

TECHNICAL SUMMARY

Rapid Drying Soils with Microwave Ovens

Summary of Report 359

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Each material used in roadway construction has its own unique properties, and testing procedures have been developed to measure them. For soil-aggregate mixtures, whether naturally occurring or chemically stabilized, compaction is a significant factor in enhancing its mechanical properties. The degree of compaction or densification is influenced by the type of soil, moisture content, and compactive effort. R. R. Proctor developed testing procedures to identify the maximum dry density and the corresponding moisture content, commonly known as optimum moisture content of a soil at a specific compactive effort. These procedures evolved to become the AASHTO T-99 or ASTM D 698 test methods.

The current DOTD procedure, TR 415-99, based on AASHTO T-99, requires a minimum of three proctor tests per 1000 foot zone to determine moisture density relationships. The moisture content is determined by the stove method using a 2200-gram sample. The stove method is conducted by placing soil in a pan over an open flame. The soil is stirred and heated until all the moisture is evaporated. A survey of field technicians indicated that it takes approximately 45 to 60 minutes to perform a moisture content test using the stove method. Quite often the contractor is in the next construction zone by the time the results are tabulated. In an effort to reduce the amount of time required to dry soils in the field, a comprehensive laboratory study was conducted to evaluate the performance of microwave ovens.

OBJECTIVE AND SCOPE

The purpose of this research was to develop a new method for quickly and accurately determining moisture content of soils in the field. Seven soils were selected for evaluation. The soil types included sand,

silt, clay, soil-aggregate mixture, and recycled soil cement base course materials. Each soil was examined in its natural state. Four soils were examined with Portland cement, and two soils were examined with lime.

RESEARCH APPROACH

In order to properly assess the microwave ovens, a two-part evaluation program was performed: accuracy/repeatability comparison and high/low moisture content evaluation. Prior to beginning testing, the devices used for testing were selected and an evaluation protocol was established.

The computer-controlled microwave oven was purchased from Geoscience Engineers. It has a 700-watt output capacity and is fitted with an electronic scale. Proprietary software furnished by the manufacturer controls the cycles of heating and cooling of the sample. The subsequent weight change is monitored by the computer and manually recorded.

Most common household microwave ovens adjust the amount of time a unit is operating at full power capacity within a selected time interval. The standard microwave oven used in this study was a Panasonic Model NN-S769S with an 1100-watt power output controlled by an inverter. This type of microwave allows adjustments of both time interval and power. Therefore, a power setting of 50 percent with a 10-minute duration produces a 550-watt output continuously for the full ten minutes. Testing with the standard microwave was conducted in accordance with ASTM D4643.

Six primary variables were addressed to ensure specimen testing accuracy and consistency. These were specimen size, operator, devices, soil type, sample preparation, and moisture content. All test specimens weighed 500 grams. Trial tests were performed by the technicians until they became proficient in using the four devices. Soils of different classifications were analyzed to ensure that the devices could be used with confidence on materials typically used or encountered in Louisiana highway construction. Results from the convection oven were used as control data to evaluate the performance of the other devices. Sample preparation was performed in strict accordance with the appropriate specifications.

CONCLUSIONS

The procedures developed and used for drying soils with microwave ovens are efficient, accurate, and safe. There were no aggregate explosions, fires, or vaporization of organics at the power settings and testing intervals used in this study. The statistical analysis methods used indicated that both microwave ovens were accurate and could be used to dry soils at a rate approximately 50 percent faster than the current method used by DOTD. Because of the difference in initial costs between the computer-controlled microwave and the standard microwave, the benefits-to-costs analysis indicated that the standard microwave oven is the most feasible device to use.

IMPLEMENTATION

The District 03 and 62 laboratory engineers have conducted field trials with the microwave oven. Their results are consistent with the findings of this report.

The recommended specification, *DOTD TR 403-01, Method C, Rapid Drying with Microwave Ovens*, written by the author, has been approved for use for soils that contain less than five percent aggregate by the Materials Specification Committee. Although the accuracy of the microwave was not questioned, concerns arose regarding the ability to select a representative sample with 500 grams for soils with greater than five percent aggregates.

It should be noted that for samples of equal size, the microwave did not prove to be faster than the stove method. The faster rate of the stove method is due to the smaller sample size of 500 grams allowed in the microwave procedure for soils as compared to the 2200 grams generally used in the field with the stove dry method.

The results of the testing program indicated that the microwave oven was also statistically comparable to the convection oven. The Project Review Committee has recommended further studies be conducted to evaluate the microwave oven for use with smaller sample sizes. Using the microwave for soil classifications and Atterberg limits would enhance the efficiency of the district laboratories since moisture contents could be obtained in 20 minutes instead of 24 hours.

The contractor on a recent DOTD project also experimented with the microwave to determine the free moisture in his aggregate stockpile. He has suggested DOTD consider allowing this application in the future.

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