# MODELLING AGGREGATE INTERLOCK LOAD TRANSFER AT CONCRETE PAVEMENT JOINTS

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# THESIS SUMMARY

## MODELLING AGGREGATE INTERLOCK LOAD TRANSFER AT CONCRETE PAVEMENT JOINTS

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**Supervisor:** Prof Emile Horak

**Co-Supervisor:** Prof Alex Visser

**Department:** Civil Engineering

**University:** University of Pretoria

**Degree:** Philosophiae Doctor (Engineering)

The South African concrete pavement community recognized the need to upgrade the South African Concrete Pavement Design and Construction Manual, to a manual based on mechanistic design principles. During a re-evaluation of factors affecting riding quality, structural service life, maintenance and rehabilitation needs, the prominent influence of joint performance in jointed concrete pavements (JCP) was re-confirmed. It was identified that the analytical equation used in the manual to predict relative movement at joints was only applicable to a small range of aggregate sizes. Further research was therefore needed, which resulted in the study presented in this thesis.

The primary objective of this research was to evaluate pavement response in terms of deflections, to static and moving impulse or dynamic loads (equivalent to traffic loads), and to take into account existing methods for modelling aggregate interlock shear transfer. This was in order to develop a fundamental model that reflects variations in joint load transfer with joint opening, load magnitude and concrete properties to replace an existing equation in the new South African mechanistic concrete pavement design manual. In the context of this thesis, modelling can be defined as the execution of pre-planned tests in a laboratory under controlled conditions using materials commonly used in the construction of concrete pavements in South Africa in order to develop an equation simulating performance in the field.

Theoretical analyses of concrete pavement models were first done by the author using the three-dimensional finite element computer software programme EverFE. This was in order to determine the ranges for the

different input variables that could be expected during modelling in the laboratory. Both aggregate interlock and dowel/concrete interaction were evaluated using EverFE.

The focus of subsequent laboratory testing was to measure relevant responses during testing of instrumented concrete pavement models. Instrumentation included load cells, actuators, linear variable displacement transducers, as well as horizontal strain displacement transducers to collect fast responses induced by dynamic loads. Thermocouples collected further information on the influence of environmental temperature. The preliminary testing also included determining the relevant engineering properties for the typical South African aggregates used in the study.

The laboratory concrete pavement test sections were constructed on rubber mats to simulate a Winkler foundation. Constructing the models on rubber mats made it possible to repeat experiments with the same founding conditions, which reduced the number of variables that had to be taken into consideration during analysis of the data.

Conclusions reached from the study were inter alia that there was no significant deterioration of the crack face during the application of up to two million dynamic load cycles, which indicated that little abrasion took place at the initial crack width. It also indicated that fatigue of the aggregates at the joint face did not play a significant role, which could be attributed to the high quality of the crushed stone used in South Africa, as well as to the fact that testing was conducted inside the controlled environment of a laboratory. Moment and inertia in the slab contributed to greater load transfer efficiency under dynamic loading, than under static loading.

A specific relationship determined from laboratory results was used to refine the aggregate interlock load transfer model in the software developed for the new mechanistic design manual. Data from field investigations of in service concrete pavements in southern Africa was used to calibrate the laboratory data.

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# ABSTRACT

**Title:** Modelling Aggregate Interlock Load Transfer at Concrete Pavement Joints

**Author:** Anna-Carin Brink

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**Keywords:** Aggregate interlock, Load transfer efficiency, Jointed concrete pavement, Winkler foundation, Dynamic and static loading, Relative movement.

The South African concrete pavement fraternity recognized the need to upgrade the South African Concrete Pavement Design and Construction Manual, to a manual based on mechanistic design principles. During a re-evaluation of factors affecting riding quality, structural service life, maintenance and rehabilitation needs, the prominent influence of joint performance was re-confirmed. Further research was needed to enable modelling of aggregate interlock load transfer at concrete pavement joints, which resulted in the study presented in this thesis.

The primary objective of this research was to evaluate pavement response in terms of deflections, to static and moving impulse or dynamic loads (equivalent to traffic loads), and to take into account existing methods for modelling aggregate interlock shear transfer (In the context of this thesis, modelling can be defined as the execution of pre-planned tests in a laboratory under controlled conditions using materials commonly used in the construction of concrete pavements in South Africa in order to develop an equation simulating performance in the field). This was in order to develop a fundamental model that reflects variations in joint load transfer with joint opening, load magnitude and concrete properties to replace an existing equation in the new South African mechanistic concrete pavement design manual.

During modelling the focus was to measure relevant responses during testing of instrumented concrete pavement models. Instrumentation included load cells, actuators, linear variable displacement transducers, as well as horizontal strain displacement transducers to collect fast responses induced by dynamic loads. Thermocouples collected further information on environmental influences. The preliminary testing also

included determining the relevant engineering properties for South African materials. The concrete pavement models were constructed on rubber mats to simulate a Winkler foundation with or without inter-layers.

Conclusions reached from the study were inter alia that there was no significant deterioration of the crack face during dynamic loading, which indicated that little abrasion took place at the initial crack width. It also indicated that in this instance fatigue of the aggregates at the joint face did not play a role, which could be attributed to the high quality of the crushed stone used in South Africa. Moment and inertia in the slab contributed to the greater load transfer efficiency under dynamic loading, than under static loading.

A specific relationship determined from laboratory results was used to refine the aggregate interlock load transfer model in the software developed for the new mechanistic design manual. Data from field investigations of in service concrete pavements in southern Africa was used to calibrate the laboratory data.

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**To my children**

**Annica and Dawid**

**and my parents**

**Danie and Annetjie Brink**

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# CONTENTS