	TMC - Tinni Management Consulting	Issue No. 10
	PAVEMENT INFORMATION NOTE	
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Calculation of the Load Carrying Capacities of LCS on Variable Strength Subgrades

Introduction

The RTA Specification DCM R82 Clause 4.3.8.4 is quite restrictive on trafficking of the Subbase. The clause states:
"Subbase must not be trafficked by either personnel or construction equipment ……., until the in-situ strength of the Subbase has reached 4.0 MPa. Thereafter, access to personnel will be acceptable, but only vehicles with gross mass less than 1.5 tonnes and construction equipment necessary for the following operations will be permitted to traffic the Subbase:

a) *surface debonding treatment and spall treatment;*
b) *base paving and then only for a distance of up to 300 m immediately ahead of the paver,* ***except*** *as specifically provided in the Specification."*

However, it does provide for an exception as in condition b). Nowadays with the 7 m^3 batch mixers, special 8 wheel, twin steer trucks need to be employed to deliver the concrete. Fully laden, these trucks are 33% over loaded and have a damage factor of 3.2 (the 4^{th} Power Rule) on the legally allowable axle group load. As such, they are not allowed on Public roads and it is normal to use suitable haul roads within the construction site and usually in the median area.

There are, however, special circumstances where these roads cannot be accommodated in the space available in the road reserve and there is the need to use the LCS as the concrete delivery haul road.

Purpose

The purpose of this report is to evaluate the bearing capacities of different strength LMC subbases on variable strength subgrades and to provide the design calculations to support the conclusions. Complete detail is provided so that this report can be used to substantiate any proposal where the need arises.

Input Parameters

Subgrade strength - CBR 3% to CBR 8%
SMZ - CBR 30% or 150 mm of 2% lime modified CBR 15% on 150 mm of CBR 15% material.
LMC - 150 mm of various compressive strengths.
f_c = 15 MPa: f_{ct} = 2.9 MPa = $0.75(f_c)^{0.5}$
f_c = 10 MPa: f_{ct} = 2.37 MPa
Load safety Factor - 1.0
Design condition - With Shoulders

Axle Group Loadings of Haul Vehicles:

- Empty : Front = 4.5 t, Rear = 3.5 t, Total = 8 t
- Laden : Front = 8.0 t, Rear = 18.0 t, Total = 26 t

Axle Load Distribution

Load	SAST	SADT	TAST	TADT	TRDT	QADT
Group	0	0	50	50	0	0
35	0	0	0	50	0	0
45	0	0	50	0	0	0
80	0	0	50	0	0	0
180	0	0	0	50	0	0

Design Principle

Normal rigid pavement design methodology applies, except the LCS is regarded as a plain concrete base. In this configuration it does not have a concrete subbase, but a flexible subgrade. This configuration is quite normal in many countries. The subgrade strength is then calculated as the equivalent strength of the 300 mm of SMZ and 700 mm of subgrade of various CBR values. In this arrangement, the Effective Strength of the subgrade does not apply.

Equivalent Subgrade Strength

The equivalency of the insitu material and the SMZ is calculated using the accepted Japanese Public Works formula. The resulting values over the top 1 m of subgrade become:

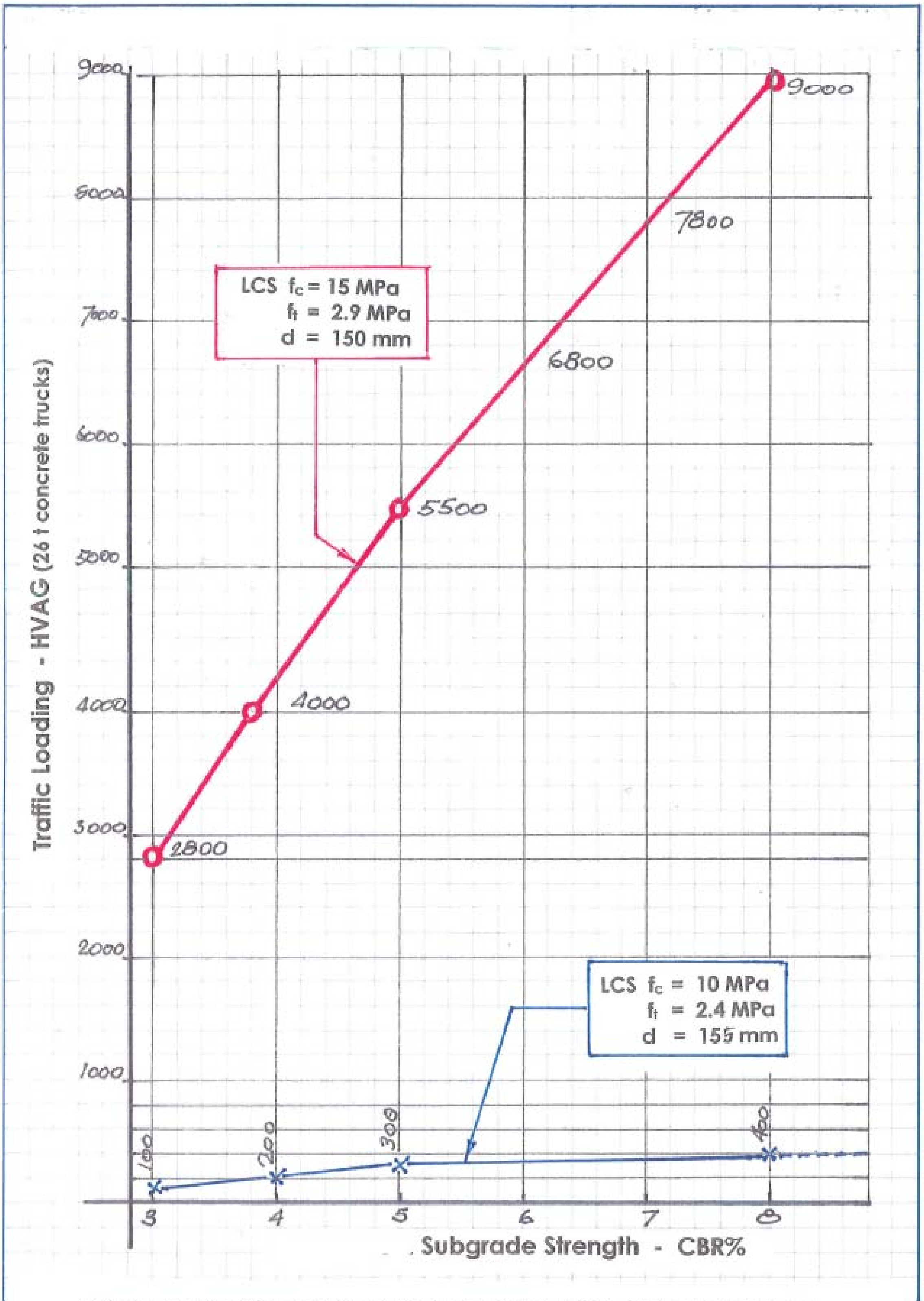
Insitu subgrade CBR %	Equivalent s/grade Strength CBR %
3	5.5
4	6.6
5	7.6
8	10.2

The designs are based on the equivalent subgrade strength.

Pavement Designs

Using the Abigroup Rigid Pavement Design software, the LCS thickness is kept constant at 150 mm and by iteration, the maximum allowable design traffic loading in Heavy Vehicle Axle Groups (HVAG) can be calculated for varying equivalent subgrade support conditions. In this instance the HVAG equals the number of trucks. Detailed designs have been carried out for LCS compressive strengths of 10 and 15 MPa. One Design Summary sheet is attached as an example. This is for a 15 MPa LCS on a subgrade of CBR 5%, which equates to an equivalent subgrade strength of CBR 7.6%.

The results are plotted on the following graph



GRAPH SHOWING HVAG REPETITIONS TO FAILURE

Quick Evaluation of Subgrade strength

For quick assessment of the subgrade strength, the Benkelman Beam deflection readings on the subgrade, before placement of SMZ, can be converted into subgrade CBR strengths using the Elastic Theory Deflection Grid (RTA). From the graph above, this provides a quick assessment of the allowable load repetitions on the granular subbase. The following are the relationships for conversion:

Deflection (mm)	Equivalent CBR (%)
0.43	30
0.75	15
1.0	7
1.2	5
1.5	3.5
2.0	2.5

Comments and Points to Note

1. The graphs apply only to the 26 t, eight wheel twin steer trucks, carrying a 33% overload on the rear axle group. The details will need to be recalculated for any other loading condition or compressive strength of the concrete. To put the significance of this in context, the legal limit for this rear axle group is 13.5 t, one pass of which is equivalent to the damage by about 13,000 cars. Using the "4^{th} Power Rule", the damage factor due to the overload is calculated as 3.2. This equates to 41,000 passes by a sedan car.
2. In this configuration the LCS acts as a thin structural layer on a subgrade "other than concrete" and thus its failure mode is "fatigue" rather than "erosion", which is the case of PCP on LCS.
3. The design is based on the LCS having "shoulders" for load distribution from the usable pavement width. Hence there should be no traffic in the nominal 0.6 m from the edge.
4. Because of the high axle loads, the 10 MPa concrete would only have a limited life, eg on CBR 5% subgrade, the failures would start after 300 passes. This figure could be increased by forcing a shift of the wheel paths by about 1 m after, say, 200 passes. (Note that this has to be relatively accurate as a shift of 2 m would put the new LH wheel path onto the old RH one).Using controlled shifting will allow three times the theoretical load repetitions.
5. From the graphs it can be seen that a more satisfactory load carrying capacity is achieved when the concrete compressive strength is 15 MPa.
6. It is essential that the assessment of the subgrade CBR is carried out before placement of the SMZ.
7. At the turn ons and offs from the pavement, special precautions for edge support should be provided. These can be in the form of a subgrade beam or use of, say, 300 mm of the SMZ material on the concrete (to distribute the wheel loads).
8. The pavement should be inspected daily for new (loading related) cracks. Occurrence of these will accelerate as then the wheels are crossing "unsupported" edges of the slabs created by the wheel loads. When this occurs, use of the LCS as a haul road should be immediately stopped.

Abigroup

Rigid Pavement Design Details

Pavement Design Tool -Version 3.0 - Austroads Pavement Design Guide 2004 (Rigid)

Project Name: Tipper Trucks on Subbase

Designer: atinni
Output Saved on: 4/03/2008 at 11:10:01 AM
Location: Anywhere

Trial Pavement:
Type: **PCP**
Tag: **2.0**

Traffic Data

Traffic input data used:	C:\concreteroads\trafficdist\Tipper Trucks on Subbase.csv
Traffic description name:	Tipper Trucks on Subbase (AT 2008)
Design traffic (HVAG):	5.50E+03
Load safety factor used:	1

Subgrade and Subbase Details

Design subgrade CBR%:	5
Subbase type:	Other - refer to designers notes
Subbase thickness:	150
Effective subgrade CBR%:	7.6

Concrete Base Details

Design flexural strength (MPa):	2.90
Trial base thickness (mm):	150
Base thickness (mm):	**150**

(If no value appears above the optimum run was not completed)

Minimum base thickness (mm):	150 (Austroads, 2004 - Table 9.7)
Pavement type is:	PCP
Shoulder condition:	With Shoulders

Summary of fatigue and erosion distress

Axle Group	% Dist.	Fatigue	Erosion
SAST	0.0	0.0	0.0
SADT	0.0	0.0	0.0
TAST	50.0	0.0	0.1
TADT	50.0	99.0	0.6
TRDT	0.0	0.0	0.0
QADT	0.0	0.0	0.0
TOTAL		99.0	0.7

Calculations show that the base thickness for a distress limit of 99.0% is 150 mm.

END