資料 7-2　土質調査結果

Ministry of Constructing & Housing
National Center for Research & Construction Labs.

Soil Investigation

For

1. **North Samawah Bridge**
2. **Hillal Bridge**
3. **Majid Bridge**
4. **Mardi Bridge**
5. **Daraji Bridge**

BAGHDAD
NOVEMBER / 2004

SOIL INVESTIGATION SITES

(1) North Samawah Bridge
(2) Hillal Bridge
(3) Majid Bridge
(4) Mardi Bridge
(5) Daraji Bridge

ABBREVIATIONS

C	Cohesion in kN/m^2
C.I.	Unconfined Compressive Strength.
C.P. %	Collapse Potential
C_c	Compression Index.
CL %	Chloride Content
CPT	Water Table. Moisture Content. Liquid
C_r	Swelling Index
Cv	Coefficient of Consolidation
D	Disturbed Sample.
e_o	Initial Void Ratio
GS	Cohesion in kN/m^2. Angle of Internal
Gyp %	Gypsum Content
K	Coefficient of Permeability
L.S	Weight.
LL	Specific Gravity.
M.C	Linear Shrinkage. Consistency Index
Ø	Angle of Internal Friction.
ORG %	Organic Matter.
P.1	Natural Unite Weight Dry Unite
P.L	Unified Soil Classification System.
pc	Reconsolidation Pressure
PH	Acidity or Alkalinity
Po	Overburden Pressure
Ps	Swelling Pressure
qu	Unconfined Compressive Strength.
SO_3 %.	Sulphate Content
SPT (N-Value)	Dynamic Cone Penetration Test
SS	Standard Penetration Test Value.
T.S.S	Total Soluble Salts
U	Undisturbed Sample.
Uni. Class.	Friction. Initial Void Ratio.
W.T	Limit. Plastic Limit Plasticity Index
γdry	Dry Unite Weight
γwet	Natural Unite Weight

REPORT NO. 1/1/46/2004-BAGHDAD

North Samawah Bridge

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North Samawah Bridge

Contents

REPORT NO. 1/1/46/2004-BAGHDAD

North Samawah Bridge

1- INTRODUCTION

1-1 Authorization and Scope

The soil investigation for this project has been conducted by the Directorate of Soil Investigation / National Centre for Research & Construction Laboratories (NCCLR) - Baghdad according to the contract with "The Engineering House Group "dated at 271 9 /2004.

The sol investigation described in this report consists of drilling the boreholes, securing representative samples, testing these samples and analyzing the soil conditions with test results.

1-2 Site Location and Description

The project is located at Al-Muthanna governorate, in Samawah city specifically on Euphrates River. The locations of the drilled boreholes are not similar in level.

2- FIELD EXPLORATION

2-1 Drilling and Sampling

Drilling was done using flight auger. The drilling rig used is of (Acker) type, which is a power driven machine. The diameters of drilled boreholes were (15.0) cm. The disturbed sample (D) were collected from the cutting of auger at any depth. The undisturbed samples marked (U) were obtained using Shelby tubes. Split spoon samples (SS) were obtained from standard split spoon used in a Standard.

Penetration Test (S.P.T), which was performed for every test boring at different intervals depending on the stratification of the soil.

The actual depth for all samples and the N-Values for S.P.T. are shown in the record of test results sheet of this report.

2-2 Number of Boreholes

Two boring points were assigned and located by the concerned authorities at the locations of abutments (one borehole at each river bank). These boring points were drilled by (NCCL) to a depth of (30.0) m. below N.G.S. The locations of these boreholes are marked on the site plan at (Fig.1)

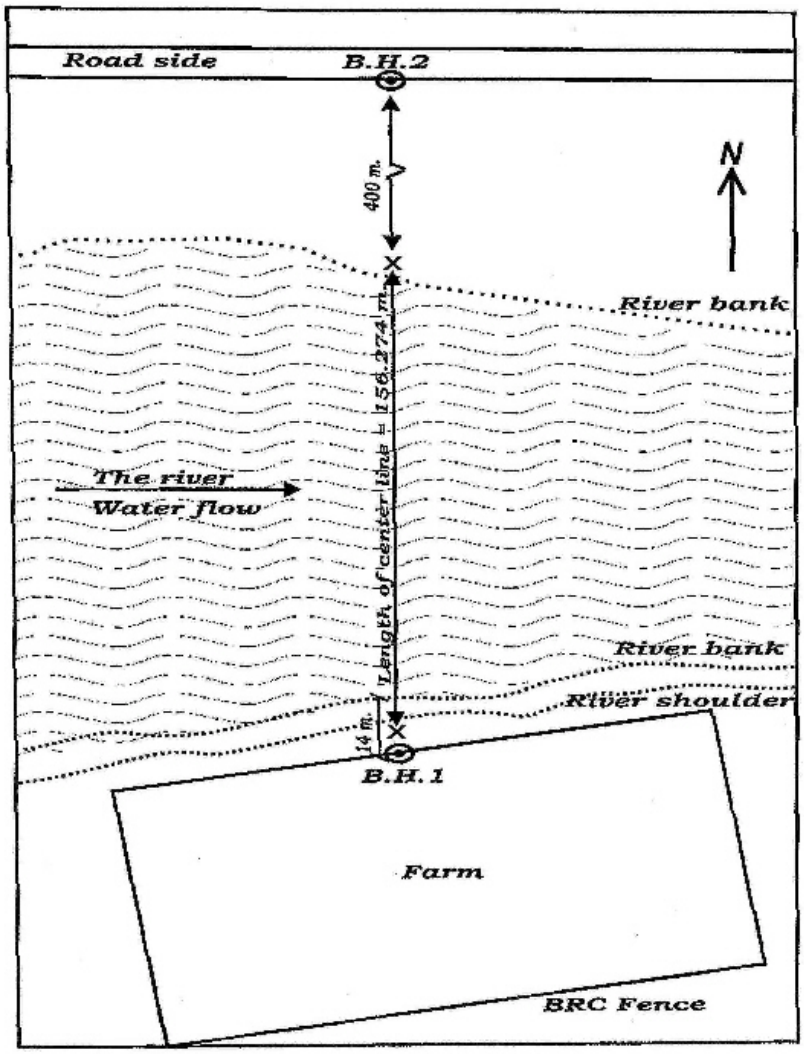

Fig. 1: Site plan for borehole locations

3- LABORATORY TESTING

Each of the soil samples received by the laboratories of the Directorate of Soil Investigations Baghdad was given a laboratory number.

The samples of the borehole were visually examined for initial classification before laboratory testing.

The test program was decided by the soil engineer. The actual test proposed for a particular sample depends on the type of sample (S.S, U & D) and the nature of its material.

A full list of tests conducted for this project is:

A - Classification Tests

- Atterberg limits (L.L, P.L).
- Grain size analysis (sieve and hydrometer analysis).
- Linear shrinkage limits (L.S).
- Unit weight (natural and dry).
- Natural moisture content.

B - Strength and Deformation Tests

- Unconfined compression strength.
- Triaxial compression test.
- Direct shear test "Consolidation test.

C - Chemical Tests

- Sulphate content (SO_3%).
- Chloride content (Cl %).
- Gypsum content (GYP %).
- PH value.
- Calcium carbonate ($CaCo_3$ %).
- Organic matter (ORG%).

The results of these tests are shown in the Record of "Tests Result sheet" appended,

4- SUBSOIL STRATIFICATION

4-1 Soil Pro file

According to the unified soil classification system (USCS), the subsoil profile for each borehole location can be summarized as follows: -

Borehole No.1 Location

- The upper soil layer consists of medium to hard brown - grey or light green lean or fat clay (CL, CH) change to silt or elastic silt (ML, MH). This layer extends from natural ground surface (N.G.S) down to a bout (19.0) m.

  Through this layer a thin layer of medium light green sand with silt or silty sand is observed from (10.5) m. to (13.0) m. depth.

- The second soil layer consists of very dense grayish blue or light brown silty sand (SM). This layer is observed below the above layer and extends to (26.0) m.

- The last soil layer consists of hard light green lean clay with sand or silty clay with sand (CL, CL-ML). This layer extends below the above layer down to the end of boring at (30.0) m. depth,

Borehole No.1 Location

- The upper soil layer is a fill layer, which consists of a mixture of (silt, sand, clay).This layer extends from existing ground surface down to about (2.0) m.
- The second soil layer consists of stiff to hard brown or green lean or fat clay (CL, CH). This layer is observed below the above layer and extends to about (9.0) m.
- The last soil layer consists of dense to very dense light green silty sand or sand with silt to silty clayey sand (SM, SP-SM, SC-SM). This layer extends below the above layer down to the end of boring at (30.0) m.

  Through this layer a thin layer of hard light brown highly gypseous lean clay (CL) is observed from (19.75)m. to (21.0)m. depth.

Details of soil stratification for each borehole are shown at the "Borelogs" appended.

4-2 Underground Water Level

The underground water level was encountered at a depth of (2.65) m. at the location of borehole No.1 and at a depth of (3.65) m. at the location of borehole No.2 below natural ground surface (N.G.S) after 24 hours from drilling termination at the time of boring (October /2004). This level may fluctuate during the coming season due to the fluctuation of water level in the Euphrates River.

5- EVALUATION AND DISCUSSION OF RESULTS

5-1 Strength of the Soil

- For the cohesive soil layer, the results of the unconfined and triaxial compression tests as well as the number of standard penetration test (S.P.T) indicate that the consistency of the cohesive soil layer is medium to hard for B.H.I site location, and stiff to hard for B.H.2, site location. The results of the unconfined and triaxial compression tests as well as the results of natural and dry densities are shown in Table (1).

Table 1: Unconfined and Triaxial test results with depth

B.H No.	*Depth (m)*	*Qu (kN/m²)*	*Triaxial Test*		*γwet (kN/m³)*	*γdry (kN/m³)*
			Cu (kN/m²)	*Ø u Degree*		
1	1.5 - 2.0	-	135	2	20.8	18.0
	3.5 - 4.0	99	-	-	19.2	15.3
	7.0 - 7.5	-	71	6	19.9	15.9
2	2.5 - 3.0	250	-	-	18.0	15.0
	6.0 - 6.5	-	131	3	19.0	15.3
	8.0 - 8.5	133	-	-	19.2	15.2

- For the cohesioless soil layer, the results of direct shear test (C, 0) and number of blows of standard penetration test (S.P.T) indicate that the relative density of this soil is medium to very dense for B.H.1 site location and dense to very dense for B.H.2 site location.

  The results of the direct shear test results with the initial wet and dry densities at test condition are shown in Table (2).

Table 2: Unconfined and triaxial test results with depth

B.H No.	*Depth (m)*	*C (kN/m²)*	*Ø Degree*	*γwet (kN/m³)*	*γdry (kN/m³)*
1	10.5 - 11.0	0	46	19.4	17.6
	25.0 - 25.5	0	40	16.6	13.6
2	13.5 - 14.5	0	39	19.4	16.7
	15.0 - 16.0	0	28	19.4	16.1
	21.0 - 22.0	0	28	19.4	17.1
	23.5 - 24.0	0	37	19.4	16.8

5-2 Consolidation Test Results

The variations of overburden (Po), preconsolidation (Pc) & swelling (Ps) pressures with depth, which are shown in Table (3), indicate that the cohesive soil layer at the two locations is in general is over consolidated. Other consolidation parameters are also shown.

Table 3: Consolidation parameters with depth

B.H No.	*Depth (m)*	*Po (kN/m²)*	*Pc (kN/m²)*	*Ps (kN/m²)*	*Void Ratio e_o*	C_c	C_r
1	3.5 - 4.0	61	170	-	0.724	0.18	0.036
	7.0 - 7.6	96	170	-	0.692	0.18	0.037
2	2.5 - 3.0	50	230	30	0.554	0.11	0.228
	6.0 - 6.5	89	230	-	0.764	0.21	0.069
	8.0 - 8.5	107	390	-	0.537	0.19	0.032

5-3 Chemical Properties

The results of the chemical tests for soil and water samples are shown in the Test Results Sheet". The results in general indicate slight sulphate content except some locations at each borehole which indicate high sulphate content (at a depth (14.75 - 15.5m.) for borehole No. 1 site location and at a depth of (19.75-21.0) m. for borehole No.2 site location). The sulphate content in general varies from (0.1) to (3.22) percent. The PH value varies from (7.36) to (8.44).

The chloride content varies from (0, 07) to (0, 83) percent. The calcium carbonate content varies from (7.5) to (50.0) percent.

5-4 Atterberg limits Test Results

The values of liquid limit (L.L), plasticity index (P.I.) and moisture content (M.C.) at different depths are shown in the "Record of test result sheets "and "borehole logs" appended.

The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit for both site locations.

6- CONCLUTION & RECOMMENDATIONS

6-1 Type of Footing

For abutments location, piled foundation should be used of reinforced concrete large diameters bored piles of (1.0, 1.5) m. in diameter arranged as in the single and double structure groupings.

6-2 Depth of Footings

It is necessary to take into consideration the scour depth in order to specify the depth of pile cap otherwise the top of the cap of piles should be at least (2) m, below N.G.L at each boring point in order to minimize the scour effect of water against the footing during the flooding time.

6-3 Length of Piles

Due to the difference in nature and strength of the soil strata as well as the difference in ground level the tips of piles are placed in different levels. Table 4. Shows the pile tip depth below the ground level at each borehole location.

Table 4: Depth of pile below the ground level

B.H No.	Depth of pile tip below the ground elevation
1	20
2	16

6-4 Working Load per a Single Pile

For both single and group action of piles, each single pile should not be loaded a Working load of more than (300 or 500) tons for piles of (1.0 or 1.5) m. diameter respectively. The working load of piles are based on the strength of concrete cylinder (1:1,5:3) of 6" in diameter and 12" in height cured for 28.0 days in wafer giving a crushing strength of not less than 3000 psi.

6-5 Loading Test for Piles

Loading test should be performed in the site on a representative number of piles. The lower results in both the working load and the resulting settlement between our recommendation and the loading test results should be adopted.

6-6 Settlement

The maximum expected settlement under piles will be within permissible limits.

6-7 Type of Cement

- Sulphate resisting cement must be used for concrete works in touch with the soil.
- The amount of cement content is 420 kg/m^3.
- Maximum free water / cement ratio is 0.45 by weight.
- Vibrators should be used in order to density fresh concrete. -Minimum concrete cover of (7.5) cm is recommended to protect reinforcement from chlorides effect

6-8 Dewatering

During construction, the under ground water should be pumped out until the construction reaches ground level

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MINISTRY OF HOUSING & CONSTRUCTION — **PROJECT:- NORTH SAMAWA BRIDGE**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS — **B.H.No.:- 1**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N"	Symbol	Description of Soil	Chemical Tests						
Field No.	Lab No.		From m.	To m.	%	L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %		Val.			SO_3 %	T.S.S %	ORG %	GYP %	$CaCo_3$ %	PH	CL %
									Borehole No. 1					**Elev.=12.65m.**									
1	2487	D	0.0	1.5					(15	75	10	0)		--	CL	Brown lean clay							
2	2488	U	1.5	2.0	16	55	31							--	CH	Very stiff brown fat clay	0.65					8.09	0.44
3	2489	SS	2.0	2.5					(19	76	5	0)		23	CL	Very stiff brown lean clay							
4	2490	U	3.5	4.0	25	42	20							--	CL	Top: do(medium)							
															ML	*Bott: brown – grey silt*							
5	2491	SS	4.0	4.5					(2	85	13	0)		18	ML	Do(very stiff)	0.05				34.0		0.13
6	2492	SS	5.5	6.0		42	20							28	CL	Very stiff brown – grey lean clay							
7	2493	D	6.0	7.0					(18	42	40	0)		--	CL	Brown – grey sandy lean clay							
8	2494	U	7.0	7.5	25	57	36							--	CH	Stiff green fat clay							
9	2495	SS	7.5	8.0										42	CL	*Hard brown lean clay*	0.22					9.44	
10	2496	SS	9.0	9.5					(37	58	5	0)		46	CL	Do							
11	2497	D	9.5	10.5										--	CL	Do							
12	2498	U	10.5	11.0						(-7-	93	0)		--	SP-SM	Light green sand with silt	0.1				11.2		0.07
13	2499	SS	11.0	11.5										17	SP-SM	Do(medium)							
14	2500	SS	12.5	13.0						(-17-	83	0)		23	SM	Medium light green silty sand							
15	2501	D	13.0	14.5		56	21							--	MH	Grey elastic silt							
16	2502	SS	14.5	15.0					(35	57	8	0)		50/6"	CL	Top: Hard grey lean clay							
															CL	Bott: do(moderately gypseous)	3.91			18.58			
17	2503	D	15.5	16.0		43	25							--	CL	Light green lean clay							
18	2504	SS	16.0	16.5					(34	52	14	0)		50/6"	CL	Do(hard)	0.75				41.8		0.81
19	2505	SS	17.5	18.0										50/6"	CL	Do							
20	2506	SS	19.0	19.5										50/6"	CL	Top: do							
									(0	30	70	0)			SM	Bott:Very dense light brown silty sand							

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PROJECT:-NORTH SAMAWA BRIDGE

RECORD OF TEST RESULTS

B.H.No.:- 1

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests						
Field No.	Lab No.		From m.	To m.	%	L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	T.S.S %	ORG %	GYP %	$CaCo_3$ %	PH	Cl %
21	2507	SS	20.5	21.0										50/4"	SM	Do							
22	2508	SS	22.0	22.5					(0	35	65	0)		50/6"	SM	Very dense grayish blue silty sand	0.81				7.5	7.42	0.53
23	2509	SS	23.5	24.0										50/5"	SM	Do							
24	2510	SS	25.0	25.5										50/6"	SM	Do	3.22						
25	2511	D	26.0	26.5		36	16							--	CL	Light green lean clay							
26	2512	SS	26.5	27.0					(19	60	21	0)		50/6"	CL	Do(hard, with sand)	0.45				50.0	7.65	0.8
27	2513	SS	28.0	28.5										50/5"	CL	Do							
28	2514	SS	29.5	30.0					(11	72	17	0)		50/5"	CL-ML	Hard light green silty clay with sand							
29	2544	Water sample															0.24					7.36	0.29

Depth of ground water = 2.65 m. below N.G.S

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PROJECT:-NORTH SAMAWA BRIDGE

RECORD OF TEST RESULTS **B.H.No.:- 2**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests						
Field No.	Lab No.		From m.	To m.	%	L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	T.S.S %	ORG %	GYP %	$CaCO_3$ %	PH	CL %
									Borehole No. 2					**Elev.=11.537m.**									
1	2515	D	0.0	1.5					(9	81	10	0)		--		Fill layer of (silt,sand,clay)	2.21						
2	2516	SS	1.5	2.0										20		Do(very stiff)							
3	2517	U	2.5	3.0	16	40	16	8						--	CL	Very stiff brown loan clay	0.45			0.88		7.83	
4	2518	SS	3.0	3.5					(34	64	2	0)		40	CL	Do(hard)							
5	2519	D	3.5	4.5		53	32							--	CH	Brown fat clay							
6	2520	SS	4.5	5.0					(33	60	7	0)		16	CL	Very stiff brown lean clay							
7	2521	U	6.0	6.5	25	62	37							--	CH	Very stiff brown fat clay							
8	2522	SS	6.5	7.0					(23	76	1	0)		54	CL	Hard brown lean clay							
9	2523	U	8.0	8.5	27	53	36							--	CH	Stiff green fat clay	0.1		0.47		21.5		0.11
10	2524	SS	8.5	9.0										64	CH	Top: do (hard)							
										(-16-		84	0)		SM	Bott: very dense light green silty sand							
11	2525	D	9.0	10.0										--	SM	Do							
12	2526	SS	10.0	10.5						(-15-		85	0)	39	SM	Do(dense)	0.1				20.3		0.16
13	2527	SS	11.5	12.0										40	SM	Do							
14	2528	SS	13.0	13.5						(-6-		94	0)	42	SP-SM	Dense light green sand with silt							
15	2529	D	13.5	14.5										--	SP-SM	Do							
16	2530	SS	14.5	15.0						(-10-		90	0)	50/6"	SP-SM	Do (v.dense)							
17	2531	D	15.0	16.0										--	SC-SM	Light green silty clayey sand	0.25					8.15	
18	2532	SS	16.0	16.5					(5	28	67	0)		50/5"	SC-SM	Do(very dense)							
19	2533	SS	17.5	18.0										50/6"	SC-SM	Top: do							
										(-11-		89	0)		SP-SM	Bott : very dense light green sand with silt							
20	2534	SS	19.0	19.5										50/6"	SP-SM	Do	0.1						

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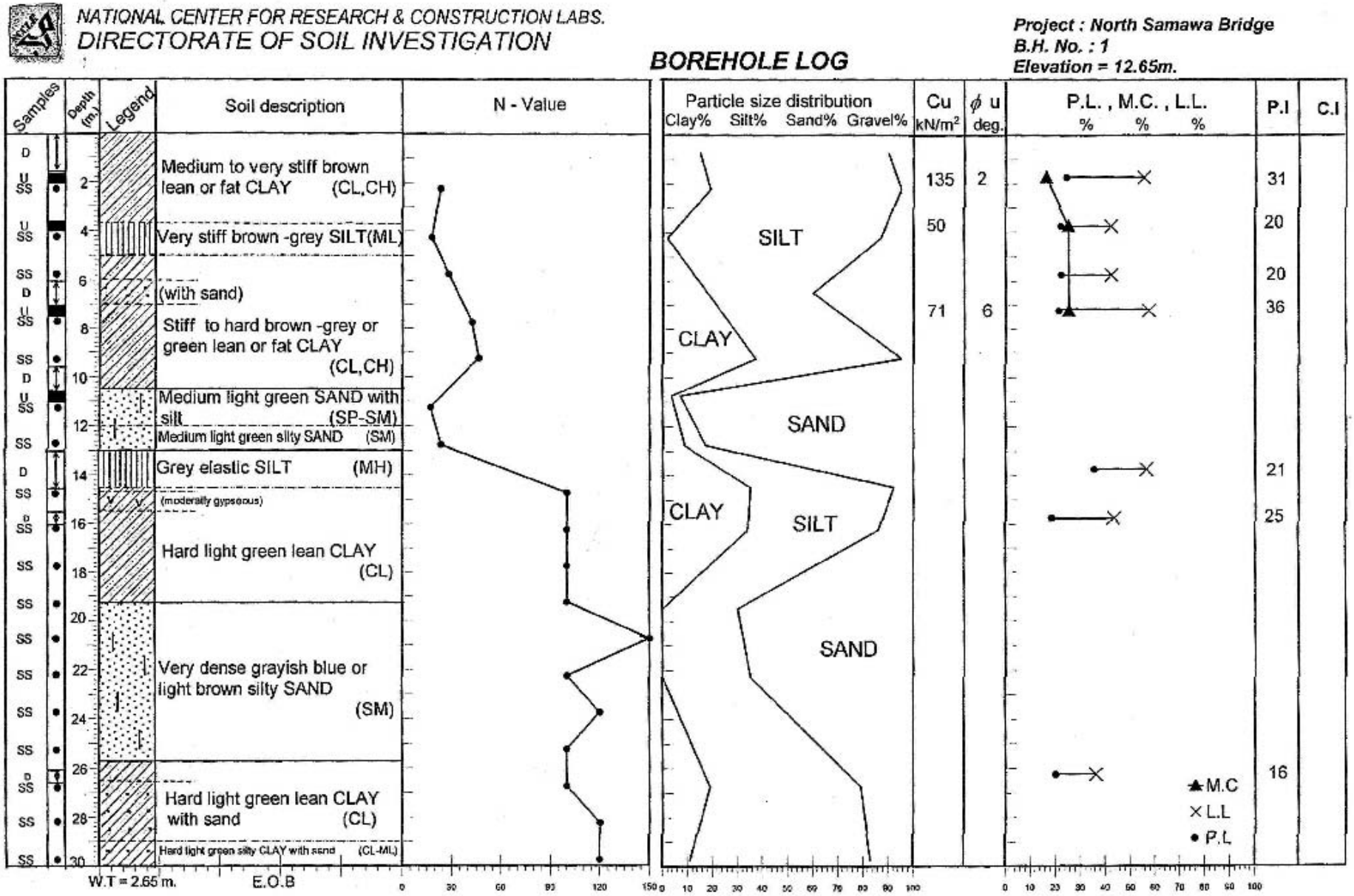
PROJECT:- NORTH SAMAWA BRIDGE

RECORD OF TEST RESULTS **B.H.No.:- 2**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests						
Field No.	Lab No.		From m.	To m.	%	L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	T.S.S %	ORG %	GYP %	$CaCo_3$ %	PH	CL %
21	2535	D	20.0	20.5		38	19							--	CL	Light brown highly gypseous lean clay							
22	2536	SS	20.5	21.0										50/5"	CL	Do (hard)	22.71			47.3			
23	2537	D	21.0	22.0										--	SP-SM	Light green sand with silt							
24	2538	SS	22.0	22.5					(-10-		90	0)		50/6"	SP-SM	Do(very dense)							
25	2539	SS	23.5	24.0										50/5"	SP-SM	Do							
26	2540	SS	25.0	25.5					(-9-		91	0)		50/4"	SP-SM	Do	0.1				16.0	8.3	0.12
27	2541	SS	26.5	27.0										50/6"	SP-SM	Do							
28	2542	SS	28.0	28.5					(-13-		87	0)		50/5"	SM	Very dense light green silty sand							
29	2543	SS	29.5	30.0										50/5"	SM	Do	0.1						
30	2545	Water sample															0.36					7.29	0.32

Depth of ground water = 3.65 m. below N.G.S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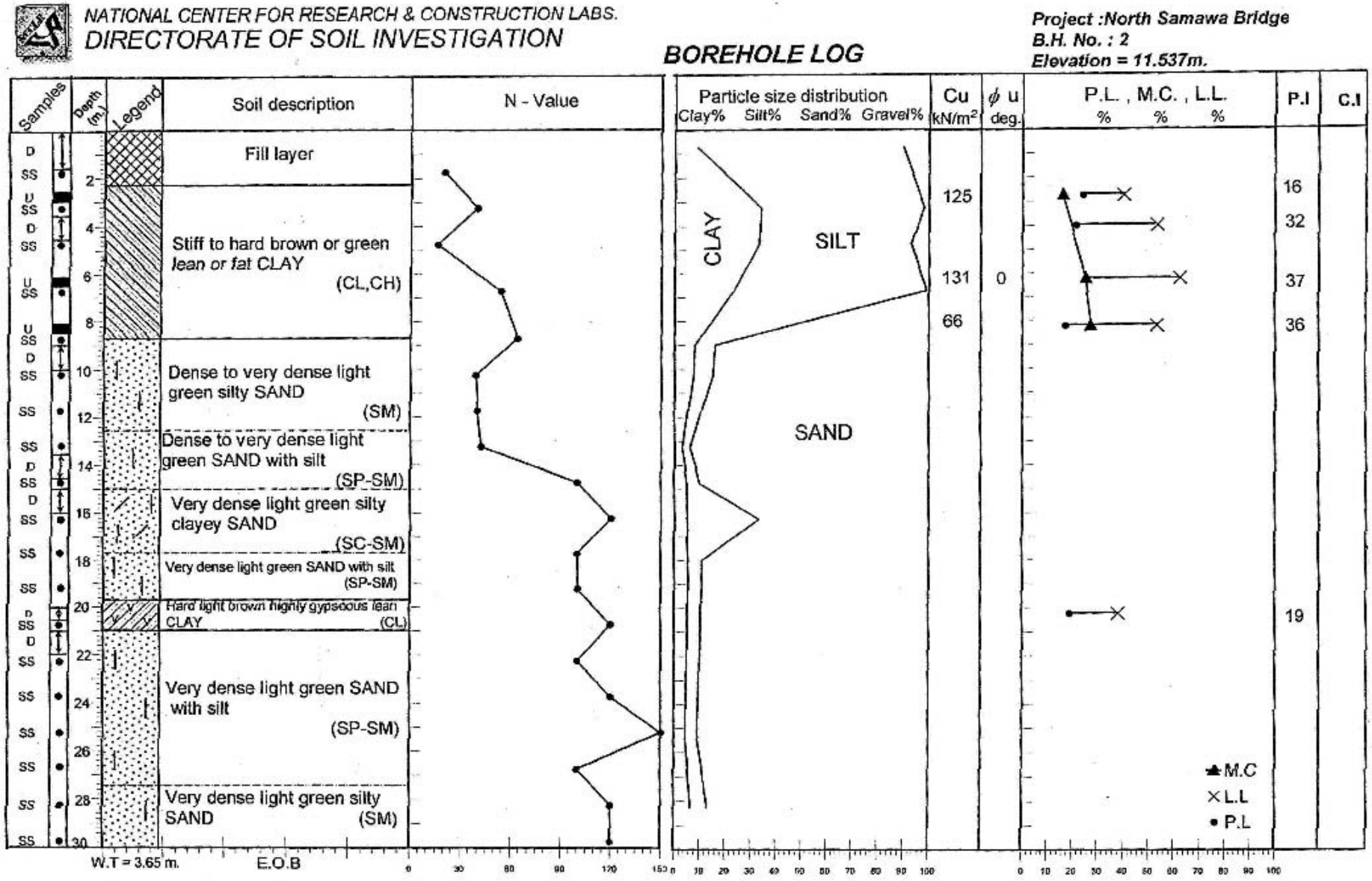
DIRECTORATE OF SOIL INVESTIGATION
BOREHOLE LOG
Project : North Samawa Bridge
B.H. No. : 1
Elevation = 12.65m.
Samples
Depth (m.)
Legend
Soil description
N - Value
Particle size distribution
Clay% Silt% Sand% Gravel%
Cu kN/m²
ϕ u deg.
P.L. , M.C. , L.L.
% % %
P.I
C.I
Medium to very stiff brown lean or fat CLAY (CL,CH)
Very stiff brown -grey SILT(ML)
(with sand)
Stiff to hard brown -grey or green lean or fat CLAY (CL,CH)
Medium light green SAND with silt (SP-SM)
Medium light green silty SAND (SM)
Grey elastic SILT (MH)
(moderatly gypseous)
Hard light green lean CLAY (CL)
Very dense grayish blue or light brown silty SAND (SM)
Hard light green lean CLAY with sand (CL)
Hard light green silty CLAY with sand (CL-ML)
W.T = 2.65 m.
E.O.B
SILT
CLAY
SAND
CLAY
SILT
SAND
135
50
71
2
6
31
20
20
36
21
25
16
M.C
L.L
P.L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DIRECTORATE OF SOIL INVESTIGATION
BOREHOLE LOG
Project :North Samawa Bridge
B.H. No. : 2
Elevation = 11.537m.
Samples
Depth (m.)
Legend
Soil description
N - Value
Particle size distribution
Clay% Silt% Sand% Gravel%
Cu kN/m²
ϕ u deg.
P.L. , M.C. , L.L.
% % %
P.I
C.I
Fill layer
Stiff to hard brown or green lean or fat CLAY (CL,CH)
Dense to very dense light green silty SAND (SM)
Dense to very dense light green SAND with silt (SP-SM)
Very dense light green silty clayey SAND (SC-SM)
Very dense light green SAND with silt (SP-SM)
Hard light brown highly gypseous lean CLAY (CL)
Very dense light green SAND with silt (SP-SM)
Very dense light green silty SAND (SM)
CLAY
SILT
SAND
125
131
66
0
16
32
37
36
19
M.C
L.L
P.L
W.T = 3.65 m.
E.O.B

REPORT NO. 1/1/47/2004-BAGHDAD

Al-Hillal Bridge at Samawah

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Content

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1- INTRODUCTION

1-1 Authorization and Scope

The soil investigation for this project has been conducted by the Directorate of Soil Investigations / National Center for Construction Laboratories and Research (NCCLR) - Baghdad according to the contract with "Dar Al-Handasah Group" dated at 29/9/2004.

The soil investigation described in this report consists of drilling the boreholes, securing representative samples, testing these samples and analyzing the soil conditions with test results.

1-2 Site Location and Description

The site is located in Samawa City. The locations of boreholes are on the banks of Ehlail River. Since the site is generally banks of river, there are differences in the level of borehole location as shown in Table (1).

2- FIELD EXPLORATION

2-1 Drilling and Sampling

Drilling was done using flight auger. The drilling rig used is of (Acker) type, which is a power driven machine. The diameter of drilled boreholes was (15.0) cm. The disturbed samples (D) were collected from the cutting of auger at any depth. The undisturbed samples marked (U) were obtained using Shelby tubes. Split spoon samples (SS) were obtained from standard split spoon used in a Standard Penetration Test (S.P.T), which was performed for each test boring at different intervals depending on the stratification of the soil.

The actual depth for all samples and the N-values for S.P.T. are shown in the record of test results sheets of this report.

2-2 Number of Boreholes

Four boring points were assigned and located by the concerned authorities. These boring point were drilled by (NCCLR), to different depths. Boreholes (B.H.1, B.H.3 and B.H.4) were drilled to a depth of 30 m., while borehole (B.H.2) was drilled to a depth of 40m. The location of these boring points is marked on the site plan at Fig. (1).

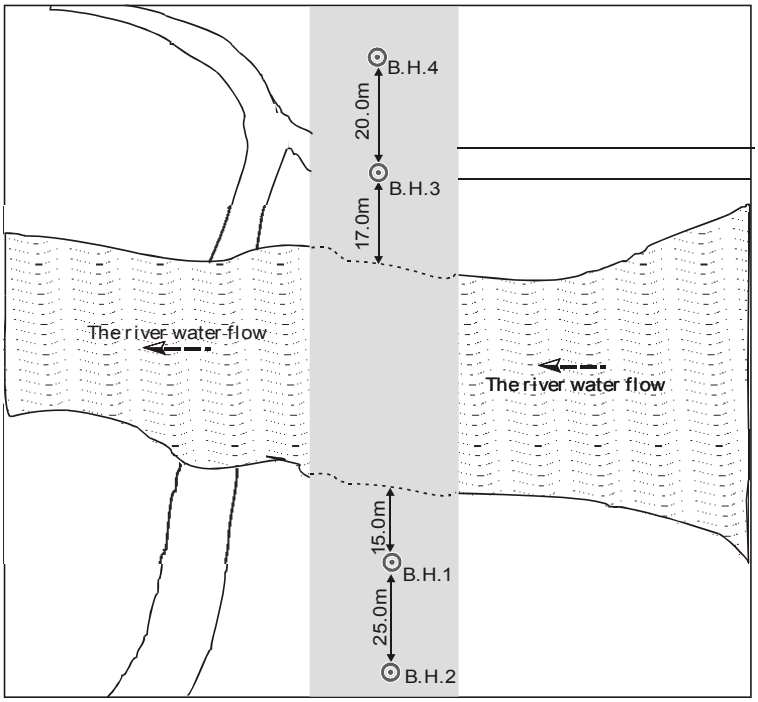

Fig.1: Site plan for boreholes location

3 - LABORATORY TESTING

Each of the soil samples received by the laboratories of the Directorate of Soil Investigations NCCLR / Baghdad was given a laboratory number. The samples of each borehole were visually examined for initial classification before laboratory testing.

The soil engineer decided the test program. The actual test proposed for a particular sample depends on the type of sample (SS, U & D) and the nature of its material. A full list of tests conducted for this project is:

A - Classification Tests

- Atterberg limits (L.L, and P.L).
- Natural moisture content.
- Unit weight (natural and dry).
- Grain Size Analysis (sieve and hydrometer).

B- Chemical Tests

- Sulphate content (SO_3 %).
- PH value.
- Gypsum content (%).
- Chlorite content (Cl %).
- Carbonate content $CaCO_3$.

C - Strength and deformation Tests

- Unconfined compression test.
- Direct shear test.

D- Consolidation Test

The results of these tests are shown in the record of test - result sheets appended.

4- SUBSOIL STRATIFICATION

4-1 Soil Profile

According to the Unified Soil Classification System (USCS), the subsoil profile can be summarized as follows:

For boreholes (1 & 2) (Left Bank)

The first soil layer consists of very stiff brown sandy elastic silt with little gypsum and little shells of fossil and O.M. This layer revealed in general down to (5.0 - 7.0) m. below N.G.L for boreholes (1 & 2) taking into consideration the difference between the level of their locations.

At the top of this layer, a layer of brown sandy silt with little shells of fossil was appeared in borehole (1).

- Below the first layer, a layer of medium to very dense grey silty sand was observed. This layer extends to (6.0 - 11.0) m. depth.
- A layer of hard brown silty fat clay with O.M. represents the third layer. This layer follows the above layer and extends to (12.0) m. depth.
- The fourth layer consists of very dense grey silty sand. This layer extends to (15.5 - 18.5) m. depth. A layer of hard grey clayey sandy elastic silt was appeared at the top of this layer in borehole (2).
- A layer of (10,0) m. thickness was followed the fourth layer. This layer consists of hard light brown to light green sandy elastic silt with little to high gypsum. A layer of very dense light green silty sand was appeared through this layer at a depth of (19.0 - 21.0) m in borehole (1).
- The last layer consists of two parts. The first one is a layer of hard grey silty fat clay extends to the depth of (30.0) m., which is the end of boring of borehole (1). In the second part the soil is hard grey sandy elastic silt extend from (30.0) m. depth to the end of boring of borehole (2) which is (40.0) m. depth.

Details of soil stratification for boreholes (1&2) are shown in the “Borelogs” appended and the “soil profiles” at Fig. (2).

For boreholes (3 & 4) (Right Bank)

- The first soil layer consists of very stiff to hard brown clayey silt with sand. This layer revealed in general down to (4.0 - 8.5) m. below N.G.L. for boreholes (3 & 4) taking into consideration the difference between the reduced levels of their locations. Also a lense of (0.5 - 1.0) m. thickness of brown lean to fat clay with sand was appeared at this layer.
- Below the first layer, a layer of hard brown silty lean to fat clay was observed. This layer extends to (13.0 - 15.0) m. depth. A layer of very dense grey silty sand was appeared through this layer at a depth of (4.0 - 4.5) m. and (10.5 - 11.0) m. in borehole (3).
- The third layer consists of dense to very dense grey silty sand. This layer follows the above layer and extends to (17.0 - 19.0) m. depth. At the bottom of this layer a lense of (1.5) m. thickness of very dense clayey sand with silt was observed in borehole (4).
- The last layer consists of hard brown silty fat clay with little gypsum. This layer extends to the end of boring at (30.0) m. depth. A layer of hard grey elastic silt with clay and sand was observed in boreholes (3 & 4) respectively.

Details of soil stratification for boreholes (3 & 4) are shown in the "Borelogs" appended and the "soil profiles" at Fig. (3).

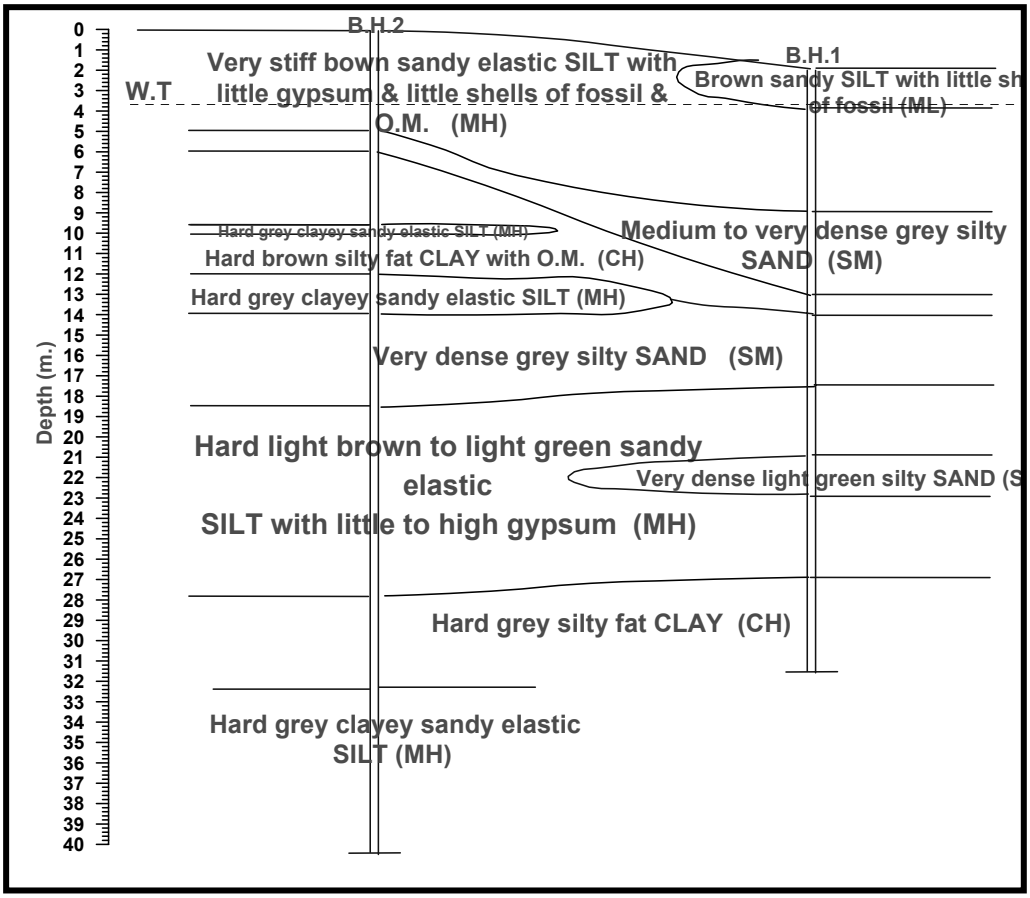

Fig. 2: Soil profile through boreholes (1 & 2)

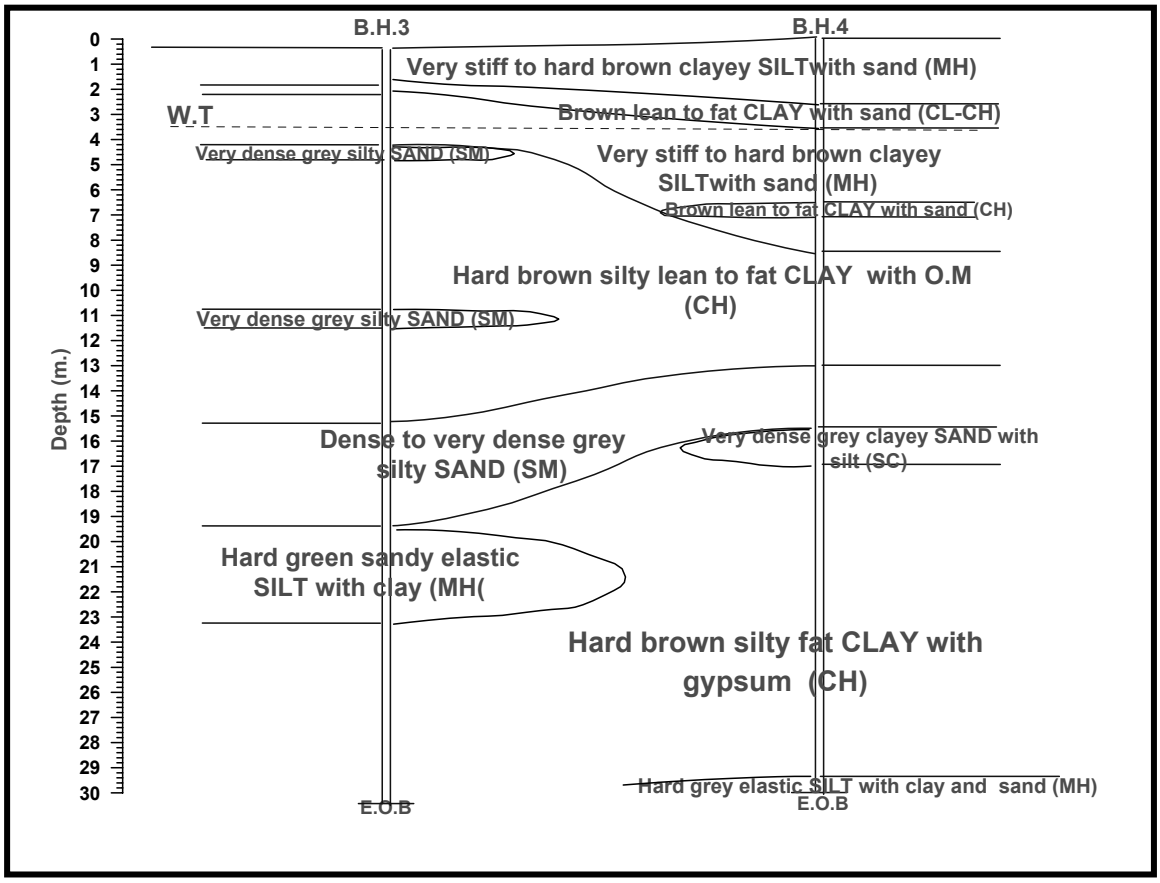

Fig. 2: Soil profile through boreholes (3 & 4)

4-2 Underground Water Level

The depth of underground water level was measured from the top surface of each borehole. This depth was measured after 24 hours from drilling termination at the time of boring (September /2004). However, it should be mentioned here that this level might be fluctuated during the coming seasons. The elevation of boreholes and the depth of water are shown in Table (1).

Table (1); Elevation of boreholes and the depth of water

B.H. No.	Elevation (m)	Depth of W.T (m)
1	10.269	1.85
2	12.379	3.95
3	11.669	3.25
4	10.069	3.65

5- EVALUATION AND DISCUSSION OF RESULTS

5-1 Atterberg limits Test Results

Record of test result sheets shows the values of liquid limit (L.L.), plastic limit (P.L), plasticity index (P.I.) and moisture content (M.C.) at different depths for all boreholes.

The results of the tests evidence that the soil of the boreholes shows medium to high plasticity.

On the other hand, it can be seen that the value of moisture content is closer to plastic limit than to the liquid limit. This trend suggests that the cohesive layer is over consolidated.

5-2 Chemical Tests

The results of the chemical tests for soil and water samples are shown in the "Test Results Sheets".

Examination of these results reveals that the amount of chemical agents which are normally aggressive to reinforce concrete (i,e, sulphates (SO_3) and chloride are very small in all depth except in depth (17.5) - (22.5)m. , where the sulphate content varies from (4.45) - (14.38) %). The sulphate content varies from (0.10) - (1.17) %, while the chloride content varies from (0.07) (1.38) %. The PH value varies from (7.05) - (8.56).

5-3 Strength of the Soil

Table (2) summarized the results of the unconfined compression test and the results of natural and dry densities for the cohesive soil layer. From this table, it is observed that the unconfined compression strength of the cohesive soil layers ranged from (55 to 500) kPa and is consistent with medium to hard soil. This is also compatible with results of standard penetration test (S.P.T).

Table 2: Unconfined compression test results with depth

BH. No.	*Depth (m.)*	*Qu* kN/m^2	γ *wet* kN/m^3	γ *dry* kN/m^3
1	4.0 - 4.5	443	19.4	15.8
2	3.5 - 4.0	386	19.3	15.6
	6.0 - 6.5	333	19.6	15.6
	9.0 - 9.5	310	- - - -	- - - -
3	1.5 - 2.0	55	19.1	15.0
	3.5 - 4.0	102	19.1	14.9
	8.0 - 8.5	500	19.1	15.6
4	4.5 - 5.0	175	19.1	15.0
	8.0 - 8.5	356	20.0	16.4

For the cohesioless soil layer, the results of direct shear (c, Ø) and number of blows of standard penetration test (S.P.T) indicate that the relative density of this soil layer is medium to very dense .The results of the direct shear test are shown in Table (3).

Table 3: Direct shear test results

BH. No.	*Depth (m.)*	*c* (kN/m^2)	*Ø (Degree)*	γ *wet* kN/m^3	γ *dry* kN/m^3
1	9.0 - 9.5	0	41	19.4	16.7
	14.5 - 15.0	0	35	19.4	17.3
2	11.5 - 12.0	0	36	19.4	16.5
	14.0 - 16.0	0	33	19.4	16.8
	16.0 - 16.5	0	32	19.4	16.7
3	10.5 - 11.0	0	35	19.4	16.4
4	12.5 - 13.0	0	26	19.4	16.3

5-4 Consolidation Test Results

The results of consolidation test are presented as preconsolidation pressure (Pc), swelling pressure (Ps), initial void ratio (eo), compression index (Cc) and rebound or swelling index (Cr) in Table (4).

It can be seen that the value of Cc ranged from (0.14) to (0.24) while the values of (Cr) ranged from (0.017) to (0.060). The variations of the overburden pressure (Po) and the over consolidation ratio (O.C.R) with depth are also presented in Table (4). As can be seen the soil layer is in general over consolidated with the values of (O.C.R) decrease with depth.

Table 4: Consolidation parameters with depth

B.H No.	*Depth (m.)*	*Po* kN/m^2	*Pc* KN/m^2	*O.C.R*	*Ps* kN/m^2	*Void ratio* e_o	C_c	C_r
1	1.5 - 2.o	36	250	6.94	95	0.486	0.14	0.036
	6.5 - 7.0	139	360	2.59	110	0.639	0.21	0.050
2	3.5 - 4.0	72	200	2.8	80	0.648	0.17	0.053
	6.0 - 6.5	123	200	1.63	35	0.755	0.20	0.043
	9.0 - 9.5	168	170	1.01	30	0.711	0.15	0.047
3	1.5 - 2.0	34	300	8.82	- - -	0.636	0.16	0.017
	3.5 - 4.0	72	250	3.47	- - -	0.837	0.24	0.53
	8.0 - 8.5	169	190	1.12	- - -	0.607	0.15	0.050
4	4.5 - 5.0	91	240	2.64	- - -	0.793	0.19	0.050
	8.0 - 8.5	167	310	1.86	55	0.668	020	0.060
	12.5 - 13.0	196	220	1.12	- - -	0.793	0.17	0.040

6- GENERAL RECOMMENDATIONS

No design data was provided by the concerned authority, therefore the following recommendations are made according to field and laboratory tests.

6-1 Type of Footing

Deep pile foundation should be used for the bridge. Reinforced concrete large diameter bored piles are recommended. The diameter and allowable working load for the suggested piles at each borehole location are shown in Table (5).

Table (5) Details of suggested piles

Dia. of Piles (m).	*Allowable Working Load (Ton)*			
	B.H.1	*B.H.2*	*B.H.3*	*B.H.4*
1.0	200	350	250	200
1.5	400	500	400	400

The working load of piles are based on the strength of concrete cylinder (1:1.5:3) of (15) cm in diameter and (30) cm. in height cured for 28 days in water giving a crushing strength of not less than (2200) ton/m^2.

6-2 Depth of Footings

The top of the cap of piles should be at least (2) m. below N.G.L at each Structure location in order to minimize the scour effect of water against the footing during the flooding time.

6-3 Length of Piles

Examination of soil profile through boreholes shows that the sub-soil strata are predominantly silt and clay. Therefore no other economical way rather than using friction piles in cohesive strata. Each single pile should be at least (22) m. in its effective length (below the bottom of the cap).

6-4 Loading Test for Piles

Loading test should be performed in the site for both single and group action if possible. The lower results in both the working load per a single pile and the resulting settlement between our recommendations and the loading test results should be adopted.

6-5 Type of Cement

- The sulphate resisting cement is recommended to be used for concrete works in a touch with the soil.
- The amount of cement content is 420 kg/m^2.
- Maximum free water / cement ratio is 0.45 by weight.

- Vibrators should be used in order to density the fresh concrete.
- Minimum concrete over of (7.5) cm. is recommended to protect reinforcement from chloride effect.

6-6 Dewatering

During construction of foundation, the ground water should be pumped out until the construction reaches ground level.

6-7 Type and Depth of Foundation

Precast or bored piles are recommended to be used. The depth of piles should be at (14.0) m. below (N.G.L). The pile cap should be at (2.0) m. below natural ground surface (N.G.S).

The working load of piles shown at table (4) is based on the strength concrete cylinder (1:1.5:3) of 6" diameter and 12" in height cured for 28 days in water giving a crushing strength of not less than (3000) psi. The tips piles should be at 12.0 m. depth.

Table 4: Details of suggested piles

Type of pile	*Diameter (m.)*	*Allowable working load (tons)*
Precast	0.28 x 0.28	35
Bored	0.6	100
Bored	0.8	220
Bored	1.0	300

Pile test should be carried out in site. The least results between our recommendations and the test results should be adopted for the working loads.

During construction, the under ground water should be pumped out until the construction reaches ground level.

6-8 Precautions Due to Sulphate and Chloride Content

- Sulphate resisting cement is recommended to be used for foundation.
- Minimum cement content is 420 kg/m^3.
- Maximum free water / cement ratio is 0.45 by weight.
- Vibrators should be used in order to densify fresh concrete.
- Coating of bottom and sides of foundations with three layers of bituminous material should be carried out.

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Engineer

HISHAM F. RAZOUKI
Head of Soil Dept.

TAHA Y. ABDULNABI
Director of Soil Inv.

MINISTRY OF CONSTRUCTION & HOUSING **PROJECT:- Al Hillal Bridge at Samawa**

NATIONAL CENTER FOR CONSTRUCTION LABORATORIES & RESEARCH

RECORD OF TEST RESULTS **B.H.No.:- 3**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				Gs	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 3					**Elevation = 11.669 m.**								
1	2432	D	0.0	1.5					(0	52	48	0)		--	MH	Brown sandy elastic silt						
2	2433	U	1.5	2.0	26	42	22		(19	76	5	0)		--	CL	Br.silty lean clay with sand	**0.57**				**7.83**	**0.07**
3	2434	SS	2.0	2.5		64	37							35	MH	Hard br. Elastic silt with clay & little sand						
4	2435	U	3.5	4.0	30				(10	85	5	0)		--	MH	Do(with little gypsum & O.M)						
5	2436	SS	4.0	4.5		55	32							43	MH	Top: do						
									(7	33	60	0)			SM	Bott: dense grey silty sand						
6	2437	SS	6.0	6.5										49	CH	Hard brown silty fat clay						
7	2438	U	8.0	8.5	22.1	50	28		(34	64	2	0)		--	CH	Do	**0.22**				**8.56**	**0.09**
8	2439	SS	8.5	9.0		54	31							57	CH	Do						
9	2440	U	10.5	11.0					(0	55	45	0)		--	SM	Grey silty sand						
10	2441	SS	11.0	11.5										49	SM	Top: do						
						38	20								CL	**Bott: hard brown silty lean clay**						
11	2442	D	12.0	13.0					(45	52	3	0)		30	CL	**Do**	**0.1**	**29.2**				
12	2443	SS	13.0	13.5		40	22							50/6"	CL	Very stiff brown silty lean clay						
13	2444	SS	15.0	15.5					(11	21	68	0)		50/6"	SM	Very dense grey silty sand with clay						
14	2445	SS	17.0	17.5										50/6"	SM	Do		42.9				
15	2446	SS	19.0	19.5					(0	60	40	0)		50/6"	MH	Hard brown sandy silt with gypsum	0.75	34.0	1.59			0.42
16	2447	D	20.0	21.0		51	27							50/6"	MH	Light green sandy silt with little gypsum	**4.45**		**8.77**			
17	2448	SS	21.0	21.5					(6	45	49	0)		50/6"	MH	Hard light green sandy silt with clay						
18	2449	SS	22.5	23.0					(25	47	28	0)		50/6"	MH	Hard light green sandy clayey silt						
19	2450	SS	24.5	25.0		61	38							50/6"	CH	Hard brown silty fat clay with sand & little gypsum						
20	2451	SS	26.0	26.5		39	32							50/5"	CL	Hard nrown silty lean clay with sand						
21	2452	D	26.5	27.5					(40	56	4	0)		50/6"	CH	Hard brown silty fat clay						
22	2453	SS	27.5	28.0		62	33							50/6"	CH	Do						
23	2454	SS	29.5	30.0					(37	48	15	0)		50/5"	CH	Hard grey silty fat clay with sand						
24	2485	Water sample															**0.18**				**7.05**	0.14

Depth of ground water = 3.25 m. below N.G.S

MINISTRY OF CONSTRUCTION & HOUSING **PROJECT:- Al Hillal Bridge at Samawa**

NATIONAL CENTER FOR CONSTRUCTION LABORATORIES & RESEARCH

RECORD OF TEST RESULTS **B.H.No.:- 4**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				Gs	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 4					**Elevation = 12.069 m.**								
1	2455	D	0.0	1.0					(25	66	7	2)		--	MH	Brown clayey silt with sand						
2	2456	SS	1.0	1.5										22	MH	Very stiff br. clayey silt with sand	**0.25**	**34.5**				**1.38**
3	2457	D	1.5	2.5					(29	73	7	0)		--	MH	Do.						
4	2458	U	2.5	3.0		55	34		(36	59	5	0)		--	CH	Br. silty fat clay with sand						
5	2459	SS	3.0	3.5		51	29							34	CH	Do. (hard)	**0.88**	**31.7**				**0.14**
6	2460	D	3.5	4.0					(26	67	7	0)		--	MH	brown clayey elastic silt with O.M						
7	2461	U	4.5	5.0	28	64	36							--	MH	Do						
8	2462	SS	5.0	5.5					(15	80	5	0)		*17*	MH	Do						
9	2463	SS	6.5	7.0		62	41							62	CH	Hard brown silty fat clay	**0.2**					**0.12**
10	2464	U	8.0	8.5	22.1				(24	74	2	0)		--	MH	Hard Br. clayey elastic silt with O.M						
11	2465	SS	8.5	9.0		51	28							69	CL	Hard Br. silty lean clay with O.M						
12	2466	D	9.0	10.0		48	31		(39	57	4	0)		--	CL	Do.						
13	2467	SS	10.0	10.5		41	23							64	CL	Do.	**0.26**					**0.12**
14	2468	SS	11.5	12.0										62	SM	Very dense grey silty sand						
15	2469	U	12.5	13.0	26				(10	51	39	0)		----	SM	Top: Do.						
															CL	Bott.: Brown lean clay						
16	2470	SS	13.0	13.5										32	CL	Top: Do.						
															SM	Bott.: Dense grey silty sand						
17	2471	SS	15.0	15.5					(- 22 -		78	0)		50/6"	SM	Very dense grey silty sand						
18	2472	D	15.5	16.5		59	39							----	SC	Very dense clayey sand with silt						
19	2473	SS	16.5	17.0					(24	16	60	0)		50/6"	SC	Do.	**0.36**	**32.7**				**0.36**
20	2474	D	17.0	18.5		53	34							----	CH	Hard light green silty fat clay with sand and little gypsum						
21	2475	SS	18.5	19.0					(42	40	18	0)		50/6"	CH	Do.						
22	2476	D	19.0	20.5		51	27							---	CH	Do						
23	2477	SS	20.5	21.0					(23	59	18	0)		50/6"	CH	Do.						
24	2478	SS	22.5	23.0		60	33							50/5	CH	Hard br.silty fat clay with little sand and little gypsum	**0.66**	**21.0**				**0.25**

MINISTRY OF CONSTRUCTION & HOUSING **PROJECT:- Al Hillal Bridge at Samawa**

NATIONAL CENTER FOR CONSTRUCTION LABORATORIES & RESEARCH

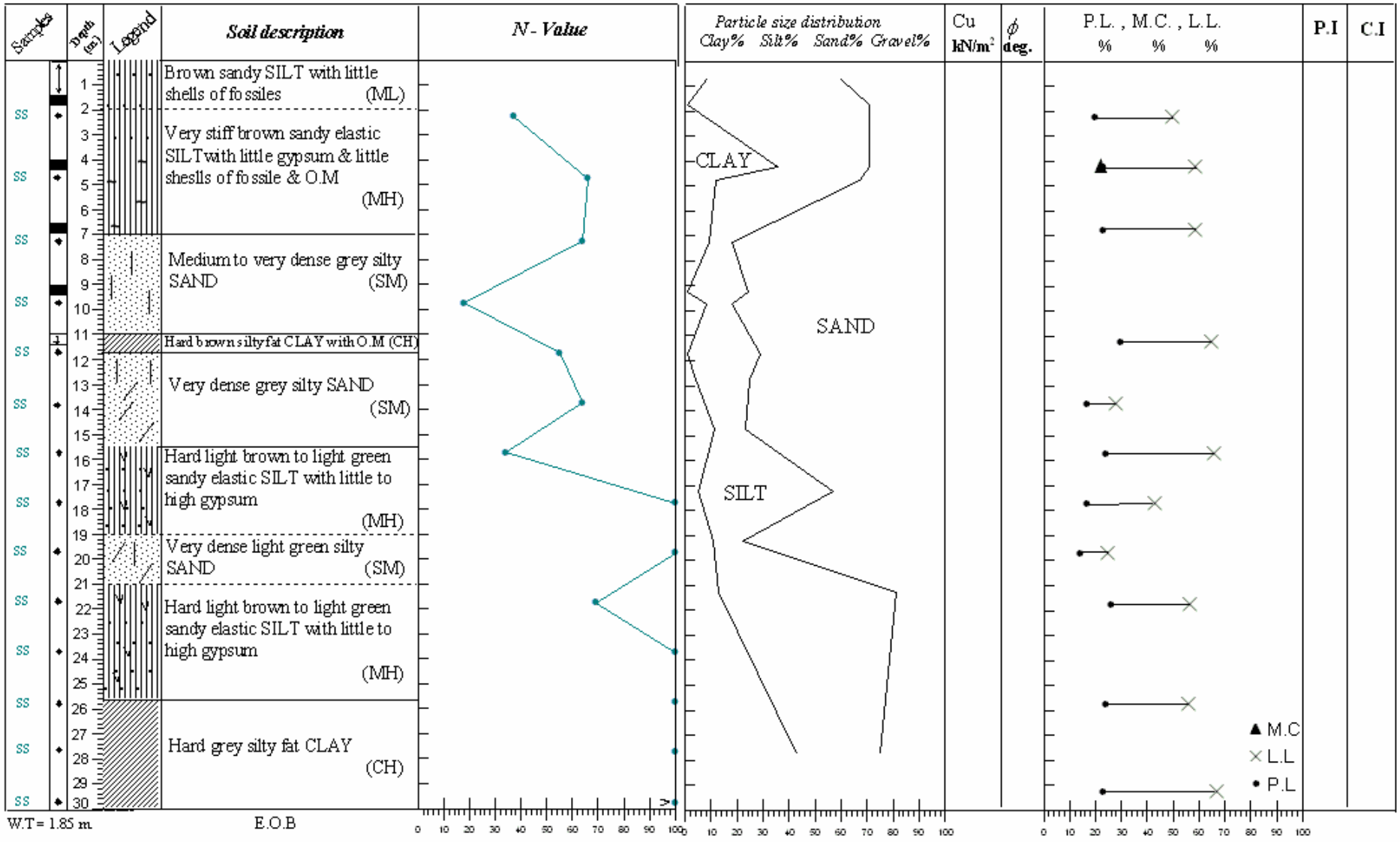
RECORD OF TEST RESULTS **B.H.No.:- 4**

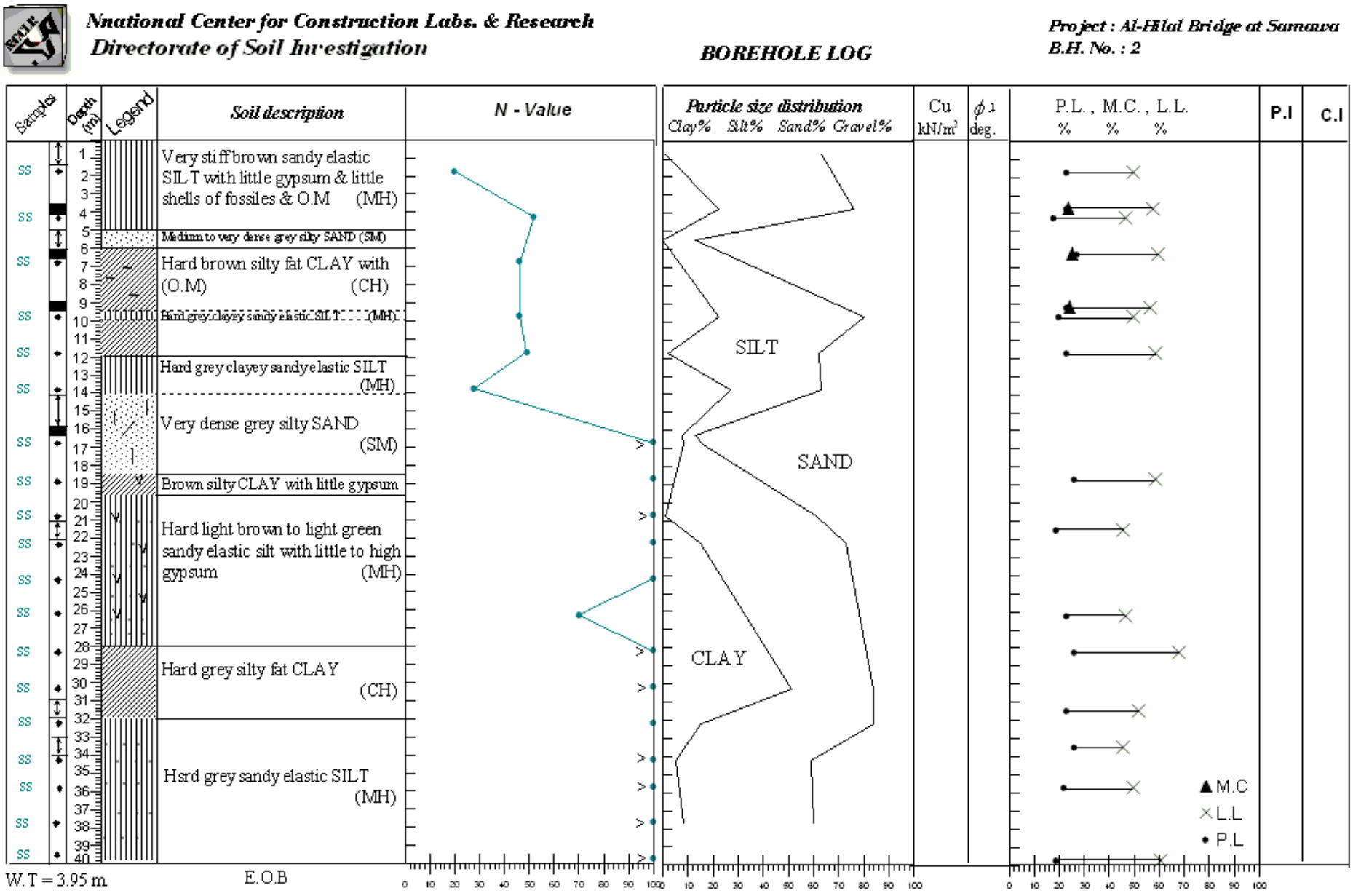
Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				Gs	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
25	2479	D	23.0	24.5					(35	60	5	0)		---	CH	Do.(with trace of sand)						
26	2480	SS	24.5	25.0		65	45							50/6	CH	Do.						
27	2481	SS	26.0	26.5					(33	65	2	0)		50/5	CH	Do.						
28	2482	SS	27.5	28.0		57	31							50/6	CH	Do.	**0.25**	**25.0**				**0.07**
29	2483	D	28.0	29.5					(35	62	3	0)		----	CH	Do.						
30	2484	SS	29.5	30.0					(11	74	15	0)		50/5	MH	Hard grey silt with little sand and clay						
31	2486	Water Sample															**0.24**				**7.34**	**0.15**
									Depth of ground water = 3.65 m. below N.G.S													

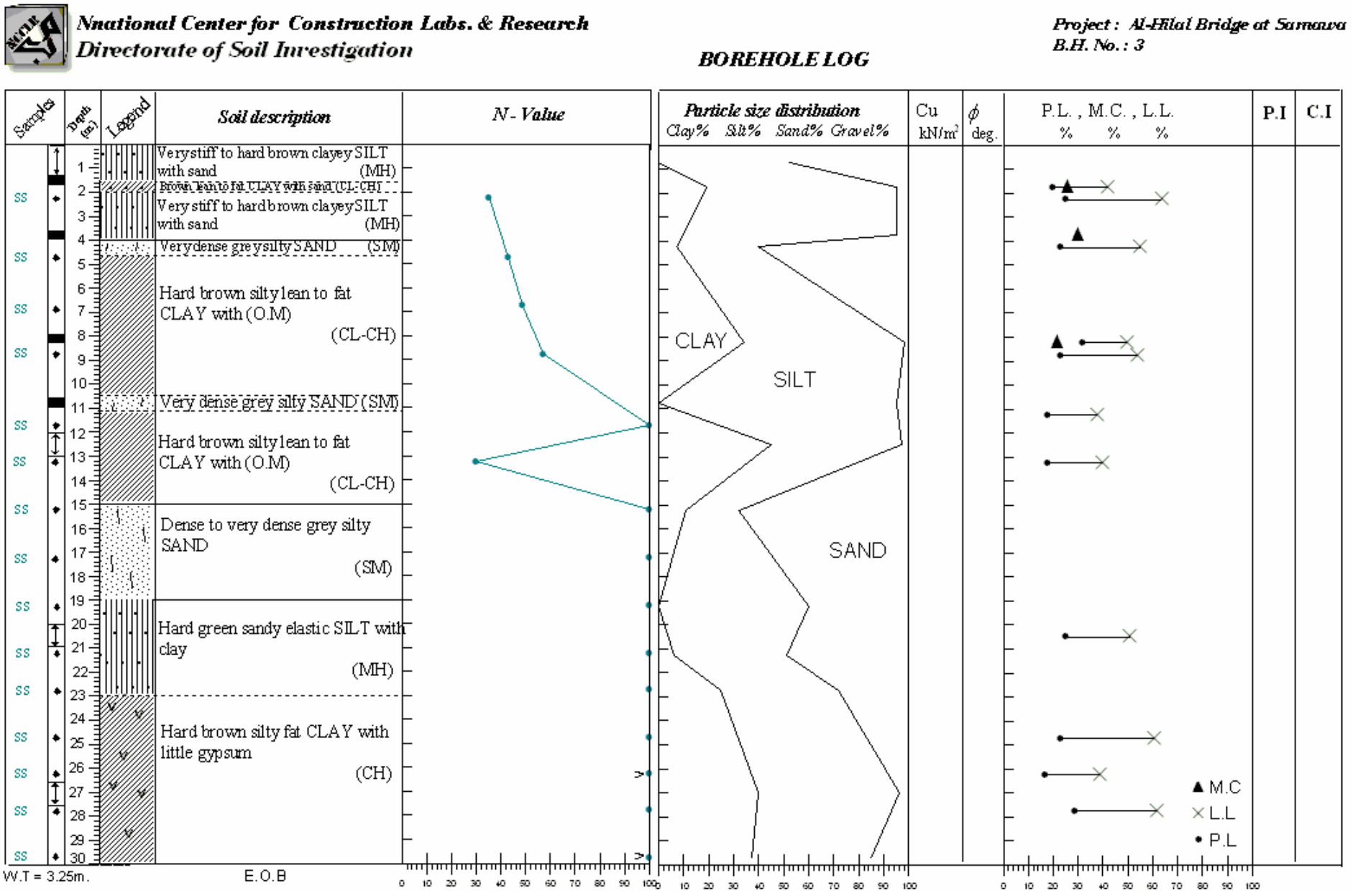
Nnational Center for Construction Labs. & Research
Directorate of Soil Investigation

BOREHOLE LOG

Project : Al-Hilal Bridge at Samawa
B.H. No. : 1



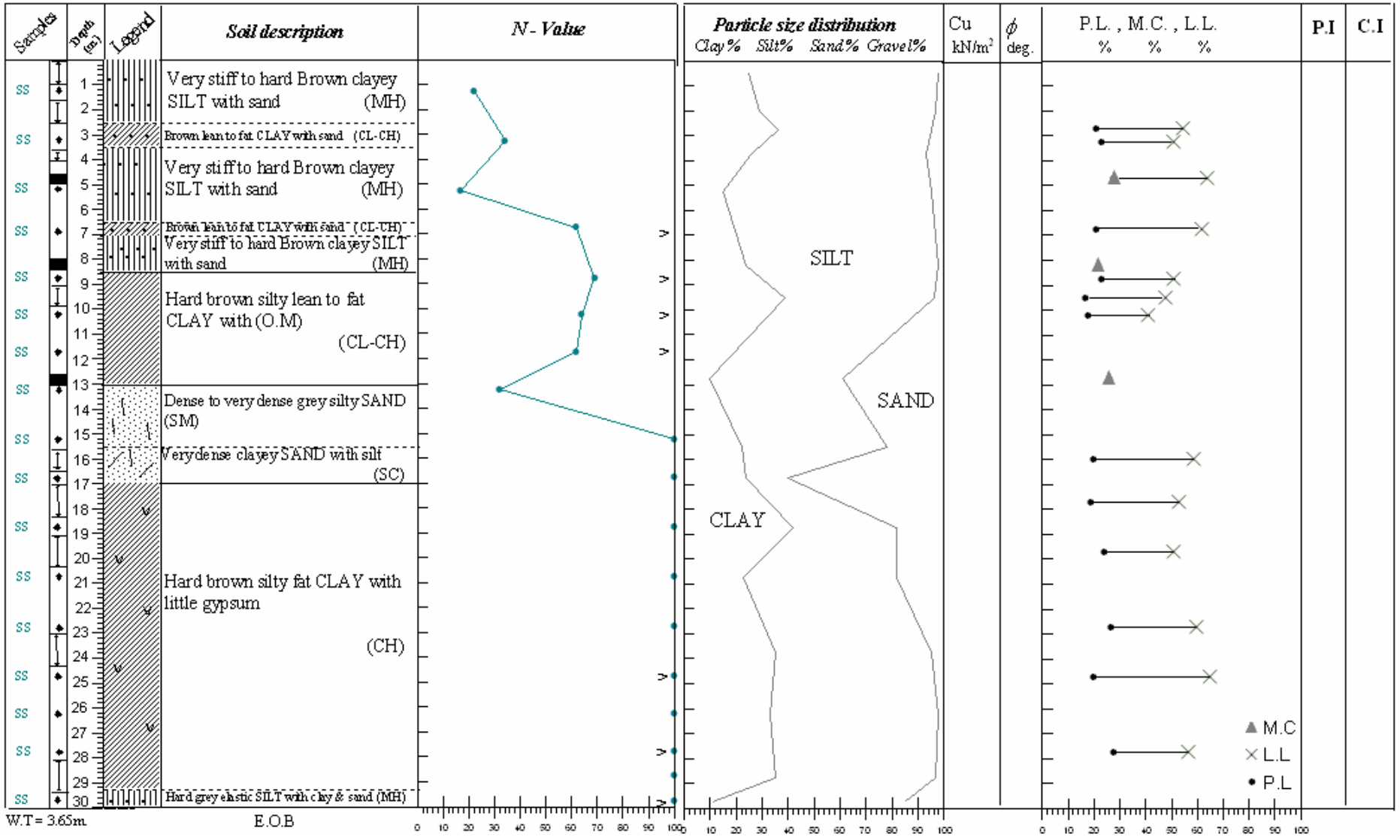

Nnational Center for Construction Labs. & Research
Directorate of Soil Investigation
BOREHOLE LOG
Project : Al-Hilal Bridge at Samawa
B.H. No. : 2
Samples
Depth (m)
Legend
Soil description
N - Value
Particle size distribution
Clay% Silt% Sand% Gravel%
Cu kN/m²
ϕ u deg.
P.L. , M.C. , L.L.
% % %
P.I
C.I
Very stiff brown sandy elastic SILT with little gypsum & little shells of fossiles & O.M (MH)
Medium to very dense grey silty SAND (SM)
Hard brown silty fat CLAY with (O.M) (CH)
Hard grey clayey sandy elastic SILT (MH)
Hard grey clayey sandy elastic SILT (MH)
Very dense grey silty SAND (SM)
Brown silty CLAY with little gypsum
Hard light brown to light green sandy elastic silt with little to high gypsum (MH)
Hard grey silty fat CLAY (CH)
Hsrd grey sandy elastic SILT (MH)
SILT
SAND
CLAY
M.C
L.L
P.L
W.T = 3.95 m
E.O.B


Nnational Center for Construction Labs. & Research
Directorate of Soil Investigation
BOREHOLE LOG
Project : Al-Hilal Bridge at Samawa
B.H. No. : 3
Samples
Depth (m)
Legend
Soil description
N- Value
Particle size distribution
Clay% Silt% Sand% Gravel%
Cu kN/m²
ϕ deg.
P.L. , M.C. , L.L.
% % %
P.I
C.I
Very stiff to hard brown clayey SILT with sand (MH)
Brown lean to fat CLAY with sand (CL-CH)
Very stiff to hard brown clayey SILT with sand (MH)
Very dense grey silty SAND (SM)
Hard brown silty lean to fat CLAY with (O.M) (CL-CH)
Very dense grey silty SAND (SM)
Hard brown silty lean to fat CLAY with (O.M) (CL-CH)
Dense to very dense grey silty SAND (SM)
Hard green sandy elastic SILT with clay (MH)
Hard brown silty fat CLAY with little gypsum (CH)
CLAY
SILT
SAND
M.C
L.L
P.L
W.T = 3.25m.
E.O.B

Nnational Center for Construction Labs. & Research
Directorate of Soil Investigation

Project : Al-Hilal Bridge at Samawa
B.H. No. : 4

BOREHOLE LOG



REPORT NO. 1/1/53/2004-BAGHDAD

Al - Majid Bridge in Samawah

REPORT NO. 1/1/53/2004-BAGHDAD

Al - Majid Bridge in Samawah

Contents

REPORT NO. 1/1/53/2004 - BAGHDAD

Al - Majid Bridge in Samawah

1- INTRODUCTION

1-1 Authorization and Scope

The soil investigation for this project has been conducted by the Directorate of Soil Investigation / National Centre for Research & Construction Laboratories (NCCLR) - Baghdad according to the contract with "Dar Al- Handasah "dated at 31/ 10 /2004.

The soil investigation described in this report consists of drilling the boreholes, securing representative samples, testing these samples and analyzing the soil conditions with test results.

1-2 Site Location and Description

The site is located at Al- Muthanna governorate specifically at Samawah city which is far from Baghdad city of about 271 Km. (south - west) .The Euphrates river pass through Al - Samawah city then divided into two small rivers (Al Majid & Al Atshan). The site is located at the two banks of al-Majid River.

2- FIELD EXPLORATION

2-1 Drilling and Sampling

Drilling was done using flight auger. The drilling rig used is of (Acker) type, which is a power driven machine. The diameters of drilled boreholes were (15.0) cm. The disturbed sample (D) were collected from the cutting of auger at any depth .The undisturbed samples marked (U) were obtained using Shelby tubes. Split spoon samples (SS) were obtained from standard split spoon used in a Standard Penetration Test (S.P.T), which was performed for every test boring at different intervals depending on the stratification of the soil.

The actual depth for all samples and the N-Values for S.P.T. are shown in the record of test results sheets of this report.

2-2 Number of Boreholes

Two boring points were assigned and located by the concerned authorities at the locations of abutments (one borehole at each river bank). These boring points were drilled to the depth of (30.0) me. The locations of these boreholes are marked on the site plan at (Fig.1).

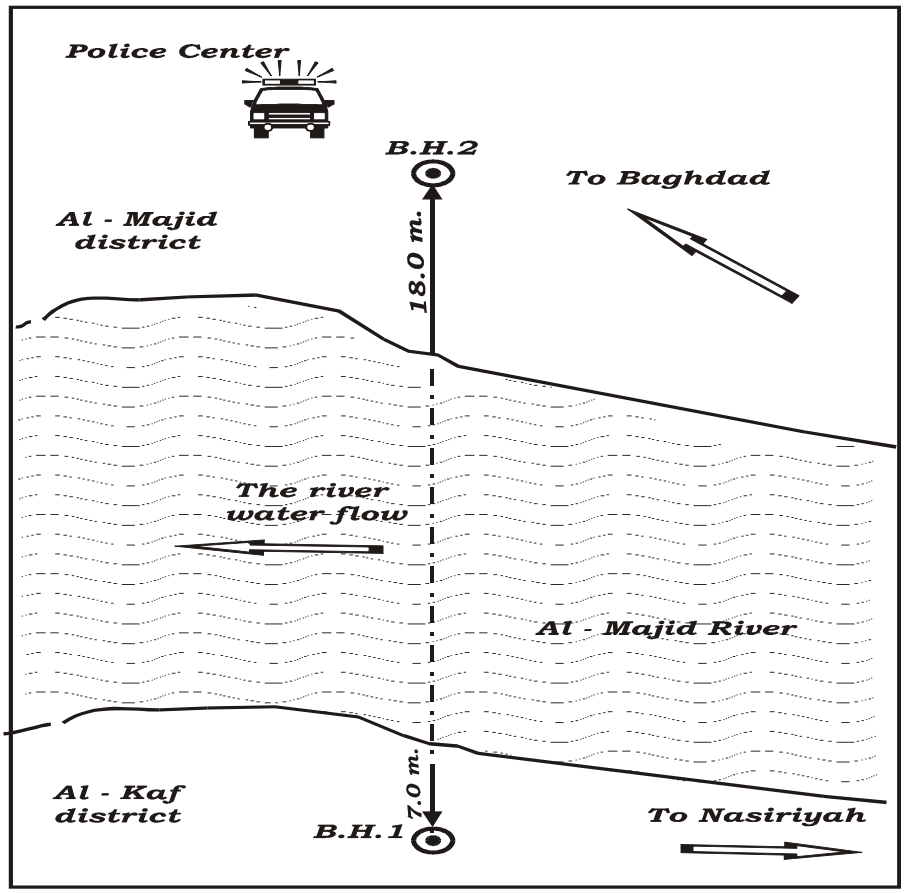


Fig. 1: Site plan for borehole locations

3- LABORATORY TESTING

Each of the soil samples received by the laboratories of the Directorate of Soil Investigations Baghdad was given a laboratory number.

The samples of the borehole were visually examined for initial classification before laboratory testing.

The test program was decided by the soil engineer. The actual test proposed for a particular sample depends on the type of sample (S.S, U & D) and the nature of its material.

A full list of tests conducted for this project is:

A - Classification Tests

- Atterberg limits (L.L, P.L).
- Grain size analysis (sieve and hydrometer analysis).
- Linear shrinkage limits (L.S).
- Unit weight (natural and dry).
- Natural moisture content.

B- Strength and Deformation Tests

- Unconfined compression strength.
- Direct shear test.

C- Consolidation Test

D- Chemical Tests for Water and Soil Samples

- Sulphate content (SO_3 %).
- Chloride content (Cl %).
- PH value.
- Calcium carbonate ($CaCo_3$ %)
- Organic matter (ORG%).

The results of these tests are shown in the Record of "Tests Result sheet "appended.

4- SUBSOIL STRATIFICATION

4-1 Soil Profile

According to the unified soil classification system (USCS), the subsoil profile for each borehole location can be summarized as follows: -

Borehole No.1 Location (Um Al- Kaf District)

- The upper soil layer consists of stiff to hard brown silt with sand and clay (ML) changes to lean clay (CL). This layer extends from (N.G.S) to (9.0) m. depth. A length of (1.0) thick of loose grey silty sand (SM) was observed.
- The second soil layer consists of medium to very dense grey silty sand (SM) to sand with silt (SP). This layer extends below the above layer to a bout (18.0) m. depth and sometimes mixed with gypsum.
- The third soil layer consists of hard brown fat clay (CH) which extends to (22.0) m.
- The last soil layer is very dense grey silty sand (SM) sometimes mixed with gypsum. This layer extends to the end of boring of (30.0) m.

Borehole No.2 Location (Al- Majid District)

- The upper soil layer consist of stiff to hard brown lean to fat clay (CL,CH) change to silt with sand & clay (ML) or elastic silt (MH) .This layer extends from (N.G.S) to (22.0)m. depth.
- The second soil layer consists of very dense grey silty sand (SM).This layer was observed below the above layer to end of boring of (30.0) m.

4-2 Underground Water Level

The underground water level was encountered at a depth of (3.25) at the location of borehole (1), and at a depth of (3.05) m. at the location of borehole (2) below natural ground surface (N.G.S) after 24 hours from drilling termination at the time of boring (November /2004). This level may fluctuate during the coming season due to the fluctuation of water level in the Euphrates River.

5- EVALUATION AND DISCUSSION OF RESULTS

5-1 Strength of the Soil

For the cohesive soil layer, the results of the unconfined compression tests and the number of standard penetration test (S.P.T) indicate that the consistency of the cohesive soil layer is stiff to hard. The results of the unconfined compression tests as well as the results of natural and dry densities are shown in Table (1).

Table 1: Unconfined test results with depth

B.H No	*Depth (m.)*	*Qu (kN/m^2)*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	5.5 - 6.0	101	19.0	15.2
2	6.0 - 6.5	203	17.5	14.6
	14.5 - 15.0	208	17.9	12.8

For the cohesion less soil layer, only one sample was tested, the results of direct shear (C, Ø) and number of blows of standard penetration test (S.P.T) indicate that the relative density of this soil is medium to very dense .The results of direct shear test results with depth are shown in table (2).

Table 2: Direct shear tests results with depth

B.H No.	*Depth (m.)*	*C (kN/m^2)*	*Ø Degree*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	14.0 - 14.5	0	30	19.4	16.0

5-2 Consolidation Test Results

The variations of overburden (Po), preconsolidation (Pc) & swelling (Ps) pressures with depth, which are shown in Table (3), indicate that the cohesive soil layer in general is over consolidated.

Table 3: Overburden, preconsolidation & swelling pressures with depth

B.H No.	*Depth (m.)*	*Po* kN/m^2	*Pc* kN/m^2	*Ps* kN/m^2	*Void ratio* e_o	C_c	C_r
1	3.5 - 4.0	56	198	---	1.45	0.54	0.077
	5.5 - 6.0	90	300	---	0.66	0.19	0.026
2	4.0 - 4.5	70	198	33	0.77	0.32	0.053
	6.0 - 6.5	88	199	32	0.83	0.29	0.058
	10.0 - 10.5	121	400	---	0.85	0.26	0.036
	14.5 - 15.0	146	400	25	1.176	0.48	0.077

5-3 Atterberg limits Test Results

The values of liquid limit (L.L.), plasticity index (P.I.) and moisture content (M.C.) at different depths are shown in the "Record of test result sheets "and "borehole logs" appended.

The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit for both site locations.

5-4 Chemical Properties

The results of the chemical tests for soil and water -amples are shown in the "Test Results Sheet".

The results in general indicate slight sulphate content except BH 1.which indicates high sulphate content at a depth of (14.0 - 14.5m.) & (26.0 - 27.0) m.

The sulphate content in general varies from (0.05) to (0.93) percent. The PH value varies from (7.88) to (8.04).

The chloride content varies from (0.08) to (0.23) percent. The calcium carbonate content varies from (28.0) to (34.0) percent.

6- GENERAL RECOMMENDATIONS

No design data was provided by the concerned authority the following recommendation is made according to field and laboratory tests.

6-1 Type OF Footing

Deep pile foundation should be used for the bridge. Large diameter bored piles are recommended. The diameter and allowable working load for the suggested piles at boreholes location are shown in Table (4).

Table 4: Details of suggested piles

Dia. of piles (m.)	*Allowable working load (ton)*
1.0	300
1.5	500

6-2 Depth of Footings

It is necessary to take into consideration the scour depth in order to specify the depth of pile cap otherwise the top of the cap of piles should be at least (3) m. below N.G.L at each boring point in order to minimize the scour effect of water against the footing during the flooding time.

6-3 Length of Piles

Due to the difference in nature and strength of the soil strata as well as the difference in ground level the tips of piles are placed at least (23) m. in its effective length (below the bottom of the cap).

6-4 Working Load per a Single Pile

For both single and group action of piles, each single pile should not be loaded a working load of more than (300 or 500) tons for piles of (1.0 or 1.5) m. diameter respectively. The working load of piles are based on the strength of concrete cylinder (1:1.5:3) of 6" in diameter and 12" in height cured for 28.0 days in water giving a crushing strength of not less than 3000 psi.

6-5 Loading Test for Piles

Loading test should be performed in the site on a representative number of piles. The lower results in both the working load and the resulting settlement between our recommendation and the loading test results should be adopted.

6-6 Settlement

The maximum expected settlement under piles will be within permissible limits.

6-7 Type of Cement

- Sulphate resisting cement must be used for concrete works in touch with the soil.
- The amount of cement content is 420 kg/m^3.
- Maximum free water / cement ratio is 0.45 by weight.
- Vibrators should be used in order to density fresh concrete.
- Minimum concrete cover of (7.5) cm is recommended to protect reinforcement from chlorides effect.

6-8 Dewatering

During construction, the under ground water should be pumped out until the construction reaches ground level.

Ban K. Mohammed
Engineer

Hisham F. Razouki
Head of Soil Dept. Consultant

Taha Yaseen
Director of Soil Investigation

MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Majid Bridge /Um al-kaf district**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 1**

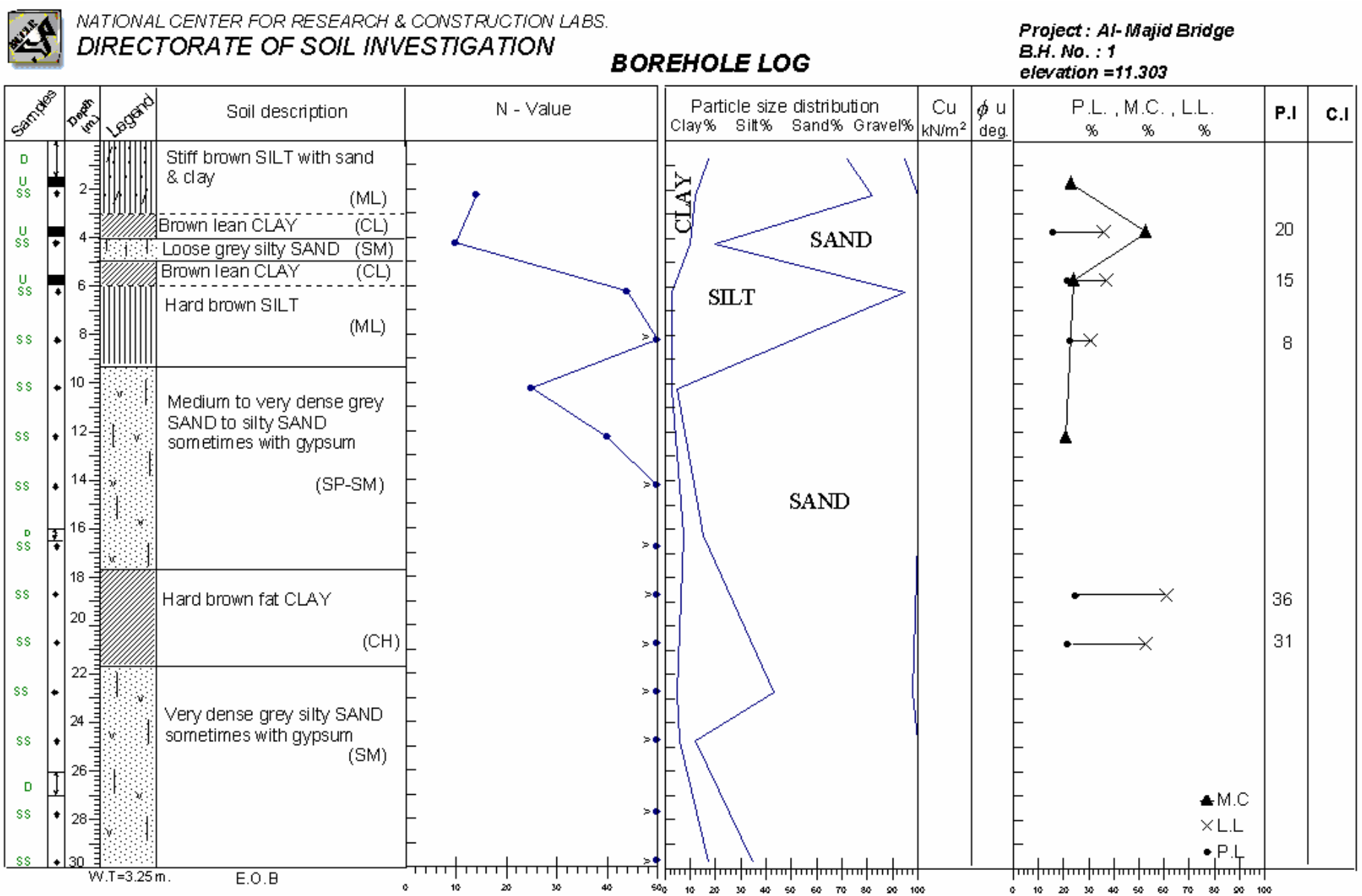
Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 1							**Elevation = 11.303 m.**						
1	3067	0.0	1.5						[17	55	23	5]		***	ML	Brown silt with sand &clay	**0.93**			**0.24**	**8.03**	**0.22**
2	3068	1.5	2.0	23										***	ML	Do						
3	3069	2.0	2.5						[12	70	18	0]		14	ML	Do (stiff)	**0.05**	**34.**				
4	3070	3.5	4.0	53	36	20							2.72	***	CL	Brown lean clay						
5	3071	4.0	4.5						[-20-		80	0]		10	SM	Loose grey silty sand						
6	3072	5.5	6.0	24	37	15							2.7	***	CL	Brown lean clay						
7	3073	6.0	6.5						[3	92	5	0]		44	ML	Hard brown silt	**0.1**				**8.0**	**0.09**
8	3074	8.0	8.5		31	8								53	ML	Do						
9	3075	10.0	10.5						[-5-		95	0]			SP	Medium grey sand						
10	3076	12.0	12.5	21										40	SP	Do (dense)						
11	3077	14.0	14.5											86/12"	SP	Gypsum soil	**23.9**		**50.7**			
12	3078	16.0	16.5						[-15-		85	0]		***	SM	Grey silty sand						
13	3079	16.5	17.0											50/5"	SM	Very dense grey silty sand						
14	3080	18.5	19.0		61	36								50/2"	CH	Hard brown fat clay						
15	3081	20.5	21.0		53	31								50/4"	CH	Do						
16	3082	22.5	23.0						[5	38	55	2]		50/6"	SM	Very dense grey silty sand						
17	3083	24.5	25.0						[-12-		88	0]		91/10"	SM	Do						
18	3084	26.0	27.0											***	SM	Do (highly gypsum)	**22.4**		**48.1**			
19	3085	27.5	28.0											50/3"	SM	Do						
20	3086	29.5	30.0						[-35-		65	0]		50/2"	SM	Do						
21	3108	Water sample															**0.20**				**7.88**	**0.23**
																Water table =3.25 m .below N.G.S						

MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Majid Bridge /Al-Majid district**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 2**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 2							**Elevation = 11.135 m.**						
1	2087	D	0.0	1.5					[15	71	14	0]		***	ML	Brown silt with sand &clay	**0.05**				**8.03**	**0.12**
2	2088	U	1.5	2.0	19	35	17	11						***	CL	Brown lean clay						
3	2089	SS	2.0	2.5		59	35							16	CH	Stiff brown fat clay						
4	2090	SS	3.5	4.0					[43	52	5	0]		21	CH	Do (very stiff)						
5	2091	U	4.0	4.5	26									***	CH	Do	**0.15**				**8.04**	**0.08**
6	2092	SS	4.5	5.0		64	39							33	CH	Do (hard)						
7	2093	U	6.0	6.5	29	58	34						2.72	***	CH	Do						
8	2094	SS	6.5	7.0		58	31							16	CH	Do (stiff)	**0.15**					
9	2095	SS	8.0	8.5					[12	45	43	0]		20	ML	Very stiff brown sandy silt	**0.20**					
10	2096	U	10.0	10.5	30	36	19						2.70	***	CL	Brown lean clay with silt						
11	2097	SS	10.5	11.0					[15	77	8	0]		20	ML	Very stiff brown silt with clay						
12	2098	SS	12.5	13.0										24	ML	Do (very stiff)						
13	2099	U	14.5	15.0	42				[59	39	2	0]	3.72	***	CH	.brown fat clay						
14	3100	SS	15.0	15.5		53	25							27	MH	Very stiff brown elastic silt						
15	3101	SS	17.0	17.5										37	MH	Do (hard)	**0.88**	**28.2**				
16	3102	SS	19.0	19.5					[45	52	3	0]		50/6"	CH	Hard brown fat clay						
17	3103	D	21.0	22.0		61	36							***	CH	Do						
18	3104	SS	23.0	23.5					[-27-		74	0]		50/4"	SM	Very dense grey silty sand	**0.84**					
19	3105	SS	25.0	25.5										50/3"	SM	Do						
20	3106	SS	27.0	27.5										50/4"	SM	Do						
21	3107	SS	29.5	30.0					[2	1	77	20]		50/2"	SM	Do (with gravel)						
																Water table =3.05 m .below N.G.S						


NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS.
DIRECTORATE OF SOIL INVESTIGATION
BOREHOLE LOG
Project : Al-Majid Bridge
B.H. No. : 1
elevation =11.303
Samples
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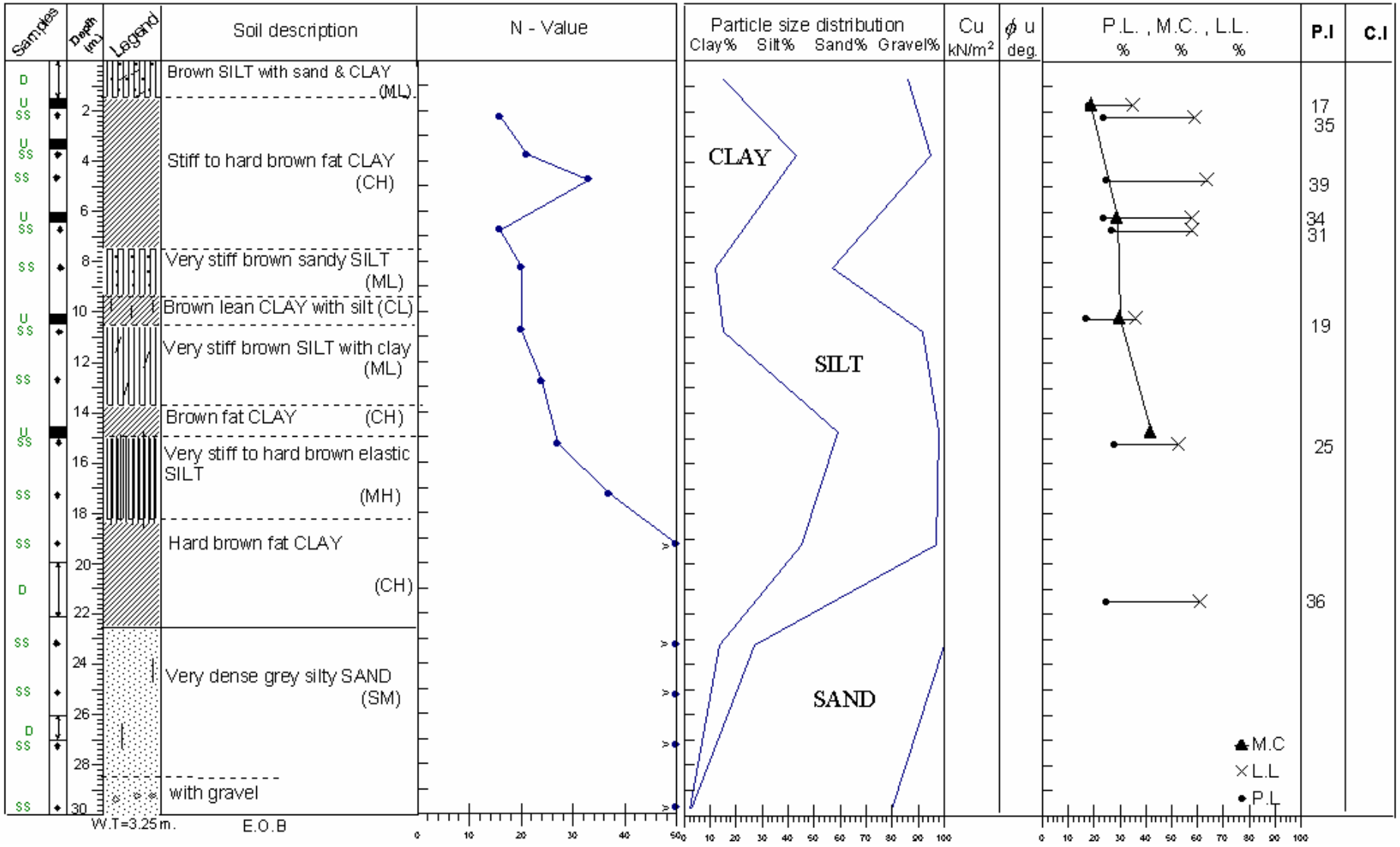
NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS.

DIRECTORATE OF SOIL INVESTIGATION

BOREHOLE LOG

Project : Al- Majid Bridge
B.H. No. : 2
elevation =11.135



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Al - Mahdi Bridge in Samawah

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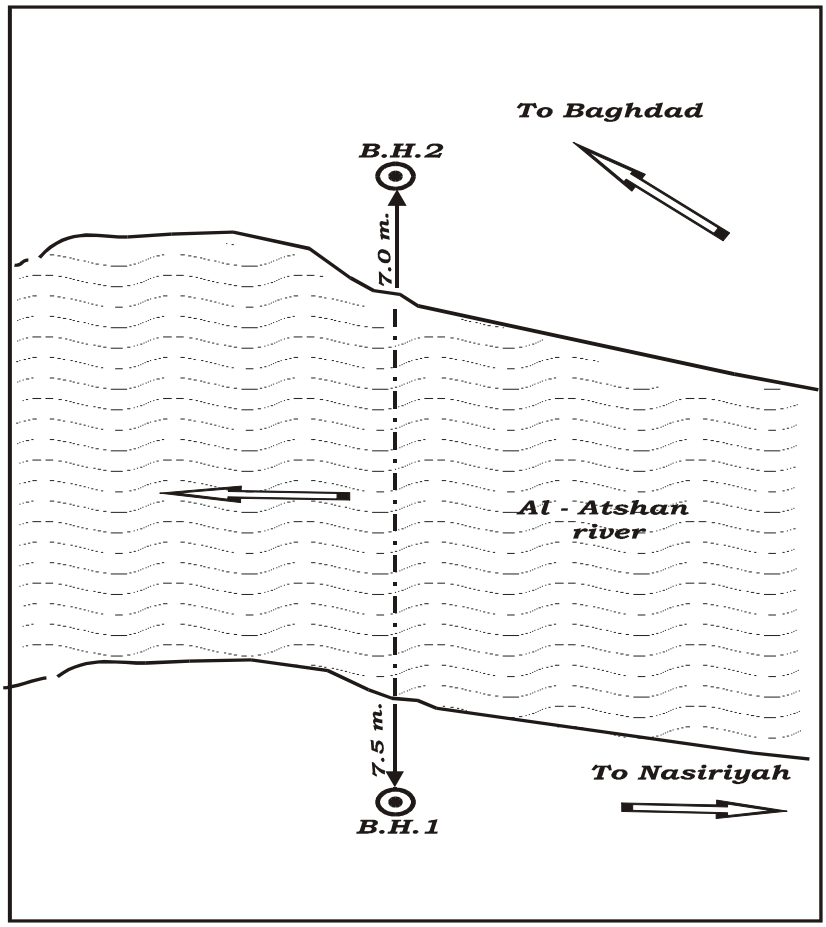

Fig. 1: Site plan for borehole locations

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A full list of tests conducted for this project is:

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- Unit weight (natural and dry).
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- Unconfined compression strength.
- Direct shear test.

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- Sulphate content (SO_3 %).
- Chloride content (Cl %).
- PH value.
- Calcium carbonate ($CaCo_3$ %)
- Organic matter (ORG%).

The results of these tests are shown in the Record of "Tests Result sheet "appended.

4- SUBSOIL STRATIFICATION

4-1 Soil Profile

According to the unified soil classification system (USCS), the subsoil profile for each borehole location can be summarized as follows: -

Borehole No.1 Location

- The main soil layer consists of cohesive soil of medium to hard brown lean to fat clay (CL,CH) change to clayey silt (ML). This layer extends from (N.G.S) to the end of boring of (30.0) m. depth. Through this layer, thin layer of medium to dense grey silty sand (SM) at different depth with (1.75 - 2.5) m. thickness.

Borehole No.2 Location

- The main soil layer consist of stiff to hard brown lean to fat clay (CL,CH) mixture with silt change to silt with sand or sandy silt (ML) to clayey silt. This layer extends from (N.G.S) to the end of boring of (30.0) m. Through this layer, a lense of very dense grey silty sand of (1.0 - 1.75) m. thick was observed in different depths.

4-2 Underground Water Level

The underground water level was encountered at a depth of (0.25) at the location of borehole (1), and at a depth of (0.12) m. at the location of borehole (2) below natural ground surface (N.G.S) after 24 hours from

drilling termination at the time of boring (November /2004). This level may fluctuate during the coming season due to the fluctuation of water level in the Euphrates River.

5- EVALUATION AND DISCUSSION OF RESULTS

5-1 Strength of the Soil

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Table 1: Unconfined test results with depth

B.H No.	*Depth (m.)*	*Qu (kN/m^2)*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	1.5 - 2.0	148	18.2	13.5
2	6.0 - 6.5	250	19.2	14.8
	4.5 - 5.0	200	19.5	15.2

For the cohesion less soil layer, only one sample was tested, the results of direct shear (C, Ø) and number of blows of standard penetration test (S.P.T) indicate that the relative density of this soil is medium to very dense .The results of direct shear test results with depth are shown in Table (2).

Table 2: Direct shear test results with depth

B.H No.	*Depth (m.)*	*C (kN/m^2)*	*Ø Degree*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	10.0 - 10.5	0	34	19.4	16.1

5-2 Consolidation Test Results

The variations of overburden (Po), preconsolidation (Pc) pressures with depth, which are shown in Table (3), indicate that the cohesive soil layer in general is over consolidated.

Table 3: Overburden, preconsolidation pressures with depth

B.H No.	Depth (m.)	Po kN/m^2	Pc kN/m^2	Void ratio e_o	C_c	C_r
1	1.5 - 2.0	18	199	0.84	0.29	0.050
	6.0 - 6.5	59	550	0.86	0.24	0.062
2	1.0 - 1.5	11	380	1.03	0.29	0.017
	4.5 - 5.0	39	170	0.83	0.13	0.037
	6.5 - 7.0	48	250	0.85	0.34	0.053

5-3 Atterberg limits Test Results

The values of liquid limit (L.L.), plasticity index (P.I.) and moisture content (M.C.) at different depths are shown in the "Record of test result sheets "and "borehole logs" appended.

The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit for both site locations.

5-4 Chemical Properties

The results of the chemical tests for soil and water samples are shown in the "Test Results Sheet".

The results in general indicate slight sulphate content. The sulphate content in general varies from (0.05) to (0.72) percent. The PH value varies from (7.66) to (8.28).

The chloride content varies from (0.09) to (0.66) percent. The organic matter content varies from (0.51) to (0.89) percent.

6- GENERAL RECOMMENDATIONS

No design data was provided by the concerned authority the following recommendation is made according to field and laboratory tests.

6-1 Type of Footing

Deep pile foundation should be used for the bridge. Large diameter bored piles are recommended. The diameter and allowable working load for the suggested piles at boreholes location are shown in Table (4).

Table 4: Details of suggested piles

Dia. of piles (m.)	*Allowable working load (ton)*
1.0	300
1.5	500

6-2 Depth of Footings

It is necessary to take into consideration the scour depth in order to specify the depth of pile cap otherwise the top of the cap of piles should be at least (3) m. below N.G.L at each boring point in order to minimize the scour effect of water against the footing during the flooding time.

6-3 Length of Piles

Examination of soil profile through boreholes shows that the sub -soil strata are predominantly silt and clay. Therefore no other economical way rather than using friction piles in cohesive strata. Each single pile should be at least (16.0) m. in its effective length (below the bottom of the cap).

6-4 Working Load per a Single Pile

For both single and group action of piles, each single pile should not be loaded a working load of more than (300 or 500) tons for piles of (1.0 or 1.5) m. diameter respectively. The working load of piles are based on the strength of concrete cylinder (1:1.5:3) of 6" in diameter and 12" in height cured for 28.0 days in water giving a crushing strength of not less than 3000 psi.

6-5 Loading Test for Piles

Loading test should be performed in the site on a representative number of piles. The lower results in both the working load and the resulting settlement between our recommendation and the loading test results should be adopted.

6-6 Settlement

The maximum expected settlement under piles will be within permissible limits.

6-7 Type of Cement

- Sulphate resisting cement must be used for concrete works in touch with the soil.
- The amount of cement content is 420 kg/m^3.
- Maximum free water / cement ratio is 0.45 by weight.
- Vibrators should be used in order to density fresh concrete.
- Minimum concrete cover of (7.5) cm is recommended to protect reinforcement from chlorides effect.

6-8 Dewatering

During construction, the under ground water should be pumped out until the construction reaches ground level.

Ban K. Mohamed
Engineer

Hisham F. Razouki
Head of Soil Dept. Consultant

Taha Yaseen
Director of Soil Investigation

MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Mahdi bridge**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 1**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 1							**Elevation =7.688 m**						
1	3022	D	0.0	1.5		44	22	12	[27	58	15	0]		***	CL	Brown silty lean clay with sand	**0.15**			**0.51**	**7.9**	**0.11**
2	3023	U	1.5	2.0	35								2.69	***	CL	Do						
3	3024	SS	2.0	2.5		48	28	12						8	CL	Do (medium)						
4	3025	D	3.0	3.5					[15	34	51	0]		***	SM	Grey silty sand	**0.05**				**8.28**	**0.09**
5	3026	SS	3.5	4.0										12	SM	Do (medium)						
6	3027	SS	5.0	5.5		45	24							48	CL	Hard brown lean clay						
7	3028	U	6.0	6.5	30				[37	60	3	0]	2.71	***	CL	Do						
8	3029	SS	6.5	7.0		47	21							43	ML	Hard brown clayey silt						
9	3030	SS	8.0	8.5					[23	74	3	0]		48	ML	Do (hard)						
10	3031	U	10.0	10.5	20									***	SM	Grey silty sand	**0.15**					
11	3032	SS	10.5	11.0					[-26-		74	0]		19	SM	Do						
12	3033	D	12.5	13.0		56	33							***	CH	Brown fat clay						
13	3034	SS	14.0	14.5					[-19-		81	0]		34	SM	Dense grey silty sand						
14	3035	SS	16.0	16.5		58	36							46	CH	Hard brown fat clay						
15	3036	SS	17.5	18.0										91/8"	CH	Do						
16	3037	SS	19.5	20.0					[29	68	3	0]		50/5"	ML	Hard brown clayey silt						
17	3038	D	21.0	21.5		61	37							***	CH	Brown fat clay		**10.9**		**0.77**		
18	3039	SS	22.0	22.5										50/6"	CH	Do (hard)				**0.89**		
19	3040	SS	24.0	24.5		64	39							50/6"	CH	Do (hard)						
20	3041	D	26.0	26.5					[24	68	8	0]		***	ML	Brown clayey silt						
21	3042	SS	27.5	28.0										50/4"	ML	Do (hard)						
22	3043	SS	29.5	30.0					[33	64	3	0]		50/4"	CL	Hard brown lean clay						
23	3066	Water sample														**Water table=0.25 m. below N.G.S**	**0.20**				**7.88**	**0.30**

MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Mahdi bridge**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 2**

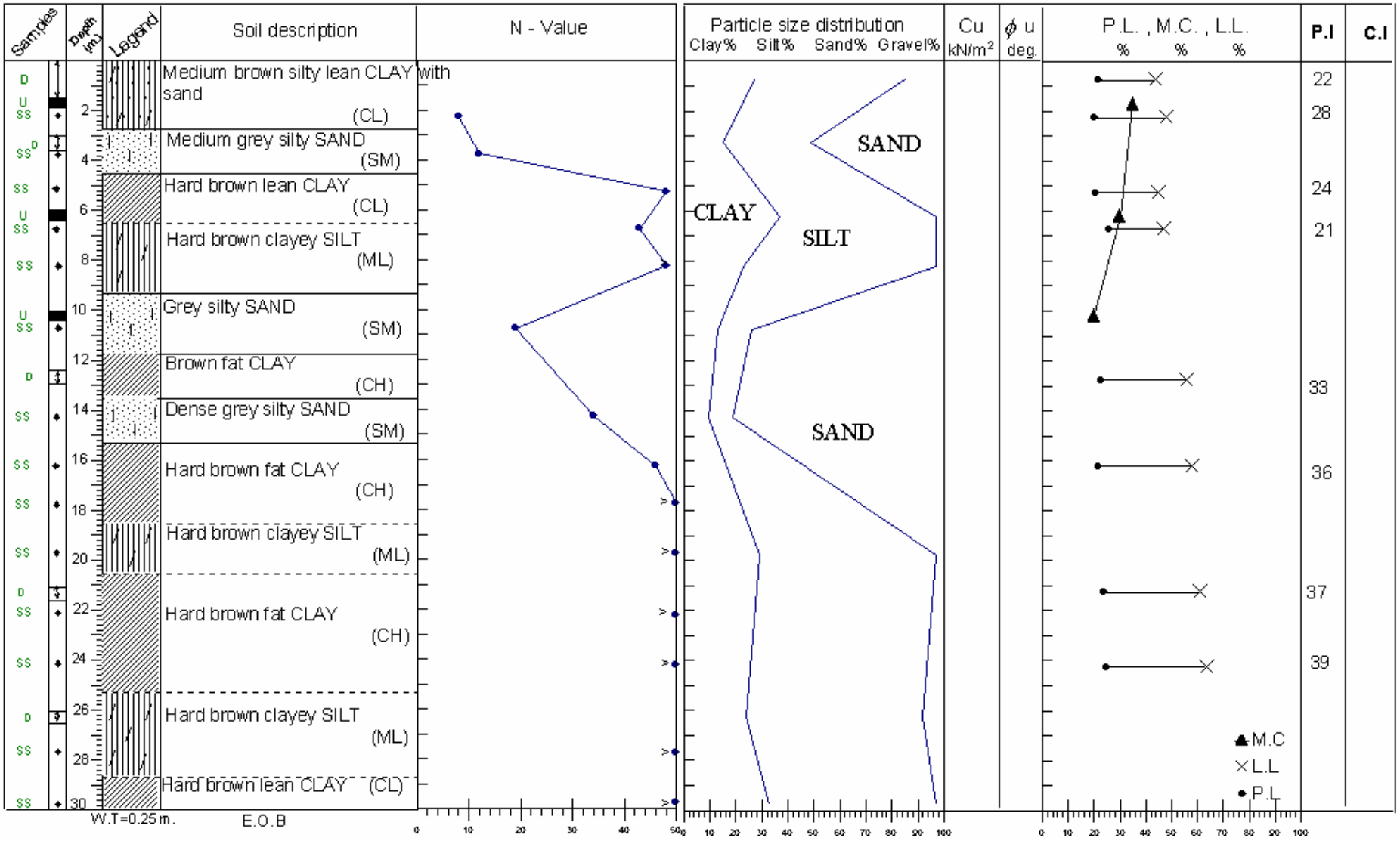
Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 2							**Elevation =7.555m.**						
1	3044	D	0.0	1.0					[8	73	19	0]		***	ML	Brown silt with sand	**0.72**			**0.69**	**7.66**	**0.66**
2	3045	U	1.0	1.5									2.7	***	ML	Do						
3	3046	SS	1.5	2.0					[5	55	40	0]		10	ML	Stiff brown sandy silt						
4	3047	SS	3.0	3.5										21	ML	Do (very stiff)	**0.10**				**8.15**	**0.09**
5	3048	U	4.5	5.0	30				[34	64	2	0]	2.7	***	CL	Brown silty lean clay						
6	3049	SS	5.0	5.5		53	30	14						56	CH	Hard brown fat clay						
7	3050	U	6.5	7.0	20	50	29						2.69	***	CL	Brown silty lean clay						
8	3051	SS	7.0	7.5					[30	67	3	0]		29	CL	Do (very stiff)	**0.05**					
9	3052	SS	9.0	9.5	15				[2	23	75	0]			SM	Very dense grey silty sand						
10	3053	D	10.5	11.0		55	32							***	CH	Brown fat clay						
11	3054	SS	12.5	13.0					[3	27	70	0]		61	SM	Very dense grey silty sand						
12	3055	SS	13.5	14.0		40	23							41	CL	Hard brown lean clay						
13	3056	D	15.0	15.5					[-24-		76	0]		***	SM	Grey silty sand						
14	3057	SS	15.5	16.0					[15	81	4	0]		50/3"	ML	Hard brown silt with clay						
15	3058	SS	17.5	18.0										50/2"	ML	Do						
16	3059	SS	19.5	20.0					[32	64	4	0]		50/3"	CL	Hard brown silty lean clay						
17	3060	D	20.5	21.0		50	25							***	CL	Do		**18.8**		**0.54**		
18	3061	SS	22.0	22.5					[22	70	8	0]		50/4"	ML	Hard brown clayey silt						
19	3062	SS	24.0	24.5										50/2"	ML	Do				**0.73**		
20	3063	SS	26.0	26.5					[20	72	8	0]		50/4"	ML	Do						
21	3064	D	27.5	28.0		55	30							***	CH	Brown fat clay						
22	3065	SS	29.5	30.0					[25	60	15	0]		50/2"	ML	Hard brown clayey silt with sand						
23		Water sample														**Water table=0.12 m. below N.G.S**						

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS.

DIRECTORATE OF SOIL INVESTIGATION

BOREHOLE LOG

Project : Al-Mahdi Bridge
B.H. No. : 1
elevation =7.688m.

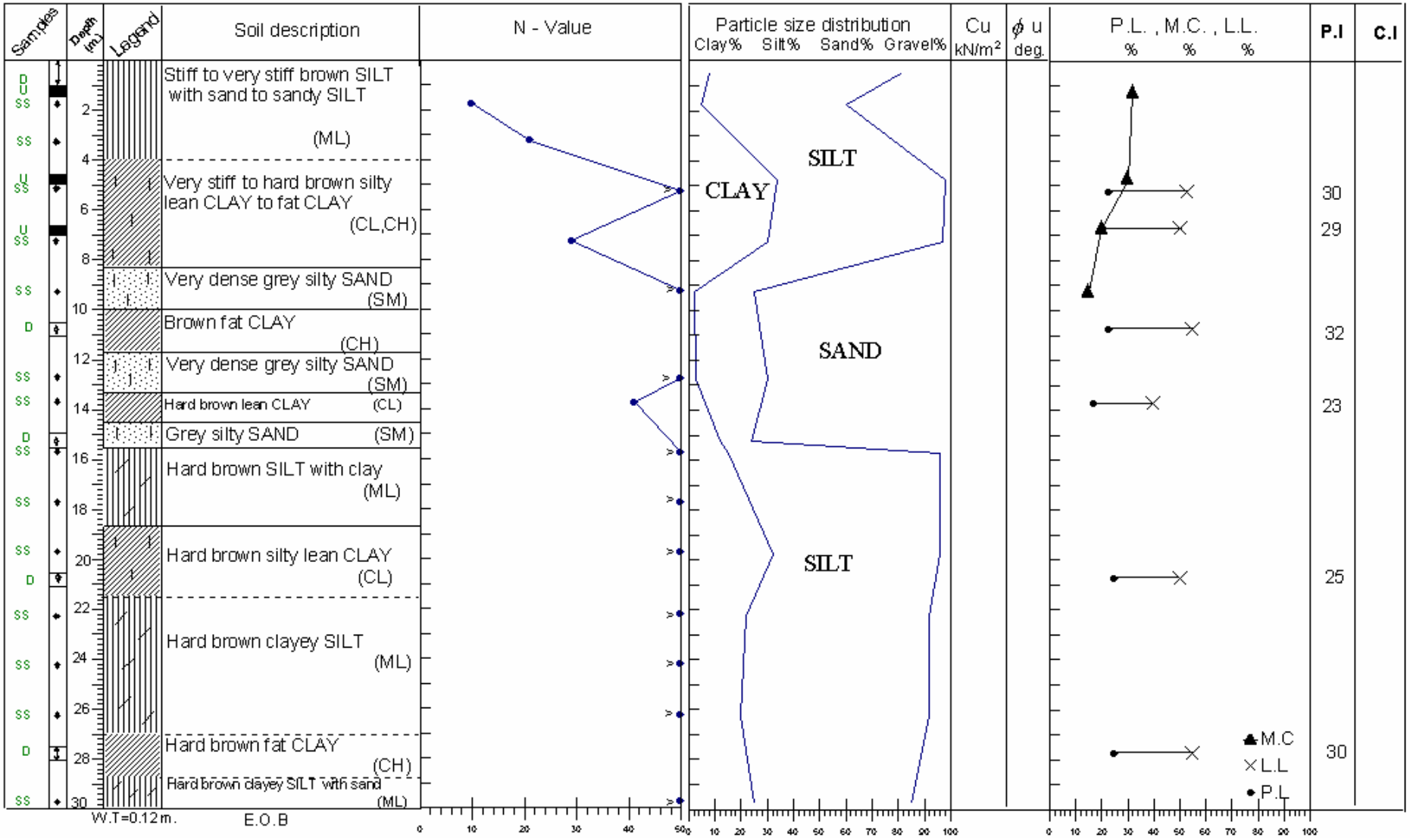


NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS.

DIRECTORATE OF SOIL INVESTIGATION

BOREHOLE LOG

Project : Al-Mahdi Bridge
B.H. No. : 2
elevation =7.555m.



REPORT NO. 1/1/5 9/2004-BAGHDAD

Al - Daraji Bridge in Samawah

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Al - Daraji Bridge in Samawah

Contents

REPORT NO. 1/1/5 9/2004 - BAGHDAD

Al - Daraji Bridge in Samawah

1- INTRODUCTION

1-1 Authorization and Scope

The soil investigation for this project has been conducted by the Directorate of Soil Investigation / National Centre for Research & Construction Laboratories (NCCLR) - Baghdad according to the contract with "Dar Al- Handasah "dated at 31/ 10 /2004.

The soil investigation described in this report consists of drilling the boreholes, securing representative samples, testing these samples and analyzing the soil conditions with test results.

1-2 Site Location and Description

The site is located at Al- Muthanna governorate near Al- Khider on Euphrates River. Which is far from Baghdad city of about 300 Km (south - west)? The locations of the drilled boreholes are not similar in level. The site is located at the two banks of Euphrates River.

2- FIELD EXPLORATION

2-1 Drilling and Sampling

Drilling was done using flight auger. The drilling rig used is of (Acker) type, which is a power driven machine. The diameters of drilled boreholes were (15.0) cm. The disturbed sample (D) were collected from the cutting of auger at any depth. The undisturbed samples marked (U) were obtained using Shelby tubes. Split spoon samples (SS) were obtained from standard split spoon used in a Standard Penetration Test (S.P.T), which was performed for every test boring at different intervals depending on the stratification of the soil.

The actual depth for all samples and the N-Values for S.P.T. are shown in the record of test results sheets of this report.

2-2 Number of Boreholes

Two boring points were assigned and located by the concerned authorities at the locations of abutments (one borehole at each river bank). These boring points were drilled to the depth of (30.0) m. The locations of these boreholes are marked on the site plan at (Fig.1).

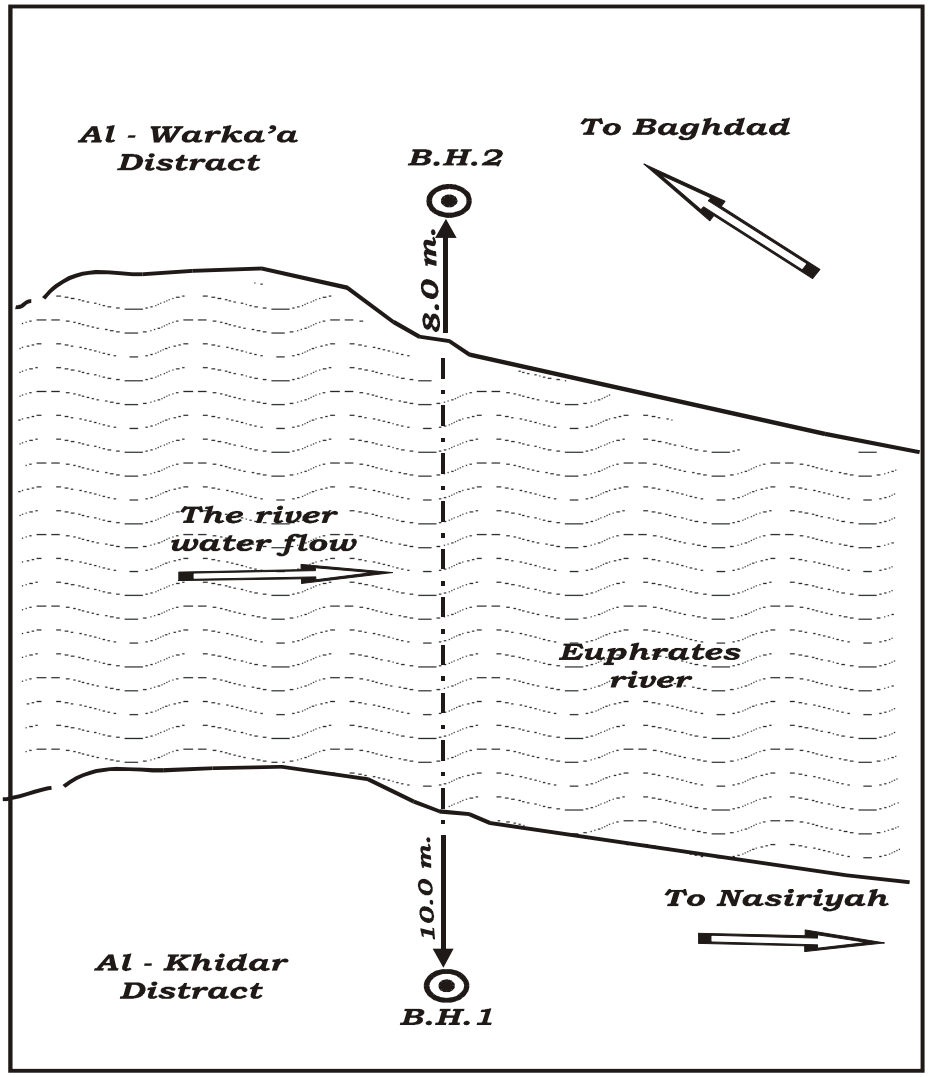

Fig. 1: Site plan for borehole locations

3- LABORATORY TESTING

Each of the soil samples received by the laboratories of the Directorate of Soil Investigations Baghdad was given a laboratory number.

The samples of the borehole were visually examined for initial classification before laboratory testing.

The test program was decided by the soil engineer. The actual test proposed for a particular sample depends on the type of sample (S.S, U & D) and the nature of its material.

A full list of tests conducted for this project is:

A- Classification Tests

- Atterberg limits (L.L, P.L).
- Grain size analysis (sieve and hydrometer analysis).
- Linear shrinkage limits (L.S).
- Unit weight (natural and dry).
- Natural moisture content.

B- Strength and Deformation Tests

- Unconfined compression strength.
- Direct shear test.

C- Consolidation Test

D- Chemical Tests for Water and Soil Samples

- Sulphate content (SO_3 %).
- Chloride content (Cl %).
- PH value.
- Calcium carbonate ($CaCo_3$ %)
- Organic matter (ORG%).

The results of these tests are shown in the Record of "Tests Result sheet "appended.

4- SUBSOIL STRATIFICATION

4-1 Soil Profile

According to the unified soil classification system (USCS), the subsoil profile for each borehole location can be summarized as follows: -

Borehole No.1 Location (Al Khidar district)

- The first soil layer consist of stiff brown lean clay (CL) or silt with sand (ML) .This layer extends from (N.G.S) to (3.0) m.
- The second soil layer consists of medium to very dense grey silty sand (SM). This layer extends below the above layer to end of boring of (30.0) m.

Borehole No.2 Location (Al Warka'a district)

- The upper soil layer consists of loose to medium grey to brown silt with clay or sandy silt (ML). This later extends from N.G.S to (5.0) m. depth.

- The second soil layer is medium grey silty sand (SM). This layer observed below the above layer to (11.0) m. depth.
- The third soil layer is noticed below the second layer to (26.0) m. depth which consists of very dense grey moderately gypseous sandy silt (ML) or silty lean clay with sand (CL).
- The last soil layer consists of very dense grey slightly gypseous silty sand (SM) .This layer extend to the end of boring of (30.0) m.

4-2 Underground Water Level

The underground water level was encountered below natural ground surface (N.G.S) after 24 hours from drilling termination at the time of boring (November /2004). This level may fluctuate during the coming season due to the fluctuation of water level in the Euphrates River. The elevation of boreholes and the depth of water are shown in Table 1.

Table 1: Elevation of boreholes & the Depth of Water Table

B.H No.	*Elevation (m.)*	*Depth of W.T (m.)*
1	9.596	3.6
2	6.268	0.3

5- EVALUATION AND DISCUSSION OF RESULTS

5-1 Strength of the Soil

For the cohesive soil layer, only one sample was tested, the results of the unconfined compression tests and the number of standard penetration test (S.P.T) indicate that the consistency of the cohesive soil layer is stiff to hard. The results of the unconfined compression tests as well as the results of natural and dry densities are shown in Table (2).

Table 2: Unconfined test results with depth

B.H No.	*Depth (m.)*	*Qu (kN/m^2)*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	1.5 - 2.0	326	18.5	15.0

For the cohesion less soil layer, the results of direct shear (C, Ø) and number of blows of standard penetration test (S.P.T) indicate that the relative density of this soil is medium to very dense .The results of direct shear test results with depth are shown in table (3).

Table 3: Direct shear tests results with depth

B.H No.	*Depth (m.)*	*C (kN/m^2)*	*Ø Degree*	*γ wet (kN/m^3)*	*γ dry (kN/m^3)*
1	16.0 - 17.0	0	37	19.4	16.4
2	1.0 - 1.5	0	38	19.4	14.5

5-2 Consolidation Test Results

The variations of overburden (Po), preconsolidation (Pc) & swelling (Ps) pressures with depth, which are shown in Table (4), indicate that the cohesive soil layer in general is over consolidated.

Table 4: Overburden, preconsolidation & swelling pressures with depth

B.H No.	*Depth (m.)*	*Po kN/m^2*	*Pc kN/m^2*	*Ps kN/m^2*	*Void ratio e_o*	C_c	C_r
1	1.5 - 2.0	31	250	30	0.87	0.28	0.042
	6.5 - 7.0	98	170	---	0.81	0.22	9.033

5-3 Atterberg limits Test Results

The values of liquid limit (L.L.), plasticity index (P.I.) and moisture content (M.C.) at different depths are shown in the "Record of test result sheets "and "borehole logs" appended.

The results generally indicate that the value of moisture content is closer to the plastic limit than to the liquid limit for both site locations.

5-4 Chemical Properties

The results of the chemical tests for soil and water samples are shown in the "Test Results Sheet".

The results in general indicate slight sulphate content. Except B.H.2 which indicate slight to moderately gypseous content from depth (13.0) m. down to (30.0) m. The sulphate content in general varies from (0.05) to (9.46) percent. The PH value varies from (7.8) to (8.45).

The chloride content varies from (0.09) to (0.53) percent. The organic matter content varies from (0.8) to (0.14) percent. The Calcium carbonate varies from (12.4) to (13.5) percent.

6- GENERAL RECOMMENDATIONS

No design data was provided by the concerned authority. The following recommendations are made according to field and laboratory tests.

6-1 Type of Footing

Deep pile foundation should be used for the bridge. Large diameter bored piles are recommended. The diameter and allowable working load for the suggested piles at boreholes location are shown in Table (4).

Table 5: Details of suggested piles

Dia. of piles (m.)	*Allowable working load (ton)*
1.0	300
1.5	500

6-2 Depth of Footings

It is necessary to take into consideration the scour depth in order to specify the depth of pile cap otherwise the top of the cap of piles should be at least (3) m. below N.G.L at each boring point in order to minimize the scour effect of water against the footing during the flooding time.

6-3 Length of Piles

Due to the difference in nature and strength of the soil strata as well as the difference in ground level the tips of piles are placed in different levels. Table 6. Shows the pile tip depth below the ground level at each borehole location.

Table 6: Depth of pile below the ground level

B.H No.	*Depth of pile tip below the ground elevation*
1	20
2	26

6-4 Working Load per a Single Pile

For both single and group action of piles, each single pile should not be loaded a working load of more than (300 or 500) tons for piles of (1.0 or 1.5) m. diameter respectively. The working load of piles are based on the strength of concrete cylinder (1:1.5:3) of 6" in diameter and 12" in height cured for 28.0 days in water giving a crushing strength of not less than 2200 ton/m^2.

6-5 Loading Test for Piles

Loading test should be performed in the site on a representative number of piles. The lower results in both the working load and the resulting settlement between our recommendation and the loading test results should be adopted.

6-6 Settlement

The maximum expected settlement under piles will be within permissible limits.

6-7 Type of Cement

- Sulphate resisting cement must be used for concrete works in touch with the soil.
- The amount of cement content is 420 kg/m^3.
- Maximum free water / cement ratio is 0.45 by weight.
- Vibrators should be used in order to density fresh concrete.
- Minimum concrete cover of (7.5) cm is recommended to protect reinforcement from chlorides effect

6-8 Dewatering

During construction, the under ground water should be pumped out until the construction reaches ground level.

Ban K. Mohammed
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MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Daraji bridge**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 1**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 1							**Elevation =9.596 m**						
1	3109	D	0.0	1.5					[13	69	18	0]		***	ML	Brown silt with sand	**0.85**				**7.89**	**0.24**
2	3110	U	1.5	2.0	23	47	23						2.72	***	CL	Brown lean clay						
3	3111	SS	2.0	2.5		37	15							16	CL	Do (stiff)						
4	3112	SS	3.5	4.0					[-32-		68	0]		24	SM	Medium grey silty sand	**0.08**				**8.45**	**0.09**
5	3113	SS	5.5	6.0										34	SM	Do (dense)						
6	3114	U	6.5	7.0	30	26	9						2.68	***	SM	Top: do						
															ML	Bott: brown silt with sand						
7	3115	SS	7.0	7.5					[-17-		83	0]		41	SM	Dense grey silty sand						
8	3116	SS	9.0	9.5										52	SM	Do (very dense)	**0.05**					
9	3117	SS	10.5	11.0					[-20-		80	0]		*35*	SM	Do (dense)						
10	3118	SS	12.5	13.0										51	SM	Do (very dense)						
11	3119	SS	14.5	15.0					[-21-		79	0]		64	SM	Do						
12	3120	D	16.0	17.0	18									***	SM	Do						
13	3121	SS	19.0	19.5										50/6"	SM	Do						
14	3122	SS	20.5	21.0										50/6"	SM	Do						
15	3123	SS	22.5	23.0					[-32-		68	0]		50/4"	SM	Do						
16	3124	SS	24.5	25.0										50/2"	SM	Do						
17	3125	D	26.5	27.0										***	SM	Do						
18	3126	SS	28.0	28.5					[-22-		78	0]		50/1"	SM	Do						
19	3127	SS	29.5	30.0										50/0.5"	SM	Do						
																Water table=3.6 m. below N.G.S						

MINISTRY OF HOUSING & CONSTRUCTION **PROJECT:- Daraji bridge**

NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS

RECORD OF TEST RESULTS **B.H.No.:- 2**

Samples		Type	Depth of Sample		M.C	Index Property			Particle size distribution & Hydrometer analysis				GS	SPT "N" val.	Symbol	Description of Soil	Chemical Tests					
Field No.	Lab No.		From m.	To m.		L.L %	P.I %	L.sh %	Clay %	Silt %	Sand %	Gravel %					SO_3 %	$CaCo_3$ %	GYP %	ORG %	PH	CL %
									Borehole No. 2							**Elevation =6.268m.**						
1	3128	D	0.0	1.0					[15	80	5	0]		***	ML	Brown silt with clay	**0.10**				**7.8**	**0.53**
2	3129	SS	1.0	1.5	34				[2	60	38	0]		10	ML	Loose grey sandy silt						
3	3130	SS	2.5	3.0										15	ML	Do (medium)	**0.10**				**8.45**	**0.30**
4	3131	SS	4.0	4.5										18	ML	Do (medium)						
5	3132	SS	6.0	6.5					[-22-		78	0]		21	SM	Medium grey silty sand						
6	3133	SS	8.0	8.5										23	SM	Do						
7	3134	SS	10.0	10.5										28	SM	Do						
8	3135	D	12.0	13.0		38	20		[26	46	28	0]		***	CL	Brown silty lean clay with sand						
9	3136	SS	13.5	14.0					[2	64	34	0]		50/3"	ML	Very dense grey moderately gypseous sandy silt	**9.46**	**13.5**		**0.08**		
10	3137	SS	15.5	16.0		32	15							50/2"	ML	Do						
11	3138	SS	17.5	18.0		37	16							50/2"	ML	Do	**9.18**					
12	3139	SS	19.5	20.0					[10	45	45	0]		50/3"	ML	Do						
13	3140	D	21.5	22.5										***	ML	Do	**6.67**	**12.4**				
14	3141	SS	22.5	23.0					[2	78	20	0]		50/2"	ML	Do						
15	3142	SS	24.5	25.0										50/3"	ML	Do						
16	3143	SS	26.5	27.0					[10	32	53	5]		50/2"	SM	Very dense grey slightly gypseous silty sand	**2.67**			**0.14**		
17	3144	D	27.0	28.0										***	SM	Do						
18	3145	SS	29.5	30.0					[-35-		57	8]		50/2"	SM	Do						
																Water table=0.30 m. below N.G.S						

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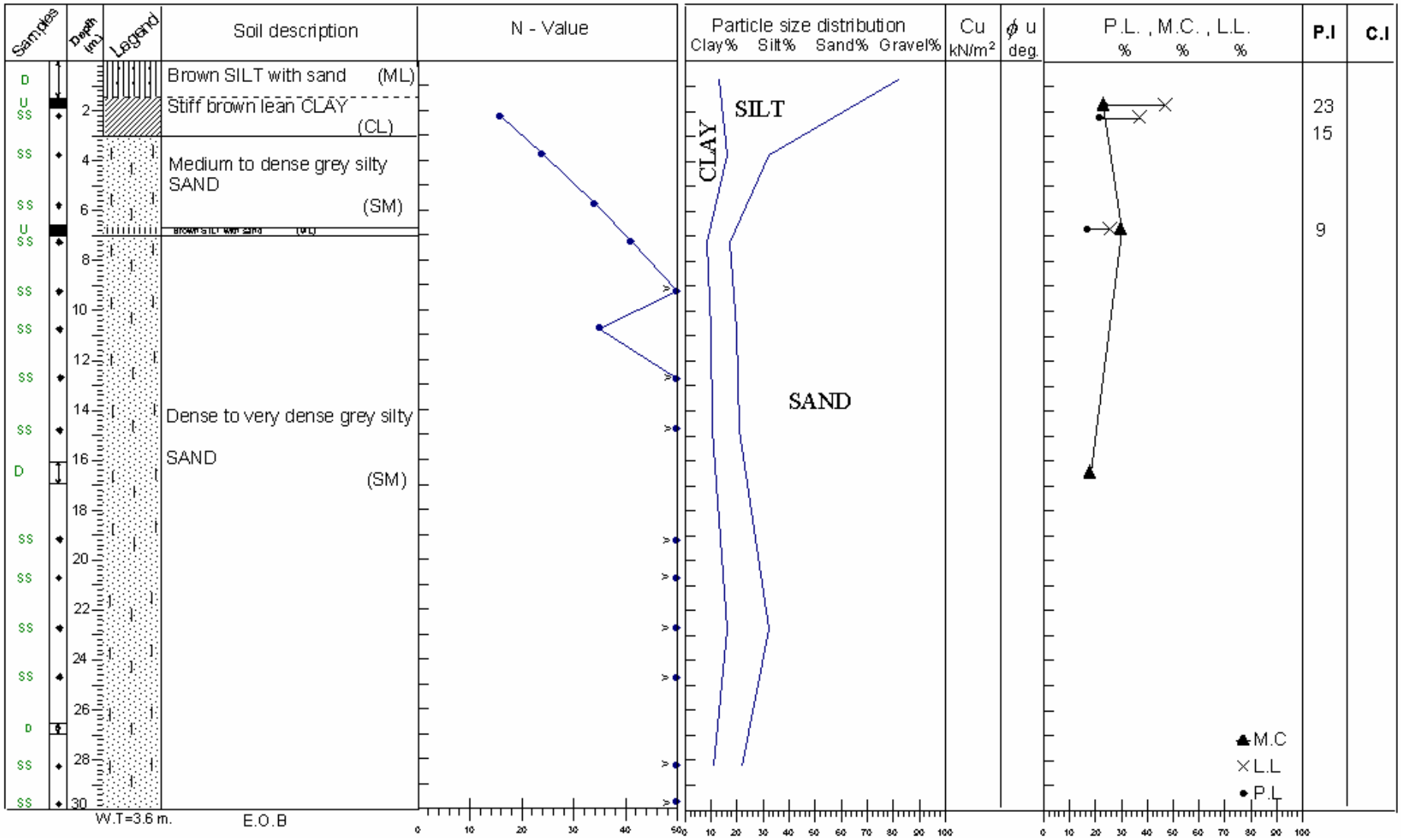
BOREHOLE LOG

Project : Al- Daraji Bridge
B.H. No. : 1
elevation =9.596m.



NATIONAL CENTER FOR RESEARCH & CONSTRUCTION LABS.

DIRECTORATE OF SOIL INVESTIGATION

BOREHOLE LOG

Project : Al- Daraji Bridge
B.H. No. : 2
elevation =6.268m.