Evaluation of Drainable Bases under Asphalt Pavements

Problem
Providing adequate drainage to a pavement system has been an important design consideration, as evidenced by recent NCHRP Synthesis 239 report, AASHTO Guide for the Design of Pavement Structures (1998), and FHWA Pavement Management and Design Policy (1992), among others. Even for a jointless asphalt pavement, water can get into base, subbase, and subgrade due to cracks on pavement surface, infiltration through shoulders and surfaces, infiltration from side ditches, and high ground water capillary action. To remove the water from the pavement system, the current trend is to use the subsurface drainage by providing open graded drainable base (either unbound or bound), sub-drainage system, and edge drains. The drainage layer, however, must be designed with an optimal combination of thickness and horizontal permeability, while maintaining adequate strength and stiffness to support pavement layers. There is a need to quantify the mechanical and hydraulic conductivity characteristics of various types of drainable base materials so that proper design of the layer thickness can be carried out by pavement engineers. Ohio Department of Transportation has adopted several types of drainable base materials specifications, including (a) ODOT 307 with IA, NJ, and CE gradation variations, (b) ODOT 308
Asphalt Treated Base, and (c) ODOT 306 Cement Treated Base. Due to findings on the effectiveness of ODOT specific drainable base materials from several pavement instrumentation sites, such as DEL-23 and LOG-33, ODOT has imposed a moratorium to stop using the drainable base in all current and future pavement construction projects. This moratorium will be in effect until such time that the life cycle cost benefits of the drainable base can be established. In the mean time, there are numerous other states that continue the use of drainable base in their pavement projects. ODOT has commissioned this research project, involving the use of laboratory testing on ODOT specific drainable base materials, field monitoring of environmental parameters (e.g., moisture, temperature, and frost penetration depth) at the newly constructed pavement at I-90, Ashtabula County, and non-destructive performance evaluation of constructed pavement under service conditions (e.g., FWD and Surface Profile Measurement). The synthesis of the findings from this research project will provide ODOT pavement engineers additional data to re-assess the moratorium concerning the banning of the use of ODOT specific drainable base materials.

**Objectives**

The main objective of this research is to assess the effectiveness of the drainable base materials based on laboratory investigation of the mechanical and hydraulic conductivity characteristics of various ODOT specific drainable base materials (ODOT 307 series, ODOT 306, and ODOT 308) as well as synthesis of long-term field performance monitoring data (i.e., moisture, temperature, frost depth) and non-destructive testing data (i.e., FWD and Pavement Profile Measurement) of these drainable base materials under in-service conditions.

**Description**

The research approach is divided into interrelated laboratory and field work. In the laboratory study, the hydraulic conductivity of ODOT specific drainable base materials and cohesive subgrade soils at the project site was evaluated using a horizontal permeameter device and a flexible wall permeameter, respectively. The structural stability of these materials was evaluated based on the characteristics of the resilient modulus, permanent deformation, and Mohr-Coulomb strength parameters. In addition, the influencing factors, such as temperature, confining pressure, freeze/thaw cycles, moisture content, gradation, and degree of saturation, were varied in the test specimens to further distinguish the variations of these stability-related mechanical properties.

The field work involves planning and carrying out an instrumentation program at the I-90 project sites (ATB.90.0.0 and ATB.90.19.56). The installed instrumentation sensors include TDR for moisture measurement, thermisters for temperature measurement, and resistivity based frost depth measuring device. Two weather stations were installed at the sites to record climatic data. The installed sensors were recorded and monitored from the beginning of the construction to the present time, providing quantitative data on moisture variations, temperature profiles, and frost penetration depth in base and subgrade, while the ambient temperature, precipitation data, wind speed and wind direction were also recorded.

Non-destructive testing using FWD techniques were conducted during
construction of each pavement layer and twice a year after the pavement was open to traffic. In addition, the international roughness index of the in-service pavement surface was monitored on a periodic basis.

A synthesis of quantitative data from laboratory tests, field monitoring, and non-destructive testing was conducted to obtain an evaluation of the effectiveness of the ODOT specific drainable base materials.

Conclusions & Recommendations

There was no evidence of full saturation in the subgrade soils at Site II, except for the ODOT 304 section where the soil remained saturated for a period of 127 days.

Based on field moisture monitoring results and laboratory permeability test results, the drainage efficiency of various ODOT specific drainable base materials can be grouped into three categories: (a) ODOT 306 Cement Treated base (25345 ft/day) and ODOT 308 Asphalt Treated base (25061 ft/day), (b) ODOT 307 NJ median gradation (3824 ft/day), ODOT 307 CE median gradation (3703 ft/day), and ODOT 307 IA median gradation (2277 ft/day), and (c) ODOT 304 medium gradation (1417 ft/day). The ODOT 304 with 15% fines has been found to have a permeability value less than adequate for effective drainable base materials.

The cement treated base exhibits the highest resilient modulus values, even after 15 cycles of freeze/thaw conditioning. With high durability resistance to freeze and thaw cycles, the cement treated base materials can be used as an attractive drainage base material for asphalt pavement.

The resistance to permanent deformation of various ODOT specific drainable base materials can be ranked from high to low as follows: ODOT 306 (cement-treated base), ODOT 307 CE, ODOT 307 IA, ODOT 304, ODOT 307 NJ, ODOT 308 (asphalt treated base) at 77 degree F, and ODOT 308 at 104 degree F. The asphalt treated base materials are highly susceptible to rutting if the temperature is high.

The ability of ODOT 308 (asphalt treated base material) to resisting water induced damage was marginal. The use of asphalt treated base materials should be re-evaluated due to durability concerns.

Implementation Potential

ODOT may consider modifying the ODOT 304 gradation requirement for use as drainable base material in pavement construction. One way to improve ODOT 304 performance as a drainable base layer for asphalt pavement is to limit the amount of fines allowed in materials.

The ODOT specific cement-treated base material can be used effectively as a base layer underneath the asphalt pavement. The high strength and stiffness values of the cement treated base materials may allow for reducing asphalt concrete layer thickness.

ODOT may need to re-assess the use of asphalt treated base materials due to the issues regarding the propensity for moisture induced damage and high rutting potential at high temperature. Potential solutions may include the use of better performance grade binder, and the change of the mix design.