ABSTRACT

At the present time, the computer program DRIP has been used as a numerical analysis tool for design of subsurface drainage in a pavement system. The SEEP/W program, however, provides an alternative analysis tool for transient water flow analysis that can take into account the variation of hydraulic conductivity with water content of unbound base materials, geometry and dimension of a pavement section, and the use of subsurface drainage pipes. This paper presents the results of a comprehensive parametric study of representative pavement subsurface drainage system using two-dimensional SEEP/W program. The parameters studied include the base hydraulic conductivity, subbase hydraulic conductivity, base layer thickness, pavement cross-slope, drainage length, base D_{60} gradation, and the location of edge drain. A statistically derived regression equation together with design charts are presented for estimating time to drain 50% of free water in a pavement system. Observations based on parametric analysis results and comparisons between DRIP analysis and SEEP/W analysis are provided for facilitate effective subsurface drainage design. Although saturated hydraulic conductivity of base material is an important factor, other factors such as Soil-Water Characteristic Curve (SWCC), variation of hydraulic conductivity with water content (degree of saturation), pavement geometry and dimensions, use of subsurface drainage pipes are also important in controlling the effectiveness of a pavement subsurface drainage system.

INTRODUCTION

It has been recognized by experts such as Cedergren (1) that premature structural and functional pavement failures can often be related to the length of time that excess moisture remains in the pavement system. The longer the duration is, the more pronounced water-induced pavement damage could be. Water-related problems in flexible pavement include reduction in strength of unbound base, subbase, and subgrade soils, stripping of asphalt pavement, shrinkage and swelling of subgrade materials, and frost heave and reduction of subgrade strength during the thaw period. Thus, providing adequate subsurface drainage in a pavement system to remove the infiltrated moisture in a timely manner is an important design consideration. This is also supported by numerous researches on the importance of providing and maintaining positive drainage system within a pavement system. For example, Frosyth et al. (2) stated that if the infiltrated water can be drained quickly, the pavement life can be extended by 33 percent for the flexible pavement systems and 50 percent for the rigid pavement systems. Cedergren (3) reported that a pavement system with a good drainage system could last two to three times longer than those without a drainage system. Christopher and McGuffey (4) estimated that free excess water can lead to reduction of the life expectancy of a pavement system by more than half. The importance of designing an effective drainage system in a pavement was fully acknowledged by AASHTO Guide for Design of Pavement Structure (AASHTO, 5) by incorporating the drainage factors in their design. The newly developed Mechanistic-Empirical Pavement Design Guide (MEPDG, 6) accounts for drainage through the use of the FHWA microcomputer program (DRIP, 7).

Most of the time, the water flow near the pavement surface occurs under unsaturated (or partially saturated) conditions where the hydraulic conductivity of the soils is not a constant value, but a function of the soil water content (Stormont and Zhou, 9). Recently, Liang (10) reported that most of the time the monitored flexible pavement sections had water content less than the ones corresponding to the full saturation. According to Philip (11), the amount of the infiltrated water is a function of materials permeability, gravity forces, and soil matric suction. In