TECHNICAL SUMMARY

Development of An Accelerated Creep Testing Procedure for Geosynthetics

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INTRODUCTION

The main design concern for the long-term stability of geosynthetic-reinforced soil structures is the prediction of the creep behavior of geosynthetics under the design loads. The current state-of-practice design methods and standards usually incorporate an allowable load for creep or a factor to obtain the allowable long-term strength of geosynthetics. Creep performance can be predicted in accelerated creep tests. In these tests, geosynthetics are subjected to creep loads at elevated temperatures. The results of these tests can be shifted to extrapolate creep behavior (at the same loading levels) to longer time intervals using time-temperature superposition principles.

Analytical methods for extrapolating creep data from accelerated tests have not yet been standardized. Some research on the temperature-dependent creep behavior of geosynthetics has been done and they demonstrated the applicability of extrapolating creep strains to longer time intervals. Temperature-creep relationships vary for each type of polymer used in soil-reinforcement applications. Moreover, extrapolation of strains from elevated temperature tests is limited to temperature ranges and loading levels which do not alter the physical nature of the polymeric specimens.

The report presents the newly developed accelerated creep testing equipment. The testing procedure and the analytical methods used to predict creep at longer time intervals are evaluated.

OBJECTIVES

The objectives of the research were:

i) Develop testing equipment and a standard testing procedure for accelerated creep test of geosynthetics at controlled elevated temperature,

ii) Evaluate time-temperature relationships of geosynthetics used in reinforced soil applications,

iii) Develop an analytical procedure for predicting creep strains at longer time intervals from the accelerated tests at elevated temperature.

SCOPE OF RESEARCH

The testing program was performed using two types of creep testing equipment. The first type consisted of five loading frames to test geosynthetic specimens in room temperature. The second type of testing equipment consisted of two creep loading frames with ovens for testing geosynthetics in elevated temperatures.

Creep tests for various durations ranging from 1,000 to 10,000 hours were performed on two types of geosynthetics commonly used in soil reinforcement applications: High Density Polyethylene (HDPE) geogrid and Polyester (PET) geogrid. These tests were performed at various loading levels ranging from 15 percent to 40 percent of the tensile strength of the geogrid and at temperatures ranging from 24°C (75°F) to 72°C (160°F).

Two analytical procedures were used in predicting creep strains at longer time intervals. These procedures are commonly used in establishing time-temperature relationships for polymers and they are the Arrhenius Equation and the time-shift principal based on the theoretical Equation.

TEST PROCEDURES

The procedure used in predicting creep strains was as follows:

1. A temperature range was selected for the testing program. The maximum temperature was lower than the melting point of the polymer, and the temperature range was within the temperature limit that does not change the physical properties of the geosynthetic.

2. A loading range was determined for the creep-testing program. The applied loads were in the visco-elastic range of the polymer tested. The procedure was successful in predicting creep response at loads up to about 45 percent of the maximum strength for the HDPE polymer

3. The 10,000-hour creep curves were established at the selected creep loads from the tests performed at room temperature.

4. Thousand-hour creep tests were performed on the geosynthetics at elevated temperatures at the same range and creep loads.

5. Temperature-shift procedures were applied on the test results to establish the master curve. The master curves up to 10,000 hours should compare well with the experimental test results.

6. The temperature-shift constants and the shift factors were compared at various loading levels and were evaluated with the theoretical curves using the WLF equation.

DISCUSSION OF RESULTS

Temperature-creep relationships in geosynthetics vary for each type of geogrid and depend on many factors such as polymer structure, manufacture process, degree of crystallinity, and glass-transition temperature. The extrapolation procedures to predict creep strains from elevated temperature tests do not apply to all types of polymers used in the geosynthetics industry.

The PET geogrid was tested at elevated temperatures close to its glass-transition temperature (75°C). Consequently, the changes in creep strains were not sufficient to successfully establish temperature-creep relationship. Tests at temperatures higher than 75°C are suggested for the PET to evaluate the extrapolation procedures for predicting creep strains at higher temperature. The HDPE polymer had a glass-transition temperature well below room temperature and showed measurable creep response at elevated temperatures.

The results using the Arrhenius equation showed that the estimation of the activation energy was sensitive to the procedure of measuring strain-rates from test results at various temperatures. The evaluation of the procedure demonstrated the difficulty of properly estimating the activation energy that corresponded to each creep load and temperature range.

An interpretation procedure based on shifting creep-temperature curves along the log-time scale was evaluated to predict creep strains at longer times. The estimation of the shift factors was established from the experimental curves and was evaluated with the empirical procedure of the WLF equation.

CONCLUSIONS

The investigation of the applicability of temperature-controlled accelerated creep tests in predicting creep strains to longer time intervals offered a practical and economical solution for testing various geosynthetics in reasonable time frames. The proposed research aimed to establish a testing procedure and analysis of accelerated creep tests. The report can help the geotechnical engineers in evaluating creep strains at longer time frames from accelerated tests for many geosynthetics used in soil reinforcement applications.

The interpretation procedure of creep test results provided the shift factors and established master curves for the High Density Polyethylene (HDPE) geogrid that could be used to predict creep strains at longer time intervals. The procedure is applicable for testing other types of polyethylene (PE) and polypropylene (PP) geogrids and geotextiles as their creep properties demonstrate a measurable response to temperature increase. Further tests at higher temperatures may be required to demonstrate the applicability of the procedure on polyester (PET) geosynthetics.

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