01_Design and anlaysis of BP under heavy loading

Performance of Different Types of Permeable Concrete Block Pavements in Accelerated Testing

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Abstract :

Permeable concrete block pavements (PCBPs) are getting attention worldwide mostly due to environmental benefits. With growing implementation of PCBPs with increased traffic loading and changing climatic conditions, it is necessary to develop guidelines for construction of such pavement structures. In this study, the performances of several types of PCBPs were investigated in accelerated pavement tests employing a heavy vehicle simulator (HVS). The development of rutting on the surface after a certain amountof load applications were compared. The impact of moisture on the performance was also investigated by raising the water table during the tests. Based on these comparisons, the existing design table for concrete block pavements in Sweden was modified to adopt for the different PCBP structures. The analyses were carried out using the pavement design software PMS Objekt, developed by the National Road Administration in Sweden. In this paper, the results from the HVS tests and the methodology used for the development of design tables for the PCBPs are summarized.

Key Words : Permeable concrete block pavements; heavy vehicle simulator; rutting; design tables; moisture

1. Introduction

Increased urbanization is leading to increased impervious land surface which adversely affects the growth of trees and vegetation and local climate. Furthermore, the increased proportion of paved surface generates increased surface run off that often overloads the existing sewerage system resulting in floods. One approach to mitigate these issues is to build permeable pavement systems that can effectively drain out storm water, retain water and help growing of trees and vegetation while maintaining their demand on structural performance [1, 2, 3].

Permeable pavements can be of different types depending on their functions and local conditions. Permeable concrete block pavements (PCBPs) are getting increased attention in Sweden where they are mostly used in parking lots and other low trafficked areas. In many cases, the structures must handle large and repeated loads such as bus traffic, cleaning machines and truck traffic. These are required to improve climate on-site and manage climate change while being functional, sustainable and inexpensive in operation. This places great demands on materials, design and execution.

This article illustrates the relative performances of a few different types of PCBPs as well as some reference structures. Based on this study, design tables for these types of structures for Swedish conditions were proposed. The methodology used for developing the design tables is briefly discussed here.

the structures tested. Further details of the methodology and the test structures can be found in [4, 5].

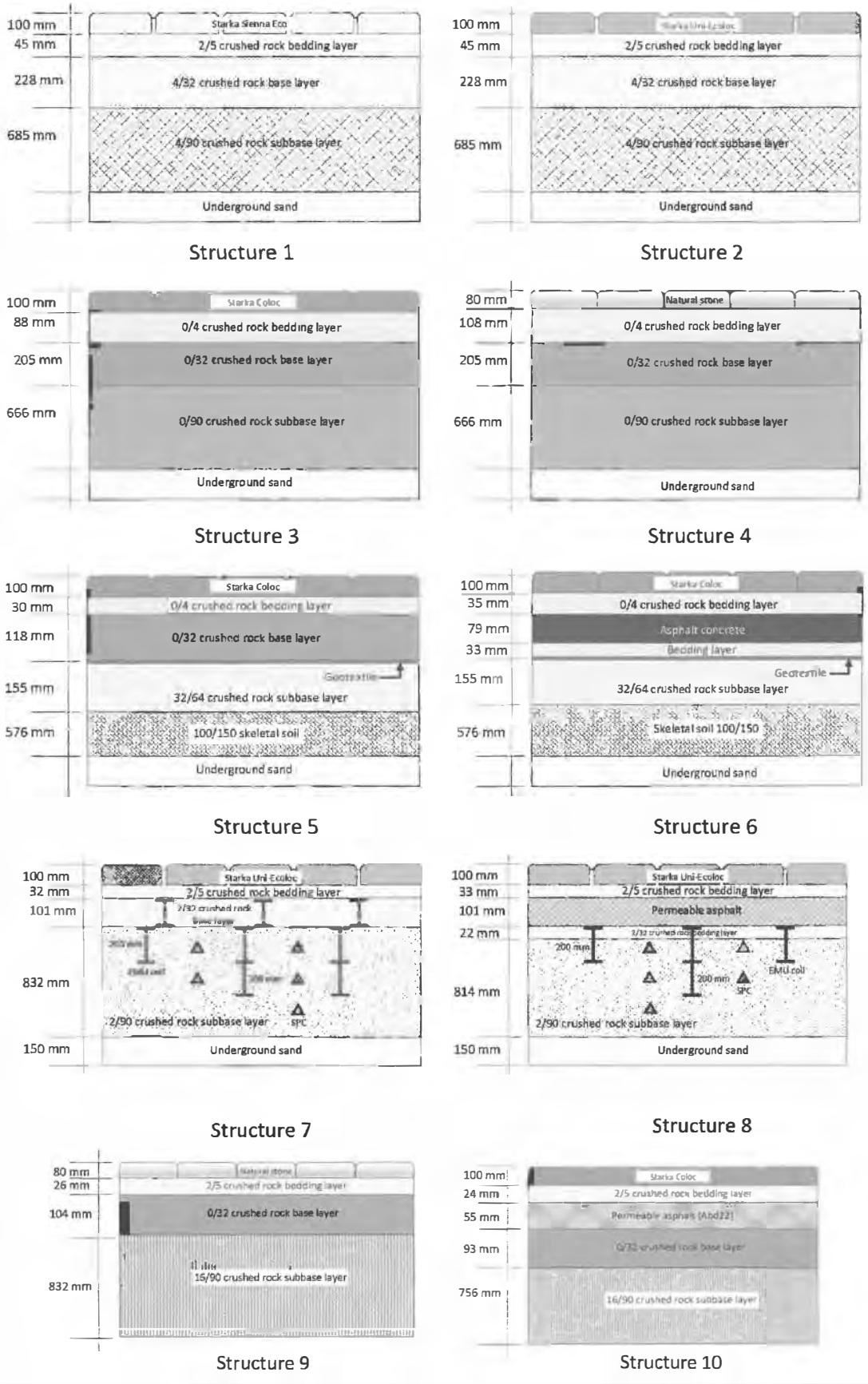

Figure 1. Figure 1. Schematic of the test structures.

3. Result and Discussions

The resulting rut depths of the structures are plotted in Figure 2. Here, the number of wheel passes were converted to equivalent standard axle loads (ESALs) of 100 kN. It can be observed that structure 8 with a permeable asphalt layer showed the best resistance against rutting. On the other hand, structures 1, 2 and 5 were the most prone to develop rutting. These structures consisted of relatively coarser unbound layers all through. The other structures (3, 4, 6, 7, 9, 10) showed average rutting performance. The performances of the structures were compared with that of Structure 3 which was a standard non-permeable structure. Even though structure 6 contained an asphalt concrete layer, it showed lower resistance against rutting compared to the most other structures probably because of the skeletal soil and coarser unbound layer. The impact of increased water table (after about 625ESALs) is visible for structures 7, 8, 9 and 10 when the groundwater table was up to half of the subbase layer. For structures 9 and 10, the impact is also visible where the groundwater table was 30 cm below the surface of the subgrade (after 200000 ESALs). However, the tests were not conducted for the same number of ESALs for all the structures.

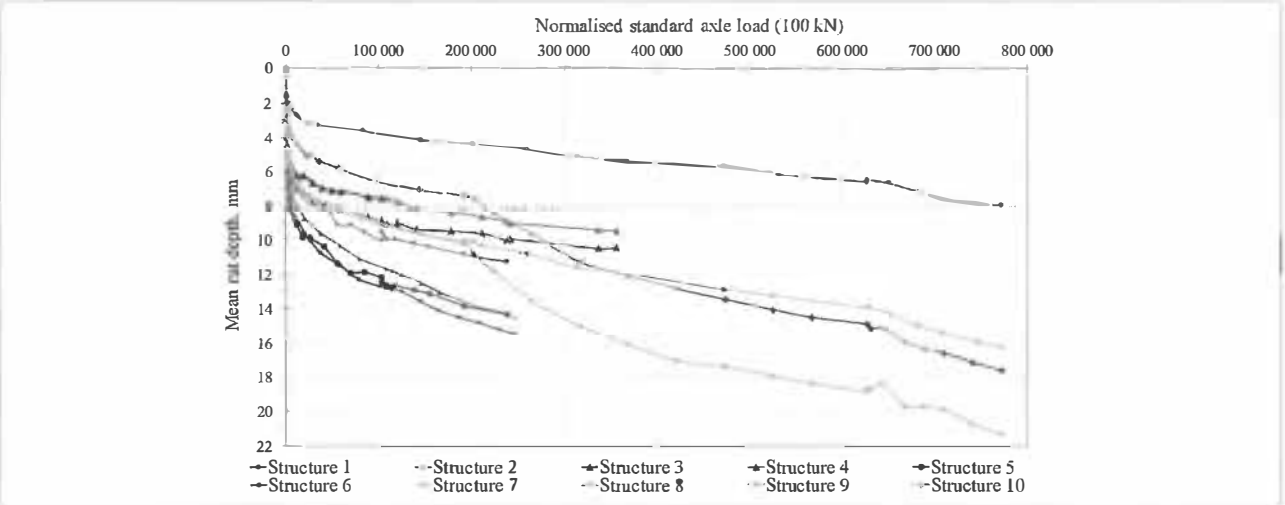

Figure 2. Development of rutting in different structure as functions of ESALs.

4. Development of Design Tables

The existing design table [5] for standard concrete block pavement structures was modified by comparing the performance of the different kinds of structures in HVS test to that of the standard structure (structure 3). The objective was to yield the same rutting performance as the standard structure (structure 3) from the permeable structures. In PMS Objekt, assuming the material properties of the different layers based on laboratory testing and literature, the subbase layer thickness required for ESALs corresponding to 12 mm rut depth (Figure 2) for the standard structure was calculated. Thereafter, the subbase layer thickness required for the structure in question was calculated to support the same ESALs. Then the percentage difference in the subbase layer thickness was applied to the existing design table to obtain the design table for the structure in question. In some cases, it was necessary to extrapolate the data for which linear extrapolation method was chosen. The design tables can be found in [5]. The schematic of the methodology used to develop the design tables is shown in Figure 3.

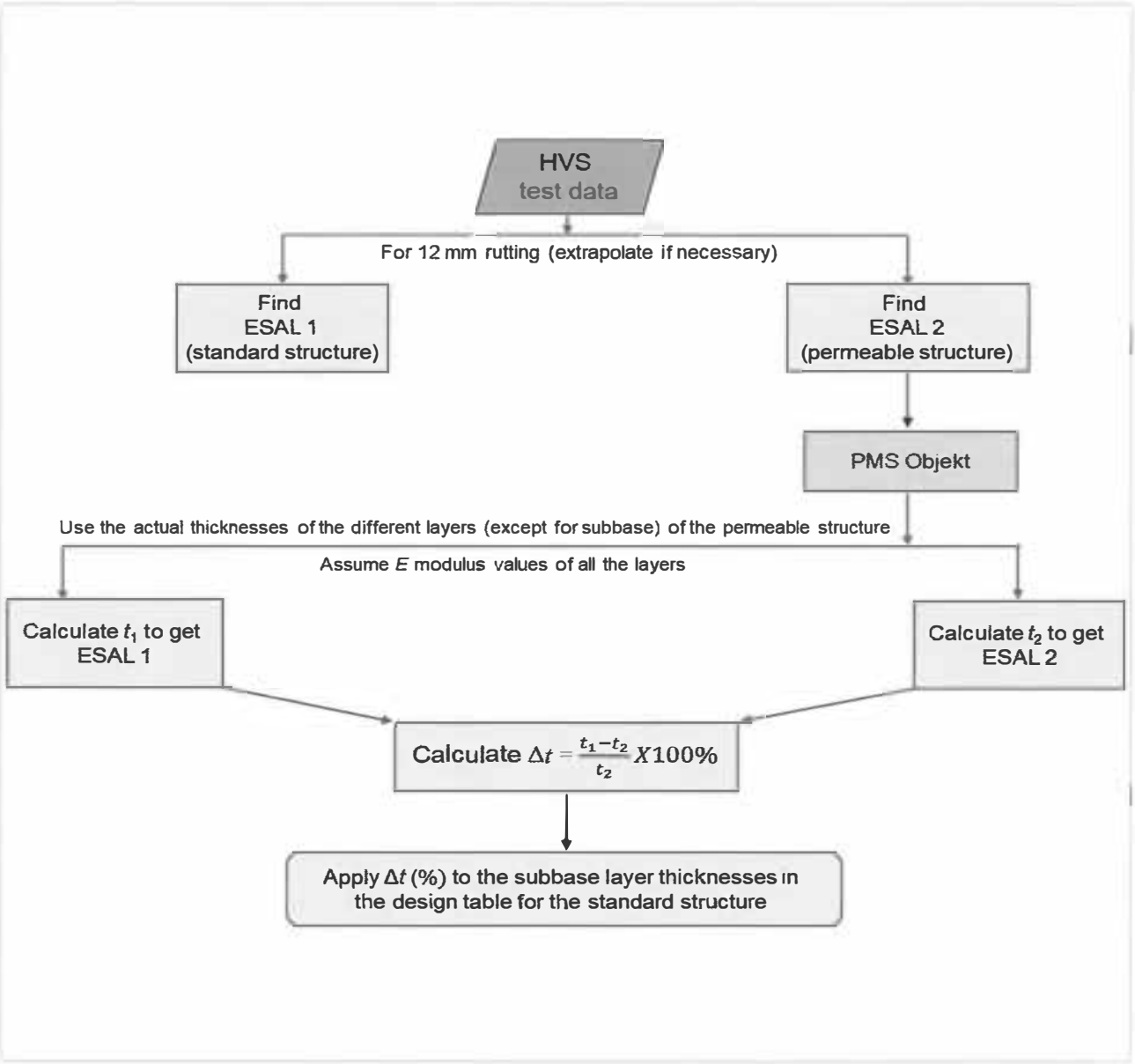

Figure 3. Methodology adopted for developing the design tables.

5. Conclusions

The rutting performances of a few different types of concrete block pavements were investigated in accelerated testing conditions. It was observed that most of the structures exhibited performance close to that of the standard structure. The structures that performed worse than the standard structure consisted of relatively coarser unbound layers all through. Based on the relative performances, design tables were developed for these structures. The underlying assumption was that the existing design table for the standard construction may be modified based on their comparative performance employing a pavement design software. Thesedesign tables may act as guidelines for designing similar pavement structures bearing in mind the empirical nature of the adopted methodology. Since there are a few uncertainties and assumptions involved in the process of the construction of the test structures and in the theoretical development of the design tables, some of the design tables for a few structures may be more reliable than the others. It should be noted that hydraulic and water storage design was not considered in this study.

References

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