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REPORT

VISCOELASTIC PAVEMENT ANALYSIS USING VEROAD

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ABSTRACT

The considerable expenditures needed to construct, maintain and rehabilitate pavement structures have made it increasingly necessary to utilise the best available resources in an optimal way. During recent decades, intensified pavement deterioration has been observed. However, some of the most frequently observed distress types of distress can neither be explained nor accounted for by conventional design procedures. Consequently, there is a continuous requirement for more advanced pavement design methods that can take into account other aspects such as actual material properties, traffic loads, climate conditions and observed types of distress.

This doctoral thesis focuses on viscoelastic analysis of flexible pavements using a linear viscoelastic multilayer program, VEROAD, together with COMPASS, an integrated mix/pavement design procedure. In the VEROAD/COMPASS approach, unlike conventional design approaches based on linear elastic theory, the materials are characterised as linear viscoelastic and the traffic load as moving. Furthermore, the mechanical properties of the mixes and the characteristics of the pavement structure are used collaterally in the calculations. Different aspects of the VEROAD/COMPASS design approach studied are described in six papers and summarised below.

Papers I and II describe the theory, validation and application of the linear viscoelastic multilayer program VEROAD. In VEROAD, Fourier transformation is used to eliminate time dependency using the correspondence principle. In the frequency domain, the elastic problem is solved at each frequency using the Burmister method. The frequency-dependent responses obtained are inversely transformed back to the time domain. The validation of VEROAD was performed by comparing calculated strain curves (longitudinal and transversal) with measured strain curves obtained in two full-scale pavement tests. Good agreement was demonstrated between strain curves calculated with VEROAD and measured strain curves. Possible practical field applications were discussed.

Paper III describes the framework of COMPASS. Required input data and material parameters are presented, together with a performance prediction analysis. A typical pavement structure was analysed in order to demonstrate the practical relevance of COMPASS. It was indicated that this design procedure provides a valuable tool for the functional evaluation of mixes and their performance in pavement structures. Furthermore, the results presented show that this viscoelastic approach also provides new and useful information regarding the performance of a pavement structure subjected to a moving load.

In Paper IV, the influence of two different rheological models (Burgers and Huet-Sayegh) on predicted pavement responses in flexible pavements was compared and analysed. A bituminous mix was extensively tested and the capability of the models to describe material behaviour was evaluated. It was found that the Burgers model satisfactorily described the material within a limited frequency range, whereas an excellent fit was obtained for all measured values using the Huet-Sayegh model. In

fact, a comparison between the calculated pavement responses obtained with the two models indicated differences in the outcome depending on the prevailing conditions. The difference is a consequence of the discrepancy between the frequency content used by VEROAD describing the load and the frequency range well described by the Burgers model. If these frequency ranges agree, only minor differences occur.

The purpose of Paper V was to evaluate the ability of the VEROAD/COMPASS design procedure to demonstrate the influence of a production-related factor (degree of compaction) on calculated pavement responses. A typical base course mix at four different degrees of compaction was analysed, and the input parameters required for the design procedure were determined. The analysis of a given pavement structure indicated that the design procedure applied is useful in evaluating different mixes and their behaviour in a pavement structure.

Finally, Paper VI demonstrates the practical application of the viscoelastic approach to flexible pavement design. Appropriate input parameters were characterised for five different mixes ranging from a high-performance modified mix to an unsatisfactorily compacted low-performance mix. A typical heavy duty pavement structure was used as reference structure. Six different versions of this structure (with different arrangements of the bituminous layers) were analysed, and the practical applicability of the viscoelastic approach was shown. In conjunction with the COMPASS design procedure, VEROAD enables a more realistic modelling of flexible pavement responses and facilitates the evaluation of new materials as well as new loading conditions in connection with pavement design.

KEYWORDS:

Flexible pavement design, viscoelastic response model, mechanical behaviour, rheological model, pavement performance, pavement evaluation, complex modulus, phase angle, VEROAD, COMPASS.

TABLE OF CONTENTS