Technical Note

TN2005-2 (Replaces TN2004-2)

Stabilization of Base Layers on Soft Subgrades Constructed Under Traffic

29th January 2005

Introduction

With the increasing use of Insitu stabilization as an effective treatment option for recycling of pavement bases, designers are trying to incorporate these pavements in many more situations. It is unfortunate the current Austroads Design Guide has not kept pace with this change in treatment options and gaps in knowledge are beginning to appear. These gaps in knowledge are leading to pavements being designed that are not constructible and/or cannot achieve the assumed design properties

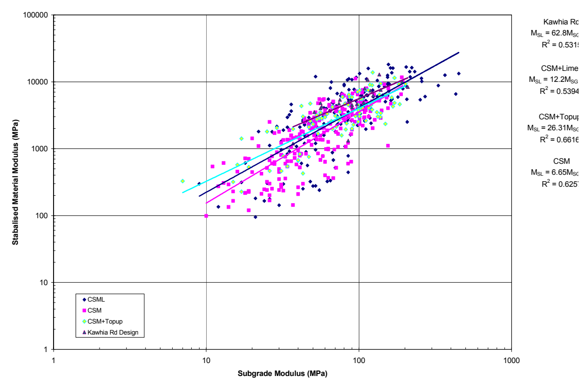
Current practice in the Austroads Pavement Design Guide is to assume that stabilized materials achieve a constant design modulus. While this may be possible for layers constructed and allowed to fully hydrate without traffic loadings, it is not possible for layers constructed under traffic.

This alone appears to be the main gap in knowledge, as designers are failing to realize that stabilized pavements, which become damaged under traffic before hydration are stress sensitive, which implies that there can be no such thing as a constant modulus. The main occurrences of this gap in knowledge presenting problems, is when designing stabilized pavements on soft sub grades. In such cases the design modulus values will rarely be achieved. To ensure that the stabilized pavement option remains a viable solution a set of rules that accounts for the maximum achievable modulus values needs to be established.

Developing Rules

To develop the set of rules for designing Insitu Stabilized pavements, constructed under traffic, over soft sub grades, FWD results from twenty one sites within the Transit New Zealand PSMC001 contact, where Insitu stabilization treatments have been employed, and opened to traffic befor hydration, were analyzed along with the pavement depths, to calculate: the base (stabilized), and subgrade modulus values.

The measured subgrade modulus was then compared against the measured base modulus for each site, as shown in the following figure.



Proposed Insitu Stabilization Rules

From the above data it was clear that there is a direct relationship between the subgrade modulus and the obtainable stabilized layer modulus, which could be used to develop a set of rules for stabilization on soft sub grades. As can be seen from the results the modulus of the ISL is strongly related to the subgrade modulus and 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 20+ 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

MATERIAL TYPE	α	β	S_e (log Scale)
CSM	6.65	1.363	0.316
CLSM	12.2	1.263	0.343
CSM+Topup	26.3	1.092	0.224
Kawiha	62.8	0.975	0.176

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

MATERIAL TYPE	90^{TH}	95^{TH}	97.5^{TH}
CSM	2.6	2.0	1.6
CLSM	2.4	3.3	2.5
CSM+Topup	13.5	11.2	9.4
Kawiha	37.1	32.2	27.9

Design Approach

Back Calculation

For sites where a proposed treatment of Insitu Stabilization is being investigated, the ELMOD analysis is to be conducted using two/three layers, consisting of a base layer, sub-base if applicable and the subgrade, according to the following rules

1. The base layer is to combine the top layers to the depth of the proposed stabilization.
2. If any base/sub-base layer/s are remaining, it is to be modeled as a one separate layer.
3. 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, if needed.

Determining Maximum Stabilization Modulus

Once the sub-base, if any and the subgrade modulus have been obtained through back-calculation of the deflection bowl, the following steps are followed to obtain the maximum stabilized layer modulus.

1. Determine the 90^{th} percentile and average subgrade modulus.
2. If sub-base exists, determine the effective subgrade modulus from Eqn 1, TN2004-1.
3. Using equation 1 and the constants α and β for the proposed material, determine the average modulus obtained on the lower 90^{th} percentile base layer modulus.
4. Using equation 1 and the 90^{th} percentile coefficients from Table 2, determine the lower 90^{th} percentile modulus of the stabilized layer for the average base layer modulus.
5. From the results of UCS test determine the stabilized pavement modulus from § 6.3.2.3 of the Austroads Pavement Design Guide.
6. The design stabilized pavement modulus is then taken as the minimum of 2, 3and 5.
7. If the maximum achievable modulus is lower than desired, the following additional steps may be considered, to achieve the desired modulus value.

a. Leave extra sub-base material in the pavement to a thickness required to achieve the desired effective subgrade modulus, which is used to determine the desired stabilized modulus value.
b. Remove to spoil the base materials and add a bridging layer over the subgrade. Using the bridging layer, determine the effective subgrade modulus; to determine the allowable stabilization modulus.
c. Stabilize an additional 150mm depth, with the additional 150mm layer used as a bridging layer over the subgrade. Then using the maximum allowable modulus for the 150mm layer, determine the effective subgrade modulus; to determine the allowable stabilization modulus.

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 stabilization modulus was determined assuming isotropy of the materials.

The design pavement shall then be designed as a three/four layer system consisting of:

1. New Seal/asphalt layer
2. New Insitu Stabilized layer
3. Existing sub-base, if any
4. Existing subgrade

The pavement should then be deigned for rutting and fatigue in accordance with PMS-QP4-002.