



Evaluation of the Geotechnical Properties of Haydite

FINAL REPORT

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Introduction

Haydite is an expanded shale light weight aggregate manufactured by the heating of shale to a temperature in excess of 2000 ° F. The purpose of this investigation was to evaluate the geotechnical engineering properties of this aggregate.

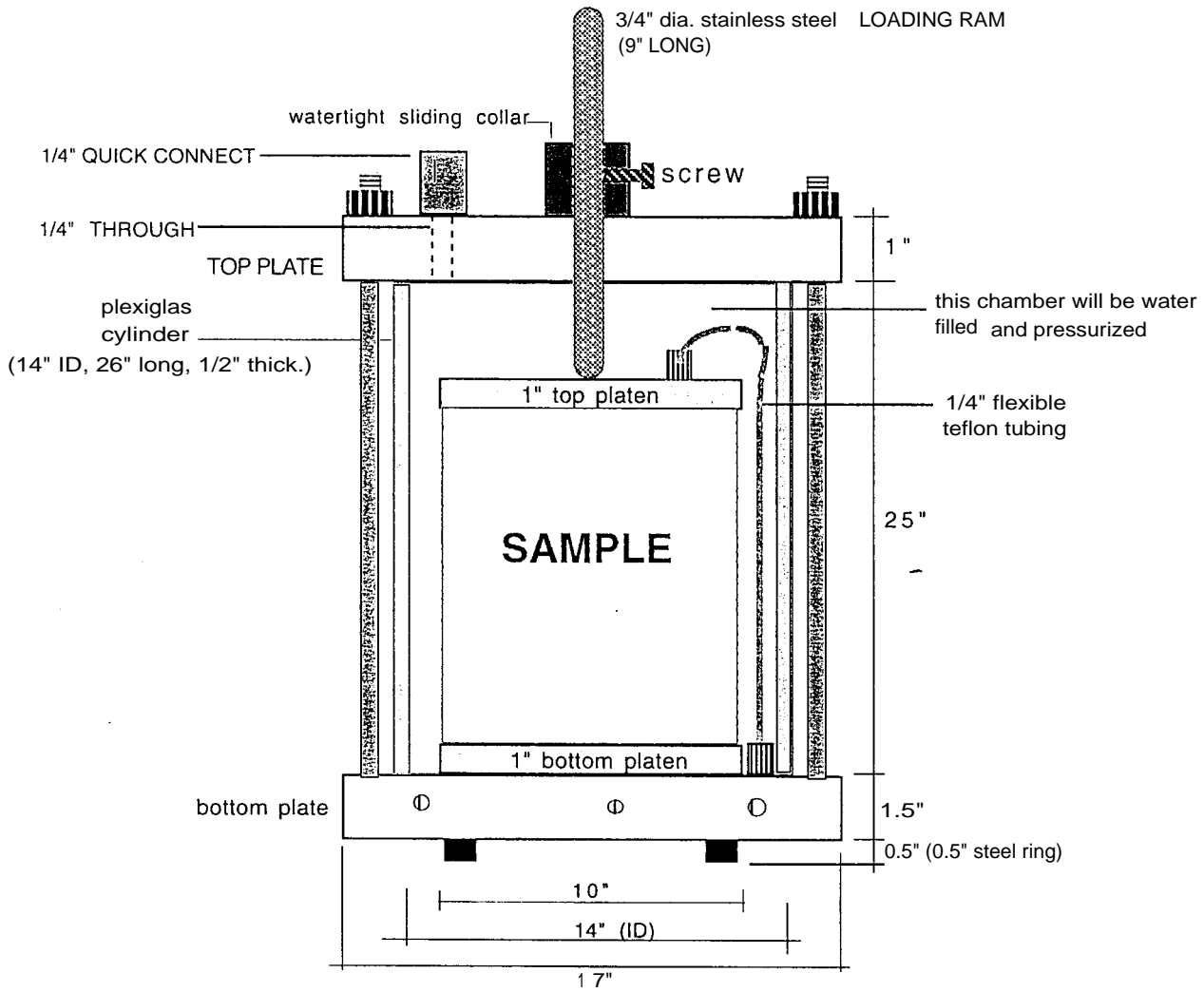
Four samples of haydite were received from DiGeronimo Aggregates at Cleveland State University. The following experiments were performed:

- A. Gradation**
- B. Unit weight: loose, compacted, long term submerged.**
- C. Specific gravity**
- D. Triaxial compression**
- E. Permeability**
- F. Chloride content**

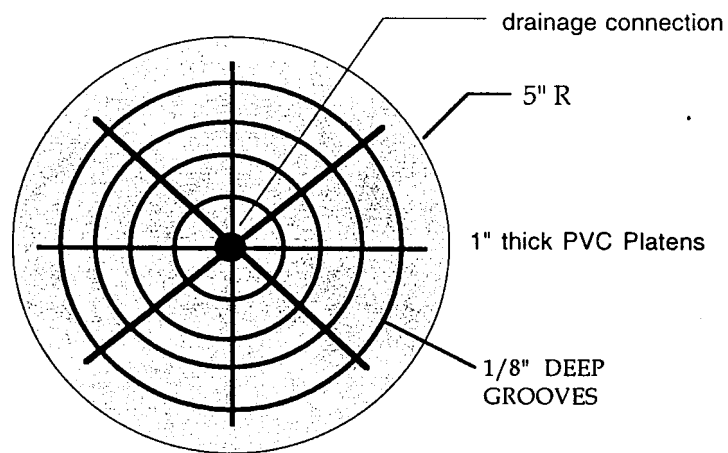
The triaxial compression test on the aggregates required a larger than usual testing cell which was designed and constructed at Cleveland State University. The sample size of this cell is 10 inches in diameter and 20 inches in length. The components of the designed cell are shown in Figure 1.

Haydite Samples

The samples were marked as follows: Cleveland B(3/8" x No.8), Cleveland C(3/4" x No.4), Brooklyn B(3/8" x No.8), and Brooklyn C(3/8" x No.4),. The Cleveland

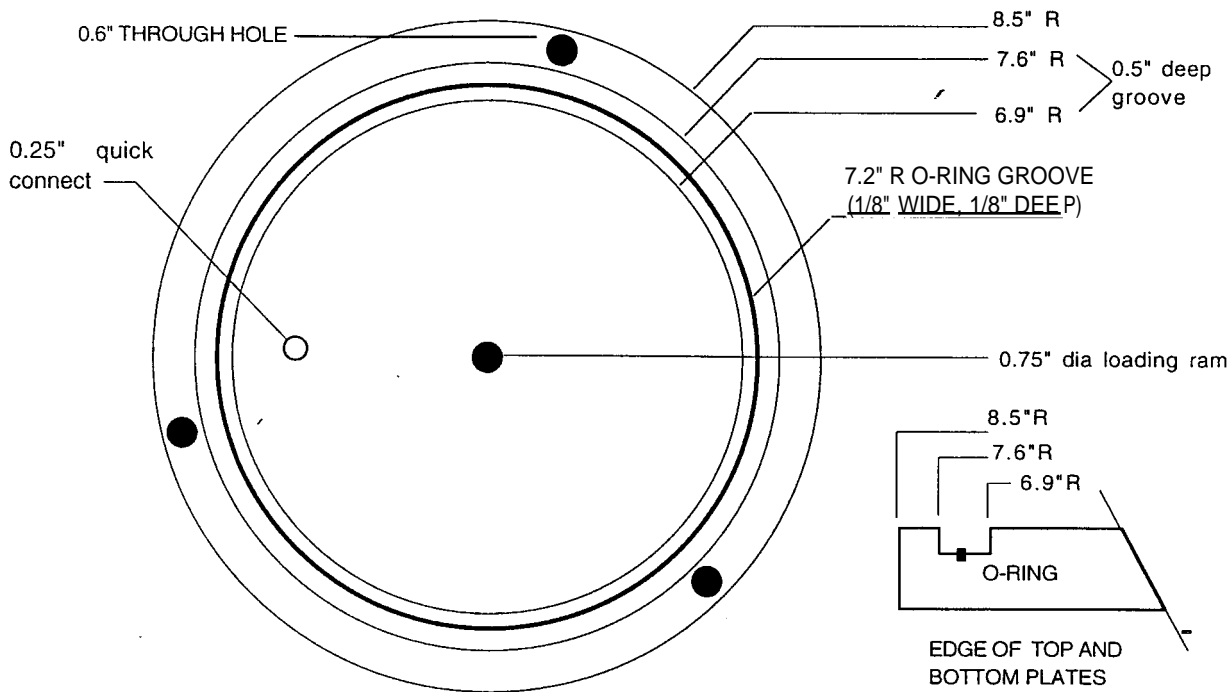


TRIAXIAL CELL

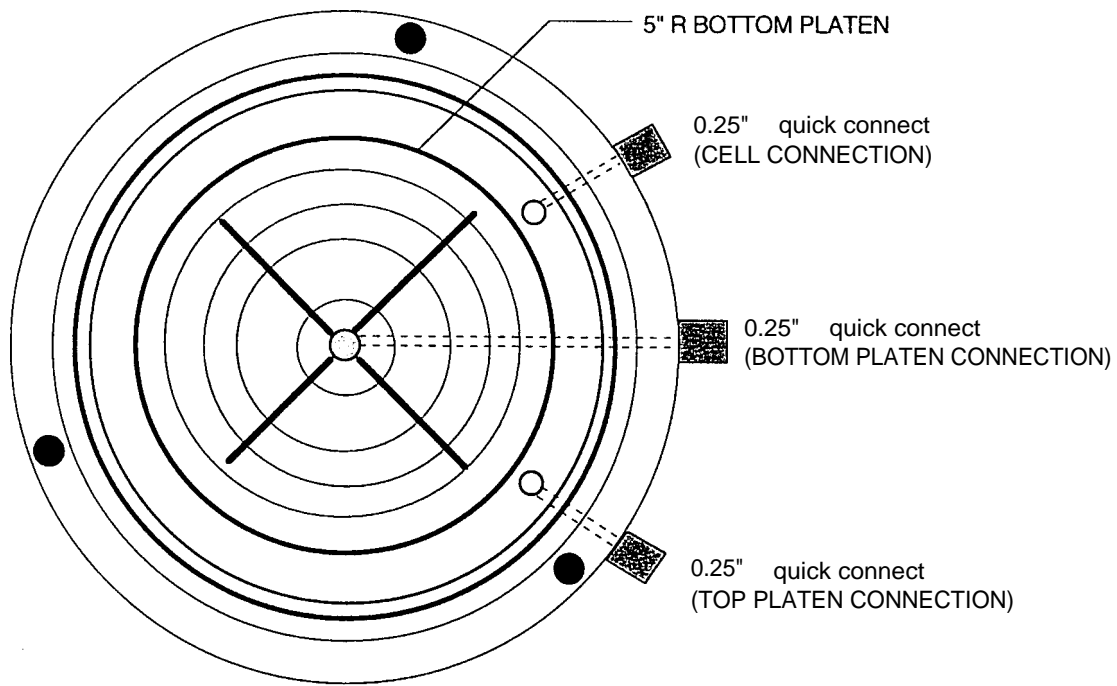


Top and Bottom Platens

Figure 1



TOP PLATE (INSIDE VIEW)



BOTTOM PLATE (INSIDE VIEW)

samples were more angular than the Brooklyn samples. All the samples were gray cohesionless material in small aggregate form.

Results

Moist samples, kept wet by water-sprinklers for several months, were supplied to CSU. These samples were considered saturated. The water contents of the samples are shown in the following table:

Cleveland B : 26.8%
 Cleveland C 21.4%
 Brooklyn B 17.7%
 Brooklyn C 13.7%

These aggregates were oven dried at 110 degrees C (230° F) for 48 hours for the tests which required dry samples.

A. Gradation (ASTM D-422 method)

The gradation of the samples were done by sieve analysis according to ASTM D 422. procedure. The retention of sample in different sieves and the grain size distribution curves are given in *Appendix A*. The average particle size diameter (D_{50}) of the sample obtained from the gradation curve and the fineness modulus (FM) are as follows:

Sample	D_{50} (mm)	FM	Satisfies ASTM C-330	Satisfies ASTM C-331
Cleveland B	5	5.55	Yes	Yes
Cleveland C	10	6.61	Yes	Yes
Brooklyn B	7	5.86	Yes	Yes
Brooklyn C	8	6.22	Yes	Yes

Comments: The gradation of the samples comply with ASTM C-330 and C-331.

B. Unit weight (ASTM C-29 method)

The dry loose unit weight ranged from 41 pcf to 50 pcf. According to ASTM C-330, the allowable maximum dry loose unit weight for *light-weight coarse aggregates* is 55 pcf. The saturated loose unit weight ranged from 48 to 56 pcf. The compacted unit weight ranged from 44 to 57 under dry conditions and 53 to 64 for saturated condition. Long term soaked samples obtained from the plants were considered - 100 % saturated. The following table lists the unit weight of the samples at dry and saturated conditions.

SI	Sample ID	Unit Weight (lbs/cft)			
		Dry Loose	Dry Compacted	Saturated Loose	Saturated Compacted
1	Brooklyn B	41	44	53	60
2	Brooklyn C	41	45	48	53
3	Cleveland B	50	57	56	64
4	Cleveland C	46	53	51	58

C. Specific Gravity (ASTM C-127)

The specific gravity tests were performed with long term soaked samples obtained from the sites. The Bulk, Bulk (SSD: Saturated Surface Dry) and Apparent specific gravity values of the samples are listed in the following table.

SI	Sample ID	Specific Gravity		
		Bulk	Bulk (SSD)	Apparent
1	Brooklyn B	1.256	1.598	1.933
2	Brooklyn C	1.136	1.382	1.501
3	Cleveland B	1.432	1.709	1.830
4	Cleveland C	1.138	1.623	1.820

D. Triaxial Compression (ASTM D-4767 method)

Triaxial Tests were performed in a large scale triaxial compression cell designed and constructed at Cleveland State University. The test samples were 10" in diameter and 20" in length and yielded the following angles of friction (~):

Cleveland B	49°
Cleveland C	49°
Brooklyn B	46°
Brooklyn C	45°

The friction angles were calculated from the shear strength correlation of cohesionless materials:

$$\tau = \sigma_v \tan \phi$$

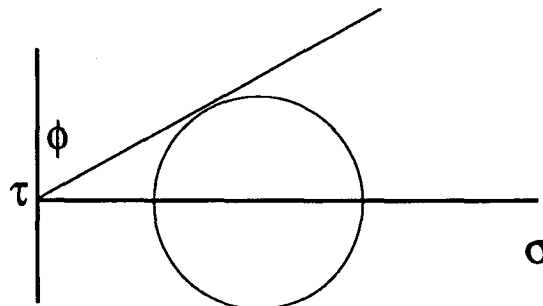


Figure 3: Mohr-circle of failure. Slope of the tangent to the failure circle is the angle of friction φ.

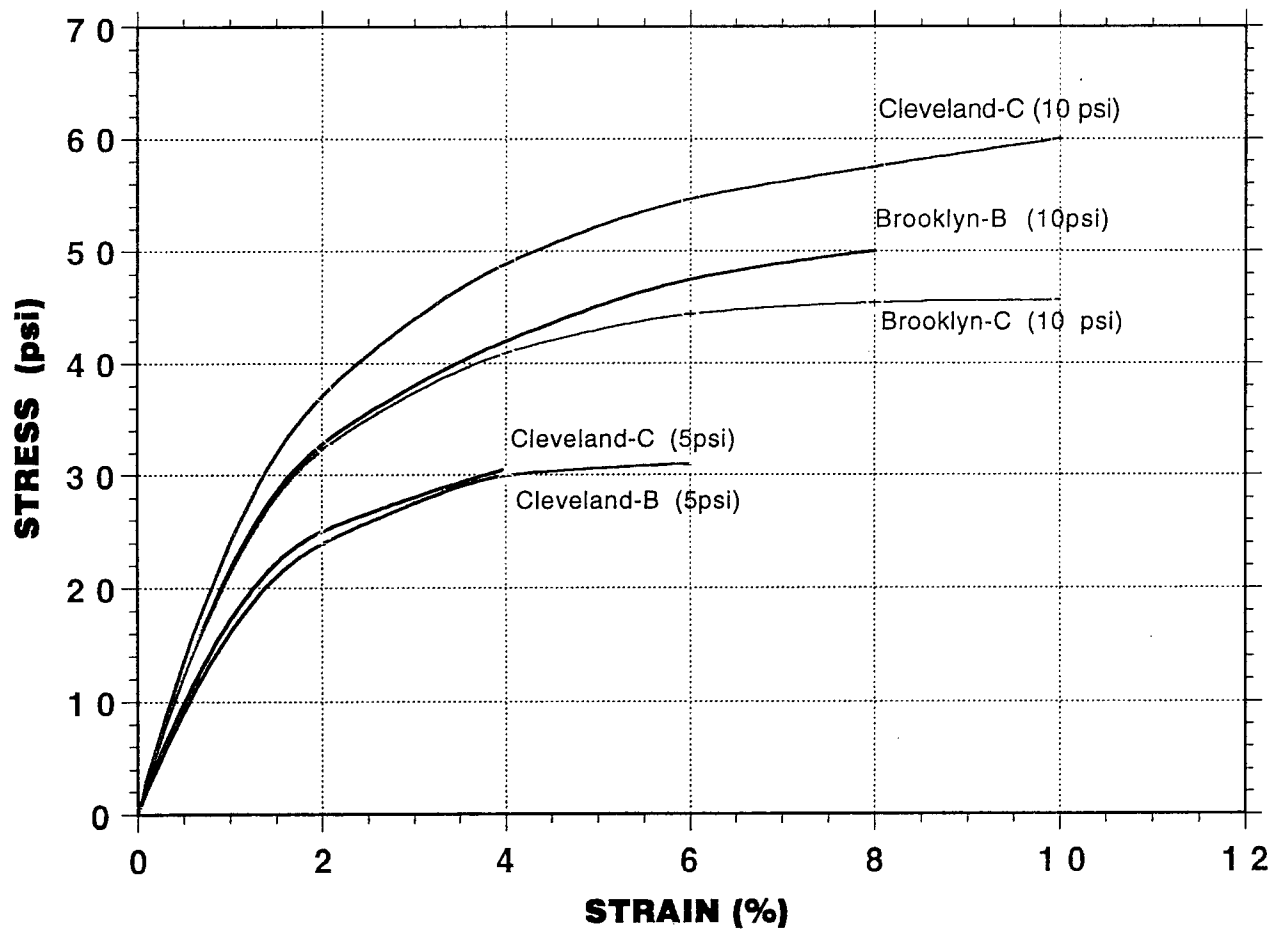


Figure: Stress-Strain curves of Cleveland and Brooklyn aggregates obtained from triaxial tests.

E. Constant Head Permeability (ASTM 2434-68 method)

The permeability of the haydite samples were measured by constant head method [ASTM 2434-68]. The samples were compacted to their dry density value. The permeability of the samples ranged between 0.143 to 0.153 cm/sec.

Sample	k at 20° C cm/sec
Cleveland B	0.146
Cleveland C	0.143
Brooklyn B	0.153
Brooklyn C	0.152

F. Chloride Content (AASHTO T-220 method)

The chloride content of the haydite aggregates were determined by AASHTO T-260 method. Followings are the chloride contents in parts per million (ppm).

Cleveland B	:	29.39 ppm
Cleveland C	:	18.50 ppm.
Brooklyn B	:	35.66 ppm
Brooklyn C	:	21.75 ppm

The allowable maximum chloride content for lightweight geotechnical fill is 100 ppm.

Comments: The chloride content is well within the maximum limit.

appendix - a

SIEVE ANALYSIS OF SOIL SAMPLES

Sample Location:

Sample Identification: Brooklyn 'B'

Project: HAYDITE

Weight of Sample : 1000 gms

Moisture Content: 15.73 %

Size: 3/8" to No. 8 (ASTM C-330 and C-331)

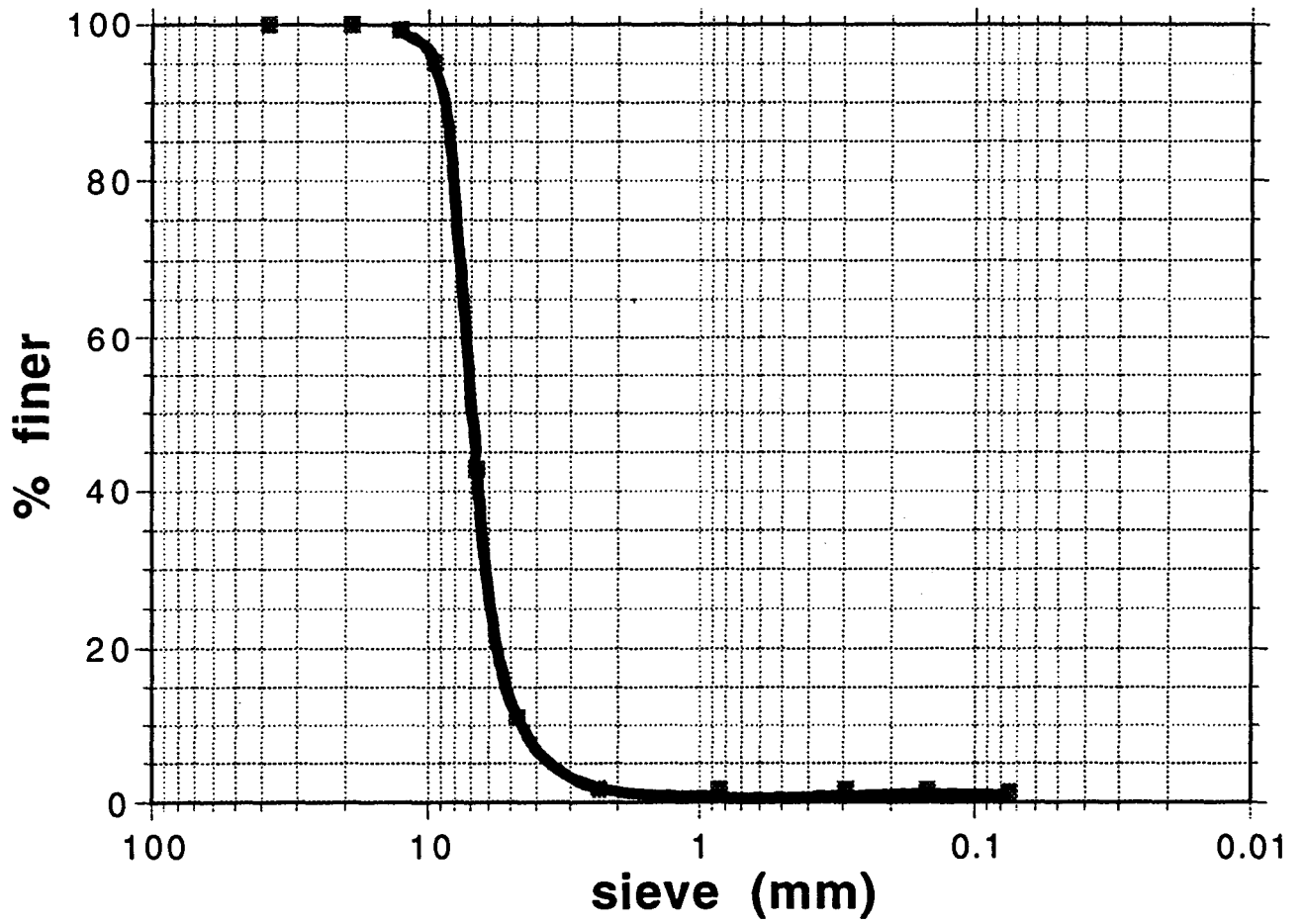
Sieve #	Sieve Size inch (mm)	Weight of Sample (gm)	% Retained	Cumulative % Retained	% Finer	ASTM C-330 %Passing	ASTM C-331 %Passing	Remarks
---	1.5"(38.10)	0	0	0	100	---	---	---
---	3/4"(19.10)	0	0	0	100	---	---	---
---	1/2"(12.70)	0	0	0	100	100-100	100-100	Okay
---	3/8"(9.52)	47.9	4.8	4.8	95.2	80-100	80-100	Okay
---	(6.680)	522.9	52.3	57.1	42.9	---	---	---
#4	3/16"(4.75)	319.0	31.9	89.0	11.0	5-40	5-40	Okay
#8	(2.362)	93.2	9.3	98.3	1.7	0-20	0-20	Okay
#20	(0.850)	0.7	0.1	98.4	1.6	---	---	---
#50	(0.295)	0.2	0	98.4	1.6	---	---	---
100	(0.149)	0.7	0.1	98.5	1.5	---	---	---
200	(0.075)	1.8	0.2	98.7	1.3	---	---	---
pan	---	13.1	1.3	100.0	0	---	---	---

Fineness Modulus : 5.86

Test Performed by: MAK

Date: _____

Gradation Curve Sample: Brooklyn 'B'



SIEVE ANALYSIS OF SOIL SAMPLES

Sample Location:

Sample Identification: Brooklyn 'C'

Project: HAYDITE

Weight of Sample : 1000 gms Moisture Content: 0 %

Size : 1/2" to No. 4 (ASTM C-330 and C-331)

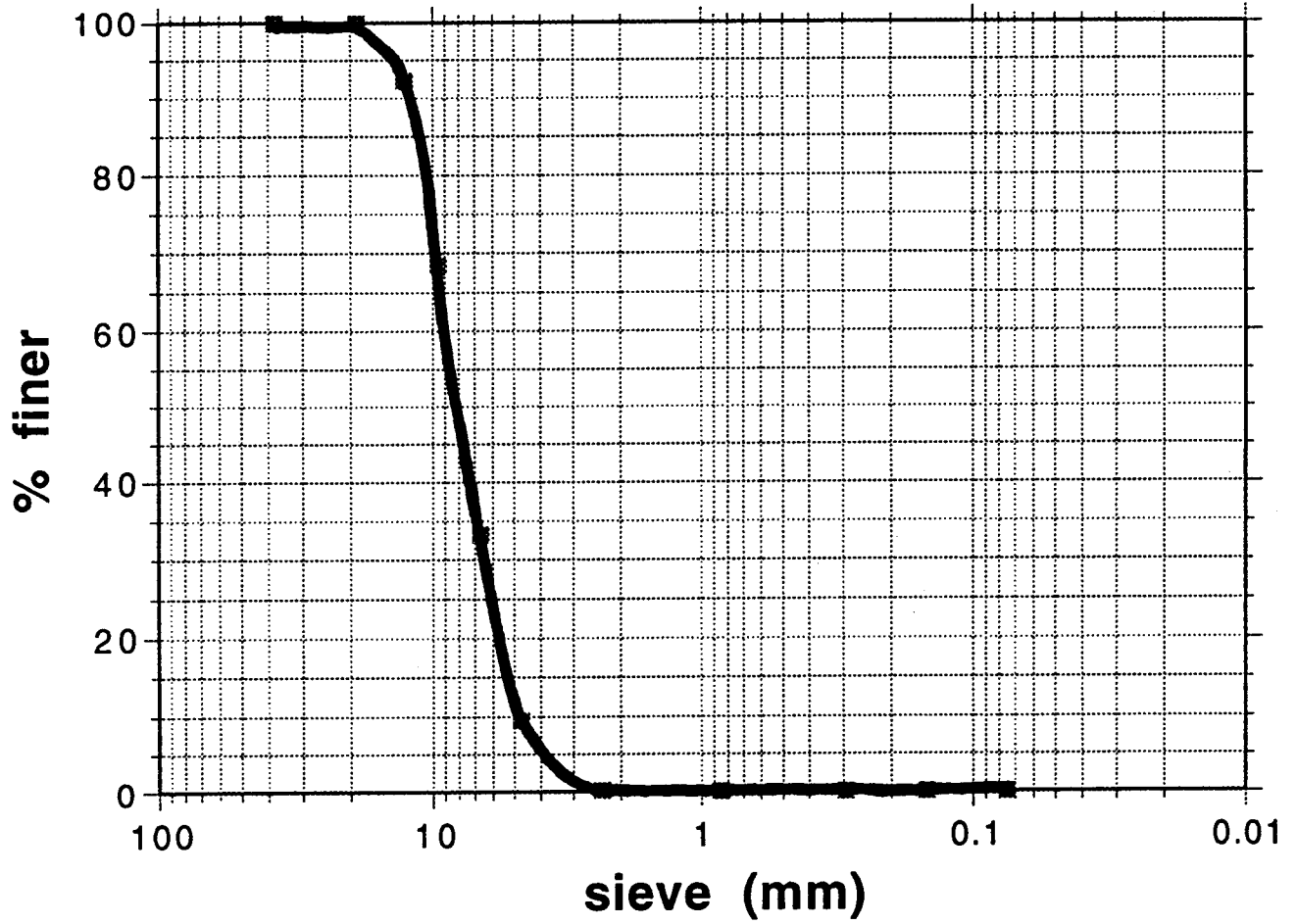
Sieve #	Sieve Size inch (mm)	Weight of Sample (gm)	% Retained	Cumulative % Retained	% Finer	ASTM C-330 %Passing	ASTM C-331 %Passing	Remarks
---	1.5"(38.10)	0	0	0	100.0	---	---	
---	3/4"(19.10)	0	0	0	100.0	100-100	100-100	Okay
---	1/2"(12.70)	76.6	7.7	7.7	92.3	90-100	90-100	Okay
---	3/8"(9.52)	240.0	24.0	31.7	68.3	40 - 80	40 - 80	Okay
---	(6.680)	349.8	35.0	66.7	33.3	---	---	
# 4	3/16"(4.75)	238.1	23.8	90.5	9.5	0 - 20	0 - 20	Okay
# 8	(2.362)	93.4	9.3	99.8	0.2	0 - 10	0 - 10	Okay
# 20	(0.850)	0.5	0.1	99.9	0.1	---	---	
# 50	(0.295)	0.1	0	99.9	0.1	---	---	
# 100	(0.149)	0.2	0	99.9	0.1	---	---	
# 200	(0.075)	0.2	0	99.9	0.1	---	---	
Pan	---	0.9	0.1	100.0	0	---	---	

Fineness Modulus : 6.22

Test Performed by: MAK

Gradation Curve

Sample Brooklyn 'C'



SIEVE ANALYSIS OF SOIL SAMPLES

Sample Location:

Sample Identification: Cleveland 'B'

Project: HAYDITE

Weight of Sample : 1000 gms Moisture Content: 17.67 %

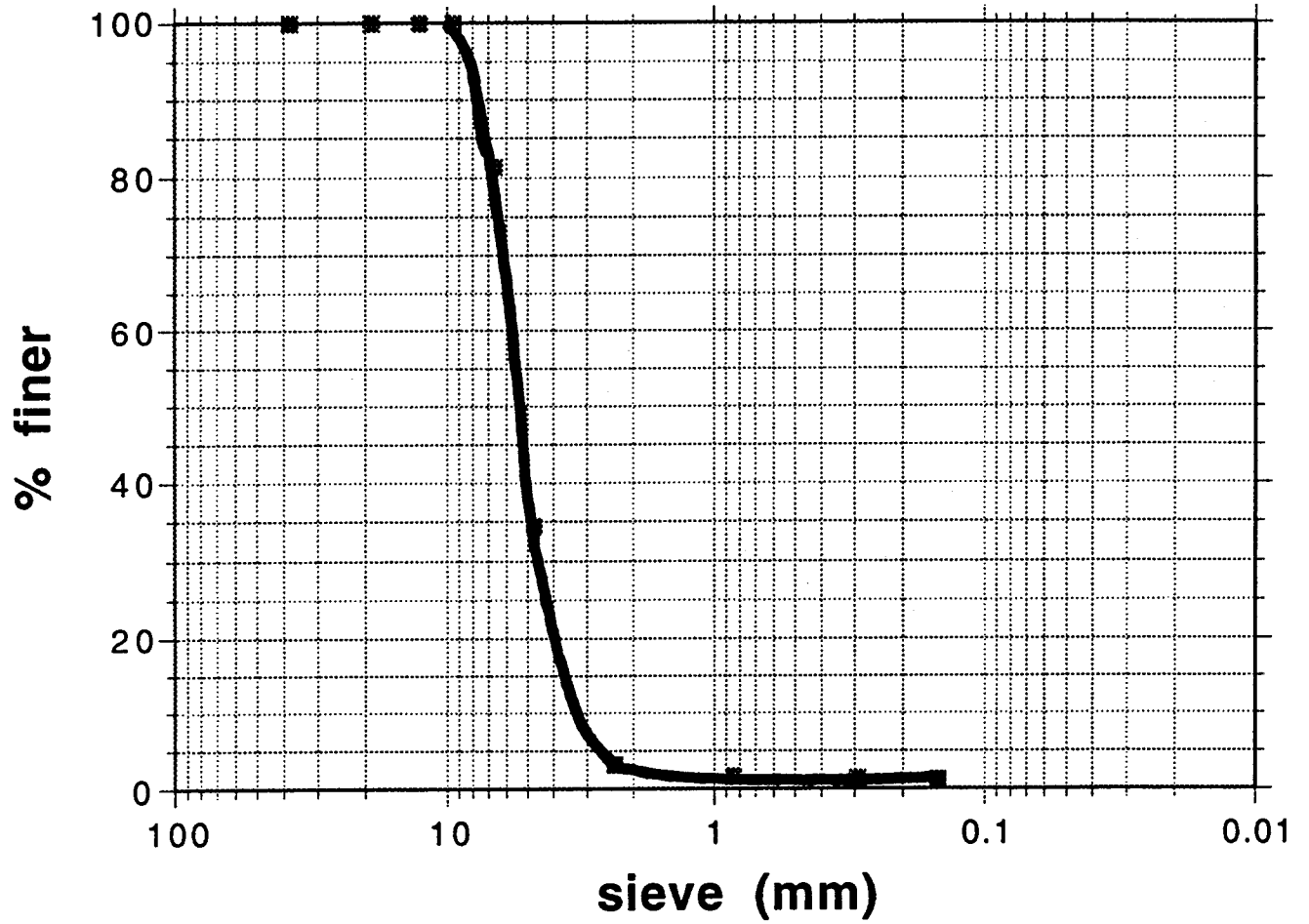
Size: 3/8" to No. 8 (ASTM C-330 and C-331)

Sieve #	Sieve Size inch (mm)	Weight of Sample (gm)	% Retained	Cumulative % Retained	% Finer	ASTM C-330 %Passing	ASTM C-331 %Passing	Remarks
---	1.5"(38.10)	0	0	0	100.0	---	---	
---	3/4"(19.10)	0	0	0	100.0	---	---	
---	1/2"(12.70)	0	0	0	100.0	100-100	100-100	Okay
---	3/8"(9.52)	0	0	0	100.0	80 -100	80 -100	Okay
---	(6.680)	186.8	18.7	18.7	81.3	---	---	
# 4	3/16"(4.75)	468.7	46.9	65.6	34.4	5 - 40	5 - 40	Okay
# 8	(2.362)	312.2	31.2	96.8	3.2	0 - 20	0 - 20	Okay
# 20	(0.850)	15.3	1.5	98.3	1.7	---	---	
# 50	(0.295)	1.5	0.2	98.5	1.5	---	---	
#100	(0.149)	1.5	0.2	98.7	1.3	---	---	
Pan	---	13.1	1.3	100.0	0	---	---	
						---	---	

Fineness Modulus : 5.55

Test Performed by: MAK

Gradation Curve Sample: Cleveland 'B'



SIEVE ANALYSIS OF SOIL SAMPLES

Sample Location:

Sample Identification: Cleveland 'C'

Project: HAYDITE

Weight of Sample : 1000 gms Moisture Content: 13.70 %

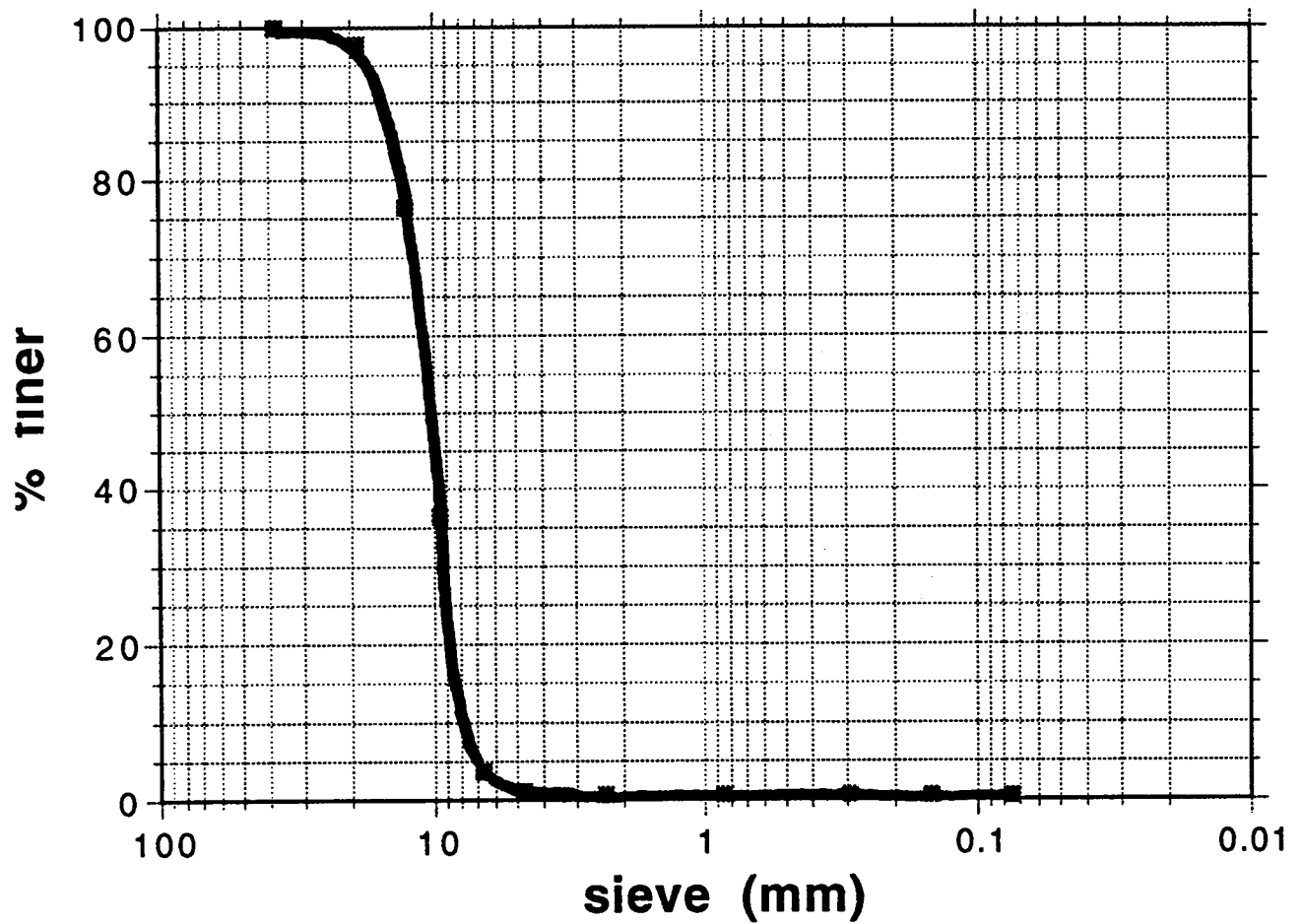
Size: 3/4" to No. 4 (ASTM C-330)

Sieve #	Sieve Size inch (mm)	Weight of Sample (gm)	% Retained	Cumulative % Retained	% Finer	ASTM C-330 % Passing	Remarks
---	1.5"(38.10)	0	0	0	100.0	---	
---	3/4"(19.10)	22.1	2.2	2.2	97.8	90-100	Okay
---	1/2"(12.70)	213.8	21.4	23.6	76.4	---	
---	3/8"(9.52)	399.2	39.9	63.5	36.5	10 - 50	Okay
---	(6.680)	327.2	32.7	96.2	3.8	---	
# 4	3/16"(4.75)	27.1	2.7	98.9	1.1	0 - 15	Okay
# 8	(2.362)	3.5	0.4	99.3	0.7	---	
# 20	(0.850)	0.2	0	99.3	0.7	---	
# 50	(0.295)	0.1	0	99.3	0.7	---	
#100	(0.149)	0.7	0.1	99.4	0.6	---	
#200	(0.075)	0.9	0.1	99.5	0.5	---	
Pan	---	6.0	0.5	100.0	0	---	

Fineness Modulus : 6.61

Test Performed by: MAK

Gradation Curve Sample Cleveland 'C'



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