CE 468 GEOTECHNICAL DESIGN
DESIGN PROBLEM: MAT FOUNDATION ON COMPRESSIBLE CLAY

An office building shall be constructed in an area where the soil profile consists of approximately 17m thick compressible clay underlied by dense sand and gravel. A hard clay underlies the sand/gravel layer. The soil profile is characterized by borehole No: 8 (attached).

The building is a 18 storey structure, with one basement and 17 floors. The foundation depth is 5m below the existing ground level. The ground water table is at a depth of 5.5m below the existing ground level.

The plan dimensions of the building is 20m * 60m . The building shall be constructed on a one meter thick mat foundation.

The typical laboratory data reflecting the strength and compressibility characteristics of the upper clay including unconsolidated undrained triaxial test and consolidation test results are given in attachments.

You are requested to check the stability of the mat foundation by considering both the bearing capacity and the settlements.

Hints:

- Consider 12.5 kPa uniformly distributed load per floor and the weight of the mat foundation to determine the loads applied to foundation soil.
- Consider immediate settlement of the compressible clay. Use $E_u/s_u = 400$ for the compressible clay.
- Evaluate the consolidation settlements settlements using compression/rebound indicies (C_c and C_r). Devide the compressible layer into 4 sublayers with equal tcicknesses.
- Cconsider the heave of the foundation soil due to foundation excavation.
- Apply Skempton – Bjerrum corrrection factor to oedometer settlement calculations assuming that the raft geometry as approximately strip shape and the pore pressure parameter A = 0.7 .
- Compare your finding with the Stroud 1974 correlations using the SPT data given in the borehole log.
- Permissible settlements for mat foundation could be taken as 8 cm. If computed settlements exceeds the permissible value, suggest alternate solutions to reduce the settlements.

Attachments:

Bore hole log,
Summary of test results
UU Trixial test results,
Consolidation test results,
Coefficients for immediate settlements
Stroud correlations,
Settlement coeffficients,
Skempton bearing capacity factor

Notes:

You may assume that 2V : 1H approximate stress distribution is valid
Saturated and natural unit weights may be assumed as 20 kN/m^3, if not given.

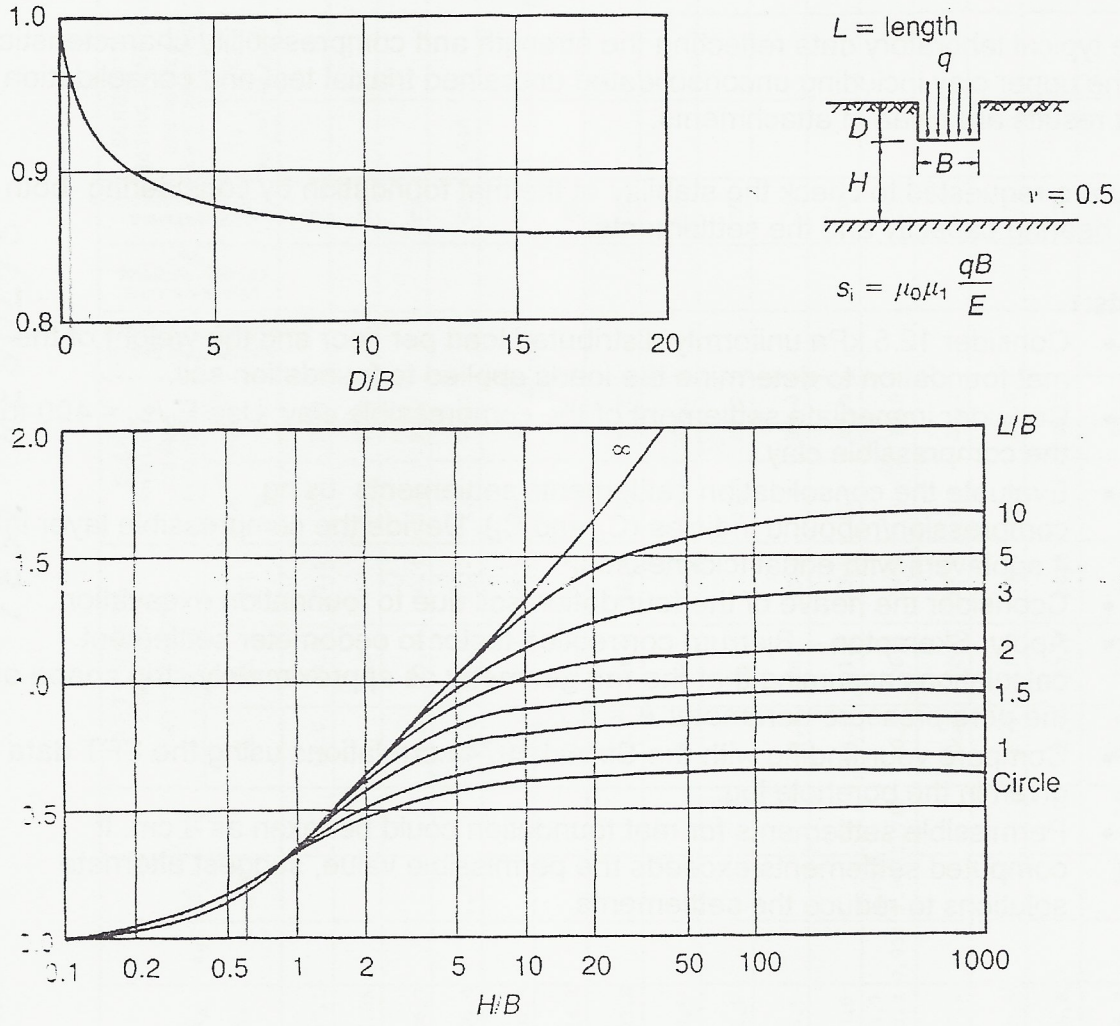

Fig. 5.15 Coefficients for vertical displacement.

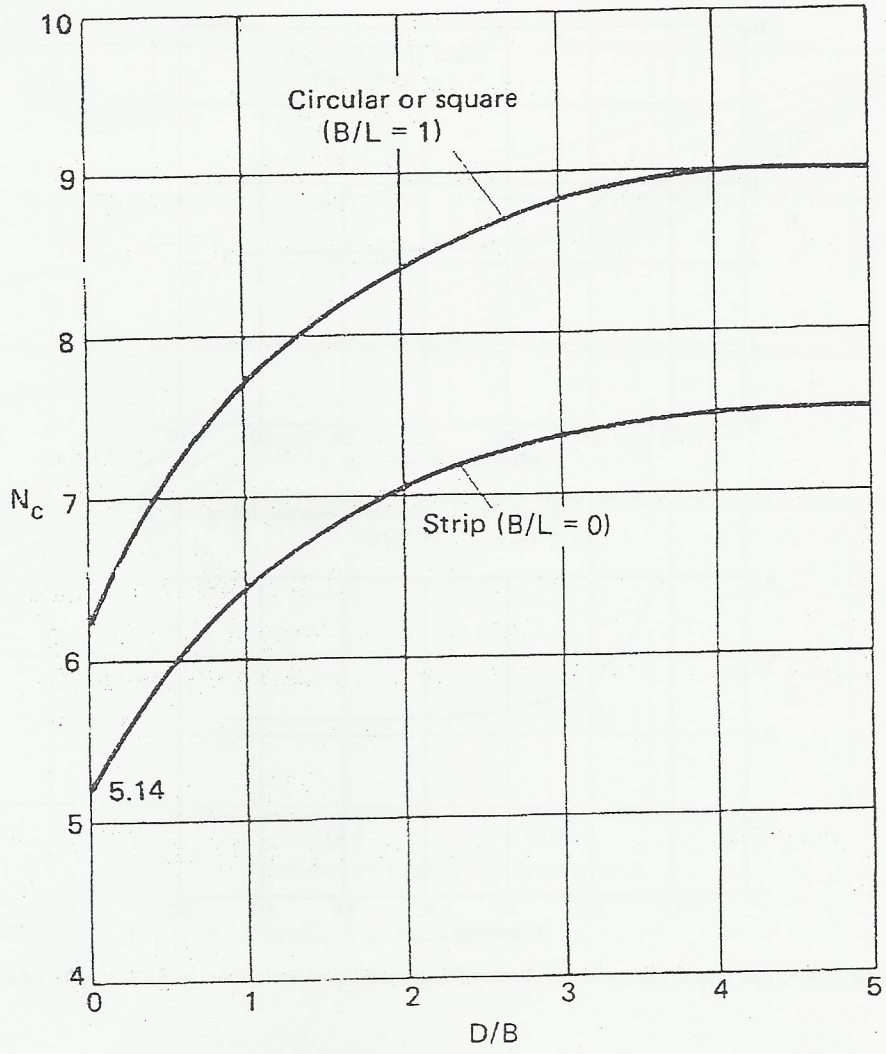

Fig. 8.5 Skempton's values of N_c for $\phi_u = 0$. (Reproduced from A.W. Skempton (1951) *Proceedings of the Building Research Congress*, Division 1, p. 181, by permission of the Building Research Establishment, © Crown copyright.)

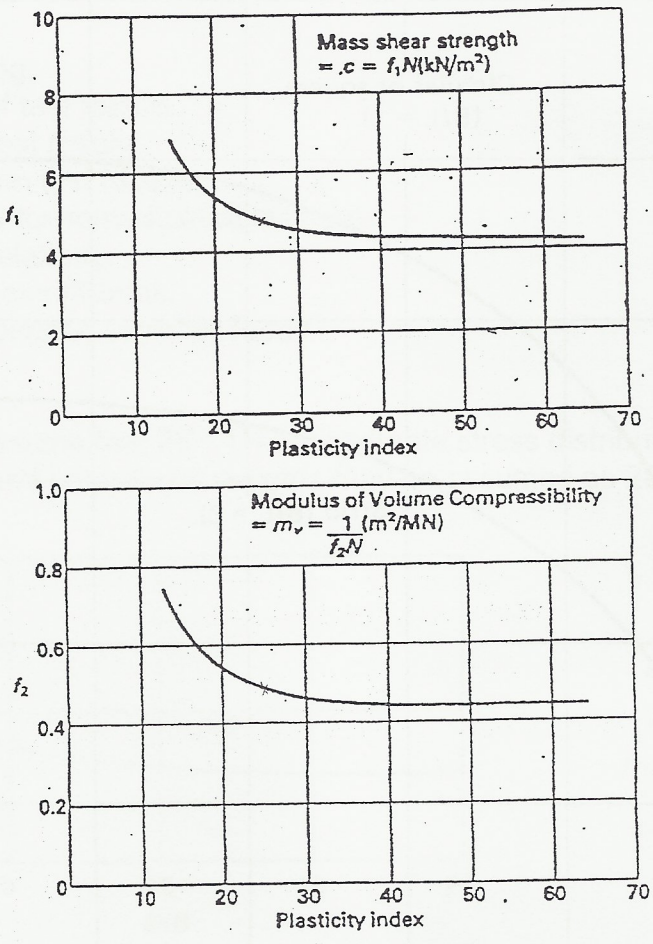

Fig. 1.4 Relationship between mass shear strength, modulus of volume compressibility, plasticity index, and SPT N-values (after Stroud[1.6])

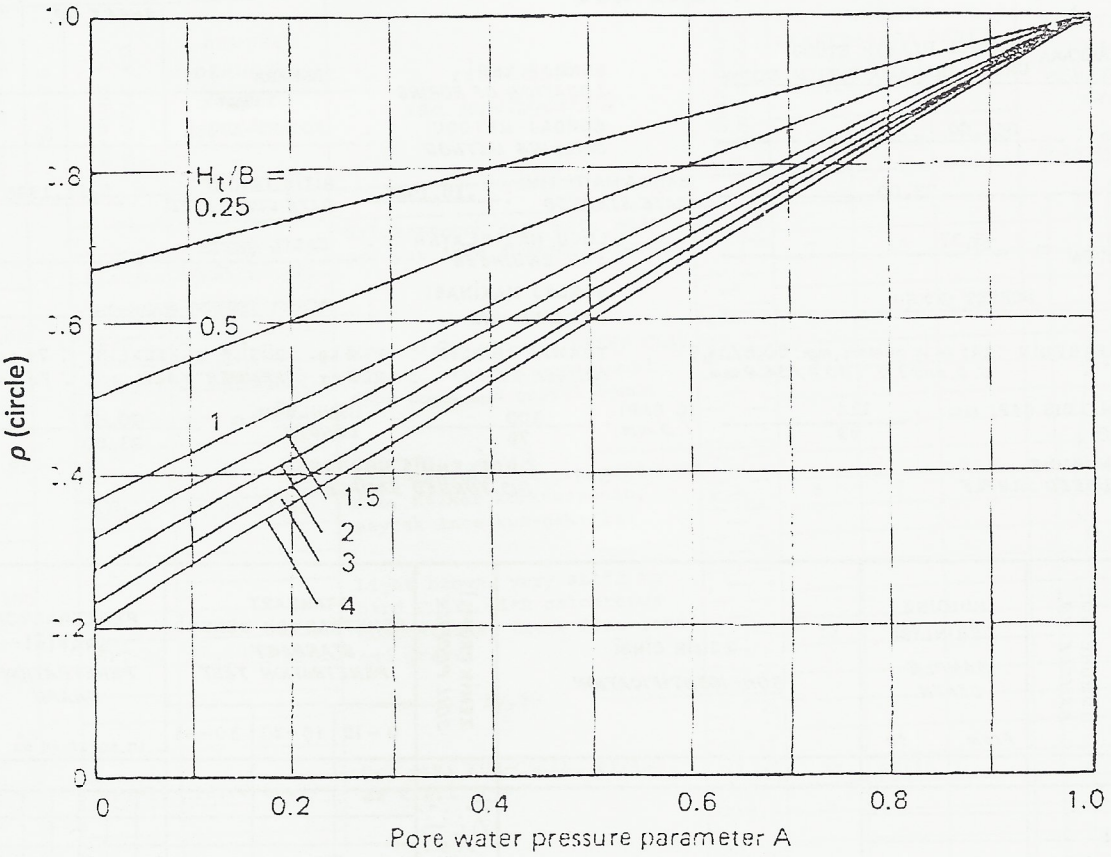

Fig. 6.25 Settlement ratio for circular loading [Eq. (6.45)].

TOKER SONDAJ ve İNŞAAT KOLL. ŞTİ.
DRILLING and CONSTRUCTION CO.

SONDAJ ARAZİ CETVELİ
FIELD LOG

SONDAJ NO. *HOLE NO.* : S-8
SAYFA NO. *SHEET NO.* : 1

PROJE ADI *PROJECT NAME* : ANKARA KENTSEL ULAŞIM ETÜDÜ / URBAN TRANSPORTATION STUDY

SONDAJ KOTU *SURFACE ELEVATION* m. : 844.00

KUYU DERİNLİĞİ *BORING DEPTH.* m. : 25.00

YERALTI SUYU KOTU *GROUND WATER ELEVATION* m. : -5,37

SONDÖR *BORING FOREMAN* : SERVET GÖKSU

STANDART PENETROMETRENİN *SPLIT SAMPLER SIZE* : Dış ve İç çapları, mm: 50,8/34,9 *O.D. and I.D. : 50.8/34.9 mm.*

MUHAFAZA BORUSUNUN *CASING SIZE : O.D. mm.* : DIŞ ÇAPI mm. : 114/89 İÇ ÇAPI *I.D mm* : 100/76 UZUNLUĞU *LENGTH* m : 20.50/23.00

UD : ÖRSELENMEMİŞ NUMUNE *THINWALL UNDISTURBED SAMPLE*

SONDAJ YERİ *LOCATION OF BORING* : ANKARA

SONDAJ METODU *DRILLING METHOD* : ROTARY-AUGER

BAŞLAMA TARİHİ *DATE STARTED* : .10.1986 BİTİŞ TARİHİ *DATE COMPLETED* : 5.11.1986

LOGU HAZIRLAYAN *SOIL ENGINEER* : HALİL ÇETİN

SONDAJ MAKİNASI *DRILLING RIG* : ACKER TEREDO MARK II

TOKMAK AĞIRLIĞI *HAMMER WEIGHT* : 63.5 kg. / 63.5 kg. DÜŞÜŞ YÜKSEKLİĞİ *HAMMER FALL* : 75 cm. / 75 cm.

SPT : ÖRSELENMİŞ NUMUNE *DISTURBED SAMPLE*

DERİNLİK *DEPTH.* m.	KAROT VE % si *CORE % RECOVERY*	% RQD	NUMUNE NO. *SAMPLE NO.*	NUMUNE DERİNLİĞİ *SAMPLE DEPTH.* From to	ZEMİN CİNSİ *SOIL IDENTIFICATION*	ZEMİN PROFİLİ *SOIL PROFILE*	STANDART PENETRASYON DENEYİ *STANDART PENETRATION TEST* 0-15 / 15-30 / 30-45	PENETRASYON GRAFİĞİ *PENETRATION GRAPH* 10 20 30 40 50
0								
					DOLGU MALZEME (İnce kum, siltli, killi, beton-tuğla kırıntıları)			
1,5			SPT-1	1.50-1.95			6 / 8 / 7	
	80							
3,0			UD-1	3.00-3.30	FILL MATERIAL (Fine sand, silt, clay with concrete and brick pieces)		A / A / A	
			SPT-2	3.30-3.75				
	31							
4,5			Vane-1		4.90			
			SPT-3	4.70-5.15	Kahverenkli, sert KİL, seyrek ince kum-çakıllı, az siltli		5 / 6 / 8	
	38				Brown, stiff CLAY, little silt, trace fine sand and gravel			
6,0			UD-2	6.00-6.50				
			SPT-4	6.50-6.95			3 / 5 / 8	
					6.90			
	73				Gri, sert-çok sert KİL, siltli, yer yer ince kum-çakıl bantlı			
7,5			SPT-5	7.50-7.95			4 / 6 / 6	
	100							
9,0			Vane-2					
			UD-3	9.20-9.50	Gray, stiff to very stiff CLAY some silt, with occasional fine sand and gravel bands			
			SPT-6	10.00-10.45			2 / 4 / 5	
10,5	100							
12,0			Vane-3					

SONDAJ ve İNŞAAT KOLL. ŞTİ.
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SONDAJ NO. / HOLE NO. : S-8

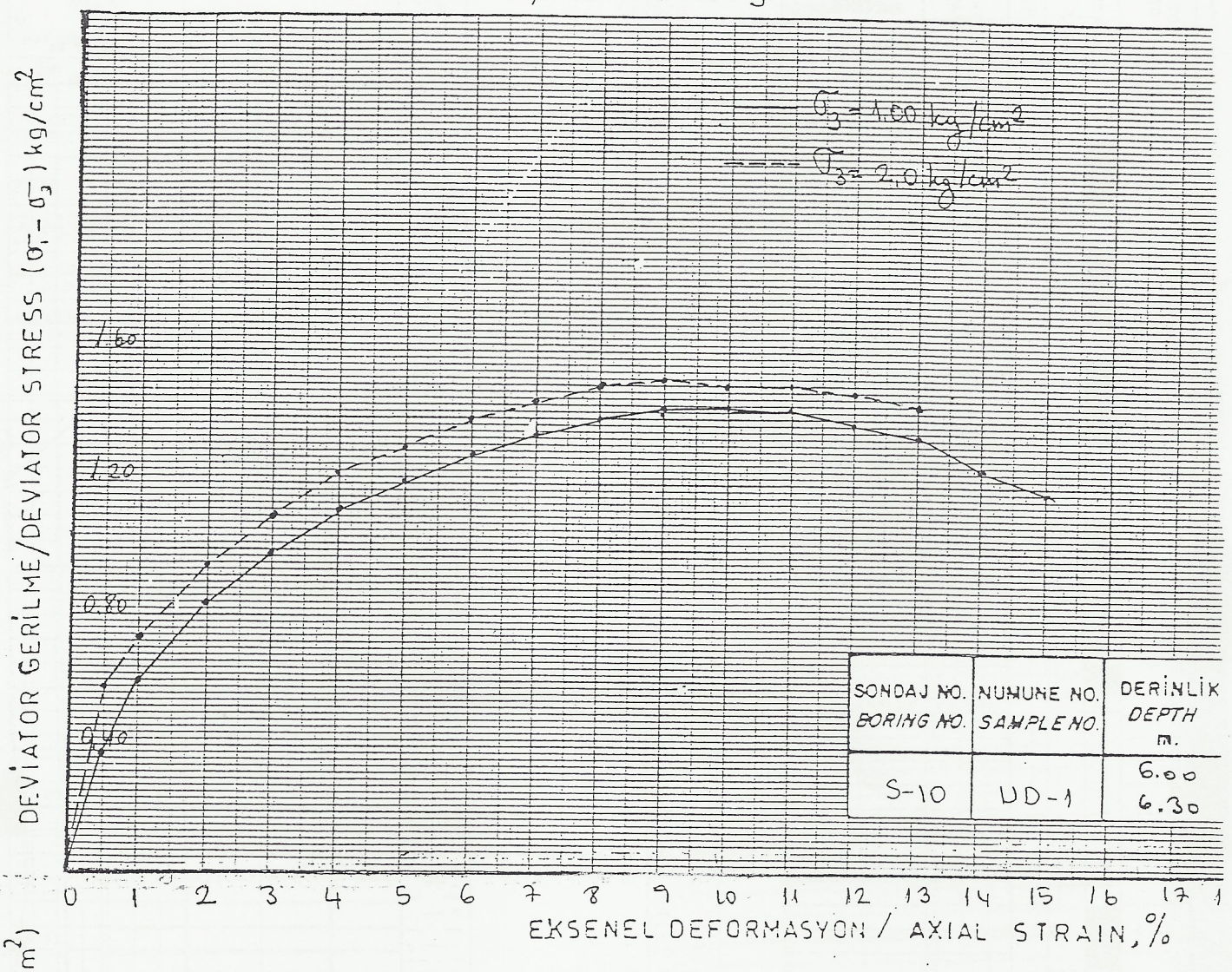
SAYFA NO. / SHEET NO. : 2

DERİNLİK DEPTH m.	KAROT VE % si CORE % RECOVERY	% ROD	NUMUNE NO. SAMPLE NO.	NUMUNE DERİNLİĞİ SAMPLE DEPTH. From / To	ZEMİN CİNSİ SOIL IDENTIFICATION	ZEMİN PROFİLİ SOIL PROFILE	STANDART PENETRASYON DENEYİ STANDART PENETRATION TEST 0-15	15-30	30-45	PENETRASYON GRAFİĞİ PENETRATION GRAPH 10 20 30 40 50
12.0										
			SPT-7	12,20-12,65	Gri, sert-çok sert KİL, siltli, yer yer ince kum-çakıl bantlı		7	10	14	
	100									
13.5			SPT-8	13,50-13,95	Gray, stiff to very stiff CLAY, some silt, with occasional fine sand and gravel bands		4	9	12	
	95									
					14,65					
15.0			SPT-9	15,00-15,45	Açık kahverenkli, çok sert-katı KİL, kalker konkresyonlu, seyrek ince kum-çakıllı		6	7	8	
	100				Light brown, very stiff to hard CLAY, with calcareous concretions, trace fine sand and gravel					
16.5			SPT-10	16,50-16,95			17	35	40	
					17,30					
	57									
18.0			SPT-11	18,00-18,20	Çok sıkı KUM-ÇAKIL, siltli, az killi		37	50/10		
	26									
19.5			SPT-12	19,50-19,76	Very dense SAND and GRAVEL, little silt and clay		48	50/11		
					21,10					
21.0										
	0				Kahverenkli, katı ÇAKILLI KİL kalker konkresyonlu, siltli					
			SPT-13	21,50-21,95			20	28	35	
22.5	77									
			SPT-14	23,00-23,45	Brown, hard GRAVELY CLAY, with calcareous concretions some silt		22	32	45	
24.0	91									
			SPT-15	24,50-24,95			14	16	17	
					25,00					
25.5					Kuyu Sonu					
					End of Boring					
27.0										
28.5										
30.0										

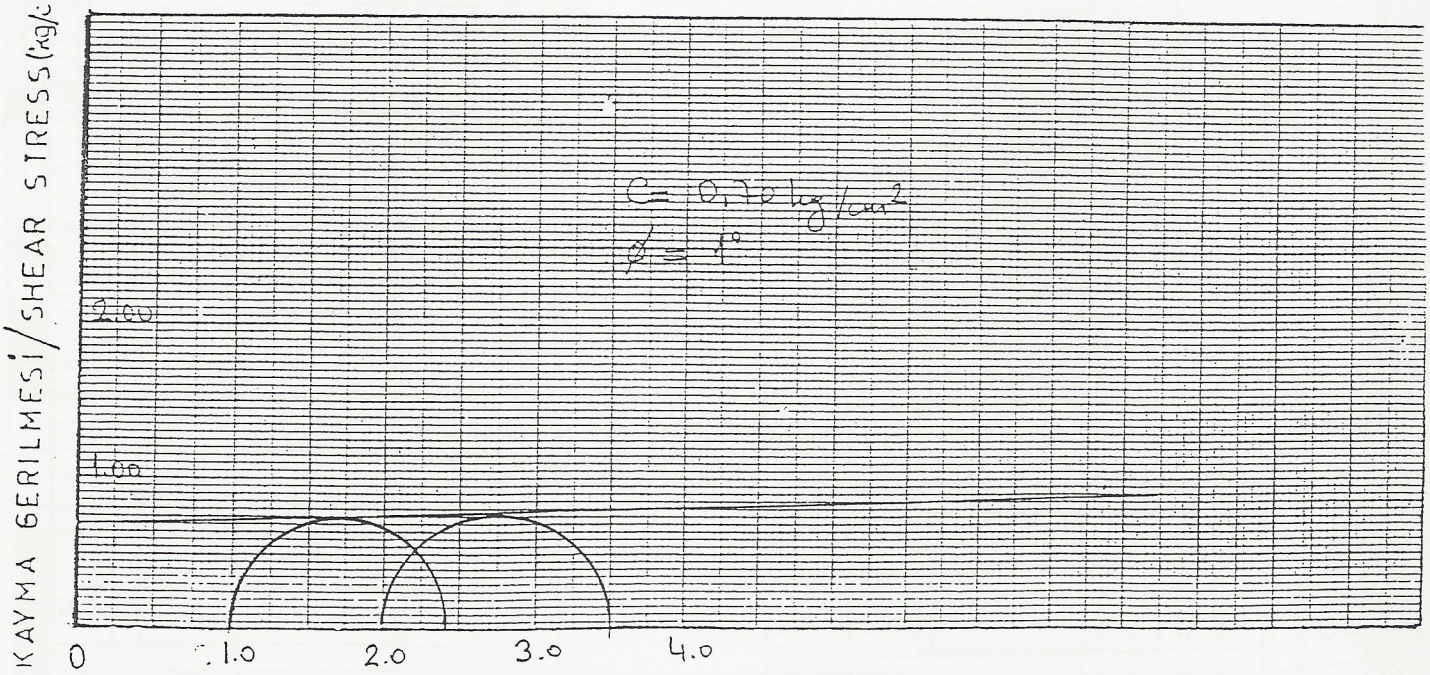
ZEMİN MEKANİĞİ LABORATUVARI
SOIL MECHANICS LABORATORY

TRIAXIAL COMPRESSION TEST
ÜÇ EKSENLİ BASINÇ DENEYİ

Proje/Project: KENTSEL ULAŞIM ETÜDÜ
Urban Transportation Study.



SONDAJ NO. *BORING NO.*	NUMUNE NO. *SAMPLE NO.*	DERİNLİK *DEPTH* m.
S-10	UD-1	6.00 6.30



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ZEMİN MEKANİĞİ LABORATUVARI
SOIL MECHANICS LABORATORY

CONSOLIDATION TEST
KONSOLİDASYON DENEYİ

Tatbik edilen basınç p (kg /cm^2)
Applied Pressure

0.1 0.25 0.5 1.0 2.0 4.0 8.0 16.0 40 80

PROJE . KENTSEL ULAŞIM ETÜDÜ
PROJECT : Urban Transportation Study

SONDAJ NO. *BORING NO.*	NUMUNE NO. *SAMPLE NO.*	DERİNLİK *DEPTH* m.
S-14	UD-2	6.00 6.30

Boşluk oranı (e)
Void Ratio

0.850
0.750
0.650
0.550

$e_o = 0,848$

Deney Öncesi : $w_n = 23,4\ \%$
Before Test $S = 73,4\ \%$
$\gamma_n = 1.79\ t/m^3$

Basınç Pressure	0.25	0.50	1.0	2.0	4.0	8.0	16	kg/cm^2
m_v 10^{-2}	3,679	3,495	3,085	2.574	1.608	0.964	0.509	cm^2/kg
C_v t_{90} 10^{-3}	8.50	6.26	6.15	5.96	5,65	3.53	3.27	cm^2/sn
C_v 10								cm^2/sn

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SOIL MECHANICS LABORATORY

DENEY SONUÇLARI
TEST RESULTS

PROJE
PROJECT : ANKARA KENTSEL ULAŞIM ETÜDÜ
URBAN TRANSPORTATION STUDY

NUMUNE *SAMPLE*			W_n	e_n	γ_n	γ_s	ATTERBERG LİMİTLERİ *ATTERBERG LIMITS*			ELEK ANALİZİ *SIEVE ANALYSIS*		HİDROMETRİK ANALİZ *HYDROMETER ANALYSIS*	ORGANİK MADDE *ORGANIC MATERIAL*	SINIFLANDIRMA *SOIL CLASSIFICATION*	SERBEST BASINÇ DENEYİ *UNCONFINED COMPRESSION TEST*		ÜÇ EKSENLİ BASINÇ DENEYİ *TRIAXIAL COMPRESSION TEST*		KESME KUTUSU DENEYİ *DIRECT SHEAR TEST*		KONSOLİDASYON DENEYİ *CONSOLIDATION TEST*		
SONDAJ NO. *BORING NO.*	NUMUNE NO. *SAMPLE NO.*	DERİNLİK *DEPTH* m.	%		t/m³		LL	PL	PI	+4# %	-200# %				q_u kg/cm²	q_r kg/cm²	C kg/cm²	Ø Derece *Degree*	C kg/cm²	Ø Derece *Degree*	Şişme Basıncı *Swelling Pressure* kg/cm²	Şişme *Swelling* %	✓
S-7	SPT-11	16.50 16.95	37.1				55.0	22.7	32.3	0	97.4			CH									
S-7	SPT-12	18.00 18.45	1.85					N.P		53.1	16.5			GC									
S-7	SPT-15	22.50 22.95	26.7				54.2	23.8	30.4	0.1	75.1			CH									
S-8	UD-1	3.00 3.30	26.4		1.925		57.9	25.9	32.0	1.2	79.9			CH	2.630								
S-8	SPT-5	7.50 7.95	32.4				48.7	18.6	30.1	0	91.0			CI									
S-8	SPT-6	10.00 10.45	34.1				40.4	22.4	18.0	8.0	80.6			CL									
S-8	SPT-8	13.50 13.95	23.8				39.7	23.0	16.7	0	79.7			CL									
S-8	SPT-10	16.50 16.95	15.5				25.7	15.1	10.6	19.6	47.3			SC									
S-8	SPT-12	19.50 19.95	12.5					N.P		33.8	17.2			SC									
S-8	SPT-14	23.00 23.45	26.9				48.9	25.1	23.8	0	79.0			CL									
S-9	UD-1	3.00 3.40	27.6				54.8	21.8	33.0	0.4	87.9			CH									
S-9	UD-2	6.00 6.50	30.9 29.3	0.953	1.820 1.950	2.740	40.0	20.2	19.8	0	98.0			CL			0.80	4					✓
S-10	SPT-1	1.50 1.95	27.4				39.0	22.0	17.0	5.8	61.2			CL									
S-10	SPT-2	3.00 3.45	23.5				29.0	19.5	9.5	0.4	60.0			CL									
S-10	SPT-3	4.70 5.15	35.6				47.7	23.5	24.2	0	98.2			CL									
S-10	UD-1	6.00 6.30	36.3		1.860	2.740	53.9	18.8	35.1	0	99.2	✓		CH			0.70	1					
S-10	SPT-5	7.70 8.15	30.6				54.5	25.3	29.2	0	98.4			CH									
S-10	UD-2	9.00 9.40	31.4		1.950		57.1	21.9	35.2	0	97.4			CH	1.09								