SMART

Science and Mechatronics Aided Research for Teachers:
A Research Experience for Teachers (RET) site

The Behavior of Recycled HDPE Under Vertical Loads Using Stepped Isothermal Methods via TCI

Mechatronics Department / Civil Engineering Department

TOUFIK AYOUB
and
MARCIA MOORE

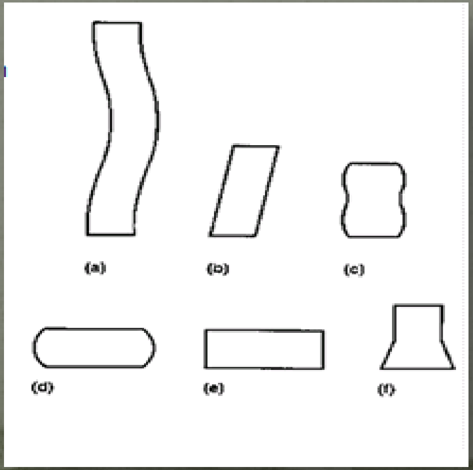
ABSTRACT

- Recycled HDPE samples were subjected to stress strains at 400psi and 800psi.
- Liquid surrounding the specimen was increased in temperature every two hours starting at 25° Celsius. The first increase was to 38°C, the second increase was from 38°C to 49° C and final increase was from 49° C 60° C for the duration of eight hour testing period.
- The specimen had a constant pressure of 400psi or 800psi during each testing period.
- The data collected was then analyzed to measure the creep effect on the specimens.

BACKGROUND INFORMATION

What is creep testing?

- Creep is the term used to describe the permanent deformation of a material placed under constant stress.
- To determine creep properties, a material is subjected to prolonged constant tension or compression loading at constant elevated temperature



Modes of deformation in compression testing

a) Buckling
b) Shearing
c) Doubling barreling
d) Barreling
e) Homogenous compression
f) Compressive instability

CONTINUE…

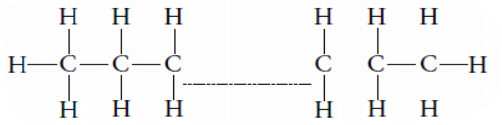


Figure 1-1c: Polyethylene Molecular Chain

What is HDPE?

- *"High-density polyethylene* (HDPE) (0.941 < density < 0.965) is a thermoplastic material composed of carbon and hydrogen atoms joined together forming high molecular weight products" (Gabriel, L).

Why use HDPE as piling/foundation for Structures?

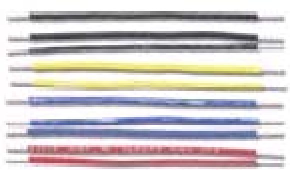
- Traditional piling such as wood, metals or concrete are very susceptible to termites, the elements and erosion.
- It also eliminates the increasingly high costs of replacing traditional piling.
- Recycled HDPE is also Environmentally friendly because it is a possible solution for the large amount of plastic discarded into landfills each year in America.

THE EXPERIMENT

EXPERIMENT DEMO FOR SMART 2010

MATERIALS

28130
(1) temperature probe

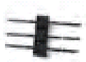


800-00016
3" pluggable jumper wires

200-01040
0.1 µF ceramic capacitor

200-02240
0.22 µF 50V poly capacitor

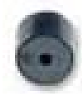
805-00002
Servo/LCD extension cables



451-00303
3-pin male/male headers

604-00002
(1) DS1620 digital thermometer

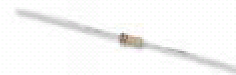
400-00001
(1) pushbutton



900-00001
(1) piezo speaker

DMP6402A Relay

Medium Temperature Heating Tapes



150-01030
(1) 10 KΩ 1/4 watt 5% resistor
(brown, black, orange)

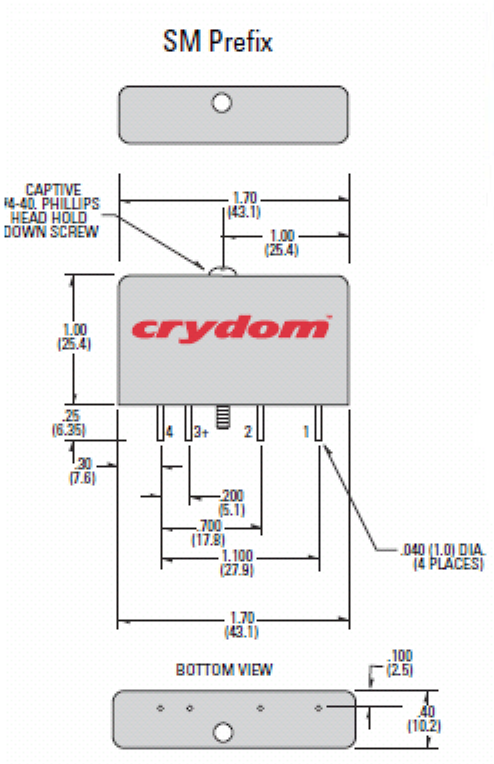
150-02210
220 Ω 1/4 W 5% resistors
(red, red, brown)

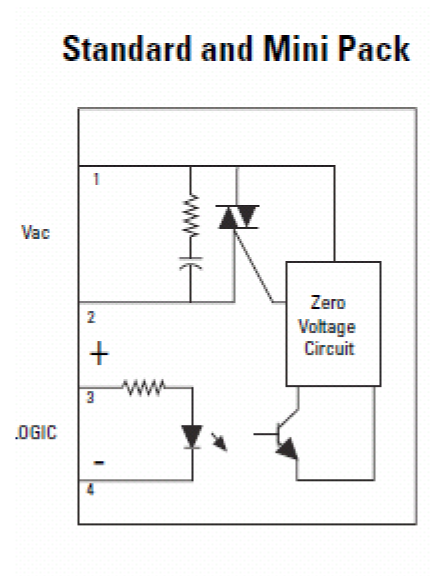
150-01011
(4) 100 Ω 1/4 watt 5% resistors
(brown, black, brown)

150-01020
(1) 1 KΩ 1/4 watt 5% resistor
(brown, black, red)

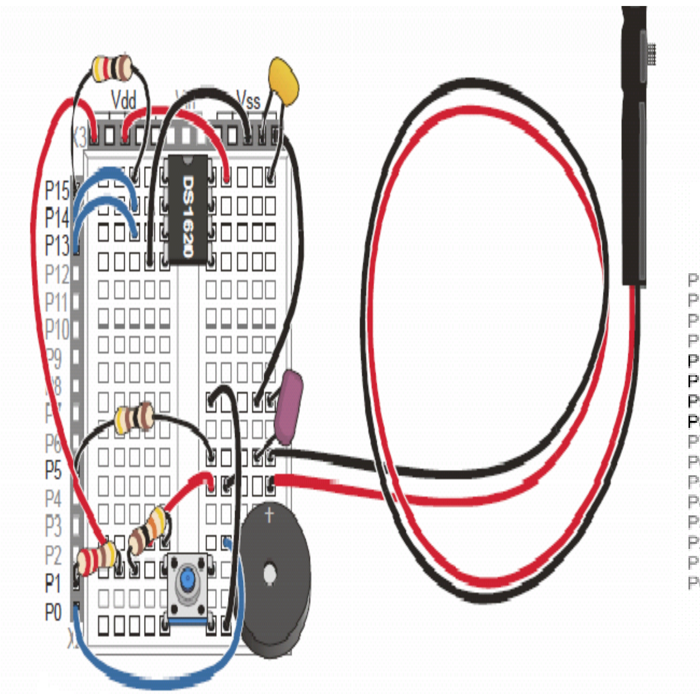
27976
(1) Parallax Serial LCD 2x16, Non-backlit

DMP6402- RELAY

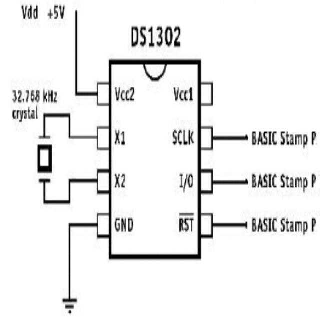


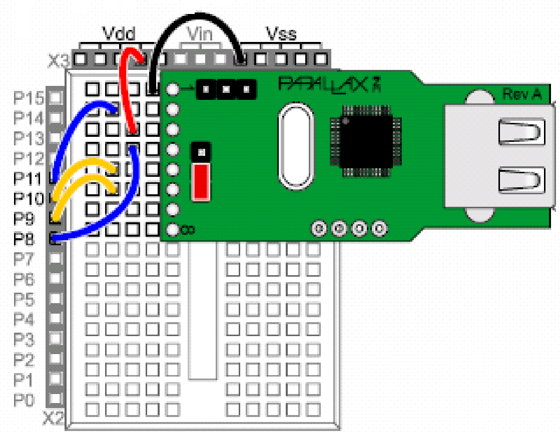


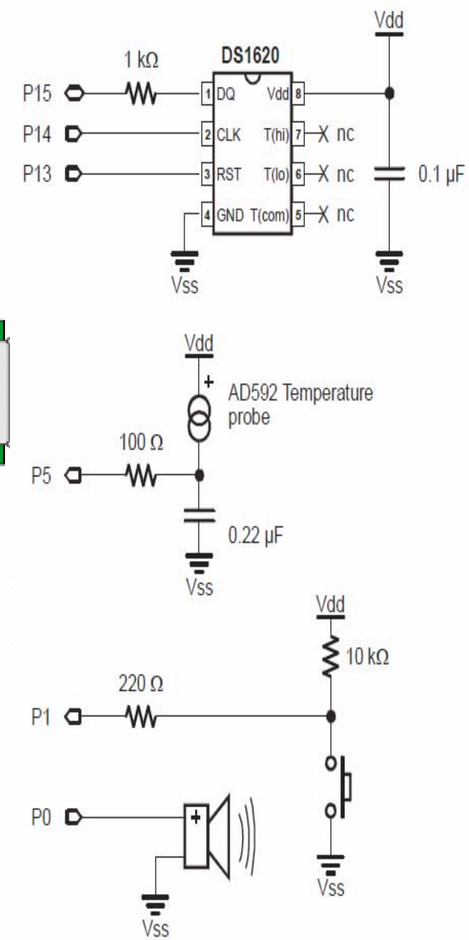
Wiring Diagram and Schematic



AD592 Temperature Sensor and RC-time Wiring Diagram







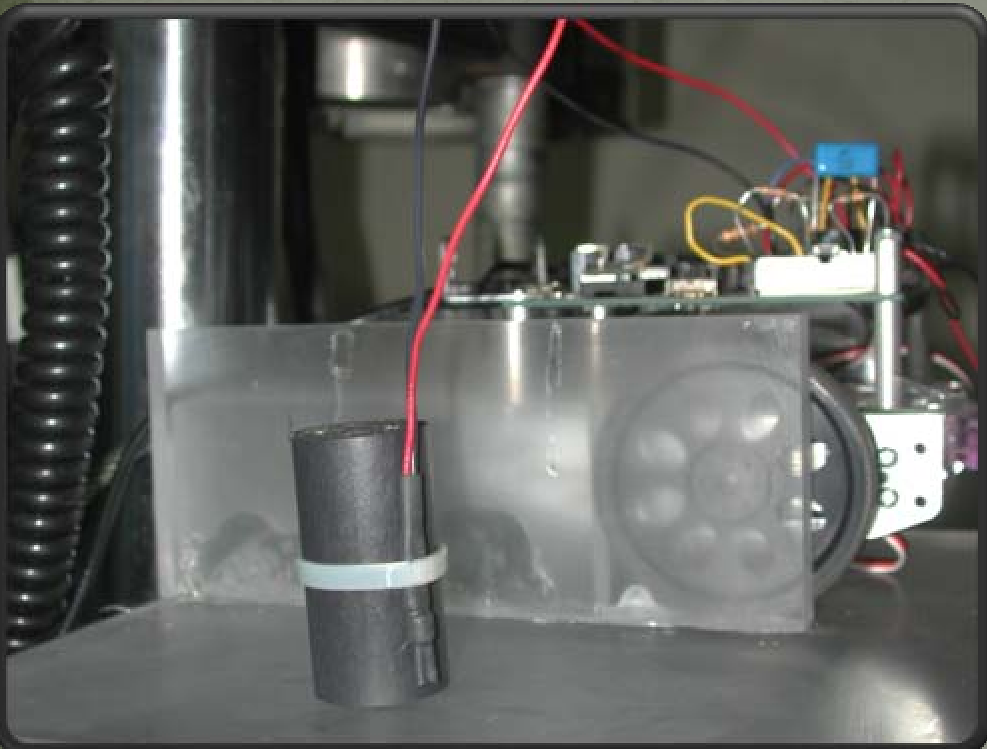
AD592 Temperature Sensor and RC-time Schematic

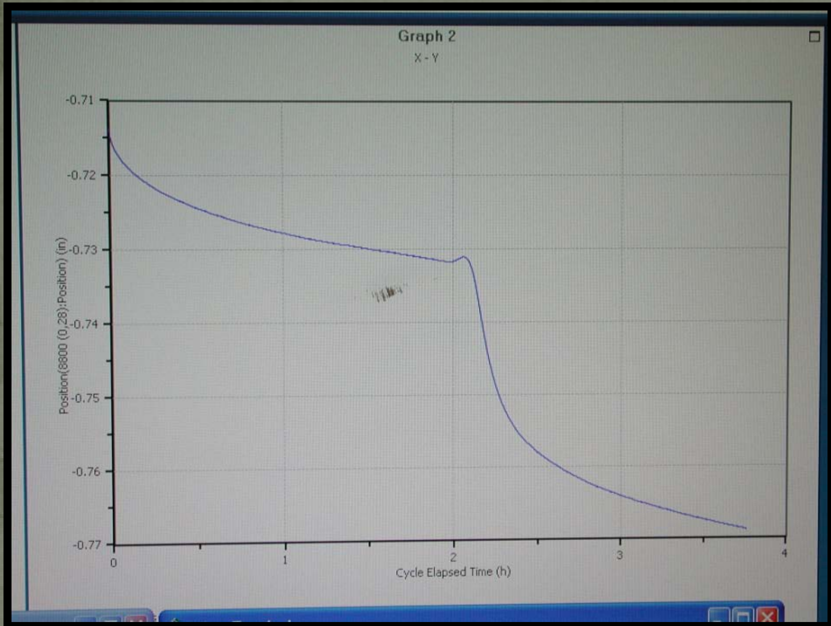
TEST SPECIMENS

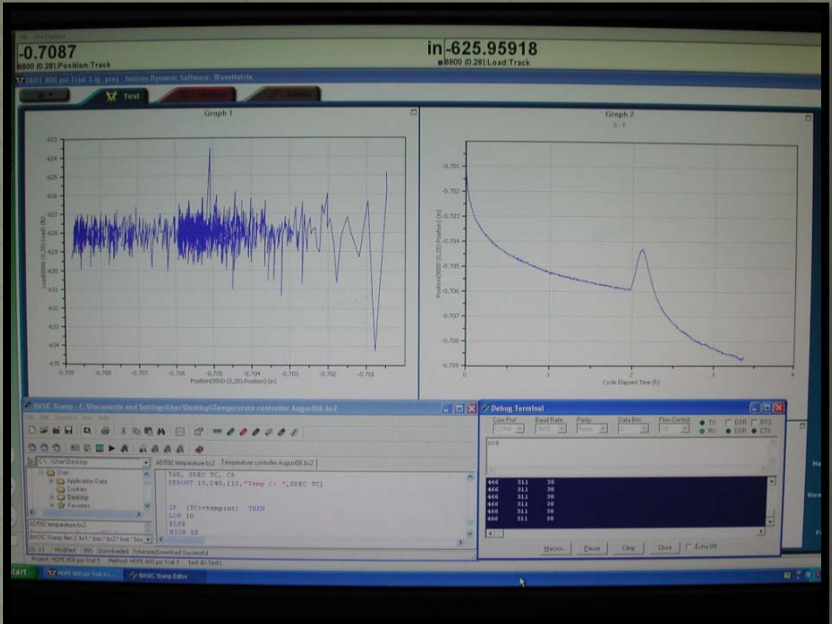
- Recycled HDPE cylindrical samples with a diameter of one inch and a height of two inches were tested.
- The composition of these samples are mostly HDPE, about 5% fiberglass, carbon black and proprietary agents.

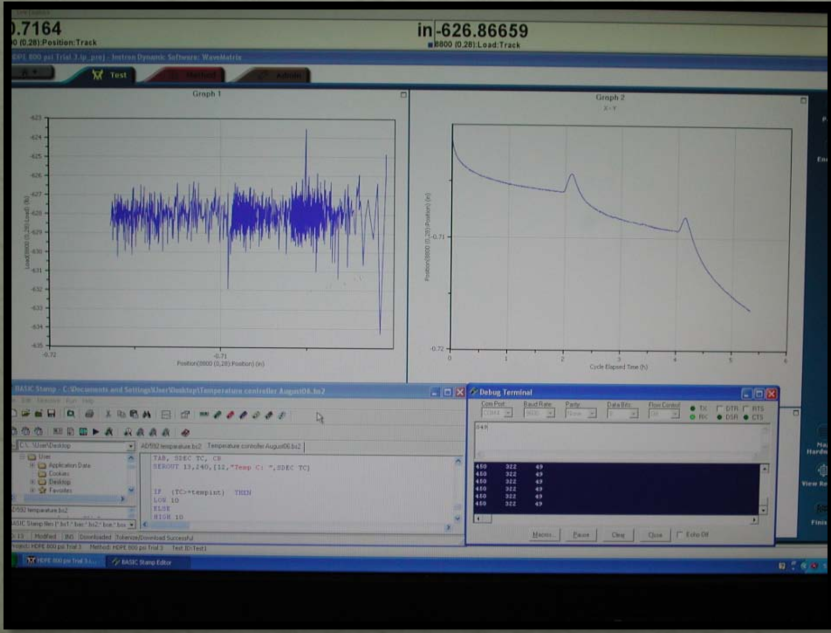
LABORATORY SET-UP

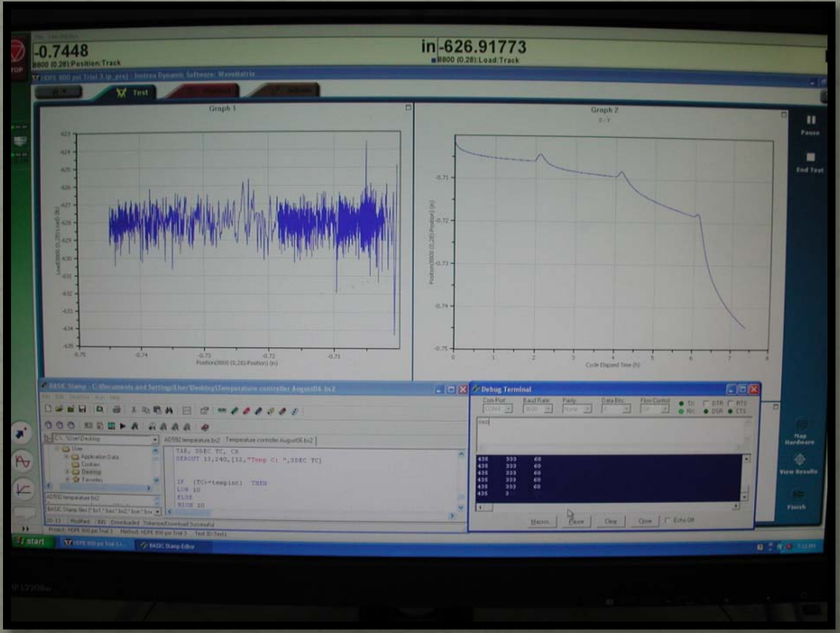
- The thermocouple is attached to the specimen.
- The heating coil is wrapped around a metal can where the specimen is placed and submerged in water.
- The specimen is sandwiched between two vertical rods of the compression machine, the top comes in direct contact with our specimen.
- Pressure is then applied on the specimen based on our pre-set parameters of 400psi and 800psi.
- Readings are recorded and expressed in a graph on the computer .



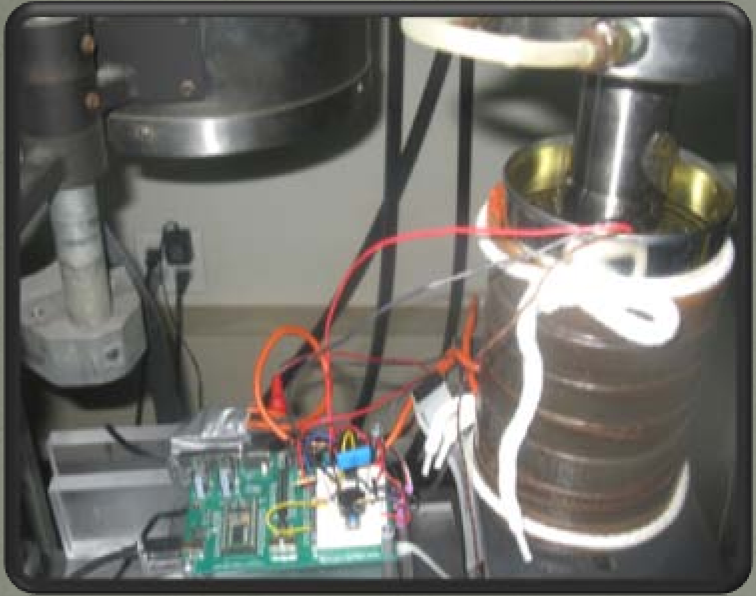

Graph 2
X - Y
-0.71
-0.72
-0.73
-0.74
-0.75
-0.76
-0.77
Position(8800 (0,28):Position) (in)
0
1
2
3
4
Cycle Elapsed Time (h)

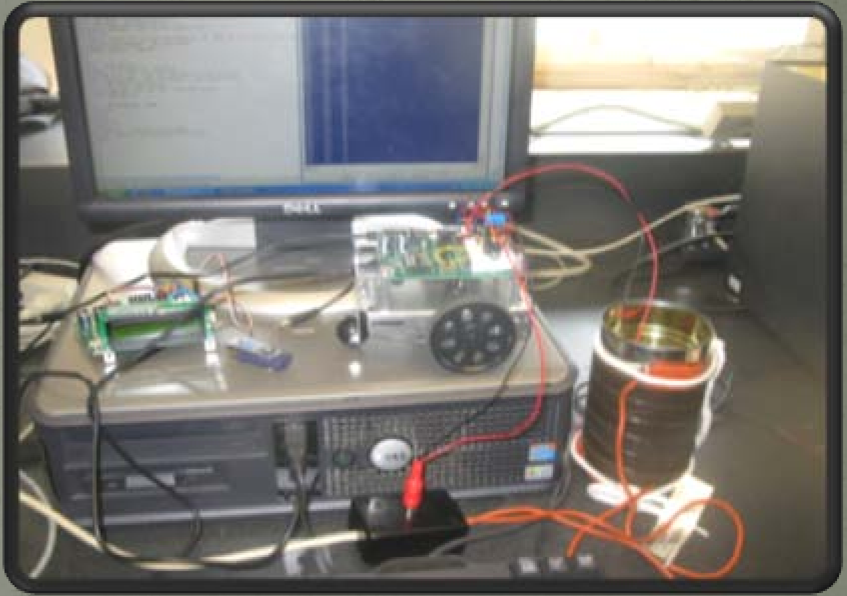

-0.7087
in -625.95918
Test
Graph 1
Graph 2
Debug Terminal


.7164
in -626.86659
Test
Graph 1
Graph 2
Debug Terminal

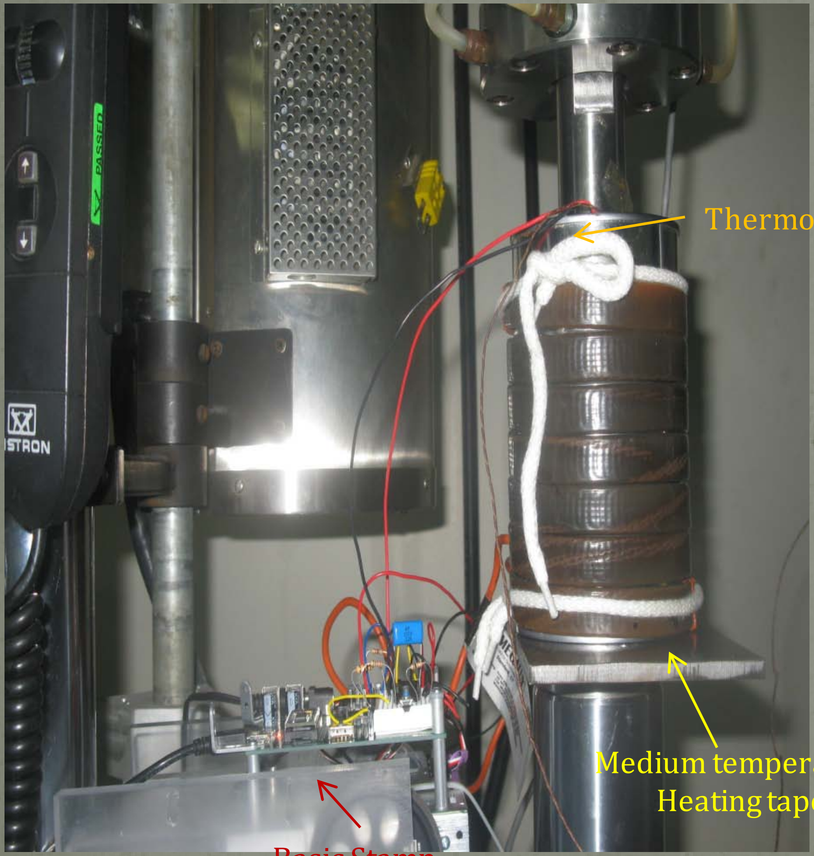

-0.7448
in -626.91773
Test
Graph 1
Graph 2
Debug Terminal

TEMPERATURE CONTROLLER





HOW DOES THE TEMPERATURE CONTROLLER WORK?



- The thermocouple, which is connected to the Basic Stamp, reads the temperature of the liquid surrounding specimen.
- The Basic Stamp then tells the heating tape through the DMP6402 relay to lower or raise temperature to produce the desired temperature we want.

THE EXPERIMENTAL PROCEDURES

- We began by building a new and improved temperature controller instrument (TCI) using the basic stamp.
- We ran several trails to insure that our TCI was performing properly and could also reach the maximum temperature require for our experiment (60°C).
- We then wrote a basic stamp program that allowed us to have a stabilized temperature we desire.
- We set the compression machine to produce pressure at 200psi, 400psi and 800psi.

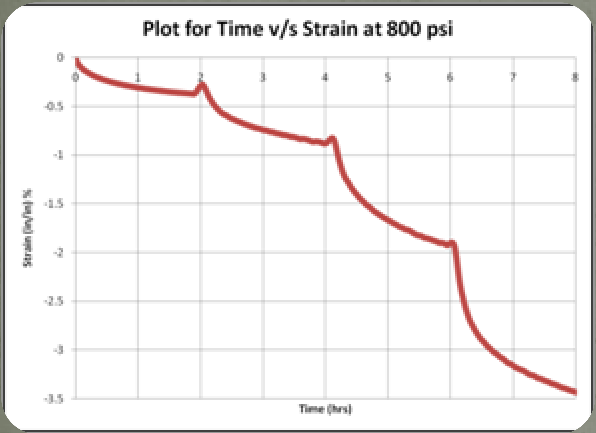
PROCEDURE CONT…..

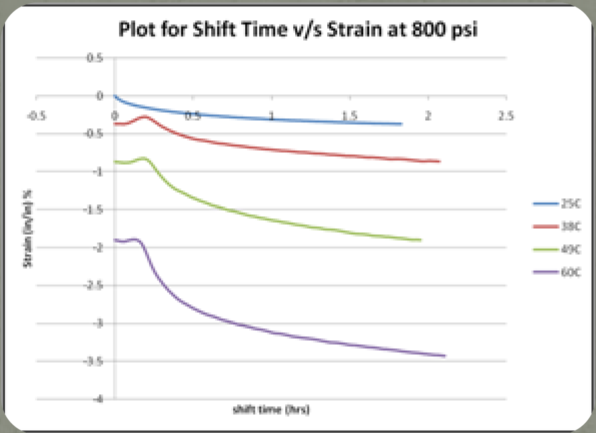
- The entire test per specimen, at each pressure was ran for 8hrs.
- We let the thermocouple calibrate to 25° Celsius at least 15-20 minutes before we began our tests to stabilize the reading.
- We then increased the temperature in 2 hour increments. Our first temperature change was from 25° C to 38° C, then 38°C to 49°C, and finally 49°C to 60°C.
- At the end we removed the thermocouple and specimen from the liquid, after we turned off all the devices we were working with.
- We examined the sample for any visible changes.

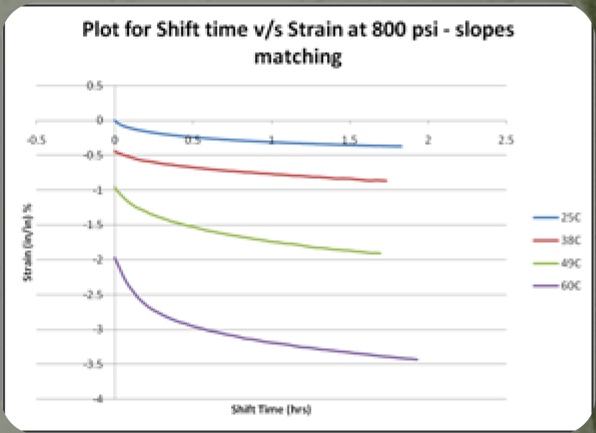
IMPORTANT TO THE PROCESS

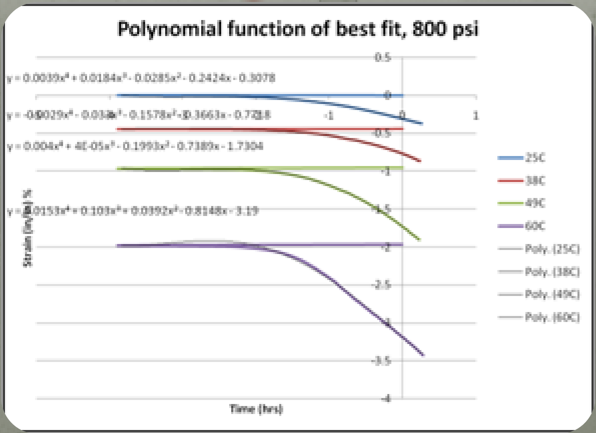
- DO NOT leave thermocouple in liquid after experiment.
- Rotate thermocouple after 3-4 uses.
- Calibrate the thermocouple before each new test.
- Have a cup of ice-water to calibrate thermocouple.
- Have an alternate device to take temperature.
- Calibrate compression machine.
- Make sure specimen is centered properly before you begin compression.

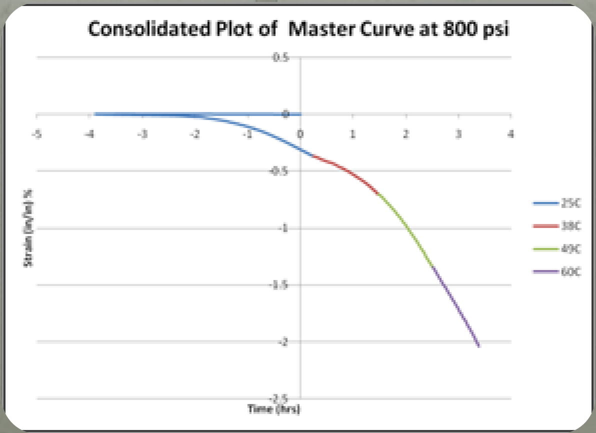
RESULTS AT 800psi



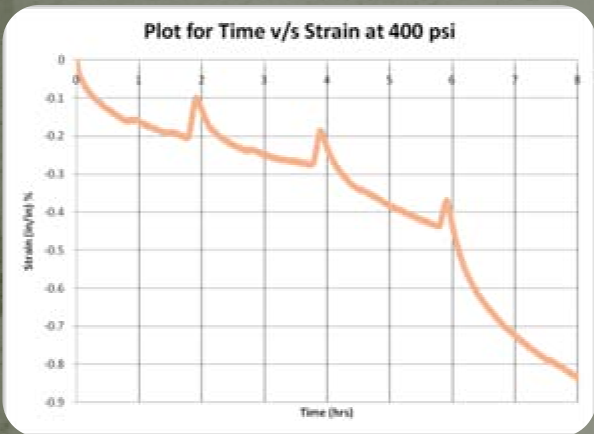


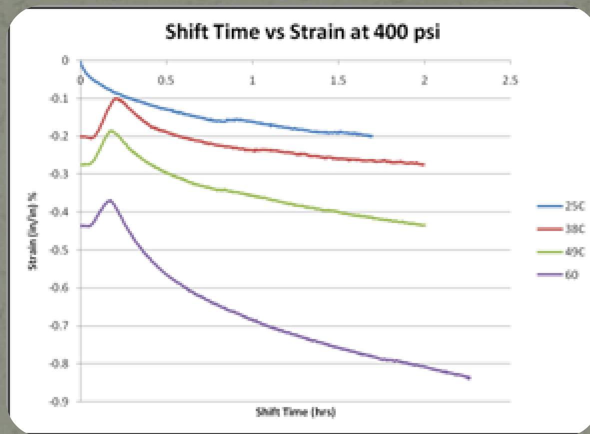


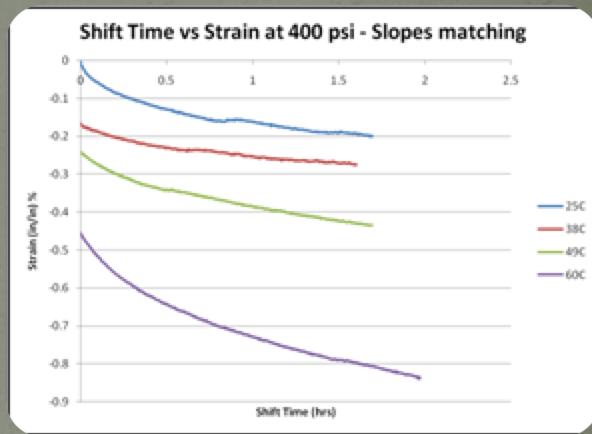


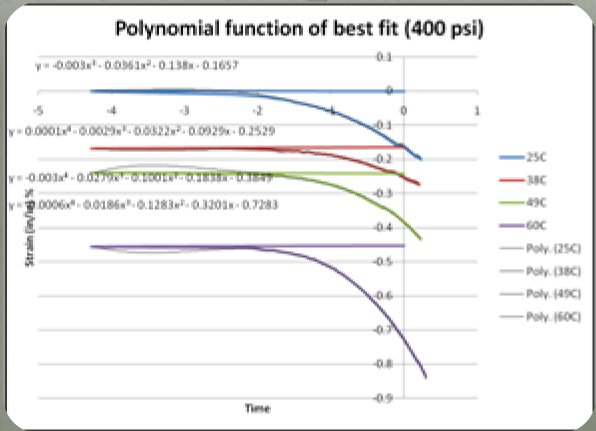


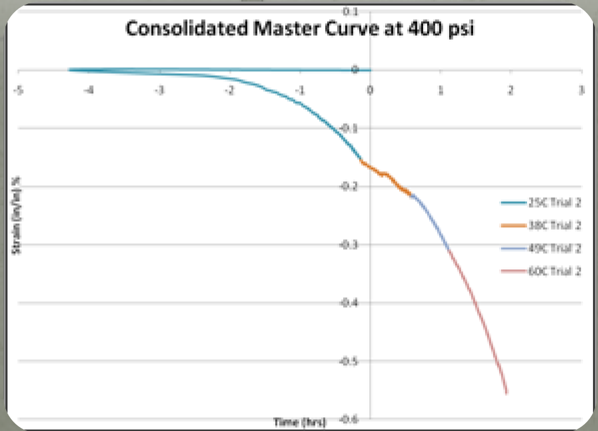
RESULTS AT 400psi











DISCUSSION

- The temperature control unit built in the mechatronics laboratory during our research project at NYU-Poly during the summer 2010 SMART program meets our requirements and expectations.
- It successfully controlled and stabilized the temperature of our specimen for a desire length of time.
- The results are comparable to the outcome obtained by the use of other testing methods for creep in prior research.
- There is no limitation to reach a desired temperature level (so far reaching up to 125 ˚Celcius) within a reasonable time period (≈5 min. to 10 min.). The test results indicate:

1. Stepped Isothermal Method (SIM) are appropriate methods for accelerating creep in compression at stresses below 5.5 MPa (800 psi).
2. Recycled HDPE experience plastic deformation at temperature at 60˚C test limit: A steeper strain (%) vs. time (hrs) curve is generated as the specimen enters its fourth temperature level of 60 ˚C.

RECOMMENDATION FOR CHANGES

- Build two devices
- Use Solder to prevent accidental disconnections.
- Use a can with a large diameter or shorter in height.

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The Behavior of Recycled HDPE Under Vertical Loads Using Stepped Isothermal Methods via TCI

NYU·poly

POLYTECHNIC INSTITUTE OF NYU

Toufik Ayoub and Marcia Moore

ABSTRACT

This research is concerned with the compressive creep behavior of the viscoelastic material, High Density Polyethylene (HDPE) commonly used to manufacture polymeric piling, decking, and fender elements. In this research, we developed a Mechatronics Apparatus to control the temperature of a specimen as it is tested for creep. A load is applied to the specimen while the temperature changes. This apparatus facilitates experimental examination of the effect of combined temperature cycles and different loading rates on the durability of recycled (HDPE) specimen bars. Through a series of cyclic temperature variation, we collected experimental data and analyzed it from several aspects: ultimate strength under different loading rates at varied temperatures of 25°C, 38°C, 49°C AND 60°C. The Stepped Isothermal Method (SIM) have been adapted to study the time and temperature dependant compressive creep of HDPE.

BACKGROUND

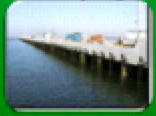
❑What is HDPE?

"High-density polyethylene (HDPE) (0.941 < density < 0.965) is a thermoplastic material composed of carbon and hydrogen atoms joined together forming high molecular weight products"(Gabriel, L).

❑Why use HDPE as piling/foundation for structures? Traditional piling such as wood, metals or concrete are very susceptible to termites, the elements and erosion. It also alleviate the increasingly high cost to replace traditional piling. HDPE is also Environmentally friendly because it is possible solution to the large amount of plastic discarded into landfills each year in America.

Different modes of deformation in compression testing

Deteriorated traditional piling



HDPE PILING

PROJECT GOALS

•Build a temperature control instrument (TCI) using basic stamp.

•Run compression tests on recycled (HDPE) specimen bars for eight hours at 400psi and 800psi.

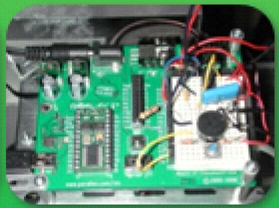
•Control and increase the temperature every two hours the of the specimen using TCI.

•Record and analyze the data collected.

MATERIALS

Instron Fasttrack™ 8800 Compression machine

Recycled HDPE specimen



Temperature control instrument (TCI) using basic stamp

Stress (psi): $\sigma = \frac{Load\ (P)}{Area\ (A)}$ Area: $A = \frac{\pi}{4} d^2$

$Strain = \frac{\Delta L}{L} = \frac{Change\ in\ length}{Initial\ length}$

PROCEDURES

➢We began by building a new and improved temperature controller instrument (TCI) using the basic stamp.

➢We ran several trails to insure that our TCI was performing properly and could also reach the maximum temperature require for our experiment (60° C).

➢We then wrote a basic stamp program that allowed us to have a stabilized temperature we desire.

We set the compression machine to produce pressure at 200psi, 400psi and 800psi. The entire test per specimen, at each pressure was ran for 8hrs.

➢We let the thermocouple calibrate to 25° Celsius at least 15-20 minutes before we began our tests to stabilize the reading.

➢We then increased the temperature in 2 hour increments. Our first temperature change was from 25° C to 38° C, then 38° C to 49°C, and finally 49°C to 60°C.

➢At the end we removed the thermocouple and specimen from the liquid, after we turned off all the devices we were working with.

➢We examined the sample for any visible changes.

HOW DOES THE TEMPERATURE CONTROLLER WORK?

- The thermocouple, which is connected to the Basic Stamp, reads the temperature of the liquid surrounding specimen.
- The Basic Stamp then tells the heating tape through the DMP6402 relay to lower or raise temperature to produce the desired temperature we want.

LABORATORY SET-UP

-The thermocouple is attached to the specimen.

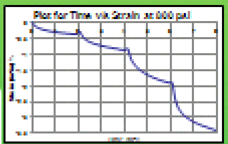
-The heating coil is wrapped around a metal can where the specimen is placed and submerged in water.

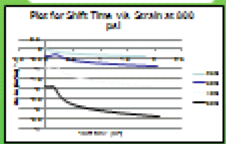
-The specimen is sandwiched between two vertical rods of the compression machine, the top comes in direct contact with our specimen.

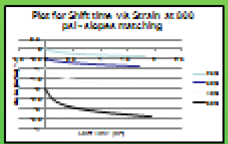
- Pressure is then applied on the specimen based on our pre-set parameters of 200psi, 400psi and 800psi.

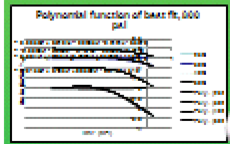
-Readings are recorded and expressed in a graph on the computer .

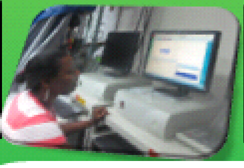
ANALYSIS OF DATA

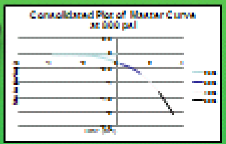












DISCUSSION

❑The temperature control instrument we built in the meets our requirements. It successfully controlled and stabilized the temperature of our specimen for a desire length of time.

❑The results are comparable to the outcome the obtained by the use of other testing methods for creep in prior research.

❑ The TCI had no limitation to reach a desired temperature level (reaching temperatures up to 125°C) within a reasonable time period (5~10 min.).

❑The test results indicate:

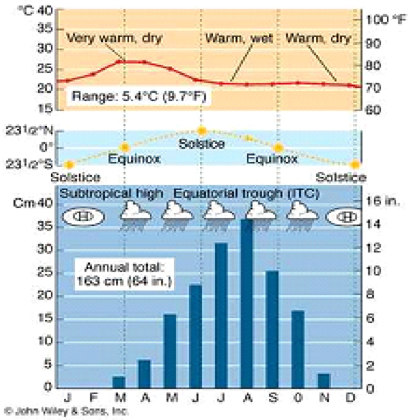
•Stepped Isothermal Method (SIM) are appropriate methods for accelerating creep in compression at stresses below 5.5 MPa (800 psi).

•Recycled HDPE experience plastic deformation at temperature at 60°C test limit: A steeper strain (%) vs. time (hrs) curve is generated as the specimen enters its fourth temperature level of 60°C.

Acknowledgments : This work is supported by the Research Experience for Teachers Site Program of National Science Foundation under grant EEC-0807286: Science and Mechatronics Aided Research for Teachers (SMART). Special thanks to Professor Magued Iskander, Saurabh Parikh, Professor Vikram Kapila, and Jared Alan Frank for their help and suggestions.

Climographs: Temperature, Precipitation, and the Human Condition

Subject Area: Physics, Physical Science, Social Study, Geography, Mathematics
Associated Unit: None
Associated Lesson: None
Activity Title: Read, analyze, and construct Climographs
Header:



Group Size: 2-4
Expendable Cost per Group: US$0.00
Grade Level: 6-10
Time required: 4 to 6 hours

Summary:
Climographs are a graphic way of displaying climate information; specifically, average temperature and precipitation. They are a valuable tool in studying climate, but also can be used to infer connections between climate and human conditions. In this lesson, students learn about how to read, analyze, and construct climographs. They also practice matching climographs to locations in the United States and in Africa, and discerning climate patterns and making some predictions about their effects on humans in different places in Africa.

Connections to the National Geography Standards:

Standard 7: "The Physical Processes That Shape the Patterns of Earth's Surface"
Standard 15: "How Physical Systems Affect Human Systems"

NYS MATH STANDARDS

6.S.4 Determine and justify the most appropriate graph to display a given set of data (pictograph, bar graph, line graph, histogram, or circle graph).

6.S.7 Read and interpret graphs

ACKNOWLEDGEMENTS

- This material is based upon work supported by the National Science Foundation under an RET Site Project with Grant #: EEC-0807286: Science and Mechatronics Aided Research for Teachers(SMART).
- Special thanks for their helpful comments and suggestions.
  - Professor Magued Iskander
  - Saumil Parikh
  - Professor Vikram Kapilla
  - Jared Alan Frank
- This work was conducted during the summer 2010 in the Soil Mechanics and Civil Engineering Lab at the NYU-Polytechnic Institute.

REFERENCES

- Gabriel, L.H., PhD. History and Physical Chemistry of HDPE, chapter 1. *www.plasticpipe.org/.../chapter-1_**history_physical_chemistry_hdpe**.pdf* .
- Parikh, Saumel (2007). Accelerated Creep Test on HDPE Using the Stepped Isothermal Method.
- www.Parallax.com (for pictures of materials and schematics)
- http://octopart.com/dmp6402a-crydom-79008#datasheets
- http://www.instron.us/wa/applications/test_types/creep_stress_relax.aspx