SOIL INVESTIGATION REPORT

Final
11/13 '99

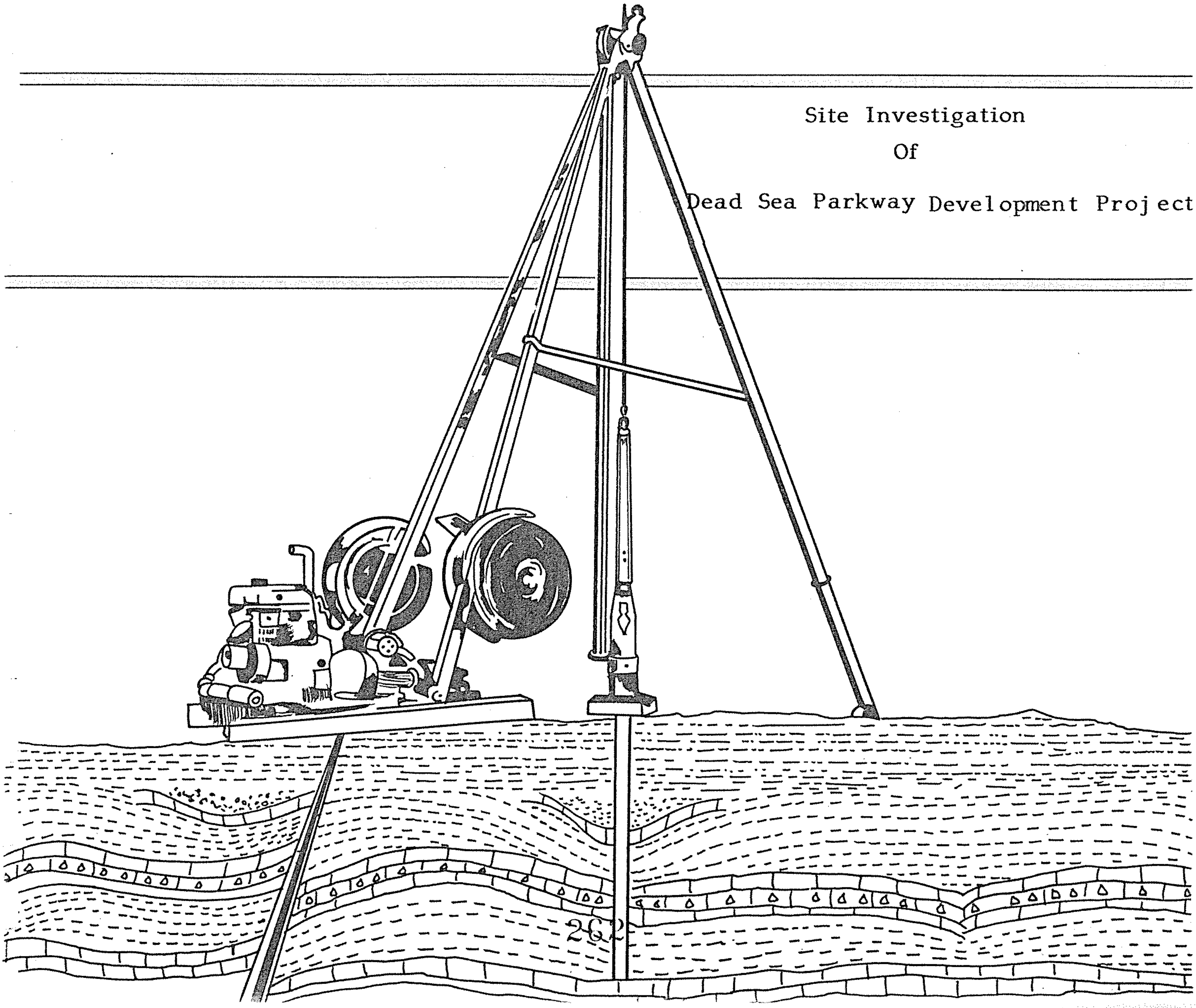
TOUKAN AND SAKET Geo-Research

Foundation Engineering & Material Testing

Site Investigation

Of

Dead Sea Parkway Development Project



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TOUKAN & SAKET
Geo - Research & Foundation
Engineering Office
Drilling , Sampling , Testing
Engineering Geology , Foundations,
Geomechanics,
& Material Testing

مكتب طوقان والساكت
للدراسات الهندسية الجيولوجية والأساسات
تثقيب ، اخذ عينات ، تحليل ،
مسح هندسي جيولوجي ، دراسة
اساسات وميكانيكا الصخور والتربة
وفحص المــواد

Ref : F.TS/246/1999
Date : 21/09/1999

Messrs : JICA Study Team
Att : Mr . Takahide Fujihira

Project : <u>Dead Sea Parkway Development</u>
<u>Site Investigation - Report</u>

Dear Sirs ,

Reference to your letter dated 21, Sept, 1999 , please find below clarification to the raised points :

1- We would like to confirm that the bedrock at the location of the drilled six boreholes of Kurnub sandstone unit is rippable by means of heavy douzers and might need rock breakers . The underlying rock below the Kurnub sandstone , (Um ishrin , Dardur Ma'in , Um irna formations) are strongly cemented and highly abrasive and might need blasting for the excavation . No drilling was performed through the mentioned formations .

2- We think there is no need for protection measures at this stage , due to good stability of the rock . Additional protection measures such as gabions and walls in wadi location could be suggested by our supervising geotechnical engineer during excavation and construction . The suggested side cut slopes could be provided easily due to large space limits available .
Engineering parameters for materials were provided in the report .

3- No chemical tests were carried out on the explored rock , due to the fact that the rock is free from Sulphates or Chlorides .

Hopping the above clarification is to your satisfaction . If you need additional information , please do not hesitate to contract us .
It is an honour to serve you .

Best Regards

Yours Faithfully

Dr. S. Saket

ص.ب ٩٢٦٨٩٧ - تلفون ٦٦٢٤٠٥ - فاكس ٦٦٤٤٨٣ - تلكس : ٢١٥٤٢ طوقان جو عمان - الأردن
P.O.Box 926897 - Telephone 662405 - Fax. 664483 Telex : 21542 Toukan Jo - Amman - Jordan

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وفحص المــواد

Ref : R99/25/1999

Date: 12/08/1999

Messrs : **JICA Study Team**

Site Investigation
Of
Dead Sea Parkway Development Project

Dear Sirs,

Upon your request, concerning the above mentioned project , we have the honour to submit for your consideration the attached report in which we summarized the results of the investigation undertaken by our firm.

We take the opportunity to express to you our highest consideration

Best Regards

Sincerely yours,

Toukan & Saket

Dr . S.Saket

ص.ب ٩٢٦٨٩٧ - تلفون ٦٦٢٤٠٥ - فاكس ٦٦٤٤٨٣ - تلكس : ٢١٥٤٢ طوقان جو عمان - الأردن
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Site Investigation
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1.0 Introduction

Upon the request of Messrs. JICA Study Team , sub-soil investigation was carried out for the proposed route and bridge sites, in accordance with the British Standards Specification, CP 2001 for site investigation .

The investigation was carried out by performing 6 boreholes, drilled at locations determined by the geotechnical Engineer to a depth of ranging between 10.0 and 35.0m .

The proposed project consists of a route connecting the Ma'in road and the Dead Sea passing by the panoramic complex project .

The drilling was concentrated at the bridge sites and at the proposed main cut locations . (see site plan) .

2.0 Scope of Work

The purpose of this study was to determine the ground conditions at the bridge and cut sites , in order to provide full information about the ground conditions and geotechnical properties of foundation materials and all other information that would assists in the Engineer in the design of proper and safe foundation and side cut slopes .

In addition representative samples were collected from the wadies for laboratory testing to assist in the design of the road .

The works included the following :

- Field visits and general description of the proposed project .
- Setting up locations of boreholes.
- Drilling 6 boreholes and carrying out the necessary field tests.
- Recovery of representative samples .
- Carrying out the required laboratory tests.

Analysis of the site investigation data, laboratory testing and geotechnical interpretation form the basis of this report.

3.0 Geomorphology & General Geology

3.1 Geomorphology

The proposed route could be divided into two main geomorphological features :

- Lower stretch
- Upper plateau

The lower stretch is the section between station 00 + 00 and 5 + 000 . The lowest elevation at the intersection with the Dead Sea highway point (station 00+000) is – 350m and the elevation at station 5 + 000 is about 120m . The terrain along this stretch is very rugged , intersected by many deeply insized gullies . This stretch is not accessable for vehicles .

The upper plateau runs on wide and long terraces and intersects two main wadies ; Wadi Himara and Wadi Al Asal . Two bridges are proposed on those wadies .

The highest point of this stretch is 170m at the intersection with ma'in road (station 9.000) and the lowest is 120 at station 5+ 000 .

Most of the proposed rock cut height in the design is less than 12m except for cuts adjacent to the proposed bridge at station 7+090 . The proposed cut height at station 6+850 is 23m and at station 7+300 is 18m .

3.2 General Geology

The rock formation outcroping along the proposed route are mainly of sedimentary origin . They could by sub – divided as follows :

- Kurnub Sandstone
- Dardur Formation
- Ma'in Formation
- Lisan Marl
- Um Ishrin sandstone Formation

Generally the above formations could be briefly described as follows and shown on the attached geologic map figure (1) , Appendix B .

- **Kurnub Sandstone**

This group crops out at the wide terrace and consists of white , medium to coarse grained and pebbly , planar cross – bedded sandstone passing upwards to trough cross- bedding sandstone in the lower part . The upper part is varicoloured , red mauve , pink , grey white and yellow , medium grained sandstone with level bedded , burrow – mettled horizons and both planner and trough cross – bedding , toward the top , channel – fill sandstone with plane fragments are common .
Kurnub group is of Cretaceuos in age .

- **Dardur Formation**

This formation crops out at the top of the cliff and consist of four member

a- black to dark green shale , dolomitic limestone and of laminated marl .

b- Cross – bedded , white sandstone with dolomitic sandstone and marl .

c- Dolomitic limestone , mainly intercalations of shale , marl , clay and mud cracks .

d- Fine to medium white , sandstone intercalated by green to yellow siltstone and clay,

The formation of Triassic in age .

- **Kurnub Sandstone Group**

- **Ma'in Formation**

This group . crops out at the middle of the cliff and consist of alternating of thinly bedded sandstone , siltstone and clay with some carbonate with trace fossils and ripple – marks and mud cracks and of Triassic in age .

This formation is divided into , Nimra and Himara groups .

- **lisan Marl Formation**

This formation rest unconformably on the older rocks at the middle of the cliff , and consists of :

a- thinly laminated marl with gypsum .

b- cross bedded calcarenit and siliciclastic sand and gravel .

c- cross bedded cemented calcarenitic and oolitic beach rock the beds were deposited in saline lake .

• Umm Ishrin Sandstone Formation

This formation crops out at the base of the cliff and consist of red brown to yellowish medium to coarse – grained sandstone with planner and trough cross – bedding and siltstone . It was deposited by fluvial barided streams and of Cambrian age .

3.3 General Description of the Material Along the Route

The rock formations along the proposed route could be described as follows :

Station 0.0 + 000 to 00 + 600	Um Ishrin formation composed of sandstone , brownish red and reddish siltstone bands , cross bedding , occasionally covered with gravels and boulders .
Station 00 + 600 to 1 + 800	(Dardur – Ma'in formation) composed of brownish reddish sandstone strongly cemented , cross bedded , coarse grained , highly jointed .
Station 1 + 800 to 3 + 900	Debris material (Lisan Marl gravel formation) composed of boulders , rounded cobbles , gravels and creamish sand , under lain by sandstone friable , weakly to strongly cemented, water streams and springs were observed .
Station 3 + 900 to 9 + 000	Massive varicoloured , strongly cemented Kurnub sandstone , coarse grained , jointed .

4.0 Method of Investigation

All drilling, sampling and testing were performed in accordance with the British Standards, CP 2001.

The sub-surface was explored by Hands of England , land Rover mounted type rig, advance by rotary drilling allowing the performance of Standard and cone penetration tests and taking representative samples.

Dry drilling to refusal in boreholes was used to recover representative samples. The boreholes were monitored for any ingress of water during dry drilling.

Representative samples were obtained during the drilling operation and were placed in tight plastic bags and wooden boxes for description.

Standard and cone penetration tests were carried out in accordance with the BS Standards 1377(Test 19) and the results were recorded on the boreholes logs at depths to which they refer.

The penetration tests were executed with 2 inchs standard sampling spoon with catchers and driven by dropping a 140 Ibs. Weight hammer with a 30 inches fall height. The 2 inches diameter spoon was lowered to the bottom of the boreholes and penetrated about 6 inches in the materials, whereupon the penetration test was started.

The "N" value is the number of blows required to produce one foot of penetration.

In defining the density of the non-cohesive materials, very loose material was considered to have standard penetration values less than 4 blows per foot, loose, between 4 and 10 blows per foot, medium dense, between 10 and 30 blows per foot, dense, between 30 and 50 blows per foot , and very dense, more than 50 blows per foot .

5.0 Field Works

5.1 Drilling

The locations of boreholes were chosen so as to represent the study area and provide as much information as possible.

A total of 6 boreholes were drilled . The locations of the drilled boreholes are shown on the attached plan .

The positioning and depth of the boreholes were determined by the geotechnical Engineer of the client .

5.2 Sampling

Continuous samples of the drilled materials were collected at regular depth intervals of 1.0m and at each lithological change of the material . The samples were labeled, described and logged. Representative samples were also obtained for laboratory testing and classification .
Additional bulk samples were collected for compaction and CBR tests .

5.3 Insitu Testing

In order to obtain an estimate of the density insitu , cone Penetration tests were performed every 1.0m as specified by the client .
The penetration tests results indicate that the penetrated material is very dense with the CPT, "N" value, more than 50 blows per foot . (see borehole logs).

Refusal results were obtained on strongly cemented parts of the sandstone .

5.4 Drilling Results

The drilled boreholes show that the penetrated rock is mainly vari-coloured sandstone of kurnub group . The bedrock is ranging between strongly cemented to weakly cemented , friable sandstone .

No cavities or water table were detected in any of the drilled boreholes . Only jointed rock was encountered where partial loss of drilling air circulation was observed . For more details see boreholes logs attached in Appendix B .

6.0 Geomechanics

A laboratory testing program was devised and performed on representative samples obtained from the study area , to establish the engineering properties of the material involved. The only tests that could be performed on such material are :

- Grainsize analysis
- Unconfined compression test
- Direct sheer test
- Compaction
- California Bearing Ratio

The results of the grainsize analysis of the tested samples are summarized in (Table 1). The material is composed of silt, between 1.5 % and 6.0 % and sand between 94.0 % and 98.5 % .

The unconfined compressive strength of the tested samples show a range between 22.6 kg/cm^2 and 293.2 kg/cm^2 (table 2) .

The direct shear test performed on remoulded samples of sandy material obtained from the drilled boreholes , show that the cohesion is zero , with a peak friction angles between 35.0 and 45.0 degrees . The results are summarized in table (3) and shown as curves .

The specific gravity of the tested samples show a range between 2.610 and 2.650 (Table 4) .

The compaction tests performed on a two samples obtained from the surface, show that the maximum dry density is ranged between 1.88 gr/cm³ and 1.940 gr/cm³ with an optimum moisture content of 3.5 % to 4.5 % . The results are presented as curves and summarized on table (5) attached .

The CBR values of the same samples ranged between 21.0 % and 28.0 %curves are attached to this report and summarized on table (5) attached .

All tests results tables are attached in Appendix A, and presented as curves attached in Appendix C .

7.0 Conclusions & Recommendation

As a result of this study and tests, the following conclusions could be summarized :

- The drilled boreholes show that the penetrated rock is vary – colored sandstone , fine to coarse grained .
- The bedrock is ranging between weakly cemented , friable to strongly cemented .
- The rock is uniform in terms of lithology and density .
- The bedrock was encountered in all of the drilled boreholes .
- No cavities or water table were encountered in the drilled boreholes .

In order to have a safe slopes and stable foundation, the following is recommended :

6.1 Foundation Type and Depth

In order to have safe structures, the foundation materials beneath the structures must have an adequate bearing capacity to support the design loads with an appropriate factor of safety and acceptable tolerable settlements.

To have safe foundation to support the structure, the following is suggested :

- Since the foundation material at the bridges site is sandstone rock, therefore footing type foundation could be employed at the proposed design level or at a minimum depth of 2.0m in to the bedrock, with an allowable bearing capacity of 5.0 kg/cm².

Generally, the following parameter could be estimated to be used for design :

Friction angle (Ø)	45-50°	(Intact rock)
	27-38	(along a joint)
	25-34	(Residual)
Cohesion (C)	= 0°	
Wet unit weight	= 2.0 T/m³	
Poisson's Ratio	= 0.23	
Stiffness Modulus	= 1150 kg/cm²	
Coefficient of Friction at base	= 0.81	
Subgrade Modulus	= 50 – 100 kg/cm³ .	

* The study area is characterized by semi – arid climate, warm and dry in the summer with rainy winter .

* As far as the seismic activity in the area, Jordan has not witnessed any serious earth quakes in the last 60 years . It is a general practice to consider the study area within zone 1 of the unified building code . Research in Jordan concluded that one earth quake with magnitude 6½ every 100 years and one earth quake with magnitude 7½ every 500 years might take place .

The intensity factor is 0.75 for zone A and it is 0.5 for zone B . of mercalli scale .

* The bedrock (Kurnub sandstone) at the location of boreholes is rippable by means of heavy douzers and might need rock breakers . The underlying rock (Um Ishreen, Dardur, Mai'n formation) are strongly cemented and highly abrasive and might need blasting for excavation .

* A horizontal peak ground acceleration of at least 0.19g is suggested to be adopted in the design of the foundations .

* In order to have safe cut slopes , a side cut slope of 1H : 3V is suggested for cut height of less than 10 meters . The slope height more than 10m should be provided with 2.5m wide bench and the upper slope be cut at 1H : 4V as shown on figures 2 & 3 .

The excavation side cut slopes and protection measures , if needed , should be under the supervision of our experienced geotechnical engineers . Modification of the side cut stopes and protection measures such as gabion in wadies , if needed , could be suggested during construction .

* The rock is free from chemically aggressive or reaction material .

The recommendation given in this report are solely based on the results of the drilled boreholes at the time investigation and our understanding , and concept of the project . Further check of the material during excavation and at the foundation level by our geotechnical engineer is very important .

Appendix A

Summary Of Tests Results

- Table (1) - Grainsize Analysis & Moisture Content
- Table (2) - Unconfined Compression Tests Results
- Table (3) - Direct Shear Tests Results
- Table (4) - Specific Gravity Tests Results
- Table (5) - Compaction & C B R Tests Results

Summary Of Tests Results

Borehole No. & Depth (m)	Grainsize Analysis		Moisture Content (%)
	Sand	Silt	
BH.1 5.0	97.0	3.0	2.3
BH.1 10.0	95.0	5.0	2.8
BH.1 13.0	96.5	3.5	2.4
BH.1 17.0	96.9	3.1	3.0
BH.2 5.0	96.9	3.1	2.6
BH.2 10.0	96.2	3.8	2.9
BH.2 15.0	95.3	4.7	3.1
BH.2 20.0	98.0	2.0	3.4
BH.2 23.0	97.6	2.4	2.7
BH.3 3.0	94.0	6.0	2.5
BH.3 6.0	98.5	1.5	3.1
BH.3 9.0	95.5	4.5	3.3
BH.4 3.0	97.5	2.5	2.7
BH.4 6.0	96.9	3.1	3.0
BH.4 9.0	97.5	2.5	3.2
BH.5 5.0	95.9	4.1	3.4
BH.5 10.0	96.5	3.5	3.1
BH.5 15.0	95.2	4.8	3.8
BH.5 20.0	96.0	4.0	3.5
BH.5 25.0	97.1	2.9	3.6
BH.5 30.0	96.5	3.5	3.9

Tabl e (1)

Continued

Borehole No. & Depth (m)	Grainsize Analysis		Moisture Content
	Sand	Silt	(%)
BH.6 3.0	95.9	4.1	2.5
BH.6 6.0	97.8	2.2	2.8
BH.6 9.0	93.5	1.5	3.0
BH.6 12.0	94.9	5.1	3.4

Table (1)

Unconfined Compression Tests Results

Borehole No. & Depth	Compressive Strength (kg / cm²)
BH.1 4.5m	120.8
BH.1 7.5m	230.4
BH.2 11.4m	22.6
BH.2 15.7m	46.8
BH.2 19.8m	260.9
BH.3 4.5m	28.1
BH.3 6.7m	201.9
BH.4 5.8m	31.4
BH.5 15.6m	88.7
BH.5 18.2m	293.2
BH.5 24.6m	71.3
BH.6 5.5m	40.3

Table (2)

Direct Shear Test Results

Boreholes No. & Depth (m)	Friction Angle (Degree) (Øp)
BH.1 8.0	40.0
BH.1 15.0	38.0
BH.2 15.0	35.0
BH.3 5.0	37.0
BH.4 5.0	39.0
BH.5 10.0	45.0
BH.5 23.0	42.0
BH.6 8.0	36.0

Table(3)

Specific Gravity Tests Results

Boreholes No . & Depth (m)	Specific Gravity
BH.1 5.0	2.610
BH.2 15.0	2.630
BH.3 6.0	2.610
BH.4 6.0	2.650
BH.5 15.0	2.640
BH.6 6.0	2.630

Table (4)

Compaction and (C B R Tests Results)

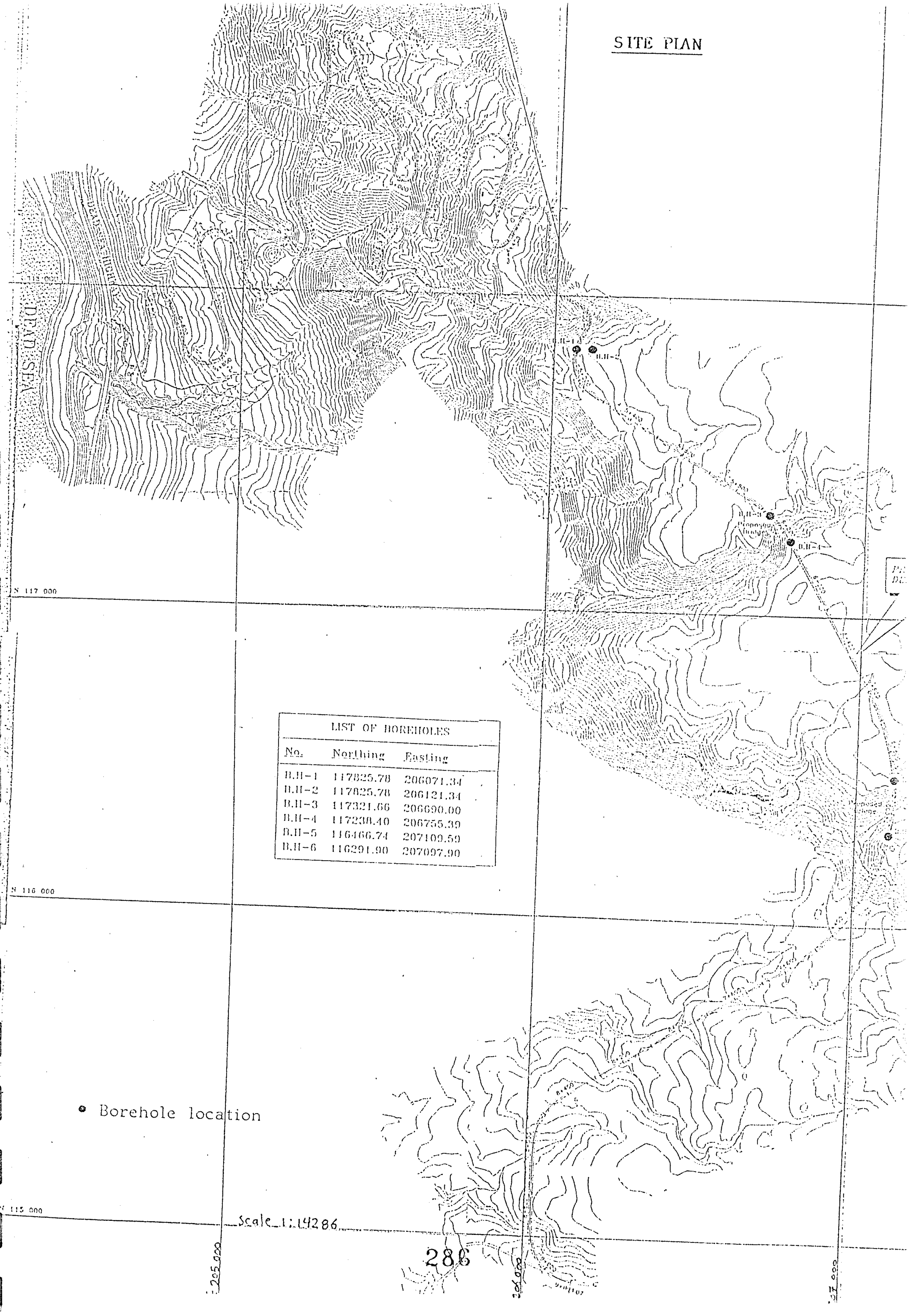
Sample No .	Max . Dry Density (gr/cm³)	O . M . C (%)	C B R at O . M . C (%)
1-	1.930	3.50	26.0
2-	1.900	4.0	23.0
3-	1.940	3.8	28.0
4-	1.880	4.5	21.0

Table (5)

Appendix B

- General Geologic Map
- Boreholes Logs

SITE PLAN



LIST OF BOREHOLES

No.	Northing	Easting
B.H-1	117825.78	206071.34
B.H-2	117825.78	206121.34
B.H-3	117321.66	206690.00
B.H-4	117238.40	206755.39
B.H-5	116466.74	207109.59
B.H-6	116291.90	207097.90

GEOLOGIC MAP

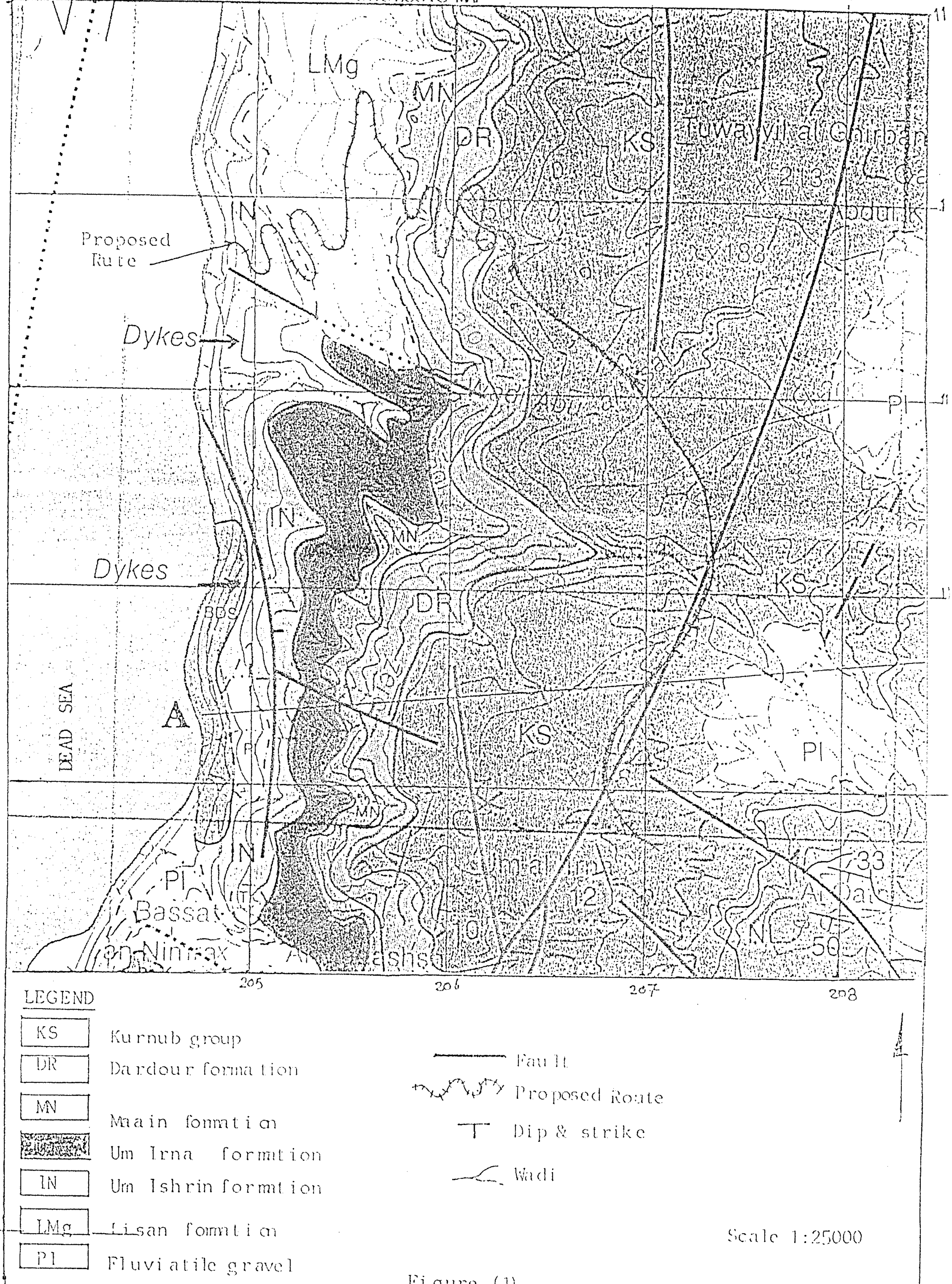
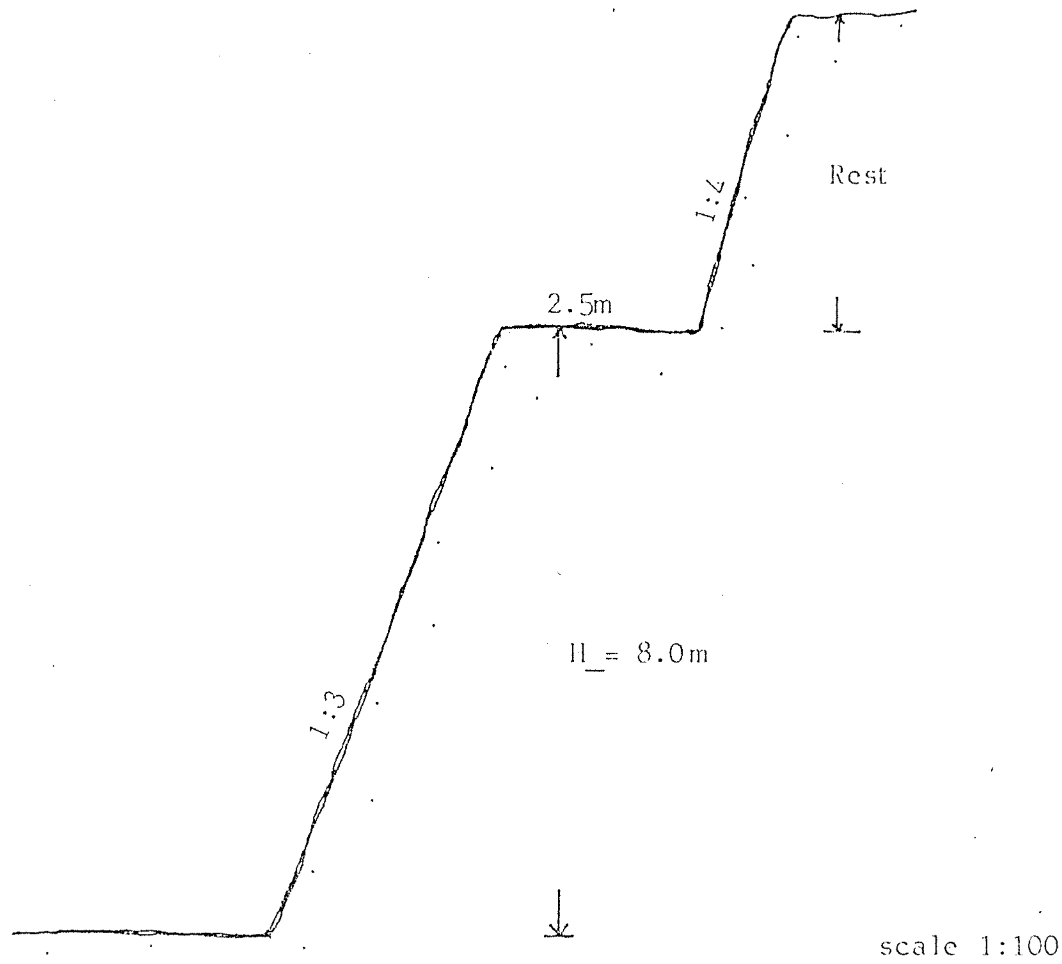
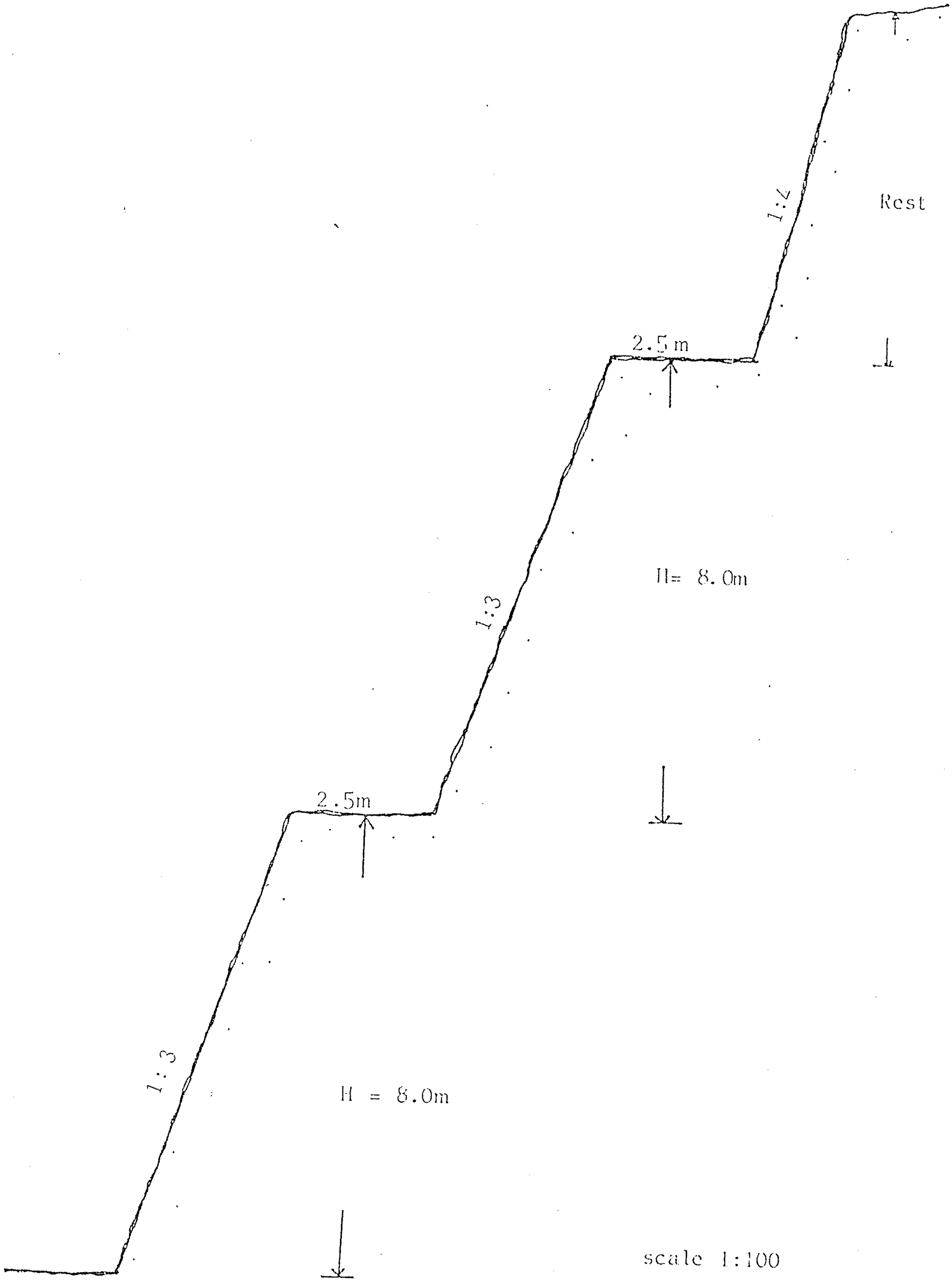


Figure (1)



Proposed typical side cut slope for stations 00+500⟶5+750 & 8+300⟶8+500

Figure(2)



Proposed typical side cut slope for stations 6+850 & 7+300.

Figure(3)

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Geo. Research

BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH1	Coordinate : E : 206071.34, N : 117825.75 — Date : Started : 23/7/1999, Finished : 24/7/1999

Depth (M)	LOG	DESCRIPTION ELEVATION : 136.36	REC (%)	RQD (%)	SPT "N"	MC (%)	LL	PI	γ (gr/cm³)	Sample No.
1		SANDSTONE , fine to coarse , vari – coloured , moderately cemented , very dense .			50/12cm					
2		SANDSTONE , fine to coarse , rosy ferrous , friable , partly strongly cemented , very dense .			50/2					
3					50/12					
4			59	00	Ref					
5					Ref					
6			62	16	50/9					
7			77	19	50/8					
8					50/16					
9					Ref					
10		SANDSTONE , medium to coarse , cream Whitish , partly rosy , strongly cemented , very dense .			50/11					
11					Ref					
12					50/13					
13					50/8					
14					50/6					
15		SANDSTONE , fine to coarse , vari – coloured , Partly strongly cemented , very dense .			50/6					
16					50/5					
17					Ref					
18					50/10					

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Geo. Research

BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH1	Coordinate : E : N : Date : Started : Finished :

Depth (M)	LOG	DESCRIPTION ELEVATION : 136.36	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	γ (gr/cm³)	Sample No.
		…. as above								
19		SANDSTONE , fine to coarse , vari – coloured , partly strongly cemented , very dense .			50/13					
20					50/3					
21		Final Depth 20.0m								
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										
35										
36										

TOUKAN & SAKET
Geo. Research

BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH2	Coordinate : E: 206121.34 N: 117825.78 — Date : Started : 24/7/1999 Finished: 27/7/1999

Depth (M)	LOG	DESCRIPTION ELEVATION : 141.86	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	γ (gr/cm³)	Sample No.
1					50/3cm					
2		SANDSTONE , fine to coarse , vari - coloured , strongly cemented , very dense .			50/4					
3					50/16					
4					50/22					
5		SANDSTONE , medium to coarse , creamish white friable , partly strongly cemented , very dense .			67/30					
6					50/13					
7					50/18					
8			80	19	50/Ref					
9					56/30					
10					50/7					
11			76	21	Ref					
12					Ref					
13					50/19					
14					50/23					
15			82	17	59/30					
16					50/4					
17		SANDSTONE , fine to coarse , vari – coloured , Partly strongly cemented , very dense .			Ref					
18					Ref					

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BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH2	Coordinate: E : 206121.34 N : 117825.78 — Date : Started : 24/7/1999 Finished : 27/7/1999

Depth (M)	LOG	DESCRIPTION ELEVATION: 141.86	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	γ (gr/cm³)	Sample No.
		... as above								
19					Ref					
			71	16						
20		SANDSTONE , fine to coarse , vari – coloured , partly strongly cemented , very dense .			50/18					
21					50/14					
22					50/6					
23					50/8					
24					50/19					
25					50/21					
26		Final Depth 25.0m								
27										
28										
29										
30										
31										
32										
33										
34										
35										
36										

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BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH3	Coordinate : E : 206690.00 N : 117321.66 — Date : Started : 27/7/1999 Finished : 28/7/1999

Depth (M)	LOG	DESCRIPTION ELEVATION: 156.60	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	(gr/cm³)	Sample No.
1		SANDSTONE , fine to coarse , vari – coloured , weakly cemented , very dense .			Ref					
2					Ref					
3					50/17cm					
4		SANDSTONE , medium to coarse , vari – coloured , weakly cemented , partly friable and Ferrous .	77	16	50/22					
5					50/3					
6			82	19	50/10					
7					50/2cm					
8		SANDSTONE , fine to coarse , rosy – whitish , strongly cemented , partly friable and ferrous .	61	00	Ref					
9					Ref					
10					50/5					
11		Final Depth 10.0m								
12										
13										
14										
15										
16										
17										
18										

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BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH4	Coordinate : E : 206755.39 N : 117238.40 — Date : Started : 28/7/1999 Finished : 29/7/1999

Depth (M)	L O G	DESCRIPTION ELEVATION: 158.72	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	(gr/cm³)	Sample No.
1		SNDSTONE , medium to coarse , vari – coloured, strongly cemented , very dense .			Ref					
2		SANDSTONE , medium to coarse , vari – coloured , weakly cemented , very dense .			50/6cm					
3					50/13					
4					50/11					
5			62	16	50/17					
6			86	21	50/21					
7		SANDSTONE , fine to coarse , greyish white partly friable and partly strongly cemented , very dense .	69	00	Ref					
8					Ref					
9					Ref					
10					50/12					
11		Final Depth 10.0m								
12										
13										
14										
15										
16										
17										
18										

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BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH5	Coordinate : E : 207109.59 N : 116466.74 — Date : Started : 29/7/1999 Finished : 01/8/1999

Depth (M)	LOG	DESCRIPTION ELEVATION: 164.64	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	(gr/cm³)	Sample No.
1		SANDSTONE , fine to coarse , vari – coloured , strongly cemented , very dense .			50/1cm					
2					Ref					
3		SANDSTONE , fine to coarse , Rosy , creamish friable , weakly cemented , very dense .			50/12					
4					50/15					
5					50/21					
6					50/18					
7					Ref					
8					Ref					
9					50/11					
10		Sandstone , fine to coarse , vari – coloured , weakly cemented , friable , with thin bands of strongly cemented , very dense .			50/17					
11					Ref					
12					50/3cm					
13			68	00	Ref					
14					50/13					
15			82	17	50/20					
16					50/18					
17					50/6					
18					50/13					

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BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway	TYPE & SIZE OF DRILLING : Rotary 4 ½"
BOREHOLE NO : BH5	Coordinate : E : N : Date : Started : Finished :

Depth (M)	LOG	DESCRIPTION ELEVATION:	REC (%)	RQD. (%)	SPT. "N"	MC. (%)	LL	PI	(gr/cm³)	Sample No.
		..... as above	90	21						
19					Ref					
20		SANDSTONE , fine to coarse , vari – coloured , weakly cemented , friable , with thin bands of strongly cemented , very dense .			Ref					
21					50/10					
			88	22						
22					Ref					
23		SANDSTONE , vari – coloured , weakly cemented , very dense .			Ref					
24					50/3					
			86	20						
25					50/11cm					
26					50/2					
27					50/4					
28		Sandstone , fine to coarse , vari – coloured , weakly cemented , friable , with thin bands of strongly cemented , very dense .			Ref					
29					Ref					
30					50/2					
31					50/6					
32										
33										
34										
35										
36		Final depth 36.0m								

Geo. Research

BOREHOLE LOG DATA SHEET

PROJECT : Dead Sea Parkway

BOREHOLE NO : BH6

TYPE & SIZE OF DRILLING : Rotary 4 ½"

Coordinate : E : 287897.90 N : 116291.90

Date : Started : 01/8/1999 Finished : 02/8/1999

ELEVATION : 128.41

Depth (M)		DESCRIPTION	TCR (%)	RQD (%)	SPT "N"	MC (%)	LL	PI	(gr/cm³)	Sample No.
1		SANDSTONE , cream , friable , weakly cemented			50/2cm					
2		SANDSTONE , fine to coarse , vari - coloured , friable , partly strongly cemented , very dense .			50/12					
3			77	80	Ref					
4					50/7					
5			86	71	Ref					
6					Ref					
7			61	66	50/6					
8		SANDSTONE , medium to coarse , cream rosy , ferrous , moderately cemented , partly friable , very dense .			50/6					
9					50/11					
10					50/17					
11					50/20					
12					Ref					
13					50/7					
14					50/5					
15					50/12					
16		Final Depth 15.0m								
17										
18										

Appendix C

Tests Results Curves

- Grainsize Analysis Curves
- Direct Shear Tests Curves
- Compaction Curves
- C B R Curves

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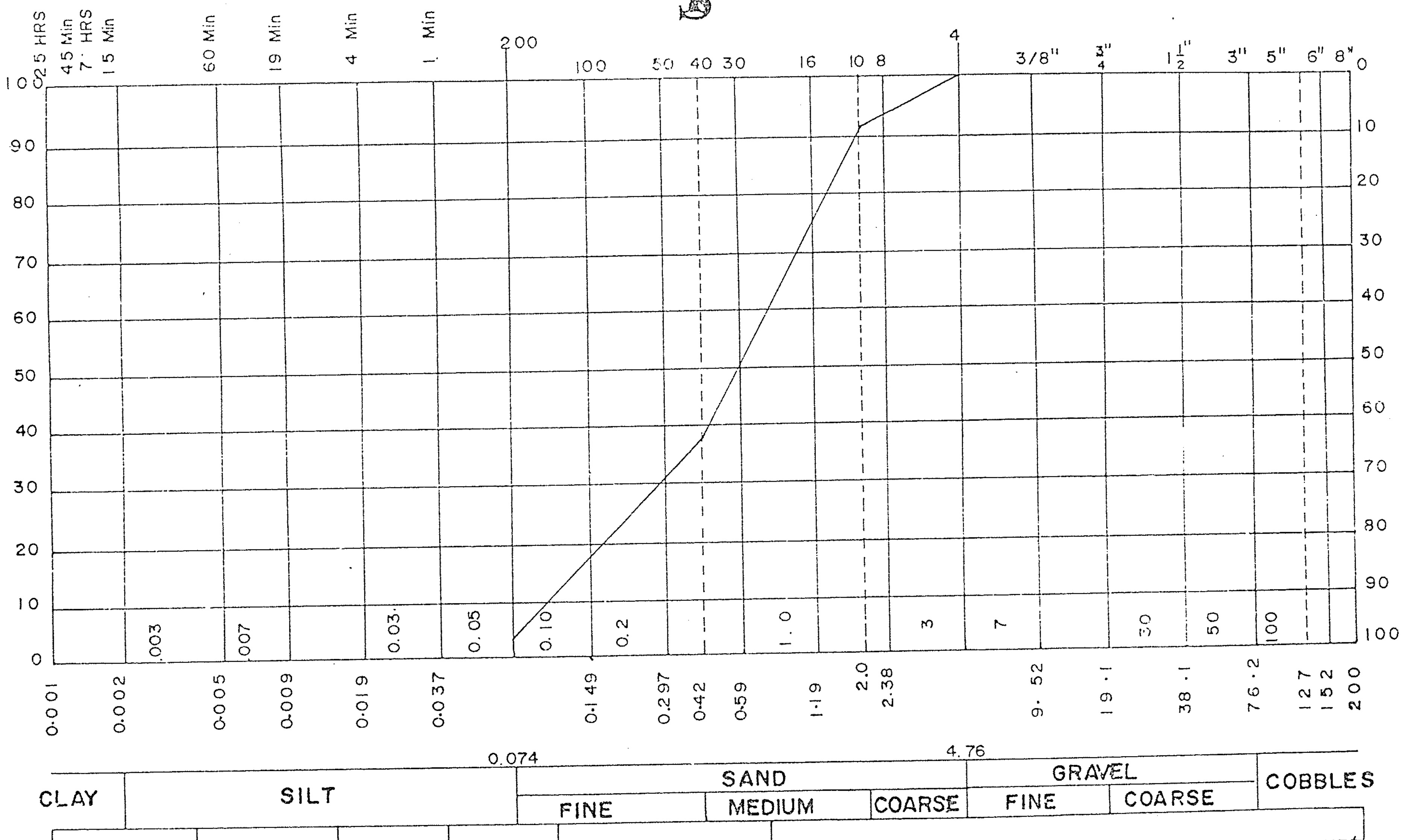
PROJECT ________

DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS

SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.1 (5.0)m	--	97.0	3.0	--

REMARKS ________

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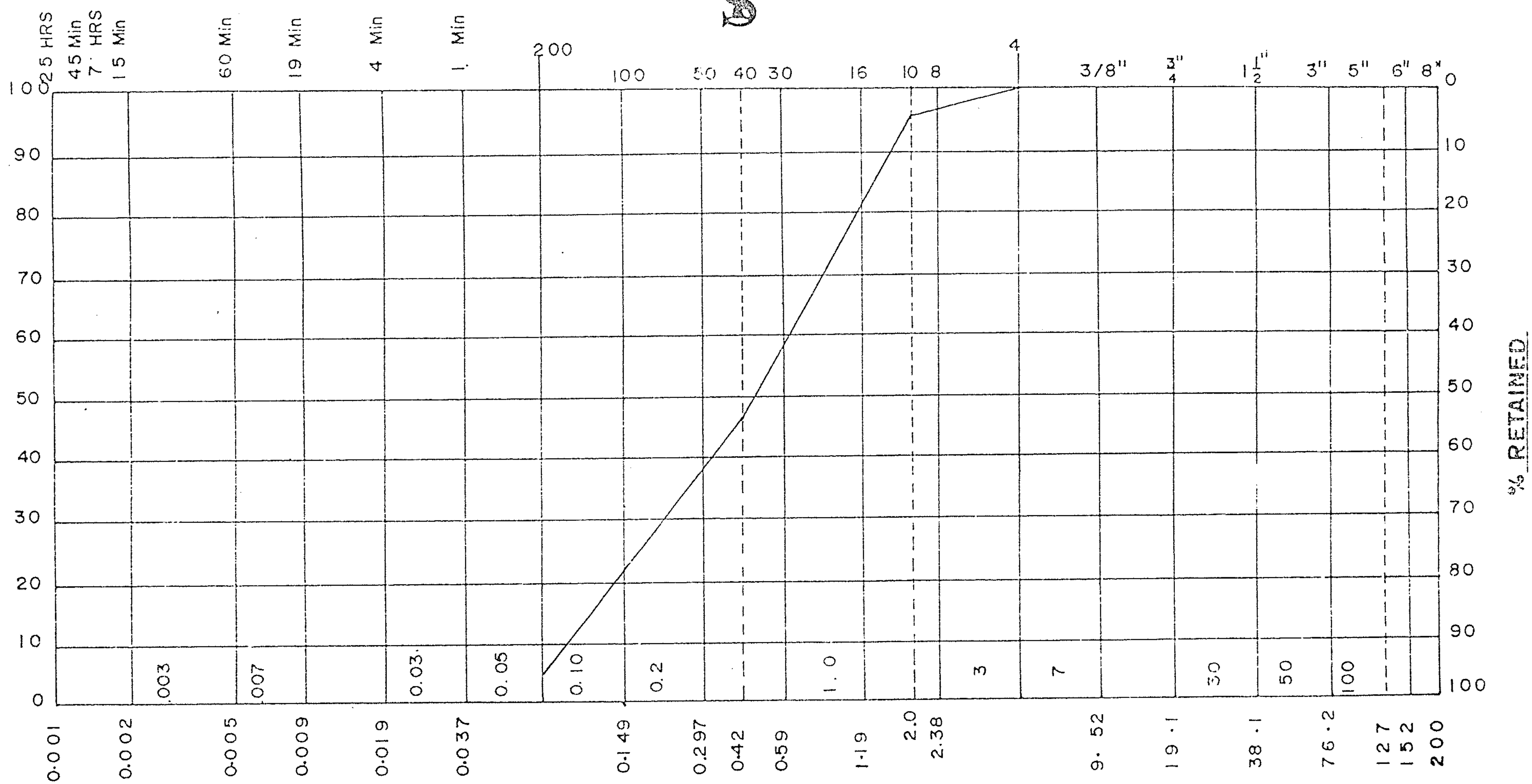
PROJECT________ DATE __________

SAMPLE No ________

HYDROMETER ANALYSIS SIEVE ANALYSIS



0.074				4.76			
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.1 (10.0)m	--	95.0	5.0	--

REMARKS ____________

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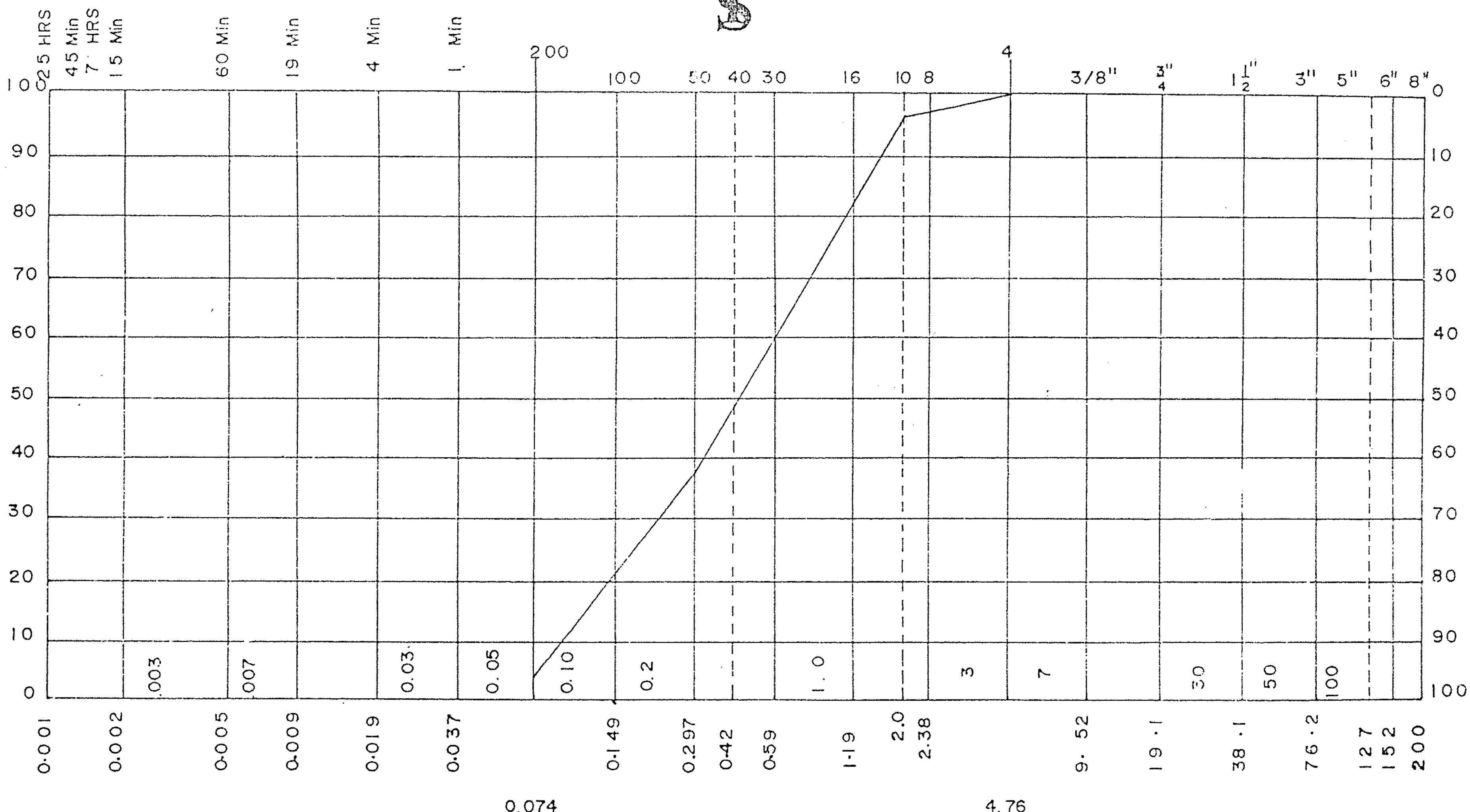
PROJECT ______

DATE ______

SAMPLE No ______



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.1 (13.0)m	—	96.5	3.5	—

REMARKS ______

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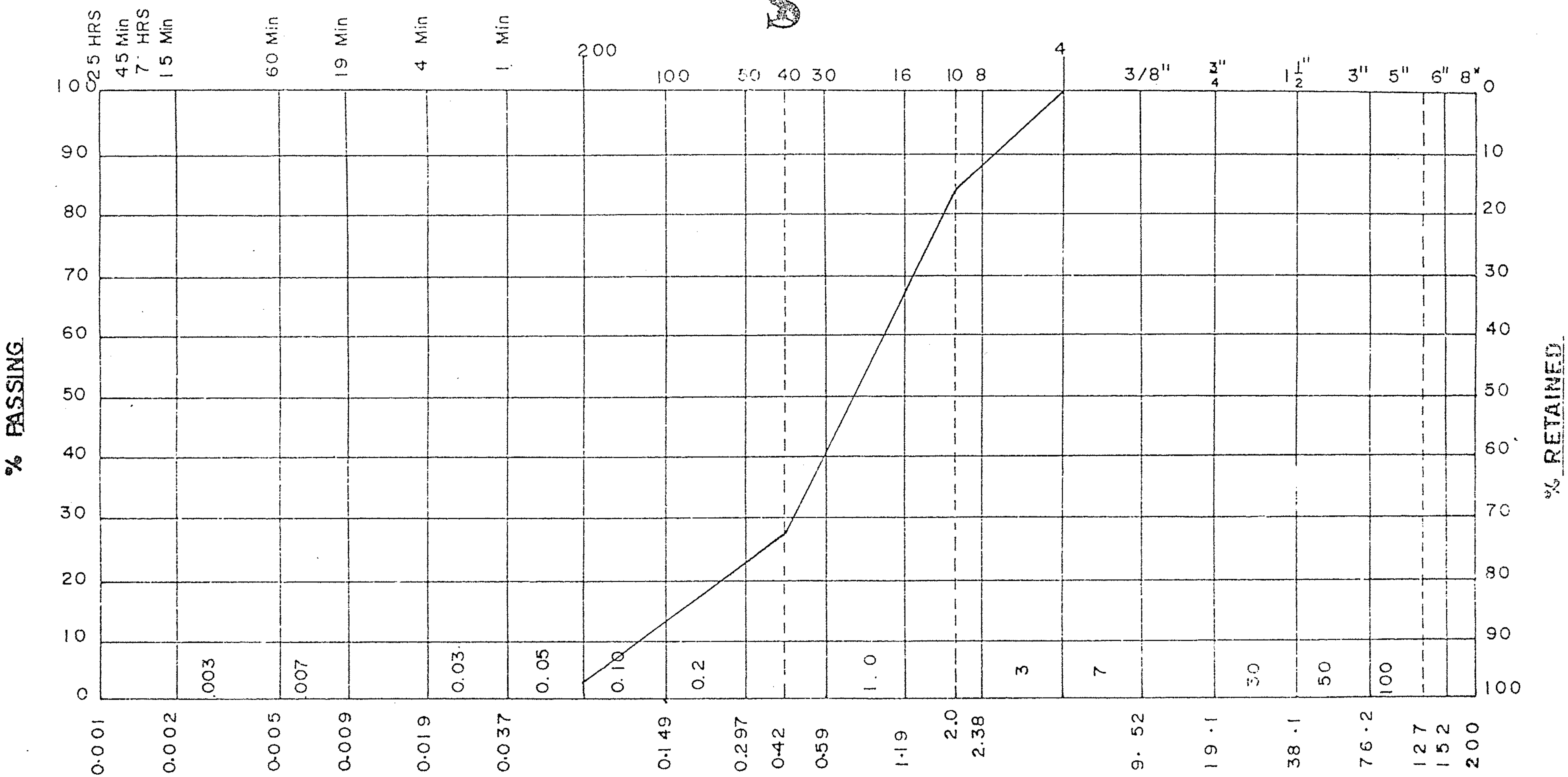
PROJECT_______ DATE ___________

SAMPLE No _______

HYDROMETER ANALYSIS SIEVE ANALYSIS



0.074				4.76			
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.1 (17.0)m	--	96.9	3.1	--

REMARKS ________________

PROJECT ______

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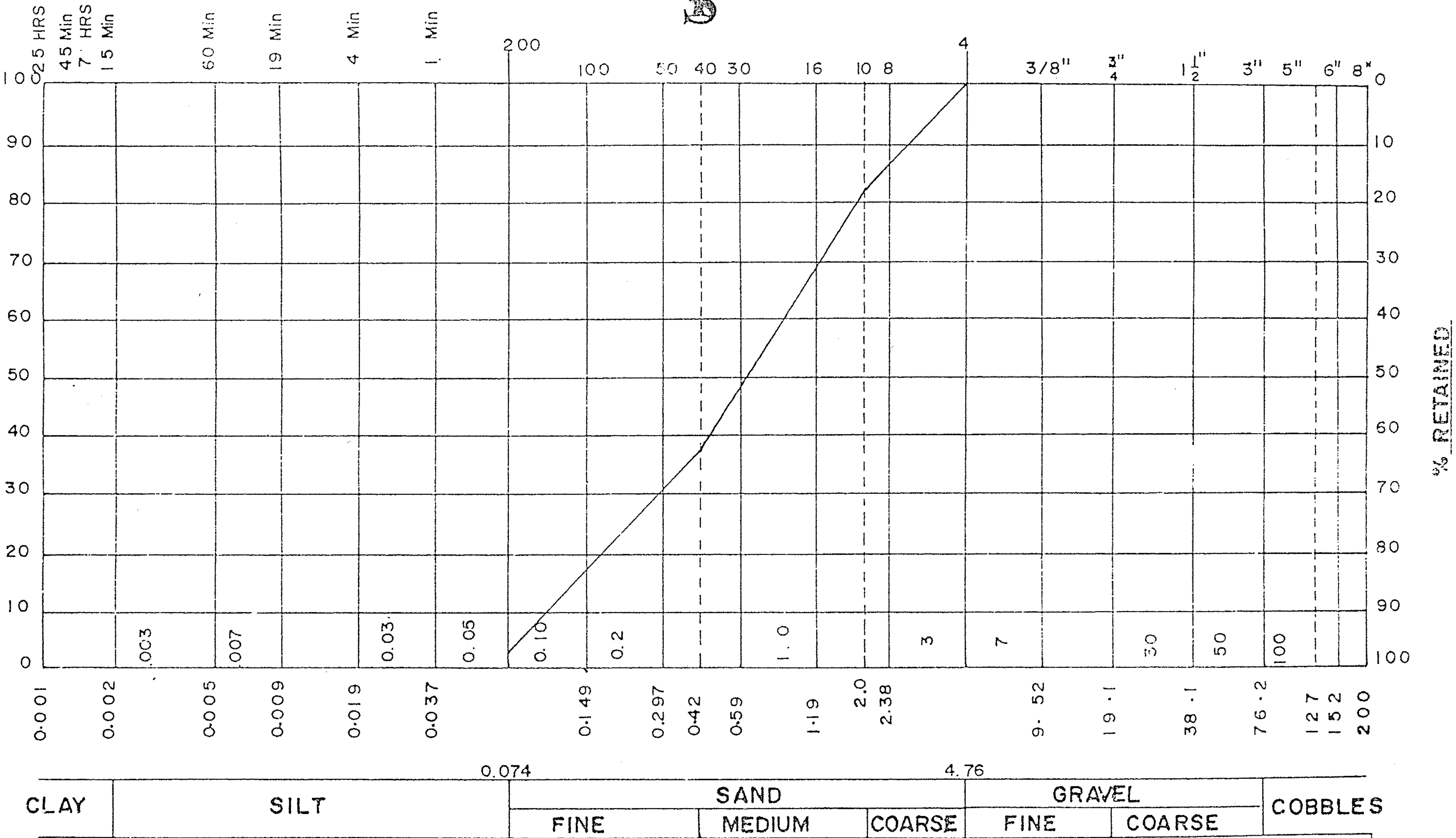
DATE ______

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.2 (5.0)m	---	96.9	3.1	---

REMARKS ______

PROJECT ______

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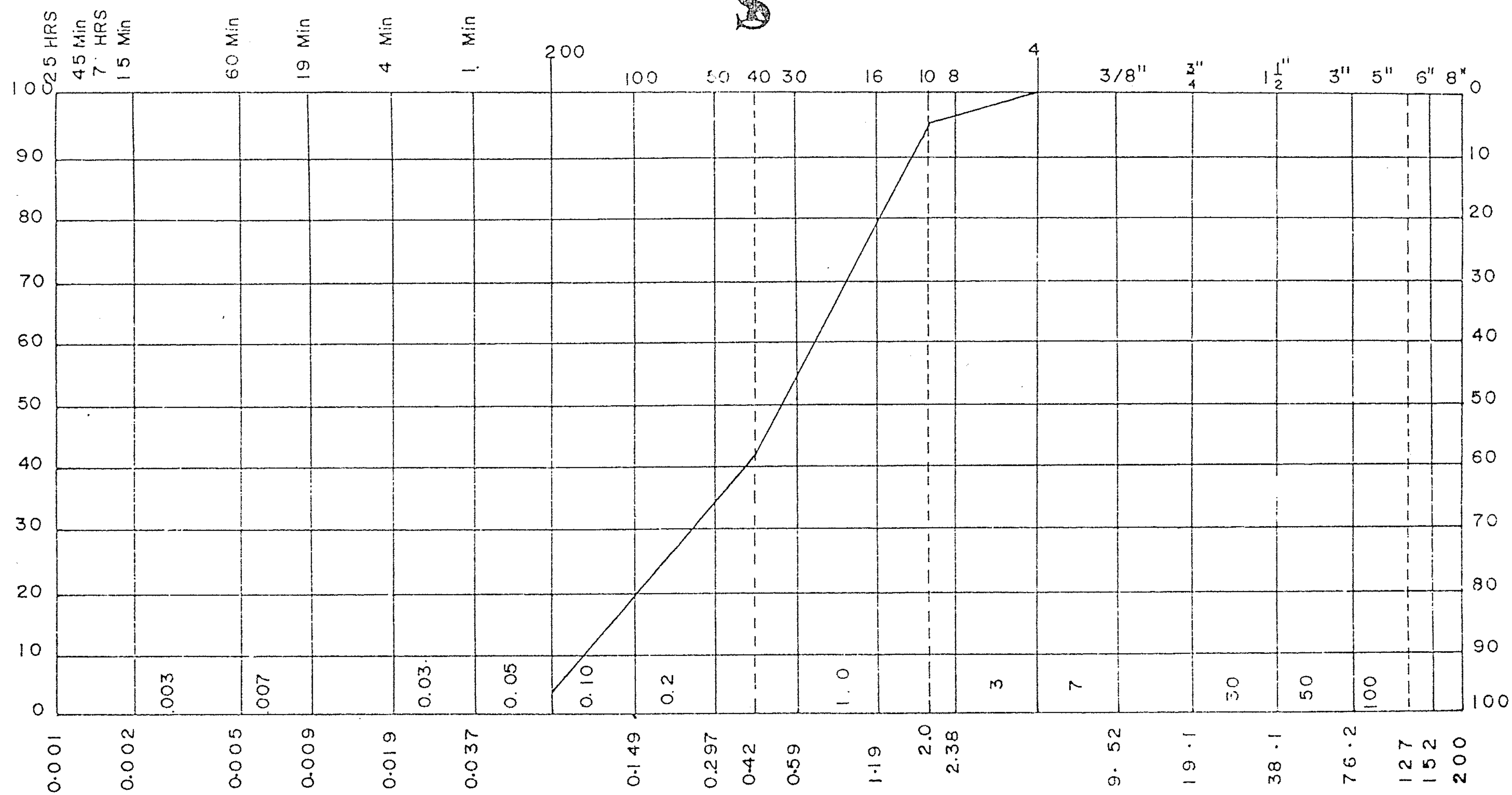
DATE ______

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074			4.76		
CLAY	SILT	SAND		GRAVEL	COBBLES
		FINE / MEDIUM / COARSE		FINE / COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH. 2 (10.0)m	--	96.2	3.8	---

REMARKS ______

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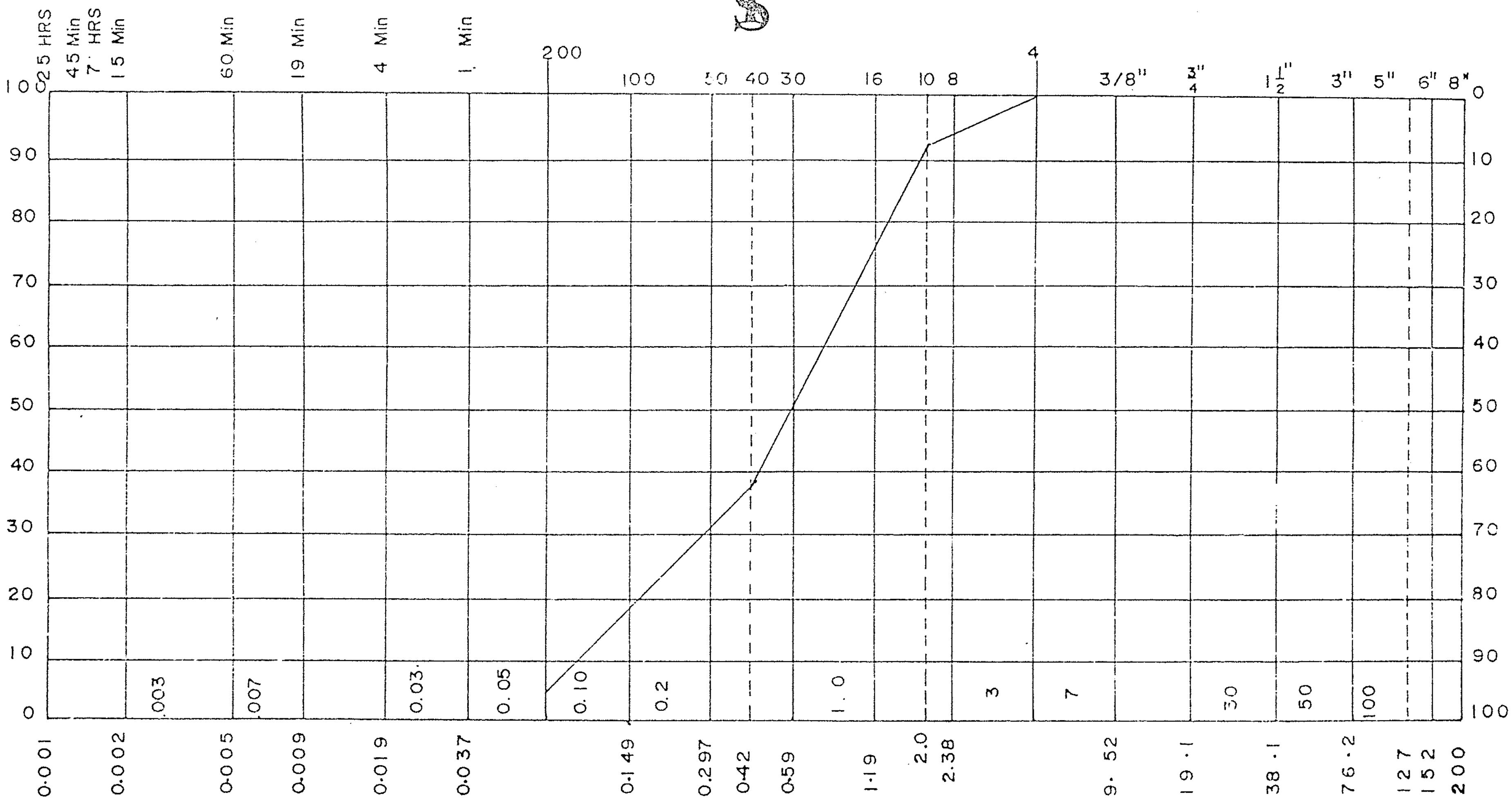
PROJECT ________

DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS

SIEVE ANALYSIS



CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.2 (15.0)m	---	95.3	4.7	---

REMARKS

PROJECT_ _ _ _ _ _ _

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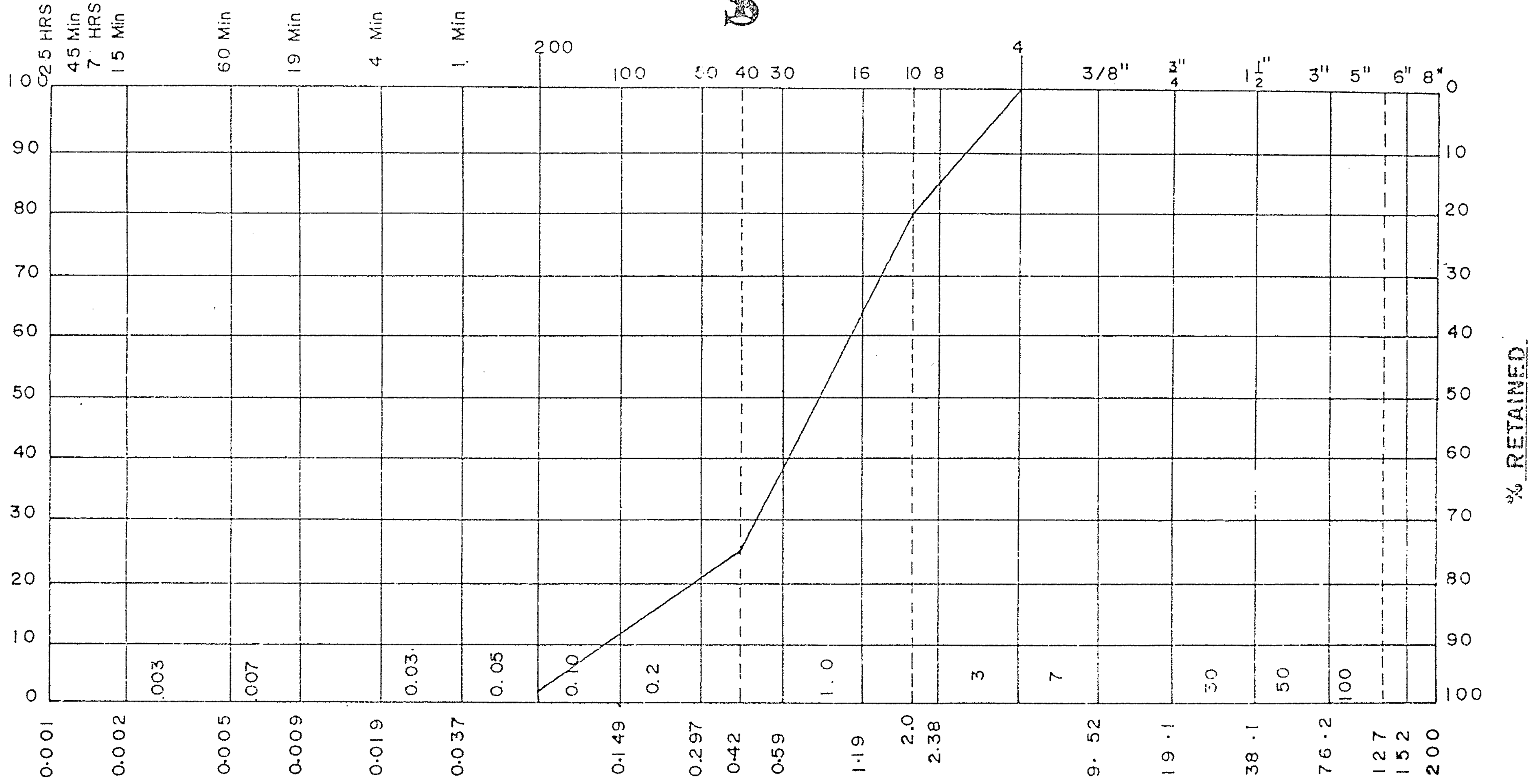
DATE _ _ _ _ _ _ _ _ _

SAMPLE No _ _ _ _ _ _

HYDROMETER ANALYSIS

SIEVE ANALYSIS



CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

0.074 4.76

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.2 (20.0)m	--	93.0	2.0	--

REMARKS

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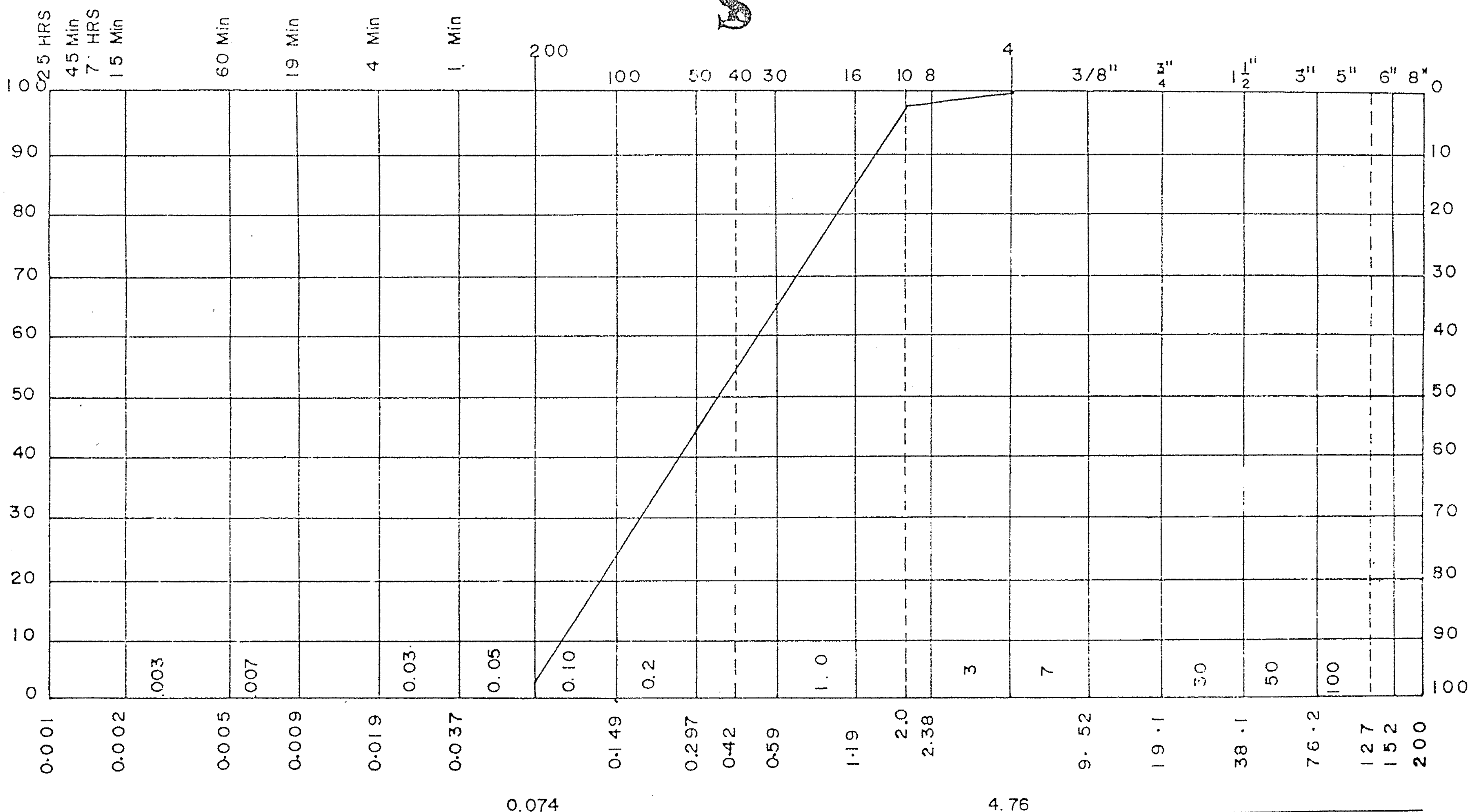
PROJECT ________ DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH 2 (23.0)m	--	97.6	2.4	--

REMARKS ________

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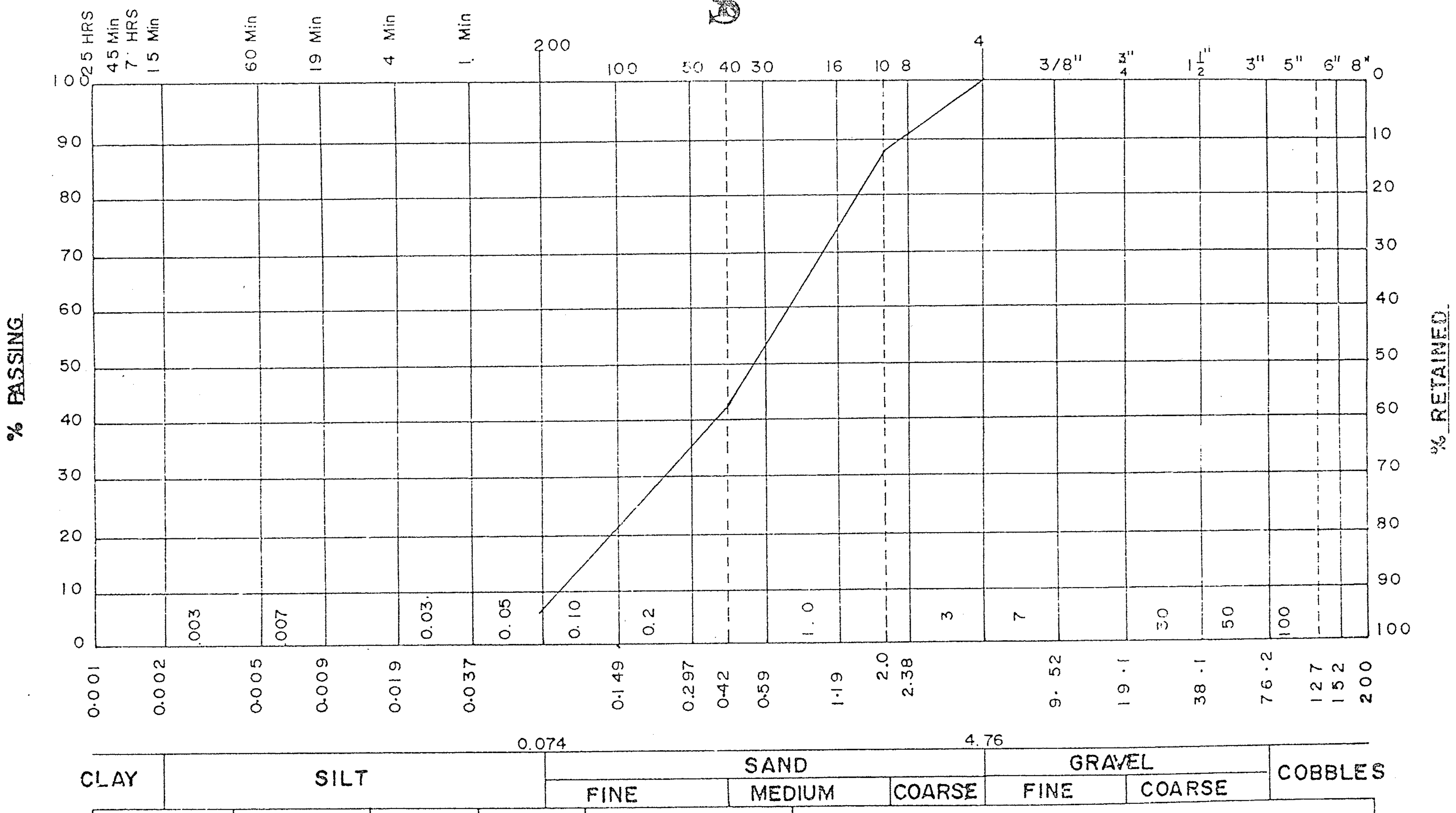
PROJECT________ DATE__________

SAMPLE No ________

HYDROMETER ANALYSIS SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH 3 (3.0)m	---	94.0	6.0	--

REMARKS ____________________

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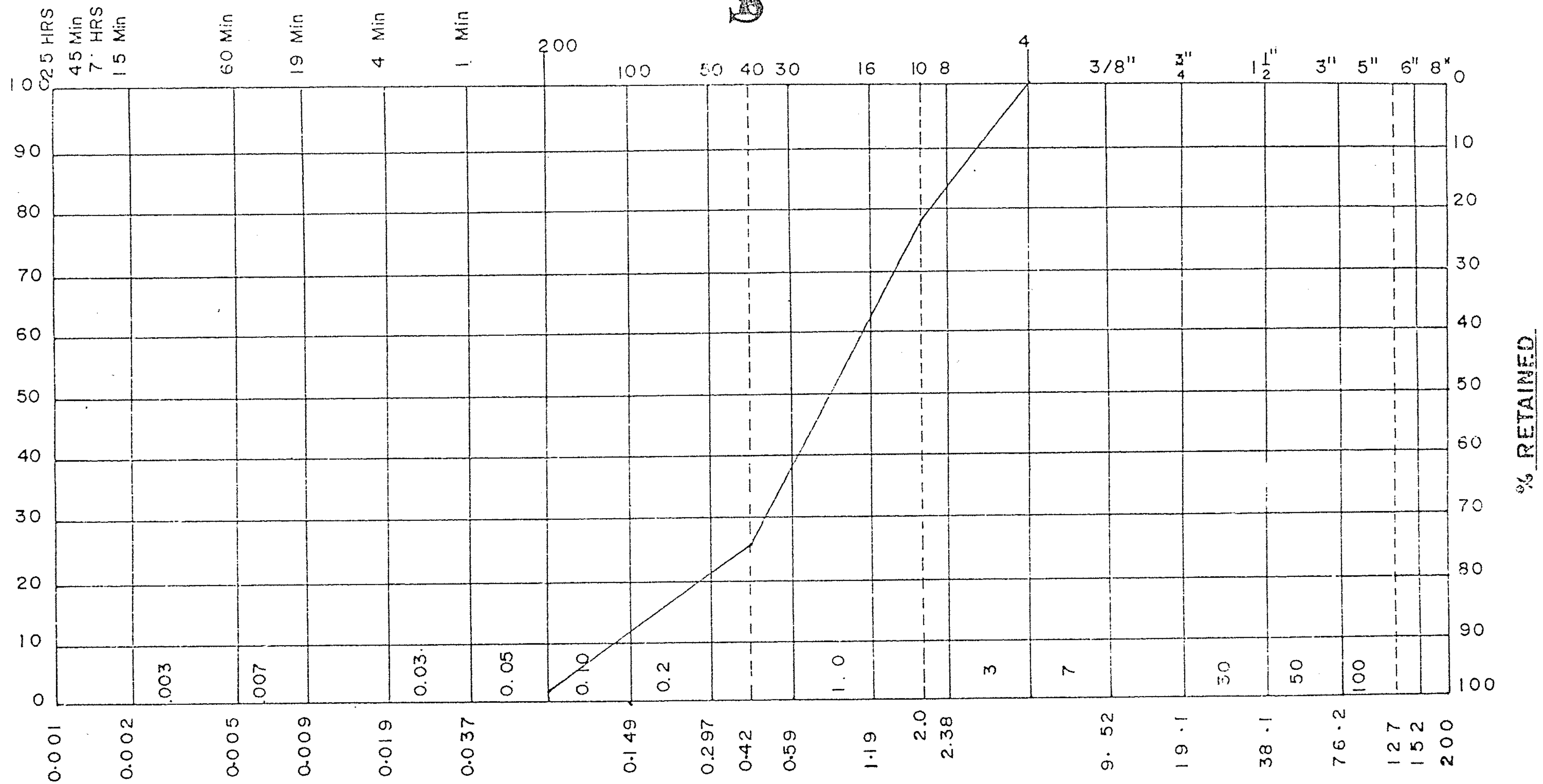
PROJECT_______

DATE __________

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



	0.074			4.76		
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.3 (6.0)m	---	98.5	1.5	--

REMARKS ______________

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Geo. Research

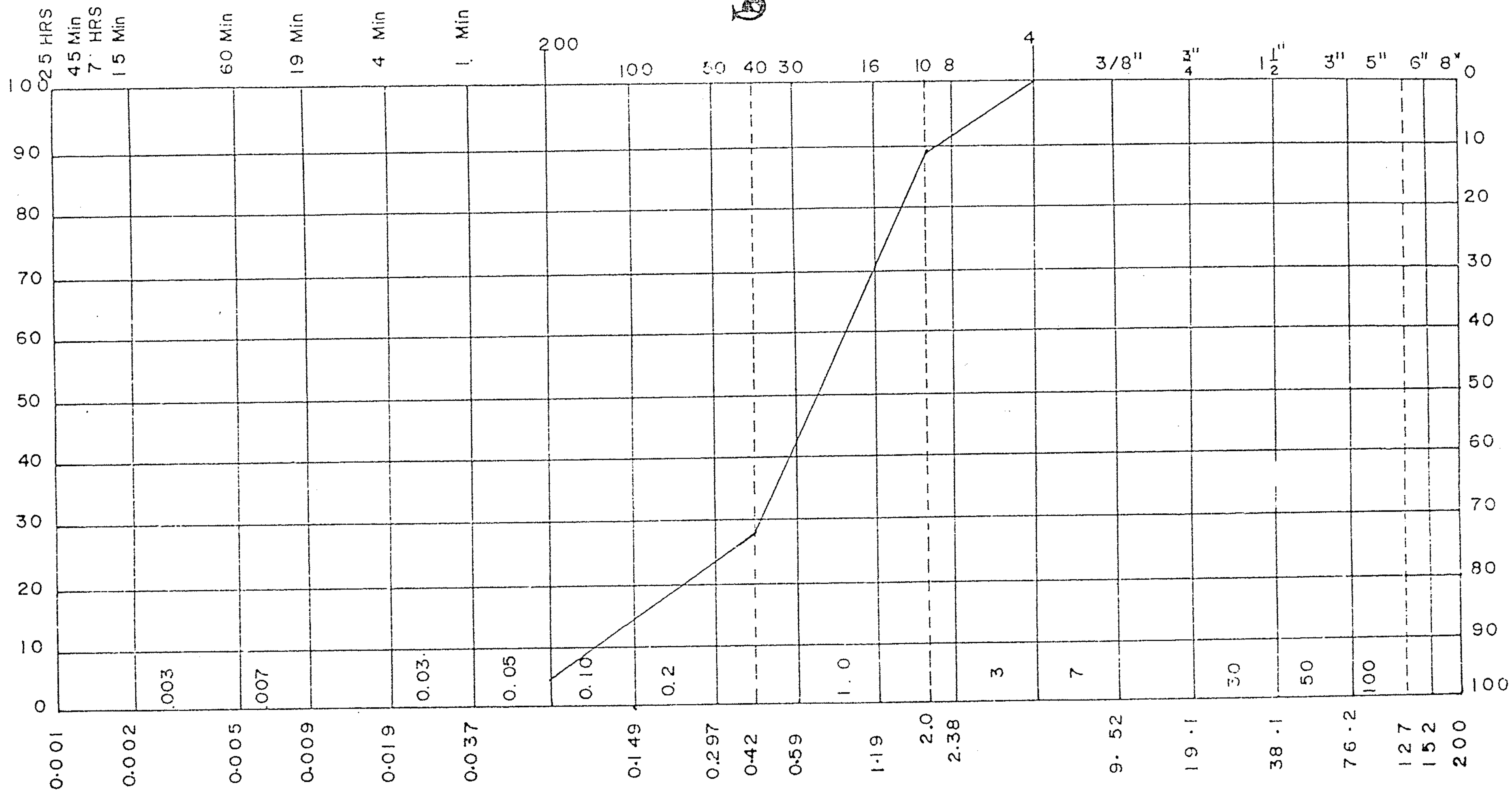
PROJECT ________

DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074			4.76			
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.3 (9.0)m	---	95.5	4.5	---

REMARKS ________

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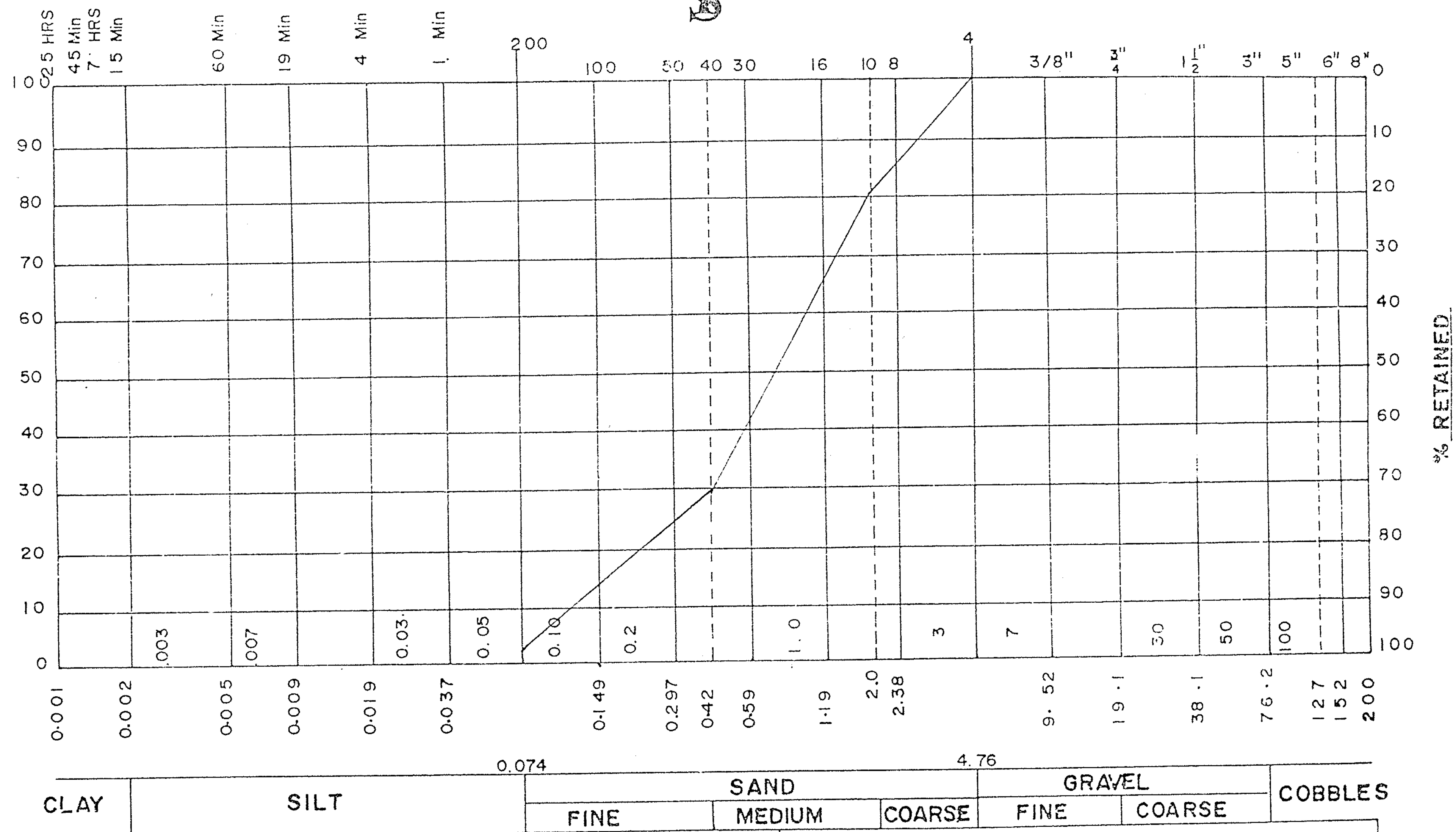
PROJECT________ DATE __________

SAMPLE No ________

HYDROMETER ANALYSIS SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.4 (3.0)m	---	97.5	2.5	---

REMARKS ________

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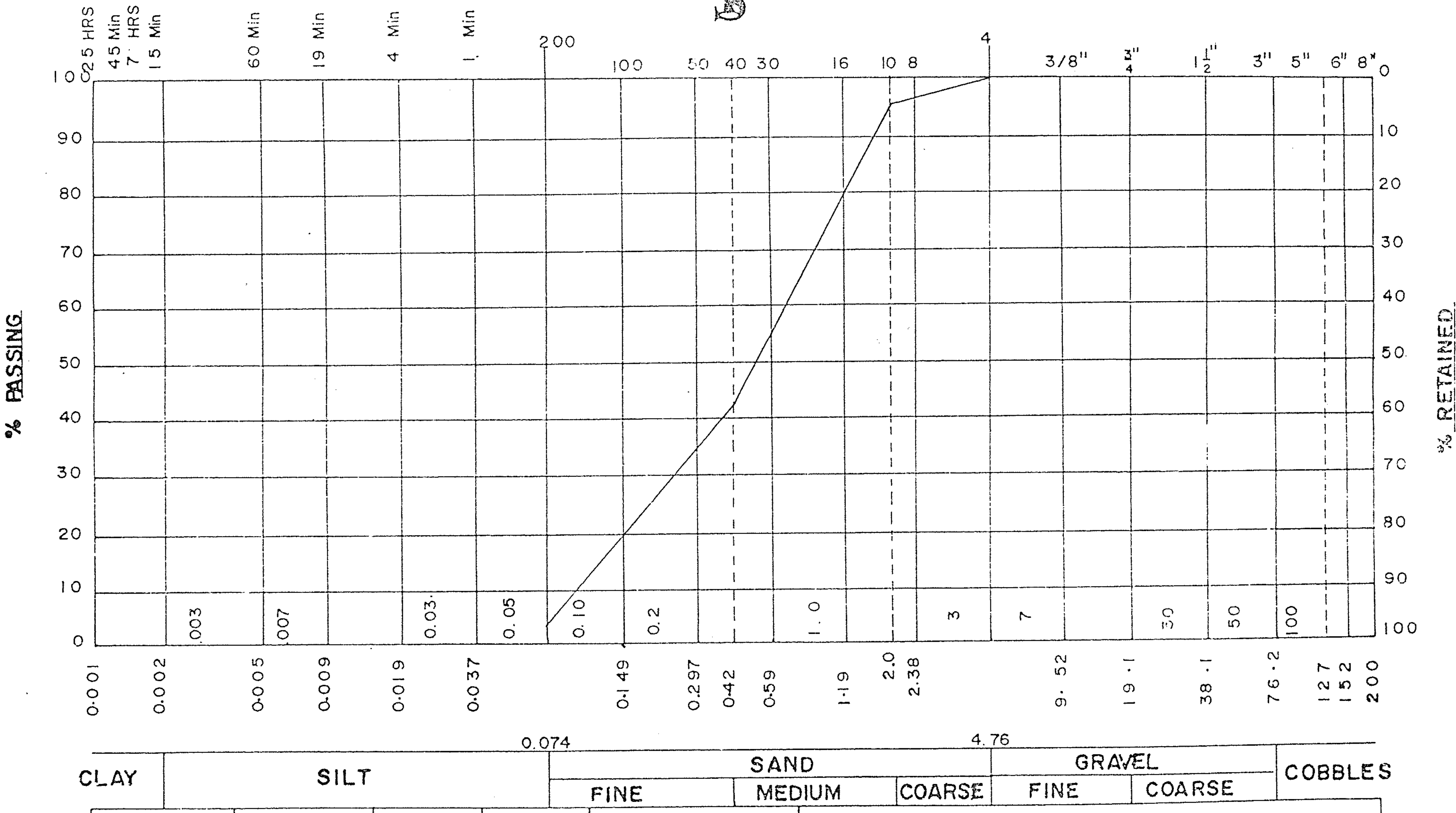
PROJECT ______

DATE ______

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.4 (6.0)m	---	96.9	3.1	--

REMARKS ______

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Geo. Research

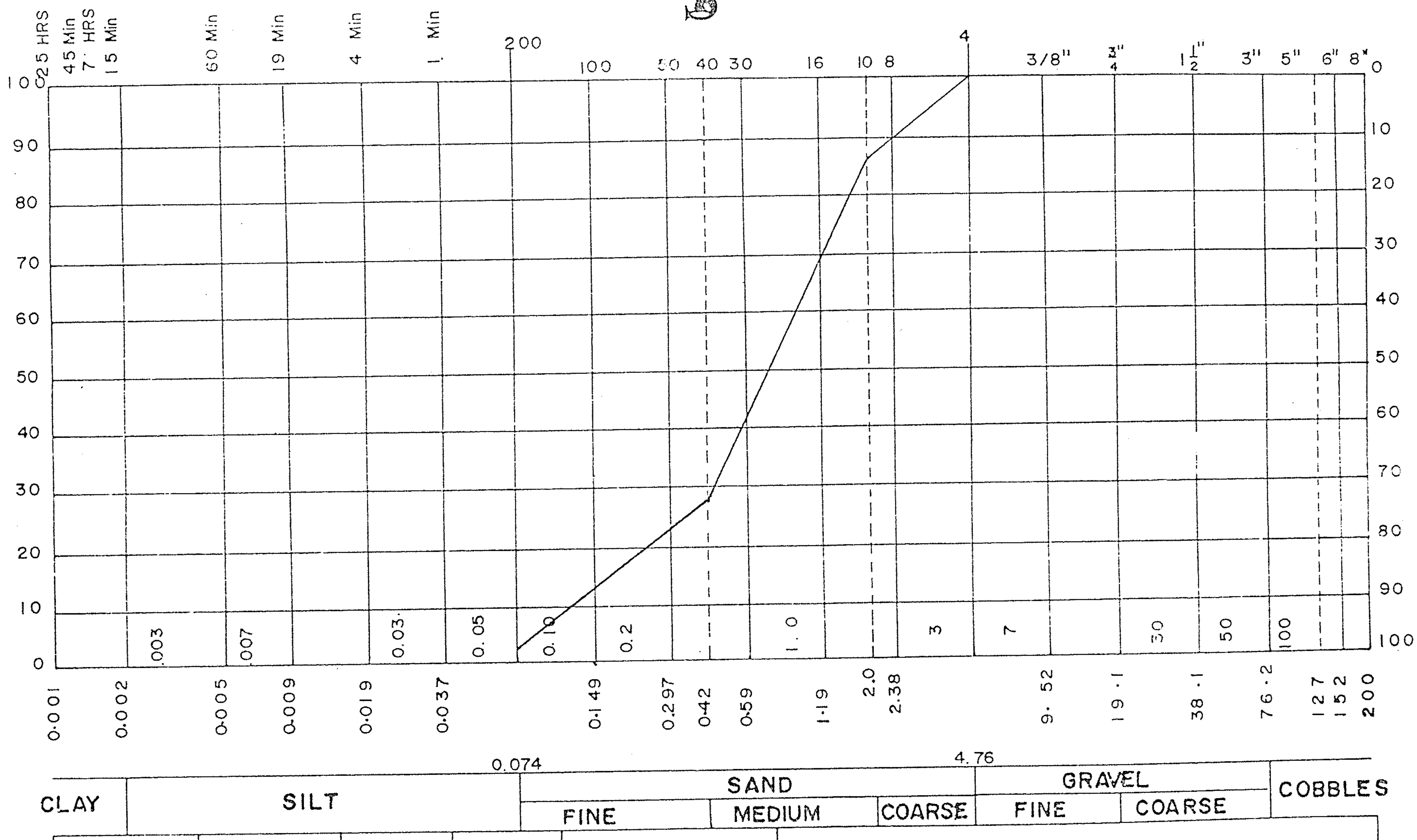
PROJECT ________

DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS

SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.4 (9.0)m	--	97.5	2.5	--

REMARKS ________

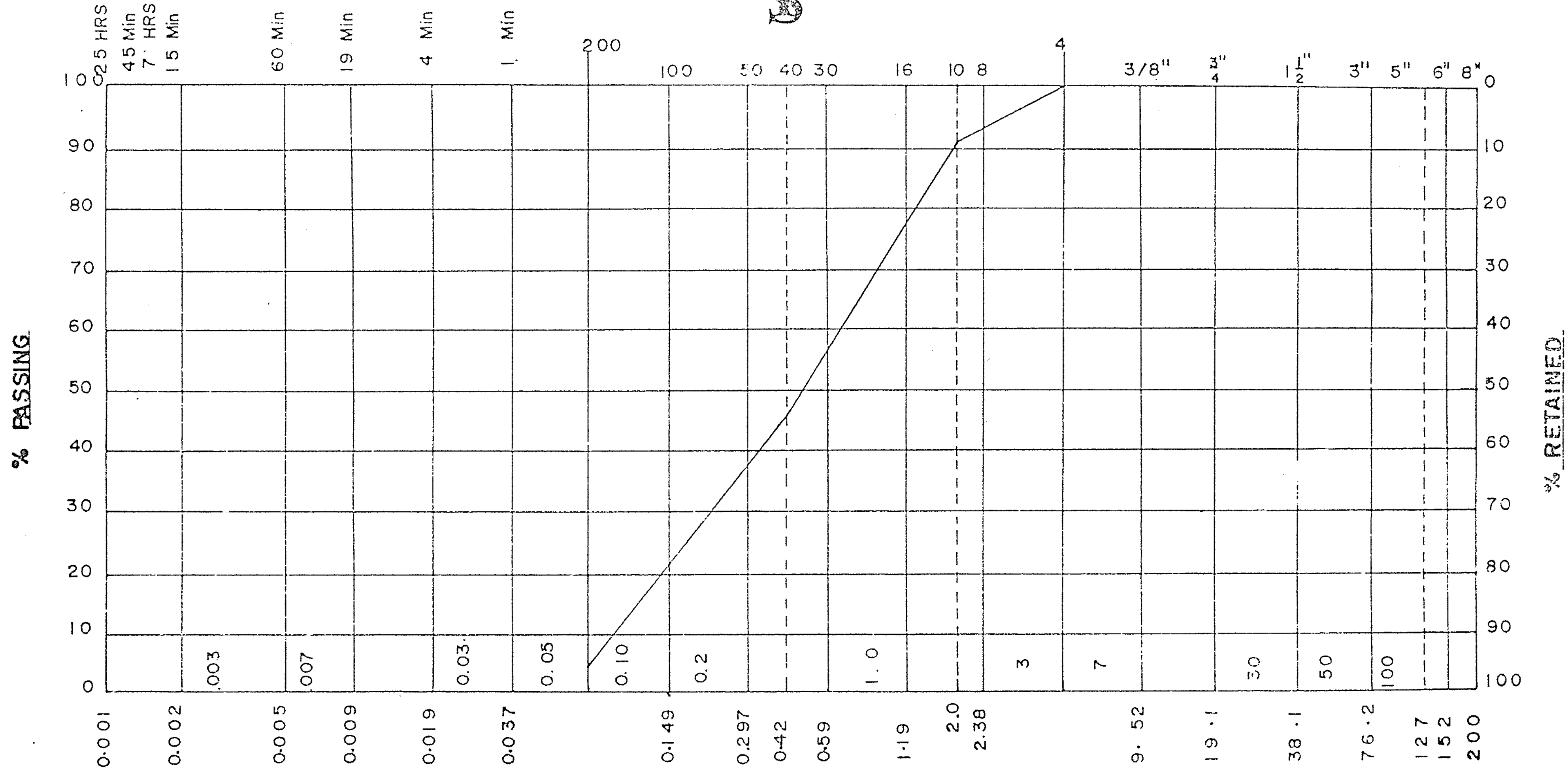
TOUKAN & SAKET

Geo. Research

PROJECT_______ DATE __________

SAMPLE No _______

HYDROMETER ANALYSIS SIEVE ANALYSIS



0.074			4.76		
CLAY	SILT	SAND			GRAVEL		COBBLES

CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.5 (5.0)m	---	95.9	4.1	--

REMARKS

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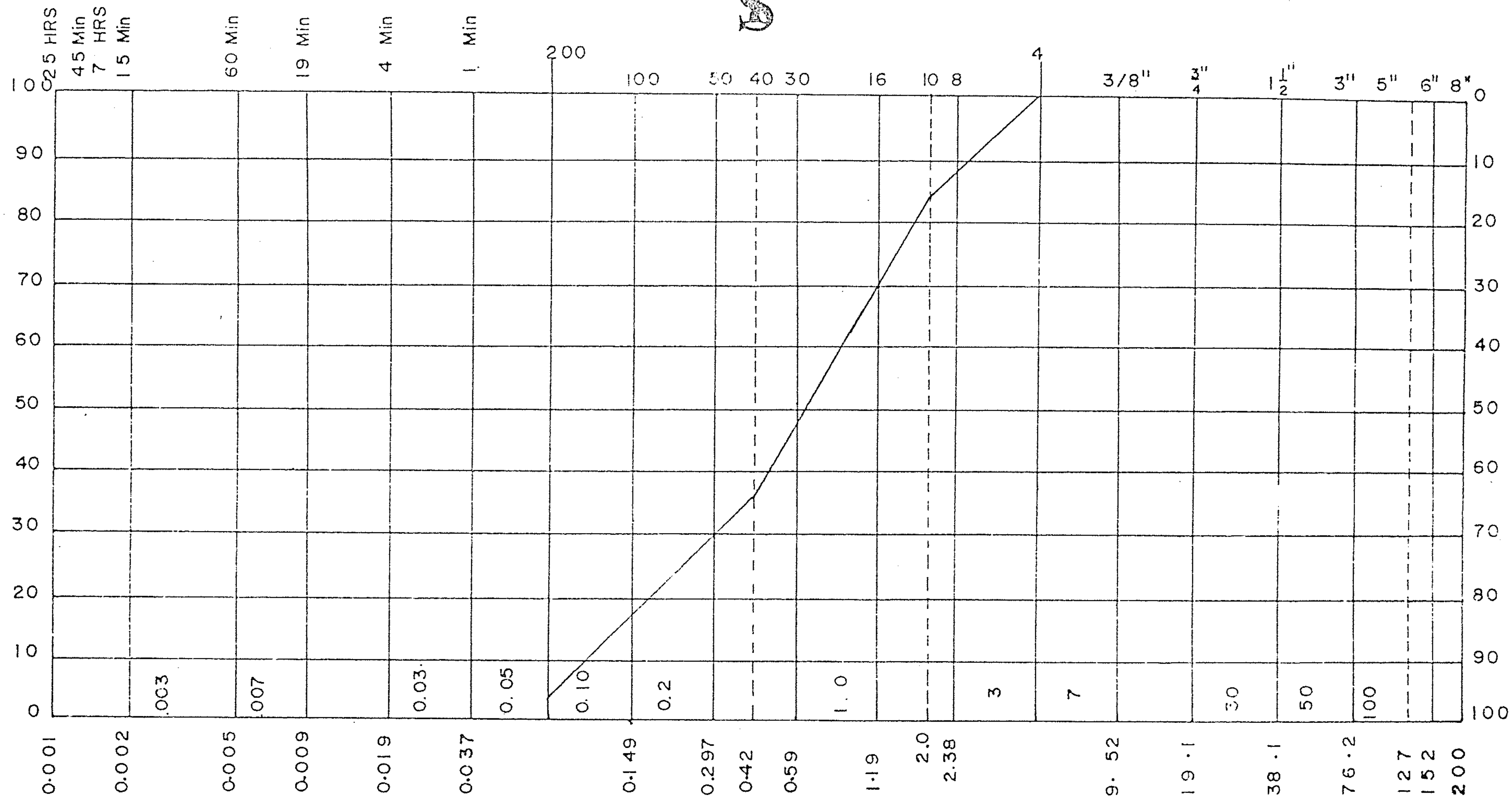
PROJECT________

DATE ________

SAMPLE No ________

HYDROMETER ANALYSIS

SIEVE ANALYSIS



CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.5 (10.0)m	---	96.5	3.5	--

REMARKS ________

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Geo. Research

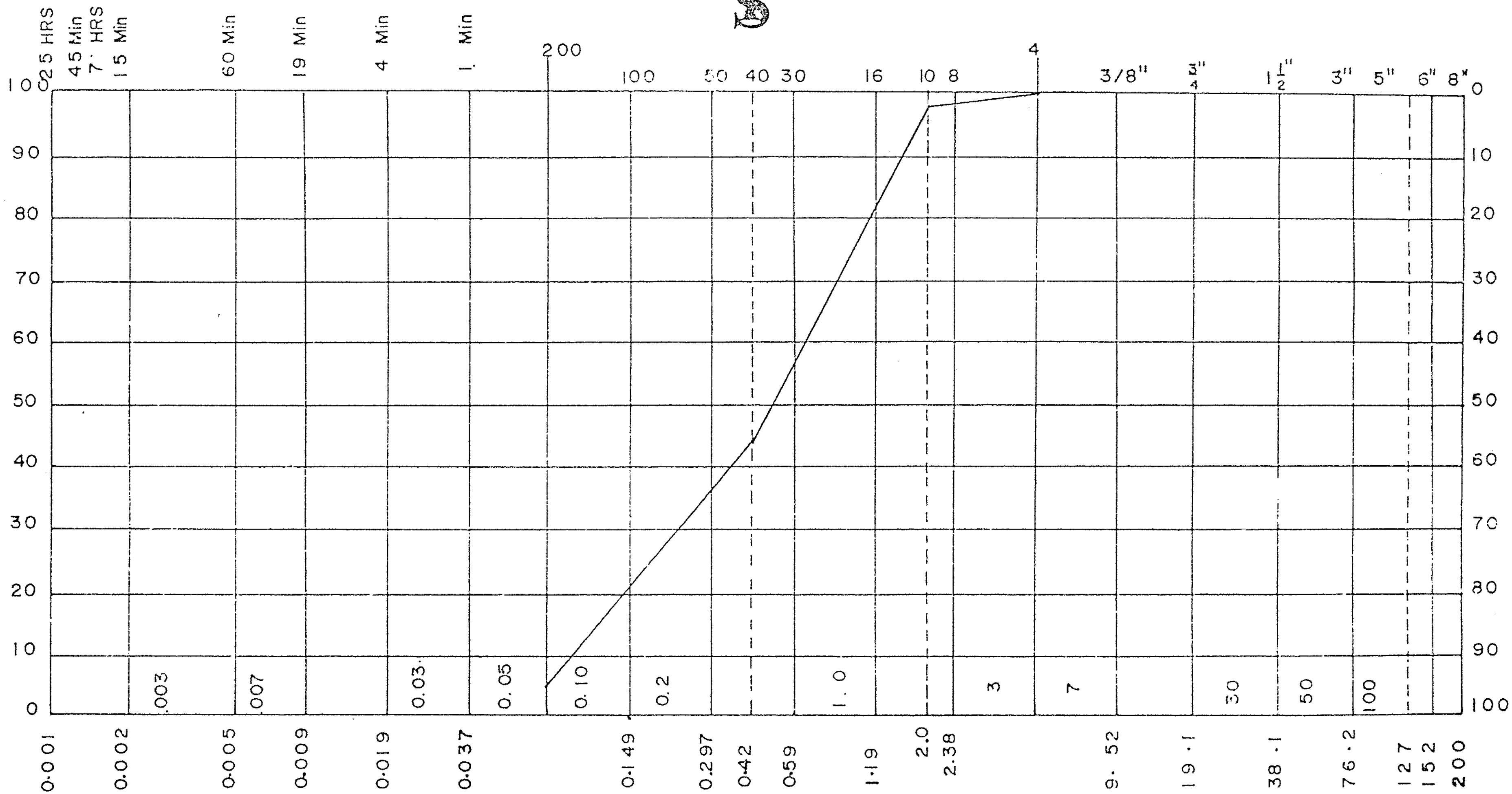
PROJECT__ ______

DATE ___________

SAMPLE No _______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074				4.76		
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH 5 (15.0)m	---	95.2	4.8	---

REMARKS ____________

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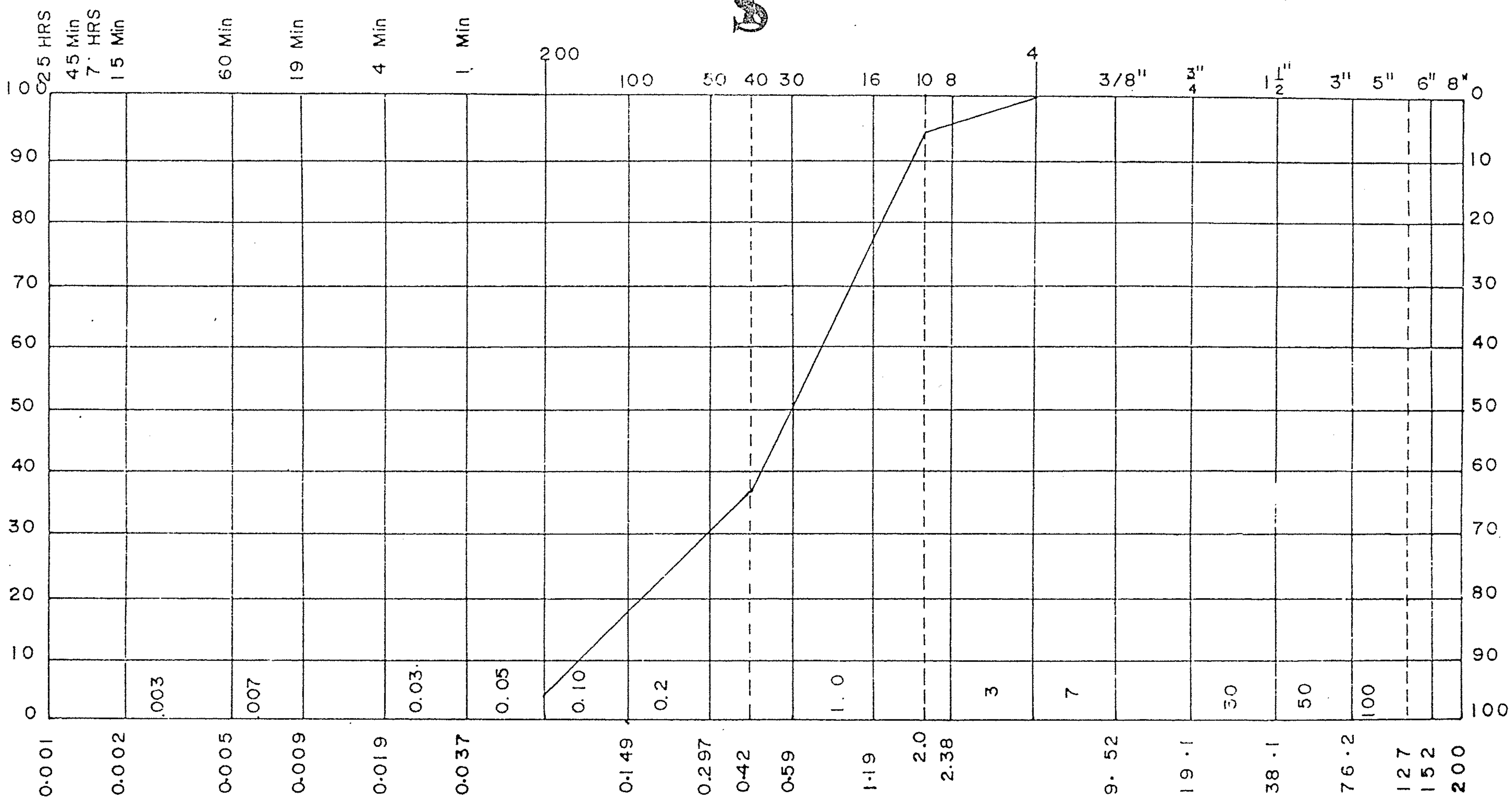
PROJECT______

DATE ________

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074				4.76		
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH 5 (20.0)m	---	96.0	4.0	---

REMARKS ______

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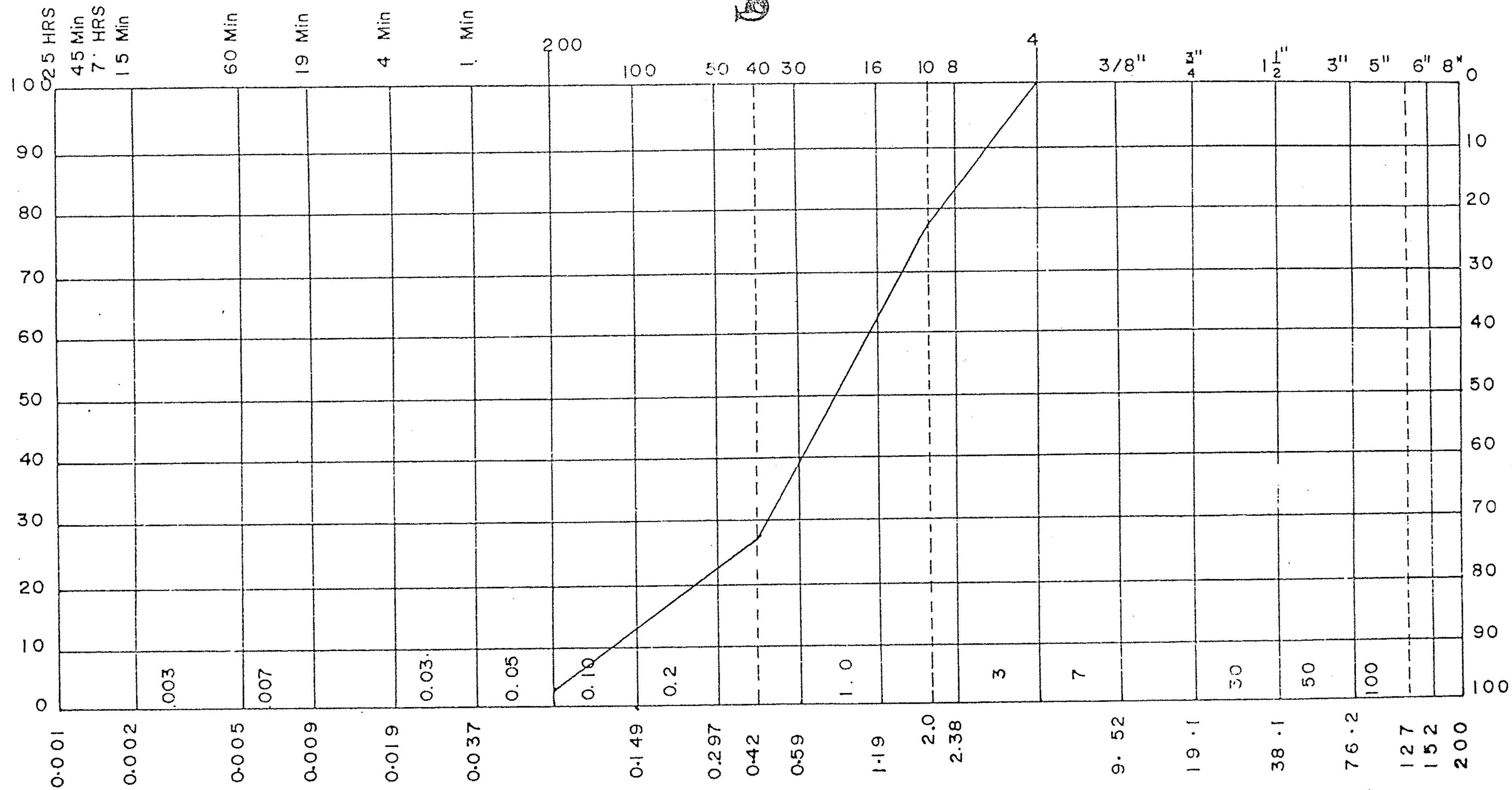
PROJECT________

DATE __________

SAMPLE No _______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074 | 4.76

CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.5 (25.0)m	---	97.1	2.9	--

REMARKS

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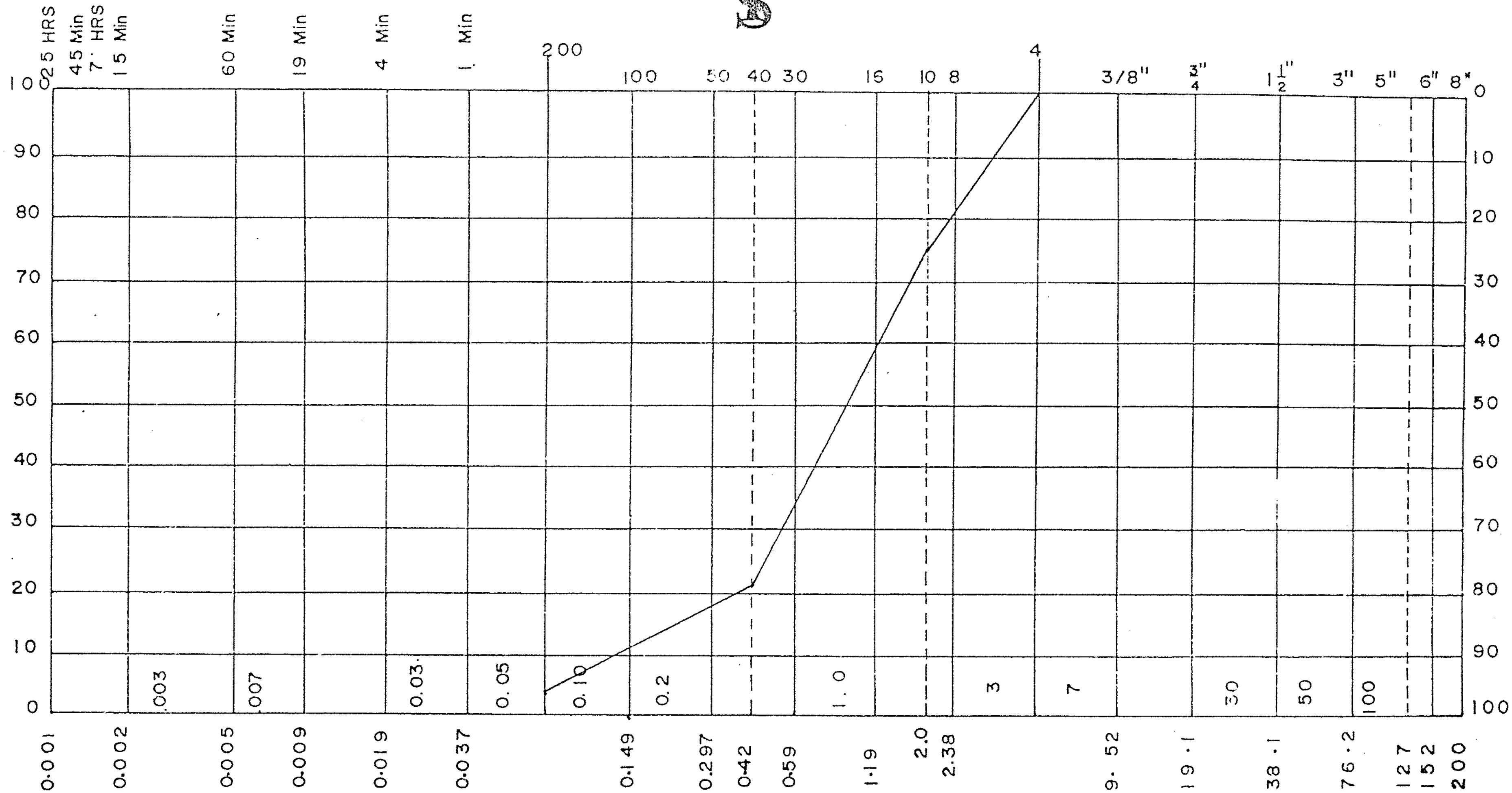
PROJECT _______

DATE __________

SAMPLE No _______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074 4.76

CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %	REMARKS
BH.5 (30.0)m	---	96.5	3.5	--	

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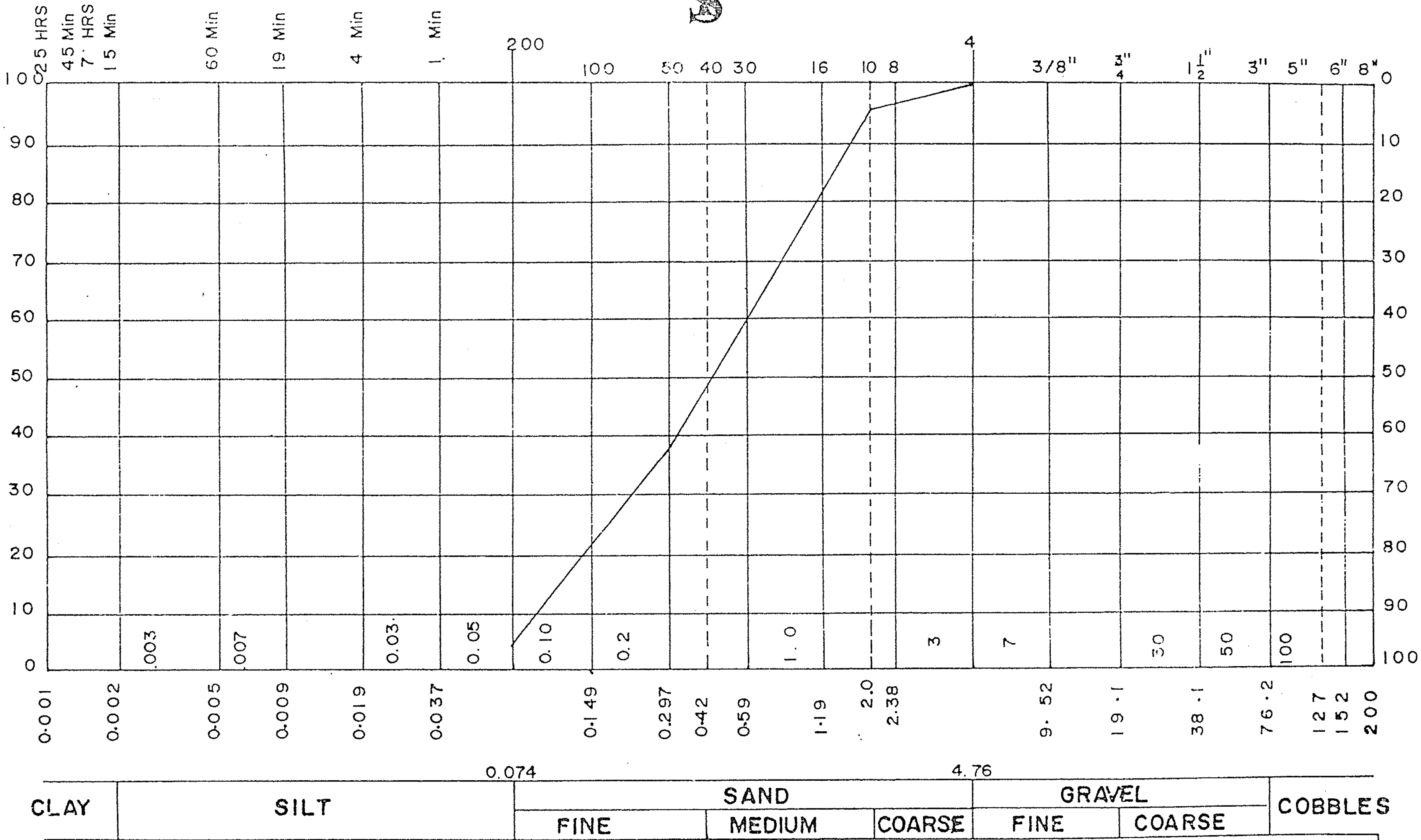
PROJECT________

DATE __________

SAMPLE No ______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.6 (3.0)m	---	95.9	4.1	--

REMARKS ________

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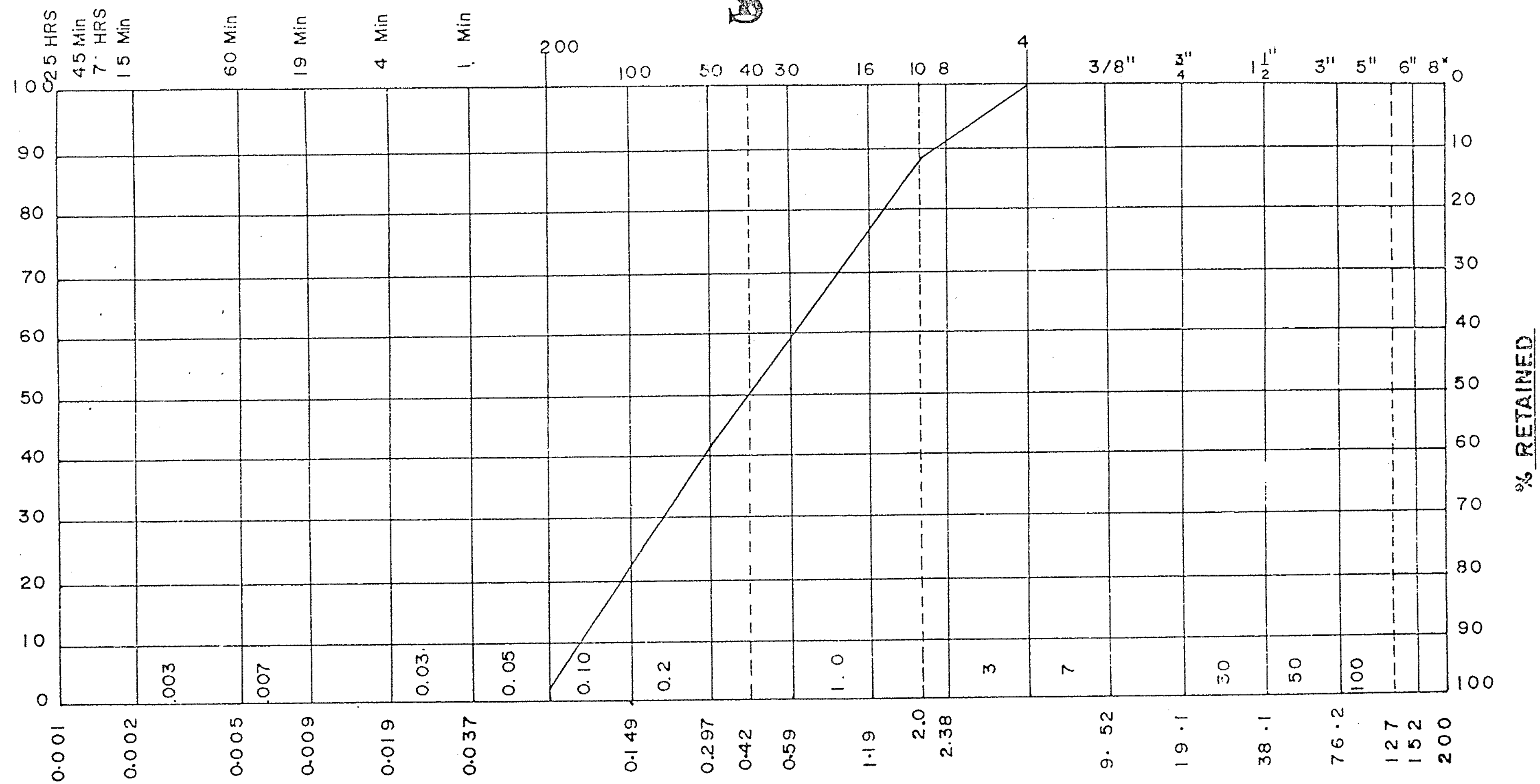
PROJECT________

DATE ___________

SAMPLE No _______

HYDROMETER ANALYSIS

SIEVE ANALYSIS



0.074				4.76				
CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %	REMARKS
BH.6 (6.0)m	---	97.8	2.2	--	

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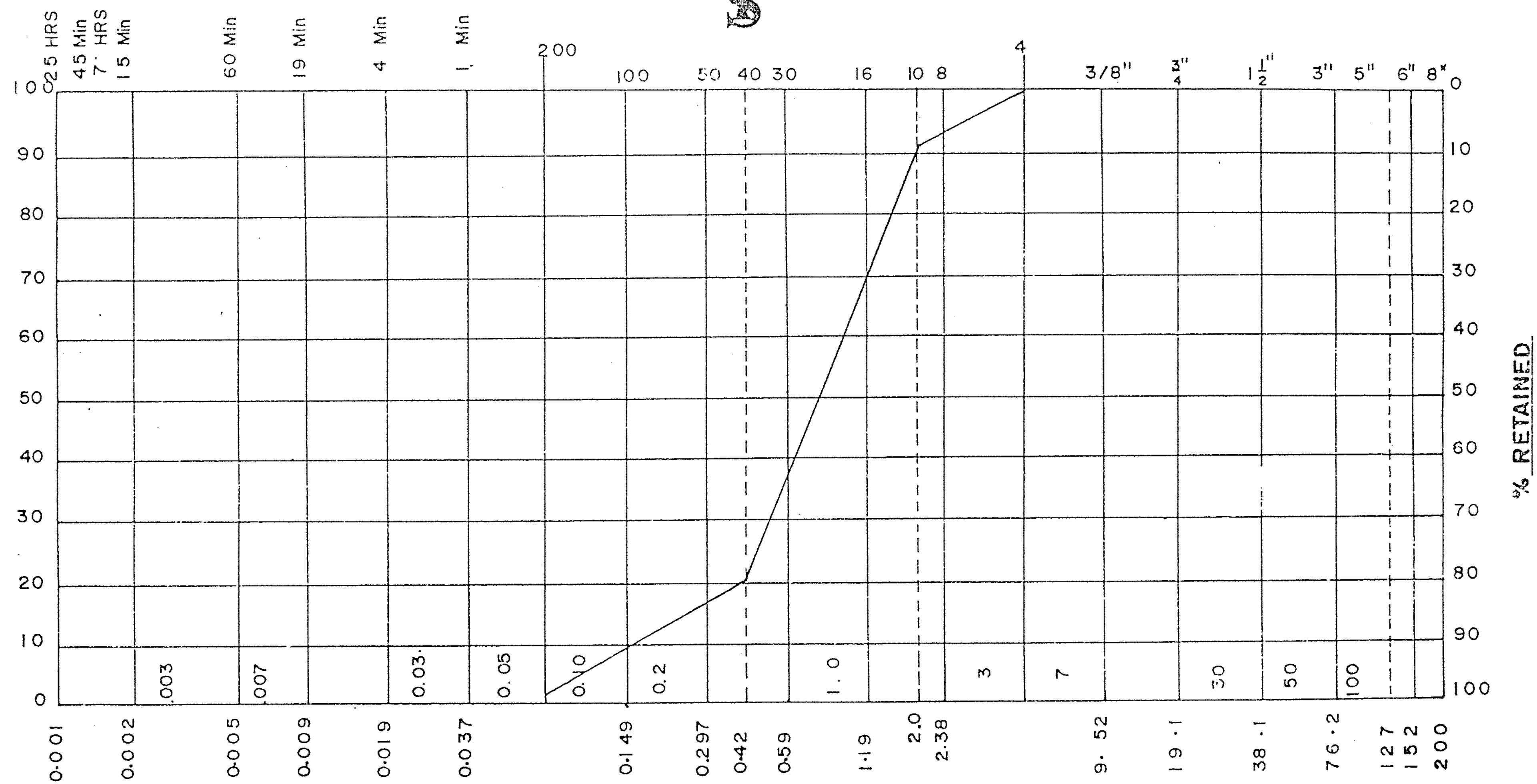
PROJECT ______ DATE __________

SAMPLE No ______

HYDROMETER ANALYSIS SIEVE ANALYSIS



CLAY	SILT	SAND			GRAVEL		COBBLES
		FINE	MEDIUM	COARSE	FINE	COARSE	

SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.6 (9.0)m	---	98.5	1.5	--

REMARKS

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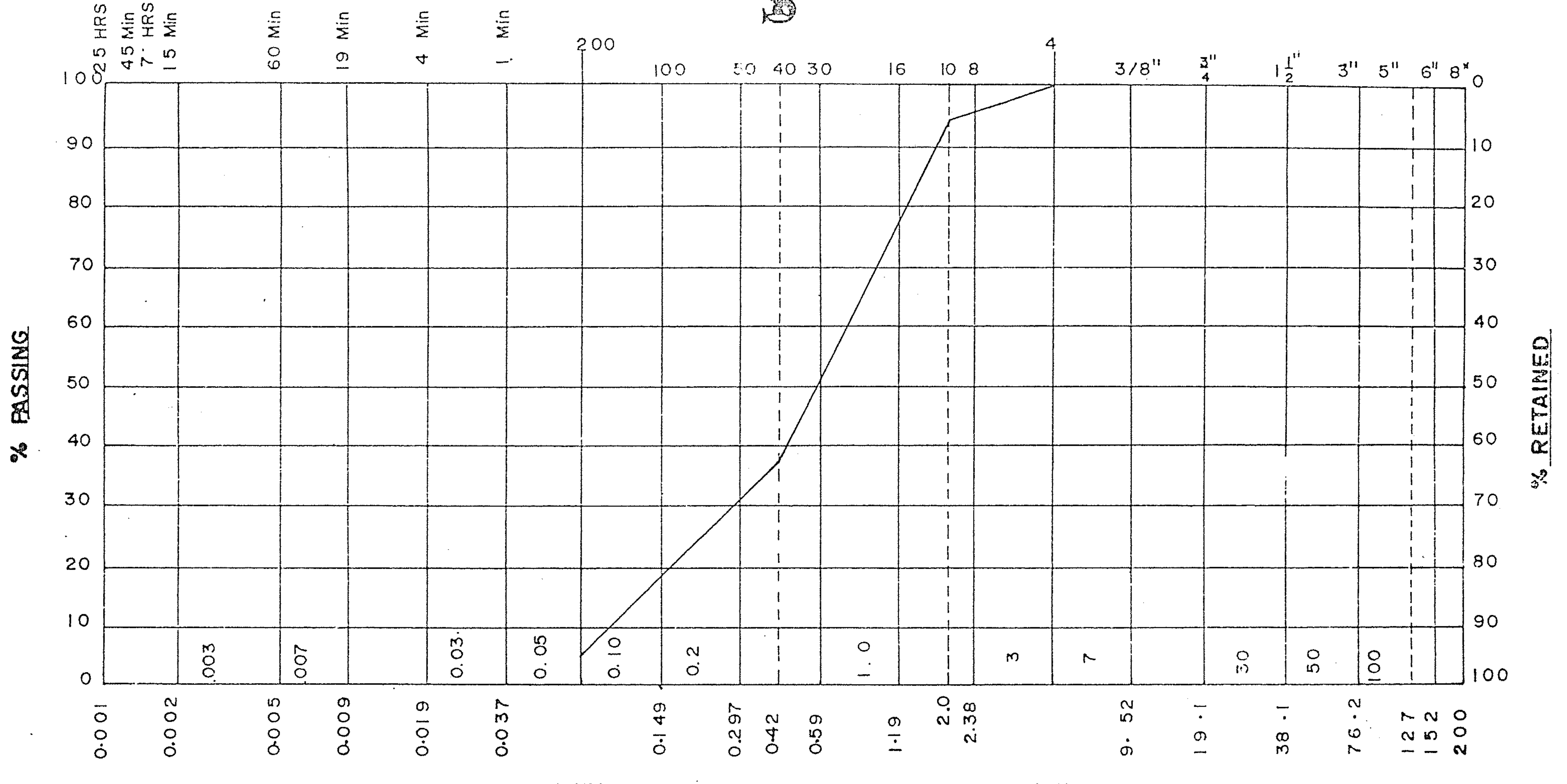
PROJECT______

DATE __________

SAMPLE No ______

HYDROMETER ANALYSIS

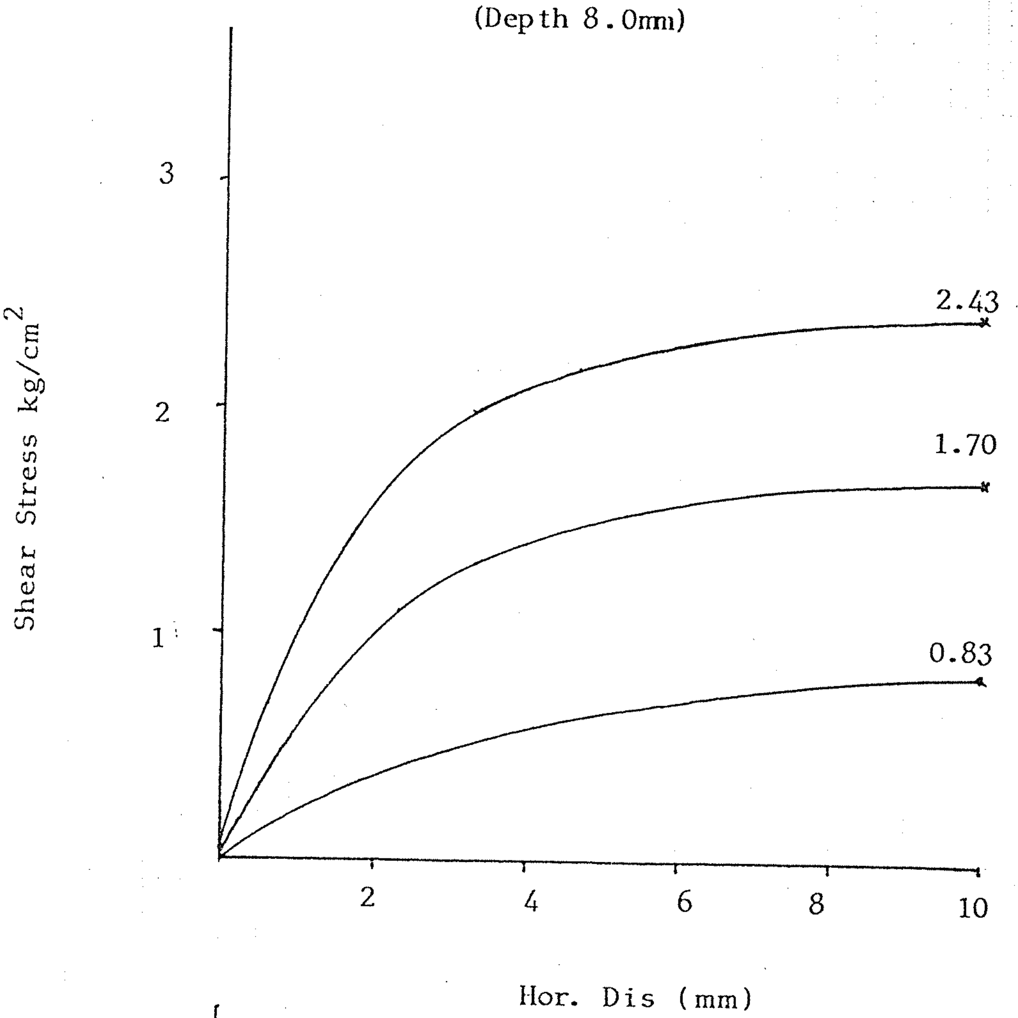
SIEVE ANALYSIS

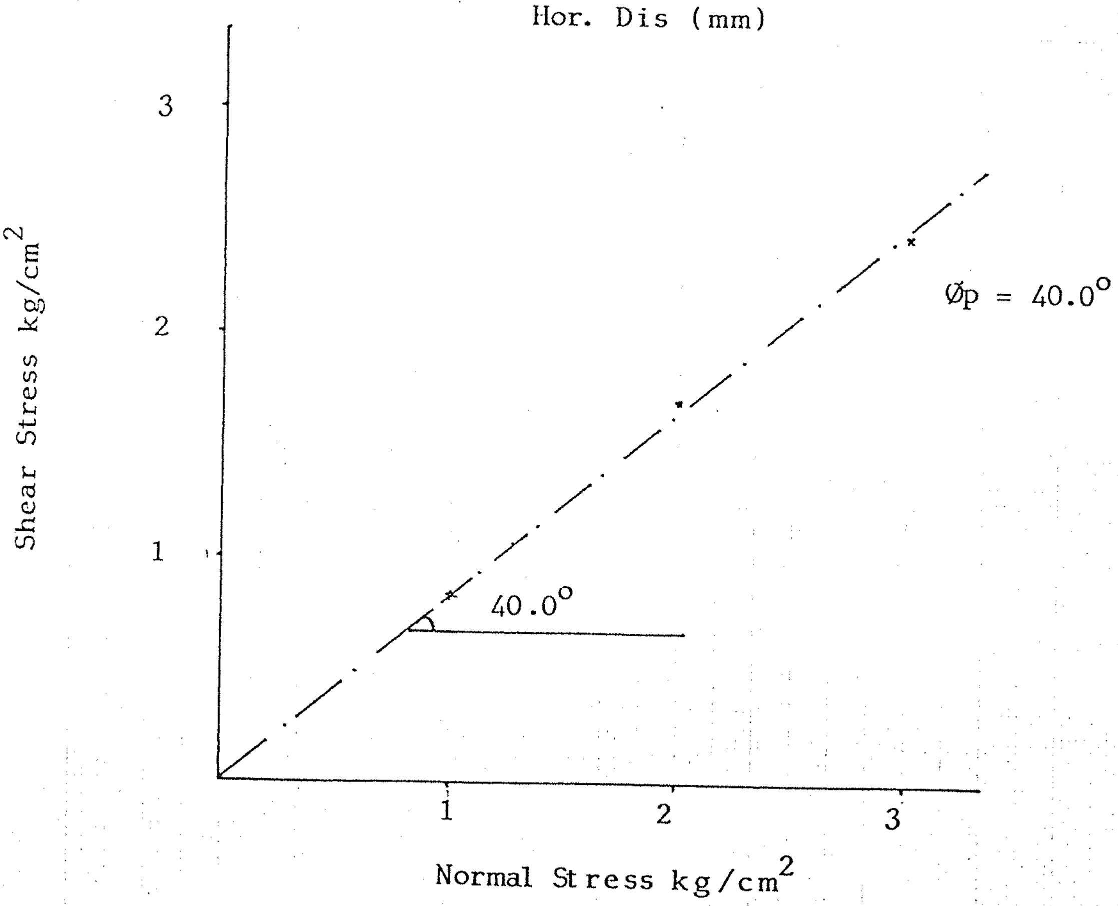


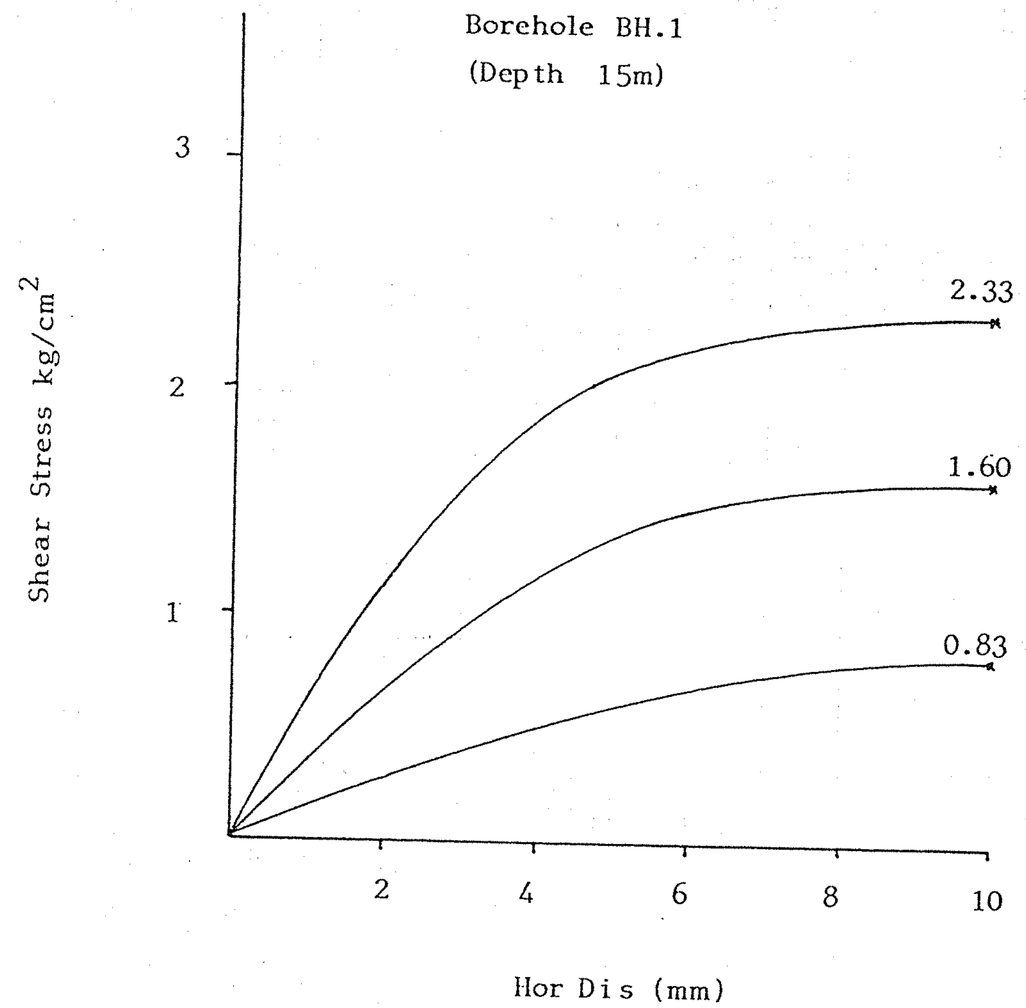
SAMPLE No	GRAVEL %	SAND%	SILT %	CLAY %
BH.6 (12.0)m	---	94.9	5.1	--

REMARKS __________

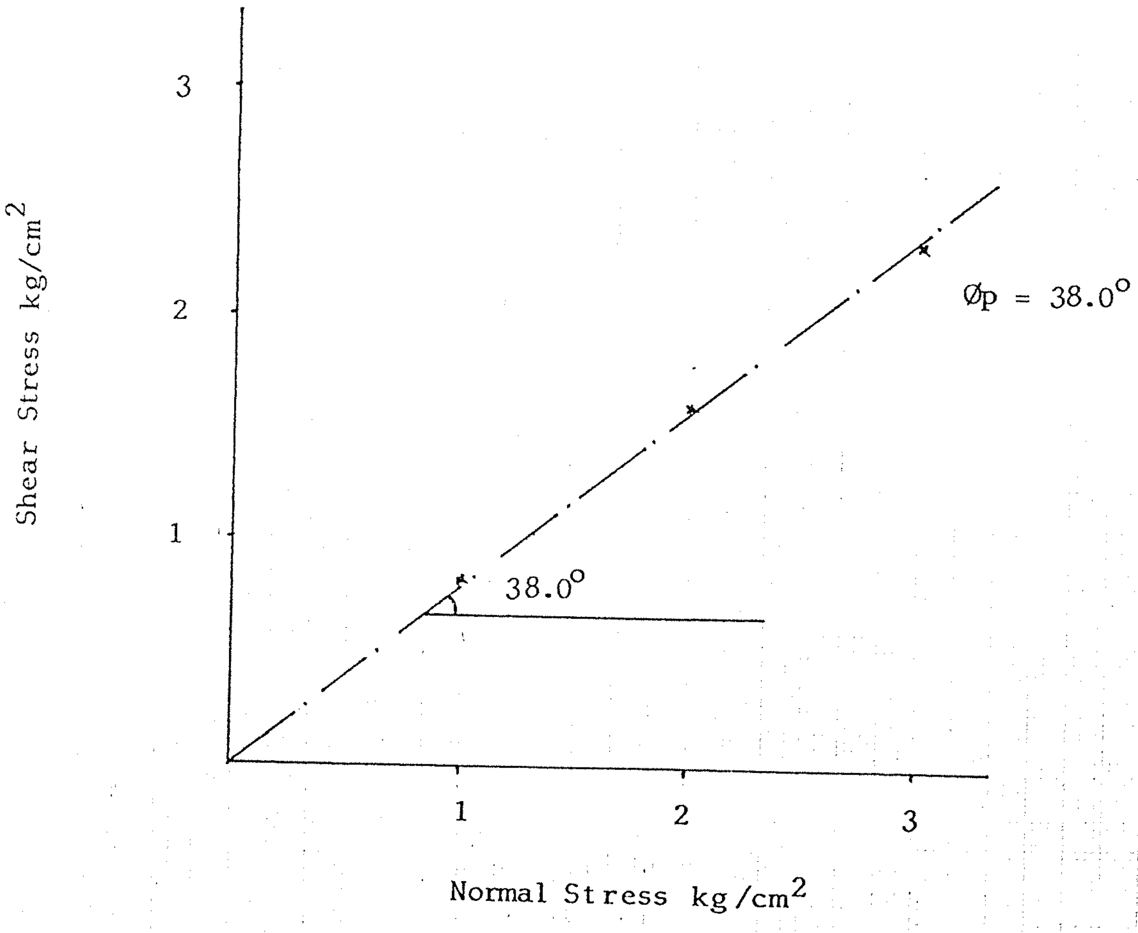
Borehole BH.1
(Depth 8.0mm)



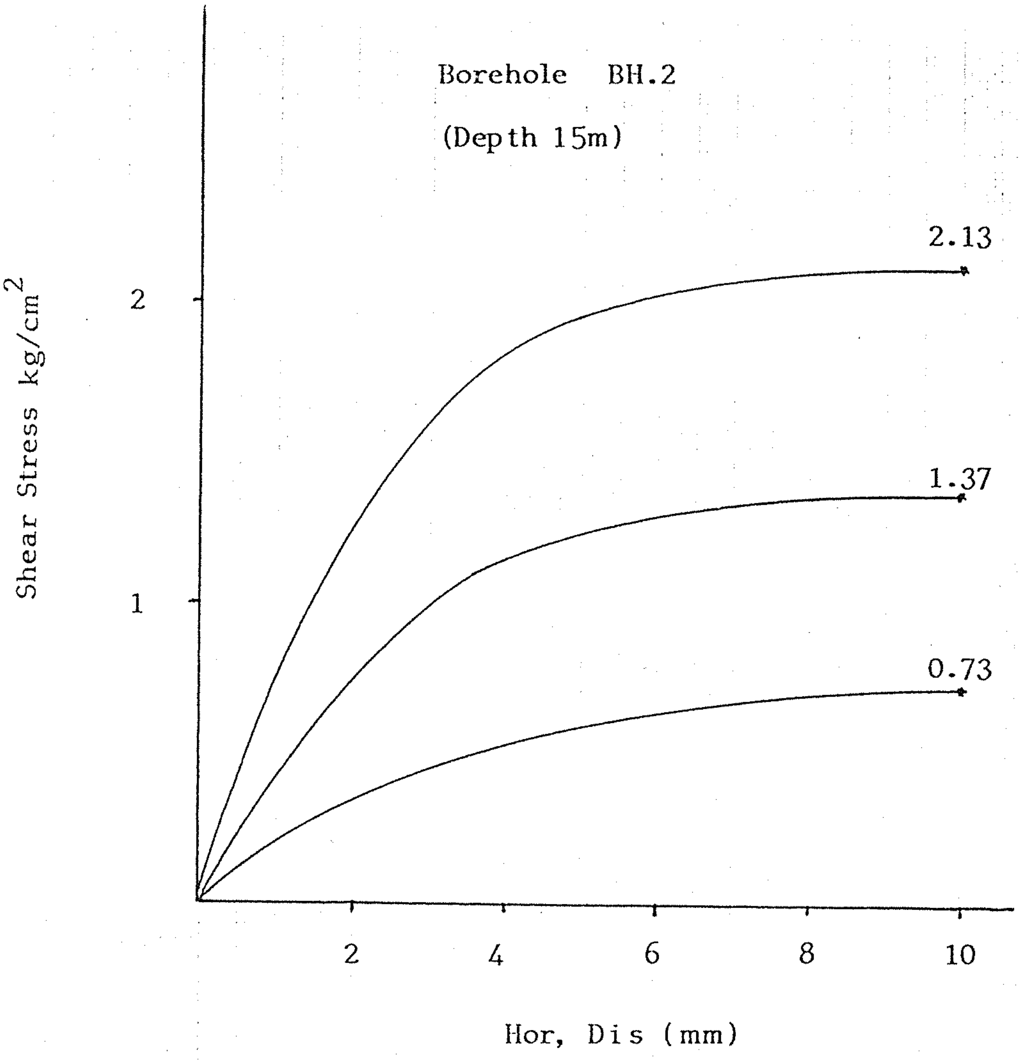


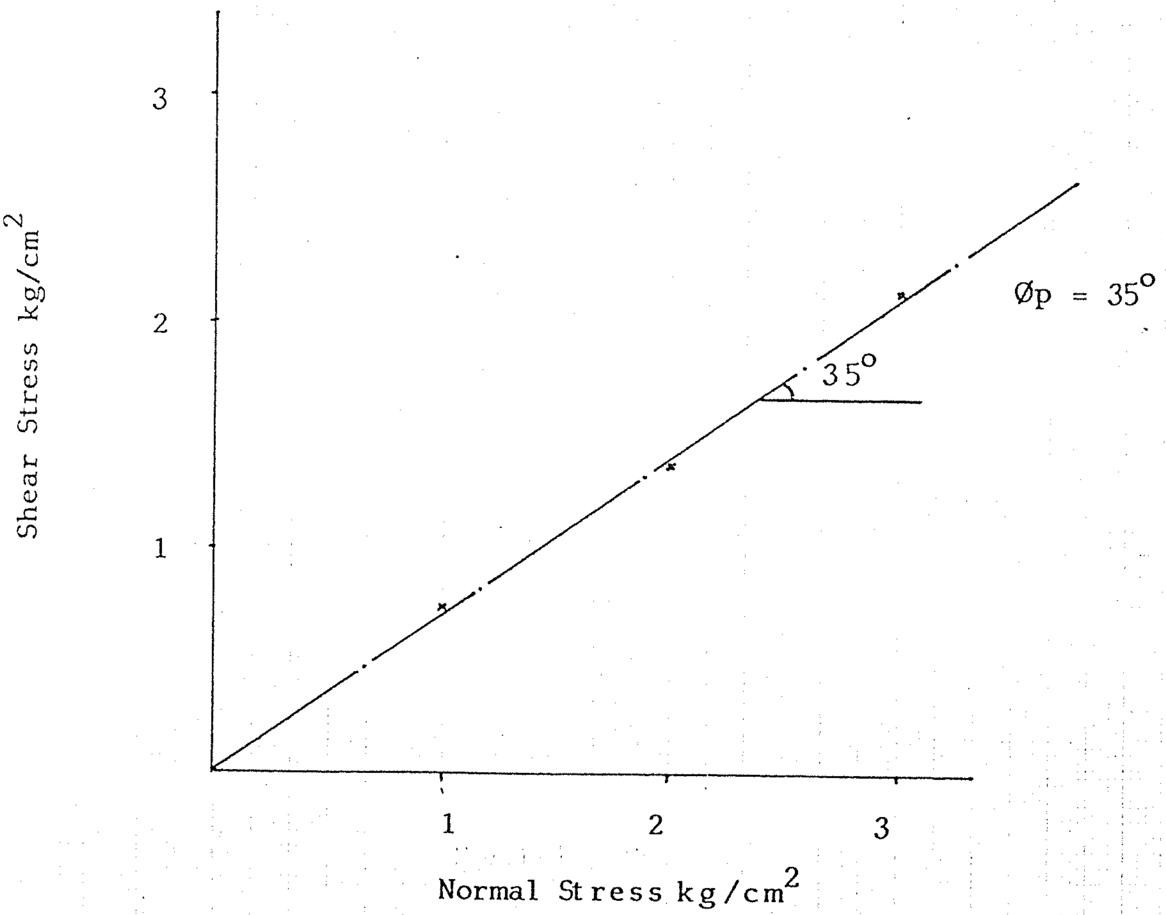


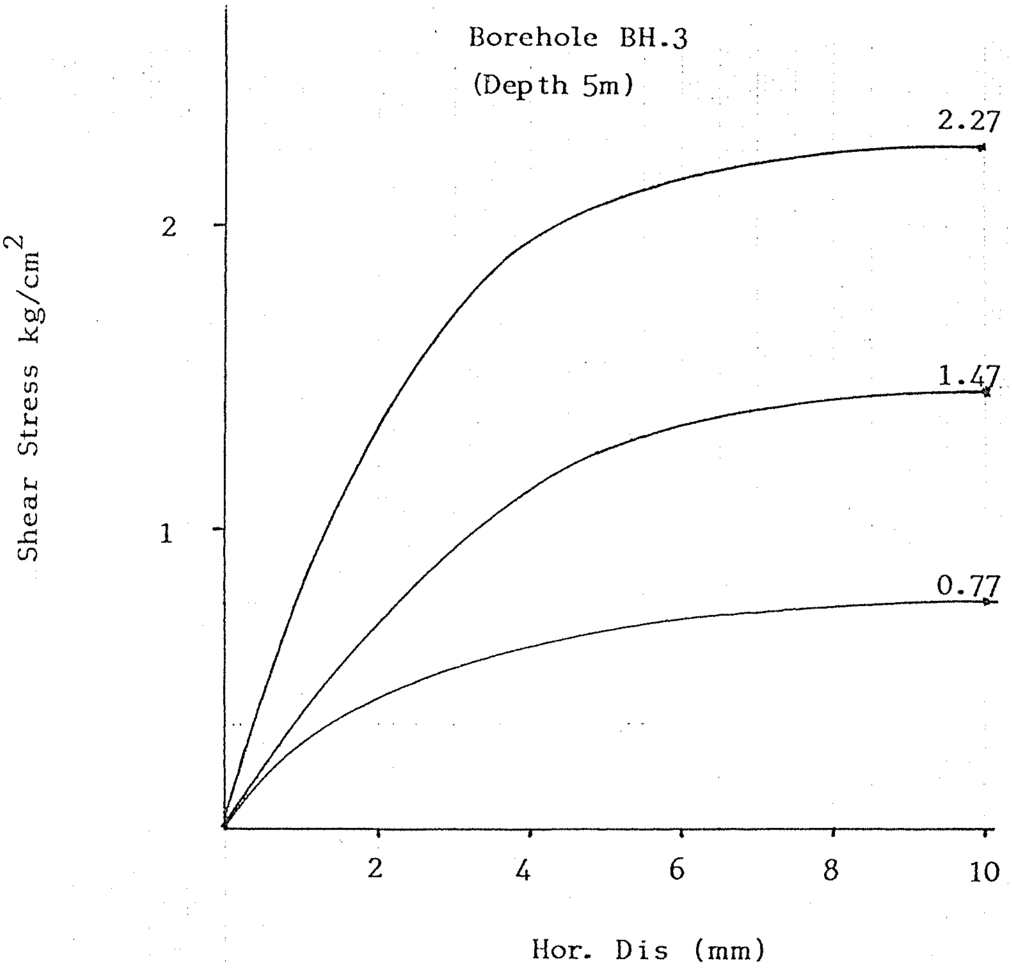
Borehole BH.1
(Depth 15m)
Shear Stress kg/cm2
3
2
1
2.33
1.60
0.83
2
4
6
8
10
Hor Dis (mm)



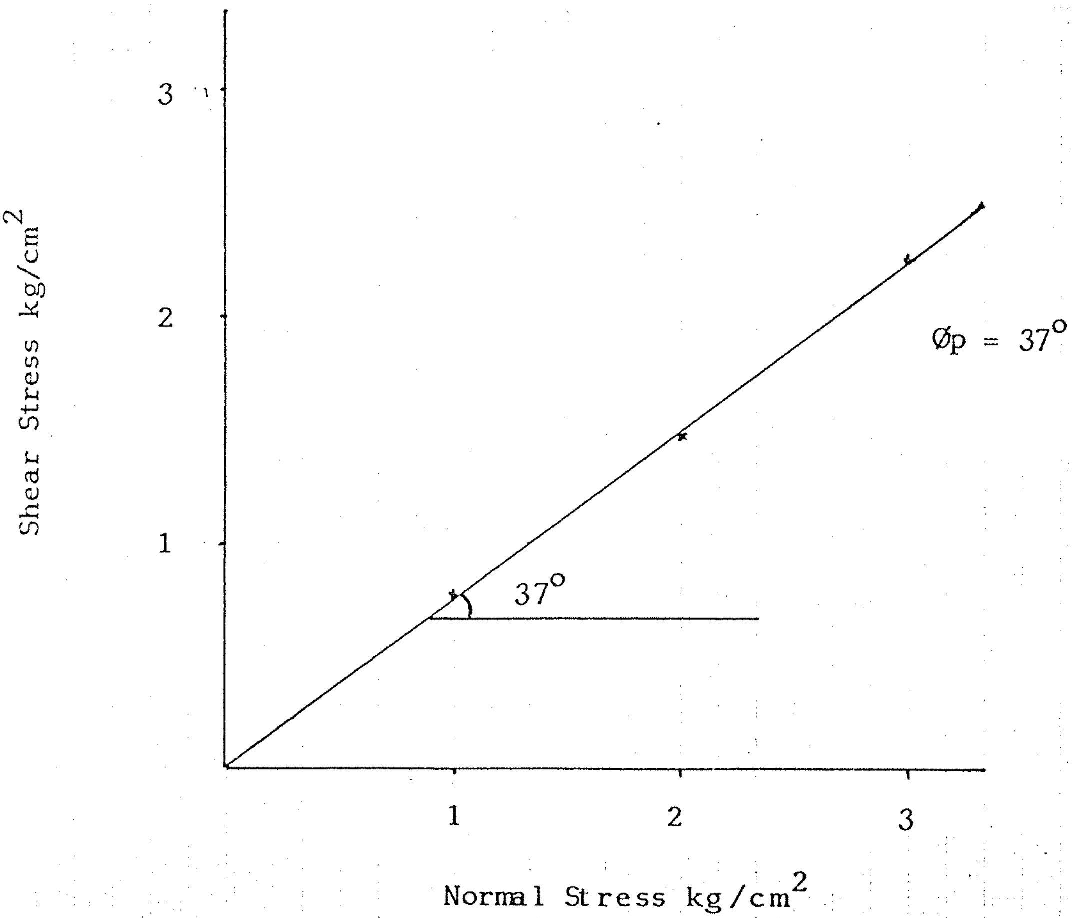
Shear Stress kg/cm2
3
2
1
Øp = 38.0°
38.0°
1
2
3
Normal Stress kg/cm2


Borehole BH.2
(Depth 15m)
Shear Stress kg/cm2
2.13
1.37
0.73
2
1
2
4
6
8
10
Hor, Dis (mm)

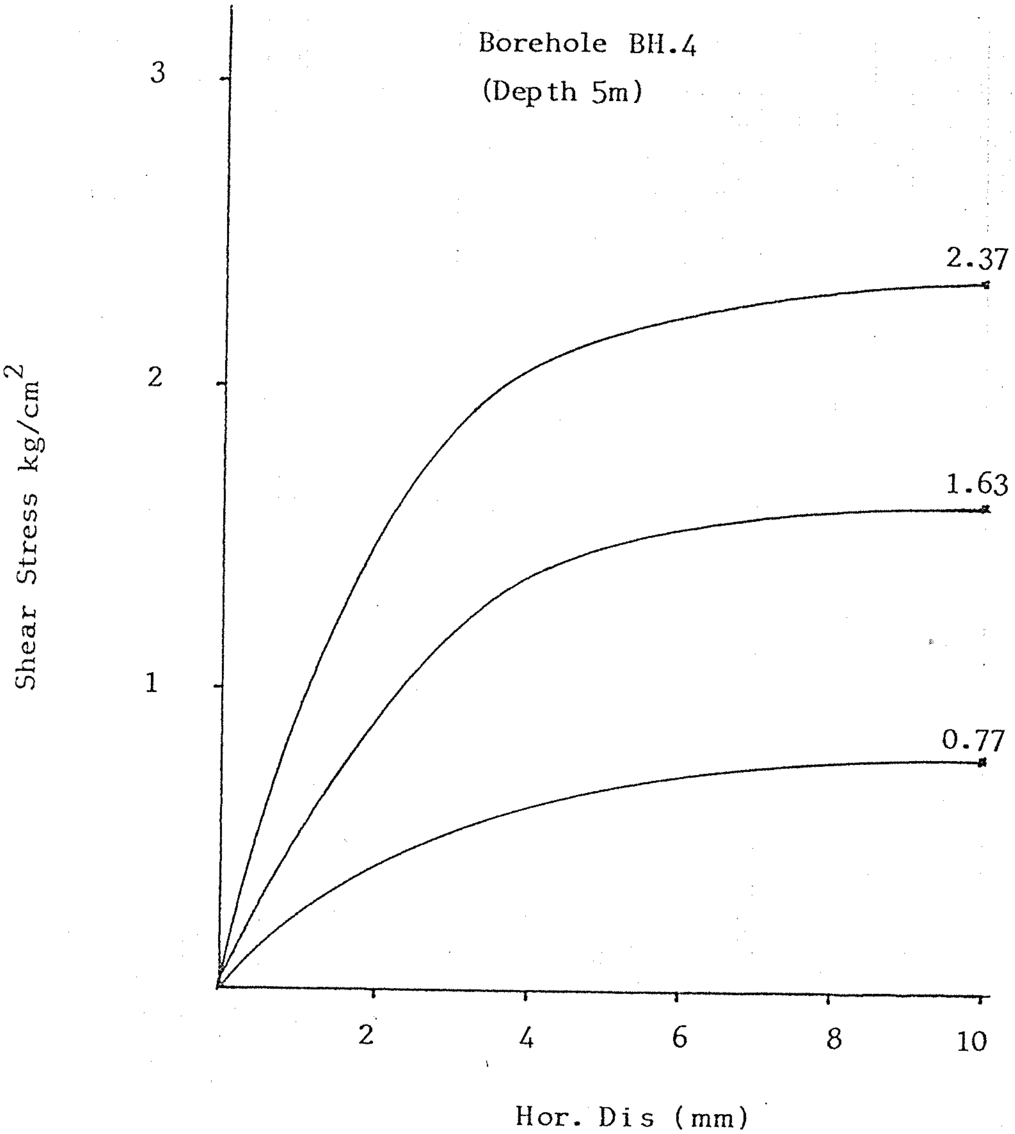

Shear Stress kg/cm2
3
2
1
Øp = 35°
35°
1
2
3
Normal Stress kg/cm2

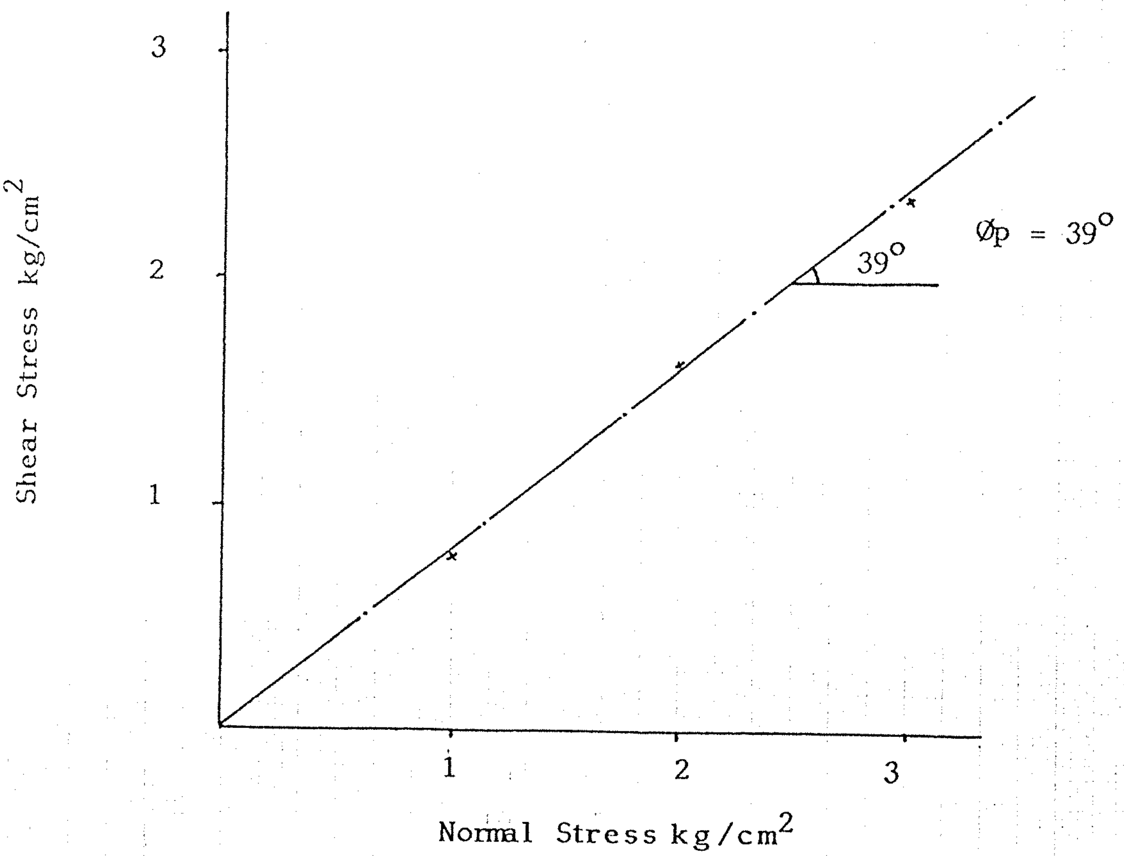


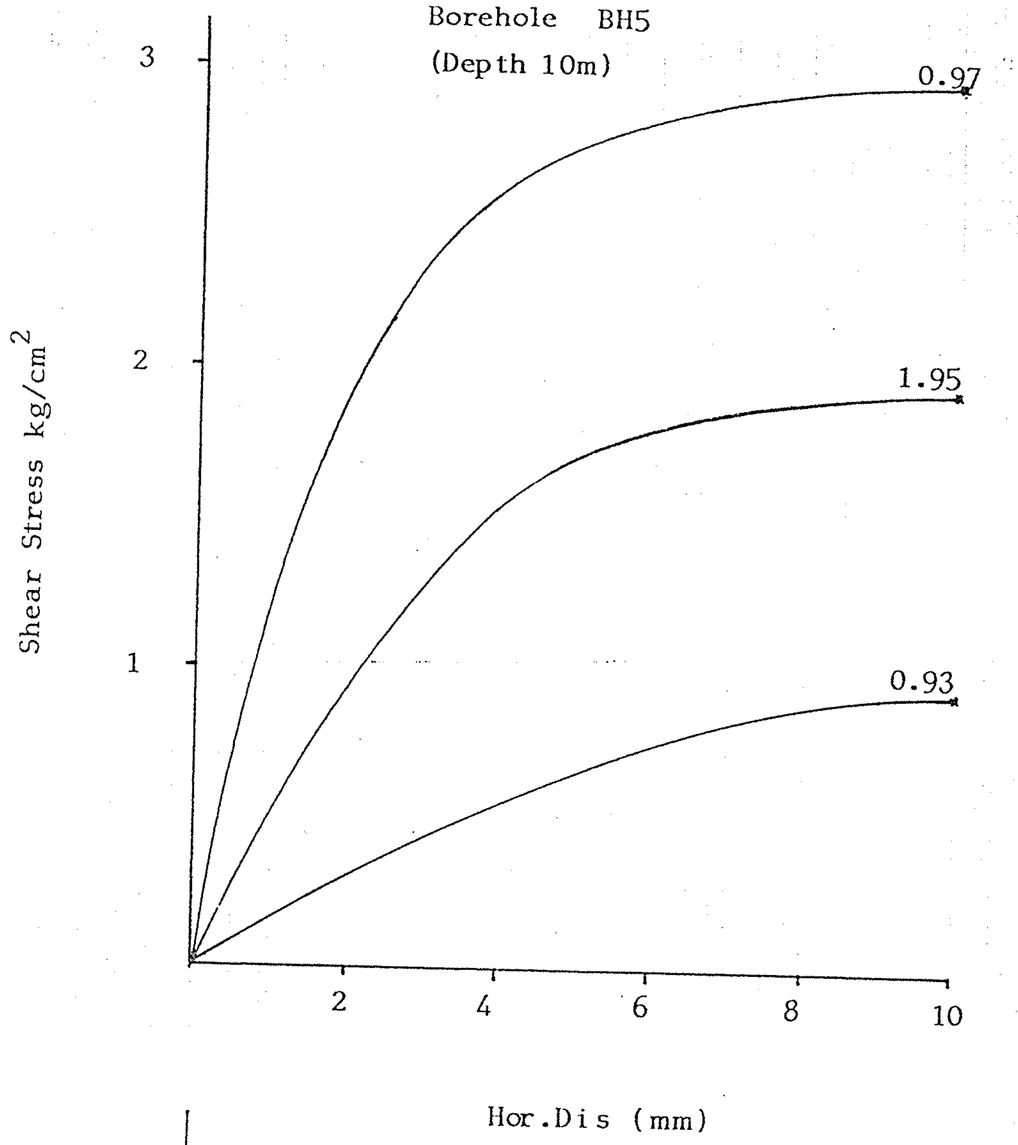
Borehole BH.3
(Depth 5m)
2.27
1.47
0.77
2
1
Shear Stress kg/cm2
2
4
6
8
10
Hor. Dis (mm)

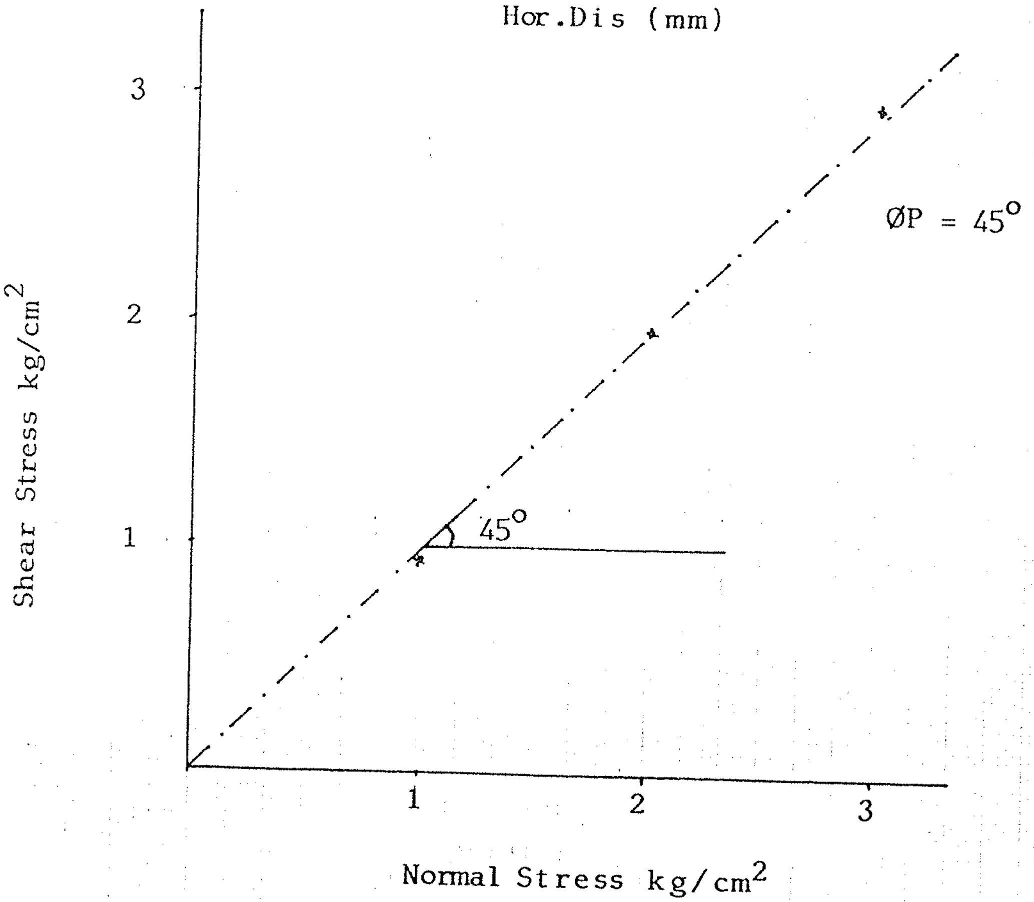


3
2
1
Shear Stress kg/cm2
Øp = 37°
37°
1
2
3
Normal Stress kg/cm2


Borehole BH.4
(Depth 5m)
2.37
1.63
0.77
Shear Stress kg/cm^2
3
2
1
2
4
6
8
10
Hor. Dis (mm)

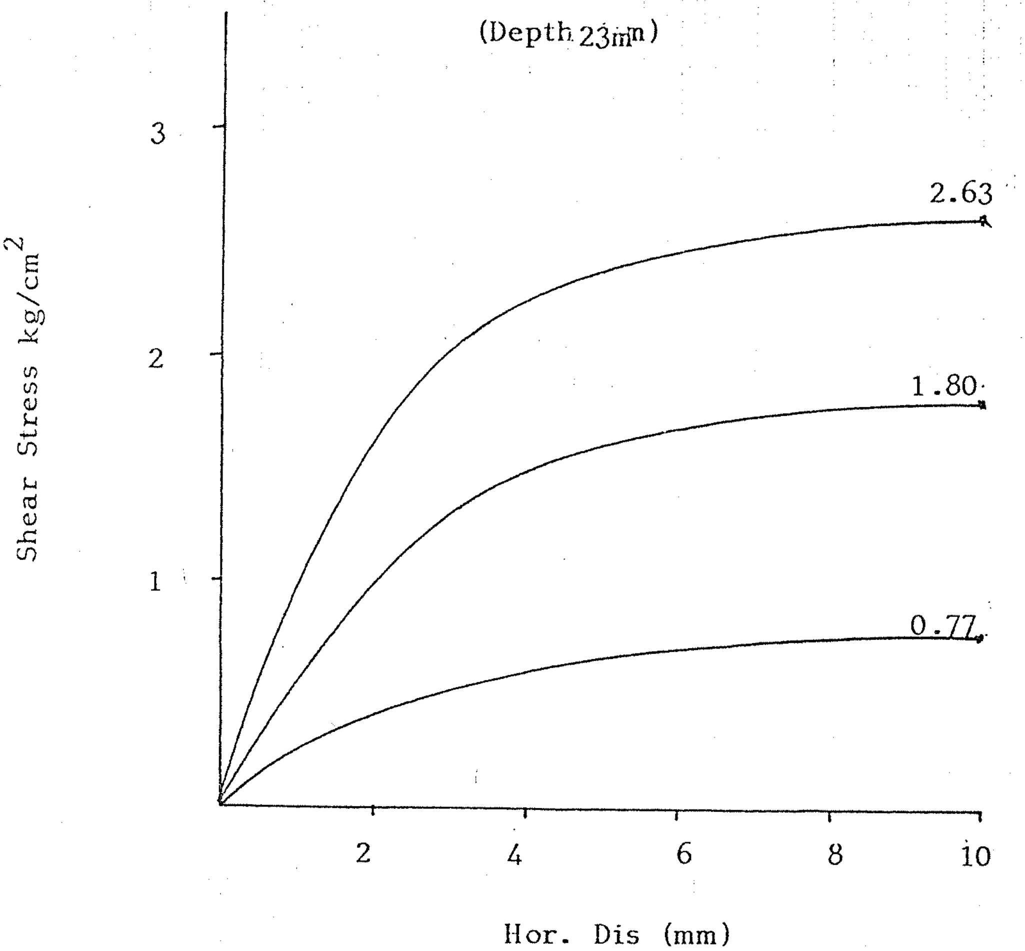

Shear Stress kg/cm^2
3
2
1
39°
Øp = 39°
1
2
3
Normal Stress kg/cm^2

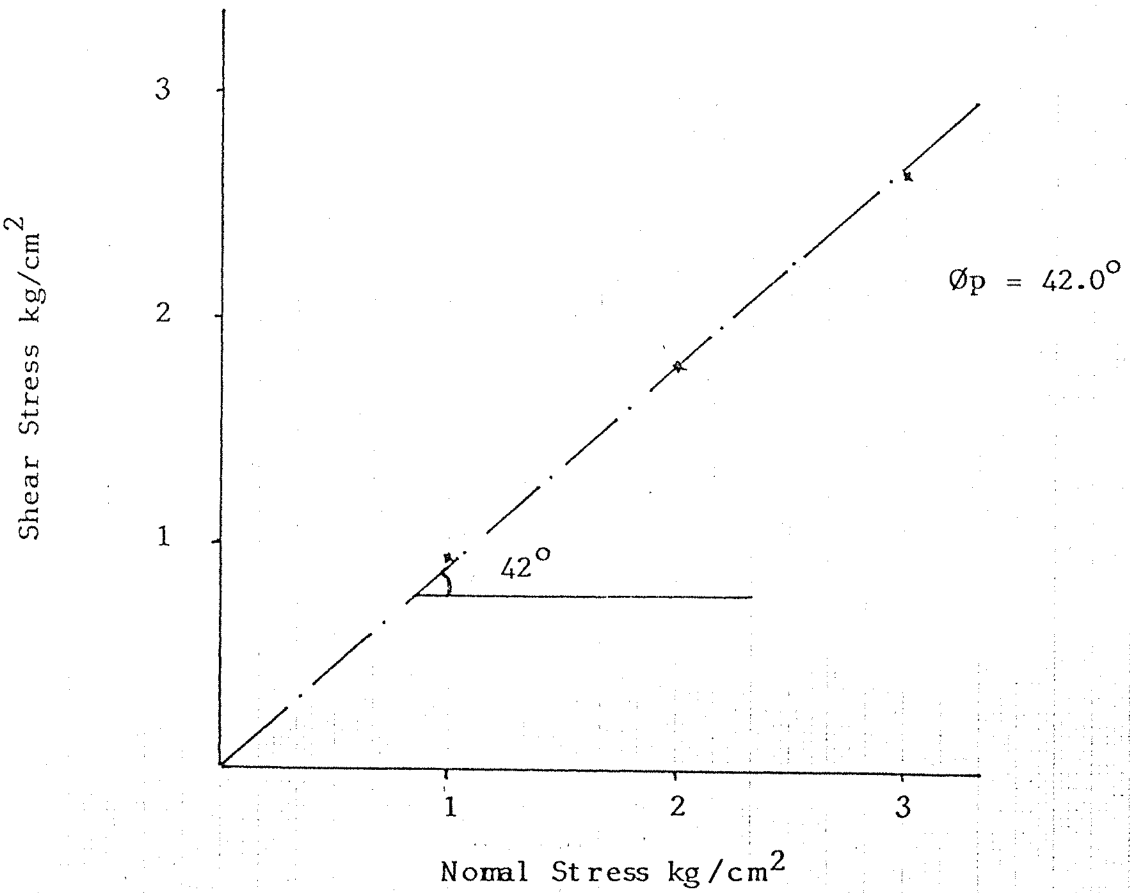

Borehole BH5
(Depth 10m)
3
2
1
Shear Stress kg/cm2
0.97
1.95
0.93
2
4
6
8
10
Hor.Dis (mm)

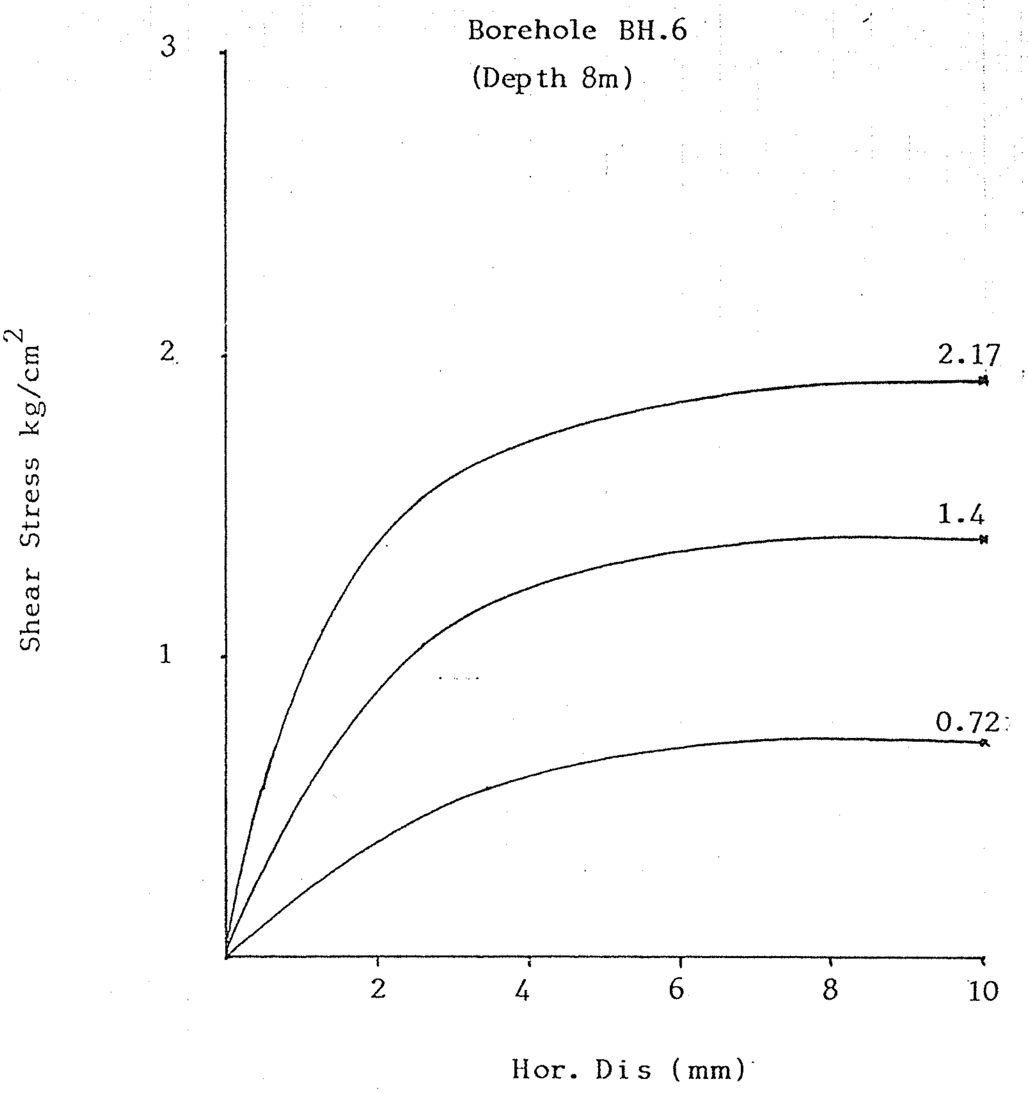

3
2
1
Shear Stress kg/cm2
ØP = 45°
45°
1
2
3
Normal Stress kg/cm2

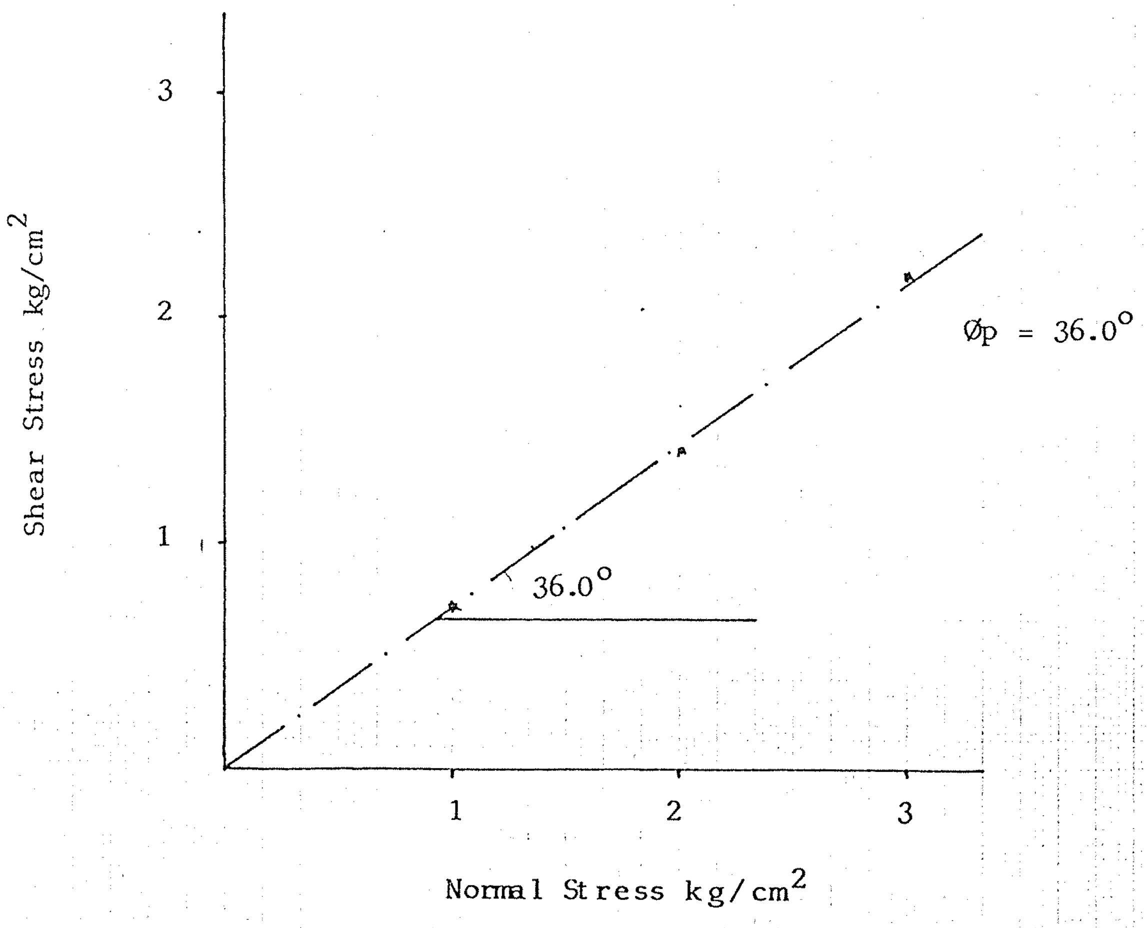
Borehole BH.5

(Depth 23m)





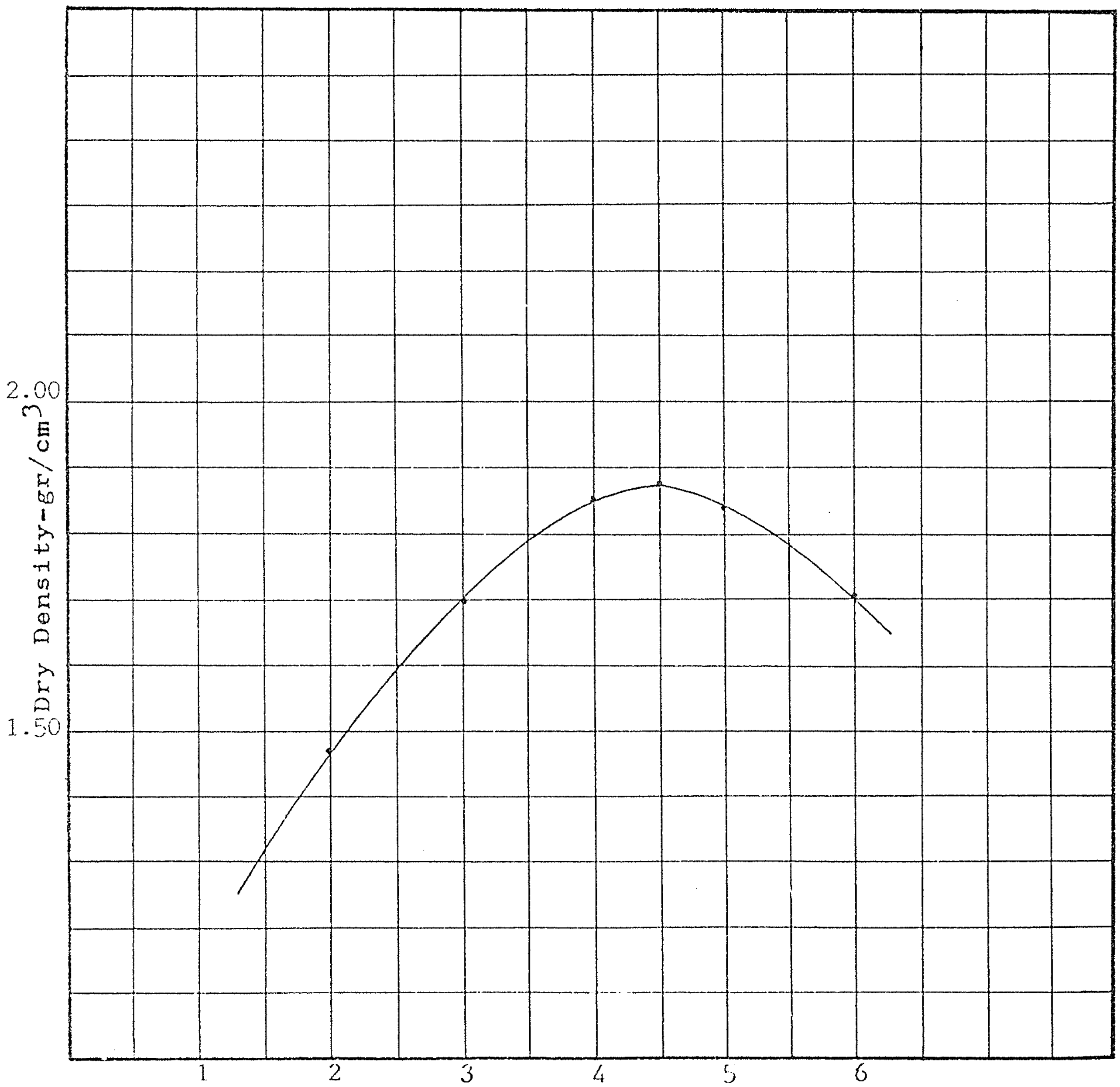

Borehole BH.6
(Depth 8m)
Shear Stress kg/cm2
3
2
1
2.17
1.4
0.72
2
4
6
8
10
Hor. Dis (mm)


Shear Stress kg/cm2
3
2
1
Øp = 36.0°
36.0°
1
2
3
Normal Stress kg/cm2

Geo-Research

Proctor Compaction Test

Sample No.: Project:



Max. Dry Density =1.88 gr/cm^2 Moisture Content(%)

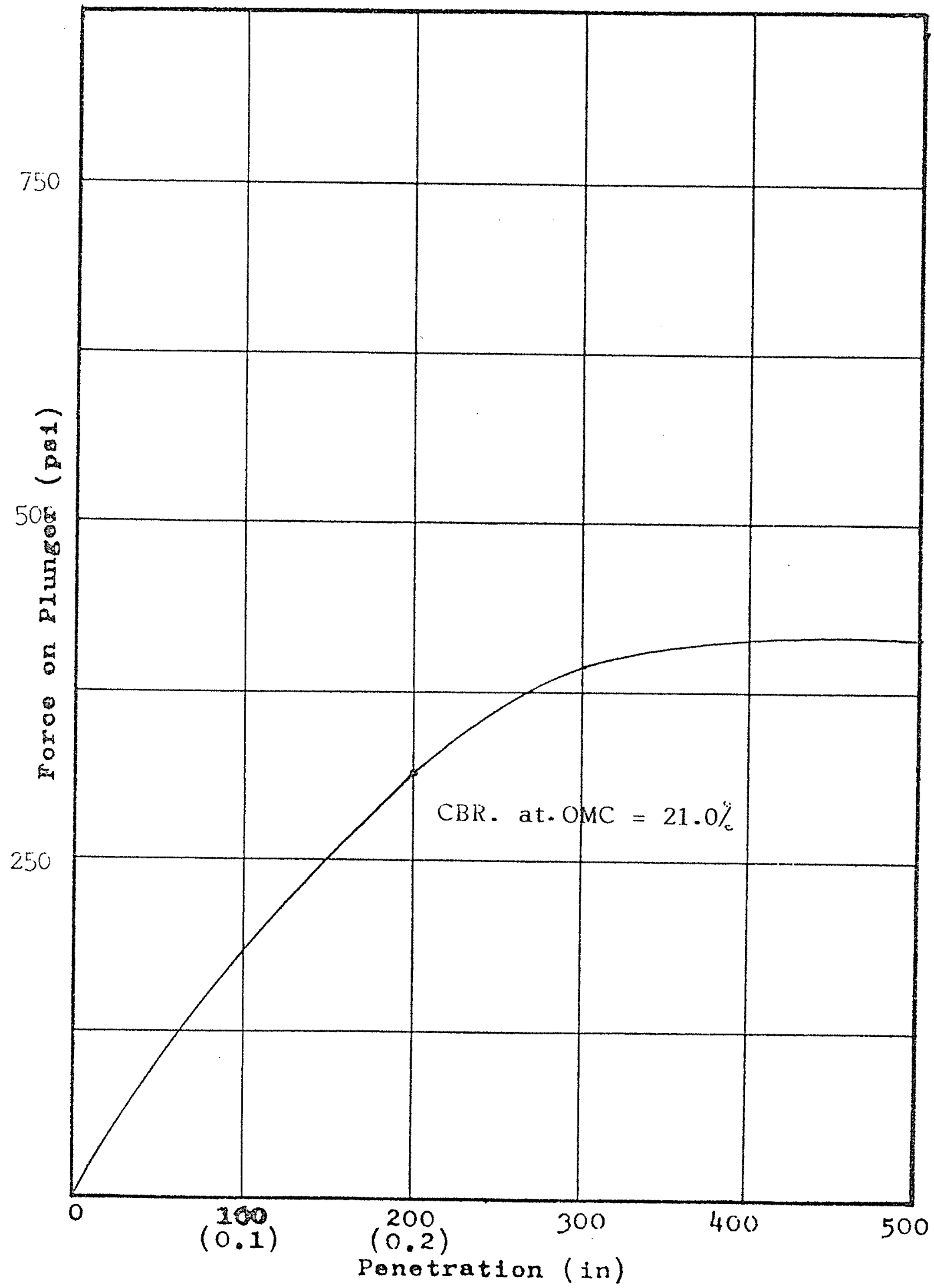
Optimum Moisture Content = 4.50%

Geo-Research

California Bearing Ratio

Project:

Sample No.:

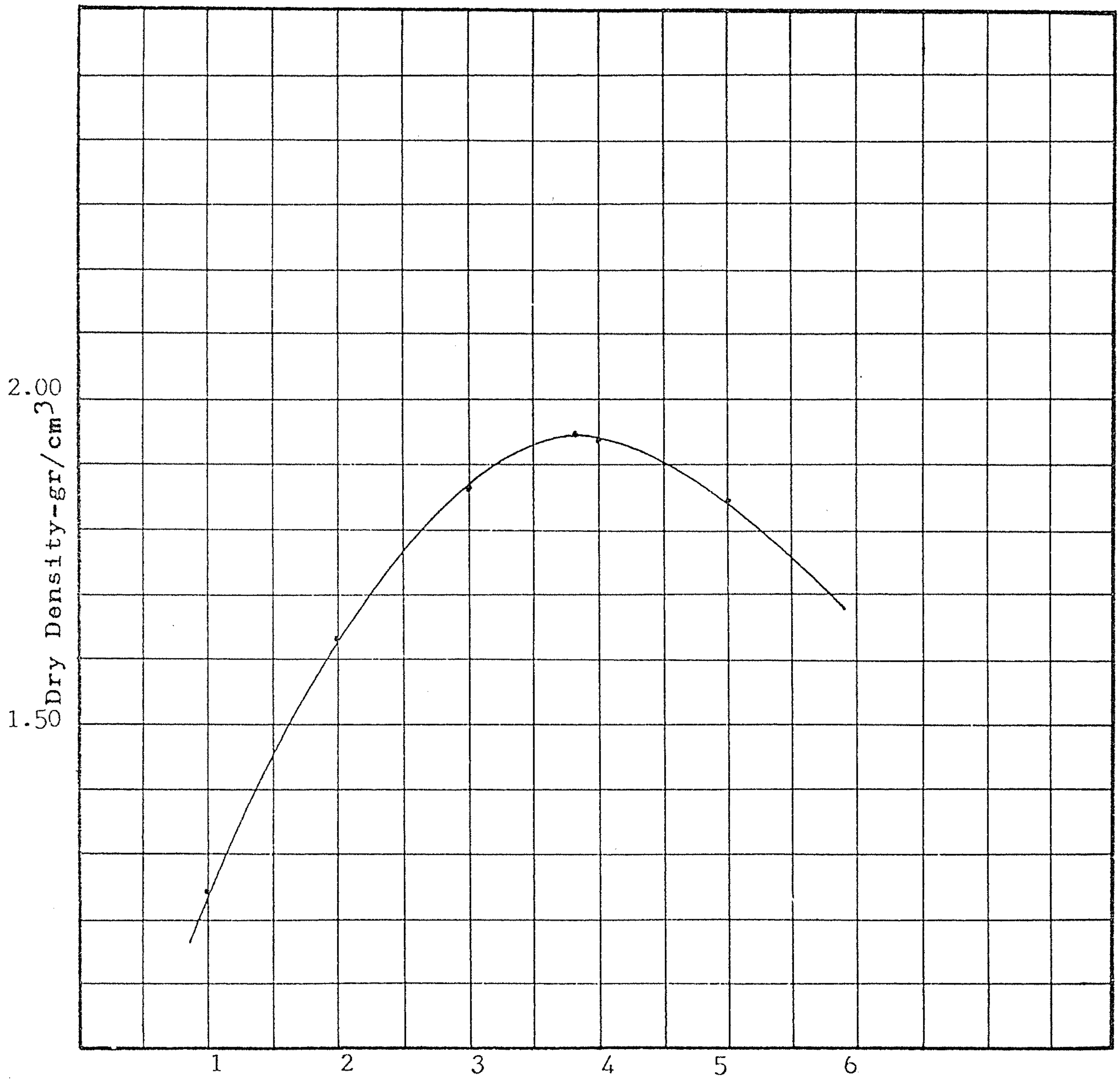


Remarks:

Geo-Research

Proctor Compaction Test

Sample No.:   Project:



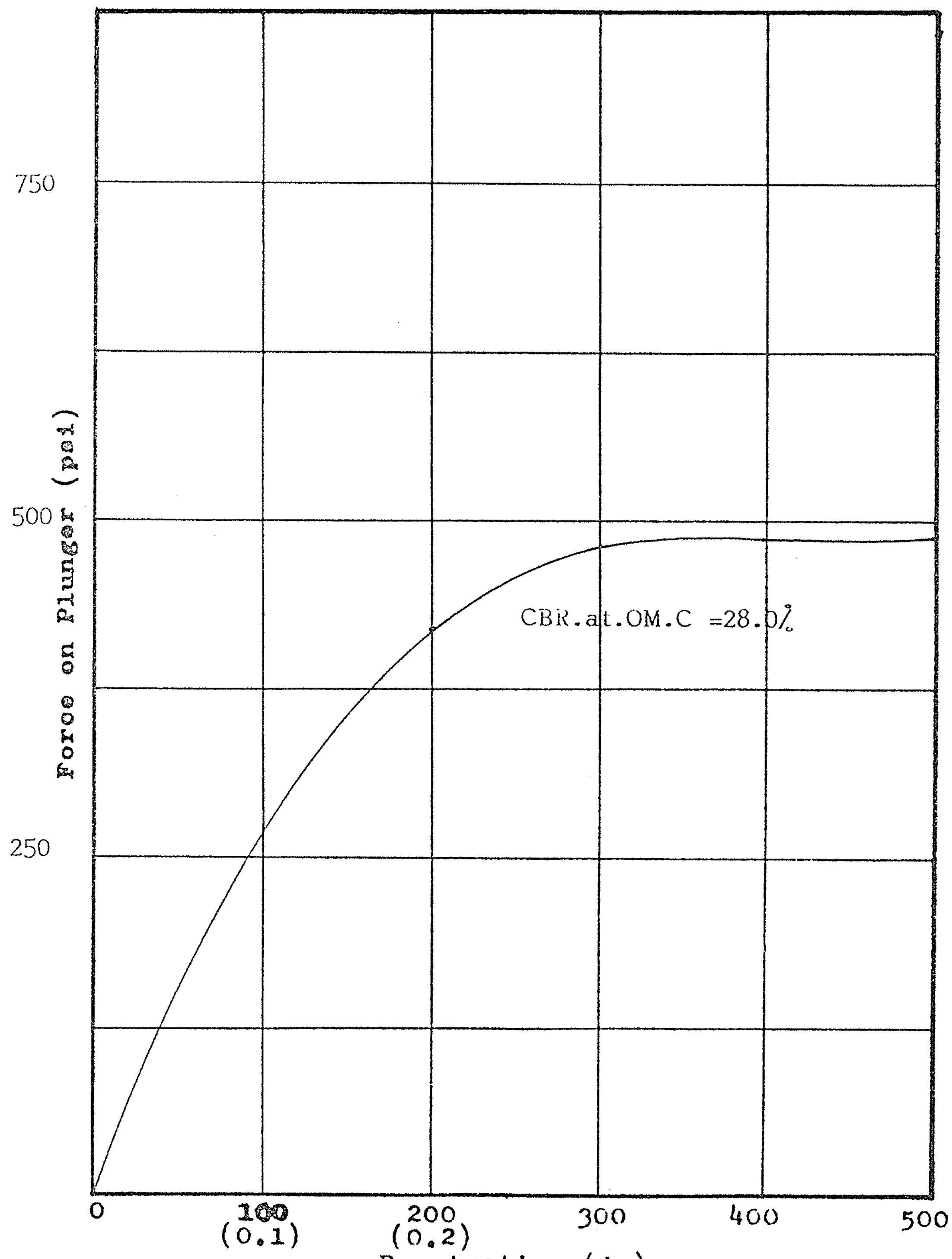
Max. Dry Density = 1.940 gr/cm2   Moisture Content(%)

Optimum Moisture Content = 3.8%

Geo-Research

California Bearing Ratio

Project: **Sample No.:**

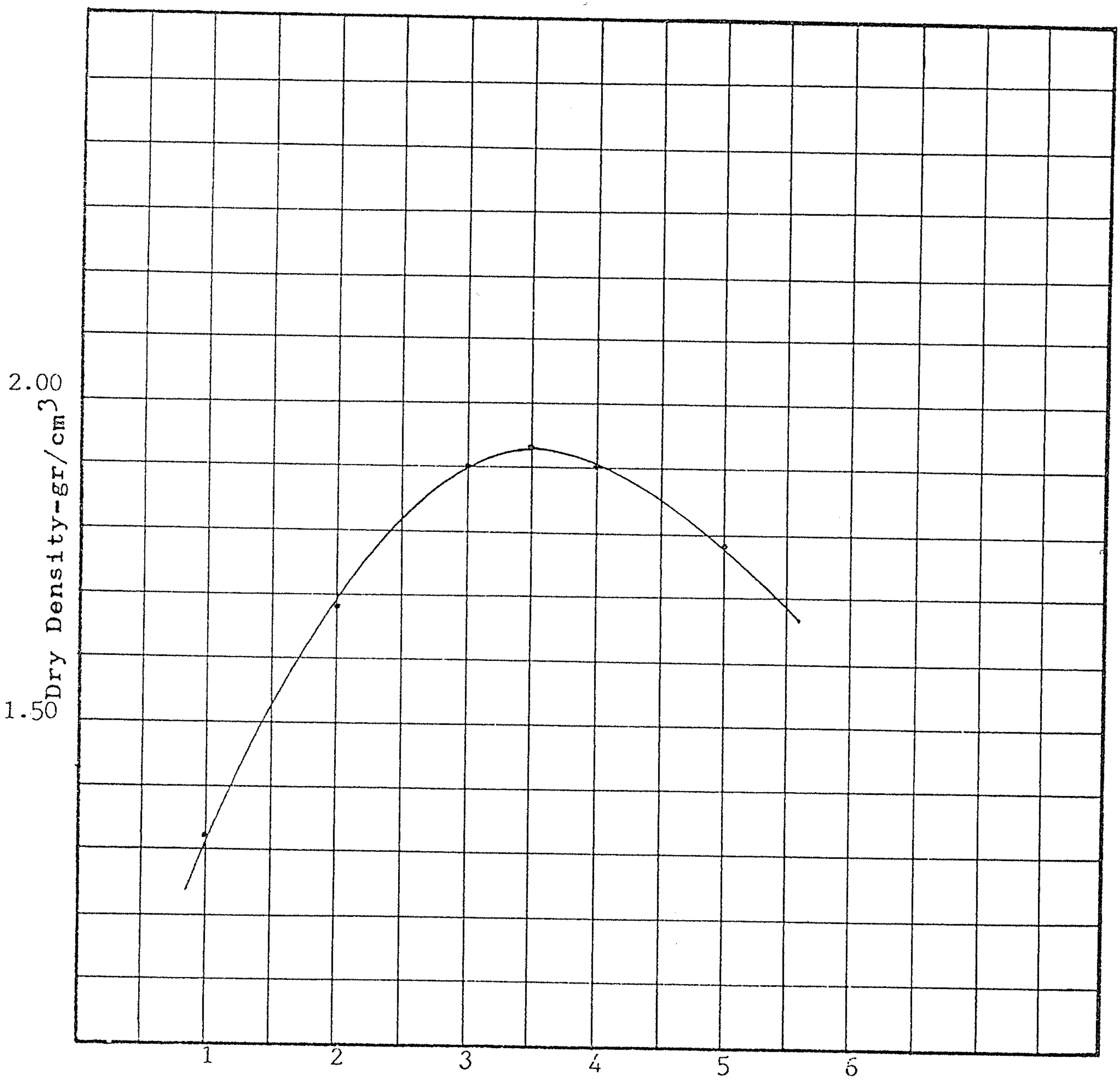


Remarks:

Geo-Research

Proctor Compaction Test

Sample No.: Project:



Max. Dry Density = 1.930 gr/cm^2 Moisture Content(%)

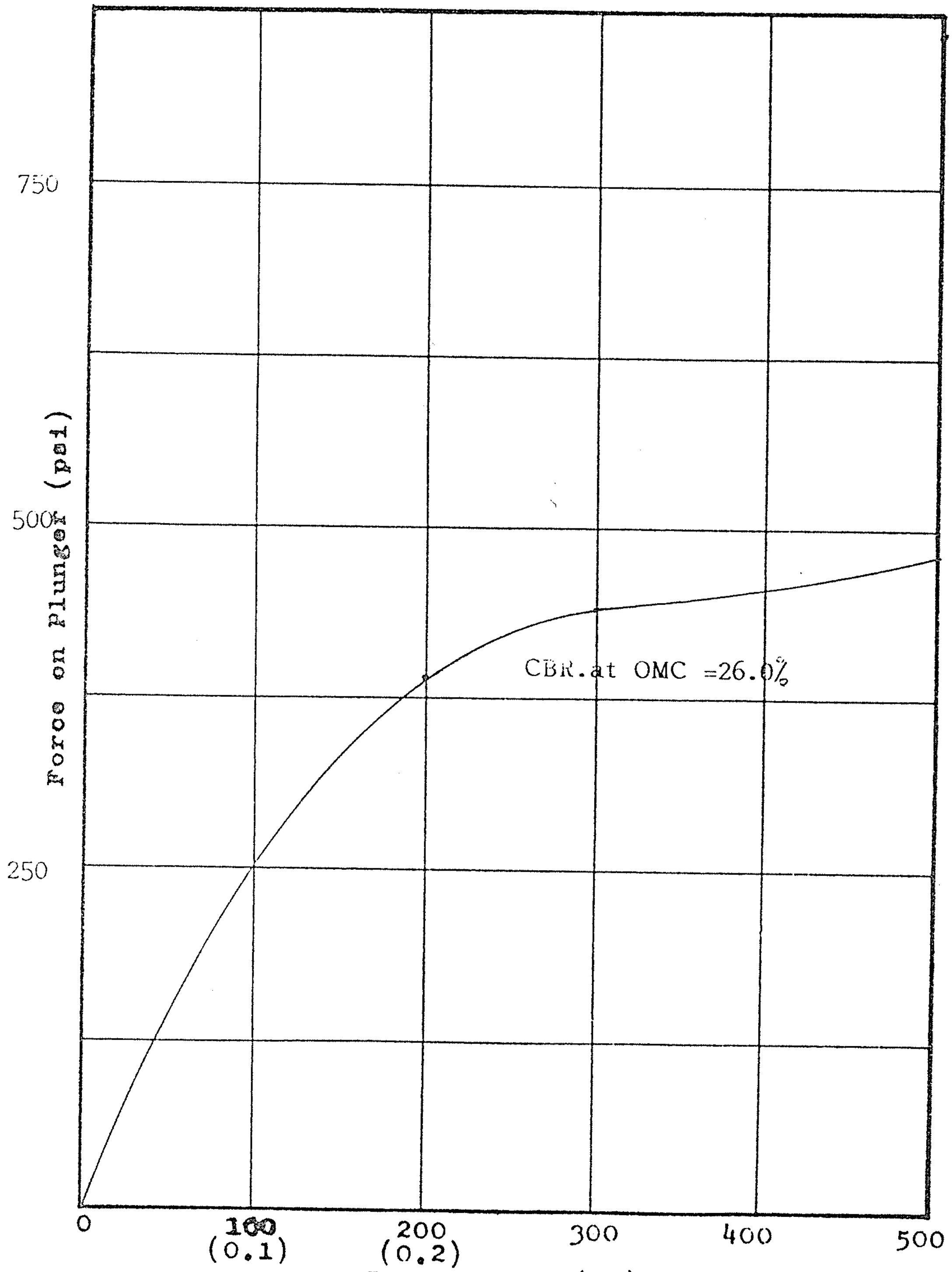
Optimum Moisture Content = 3.50%

Geo-Research

California Bearing Ratio

Project:

Sample No.:



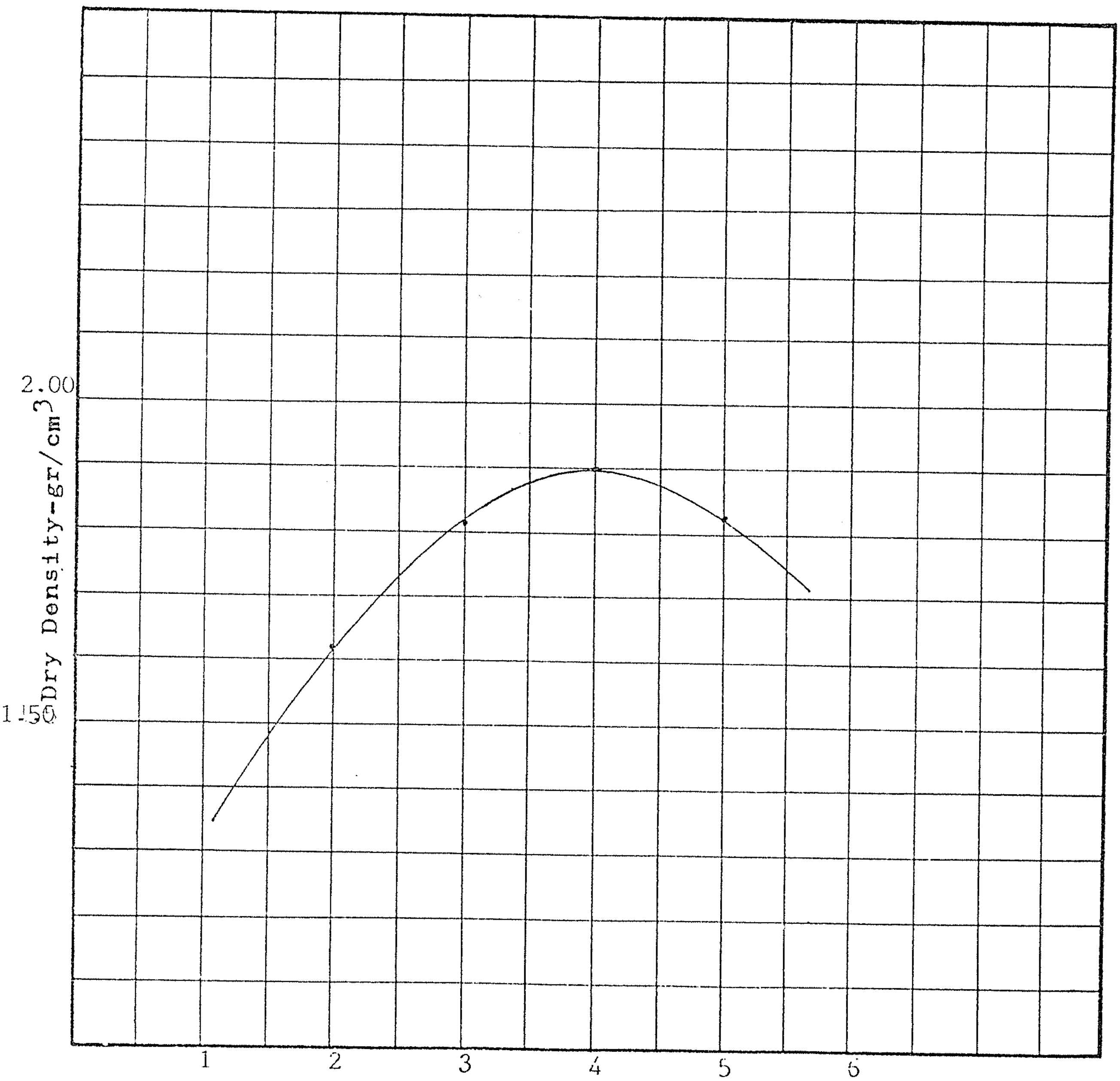
Remarks:

Geo-Research

Proctor Compaction Test

Sample No.:

Project:



Max. Dry Density = 1.90 gr/cm^2

Moisture Content(%)

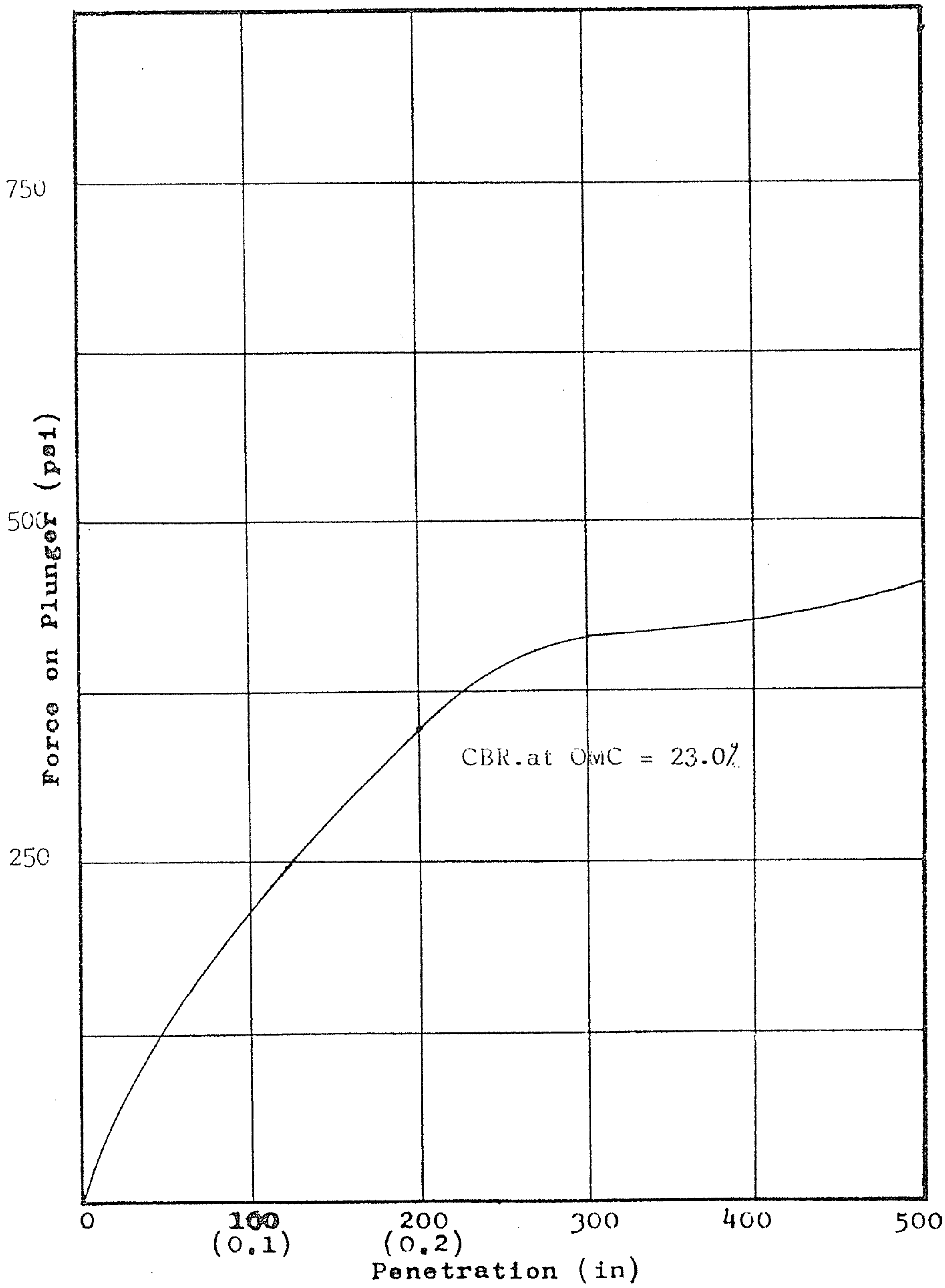
Optimum Moisture Content = 4.0%

Geo-Research

California Bearing Ratio

Project:

Sample No.:



Remarks:

Dead Sea Parkway Development

Specification General Tests Requirements	Actual Performed Tests	Remarks
1) Specific gravity	1) Performed	
2) Grain-size analysis	2) Performed	
3) Liquid/Plastic Limit	3) Not Preformed	Material is non-plastic
4) Moisture test	4) Performed	
5) Unconfined compression test	5) Performed	
6) Triaxial compression test	6) Not Performed	No undisturbed samples Material is non-plastic
7) Consolidation test	7)	As above ...
8) Chemical test (PH, sulfur and chloride contents)	8)	The rock is free from aggressive or reactive material .
9) CBR test for Road Design	9) Performed	
10) Compaction for Road Design	10) Performed	
	11) Direct shear test	Direct shear test was performed on remoulded material due to non-cohessive nature of rock .