UNIVERSITY OF CYPRUS

UNIVERSITY CAMPUS

GEOTECHNICAL INVESTIGATION REPORT

For

SITE 4

POTENTIAL SITE FOR FUTURE DEVELOPMENT

Client: UNIVERSITY OF CYPRUS

Nicosia, February 2004
SH Soil Engineering Ltd

CONTENTS

1. INTRODUCTION

This report gives account of the geotechnical investigations carried out in the area of Site '4' of the Campus of the University of Cyprus. The report describes the field and laboratory work carried out and includes all the results of the in-situ and laboratory tests performed. It gives an account of the engineering properties of the strata encountered and typical values of allowable bearing capacity and settlement of foundations.

The work was undertaken on behalf of the Office for the Development of the University Campus of the University of Cyprus, after the award of the relevant Contract to SH Soil Engineering Ltd by the University of Cyprus, letter reference Π.Κ. 115.1.6.28/CDO 028/3.

The University Campus is located 5.5 km South-East of Nicosia center in the broader area of Athalassa, Figure 1. The location of Site '4' area investigated is shown in Figure 2.

The Geological Survey Department and others previously carried out geological investigations in the broader area of the University Campus and in specific areas where various structures and works have been constructed. The work carried out previously is described in the following reports:

1. University of Cyprus, Geological – Geotechnical Report, July 1994. (Geological Survey Department)
2. Supplementary exploratory boreholes drilled at the proposed site of the University of Cyprus, April 1995 (Geological Survey Department).
3. University of Cyprus- Detailed Geological Investigation, June 1998 (Geological Survey Department)
4. Site Investigations for the proposed buildings of the University of Cyprus- Volumes I and II, September 1998 (Geoinvest Ltd)

The purpose of this geotechnical investigation was to establish the geological profile of the site investigated, obtain the geotechnical characteristics and engineering properties of the strata encountered, and record the water table profile at the site.

The site investigated is a potential site for future development and will be used for the construction of various buildings. There are no details of the proposed buildings available at this stage.

2. FIELD WORK

The Field Work carried out consisted of the drilling of five boreholes having a total depth of 42.50m, the recovery of disturbed and undisturbed soil samples, in-situ testing, measurement of the water table and taking water samples for chemical analysis.

Drilling was carried out using the rotary 'crawler' type rig, Casagrande C6 type, and a high capacity air compressor for removing the drilled material.

2.1 Boreholes

The five boreholes drilled in this area were numbered N14 to N18 and their respective depths were 7.50, 7.50, 7.50, 10.50 and 9.50m. Their approximate position is shown on the Borehole Location Plan, Fig 2. The boreholes had a diameter of 135 mm and the method of drilling used was a combination of rotary and percussive drilling using the 'down-the-hole hammer'. The cuttings of the soil were removed using air and sometimes air and water flushing. With this method all boreholes are cased during the drilling process.

The soil layers encountered in the boreholes are described in the Borehole Records, Figs. 4 to 8, Appendix A. Photographs of the samples of the soil layers encountered are presented in Figs. 9 to 11, Appendix A.

2.2. Sampling

Four types of soil samples were recovered from the boreholes during drilling:

(a) **Disturbed** representative bulk samples were recovered from the soil cuttings brought to the surface by air flushing. These samples are suitable for identifying and describing the soil layers encountered and carrying out classification tests, such as particle size distribution, Atterberg Limits etc.

(b) **Disturbed** samples recovered from the split spoon sampler of the Standard Penetration Tests. These are suitable for identifying and describing more accurately the soil layers encountered and performing classification tests as above.

(c) **Undisturbed** cohesive samples recovered from the split spoon sampler of the Standard Penetration Test. Apart from the above classification tests, these samples are suitable for performing Unconfined Compression Tests and in some cases Quick Undrained Triaxial Tests. In addition they can be used for carrying out natural moisture content tests and natural density tests.

(d) Two **Undisturbed (U100)** samples were recovered from the two types of khaki Marl and grey Marl. The samples were taken using 100mm diameter by 460mm long U100 sampling tubes. Penetration of the tubes was effected by pushing them into the soil layers using the drilling rig equipment.

2.3 In-situ Testing

In-situ testing performed in the boreholes consisted of the Standard Penetration Test (SPT). The tests were performed at intervals of 1.50m. The total number of tests performed was 26 and the results are recorded in the Borehole Records. The SPT results are also presented graphically in Figures 12 and 13. The tests were performed in accordance with BS 1377:90 tittled 'Methods of Testing Soils for Civil Engineering Purposes'. A standard split spoon sampler is driven into the soil to a depth of 450 mm by the repeated blows of a 63.5 kg standard penetration monkey trip hammer. The number of blows for every 150mm penetration is recorded. The penetration resistance 'N' is defined as the number of blows required to drive the sampler into the soil the last 300 mm.

In the sandy coarse gravel layers the open split sampler is substituted by a closed cone sampler. In this case no sample is recovered.

3. LABORATORY TESTING

A program of laboratory testing was carried out on a selection of the disturbed and undisturbed samples recovered. The tests included classification tests (natural moisture content, particle size distribution, Atterberg limits, specific gravity, natural density), shear strength tests (unconfined compression and triaxial tests) swelling and consolidation tests on samples of the Marl and chemical tests on soils. A full chemical analysis of a water sample was also carried out. The number and type of tests carried out are outlined in the following sections and the results are presented in the relevant Figures in Appendix B and in tabular form in Tables 1, 2 and 3.

The purpose of the laboratory tests was to establish the mechanical characteristics of the soil layers and deduce their engineering properties, which are required for the proper design of the foundations of the proposed structures.

3.1 Classification Tests

Classification tests carried out on selected samples included natural moisture content, liquid and plastic limit, particle size distribution by wet sieving and sedimentation (hydrometer) tests, specific gravity and density tests. The results of these tests enable the classification and correlation of the soil strata and their comparison with other tests such as SPT, shear strength and consolidation tests. They are also useful for a better understanding of the behavior of the soil layers encountered.

3.1.1 Natural Moisture Content

A total of 25 natural moisture content tests were performed mainly on cohesive samples, most of them samples of Marl, recovered from the split spoon sampler and from the undisturbed U100 samples. The results are presented in a graphical form, Fig.14, where the moisture content was plotted against depth. They are also presented in the Summary of Test Results Table 1 and recorded on Figures presenting the Unconfined Compression and Triaxial Tests.

The variation with depth of the moisture content of the Marl, Fig. 14, shows, as expected, lower moisture content at shallow depths which increases with depth. Over the depth range of 1.0 to 4.0m, the moisture content of the Marl recorded varies from 17% to 27%. For depths greater than 4.0m, the moisture content of the Marl ranges form 24% to 37%.

3.1.2. Atterberg Limits

The Liquid Limit of five cohesive samples was found using the Cone Penetration Method. Their Plastic Limits were also determined and hence their Plasticity Index obtained. The results are presented in Figures 15 to 19, and in the Summary of Test Results, Table 1. Four of the samples were from the khaki silty Marl and gave liquid limits of 52.0% to 55.3% with plastic limits ranging from 33.1% to 34.8% and plasticity index ranging from 18.9% to 20.5 %. The fifth sample was from the grey silty Marl giving a lower Liquid Limit of 49.5%, plastic limit of 29.4% and plasticity index 20.1%.

The above results have also been plotted on the Plasticity Classification Chart, Figure 20. The results plot below the A-line for all Marl samples. According to this Chart the khaki Marl may be characterized as highly elastic silt of high plasticity, and the grey Marl as inorganic Silt of intermediate plasticity.

3.1.3. Specific Gravity

The specific gravity of five cohesive or fine-grained samples tested also for their particle size distribution (hydrometer), was found. Four samples of the khaki Marl gave specific gravity values of 2.75 to 2.80 whereas one sample of the grey Marl, gave a value of 2.75.

3.1.4 Natural Density Tests

Thirteen natural density tests were carried out on khaki silty Marl samples and three on the grey silty Marl. The density of the khaki Marl was found to vary from 19.3 to 20.5 kN/m^3 with an average value of 19.9 kN/m^3 and that of the grey silty Marl ranged between 19.4 and 19.6 kN/m^3 with an average value of 19.5 kN/m^3. The results are presented in the Summary of Test Results, Table 1 and on the Figures of the Unconfined Compression and Triaxial tests.

3.1.5 Particle Size Distribution

The particle size distribution of 19 samples was found. Five of the samples were cohesive Marl samples and the hydrometer (sedimentation) method was used for the finer particles and wet sieving for the coarser ones. The remaining 4 samples were non-cohesive, silty sands and gravels and the wet sieving method was adopted. The results are presented in Figures 21 to 29.

Four samples of the khaki Marl gave 20 to 24% clay size particles (>2m), 53 and 64% Silt and 12 and 27% fine sand. The sample of grey Marl gave 21% clay, 69% silt and 10% fine sand.

The particle size distribution of the alluvium deposits show a variation of Sands with Gravels and sandy Gravels. Two gradings of predominantly sand samples gave sand content of 54 and 65% with gravel content of 19 to 23% and 16 to 23% silt. Two gravel samples gave gravel content ranging from 61 to 68% with sand content of 24% and 8 to 15% silt.

It must be mentioned that large size gravels could not be included in the samples recovered from the boreholes since these were broken down by the drilling operations. Therefore this should be born in mind when examining the particle size distribution curves of the sandy gravels.

3.2 Unconfined Compression Tests

Ten unconfined compression tests were performed on selected cohesive samples. All samples were selected from the khaki silty Marl, three of which were sandy. The samples were recovered from the split spoon sampler and were considered suitable for these tests. The tests were performed using the triaxial compression machine with suitable attachments designed for such tests.

The stress-strain curves obtained are presented in Figures 30 to 34. The undrained cohesion c_u obtained from the 7 samples of the khaki silty Marl ranged from 146 to 385 kN/m^2 with an average of 259 kN/m^2. The three samples of the khaki sandy silty Marl gave c_u values of 85 to 110 kN/m^2 with an average of 94 kN/m^2 .

3.3 Triaxial Tests

Two sets of quick undrained triaxial tests were carried out on undisturbed samples of the khaki silty Marl and of the grey silty Marl. The tests were performed on samples recovered from the U100 sampler. The samples tested had a diameter of 35mm and a height of 70mm. They were tested in the triaxial machine using cell pressures of 100, 200 and 300 kN/m^2.

The stress-strain curves obtained are presented in Figs. 35 & 36 and the Mohr circle of stresses in Figs. 37 & 38. The undrained cohesion c_u obtained from the Mohr circle of stresses was 300kN/m^2 for the khaki Marl with an angle of shearing resistance φ_u of 6°, whereas for the grey Marl, c_u was found to be 170kN/m^2 and φ_u value of 4°.

3.4 Swelling Pressure Tests

Swelling Pressure Tests were performed on undisturbed specimens which were also tested for their consolidation characteristics. The tests were performed in the Oedometer front loading machine on two Marl samples, one from the khaki Marl and the other from the grey Marl. The specimens had a diameter of 50 mm and a thickness of 19.05mm.

After placing the specimen in the Oedometer machine, it was first loaded with a load approximately equal to its effective overburden pressure. Water was then added to the consolidation cell and the specimen observed for any swelling tendency. In case a tendency for swelling was observed, this was prevented by loading the specimen accordingly. The loads on the specimen and the corresponding time were recorded. The results are presented in Figs. 39 and 40.

The swelling pressure observed for both samples tested, was limited to 25 kN/m^2.

3.5 Consolidation Tests

After completion of the swelling pressure test, the consolidation test was started by adding load on the specimen and recording its compression at frequent time intervals. The load on the specimen was doubled every 24 hours until the maximum pressure of 1600 kN/m^2 was reached. The specimen was then unloaded in stages every 24 hours, allowing the specimen to swell and recording the swelling of the specimen at each load. From the compression measurements, the void ratio 'e' v_s log Pressure was produced and the modulus of volume change m_v and the coefficient of consolidation c_v were calculated.

Two consolidation tests were performed, on samples of the khaki and grey Marl. The results are presented in Figures 41 to 52, and in Table 2. For the khaki Marl m_v values varied from 1.68 to 3.68×10^{-5} m^2/kN with an average of 2.63×10^{-5} m^2/kN and c_v from 5.09 to 5.90 m^2/year with an average of 5.43 m^2/year. For the grey Marl, the corresponding m_v values varied from 4.59 to

6.41 x 10^{-5} m^2/kN with an average of 4.27 x 10^{-5} m^2/kN and c_v from 3.10 to 3.76 $m^2/year$ with an average of 3.39 $m^2/year$.

3.6 Montmorillonite and Chemical Tests

One montmorillonite test was carried out to determine the montmorillonite content of a sample of the khaki siltyMarl. Montmorillonite tests are not included in the British Standard Methods of test for Soils for Civil Engineering Purposes BS 1337:1990, but this was a requirement from the Client.

The montmorillonite content of the sample of the khaki silty Marl was found to be 17.5%.

The chemical tests carried as required by the Contract, included the determination of sulphate content of SO_4 and Chloride content Cl. The same soil sample of the khaki silty Marl was analyzed and the results are the following:

BH/depth	**Soil type**	**SO_4 (%)**	**SO_3 (%)**	**Cl (%)**	**Montmorillonite (%)**
N16/7.00-7.45m	Khaki silty Marl	0,064	0,053	0,018	17.5

3.7 Chemical Tests on Water

Full water chemical analysis was carried out on one water sample taken from Borehole N18 and the results are given in Table 3, Appendix B.

4. SITE GEOLOGY

4.1 The Site

Site No. '4' as it is designated on the Location Plan in Fig. 2, has a rectangular shape with approximate dimensions of 100x165m. The site slopes towards the Southeast having a steeper slope near its Northwestern boundary. The only vegetation existing on the site was dry grass.

4.2 General Geology

A stream, named Kaloyeros, flows from Southwest to Northeast, separating the Campus area in two. A valley of about 400 to 500 meters wide extends on both sides of the stream.

The main bedrock in the broader area of the University Campus is the Marl of the Nicosia-Athalassa Formation. The Marl is stiff to hard and has a yellowish-khaki colour. The khaki Marl is underlain by the grey Marl which is usually more silty and sandy.

The Marl is overlain by younger deposits, such as the Fanglomerates, composed mainly of gravels in a calcareaous silty sand matrix with a variable degree of cementation. This layer is found on the hillsides or on top of the hills on either side of the valley. Talus, or hill wash material, usually composed of brown clayey sandy silty or sandy silty clay is found on the lower part of the hill slopes and in the stream valley.

Finally, the stream valley is covered by Alluvium deposits composed of sands and sandy gravels. The overall depth of the Alluvium deposits reaches a maximum of 9.0 metres.

4.3 Information from Boreholes

The strata encountered by the boreholes drilled within Site 4 are shown in the Geological Section Fig. 3 and may be distinguished into four layers:

Layer 1 is the uppermost layer and is composed of brown clayey sandy silt with some gravel in places. In some places, beds of sand and gravel were found to exist between the cohesive clay beds, as in Borehole N18. The maximum thickness of this layer was found to be 6.0m in Borehole N18. This layer was most probably formed from slope-wash material.

Layer 2, is underlying Layer 1, and is composed of beds of Sands, and sandy Gravels. Its maximum thickness as found in Borehole N17 was 4.00m. This layer forms the Alluvium river deposits. The maximum overall thickness of the superficial deposits (Layers 1 and 2) in this area, which cover the khaki Marl, was found to be 7.40m.

Layer 3 is the khaki silty Marl which is stiff to hard, with a considerable variation in thickness. This layer has a greater thickness in the Northwestern part of the site where the Alluvium deposits are absent. Is thickness in the Southwestern part is smaller and in Borehole N17 was found to be 2.70m.

Layer 4 is the stiff to hard grey silty sandy Marl below the khaki Marl, which has been encountered only in Boreholes N17.

4.4 Ground Water

Ground water was encountered during drilling in Boreholes N17 and N18. The depth of the water was measured in these boreholes and the water table was found to be at about the same elevation in both Boreholes. The recorded water depths are given on the Borehole Records and have been plotted on the Geological Section, Figure 3.

5. ENGINEEERING PROPERTIES OF STRATA

The laboratory test results have been presented in Section 3. The engineering properties of the layers encountered presented in this section, are based on the laboratory test results and the in-situ testing.

5.1 Layer 1

Visual examination of samples of Layer 1 shows a variation from clayey Silt to silty Clay with the presence of sands and gravels in places. This layer is quite variable both in texture and engineering characteristics. This is also reflected in the results of the Standard Penetration Tests which have been plotted in Fig. 13.

Twelve Standard Penetration Tests carried out in this layer, gave values of Standard Penetration Resistance N varying from 14 to 32 with one high value of 150 and a low value of 11. The average N value in the cohesive sub-layers was 19.5 and in the sandy gravel sub-layers the average N value was 26.

5.2 Layer 2

This layer consists of sands and sandy gravels and laboratory testing was restricted to wet sieving to obtain the particle size distribution of various samples. The results are discussed in Section 3.1.

In view of the limited thickness of this layer which was encountered in three of the Boreholes , the number of the in-situ Standard Penetration Tests was limited to four. The results obtained have been plotted in Figure 13. The Standard Penetration Resistance 'N' is lower for the Sand layers and higher for the more gravelly layers. The existence of large gravels gave one high N value of 44. The remaining three N values varied from 28 to 39, with an average value of 33.3.

The modulus of compressibility E_s for the sandy gravel deposits can be obtained from empirical relationships using the average value of N. Taking the average N of 33.3 for sandy gravel deposits, the value of E_s is given as 42,000 kN/m^2.

From empirical relationships also, we can obtain an average value of the angle of shearing resistance ϕ. For an average N=33.3, ϕ value can be taken conservatively as 37° for the sandy gravels.

5.3 Layer 3

This is the khaki silty Marl. A considerable number of tests were performed on samples of this layer, i.e. classification tests, shear strength tests and compressibility tests. Also in-situ SPT tests were performed.

5.3.1. Classification Tests

For the natural moisture content, Atterberg Limits, natural density and particle size distribution, please refer to Section 3.

5.3.2. Standard Penetration Resistance

The Standard Penetration Resistance values measured for the Marl are presented in Figure 12. Twelve SPTs were performed. With the exemption of two high N values equal to 41 and 48, the remaining ten values ranged from 19 to 39 with an average of 30.

5.3.3. Shear Strength

In addition to the Standard Penetration tests, in order to assess the shear strength of the khaki Marl, one set of quick undrained triaxial tests and ten tests of unconfined compression have been carried out. The undrained cohesion c_u obtained from the unconfined compression tests on three sandy samples of the khaki Marl ranged from 85 to 110 with an average of 94 kN/m^2. The remaining seven samples of the khaki silty Marl, gave c_u values ranging from 146 to 385 with an average of 259 kN/m^2.

The triaxial test performed on samples of the khaki Marl from the depth of 7.0m, gave a c_u value of 300 kN/m^2 and ϕ_u of 6°.

5.3.4 Modulus of Elasticity Es

The modulus of elasticity Es of the khaki Marl can be estimated from the stress-strain curves of the unconfined compression and triaxial test. This was estimated to have an average value of 30,000 kN/m^2. The in-situ Es, however, is almost 2 to 5 times greater than the values estimated from the stress-strain curves. Therefore, an approximate value for Es for the khaki Marl of 70,000 kN/m^2 may be taken when calculating the immediate elastic settlement of the foundations. The stress-strain curves of the sandy Marl samples indicate lower values of Es and of the order of 25 000 to 30 000 kN/m^2.

5.3.5. Swelling and Compressibility of the Marl

One specimen of the Khaki Marl tested for its swelling potential developed a swelling pressure of 25 kN/m^2.

By plotting the plasticity index and clay fraction of the Marl on the Chart for Expansiveness of Soils, Fig. 53, the expansiveness of the Marl is shown to be 'medium'.

The values of the coefficient of volume change m_v of the khaki Marl were found to range between 1.68 to 3.68 x10^{-5} m^2/kN with an average value of 2.63x10^{-5} m^2/kN. The values of m_v are used to estimate the amount of consolidation settlement of foundations. Consolidation settlement can also be estimated using the e-log p curve obtained, Fig 41.

The coefficient of consolidation c_v was found to vary from 5.09 to 5.90 m^2/year with an average of 5.43 m^2/year. The c_v values are used to estimate the time (number of years) the consolidation settlement will be completed.

5.4 Layer 4

The engineering properties of the grey Marl layer differ only slightly from those of the khaki Marl. The grey Marl was found to have a lower Liquid Limit and plasticity index but a similar amount of clay size particles.

5.4.1 Standard Penetration Resistance

No Standard Penetration Tests were performed in this layer.

5.4.2 Shear Strength

One set of triaxial tests performed gave undrained cohesion c_u of 170 kN/m^2 and angle of shearing resistance ϕ_u of 4°.

5.4.3 Swelling and Consolidation

The sample tested has shown a swelling pressure of 25 kN/m^2. The plot in Figure 53 of the plasticity index and clay fraction of the sample, shows that the grey Marl has a medium expansiveness potential.

The coefficient of volume change m_v was found to vary from 4.59 to $6.41x10^{-5}m^2/kN$ with an average of $4.27x10^{-5}$ m^2/kN and the coefficient of consolidation c_v, varied from 3.10 to 3.76 m^2/year with an average of 3.39 m^2/year.

6. BEARING CAPACITY AND SETTLEMENT OF FOUNDATIONS

The Bearing Capacity of the strata encountered and the settlement of the foundations depend not only on the engineering properties of the strata but on the type, shape and depth of the foundations to be adopted. Hence, the allowable bearing capacity values and estimated expected settlement given below are only indicative. The bearing capacity and settlement of foundations can be found when the foundation loads, their depth and type are known.

6.1 Bearing Capacity

6.1.1 Layer 1-Top silty clayey Soil

Assuming a $\phi_u=0$ soil and taking $c_u= 120$ kN/m^2 the safe Bearing Capacity of isolated foundations may be estimated using Skempton's bearing capacity formula

$$q_{safe}=(c_u N_u)/F + \gamma' D$$

where: c_u=undrained cohesion, kN/m^2

N_c = Bearing capacity factor

F= factor of safety

$\gamma'D$ = effective overburden at foundation level

For a square foundation of 1.5 m at a depth of 2.5m, N_c=8.3 and assuming F=3.0, q_{safe} is calculated to be 380 kN/m^2. In order to minimize settlement, an Allowable Bearing Capacity of 300 kN/m^2 can be adopted.

6.1.2 Layer 2- Sands and Sandy Gravels

The allowable bearing for this layer can be estimated using the empirical relationship between standard penetration resistance and allowable bearing pressure proposed by Terzaghi and Peck. This correlation was intended to limit the foundation settlement to a maximum of 25 mm.

Using an average value of Standard Penetration Resistance of 30, for a foundation width of 1.50m, the allowable bearing capacity obtained from the relevant chart is 350 kN/m^2. However, consideration should be given to possible existence of weaker lenses of silt or fine sand and the foundations designed accordingly.

6.1.3 Khaki Marl

For foundations resting on the upper part of the khaki Marl layer, the bearing capacity can be estimated assuming $\phi_u=0$ and $c_u=190$ kN/m^2 (conservative assumption) and a factor of safety of 3.0, the safe bearing capacity is found to be 575 kN/m^2. To minimize settlement, an allowable bearing pressure of 500 kN/m^2 may be used.

6.2 Settlement

Foundation settlement would not exceed 25 mm for foundations constructed on Layers 1 and 2 under the assumptions made in sections 6.1.1 and 6.1.2 above, and using the allowable pressures stated. In view of the variability of these layers, this should be checked by carrying out settlement calculations during the design of the foundations.

For foundations constructed on the khaki Marl, foundation settlement 's' is made up of the immediate elastic 's_i' and consolidation settlement 's_c'.

$$s = s_i + s_c$$

Now $$s_i = \mu_o \, \mu_i \times q \, B/E_s$$

Where:

μ_o and μ_i depend on the depth and size of the foundation and are obtained from Charts published by Janbu and Bjerrum

q is the effective bearing pressure

B is the foundation width

Es is the elastic or compressibility modulus

For a 1.5 m square foundation, loaded with maximum pressure of 500 kN/m^2 (effective = 367.5kN/m^2), at a depth of 2.5 m and taking Es = 70,000 kN/m^2

The immediate elastic settlement was found = 3.4 mm

The consolidation settlement $s_c = \mu \Sigma m_v \Delta_\sigma h$

Where:

μ = coefficient of settlement (0.5 for overconsolidated clays)

m_v = coefficient of volume change (2.63 x10^{-5} m^2/kN)

Δ_σ= change in stress due to foundation load

h= thickness of clay layer considered

Values of Δ_σ for the various clay layers considered are calculated using the appropriate 'Influence coefficients' found from suitable charts.

For the same foundation and load considered above, the consolidation settlement was estimated to about 13.3 mm.

Hence total settlement = 3.4+13.3 = **16.7 mm**

CONCLUSIONS AND RECOMMENDATIONS

The strata encountered by the boreholes drilled may be differentiated into at least four layers:

Layer 1 which is composed of brown clayey silt or silty clayey Soil, with the presence of some gravel and sand in places, is a layer of variable shear strength as indicated by the SPT tests results. The estimated allowable bearing capacity for this layer, calculated for a 1.5 m square footing placed at 2.5 m depth, is 300 kN/m^2. Foundation settlement for such footing is expected to be not greater than 25 mm.

Layer 2, consists of sands and gravels with varying degree of compaction but with a relatively high average 'N' value. The estimated allowable bearing capacity for this layer for a 1.5 m square footing is 350 kN/m^2. Settlement is expected to be not more than 25 mm. The possible existence of weaker lenses of silt or fine sand should be taken carefully into consideration during the design of the foundations.

Layer 3, is the khaki Marl which has relatively high shear strength. The allowable bearing capacity for a 1.5m square foundation at 2.5m depth was calculated to 500 kN/m^2 in order to keep the settlement to acceptable limits. Settlement for the same foundation (1.5m square at 2.5m depth) was estimated to about 17 mm.

Layer 4, the grey Marl is more silty with shear strength values of the same order as for the khaki Marl.

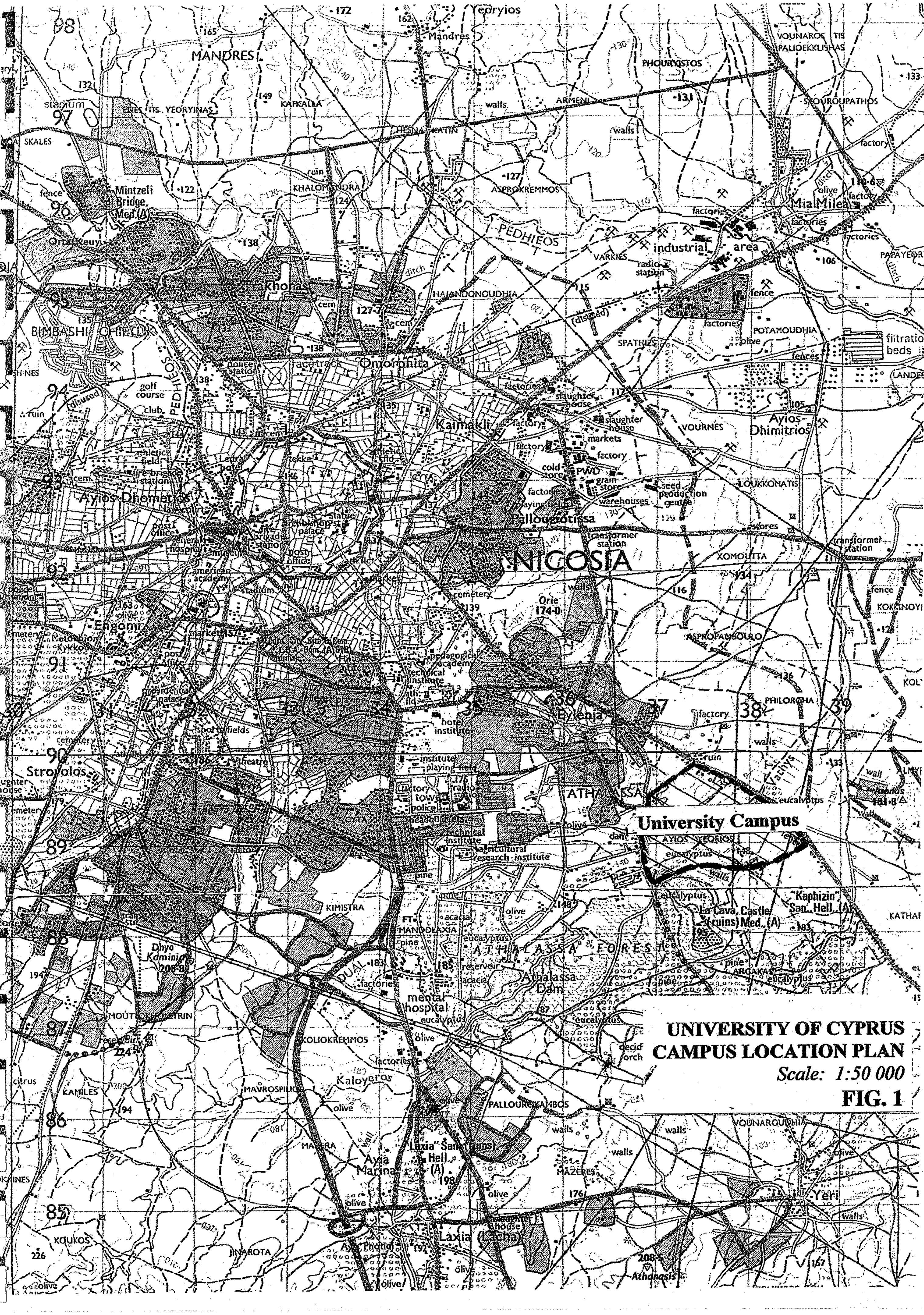
Any type of foundation can be used on the above layers, such as isolated pad footings, strip footings, raft and piles. However, in view of the different nature of the above layers, and the possibility of the foundations of the same building to bear on different layers, the foundation type, bearing capacity and foundation settlement must be reconsidered carefully and relevant calculations performed by an experienced geotechnical engineer using the engineering parameters given in this report.

Consultation with a Geotechnical Engineer during the design of the foundations is strongly recommended. Professional consideration of the engineering properties and extensive calculations for the bearing capacity and settlement of the foundations should be made in order to achieve both safe and economic foundations.

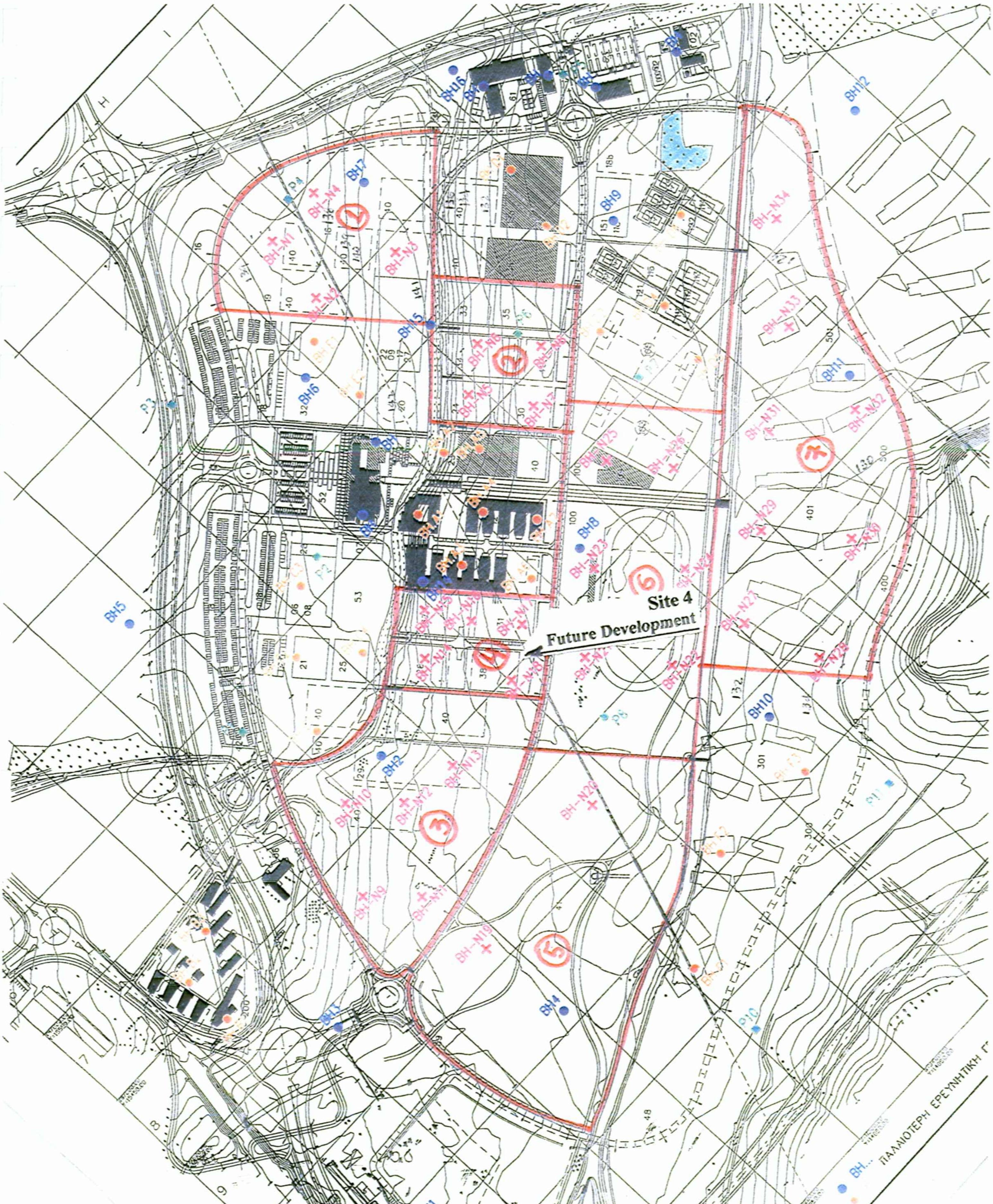
Due to rapid deterioration of the Marl when exposed, it is very important to keep such exposure to minimum. As soon as the excavation for the foundation is completed and the bottom of the excavation cleaned carefully, it should be covered with a blinding concrete of about 80mm thick. The construction of the foundations should proceed and completed as soon as possible. Drying and wetting of the bottom of excavations in the Marl should be avoided.

Sulphates in soils or groundwater may attack concrete depending on their concentration. For sulphate concentration in soils less than 0.2% of SO_3, ordinary Portland cement may be used with maximum water/cement ratio of 0.55. For SO_3 of 0.2% - 0.5%, the minimum cement content should be 330 kg/m^3 and the water cement ratio less than 0.50. Since the SO_3 obtained from the chemical analysis on a Marl sample was 0.055%, no special measures are required.

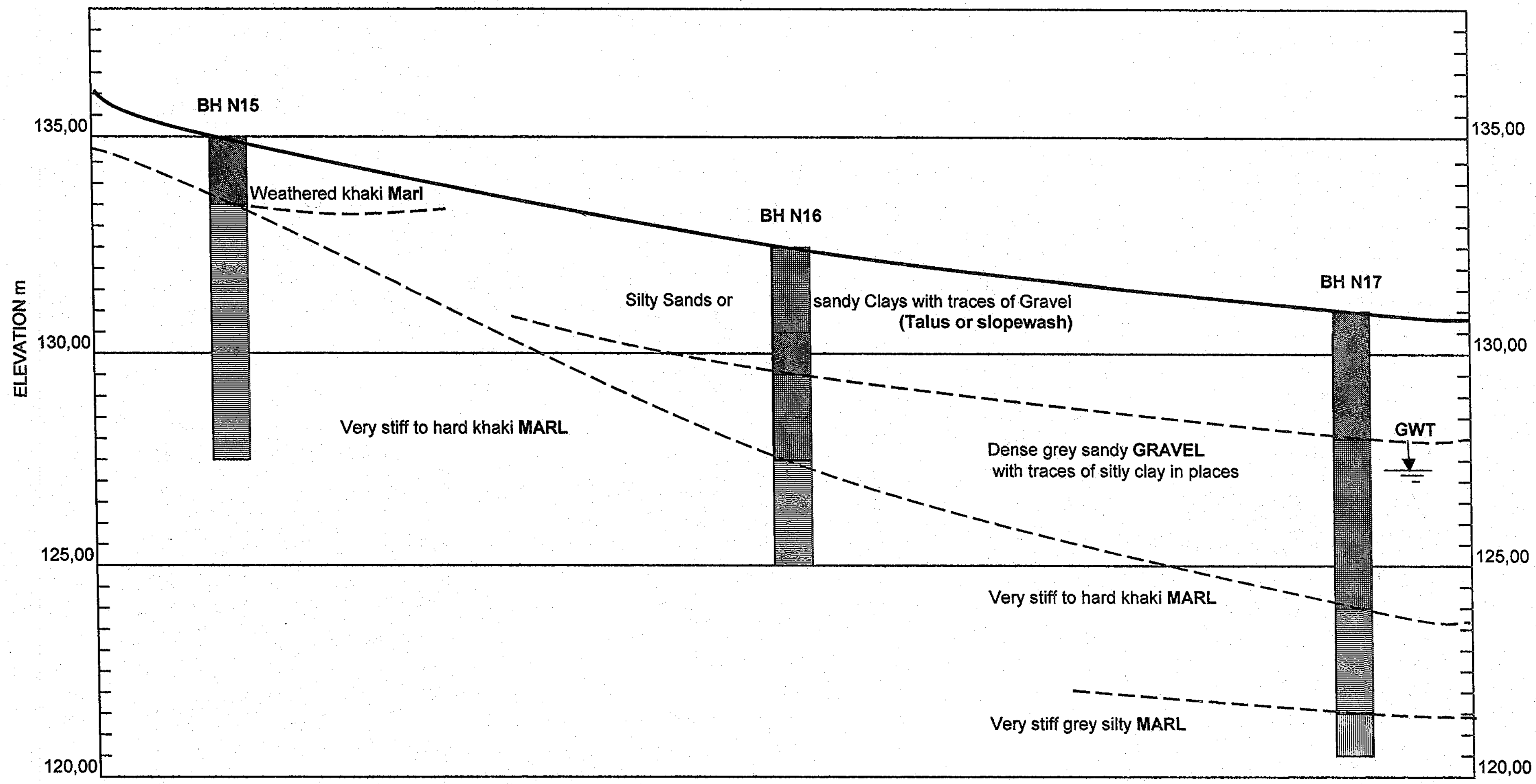
APPENDIX A



UNIVERSITY OF CYPRUS
CAMPUS LOCATION PLAN
Scale: 1:50 000
FIG. 1



UNIVERSITY OF CYPRUS
UNIVERSITY CAMPUS
BOREHOLE LOCATION PLAN
Scale: 1:5000
FIG. 2



NOTE:
Drawn boundaries between layers are infered, based on the borehole findings and are not exact

CAMPUS OF UNIVERSITY OF CYPRUS
SITE 4
GEOLOGICAL SECTION
FIG. 3

BOREHOLE RECORD

SURFACE LEVEL: *135.5 m approx.** **NOMINAL B.H. DIA.:** *135mm* **BH.NO./Sht No. N14**
DATE STARTED: *6/11/03* **DATE COMPLETED:** *6/11/03* **SCALE:** *1:100*
DRILLING METHOD: *Rotary with air and air-water flushing*
**from contour map*

STRATA	B.H. LOG	B.H. DEPTH (m)	SAMPLE & SPT	SAMPLE & SPT DEPTH (m)	S.P.T. NUMBER N	GROUND WATER & REMARKS
Very dense grey sandy **GRAVEL**						
			∇c	1.00-1.12	150*	*Extrapolated. 60 blows for 12cm
			●			
		1.85				
Very stiff to hard khaki silty **MARL** sandy in places			s∇	2.50-2.95	32	No groundwater encountered during drilling
			●			
			s∇	4.00-4.45	39	
			●			
			s∇	5.50-5.95	36	
			●			
			☐	7.00-7.45		
Bottom of Borehole		7.50				
						s=split spoon sampler c=closed cone sampler

UNDISTURBED ☐ **{No}** **SAMPLE U100 {Blows}**	**DISTURBED SAMPLE** ●	**WATER SAMPLE O**	**BULK SAMPLE** ⇓	**STANDARD PENETRATION TEST** s∇c

Project **University of Cyprus**	Location **University Campus - Site "4"**	INVESTIGATION No. 03/09/01
client **University of Cyprus**	engineer **Stelios Achniotis**	**BOREHOLE No. N14**

SH Soil Engineering Ltd, P.O.Box 25457, Nicosia. ***FIG.4***

BOREHOLE RECORD

SURFACE LEVEL: *135.2 m approx.** **NOMINAL B.H. DIA.:** *135mm* **BH.NO./Sht No. N15**

DATE STARTED: *7/11/03* **DATE COMPLETED:** *7/11/03* **SCALE:** *1:100*

DRILLING METHOD: *Rotary with air and air-water flushing*

**from contour map*

STRATA	B.H. LOG	B.H. DEPTH (m)	SAMPLE & SPT	SAMPLE & SPT DEPTH (m)	S.P.T. NUMBER N	GROUND WATER & REMARKS
Stiff weathered khaki **Marl**						
		1.00	s∇	1.00-1.45	14	
			●			
Very stiff to hard khaki silty **MARL** sandy in places						
			s∇	2.50-2.95	26	No groundwater encountered during drilling
			●			
			s∇	4.00-4.45	42	
			●			
			s∇	5.50-5.95	24	
			●			
			s∇	7.00-7.45	23	
Bottom of Borehole		7.50				
						s=split spoon sampler c=closed cone sampler

UNDISTURBED ☐ **{No}** **SAMPLE U100 {Blows}**	**DISTURBED SAMPLE** ●	**WATER SAMPLE O**	**BULK SAMPLE** ⇓	**STANDARD PENETRATION TEST** s∇c

Project **University of Cyprus**	Location **University Campus - Site "4"**	INVESTIGATION No. 03/09/01
client **University of Cyprus**	engineer **Stelios Achniotis**	**BOREHOLE No. N15**

SH Soil Engineering Ltd, P.O.Box 25457, Nicosia. ***FIG.5***

BOREHOLE RECORD

SURFACE LEVEL: *132.6 m approx.** **NOMINAL B.H. DIA.:** *135mm* **BH.NO./Sht No. N16**

DATE STARTED: *7/11/03* **DATE COMPLETED:** *7/11/03* **SCALE:** *1:100*

DRILLING METHOD: *Rotary with air and air-water flushing*

**from contour map*

STRATA	B.H. LOG	B.H. DEPTH (m)	SAMPLE & SPT	SAMPLE & SPT DEPTH (m)	S.P.T. NUMBER N	GROUND WATER & REMARKS
Medium dense brown silty **SAND** and grey **GRAVEL**						
			s∇	1.00-1.45	27	
			●			
		1.90				
Stiff brown silty sandy **clayey SOIL**			s∇	2.50-2.95	15	No groundwater encountered during drilling
		3.10	●			
Dense grey sandy **GRAVEL** with traces of silty Clay						
			s∇	4.00-4.45	39	
			●			
		4.80				
Very stiff to hard khaki silty **MARL**			s∇	5.50-5.95	41	
			●			
			s∇	7.00-7.45	36	
Bottom of Borehole		7.50				
						s=split spoon sampler c=closed cone sampler

UNDISTURBED ☐ {No} SAMPLE U100 {Blows}	DISTURBED SAMPLE ●	WATER SAMPLE O	BULK SAMPLE ⇓	STANDARD s∇c PENETRATION TEST

Project **University of Cyprus** — Location **University Campus - Site "4"**	INVESTIGATION No. 03/09/01
client **University of Cyprus** — engineer **Stelios Achniotis**	**BOREHOLE No. N16**

SH Soil Engineering Ltd, P.O.Box 25457, Nicosia. ***FIG. 6***

BOREHOLE RECORD

SURFACE LEVEL: *131.2 m approx.** **NOMINAL B.H. DIA.:** *135mm* **BH.NO./Sht No. N17**

DATE STARTED: *10/11/03* **DATE COMPLETED:** *11/11/03* **SCALE:** *1:100*

DRILLING METHOD: *Rotary with air and air-water flushing*

**from contour map*

STRATA	B.H. LOG	B.H. DEPTH (m)	SAMPLE & SPT	SAMPLE & SPT DEPTH (m)	S.P.T. NUMBER N	GROUND WATER & REMARKS
Stiff brown silty sandy **CLAY** with gravel in places						
			s∇	1.00-1.45	11	
			●			
			s∇	2.50-2.95	23	
		3.00	●			Water noticed at 4.00m during drilling
Dense grey sandy **GRAVEL**						
			∇c	4.00-4.45	28	Depth of water on 11/11/03 before start of drilling 3.95m
			●			
			∇c	5.50-5.95	33	
			●			
		7.00	s∇	7.00-7.45	48	
Very stiff to hard khaki silty **MARL**						
			●			
			s∇	8.50-8.95	22	
			●			
		9.70				
Very stiff grey silty **MARL**			□	10.00-10.45		
Bottom of Borehole		10.50	●			
						s=split spoon sampler c=closed cone sampler

UNDISTURBED □ **{No}** **SAMPLE U100 {Blows}**	**DISTURBED SAMPLE** ●	**WATER SAMPLE** o	**BULK SAMPLE** ⇓	**STANDARD PENETRATION TEST** s∇c

Project **University of Cyprus**	Location **University Campus - Site "4"**	INVESTIGATION No. 03/09/01
client **University of Cyprus**	engineer **Stelios Achniotis**	**BOREHOLE No. N 17**

SH Soil Engineering Ltd, P.O.Box 25457, Nicosia. ***FIG. 7***

BOREHOLE RECORD

SURFACE LEVEL: *131.8 m approx.** **NOMINAL B.H. DIA.:** *135mm* **BH.NO./Sht No. N18**
DATE STARTED: *5/11/03* **DATE COMPLETED:** *6/11/03* **SCALE:** *1:100*
DRILLING METHOD: *Rotary with air and air-water flushing*

**from contour map*

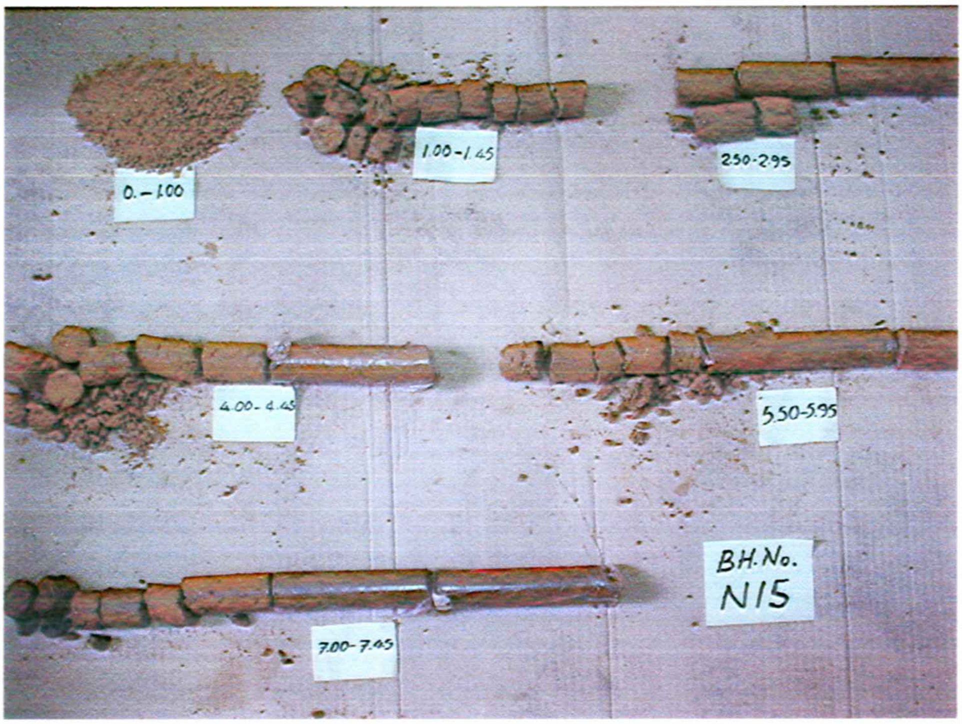
STRATA	B.H. LOG	B.H. DEPTH (m)	SAMPLE & SPT	SAMPLE & SPT DEPTH (m)	S.P.T. NUMBER N	GROUND WATER & REMARKS
Stiff brown silty sandy **CLAY**with gravel in places						
			s∇	1.00-1.45	16	
			●			
			s∇	2.50-2.95	25	
		3.00	●			Water noticed at 4.00m
Medium dense brown silty **SAND** and grey **GRAVEL**						during drilling
			∇c	4.00-4.45	17	Depth of water on 6/11/03
		4.70	●			before start of drilling 4.00m
Very stiff khaki sandy **CLAY**			o			
			s∇	5.50-5.95	32	
		6.00	●			
Dense grey sandy **GRAVEL**			●			
			∇c	7.00-7.45	44	
		7.40				
Very stiff to hard khaki silty **MARL**						
			●			
			s∇	9.00-9.45	19	
Bottom of Borehole		9.50				
						s=split spoon sampler
						c=closed cone sampler

UNDISTURBED ☐ {No} SAMPLE U100 {Blows}	DISTURBED SAMPLE ●	WATER SAMPLE o	BULK SAMPLE ⇓	STANDARD PENETRATION TEST s∇c

Project **University of Cyprus**	Location **University Campus - Site "4"**	INVESTIGATION No. 03/09/01
client **University of Cyprus**	engineer **Stelios Achniotis**	**BOREHOLE No. N 18**

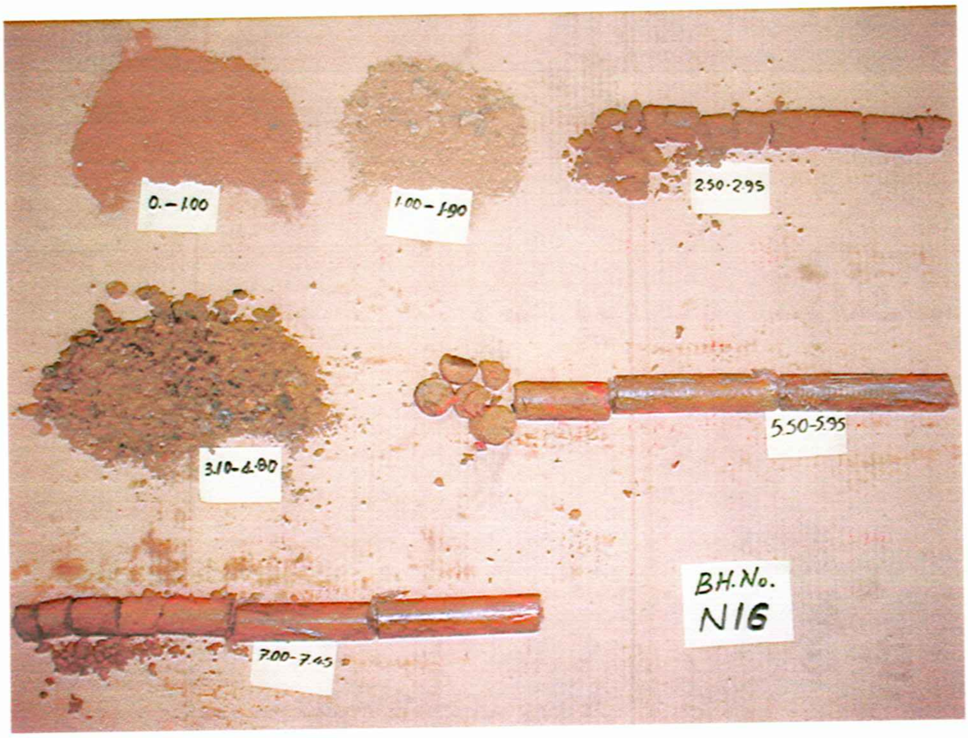
SH Soil Engineering Ltd, P.O.Box 25457, Nicosia. ***FIG. 8***

Samples from BH N14

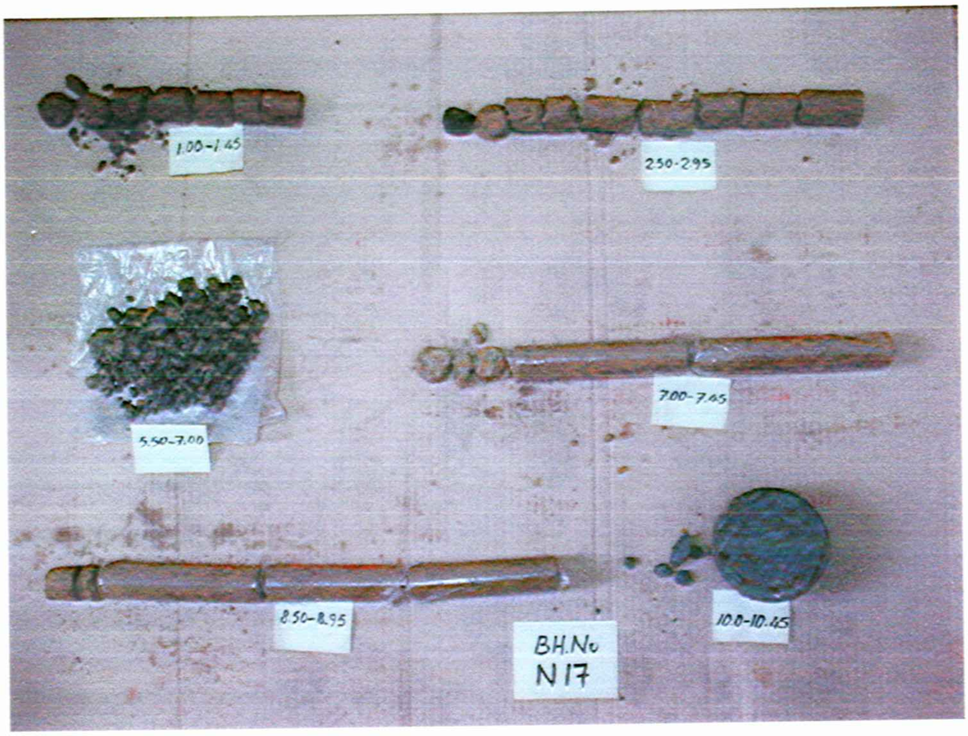


Samples from BH N15

FIG. 9



Samples from BH N16



Samples from BH N17

FIG. 10

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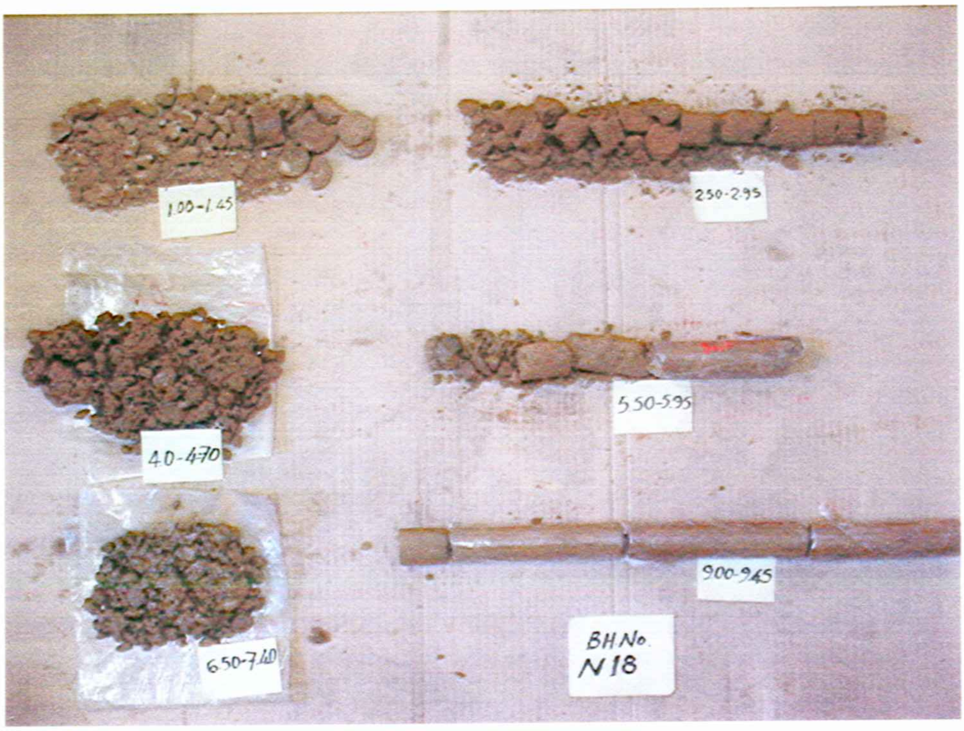
Tel. 22663191, Fax 22663192



Samples from BH N18

FIG. 11

STANDARD PENETRATION RESISTANCE

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus **Soil:** Khaki silty Marl

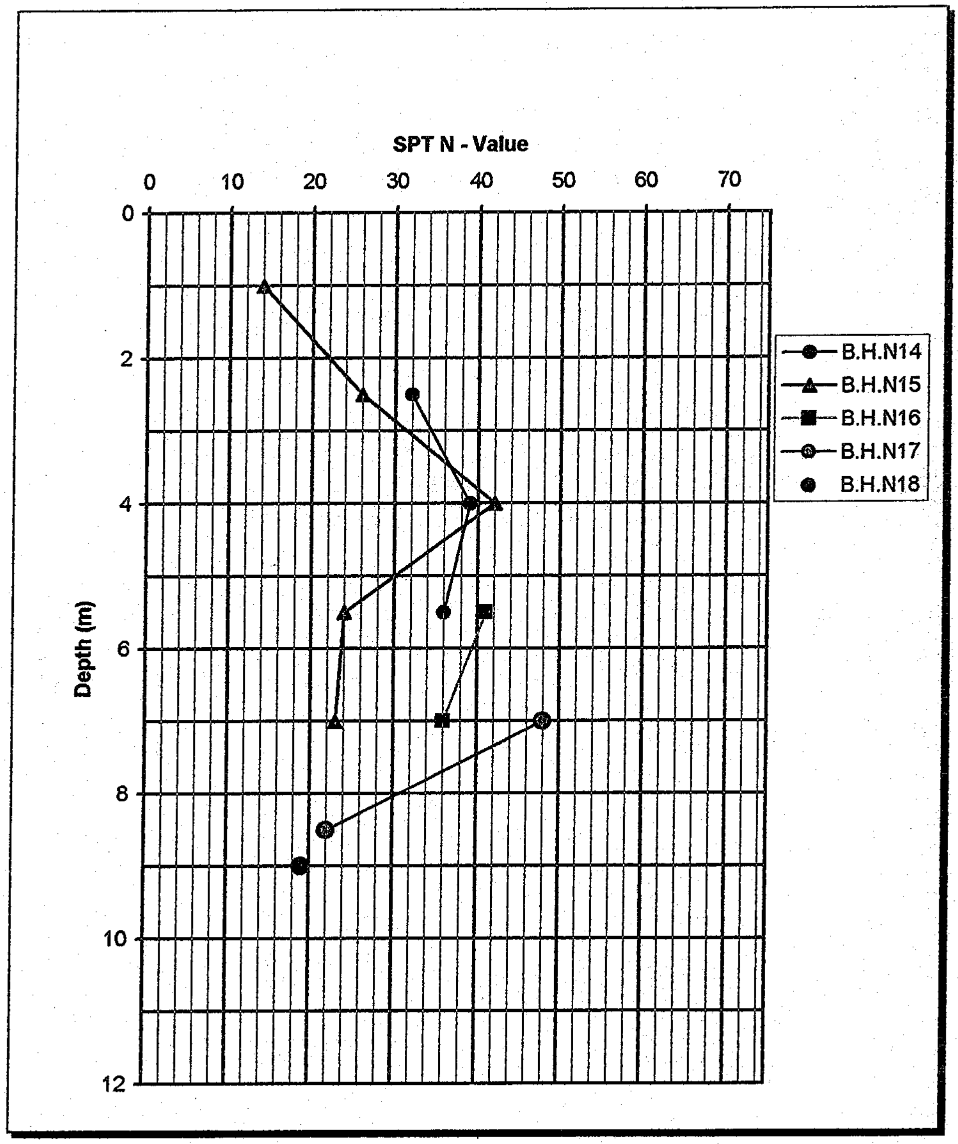


FIG.12

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Tel. 22663191, Fax 22663192

STANDARD PENETRATION RESISTANCE

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus **Soil:** Superficial and Alluvium deposits

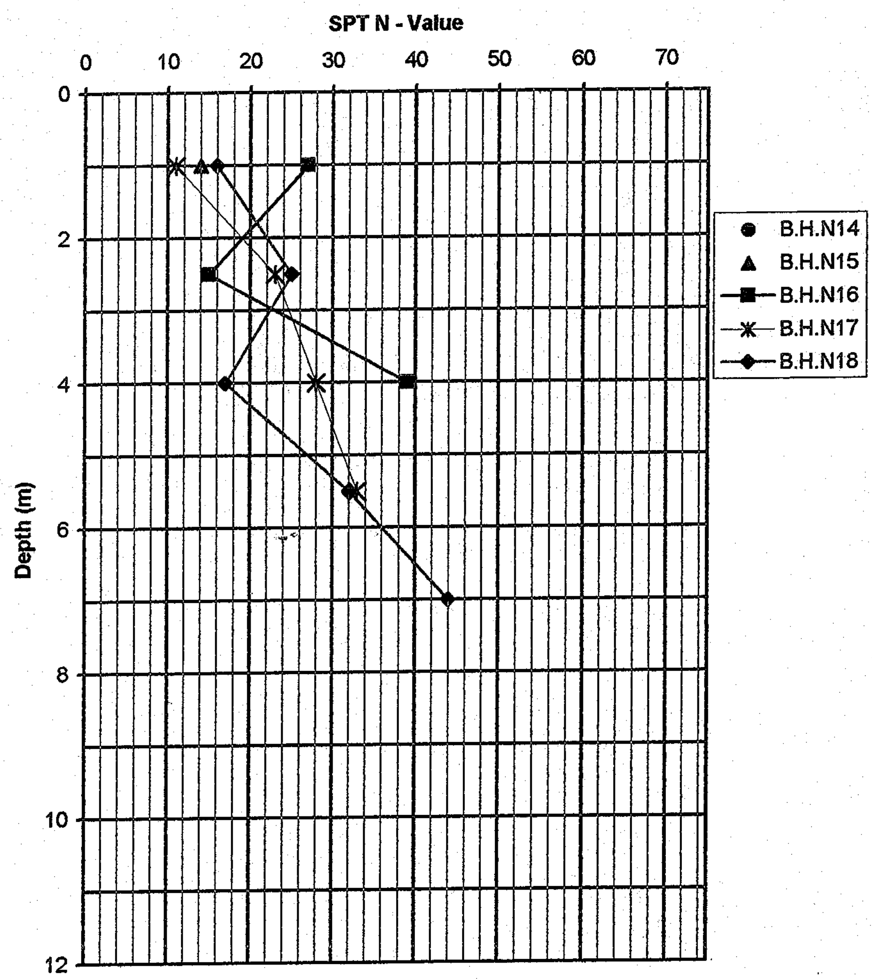

FIG.13

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Tel. 22663191, Fax 22663192

APPENDIX B

LABORATORY TEST RESULTS

- Tables 1, 2 and 3
- Figs. 14 to 53: Laboratory Test Results

TABLE 1

SUMMARY OF TEST RESULTS

B.H. NO.	Depth m	Natural Moisture Content %	Natural Density kN/m3	Specific Gravity	Liquid Limit %	Plastic Limit %	Plasticity Index %	Cohesion cu kN/m2	Angle φu	Soil Type
N14	2,50	23,43								Khaki silty Marl
	4,00	26,53	19,7	2,77	53,5	34,1	19,4	385		Khaki silty Marl
	5,50	24,28	20,0					110		Khaki sandy silty Marl
	7,00	33,27*	19,3*	2,80	54,5	34,5	20,0	300	6	Khaki silty Marl
N15	1,00	21,14								Weathered khaki silty Marl
	2,50	26,28								Khaki silty Marl
	4,00	23,96	20,5					88		Khaki sandy silty Marl
	5,50	30,19	19,5	2,75	52,0	33,1	18,9	202		Khaki silty Marl
	7,00	29,65	19,9					151		Khaki silty Marl
N16	2,50	19,49								Brown silty clay
	5,50	28,47	19,9					355		Khaki silty Marl
	7,00	26,64	20,5	2,76	55,3	34,8	20,5	317		Khaki silty Marl
N17	1,00	19,43								Brown silty clay
	2,50	16,58								Brown silty clay
	7,00	27,84	20,1					85		Khaki-yellowish sandy Marl
	8,50	33,34	19,9					155		Khaki silty Marl
	10,00	32,59*	19,5*	2,75	49,5	29,4	20,1	170	4	Grey silty Marl
N18	1,00	16,68								Brown silty clay
	2,50	17,85								Brown silty clay
	5,50	27,33								Khaki sandy Marl
	9,00	36,48	19,9					146		Khaki silty Marl

*Average of three results

TABLE 2

SUMMARY OF CONSOLIDATION TEST RESULTS

B.H. NO.	Depth m	Soil Type	Initial Moisture Content %	Final Moisture Content %	Initial Bulk Density kN/m^3	Initial Void Ratio	Final Void Ratio	Av. Coeffic. of Vol. Change m_v $m^2/kN x 10^{-5}$	Av. Coeffic.of Consolidation c_v $m^2/year$	Initial Saturation Sr %
N14	7,0-7,45	Khaki silty MARL	33,1	33,4	19,5	0,910	0,877	2,627	5,434	100
N17	10,0-10,45	Grey silty MARL	32,1	29,7	19,4	0,868	0,774	4,273	3,390	100

ΧΗΜΙΚΟ ΕΡΓΑΣΤΗΡΙΟ | ΑΡΙΣΤΟΥ ΛΟΥΚΑΪΔΗ ΛΤΔ
Λεωφόρος Λάρνακας 77, 2102 Αγλαντζιά
Τ.Θ. 20379, CY-2151 Λευκωσία, Κύπρος
Τηλ. +357 22 874 872, Φαξ. +357 22 874 873
ηλ. διεύθυνση: arischemlab@cytanet.com.cy

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P.O. Box 20379, CY-2151 Nicosia, Cyprus
Tel. +357 22 874 872, Fax. +357 22 874 873
e-mail: arischemlab@cytanet.com.cy

Aristos Loucaides
Chemical Laboratory ltd

File ref.: W1031
Lab ref.: 623/2003

Date: 13-12-2003

TEST CERTIFICATE

Name: S. H. Soil Engineering Ltd.
Sample type: Water in plastic bottle – **N18**
Area of sampling: University of Cyprus new campus - Nicosia
Date received: 08-12-2003
Date reported: 13-12-2003

TABLE 3

pH	**7.76**	6.5-9.5
Electrical conductivity, mS/cm	**4.35**	2.50
Total hardness, mg/l as $CaCO_3$	**1224**	500
SAR	**5.59**	
Langelier saturation index		

Anions	mg/l	mg/l	meq/l	Cations	mg/l	mg/l	meq/l
Chlorides, Cl^-	**1035**	250	29.15	Sodium, Na^+	**449**	200	19.52
Sulphates, SO_4^{2-}	**490**	250	10.21	Potassium, K^+	**16.0**	12.0	0.33
CarbonatesCO_3^{2-}	**0**		0.00	Calcium, Ca^{2+}	**221**	150	11.05
BicarbonatesHCO_3^-	**229**		3.75	Magnesium, Mg^{2+}	**163**	50	13.36
Nitrates, NO_3^-	**44.2**	50.0	0.71	Ammonium, NH_4^+		0.5	0.00
Nitrites, NO_2^-	**0.528**	0.100	0.01	Boron, B	**0.5**	1.0	
Fluoride,F^-		1.0					
Totals	**1799**		43.84	Totals	**849**		44.26

COMMENTS:
The numbers in blue in the middle column, show the upper limit of concentration for human consumption.

For the Chemical Laboratory,

Aristos Loucaides, B.Eng(Hons), MBA, AMIChemE,
Analyst / Laboratory director.

Results reported relate to the sample received at the laboratory

NATURAL MOISTURE CONTENT

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

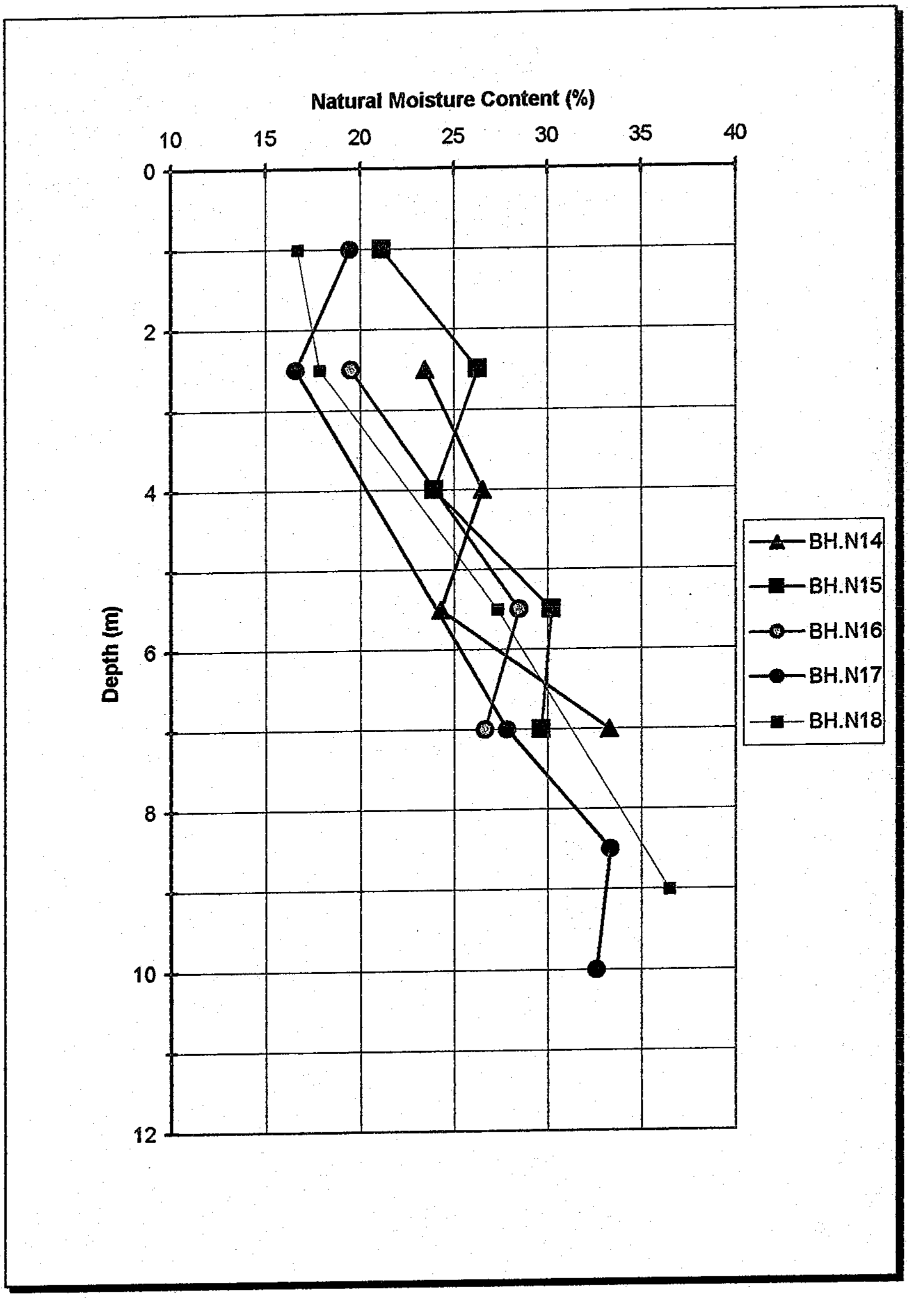


FIG.14

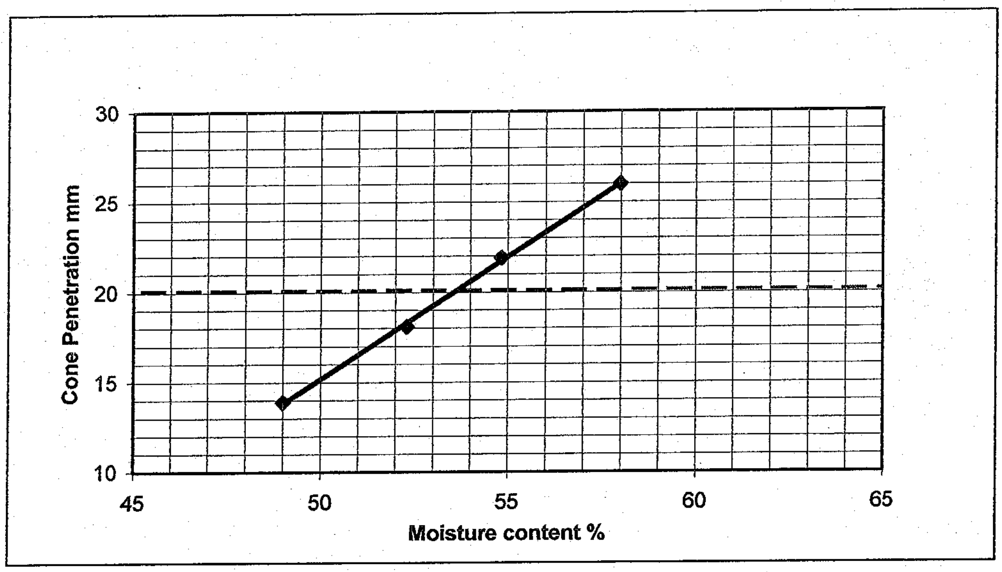
UC4 NAT MOISTURE CONTENT

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

Liquid Limit Test

Cone Penetration Method

Project: University of Cyprus **BH No.:** N14 **Date:** 30/1/2004
Site Location: University Campus - Site "4" **Depth:** 4,0-4,45m **Operator:**
Client: University of Cyprus **Soil:** Khaki silty MARL



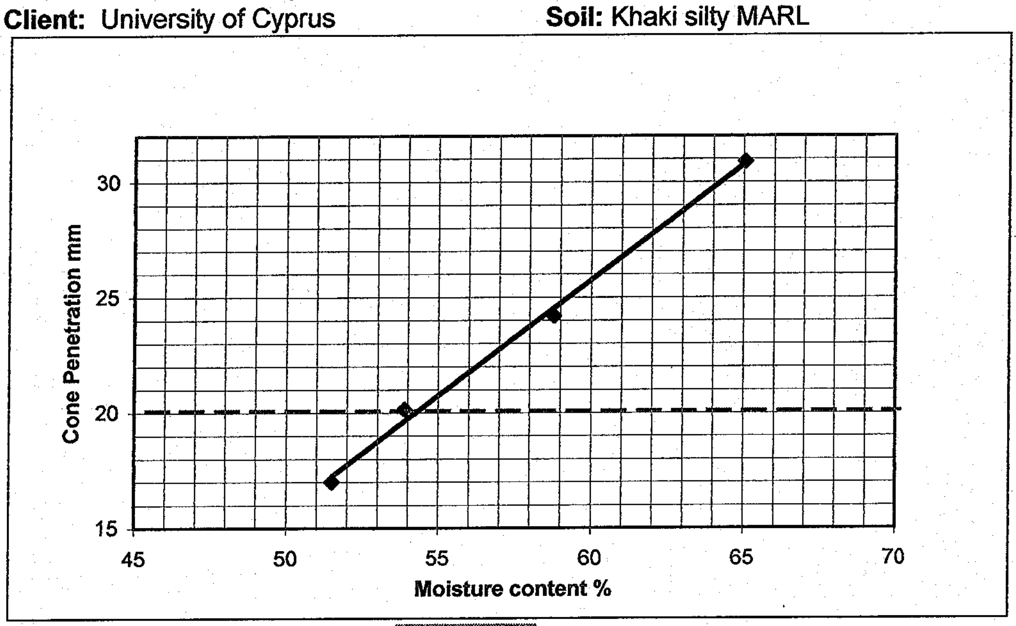
Liquid limit	53,5%
Plastic limit	34,1%
Plasticity Index	19,4%

FIG. 15

Liquid Limit Test

Cone Penetration Method

Project: University of Cyprus **BH No.:** N14 **Date:** 30/1/2004
Site Location: University Campus - Site "4" **Depth:** 7,0-7,45m **Operator:**
Client: University of Cyprus **Soil:** Khaki silty MARL



Liquid limit	54,5%
Plastic limit	34,5%
Plasticity Index	20,0%

FIG. 16

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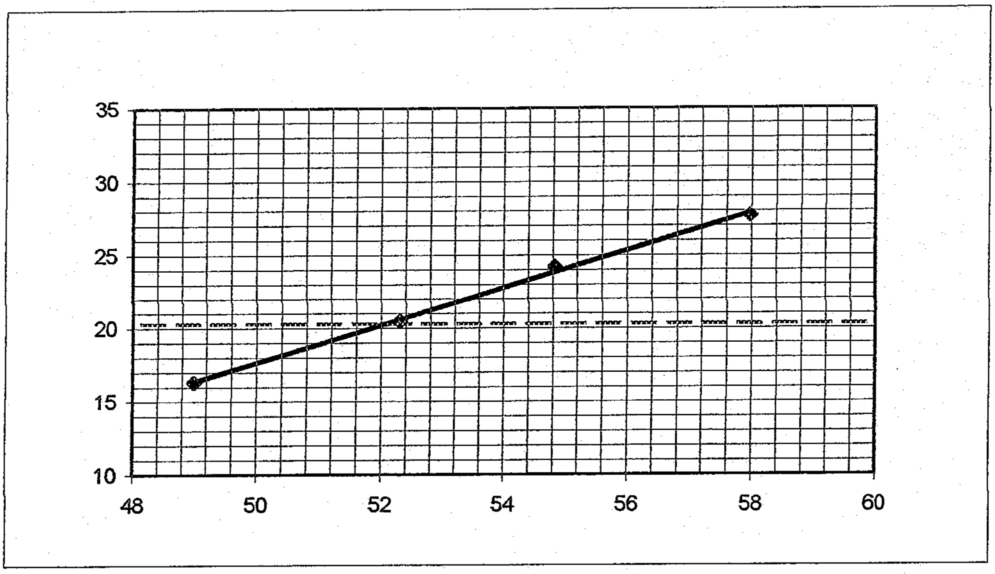
Tel. 22663191, Fax 22663192

Liquid Limit Test

Cone Penetration Method

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus
BH No.: N15
Depth: 5,5m
Soil: Khaki silty MARL
Date: 30/1/2004
Operator:



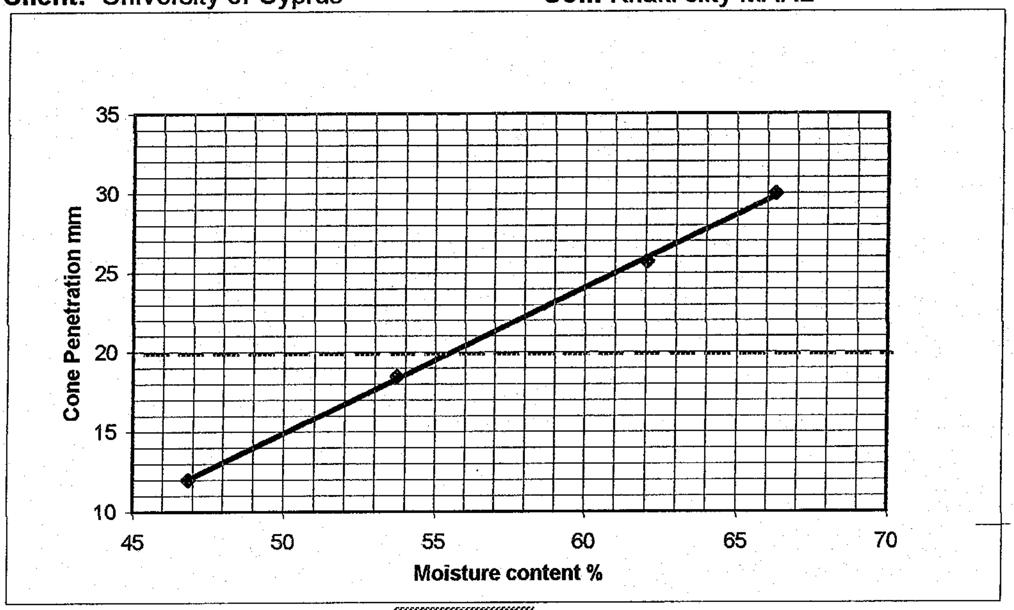
Liquid limit	52,0%
Plastic limit	33,1%
Plasticity Index	18,9%

FIG.17

Liquid Limit Test

Cone Penetration Method

Project: University of Cyprus
Site Location: University Campus - Site "6"
Client: University of Cyprus
BH No.: N16
Depth: 7.00m
Soil: Khaki silty MARL
Date: 29/1/2004
Operator:



Liquid limit	55,3%
Plastic limit	34,8%
Plasticity Index	20,5%

FIG.18

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Tel. 22663191, Fax 22663192

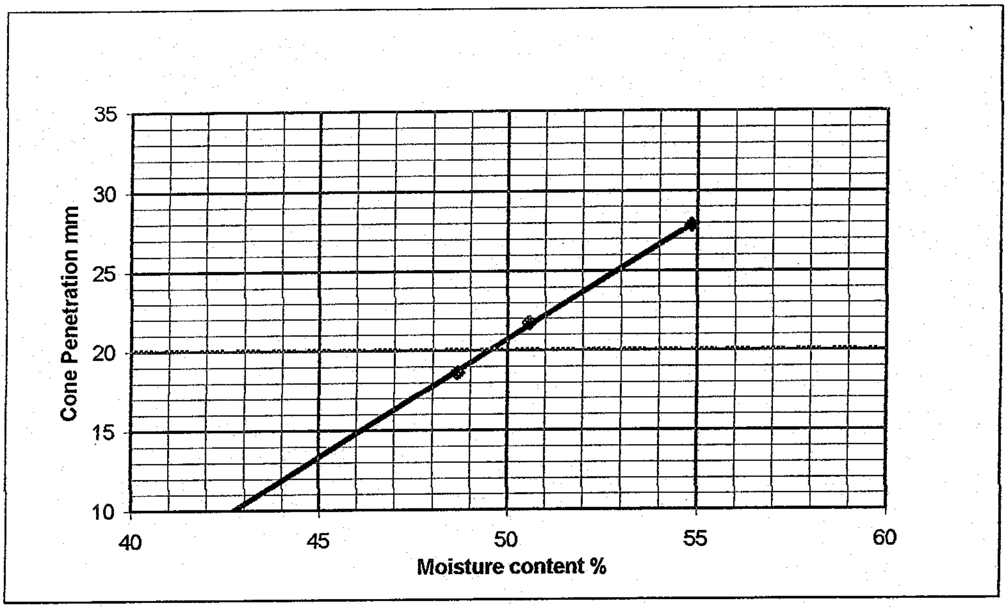
Liquid Limit Test

Cone Penetration Method

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,00m
Soil: Grey silty MARL

Date: 29/1/2004
Operator:



Liquid limit	49,5%
Plastic limit	29,4%
Plasticity Index	20,1%

FIG. 19

UC4 LIQUID LIMIT LL N17

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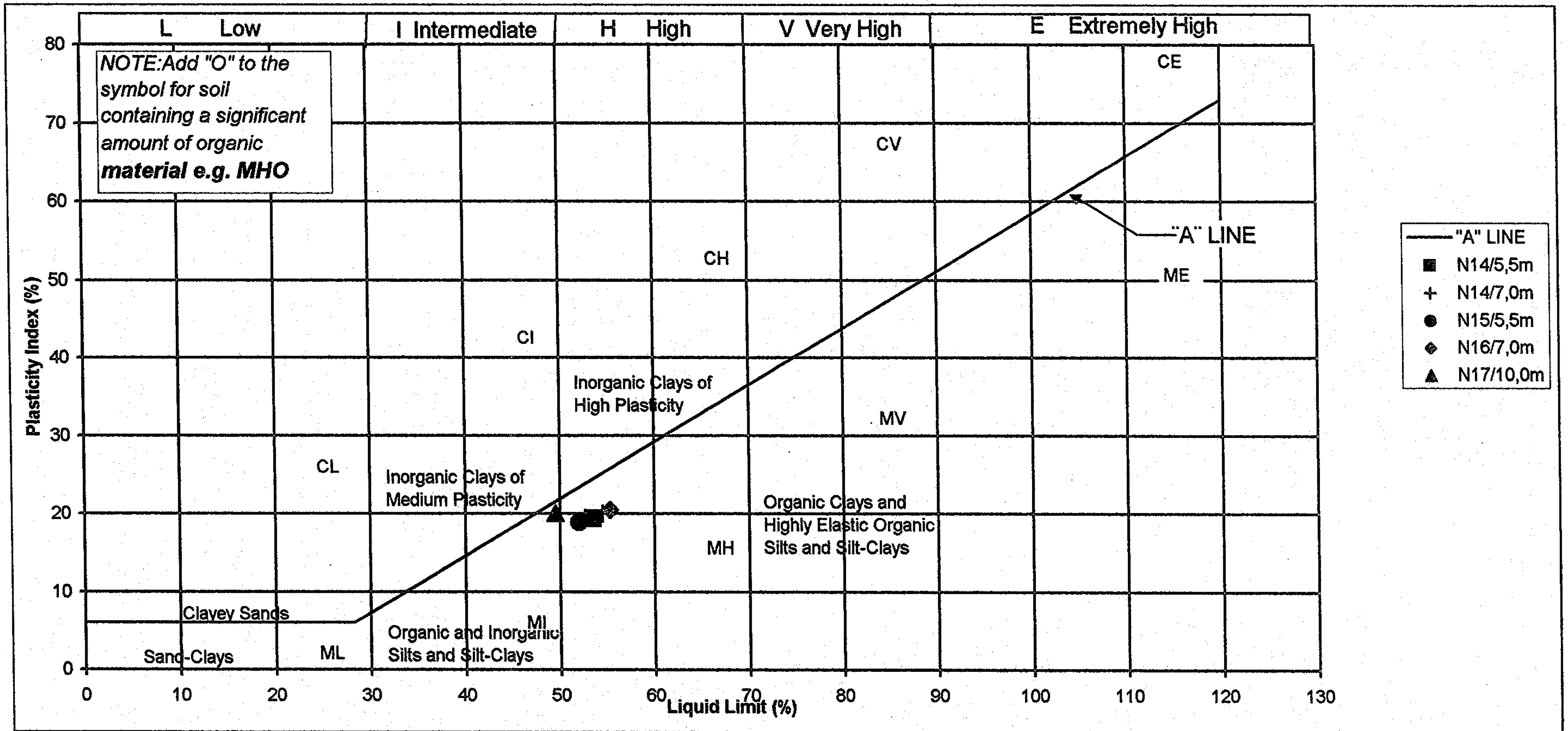
Tel. 22663191, Fax 22663192

PLASTICITY CLASSIFICATION CHART

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

Date: January 2004
Operator:



SILT(M-SOIL),M,plots below "A" Line
CLAY,C,plots above "A" Line
M and C may be combined as FINE SOIL,F

FIG. 20

UC4 LIQUID LIMIT

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Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Wet Sieving and Hydrometer

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 4,0-4,45m
Soil: Khaki silty MARL

Date: 19-21/1/04
Operator:
Sieving: Wet

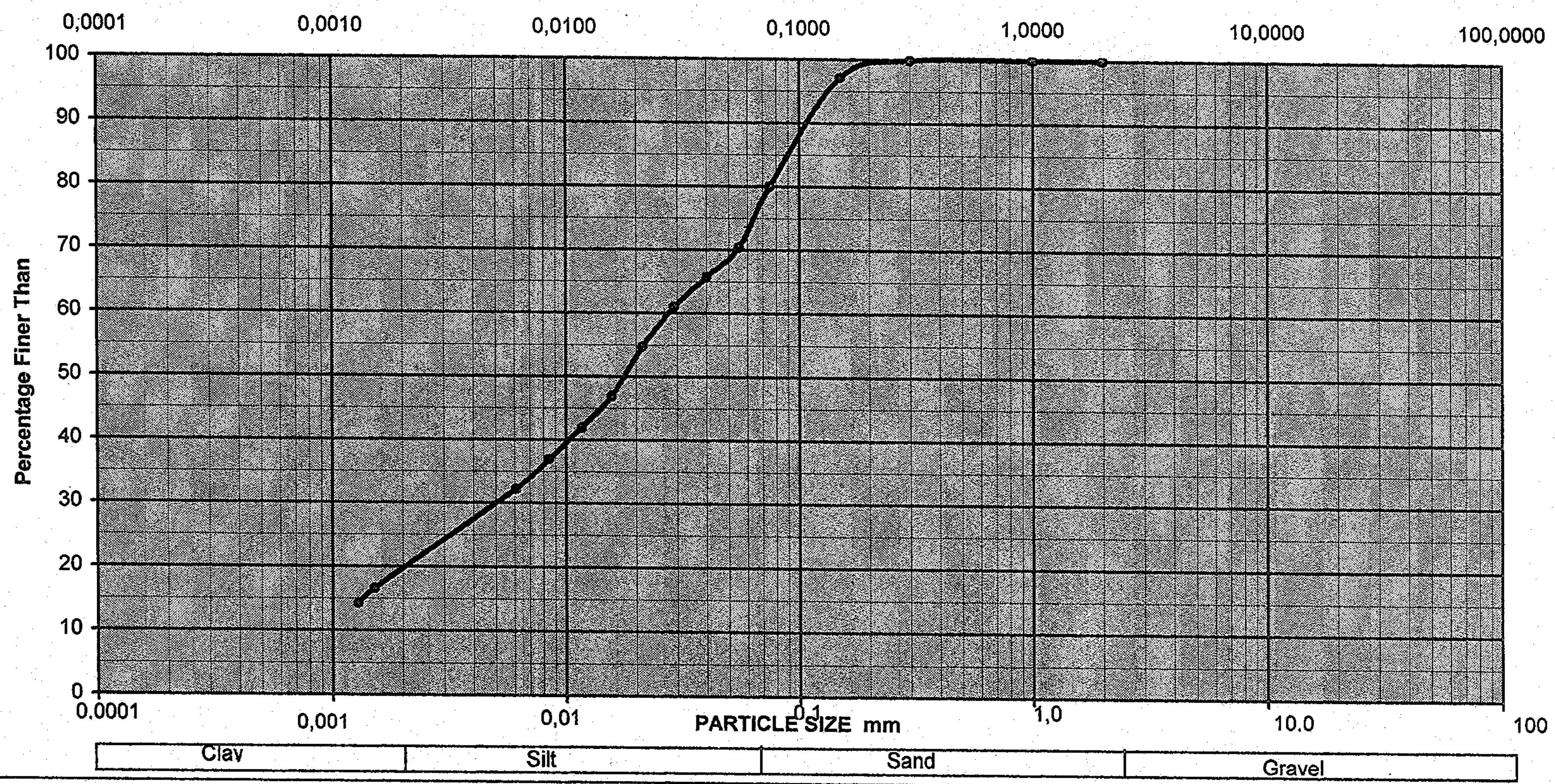


FIG. 21

UC4 HYDROMETER2 G N14-4

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Wet Sieving and Hydrometer

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty Marl

Date: 19-21/1/04
Operator:
Sieving: Wet

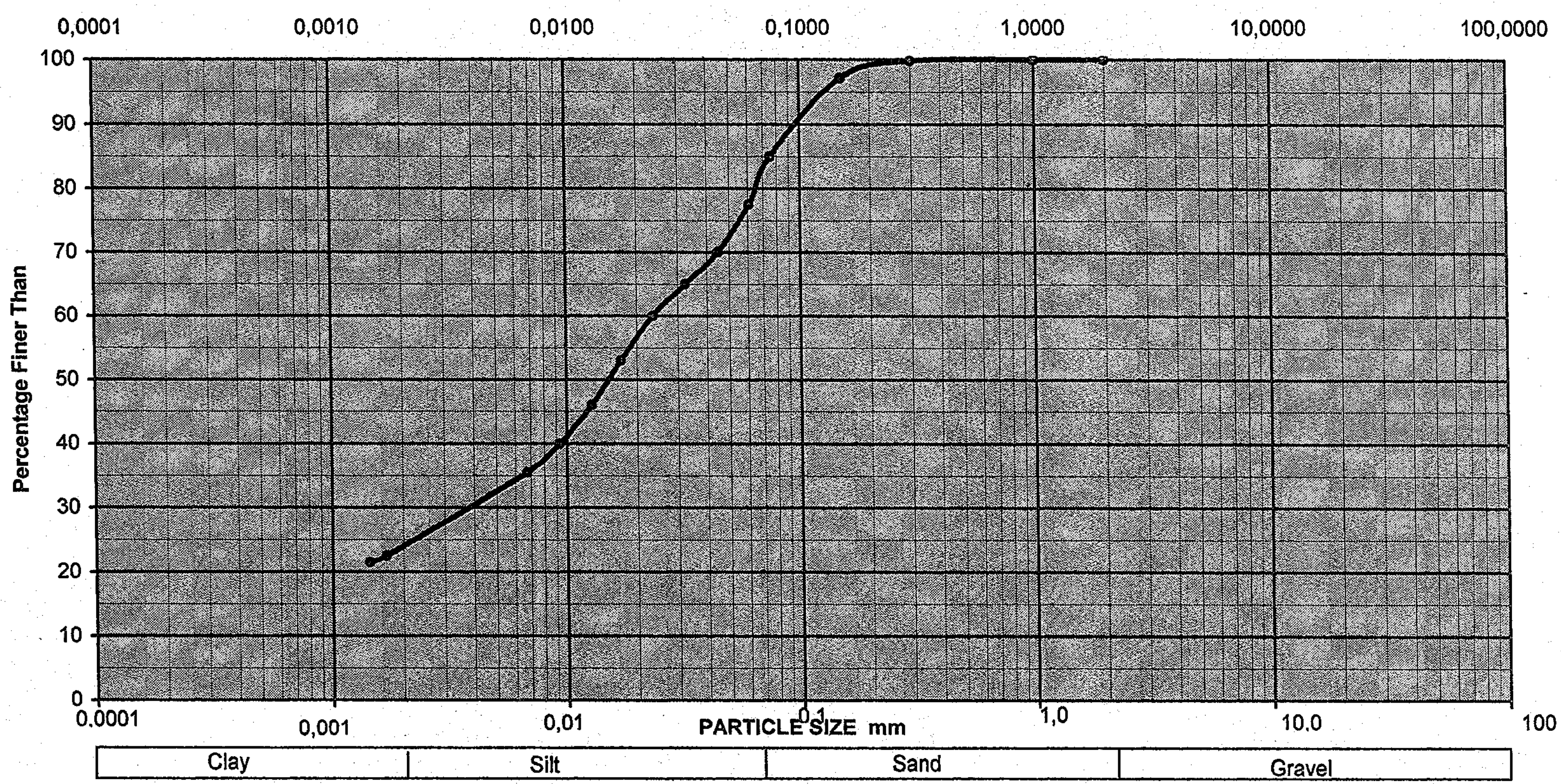


FIG. 22

UC4 HYDROMETER1 G N14-7,0

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Wet Sieving and Hydrometer

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N15
Depth: 5,50-5,95m
Soil: Khaki silty MARL

Date: 19-21/1/04
Operator:
Sieving: Wet

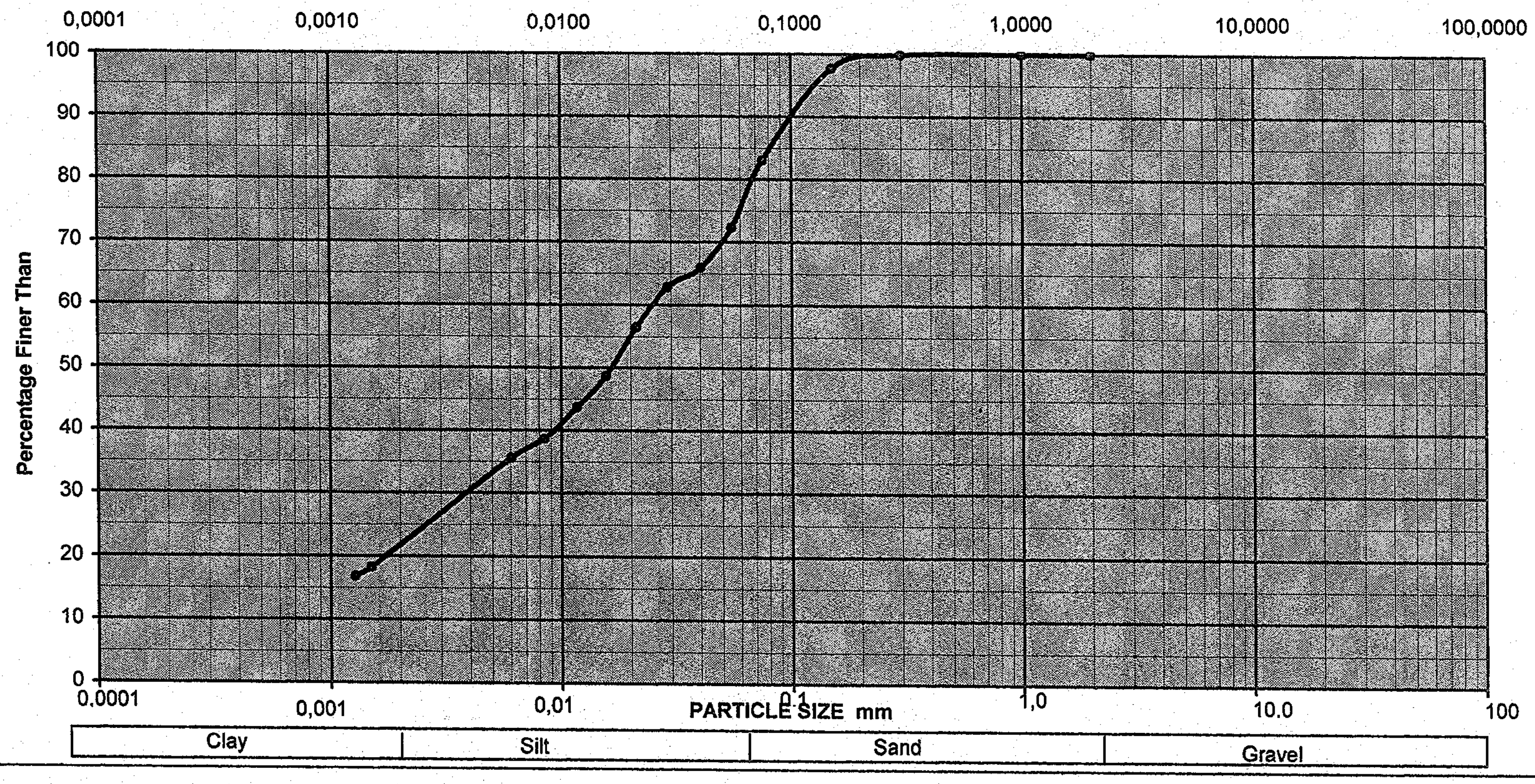


FIG. 23

UC4 HYDROMETER2 G N15-5,5

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N16
Depth: 3,1-4,80m
Soil: Grey sandy Gravel with silt

Date: 20/1/04
Operator:
Sieving: Wet

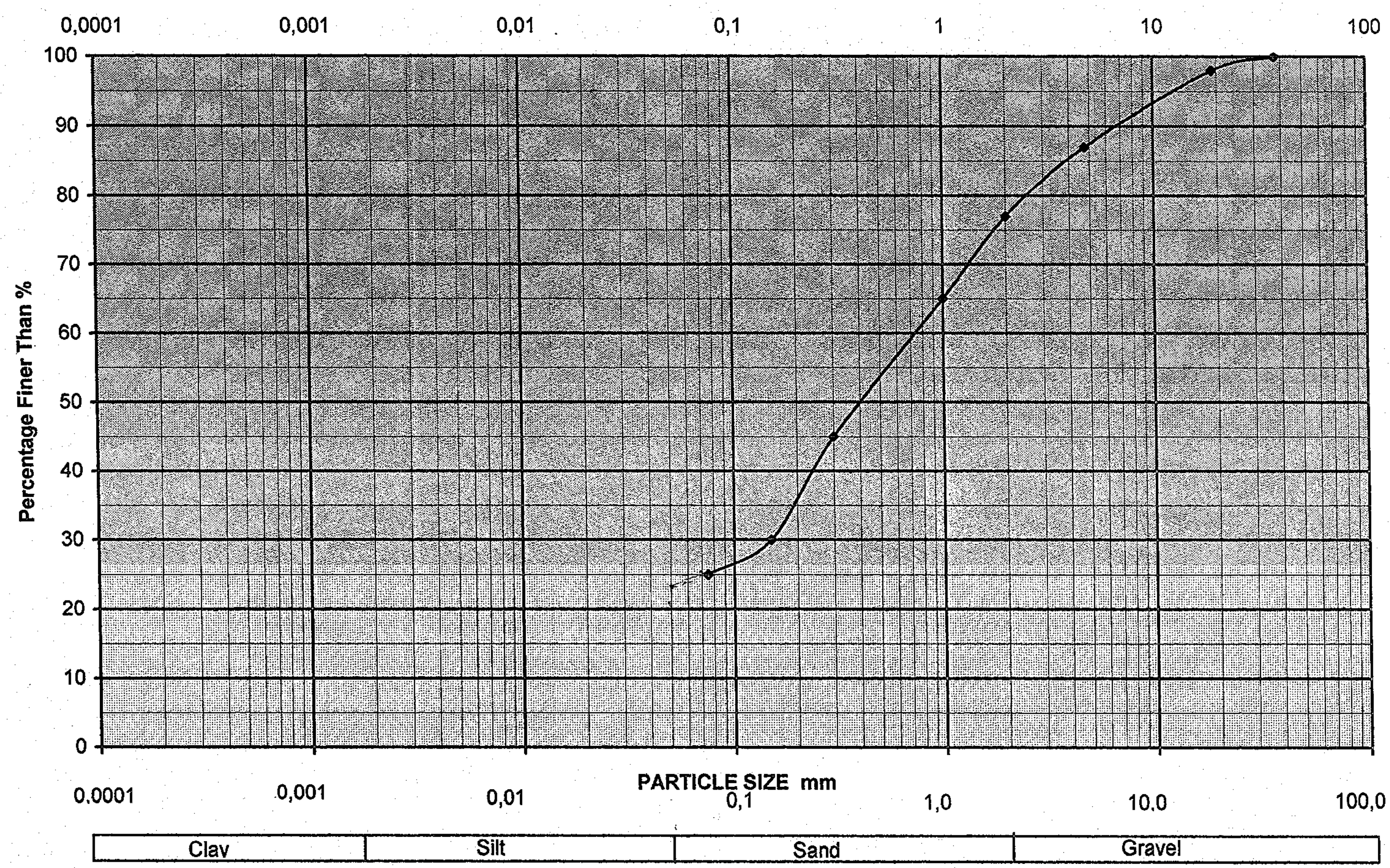


FIG. 24

UC4 GRADINGS N16 3,1

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax22663192

PARTICLE SIZE DISTRIBUTION

Wet Sieving and Hydrometer

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N16
Depth: 7,0-7,45m
Soil: Khaki silty MARL

Date: 19-21/1/04
Operator:
Sieving: Wet

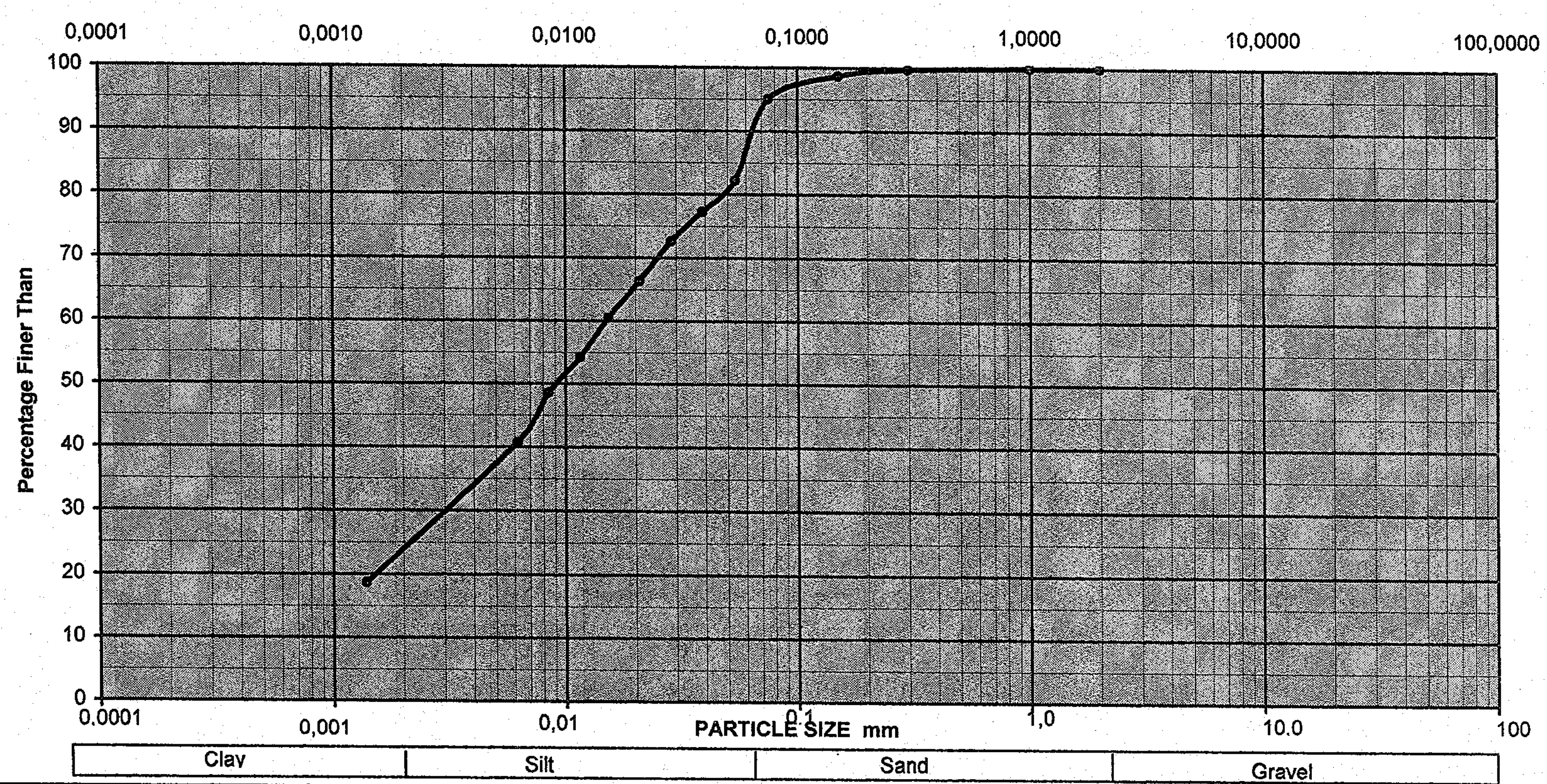


FIG. 25

UC4 HYDROMETER3 G N16-7,0

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 5,5-7,0m
Soil: Grey sandy Gravel

Date: 20/1/04
Operator:
Sieving: Wet

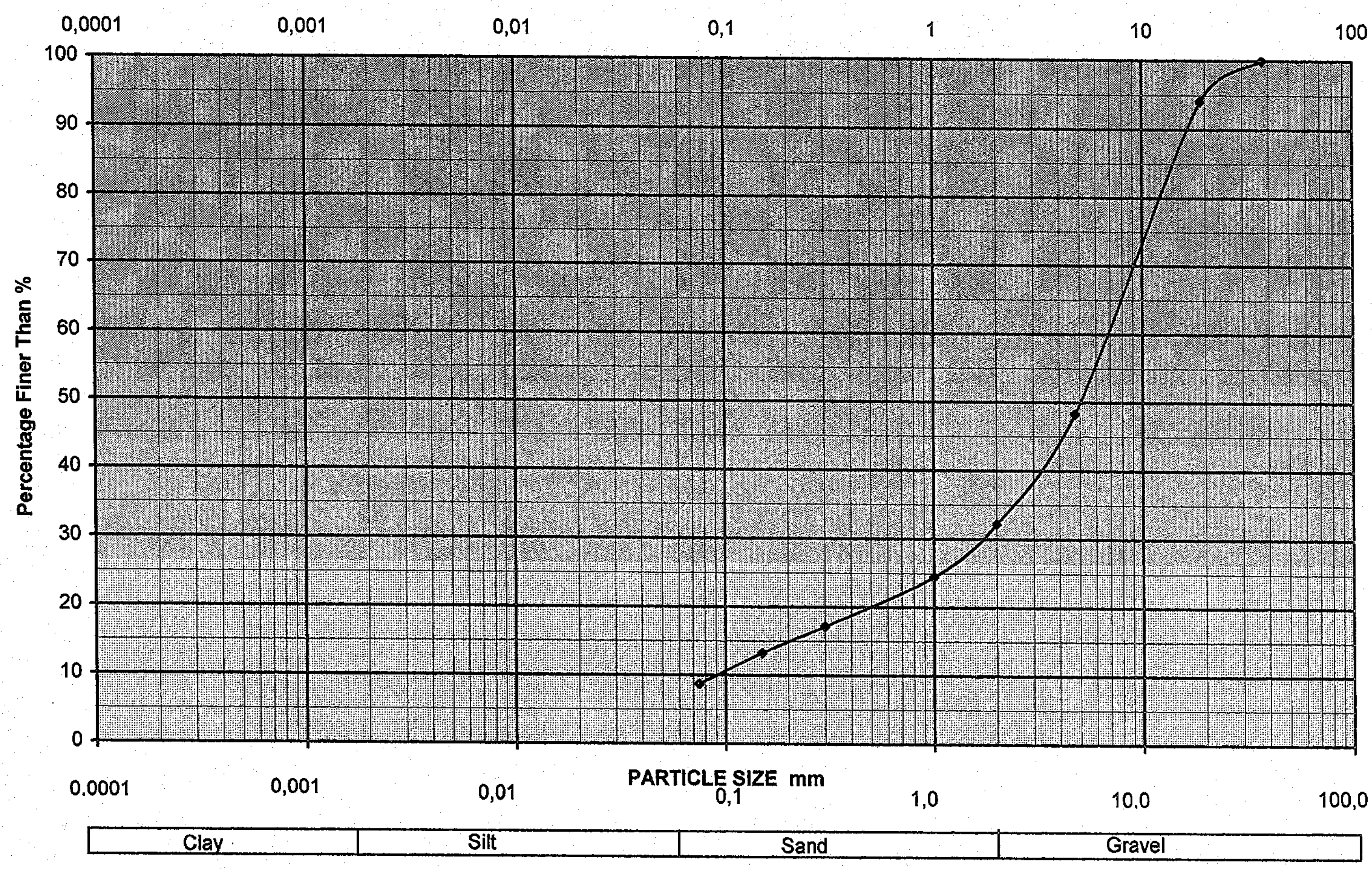


FIG. 26

UC4 GRADINGS N17 5,5

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax22663192

PARTICLE SIZE DISTRIBUTION

Wet Sieving and Hydrometer

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL

Date: 19-21/1/04
Operator:
Sieving: Wet

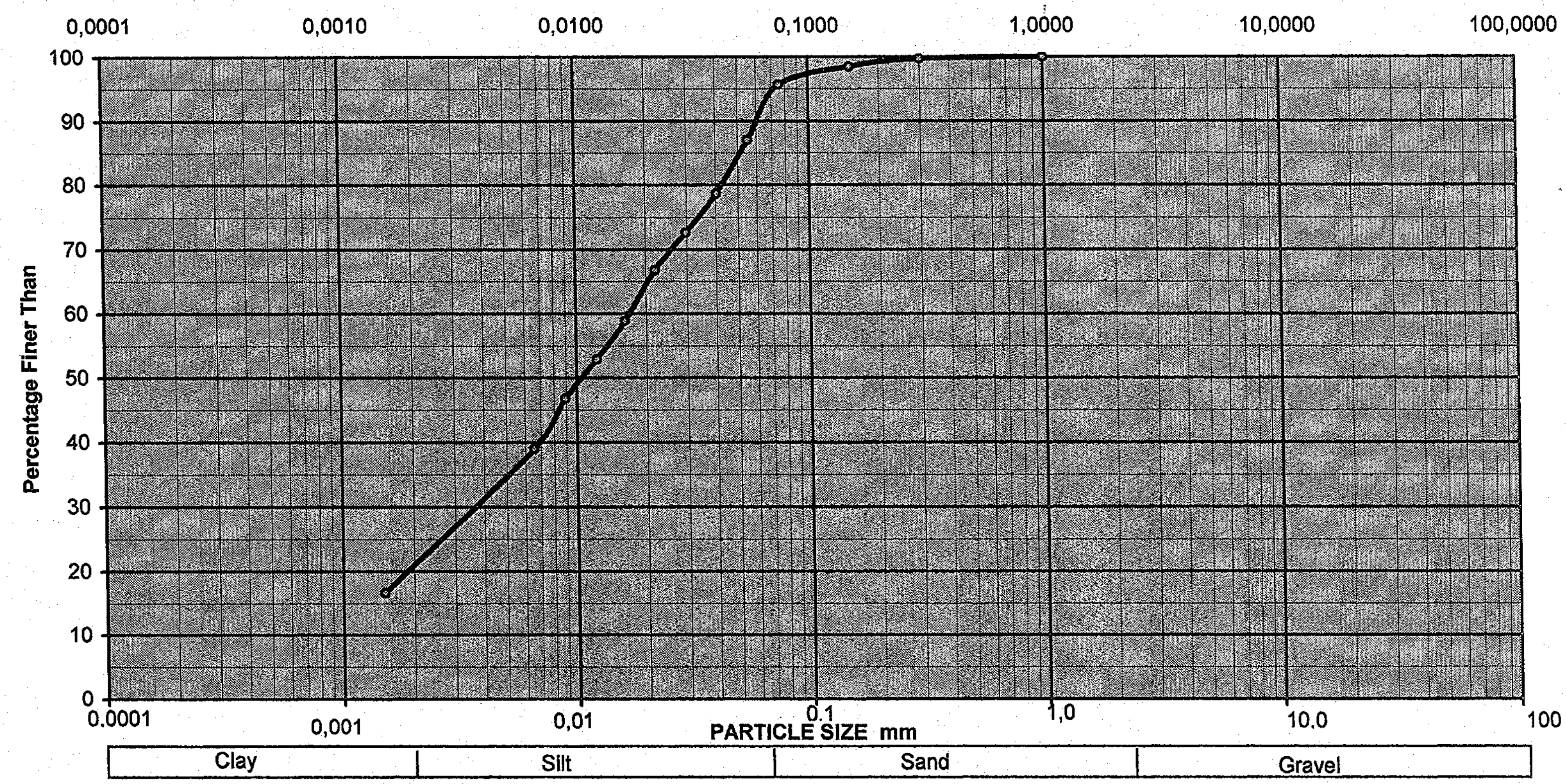


FIG. 27

UC4 HYDROMETER1 G N17-10,0

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

PARTICLE SIZE DISTRIBUTION

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N18
Depth: 4,0-4,70m
Soil: Sand and grey Gravel with silt

Date: 19/1/04
Operator:
Sieving: Wet

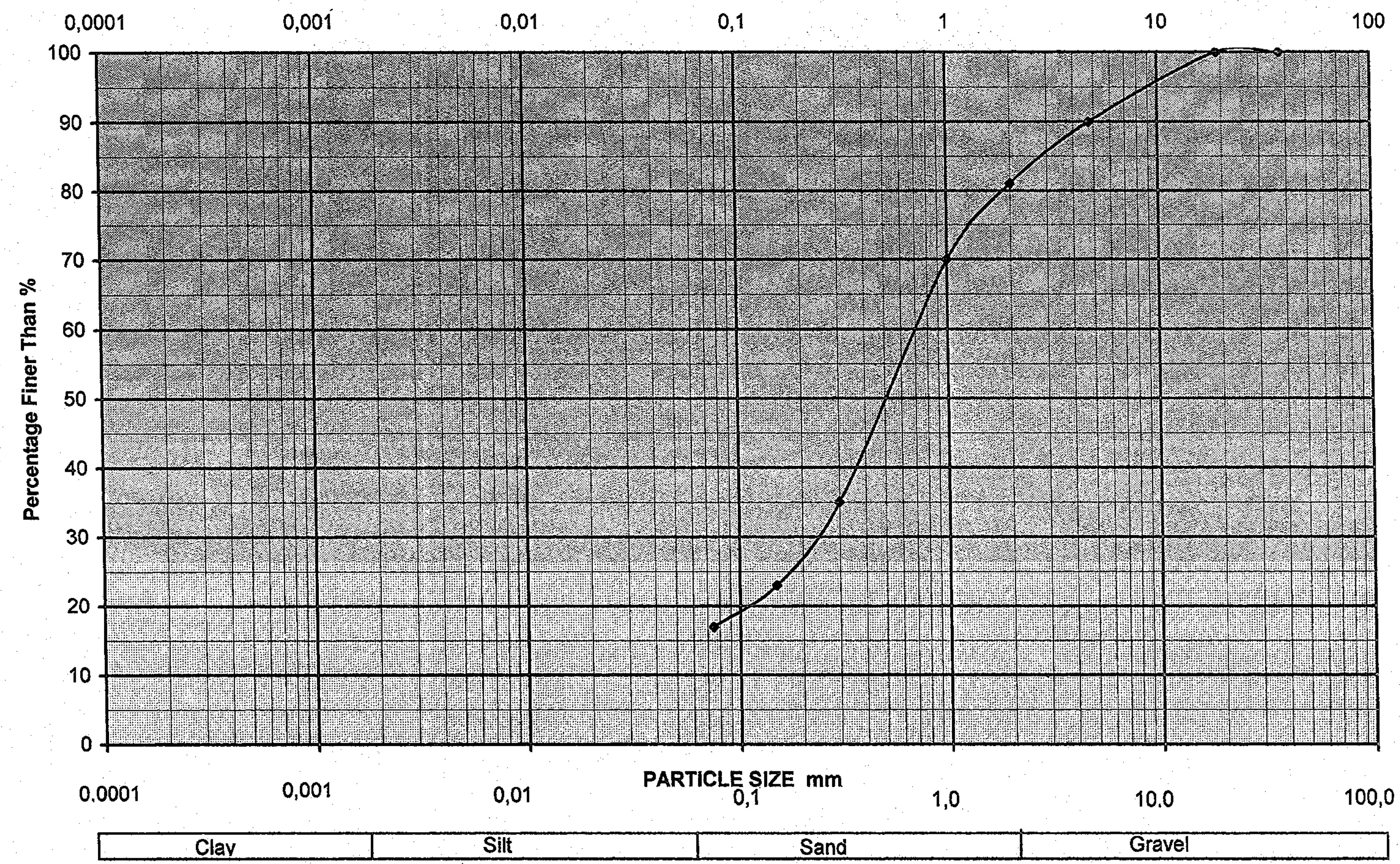


FIG. 28

UC4 GRADINGS N18 4,0

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax22663192

PARTICLE SIZE DISTRIBUTION

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N18
Depth: 6,5-7,4m
Soil: Grey sandy Gravel

Date: 19/1/04
Operator:
Sieving: Wet

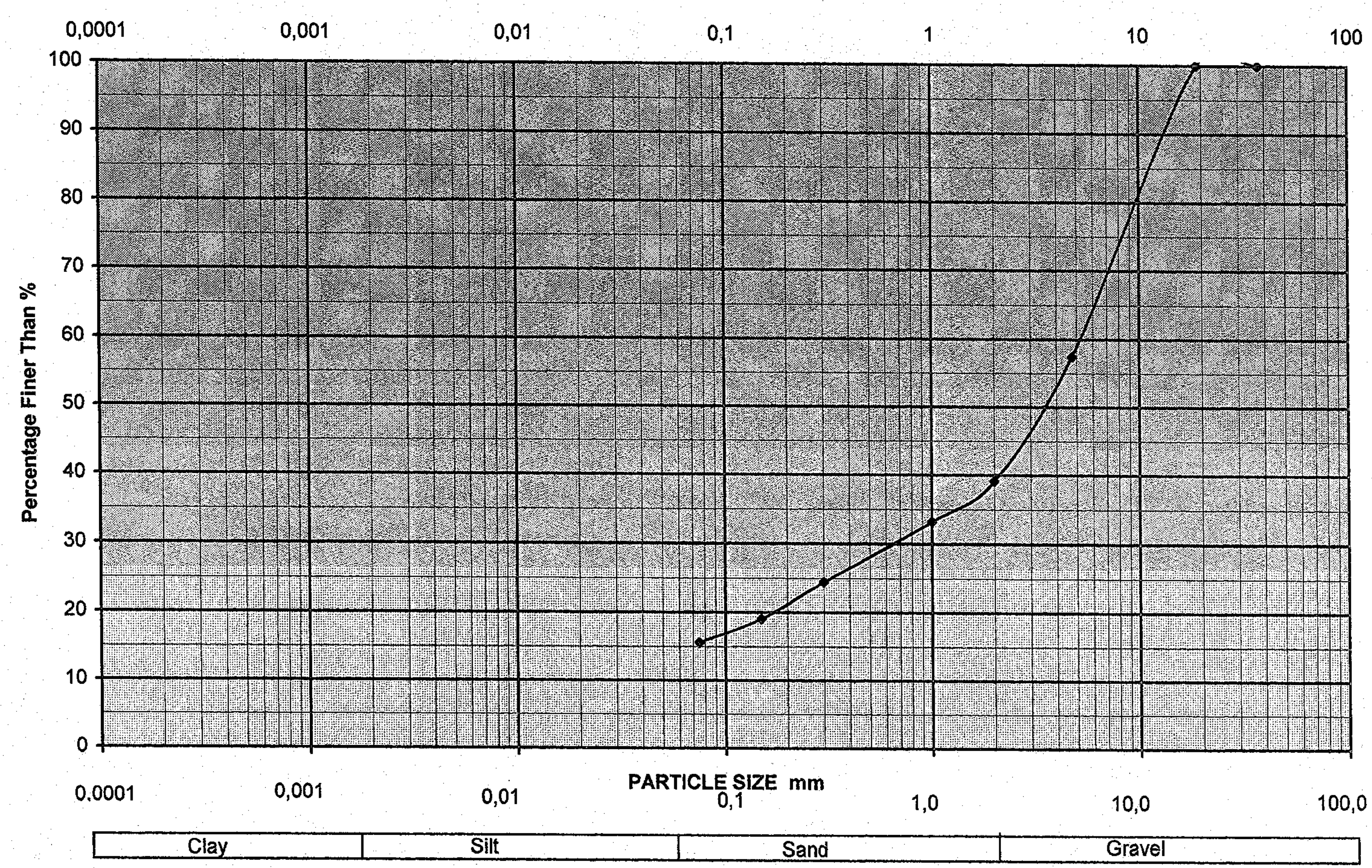


FIG. 29

UC4 GRADINGS N18 6,5

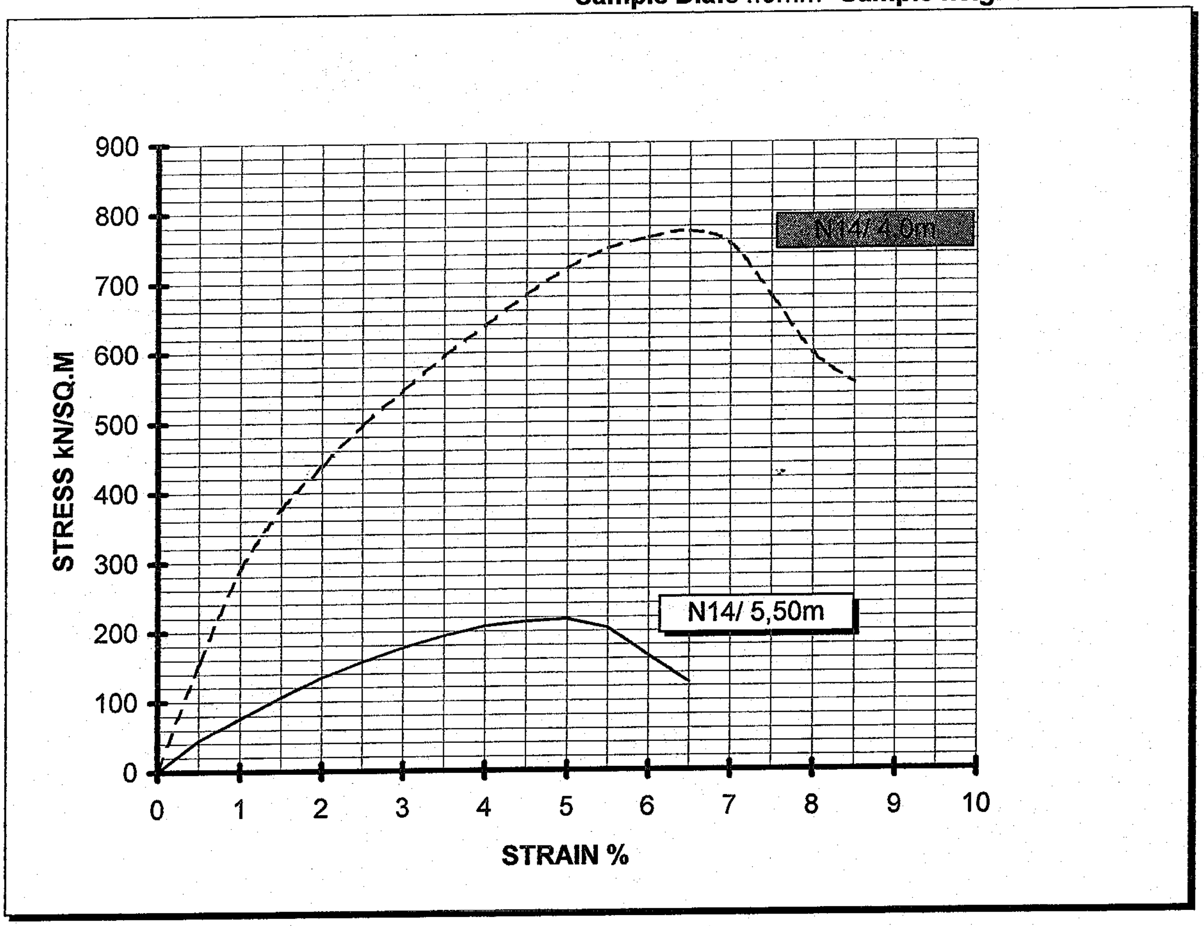
SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax22663192

UNCONFINED COMPRESSION TEST

Project: University of Cyprus
BH No.: N14
Date: 24/1/04

Site Location: University Campus - Site "4"
Depth: 4,0&5,50m
Operator:

Client: University of Cyprus
Soil: 4,0m: Khaki silty MARL
5,5m: Khaki sandy and silty MARL
Sample Dia: 34.5mm **Sample height:** 70mm



Specimen No.	BH No.	Depth m	Bulk Density kN/m3	Natural Moisture Content %	Undrained Cohesion Cu kN/m2
1	N14	4,00	19,7	26,53	385
2	N14	5,50	20,0	24,28	110

FIG. 30

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

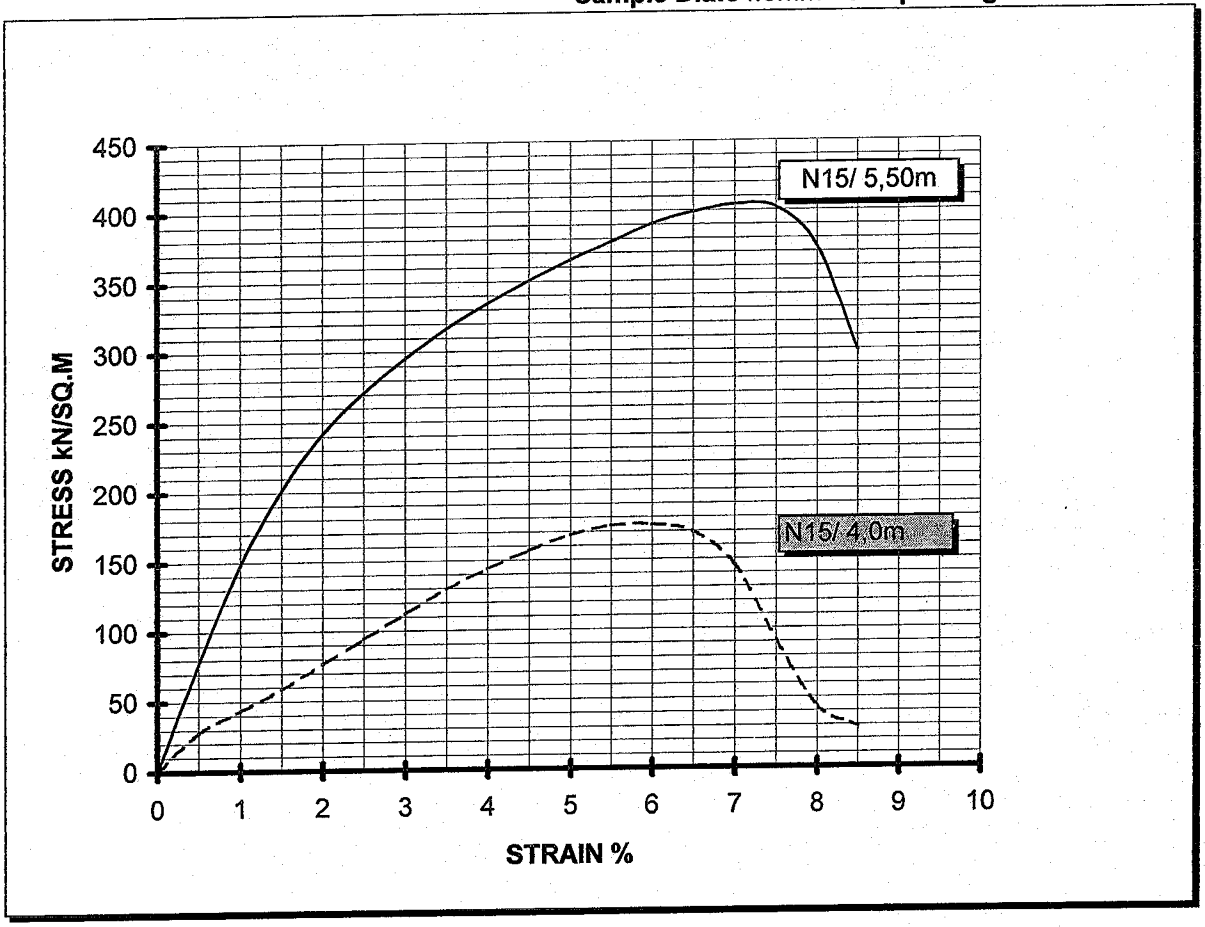
UNCONFINED COMPRESSION TEST

Project: University of Cyprus **BH No.:** N15 **Date:** 24/1/04

Site Location: University Campus - Site "4" **Depth:** 4,0&5,50m **Operator:**

Client: University of Cyprus **Soil:** 4,0m: Khaki silty sandy MARL
5,5m: Khaki silty MARL

Sample Dia:34.3mm **Sample height:** 70mm



Specimen No.	BH No.	Depth m	Bulk Density kN/m3	Natural Moisture Content %	Undrained Cohesion Cu kN/m2
1	N15	4,00	20,5	23,96	88
2	N15	5,50	19,5	30,19	202

FIG. 31

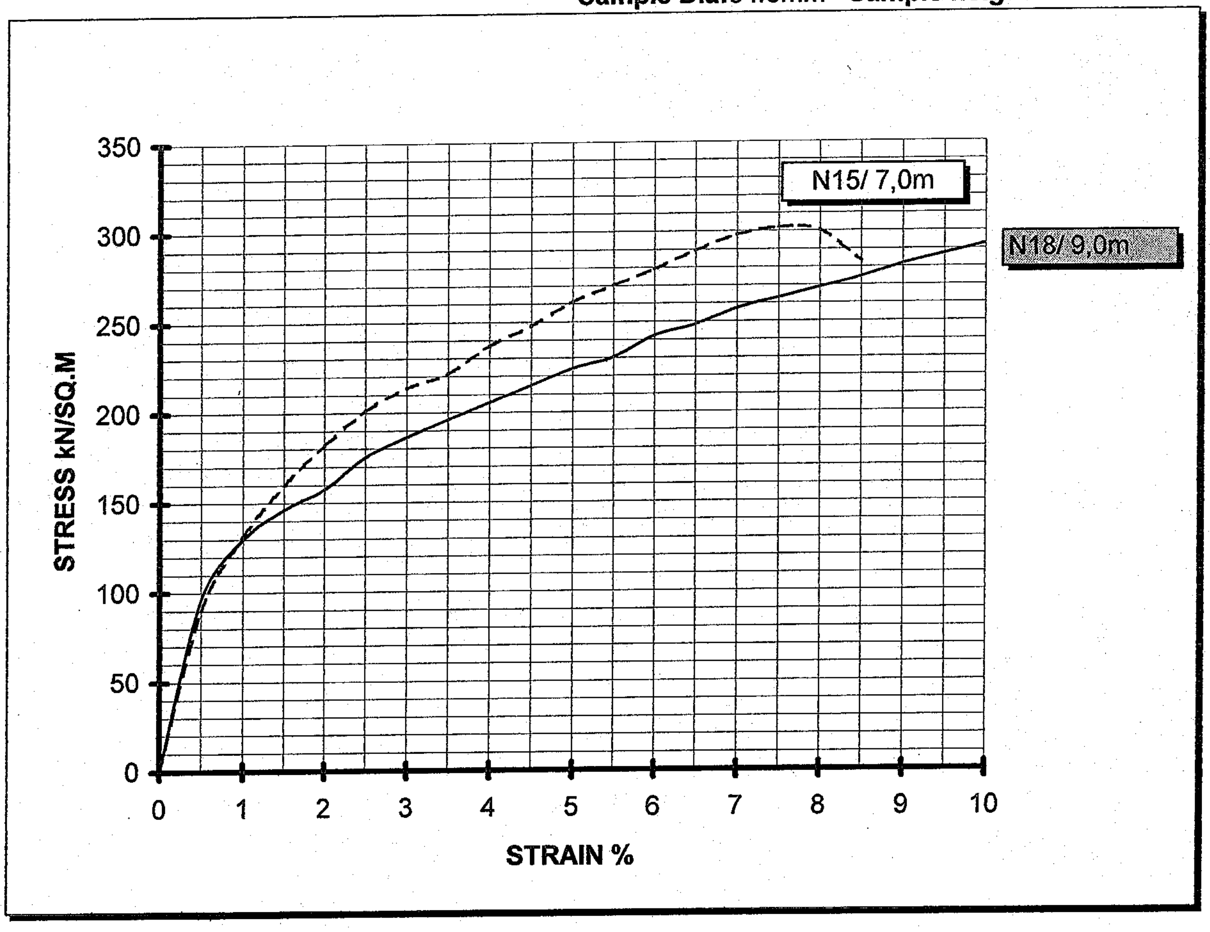
SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

UNCONFINED COMPRESSION TEST

Project: University of Cyprus
BH No.: N15&N18
Date: 26/1/04

Site Location: University Campus - Site "4"
Depth: 7,0&9,0m
Operator:

Client: University of Cyprus
Soil: 7,0m: Khaki silty MARL
9,0m: Khaki silty MARL
Sample Dia:34.3mm **Sample height:** 70mm



Specimen No.	BH No.	Depth m	Bulk Density kN/m3	Natural Moisture Content %	Undrained Cohesion Cu kN/m2
1	N15	7,00	19,9	29,65	151
2	N18	9,00	19,3	36,48	146

FIG. 32

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

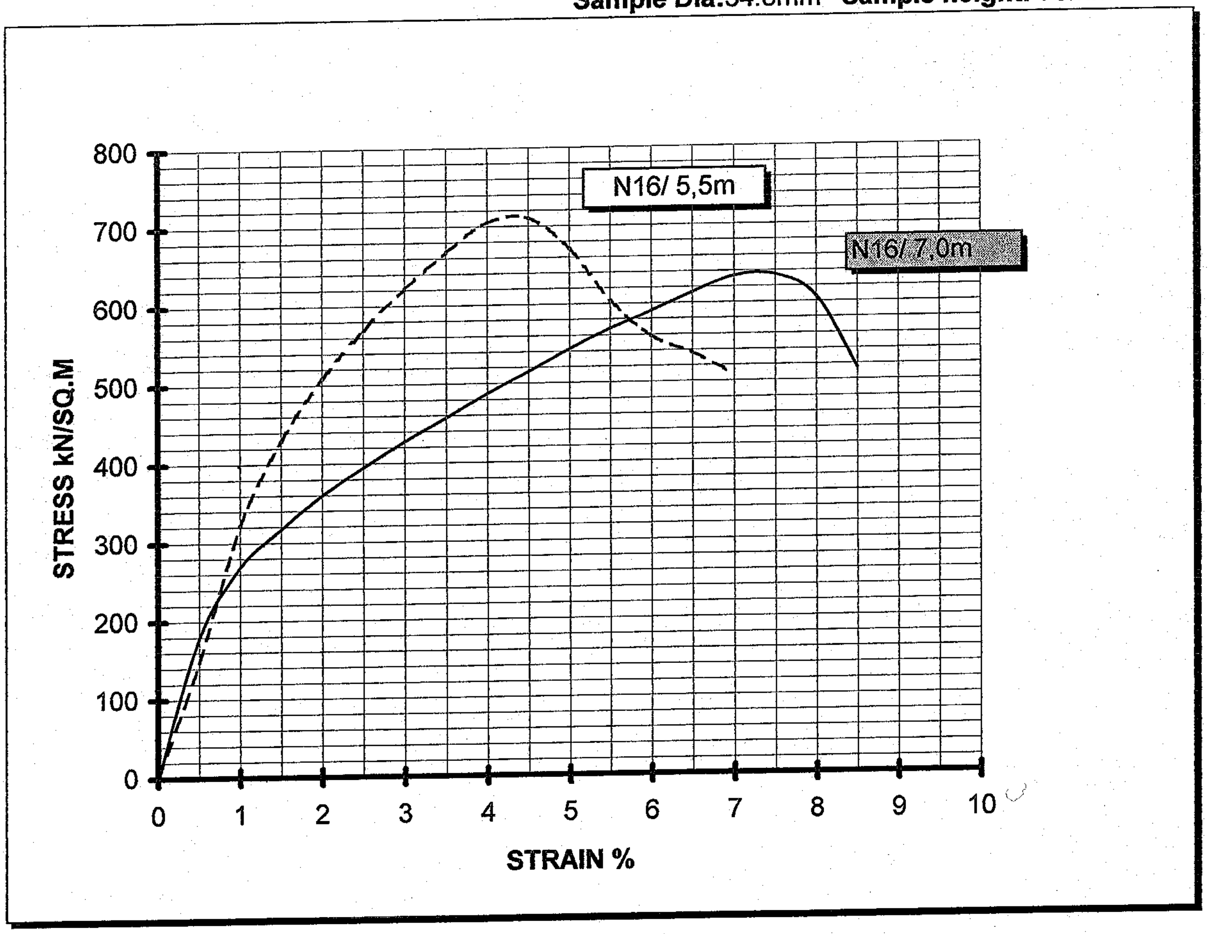
UNCONFINED COMPRESSION TEST

Project: University of Cyprus | **BH No.:** N16 | **Date:** 26/1/04

Site Location: University Campus - Site "4" | **Depth:** 5,5&7,0m | **Operator:**

Client: University of Cyprus | **Soil:** Khaki silty MARL

Sample Dia: 34.3mm | **Sample height:** 70mm



Specimen No.	BH No.	Depth m	Bulk Density kN/m3	Natural Moisture Content %	Undrained Cohesion Cu kN/m2
1	N16	5,50	19,9	28,47	355
2	N16	7,00	20,5	26,64	317

FIG. 33

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

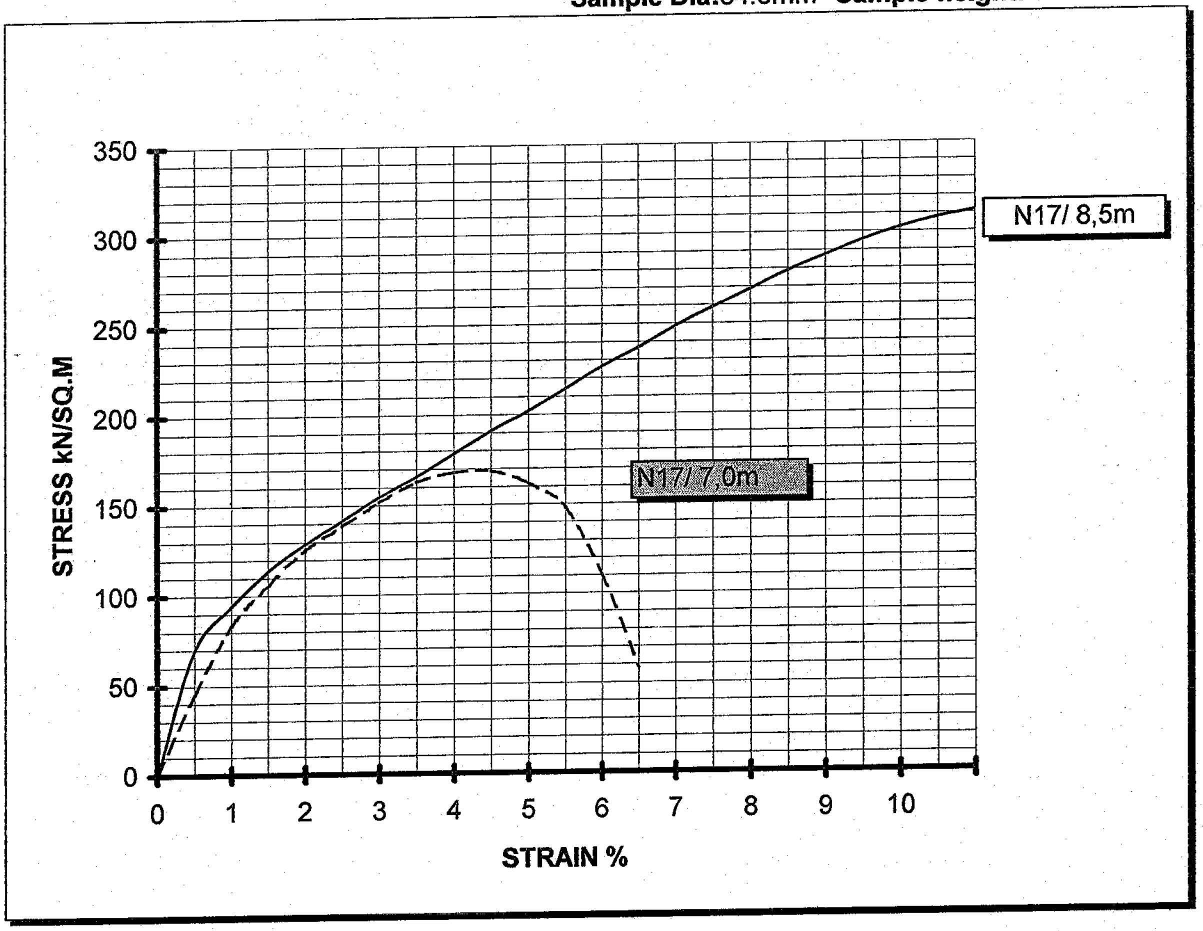
UNCONFINED COMPRESSION TEST

Project: University of Cyprus | **BH No.:** N17 | **Date:** 26/1/04

Site Location: University Campus - Site "4" | **Depth:** 7,0&8,5m | **Operator:**

Client: University of Cyprus | **Soil:** 7,0m: Khaki-yellowish sandy MARL; 8,5m: Stiff khaki silty MARL

Sample Dia:34.3mm **Sample height:** 70mm



Specimen No.	BH No.	Depth m	Bulk Density kN/m3	Natural Moisture Content %	Undrained Cohesion Cu kN/m2
1	N17	7,00	20,1	27,87	85
2	N17	8,50	19,9	33,34	155

FIG. 34

UC4 UNCONF COMPR

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

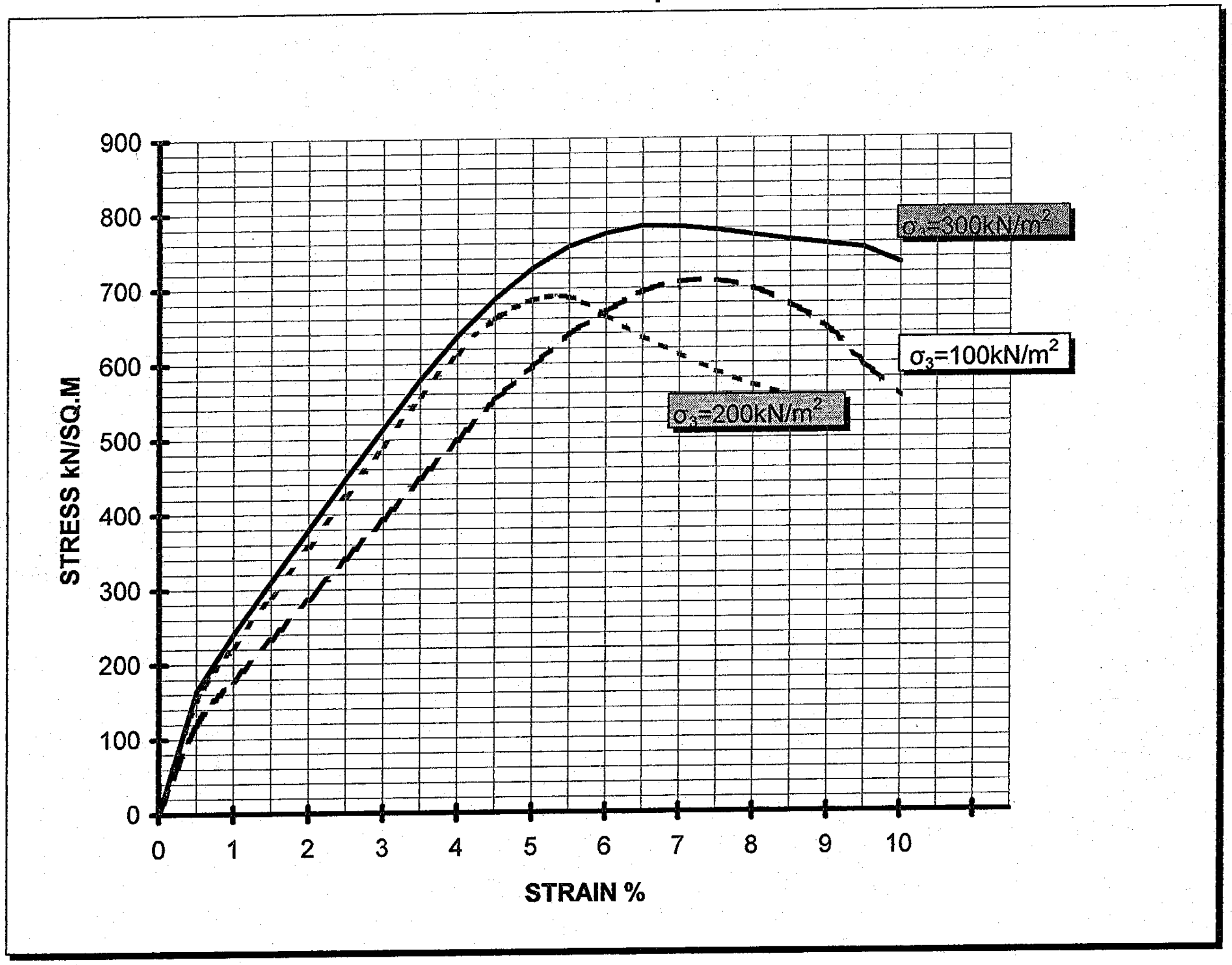
UNDRAINED TRIAXIAL TEST
STRESS Vs STRAIN CURVES

Project: University of Cyprus **BH No.:** N14 **Date:** 21/1/04

Site Location: University Campus - Site "4" **Depth:** 7,0-7,45m **Operator:**

Client: University of Cyprus **Soil:** Khaki silty MARL

Sample Dia: 35mm **Sample height:** 70mm



Specimen No.	Cell Pres. σ_3 kN/m^2	Bulk Dens. kN/m^3	Moist.Cont. %
1	100	19,4	33,36
2	200	19,3	33,43
3	300	19,2	33,02

FIG. 35

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No. 22663191, Fax 22663192

UNDRAINED TRIAXIAL TEST

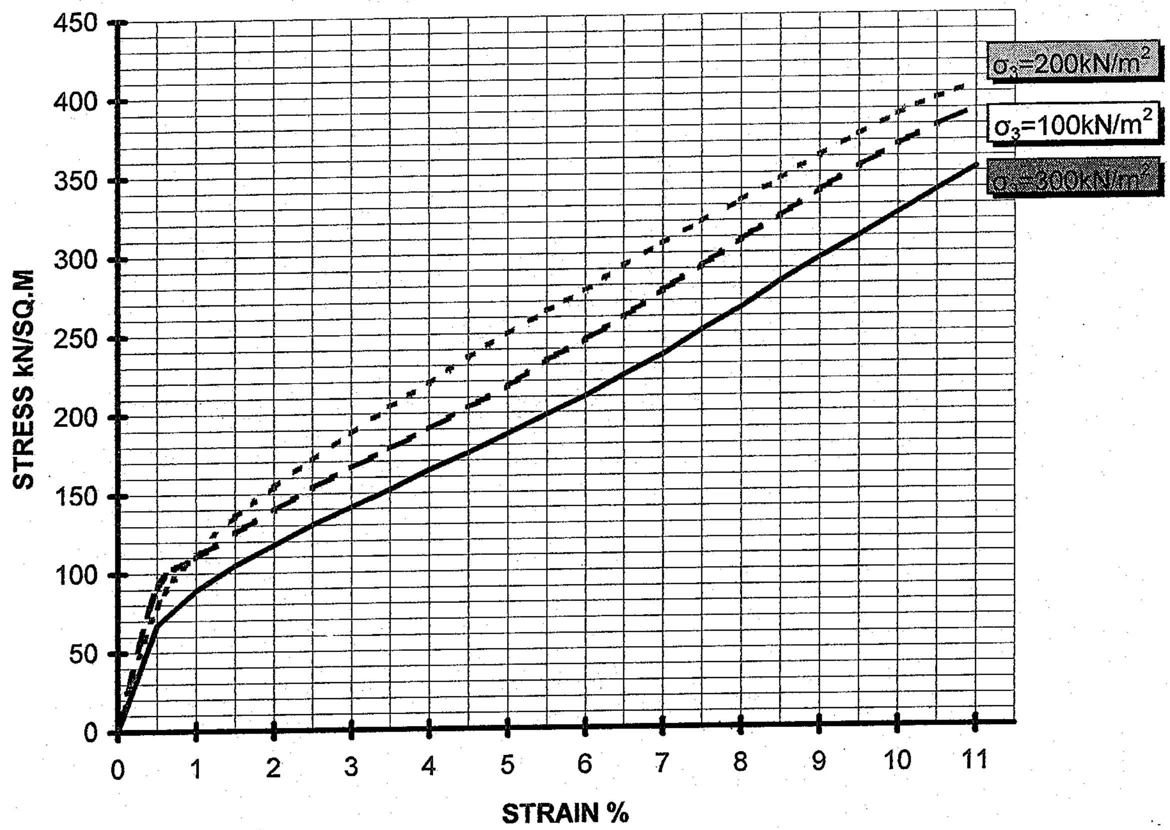
STRESS Vs STRAIN CURVES

Project: University of Cyprus
BH No.: N17
Date: 22/1/04

Site Location: University Campus - Site "4"
Depth: 10,0-10,45m
Operator:

Client: University of Cyprus
Soil: Grey silty MARL

Sample Dia:35mm
Sample height: 70mm



Specimen No.	Cell Pres. σ_3 kN/m^2	Bulk Dens. kN/m^3	Moist.Cont. %
1	100	19,5	32,39
2	200	19,4	32,93
3	300	19,6	32,44

FIG. 36

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No. 22663191, Fax 22663192

UC4 TRIAXIAL

UNDRAINED TRIAXIAL TEST
MOHR CIRCLE OF STRESSES

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty MARL
Sample Dia:35mm

Date: 21/1/2004
Operator:
Sample height: 70mn

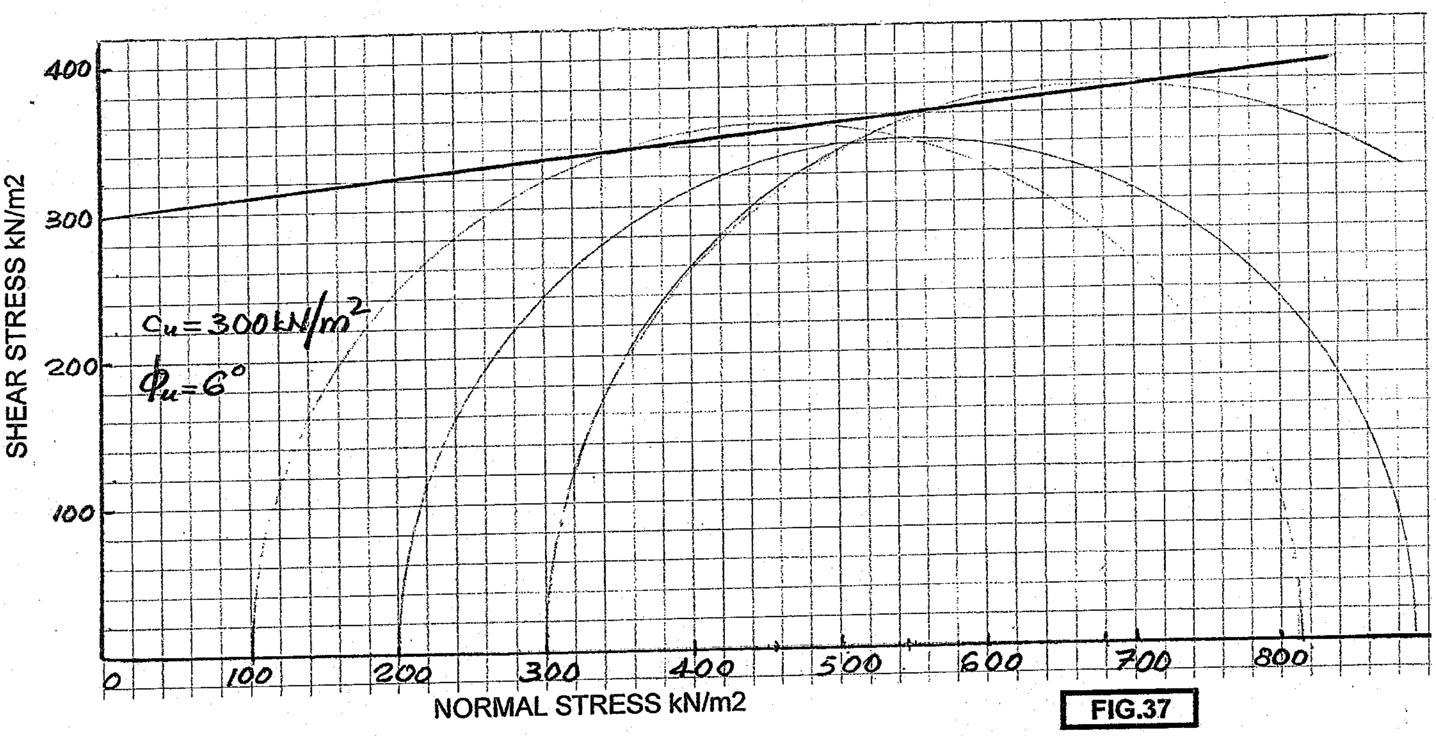


FIG.37

UNDRAINED TRIAXIAL TEST
MOHR CIRCLE OF STRESSES

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL
Sample Dia:35 mm

Date: 22/1/2004
Operator:
Sample height: 70mn

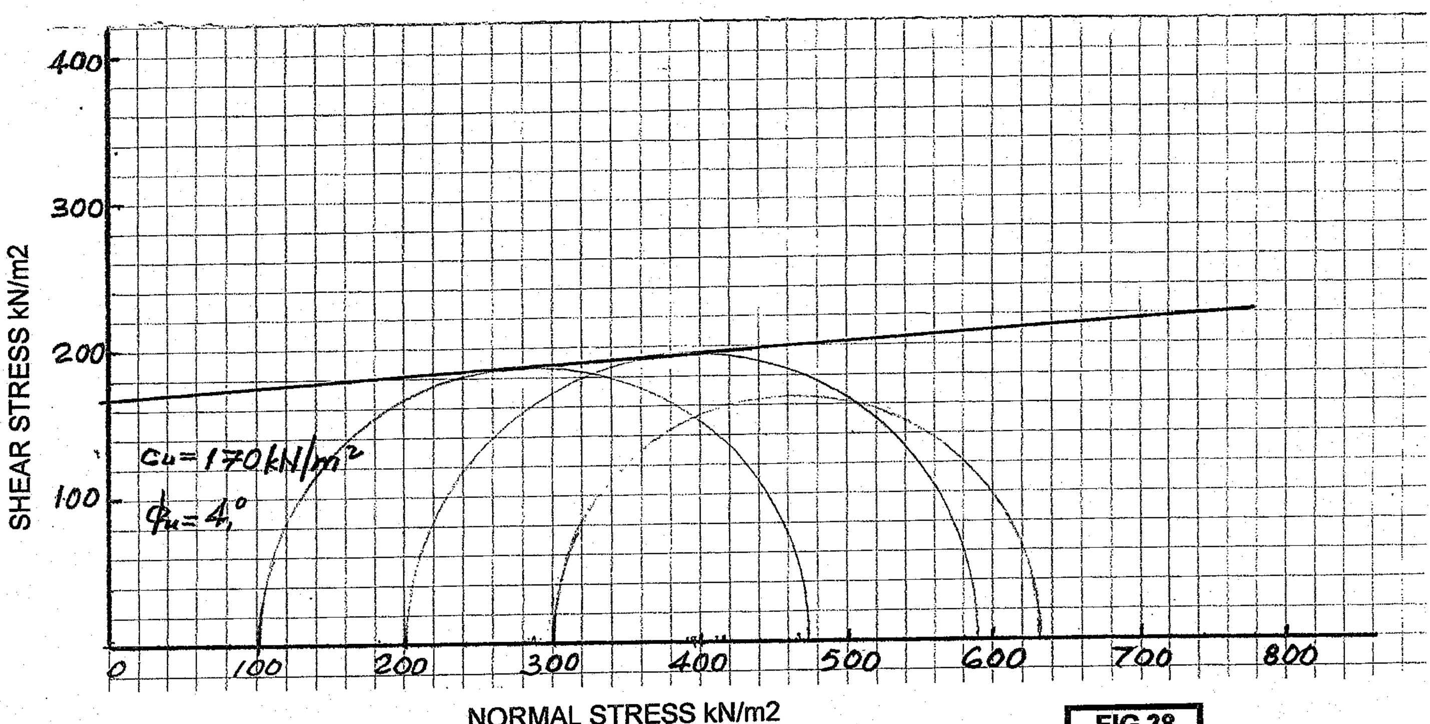


FIG.38

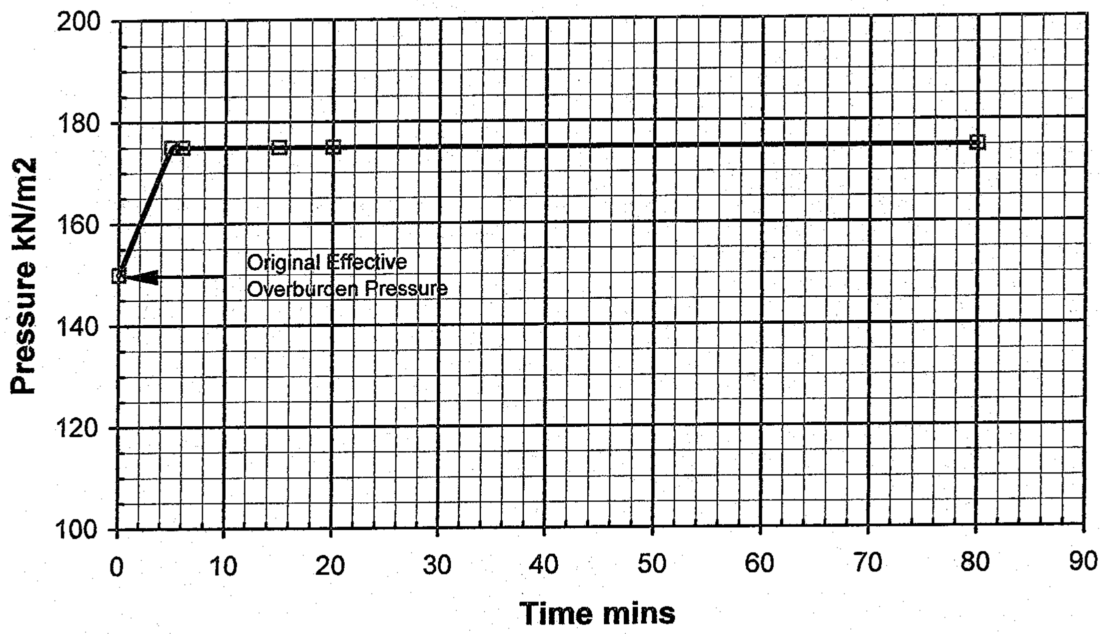
SH Soil Engineering Ltd, *P.O.Box 25457, 1310 Nicosia, Tel. 22663191, Fax 22663192*

SWELLING PRESSURE TEST

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty MARL

Date: 20/1/04
Operator:



Maximum swelling pressure measured = 175 -150 = **25 kN/m2**

FIG. 39

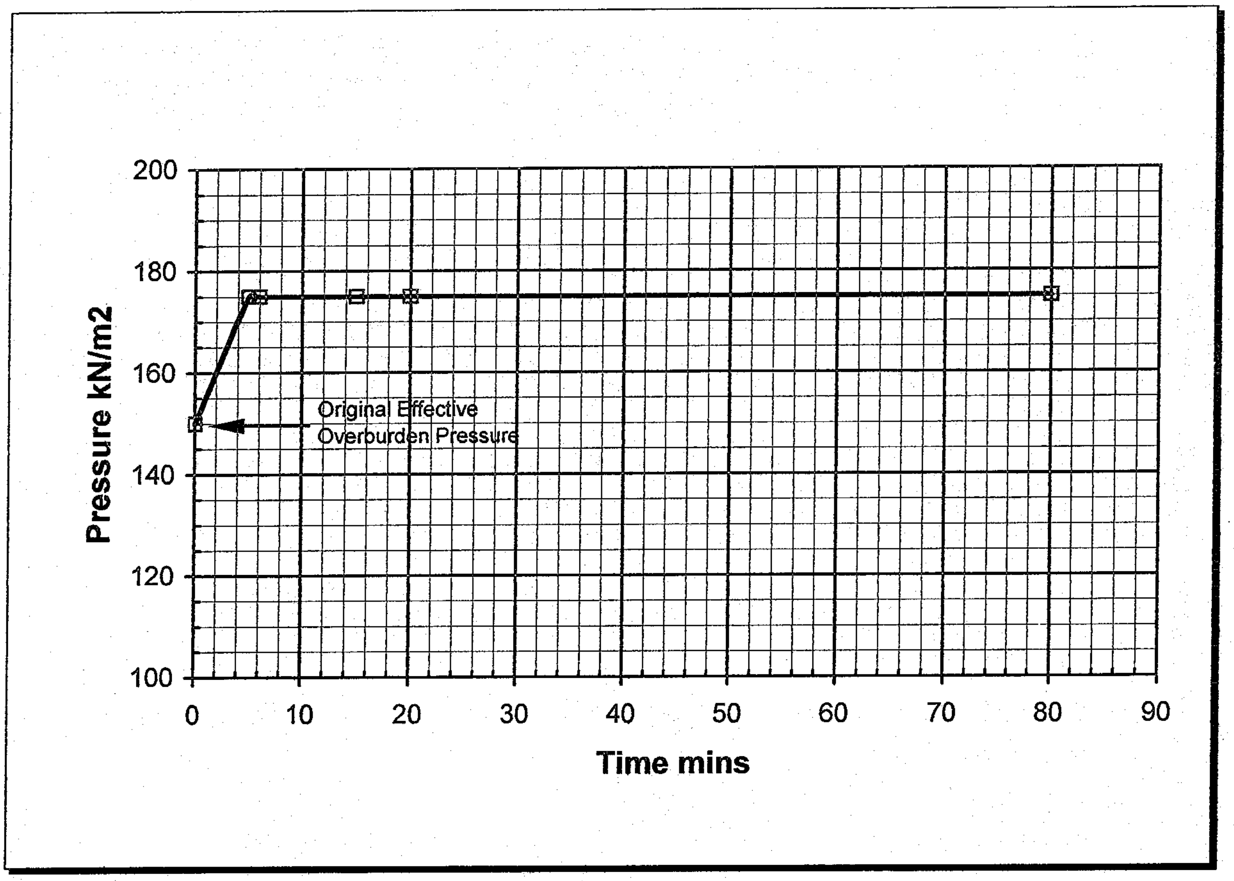
SH SOIL ENGINEERING LTD
P.O.Box 25457, 1310 Nicosia
Tel.No.22336191, Fax 22663192

SWELLING PRESSURE TEST

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL

Date: 20/1/04
Operator:



Maximum swelling pressure measured = 175 -150 = **25 kN/m2**

FIG. 40

SH SOIL ENGINEERING LTD
P.O.Box 25457, 1310 Nicosia
Tel.No.22336191, Fax 22663192

CONSOLIDATION TEST

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty MARL

Date: 20 to 27/1/04
Operator:

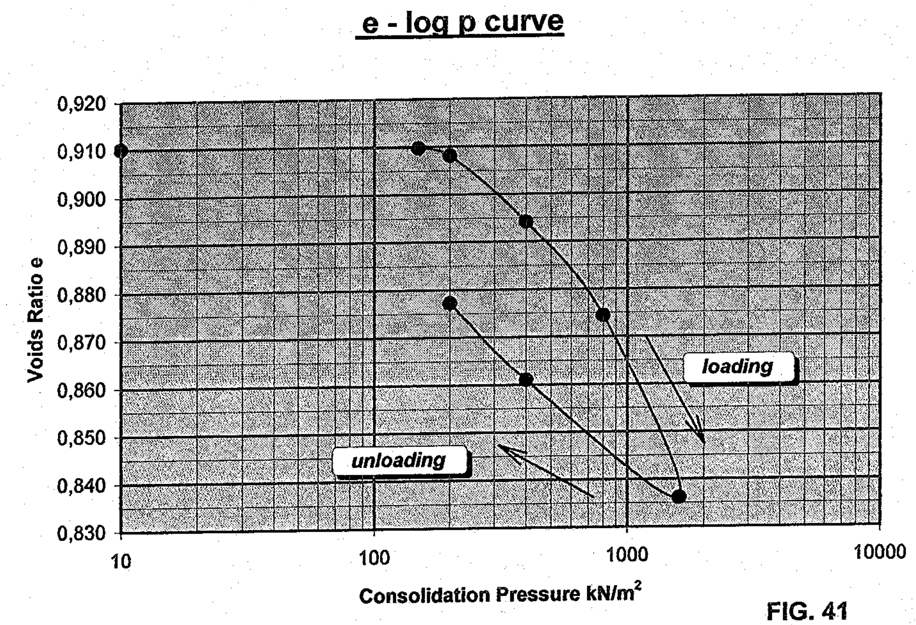


FIG. 41

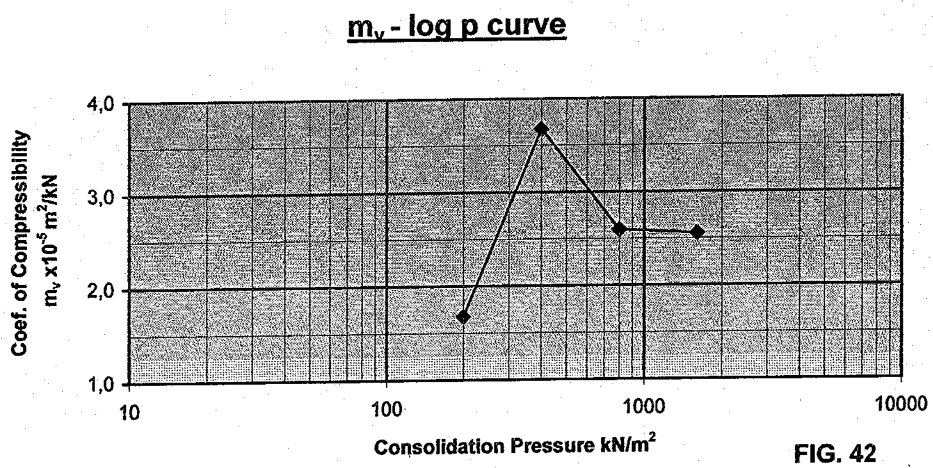


FIG. 42

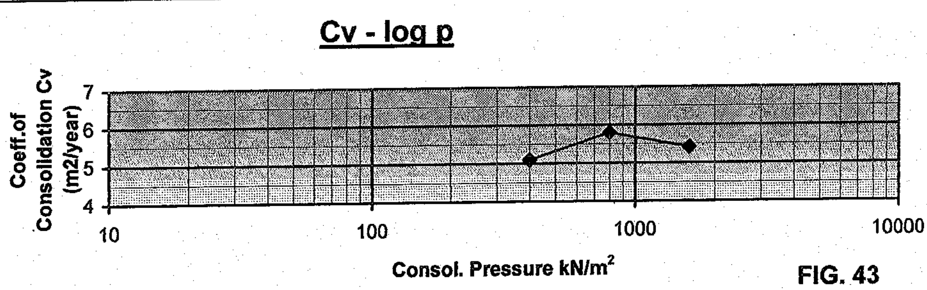


FIG. 43

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

CONSOLIDATION TEST

Consolidation Vs Sq.Root Time Curves

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty MARL

Date: 20 to 27/1/04
Operator:

Pressure: 400kN/m2

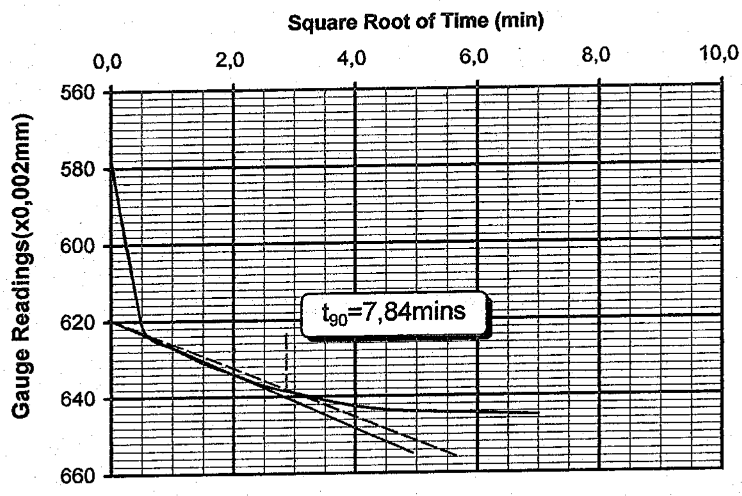


FIG. 44

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

CONSOLIDATION TEST

Consolidation Vs Sq.Root Time Curves

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N14
Depth: 7,0-7,45m
Soil: Khaki silty MARL

Date: 20 to 27/1/04
Operator:

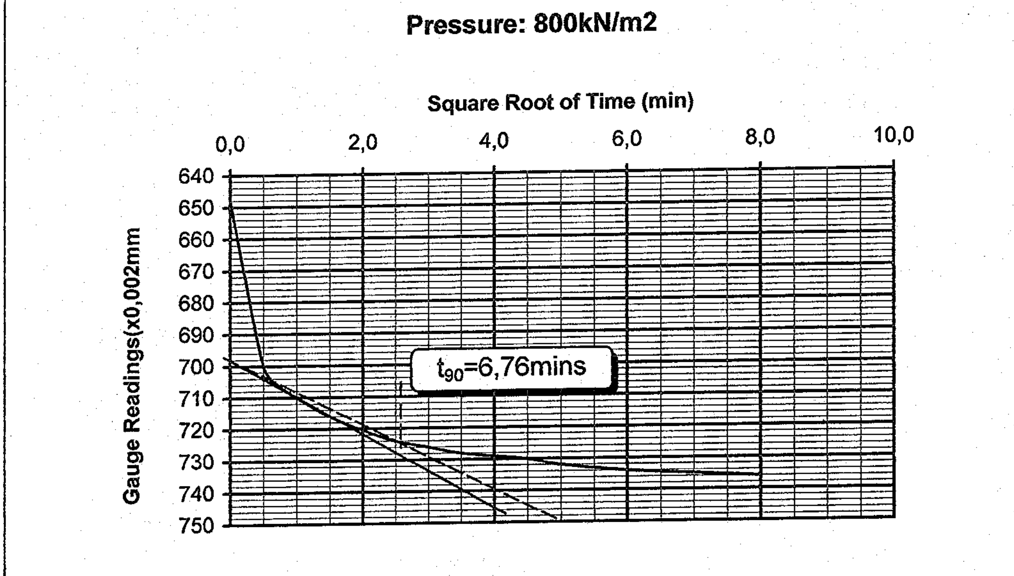


FIG. 45

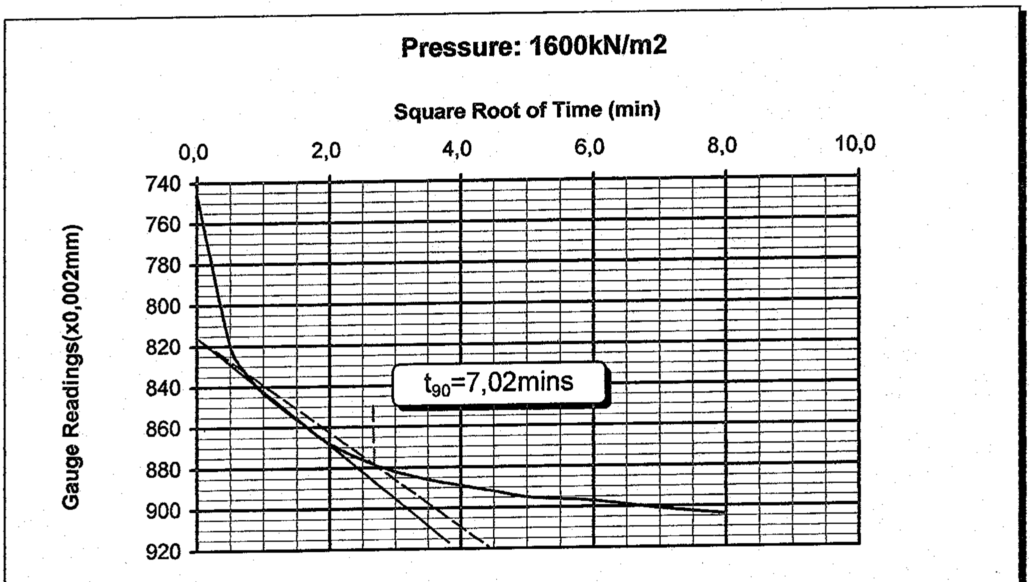


FIG. 46

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

CONSOLIDATION TEST

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL

Date: 20 to 27/1/04
Operator:

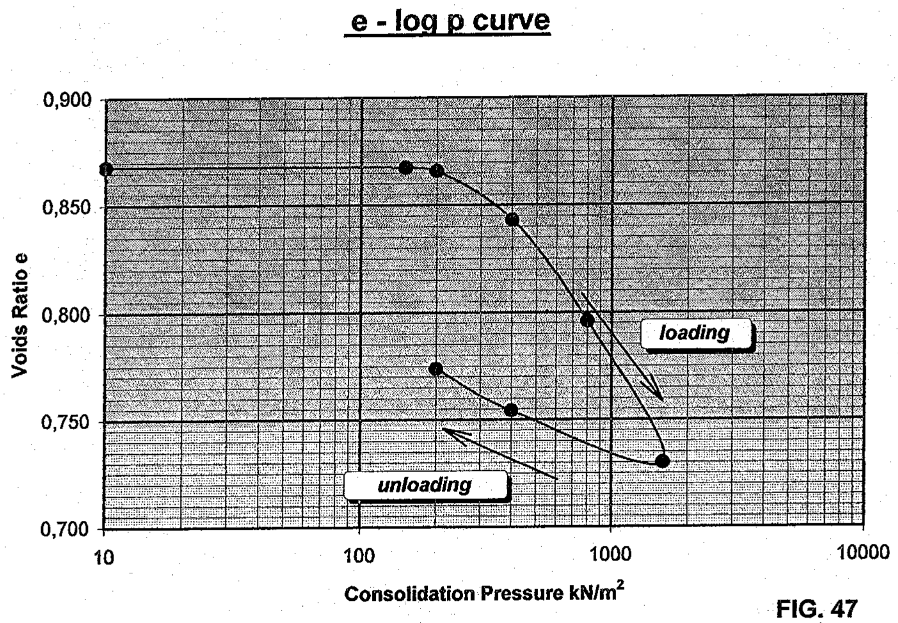


FIG. 47

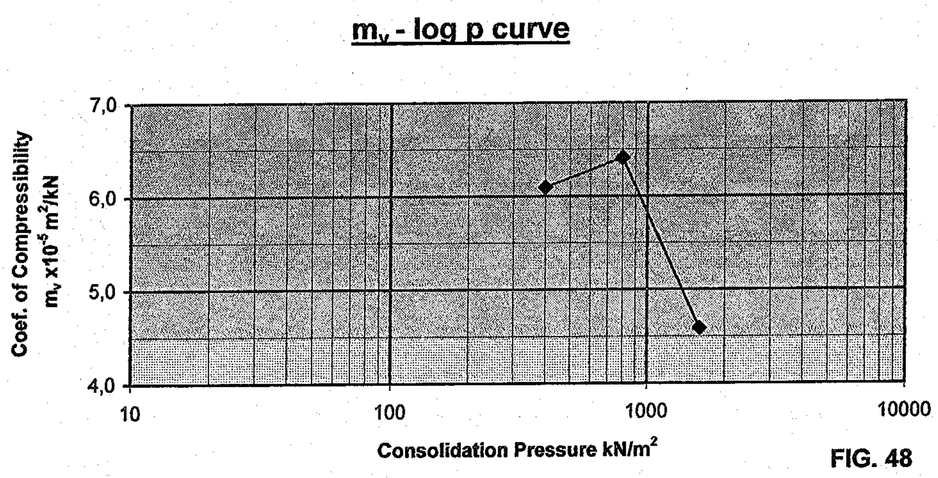


FIG. 48

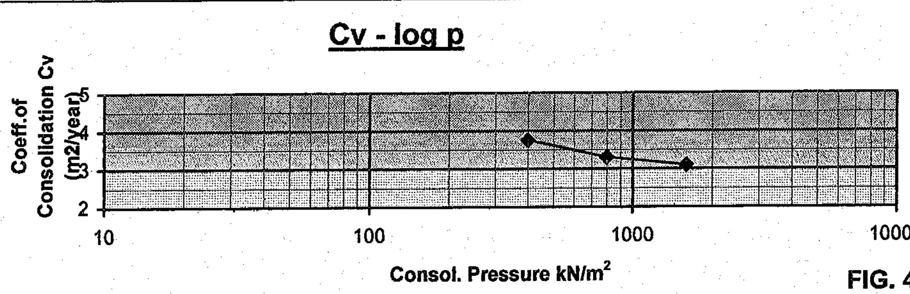


FIG. 49

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel.No.22663191, Fax 22663192

CONSOLIDATION TEST

Consolidation Vs Sq.Root Time Curves

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL

Date: 20 to 27/1/04
Operator:

Pressure: 400kN/m2

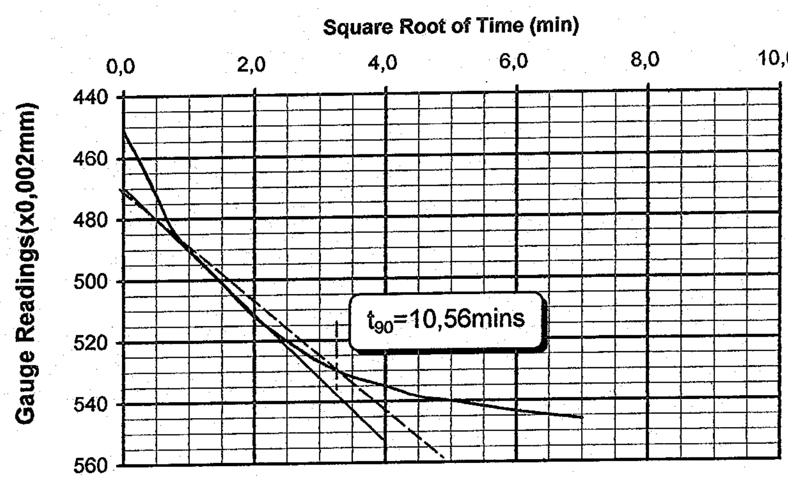


FIG. 50

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel. 22663191, Fax 22663192

CONSOLIDATION TEST

Consolidation Vs Sq.Root Time Curves

Project: University of Cyprus
Site Location: University Campus - Site "4"
Client: University of Cyprus

BH No.: N17
Depth: 10,0-10,45m
Soil: Grey silty MARL

Date: 20 to 27/1/04
Operator:

Pressure: 800kN/m2

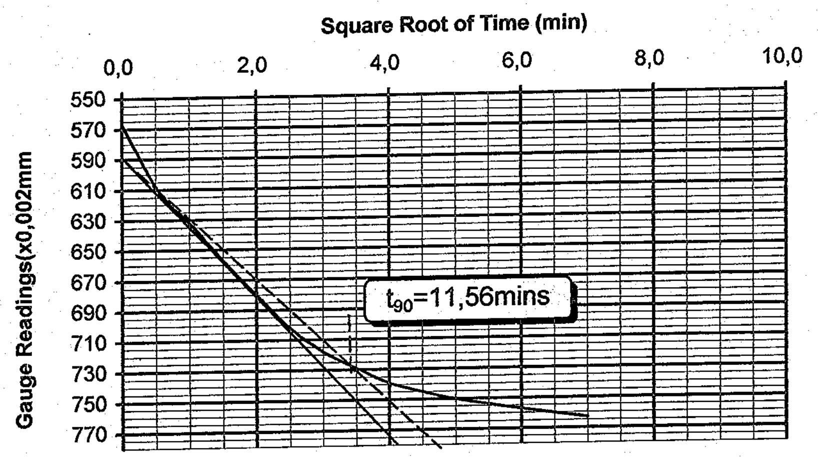


FIG. 51

Pressure: 1600kN/m2

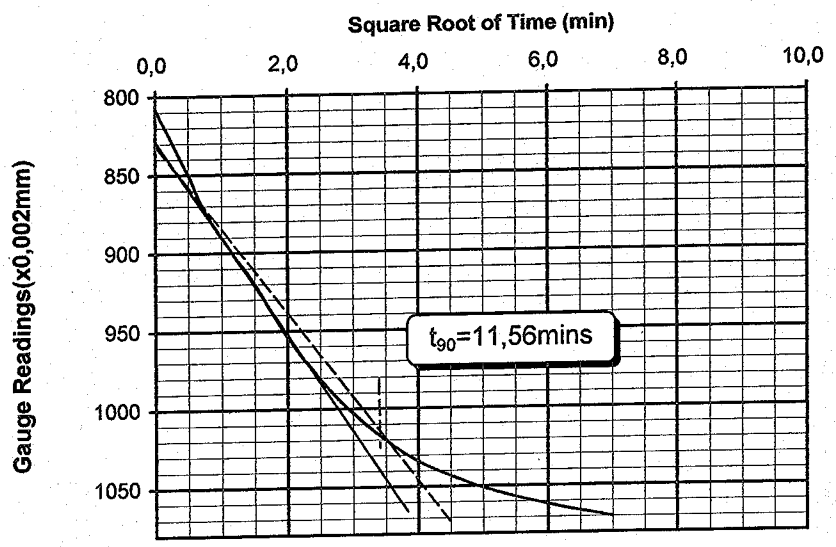
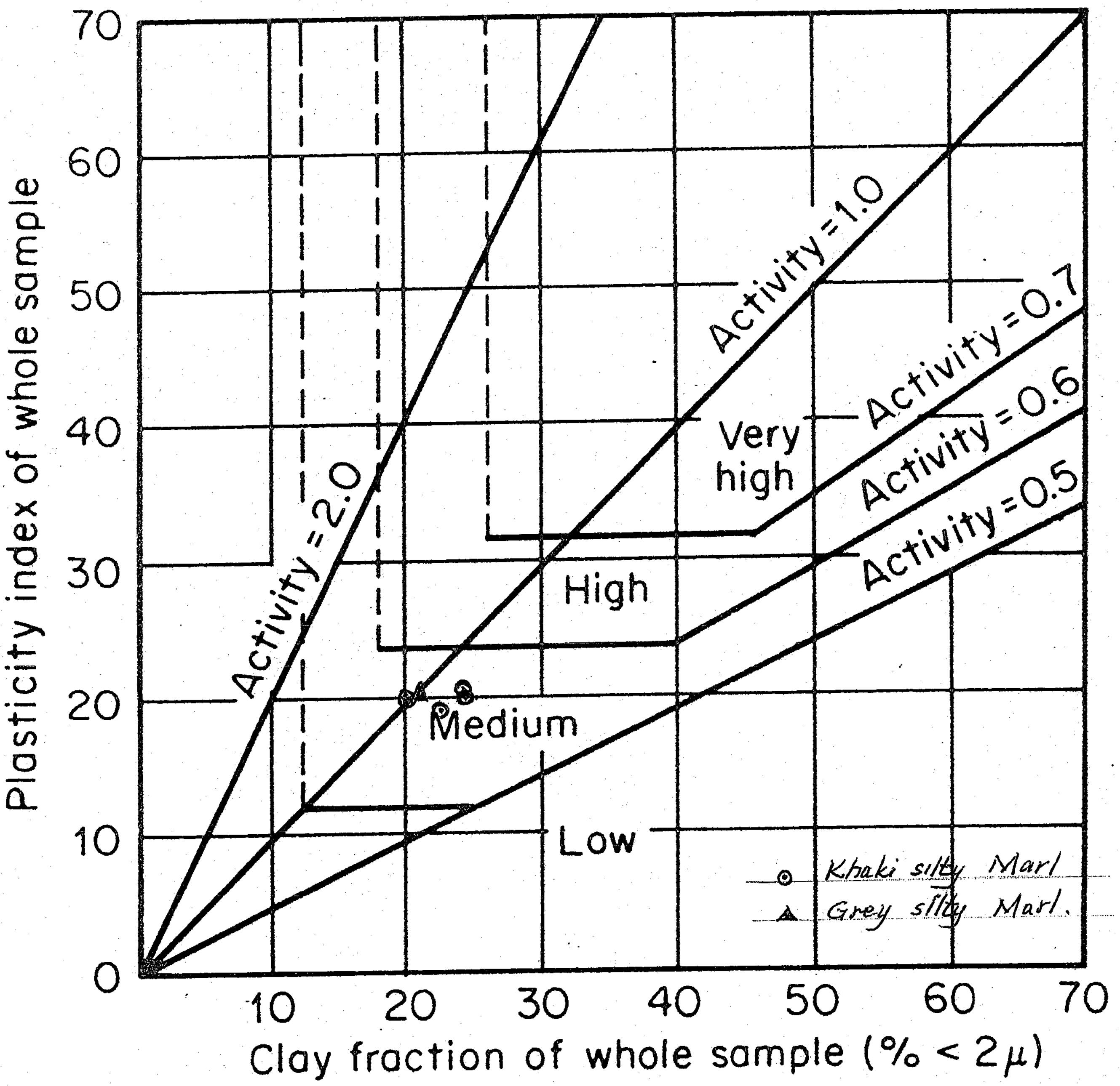


FIG. 52

SH Soil Engineering Ltd
P.O.Box 25457, 1310 Nicosia
Tel 22663191, Fax 22663192



Potential expansiveness	Inch per foot of soil*
Very high	1.0
High	0.5
Medium	0.25
Low	0

*After Van der Merwe (1975).[65b]

FIG. 10.40 Proposed modified chart for determining expansiveness of soils. [*From Williams and Donaldson (1980)*[65a]*; after Van der Merwe (1975)*[65b].]

FIG. 53