APPENDIX F: Best Practice for Load Damage Calculations

Austroads practice for load damage assessment now requires updating (as explained with examples in the appended extract from "Pavement Analysis").

Mechanistic methods that methodically evaluate the moduli, stresses and strains in the relevant pavement layers have much greater reliability.

Improved procedures are outlined on the following pages (suggested modifications to Appendix I from Austroads).

Highlighted text emphasises the most important paragraphs. Underlined text was added, while crossed out text indicates the former wording.

Data and methods are now accessible that enable full appreciation and improved interpretation with more cost effective and reliable outcomes. The state-of-the-art best practice is simpler and faster.
Suggested changes to Austroads

APPENDIX I  PROCEDURES FOR EVALUATION OF PAVEMENT DAMAGE DUE TO SPECIALISED VEHICLES

I.1  Introduction

This appendix provides guidance on the damage to road pavements caused by the passage of vehicle loads that do not comply with prescriptive regulations for heavy vehicles in the areas of mass, dimensions, and configurations. Such vehicles may include mobile cranes and specialised vehicles with unusual configurations of axle wheel loads, tyre loads and types. Such damage assessments may be used to assess whether a permit should be issued for the use of the vehicle on the road network.

In undertaking the damage evaluation, due consideration needs to be given to the different pavement configurations anticipated to be trafficked by the specialised vehicle as the damaging effect varies with pavement type and distress mode. Usually the assessment would include the complete range of pavement types expected in-service along the route defined by the specialised vehicle permit application.

As pavement damage varies with pavement type and distress mode, guidance is given below of the procedure to use according to the pavement type.

I.2  Granular Pavements with Thin Bituminous Surfacing

The empirical Scala and Potter (1961) deflection-based method was developed from field deflection measurements of bituminous surfaced granular pavements. A review of alternative assessment methods by Jameson (2004) recommended it be used for granular pavements with thin bituminous surfacing.

The Scala and Potter method is simple to use and equations have been fitted (Jameson 2004) to the Scala and Potter design chart which enable the procedure to be completed using spreadsheets. A minor modification to the Equation for L10 has been made such that the procedure calculates a Load Equivalence Factor of 1 for a Standard Axle (Section 8) fitted with commonly used 11R22.5 tyres. (The Load Equivalence Factor is the ESA of pavement damage due to a single pass of an axle). Note that an 11R22.5 tyre is a radial (R) tyre with a nominal tyre section width of 11 inches (279 mm) and a nominal rim diameter of 22.5 inches (572 mm). This is the most commonly used Australian heavy vehicle tyre.

The following steps are used to estimate the ESA of damage due to a single pass of a specialised vehicle, the so-called Load Equivalance Factor (LEF):

1. Divide the vehicle into individual single axles and estimate the load on each axle (L10).
2. Estimate the tyre contact width (TCW) for each tyre on each axle in millimetres using the nominal tyre section width (NTSW) and the following relationships (Equation A21 and Equation A22):

   \[
   \text{if } \text{NTSW} < 300 \text{ mm: } \text{TCW} = 2.1705\text{NTSW} - 0.002115\text{NTSW}^2 - 217 \quad \text{A21}
   \]

   \[
   \text{if } \text{NTSW} \geq 300 \text{ mm: } \text{TCW} = 1.3322\text{NTSW} - 0.0005515\text{NTSW}^2 - 109 \quad \text{A22}
   \]
3 Estimate that load on each tyre (LTD) in kN which, when the tyre is acting in isolation, will produce the same maximum pavement deflection as the Standard Axle. This is done using the tyre contact width (TCW) and the following relationship (Equation A23):

\[ L_{TD} = 18.47 + 0.03843TCW \]  

A23

4 With each tyre on the axle supporting a load LTD, determine the ratio (d/d1) of the maximum deflection under the axle to the maximum pavement deflection under an isolated tyre. This ratio is determined as follows:

Select the position on the axle where the maximum surface deflection is expected.

(a) For each tyre on the axle, determine the transverse distance (TD) (tyre centreline to tyre centreline expressed in units of contact width) of the tyre from the position of the selected tyre and calculate the corresponding normalised deflection (ND) from the following relationship (Equation A24):

\[ ND = \frac{1}{{1 - 0.085826TD + 1.755TD^2 - 0.7555TD^3 + 0.1389TD^4}} \]  

A24

(b) Sum the normalised deflections obtained. The resulting number is the ratio \(d/d1\).

5 Determine that load per tyre (LTD) which will produce a maximum strain in the critical layer of the pavement equal to the maximum strain pavement deflection under the axle equal to the maximum pavement deflection under the Standard Axle. Note the critical layer is the layer which governs the life of the pavement (the layer which causes the terminal condition). Using a linear relationship between load and deflection, gives (Equation A25):

\[ L_{T1} = \frac{L_{TD}}{d/d1} \]  

A25

6 Determine the load on the axle (LA) which produces the same damage as the Standard Axle from the product of the number of tyres on the axle (n) and the load per tyre (LTD), i.e. Equation A26:

\[ L_{A1} = nL_{T1} \]  

A26

7 Determine the ratio of damage caused by the axle when the axle load is LA to the damage caused by the Standard Axle by applying the load damage exponent, calculated for the critical layer and critical distress mode fourth-power-law. Following convention, which defines the damage ratio as the Load Equivalence Factor (LEF) gives (Equation A27):

\[ LEF_{LA} = \left( \frac{L_A}{L_{A1}} \right)^{A27} \]  

A27

8 Having determined the LEF for each axle of the vehicle by the above method, a LEF for the vehicle (ratio of damage caused by one load repetition of the vehicle to the damage caused by one load repetition of a Standard Axle) is determined by simply summing the LEFs for each axle of the vehicle, i.e. Equation A28:

\[ LEF_{V} = \sum_{i=1}^{NAX} LEF_{i\text{ax}} \]  

A28

where

\[ LEF_{V} = \text{the Load Equivalence Factor for the vehicle} \]

\[ LEF_{i\text{ax}} = \text{the Load Equivalence Factor for the } i^{th} \text{ axle, and} \]

\[ NAX = \text{the number of axles on the vehicle.} \]