EB-1


0.00m
1.50m
3.00m
4.50m
6.00m
7.50m
9.00m
10.00m
11.00m
12.50m
14.00m
16.00m
17.50m
18.00m
19.00m
20.00m

EB-2


1.50m
3.00m
4.50m
6.00m
7.50m
9.00m
10.50m
12.00m
14.00m
16.00m
18.00m
20.00m

EB-3

SB-1


0.00m
0.50m
1.50m
3.00m
4.50m
6.00m
6.50m
6.50m
7.00m
9.00m
11.00m
13.00m
14.00m
16.00m
18.00m
20.00m

SB-2


4.65m
6.10m
3.00m
1.50m
5.50m
4.50m
7.50m
16.00m
9.00m
14.00m
18.00m
9.15m
12.00m
20.00m
10.50m

SB-3


0.00m
2.00 m
4.20m
7.50 m
10.00m
5.50m
3.20m
13.50m
15.50m
17.00m
19.00m
20.00m

Geotechnical Calculations for Medieval Chapel

Structural Details and Loadings

BW	Building Width	9.00	m	
BL	Building Length	10.00	m	
Bn	Number of Floor	1		
BH	Floor Hight	4.00	m	
FW	Foundation Width	10.00	m	
FL	Foundation Length	12.00	m	
FT	Foundation Thickness	0.50	m	
FD	Foundation Depth	0.50	m	
CBH	Connection Beams Hight	0.50	m	
γC	Unit Volume Weight of R/Conc.	2.50	Ton/m³	(TS498)
XG	Structural Dead Load	0.25	Ton/m²	(TS498)
XQ	Structural Live Load	0.50	Ton/m²	(TS498)
fg	Dead Load Coefficient	1.4		
fq	Live Load Coefficient	1.6		
BA	Av. Floor Area	90.00	m²	(BW*BL)
BST	Av. Floor Thickness	0.33	m	(Columns,Beams,Slabs)
WBs	Building Weight	73.13	Ton	(Bn*γC*BA*BST)
Wd	Total Building Dead Load	22.50	Ton	(Bn)*XG*BA
WG	Total Building Load	95.63	Ton	(WBs+Wd)
WQ	Total Building Live Load	90.00	Ton	(Bn+1)*XQ*BA
G	Design Building Load	133.88	Ton	(fg*WG)
Q	Design Building Live Load	144.00	Ton	(fq*WQ)
F	Foundation Load	240.00	Ton	(Con. Beams+Fill Weight)
V	Total Design Load	517.88	Ton	(G+Q+F)
σ	**Average Foundation Stress**	**4.32**	**Ton/m²**	(V/Area of Foundation)

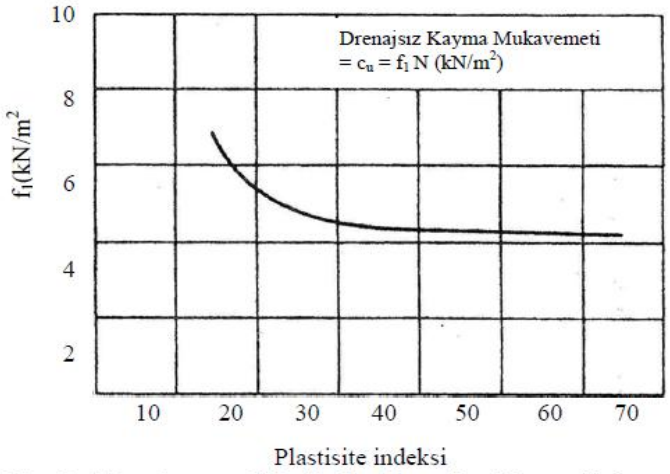
Corrected SPT-(N1)60 Table

Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
EB-1	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
	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
EB-2	3.00	50	0.75	60.72	1.26	45	28.1	35.3
	4.50	50	0.85	84.21	1.07	45	31.9	34.0
	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
EB-3	1.50	30	0.75	30.02	1.79	45	16.9	30.1
	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
	Groundwater Level =		6.80	m	Av. Nat. Unit Weight =		20.01	KN/m³

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

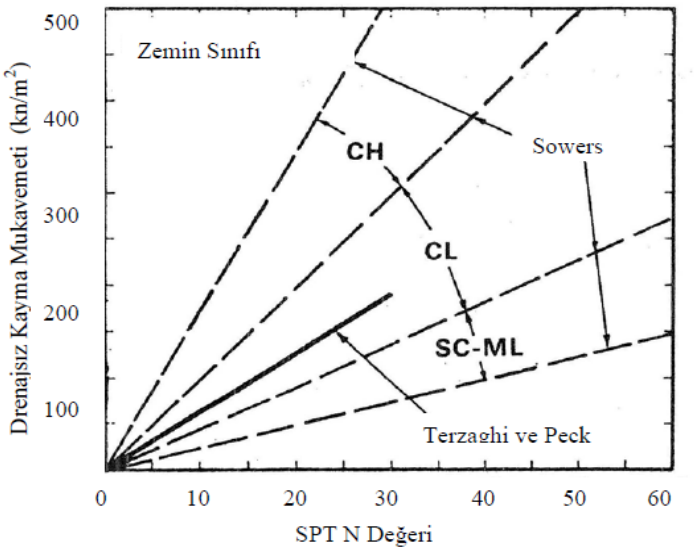
$c_u = f_1 * N \ kN/m^2$;

f_1 : 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 → Cu = 122.14



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"; → Cu = 110.00

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 ($q_f = c*N_c*S_c*F_{cd} + \gamma'_s*D_f*N_q*S_q*F_{qd} + ½*\gamma'_s*B*N_\gamma*S_\gamma*F_{\gamma d}$)

Bearing Capacity Factors:		Shape Factors:		Depth Factors:	
Nc =	5.14	Sc =	1.16	Fcd =	0.98
Nq =	1.00	Sq =	1.00	Fqd =	1.00
Nγ =	0.00	Sγ =	0.67	Fγd =	0.00

Effective Stress beneath Foundation:	σ' =	1.01	Ton/m²	
Bearing Capacity, qf =		**28.37**	**Ton/m²**	
Allowable Bearing capacity of CLAY =		**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 ($q_f = c*N_c*S_c*F_{cd} + \gamma'_s*D_f*N_q*S_q*F_{qd} + ½*\gamma'_s*B*N_\gamma*S_\gamma*F_{\gamma d}$)

Bearing Capacity Factors:		Shape Factors:		Depth Factors:	
Nc =	6.71	Sc =	1.16	Fcd =	0.98
Nq =	1.67	Sq =	1.00	Fqd =	1.00
Nγ =	0.53	Sγ =	0.67	Fγd =	0.00

Effective Stress beneath Foundation:	σ' =	1.01	Ton/m²	
Bearing Capacity, qf =		**30.44**	**Ton/m²**	
Allowable Bearing capacity of MARL =		**10.15**	**Ton/m²**	**Safe...**

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

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

(Hoek-Brown Yield Criteria)

Assumed **GSI** value;	30
Assumed **"m_i"** value;	15
Assumed **"D"** value;	0.6

$$m_b = m_i \exp\left(\frac{GSI-100}{28-14D}\right) \qquad m = 0.42173$$

$$s = \exp\left(\frac{GSI-100}{9-3D}\right) \qquad s = 0.00006$$

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-GSI/15} - e^{-20/3}\right) \qquad a = 0.52279$$

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

Point Load Bearing Index Table				
Location	**Sample Number**	**Min. $I_{s(50)}$ (kg/cm²)**	**Avr. $I_{s(50)}$ (kg/cm²)**	**Max. $I_{s(50)}$ (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 =	14.88	kg/cm²
Average Halfway Point Load Bearing Index =	21.37	kg/cm²
Average Max. Point Load Bearing Index =	28.01	kg/cm²

Min. σci =	178.55	kg/cm²	
Avr. σci =	256.46	kg/cm²	
Max. σci =	336.07	kg/cm²	is expected.

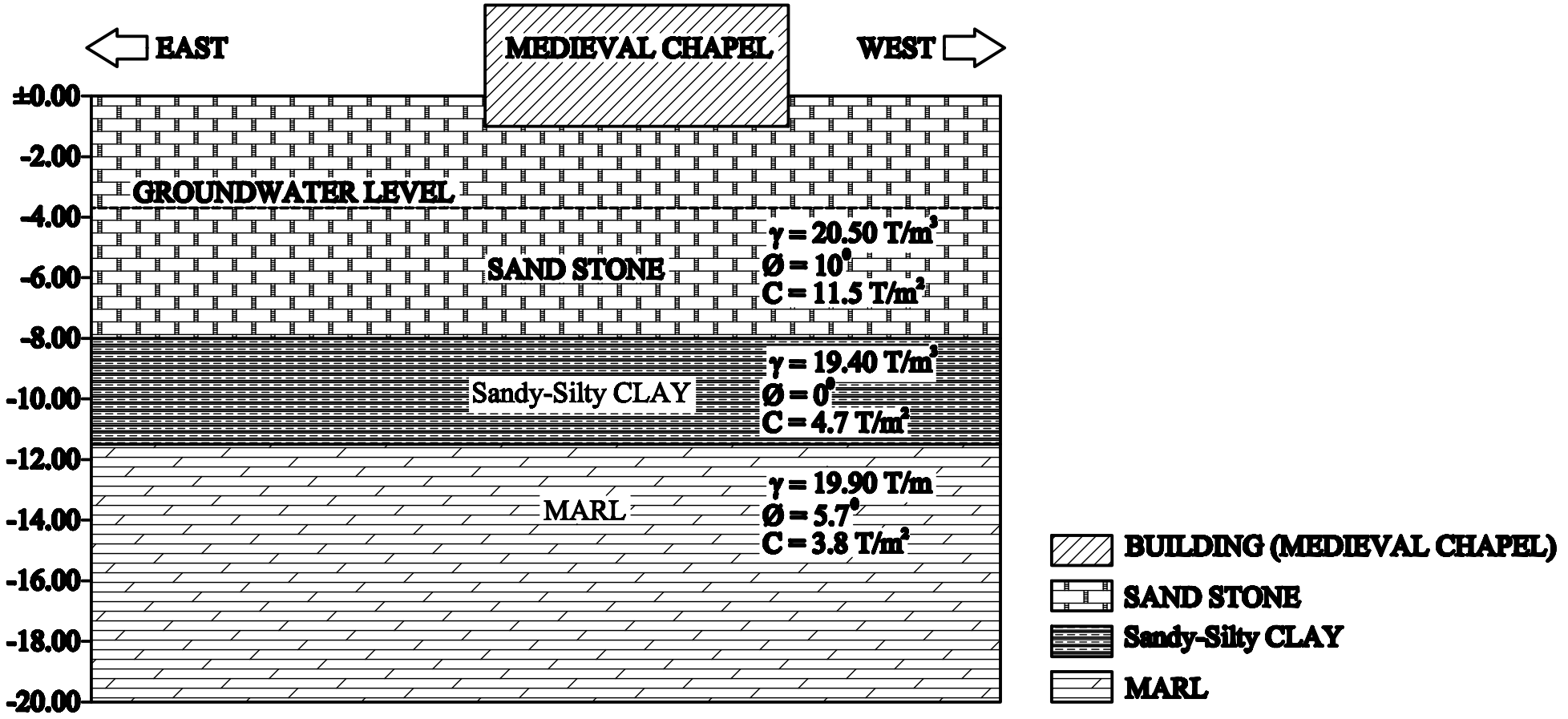
According to above values; Min. Ultimate Bearing Capacity **(qu_{min})** =	10.42	kg/cm²
Avr. Ultimate Bearing Capacity **($qu_{avr.}$)** =	14.97	kg/cm²
Max. Ultimate Bearing Capacity **(qu_{max})** =	19.62	kg/cm²

In conservative case, Allowable Bearing capacity of SAND STONE =	3.47	kg/cm²
In halfway case, Allowable Bearing capacity of SAND STONE =	4.99	kg/cm²
In optimist case, Allowable Bearing capacity of SAND STONE =	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)

σ_{sf} = 4.24 kg/cm² → 42.38 Ton/m²
(Allowable Bearing capacity of SAND STONE)

Ahmet Sönmezler
Civil Engineer
(Geotechnical Engineer)



IDEALISED SOIL PROFILE
SCALE: 1/200

Figure 1. General view of the study area

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

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

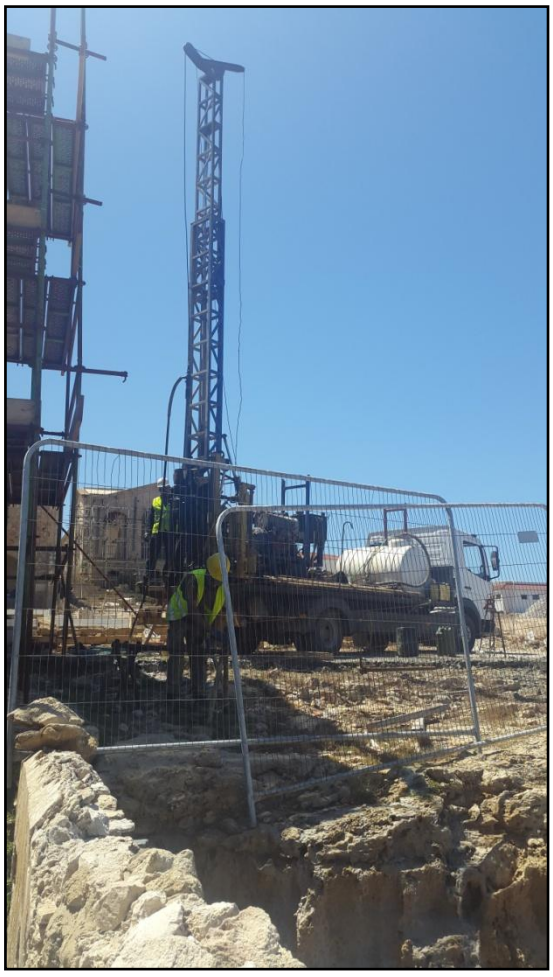


Figure 4. Borehole logging of SB-3

Figure 5. Borehole logging of EB-3

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

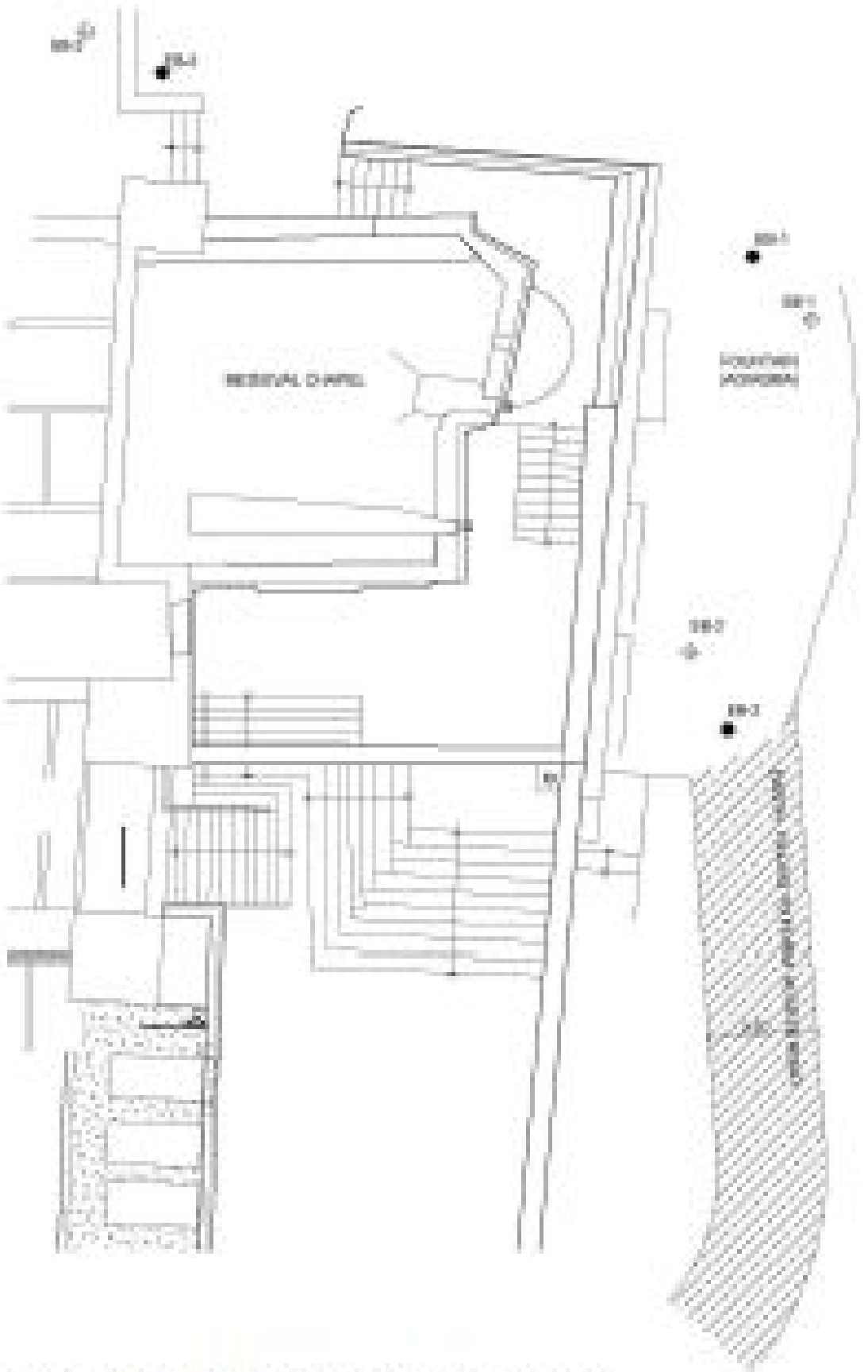


Figure 1: Plan of site with indications of borehole positions

GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-1
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	13.05.2015
GROUND LEVEL	0,30 m		**DATE COMPLETED**	13.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	3.70 m
COORDINATES	**X**	642656		
	Y	3947482		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00								Concrete (0.00-1.00 m)						
2.00								Yellowish cream, Moderately strong, Slightly weathered SANDSTONE (1.00-8.80m)		III	II			27
3.00														23
4.00														
5.00		C												24
6.00														
7.00														16
8.00														15
9.00								Yellowish, dark grey, Medium dense SAND (8.80-10.00 m)						
10.00		SPT 1 9.50 9.95m	13	11	12	23								
11.00		C						Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m)		II	III			
12.00								Core very fractured, sometimes very weak and moderately weathered						
13.00		SPT 2 12.50 12.80m	25	32	50/15	R								
		UD 1 13.20 13.50m												

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-1
PAGE NO	2/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	13.05.2015
GROUND LEVEL	0,30 m		**DATE COMPLETED**	13.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	3.70 m
COORDINATES	**X**	642656		
	Y	3947482		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00		SPT3 14.00 14.15m	32	50/30		R		Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weathered		II	III			
15.00														
16.00		SPT4 16.00 16.30m	28	34	50/15	R								
17.00														
18.00		C												
19.00														
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-2
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY	**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia	**DATE COMMENCED**	15.05.2015
GROUND LEVEL	0,30 m	**DATE COMPLETED**	15.05.2015
BOREHOLE DEPTH	20.00 m	**GROUNDWATER LEVEL**	3,80 m
COORDINATES	X 642659		
	Y 3947478		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00								Yellowish cream, weak, moderately weathered SANDSTONE (0.00-3.00m)		II	III			0
2.00		C												
3.00		SPT 1 3.00 3.35m	23	32	50/10	R								
4.00								Brown Hard Silty Clay (3.00-4.00m)						
5.00		SPT 2 4.50 4.80m	19	29	50/15	R								
6.00														
7.00														
8.00								Greenish grey, lamella, moderately weathered, weak, Hard MARL (4.00-20.00m)						
9.00										II	III			
10.00		C						Core very fractured, sometimes very weak and moderately weathered						
11.00														
12.00														
13.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-2
PAGE NO	2/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	15.05.2015
GROUND LEVEL	0,30 m		**DATE COMPLETED**	15.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	3,80 m
COORDINATES	**X**	642659		
	Y	3947478		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00		SPT 14.00 3 14.15m	37	50/30		R		Greenish grey, lamella, moderately weathered, weak, Hard MARL (4.00-20.00m)						
15.00		C												
16.00		SPT 16.00 4 16.35m	22	28	50/10	R		Core very fractured, sometimes very weak and moderately weathered						
17.00														
18.00		C												
19.00		UD 18.50 1 18.80m												
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

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GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-3
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	08.05.2015
GROUND LEVEL	0,50 m		**DATE COMPLETED**	08.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	6.80 m
COORDINATES	**X**	642652		
	Y	3947495		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00														
2.00		SPT 1.50 1 1.95m	18	16	14	30		Yellowish cream, Highly weathered SANDSTONE (0.00-4.00m)			IV			12
3.00		SPT 3.00 2 3.45m	14	18	16	34								
4.00														
5.00								Yellowish cream, weak, Slightly weathered SANDSTONE (4.00-8.00m)		II	II			14
6.00		C												
7.00														
8.00								Grey, Conglomerate (8.00-8.50 m)						
9.00		SPT 9.00 3 9.45m	12	16	28	44		Brown, Hard Sandy Silt (8.50-12.20m) sometimes very weak levels						
10.00														
11.00		C												
12.00														
13.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	EB-3
PAGE NO	2/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	08.05.2015
GROUND LEVEL	0,50 m		**DATE COMPLETED**	08.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	6.80 m
COORDINATES	**X**	642652		
	Y	3947495		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00		UD 1 13.50 13.80m						Greenish grey, lamella, moderately weathered, weak, Hard MARL (12.20-20.00m)		II	III			
15.00														
16.00														
17.00		C						Core very fractured, sometimes very weak and moderately weathered						
18.00														
19.00		UD 2 19.00 19.50m												
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)

I	Very weak (1-5 MPa)
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)

WEATHERING

I	Fresh
II	Slightly weathered
III	Moderately weathered
IV	Highly weathered
V	Completely weathered
VI	Residual soil

FINE GRAINED

N=0-2	Very soft
N=3-5	Soft
N=6-9	Firm
N=10-16	Stiff
N=17-30	Very stiff
N >30	Hard

COARSE GRAINED

N=0-4	Very loose
N=4-10	Loose
N=10-30	Medium dense
N=30-50	Dense
N >50	Very dense

Rock Quality Designation (RQD)

0-25	%	Very poor
25-50	%	Poor
50-75	%	Fair
75-90	%	Good
90-100%		Excellent

FRACTURE INDEX/m

<1	Wide	W
1-2	Moderate	M
2-10	Close	Cl
10-20	Intense	I
>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	SB-1
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY	**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia	**DATE COMMENCED**	12.05.2015
GROUND LEVEL	0,30 m	**DATE COMPLETED**	12.05.2015
BOREHOLE DEPTH	20.00 m	**GROUNDWATER LEVEL**	3.70 m
COORDINATES	X 642659		
	Y 3947482		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00								Concrete (0.00-2.70 m)						
2.00														
3.00								Yellowish brown, slightly weathered some levels moderately weathered SANDSTONE (2.70-5.00m)			II			32
4.00														
5.00											III			
6.00		SPT 6.00 1 6.45m	15	13	14	27		Greenish grey, lamella,moderately weathered, MARL (5.00-6.00m) Core very fractured,sometimes very weak and moderately weathered						
7.00								Yellowish, dark grey, Medium dense SAND (6.00-7.00 m)						
8.00														
9.00														
10.00								Greenish grey, lamella, moderately weathered, MARL (7.00-20.00m) Core very fractured, sometimes very weak and moderately weathered			III			
11.00														
12.00														
13.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

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GEOTEST
Zemin Kaya ve Yapı Malzemeleri Laboratuvarı

GEOTEST

BOREHOLE LOG

BOREHOLE NO	SB-1
PAGE NO	2/2

PROJECT		APOSTOLOS ANDREAS MONASTERY	BORING METHOD	Rotary core drilling
BOREHOLE LOCATION		Karpasia	DATE COMMENCED	12.05.2015
GROUND LEVEL		0,30 m	DATE COMPLETED	12.05.2015
BOREHOLE DEPTH		20.00 m	GROUNDWATER LEVEL	3.70 m
COORDINATES	X	642659		
	Y	3947482		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00								Greenish grey, lamella, moderately weathered, MARL (7.00-20.00m) Core very fractured, sometimes very weak and moderately weathered			III			
15.00														
16.00														
17.00														
18.00														
19.00														
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	SB-2
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY	**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia	**DATE COMMENCED**	14.05.2015
GROUND LEVEL	0,30 m	**DATE COMPLETED**	14.05.2015
BOREHOLE DEPTH	20.00 m	**GROUNDWATER LEVEL**	3.80 m
COORDINATES	X 642657		
	Y 3947479		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00								Yellowish cream, Slightly weathered SANDSTONE (0.00-3.50m)			II			
2.00														
3.00														
4.00								Brown Hard Silty Clay (3.50-4.50m)						
5.00		SPT 1 4.50 4.65m	22	50/30		R								
6.00		SPT 2 6.00 6.10m	7	10	50/35	R								
7.00								Greenish grey, lamella, moderately weathered, Hard MARL (4.50-20.00m)						
8.00														
9.00		SPT 3 9.00 9.15m	20	50/30		R		Core very fractured, sometimes very weak and moderately weathered			III			
10.00														
11.00														
12.00														
13.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

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Zemin Kaya ve Yapı Malzemeleri Laboratuvarı

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BOREHOLE LOG

BOREHOLE NO	SB-2
PAGE NO	2/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	14.05.2015
GROUND LEVEL	0,30 m		**DATE COMPLETED**	14.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	3.80 m
COORDINATES	**X**	642657		
	Y	3947479		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00								Greenish grey, lamella, moderately weathered, Hard MARL (4.50-20.00m) Core very fractured, sometimes very weak and moderately weathered			III			
15.00														
16.00														
17.00														
18.00														
19.00														
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

GEOTEST

BOREHOLE LOG

BOREHOLE NO	SB-3
PAGE NO	1/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	07.05.2015
GROUND LEVEL	0,50 m		**DATE COMPLETED**	07.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	6.80 m
COORDINATES	**X**	642651		
	Y	3947495		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
1.00								Yellowish cream, Slightly weathered SANDSTONE (0.00-5.50m)			II			48
2.00														24
3.00														
4.00														
5.00														
6.00								Brown Hard Sandy Silt (5.50-10.00m)						
7.00														
8.00		SPT 1 7.50 7.95m	10	14	32	46								
9.00														
10.00		SPT 2 10.00 10.15m	32	50/30		R		Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weathered						
11.00														
12.00														
13.00		SPT 3 13.00 13.30m	25	50/30		R								

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

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Zemin Kaya ve Yapı Malzemeleri Laboratuvarı

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BOREHOLE LOG

BOREHOLE NO	SB-3
PAGE NO	2/2

PROJECT	APOSTOLOS ANDREAS MONASTERY		**BORING METHOD**	Rotary core drilling
BOREHOLE LOCATION	Karpasia		**DATE COMMENCED**	07.05.2015
GROUND LEVEL	0,50 m		**DATE COMPLETED**	07.05.2015
BOREHOLE DEPTH	20.00 m		**GROUNDWATER LEVEL**	6.80 m
COORDINATES	**X**	642651		
	Y	3947495		

Depth (m)	Water Table	Samples	STANDART PENETRATION TEST: Number of Blows 0-15 cm	15-30 cm	30-45 cm	N	Graph 10 20 30 40 50	GEOTECHNICAL DESCRIPTION	LEGEND	Strength	Weathering	Fracture Index/m	Core Recovery %	RQD %
14.00								Greenish grey, lamella, moderately weathered, Hard MARL (10.00-20.00m) Core very fractured, sometimes very weak and moderately weathered						
15.00														
16.00														
17.00														
18.00														
19.00														
20.00								*END OF BOREHOLE 20.00m*						
21.00														
22.00														
23.00														
24.00														
25.00														
26.00														

STRENGTH (Rocks)		WEATHERING		FINE GRAINED		COARSE GRAINED	
I	Very weak (1-5 MPa)	I	Fresh	N=0-2	Very soft	N=0-4	Very loose
II	Weak (5-25 MPa)	II	Slightly weathered	N=3-5	Soft	N=4-10	Loose
III	Moderately strong (25-50 MPa)	III	Moderately weathered	N=6-9	Firm	N=10-30	Medium dense
IV	Strong (50-100 MPa)	IV	Highly weathered	N=10-16	Stiff	N=30-50	Dense
V	Very strong (100-250 MPa)	V	Completely weathered	N=17-30	Very stiff	N >50	Very dense
VI	Extremely strong (>250 Mpa)	VI	Residual soil	N >30	Hard		

Rock Quality Designation (RQD)		FRACTURE INDEX/m		
0-25 %	Very poor	<1	Wide	W
25-50 %	Poor	1-2	Moderate	M
50-75 %	Fair	2-10	Close	Cl
75-90 %	Good	10-20	Intense	I
90-100%	Excellent	>20	Crushed	Cr

SPT : Standart penetration test
N : Standart penetration resistance
D : Disturbed sample
UD : Undisturbed sample
C : Core sample
X : X-ray diffraction sample

Drilling Engineers : Naim KORKMAZCAN
Samiye İNCE

Signature:

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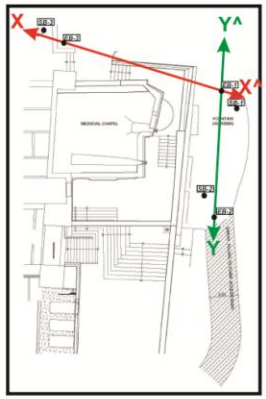
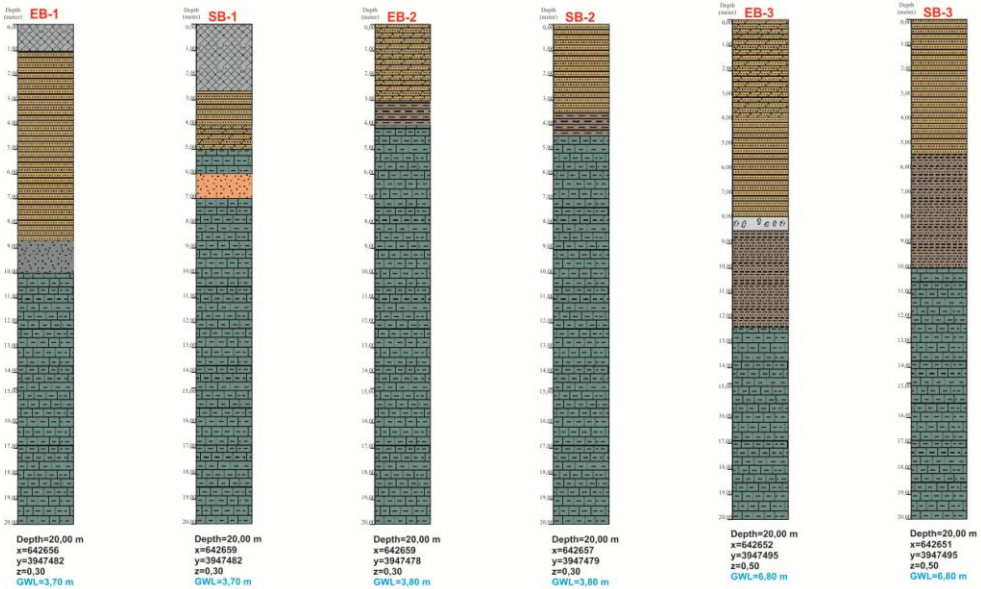
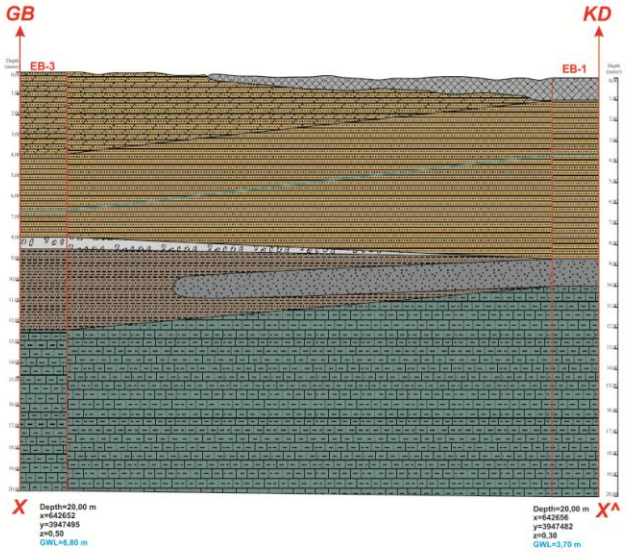
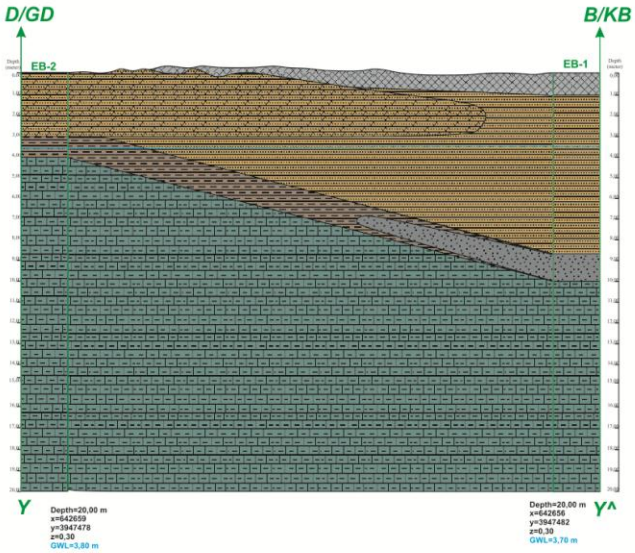
Dr. Küçük Bülent Hamitköy Karaoğlu Yeşiyurt Arkası Yaz Sokak D:1 Lefkoşa, Mersin 10 – TÜRKİYE
Tel: 0392 223 7547 Faks: 0392 223 7547 Cep: 0533 863 8101 e-mail:mastermap2005@hotmail.com

APOSTOLOS ANDREAS MONASTERY BOREHOLE LOGGING AND GEOLOGICAL SECTIONS









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Unscaled

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PROJECT	APOSTOLOS ANDREAS MONASTERY	
MASTERMAP LTD. ŞTİ GEOTEST Zemin Kaya ve Yapı Malzemeleri Laboratuvarı		
DATE OF WORK	APRIL 2015	
NAME-SURNAME	JOB	SIGNATURE
PREPARE OF LOG Naim KORKMAZCAN Samiye İNCE	 Mhs. Geo. Eng. Mhs. Geo. Eng.	
Abdulkadir KANIK	Driller	

MASTERMAP LTD. ŞTİ GEOTEST Zemin Kaya ve Yapı Malzemeleri Laboratuvarı

Iskele District - Dipkarpaz Municipality

APOSTOLOS ANDREAS MONASTERY – MEDIEVAL CHAPEL

REFURBISHMENT PROJECT

Dipkarpaz

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

Engineer : Ali Çağlar (UNDP)
Engineer Representative: Cem Taneri (UNDP)
Project Manager : Yakup Tel (Telza-Fixico)
Site Architect : Ahmet Işıman
Site Engineer : Pieris Hadjipieris
Geology Engineers : Naim Korkmazcan - Samiye İnce

COMPANY DETAILS OF BOREHOLING AND FIELD / LAB. TESTS IMPLEMENTATION

NAME	:	GEOTEST Ltd. Şti. "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

Dipkarpaz

APOSTOLOS ANDREAS MONASTERY

REPORT DATE AND REPORT SUBMIT COMISSION

CHAMBERS OF CIVIL ENGINEERS
June 2015

CONTENTS

APPENDIX

FIGURE LIST

TABLE LIST

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

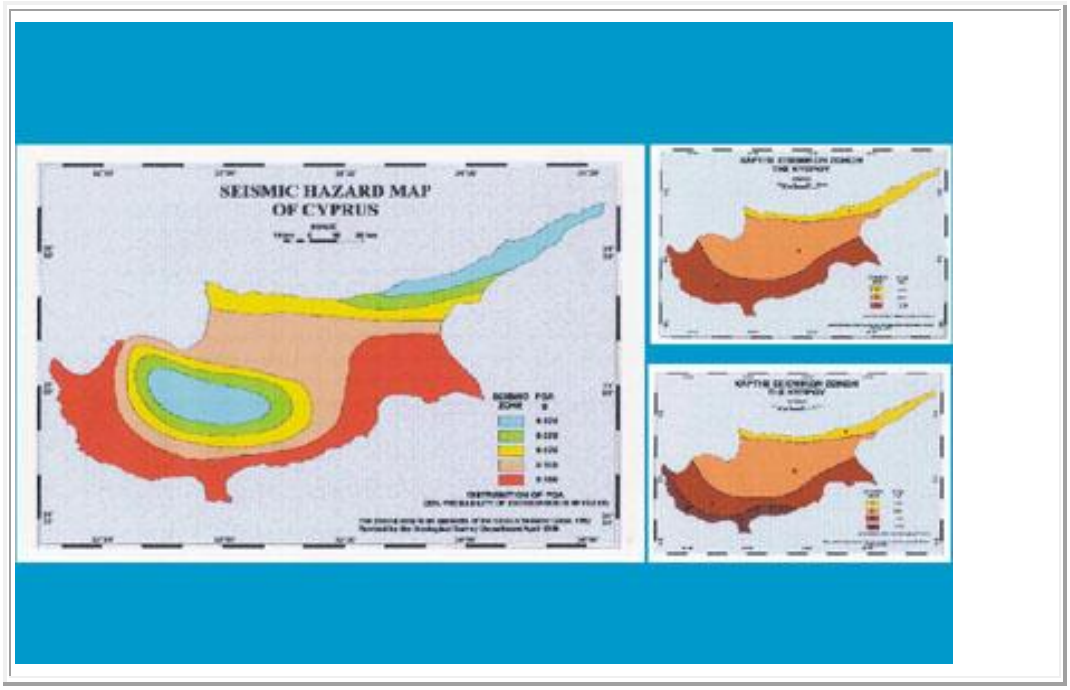

Figure 2.1- Cyprus seismic risk maps

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.

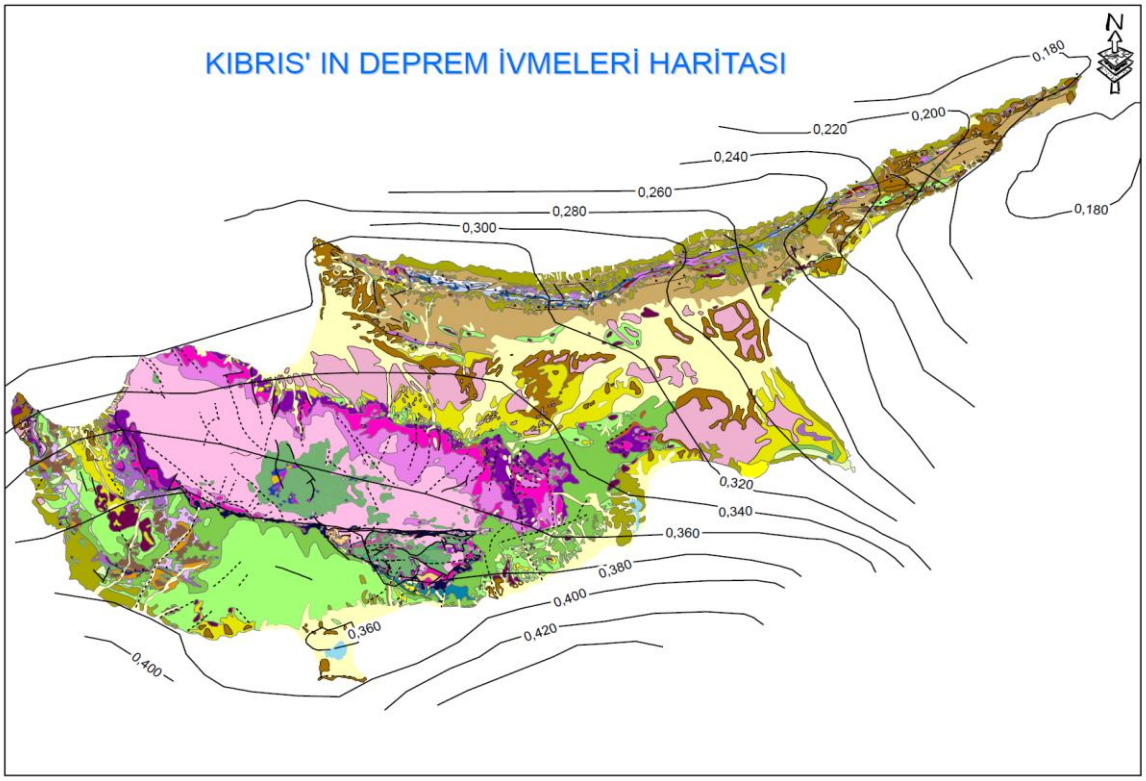

Figure 2.2: Seismic Acceleration Map

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	Coordinates		Borehole depth (m)
	To the Right (X)	To the Up (Y)	
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
EB-1	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
	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

Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
EB-2	3.00	50	0.75	60.72	1.26	45	28.1	35.3
	4.50	50	0.85	84.21	1.07	45	31.9	34.0
	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

Borehole No	Depth (m)	Field SPT-N Value	Stem Lenght Cor. (Nt)	Effective Stress σ' (Kpa)	Cor. Factor (Cn)	Energy Ratio (%)	N60	(N1)60
EB-3	1.50	30	0.75	30.02	1.79	45	16.9	30.1
	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
Groundwater 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 **$h_1 \leq$ 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.

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

In here;

qf=Bearing capacity of shallow foundation (Ton/m^2), γ =Unit Weight of Soil (Ton/m^3),

c= Cohesion (Ton/m^2),

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.

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

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

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

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)

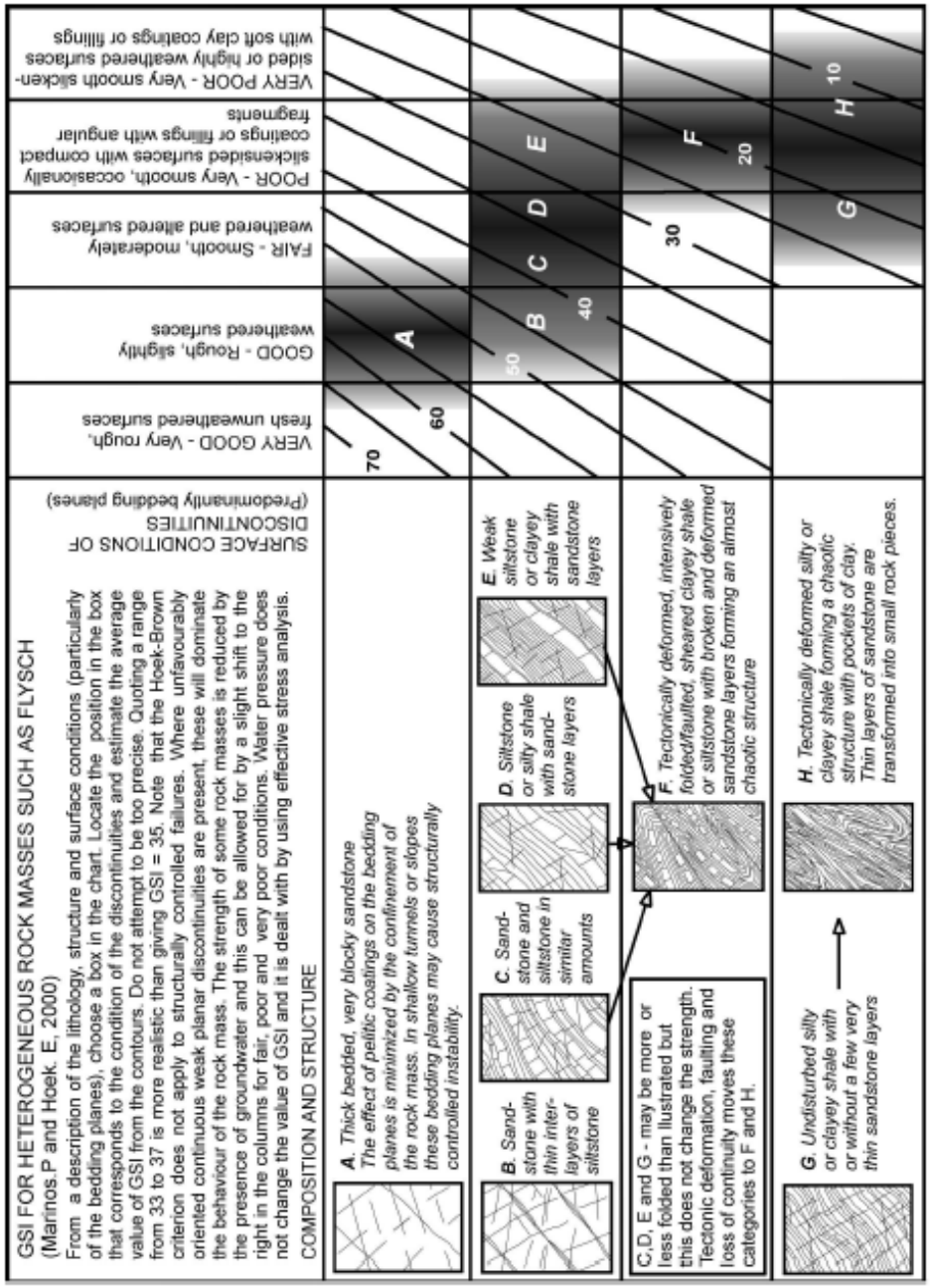

Table 5.2.2.2: Determination of GSI Value respect to Geological Definition

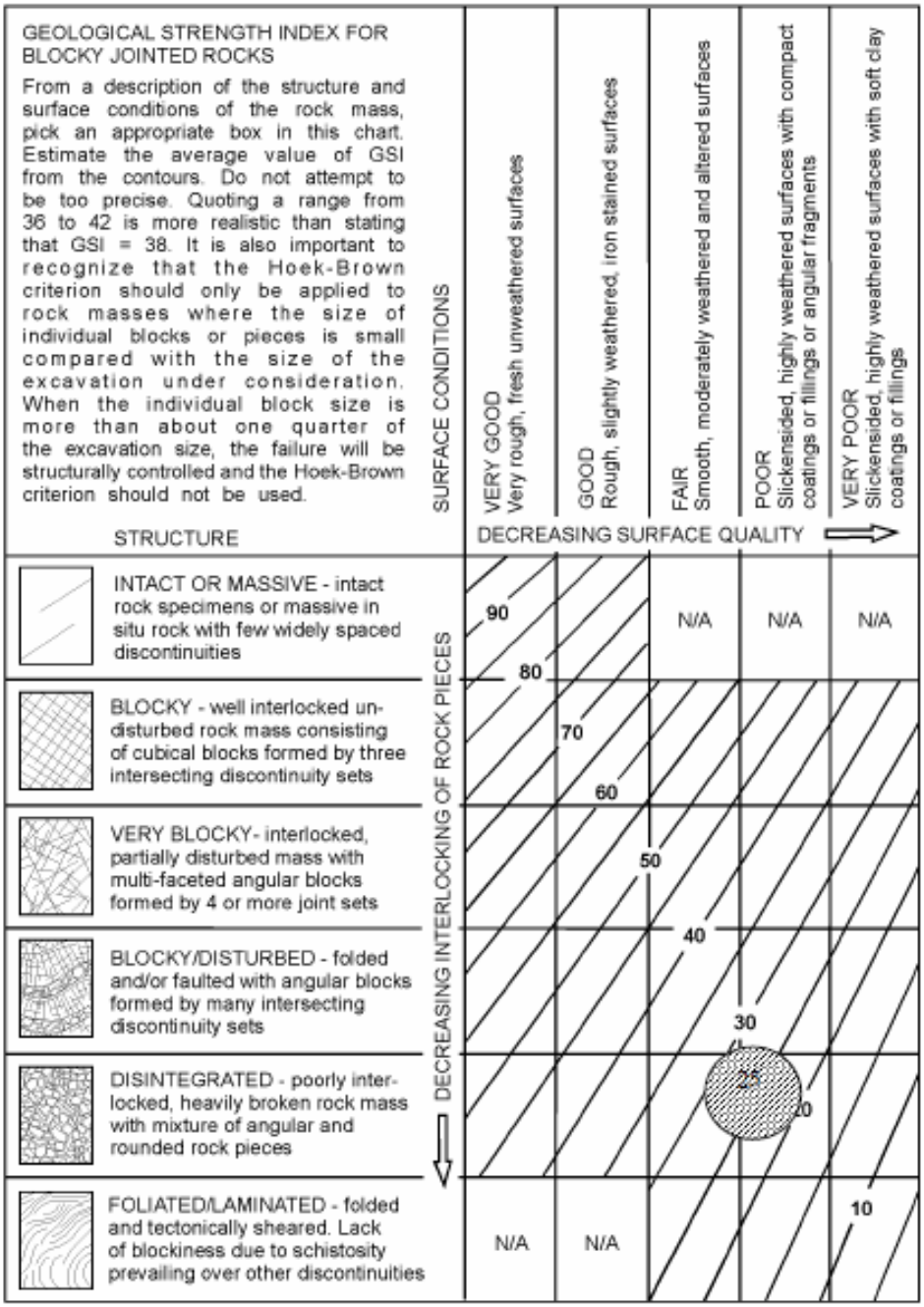

Table 5.2.2.3: "mi" Constant Values for Rock Groups

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	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)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestones (10 ± 2)	Micritic Limestones (9 ± 2)	Dolomites (9 ± 3)
		Evaporites		Gypsum 8 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4) Metasandstone (19 ± 3)	Quartzites 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolites 26 ± 6		
	Foliated**		Gneiss 28 ± 5	Schists 12 ± 3	Phyllites (7 ± 3)	Slates 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	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=20….25 $I_{s(50)}$
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,

σci = 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 ≤ F < 1.20; Soil Liquefaction risk is present.

IF 1.20 ≤ 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.

$$CSR = 0.65 \times r_d \times \frac{\sigma_v}{\sigma'_v} \times \frac{a_{max}}{g}$$

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

GEOTECHNIC CALCULATIONS SUMMARY

****

1. Investigation area is **3rd degree** earthquake region.
2. Soil Group is **(C)**
3. Local Soil Category is **(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 ≈ **42.38 T/m^3**
   Sandy-Silty CLAY ≈ **9.46 T/m^3**
   MARL ≈ **10.15 T/m^3**
8. Factor of Safety against Soil Liquefaction
   F=1.52

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REFERENCES:

1. BELL, F.G. (1985) "*Engineering Properties of Soils and Rocks*", 2nd Edition, Butterworths, England

2. BOWLES, J.E. (1996) "*Foundation Analysis and Design*", 5th Edition, McGraw-Hill

3. CANADIAN GEOTECHNICAL SOCIETY (1985) "*Foundation Engineering Manual*", 2nd Edition

4. CARTER, M. & BENTLEY, S.P. (1991) "*Correlations of Soil Properties*",
Pentech Press Publishers, London

5. CODUTO, D.P. (2001) "*Foundation Design - Principles and Practices*", 4th Edition, PWS Publishing

6. DAS, B.M. (1998) "*Principles of Foundation Engineering*", 4th Edition, PWS Publishing

7. EPRI (1990) "*Manual on Estimating Soil Properties for Foundation Design*"

8. FHWA Manual (1997) "*Subsurface Investigations"*

9. HUNT, R.E. (1986) "*Geotechnical Engineering Analysis & Evaluation*", McGraw-Hill

10. INTERIM Specifications (1995) "*Specifications"*, 15th Edition, AASHTO

11. **Geoteknik Tasarım Esasları (2007)** T.C. Ulaştırma Bakanlığı DLH Genel Müdürlüğü

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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

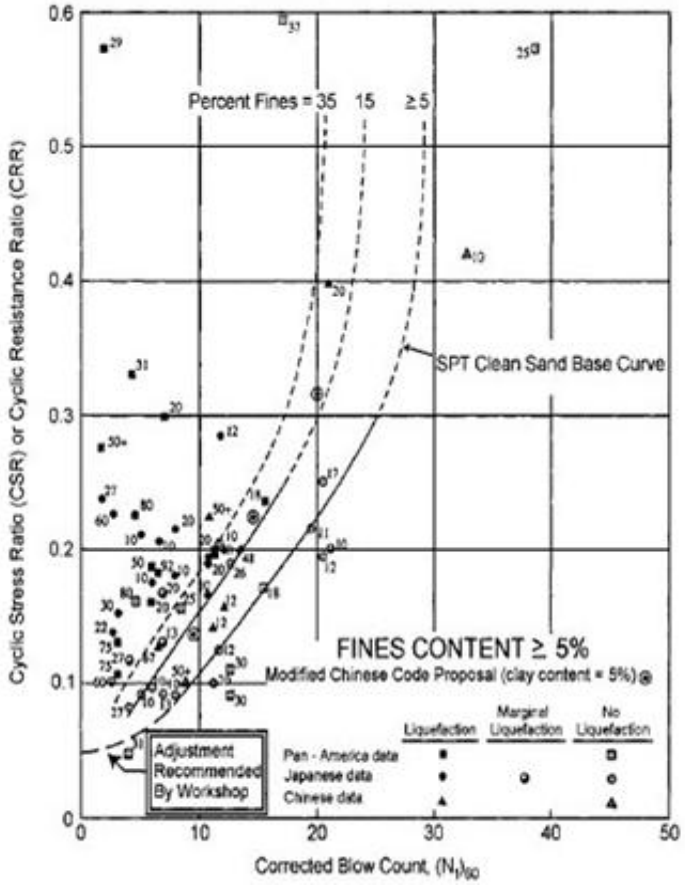
EB-1 (Calculation for Critical Layer at 9.50 m depth)

Liquefaction Resistance (CRRm):

$CRR_m = K_m \times K_{pl} \times CRR_{7.5}$

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)

$CRR_{7.5}$ = **0.180**

(Read from the Graph)

M = 6.0 (Design Magnitude Earthquake) → (Earthquake Correction Factor) K_m = **1.32** (Obtained from the correlation)

wl = 0.0 (Liquid Limit)

wp = 0.0 (Plastic Limit)

Ip = 0.0 (Plasticity Index) → (Plasticity Correction Factor) K_{pl} = **1.00** (Obtained from the correlation)

CRR_m = 0.237 (Liquefaction Resistance)

Cyclic Stress Ratio in Earthquake Condition (CSR):

$CSR = 0.65 \times r_d \times \frac{\sigma_v}{\sigma'_v} \times \frac{a_{max}}{g}$

If;

Z < 9.15 m	→	**$r_d = 1 - 0.00765 \times Z$**
9.15 m ≤ Z < 23 m	→	**$r_d = 1.174 - 0.0267 \times Z$**
23 m ≤ Z < 30 m	→	**$r_d = 0.744 - 0.0082 \times Z$**
30 m ≤ Z	→	**$r_d = 0.5$**

(Soil Ductility Correction Factor)

Z =	9.50	m	(Depth)	→	**r_d =**	**0.920**
σ_v =	183.35	Kpa	(Total Vertical Stress)			
σ'_v =	126.45	Kpa	(Total Effective Vertical Stress)			
a_{max} =	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)

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

Eğer;

F < 1.00	→	**Soil Liquefaction is expected**
1.00 ≤ F < 1.20	→	**Soil Liquefaction risk is present**
1.20 ≤ F	→	**Soil Liquefaction is not expected**

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

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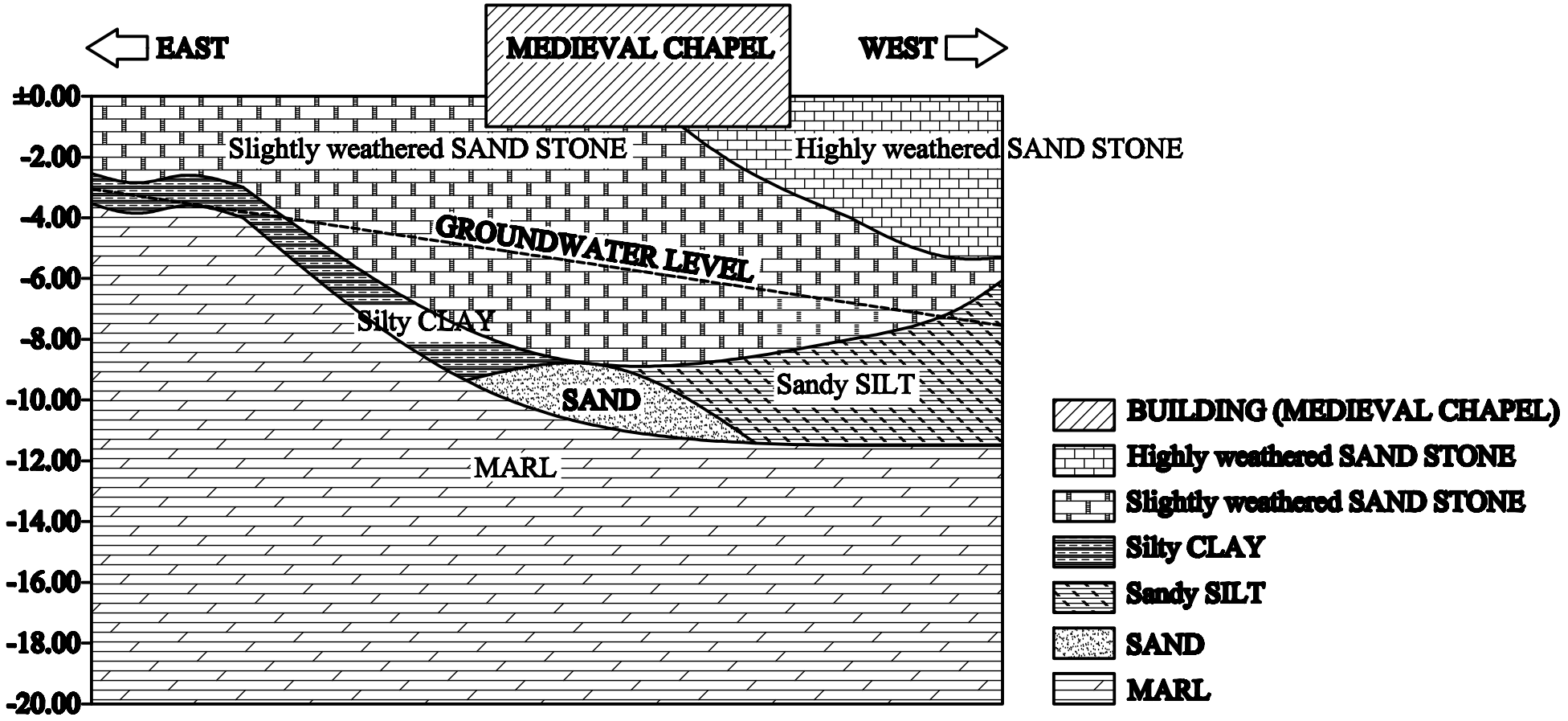

STRATIFICATION OF SOIL LAYERS
SCALE: 1/200