LTRC
Louisiana Transportation Research Center

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# TECHNICAL SUMMARY

Summary of Report Number 283

# INVESTIGATION OF THE USE OF RESILIENT MODULUS FOR LOUISIANA SOILS

## INTRODUCTION

The Louisiana Department of Transportation and Development (LADOTD), like many other state transportation agencies, uses empirical procedures in the design of highway pavement. These empirical design procedures require soil parameters, such as soil support value, California Bearing Ratio (CBR) and Texas triaxial value. Testing methods to obtain the soil parameters employ static compression loading of the specimen. The test methods do not adequately assess or represent the response of the pavement materials to the dynamic loading to which they are actually exposed under service conditions. Recognizing this deficiency, the 1986 *AASHTO Guide for Design of Pavement Structures* recommended using resilient modulus ($M_r$) as a definitive property to characterize flexible pavement materials. The resilient modulus is a dynamic response defined as the ratio of the repeated axial deviator stress to the recoverable axial strain. Sophisticated laboratory and field testing procedures are required for determining this property. The concept of using resilient modulus in mechanistic design methods provides a better understanding of pavement behavior, efficient use of pavement materials, and a reliable and realistic pavement design.

Currently, LADOTD uses a relationship developed for Louisiana soils to estimate soil support values. The relationship requires an R value which can be derived from soil classification and engineering properties. The resilient modulus can also be determined from an R value - $M_r$ relationship developed by Temple and Shah (1987). This relationship was implemented in an automated procedure for estimating the roadbed resilient modulus by simply inputting basic soil classification properties. This implementation has allowed LADOTD to use this software for designing flexible pavements. The above relationship was empirical and was not fully supported by the soil laboratory test results. It should also be noted that this procedure was developed as an interim design procedure and needs to be replaced with a procedure which implements AASHTO recommended methods.

After the 1986 AASHTO design guide recommendations, several transportation agencies started implementing laboratory testing procedures for determining the resilient moduli of the soils. Some of the agencies are in the process of modifying or reevaluating the existing procedures for testing their locally available soils. The transportation agencies in Louisiana will be able to use AASHTO recommended laboratory procedures based on the success of the present investigation.

## OBJECTIVE & SCOPE

The main objective of the research is to provide a laboratory methodology for resilient modulus testing which can be implemented to design flexible pavements mechanistically in Louisiana. The results from laboratory methodologies will be used to validate the existing soil properties - $M_r$ relationships used in Louisiana. The outcome of this research study will be the development of a laboratory research tool that will provide LTRC with the ability to conduct diagnostic work for LADOTD. The tool will also be used as a part of the materials characterization process in the Accelerated Loading Facility at LTRC. Other objectives of the study are to understand the influence of testing procedures (AASHTO T-294, T-292), the LVDT's measurement locations, and the physical soil characteristics on the resilient modulus of soils. Field nondestructive testing procedures will be evaluated by comparing them with laboratory results conducted on core samples. Two soil types, a blasting sand and a silty clay, will be investigated under conditions representing a simulation of the physical and stress states of soils beneath flexible pavements subjected to moving wheel loads. The conclusions based on the test results are valid for the soils tested in this investigation.

## APPROACH

A research study was initiated to develop a laboratory test procedure to characterize subgrade soils based on the structural properties obtained from repeated load triaxial testing. A statistically designed test factorial was used to examine the influence of the measurement system and AASHTO testing procedure on the resilient modulus test results. Two in-cell axial deformation measurement systems (one at the ends and the other one at the middle one-third of the specimen height), two AASHTO test procedures, T-292 and T-294, and two soil types (cohesive and granular) were used. In addition, this study examined the influence of moisture content and dry density variation on the test results. Three levels of moisture content and dry density were used in both cohesive and granular soils.

## CONCLUSIONS

The $M_r$ of both soils increases with an increase in the confining pressure. This increase in sands is attributed to an increase in stiffness as well as the reduction in dilatancy properties. The increase of resilient properties in silty clays is attributed to a slight increase in strength as well as the assumed reduction in the pore pressure development at higher confining pressures. The moisture content, as expected, appears to have more influence on silty clay $M_r$ results than on the sand results. This is mainly attributed to the pore pressure development in silty clays.

The T-294 procedure resulted in higher moduli than the T-292 procedure. This is due to smaller bulk stress fluctuations in conditioning and testing stress levels in the T-294 procedure which is assumed to provide less disturbance to the soil specimen. The middle measurement system provided higher resilient moduli than the end measurement system, possibly due to fewer system compliance errors and end friction effects. Also noted in the silty clay test results is that the confining stress appears to have a major influence on the measurements.

The Louisiana developed correlations, though not accounting for confining and deviatoric stresses, have provided $M_r$ values on field core samples which are quite close to laboratory investigations at low confining and deviatoric stresses. However, there is a need to incorporate confining and deviatoric stresses and moisture content and dry density properties into the existing empirical correlations to make the correlations more practical. Correlations in the form of bulk and deviatoric stress model constants are developed for the soils tested in this study.

## RECOMMENDATIONS

Future research in this area should attempt to cover a wider range of the different soil types in Louisiana subgrades and provide ranges of resilient modulus values for those soils at various moisture contents and dry density levels. The AASHTO recommended T-294 procedure needs to be used in the testing phase. Any such study should address the influences of soil grain size and shapes, moisture-density relations, specimen preparation procedures, and testing stresses on the resilient modulus values.



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