PROJECT PROPOSAL SUMMARY REPORT – (2007/08)

Project Number: 1/07/31

Title:	**Development of a Basecourse/Subbase Design Criterion**
Researcher:	**Dr Greg Arnold, Pavespec Ltd (assisted by Stevensons Laboratory for testing) 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 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 a Repeated Load Triaxial apparatus 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:	The Austroads Pavement Design Guide is currently used in New Zealand for pavement design. This design guide includes a design criterion for the subgrade limiting the subgrade strain value. In the last few years significant concerns have been raised by industry in New Zealand about the uncertainty in the validity of the Austroads subgrade strain criterion. Within the Austroads design procedure; a strain criterion limiting the vertical elastic subgrade strain is used to limit the risk of rutting within the basecourse/subbase as well. Basecourse/subbase performance is controlled with material specifications such as grading limits. However, these methods do not consider the plastic deformation performance of the basecourse/subbase layers. Hence, the predicted life in terms of ESAs (Equivalent Standard Axles) using the Austroads approach can sometimes indicate a long pavement life. However, the observed performance (rutting, surface integrity and roughness etc) can indicate much shorter lives. As an example, recent research conducted by ARNOLD (*2006*) has shown that the Austroads subgrade strain criterion was a poor predictor of pavement life at the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF). Rutting within the basecourse/subbase is one of the main causes of damage on New Zealand's roads and latest studies dealing with the improvement of design methods for flexible pavements have pointed out the key role played by plastic deformations in the basecourse/subbase. For instance, the basecourse in the CAPTIF pavements contributed on average 70% of the total amount of the surface rutting (Steven 2005). In spite of this, adequate methods for predicting plastic basecourse/subbase deformations are lacking. Recent research conducted by the applicants was focused to investigate the stress-strain relationship of various New Zealand basecourse materials using the Repeated Load Triaxial (RLT[1]) test in the LTNZ 2006-07 research project, *Performance* ***Tests for Road Aggregates and Alternative Materials***. As a result of this research, a relationship between the elastic strains and the plastic strain rates for the basecourse

aggregates used at CAPTIF (Figure 1) was developed and compared with the field performance.

Figure 1 shows on one hand that there is a relationship between the elastic and plastic (long term) deformation behaviour and on the other hand that the plastic strains measured during the RLT tests were close to those that actually occurred at CAPTIF. Thus, the new approach developed shows potential for use in pavement design and hence this research proposal aims to use this strain approach to derive a pavement design criterion for the basecourse/subbase. The criterion should take into account the number of ESAs applied and lead to different pavement designs based on the quality of the aggregate. The aim is not to produce a generic relationship for all basecourses as these vary in quality but rather a methodology of developing a material specific strain criterion from Repeated Load Triaxial testing. Relationships found for typical weak, medium and high quality basecourses where RLT testing has been conducted will be reported.

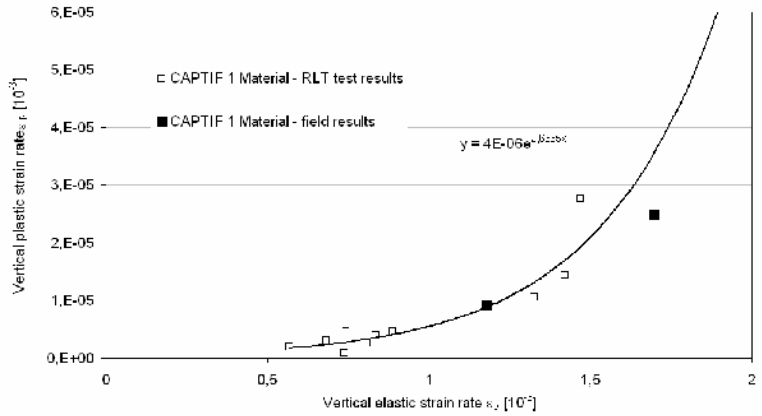

Figure 1. Axial elastic strain versus plastic strain rate for CAPTIF 1 material (Greywacke from Pounds Rd Quarry), RLT test results and CAPTIF results

From the RLT test results on basecourse materials, a N-ε_{el} relationship will be developed relating the elastic properties, described by the elastic strains ε_{el} and the number of ESAs. The material parameters of the basecourse materials required for this approach will be determined using test results obtained in the research project, *Performance* ***Tests for Road Aggregates and Alternative Materials*** and complimented with some commercial test results. Further, RLT tests will however be required for other aggregates including subbase materials.

Finally, the new approach will be validated using CAPTIF results for two different basecourse materials.

The objectives of the research project are to:

A. Conduct and analyse RLT test results on different basecourse /subbase materials regarding the elastic strain/ plastic strain rate relationship;
B. Develop a new basecourse/subbase strain criterion based on the RLT test results;
C. Validate the basecourse/subbase strain criterion to observed field performance at CAPTIF;
D. Implement the RLT test method to determine the basecourse/subbase strain criterion in Transit's RLT testing specification and revise the Transit New Zealand's NZ Supplement to the Austroads Pavement Design Guide to incorporate the basecourse/sub-base strain criterion;
E. Present findings to suitable conferences and Industry workshops.

The Tasks required to achieve these objectives are:

1. Undertake a literature review about basecourse/subbase deformation criterion within an analytical pavement design process;
2. Analyse RLT test results from various basecourse materials around New Zealand regarding the elastic strain/plastic strain rate relationship from Transit

	New Zealand's RLT test data-base; 3. Undertake and analyse eight RLT tests on four different subbase materials at two different moisture conditions; 4. Develop a suitable pavement design criterion for the basecourse/subbase; 5. Determine N-ε_{el} curves for all basecourse and subbase materials investigated; 6. Compare lives predicted with the design curves produced in Task 5 with pavement lives/performance at CAPTIF; 7. Draft changes to the NZ Supplement to the Austroads Pavement Design Guide and RLT Testing specification incorporating the method of determining the basecourse/subbase strain criterion from RLT tests; 8. Present findings to suitable conferences and Industry workshops. ***(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 design of basecourse/subbase layers. Further, the new design criterion can be used to determine the pavement life more accurately in particular for high trafficked roads and to avoid early pavement failures. **A conservative benefit cost ratio in the first 5 years of 4.2 is calculated for this project.** David Alabaster from Transit New Zealand has assisted in the development of this proposal and will ensure results are implemented into Transit New Zealand's standards and related contracts.
How the proposed project takes account of the evolving transport environment:	The evolving transport will likely be higher axle loads and more off them. This research will ensure that New Zealand's low cost granular pavements can withstand the heavier loads by considering the performance of granular materials within the design process through an appropriate strain criterion. Further, this will extend the use of granular pavements and reduce the need of structural asphalt pavements that require more bitumen that will become more scarce and costly in the future.
Contribution to Land Transport NZ's objectives, goals and trends:	Should this design criterion be implemented in the pavement design guide there will be a significant benefit in terms of optimised pavement design in particular for high trafficked roads. This will significantly reduce the risk of early pavement failure and avoid "over-designing" the basecourse/pavement and lead to an efficient use of environmental resources
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 methodology for determining the basecourse /subbase strain criterion from RLT testing to enable a material specific pavement design that considers deformations in the granular materials. This methodology and design method will be included in revisions of the New Zealand Supplement to the Austroads Pavement Design Guide and Repeated Load Triaxial (RLT) testing specification.
note 3 Project Status:	**New project**

PROJECT COSTS AND DURATION *(Indicative)*					
	Total	**2007/08**	**2008/09**	**2009/010**	**2011 -**
Project Cost to Land Transport NZ:					
Co-funding:					
Total Project Cost (NZ$):					
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**	**50**
Position:	**Director, Pavement Engineer, Pavespec Ltd**	
Name:	**Dr Sabine Werkmeister**	**50**
Position:	**Researcher, University of Canterbury**	
PEER REVIEWERS		
Name:	**Brennan Daly**	
Organisation:	**Transfield Services Ltd – Representing Roading NZ**	
Name:	**David Alabaster**	
Organisation:	**CAPTIF Manager, Transit New Zealand**	
Confidentiality:	**Nil**	