

Restricted

Division of Roads and Transport Technology, CSIR

REPORT ON STEP PROJECT

Project Number: TIJ68
Project Title: Subgrade Design Models
Programme: Transport Infrastructure
Project Leader: H L Theyse
Project Team:
Project Amount: R 70 000-00
Date Completed: 28 February 2002
Date Deliverable: 28 February 2002

Description of work done (half to two pages):

Masters degree thesis: H L Theyse

Title: **The Development of Mechanistic-Empirical Permanent Subgrade Deformation Models from Heavy Vehicle Simulator Data**

The work was aimed at improving the accuracy of one of the components of a flexible pavement design procedure commonly used in South Africa, namely the South African Mechanistic-Empirical Design Method (SAMDM). This was achieved through the development of a new design approach and permanent deformation model for the pavement subgrade. The new distress model for the pavement subgrade was developed from a comprehensive Accelerated Pavement Testing (APT) database on subgrade behaviour and permanent deformation that was generated by a fleet of Heavy Vehicle Simulators (HVSs) over 20 years of testing in South Africa.

A literature review of the origin of the current subgrade design model that is used by the South African Mechanistic-Empirical Design Method revealed that this model, which was developed from the AASHO road test data, was adjusted for South African conditions based on general observations of subgrade behaviour without any rigorous calibration. Previous researchers have illustrated the potential of using Heavy Vehicle Simulator data to develop structural pavement design models and it was decided to apply a similar process to the permanent deformation of the pavement subgrade. A general, multi-dimensional empirical model was formulated for the subgrade permanent deformation and the characteristics of the model were investigated at the hand of previously published permanent deformation data and mathematical assessment.

The investigation consisted of two components, namely, the evaluation of the resilient and permanent deformation response of the pavement subgrade with the emphasis being more on the permanent deformation response. In terms of the resilient response of the subgrade, it was shown that the vertical depth deflection and vertical strain could be modelled accurately if an appropriate set of resilient modulus values was selected for the pavement layers. The resilient response of selected HVS sections also illustrated the stress-dependent behaviour of subgrade material resulting in resilient modulus values well outside the range that would normally be expected for natural gravel subgrade material. It was found that the elastic subgrade deflection correlated the best with the subgrade bearing capacity in terms of the number of load repetitions that could be sustained before a terminal rut condition is reached.

In fact, the vertical subgrade strain that is currently used in the South African Mechanistic-Empirical Design Method correlates poorly with subgrade bearing capacity and has to be replaced with elastic subgrade deflection.

A set of subgrade design models was developed for different levels of permanent subgrade deformation. The subgrade design model accommodate loading conditions ranging from a 40 kN dual-wheel load to a 100 kN dual-wheel load and subgrade materials from a material quality one class better than what would normally be used for a subgrade to the lowest possible material class. The model is therefore very flexible in terms of its application and yields more realistic bearing capacity estimates for the pavement subgrade than the current subgrade design criteria included in the SAMDM.

Keywords: Mechanistic-empirical pavement design, Permanent subgrade deformation, Subgrade vertical strain, Subgrade elastic deflection, Subgrade bearing capacity.

Related Materials: