MOISTURE RETENTION CHARACTERISTICS OF CLAYMAX®
IN HOT, ARID CONDITIONS

Claymax was exposed to long-term arid conditions to determine its moisture retention characteristics. Three specimens of Claymax were tested with different overburden pressures to simulate different field soil cover conditions. All specimens were hydrated in fresh water approximately 24 hours before testing began. Following hydration, test specimens were placed in an environmental chamber to simulate daytime and nighttime conditions in an arid environment. Water content measurements were performed on the Claymax specimens throughout the test duration in the arid environment.

Test number 1 was performed without any confining pressure. Test number 2 was performed with a confining pressure equivalent to 70 psf and test specimen number 3 was performed with a confining pressure equivalent to 160 psf. Water content samples were periodically taken from the Claymax and from the overlying sand used to provide the confining pressure.

Test results indicate that the application of an overburden soil to Claymax enhances its moisture retention characteristics. The water content of Claymax with sand cover does not decrease significantly when subjected to arid conditions lasting up to several months. It should be noted that this laboratory testing did not take into account evaporation due to wind nor did it simulate transpiration from plants. Wind and plant uptake would result in lower moisture contents and desiccation of the GCL. Thus, CETCO suggests that membrane-laminated GCLs (such as Bentomat CL) or composite caps consisting of a geomembrane and a geotextile-encased GCL be used in cover applications.

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FINAL REPORT
OF
CLAYMAX MOISTURE RETENTION
TEST PROGRAM

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GeoServices Project Number: P1138
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1. INTRODUCTION

1.1 Terms of Reference

This report was prepared by Mr. John R. Bennett and Mr. Scott M. Luettich, P.E. and was reviewed by Dr. Neil D. Williams, P.E. of GeoServices, Inc. Consulting Engineers (GeoServices). The work was conducted at GeoServices Geomechanics and Environmental Laboratory (GEL) in Norcross, Georgia at the request of Mr. William J. Simpson of James Clem Corporation (Clem).

GeoServices was requested to perform laboratory tests to evaluate the moisture retention properties of **CLAYMAX** liner under simulated dry, arid conditions. The work is being performed in general accordance with GEL Proposal Number XG89511, issued to James Clem Corporation on 14 February 1989, the Proposal Addendum issued on 14 August 1989, and the letter of authorization issued by Clem on 12 December 1989.

1.2 Report Organization

This report is organized as follows:

* Section 1 presents the terms of reference and report organization;
* Section 2 presents the purpose and scope of the work;
* Section 3 presents details of the test equipment and procedure; and
* Section 4 presents the results of the tests.

2. PURPOSE AND SCOPE OF WORK

The purpose of the test program was to measure the moisture retention characteristics of **CLAYMAX** when exposed to long term arid environments. The scope of the work included monitoring the moisture content of three hydrated samples of **CLAYMAX** placed in a temperature and humidity-controlled chamber. Different overburden pressures were applied to each of the three samples to simulate various soil cover conditions. Water content measurements were obtained from the **CLAYMAX** samples regularly throughout the ten-month test duration.

3. TEST EQUIPMENT AND PROCEDURES

3.1 Test Equipment

All tests were performed in a climate-controlled chamber, approximately 5 ft (1.5 m) long by 3 ft (0.9 m) wide by 2 ft (0.6 m) deep. The chamber operates on a timed cycle in order to simulate day and night conditions. The chamber maintains a constant temperature of 95±2°F with a relative humidity of 30±5% during the day cycle, and a temperature of 70±2°F with a relative humidity of 50±5% during the night cycle.

3.2 Test Procedures

3.2.1 Test Number 1

Test Number 1 was performed using a specimen of CLAYMAX approximately 12 in. (30 cm) by 7 in. (18 cm). The specimen was hydrated with water for 24 hours in a pan approximately 3 in. (8 cm) deep without any confining stress (overburden soil) applied to the specimen. After hydration, the specimen was placed in the climate-controlled chamber and the exposure was started on 18 February 1989. Water content samples were taken regularly from the bentonite specimen and the moisture content was determined in accordance with ASTM D-2216.

3.2.2 Test Number 2

Test Number 2 was performed using a specimen of CLAYMAX approximately 12 in. (30 cm) by 7 in. (18 cm). The specimen was hydrated for 24 hours, in a deep pan with 8 in. (20 cm) of overburden soil (ASTM C-33 concrete sand) placed over the specimen. This resulted in an overburden pressure of approximately 70 psf (3.5 kPa). After hydration, the specimen was placed in the climate-controlled chamber and the exposure period was started on 18 February 1989. Water content samples were taken regularly from the CLAYMAX specimen and from the overlying sand at depths of 0,1.5, and 8 in. (0,4,and 20 cm).

3.2.3 Test Number 3

Test Number 3 was performed using a specimen of CLAYMAX approximately 18 in. (45 cm) by 30 in. (76 cm). The specimen was hydrated for 24 hours in a box approximately 19 in. (49 cm) deep with 18 in. (46 cm) of overburden soil (sand) applied to the specimen. This resulted in an overburden pressure of approximately 160 psf (8 kPa). After hydration, the specimen was placed in the climate-controlled chamber and the exposure period was started on 18 February 1989. Water content samples were taken regularly from the CLAYMAX and from the overlying sand at depths of 0,8, and 18 in. (0,20,and 46 cm). After a total drying period of ten months, Sample 3 was excavated and photographs were obtained. These photographs (enclosed with this report) indicate fairly widespread dessication, with the average width of the dessication cracks measured to be approximately 0.25 in. (0.64 cm).

4. TEST RESULTS

4.1 Test Number 1

Hydration of the CLAYMAX specimen under zero confining stress resulted in a significant increase in thickness from approximately 0.2 in. (0.5 cm) to slightly over 1.5 in. (3.8 cm) after the 24-hour hydration period. Initial water content samples of the specimen, obtained immediately after the 24-hour hydration period, indicated an average value of approximately 1300%. Water content samples were again taken after four days of exposure. An average value of approximately 700% was obtained. Water content samples were again taken after 21, 47, and 90 days. The average values obtained were less than 15%, 6%, and 1% respectively. Visual inspections of the specimen during the test revealed dessication, cracking and separation of the bentonite within 5 days of starting the exposure conditions. The water content results are presented in Table 1. The water content values of the bentonite are plotted as a function of time as shown in Figure 1-A, included in the Appendix.

4.2 Test Number 2

Hydration of CLAYMAX under 8 in. (20 cm) of sand resulted in an increase in thickness from approximately 0.2 in. (0.5 cm) to approximately 0.3 in. (0.75 cm) after 24 hours. Initial water content samples indicated an average value of approximately 250% for the CLAYMAX and approximately 11% to 12% for the overlying sand. Water content samples were taken from the sand and CLAYMAX after 3, 15, 25, 40, 90, 154, 235, and 294 days of exposure. These results are presented in Table 2. The water content of the sand, plotted as a function of time, is shown in Figure 2-A. The water content of the bentonite as a function of time is shown in Figure 2-B.

4.3 Test Number 3

Hydration of CLAYMAX under 18 in. (48 cm) of sand resulted in an increase in thickness from approximately 0.2 in. (0.5 cm) to approximately 0.3 in. (0.75 cm). Initial water content samples indicated an average value of 300% for the CLAYMAX specimen and 10% to 11% for the overlying sand. Water content samples were again taken from the sand and CLAYMAX after 3, 15, 25, 40, 90, 154, 235, and 294 days of exposure. These results are presented in Table 3. Water content values are plotted as a function of time for the sand and bentonite, as shown in Figures 3-A and 3-B, respectively.

4.4 <u>Discussion</u>

The water content and thickness of the CLAYMAX specimen hydrated under zero confining stress (Test Number 1) were initially much higher than for the CLAYMAX specimens hydrated under positive confining stresses (Tests Number 2 and 3). The water content of the unconfined CLAYMAX specimen decreased rapidly as the test progressed, whereas the water content of CLAYMAX did not decrease significantly when subjected to confining pressure. The initial hydration characteristics as well as the long-term moisture retention characteristics of CLAYMAX were apparently influenced greatly by the application of confining pressure. Furthermore, the insulation effect (both temperature and humidity) of the overlying sand apparently enhanced the moisture retention characteristics of the CLAYMAX. The test results did not indicate a significant difference in moisture retention between Tests Number 2 and 3.

APPENDIX

Table 1
Water Content Results

Test Number 1

Soil Type	Depth (in.)	Elapsed Time (days) 0	4	21	47	90
Bentonite	0	1300%	690%	15%	6%	1%

Table 2
Water Content Results

Test Number 2

Soil Type	Depth (in.)	Elapsed Time (days) 0	3	15	25	40	90	154	235	294
Sand	0	11%	0.8%	0.1%	0	0	0	0	0	0
Sand	1.5	11%	7%	7%	7%	5%	0.2%	0	0	0
Sand	8.0	12%	8%	7%	7%	7%	1%	0	0	0
Bentonite	8.5	260%	--	--	280%	--	260%	180%	20%	1%

Table 3
Water Content Results

Test Number 3

Soil Type	Depth (in.)	Elapsed Time (days) 0	3	15	25	40	90	154	235	294
Sand	0	6%	0.3%	0.1%	0	0	0	0	0	0
Sand	8	12%	8%	8%	8%	8%	3%	0.4%	0	0
Sand	18	18%	16%	13%	12%	11%	5%	3.5%	2%	0
Bentonite	18.5	300%	--	--	265%	--	248%	203%	116%	37%

MOISTURE RETENTION
CLAYMAX
TEST No. 1

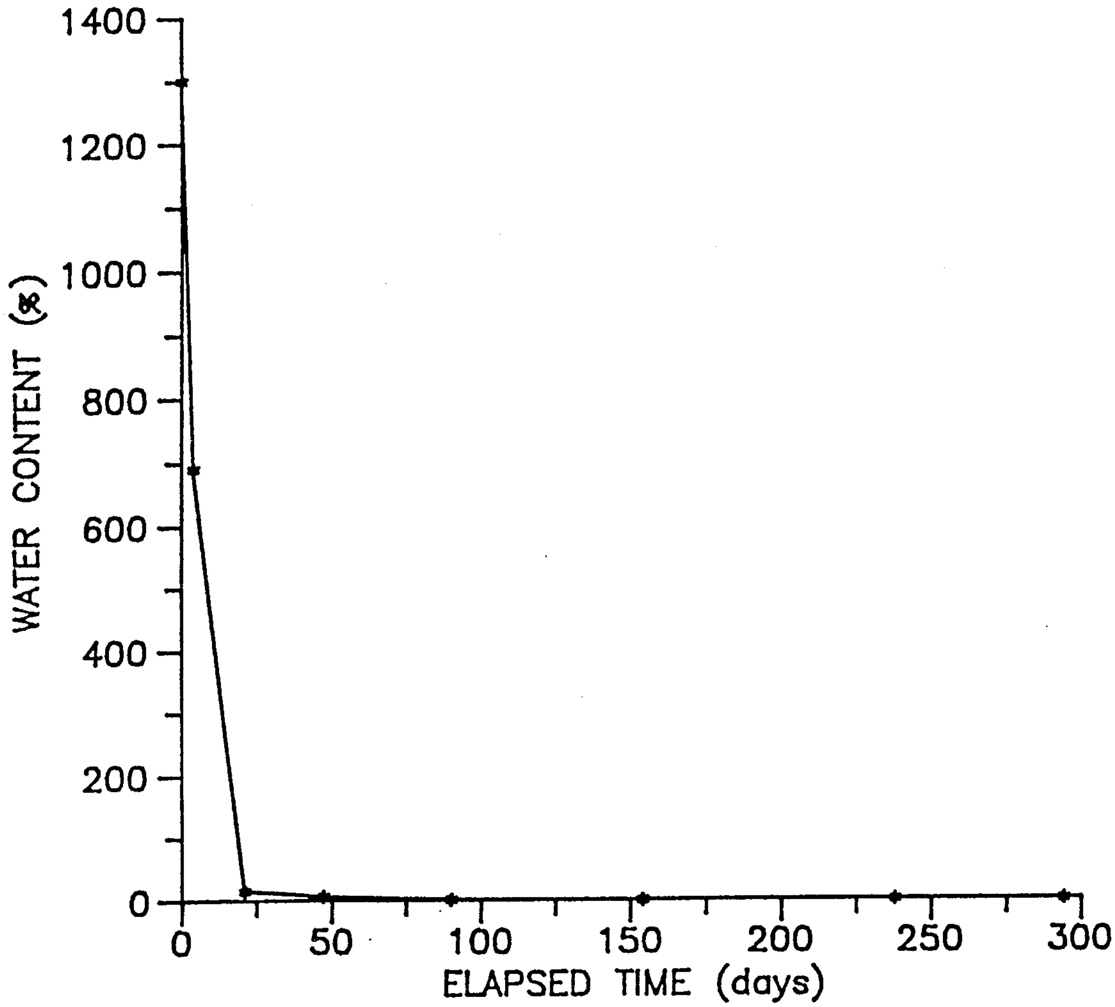

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FIGURE NO.	1-A
PROJECT NO.	P1138
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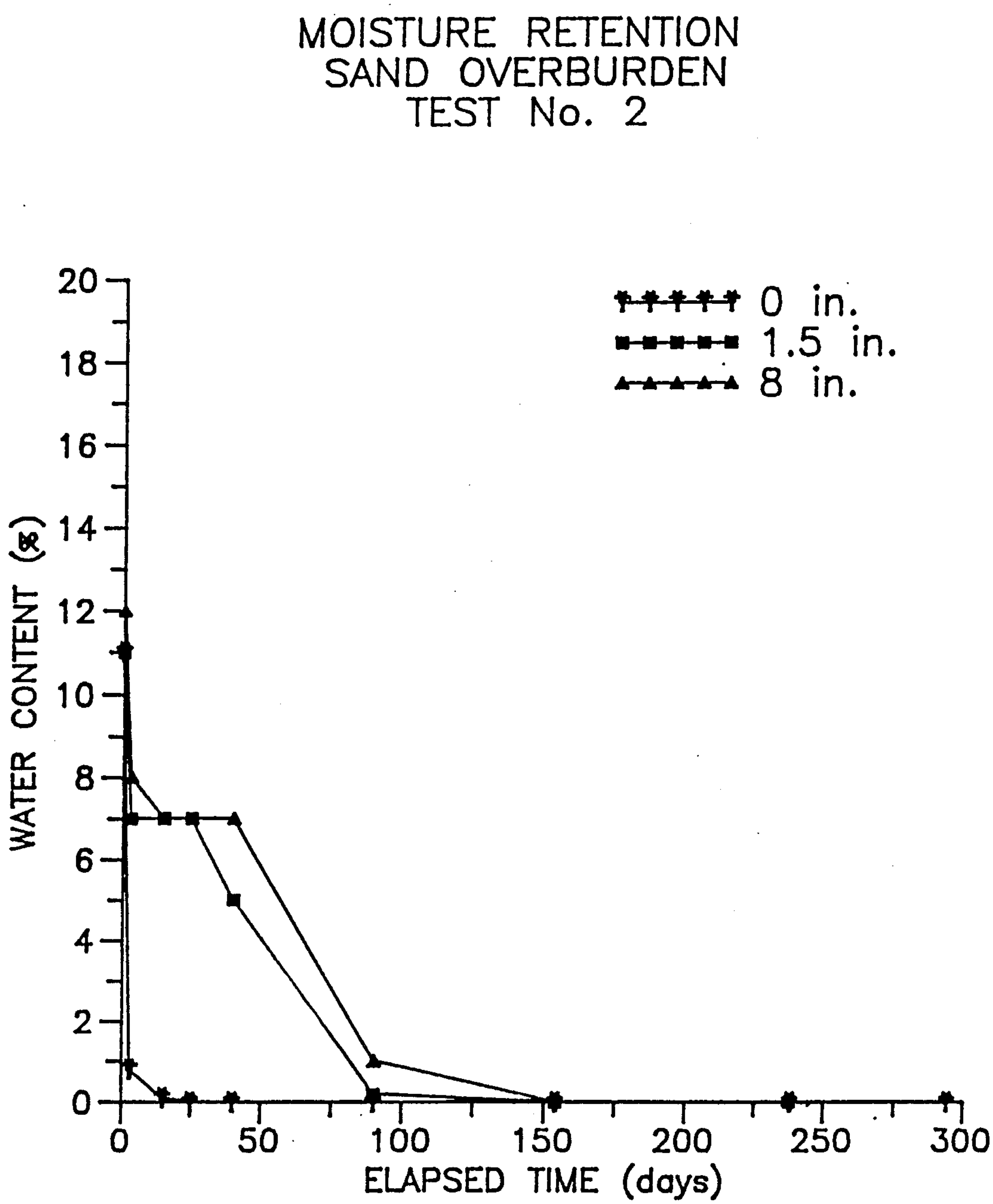

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FIGURE NO.	2-A
PROJECT NO.	P1138
DOCUMENT NO.	NL90020
PAGE NO.	

MOISTURE RETENTION
CLAYMAX
TEST No. 2

CONFINING STRESS = 70 psf (3.5 kPa)

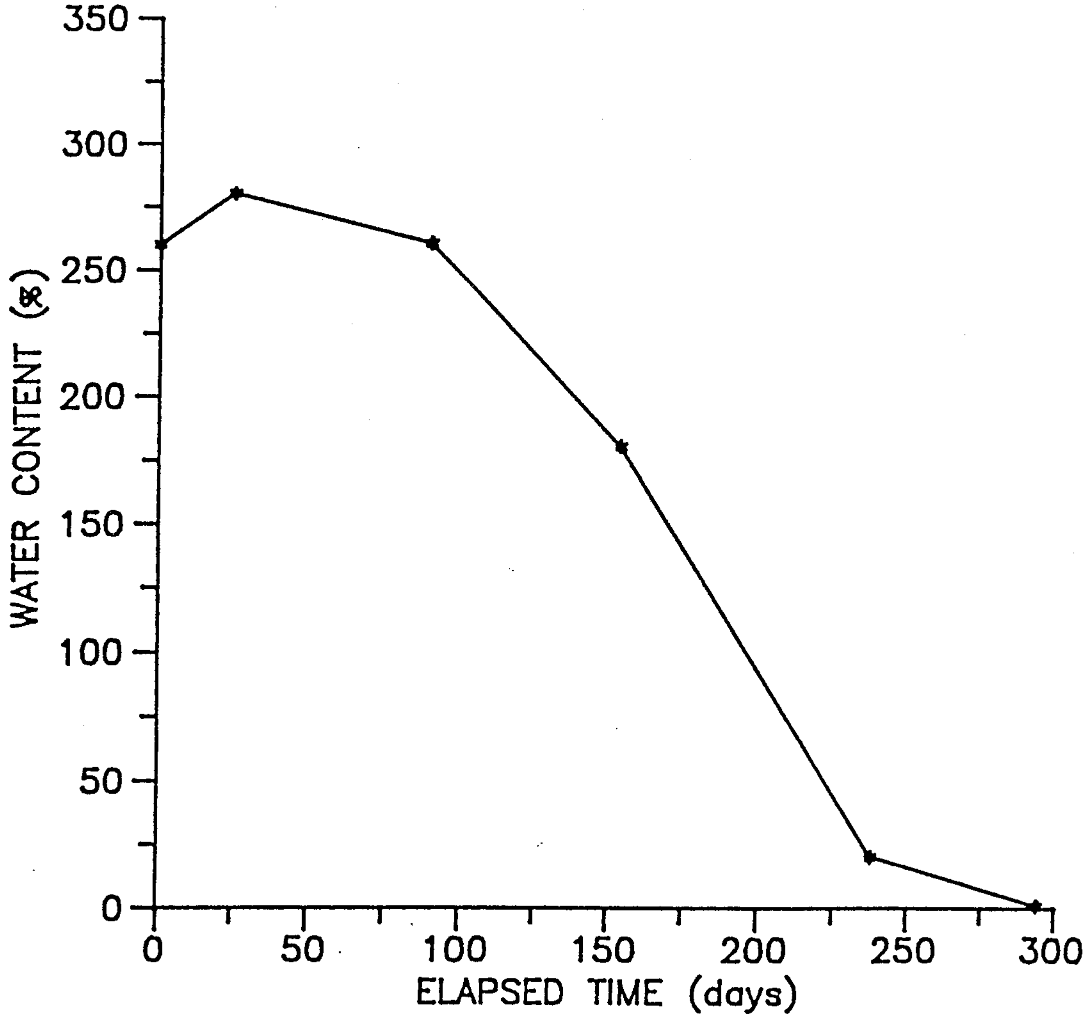

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FIGURE NO.	2-B
PROJECT NO.	P1138
DOCUMENT NO.	NL90020
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MOISTURE RETENTION
SAND OVERBURDEN
TEST No. 3

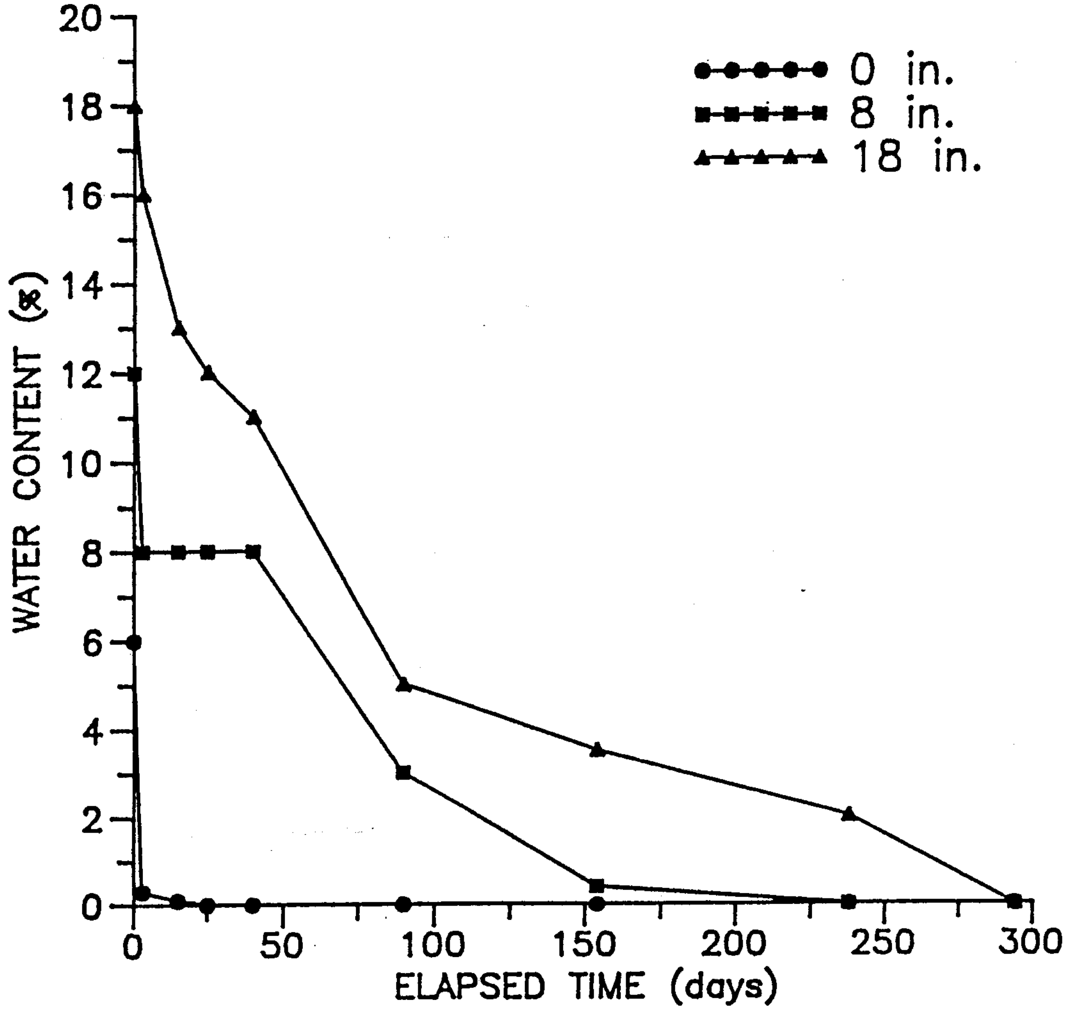

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FIGURE NO.	3-A
PROJECT NO.	P1138
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MOISTURE RETENTION
CLAYMAX
TEST No. 3

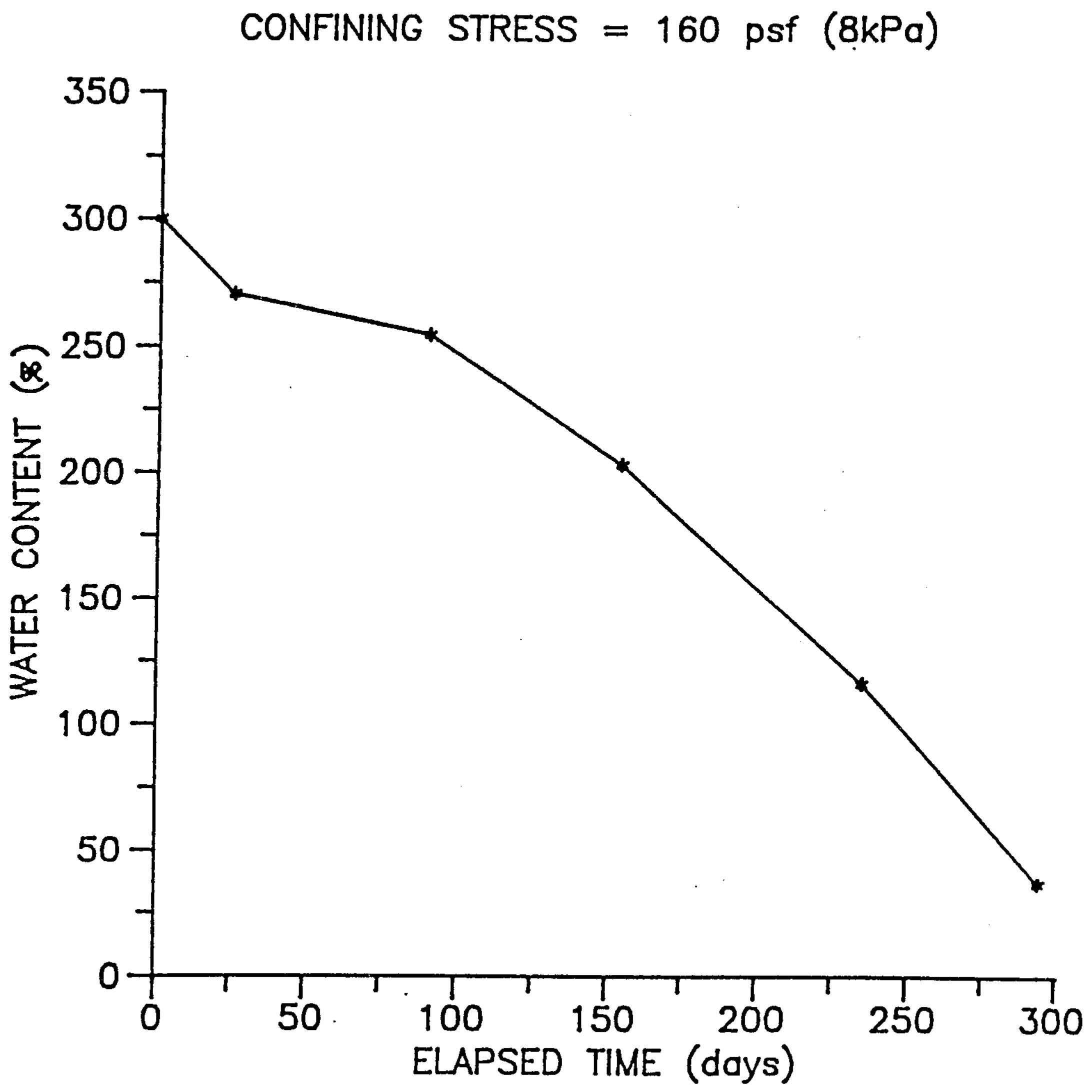

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FIGURE NO.	3-B
PROJECT NO.	P1138
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