RESEARCH PROJECT SUMMARY
– EXPRESSION OF INTEREST (2007/08)

Project Number: 1/07/33
(allocated by Land Transport NZ)

Title:	**Pavement Thickness Design Charts Derived from Rut Depth Models**
Researcher:	**Dr Greg Arnold, Pavespec Ltd and Dr Sabine Werkmeister, University of Canterbury.** *Dr Greg Arnold of Pavespec Ltd is undertaking several 2006/07 Land Transport NZ research projects sub-contracting through Transit New Zealand which include those relating to Repeated Load Triaxial testing. This proposal is a direct contract between Pavespec Ltd and Land Transport New Zealand rather than sub-contracting through Transit New Zealand. Transit New Zealand will still be involved in this project and the change is to reduce the time of Transit staff administering the project payments. Pavespec Ltd owns a Repeated Load Triaxial (RLT) testing apparatus necessary for this research which will be located at Stevensons Laboratory in Drury to enable the use of other laboratory resources. University of Canterbury also have an RLT and will assist in the testing.*
Key Topic Area:	**1. Asset Management**
Key topic area objective:	**1b. understanding pavement performance/deterioration, including regional variations**

PROJECT DETAILS

Description/ Research Objectives:

Tests at CAPTIF (Canterbury Accelerated Pavement Testing Indoor Facility) studying the effects of changes in mass limits used two different pavement depths and three aggregate types on the same subgrade type (CBR=10). The two basecourse depths used were 200 and 275 mm and from Figure 8.4 in the AUSTROADs Pavement Design Guide (2004) this represents pavement lives of 0.1 and 2 million ESAs (Equivalent Standard Axles) respectively. However, the results from the CAPTIF tests (Arnold et al, 2003) predict only minor differences in pavement life due to changes in pavement depth (Table 1). This questions the applicability of the current AUSTROADs pavement thickness design chart and associated AUSTROADs Strain Criterion used in design.

Table 1 – Pavement life predicted for each segment in CAPTIF Mass Limits test (Arnold et al, *2006*)

Segment	Material	Depth (mm)	Number [1]ESAs for 20mm Rut Depth (*Predicted from linear extrapolation of data*)	Life predicted by Austroads
A	Australian AP20	275	3.5 million	2 million
B	Australian AP20	200	4.2 million	0.1 million
C	TNZ M4 (AP40)	200	3.6 million	0.1 million
D	TNZ M4 (AP40)	275	4.2 million	2 million

[1] ESA is equal to 8.2 tonnes on a dual tyred single axle or 80 kN.

The above CAPTIF pavements were modelled as part of Arnold's PhD at the University of Nottingham, England (Arnold, 2004). This model utilised a relationship with stress and deformation derived from repeated load triaxial tests (RLT[1]) on the aggregates and subgrade used at CAPTIF. A finite element model was used to compute stresses, which were inputted into a simplified plastic deformation model to calculate the surface rut depth. Predicted rut depths were close to those that actually occurred at CAPTIF (Table 1). In addition, an elastic strain dependant rut depth model was developed by Werkmeister (2006) based on elastic and plastic RLT tests and successfully validated using CAPTIF results. A finite element model was used to compute elastic strains under the wheel load, which were inputted into a simplified plastic deformation model to calculate the surface rut depth.

Thus the rut depth models used by Arnold (2004) and Werkmeister (2006) show potential for use in pavement design within New Zealand and hence this research proposal aims to use these rut depth models to derive pavement thickness design charts for granular pavements. Modelling different pavement types to predict rut depth will require additional RLT[1] tests on one CAPTIF aggregate and four different subgrade types/strengths (CBR values) not as yet tested

However, because the performance properties of basecourse materials within New Zealand vary widely several design charts will be developed for good, intermediate and poor performing basecourse materials as determined from Repeated Load Triaxial testing from the recent LTNZ project, *Performance Tests for Road Aggregates and Alternative Materials*.

Prior to implementing the new design charts they will be checked against measured performance of Transit's Long Term Pavement Performance Sites.

The objectives of the research project are to:

A. To prove the rut depth models can predict pavement life of recent tests conducted at CAPTIF with different pavement depths and subgrade types;
B. Extend the validated rut depth models to predict pavement lives for a complete range of basecourse materials (good, intermediate and poor performing), pavement depths and subgrade types;
C. Produce several new pavement thickness design charts for different strength basecourses based on the rut depth model predictions;
D. Validate the pavement thickness design charts to observed field performance for sites used in the Long Term Pavement Performance Study;
E. Implement the pavement thickness design charts into Transit New Zealand's NZ Supplement to the AUSTROADs Pavement Design Guide;
F. Present findings to suitable conferences and Industry workshops.

References:

AUSTROADS (2004). Pavement Design – A Guide to the structural design of road pavements, AP-G17/04, Austroads, Sydney, Australia.
Arnold G., 2004. Rutting of Granular Pavements. PhD Thesis, University of Nottingham, Nottingham, UK.
Arnold, G., Alabaster, D.A., Steven, B.D. *2006 (in press)*. Effect on Pavement Wear of an Increase in Mass Limits for Heavy Vehicles – Concluding Report. *Land Transport New Zealand Research Report*.
Werkmeister, S., 2006, Prediction of Pavement Response using Accelerated Test Results of New Zealand's CAPTIF Facility, University of Canterbury, Final Research Report.

(1 : The RLT (Repeated Load Triaxial) apparatus applies repetitive loading on cylindrical materials for a range of specified stress conditions, the output is deformation (shortening of the cylindrical sample) versus number of load cycles (usually 50,000) for a particular set of stress conditions. Multi-stage RLT tests are used to obtain deformation curves for a range of stress conditions to develop models for predicting rutting)

How the proposed research addresses the issue or problem and its seriousness and urgency:	**The main issues are that the AUSTROADs Pavement Design Guide may not be appropriate for thin surfaced granular pavements based on results from accelerated pavement testing at CAPTIF. Further, the rut depth models developed by Arnold (2004) and Werkmeister (2006) could be used to derive more appropriate pavement thickness design curves that will likely reduce the amount of aggregate required. This project will result in reduced aggregate thicknesses to lessen the demand of aggregate on a scarce resource and significantly reduce pavement construction costs. In the first five years a conservative benefit cost ratio of 4.5 is calculated.**
How the proposed project takes account of the evolving transport environment:	**The evolving transport environment will likely be increasing heavy vehicles with higher axles, reducing aggregate resources as quarries close, demand for aggregates will increase with a growing infrastructure, oil and the cost of bitumen will increase and thus use of structural asphalt will be limited. This research will cater for these changes by: reducing aggregate depth in the pavement, targeting the good quality aggregates for higher trafficked roads and being able to extend the design of granular roads for high traffic in replace of structural asphalt pavements.**
Contribution to Land Transport NZ's objectives, goals and trends:	**This project will increase the sustainability of road construction through prolonging the life of pavements, reducing aggregate use and reducing the cost of road construction by reducing pavement depth and the ability to design granular pavements for high trafficked roads negating the need for structural asphalt pavements (i.e. less use of bitumen).**
When/How/By Whom will the research output be used/ and Information Transfer Initiatives:	**Regular meetings prior to and after each task will be held with the peer reviewers and Roading New Zealand's pavement committee to ensure the project objectives are achieved and the outcome is acceptable to all parties. The output of this project will be a pavement thickness design charts for use for the design of thin-surfaced granular pavements for inclusion in the New Zealand Supplement to the Pavement Design Guide.**
[note 3] Project Status:	**This is a revised version of a Transit New Zealand project submitted for funding in the 2006-07 year. Transit NZ still consider this a high priority project and asked Pavespec Ltd to re-submit the proposal.**

PROJECT COSTS (NZ$) and DURATION *(Indicative)*					
	Total	**2007/08**	**2008/09**	**2009/10**	**2010 -**
Project Cost to Land Transport NZ:					
Co-funding:					
Total Project Cost:					
Start Date:	**01/08/2007**	**Completion Date:**	**30/08/2009**	**Duration (months):**	**24**

PROJECT MANAGER			
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KEY PERSONNEL	**Name key researchers and the % of the project time apportioned to them**	**% time**
Name:	**Dr Greg Arnold (assisted by resources and staff (Jayden Ellis) at Stevensons Laboratory, Drury).**	**50**
Position:	**Director/Pavement Engineer PaveSpec Ltd**	
Name:	**Dr Sabine Werkmeister and lab staff**	**50**
Position:	**Researcher University of Canterbury**	

PEER REVIEWERS	
Name:	**David Alabaster**
Organisation:	**Transit New Zealand**
Name:	**Dr David Hutchison**
Organisation:	**Works Infrastructure (representing Roading New Zealand).**

Confidentiality:	***Nil***

Please note any confidentiality issues or commercially sensitive information Land Transport NZ should be aware of regarding your proposal. (Researchers are invited to discuss confidentiality issues with the Road Policing and Research Programmes' Manager)