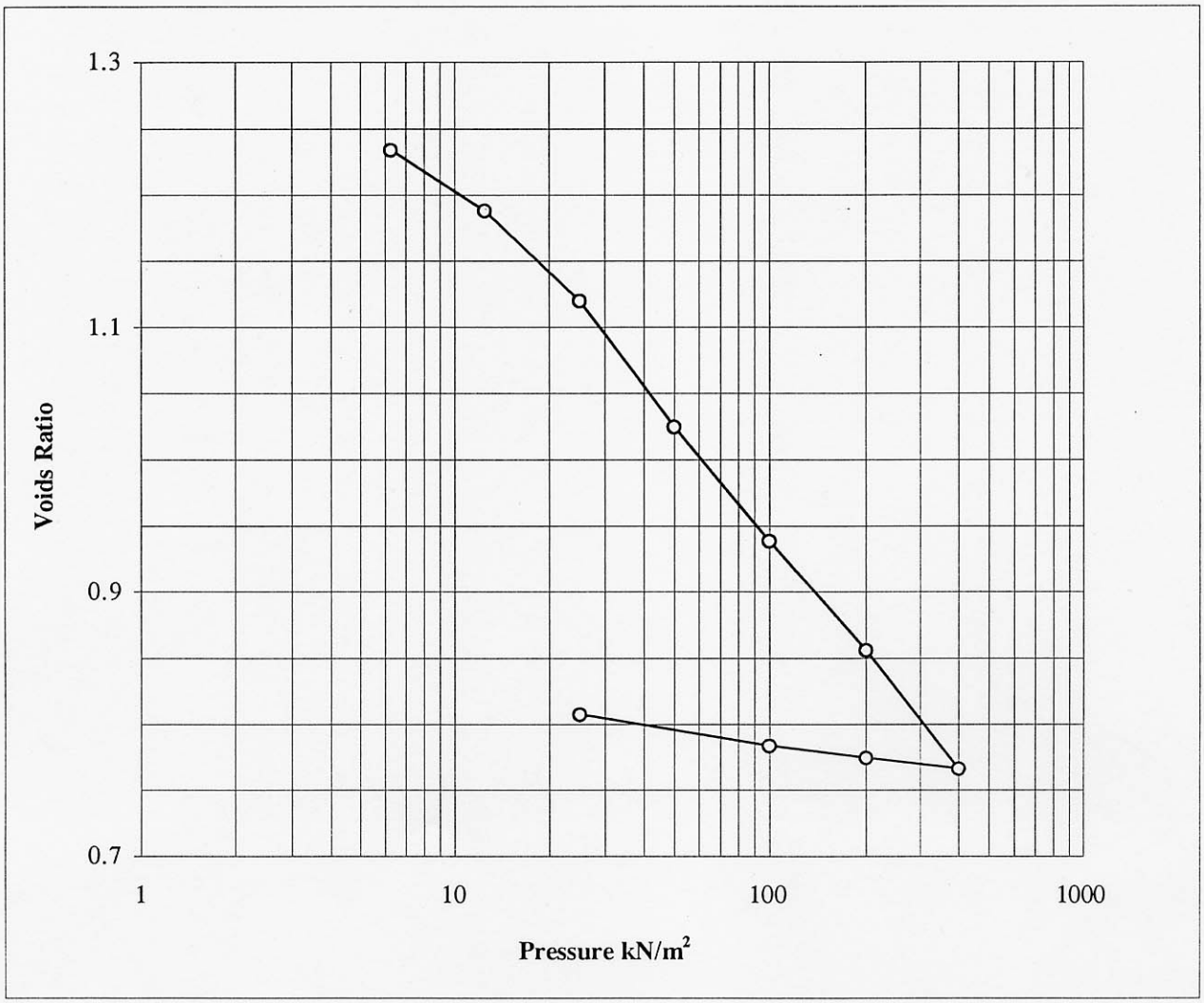
Date 24-Jun-99

Sample No: 16/28 SC002
Borehole No:
Depth: 0.55 - 0.58m.



JOB: Rockall DATE: 12/07/99

SAMPLE 83/20 SC003
BOREHOLE NO:
DEPTH: 0.75- 0.78m.



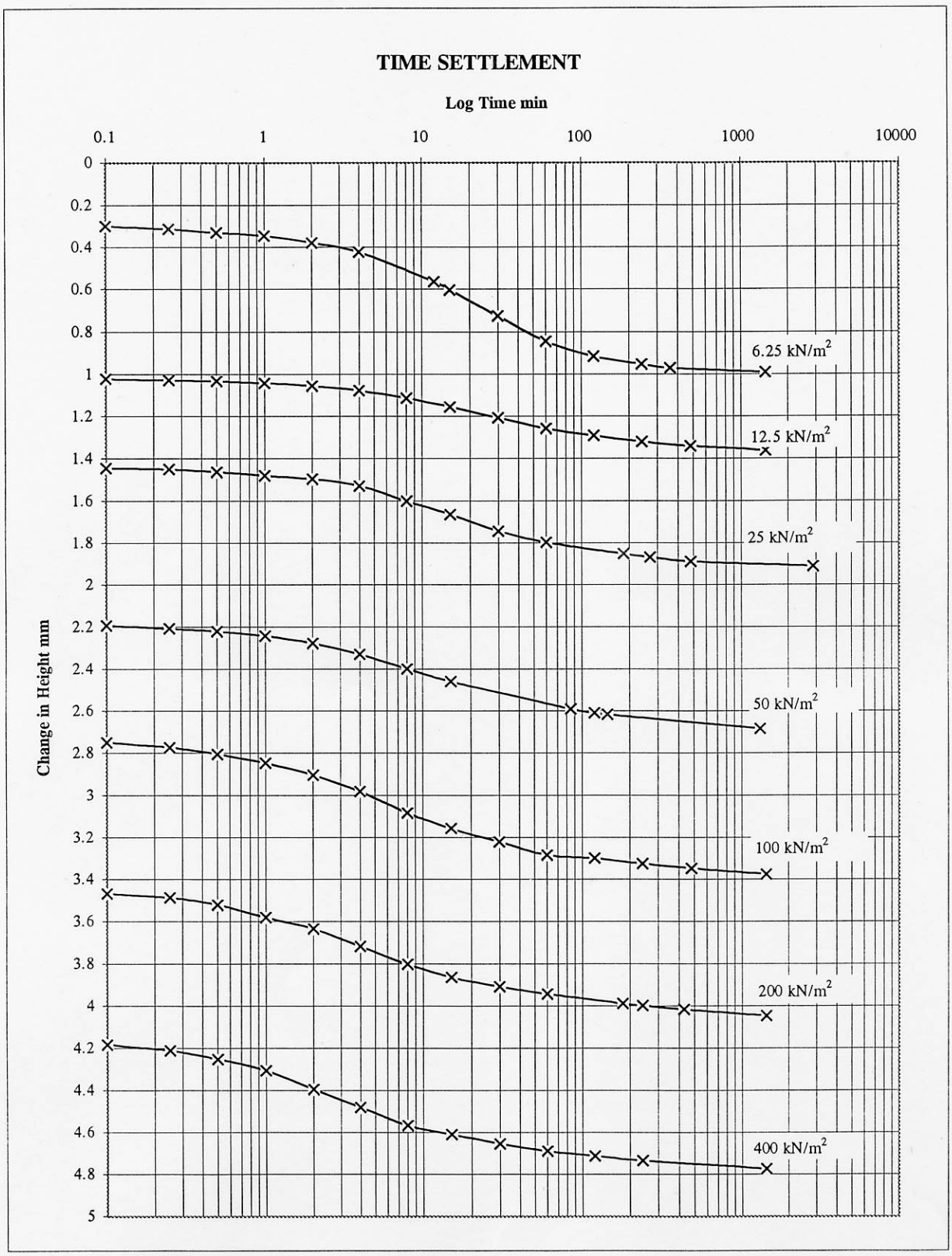
Visual Description : Soft grey clay

Specimen height mm	19.05		Bulk Density Mg/m3	1.67
Specimen diameter	76.2		Dry Density Mg/m3	1.15
Specific Gravity	2.7	(measured)	Degree of saturation	91.84
w% trimmings	48.75		Initial voids ratio	1.3567
w% specimen	46.15			

Pressure range kN/m²		m_v m²/MN	c_v (log) m²/yr	c_v (root) m²/yr
0	6.25	8.3318	0.6393	0.6369
6.25	12.5	3.2960	0.5536	0.5909
12.5	25	2.4878	0.9852	0.7277
25	50	1.7974	1.1767	1.6845
50	100	0.8481	1.6680	2.3252
100	200	0.4275	2.4463	2.9011
200	400	0.2420	2.3216	3.8060

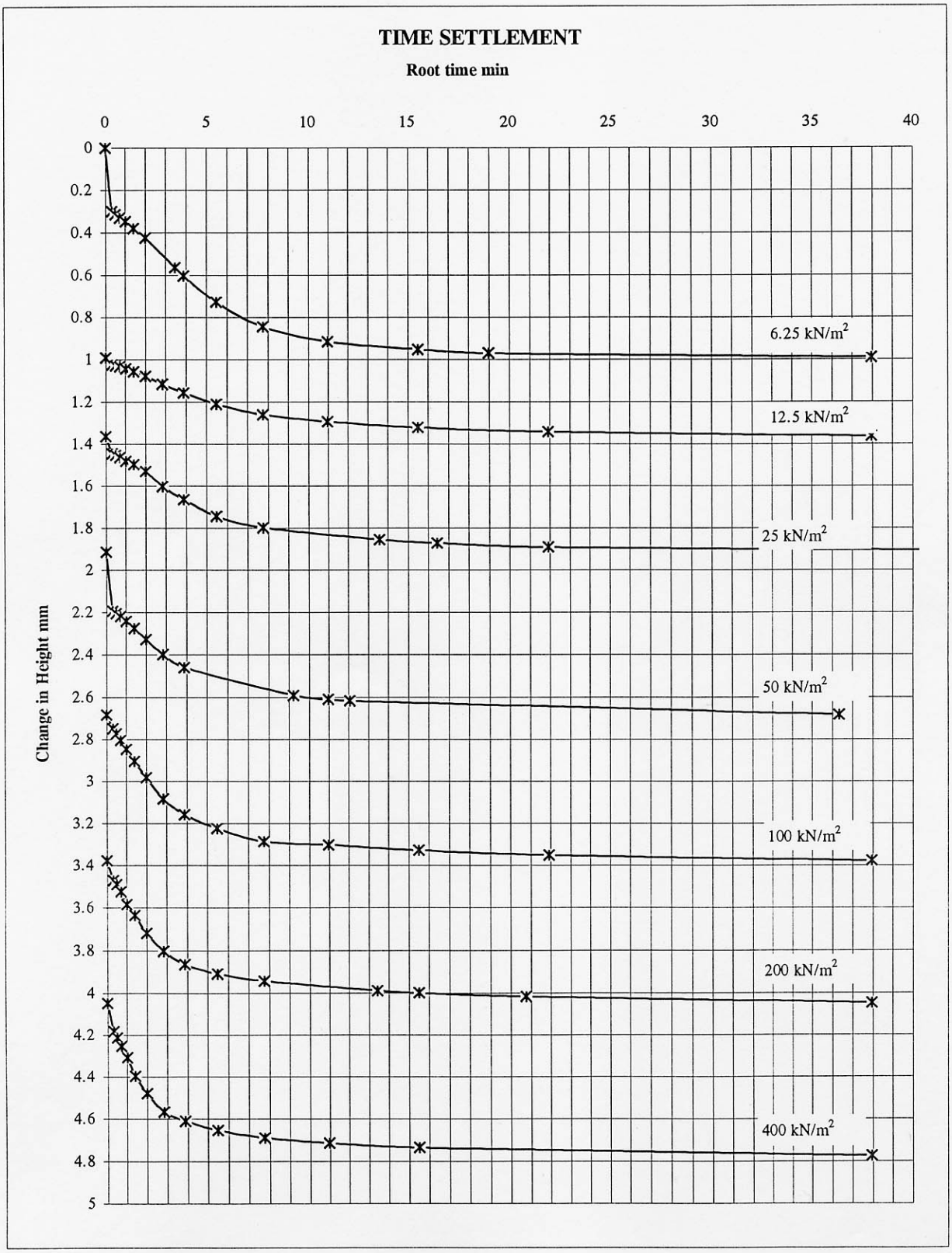
JOB:Rockall DATE: 12/07/99

SAMPLE NO: 83/20 SC003
BOREHOLE NO:
DEPTH: 0.75 - 0.78m .



JOB: Rockall DATE: 12/07/99

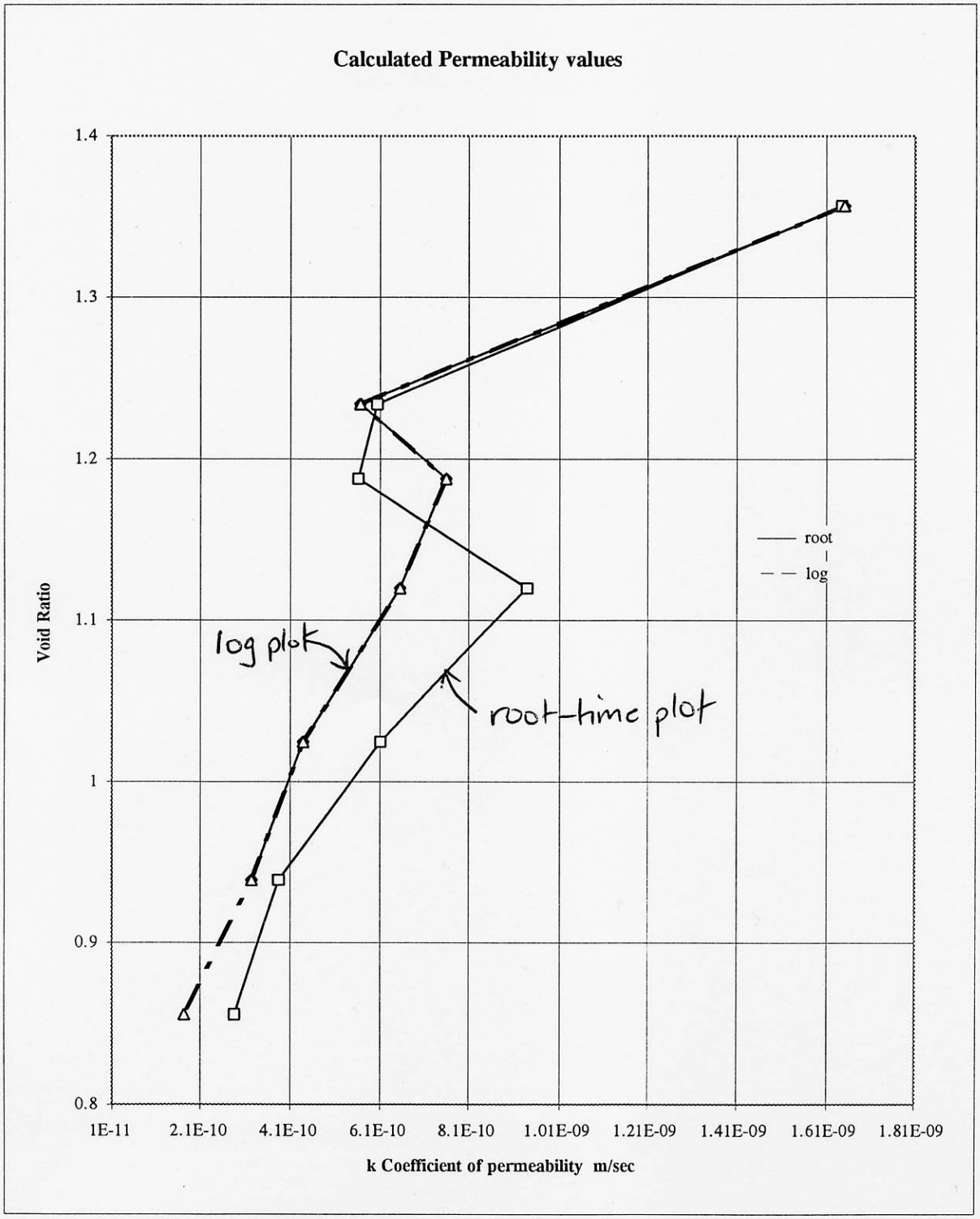
SAMPLE NO: 83/20 SC003
BOREHOLE NO:
DEPTH: 0.75- 0.78m.



Job: Rockall

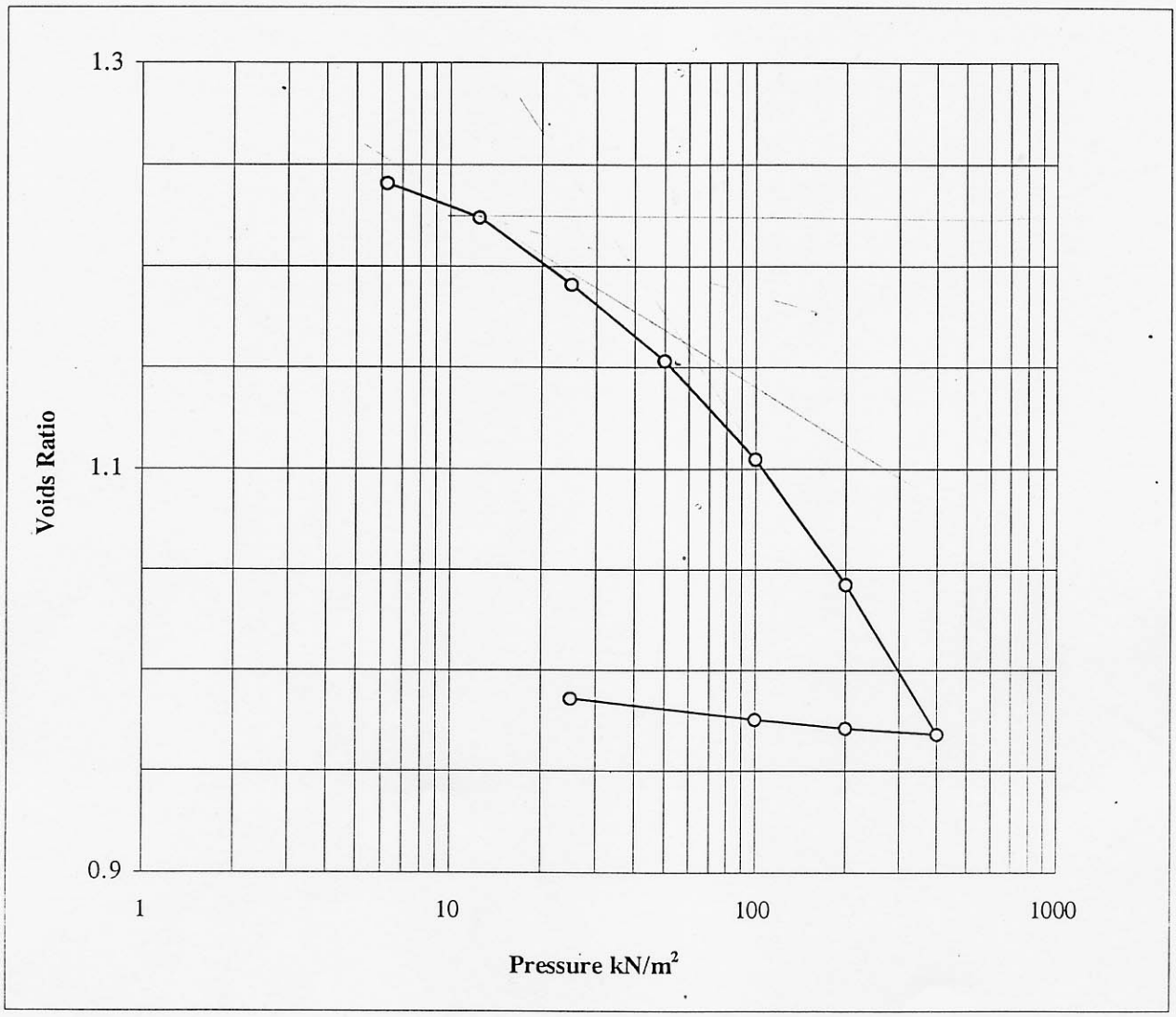
Date 12/07/99

Sample No: 83/20 SC003
Borehole No:
Depth: 0.75 - 0.78m.



JOB: Rockall DATE: 08/07/99

SAMPLE 78/28 SC007
BOREHOLE NO:
DEPTH: 0.87- 0.90m.



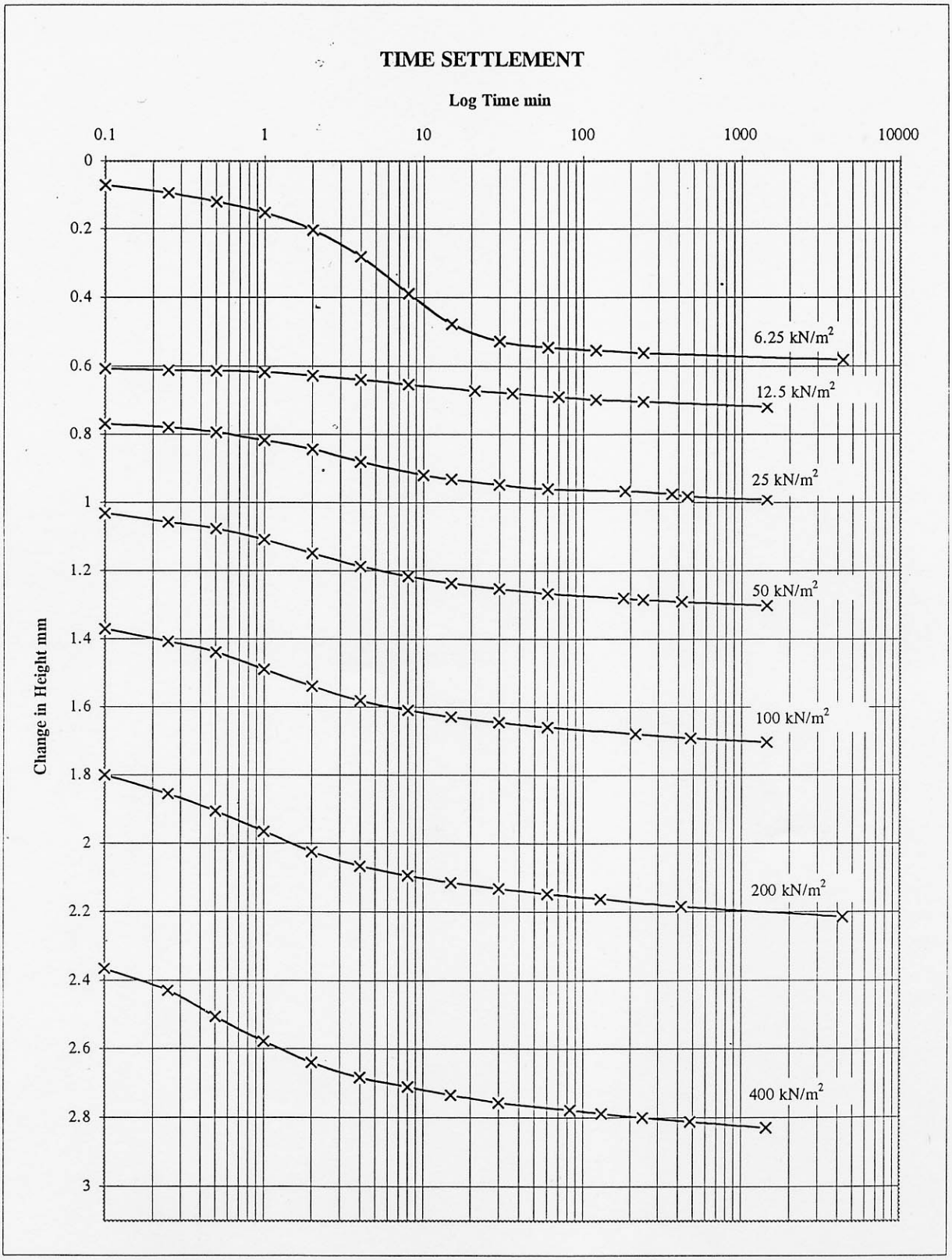
Visual Description : Soft beige clay

Specimen height mm	19.05		Bulk Density Mg/m3	1.64
Specimen diameter	76.2		Dry Density Mg/m3	1.08
Specific Gravity	2.49	(measured)	Degree of saturation	99.72
w% trimmings	48.74		Initial voids ratio	1.3114
w% specimen	52.52			

Pressure range kN/m²		m_v m²/MN	c_v (log) m²/yr	c_v (root) m²/yr
0	12.5	4.8882	2.2874	2.4413
12.5	25	1.1956	2.2004	2.3485
25	50	1.1871	3.7420	4.6867
50	100	0.6911	6.4096	7.3499
100	200	0.4508	10.0055	8.5432
200	400	0.2952	15.1875	14.4087

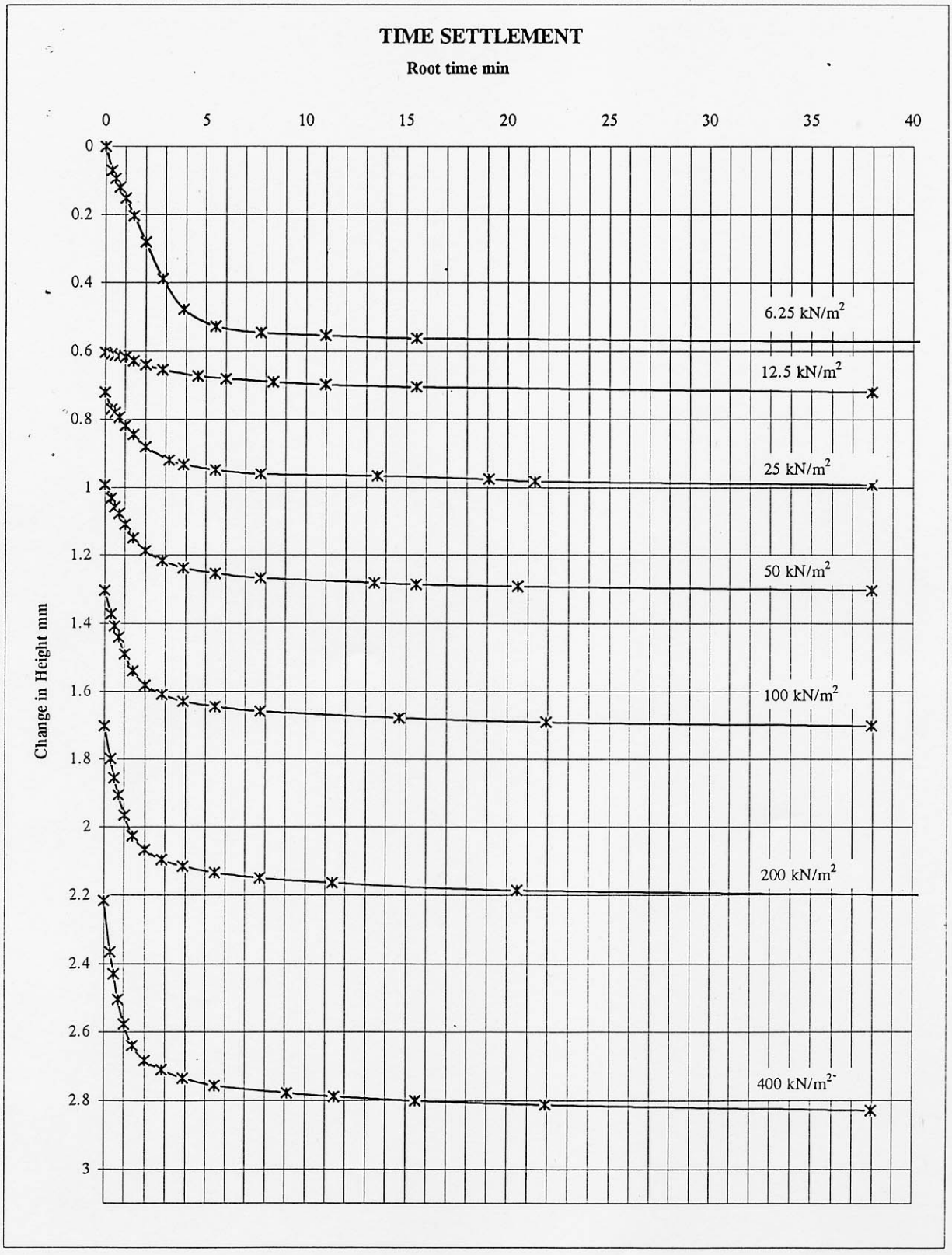
JOB:Rockall DATE: 08/07/99

SAMPLE NO: 78/28 SC007
BOREHOLE NO:
DEPTH: 0.87- 0.90mm.



JOB: Rockall DATE: 08/07/99

SAMPLE NO: 78/28 SC007
BOREHOLE NO:
DEPTH: 0.87- 0.90m.



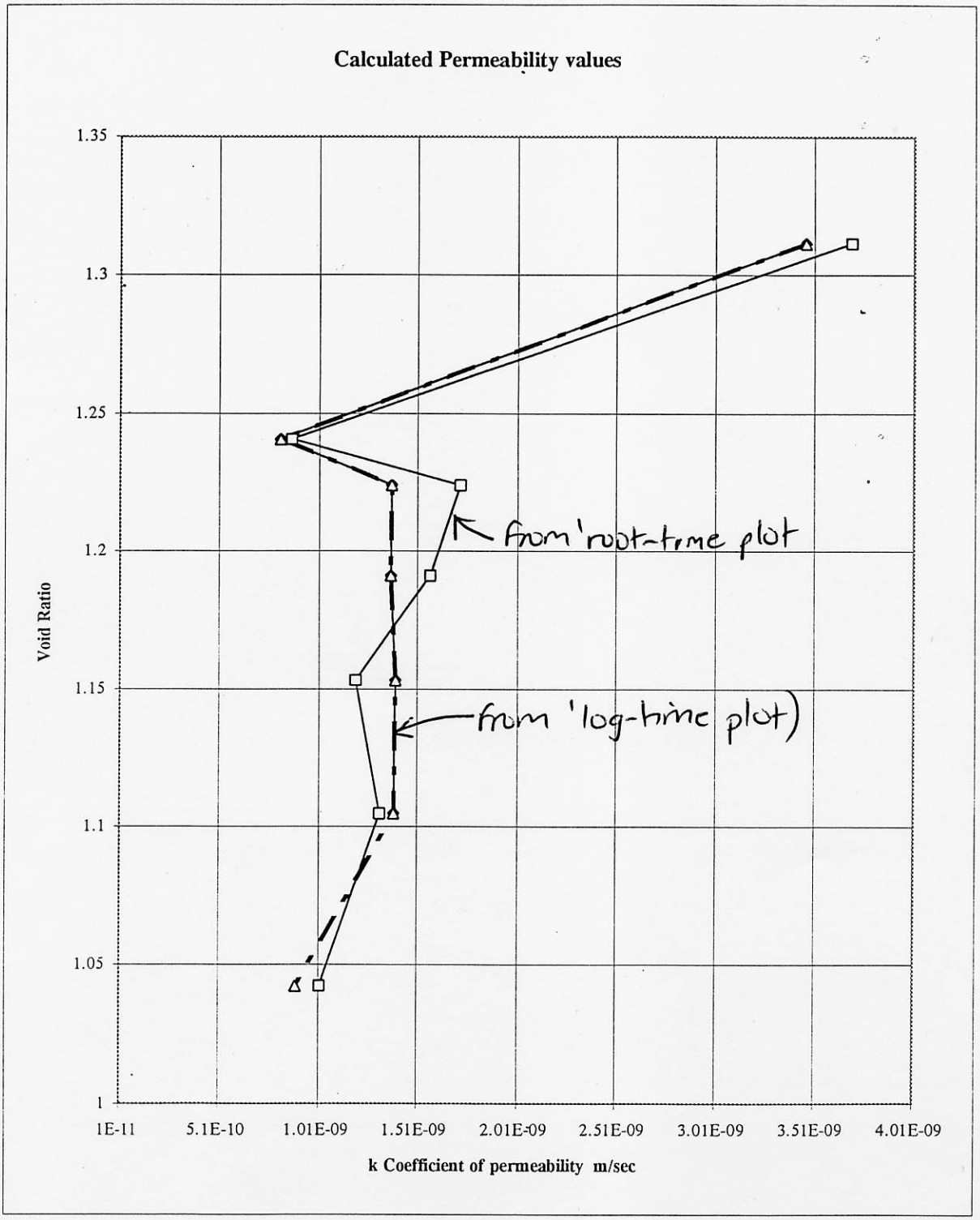
Job: Rockall

Date 08/07/99

Sample No: 78/28 SC007

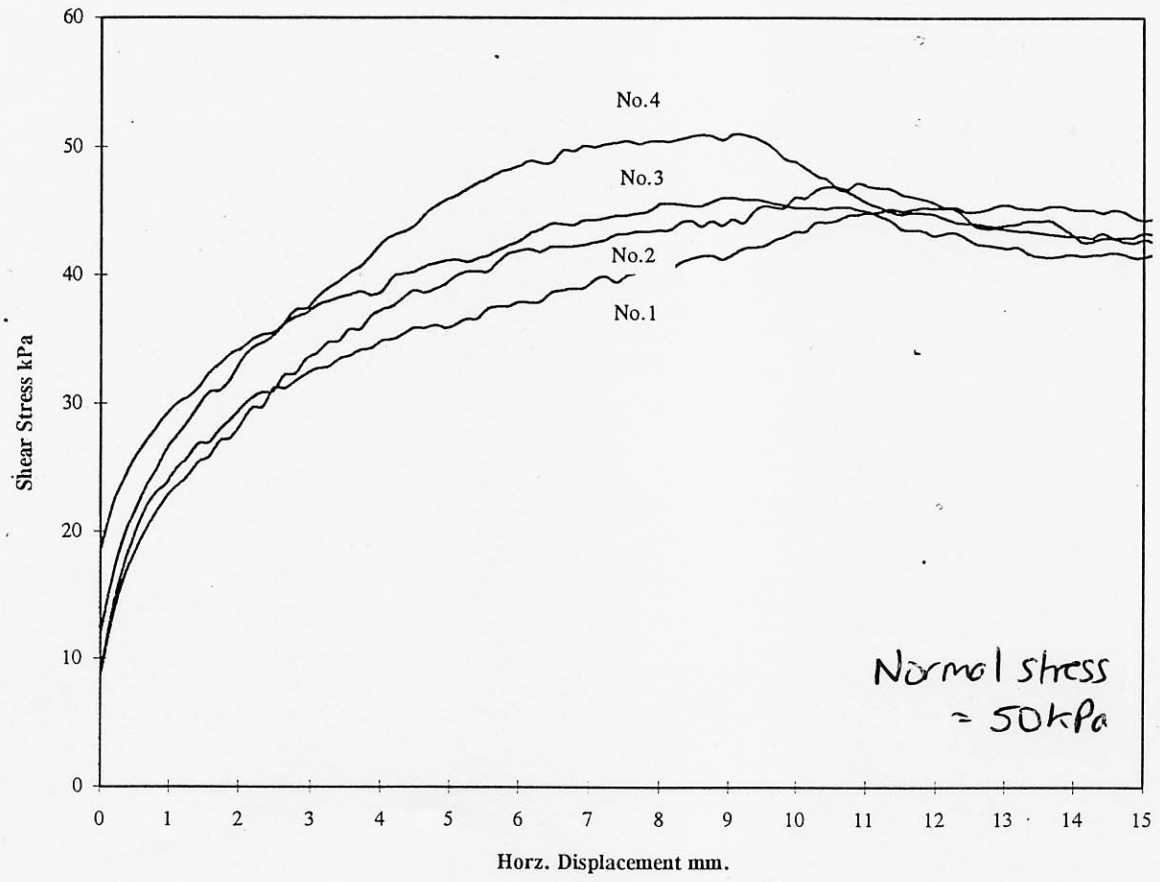
Borehole No:

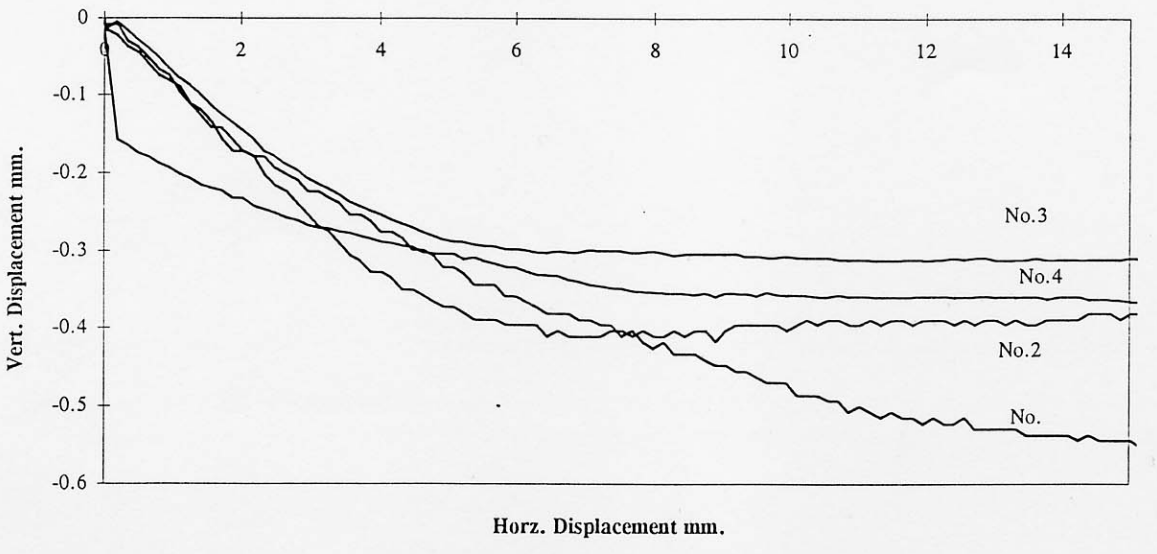
Depth: 0.87 - 0.90m.



Job:Rockall
Sample No. 16/28 SC002 0.9 -0.95m

Consolidated Drained Shearbox Test





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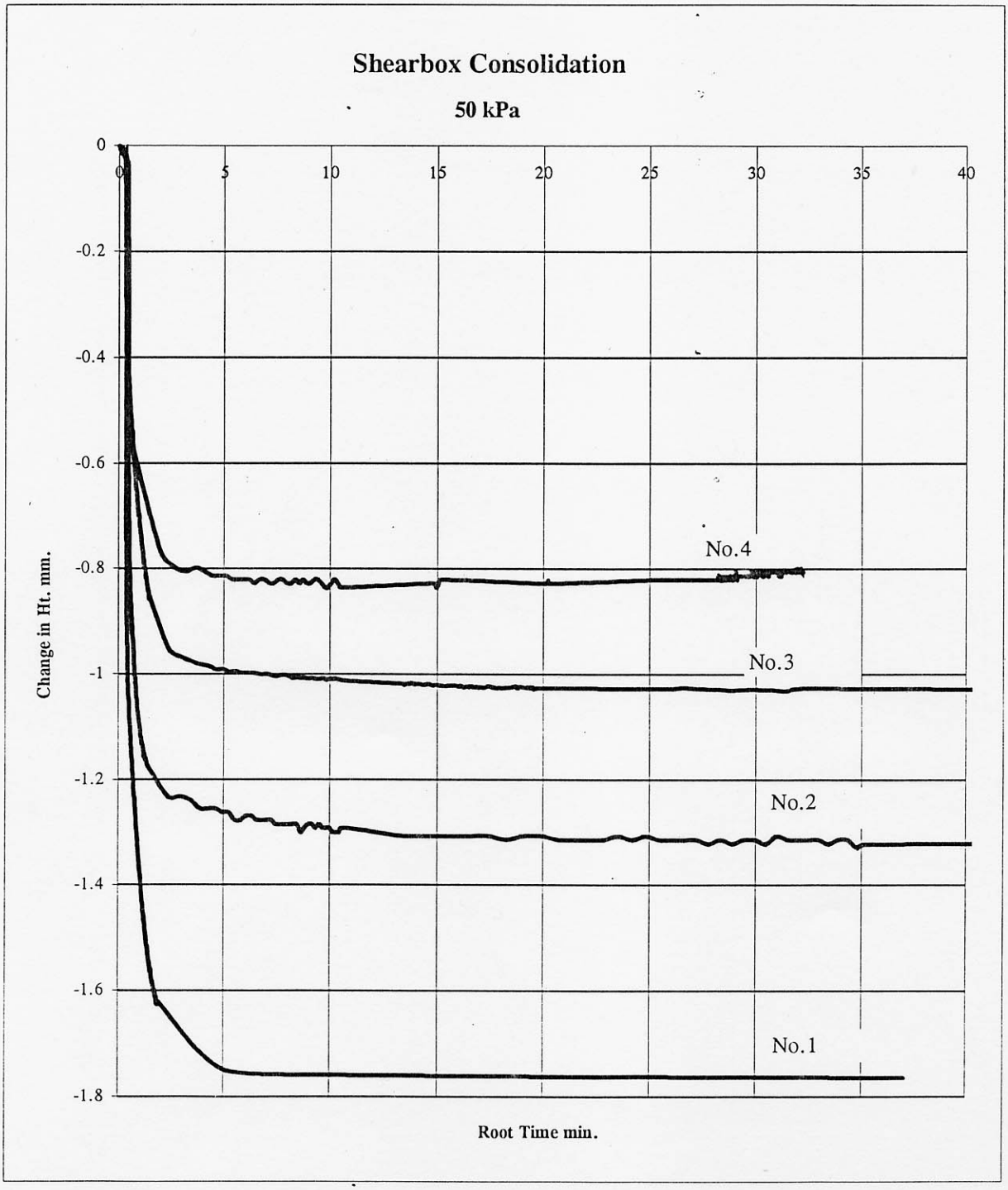
Trinity College, Dublin.

Job: Rockall
Sample No: 16/28 SC002 0.9 - 0.95m..



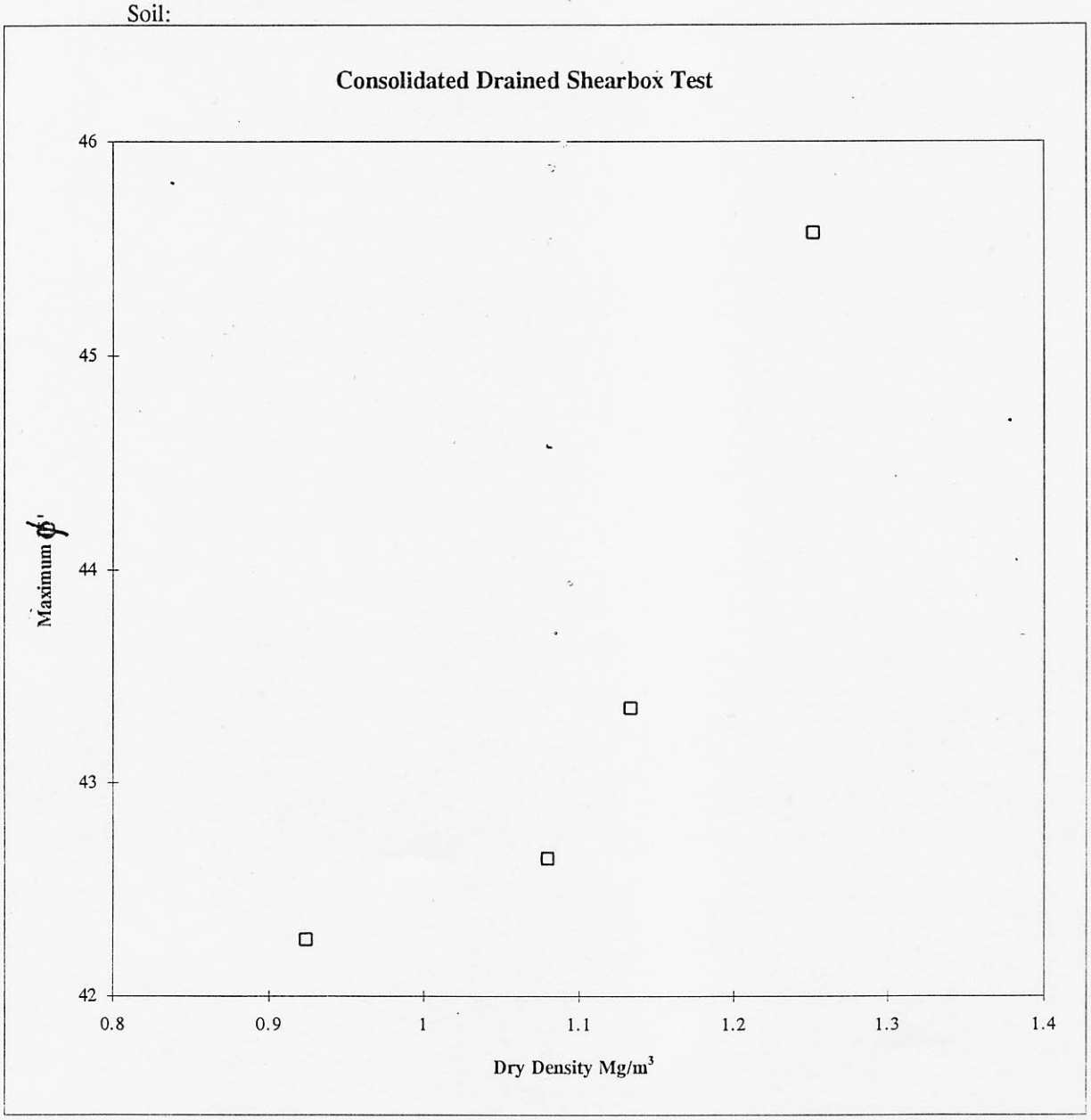
Geotechnical Laboratories,
Trinity College, Dublin

Job: Rockall

Date: 26.5.99

Sample No. 16/28 SC002 0.9 - 0.95m.

Soil:



Peak Shear Stress kPa	Initial B.D. Mg/m^3	B.D. after Consolidation Mg/m^3	W/C After test %	Dry Density after Consolidation Mg/m^3
45.44	1.522	1.669	64.7	0.924
46.05	1.608	1.722	59.5	1.080
47.2	1.663	1.753	54.8	1.133
51.01	1.737	1.81	44.7	1.251

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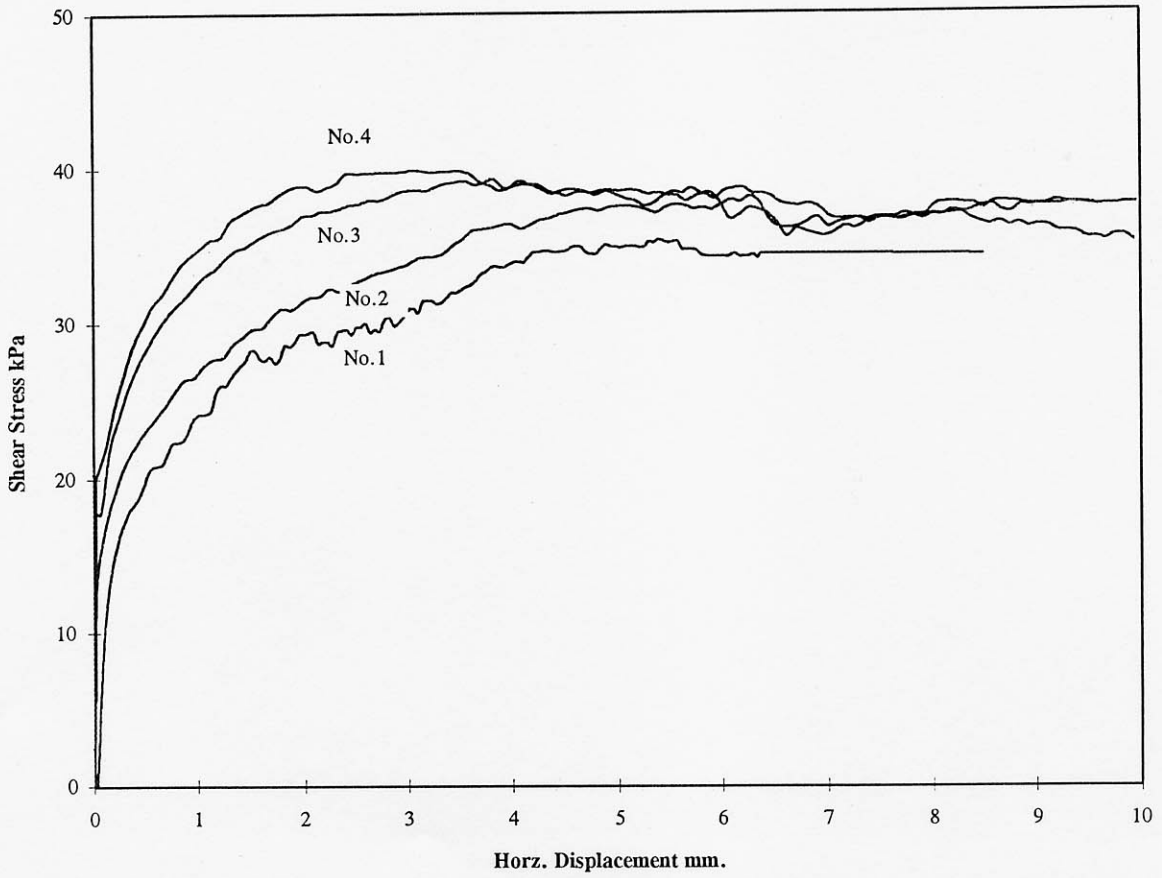
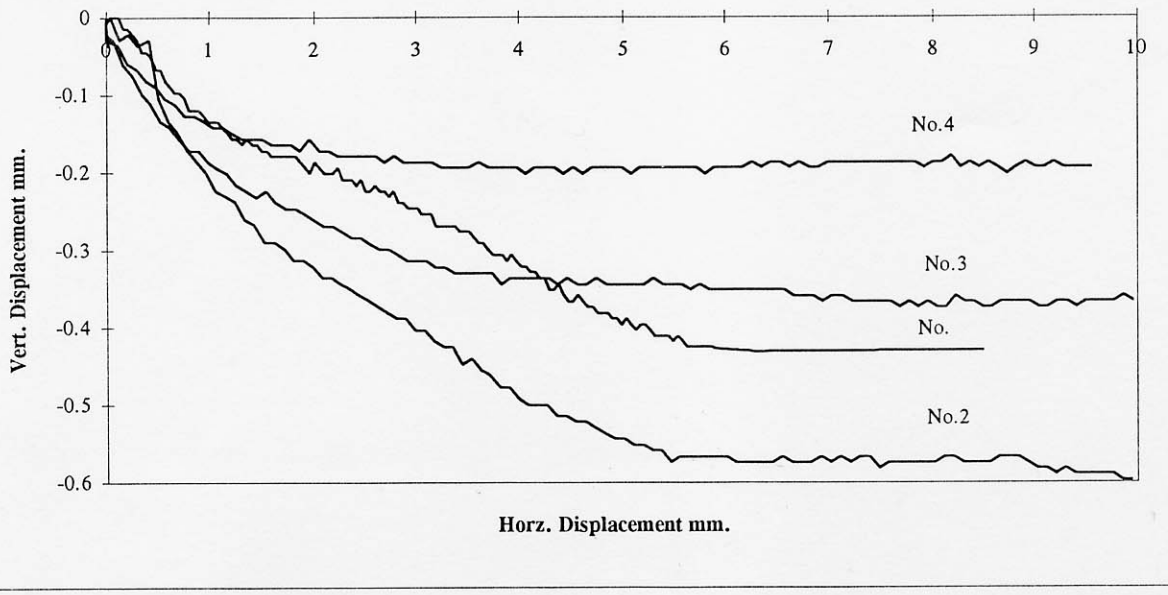
Job:Rockall
Sample No .83/20 SC003 0.68 - 0.75m

Date 13.7.99

Consolidated Drained Shearbox Test





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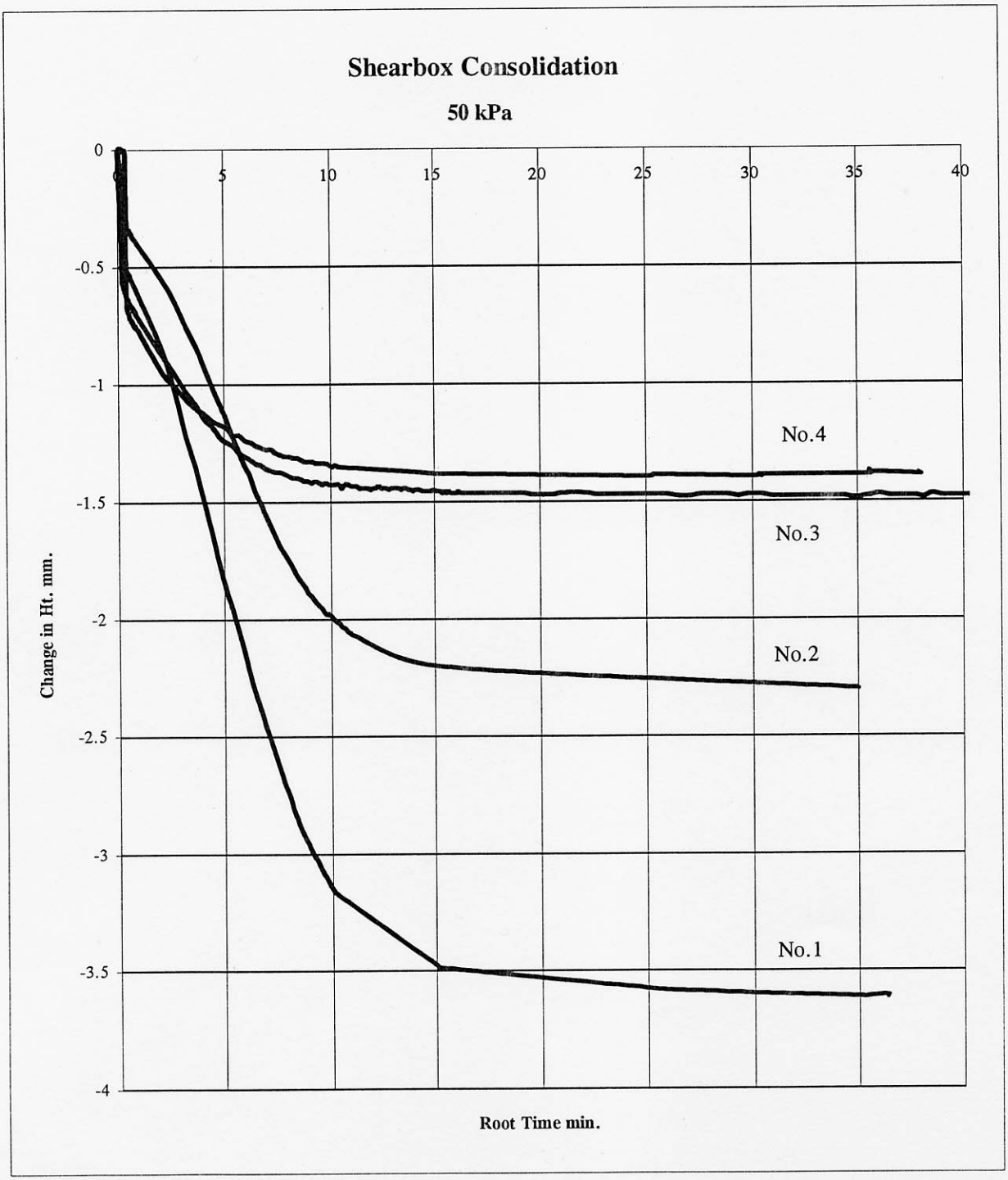
Job: Rockall
Sample No: 83/20 SC003 0.68 - 0.75m..

Date 13.7.99



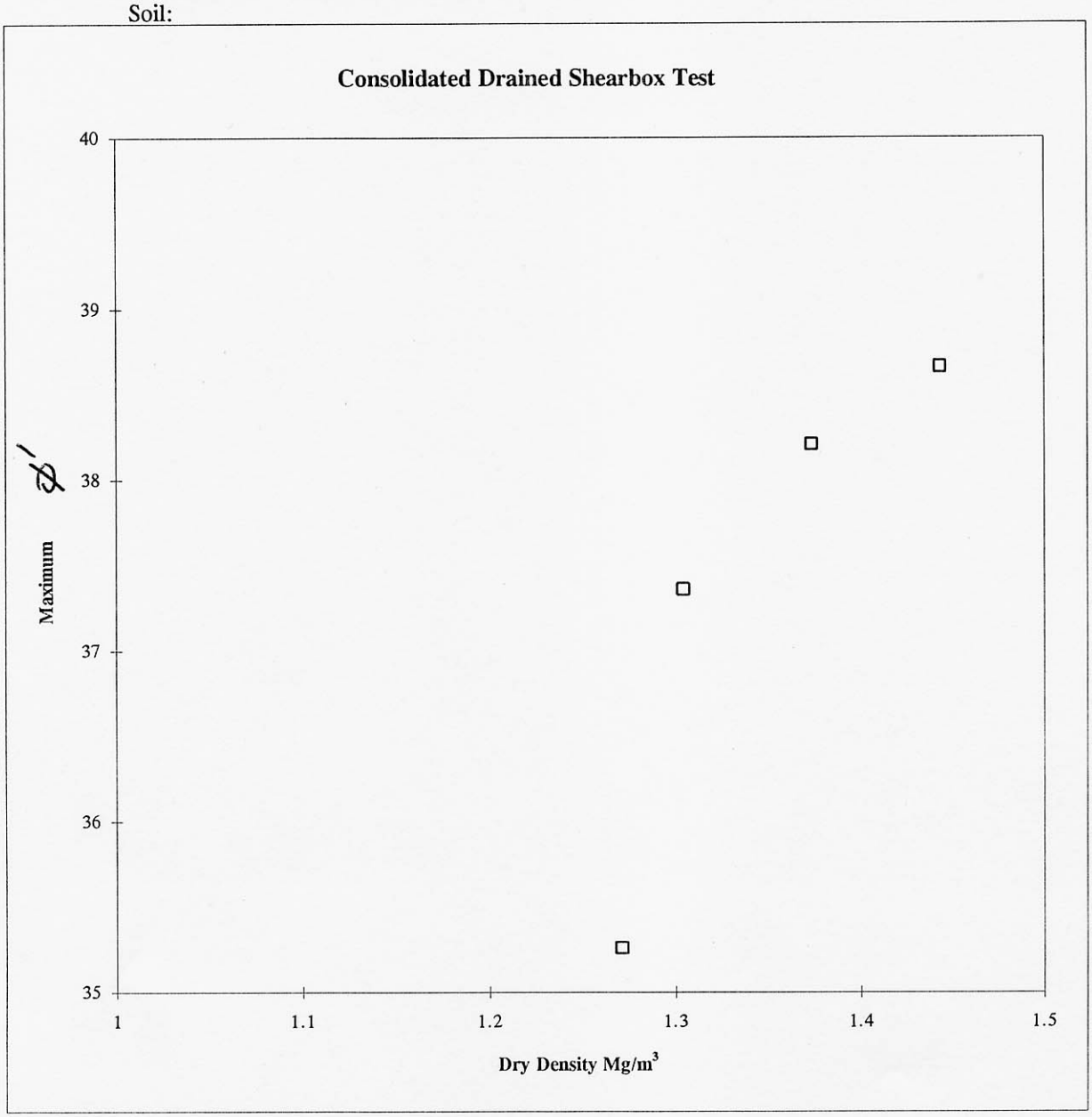
Geotechnical Laboratories,
Trinity College, Dublin

Job: Rockall

Date: 13.7.99

Sample No. 83/20 SC003 0.68 - 0.75m.

Soil:



Peak Shear Stress kPa	Initial B.D. Mg/m^3	B.D. after Consolidation Mg/m^3	W/C After test %	Dry Density after Consolidation Mg/m^3
35.35	1.59	1.94	52.7	1.271
38.18	1.68	1.9	45.7	1.304
39.36	1.76	1.9	38.6	1.373
40.01	1.84	1.97	36.7	1.443

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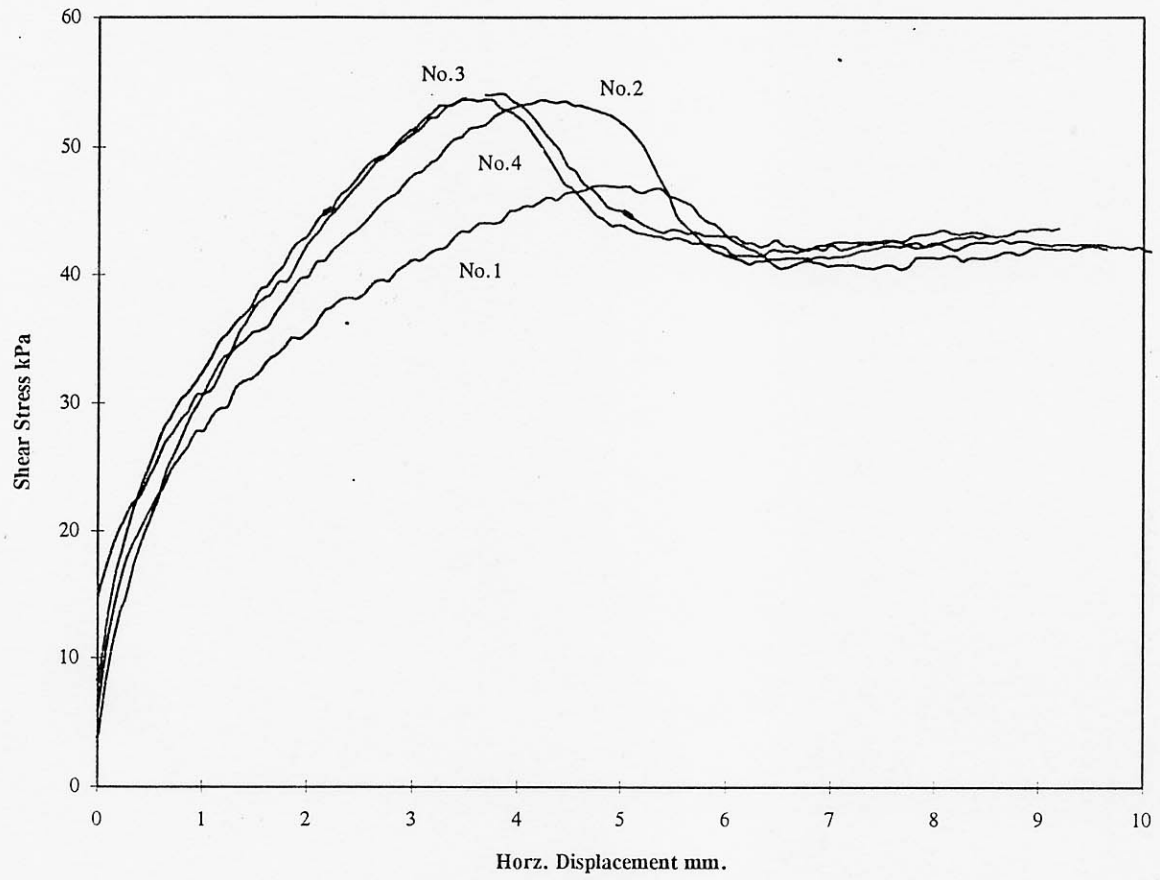
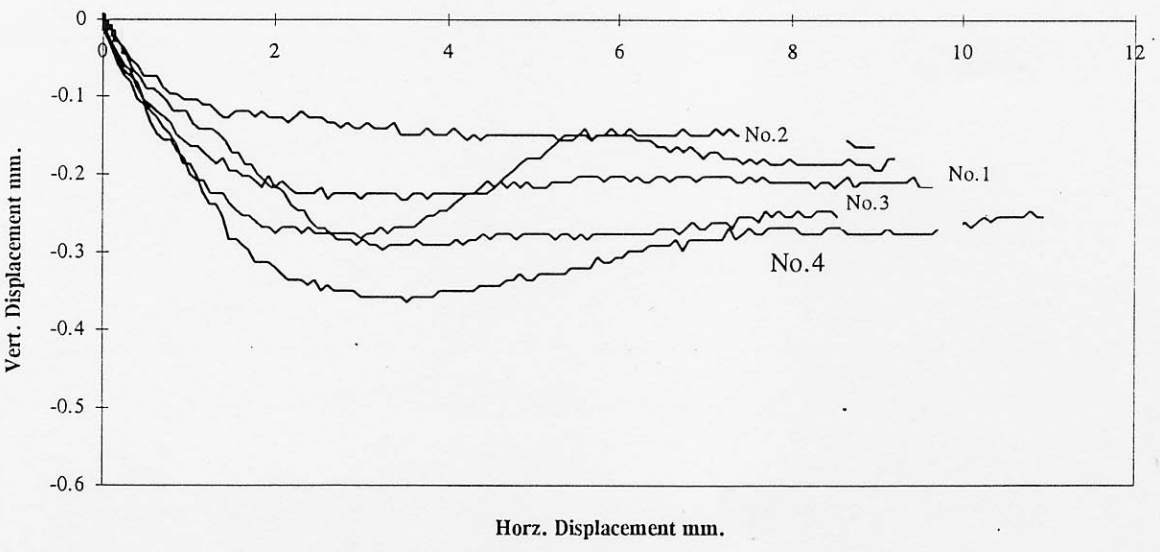
Job:Rockall

Date 23.6.99

Sample No. 78/28 SC007 1.2 - 1.25m

Consolidated Drained Shearbox Test





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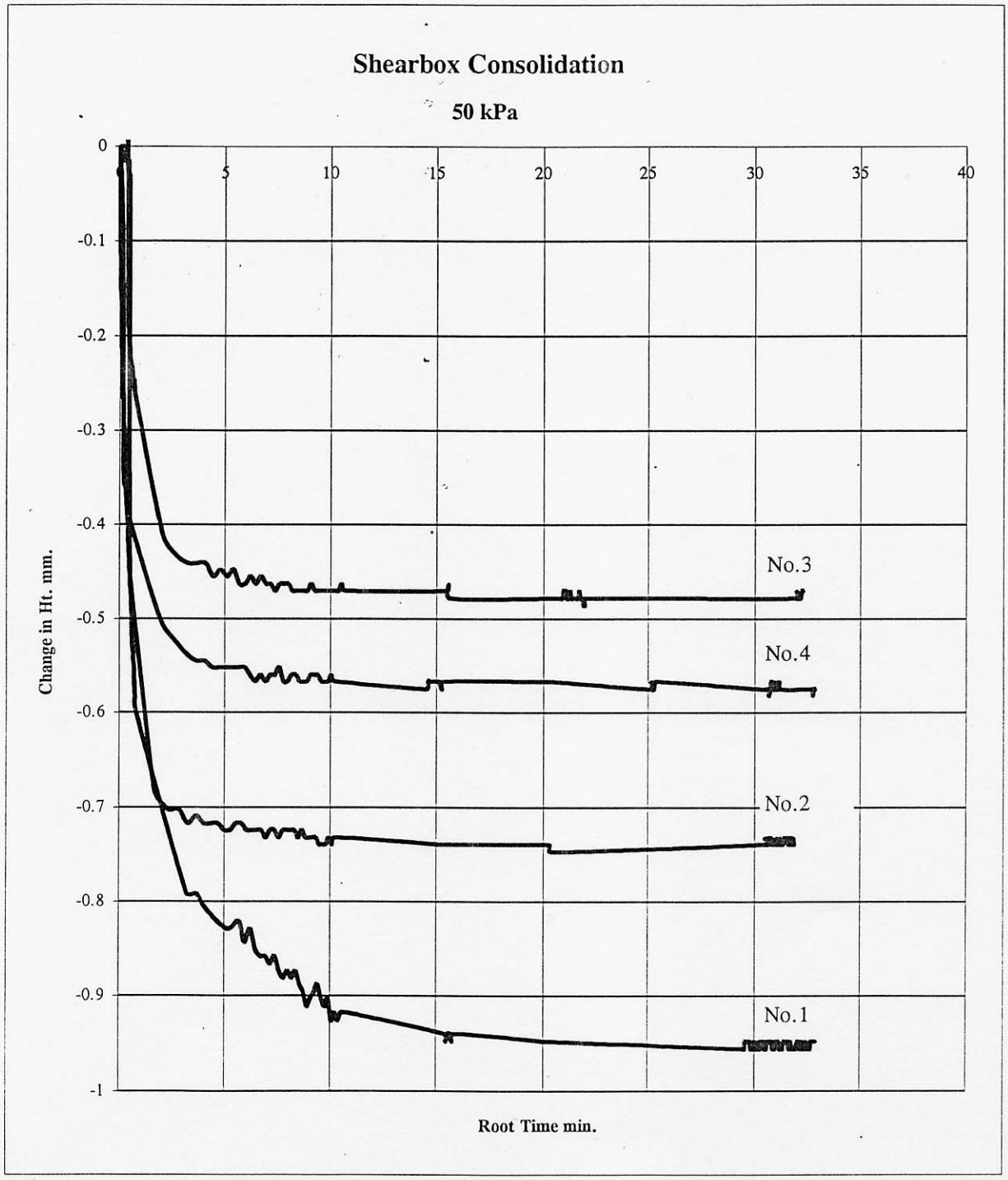
Job: Rockall
Sample No: 78/28 SC007 1.2 - 1.25m..

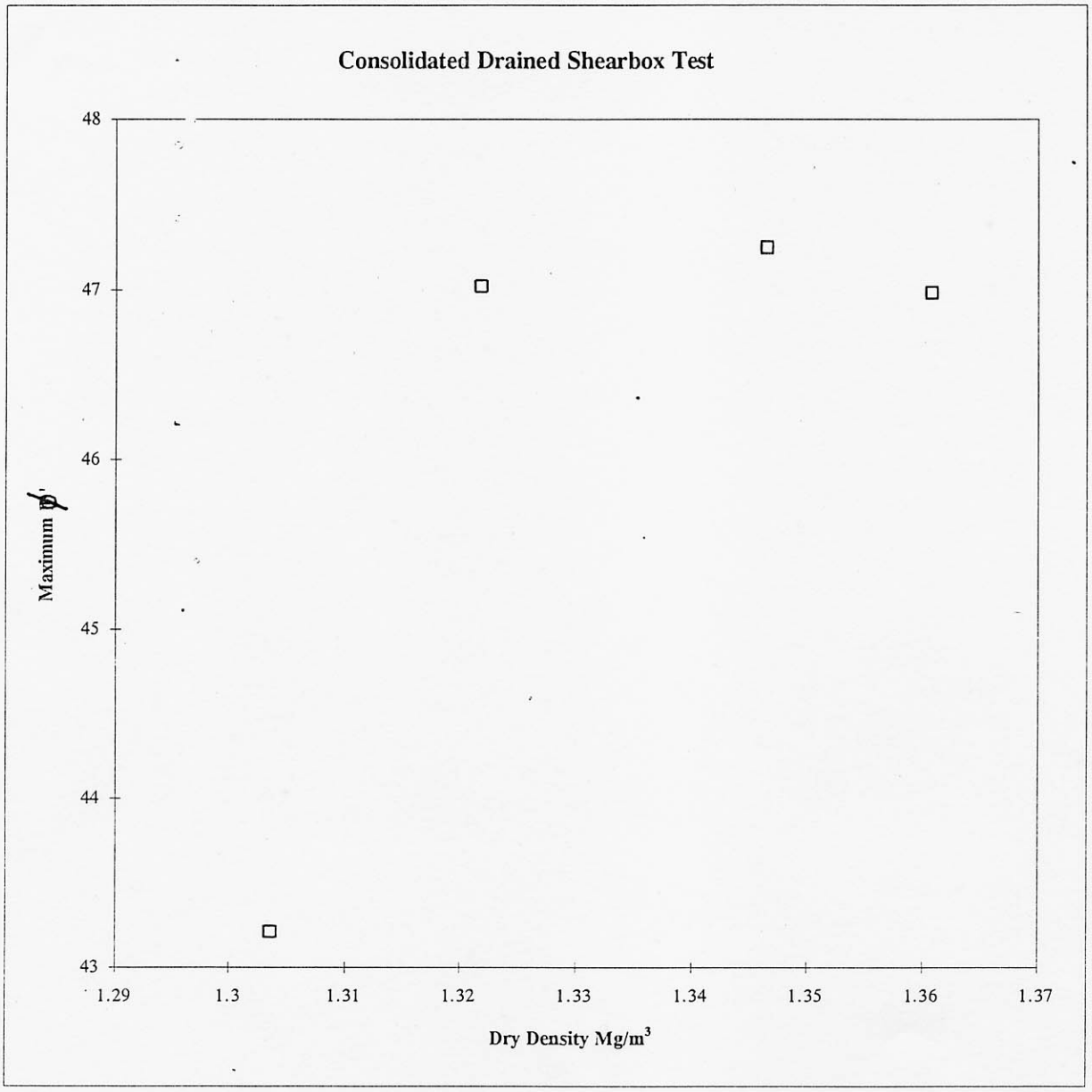


Geotechnical Laboratories,
Trinity College, Dublin

Job: Rockall

Date: 23.6.99

Sample No. 78/28 SC007 1.2 - 1.25m.



Peak Shear Stress kPa	Initial B.D. Mg/m^3	B.D. after Consolidation Mg/m^3	W/C After test %	Dry Density after Consolidation Mg/m^3
46.97	1.747	1.834	40.7	1.304
53.59	1.816	1.886	38.6	1.361
54.09	1.784	1.827	35.7	1.347
53.56	1.679	1.729	30.8	1.322

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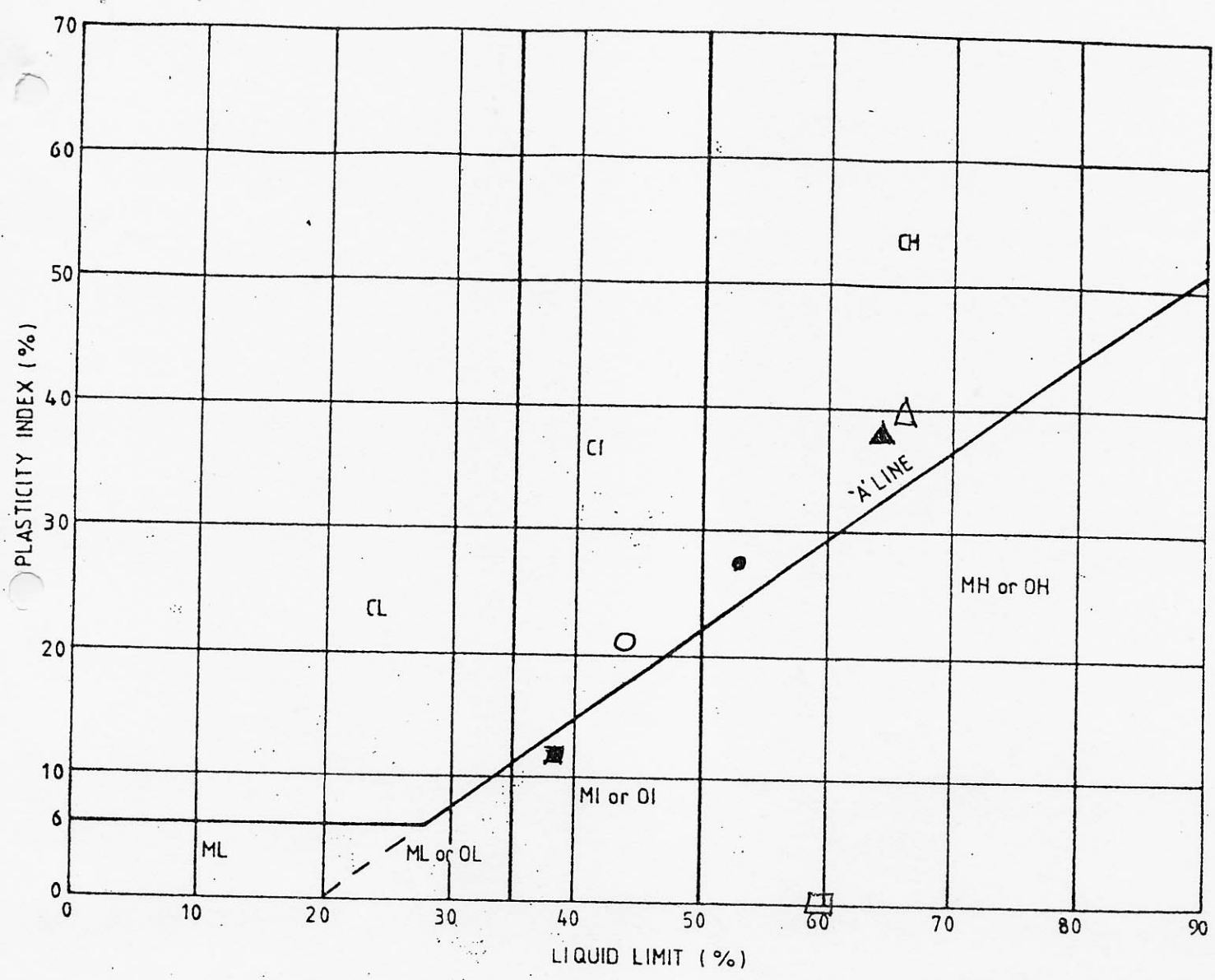


The fine grained soils are divided into three groups:

M Inorganic silts
C Inorganic clays
O Organic silts & clays

The soils are further divided into liquid limits of:

L Lower than 35%
I Between 35% & 50%
H Higher than 50%

- ● 83/20 SC003 2.2/2.3m
- ○ 83/21 SC003 1.5/1.6m
- ■ 83/24 SC002 0.65/0.8m
- □ 83/24 SC002 1.4/1.5m
- ▲ 11/20 SC002 0.4/0.6m
- △ 11/20 SC003 1.1/1.3m

Draft

Plasticity Chart

RSG

Liquid limit (cone penetrometer) and plastic limit

Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG

BH 83/24 SC002 0.65 / 0.8 m

							Operator:	GC									
							Checked:	ML									
Liquid Limit Sample 1							Date:	11/06/99									
Test No.	1			2			3			4			5				
Dial Gauge Readings																	
Average Penetration (mm)	13.80			17.7			18.1			24.2			22.4				
Container Designation	12			17			18			104			I				
Mass of wet Soil + Container	26.31			26.19			25.33			29.3			18.8				
Mass of dry Soil + Container	23.05			22.89			22.23			24.9			16.0				
Mass of Container	14.04			14.08			14.08			13.91			9.1				
Mass of Moisture	3.26			3.3			3.1			4.4			2.8				
Mass of dry Soil	9.01			8.8			8.15			11.0			6.9				
Moisture Content	36.2%			37.5%			38.0%			40.0%			40.2%				
Liquid Limit	38.7%																
Plastic Limit Sample 1																	
Test No.	1	2	3	4	Average												
Container no	2	3	9														
Mass of wet Soil + Container	20.21	18.23	19.71														
Mass of dry Soil + Container	18.92	17.34	18.50														
Mass of Container	14.07	14.01	14.01														
Mass of Moisture	1.29	0.89	1.21	0.0													
Mass of dry Soil	4.85	3.33	4.49	0.0													
Moisture Content	26.6%	26.7%	26.9%	#DIV/0!	26.8%												
Plasticity Index	12%																

Liquid limit (cone penetrometer) and plastic limit

Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG

BH 83/24 SC002 1.4 / 1.5 m

Operator: GC
Checked: ML
Date: 11/06/99

Liquid Limit Sample 1

Test No.	1	2	3	4	5
Dial Gauge Readings					"Natural"
Average Penetration (mm)	14.70	15.6	20.9	25.4	21.8
Container Designation	21	131	11	3	15
Mass of wet Soil + Container	23.22	25.83	24.65	24.83	16.89
Mass of dry Soil + Container	19.96	21.53	20.81	20.7	13.7
Mass of Container	14.25	14.14	14.15	13.92	8.68
Mass of Moisture	3.26	4.3	3.84	4.2	3.2
Mass of dry Soil	5.71	7.4	6.66	6.8	5.0
Moisture Content	57.1%	58.2%	57.7%	61.4%	62.9%

Liquid Limit 59.7%

Original nmc = 74%

Plastic Limit Sample 1

Test No.	1	2	3	4	Average
Container no					
Mass of wet Soil + Container					
Mass of dry Soil + Container					
Mass of Container					
Mass of Moisture	0.00	0.00	0.00	0.0	
Mass of dry Soil	0.00	0.00	0.00	0.0	
Moisture Content	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Plasticity Index: Non plastic too sandy

Liquid limit (cone penetrometer) and plastic limit

Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG

BH 83/20 SC003 1.5 / 1.6 m

Operator:	GC
Checked:	ML
Date:	11/06/99

Liquid Limit Sample 1

Test No.	1	2	3	4	5
Dial Gauge Readings					
Average Penetration (mm)	13.5	16.2	18.8	20.5	24.7
Container Designation	21	131	11	3	15
Mass of wet Soil + Container	22.0	23.34	23.12	25.24	16.5
Mass of dry Soil + Container	19.7	20.71	20.48	21.8	14.0
Mass of Container	14.2	14.14	14.14	13.92	8.68
Mass of Moisture	2.2	2.63	2.64	3.4	2.5
Mass of dry Soil	5.5	6.6	6.34	7.9	5.3
Moisture Content	40.1%	40.0%	41.6%	43.5%	47.8%

Liquid Limit 43.6%

Plastic Limit Sample 1

Test No.	1	2	3	4	Average
Container no	103	14	23		
Mass of wet Soil + Container	19.85	18.73	18.05		
Mass of dry Soil + Container	18.81	17.85	17.32		
Mass of Container	14.13	14.11	14.07		
Mass of Moisture	1.04	0.88	0.73	0.0	
Mass of dry Soil	4.68	3.74	3.25	0.0	
Moisture Content	22.2%	23.5%	22.5%	#DIV/0!	22.7%

Plasticity Index 21%

Liquid limit (cone penetrometer) and plastic limit
Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG
BH 83/20 SC003 2.2 / 2.3 m

Operator:	GC
Checked:	ML
Date:	17/06/99

Liquid Limit Sample 1

Test No.	1			2			3			4			5		
Dial Gauge Readings															
Average Penetration (mm)	14.4			15.6			18.2			20.3			23.3		
Container Designation	21			131			11			3			15		
Mass of wet Soil + Container	25.2			22.95			27.54			26.01			23.81		
Mass of dry Soil + Container	21.9			20.02			23			21.8			18.4		
Mass of Container	14.3			14.14			14.15			13.92			8.68		
Mass of Moisture	3.2			2.93			4.54			4.2			5.4		
Mass of dry Soil	7.7			5.9			8.85			7.9			9.8		
Moisture Content	42.1%			49.8%			51.3%			53.6%			55.2%		

Liquid Limit 53.0%

Plastic Limit Sample 1

Test No.	1	2	3	4	Average
Container no	103	14	23		
Mass of wet Soil + Container	19.58	21.01	19.56		
Mass of dry Soil + Container	18.48	19.62	18.47		
Mass of Container	14.13	14.11	14.07		
Mass of Moisture	1.10	1.39	1.09	0.0	
Mass of dry Soil	4.35	5.51	4.40	0.0	
Moisture Content	25.3%	25.2%	24.8%	#DIV/0!	25.1%

Plasticity Index 28%

Liquid limit (cone penetrometer) and plastic limit

Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG

BH 11/20 SC002 0.4 / 0.6 m

Operator: GC
Checked: ML
Date: 11/06/99

Liquid Limit Sample 1

Test No.	1	2	3	4	5
Dial Gauge Readings					
Average Penetration (mm)	16.00	17	19.5	22.0	
Container Designation	12	17	18	104	
Mass of wet Soil + Container	24.70	26.58	27.4	29.37	
Mass of dry Soil + Container	20.60	21.73	22.18	23.2	
Mass of Container	14.04	14.08	14.08	13.91	
Mass of Moisture	4.10	4.85	5.22	6.2	
Mass of dry Soil	6.56	7.7	8.1	9.2	
Moisture Content	62.5%	63.4%	64.4%	67.3%	

Liquid Limit 65.5%

Plastic Limit Sample 1

Test No.	1	2	3	4	Average
Container no	2	3	9		
Mass of wet Soil + Container	22.91	20.03	22.48		
Mass of dry Soil + Container	21.01	18.74	20.68		
Mass of Container	14.07	14.01	14.01		
Mass of Moisture	1.90	1.29	1.80	0.0	
Mass of dry Soil	6.94	4.73	6.67	0.0	
Moisture Content	27.4%	27.3%	27.0%	#DIV/0!	27.2%

Plasticity Index 38%

Liquid limit (cone penetrometer) and plastic limit

Test to BS1377 : Part 2 : 1990 : 4.3 / 4.4

RSG

BH 11/20 SC002 1.1 / 1.3 m

							Operator:	GC									
							Checked:	ML									
Liquid Limit Sample 1							Date:	11/06/99									
Test No.	1			2			3			4			5				
Dial Gauge Readings																	
Average Penetration (mm)	14.40						17.4			19.9							
Container Designation	21			131			11			3							
Mass of wet Soil + Container	27.17			25.53			29.73			30.92							
Mass of dry Soil + Container	22.40			22.08			23.73			24.1							
Mass of Container	14.25			14.14			14.15			13.92							
Mass of Moisture	4.77			3.45			6			6.8							
Mass of dry Soil	8.15			7.9			9.58			10.2							
Moisture Content	58.5%						62.6%			67.2%							
Liquid Limit	67.1%																
Plastic Limit Sample 1																	
Test No.	1	2	3	4	Average												
Container no	103	14	23														
Mass of wet Soil + Container	23.17	23.24	21.52														
Mass of dry Soil + Container	21.26	21.33	19.93														
Mass of Container	14.13	14.11	14.07														
Mass of Moisture	1.91	1.91	1.59	0.0													
Mass of dry Soil	7.13	7.22	5.86	0.0													
Moisture Content	26.8%	26.5%	27.1%	#DIV/0!	26.8%												
Plasticity Index	40%																

BS1377 : 1990 : Part 2: 6.0

Carbonate content - rapid titration method

Operator: GC

Site: RSG

Checked: ML

Date: 4/8/99

Soil specimen		BH83/24 SC002 1.1 m	BH83/24 SC002 1.5 m	BH11/20 SC002 Mid.	BH11/20 SC002 Bot.	BH83/20 SC003 1.7 m	BH83/20 SC003 2.3 m
Specimen Reference		A	B	E	F	C	D
Mass of dry specimen (m)	g	5.07	5.03	5.09	5.39	5.13	5.31
Concentration of acid solution (H)		1	1	1	1	1	1
Volume of sodium hydroxide used (V) - Test 1	ml	10	7.8	20.7	20.2	13.2	17
Volume of sodium hydroxide used (V) - Test 2	ml	10.3	8	21.5	21.5	13.6	17.5
Carbonate content as CO_2 - Test 1*	%	26.04	30.09	7.43	7.84	20.24	13.26
Carbonate content as CO_2 - Test 2	%	25.51	29.74	6.05	5.71	19.56	12.43
Average carbonate content as CO_2	%	25.78	29.92	6.74	6.78	19.90	12.84

* = 8.8(25H-V)/m

carbcon.xls

BS1377 : 1990 : Part 2: 9.5*

Organic content H_2PO_4 method

Operator: GC

Site: RSG

Checked: ML

Date: 4/8/99

Soil		BH83/24	BH83/24	BH11/20	BH11/20	BH83/20	BH83/20
specimen		SC002	SC002	SC002	SC002	SC003	SC003
		1.1 m	1.5 m	Mid.	Bot.	1.7 m	2.3 m
Specimen No.		A	B	E	F	C	D
Organic content	%	4.60	12.96	13.84	1.06	1.14	1.54

* Note that this test is carried out as part of the preparation phase of the hydrometer test.

The results may be misleading if the soil contains an appreciable carbonate content - see BS1377, or Head, Vol. 1

orgcon.xls

BS1377 : 1990 : Part 2

Specific gravity of fine grained soil particles

Operator: GC

Site: RSG

Checked: ML

Date: 14/6/99

Soil specimen		BH83/24 SC002 0.7 m	BH83/24 SC002 1.3 m	BH11/20 SC002 0.44 m	BH11/20 SC002 1.33 m	BH83/20 SC003 1.5 m	BH83/20 SC003 1.9 m
Bottle number		3422	775	3398	838	3440	0
Mass of bottle + soil + water (m3)	g	85.424	82.368	85.7799	83.5965	86.2121	89.4564
Mass of bottle + soil (m2)	g	37.2693	35.9812	39.979	37.3752	39.5109	41.7621
Mass of bottle full of water only (m4)	g	81.639	77.5326	80.4318	78.1895	80.4069	84.2554
Mass of bottle (m1)	g	31.1189	27.7268	31.0531	28.3613	30.0408	33.104
Mass of water used (m3 - m2)	g	48.1547	46.3868	45.8009	46.2213	46.7012	47.6943
Mass of soil used (m2 - m1)	g	6.1504	8.2544	8.9259	9.0139	9.4701	8.6581
Volume of soil (m4 - m1) - (m3 - m2)	ml	2.3654	3.419	3.5778	3.6069	3.6649	3.4571
Specific gravity of soil particles Gs = (m2 - m1) / ((m4 - m1) - (m3 - m2))		2.600	2.414	2.495	2.499	2.584	2.504

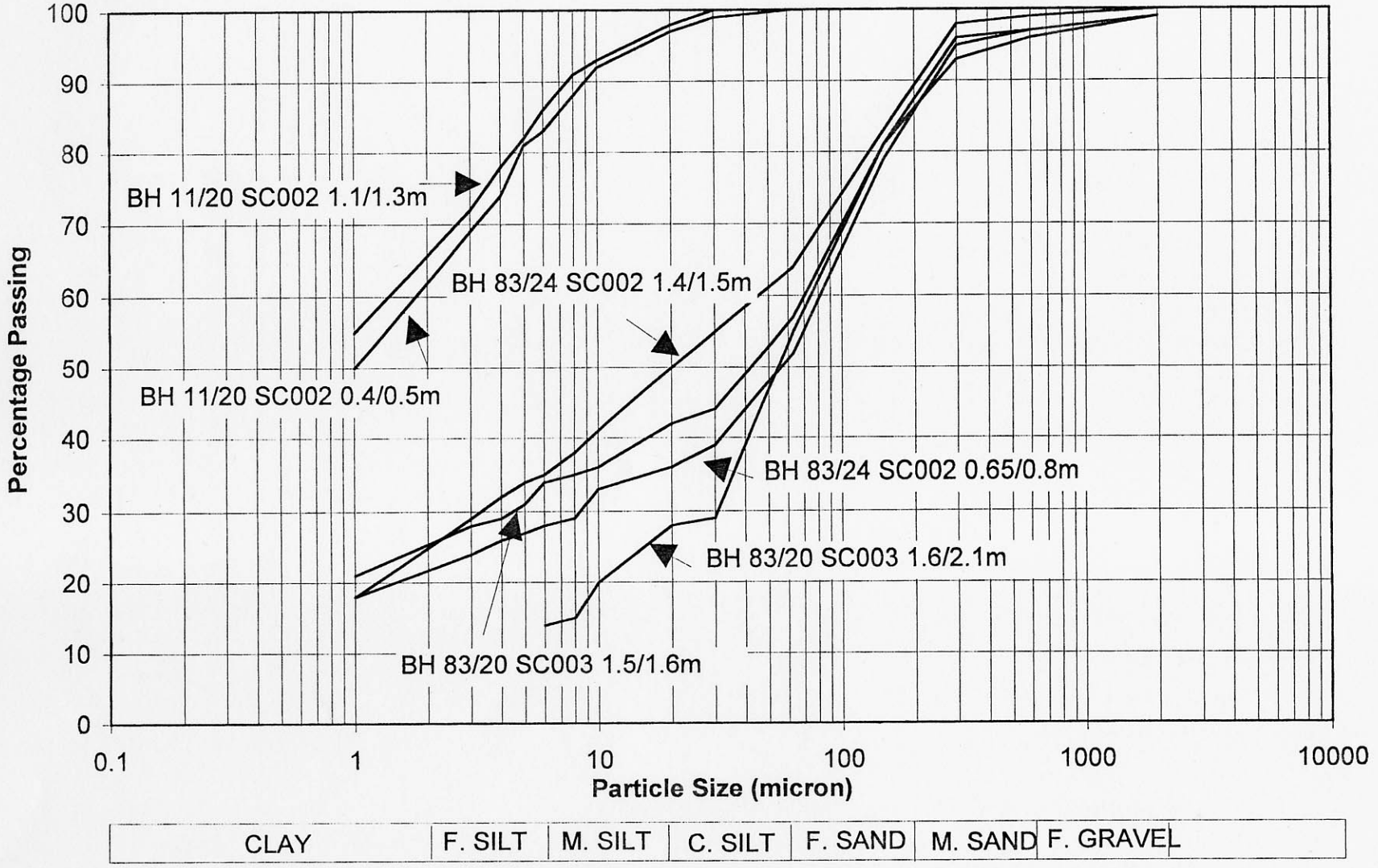
specgrav.xls

RSG

Particle Size Distribution Data

BH	Depth (m)	BH	Depth (m)	BH	Depth (m)	BH	Depth (m)	BH	Depth (m)	BH	Depth (m)
11/20 SC002	0.4 / 0.5	11/20 SC002	1.1 - 1.3	83/24 SC002	1.4 - 1.5	83/24 SC002	0.65 - 0.8	83/20 SC003	1.6 - 2.1	83/20 SC003	1.5 - 1.6
Sieve (micron)	Percent Passing		Percent Passing		Percent Passing		Percent Passing		Percent Passing		Percent Passing
2000	100		100		100		99		99		99
600	100		100		99		97		97		96
300	100		100		98		95		96		93
150	100		100		83		79		81		81
63	100		100		64		52		55		57
30	99		100		55		39		29		44
20	97		98		50		36		28		42
10	92		93		41		33		20		36
8	88		91		38		29		15		35
6	83		86		35		28		14		34
5	81		82		34		27				31
4	74		78		32		26				29
3	69		72		29		24				28
1	50		55		18		18				21
0.7	41		49		13		16				19

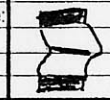
RSG/Disk2/psd.xls



RSG - Particle Size Distribution Curves

RSG - Consolidated Undrained Triaxial Test

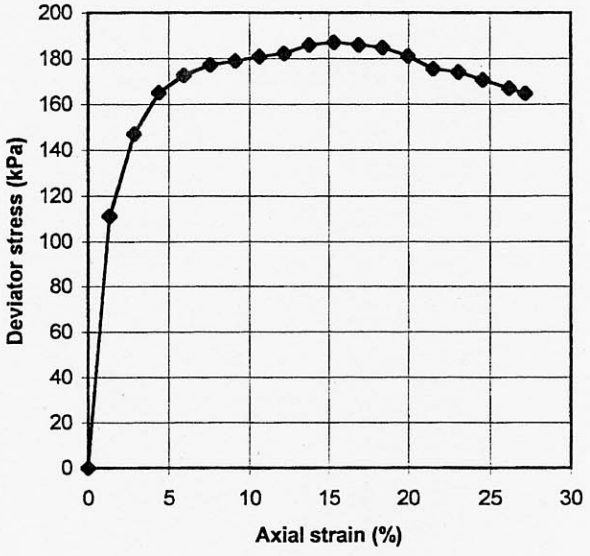
BS1377 : Part 8 : 1990

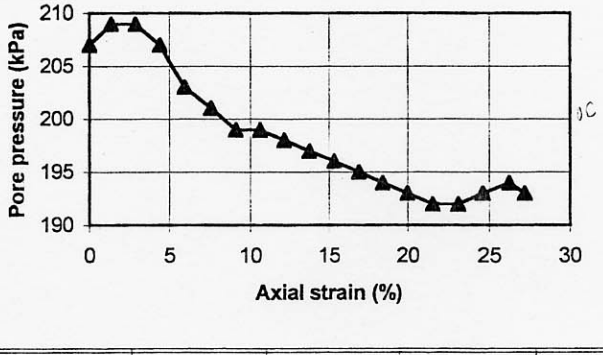
Borehole:	83/24
Sample No:	SC002
Depth (m):	0.65 - 0.75
Date:	12-14/7/99
Operator:	GC
Checked:	ML
Mode of failure:	

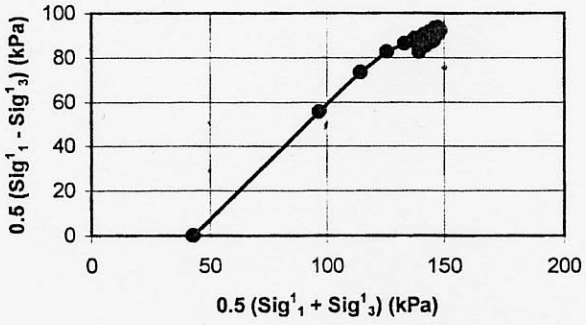
Initial Length (mm)	76.2
Initial diameter (mm)	38.1
Moisture content sample (%)	37
Moisture content trimmings (%)	38
Degreee of saturation (B)	1
Density before test (Mg/m^3)	1.839
Area before test (mm^2)	1140.094494
Volume before test (cm^3)	86.87520044

Moisture content after test (%)	29
Vol. change during consol. (%)	3
Length at start of shearing (mm)	75.4
Area at start of shearing (mm^2)	1117.3
Diameter at start of shearing (mm)	37.7
Volume at start of shearing (cm^3)	84.28632
Rate of shear (mm / min)	2.9

Time (secs)	Load (N)	PWP (kPa)	Displacement (mm)	Compression (mm)	Area (mm2)	Deviator stress (kPa)	Strain (%)	0.5($sig'1$-$Sig'3$) (kPa)	($sig'1$) (kPa)	0.5($sig'1$+$Sig'3$) (kPa)
0	0	207	1.8	0	1117.3	0	0	0	43	43
25	126	209	2.79	0.99	1132.7	111.2	1.3	55.6	152.2	96.6
50	169	209	3.93	2.13	1150.3	146.9	2.8	73.5	187.9	114.5
75	193	207	5.11	3.31	1169.2	165.1	4.4	82.5	208.1	125.5
100	205	203	6.27	4.47	1188.3	172.5	5.9	86.3	219.5	133.3
125	214	201	7.48	5.68	1208.9	177.0	7.5	88.5	226.0	137.5
150	220	199	8.65	6.85	1229.6	178.9	9.1	89.5	229.9	140.5
175	226	199	9.8	8	1250.5	180.7	10.6	90.4	231.7	141.4
200	232	198	10.95	9.15	1272.2	182.4	12.1	91.2	234.4	143.2
225	241	197	12.16	10.36	1295.9	186.0	13.7	93.0	239.0	146.0
250	247	196	13.36	11.56	1320.3	187.1	15.3	93.5	241.1	147.5
275	250	195	14.53	12.73	1344.9	185.9	16.9	92.9	240.9	147.9
300	253	194	15.65	13.85	1369.4	184.8	18.4	92.4	240.8	148.4
325	253	193	16.85	15.05	1396.6	181.2	20.0	90.6	238.2	147.6
350	250	192	18.04	16.24	1424.7	175.5	21.5	87.7	233.5	145.7
375	253	192	19.23	17.43	1454.0	174.0	23.1	87.0	232.0	145.0
400	253	193	20.33	18.53	1482.1	170.7	24.6	85.4	227.7	142.4
425	253	194	21.54	19.74	1514.3	167.1	26.2	83.5	223.1	139.5
440	253	193	22.29	20.49	1535.0	164.8	27.2	82.4	221.8	139.4


Deviator stress (kPa)
200
180
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
Axial strain (%)


Pore pressure (kPa)
210
205
200
195
190
0
5
10
15
20
25
30
Axial strain (%)


0.5 (Sig'1 - Sig'3) (kPa)
100
80
60
40
20
0
0
50
100
150
200
0.5 (Sig'1 + Sig'3) (kPa)

RSG - Consolidated Undrained Triaxial Test

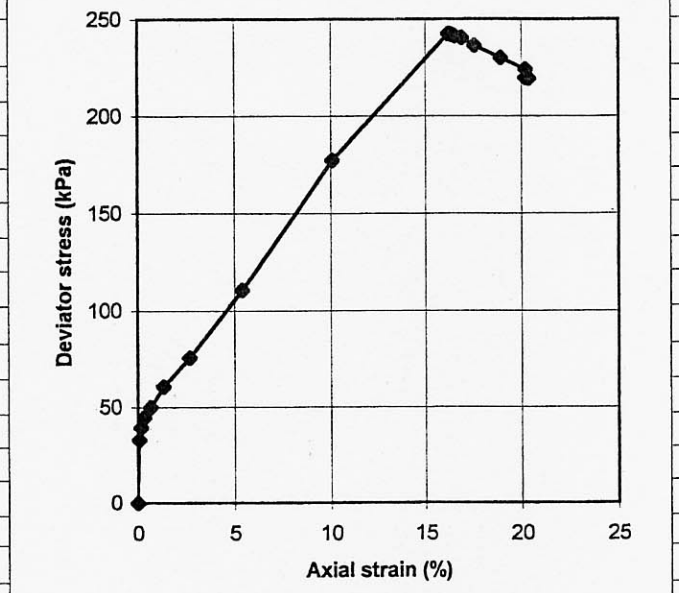
BS1377 : Part 8 : 1990

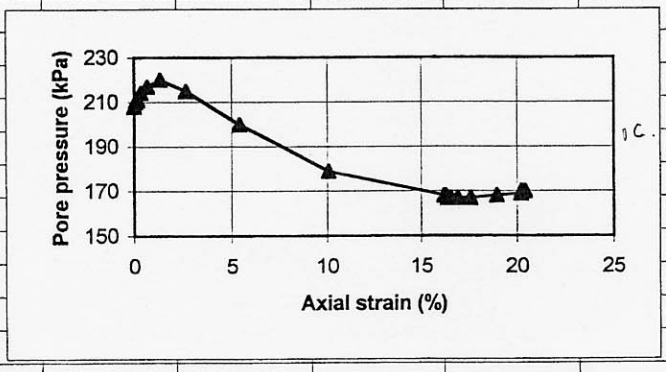
Borehole:	83/20
Sample No:	SC003
Depth (m):	1.4 - 1.5
Date:	21-22/7/99
Operator:	GC
Checked:	ML
Mode of failure:	

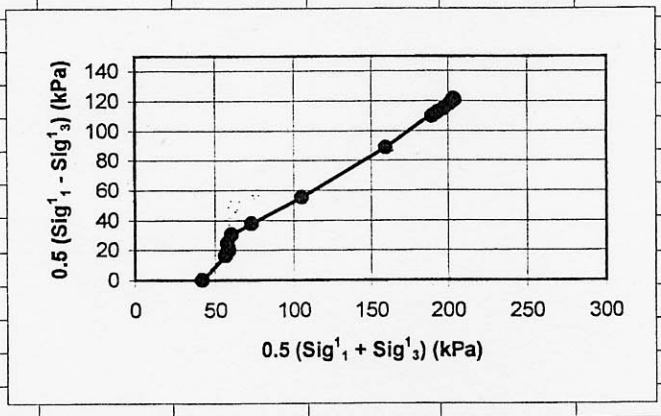
Initial Length (mm)	76.2
Initial diameter (mm)	38.1
Moisture content sample (%)	36
Moisture content trimmings (%)	39
Degreee of saturation (B)	1
Density before test (Mg/m^3)	1.819
Area before test (mm^2)	1140.09
Volume before test (cm^3)	86.88

Moisture content after test (%)	28
Vol. change during consol. (%)	6.2
Length at start of shearing (mm)	74.6
Area at start of shearing (mm^2)	1093.0
Diameter at start of shearing (mm)	37.3
Volume at start of shearing (cm^3)	81.56
Rate of shear (mm / min)	0.52

Time (secs)	Load (N)	PWP (kPa)	Displacement (mm)	Compression (mm)	Area (mm2)	Deviator stress (kPa)	Strain (%)	0.5(sig'1-Sig'3) (kPa)	(sig'1) (kPa)	0.5(sig'1+Sig'3) (kPa)
0	0	208	4.22	0	1093.0	0	0	0	42	42
2.4	36	210	4.27	0.05	1094.1	32.9	0.1	16.5	72.9	56.5
3.9	43	211	4.34	0.12	1095.1	39.3	0.2	19.6	78.3	58.6
5.5	49	214	4.47	0.25	1097.0	44.7	0.3	22.3	80.7	58.3
7.7	55	217	4.73	0.51	1100.9	50.0	0.7	25.0	83.0	58.0
11.0	67	220	5.23	1.01	1108.3	60.5	1.3	30.2	90.5	60.2
15.5	85	215	6.24	2.02	1123.8	75.6	2.7	37.8	110.6	72.8
21.9	128	200	8.29	4.07	1156.4	110.7	5.4	55.3	160.7	105.3
30.0	216	179	11.81	7.59	1217.2	177.5	10.1	88.7	248.5	159.7
38.0	317	168	16.43	12.21	1307.3	242.5	16.2	121.2	324.5	203.2
38.1	317	168	16.47	12.25	1308.1	242.3	16.2	121.2	324.3	203.2
38.2	317	167	16.56	12.34	1310.0	242.0	16.4	121.0	325.0	204.0
38.4	317	167	16.69	12.47	1312.8	241.5	16.5	120.7	324.5	203.7
38.8	317	167	16.95	12.73	1318.3	240.5	16.9	120.2	323.5	203.2
39.6	314	167	17.46	13.24	1329.3	236.2	17.6	118.1	319.2	201.1
41.1	311	168	18.48	14.26	1351.7	230.1	18.9	115.0	312.1	197.0
42.5	308	169	19.45	15.23	1373.8	224.2	20.2	112.1	305.2	193.1
42.5	302	170	19.47	15.25	1374.3	219.8	20.2	109.9	299.8	189.9
42.6	302	170	19.52	15.3	1375.4	219.6	20.3	109.8	299.6	189.8
42.7	302	170	19.59	15.37	1377.1	219.3	20.4	109.7	299.3	189.7
	302									


Deviator stress (kPa)
250
200
150
100
50
0
0
5
10
15
20
25
Axial strain (%)


Pore pressure (kPa)
230
210
190
170
150
0
5
10
15
20
25
Axial strain (%)


0.5 (Sig'1 - Sig'3) (kPa)
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
0.5 (Sig'1 + Sig'3) (kPa)

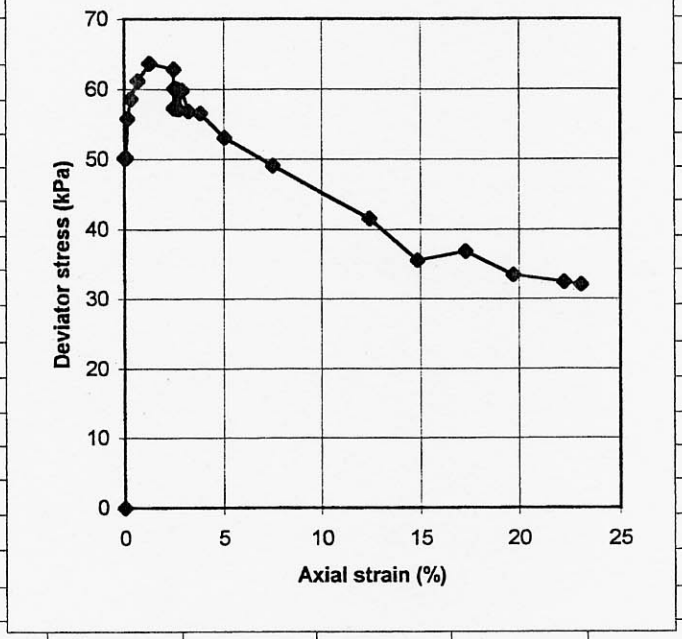
RSG - Consolidated Undrained Triaxial Test
BS1377 : Part 8 : 1990

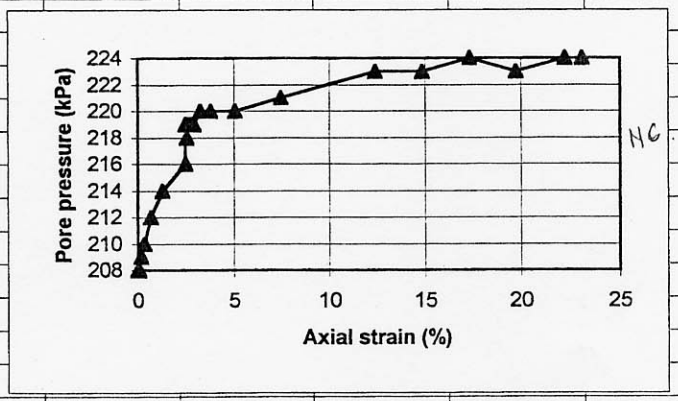
Borehole:	11/200
Sample No:	SC002
Depth (m):	0.4 - 0.5
Date:	19-20/7/99
Operator:	GC
Checked:	ML
Mode of failure:	

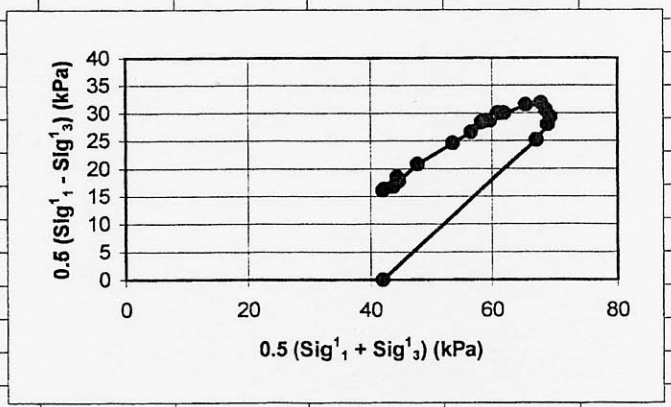
Initial Length (mm)	76.2
Initial diameter (mm)	38.1
Moisture content sample (%)	55
Moisture content trimmings (%)	68
Degreee of saturation (B)	1
Density before test (Mg/m^3)	1.587
Area before test (mm^2)	1140.09
Volume before test (cm^3)	86.88

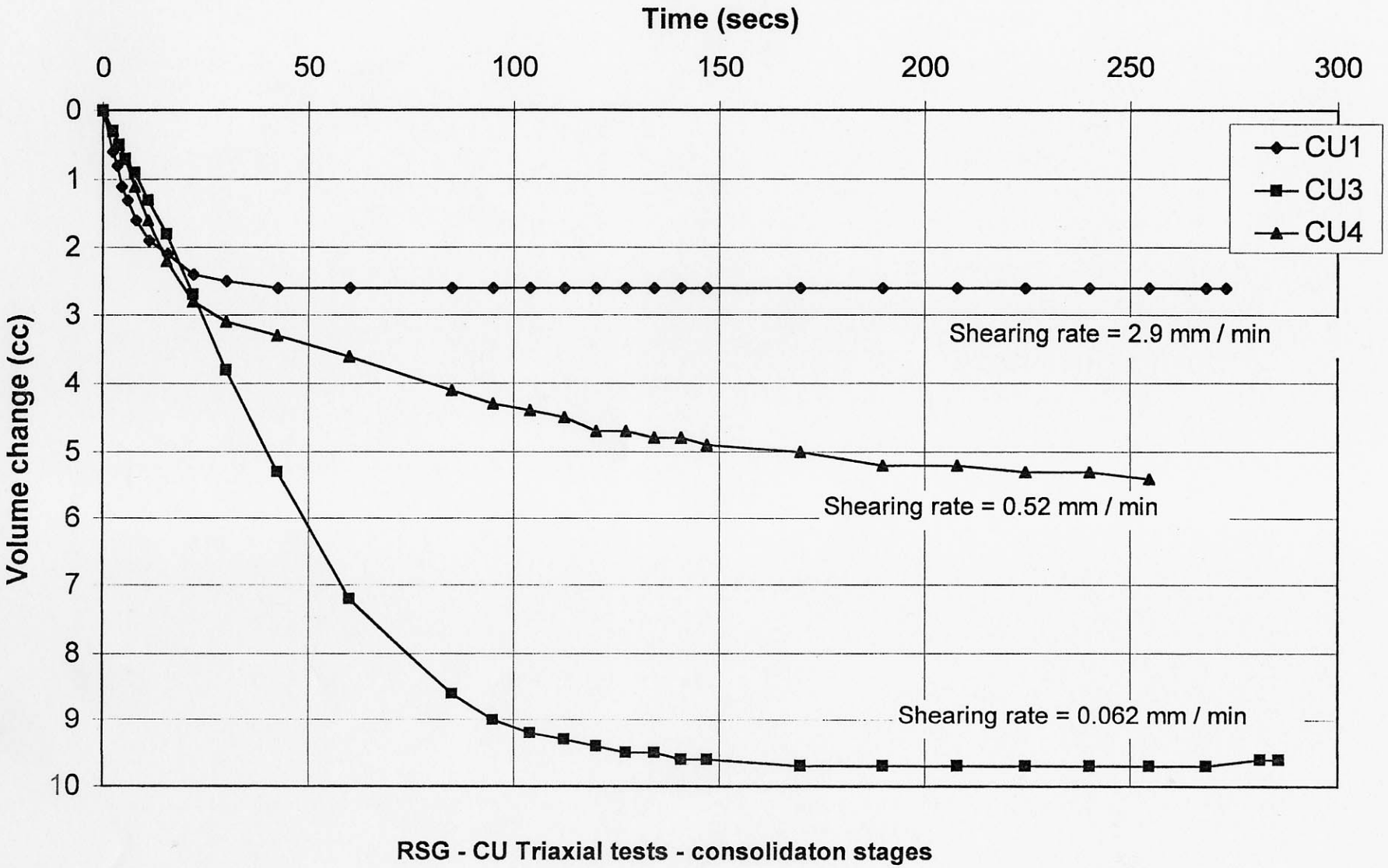
Moisture content after test (%)	44
Vol. change during consol. (%)	11.1
Length at start of shearing (mm)	73.4
Area at start of shearing (mm^2)	1055.7
Diameter at start of shearing (mm)	36.7
Volume at start of shearing (cm^3)	77.47
Rate of shear (mm / min)	0.062

Time (secs)	Load (N)	PWP (kPa)	Displacement (mm)	Compression (mm)	Area (mm2)	Deviator stress (kPa)	Strain (%)	0.5(sig'1-Sig'3) (kPa)	(sig'1) (kPa)	0.5(sig'1+Sig'3) (kPa)
0	0	208	1.27	0	1055.7	0	0	0	42	42
2.4	53	208	1.28	0.01	1055.6	50.2	0.0	25.1	92.2	67.1
3.5	53	208	1.28	0.01	1055.6	50.2	0.0	25.1	92.2	67.1
4.6	53	208	1.3	0.03	1055.9	50.2	0.0	25.1	92.2	67.1
6.0	53	208	1.33	0.06	1056.3	50.2	0.1	25.1	92.2	67.1
8.1	59	209	1.39	0.12	1057.2	55.8	0.2	27.9	96.8	68.9
11.2	62	210	1.51	0.24	1058.9	58.6	0.3	29.3	98.6	69.3
15.7	65	212	1.76	0.49	1062.5	61.2	0.7	30.6	99.2	68.6
22.0	68	214	2.19	0.92	1068.8	63.6	1.3	31.8	99.6	67.8
30.1	68	216	3.09	1.82	1082.3	62.8	2.5	31.4	96.8	65.4
42.4	62	219	3.09	1.82	1082.3	57.3	2.5	28.6	88.3	59.6
42.4	65	219	3.11	1.84	1082.6	60.0	2.5	30.0	91.0	61.0
42.5	65	219	3.11	1.84	1082.6	60.0	2.5	30.0	91.0	61.0
42.6	65	218	3.13	1.86	1082.9	60.0	2.5	30.0	92.0	62.0
42.8	65	219	3.15	1.88	1083.2	60.0	2.6	30.0	91.0	61.0
43.0	65	219	3.17	1.9	1083.5	60.0	2.6	30.0	91.0	61.0
43.2	65	219	3.17	1.9	1083.5	60.0	2.6	30.0	91.0	61.0
43.3	62	219	3.18	1.91	1083.6	57.2	2.6	28.6	88.2	59.6
43.4	65	219	3.2	1.93	1084.0	60.0	2.6	30.0	91.0	61.0
43.6	65	219	3.23	1.96	1084.4	59.9	2.7	30.0	90.9	61.0
43.9	62	219	3.28	2.01	1085.2	57.1	2.7	28.6	88.1	59.6
44.6	65	219	3.4	2.13	1087.0	59.8	2.9	29.9	90.8	60.9
45.9	62	220	3.64	2.37	1090.7	56.8	3.2	28.4	86.8	58.4
48.4	62	220	4.05	2.78	1097.0	56.5	3.8	28.3	86.5	58.3
52.6	59	220	4.96	3.69	1111.3	53.1	5.0	26.5	83.1	56.5
60.6	56	221	6.74	5.47	1140.4	49.1	7.5	24.6	78.1	53.6
73.9	50	223	10.34	9.07	1204.3	41.5	12.4	20.8	68.5	47.8
95.2	44	223	12.15	10.88	1239.1	35.5	14.8	17.8	62.5	44.8
104.2	47	224	13.96	12.69	1276.1	36.8	17.3	18.4	62.8	44.4
112.5	44	223	15.74	14.47	1314.6	33.5	19.7	16.7	60.5	43.7
120.3	44	224	17.57	16.3	1356.7	32.4	22.2	16.2	58.4	42.2
127.5	44	224	18.2	16.93	1371.9	32.1	23.1	16.0	58.1	42.0
130.0	41	224								


Deviator stress (kPa)
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Axial strain (%)


Pore pressure (kPa)
224
222
220
218
216
214
212
210
208
0
5
10
15
20
25
Axial strain (%)
NC


0.5 (Sig'1 - Sig'3) (kPa)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
0.5 (Sig'1 + Sig'3) (kPa)



RSG - CU Triaxial tests - consolidaton stages

RSG - Oedometer Tests - Calculation of cv, mv and k

83/20 SC003

Inc	Load (kPa)	Compress (mm)	Hbar (mm	sqrt(t90) (secs)	t90 (mins)	cv* (m2/yr	M (kPa)	mv (m2/MN)	k (m/s)	Comment
1	15	0.915	18.543	31.15	16.2	2.38	311.48	3.21	2.38E-09	
2	24	0.313	18.386	46.72	36.4	1.04	546.33	1.83	5.93E-10	
3	52	0.507	18.133	31.2	16.2	2.27	1049.31	0.95	6.73E-10	
4	104	0.7	17.783	31.96	17.0	2.08	1411.43	0.71	4.59E-10	
5	228	0.795	17.385	25	10.4	3.25	2963.52	0.34	3.41E-10	
6	460	0.85	16.960	15.6	4.1	7.94	5185.88	0.19	4.76E-10	
7	228	-0.06	16.990							
8	104	-0.07	17.025							
9	228	0.05	17.000	3.3	0.2	178.34				Reload
10	460	0.15	16.925	3.3	0.2	176.77				Reload
11	920	0.815	16.518	13.4	3.0	10.21	10723.93	0.09	2.96E-10	

11/20 SC002

Inc	Load (kPa)	Compress (mm)	Hbar (mm	sqrt(t90) (secs)	t90 (mins)	cv (m2/yr)	M (kPa)	mv (m2/MN)	k (m/s)	Comment
1	7.5	0.812	18.594	69.17	79.7	0.49	175.49	5.70	8.61E-10	
2	15	0.49	18.349	69.17	79.7	0.47	290.82	3.44	5.06E-10	
3	24	0.446	18.126	64.17	68.6	0.54	383.41	2.61	4.35E-10	
4	52	1.062	17.595	64.17	68.6	0.51	500.94	2.00	3.14E-10	
5	110	1.052	17.069	56.67	53.5	0.61	1047.53	0.95	1.81E-10	
6	228	1.325	16.4065	52.5	45.9	0.66	1692.08	0.59	1.21E-10	
7	110	-0.11	16.4615							
8	52	-0.22	16.5715							
9	110	0.11	16.5165	25	10.4	2.93				Reload
10	228	0.23	16.4015	20	6.7	4.52				Reload

83/24 SC003

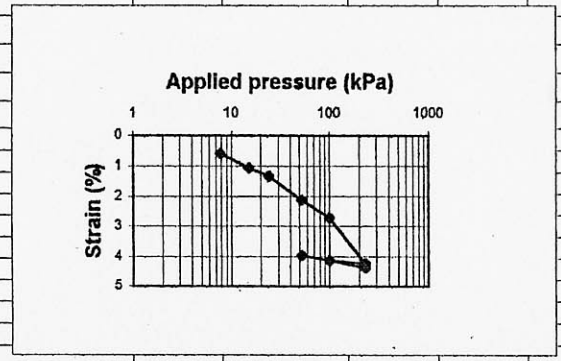
Inc	Load (kPa)	Compress (mm)	Hbar (mm	sqrt(t90) (secs)	t90 (mins)	cv (m2/yr)	M (kPa)	mv (m2/MN)	k (m/s)	Comment
1	7.8	0.11	18.945	12.5	2.604166667	15.44	1347.273	0.74	3.56E-09	
2	15	0.085	18.9025	9.2	1.410666667	28.37	1609.412	0.62	5.48E-09	
3	24	0.053	18.876	18.3	5.5815	7.15	3226.415	0.31	6.89E-10	
4	52	0.152	18.8	5	0.416666667	95.00	3500	0.29	8.44E-09	
5	100	0.115	18.7425	10.8	1.944	20.24	7930.435	0.13	7.94E-10	
6	228	0.285	18.6	5.8	0.560666667	69.11	8533.333	0.12	2.52E-09	
7	100	-0.02	18.61		0					
8	52	-0.03	18.625		0					
9	100	0.03	18.61	3.3	0.1815	213.71				Reload
10	228	0.05	18.585	3.3	0.1815	213.14				Reload

Notes:

* Head (1994) states that when cv > 100 m2/yr, then it should be quoted as > 100 m2/yr

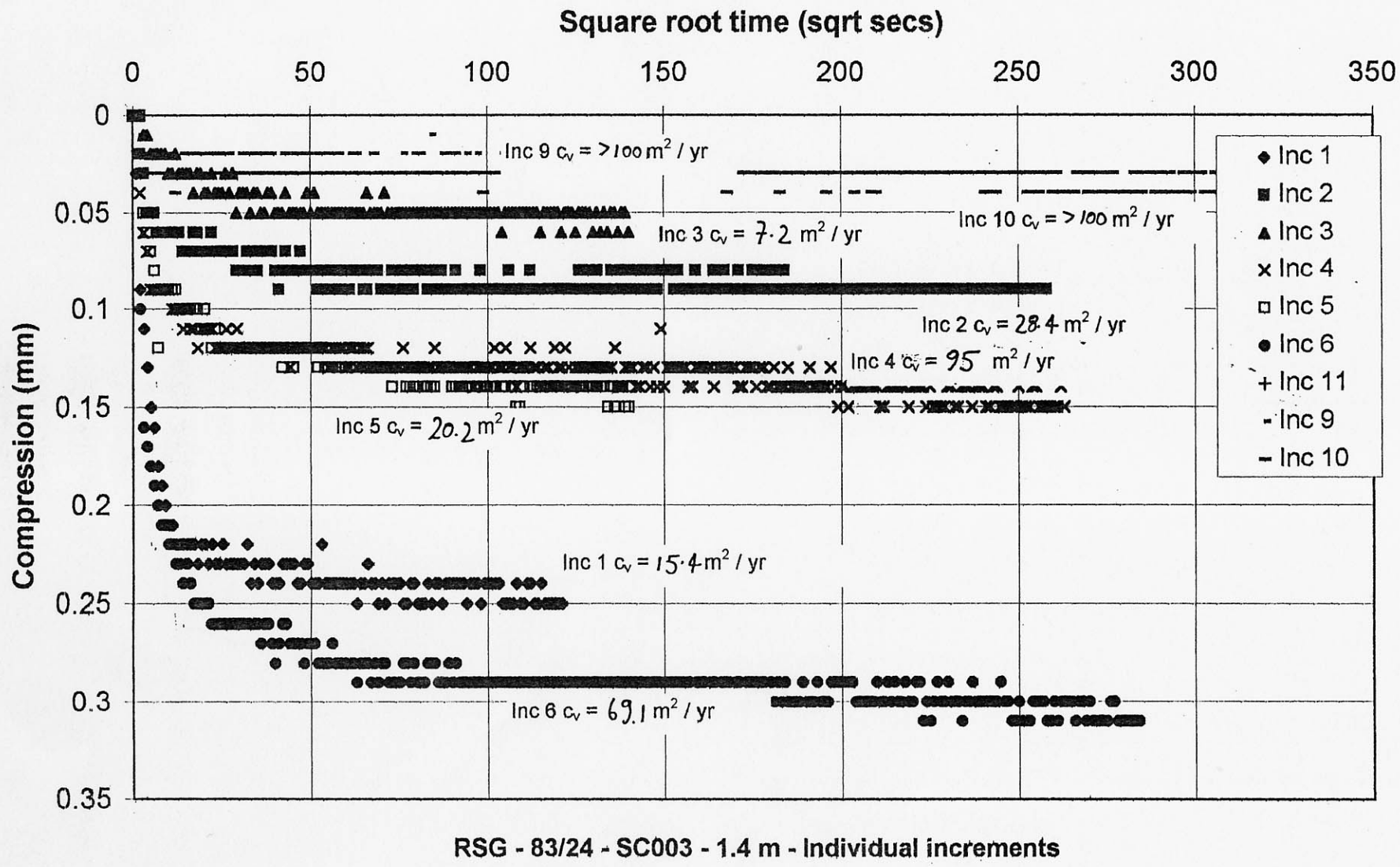
cv.xls

MSL OEDOMETER TEST RESULTS				Comments:									
				50 mm dia. cell									
PROCESSING OF GENERAL DATA													
Test No. RSG3	BH 83/24	Sample SCOO3	Depth (m) 1.4										
	Input Required				Input Required								
Initial w soil sample(%)	**	62.000		F (mm-1)		0.126							
Initial w trimmings 1 (%)	**	62.000		Final mass (g)	**	60:300							
Initial w trimmings 2 (%)	**	60.000		Delta H total (mm)	**	0.830							
Final w soil sample (%)	**	56.000		Final density (Mg/m3)		1.690							
Design w (%)		61.333		Final dry density (Mg/m3)		1.083							
Initial mass (g)	**	62.630		Final void ratio		1.308							
Initial density (Mg/m3)		1.679		Delta e total		0.105							
Initial dry density (Mg/m3)		1.041		Final void ratio		1.298							
Initial void ratio		1.403											



Increment No.	Load	Measured Comp	Inc 1 Corr	Compliance Error	Corr Sec Comp	Corrected Comp.	Cumulative Comp.	Strain (%)	Void Rat Chg.	Void Ratio	Spec Vol	M
	kPa	mm	mm	mm	mm	mm	mm					kPa
1	7.8	0.25	0.13	0.01	0	0.11	0.11	0.57895	0.0139	1.389	2.389	1347.27
2	15	0.09	0	0.005	0	0.085	0.195	1.02632	0.0107	1.378	2.378	1609.41
3	24	0.06	0	0.007	0	0.053	0.248	1.30526	0.0067	1.371	2.371	3226.42
4	52	0.16	0	0.008	0	0.152	0.4	2.10526	0.0192	1.352	2.352	3500
5	100	0.14	0	0.025	0	0.115	0.515	2.71053	0.0145	1.337	2.337	7930.43
6	228	0.31	0	0.025	0	0.285	0.8	4.21053	0.0360	1.301	2.301	8533.33
7	100	-0.02	0	0	0	-0.02	0.78	4.10526	-0.0025	1.304	2.304	
8	52	-0.03	0	0	0	-0.03	0.75	3.94737	-0.0038	1.308	2.308	
9	100	0.03	0	0	0	0.03	0.78	4.10526	0.0038	1.304	2.304	
10	228	0.05	0	0	0	0.05	0.83	4.36842	0.0063	1.298	2.298	
11						0	0.83	4.36842	0.0000	1.298	2.298	
					Total Comp (mm)	0.83						

83/24 SC003 1.4 m



RSG - 83/24 - SC003 - 1.4 m - Individual increments

oed 8324 x ls

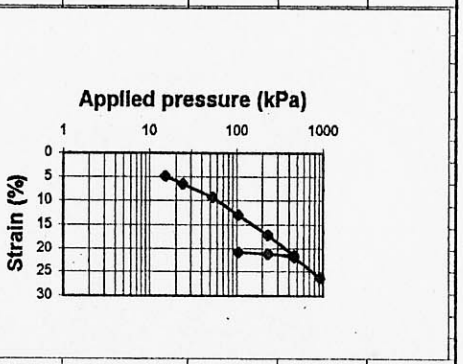
MSL OEDOMETER TEST RESULTS

PROCESSING OF GENERAL DATA

Comments:
50 mm dia. cell

Test No. RSG1	BH 83/20	Sample SC003	Depth (m) 2.1-2.2 m

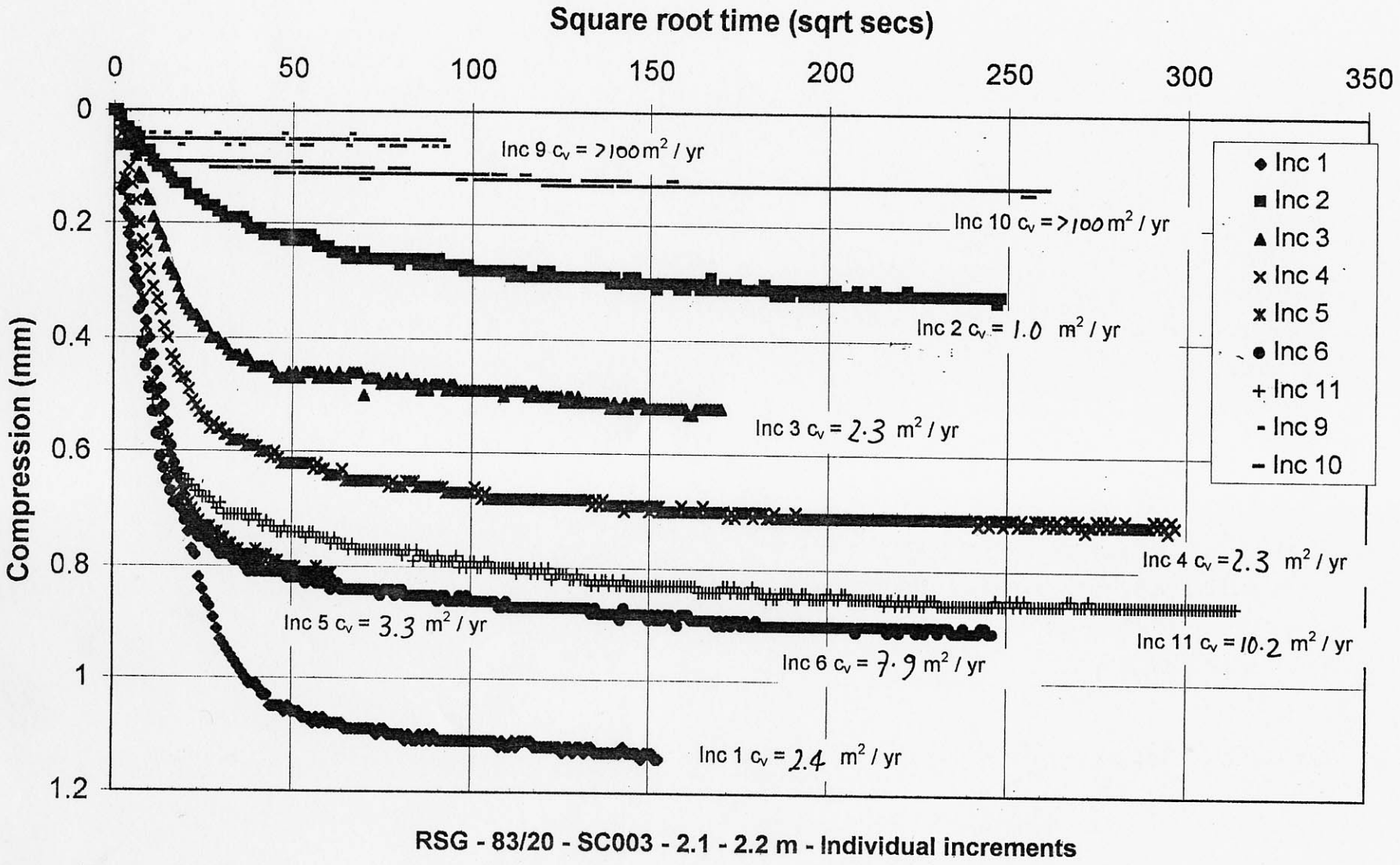
	Input Required			Input Required	
Initial w soil sample(%)	**	61.000	F (mm-1)		0.121
Initial w trimmings 1 (%)	**	61.000	Final mass (g)	**	54.910
Initial w trimmings 2 (%)	**	58.000	Delta H total (mm)	**	4.965
Final w soil sample (%)	**	36.000	Final density (Mg/m3)		1.992
Design w (%)		60.000	Final dry density (Mg/m3)		1.465
Initial mass (g)	**	64.680	Final void ratio		0.707
Initial density (Mg/m3)		1.734	Delta e total		0.603
Initial dry density (Mg/m3)		1.084	Final void ratio		0.704
Initial void ratio		1.307			



Increment No.	Load	Measured Comp	Inc 1 Corr	Compliance Error	Corr Sec Comp	Corrected Comp.	Cumulative Comp.	Strain (%)	Void Rat Chg.	Void Ratio	Spec Vol	M
	kPa	mm	mm	mm	mm	mm	mm					kPa
1	15	1.13	0.2	0.015	0	0.915	0.915	4.815789	0.1111	1.196	2.196	311.4754
2	24	0.32	0	0.007	0	0.313	1.228	6.463158	0.0380	1.158	2.158	546.3259
3	52	0.52	0	0.013	0	0.507	1.735	9.131579	0.0616	1.096	2.096	1049.31
4	104	0.72	0	0.02	0	0.7	2.435	12.81579	0.0850	1.011	2.011	1411.429
5	228	0.82	0	0.025	0	0.795	3.23	17	0.0965	0.915	1.915	2963.522
6	460	0.91	0	0.06	0	0.85	4.08	21.47368	0.1032	0.812	1.812	5185.882
7	228	-0.06	0	0	0	-0.06	4.02	21.15789	-0.0073	0.819	1.819	
8	104	-0.07	0	0	0	-0.07	3.95	20.78947	-0.0085	0.828	1.828	
9	228	0.05	0	0	0	0.05	4	21.05263	0.0061	0.821	1.821	
10	460	0.15	0	0	0	0.15	4.15	21.84211	0.0182	0.803	1.803	
11	920	0.85	0	0.035	0	0.815	4.965	26.13158	0.0990	0.704	1.704	10723.93
					Total Comp (mm)	4.965						

83/20 SC003 2.1 - 2.2 m

oda20.xls



RSG - 83/20 - SC003 - 2.1 - 2.2 m - Individual increments

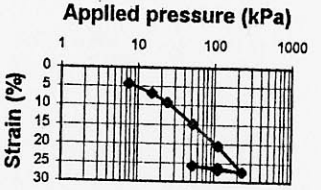
MSL OEDOMETER TEST RESULTS

PROCESSING OF GENERAL DATA

Comments:
50 mm dia. cell

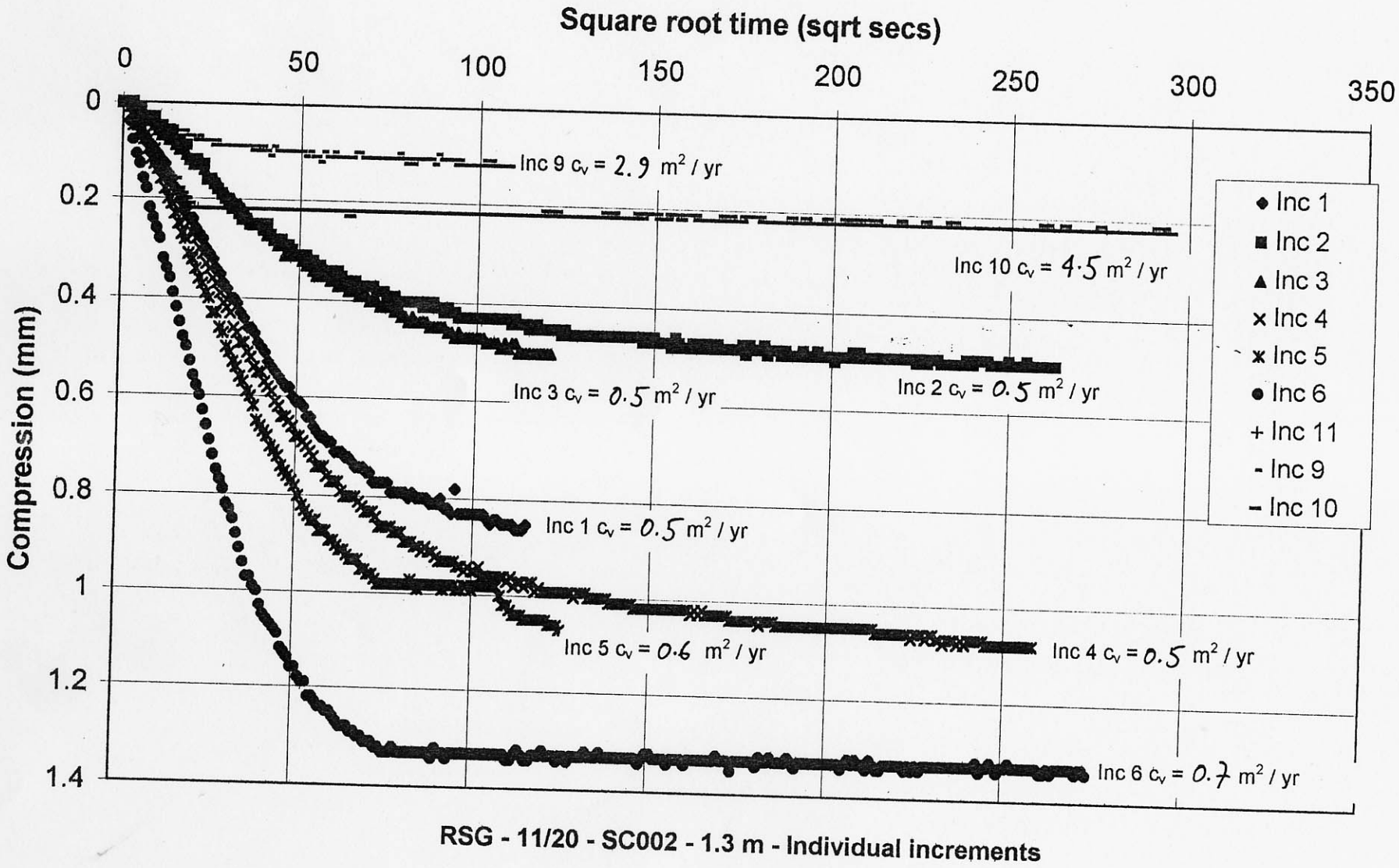
Test No. RSG2	BH 11/20	Sample SC002	Depth (m) 1.3 m
	Input Required		
Initial w soil sample(%)	**	76.000	
Initial w trimmings 1 (%)	**	76.000	
Initial w trimmings 2 (%)	**	69.000	
Final w soil sample (%)	**	44.000	
Design w (%)		73.667	
Initial mass (g)	**	60.350	
Initial density (Mg/m3)		1.618	
Initial dry density (Mg/m3)		0.931	
Initial void ratio		1.684	

	Input Required	
F (mm-1)		0.141
Final mass (g)	**	49.540
Delta H total (mm)	**	5.197
Final density (Mg/m3)		1.827
Final dry density (Mg/m3)		1.269
Final void ratio		0.970
Delta e total		0.734
Final void ratio		0.950



Increment No.	Load	Measured Comp	Inc 1 Corr	Compliance Error	Corr Sec Comp	Corrected Comp.	Cumulative Comp.	Strain (%)	Void Rat Chg.	Void Ratio	Spec Vol	M
	kPa	mm	mm	mm	mm	mm	mm					kPa
1	7.5	0.85	0.03	0.008	0	0.812	0.812	4.273684	0.1147	1.569	2.569	175.4926
2	15	0.5	0	0.01	0	0.49	1.302	6.852632	0.0692	1.500	2.500	290.8163
3	24	0.45	0	0.004	0	0.446	1.748	9.2	0.0630	1.437	2.437	383.4081
4	52	1.08	0	0.018	0	1.062	2.81	14.78947	0.1500	1.287	2.287	500.9416
5	110	1.07	0	0.018	0	1.052	3.862	20.32632	0.1486	1.138	2.138	1047.529
6	228	1.35	0	0.025	0	1.325	5.187	27.3	0.1872	0.951	1.951	1692.075
7	110	-0.11	0	0	0	-0.11	5.077	26.72105	-0.0155	0.967	1.967	
8	52	-0.22	0	0	0	-0.22	4.857	25.56316	-0.0311	0.998	1.998	
9	110	0.11	0	0	0	0.11	4.967	26.14211	0.0155	0.982	1.982	
10	228	0.23	0	0	0	0.23	5.197	27.35263	0.0325	0.950	1.950	
11												
					Total Comp (mm)	5.197						

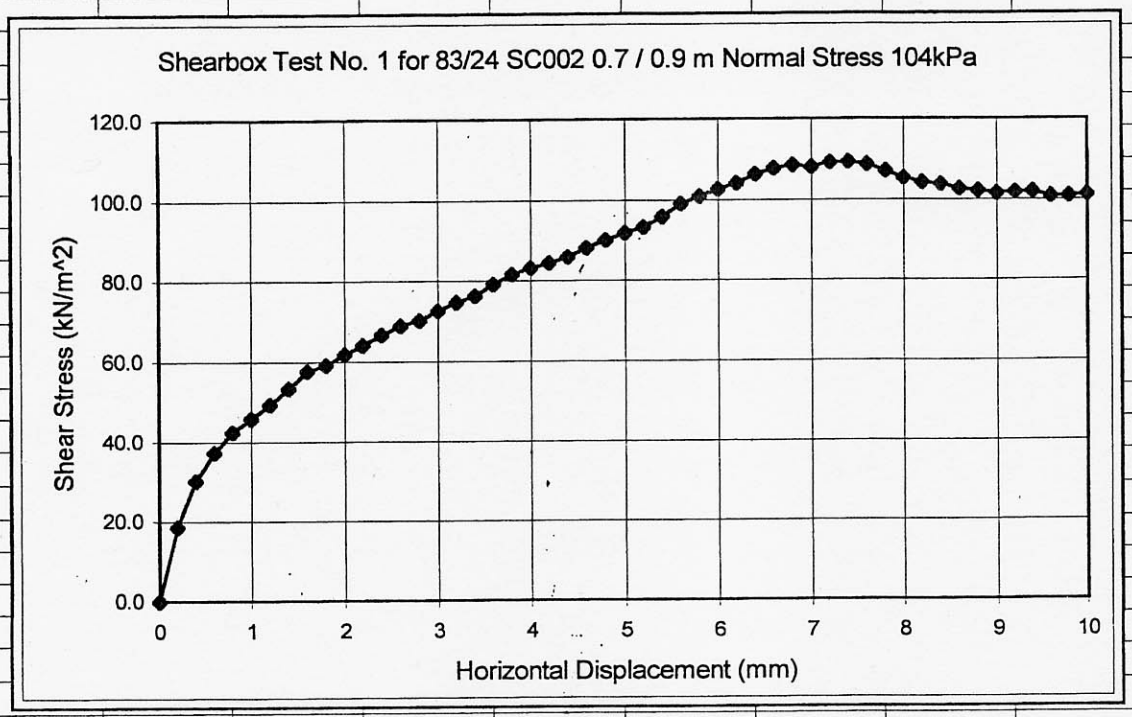
11/20 SC002 1.3 m

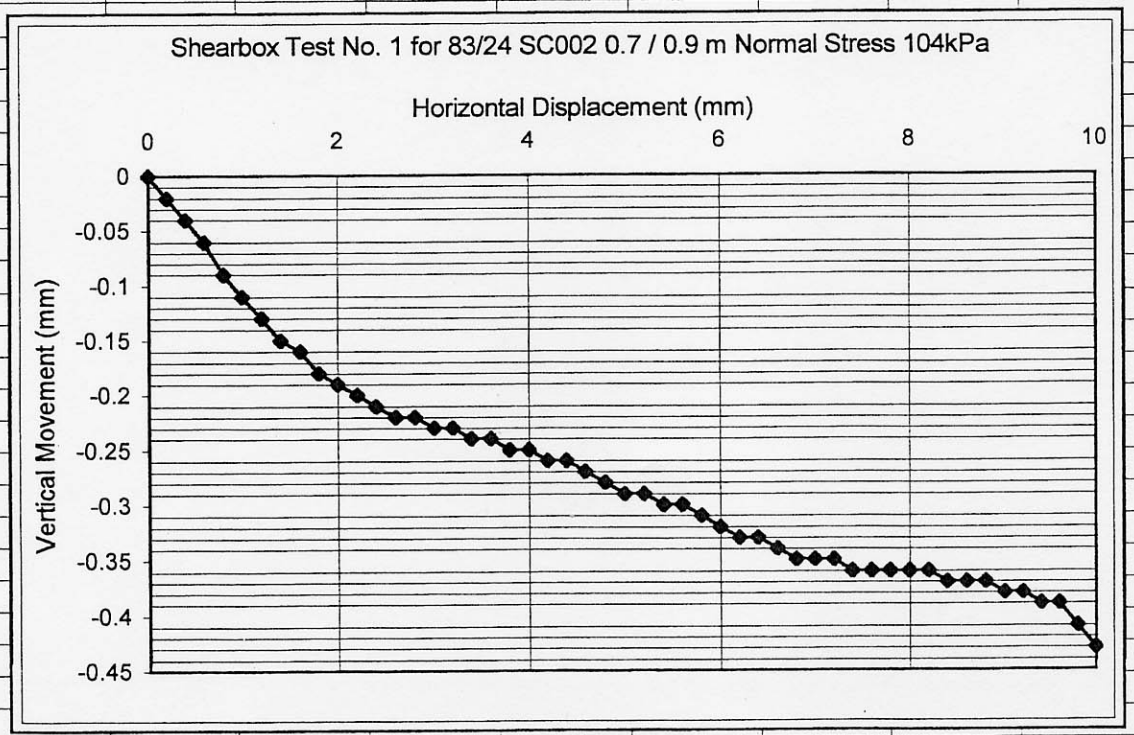


RSG - 11/20 - SC002 - 1.3 m - Individual increments

SHEARBOX TEST	NO. 83/24 SCOO2 0.7/0.9 m (1)						
Location:	RSG 83/24			Job ref:		99/1	
				Borehole ref:		BHSC002	
Soil Description:	white sandy silt			Sample no.:		1	
Test method:	BS 1377 : Part 7 : 1990 : 4/5			Depths:		0.7 / 0.9m	
Machine:	Wykeham Farrance 1978			Sampling method:		Grab	
Specimen dimensions:	L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS	
Specimen Type:	Remoulded /Submerged			Sampling Date:			
Testing Date / Time:	06/07/99			Preparation:	light tamping / 3 layers		
Testing Location:	Soil Mechanics Dept., U.C.D.						
PREPARATION PROCEDURE				**BEFORE TEST**			
Rate of Strain:			0.048mm/min	Moisture Content		%	53.81
Normal Stress:			104 kN/m^2	Bulk Density		kg/m^3	1633.47
Weight to be added:			1 kg	Dry Density		kg/m^3	1061.98
Average Moisture content of insitu samples :				Specific Gravity (measured)		Gs	2.5
Moisture content of sample after test (%):			50.88	Porosity		%	57.52
WEIGHINGS BEFORE TEST				Voids ratio		e	1.35
Soil specimen + cutter	g		235.66	Degree of Saturation		%	99.35
Cutter	g		114.49	Operator:		GC	
Soil specimen	g		121.17	Approved:		ML	

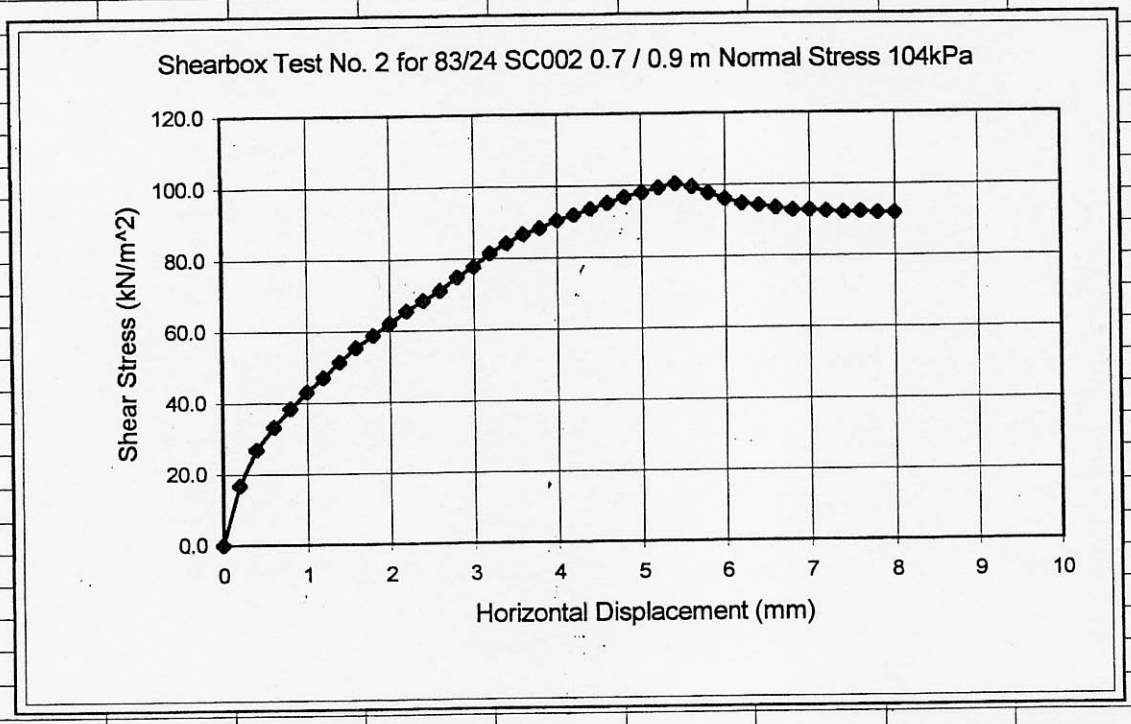
Test 1 - shearing				checked with H.C.		
BH 83/24 SC002 0.7 / 0.9m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	6.09	0	0	0.000	0.0
20	0.2	6.07	-0.02	83	0.067	18.6
40	0.4	6.05	-0.04	135	0.109	30.2
60	0.6	6.03	-0.06	166	0.134	37.2
80	0.8	6	-0.09	189	0.152	42.3
100	1	5.98	-0.11	204	0.164	45.7
120	1.2	5.96	-0.13	220	0.177	49.3
140	1.4	5.94	-0.15	238	0.192	53.3
160	1.6	5.93	-0.16	257	0.207	57.5
180	1.8	5.91	-0.18	264	0.213	59.1
200	2	5.9	-0.19	276	0.222	61.8
220	2.2	5.89	-0.2	286	0.231	64.0
240	2.4	5.88	-0.21	297	0.239	66.5
260	2.6	5.87	-0.22	307	0.247	68.7
280	2.8	5.87	-0.22	313	0.252	70.1
300	3	5.86	-0.23	324	0.261	72.6
320	3.2	5.86	-0.23	333	0.268	74.6
340	3.4	5.85	-0.24	340	0.274	76.1
360	3.6	5.85	-0.24	353	0.285	79.0
380	3.8	5.84	-0.25	364	0.293	81.5
400	4	5.84	-0.25	371	0.299	83.1
420	4.2	5.83	-0.26	377	0.304	84.4
440	4.4	5.83	-0.26	383	0.309	85.8
460	4.6	5.82	-0.27	393	0.317	88.0
480	4.8	5.81	-0.28	402	0.324	90.0
500	5	5.8	-0.29	410	0.330	91.8
520	5.2	5.8	-0.29	416	0.335	93.2
540	5.4	5.79	-0.3	428	0.345	95.8
560	5.6	5.79	-0.3	442	0.356	99.0
580	5.8	5.78	-0.31	450	0.363	100.8
600	6	5.77	-0.32	458	0.369	102.6
620	6.2	5.76	-0.33	464	0.374	103.9
640	6.4	5.76	-0.33	474	0.382	106.1
660	6.6	5.75	-0.34	481	0.388	107.7
680	6.8	5.74	-0.35	484	0.390	108.4
700	7	5.74	-0.35	482	0.388	107.9
720	7.2	5.74	-0.35	487	0.393	109.1
740	7.4	5.73	-0.36	488	0.393	109.3
760	7.6	5.73	-0.36	485	0.391	108.6
780	7.8	5.73	-0.36	478	0.385	107.0
800	8	5.73	-0.36	470	0.379	105.2
820	8.2	5.73	-0.36	465	0.375	104.1
840	8.4	5.72	-0.37	463	0.373	103.7
860	8.6	5.72	-0.37	458	0.369	102.6
880	8.8	5.72	-0.37	456	0.368	102.1
900	9	5.71	-0.38	453	0.365	101.4
920	9.2	5.71	-0.38	454	0.366	101.7
940	9.4	5.7	-0.39	455	0.367	101.9
960	9.6	5.7	-0.39	450	0.363	100.8
980	9.8	5.68	-0.41	450	0.363	100.8
1000	10	5.66	-0.43	451	0.364	101.0

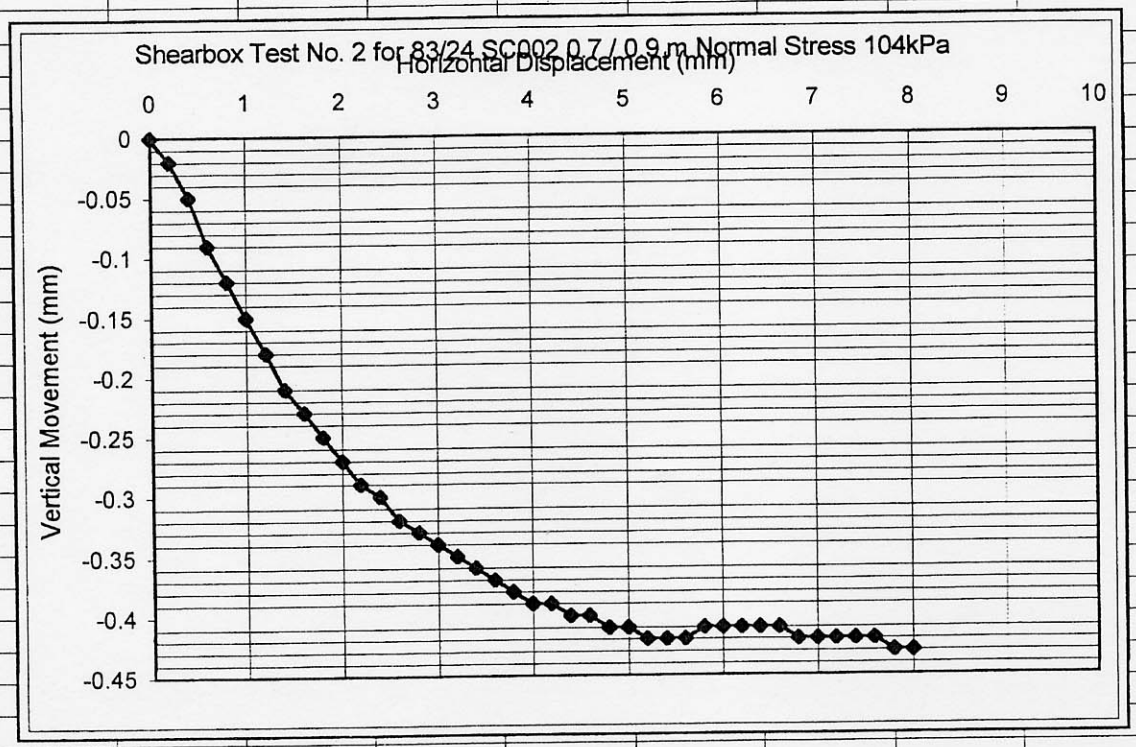

Shearbox Test No. 1 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Shear Stress (kN/m^2)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
1
2
3
4
5
6
7
8
9
10
Horizontal Displacement (mm)


Shearbox Test No. 1 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
2
4
6
8
10
Vertical Movement (mm)
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45

SHEARBOX TEST		NO. 83/24 SCOO2 0.7 / 0.9 m (2)							
Location:		RSG 83/24			Job ref:		99/1		
					Borehole ref:		BHSC002		
Soil Description:		white sandy silt			Sample no.:		2		
Test method:		BS 1377 : Part 7 : 1990 : 4/5			Depths:		0.7 / 0.9m		
Machine:		Wykeham Farrance 1978			Sampling method:		Grab		
Specimen dimensions:		L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS		
Specimen Type:		Remoulded /Submerged			Sampling Date:				
Testing Date / Time:		07/07/99			Preparation:	light tamping / 3 layers			
Testing Location:		Soil Mechanics Dept., U.C.D.							
PREPARATION PROCEDURE					**BEFORE TEST**				
Rate of Strain:				0.048mm/min	Moisture Content		%	46.87	
Normal Stress:				104 kN/m^2	Bulk Density		kg/m^3	1494.62	
Weight to be added:				1 kg	Dry Density		kg/m^3	1017.65	
Average Moisture content of insitu samples :					Specific Gravity (measured)		Gs	2.5	
Moisture content of sample after test (%):				45.67	Porosity		%	59.29	
WEIGHINGS BEFORE TEST					Voids ratio		e	1.46	
Soil specimen + cutter		g		236.12	Degree of Saturation		%	80.44	
Cutter		g		114.49	Operator:		GC		
Soil specimen		g		121.63	Approved:		ML		

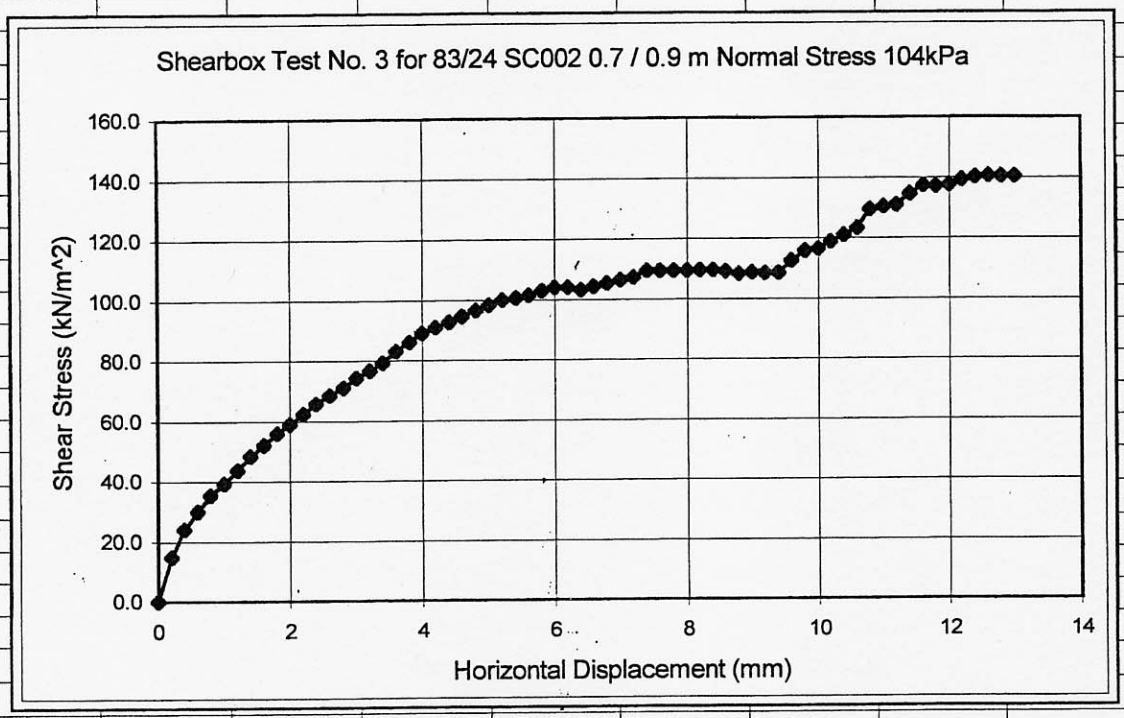
Test 2 - shearing				checked with H.C.		
BH 83/24 SC002 0.7 / 0.9m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	8.05	0	0	0.000	0.0
20	0.2	8.03	-0.02	75	0.060	16.8
40	0.4	8	-0.05	120	0.097	26.9
60	0.6	7.96	-0.09	148	0.119	33.1
80	0.8	7.93	-0.12	171	0.138	38.3
100	1	7.9	-0.15	192	0.155	43.0
120	1.2	7.87	-0.18	210	0.169	47.0
140	1.4	7.84	-0.21	229	0.185	51.3
160	1.6	7.82	-0.23	247	0.199	55.3
180	1.8	7.8	-0.25	262	0.211	58.7
200	2	7.78	-0.27	277	0.223	62.0
220	2.2	7.76	-0.29	292	0.235	65.4
240	2.4	7.75	-0.3	305	0.246	68.3
260	2.6	7.73	-0.32	317	0.256	71.0
280	2.8	7.72	-0.33	334	0.269	74.8
300	3	7.71	-0.34	347	0.280	77.7
320	3.2	7.7	-0.35	364	0.293	81.5
340	3.4	7.69	-0.36	376	0.303	84.2
360	3.6	7.68	-0.37	387	0.312	86.7
380	3.8	7.67	-0.38	394	0.318	88.2
400	4	7.66	-0.39	404	0.326	90.5
420	4.2	7.66	-0.39	410	0.330	91.8
440	4.4	7.65	-0.4	418	0.337	93.6
460	4.6	7.65	-0.4	425	0.343	95.2
480	4.8	7.64	-0.41	432	0.348	96.7
500	5	7.64	-0.41	438	0.353	98.1
520	5.2	7.63	-0.42	443	0.357	99.2
540	5.4	7.63	-0.42	448	0.361	100.3
560	5.6	7.63	-0.42	444	0.358	99.4
580	5.8	7.64	-0.41	436	0.351	97.6
600	6	7.64	-0.41	429	0.346	96.1
620	6.2	7.64	-0.41	423	0.341	94.7
640	6.4	7.64	-0.41	421	0.339	94.3
660	6.6	7.64	-0.41	418	0.337	93.6
680	6.8	7.63	-0.42	414	0.334	92.7
700	7	7.63	-0.42	414	0.334	92.7
720	7.2	7.63	-0.42	413	0.333	92.5
740	7.4	7.63	-0.42	411	0.331	92.0
760	7.6	7.63	-0.42	412	0.332	92.3
780	7.8	7.62	-0.43	410	0.330	91.8
800	8	7.62	-0.43	410	0.330	91.8
820	8.2					
840	8.4					
860	8.6					
880	8.8					
900	9					
920	9.2					
940	9.4					
960	9.6					
980	9.8					
1000	10					

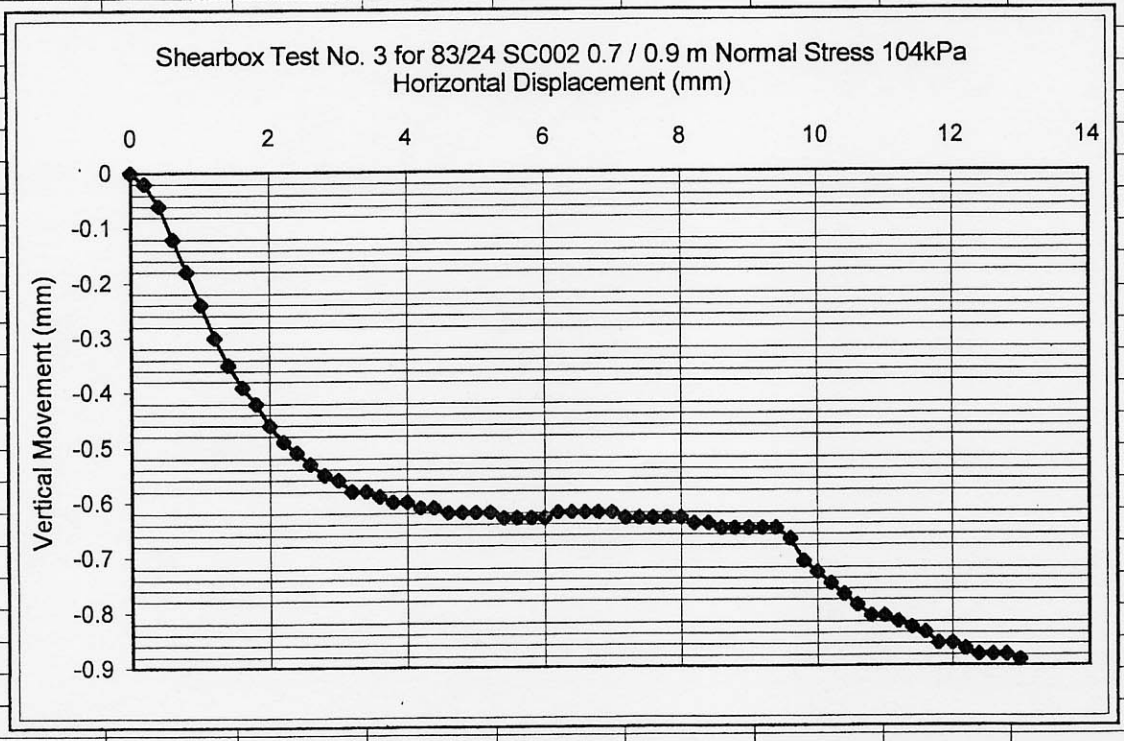

Shearbox Test No. 2 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Shear Stress (kN/m^2)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
1
2
3
4
5
6
7
8
9
10
Horizontal Displacement (mm)


Shearbox Test No. 2 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
1
2
3
4
5
6
7
8
9
10
Vertical Movement (mm)
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45

SHEARBOX TEST	NO. 83/24 SCOO2 0.7 / 0.9 m (3)				
Location:	RSG 83/24		Job ref:	99/1	
			Borehole ref:	BHSC002	
Soil Description:	white sandy silt		Sample no.:	3	
Test method:	BS 1377 : Part 7 : 1990 : 4/5		Depths:	0.7 / 0.9m	
Machine:	Wykeham Farrance 1978		Sampling method:	Grab	
Specimen dimensions:	L (60mm) x B(60mm) x H(21.61mm)		Sampling Contractors:	BGS	
Specimen Type:	Remoulded /Submerged		Sampling Date:		
Testing Date / Time:	08/07/99		Preparation:	light tamping / 3 layers	
Testing Location:	Soil Mechanics Dept., U.C.D.				
PREPARATION PROCEDURE			**BEFORE TEST**		
Rate of Strain:		0.048mm/min	Moisture Content	%	41.37
Normal Stress:		104 kN/m^2	Bulk Density	kg/m^3	1444.49
Weight to be added:		1 kg	Dry Density	kg/m^3	1021.78
Average Moisture content of insitu samples :			Specific Gravity (measured)	Gs	2.5
Moisture content of sample after test (%):		43.13	Porosity	%	59.13
WEIGHINGS BEFORE TEST			Voids ratio	e	1.45
Soil specimen + cutter	g	232.04	Degree of Saturation	%	71.49
Cutter	g	114.49	Operator:	GC	
Soil specimen	g	117.55	Approved:	ML	

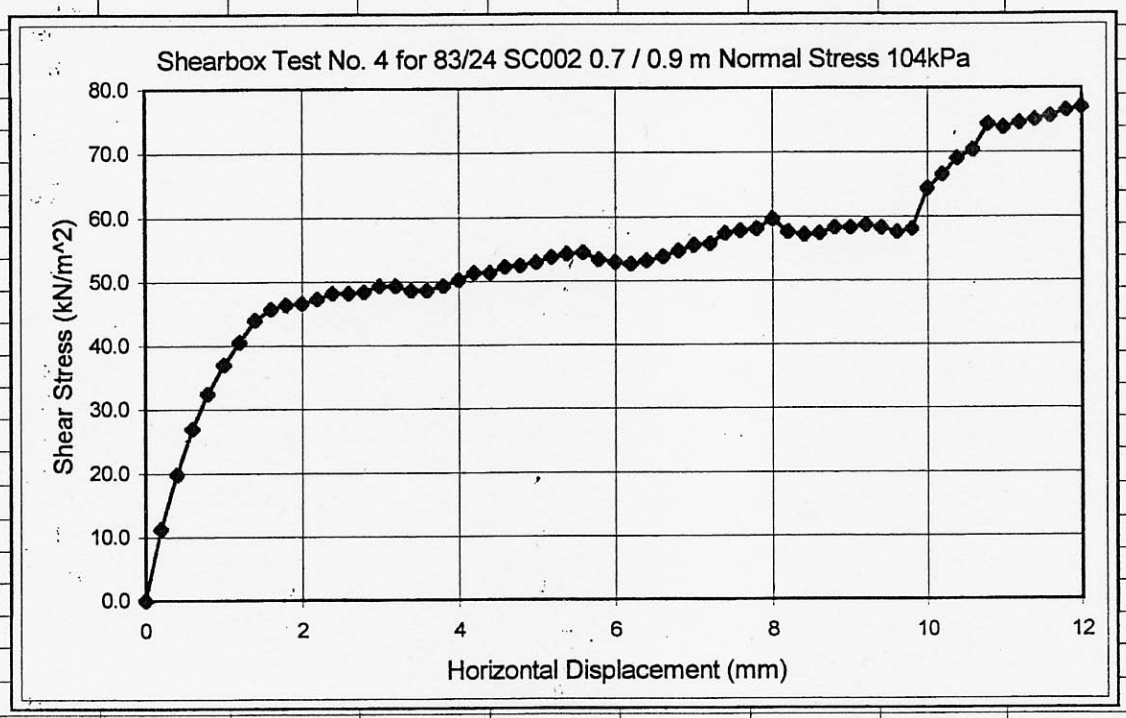
	Test 3 - shearing				checked with H.C.		
	BH 83/24 SC002 0.7 / 0.9m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
					SS = SF / *A		
					'=SF/0.00359940m^2		
	Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
	(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
	0	0	7.81	0	0	0.000	0.0
	20	0.2	7.79	-0.02	66	0.053	14.8
	40	0.4	7.75	-0.06	107	0.086	24.0
	60	0.6	7.69	-0.12	134	0.108	30.0
	80	0.8	7.63	-0.18	158	0.127	35.4
	100	1	7.57	-0.24	175	0.141	39.2
	120	1.2	7.51	-0.3	195	0.157	43.7
	140	1.4	7.46	-0.35	216	0.174	48.4
	160	1.6	7.42	-0.39	232	0.187	52.0
	180	1.8	7.39	-0.42	249	0.201	55.8
	200	2	7.35	-0.46	263	0.212	58.9
	220	2.2	7.32	-0.49	278	0.224	62.3
	240	2.4	7.3	-0.51	293	0.236	65.6
	260	2.6	7.28	-0.53	306	0.247	68.5
	280	2.8	7.26	-0.55	317	0.256	71.0
	300	3	7.25	-0.56	331	0.267	74.1
	320	3.2	7.23	-0.58	342	0.276	76.6
	340	3.4	7.23	-0.58	353	0.285	79.0
	360	3.6	7.22	-0.59	371	0.299	83.1
	380	3.8	7.21	-0.6	384	0.310	86.0
	400	4	7.21	-0.6	397	0.320	88.9
	420	4.2	7.2	-0.61	406	0.327	90.9
	440	4.4	7.2	-0.61	414	0.334	92.7
	460	4.6	7.19	-0.62	422	0.340	94.5
	480	4.8	7.19	-0.62	431	0.347	96.5
	500	5	7.19	-0.62	438	0.353	98.1
	520	5.2	7.19	-0.62	446	0.359	99.9
	540	5.4	7.18	-0.63	449	0.362	100.5
	560	5.6	7.18	-0.63	453	0.365	101.4
	580	5.8	7.18	-0.63	459	0.370	102.8
	600	6	7.18	-0.63	464	0.374	103.9
	620	6.2	7.19	-0.62	464	0.374	103.9
	640	6.4	7.19	-0.62	460	0.371	103.0
	660	6.6	7.19	-0.62	465	0.375	104.1
	680	6.8	7.19	-0.62	470	0.379	105.2
	700	7	7.19	-0.62	475	0.383	106.4
	720	7.2	7.18	-0.63	479	0.386	107.3
	740	7.4	7.18	-0.63	488	0.393	109.3
	760	7.6	7.18	-0.63	488	0.393	109.3
	780	7.8	7.18	-0.63	488	0.393	109.3
	800	8	7.18	-0.63	488	0.393	109.3
	820	8.2	7.17	-0.64	489	0.394	109.5
	840	8.4	7.17	-0.64	489	0.394	109.5
	860	8.6	7.16	-0.65	487	0.393	109.1
	880	8.8	7.16	-0.65	483	0.389	108.2
	900	9	7.16	-0.65	485	0.391	108.6
	920	9.2	7.16	-0.65	484	0.390	108.4
	940	9.4	7.16	-0.65	484	0.390	108.4
	960	9.6	7.14	-0.67	502	0.405	112.4
	980	9.8	7.1	-0.71	517	0.417	115.8
	1000	10	7.08	-0.73	520	0.419	116.4
	1020	10.2	7.06	-0.75	530	0.427	118.7
	1040	10.4	7.04	-0.77	540	0.435	120.9
	1060	10.6	7.02	-0.79	550	0.443	123.2
	1080	10.8	7	-0.81	578	0.466	129.4
	1100	11	7	-0.81	582	0.469	130.3
	1120	11.2	6.99	-0.82	585	0.472	131.0
	1140	11.4	6.98	-0.83	601	0.484	134.6
	1160	11.6	6.97	-0.84	613	0.494	137.3
	1180	11.8	6.95	-0.86	612	0.493	137.0
	1200	12	6.95	-0.86	614	0.495	137.5
	1220	12.2	6.94	-0.87	622	0.501	139.3
	1240	12.4	6.93	-0.88	626	0.505	140.2
	1260	12.6	6.93	-0.88	628	0.506	140.6
	1280	12.8	6.93	-0.88	627	0.505	140.4
	1300	13	6.92	-0.89	627	0.505	140.4

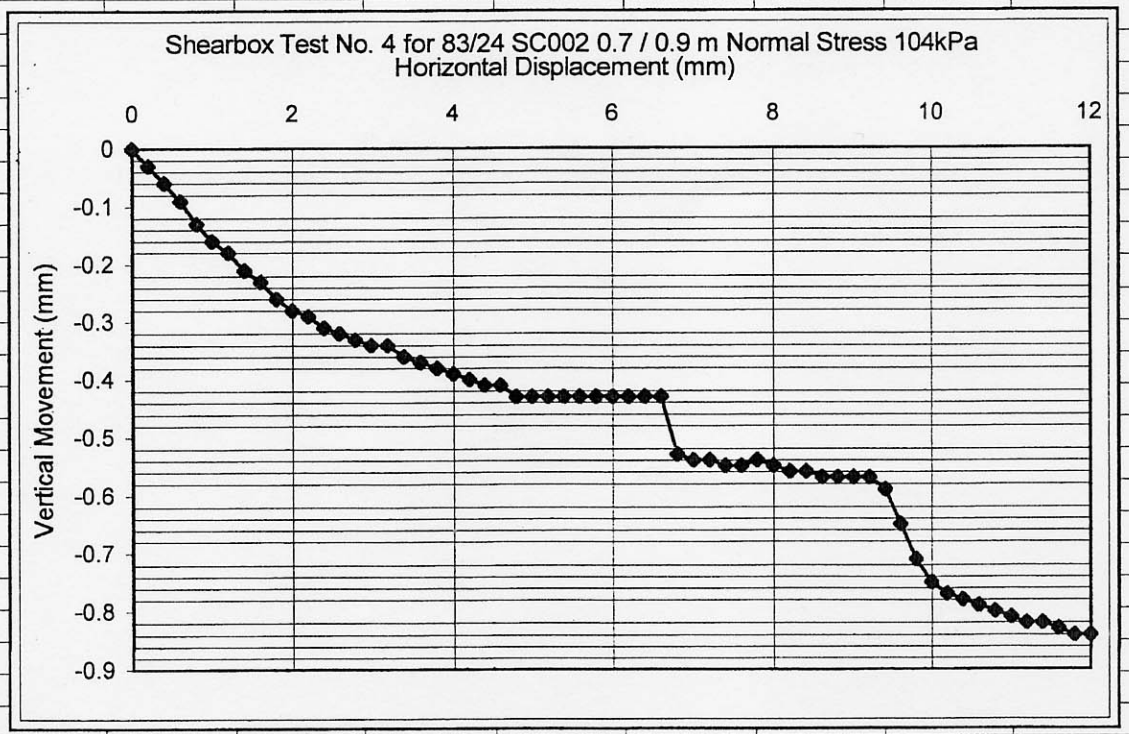

Shearbox Test No. 3 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Shear Stress (kN/m^2)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
2
4
6
8
10
12
14
Horizontal Displacement (mm)


Shearbox Test No. 3 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
2
4
6
8
10
12
14
Vertical Movement (mm)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9

SHEARBOX TEST			**NO. 83/24 SCOO2 0.7/0.9 m (4)**						
Location:		RSG 83/24			Job ref:		99/1		
					Borehole ref:		BHSC002		
Soil Description:		white sandy silt			Sample no.:		4		
Test method:		BS 1377 : Part 7 : 1990 : 4/5			Depths:		0.7 / 0.9m		
Machine:		Wykeham Farrance 1978			Sampling method:		Grab		
Specimen dimensions:		L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS		
Specimen Type:		Remoulded /Submerged			Sampling Date:				
Testing Date / Time:		06/07/99			Preparation:		light tamping / 3 layers		
Testing Location:		Soil Mechanics Dept., U.C.D.							
PREPARATION PROCEDURE					**BEFORE TEST**				
Rate of Strain:				0.048mm/min	Moisture Content		%	34.69	
Normal Stress:				104 kN/m^2	Bulk Density		kg/m^3	1340.77	
Weight to be added:				1 kg	Dry Density		kg/m^3	995.45	
Average Moisture content of insitu samples :					Specific Gravity (measured)		Gs	2.5	
Moisture content of sample after test (%):				40.58	Porosity		%	60.18	
WEIGHINGS BEFORE TEST					Voids ratio		e	1.51	
Soil specimen + cutter		g		223.60	Degree of Saturation		%	57.38	
Cutter		g		114.49	Operator:		GC		
Soil specimen		g		109.11	Approved:		ML		

Test 4 - shearing				checked with H.C.		
BH 83/24 SC002 0.7 / 0.9m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	7.83	0	0	0.000	0.0
20	0.2	7.8	-0.03	50	0.040	11.2
40	0.4	7.77	-0.06	88	0.071	19.7
60	0.6	7.74	-0.09	120	0.097	26.9
80	0.8	7.7	-0.13	145	0.117	32.5
100	1	7.67	-0.16	165	0.133	36.9
120	1.2	7.65	-0.18	181	0.146	40.5
140	1.4	7.62	-0.21	196	0.158	43.9
160	1.6	7.6	-0.23	204	0.164	45.7
180	1.8	7.57	-0.26	207	0.167	46.4
200	2	7.55	-0.28	208	0.168	46.6
220	2.2	7.54	-0.29	211	0.170	47.2
240	2.4	7.52	-0.31	215	0.173	48.1
260	2.6	7.51	-0.32	215	0.173	48.1
280	2.8	7.5	-0.33	216	0.174	48.4
300	3	7.49	-0.34	220	0.177	49.3
320	3.2	7.49	-0.34	220	0.177	49.3
340	3.4	7.47	-0.36	217	0.175	48.6
360	3.6	7.46	-0.37	217	0.175	48.6
380	3.8	7.45	-0.38	220	0.177	49.3
400	4	7.44	-0.39	224	0.181	50.2
420	4.2	7.43	-0.4	229	0.185	51.3
440	4.4	7.42	-0.41	229	0.185	51.3
460	4.6	7.42	-0.41	233	0.188	52.2
480	4.8	7.4	-0.43	234	0.189	52.4
500	5	7.4	-0.43	236	0.190	52.8
520	5.2	7.4	-0.43	240	0.193	53.7
540	5.4	7.4	-0.43	242	0.195	54.2
560	5.6	7.4	-0.43	243	0.196	54.4
580	5.8	7.4	-0.43	238	0.192	53.3
600	6	7.4	-0.43	236	0.190	52.8
620	6.2	7.4	-0.43	235	0.189	52.6
640	6.4	7.4	-0.43	237	0.191	53.1
660	6.6	7.4	-0.43	240	0.193	53.7
680	6.8	7.3	-0.53	244	0.197	54.6
700	7	7.29	-0.54	248	0.200	55.5
720	7.2	7.29	-0.54	249	0.201	55.8
740	7.4	7.28	-0.55	256	0.206	57.3
760	7.6	7.28	-0.55	258	0.208	57.8
780	7.8	7.29	-0.54	259	0.209	58.0
800	8	7.28	-0.55	266	0.214	59.6
820	8.2	7.27	-0.56	257	0.207	57.5
840	8.4	7.27	-0.56	255	0.206	57.1
860	8.6	7.26	-0.57	256	0.206	57.3
880	8.8	7.26	-0.57	260	0.210	58.2
900	9	7.26	-0.57	260	0.210	58.2
920	9.2	7.26	-0.57	262	0.211	58.7
940	9.4	7.24	-0.59	260	0.210	58.2
960	9.6	7.18	-0.65	257	0.207	57.5
980	9.8	7.12	-0.71	259	0.209	58.0
1000	10	7.08	-0.75	287	0.231	64.3
1020	10.2	7.06	-0.77	297	0.239	66.5
1040	10.4	7.05	-0.78	308	0.248	69.0
1060	10.6	7.04	-0.79	314	0.253	70.3
1080	10.8	7.03	-0.8	332	0.268	74.3
1100	11	7.02	-0.81	330	0.266	73.9
1120	11.2	7.01	-0.82	333	0.268	74.6
1140	11.4	7.01	-0.82	335	0.270	75.0
1160	11.6	7	-0.83	338	0.272	75.7
1180	11.8	6.99	-0.84	342	0.276	76.6
1200	12	6.99	-0.84	344	0.277	77.0

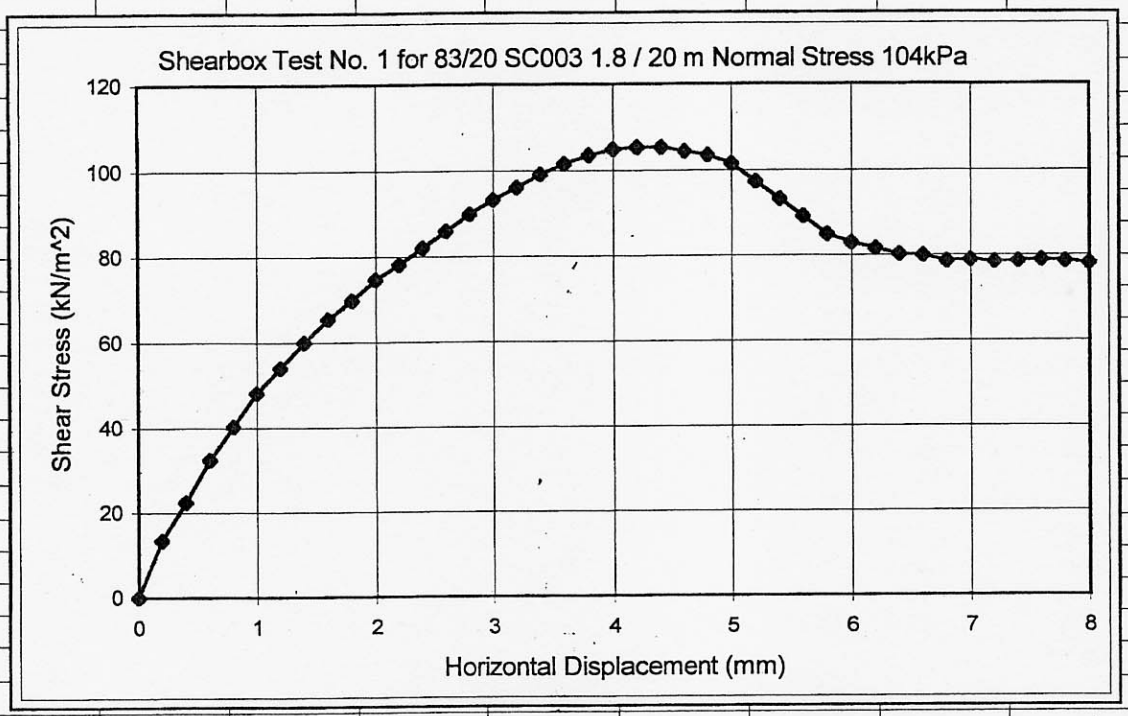

Shearbox Test No. 4 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Shear Stress (kN/m^2)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
2
4
6
8
10
12
Horizontal Displacement (mm)

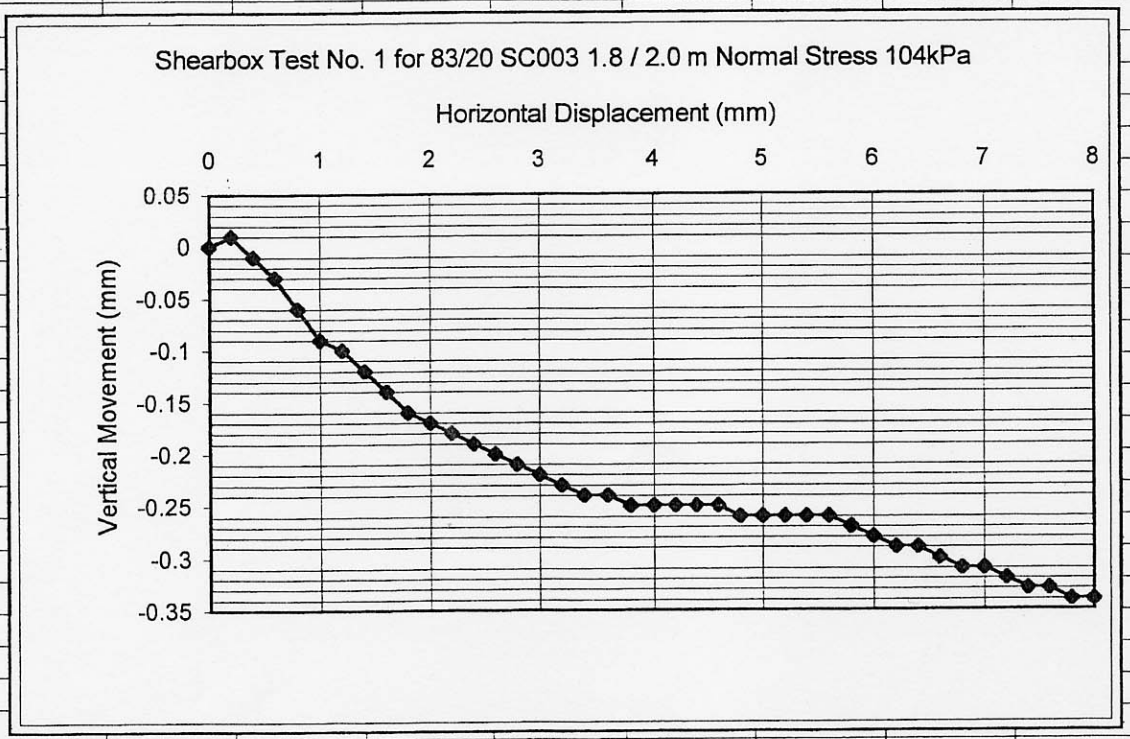

Shearbox Test No. 4 for 83/24 SC002 0.7 / 0.9 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
2
4
6
8
10
12
Vertical Movement (mm)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9

SHEARBOX TEST			**NO. 83/20 SCOO3 1.8/2.0 m (1)**						
Location:		RSG 83/20			Job ref:		99/1		
					Borehole ref:		BHSC003		
Soil Description:		Silty fine sand			Sample no.:		1		
Test method:		BS 1377 : Part 7 : 1990 : 4/5			Depths:		1.8/ 2.0m		
Machine:		Wykeham Farrance 1978			Sampling method:		Grab		
Specimen dimensions:		L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS		
Specimen Type:		Remoulded /Submerged			Sampling Date:				
Testing Date / Time:		23/06/99			Preparation:	light tamping / 3 layers			
Testing Location:		Soil Mechanics Dept., U.C.D.							
PREPARATION PROCEDURE					**BEFORE TEST**				
Rate of Strain:				0.06mm/min	Moisture Content		%	58.10	
Normal Stress:				104 kN/m^2	Bulk Density		kg/m^3	1387.72	
Weight to be added:				1 kg	Dry Density		kg/m^3	877.75	
Average Moisture content of insitu samples :					Specific Gravity (measured)		Gs	2.5	
Moisture content of sample after test (%):				57.20	Porosity		%	64.89	
WEIGHINGS BEFORE TEST					Voids ratio		e	1.85	
Soil specimen + cutter		g		227.32	Degree of Saturation		%	78.59	
Cutter		g		114.49	Operator:		GC		
Soil specimen		g		112.83	Approved:		ML		

3
5

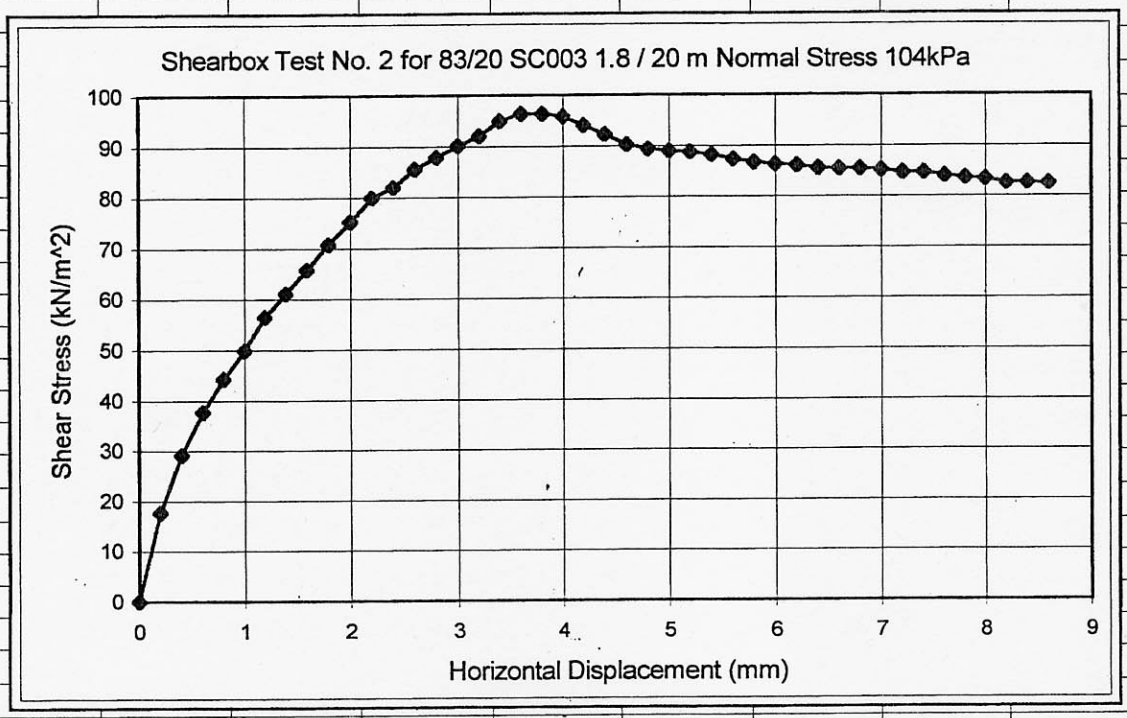
Test 1 - shearing				checked with H.C.		
BH 83/20 SC003 1.8 / 20m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	7.41	0	0	0	0
20	0.2	7.42	0.01	60	0.04836	13.43557
40	0.4	7.4	-0.01	100	0.0806	22.39262
60	0.6	7.38	-0.03	145	0.11687	32.4693
80	0.8	7.35	-0.06	180	0.14508	40.30672
100	1	7.32	-0.09	215	0.17329	48.14414
120	1.2	7.31	-0.1	241	0.194246	53.96622
140	1.4	7.29	-0.12	268	0.216008	60.01222
160	1.6	7.27	-0.14	292	0.235352	65.38645
180	1.8	7.25	-0.16	312	0.251472	69.86498
200	2	7.24	-0.17	333	0.268398	74.56743
220	2.2	7.23	-0.18	349	0.281294	78.15025
240	2.4	7.22	-0.19	366	0.294996	81.95699
260	2.6	7.21	-0.2	384	0.309504	85.98766
280	2.8	7.2	-0.21	401	0.323206	89.79441
300	3	7.19	-0.22	416	0.335296	93.1533
320	3.2	7.18	-0.23	429	0.345774	96.06434
340	3.4	7.17	-0.24	442	0.356252	98.97538
360	3.6	7.17	-0.24	453	0.365118	101.4386
380	3.8	7.16	-0.25	462	0.372372	103.4539
400	4	7.16	-0.25	468	0.377208	104.7975
420	4.2	7.16	-0.25	470	0.37882	105.2453
440	4.4	7.16	-0.25	470	0.37882	105.2453
460	4.6	7.16	-0.25	466	0.375596	104.3496
480	4.8	7.15	-0.26	462	0.372372	103.4539
500	5	7.15	-0.26	453	0.365118	101.4386
520	5.2	7.15	-0.26	434	0.349804	97.18398
540	5.4	7.15	-0.26	416	0.335296	93.1533
560	5.6	7.15	-0.26	398	0.320788	89.12263
580	5.8	7.14	-0.27	379	0.305474	84.86803
600	6	7.13	-0.28	370	0.29822	82.8527
620	6.2	7.12	-0.29	364	0.293384	81.50914
640	6.4	7.12	-0.29	358	0.288548	80.16558
660	6.6	7.11	-0.3	357	0.287742	79.94166
680	6.8	7.1	-0.31	351	0.282906	78.5981
700	7	7.1	-0.31	352	0.283712	78.82203
720	7.2	7.09	-0.32	350	0.2821	78.37417
740	7.4	7.08	-0.33	351	0.282906	78.5981
760	7.6	7.08	-0.33	352	0.283712	78.82203
780	7.8	7.07	-0.34	351	0.282906	78.5981
800	8	7.07	-0.34	349	0.281294	78.15025

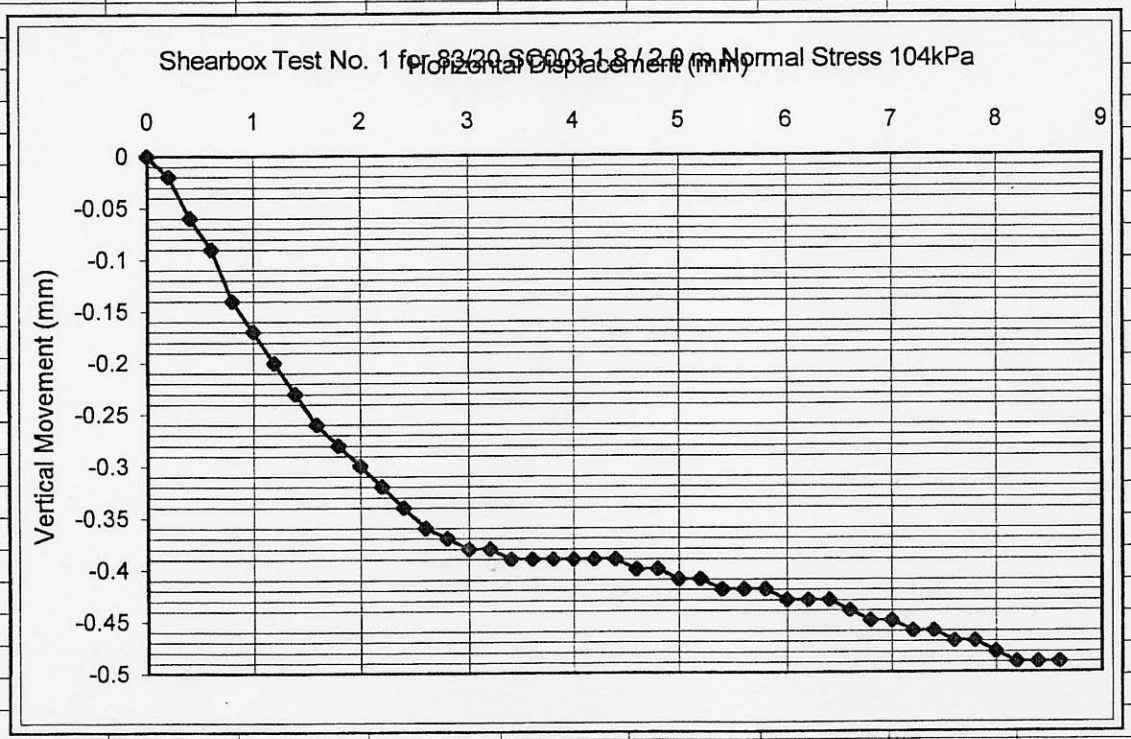

Shearbox Test No. 1 for 83/20 SC003 1.8 / 20 m Normal Stress 104kPa
Shear Stress (kN/m^2)
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
Horizontal Displacement (mm)


Shearbox Test No. 1 for 83/20 SC003 1.8 / 2.0 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
1
2
3
4
5
6
7
8
Vertical Movement (mm)
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35

SHEARBOX TEST	NO. 83/20 SCOO3 1.8/2.0 m (2)						
Location:	RSG 83/20		Job ref:		99/1		
			Borehole ref:		BHSC003		
Soil Description:	Silty fine sand		Sample no.:		2		
Test method:	BS 1377 : Part 7 : 1990 : 4/5		Depths:		1.8/ 2.0m		
Machine:	Wykeham Farrance 1978		Sampling method:		Grab		
Specimen dimensions:	L (60mm) x B(60mm) x H(21.61mm)		Sampling Contractors:		BGS		
Specimen Type:	Remoulded /Submerged		Sampling Date:				
Testing Date / Time:	24/06/99		Preparation:	light tamping / 3 layers			
Testing Location:	Soil Mechanics Dept., U.C.D.						
PREPARATION PROCEDURE			**BEFORE TEST**				
Rate of Strain:		0.048mm/min	Moisture Content		%	52.88	
Normal Stress:		104 kN/m^2	Bulk Density		kg/m^3	1441.66	
Weight to be added:		1 kg	Dry Density		kg/m^3	943.01	
Average Moisture content of insitu samples :			Specific Gravity (measured)		Gs	2.5	
Moisture content of sample after test (%):		53.04	Porosity		%	62.28	
WEIGHINGS BEFORE TEST			Voids ratio		e	1.65	
Soil specimen + cutter	g	231.81	Degree of Saturation		%	80.07	
Cutter	g	114.49	Operator:		GC		
Soil specimen	g	117.32	Approved:		ML		

Test 2 - shearing				checked with H.C.		
BH 83/20 SC003 1.8 / 20m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	8.54	0	0	0	0
20	0.2	8.52	-0.02	79	0.064	17.7
40	0.4	8.48	-0.06	130	0.105	29.1
60	0.6	8.45	-0.09	168	0.135	37.6
80	0.8	8.4	-0.14	198	0.160	44.3
100	1	8.37	-0.17	223	0.180	49.9
120	1.2	8.34	-0.2	252	0.203	56.4
140	1.4	8.31	-0.23	273	0.220	61.1
160	1.6	8.28	-0.26	294	0.237	65.8
180	1.8	8.26	-0.28	316	0.255	70.8
200	2	8.24	-0.3	336	0.271	75.2
220	2.2	8.22	-0.32	357	0.288	79.9
240	2.4	8.2	-0.34	366	0.295	82.0
260	2.6	8.18	-0.36	382	0.308	85.5
280	2.8	8.17	-0.37	392	0.316	87.8
300	3	8.16	-0.38	402	0.324	90.0
320	3.2	8.16	-0.38	411	0.331	92.0
340	3.4	8.15	-0.39	424	0.342	94.9
360	3.6	8.15	-0.39	430	0.347	96.3
380	3.8	8.15	-0.39	430	0.347	96.3
400	4	8.15	-0.39	428	0.345	95.8
420	4.2	8.15	-0.39	420	0.339	94.0
440	4.4	8.15	-0.39	412	0.332	92.3
460	4.6	8.14	-0.4	403	0.325	90.2
480	4.8	8.14	-0.4	399	0.322	89.3
500	5	8.13	-0.41	397	0.320	88.9
520	5.2	8.13	-0.41	396	0.319	88.7
540	5.4	8.12	-0.42	394	0.318	88.2
560	5.6	8.12	-0.42	390	0.314	87.3
580	5.8	8.12	-0.42	387	0.312	86.7
600	6	8.11	-0.43	385	0.310	86.2
620	6.2	8.11	-0.43	384	0.310	86.0
640	6.4	8.11	-0.43	382	0.308	85.5
660	6.6	8.1	-0.44	381	0.307	85.3
680	6.8	8.09	-0.45	381	0.307	85.3
700	7	8.09	-0.45	380	0.306	85.1
720	7.2	8.08	-0.46	378	0.305	84.6
740	7.4	8.08	-0.46	378	0.305	84.6
760	7.6	8.07	-0.47	375	0.302	84.0
780	7.8	8.07	-0.47	373	0.301	83.5
800	8	8.06	-0.48	372	0.300	83.3
820	8.2	8.05	-0.49	369	0.297	82.6
840	8.4	8.05	-0.49	369	0.297	82.6
860	8.6	8.05	-0.49	368	0.296608	82.4

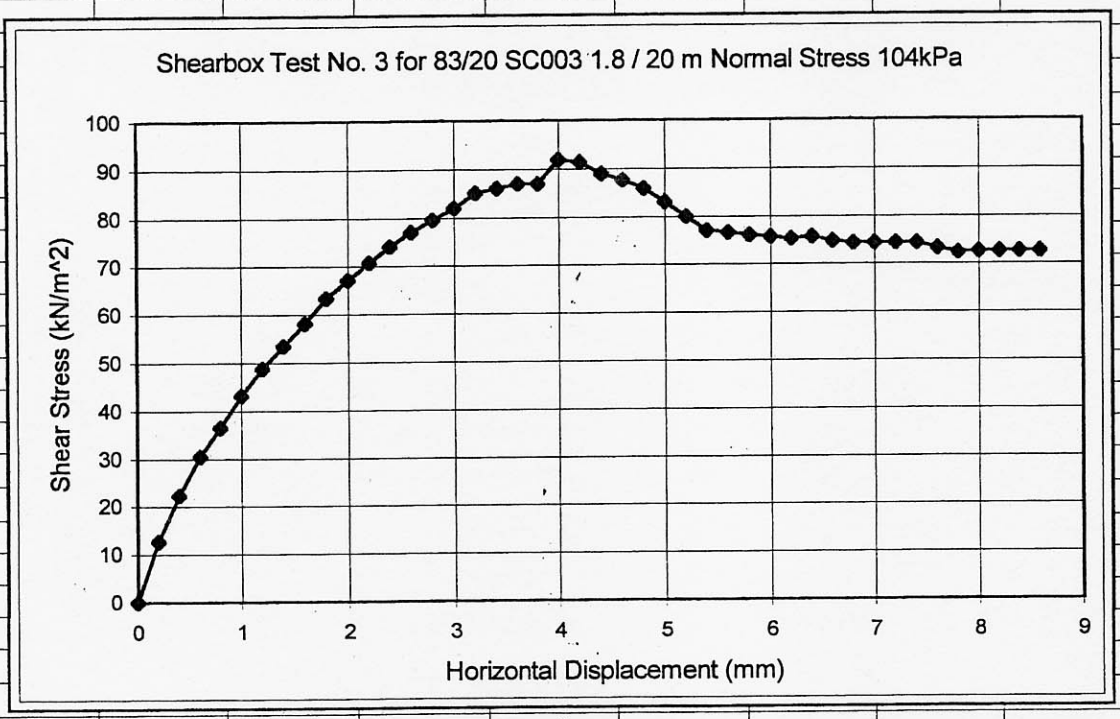

Shearbox Test No. 2 for 83/20 SC003 1.8 / 20 m Normal Stress 104kPa
Shear Stress (kN/m^2)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Horizontal Displacement (mm)

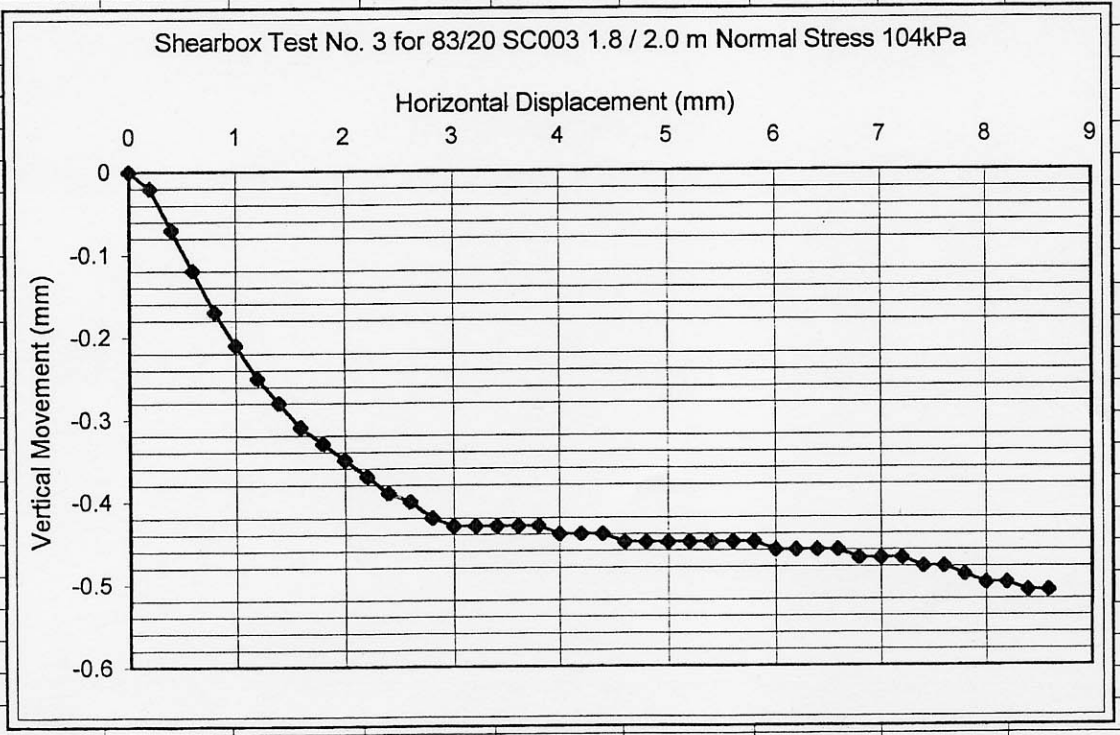

Shearbox Test No. 1 for 83/20 SC003 1.8 / 2.0 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
1
2
3
4
5
6
7
8
9
Vertical Movement (mm)
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5

SHEARBOX TEST	NO. 83/20 SCOO3 1.8/2.0 m (3)						
Location:	RSG 83/20			Job ref:		99/1	
				Borehole ref:		BHSC003	
Soil Description:	Silty fine sand			Sample no.:		3	
Test method:	BS 1377 : Part 7 : 1990 : 4/5			Depths:		1.8/ 2.0m	
Machine:	Wykeham Farrance 1978			Sampling method:		Grab	
Specimen dimensions:	L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS	
Specimen Type:	Remoulded /Submerged			Sampling Date:			
Testing Date / Time:	25/06/99			Preparation:	light tamping / 3 layers		
Testing Location:	Soil Mechanics Dept., U.C.D.						
PREPARATION PROCEDURE				BEFORE TEST			
Rate of Strain:			0.048mm/min	Moisture Content		%	49.35
Normal Stress:			104 kN/m^2	Bulk Density		kg/m^3	1449.89
Weight to be added:			1 kg	Dry Density		kg/m^3	970.79
Average Moisture content of insitu samples :				Specific Gravity (measured)		Gs	2.5
Moisture content of sample after test (%):			50.53	Porosity		%	61.17
WEIGHINGS BEFORE TEST				Voids ratio		e	1.58
Soil specimen + cutter	g		232.48	Degree of Saturation		%	78.33
Cutter	g		114.49	Operator:		GC	
Soil specimen	g		117.99	Approved:		ML	

Test 3 - shearing				checked with H.C.		
BH 83/20 SC003 1.8 / 20m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	8.65	0	0	0	0
20	0.2	8.63	-0.02	57	0.046	12.8
40	0.4	8.58	-0.07	100	0.081	22.4
60	0.6	8.53	-0.12	136	0.110	30.5
80	0.8	8.48	-0.17	163	0.131	36.5
100	1	8.44	-0.21	193	0.156	43.2
120	1.2	8.4	-0.25	218	0.176	48.8
140	1.4	8.37	-0.28	239	0.193	53.5
160	1.6	8.34	-0.31	260	0.210	58.2
180	1.8	8.32	-0.33	283	0.228	63.4
200	2	8.3	-0.35	300	0.242	67.2
220	2.2	8.28	-0.37	316	0.255	70.8
240	2.4	8.26	-0.39	331	0.267	74.1
260	2.6	8.25	-0.4	344	0.277	77.0
280	2.8	8.23	-0.42	355	0.286	79.5
300	3	8.22	-0.43	366	0.295	82.0
320	3.2	8.22	-0.43	380	0.306	85.1
340	3.4	8.22	-0.43	384	0.310	86.0
360	3.6	8.22	-0.43	388	0.313	86.9
380	3.8	8.22	-0.43	388	0.313	86.9
400	4	8.21	-0.44	410	0.330	91.8
420	4.2	8.21	-0.44	408	0.329	91.4
440	4.4	8.21	-0.44	397	0.320	88.9
460	4.6	8.2	-0.45	391	0.315	87.6
480	4.8	8.2	-0.45	383	0.309	85.8
500	5	8.2	-0.45	371	0.299	83.1
520	5.2	8.2	-0.45	357	0.288	79.9
540	5.4	8.2	-0.45	344	0.277	77.0
560	5.6	8.2	-0.45	342	0.276	76.6
580	5.8	8.2	-0.45	340	0.274	76.1
600	6	8.19	-0.46	338	0.272	75.7
620	6.2	8.19	-0.46	336	0.271	75.2
640	6.4	8.19	-0.46	338	0.272	75.7
660	6.6	8.19	-0.46	334	0.269	74.8
680	6.8	8.18	-0.47	332	0.268	74.3
700	7	8.18	-0.47	332	0.268	74.3
720	7.2	8.18	-0.47	332	0.268	74.3
740	7.4	8.17	-0.48	332	0.268	74.3
760	7.6	8.17	-0.48	327	0.264	73.2
780	7.8	8.16	-0.49	323	0.260	72.3
800	8	8.15	-0.5	324	0.261	72.6
820	8.2	8.15	-0.5	324	0.261	72.6
840	8.4	8.14	-0.51	324	0.261	72.6
860	8.6	8.14	-0.51	324	0.261	72.6

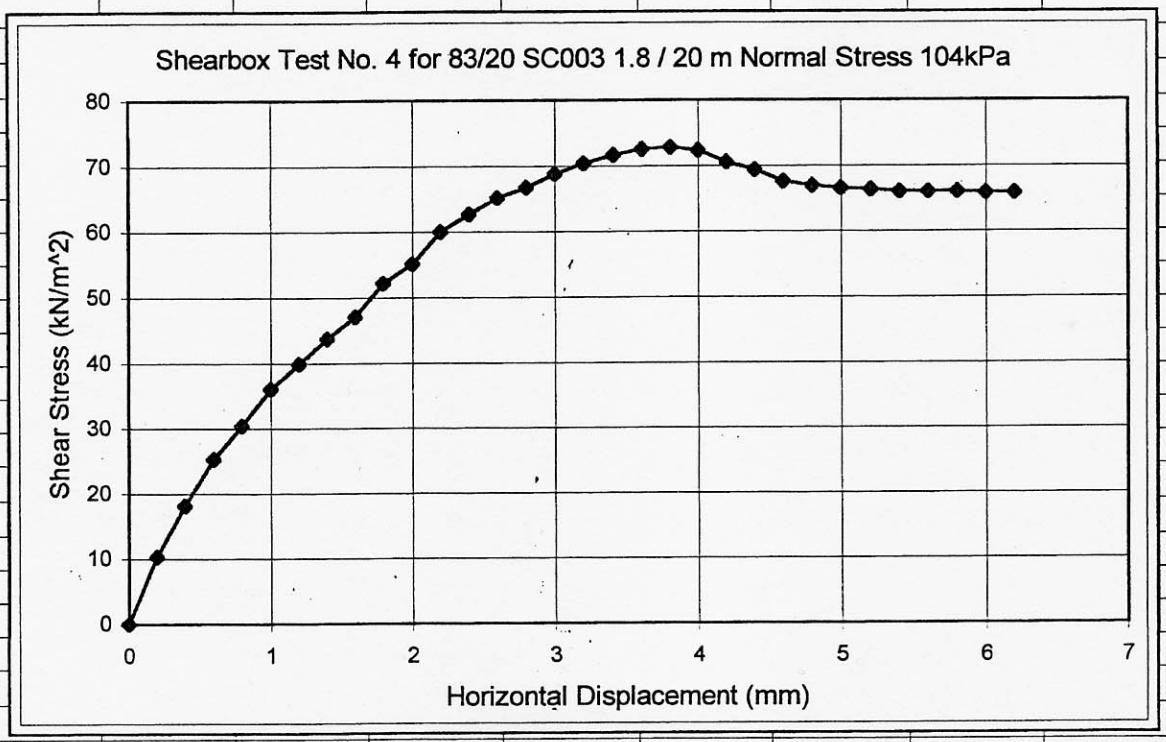
34.9

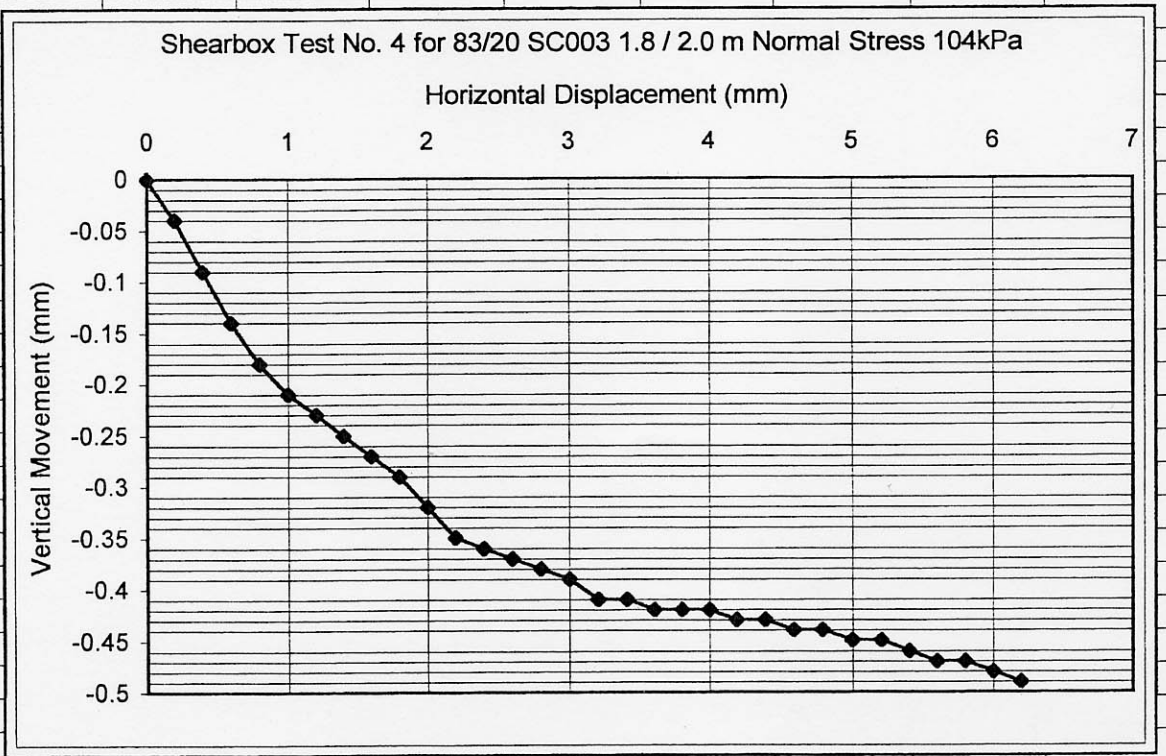

Shearbox Test No. 3 for 83/20 SC003 1.8 / 20 m Normal Stress 104kPa
Shear Stress (kN/m^2)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Horizontal Displacement (mm)


Shearbox Test No. 3 for 83/20 SC003 1.8 / 2.0 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
1
2
3
4
5
6
7
8
9
Vertical Movement (mm)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6

SHEARBOX TEST			**NO. 83/20 SCOO3 1.8/2.0 m (4)**						
Location:		RSG 83/20			Job ref:		99/1		
					Borehole ref:		BHSC003		
Soil Description:		Silty fine sand			Sample no.:		4		
Test method:		BS 1377 : Part 7 : 1990 : 4/5			Depths:		1.8/ 2.0m		
Machine:		Wykeham Farrance 1978			Sampling method:		Grab		
Specimen dimensions:		L (60mm) x B(60mm) x H(21.61mm)			Sampling Contractors:		BGS		
Specimen Type:		Remoulded /Submerged			Sampling Date:				
Testing Date / Time:		26/06/99			Preparation:	light tamping / 3 layers			
Testing Location:		Soil Mechanics Dept., U.C.D.							
PREPARATION PROCEDURE					**BEFORE TEST**				
Rate of Strain:				0.048mm/min	Moisture Content		%	49.02	
Normal Stress:				104 kN/m^2	Bulk Density		kg/m^3	1389.31	
Weight to be added:				1 kg	Dry Density		kg/m^3	932.31	
Average Moisture content of insitu samples :					Specific Gravity (measured)		Gs	2.5	
Moisture content of sample after test (%):				51.59	Porosity		%	62.71	
WEIGHINGS BEFORE TEST					Voids ratio		e	1.68	
Soil specimen + cutter		g		227.55	Degree of Saturation		%	72.88	
Cutter		g		114.49	Operator:		GC		
Soil specimen		g		113.06	Approved:		ML		

Test 4 - shearing				checked with H.C.		
BH 83/20 SC003 1.8 / 20m Normal Stress 104kPa				SF = PRGR x 0.000806 kN/div		
				SS = SF / *A		
				'=SF/0.00359940m^2		
Horizontal Displacement Reading	Horizontal Displacement	Vertical Displacement Reading	Expansion(+) Settlement (-)	Proving Ring Guage Reading	Shear Force	Shear Stress
(0.01mm)	(mm)	(0.01mm)	(mm)	(0.002mm)	(kN)	(kN/m^2)
0	0	8.37	0	0	0	0
20	0.2	8.33	-0.04	46	0.037	10.3
40	0.4	8.28	-0.09	81	0.065	18.1
60	0.6	8.23	-0.14	113	0.091	25.3
80	0.8	8.19	-0.18	136	0.110	30.5
100	1	8.16	-0.21	161	0.130	36.1
120	1.2	8.14	-0.23	178	0.143	39.9
140	1.4	8.12	-0.25	195	0.157	43.7
160	1.6	8.1	-0.27	210	0.169	47.0
180	1.8	8.08	-0.29	233	0.188	52.2
200	2	8.05	-0.32	246	0.198	55.1
220	2.2	8.02	-0.35	268	0.216	60.0
240	2.4	8.01	-0.36	280	0.226	62.7
260	2.6	8	-0.37	291	0.235	65.2
280	2.8	7.99	-0.38	298	0.240	66.7
300	3	7.98	-0.39	307	0.247	68.7
320	3.2	7.96	-0.41	314	0.253	70.3
340	3.4	7.96	-0.41	320	0.258	71.7
360	3.6	7.95	-0.42	324	0.261	72.6
380	3.8	7.95	-0.42	325	0.262	72.8
400	4	7.95	-0.42	323	0.260	72.3
420	4.2	7.94	-0.43	315	0.254	70.5
440	4.4	7.94	-0.43	310	0.250	69.4
460	4.6	7.93	-0.44	302	0.243	67.6
480	4.8	7.93	-0.44	299	0.241	67.0
500	5	7.92	-0.45	297	0.239	66.5
520	5.2	7.92	-0.45	296	0.239	66.3
540	5.4	7.91	-0.46	295	0.238	66.1
560	5.6	7.9	-0.47	295	0.238	66.1
580	5.8	7.9	-0.47	295	0.238	66.1
600	6	7.89	-0.48	294	0.237	65.8
620	6.2	7.88	-0.49	294	0.237	65.8

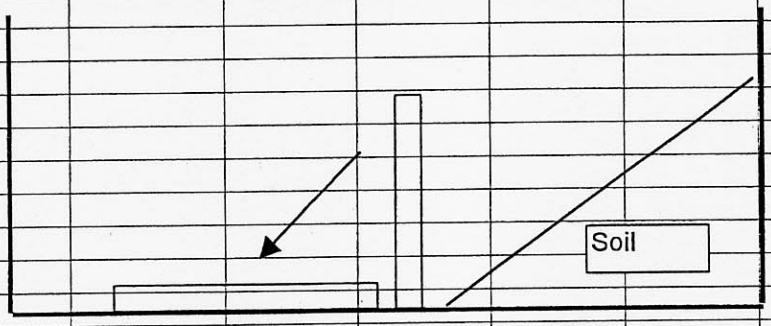

Shearbox Test No. 4 for 83/20 SC003 1.8 / 20 m Normal Stress 104kPa
Shear Stress (kN/m^2)
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
Horizontal Displacement (mm)


Shearbox Test No. 4 for 83/20 SC003 1.8 / 2.0 m Normal Stress 104kPa
Horizontal Displacement (mm)
0
1
2
3
4
5
6
7
Vertical Movement (mm)
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
-0.45
-0.5

RSG - Angle of Repose Test

Operator:	GC
Checked:	ML

Technique: Dry soil in model retaining wall experiment repeated 5 times

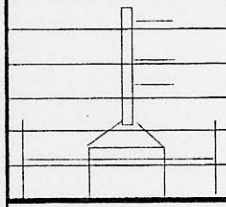


Borehole	Sample No.	Angle of Repose Deg.
BH 11/20	SC002	40
BBH 83/24	SC002	32
BH 83/20	SC003	30

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/24
Sample No:	SC002 - 1
Depth (m):	Entire sample
Date:	09/08/99
Mode of preparation:	3 layers / light
	soaked o/night
Operator:	GC
Checked:	ML



Sample length, L (mm)	126.72
Sample diameter,D (mm)	105.4
Moisture content trimmings 1 (%)	37.6
Moisture content trimmings 2 (%)	37.5
Average moisture content (%)	37.55
Specific gravity	2.5
Sample area, A (mm^2)	8725.13
Sample volume (cm^3)	1105.65
Mass of sample (g)	1323.55
Bulk density (Mg/m^3)	1.197
Dry density (Mg/m^3)	0.870
Void ratio	1.87
Test temperature (Deg. C)	22

Standpipe dia. (mm)	9.5	Area, a (mm^2)	70.882

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	485	0	0	0		0
h3	415	0.133	0.133	0.133		0.133
h2	345	0.28	0.28	0.28		0.28

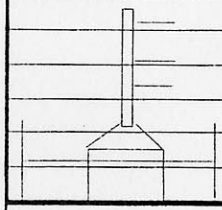
Test run 1 - 3	height ratio =	1.169	k =	2.012E-05	m/s
Test run 3 - 2	height ratio =	1.203	k =	2.158E-05	m/s
			Average k =	2.085E-05	m/s
			Temp correction =	0.92	
			Test result k =	**1.918E-05**	**m/s**

83/24 SC002 (1)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/24
Sample No:	SC002 - 2
Depth (m):	Entire sample
Date:	10-11/08/1999
Mode of preparation:	3 layers / medium
	soaked o/night
Operator:	GC
Checked:	ML



Sample length, L (mm)	126.72
Sample diameter,D (mm)	105.4
Moisture content trimmings 1 (%)	40.21
Moisture content trimmings 2 (%)	40.18
Average moisture content (%)	40.195
Specific gravity	2.5
Sample area, A (mm^2)	8725.13
Sample volume (cm^3)	1105.65
Mass of sample (g)	1606.5
Bulk density (Mg/m^3)	1.453
Dry density (Mg/m^3)	1.036
Void ratio	1.41
Test temperature (Deg. C)	22

Standpipe dia. (mm)	9.5	Area, a (mm^2)	70.882

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	485	0	0	0	0	0
h3	415	1.833	1.58	1.667	1.417	1.624
h2	345	3.95	3.45	1.75	3.07	3.055

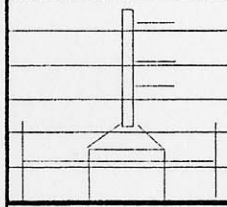
Test run 1 - 3	height ratio =	1.169	k =	1.648E-06	m/s
Test run 3 - 2	height ratio =	1.203	k =	2.217E-06	m/s
			Average k =	1.932E-06	m/s
			Temp correction =	0.92	
			Test result k =	**1.7776E-06**	**m/s**

83/24 SC002 (2)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/24		Sample length, L (mm)	126.72		
Sample No:	SC002 - 3		Sample diameter,D (mm)	105.4		
Depth (m):	Entire sample		Moisture content trimmings 1 (%)	37.7		
Date:	12-13/08/1999		Moisture content trimmings 2 (%)	38.3		
Mode of preparation:	3 layers / medium		Average moisture content (%)	38		
	soaked o/night		Specific gravity	2.5		
Operator:	GC		Sample area, A (mm^2)	8725.13		
Checked:	ML		Sample volume (cm^3)	1105.65		
h1			Mass of sample (g)	1408.8		
h3			Bulk density (Mg/m^3)	1.274		
h2			Dry density (Mg/m^3)	0.923		
			Void ratio	1.71		
			Test temperature (Deg. C)	22		
Datum						



Standpipe dia. (mm)	9.5	Area, a (mm^2)	70.882			

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	485	0	0	0	0	0
h3	415	0.1	0.1	0.1	0.1	0.100
h2	345	0.2	0.2	0.2	0.2	0.2

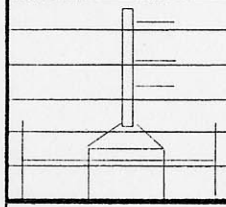
Test run 1 - 3	height ratio =	1.169	k =	2.676E-05	m/s
Test run 3 - 2	height ratio =	1.203	k =	3.172E-05	m/s
			Average k =	2.924E-05	m/s
			Temp correction =	0.92	
			Test result k =	**2.6899E-05**	**m/s**

83/24 SC002 (3)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/24		Sample length, L (mm)	126.72		
Sample No:	SC002 - 4		Sample diameter,D (mm)	105.4		
Depth (m):	Entire sample		Moisture content trimmings 1 (%)	41.6		
Date:	16/08/99		Moisture content trimmings 2 (%)	40.5		
Mode of preparation:	3 layers / dense		Average moisture content (%)	41.05		
	soaked o/night		Specific gravity	2.5		
Operator:	GC		Sample area, A (mm^2)	8725.13		
Checked:	ML		Sample volume (cm^3)	1105.65		
h1			Mass of sample (g)	1678.15		
h3			Bulk density (Mg/m^3)	1.518		
h2			Dry density (Mg/m^3)	1.076		
			Void ratio	1.32		
			Test temperature (Deg. C)	22		
Datum						



Standpipe dia. (mm)	9.5	Area, a (mm^2)	70.882			
Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	485	0	0	0	0	0
h3	415	4.08	4.08			4.080
h2	345	9.267	9.25			9.259

Test run 1 - 3	height ratio =	1.169	k =	6.559E-07	m/s
Test run 3 - 2	height ratio =	1.203	k =	6.124E-07	m/s
			Average k =	6.342E-07	m/s
			Temp correction =	0.92	
			Test result k =	**5.8344E-07**	**m/s**

83/24 SC002 (4)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/20		Sample length, L (mm)	126.68		
Sample No:	SC003 - 1		Sample diameter,D (mm)	105.44		
Depth (m):	Entire sample		Moisture content trimmings 1 (%)	39.9		
Date:	09/08/99		Moisture content trimmings 2 (%)	40.4		
Mode of preparation:	3 layers / light		Average moisture content (%)	40.15		
	soaked o/night		Specific gravity	2.54		
Operator:	GC		Sample area, A (mm^2)	8731.76		
Checked:	ML		Sample volume (cm^3)	1106.14		
h1			Mass of sample (g)	1738.38		
h3			Bulk density (Mg/m^3)	1.572		
h2			Dry density (Mg/m^3)	1.121		
			Void ratio	1.27		
			Test temperature (Deg. C)	22		
Datum						
Standpipe dia. (mm)	10.35	Area, a (mm^2)	84.134			

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	553	0	0	0	0	0
h3	483	0.1667	0.1667	0.1667		0.167
h2	413	0.35	0.35	0.35		0.350

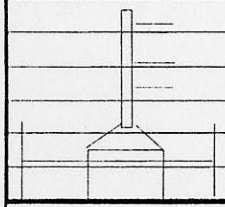
Test run 1 - 3	height ratio =	1.145	k =	1.653E-05	m/s
Test run 3 - 2	height ratio =	1.169	k =	1.739E-05	m/s
			Average k =	1.696E-05	m/s
			Temp correction =	0.92	
			Test result k =	**1.5601E-05**	**m/s**

83/20 SC003 (1)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/20		Sample length, L (mm)	126.68		
Sample No:	SC003 - 2		Sample diameter,D (mm)	105.44		
Depth (m):	Entire sample		Moisture content trimmings 1 (%)	38.3		
Date:	10-11/08/1999		Moisture content trimmings 2 (%)	38.5		
Mode of preparation:	3 layers / med. - den.		Average moisture content (%)	38.4		
	soaked o/night		Specific gravity	2.54		
Operator:	GC		Sample area, A (mm^2)	8731.76		
Checked:	ML		Sample volume (cm^3)	1106.14		
h1			Mass of sample (g)	1964.1		
h3			Bulk density (Mg/m^3)	1.776		
h2			Dry density (Mg/m^3)	1.283		
			Void ratio	0.98		
			Test temperature (Deg. C)	22		
Datum						



Standpipe dia. (mm)	4.5	Area, a (mm^2)	15.904			

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	900	0	0	0	0	0
h3	880	17	12	23.5		17.500
h2	860	39.33	27	57		41.110

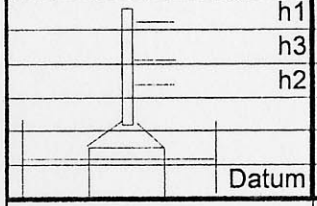
Test run 1 - 3	height ratio =	1.023	k =	4.941E-09	m/s
Test run 3 - 2	height ratio =	1.023	k =	3.747E-09	m/s
			Average k =	4.344E-09	m/s
			Temp correction =	0.92	
			Test result k =	**3.9967E-09**	**m/s**

83/20 SC003 (2)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/20
Sample No:	SC003 - 3
Depth (m):	Entire sample
Date:	12-13/08/1999
Mode of preparation:	3 layers / medium
	soaked o/night
Operator:	GC
Checked:	ML



Sample length, L (mm)	126.68
Sample diameter,D (mm)	105.44
Moisture content trimmings 1 (%)	30.8
Moisture content trimmings 2 (%)	30.8
Average moisture content (%)	30.8
Specific gravity	2.54
Sample area, A (mm^2)	8731.76
Sample volume (cm^3)	1106.14
Mass of sample (g)	1529.1
Bulk density (Mg/m^3)	1.382
Dry density (Mg/m^3)	1.057
Void ratio	1.40
Test temperature (Deg. C)	22

Standpipe dia. (mm)	10.35	Area, a (mm^2)	84.134

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	556	0	0	0	0	0
h3	486	0.0833	0.0833	0.0833		0.083
h2	416	0.1667	0.1667	0.1667		0.167

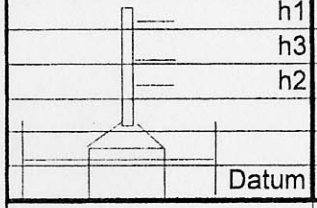
Test run 1 - 3	height ratio =	1.144	k =	3.288E-05	m/s
Test run 3 - 2	height ratio =	1.168	k =	3.796E-05	m/s
			Average k =	3.542E-05	m/s
			Temp correction =	0.92	
			Test result k =	**3.2587E-05**	**m/s**

83/20 SC003 (3)

RSG - Falling Head Permeability Test

BS1377 : Part 5 : 1990

Borehole:	83/20
Sample No:	SC003 - 4
Depth (m):	Entire sample
Date:	16/08/99
Mode of preparation:	3 layers / dense
	soaked o/night
Operator:	GC
Checked:	ML



Sample length, L (mm)	126.68
Sample diameter,D (mm)	105.44
Moisture content trimmings 1 (%)	32
Moisture content trimmings 2 (%)	32.3
Average moisture content (%)	32.15
Specific gravity	2.54
Sample area, A (mm^2)	8731.76
Sample volume (cm^3)	1106.14
Mass of sample (g)	1921.58
Bulk density (Mg/m^3)	1.737
Dry density (Mg/m^3)	1.315
Void ratio	0.93
Test temperature (Deg. C)	22

Standpipe dia. (mm)	4.5	Area, a (mm^2)	15.904

Ref. Pt.	Height above outlet (mm)	Test 1 time (min)	Test 2 time (min)	Test 3 time (mins)	Test 4 time (mins)	Average time (mins)
h1	902	0	0	0	0	0
h3	852	15.667				15.667
h2	802	38.08				38.080

Test run 1 - 3	height ratio =	1.059	k =	1.401E-08	m/s
Test run 3 - 2	height ratio =	1.062	k =	1.038E-08	m/s
			Average k =	1.220E-08	m/s
			Temp correction =	0.92	
			Test result k =	**1.1219E-08**	**m/s**

83/20 SC003 (4)

University College Dublin

Soil Mechanics Laboratory

Results of Triaxial Permeability Test

Sheet 1: Preparation & Saturation Stage

Project RSG - Soil Characterisation Study
Client RSG
Date 11/08/99
Sample 11/20 SC002
Depth Entire sample

Method of Preparation: Remoulded using light rammer

Basic Data:

Moisture Content	44.50%
Bulk Density	1.786 Mgm^3

Saturation

Step No.	Cell Pressure kPa	Back Pressure kPa	P.W.P. kPa	$\overline{B}$
1	0	0	0	
	100		98	0.98
	200		198	0.99
	250		245	0.98

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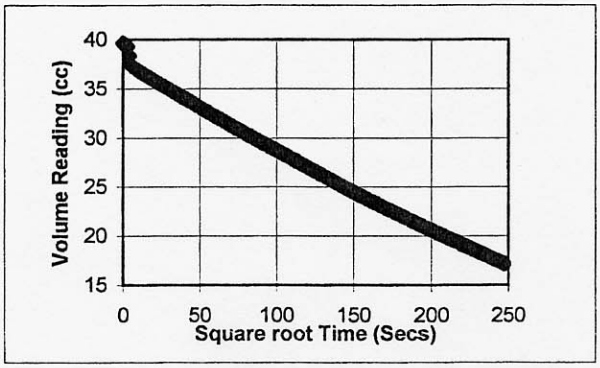
Results of Triaxial Permeability Test

Sheet 2: Consolidation Stage

Project RSG - Soil Characterisation Study
Client RSG
Date 11/08/99
Sample 11/20 SCOO2
Depth Entire Sample

Cell Pressure: 250 kPa
Back Pressure: 200 kPa



Pore Pressure: Pore pressure reading reduced quickly to back pressure, therefore stage halted.

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Results of Triaxial Permeability Test

Sheet 3: Permeability Test Stage

Client: RSG

Project: RSG - Soils Characterisation Study

Sample Ref.: 11/20 SC002 - Entire Sample

p_1 = 290 kPa

p_2 = 0

Cell p = 300 kPa

Mean Effective Stress = 155 kPa

Temperature = 20°C

Sample Area = 8332.3 mm^2

Average Height =125 mm

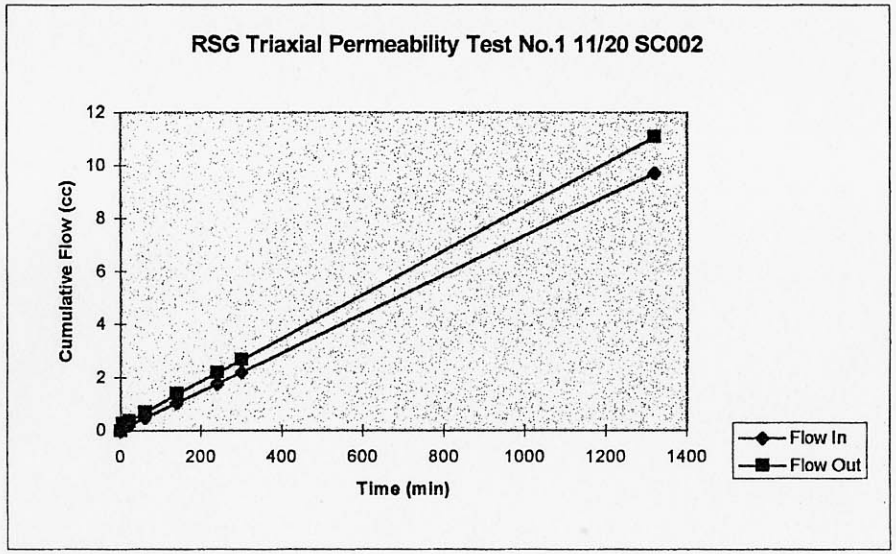
Hydraulic Gradient = 236.5

Gradient of slope, q = 8.0 x 10^{-3} ml/min

k = 6.77 x 10^{-11} m/s

Calculations to Head Vol 3, Sec 20.4

Date	Clock Time	Elapsed Time (min)	VCI (in) (cc)	α V (in) (cc)	VCI (out)/ 2 (cc)	α V (out) (cc)
16/08/99	12PM	0	6.26	0	35.1	0
"		5	6.36	0.10	34.8	0.3
"		10	6.4	0.14	34.8	0.3
"		20	6.48	0.22	34.70	0.4
"		60	6.76	0.50	34.40	0.7
"		140	7.34	1.08	33.7	1.4
"		240	8.05	1.79	32.9	2.2
"		300	8.5	2.24	32.4	2.7
17/08/99	10AM	1320	16.00	9.74	24	11.1

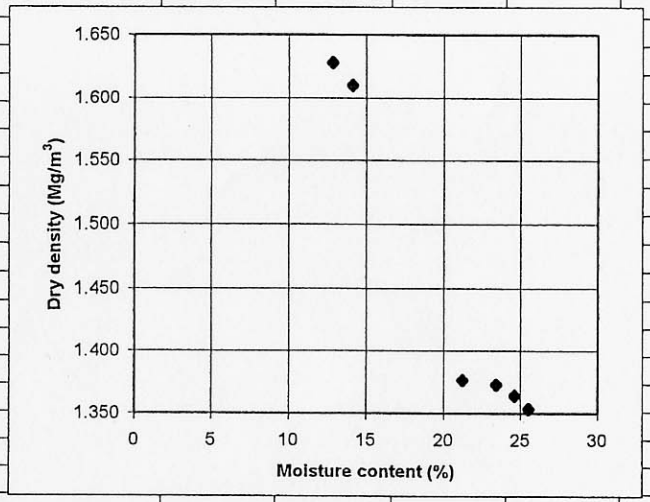


Note: This test was attempt number 7 to carry out the permeability phase.
The previous 6 attempts were at p1 values of between 60 kPa to 280 kPa.
These values were too low to push water through the sample.

RSG - Proctor Compaction Test
BS1377 : Part 4 : 1990

Borehole:	83/24
Sample No:	SC002
Depth (m):	Entire sample
Date:	17-19/08/1999
Mode of preparation:	4.5 kg rammer
Single/separate sample	Single
Total mass of sample (g)	2825
Operator:	GC
Checked:	ML

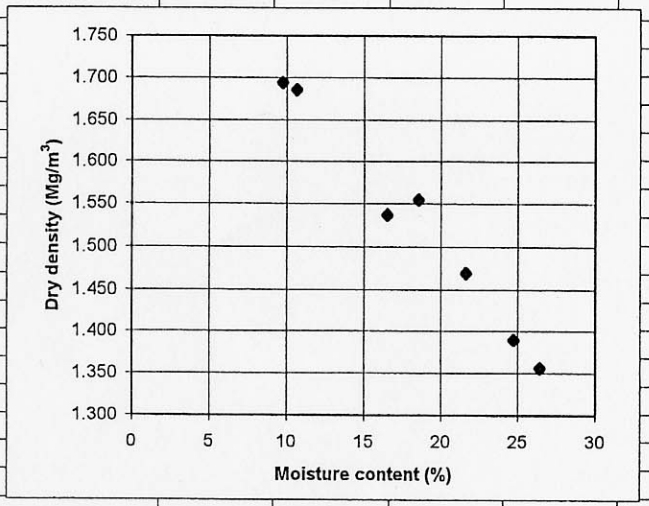
Test No.	1	2	3	4	5	6
Mass of mould+base+compacted specimen (m_2) (g)	7024	7050	7056	7055	7010	7193
Mass of mould+base (m_1) (g)	5356	5356	5356	5356	5356	5356
Mass of compacted specimen (m_2 - m_1) (g)	1668	1694	1700	1699	1654	1837
Bulk density = (m_2 - m_1)/1000 (Mg/m^3)	1.668	1.694	1.7	1.699	1.654	1.837
Moisture content container No.	38	1	39	25	22	1
Moisture content (%)	21.2	23.4	24.6	25.5	28.3	14.1
Dry density (Mg/m^3)	1.376	1.373	1.364	1.354	1.289	1.610



RSG - Proctor Compaction Test
BS1377 : Part 4 : 1990

Borehole:	83/20
Sample No:	SC003
Depth (m):	Entire sample
Date:	17-19/08/1999
Mode of preparation:	4.5 kg rammer
Single/separate sample	Single
Total mass of sample (g)	2750
Operator:	GC
Checked:	ML

Test No.	1	2	3	4	5	6	7
Mass of mould+base+compacted specimen (m_2) (g)	7147	7198	7143	7089	7070	7220	7214
Mass of mould+base (m_1) (g)	5356	5356	5356	5356	5356	5356	5356
Mass of compacted specimen (m_2 - m_1) (g)	1791	1842	1787	1733	1714	1864	1858
Bulk density = (m_2 - m_1)/1000 (Mg/m^3)	1.791	1.842	1.787	1.733	1.714	1.864	1.858
Moisture content container No.	38	1	39	25	22	1	2
Moisture content (%)	16.5	18.5	21.6	24.7	26.4	10.6	9.7
Dry density (Mg/m^3)	1.537	1.554	1.470	1.390	1.356	1.685	1.694



RSG - Maximum Void Ratio			
BS1377 : Part 4 : 1990			
Borehole:	83/24		
Sample No:	SC002		
Depth (m):	Entire sample		
Date:	17-19/08/1999		
Mode of preparation:	Loose pour		
Single/separate sample	Single		
Total mass of sample (g)	2825		
Operator:	GC		
Checked:	ML		
Test No.	1	2	3
Mass of mould+base+compacted specimen (m_2) (g)	6206		
Mass of mould+base (m_1) (g)	5356		
Mass of compacted specimen (m_2 - m_1) (g)	850		
Bulk density = (m_2 - m_1)/1000 (Mg/m^3)	0.85		
Moisture content container No.	38		
Moisture content (%)	18.2		
Dry density (Mg/m^3)	0.719		
Specific gravity	2.5		
Void ratio	2.476		

RSG - Minimum Void Ratio
BS1377 : Part 4 : 1990

Borehole:	83/24
Sample No:	SC002
Depth (m):	Entire sample
Date:	17-19/08/1999
Mode of preparation:	4.5 kg ram
Single/separate sample	Single
Total mass of sample (g)	2825
Operator:	GC
Checked:	ML

Test No.	1	2	3
Mass of mould+base+compacted specimen (m_2) (g)	7024		
Mass of mould+base (m_1) (g)	5356		
Mass of compacted specimen (m_2 - m_1) (g)	1668		
Bulk density = (m_2 - m_1)/1000 (Mg/m^3)	1.668		
Moisture content container No.	13		
Moisture content (%)	21.2		
Dry density (Mg/m^3)	1.376		
Specific gravity	2.5		
Void ratio	0.817		

RSG - Maximum Void Ratio			
BS1377 : Part 4 : 1990			
Borehole:	83/20		
Sample No:	SC003		
Depth (m):	Entire sample		
Date:	17-19/08/1999		
Mode of preparation:	Loose pour		
Single/separate sample	Single		
Total mass of sample (g)	2750		
Operator:	GC		
Checked:	ML		
Test No.	1	2	3
Mass of mould+base+compacted specimen (m_2) (g)	6302		
Mass of mould+base (m_1) (g)	5356		
Mass of compacted specimen (m_2 - m_1) (g)	946		
Bulk density = (m_2 - m_1)/1000 (Mg/m^3)	0.946		
Moisture content container No.	38		
Moisture content (%)	13.5		
Dry density (Mg/m^3)	0.833		
Specific gravity	2.54		
Void ratio	2.047		

APPENDIX V

PETROGRAPHIC REPORT
Gareth Jones

PALÆOZOIC DATING
INDUSTRIAL MINERALS
SHOW CAVE DEVELOPMENT
MATURATION AND KARST STUDIES

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Report No. 1999/32

To JBA

Petrographic Report on
Six Gravity Core Samples
11/20-sc002,
16/28-sc002,
78/28 -sc007,
83/20-sc003 (x2),
83/24-sc002
from the

Rockall Trough

JBA Job 2107

EurGeol Gareth Ll. Jones
BSc, MSc, PGeo
David Doff, BSc PhD

10 August 1999

Introduction

Six gravity cores were examined to determine their petrography. After hand specimen description, it was decided that five were suitable for thin section analysis after impregnation with epoxy resin. The sixth was a clay sample and this was examined by X-Ray Diffraction

Summary Results

Sample	Depth (m)		Method
11/20-sc002,	**1.1 - 1.3m**	Box 2 of 2	HS XRD
Plastic brown illite and kaolinite clay with minor quartz and calcite silt. The clay also contains some dolomite and salt (NaCl)			
16/28-sc002,	**1.1m**	Box 2 of 2	HS TS
Light brown clay with foraminifers and quartz silt, occasional larger bioclasts			
78/28-sc007,	**1.18m**	Box 2 of 2	HS TS
Light fawn foraminiferal sand with quartz, occasional volcanic lithoclasts			
83/20-sc003,	**1.3m**	Box 2 of 3	HS TS
Light brown very muddy sand of quartz grains and foraminifera, occasional greywacke lithoclasts			
	2.2-2.3m	Box 3 of 3	HS TS
Light brown (muddy) coarse sand of quartz grains and foraminifera			
83/24-sc002,	**0.8-0.9m**	Box 2 of 3	HS TS
Light grey (muddy) coarse sand of quartz grains and bioclasts			

HS = Hand specimen, TS = Thin section, XRD = X-Ray diffraction

Recommendation

All except the first clay sample were productive in foraminifera. A fauna that was picked from 78/28-sc007, 1.18m was abundant. It is recommended that all five sandy samples are examined by a micropalæontologist to obtain detailed biostratigraphic information concerning the age of the sample.

Detailed Petrography

11/20-sc002, 1.10-1.30m
Box 2 of 2

HAND SPECIMEN
Appearance :

Plastic brown silty clay - loose sediment

BINOCULAR :

Clay with scattered silt grains - ?quartz

Due to its fine nature , it was not considered worth-while making a thin section of this sample, so the X-Ray Diffraction technique was chosen.

XRD:
Dr. D. Doff.

XRD examination of the clay and the silt particles shows that the silt particles are composed of quartz and calcite which can be attributed to quartz grains and bioclast debris

The clay is composed of the clay minerals illite and kaolinite, with quartz and calcite present again. Also present are dolomite and salt (NaCl)

Summary: Plastic brown illite and kaolinite clay with minor quartz and calcite silt.
The clay also contains some dolomite and salt (NaCl)

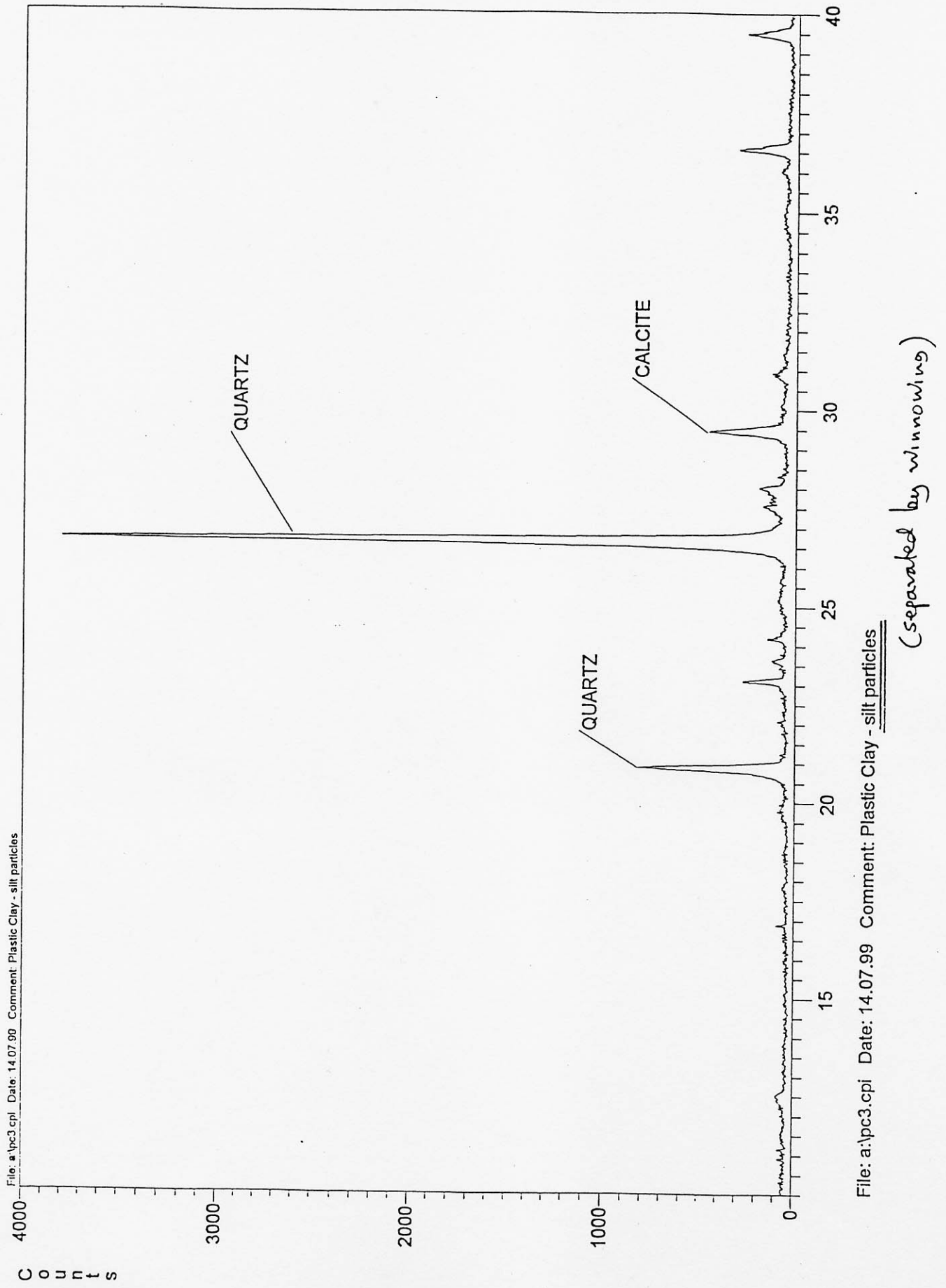


Fig. 1 XRD printout from silt fraction of 11/20-sc002, 1.10-1.30m

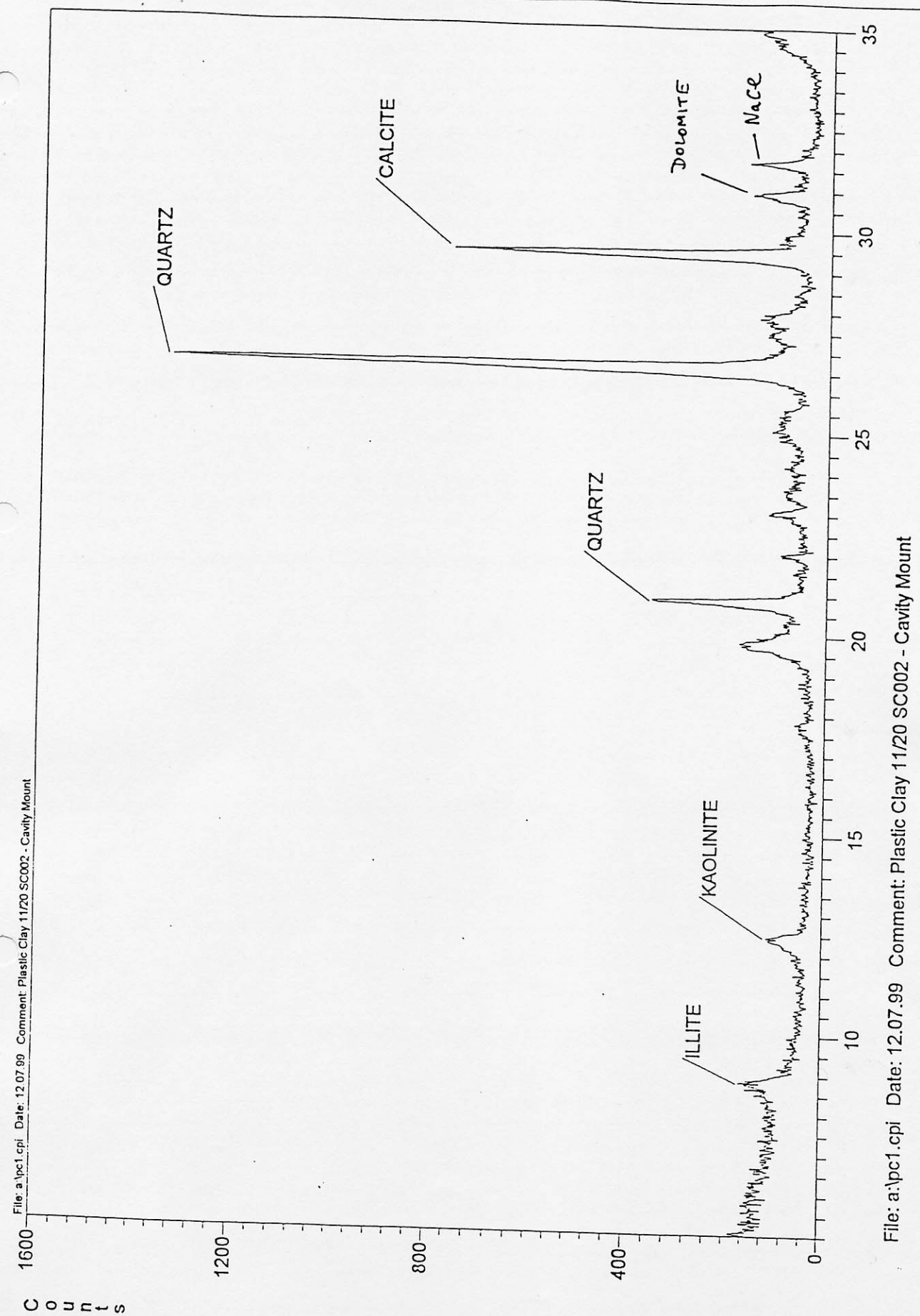


Fig. 2 XRD printout from plastic clay fraction of 11/20-sc002, 1.10-1.30m

16/28-sc002, 1.1m Box 2 of 2

HAND SPECIMEN
Appearance :

Light brown, silty clay - loose sediment

Binocular :

Muddy, medium-grained sand of mineral grains and bioclasts.

THIN SECTION
Petrography :

Medium-grained argillaceous bioclastic and quartz sand.

Grains consist of 0.1-0.3mm uni- and plurilocular foraminiferal tests.	
<0.1mm sub-angular to sub-rounded quartz grains	<40%
set in a brown clay matrix	<30%
occasional lithoclasts of reworked clay	<30%
occasional grit to pebble size bioclasts of brachiopod shells, etc.	

Summary: Light brown clay with foraminifers and quartz silt, occasional larger bioclasts

78/28-sc007, 1.18m Box 2 of 2

HAND SPECIMEN
Appearance :

Light fawn coarse sand - loose sediment

Binocular :

Coarse sand consisting dominantly of foraminiferal tests. Some other bioclasts and occasional rounded? quartz grains and metallic minerals.

THIN SECTION
Petrography :

Muddy foraminiferal sand.

0.1-0.3mm uni- and plurilocular foraminiferal tests.	
silt - grit angular to sub-angular quartz grains	<70%
in a clay matrix	<20%
occasional gravel-grained lithoclasts of volcanic, angular, glass-rich tuff	~10%
occasional rounded clast of glass with large crystals of quartz after feldspar	

Summary: Light fawn foraminiferal sand with quartz, occasional volcanic lithoclasts

Plate I

Ia. 16/28-sc002, 1.1m.

A clump of light brown clay with angular quartz grains and foraminifera.

4mm field of view, plane polarised light

Ib,c. 78/28-sc007, 1.18m

Ib. Washed coarse foraminiferal sand with quartz grains and occasional volcanic lithoclasts.

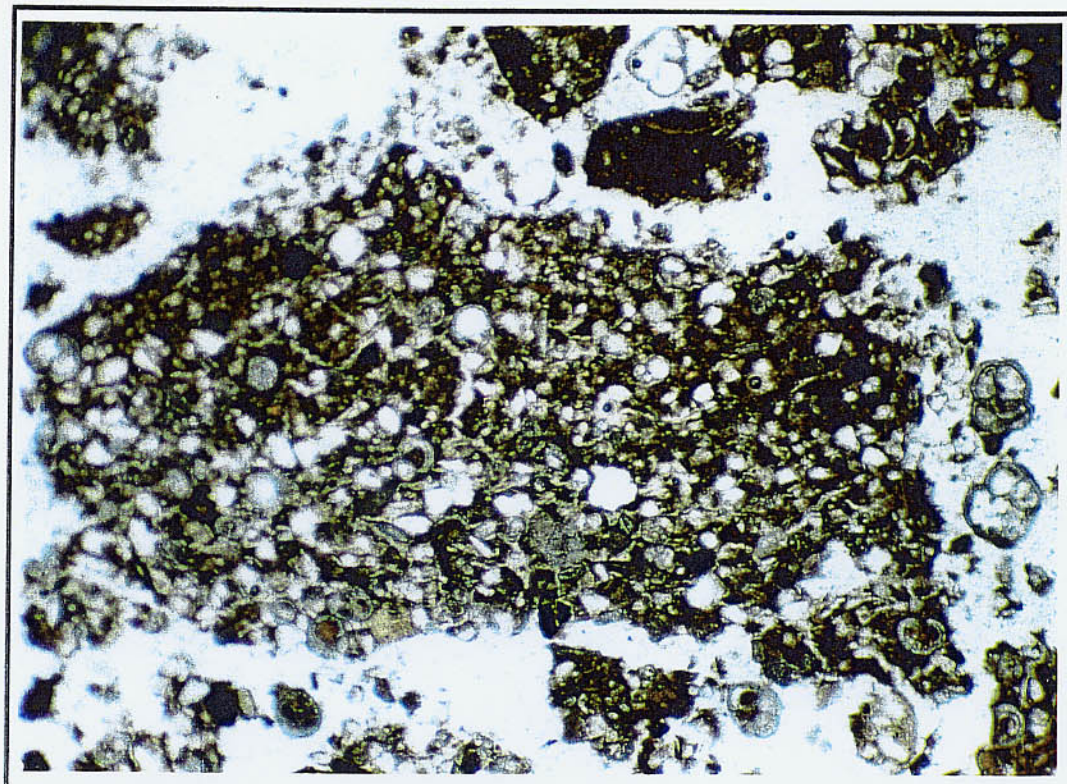
2.5mm field of view, normal light

Ic. Clay crumb with foraminifera and angular quartz grains, many free foraminifera around, sub-angular volcanic clast to south

2.5mm field of view, normal light

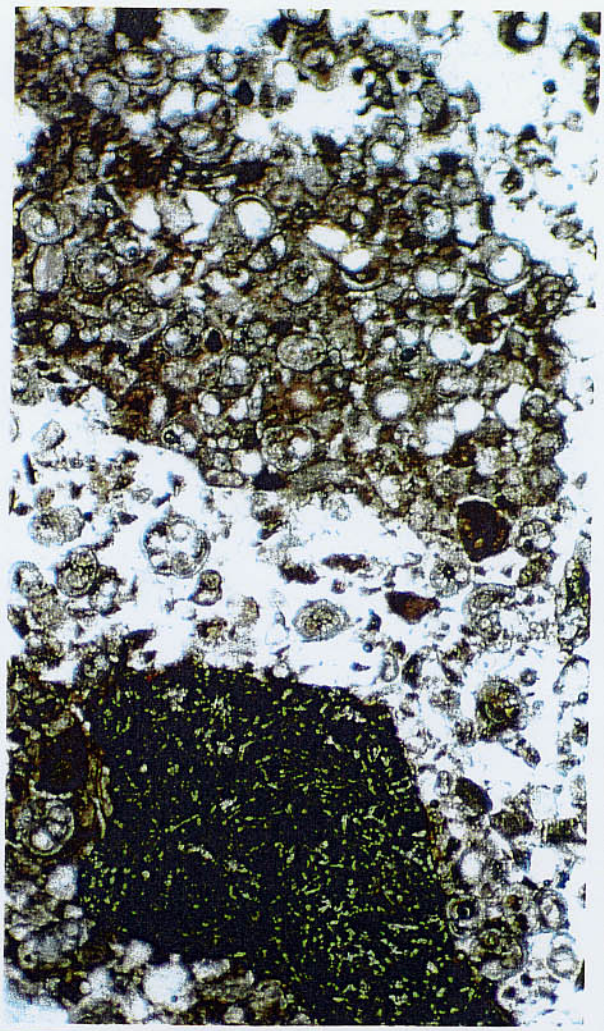
Plate I

16/28-sc002
78/28-sc007



Ia.

Ib. Ic.



83/20-sc003, 1.3m Box 2 of 3

HAND SPECIMEN
Appearance :

Light to mid-brown, very muddy sand - loose sediment.

Binocular :

Medium-grained sand in silty mud. Sand grains are bioclasts and mineral grains.

THIN SECTION
Petrography :

Very muddy brown clay with coarse bioclasts and quartz grains

mostly uni- and plurilocular foraminiferal tests <0.2mm	<25%
and fine to coarse angular to sub-angular quartz grains	<25%
occasional lithoclasts including rounded 2mm fine-grained greywacke clast and very irregular and vesicular <1mm grains of opaque material.	<3%
in a clay matrix	~50%

Summary: Light brown very muddy sand of quartz grains and foraminifera, occasional greywacke lithoclasts

83/20-sc003, 2.21-2.30m Box 3 of 3

HAND SPECIMEN
Appearance :

Light brown, (muddy) coarse-grained sand - loose sediment.

Binocular :

(Muddy) coarse-grained, bioclastic sand with mineral grains. Bioclasts are dominantly foraminiferal tests, but include a 4mm brachiopod fragment.

THIN SECTION
Petrography :

Muddy coarse to very coarse-grained sand of coarse bioclasts and quartz grains

Coarse to very coarse bioclasts, uni- and plurilocular foraminifera	<20%
and other bioclast debris	<0.5%
fine to coarse sub-angular to sub-rounded quartz grains	<30%
in brown clay matrix	<45%

Summary: Light brown muddy coarse sand of quartz grains and foraminifera

Plate II

83/20-sc003, 1.3m

IIa. Light brown very muddy sand of quartz grains and occasional foraminifera.
4mm field of view, plane polarised light

IIb. Rare rounded greywacke lithoclasts.
2.5mm field of view, plane polarised light

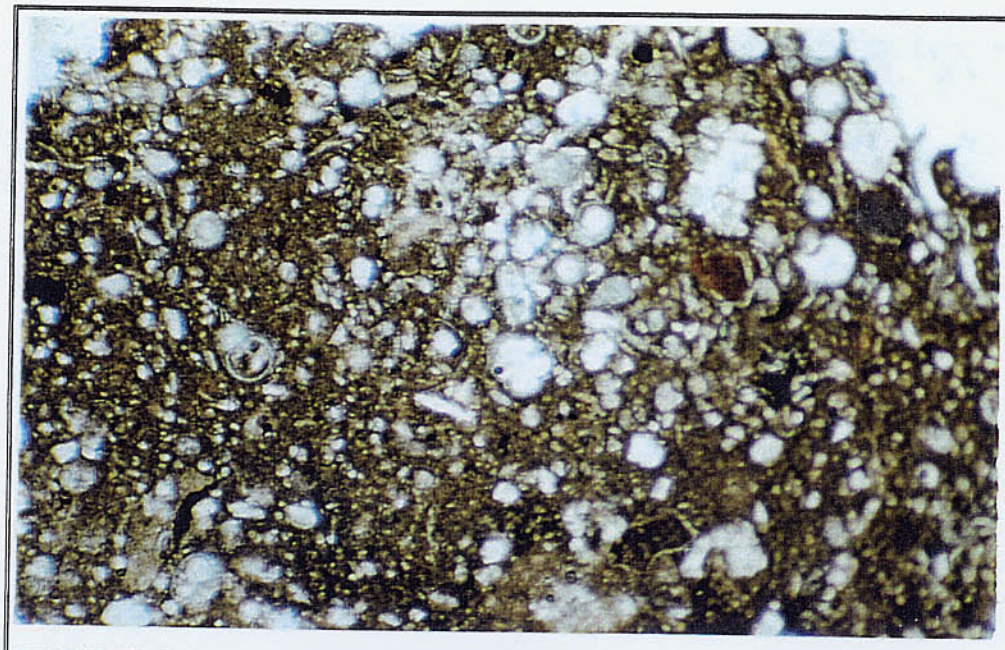
IIc. Rare irregular vuggy opaque grain
2.5mm field of view, plane polarised light

83/20-sc003, 2.21-2.30m

IId. (Muddy) coarse sand of quartz grains and foraminifera
4mm field of view, plane polarised light

Plate II

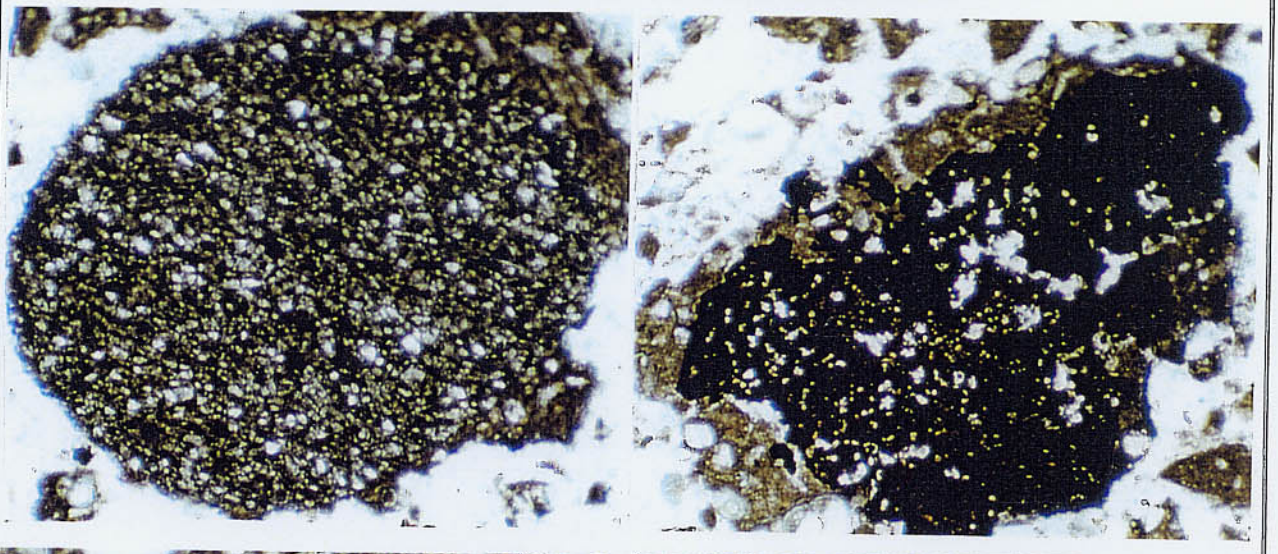
83/20-sc003

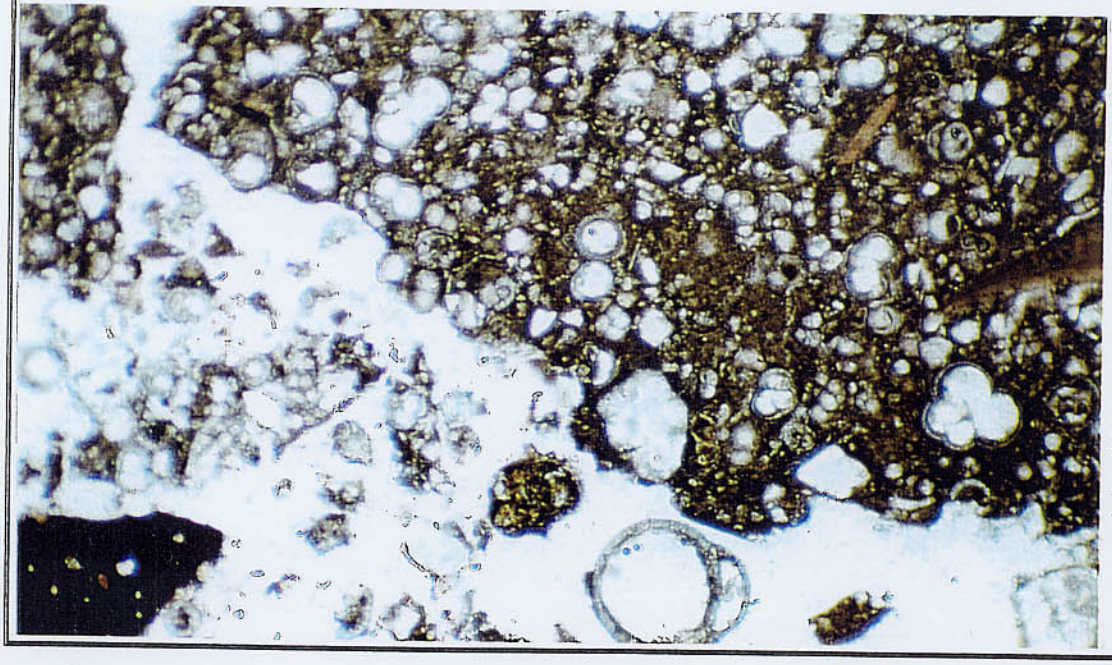


1.3m

IIa

IIb IIc





2.21-2.30m

IId

83/24-sc002, 0.80-0.90m Box 2 of 3

HAND SPECIMEN
Appearance :

Light grey, muddy, coarse sand - loose sediment

Binocular :

Coarse sand, bioclastic grains mostly foraminiferal tests with minor rounded mineral grains, mainly quartz.

THIN SECTION
Petrography :

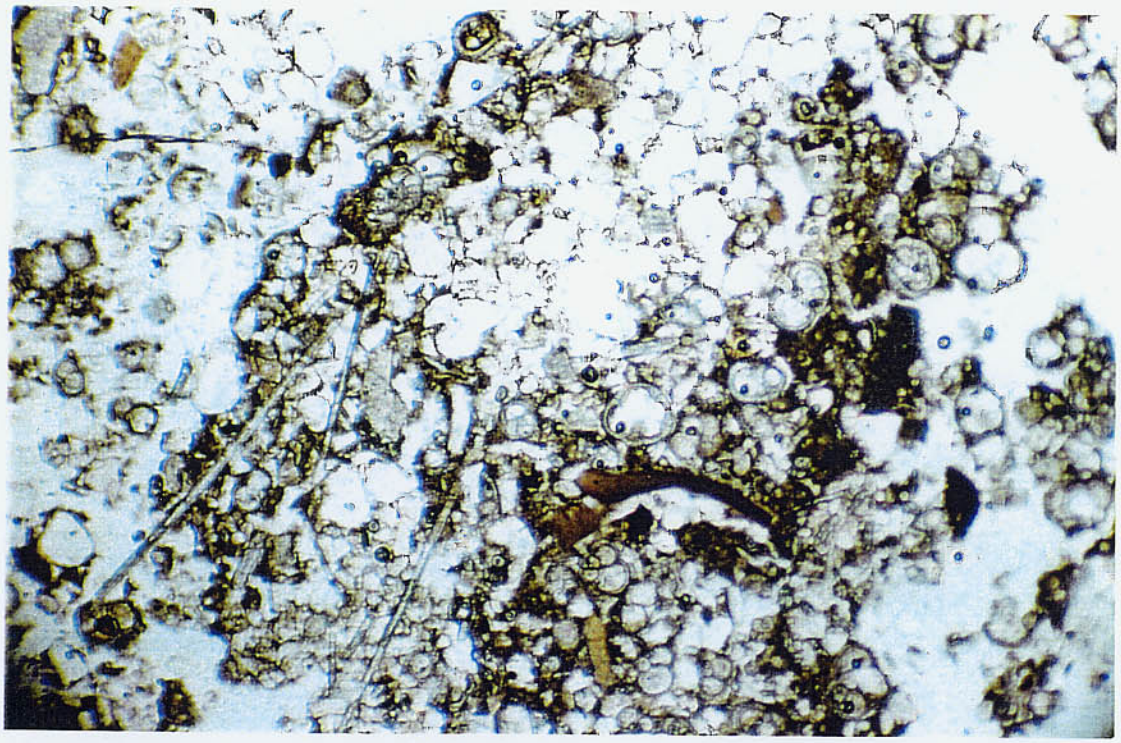
(Muddy) coarse foraminiferal and quartz sand.

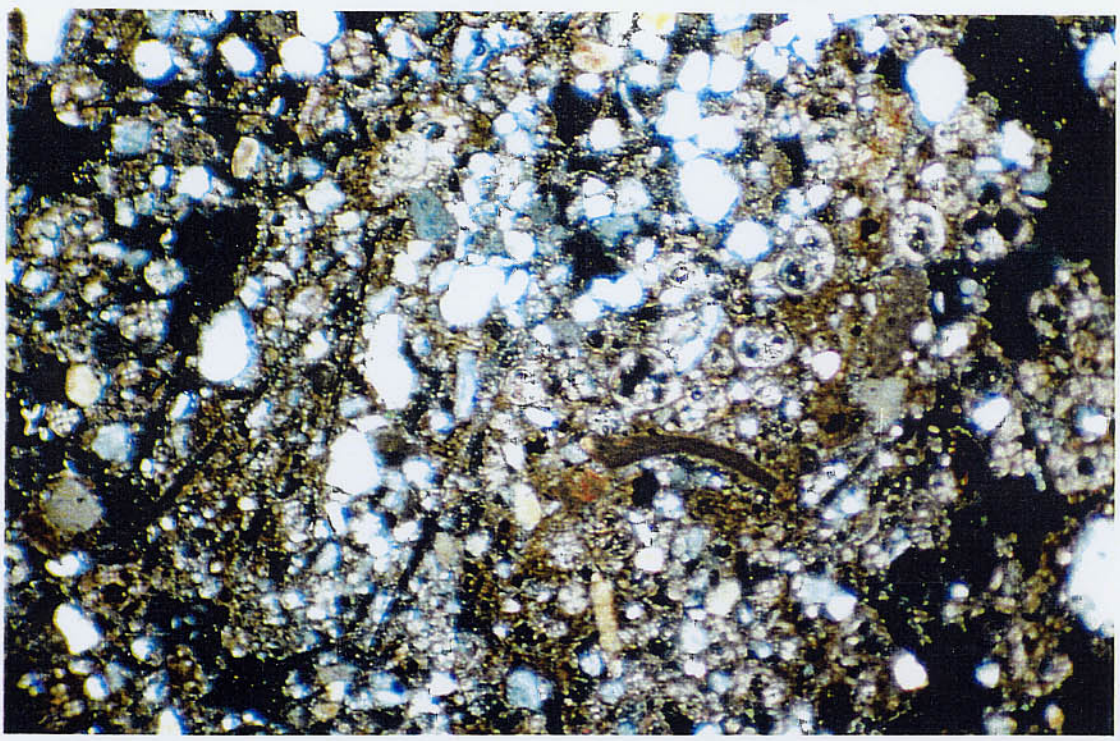
Uni- and plurilocular foraminifera	<30%
other bioclasts - brachiopod, gastropod, echinoid spine, sponge spicule	< 5%
fine to coarse quartz sand	<50%
other lithoclasts including chalcedony, chert, dolomite in a clay matrix	~15%

Summary: Light grey (muddy) coarse sand of quartz grains and bioclasts

Plate III

83/24-sc002





83/24-sc002, 0.80-0.90m

IIIa. Light grey (muddy) coarse sand of quartz grains, foraminifera and other bioclasts including brachiopod fragment and siliceous sponge spicules. 5mm field of view, plane polarised light

IIIb. as above
5mm field of view, crossed polarisers