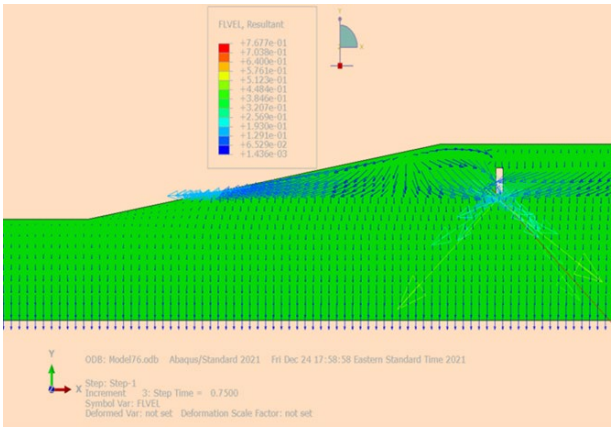
TN TDOT Department of Transportation

Research Summary

Evaluating Roadway Subsurface Drainage Practices



Project Number:
RES2019-18

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Structures

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WHAT WAS THE RESEARCH NEED?

Poor subsurface drainability causes an accumulation of water within the aggregate base, reducing its strength. In many road sections, the aggregate material used for the base is obtained from local sources, while the in-situ soils are used for the subgrade. However, these in-situ soils and local materials are often insufficiently characterized in terms of drainability and may not satisfy the drainage needs at a site. This is particularly important in Tennessee, where the state has large land use, topography, and geology variability.

WHAT WERE THE RESEARCH OBJECTIVES?

This project addresses the following four objectives:

1) Identify critical areas in Tennessee that are prone to poor drainage.
2) Assess the performance of different drainage designs for critical areas in Tennessee with a drainage calculator.
3) Evaluate the performance of roadway designs, considering rainfall penetration through pavement joints and cracks, as well as lateral seepage from ditches.
4) Develop nomographs for roadway design considering rainfall, hydropedological properties, Time to Drain, and pavement integrity.

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WHAT WAS THE RESEARCH APPROACH?

The research team conducted a comprehensive review of subgrade soils in Tennessee to identify areas exhibiting inefficient drainage, followed by an evaluation of the drainage for roadway designs in the state. Four different roadway surfaces, two types of aggregate bases, and three subgrade soils were selected. Saturated hydraulic conductivity was quantified via falling head tests and the pavement roughness condition was correlated to different hydropedological properties. Three sets of 72 simulations were conducted using a simple drainage calculator of two layers. Detailed simulations with the Finite Element Method software, ABAQUS, were also performed to examine drainage of a whole pavement-aggregate-soil structure under a rainfall event. The relationship between saturation and permeability of base/soil was deduced from the results and the influence of pavement dimensions. Laboratory experiments were conducted in a vertical column that included a surface pavement layer, an aggregate base, and a subgrade soil to verify the model results. Based on the relationship between the base saturation and base/subgrade hydraulic conductivity, and the influence of pavement dimensions, a nomograph was developed to assess the compatibility of base and subgrade materials and pavement structural characteristics in ensuring the drainability of pavement.

WHAT WERE THE FINDINGS?

Key findings include:

- Subgrade soil is the most important characteristic influencing pavement drainability.
- Pavement drainability is influenced by the combination of base and subgrade material.
- Based on the regressed equations concerning 2h drainage saturation, it is found that the TDOT base and subgrade materials can sometimes cause the drainability of pavement below the 2h-50% draining standard.
- The most vulnerable part of pavement during rainfall is the shoulder because the middle part of pavement is protected by surface structure. Rainfall entering through cracks or joints had limited effects on saturation levels.
- Based on the regressed equation concerning saturation during heavy rainfall, it is found that TDOT base and subgrade materials rarely cause fully saturated pavements.

IMPLEMENTATION AT TDOT

The research team recommends the following to TDOT:

- If K_{soil} is too small (e.g., less than 0.00225 m/hr), chert is not recommended as the base material because of its low permeability.
- Aggregate base materials with a permeability large enough (e.g., larger than 44 m/hr) can be used with any subgrade soil type in Tennessee and still provide sufficient roadway drainage.
- It is recommended to check the compatibility of base and subgrade materials and pavement structural characteristics using the nomograph to ensure the drainability of pavement.
- A comprehensive assessment should be done for any target pavement section, including quantitative assessment, qualitative assessment, and abnormity assessment.

MORE INFORMATION

Find the final report here: https://www.tn.gov/content/dam/tn/tdot/long-range-planning/research/final-reports/res2019-final-reports/RES2019-18_Final_Report_Approved.pdf.

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