PHYSICAL PROPERTIES OF MICHIGAN MARLS

THESIS FOR DEGREE OF B. S.

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PHYSICAL PROPERTIES OF MICHIGAN MARLS.

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THESIS

INTRODUCTION

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PREFACE.

It is the purpose of this thesis to tell something about the physical properties of Michigan marls. Nothing has ever been written concerning these in any textbooks and the results given here are obtained by actual experimentation with the marl and checked as close as possible with the ideas concerning them held by men who have been in close association with marl for a number of years.

The material found in this book will not be found in print anywhere else and it is hoped that this material will be of value to anyone who desires to carry on any further investigations regarding these properties, and to give some beneficial information regarding weight and shrinkage which would be of assistance to the engineering world.

In obtaining this material it has been necessary to interview the chemists at several cement plants as well as actually making the tests with the marl.

Marl.

The origin of marl has been discussed a great deal. It is now ascribed to the action of fresh water algae, which precipitate it or throw it down from solution.

Whether this be the truth or not, it's close and intimate connection with fresh water lakes is too patent to be denied. In searching for it, therefore, the obvious method is to observe the locality for flat meadows or marshes, which have the appearance of having been at one time the site of glacial lakes.

Marl consists of the amorphous or organic form of calcium carbonate mixed with varying amounts of soil, sand humus, snails, shells, etc. It is a soft,damp,gray or blackish earth somewhat like bulk sugar in appearance; it has little plasticity when worked up with water like a clay, and still less hardness or strength when dried. It dissolves in any acid, even vinegar, with much effervescence and foaming.

Marl beds run in strata and vary in the calcium carbonate content and depth within a very few feet to a great extent. A map is shown which well illustrates the topography of a marl bed.

Sampling Equipment.

It is necessary in order to make a correct analysis to have a set of sampling tools to get accurate and uniform samples under as nearly as possible the same conditions.

A description of two kinds of samplers will be given one of which has been in use for about two years and the other only a month.

One sampler consists of a one-half inch pipe cut in sections three feet long with a T shaped handle. A half-inch brass tube six inches long is fastened to each one of these three foot sections in such a manner so that by rotating the rod the pressure of the earth forces this tube to turn about the pipe so that by pushing the rod six inches further into the ground the tube will be filled and by rotating the rod in the opposite direction the tube will again close. A drawing is shown which better illustrates the idea.

This sampler gives a very accurate sample and also gives the depth the sample is taken below the level of the ground. It is best for obtaining samples for chemical analysis. The main fault of this which is quite a serious one is that if the marl is a little sandy or contains some such similar material the sand will get in the swivel and will not open or close and is very hard to clean, sometimes having to be taken apart. If the person handling this sampler is not careful it is very easily bent and if a larger pipe is used with the same principle it is hard to push into the ground.

The second sampler which has just been devised consists of a one inch pipe made in three foot lengths which can be put together with pipe sleeves. It has a T shaped handle and a slot is cut in the bottom section which when the pipe is rotated fills with marl or material at that depth.

This sampler does not give as accurate samples but it always works and is more easily pushed into and withdrawn from the soil. It is not easily bent when the needed weight is applied to force it into the ground. The samples that are obtained with this are sufficiently accurate for the general run of tests that re made on marl.

The method of sampling used was to take a post-hole digger and remove the top-soil and go a foot into the marl and then fill a pint carton with the material.

This method was used because the greatest variation of marl in this bed was found at depths of about five feet and larger samples were needed than could be obtained with either of the above-mentioned samplers.

Procedure:

1. Percentage of marl that is water. Weighed fifty grams of sample to be tested and then placed sample on oven and baked until all moisture had left. Weighed the material that was left and computed the percentage water.

2. Shrinkage. Filled a 2" cubical tin cup level full of the marl and baked until moisture left. With the aid of calipers the area of the volume remaining was computed. The marl remaining after the water was taken out was then pulverized and the volume of this measured. The shrinkage was then computed.

3. Weight per cubic yard of wet and dry. Weighed the marl in a tube wet and computed weight. Then dried the sample by baking and weighed the material remaining.

Sample #1.

Chemical Analysis

SiO_2	1.54
R_2O_3	1.58
CaO	49.83
$CaCO_3$	88.96
MgO	1.71
$MgCO_3$	3.53
Vol.Mat.	46.29
	100.94

Organic Matter 5.33

Physical Analysis.

Wt. with water 100g.

Wt. without water 46.3g.

% of marl water is 46.3

Shrinkage measured with calipers and computed of cube was 13.2% of original volume.

After being broken up into fine particles it was 22.1%

Wt. of sample/cu.yd. wet 2420#

Wt. of sample/cu.yd. dry 1350#

Color- Grey.

Sample #2.

Chemical Analysis

SiO_2	1.74
R_2O_3	1.60
CaO	48.18
$CaCO_3$	86.03
MgO	1.92
$MgCO_3$	4.61
Vol. Mat.	46.48
	99.98

Organic Matter 6.55

Physical Analysis.

Color- Grey-soapy.

Wt. with water 50g.

Wt. without water 25.6g.

% of marl water 51.2 by wt.

Shrinkage measured with calipers 14.4%

After being broken up 18.0%

Wt. of sample/cu.yd. wet 2440#

Wt. of sample/cu.yd. dry 1210#

Sample #3.

Chemical Analysis

SiO_2	3.28
R_2O_3	2.12
CaO	45.72
$CaCO_3$	81.64
MgO	1.71
$MgCO_3$	3.57
Vol.Mat.	47.32
	100.15

Organic Matter 9.54

Physical Analysis

Color- greyish black.

Wt. with water 50g.

Wt. without water 19.6g.

% of marl water 60.8

Shrinkage measured with calipers in % 18.4.

Shrinkage after being broken into fine particles 20.2%

Wt. of sam./cu.yd. wet 1750#

Wt. of sam./cu.yd. dry 1080#

Sample #4.

Chemical analysis

SiO_2	1.32
R_2O_3	1.40
CaO	49.82
$CaCO_3$	88.96
MgO	1.91
$MgCO_3$	4.00
Vol.Mat.	45.96
	100.41

Organic Matter 9.54

Physical Analysis

Color-Iron grey

Wt. with water [illegible]0g.

Wt. without water 30.9g.

% of marl water by wt. 58.8

Shrinkage measured with calipers 17.3%

Shrinkage after being broken into fine particles 23.3%

Wt. of sam./cu.yd. dry 1120#

Wt. of sam./cu.yd. wet 2720#

Sample #5

Chemical Analysis

SiO_2	.70
R_2O_3	1.14
CaO	51.62
$CaCO_3$	91.18
MgO	1.84
$MgCO_3$	3.86
Vol. Mat.	44.31
	99.61

Organic Matter 2.73

Physical Analysis

Color- Blackish grey.

Wt. with water 50g.

Wt. without water 21.2g.

% of marl water 57.6 by wt.

Shrinkage as measured by calipers was 15.7%

Shrinkage after being pulverized 19.7%

Wt. of sam./cu.yd. 1090# dry

Wt. of sam./cu.yd. 2575# wet

Sample #6

Chemical analysis

SiO_2	1.28
R_2O_3	1.62
CaO	49.71
$CaCO_3$	88.71
MgO	1.91
$MgCO_3$	3.99
Vol. Mat.	46.22
	100.74

Physical Analysis

Color- grey

wt. with water 50g.

wt. without water 25.4

% of marl water 49.2 by wt.

Shrinkage as measured by calipers 14.4%

Shrinkage after being pulverized 23.2%

Wt. of sam./cu.yd. 1300# dry

Wt. of sam./cu.yd. 2560# wet

Sample # 7.

Chemical Analysis

SiO_2	.83
R_2O_3	1.12
CaO	51.59
$CaCO_3$	87.88
MgO	1.75
$MgCO_3$	3.81
Vol.Mat.	44.71
	99.95

Organic Matter 2.65

Physical Analysis

Color- whitish grey-chalk.

Wt. with water 50g.

Wt. without water 30.9g.

% of marl water by wt. 38.2

Shrinkage as measured by calipers was 14.6 %

Shrinkage after being pulverized 17.6 %

Wt. of sam./cu.yd. 1450# dry.

Wt. of sam./cu.yd. 2345# wet

Sample #8

Chemical Analysis

SiO_2	1.24
R_2O_3	1.57
CaO	48.64
$CaCO_3$	87.18
MgO	1.87
$MgCO_3$	3.97
Vol.Mat.	46.68
	100.10

Organic Matter 5.03

Physical Analysis

Color- blackish grey.

Wt. with water 50g.

Wt. without water 25g.

% water 50

Shrinkage as measured by calipers 18.54%

Shrinkage after being pulverized 27.7%

Wt. of sam./cu.yd. 1290# dry

Wt. of sam./cu.yd. 2580# wet

Sample#9

Chemical Analysis

SiO_2	2.50
R_2O_3	2.64
CaO	46.4[illegible]
$CaCO_3$	82.94
MgO	1.60
$MgCO_3$	3.34
Vol.Mat.	46.53
	103.05
Organic Matter	8.29

Physical Analysis

Color- grey.

Wt. with water 50g.

Wt. without water 27.5g.

% water by wt. 45

Shrinkage by drying 28%

Shrinkage after pulverizing 35%

Wt. of sample/cu.yd. 1400# dry

Wt. of sample/cu.yd. 2550#wet

Sample #10.

Chemical Analysis

SiO_2	1.20
R_2O_3	1.62
CaO	49.92
$CaCO_3$	89.20
MgO	1.80
$MgCO_3$	3.77
Vol. Mat.	46.18
	100.72
Organic Matter	4.93

Physical Analysis

Color - chalk.

Wt. with water 50g.

Wt. without water 29.6g.

% water by wt. 40.8

Shrinkage by drying 18%

Shrinkage after pulverizing 26%

Wt. of sample/cu.yd. 1380# dry

Wt. of sample/cu.yd. 2340# wet

Sample #11.

Chemical Analysis

SiO_2	2.54
R_2O_3	2.00
CaO	47.16
$CaCO_3$	84.21
MgO	1.69
$MgCO_3$	3.50
V.M.	46.24
	99.63

Organic Matter 5.34

Physical Analysis.

Color- grey-soapy.

Wt. with water 50g.

Wt. without water 25.6g.

% water by wt. 48.8

Shrinkage by drying 17.7%

Shrinkage after pulverizing 27.7%

Wt. of sample/cu.yd. 1255#dry

Wt.of sample/cu.yd. 2450#wet

Sample #12.

Chemical Analysis

SiO_2	5.26
R_2O_3	3.48
CaO	37.74
$CaCO_3$	67.39
MgO	1.94
$MgCO_3$	4.06
V.M.	51.32
	99.74

Organic Matter 19.55

High in silica, low in lime.

Color- brownish grey

Wt. with water 50g.

Wt. without water 20g.

% water by wt. 60%

Shrinkage after drying 22%

Shrinkage after pulverizing 33%

Wt. of sample/cu.yd. 940# dry

Wt. of sample/cu.yd. 2350#wet

Sample #13.

Chemical analysis

SiO_2	1.22
R_2O_3	1.60
CaO	48.49
$CaCO_3$	86.59
MgO	1.94
$MgCO_3$	4.06
V.M.	46.88
	100.13

Organic Matter 6.66

Physical Analysis

Color - chalk grey.

Wt. with water 50g.

Wt. without water 26.9g.

% water by wt. 46.2

Shrinkage by drying 18.3%

Shrinkage after pulverizing 28.3%

Wt. of sample/cu.yd. 1290# dry

Wt. of sample/cu.yd. 2400# wet

Sample #14.

Chemical Analysis

SiO_2	1.16
R_2O_3	1.68
CaO	50.1
$CaCO_3$	89.46
MgO	1.84
$MgCO_3$	3.86
V.L.	45.15
	99.93

Organic Matter 3.77

Physical Analysis

Color- chalk.

Wt. with water 50g.

Wt. without water 29.4g.

% water by wt. 41.2

Shrinkage by drying 19.8%

Shrinkage by drying and pulverizing 26.7%

Wt. of sample/cu.yd. 1420# dry

Wt. o fsample/cu.yd. 2420# wet

Sample #15

Chemical Analysis

SiO_2	3.44
R_2O_3	1.72
CaO	48.69
$CaCO_3$	86.94
MgO	1.56
$MgCO_3$	3.76
V.M.	44.27
	99.68

Organic Matter 4.39

Physical Analysis

Color- grey

Wt. with water 50g.

Wt. without water 24g.

% water by wt. 52

Shrinkage after drying 19.1%

Shrinkage after drying and pulverizing 29.1%

Wt. of sam./cu.yd. 1080# dry

Wt. of sam./cu.yd. 2260# wet

Sample #16

Chemical Analysis

SiO_2	1.26
R_2O_3	1.16
CaO	49.62
$CaCO_3$	88.61
MgO	1.72
$MgCO_3$	3.61
V.M.	46.52
	100.28

Organic Matter 5.64

Physical Analysis

Color- blackish-soapy.

Wt. with water 50g.

Wt. without water 22.1g

% water by wt. 55.8

Shrinkage after drying 18.3%

Shrinkage after drying and pulverizing 28.8%

Wt. of sam./cu.yd. 1050# dry

Wt. of sam./cu.yd. 2380# wet

Sample #17

Chemical Analysis

SiO_2	.70
R_2O_3	1.14
CaO	51.62
$CaCO_3$	91.18
MgO	1.84
$MgCO_3$	3.86
V.M.	44.31
	99.61

Organic Matter 2.73

Physical Analysis

Color- white-chalk.

Wt. with water 50g.

Wt. without water 24g.

% water by wt. 52.

Shrinkage after drying 14.3%

Shrinkage after drying and pulverizing 17.8 %

Wt. of sam./cu.yd. 1090# dry

Wt. of sam./cu.yd. 2280#wet

Sample #18.

Chemical Analysis

SiO_2	.72
R_2O_3	.96
CaO	49.32
$CaCO_3$	88.07
MgO	1.91
$MgCO_3$	3.99
V.M.	48.06
	100.97

Organic Matter 7.23

Physical Analysis

Color- Blackishgrey

Wt. with water 50g.

Wt. without water 29g.

% water by wt. 42.

Shrinkage after drying 13.9%

Shrinkage after drying and pulverizing 16.6%

Wt. of sam./cu.yd. 1490# dry

Wt. of sam./cu.yd. 2560# wet

Sample #19

Chemical Analysis

SiO_2	3.68
R_2O_3	2.20
CaO	47.16
$CaCO_3$	84.11
MgO	1.72
$MgCO_3$	3.60
V.M.	45.77
	100.53

Organic Matter 6.90

Physical Analysis

Color- brownish-grey

Wt. with water 50g.

Wt. without water 22.5g.

% water by wt. 55

Shrinkage after drying 21.2%

Shrinkage after drying and pulverizing 25.1 %

Wt. of sam./cu.yd. 1050# dry

Wt. of sam./cu.yd. 2340# wet

Sample #20

Chemical Analysis

SiO_2	1.28
R_2O_3	1,86
CaO	49.33
$CaCO_3$	88.09
MgO	1.71
$MgCO_3$	3.59
V.M.	46.17T
	100.35

Organic Matter 5.53

Physical Analysis

Color- grey

Wt. with water 50g.

Wt. without water 25.5g.

% water by wt. 49

Shrinkage after drying 28.5%

Shrinkage after drying and pulverizing 20.2 %

Wt. of sam./cu.yd. 1300# dry

Wt. of sam./cu.yd. 2550# wet

Sample # 21.

Chemical Analysis

SiO_2	1.66
R_2O_3	1.26
CaO	50.53
$CaCO_3$	90.23
MgO	1.79
$MgCO_3$	3.74
V.M.	44.42
	99.66

Organic Matter 2.77

Physical Analysis

Color- Greyish black

Wt. with water 50g.

Wt. without water 26.5g.

% water by wt. 47.

Shrinkage after drying 12.2%

Shrinkage after drying and pulverizing 18.6%

Wt. of sam./cu.yd. 1310# dry

Wt. of sam.?cu.yd. 2480# wet

Sample #22.

Chemical Analysis

SiO_2	1.54
R_2O_3	1.12
CaO	49.71
$CaCO_3$	88.77
MgO	1.79
$MgCO_3$	3.74
V.M.	45.94
	99.32

Organic Matter 4.93

Physical Analysis

Color- chalk

Wt. with water 50g.

Wt. without water 29.5g.

% water by wt. 41.5

Shrinkage after drying 10.0%

Shrinkage after drying and pulverizing 17.3%

Wt. of sam./cu.yd. 1380# dry

Wt. of sam./cu.yd. 2350# wet

Sample# 23.

Chemical Analysis.

SiO_2	1.12
R_2O_3	1.10
CaO	50.82
$CaCO_3$	90.75
MgO	1.76
$MgCO_3$	3.68
V.M.	45.64
	100.44

Organic Matter 4.79

Physical Analysis

Color: Grey-chalk

Wt. with water 50g.

Wt. without water 24.5g.

% water by wt. 51

Shrinkage after drying 15.1%

Shrinkage after drying and pulverizing 27.3%

Wt. of sam./cu.yd. 1180# dry

Wt. of sam./cu.yd. 2410# wet

Sample #24.

Chemical Analysis

SiO_2	1.08
R_2O_3	.94
CaO	50.61
$CaCO_3$	90.38
MgO	1.78
$MgCO_3$	3.72
V.M.	45.23
	99.64

Organic Matter 3.52

Physical Analysis

Color: grey

Wt. with water 50g.

Wt. without water 28.2g.

% water by wt. 43.6

Shrinkage after drying 10.2%

Shrinkage after drying and pulverizing 199%

Wt. of sam./cu.yd. 1290# dry

Wt. of sam./cu.yd. 2290# wet

Sample #25

Chemical Analysis

SiO_2	2.18
R_2O_3	1.32
CaO	49.82
$CaCO_3$	88.96
MgO	1.58
$MgCO_3$	3.30
V.M.	45.13
	100.03

Organic Matter 4.11

Physical Analysis

Color: blackish-grey.

Wt. with water 50g.

Wt. without water 28.2

% water by wt. 43.6

Shrinkage after drying 13.2%

Shrinkage after drying and pulverizing 17.7%

Wt. of sam./cu.yd. 1400#

Wt. of sam./cu.yd. 2490#

Sample #26

Chemical Analysis

SiO_2	1.24
R_2O_3	1.12
CaO	50.42
$CaCO_3$	85.92
MgO	1.72
$MgCO_3$	3.48
V.M.	45.51
	100.01

Organic Matter 5.43

Physical Analysis

Color: Grey-soapy

Wt. with water 50g.

Wt. without water 26.6

% water by wt. 46.8

Shrinkage after drying 14.9%

Shrinkage after drying and pulverizing 26.6%

Wt. of sample/cu.yd. 1310# dry

Wt. of sample/cu.yd. 2460# wet

Sample #27

Chemical Analysis

SiO_2	3.24
R_2O_3	2.08
CaO	45.68
$CaCO_3$	80.48
MgO	1.83
$MgCO_3$	3.84
V.M.	47.16
	99.99

Organic Matter 9.04

Physical Analysis

Color: Blackish-grey

Wt. with water 50g.

Wt. without water 21.2

% water by wt. 57.6

Shrinkage after drying 14.7%

Shrinkage after drying and pulverizing 28.8%

Wt. of sam./cu.yd. 1030# dry

Wt. of sam./cu.yd. 2440# wet

Sample # 28.

Chemical Analysis

SiO_2	4.83
R_2O_3	3.82
CaO	40.42
$CaCO_3$	72.56
MgO	1.87
$MgCO_3$	4.02
V.M.	48.78
	99.72

Organic Matter 17.36

High in silica, low in lime.

Physical Analysis

Color: Dark-brownish-grey.

Wt. with water 50g.

Wt. without water 20g

% water by wt. 60

Shrinkage after drying 12.1%

Shrinkage after drying and pulverizing 26.8%

Wt. of sam./cu.yd. 960# dry

Wt. ofsam./ cu.yd. 2400# wet

Sample #29

Chemical Analysis

SiO_2	2.50
R_2O_3	2.01
CaO	47.02
$CaCO_3$	84.11
MgO	1.70
$MgCO_3$	3.50
V.M.	47.79
	101.02

Organic Matter 5.34

Physical Analysis

Wt. with water 50g.

Wt. without water 26.8g.

% water by wt. 46.2

Shrinkage after drying 11.2%

Shrinkage after drying and pulverizing 27.2 %

Wt. of sam./cu.yd. 1380# dry

Wt. of sam./cu.yd. 2560# wet

From the data given the following resultsare determined:

1. Color. Could not check results close enough to make any definite statements inregard to this physical property.

2. Cohesion. Marl does not have any cohesive qualities. There does not seem to be any chemical reaction taking place in the marl itself except when acid or some similar reagent is introduced.

3. Water Content. The water content varies with the organic matter. High organic matter results in high moisture.

4. Adhesion. Some of the samples taken were made into brickets and baked for a sufficient length of time to be thoroughly free of moisture and were then put in a concrete testing machine and broken. They held approximately 5# in tension. The results of this test were not apparently beneficial or did not have any bearing on anything concerning the physical properties of especial importance.

5. Shrinkage. The average shrinkage for allsamples taken of both the dried and the dried and pulverized was exactly 20%. The lowest was 10.2% and the highest 29.1% of original volume.

6. Weight per cubic yard. The average wt. of marl per cubic yard wet was found to be 2420#. The average wt. of marl per cubic yard dry was found to be 1235 pounds.