Best Practice Reference

The Cost Impact of Additional Loading on Existing Sealed Road Pavements

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Version History

Version	Release Date	Release Notes
1.0	December 2025	Initial release of NTRO Best Practice document

Foreword

NTRO Best Practice References exist to articulate how a transport network owner or operator should require a specific, contemporary issue/challenge to be solved/resolved to ensure that it is delivering positive outcomes and meeting its statutory safety-, serviceability- and sustainability-related obligations effectively and efficiently. Rather than being totally prescriptive, NTRO Best Practice References identify the key building blocks to be followed to arrive at a desired outcome or solution and how they interrelate and combine. They are supported by NTRO and other specifications and/or test methods that set out which things must be done and specifically how they are to be done.

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1. Introduction

1.1 Scope

This Best Practice Reference addresses the cost impact of additional loading on pavement assets. It provides practitioners and authorities responsible for managing road assets with a standard framework and guidelines for the assessment, analysis and quantification of the impact of additional traffic loading on existing sealed road pavements. Additional loading of a specific route or road section(s) refers to when heavy vehicles are allowed to undertake a freight task greater that the normal (or base) loading, such that it has the potential to significantly accelerate pavement wear, Additional loading can shorten the lifespan of road pavements and surfacings, especially on pavements not designed for them. Flexible pavements, such as sealed granular pavements which are common in rural/low-volume roads, are especially vulnerable.

Consequently, these roads often require more frequent maintenance (e.g. patching, resurfacing) and earlier rehabilitation, resulting in increased life cycle costs under higher loading scenarios. Accordingly, it is important to establish a reliable method for estimating the increased pavement deterioration resulting from additional loading and to quantify the associated reduction in pavement value in monetary terms.

This Best Practice Reference provides pavement asset owners with a transparent and repeatable process to determine user contributions for increased traffic loading. It is trusted by both industry and asset owners as a fair process for determining sufficiently accurate contributions required for maintenance and rehabilitation whilst ensuring value for money.

The loss of value includes the direct financial impacts of additional pavement loading arising from increased maintenance and repair costs, shortened pavement life leading to early reconstruction, and reduced return on investment for road agencies. There are other indirect costs associated with the increased loading, such as the increase in vehicle operating costs due to an increase in pavement roughness, travel time cost, safety risk, etc., that are outside of the scope of this document. Also, the cost impact on unsealed roads is outside the scope of this document.

1.2 Factors Impacting Life Cycle Performance and Costs

When considering the effect of additional loading on a road network, several factors must be considered, including:

- the magnitude and duration of the additional loading
- the structural strength and load-based capacity of the existing road and current and projected road conditions
- the cost of road maintenance and preservation and renewal activities accounting for the levels of service applicable under the current and additional loading scenarios.

The above impacts as further dependent on several specific factors, including:

- the vehicle type(s) and axle loads and configurations proposed for undertaking the additional loading, including whether they are loaded to general mass limits or to an alternative approved scheme[1]

[1] Whereas general mass limits for heavy vehicles are established country-wide, alternative limits may be applied upon approval by the road owner or through state and territory regulations. The schemes differ between jurisdictions and should be consulted and those to be applied agreed upon for the purposes of any agreement.

- geographic and network considerations, acknowledging that regional and rural roads often lack sufficient pavement depth to handle higher axle loads and face higher costs due to remoteness and local industry capacity.

1.3 Applicable Methods

There are 2 primary methods available to determine the cost impact of additional loading on existing sealed road pavements.

The first method (recommended) determines the costs associated with additional loading based on the marginal cost of road wear, and it is based on life cycle performance and cost impacts compared to a base loading scenario (i.e. current loading conditions). This method has been endorsed by Austroads and the National Transport Commission for nationwide use and is also embedded in state- and territory-specific guidance. This method may be used in a wide variety of circumstances. These marginal costs can be built up from location-specific data using established or custom-built tools using evidence-based pavement performance relationships and well-researched input data or drawn on a predetermined set of solutions that have been established for application across specific jurisdictions or operating conditions that represent either physical sections of the network or representative sections typical of the network. This method is prescribed in this Best Practice Reference.

The second approach is known as 'make good' or maintenance and franchise agreements. This approach is applied on an agreed case-by-case basis. It can include adaptations of the marginal cost method applied on a project basis using network-based performance relationships and location-specific data. Or it can include specific requirements, like maintaining a project or road to a predefined service level standard/performance measure, including in response to specific defects and hazards with prescribed response times, or applying major repairs and resurfacing and rehabilitation treatments under specified conditions. Handover conditions may be augmented with specified surfacing and pavement remaining life requirements. This approach lends itself to high-value assets managed under franchise arrangements, and it is commonly applied to public roads and requires the use of high-quality road condition and structural data, traffic and historical construction, and maintenance data.

Make good agreements tend to be very specific and include maintaining a road to defined conditions that are also met at handover, with the possibility of a surfacing and/or a rehabilitation treatment applied to extend the life of the respective assets to specified values. The latter treatments, if part of an agreement, are likely to be determined based on established treatment evaluation and design requirements. Such an arrangement can apply to specific public roads, especially in conditions where a development generates significant additional loading, e.g. through the extraction of primary resources such as minerals, aggregates, forestry products, etc.

For method 2, parties to an agreement may choose to employ a cost-based compensation either throughout the term of an agreement or at handover. Alternatively, the agreement may require the assets to be maintained and handed over in conformance to the prescribed performance standards. Specialist assistance should be sought where this method is applied. Details of method 2 are not prescribed in this Best Practice Reference.

1.4 Referenced Documents

The following documents are referenced in this Best Practice Reference and are essential for its application:

Austroads	*Deploy and refine the road wear modelling methodologies: FAMLIT final report*, 2015
Austroads	*Freight axle mass limits investigation tool (FAMLIT) user guide*, 2015
NACOE	*Harmonisation of pavement impact assessment: updates and extended marginal cost values: Year 1*, 2017
WALGA & NTRO	*User Guide: Estimating the incremental cost impact on sealed local roads from additional freight tasks*, 2025

1.5 Terms, Definitions, Acronyms/Abbreviations

Table 1.1: Abbreviations and definitions

Term	Definition
ESA	Equivalent standard axle
SAR	Standard axle repetition
FAMLIT	Freight Axle Mass Limit Investigation Tool
LCC	Life cycle costing
PLCCDT	Pavement Life Cycle Costing Demonstration Tool

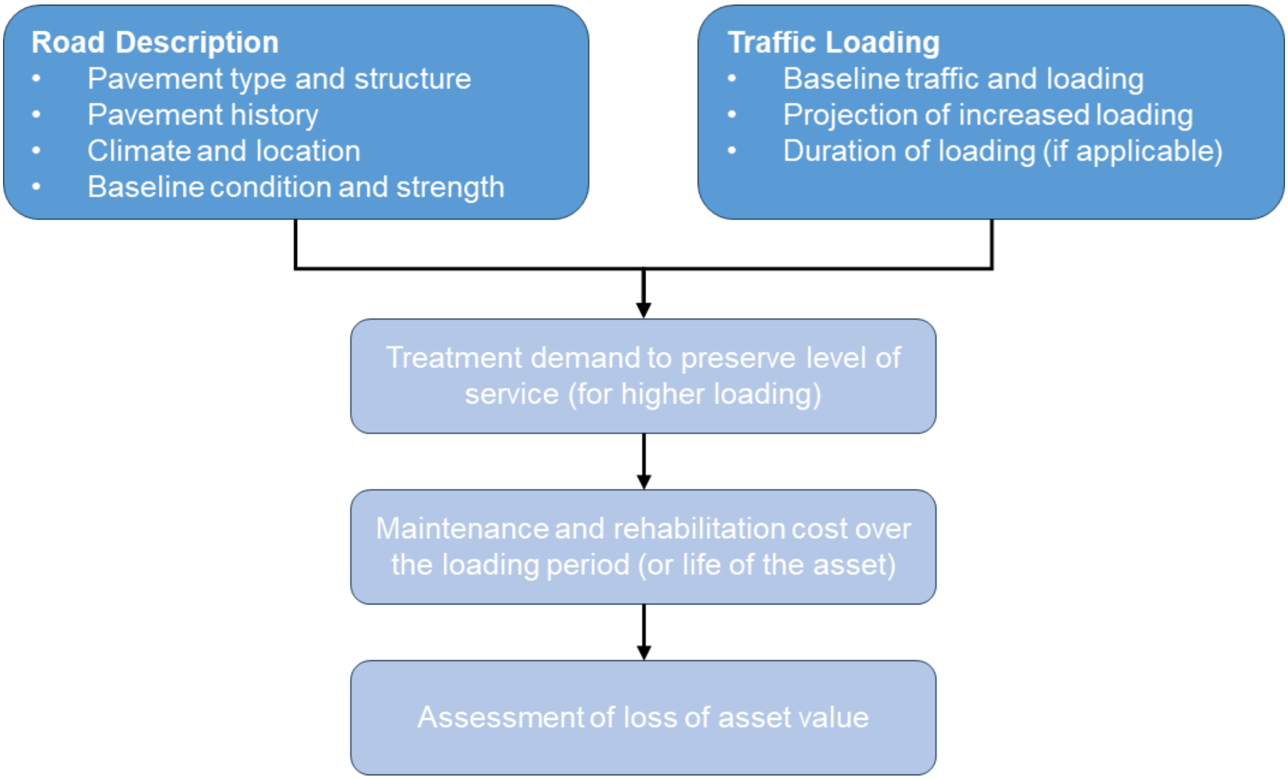
2. Framework

2.1 General Framework

A framework is presented to outline the generic steps involved in determining the loss of value from increased pavement loading. Adopting a method to quantify the cost associated with additional pavement loading might vary by asset owner, with several road authorities establishing preferred methods. In light of the framework, it is recommended that a marginal cost–based method be used to quantify the additional loading on existing pavements.

The framework is outlined in Figure 2.1. The first steps in the top boxes define the required inputs: baseline and projected pavement details, requirements, and traffic loading. The second steps in the 3 lighter boxes assess the maintenance and rehabilitation costs to meet the agreed level of service and then reports the loss of the asset's value due to increased loading.

Figure 2.1: Flowchart of the framework to determine the loss of value of pavements due to increased loading



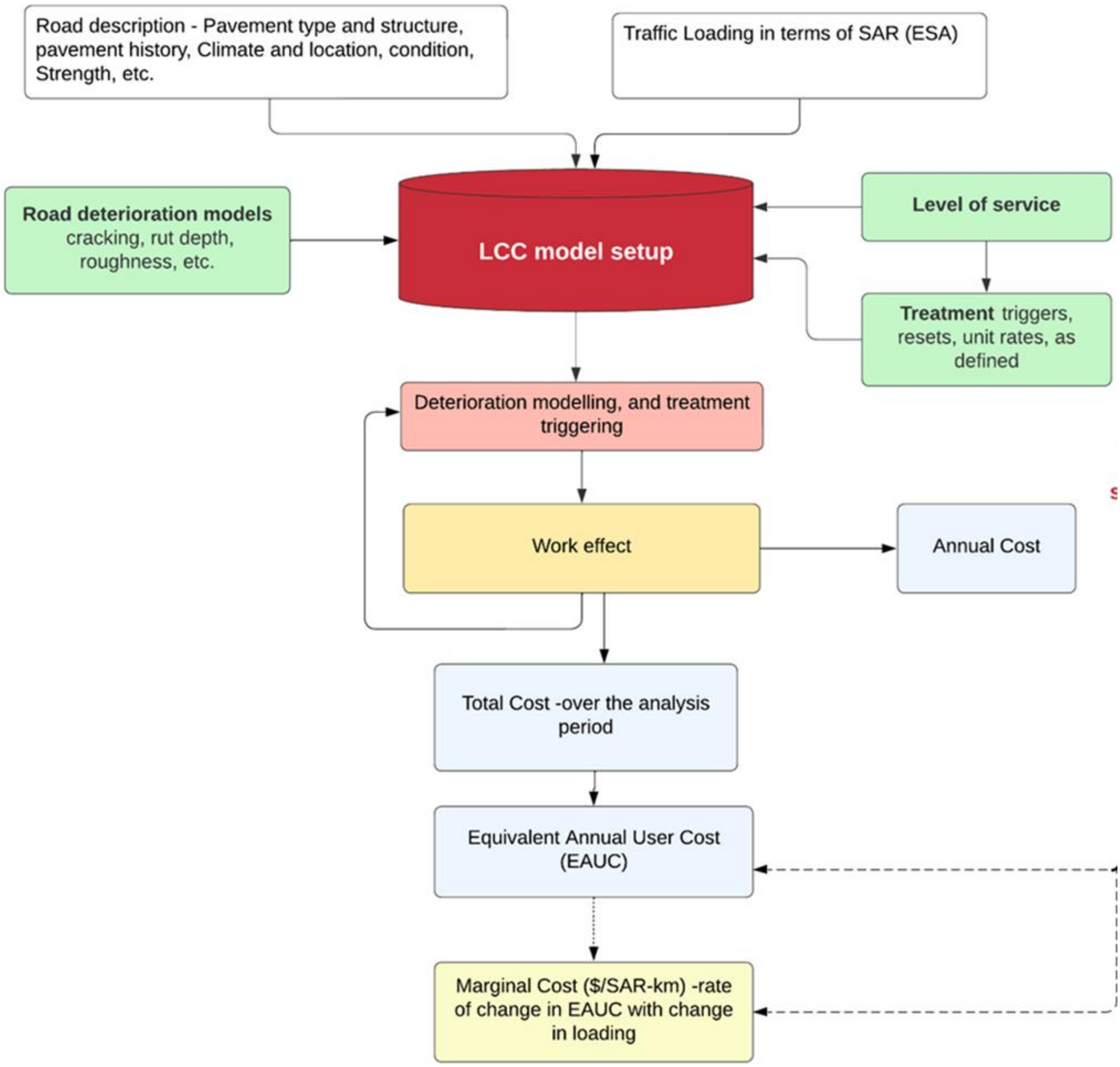
2.2 Marginal Cost Method

2.2.1 Description and Basis

Marginal cost is defined as the difference in the cost of maintaining a road in a serviceable condition arising from an increase in traffic loading above current or base traffic. Analysis has shown that the marginal cost is mostly dependent on the magnitude and duration of the additional load, the structural strength of the road and the cost of road maintenance activities.

Marginal cost can be calculated/estimated in different ways – either by analysing the full network or by estimating using pre-defined catalogues based on road features and conditions. Each process involves a life cycle costing (LCC) analysis using pavement deterioration models to determine the change in the maintenance cost to keep the network in the same condition (i.e. prevent further deterioration) with the changes in the loading scenarios. The resulting values can then be used to determine the cost from any additional loading on a road section/part of the road network. Figure 2.2 schematically displays the process for deriving the marginal cost using various loading scenarios.

Figure 2.2: Analysis flowchart to perform marginal cost method



2.2.2 Marginal Cost Estimation

Following the procedures outlined in the above flowchart, a marginal cost value based on the standard axle repetition (SAR) per km can be produced and assigned to all sections of the road network. Alternatively, the same procedures can be adopted to prepare catalogues of marginal cost for combinations of road hierarchy, condition level, traffic category, different period of additional loading and different cost zones. Both are described below.

Approach 1: Full network analysis and derivation of marginal cost for each road section

This approach is suitable for state road agencies and large local governments with the availability of extensive network-level condition data, deflection information and other road asset information required for a full LCC analysis. This approach involves:

- analysing the full network with relevant data
- analysing and estimating the section-level marginal cost from the LCC analysis, as in the flowchart (Figure 2.2)
- incorporating the marginal cost values within the road database.

Approach 2: Estimation of marginal cost based on a set of catalogues

A catalogue of charts can be developed to represent the spectrum of scenarios that are likely to be encountered on local government roads. This approach involves:

- creating hypothetical analysis sections based on:
  - road hierarchy
  - condition level
  - traffic category
  - different period of additional loading
  - different cost zone
- analysing and estimating the marginal cost for each of the sections using the LCC analysis, as in the flowchart (Figure 2.2)
- incorporating the marginal cost values for each combination within a chart with the aim of creating a suite of charts including all combinations.

2.2.3 Available Tools

There are 2 primary analysis tools that can be used to determine the marginal cost of road wear, and these are described below.

Freight Axle Mass Limit Investigation Tool (FAMLIT)

FAMLIT was developed through an Austroads project to offer asset managers a ready means to determine the marginal cost of road wear (Austroads 2015a, 2015b). The tool evolved from state-based studies and then national studies, with a national approach published in 2012 and further updates published in 2015. FAMLIT is a network-level pavement life cycle costing analysis tool that has been specifically tailored to produce load-wear cost relationships suitable for estimating the marginal cost. The tool uses a combination of road deterioration models, works effects models and road condition triggers to run a year-by-year analysis over 50 years that computes the effects of increasing axle group mass or an increased task.

Pavement Life Cycle Costing Analysis Demonstration Tool (PLCCDT)

The PLCCDT uses the deterministic road deterioration models developed through the Austroads long-term pavement performance study. These deterioration models predict the deterioration of roughness, rutting, cracking and strength during the gradual deterioration phase. Through the National Asset Centre of

Excellence (NACOE), the PLCCDT has been modified to include the additional functionalities of the FAMLIT tool (Toole, Roper, & Noya 2017). A PLCCDT version of the FAMLIT tool is also available to analyse the marginal cost from additional heavy vehicle loadings.

2.3 Published Libraries and Sources

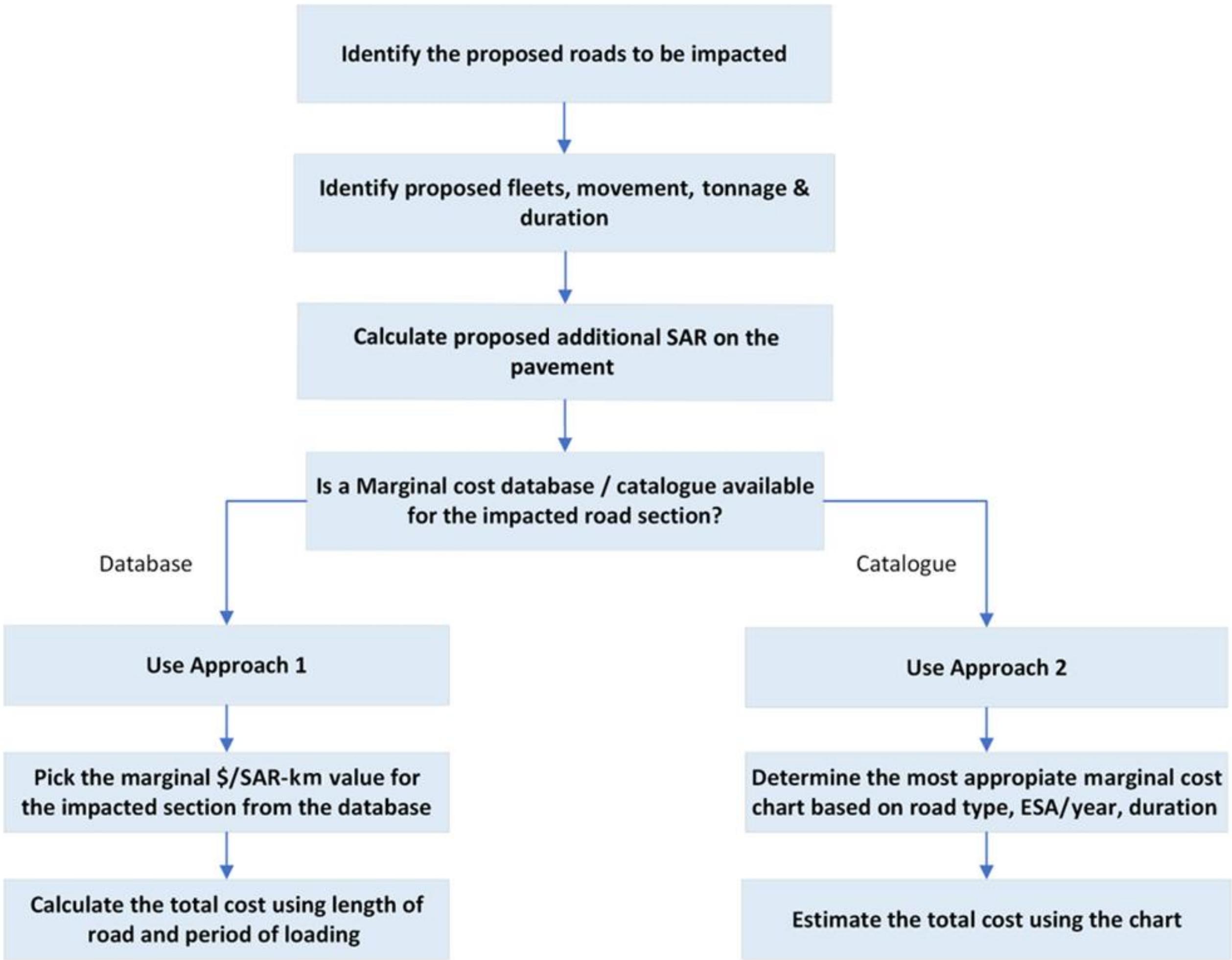
At a state level, Queensland Department of Transport and Main Roads and Main Roads WA have both developed marginal cost estimates for their full network. At a local level, the WA Local Government Association has developed a series of marginal cost charts for different combinations of traffic, loading periods and treatment cost zones (WALGA& NTRO 2025).

3. Cost Estimation Process

This section provides step-by-step guidance for estimating the cost associated with the loss of pavement value due to additional loading using the marginal cost approach. The common steps are followed by the specific steps that depend on the approach selected (i.e. network analysis vs catalogue based).

The cost estimation process is presented in Figure 3.1 and outlined below.

Figure 3.1: Flowchart outlining the cost estimation step-by-step process



The steps to perform the cost estimation are described below:

a) Identify the proposed roads to be impacted and record:
   i. pavement type (e.g. spray seal on unbound granular, asphalt on unbound granular, spray seal on foam bitumen, etc.)
   ii. design parameters or, if not available, road classification[2].
b) Identify the proposed fleet, movements and tonnage, including the length impacted and the duration.
c) Identify the proposed SAR impact on the road network.

[2] If road usage varies significantly from the expected classification, a project-specific specification may be required.

d) Estimate the remaining capacity of the pavements.

If the calculated marginal cost database using approach 1 (full network analysis) is available for the impacted sections, use the database and apply the following steps:

- Identify the relevant marginal cost rate per SAR-km from the road database for each section in the impact assessment area.
- Calculate the cost impact, i.e. the contribution required to be paid to the relevant asset owner to offset the loss of value of the pavement, using Equation 1.

$$Pavement\ Contribution = \sum_{i=1}^{n} (C + O)_i \times MC_i \times L_i \quad (1)$$

where

i	=	each road segment triggered
C	=	the construction period SARs
O	=	the operational period SARs for the impact mitigation period
MC	=	the relevant marginal cost (per SAR-km) prescribed in the department's database for each road segment
L	=	the length of road section in km
n	=	the number of road segments triggered in the impact assessment area

If a full network-level analysis is not possible, then the cost impact can be estimated using the catalogue-based approach (approach 2):

- Select the most appropriate marginal cost graph from the catalogue based on road type, ESA/year and period of loading.
- Calculate the marginal cost of the additional task.

4. Data Requirements

The data required for the marginal cost method is outlined in Table 4.1.

Table 4.1: Required inputs for the marginal cost method

Parameter (unit)	Description
Road name	Unique road/pavement identification name.
Road class	The subgroup that the road belongs to for allocating traffic loading.
Pavement type	The primary material type of the pavement; GN = granular pavement with a spray seal, AC = asphaltic concrete, CS = cement stabilised. The pavement type selected will influence the deterioration model.
TMI	The Thornthwaite Moisture Index climate variable.
Overlay design traffic growth (%/year)	Traffic growth used when calculating the new overlay thickness based on the design life.
Reseal cost ($/m^2)	Reseal works cost ($/m^2).
Overlay ($/m^3)	Overlay works cost for the minimum thickness of a mill and replace overlay or the total thickness of a non-mill and replace overlay ($/m^3).
Direction factor (-)	Proportion of the traffic assigned to the lane being modelled (e.g. 1 for all traffic, 0.5 for 50%).
Traffic growth (%)	Traffic growth for the vehicle count or SAR loading applied to the road (%/year). Does not have to be the same as the overlay design traffic growth.
SNP	Pavement modified structural number at the start of the analysis.
RI_0 (m/km)	Road roughness using the International Roughness Index at the start of the analysis period.
AADT	Annual average daily traffic (vehicles per day) for the road.
HV classification	Number of the heavy vehicles (HVs) in different Austroads vehicle class, for SAR calculation.
TSRS (years)	Time since last reseal of the pavement.
TSOVL (years)	Time since last overlay of the pavement.
TSRE (years)	Time since last reconstruction or since construction.
Road length (m)	Length of the road section.
Road width (m)	Width of the road section.
Initial SNP	Pavement modified structural number at construction or zero pavement age.
ME constant	Annualised pavement maintenance expenditure (ME) ($/lane-km/year). It is an input to the roughness deterioration model and part of the routine maintenance cost.
D_{rut} K-factor	Delta rut calibration factor for the roughness deterioration model.
D_{IRI} K-factor	Delta roughness calibration factor for the roughness deterioration model.
CBR	California Bearing Ratio of subgrade.

References

Austroads 2015a, Deploy and refine the road wear modelling methodologies: FAMLIT final report. Austroads, No. AP-R501-15.

Austroads 2015b, Freight axle mass limits investigation tool (FAMLIT) user guide. Austroads, No. AP-R502-15.

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