BEHAVIOUR OF CEMENTITIOUS SUBBASE LAYERS IN BITUMEN BASE ROAD STRUCTURES

BY

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SUMMARY

The process of designing cementitious layers (weakly and strongly cemented) against fatigue distress in road structures is well accepted. Research and field investigations with the aid of the Heavy Vehicle Simulator (HVS) revealed, however, that almost all weakly cemented subbase layers undergo non-traffic and traffic-associated cracking and eventually degradation of the cemented material into a granular state (postcracked phase). It is therefore very important to analyse these layers in the postcracked phase and to incorporate the results of this analysis in the design, for both new and rehabilitation designs. The investigations revealed that the rate of degradation of these materials is largely dependent on traffic loading and the moisture conditions within the pavement layers.

The purpose of this study is to investigate the behaviour of weakly cemented subbase layers in road structures mainly under a bitumen base between 90 mm and 140 mm thick. This behaviour includes both precracked and postcracked phases. It is shown that the fatigue life of bitumen base layers is mainly governed by the condition of the weakly cemented subbase layers.

In Chapter 1 a brief historical review is given of the development of fatigue distress criteria of the cementitious layers. It is shown that the maximum horizontal tensile strain at the bottom of these layers is the main distress criterion in the precracked phase. Unconfined compressive strength and durability requirements are also discussed.

Some aspects of the current design methods are outlined in Chapter 2. The concept of equivalent granular states in the post-cracked phase of cementitious layers was derived from HVS test findings. However, before this document no behavioural prediction models were available to quantify accurately the postcracked state of these layers. The actual mechanisms of distress were also not clear.

In Chapter 3, a detailed investigations and analysis of ten different HVS tests at four different sites in Natal are discussed. The purpose of the analysis, is firstly to illustrate the powerful method of full-scale accelerated HVS-type testing and secondly to indicate the importance of the upper subbase layer, the initial condition of the in-situ structure, the importance of water conditions within the pavement structure, and finally the different states of behaviour of this type of road structure, including predictions of future behaviour based on linear elastic theory. The characteristics of the weakly cemented upper subbase layer are shown to be of paramount importance in the final behaviour of these structures.

In Chapter 4 a method of analysing the behaviour of mainly weakly cemented layers in the postcracked phase is proposed. This method arises from the HVS testing discussed in Chapter 3, and may be regarded as the most important improvement on the current method discussed in Chapter 2. The analysis incorporates the determination of the effective elastic moduli of weakly cemented subbase layers, including both the wet and the dry periods during the structural design period of these layers.

In Chapter 5 the effect of relatively weak interlayers within asphalt base structures is discussed and evaluated. The analysis incorporates the relative position and thickness of the interlayer during both wet (low modulus) and dry (high modulus) conditions.

A summary and detailed discussion, together with recommendations for future research, are given in Chapter 6. The need for the incorporation of durability (erodibility) criteria for weakly cemented materials is also discussed. More research should be done on the effects of accelerated curing compared with normal curing methods. This investigation includes aspects of soil-lime-cement reactions together with delayed compaction techniques to reduce shrinkage cracking. The need for better quality control as well as improved construction techniques for weakly cemented materials is also discussed.

This thesis also contains two appendices. In the first of these detailed photographic records of the different HVS tests and performances are given. In the second appendix an example of an input computer program to plot the three dimensional behavioural model is given.

OPSOMMING

Die proses om sementerende lae (swak- en sterkgesementeerd) teen verswakking vanweë vermoeiing in padstrukture, te ontwerp, is allerweë goed.

Veldondersoeke en navorsing wat met behulp van die Swaarvoertuigna-bootser (SVN) uitgevoer is, het egter aangetoon dat byna alle swakgesementeerde stutlae kraakvorming ondergaan wat aan nie-verkeersverwante en verkeersverwante invloed te wyte is en gevolglik aanleiding gee tot die degradering (afbreking) van die gesementeerde materiaal tot 'n korrelrige materiaal (nakraakfase). Dit is dus baie belangrik om hierdie lae tydens die nakraakfase te ontleed en in die ontwerp vir sowel nuwe as vernuwingsontwerpe, in te sluit. Die ondersoeke het getoon dat die tempo van degradering van hierdie materiale in 'n groot mate afhanklik is van die verkeersbelasting en die vogtoestande in die plaveisel.

Die doel van hierdie studie is om ondersoek in te stel na die gedrag van die swakgesementeerde stutlae in padstrukture, onder hoofsaaklik 'n bitumenkroonlaag wat tussen 90 mm en 140 mm dik is. Hierdie gedrag sluit die voor- sowel as nakraakfase van die swakgesementeerde stutlae in.

In Hoofstuk 1 word 'n bondige historiese oorsig gegee van die ontwikkeling kriteria vir verswakking vanweë vermoeiing vir gesementeerde lae. Daar word aangetoon dat die belangrikste verswakkingskriterion in die voorkraakfase van hierdie lae die maksimum horisontale trekvervorming op die bodem van die laag is. Onbegrensde druksterkte en duursaamheidsvereistes word ook bespreek.

Sekere aspekte van die huidige ontwerpmetodes word in breë trekke in Hoofstuk 2 bespreek. Die konsep var ekwivalente korrelrige toestande in die nakraakfase van sementerende lae is uit SVN-toetsresultate afgelei. Daar bestaan egter geen vroeëre gedragsvoorspellingsmodelle wat die nakraaktoestand van hierdie lae akkuraat kan kwantifiseer nie. Die werklike verswakkingsmeganismes was ook nie duidelik nie.

In Hoofstuk 3 word 'n gedetailleerde ondersoek en ontleding van tien verskillende SVN-toetse wat op vier verskillende terreine in Natal uitgevoer is, bespreek. Die doel van die ontleding is eerstens om die kragtige metode van volskaalse versnelde SVN-tipe toetswerk aan te toon; tweedens om die belangrikheid van die boonste stutlaag, die aanvanklike toestand van die in situ-struktuur, die invloed van watertoestand in die plaveisel en laastens die verskillende gedragstoestande van hierdie tipe padstruktuur tesame met toekomstige gedragsvoorspelling gebaseer op die linieêre elastisiteitsteorie, aan te toon. Daar word aangetoon dat die eienskappe van die swakgesementeerde boonste stutlaag van pertinente belang is in die finale gedrag van hierdie strukture.

'n Metode om die gedrag van hoofsaaklik swakgesementeerde lae in die nakraakfase te ontleed, word in Hoofstuk 4 voorgestel. Hierdie metode spruit voort uit die SVN-toetswerk wat in Hoofstuk 3 bespreek is, en kan beskou word as die mees belangrikste verbetering aan die huidige metode wat in Hoofstuk 2 bespreek word. Die ontledings sluit hoofsaaklik bepaling van die effektiewe elastisiteitsmoduli van swakgesementeerde stutlae in met inbegrip van sowel die nat as droë periodes gedurende die beplande struktuurgebruiksduur van hierdie lae.

In Hoofstuk 5 word die effek van relatief swak tussenlae in asphaltkroonlaagstrukture bespreek en geëvalueer. Die ontleding sluit die relatiewe posisie en dikte van die tussenlaag gedurende die nat (lae modulus) sowel as die droë (hoë modulus) toestand in.

'n Opsomming en gedetailleerde bespreking, tesame met aanbevelings vir toekomstige navorsing, word in Hoofstuk 6 aangegee. Die behoefte vir die insluiting van duursaamheidskriteria (erodeerbaarheid) vir swakgesementeerde materiale word ook bespreek. Meer navorsing behoort ook gedoen te word op die uitwerkings van versnelde nabehandeling in vergelyking met normale nabehandelingsmetodes. Hierdie ondersoek sluit aspekte in oor grond-kalk-sementreaksies tesame met vertraagde verdigtingsmetodes om krimpingskrake te verminder. Die behoefte aan beter gehaltebeheer asook verbeterde konstruksietegnieke vir swakgesementeerde materiale word ook bespreek.

Hierdie proefskrif bevat ook twee bylaes. In die eerste bylae word omvattende fotografiese verslae van die verskillende SVN-toetse en -werkverrigting gegee. In die tweede bylae word 'n voorbeeld gegee van 'n rekenaarinvoerprogram waarmee die driedimensionele gedragsmodel gestip kan word.

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CONCEPTS ARE UNLIMITED
CONCEPTS ARE IMPRESSIVE
BUT ITS ONLY DATA THAT WORKS!

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