











Geotechnical Calculations for Medieval Chapel

		St	ructural [Details an	d Loading	S			
В	W	Building Wid	th		9.00	m			
В	3L	Building Leng	gth		10.00	m	<u> </u>		
В	n	Number of FI	oor		1				
В	H	Floor Hight			4.00	m			
F	W	Foundation V	Vidth		10.00	m			
F	L	Foundation L	ength.		12.00	m			
F	T	Foundation T	hickness		0.50	m			
F	D	Foundation D	Depth		0.50	m			
C	BH	Connection E	Beams High	t	0.50	m			
γ	С	Unit Volume	Weight of F	R/Conc.	2.50	Ton/m³	(TS498)		
X	G	Structural De	ad Load		0.25	Ton/m²	(TS498)		
X	Q	Structural Liv	e Load		0.50	Ton/m²	(TS498)		
fg	9	Dead Load Coefficient			1.4				
fe	fq Live Load Coefficient			1.6					
_	A				90.00	m²	(BW*BL)		
-	ST	Av. Floor Thickness			0.33	m	(Columns,Beams,Slabs)		
V	VBs	Building Wei	ght		73.13	Ton	(Bn*γC*BA*BST)		
Ļ.				,	00.50	-	ļ		
_	Vd	Total Building		d	22.50	Ton 	(Bn)*XG*BA		
_	VG	Total Building			95.63	Ton 	(WBs+Wd)		
_	VQ .	Total Building	~		90.00	Ton	(Bn+1)*XQ*B/	Ą	
G	j	Design Build			133.88	Ton	(fg*WG)		
C		Design Build		ad	144.00	Ton	(fq*WQ)		
F		Foundation L			240.00	Ton	(Con. Beams+Fill Weight)		
V		Total Design			517.88	Ton	(G+Q+F)		
O		Average Fou	undation St	ress	4.32	Ton/m ²	(V/Area of Fou	undation)	
		(Corrected	SPT-(N1	l)60 Table				
C	epth (m)	Field SPT- N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60	
	9.50	23	0.95	126.45	0.87	45	16.4	14.3	
	12.50	50	1.00	154.92	0.79	45	37.5	29.5	
1	14 00	50	1 00	169 16	0.75	45	37.5	28.2	

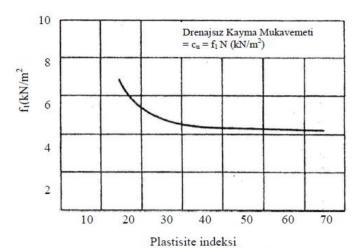
Borehole No	Depth (m)	Field SPT- N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
	9.50	23	0.95	126.45	0.87	45	16.4	14.3
EB-1	12.50	50	1.00	154.92	0.79	45	37.5	29.5
LD-1	14.00	50	1.00	169.16	0.75	45	37.5	28.2
	16.00	50	1.00	188.14	0.71	45	37.5	26.8
Groundwater Level = 3.70 m Av. Nat. Unit Weight = 19.30 KN/m³								
	3.00	50	0.75	60.72	1.26	45	28.1	35.3
EB-2	4.50	50	0.85	84.21	1.07	45	31.9	34.0
LD-2	14.00	50	1.00	183.30	0.72	45	37.5	27.1
	16.00	50	1.00	204.16	0.68	45	37.5	25.7
Groundwater Level = 3.80 m Av. Nat. Unit Weight = 20.24 KN/m³								
	1.50	30	0.75	30.02	1.79	45	16.9	30.1
EB-3	3.00	34	0.75	60.03	1.26	45	19.1	24.2
	9.00	44	0.95	158.51	0.78	45	31.4	24.4
,	Groundy	vater Level =	6.80	m	Av. Nat. Unit	Weight =	20.01	KN/m³

Average SPT-N =	43.1	Average (N1)60 =	27.1	
* USCS	\rightarrow SM - ML - CH	Soils Plmax =	25.40	
* Uniaxial Pressure Test;	→ Undrained She	ear Strength =	45.86	KN/m²
	(For Sandy-Silty	CLAY Layer)		
* USCS	→ MH Soils PI	max =	23.70	
* Triaxial Compression Test;	→ Cohession =		36.87	KN/m²
	→ Internal Angle	of Friction =	5.7	degree
	(For MARL Laye	r)		

$$c_u = f_1 * N k N / m^2$$
;

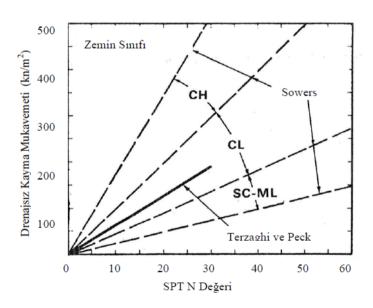
f₁: zemin plastisite endisine bağlı katsayı,

N: zeminin SPT direnci, darbe/30cm



Standart Penetrasyon N Değeri ve Drenajsız Kayma Mukavemeti İlişkisi (Stroud 1974)

* Stroud (1974) Graph; C' = f1 * N (KN/m²) For N = 27.1 and PI = 25.4; f1 = $4.5 \rightarrow Cu =$



SPT N Değeri ile Drenajsız Kayma Mukavemeti İlişkisi (Terzaghi ve Peck, 1967, ve Sowers, 1979)

* Sowers (1978) Graph;

For N = 27.1 and "SM-ML-CH Soils"; \rightarrow Cu =

110.00

122.14

Soil Parameters Table for Sandy-Silty CLAY Layer

G.S.	Factor of Safety	3	
Cu	Cohesion	4.67	Ton/m²
Φ'	Angle of Internal Friction	0.0	Derece
γ	Natural Unit Volume Weight	2.02	Ton/m³
Es	Modulus of Elasticity	-	Ton/m²
ν	Poisson Ratio	0.30	
WL	Groundwater Level	3.70	m

1a) Soil Bearing Capacity Calculation for Sandy-Silty CLAY Layer:

Hansen Equation (q_f= $c^*N_c^*S_c^*F_{cd} + \gamma'_s^*D_f^*N_q^*S_q^*F_{qd} + \frac{1}{2}\gamma'_s^*B^*N_v^*S_v^*F_{vd}$)

Bearing Capacity Factors:

Depth Factors:

Nc	=
Nq	=
Νγ	=

5.14
1.00
0.00

Sγ=

Effective Stress beneath Foundation:

Rearing Canacity of -

bearing capacity,	4ı –
Allowable Bearing	capacity of CLAY =

28.37
9.46

Ton/m²

Safe...

Soil Parameters Table for MARL Layer

G.S.	Factor of Safety	3	
Cu	Cohesion	3.76	Ton/m²
Φ'	Angle of Internal Friction	5.7	Derece
γ	Natural Unit Volume Weight	2.02	Ton/m³
Es	Modulus of Elasticity	-	Ton/m²
ν	Poisson Ratio	0.30	
WL	Groundwater Level	3.70	m

1b) Soil Bearing Capacity Calculation for MARL Layer:

Hansen Equation (q_f= $c^*N_c^*S_c^*F_{cd} + \gamma'_s^*D_f^*N_q^*S_q^*F_{qd} + \frac{1}{2}\gamma'_s^*B^*N_\gamma^*S_\gamma^*F_{\gamma d}$)

Bearing Capacity Factors:

Depth Factors:

Nc	=
Nq	=

Ny =

6.71
1.67
0.53

Fyd =

Safe...

Effective Stress beneath Foundation:

Ton/m²

ре	arıng	Capac	ity, qi	=			
ΑII	owab	le Bea	rina ca	apacity	of M	IARL	=

30.44
10.15

1c) Rock Bearing Capacity Calculation for SAND STONE Layer:

$$q_{ult}$$
 (Nihai taşıma gücü) = $\sigma_{ci} \left[\sqrt{s} + (m\sqrt{s} + s)^a \right]$

(Hoek-Brown Yield Criteria)

Assumed **GSI** value;

Assumed "mi" value; Assumed "D" value;

$$m_b = m_i \exp\left(\frac{GSI - 100}{28 - 14D}\right)$$

$$s = \exp\left(\frac{GSI - 100}{9 - 3D}\right)$$

$$a = \frac{1}{2} + \frac{1}{6} \left(e^{-GSI/15} - e^{-20/3} \right)$$

$\sigma ci = 12*I_{s(50)}$

		Point Load Bearing In	idex Table	
Location	Sample	Min. I _{s(50)}	Avr. I _{s(50)}	Max. I _{s(50)}
Location	Number	(kg/cm²)	(kg/cm²)	(kg/cm²)
EB-1	6	19.20	27.54	38.29
EB-2	2	10.41	15.15	19.90
EB-3	5	15.03	21.42	25.83

Average Min. Point Load Bearing Index =
Average Halfway Point Load Bearing Index =
Average Max. Point Load Bearing Index =

14.88	kg/cm²
21.37	kg/cm²
28.01	kg/cm²

Min. σ ci = 178.55 kg/cm² Avr. σ ci = 256.46 kg/cm²

Max. $\sigma ci = 336.07$ kg/cm² is expected.

According to above values; Min. Ultimate Bearing Capacity (qu_{min}) = 10.42 kg/cm²

Avr. Ultimate Bearing Capacity (qu_{avr.}) = 14.97 kg/cm²

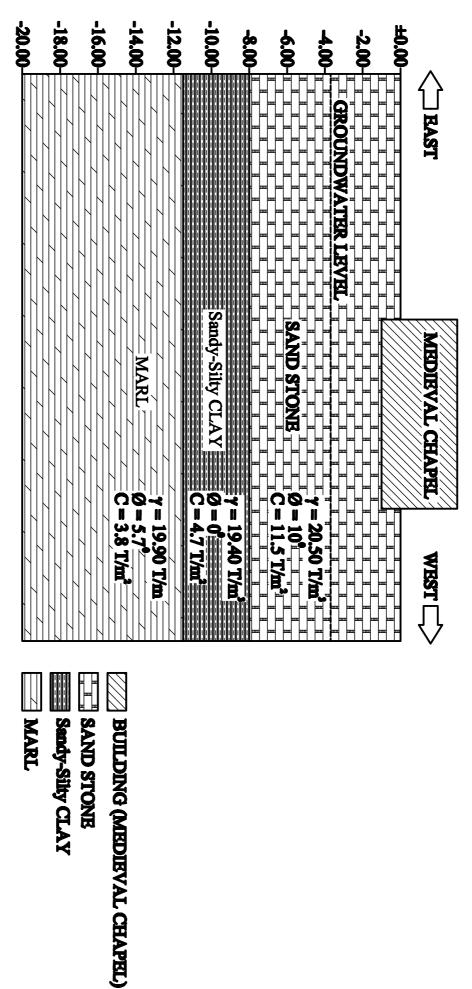
Max. Ultimate Bearing Capacity $(qu_{max}) = 19.62 \text{ kg/cm}^2$

In conservative case, Allowable Bearing capacity of SAND STONE =
In halfway case, Allowable Bearing capacity of SAND STONE =
In optimist case, Allowable Bearing capacity of SAND STONE =

3.47 kg/cm² 4.99 kg/cm² 6.54 kg/cm²

Regarding to use safe data, the values that is obtained above is assessed by Simpson Average method. (weightly conservative case value is used)

Osf = 4.24 kg/cm² → 42.38 Ton/m² (Allowable Bearing capacity of SAND STONE)



IDEALISED SOIL PROFILE SCALE: 1/200

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Figure 1. General view of the study area



Figure 2. Field work for EB-3 and SB-3 Boreholes.



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Figure 3. Field work for EB-2, SB-2, EB-1 and SB-1 Boreholes.



Figure 4. Borehole logging of SB-3



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Figure 5. Borehole logging of EB-3



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Figure 6. General view of the study area (SB-1, EB-1, SB-2 and EB-2 Boreholes).



Figure 7. Borehole logging of SB-1

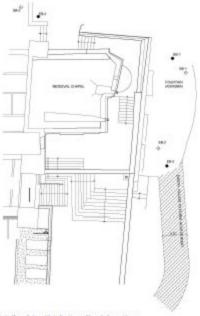


Figure 1: Plan of site with indications of borehole positions

	F(7	וי	7 (Qr	Г	F	3O]	REHOLE		BOREH(OLE	=	EE	3-1
U				<u>'</u>) .	ı			LOG		PAGI NO	Ε		1/	/2
PROJEC	T			APO	STOL	OS AN	IDREAS MONA	STERY	BORING METHOD		Rotary	CC	re	drill	ing
BOREHO	OLE LO	CATIO	N	Kar	pasi	а			DATE COMMENCED	ı	13.05.	20 <i>′</i>	15		
GROUN	D LEVE	EL		0,3	0 m				DATE COMPLETED		13.05.	201	15		
BOREHO	OLE DE	PTH		20.	00 m	1			GROUNDWATER LE	VEL	3.70 m	1			
COORD	INATES	5	X	642	2656										
		_	Y	394	1748	2									
	le l		ST	AND	ART	PEN	ETRATION T	TEST						Д	%
(m)	Tab	Sa			of Blo		Graph		GEOTECHNICAL	LE	CEND		ρū	ndex/	very
Depth (m)	Water Table	Samples	0-15 cm	15-30 cm		N	10 20 30 4	0 50	DESCRIPTION	LE	GEND	Strength	Weathering	Fracture Index/m	Core Recovery % RQD %
				100.00			10 20 30 4	30	Concrete (0.00-1.00 m)		30()0()0()0()				
1.00 - 2.00 - 3.00 - 4.00 - 5.00 - 6.00 - 7.00 -		С							Yellowish cream, Moderately strong, Slightly weathered SANDSTONE (1.00-8.80m)			III	11		27 23 24 16 15
9.00		SPT 9.50	13	11	12	23			Yellowish, dark grey, Medium dense SAND						
10.00- 11.00- 12.00- 13.00-		1 9.95m C SPT12.50 2 12.80m UD 13.20 1 13.50m	25	32	50/15				Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weathered			П	Ш		
STRENG	ΓΗ (Rocks	s)		WEA	THER	ING	1	FINE GR		COARS	SE GRAINE				
II Weak III Mode IV Strong V Very	I Very weak (1-5 MPa) I Fresh II Weak (5-25 MPa) II Slightly we III Moderately strong (25-50 MPa) III Moderately IV Strong (50-100 MPa) IV Highly wea V Very strong (100-250 MPa) V Completely						hered Meathered Mered Mered Meathered Mered Mered Mered Meathered Mered	N=0-2 N=3-5 N=6-9 N=10-16 N=17-30 N >30	Soft Firm Stiff Very stiff Hard	N=0-4 N=4-10 N=10-3 N=30-5 N>50	0 Mediu	m de	ense		
0-25 % 25-50 %	Very poor Poor	ation (RQE))	<1 1-2 2-10	Wic Mo Clo	derate	W II M CI CI	N : Sta D : Dis UD : Uno C : Cor	ndart penetration test ndart penetration resistance turbed sample disturbed sample re sample ay diffraction sample						
75-90 %	50-75 % Fair 2-10 Close 75-90 % Good 10-20 Intens						1	100	ngineers : Naim KORKMAZCA Samiye İNCE	N	Signatur	e:			



C	E(77	וין	F (Qr	Г		BC	REHOL	E	BOREH NO	OLI	E	E	3-1	ı
U			•		.				LOG		PAG NO			2	/2	
PROJEC	eT .			APC	STOL	OS AI	DREAS MON	ASTER	Y BORING METHO	DD	Rotary	/ CC	re	dril	ling]
BOREH	OLE LO	CATIO	N	Kar	pasi	а			DATE COMMEN	CED	13.05.					
GROUN	D LEVE	L		0,3	0 m				DATE COMPLET	ED	13.05.	20	15			
BOREH	OLE DE	PTH		20.	00 m	1			GROUNDWATER	LEVEL	3.70 n	n				
COORD	INATES	;	X	642	2656											
			Y	394	1748	2										
	ole		ST	CAND	ART	PEN	ETRATION	TEST	,					/m	%	
(E)	Tal	es	Nu	mber	of Blo	ws	Graph		GEOTECHNIC	CALLE	GEND		ng n	Index	overy	
Depth (m)	Water Table	Samples	0-15 cm	15-30 cm	30-45 cm	N	10 20 30	40 50	DESCRIPTIO	N LE	GEND	Strength	Weathering	Fracture Index/m	Core Recovery	RQD %
14.00- 15.00- 16.00- 17.00- 18.00- 19.00- 20.00- 21.00- 22.00- 23.00-	14.00- SPT14.00 3 14.15m 15.00- 16.00- 17.00- 18.00- C 19.00- 21.00- 22.00-					R			Greenish grey, lamella moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weath	ered		II	1111			
				I II III IV V VI FRA <1 1-2 2-10	Highly Compl Residu CTUR Wid Mo Clo	y weat rately weath weath letely wal soil RE INI de derate se	veathered lered veathered Veathered W M Cl	N=0-2 N=3-5 N=6-9 N=10-1 N=17-3 N>30 SPT : 1 D : 1 UD : 1 C : 6		COAR N=0-4 N=4-10 N=10-3 N=30-3 N>50	30 Mediu	oose m de				
75-90 %	0-75 % Fair 2-10 Close 5-90 % Good 10-20 Intense						I Cr		Engineers : Naim KORKM Samiye İNCE	AZCAN	Signatur	e:				



C	F(07		7 (Qr	Г	I	3O]	REHOLE		BOREH NO	OLI	E	EB	3-2
U				<u>'</u>) .				LOG		PAG NO			1/	2
PROJEC	ET			APC	STOL	OS AN	DREAS MONA	STERY	BORING METHOD		Rotary	/ CC	re	drilli	ing
BOREH	OLE LO	CATIO	N	Kar	pasi	а			DATE COMMENCEI)	15.05.				
GROUN	D LEVE	L			0 m				DATE COMPLETED		15.05.	20	15		
BOREH				-	00 m	1			GROUNDWATER LE	VEL	3,80 m				
COORD			X		2659			1							
		_	Y		1747	8									
	le		ST				ETRATION '	TEST						E	%
(m)	Tab	83			of Blo		Graph		GEOTECHNICAI		CEND		o.o	ndex/	Recovery %
Depth (m)	Water Table	Samples	0-15 cm	15-30 cm		N	10 20 30 4	10 50	DESCRIPTION	LE	GEND	Strength	Weathering	Fracture Index/m	Core Reco RQD %
2.00 -		C SPT 3.00	23	32	50/10	R			Yellowish cream, weak, moderately weathered SANDSTONE (0.00-3.00m)				Ш		0
									Hard Silty Clay						
4.00		SPT 4.50 4.80m	19	29	50/15	R			Greenish grey, lamella, moderately weathered, weak, Hard MARL (4.00-20.00m) Core very fractured, sometimes very weak and moderately weathered	8666		П	==		
STRENG			\perp		THER	ING		FINE GR		TOTAL AND SEC.	SE GRAINE				
II Weak (5-25 MPa) II S III Moderately strong (25-50 MPa) III M IV Strong (50-100 MPa) IV F V Very strong (100-250 MPa) V C VI Extremely strong (>250 Mpa) VI F					Highly Compl	ately w weath letely v	hered II weathered II weathered II weathered II	N=0-2 N=3-5 N=6-9 N=10-16 N=17-30 N >30	Very soft Soft Firm Stiff Very stiff Hard	N=0-4 N=4-10 N=10-3 N=30-5 N >50	0 Mediu	m de			
0-25 % 25-50 % 50-75 %	Strong (50-100 MPa) Very strong (100-250 MPa) Extremely strong (>250 Mpa) VI Residual st Quality Designation (RQD) Very poor					le derate se	W II M CI	N : Sta D : Dis UD : Uno C : Con	ndart penetration test ndart penetration resistance turbed sample disturbed sample re sample ay diffraction sample						
75-90 % 90-100%	>20		shed		Orilling E	ngineers : Naim KORKMAZCA Samiye İNCE	AN	Signatur	e:						



G	F(77	וין	L (Qr	Г		В	0	REHOLE	2	BOREH NO	OLE		EE	3-2
U.					.					LOG		PAG NO			2/	2
PROJEC	T			APC	STOL	OS AI	NDREAS MOI	NAST	ERY	BORING METHOD		Rotary			drill	ing
BOREHO	OLE LO	CATIO	N		rpasi	a				DATE COMMENCE	D	15.05.				
GROUN					0 m					DATE COMPLETED		15.05.		5		
BOREHO					00 m	1				GROUNDWATER L	EVEL	3,80 m	1			
COORD	INATES		X		2659			_								
			Y		1747		EED ATIO	T CENT	COR	T	T					
€	able						ETRATIO		ST	CEOTECHNICA					lex/m	% 11
Depth (m)	Water Table	Samples	Nu	mber	T	ws	Grap	n		GEOTECHNICA DESCRIPTION	L LE	GEND	tt.	Weathering	ıre Inc	Core Recovery RQD %
Dep	Wat	Sam	0-15 cm	15-30 cm	30-45 cm	N	10 20 20	40	50	DESCRIPTION			Strength	Weath	Fracture Index/m	Core I
	-						10 20 30	40	50		366				_	+
=																
14.00-		SPT 14.00 3 14.15m		50/30		R										
=		3 14.1311	1													
15.00		С								Greenish grey, lamella, moderately						
16.00							-		#	weathered, weak,						
16.00		SPT 16.00 4 16.35m	22	28	50/10	R			•	Hard MARL (4.00-20.00m)	- 1886 - 1886					
		10.0011								Core very fractured,						
17.00										sometimes very weak and moderately weathered						
18.00		С								and moderately weathered		- - - - - - - - - -				
10.00		110 40 50									388					
19.00-		UD 18.50 1 18.80m														
												- - - - - - - -				
20.00											3000					
										END OF BOREHOL	.E					
21.00-										20.00m						
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									₩							
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26.00																
26.00-																
STRENGT	ГН (Rocks	i)		WEA	THER	ING		FIN	E G	RAINED	COARS	SE GRAINE	D			
	weak (1-5 l (5-25 MPa				Fresh Slightl	V Wee	thered	N= N=		Very soft Soft	N=0-4 N=4-10	Very l	oose			
III Mode	rately stron	ng (25-50 l	MPa)	III	Moder	ately v	weathered	N=	5-9	Firm	N=10-3	0 Mediu		nse		
	g (50-100 N strong (100)		Highly Compl		nered weathered		10-16 17-30		N=30-5 N > 50	50 Dense Very d				
VI Extre	mely strong	g (>250 M	pa)		Residu			N >	30	Hard						
Rock Quali	ty Designa	tion (RQI	D)	FRA	CTUR	E IN	DEX/m	SPT N		andart penetration test andart penetration resistance						
	1 1 2 Madamat							D UD	: D	sturbed sample ndisturbed sample						
	Poor Fair			2-10	Clo	se	Cl	C X	: C	ore sample ray diffraction sample						
75-90 %	0-75 % Fair 2-10 Close						I Cr			Engineers : Naim KORKMAZO	CAN	Signatur	ο.			



C	F	7	וי	7 (Q'	Г	I	30	REHOLE		BOREH NO	OLI	E	E	3-3	3
J					.				LOG		PAGI NO			1	/2	
PROJEC	CT			APO	STOL	OS AN	NDREAS MONA	STERY	BORING METHOD		Rotary	/ CC	ore	dril	ling]
BOREH	OLE LO	CATIO	N	Kar	pasi	а			DATE COMMENCED		08.05.	20	15			
GROUN	D LEVE	EL		0,5	0 m				DATE COMPLETED		08.05.	20	15			
BOREH	OLE DE	PTH		20.	00 m	1			GROUNDWATER LEV	EL	6.80 m	1				
COORD	INATES	3	X	642	2652											
			Y	394	1749	5										
	ble		ST	AND	ART	PEN	ETRATION '	TEST						w/m	% A	
ш	r Ta	les	Nur	nber (of Blo	ws	Graph		GEOTECHNICAL	LE	GEND		ing	Inde	cover	
Depth (m)	Water Table	Samples	0-15 cm	15-30 cm	30-45 cm	N	10 20 20	10. 50	DESCRIPTION		GEI (D	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
		• • • • • • • • • • • • • • • • • • • •	0	_	67		10 20 30 4	10 50				J.	_	_		_
1.00 -																
		SPT 1.50 1 1.95m	18	16	14	30			Yellowish cream,							
2.00 -		1.95m	11500 0 00						Highly weathered SANDSTONE				IV		1	
=									(0.00-4.00m)							
3.00		SPT 3.00 2 3.45m	14	18	16	34			(0.00-4.0011)							12
		2 3,43111														
4.00																
= _{5.00}															Ī	
5.00																
6.00									Yellowish cream, weak, Slightly weathered				١,,			
6.00		С							SANDSTONE			II	11			14
									(4.00-8.00m)							
[7.00																
8.00																
									Grey, Conglomerate (8.00-8.50 m)		808 80601	_	L			
9.00		_														
		SPT 9.00 3 9.45m	12	16	28	44		•								
10.00									Brown,							
									Hard Sandy Silt (8.50-12.20m)							
11.00-		С							sometimes very	₩₩						
		C							weak levels							
12.00-																
13.00-																
STRENG	TH (Pools	9)		WEA	THER	INC		FINE GF	PAINED		E GRAINE	D.	_			
	weak (1-5		+		Fresh	1110		N=0-2	A STATE OF THE PARTY OF THE PAR	V=0-4	Very lo					
II Weak	(5-25 MPa		(Pa)		Slightl			N=3-5 N=6-9	Soft	N=4-10 N=10-3	Loose					
IV Stron	g (50-100 l	MPa)		IV	Highly	weath	nered	N=10-16	Stiff	N=30-5	0 Dense					
)-250 MPa) g (>250 Mp			Compl Residu			N=17-30 N > 30	Very stiff Hard	N >50	Very d	ense				
Rock Quali		•		montos at	CTUR		DEX/m	SPT : Sta	andart penetration test							
MANAGENA MARKE 6	Very poor			<1	Wid	le	W	D : Dis	andart penetration resistance sturbed sample							
25-50 %	Poor			1-2 2-10		derate se	Cl	C : Co	disturbed sample ore sample							
75-90 %	Fair Good			10-20	0 Inte	nse	I	0.00	ray diffraction sample namers Naim KORKMAZCAN	٧	Cianat	٥.				
90-100%	Excellent			>20	Cru	shed	Cr I	Juling E	Ingineers : Naim KORKMAZCAP Samiye İNCE	100	Signatur	e.				



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STRENC	TH (Rocks	9		WEA	ТИБР	INC		FINE	RAINED	COAP	SE GRAINE	D				ヿ
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25-50 % 50-75 % 75-90 %				1-2 2-10 10-2 >20	Clo 0 Inte		M Cl I Cr	C : C X : X	ndisturbed sample ore sample -ray diffraction sample Engineers: Naim KORKMAZO Samiye INCE	CAN	Signatur	e:				



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Depth (m)	Water Table	Samples	0-15 cm	15-30 cm	30-45 cm	N	10 20 30	40 50	DESCRIPTION	LE	GEND	Strength	Weathering	Fracture Index/m	Core Reco RQD %
1.00 -									Concrete (0.00-2.70 m)						
3.00 -									Yellowish brown, slightly weathered some levels moderately weathered SANDSTONE				11		32
5.00									(2.70-5.00m) Greenish grey, lamella,moderately weathered, MARI. (5.00-6.00m) Core very fractured,sometimes very wea				III		
		SPT 6.00 1 6.45m	15	13	14	27	•		Core very fractured, sometimes very wear and moderately weathered Yellowish, dark grey,	-					
7.00									Medium dense SAND (6.00-7.00 m)	3000					
9.00									Greenish grey, lamella, moderately						
10.00-									weathered, MARL (7.00-20.00m) Core very fractured, sometimes very weak and moderately weathered				111		
12.00-									and moderately weathered						
0777	nv :								1		38665	<u></u>			
I Very II Weak III Mode IV Strong V Very S	II Weak (5-25 MPa) II Slightly we III Moderately strong (25-50 MPa) IV Highly weak V Very strong (100-250 MPa) V Completely						veathered hered veathered	N=0-2 N=3-5 N=6-9 N=10-16 N=17-30 N >30	Very soft Soft Firm Stiff Very stiff Hard	N=0-4 N=4-10 N=10-3 N=30-5 N >50	0 Mediu	oose m de	ense		
0-25 % 25-50 %	ty Designa Very poor Poor Fair	ntion (RQE))	<1 1-2 2-10	Wie Mo Clo	de derate se	W M Cl	N : Sta D : Dis UD : Un C : Cor	ndart penetration test indart penetration resistance sturbed sample disturbed sample re sample ray diffraction sample						
75-90 %	Good Excellent			10-20 >20		ense ished	I Cr	Drilling E	Naim KODKMAZO	AN	Signatur	e:			



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BOREH	OLE DE	PTH			00 m	1				GROUNDWATER L	EVEL	3.70 m	1				
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n) h	T I	ples	Nu		1	ws	Grapl	h		GEOTECHNICA	L LE	GEND	£	ering	re Ind	ecove	,0
Dept	Wate	Sam	0-15 cm	15-30 cm	30-45 cm	N	10 20 30	40 :	50	DESCRIPTION			Strength	Weathering	Fracture Index/m	Core Recovery	RQD %
14.00- 15.00- 16.00- 17.00- 18.00- 19.00- 20.00- 21.00- 22.00- 23.00- 24.00- 25.00- 26.00-	14.00- 15.00- 16.00- 17.00- 18.00- 19.00- 20.00- 21.00- 22.00- 23.00- 24.00- 25.00- 26.00- RENGTH (Rocks) Very weak (1-5 MPa) Weak (5-25 MPa) Weak (5-25 MPa) Woderately strong (25-50 MPa) Strong (50-100 MPa) Very strong (100-250 MPa) Extremely strong (>250 Mpa) Extremely strong (>250 Mpa) Extremely strong (>250 Mpa) Extremely strong (>250 Mpa) C Quality Designation (RQD) FRACTURE									Greenish grey, lamella, moderately weathered, MARL (7.00-20.00m) Core very fractured, sometimes very weak and moderately weathered				111			
				The same	71735 - 13757	ING				Very soft		SE GRAINE Very le					_
II Weak (5-25 MPa) II Slightly weat III Moderately strong (25-50 MPa) III Moderately IV Strong (50-100 MPa) IV Highly weat V Very strong (100-250 MPa) V Completely VI Extremely strong (>250 Mpa) VI Residual soi							veathered nered weathered		-5 -9 0-16 7-30		N=0-4 N=4-10 N=10-3 N=30-5 N >50	0 Mediu	m de				
Rock Quali	ty Designa	tion (RQ	D)	FRA	CTUR	E INI	DEX/m	SPT N		andart penetration test andart penetration resistance							
25-50 % 50-75 % 75-90 %	Very poor Poor Fair Good Excellent		<1 1-2 2-10 10-20 >20	Mo Clo Inte	derate se	W M Cl I Cr	D UD C X	: Di : Ur : Co : X-	andart penetration resistance sturbed sample ne sample ray diffraction sample Engineers: Naim KORKMAZO Samiye INCE	CAN	Signatur	e:					



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Depth (m)	Water Table	Samples	0-15 cm	15-30 cm	30-45 cm	N	10 20 30	40 50	DESCRIPTION			Strength	Weathering	Fracture Index/m	Core R	RQD %
1.00 - 2.00 - 3.00 - 4.00 - 5.00 - 6.00 -		SPT 4.50 1 1 4.65n SPT 6.00 2 6.10m	7	50/30	50/35.	R			Yellowish cream, Slightly weathered SANDSTONE (0.00-3.50m) Brown Hard Silty Clay (3.50-4.50m)				II			
7.00		SPT 9.00 3 9.15m	20	50/30		R			Greenish grey, lamella, moderately weathered, Hard MARL (4.50-20.00m) Core very fractured, sometimes very weak and moderately weathered				ш			
OTDEN C	TH (P ·			11 m	TOTAL STREET	DVC		EINE CT	NA INED	388	320002	<u> </u>				_
I Very II Weak III Mode IV Stron V Very VI Extre	II Weak (5-25 MPa) III Moderately strong (25-50 MPa) IV Strong (50-100 MPa) V Very strong (100-250 MPa) VI Extremely strong (>250 Mpa) VI Residual strong (RQD) FRACTURE II Wide						veathered hered veathered		Very soft Soft Firm Stiff	N=0-4 N=4-10 N=10-3 N=30-5 N >50	0 Mediu	oose ım de				
25-50 % 50-75 % 75-90 %	Very poor Poor Fair Good Excellent			<1 1-2 2-10 10-2 >20	Mo Clo O Inte	derate	W M Cl I Cr	D : Dis UD : Un C : Co X : X-	andart penetration resistance sturbed sample disturbed sample ser sample ray diffraction sample and incomple sampl	CAN	Signatu	re:				



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I Very II Weak III Mode IV Strong V Very VI Extree Rock Quali	FH (Rocks, weak (1-5 M (5-25 MPa rately strong (50-100 M strong (100 mely strong ty Designa)	MPa) ag (25-50] MPa) -250 MPa g (>250 M	MPa)) pa)	WEA IIIIIIIV V VI FRA <1	THER Fresh Slightl Moder Highly Compi Residu	y weat rately w weath letely v ial soil	hered veathered ered veathered veathered	FINE G N=0-2 N=0-5 N=0-9 N=10-10 N=7-30 SPT : S N : S D : D	O Very stiff Hard andart penetration test tandart penetration resistance isturbed sample	LE	30 Mediu	oose m de						
25-50 % 50-75 % 75-90 % 90-100%	1-2 2-10 10-20 >20	Clo 0 Inte		M Cl I Cr	C : C X : X	ndisturbed sample ore sample -ray diffraction sample Engineers: Naim KORKMAZ Samiye INCE	CAN	Signatur	Signature:									



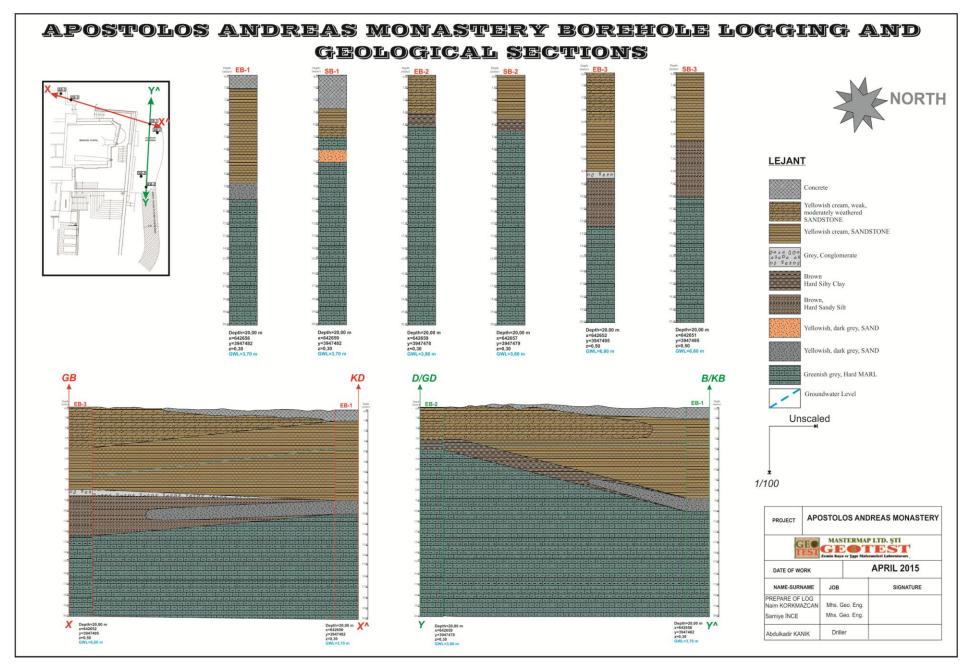
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Depth (m)	Water Table	Samples	0-15 cm		T	N	10 20 30	40 5	:0	DESCRIPTION	LE	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %		
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11.00- 11.00- 12.00- 13.00-		SPT10.00 2 10.15m SPT13.00 3 13.30m	32			R				Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weathered								
STRENGTH (Rocks) WEATHE					THER	ING		FINI	E GI	RAINED	COARS	E GRAINE	RAINED					
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GROUN	D LEVE	L		0,5	0 m				DATE COMPLET	ED	07.05.	20	15			
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le le		ST	AND	ART	PEN	ETRATION	TEST						/m	%		
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Depth (m)	Water Table	Samples	0-15 cm	15-30 cm			10 20 30 40 50		DESCRIPTIO	N	LEGEND		Weathering	Fracture Index/m	Core Recovery	RQD %
14.00- 15.00- 16.00- 17.00- 18.00- 19.00- 20.00- 21.00- 22.00- 24.00- 25.00- 26.00-	ГН (Rocks)		WEA	тнек	ING		FINE (Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weather 20.00m	OLE	SE GRAINE	D				
STRENGTH (Rocks) WEATHERING I Very weak (1-5 MPa) I Fresh								FINE GRAINED N=0-2 Very soft			Very le					\neg
II Weak III Mode IV Strong V Very s VI Extrei)	II III IV V	Slightl Moder Highly	ately w weath etely v	veathered	N=3-5 N=6-9 N=10-1 N=17-3 N >30	Soft Firm 6 Stiff	N=0-4 N=4-10 N=10-3 N=30-5 N >50	0 Loose 30 Medium dense 50 Dense							
Rock Quali	ty Designa	tion (RQI	D)	FRA	CTUR	E IND	DEX/m		standart penetration test standart penetration resistance							
0-25 % 25-50 % 1 50-75 % 1 75-90 % 0 90-100% 1		<1 1-2 2-10 10-20 >20	Clo 0 Inte	derate se	W M Cl I Cr	D : I UD : I C : C X : 2	Disturbed sample Judisturbed sample Core sample Cray diffraction sample Engineers: Naim KORKM/ Samiye INCE	AZCAN	Signature:							









Iskele District - Dipkarpaz Municipality APOSTOLOS ANDREAS MONASTERY – MEDIEVAL CHAPEL REFURBISHMENT PROJECT <u>Dipkarpaz</u>



GEOTECHNICAL SITE INVESTIGATION REPORT

PREPARED BY

AHMET SÖNMEZLER

Civil Engineer Geotechnical Engineer June 2015

PROJECT NAME

APOSTOLOS ANDREAS MONASTERY – MEDIEVAL CHAPEL REFURBISHMENT PROJECT

GEOTECHNICAL SITE INVESTIGATION REPORT

PROJECT TEAM

<u>Engineer</u> : Ali Çağlar (UNDP)

Engineer Representative: Cem Taneri (UNDP)

Project Manager : Yakup Tel (Telza-Fixico)

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<u>Site Engineer</u> : Pieris Hadjipieris

Geology Engineers : Naim Korkmazcan - Samiye İnce

COMPANY DETAILS OF BOREHOLING AND FIELD / LAB. TESTS IMPLEMENTATION

NAME : GEOTEST Ltd. Sti.

"Zemin ve Yapı Malzemeleri Laboratuarı"

ADRESS: K. Kaymaklı / LEFKOŞA (NICOSIA)

TELEPHONE : 0392 2257 047 / 0533 827 4757 GSM: 0533 863 8151

PROJECT LOCATION

Iskele District - Dipkarpaz Municipality

<u>Dipkarpaz</u>

APOSTOLOS ANDREAS MONASTERY

REPORT DATE AND REPORT SUBMIT COMISSION

CHAMBERS OF CIVIL ENGINEERS

June 2015

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APPENDIX

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APPENDIX-2: LOCATION MAP

APPENDIX-3: CORE BOXES AND BOREHOLE LOGS

APPENDIX-4: STRATIFICATION OF SOIL LAYERS AND IDEALISED SOIL PROFILE

APPENDIX-5: LABORATORY TEST RESULTS

FIGURE LIST Figure 2.1: Cyprus Seismic Risk Map......5 **TABLE LIST Table 4.1:** Corrected SPT-N Values Table 5.1: Soil Groups......8 Table 5.2: Local Soil Category....... Table 5.4: Determination of Plasticity Degree according to Plasticity Index (Leonards, 1962).....9 **Table 5.5:** Classification of Swelling Soils (O'Neil and Poormoayed, 1980)..... Table 5.2.2.1: Determination of GSI Value for Heterogeneous Rock Masses (Marinos & Hoek)......11 Table 5.2.2.4: Relationship Models between Uniaxial Compression Strength and Point Load Strength

1. PURPOSE AND SCOPE

In Apostolos Andreas Monastery – Medieval Chapel Refurbishment Project is planned in Dipkarpaz Municipality – Iskele District. In May 2015, three exploratory boreholes are carried out to the planned area of refurbishment project in scope of Geotechnical investigation works. This report is prepared by considering the laboratory test results obtained from the samples by boreholing. Planning will go on towards with this report.

This report includes geotechnical evaluations about subsoil and present building and required precautions that should be taken and some suggestions as a part of improvement plan. In the light of this works, geotechnical report is prepared for investigation of region, stratigraphy of lythologic units and their geotechnical properties such as bearing capacity, swelling and soil liquefaction with other risk frames and it will also includes the assessments for improvement plan availability.

2. SEISMICITY

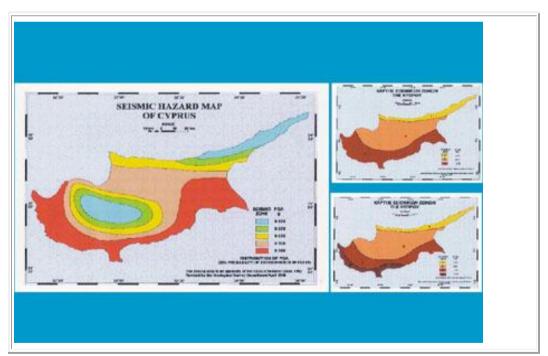


Figure 2.1- Cyprus seismic risk maps

Cyprus seismic acceleration map is prepared. The variation of acceleration of seismic waves according to the soil in different places is shown in this map in Figure 2.2, during the earthquake.

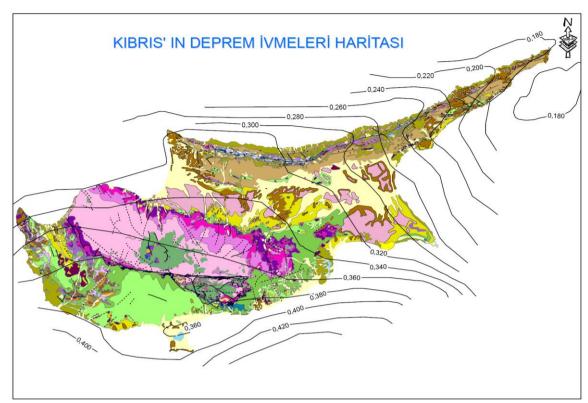


Figure 2.2: Seismic Acceleration Map

3. GEOTECHNICAL BOREHOLING WORKS AND FIELD TESTS

Exploratory boreholes are carried out for; stratification of soil-rock formations, determination of physical properties and manifesting of index and strength parameters.

3.1. Boreholings

In 13.05.2015, three exploratory boreholes with total depths of (3x20m) 60.0 m and three satellite boreholes with total depths of (3x20m) 60.0 m are carried out in investigation area by using Rotary boreholing machine mounted on lorry. As a boreholing technic, rotary wet system is used and proper samples are taken with some cores.

SPT Tests are carried out for determination of stiffness of passed units and taking some disturbed samples. Rock samples are taken by using core. In some thinner material including zones such as clay and silts, some undisturbed (UD) samples are also taken. Borehole coordinates and depths are given in Table 3.1 below.

Table 3.1: Borehole Coordinates and Depths (6 Degree UTM) 1/25,000

Borehole	Coord	Parahala danth (m)	
Богенове	To the Right (X) To the Up (Y)		Borehole depth (m)
EB-1	642656	3947482	20.0
EB-2	642659	3947478	20.0
EB-3	642652	3947495	20.0
SB-1	642659	3947482	20.0
SB-2	642657	3947479	20.0
SB-3	642651	3947495	20.0

4. GEOTECHNICAL PROPERTIES OF INVESTIGATED AREA

4.1. Determination of Mechanical Properties of Soils

SPT results obtained in the field within varied depths are corrected and given in the Table 4.1 below.

Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
	9.50	23	0.95	126.45	0.87	45	16.4	14.3
EB-1	12.50	50	1.00	154.92	0.79	45	37.5	29.5
ED-1	14.00	50	1.00	169.16	0.75	45	37.5	28.2
	16.00	50	1.00	188.14	0.71	45	37.5	26.8
	Groundwa	ater Level =	3.70	m	Av. Nat. Unit	Weight =	19.30	KN/m³
Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
	3.00	50	0.75	60.72	1.26	45	28.1	35.3
EB-2	4.50	50	0.85	84.21	1.07	45	31.9	34.0
ED-2	14.00	50	1.00	183.30	0.72	45	37.5	27.1
	16.00	50	1.00	204.16	0.68	45	37.5	25.7
	Groundwa	ater Level =	3.80	m	Av. Nat. Unit	Weight =	20.24	KN/m³
Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
	1.50	30	0.75	30.02	1.79	45	16.9	30.1
EB-3	3.00	34	0.75	60.03	1.26	45	19.1	24.2
	9.00	44	0.95	158.51	0.78	45	31.4	24.4
	Groundwa	ater Level =	6.80	m	Av. Nat. Unit	Weight =	20.01	KN/m³

5. GEOTECHNICAL PROPERTIES OF SOIL AND ROCK LAYERS

5.1. Dynamic and Elastic Parameters of Soil

Table 5.1: Soil Groups

Soil Group	Definition of Soil Group	Stand. Penetr. (N/30)	Relative Compact. (%)	Uniaxial Press. Strength (kPa)	Shear Wave Velocity (m/s)
(C)	1. Very disintegrated metamorphic and cemented sedimentary rocks that has soft discontinuity planes	_		< 500	400–700
	2. Medium tight sand, gravel	10-30	35–65		200–400
	3. Stiff clay and silty clay	8–16	_	100-200	200-300

Since silty clay and marl units are assumed to be stiff and sandstone units are accepted as very disintegrated metamorphic and cemented sedimentary rocks that has soft discontinuity planes, general subsoil is projected within **Group C.**

Table 5.2: Local Soil Category

Local Soil Category	According to Table 5.1, Soil Group and Upper Soil Layer Thickness (h ₁)
Z2 ***	$h_1 > 15$ m Group (B) Soils $h_1 \le 15$ m Group (C) Soils ***

Since the thickness of Group C soils within investigated depth is less than 15 m, local soil category is assessed as **Z2**.

Table 5.3: Spectrum Characteristic Periods (T_A, T_B)

Local Soil Category	T _A (second)	T _B (second)
Z1	0.10	0.30
Z2 ***	0.15 ***	0.40 ***
Z3	0.15	0.60
Z4	0.20	0.90

Spectrum characteristic periods for **Z2** soils are;

 $T_A(second) = 0.15$ $T_B(second) = 0.40$ values should be taken.

5.2. Swelling, Bearing Capacity Analyses and Soil Liquefaction and Assessment

According to the investigated area evaluations and borehole observations, upper units are classified as Sand Stone, beneath units are classified as Sandy-Silty CLAY and at the end of borehole units are classified as MARL. Geotechnical assessments will be carried out weightily in this sense.

5.2.1. Atterberg Limits and Swelling Potential

Swelling potential of CLAY and MARL units are evaluated by Plasticity Index data according to the given Table 5.4 below.

Table 5.4: Determination of Plasticity Degree according to Plasticity Index (Leonards, 1962)

Plasticity Index PI (%)	Plasticity Degree	Dry Strength
0-5	Non-Plastic	Very Low
5-15	Low Plastic	Low
15-40	Plastic	Medium
>40	High Plastic	High

Table 5.5: Classification of Swelling Soils (O'Neil and Poormoayed, 1980)

LIQUID LIMIT	PLASTICITY İNDEKSI	SWELLING POTENTIAL	CLASSIFICATION OF SWELLING POTENTIAL
<50	<25	<0,5	Low
50-60	25-35	0,5-1,5	Medium
>60	>35	>1,5	High

CLAY and MARL units are evaluated as having **Medium Swelling** potential in respect to index properties.

5.2.2. Bearing Capacity Calculations

Most commonly used formula in order to calculate bearing capacity for shallow foundations on soil is **Hansen Equation**, as given below.

$$qf = c*Nc*Sc*Fcd+ y*Df*Nq*Sq*Fqd+ \frac{1}{2}*\sigma's*B*N\gamma*S\gamma*F\gamma d$$

In here;

qf=Bearing capacity of shallow foundation (Ton/m²), γ =Unit Weight of Soil (Ton/m³), c= Cohesion (Ton/m²),

B=Foundation width (m), Df=Foundation depth (m), Nc, Nq, Nγ; Bearing capacity factors, Sc, Sq, Sγ; Shape Factors, Fcd, Fqd, Fγd; Depth Factors.

In bearing capacity calculations for rock formations, Hoek-Brown Yield criteria should also be considered as given below.

$$q_{\text{ult}}$$
 (Nihai taşıma gücü) = $\sigma_{\text{ci}} \left[\sqrt{s} + (m\sqrt{s} + s)^{a} \right]$

In here;

"σci", Uniaxial Compression strength value (UCS) of rock.

"m", "s" and "a" are experimental constants that are obtained from Geologic Strength Index (GSI). By getting GSI Values tables given below can be used.

By means of GSI values from the table 5.2.2.1. and table 5.2.2.2. "m", "s" and "a" constants can be obtained. Equations that can be used for those constants are

$$m_b = m_i \exp\left(\frac{GSI - 100}{28 - 14D}\right)$$
 $s = \exp\left(\frac{GSI - 100}{9 - 3D}\right)$ $a = \frac{1}{2} + \frac{1}{6}\left(e^{-GSI/15} - e^{-20/3}\right)$

Here "**mi**" and "**D**" factors are present. "**mi**" constant value can be obtained by using table 5.2.2.3 below.

In order to get "m" and "s", **Disturbing Factor (D)** value is also effective. Disturbing factor can be chance between 0.0-1.0 range according to disturbance case of rock core.

Table 5.2.2.1: Determination of GSI Value for Heterogeneous Rock Masses (Marinos & Hoek)

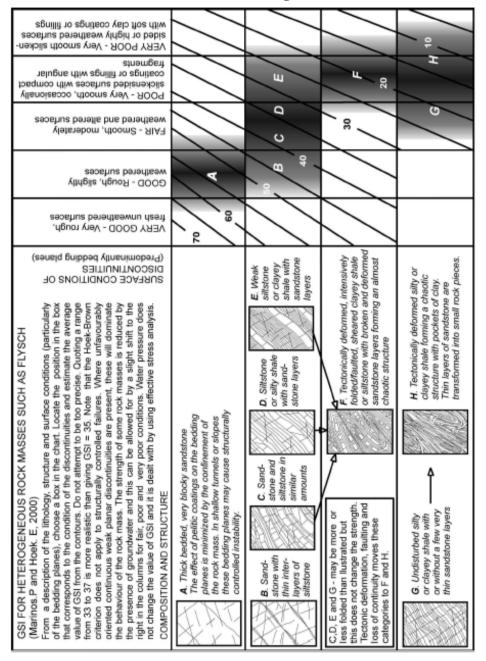


Table 5.2.2.2: Determination of GSI Value respect to Geological Definition

			_			
GEOLOGICAL STRENGTH INDEX FOR BLOCKY JOINTED ROCKS From a description of the structure and surface conditions of the rock mass, pick an appropriate box in this chart. Estimate the average value of GSI from the contours. Do not attempt to be too precise. Quoting a range from 36 to 42 is more realistic than stating that GSI = 38. It is also important to recognize that the Hoek-Brown criterion should only be applied to rock masses where the size of individual blocks or pieces is small compared with the size of the excavation under consideration. When the individual block size is more than about one quarter of the excavation size, the failure will be structurally controlled and the Hoek-Brown criterion should not be used.	SURFACE CONDITIONS	TO VERY GOOD Wery rough, fresh unweathered surfaces	図 G GOOD G Rough, slightly weathered, iron stained surfaces	FAIR Smooth, moderately weathered and altered surfaces	POOR Slickensided, highly weathered surfaces with compact coatings or fillings or angular fragments	VERY POOR Slickensided, highly weathered surfaces with soft clay coatings or fillings
INTACT OR MASSIVE - intact rock specimens or massive in situ rock with few widely spaced discontinuities	CES	90		N/A	N/A	N/A
BLOCKY - well interlocked un- disturbed rock mass consisting of cubical blocks formed by three intersecting discontinuity sets	OF ROCK PIECES		70 60			
VERY BLOCKY- interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets	DECREASING INTERLOCKING OF		5			
BLOCKY/DISTURBED - folded and/or faulted with angular blocks formed by many intersecting discontinuity sets	REASING INT			40 -	30	
DISINTEGRATED - poorly inter- locked, heavily broken rock mass with mixture of angular and rounded rock pieces						
FOLIATED/LAMINATED - folded and tectonically sheared. Lack of blockiness due to schistosity prevailing over other discontinuities		N/A	N/A			10

Table 5.2.2.3: "mi" Constant Values for Rock Groups

Rock	Class	Group	Texture			
type			Coarse	Medium	Fine	Very fine
NTARY	Clastic		Conglomerates* (21 ± 3) Breccias (19 ± 5)	Sandstones 17 ± 4	Siltstones 7 ± 2 Greywackes (18 ± 3)	Claystones 4 ± 2 Shales (6 ± 2) Marls (7 ± 2)
SEDIMENTARY		Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestones (10 ± 2)	Micritic Limestones (9 ± 2)	Dolomites (9 ± 3)
	Non- Clastic	Evaporites		Gypsum 8 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliate	d	Marble 9 ± 3	Homfels (19 ± 4) Metasandstone (19 ± 3)	Quartzites 20 ± 3	
METAN	Slightly foli	ated	Migmatite (29 ± 3)	Amphibolites 26 ± 6		
	Foliated**		Gneiss 28 ± 5	Schists 12 ± 3	Phyllites (7 ± 3)	Slates 7 ± 4
		Light	Granite 32 ± 3 Grano dio (29 ± 3			
Snc	Plutonic	Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
GNEOUS	Hypabyssal	•	Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25±5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3) Basalt (25 ± 5)	Obsidian (19 ± 3)
		Pyroclastic	Agglomerate (19 ± 3)	Breccia (19 ± 5)	Tuff (13 ± 5)	

"σci" (UCS) value can be calculated by using **Point Load Strength Index** (**Is**(50)). In this field, different models famulated by different experts can be used. Those models are given in the table 5.2.2.4 below;

Table 5.2.2.4: Relationship Models between Uniaxial Compression Strength and Point Load Strength Index According to Different Experts

Araştırmacı	Model
D'andre et al. (1964)	UCS=15.3 I _{s(50)} +16.3
Broch & Franklin 1972	UCS=24 I _{s(50)}
Bieniawski (1975)	UCS=23 I _{s(50)}
Hassani et al. (1980)	UCS=29 I _{s(50)}
Read vd. (1980)	
Sedimanter kayaç	UCS=16 I _{s(50)}
Bazalt	UCS=20 I _{s(50)}
Forster (1983)	UCS=14.5 I _{s(50)}
Gunsallus & Kulhway (1984)	16.5 I _{s(50)} +51
ISRM (1981)	UCS=2025 I _{s(50)}
Cargill & Shakoor (1990)	UCS=23 I _{s(54)} +13
Grasso vd. (1992)	UCS=9.30 I _{s(50)} +20.04
Chau & Wong (1996)	UCS=12.5 I _{s(50)}
Kahraman (1996)	
Kömür yan kayaçları	UCS=23.62 I _{s(50)} -2.69
Diğer kayaçlar	UCS=8.48 I _{s(50)} +9.51
Bu çalışma	UCS = $10.957 I_{s(50)}$

If all the relationships above are considered,

 $\sigma ci = 12*Is(50)$ Relation will give safe results.

5.2.3. Determination of Soil Liquefaction Potential

F; Factor of safety,

If F < 1.00; Soil Liquefaction is expected during earthquake condition.

IF $1.00 \le F < 1.20$; Soil Liquefaction risk is present.

IF $1.20 \le F$; Soil Liquefaction is not expected during earthquake condition.

Factor of Safety can be calculated by the formula below,

F = CRRm / CSR

In here; CRRm: Resistance Factor of Soil against Liquefaction

CSR: Cyclic Stress Ratio in earthquake condition.

CSR = $0.65 \times \text{rd} \times \underline{\sigma_V} \times \underline{\text{amax}}$ $\sigma'_V = g$

 $CRRm = Km \times Kpi \times CRR_{7.5}$

GEOTECHNIC CALCULATIONS SUMMARY

- 1. Investigation area is 3^{rd} degree earthquake region.
- 2. Soil Group is (C)
- 3. Local Soil Category is (\mathbf{Z}_2)
- 4. Spectrum characteristics periods of soil is;

 $T_A=0.15sn, T_B=0.40sn$

- 5. Shear wave velocity, in CLAY and MARL units 200-300 m/s In SAND STONE units 400-700 m/s.
- 6. For seismic calculations, effective soil acceleration coefficient is $A_0 = 0.20$.
- 7. Allovable Bearing Capacity of Layers beneath foundation;

SAND STONE \approx 42.38 T/m³ Sandy-Silty CLAY \approx 9.46 T/m³ MARL \approx 10.15 T/m³

8. Factor of Safety against Soil Liquefaction

F=1.52

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APPENDIX-1: GEOTECHNICAL CALCULATIONS

APPENDIX-2: LOCATION MAP

APPENDIX-3: CORE BOXES AND BOREHOLE LOGS

APPENDIX-4: STRATIFICATION OF SOIL LAYERS AND IDEALISED SOIL PROFILE

APPENDIX-5: LABORATORY TEST RESULTS

Soil Liquefaction Potential Calculation

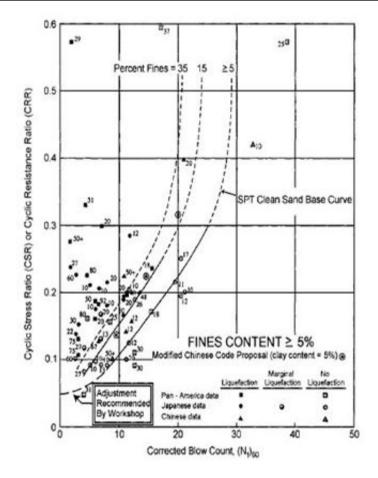
EB-1 (Calculation for Critical Layer at 9.50 m depth)

Liquefaction Resistance (CRRm):

CRRm = Km x Kpi x CRR7.5

Groundwater Level = 3.70 m Av.Nat. Unit Weight = 19.30 KN/m³

Borehole No	Depth (m)	Field SPT- N Value	Energy Ratio (%)	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	N60	(N1)60
EB-1	9.50	23	45	0.95	126.45	0.87	16.4	14.3



Sandy Layer at 9.50 m Depth.					
(N1)60 =	14				
-No 200 = 5.60 (%)					
(Fine Grain Percent)					
CRR7.5 = 0.180					
(Read from the Graph)					

M =	6.0	(Design Magnitude Earthquake)
wl = wp =		(Liquid Limit) (Plastic Limit)
Ip =	0.0	(Plasticity Index)

(Earthquake Correction Factor)

→ Km = 1.32

(Obtained from the correlation)

(Plasticity Correction Factor)

→ KpI = 1.00

(Obtained from the correlation)

CRRm = 0.237 (Liquefaction Resistance)

Cyclic Stress Ratio in Earthquake Condition (CSR):

 $CSR = 0.65 \times rd \times \underline{\sigma_v} \times \underline{a_{max}}$

σ'v g

lf;

Z < 9.15 m \rightarrow rd = 1 - 0.00765 x Z $9.15 \text{ m} \le Z < 23 \text{ m}$ \rightarrow rd = 1.174 - 0.0267 x Z $23 \text{ m} \le Z < 30 \text{ m}$ \rightarrow rd = 0.744 - 0.0082 x Z

30 m \leq Z \rightarrow rd = 0.5

 $\sigma_V = 183.35$ Kpa (Total Vertical Stress)

 $\sigma'v =$ 126.45 Kpa (Total Effective Vertical Stress)

amax = 1.77 m/s² (Max. Soil Surface Acceleration) (For Dipkarpaz 0.18g)

g = 9.81 m/s² (Gravitational Acceleration)

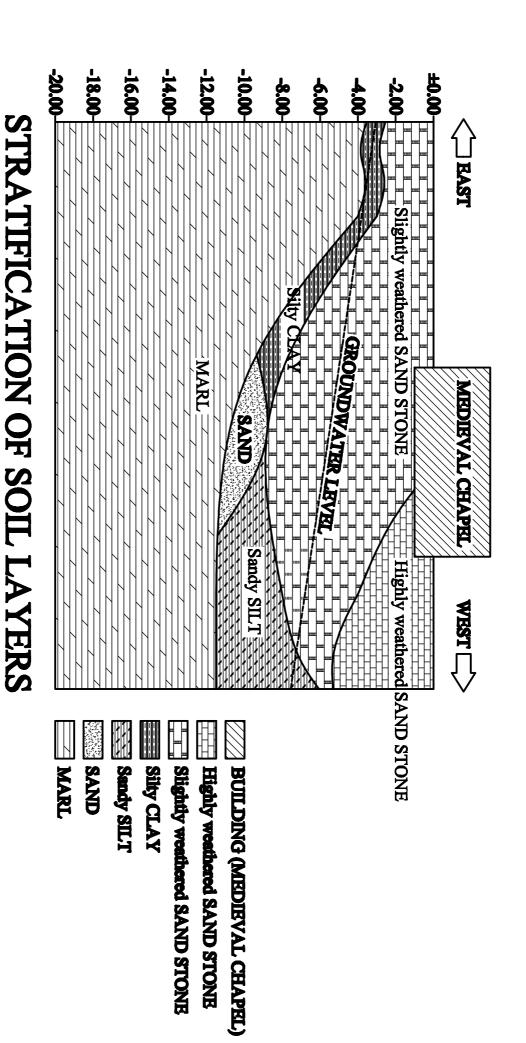
CSR = 0.156 (Cyclic Stress Ratio)

F = CRRm / CSR (Factor of Safety against Soil Liquefaction)

Eğer;

F < 1.00 \rightarrow Soil Liquefaction is expected 1.00 ≤ F < 1.20 \rightarrow Soil Liquefaction risk is present 1.20 ≤ F \rightarrow Soil Liquefaction is not expected

F = 1.52 > 1.00 → Soil Liquefaction is not expected..



SCALE: 1/200