Technical Note

TN2005-1 (Replaces TN2004-1)

Confined Thin Granular Overlay Design

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Pavement Management Services
Optimising Pavement Design and Maintenance

Introduction

A common treatment option gaining favor, particularly in New Zealand, is a thin granular overlay over sealed pavements without first removing the existing seal coat. This treatment is beneficial from a structural design point of view, because the confining of the granular layer between the two seal layers, leads to larger modulus being achieved in the granular layer, due to the confining pressure.

Traditional design methods such as the Austroads Design Guide, do not allow the designer to determine with any degree of confidence the modulus that can be achieved with such an overlay; additionally, layer ratio methods such as that of the USACE, while better than that of the Austroads approach, do not allow for the increased modulus that can be achieved as a function of the confining pressure of the overlay. The lack of an appropriate method represents a major deficiency, in the design procedure for such pavements.

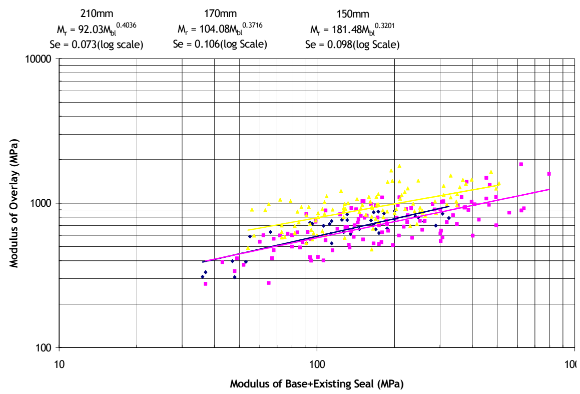
Method and Data

To overcome this deficiency, FWD results from nine sites within the Transit New Zealand PSMC001 contact, where this treatment has been employed were analyzed along with the pavement depths, to calculate: the Thin Granular Overlay (TGO), sub-base (including all previous base layers and the existing seal) and subgrade modulus values.

These results where then analysed to determine the actual in-place modulus achieved by the TGO.

Proposed Model

Shown following is the chart of the recorded TGO modulus plotted against that of the base layer modulus (including seal).



As can be seen from the results the modulus of the TGO is strongly related to the base layer modulus an can be approximated using a simple power relationship as shown following:

$$M_r = \alpha M_{bl}{}^{\beta} \quad \text{Equation 1}$$

Where:
M_r is the TGO modulus
M_{bl} is the base layer modulus
α,β are regression coefficients

The proposed model form, along with the 480 data points, obtained from the nine sites, were combined in a numerical optimisation procedure to obtain the corresponding regression constants, which are shown in Table 1 following.

Table 1 Thickness Constants

LAYER THICKNESS	α	β	S_e (log Scale)
210mm	92	0.40	0.073
170mm	104	0.37	0.106
<150mm	181	0.32	0.098

Table 1 shown previously documents the overlay modulus based on a least square regression, however when determining modulus for use in design confidence equations will sometimes need to be used. To achieve this only modification of the α constant is required, table 2 following, shows the revised α factor to be used in equation 1 for confidence design.

Table 2 Revised α Factors for Confidence

LAYER THICKNESS	90TH	95TH	97.5TH
210mm	72.84	68.40	64.24
170mm	82.34	77.33	57.50
<150mm	143.31	134.58	100.06

Design Approach

Back Calculation

For sites where a proposed treatment of a confined thin granular overlay is being investigated, the ELMOD analysis is to be conducted using two layers, consisting of a sub-base layer and the subgrade, according to the following rules

1. The base layer is to combine all layers above the subgrade, as well as the existing seal layer and must be a minimum of 150mm thick.
2. The subgrade is to be the existing subgrade layer.

The results of the FWD testing should then be back-calculated using the "deflection basin fit" approach, with no fixed modulus values or seed values. The results should then be viewed against reality and modulus values fixed to a range if needed.

Determining Overlay Modulus for Deterministic Design

Once the sub-base and subgrade modulus have been obtained through back-calculation of the deflection bowl, the following steps are followed to obtain the TGO modulus value.

1. Determine the 90th percentile and average base layer modulus.
2. Using equation 1 and the constants α and β for the proposed layer thickness, determine the average modulus obtained on the lower 90th percentile base layer modulus.
3. Using equation 1 and the 90th percentile coefficients from Table 2, determine the lower 90th percentile modulus of the overlay for the average base layer modulus.
4. The design modulus shall then be taken as the lower of the two-modulus values.

Forward Calculation

All forward calculations are to be performed using a linear elastic program assuming an isotropic material for all layers, as all back calculated modulus values as well as the calculated overlay modulus were determined assuming isotropy of the materials. The design pavement shall then be designed as a four-layer system consisting of:

1. *New Seal/asphalt layer*
2. *New thin granular overlay*
3. 90th Percentile existing sub-base (all layers above the subgrade including the existing seal layer)
4. 90th Percentile existing subgrade

The pavement should then be designed for rutting and fatigue if applicable, in accordance with PMS-QP4-002.

Material Design

For TGO design, care must be taken to ensure moisture cannot be trapped between the two impermeable seal layers; this is achieved by ensuring the permeability of the proposed TGO layer is sufficient to drain any infiltration of water into the layer.

If the permeability of the proposed layer is not sufficient, removing the fine proportion from the gradation may increase the permeability of the proposed layer. However, it must be noted that, the removal of the fine proportion of the gradation will affect the stability of the TGO layer, and the proposed gradation must then be checked to ensure an adequate CBR is still obtained (>40). If not, the material may need to be modified by the addition of a small amount of cement to increase the stability of the mix.

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