AMENDMENTS TO PAVEMENT DESIGN MANUAL

Re: Updated Requirements for Agency Practice, Design Inputs and Design Report Contents

Introduction

This design bulletin provides a number of updated requirements to the Pavement Design Manual (1997) which can be broadly grouped into categories of Agency Practices, Design Inputs, and Design Report Contents.

Agency Practices

1. Use of DARWin 3.1 and more recent

   DARWin 3.1 is the back-calculation software normally used for Alberta Transportation.

   Darwin 3.1 and above reads all 9 sensors. Release 3.1 or above shall be used for all design back-calculations and shall utilize all 9 sensor readings from FWD testing.

   Pavement designers are advised that AASHTO no longer provides technical support for DARWin and alternate software may be used with the agreement/approval of the department. Output requirements remain the same.

2. Long life pavement designs for urban and interchange areas

   Long life pavement designs (which includes the concept of Perpetual Pavement) has as a central goal the ability to maintain and rehabilitate a pavement section without adding pavement thickness. The ability to not add pavement thickness is important in areas where physical infrastructure (i.e. overhead bridge structures or adjoining concrete curb/barrier) make it impossible or more costly to raise the elevation of the existing pavement).

   For Alberta Transportation, long life pavements fall in two categories – one being the full materials design with different mixes at different layers to address cracking and rutting, and two the more common application for small sites where the goal is simply to increase the structure for logistic reasons, i.e. roundabouts, railway crossings, bridge approaches and bridge underpass pavements.

   All small site applications shall have an increased structure constructed to provide sufficient structural capacity for a 50 year design period. Within the 50 year period milling and replacing surface layers would be the expected rehabilitation method. Such small site projects (e.g. under a bridge, at intersections) will not require special mix design or asphalt binders. The increased structure in these cases should be by increasing the ACP thickness rather than base thickness. At bridges (underpasses) the thicker structure should extend 50m past the bridge crossing and then be tapered over the next 50 m to the
normal pavement structure.

Larger scale projects requiring long life pavements must be designed to resist bottom-up fatigue cracking and low-temperature transverse cracking through the selection of specific mixes and asphalts. In such instances the department will provide direction for the specification of such mixtures.

3. Special considerations for adding lanes (passing lanes, climbing lanes etc).

In some cases Alberta Transportation has experienced poor performance when widening existing pavement structures. The cause is not fully known but may relate to weaker than assumed existing shoulder area pavements, drainage impact from the newly widened roadway, or construction deficiencies/difficulties when constructing widened sections.

Where part of the shoulder is to be incorporated into the new lane, testing (FWD) may be required to assess the condition of the shoulder area.

In no case shall the joint between the existing pavement and the widened pavement fall within the vicinity of the wheel path. As required, the existing pavement shall be cut back and removed, and the underlying base removed to provide a consistent and homogeneous structure. The joint shall align with the shoulder-line, the lane edge, or between the wheel path location (within a tolerance of +/- 200mm). Tapered joints due to realignment shall be designed as square or slight diagonal transverse joints. At a minimum the top lift of asphalt must be benched (typically a minimum of 0.5 m) in to the existing asphalt via milling. In most cases this is detail the Prime Consultant needs to address, however it is the expectation to identify the needs in the pavement design report.

In all cases when widening, lateral drainage of the existing base material must be provided. In all cases the bottom of the new granular shall match or extend deeper than the existing granular materials. Sub-base (pit run) may be used to maintain lateral drainage but shall not result in a reduction of the granular base to less than 400 mm.

4. Shoulder widths

On all widening projects, including the addition of auxiliary lanes and intersection improvements, the Department’s standard practice is to provide enough shoulder width for two future overlays. Design cross sections shall show this requirement.

5. Use of Cold In-Place Recycling (CIR) and Full Depth Reclamation (FDR)

CIR and FDR are two similar processes yet different technologies to recycle material in-place. FDR is appropriate for fatigue and transverse cracked pavements and CIR is considered appropriate for addressing heavily transverse cracked pavements.

CIR is the removal of a partial depth of the existing asphalt pavement which is sized, stabilized and laid down in a continuous operation. Treatment depths are typically 80 to 120 mm. It is recommended that a minimum thickness of 50 mm asphalt material remains below the CIR to support equipment, however leaving any additional material (i.e. more than 50mm) also impacts the potential to minimize reflective cracking. The asphalt pavements should be less than about 200 mm to consider CIR. Consideration should also
be given to the base and subgrade strength in regards to supporting the CIR equipment. For pavements with significant cross fall deficiencies or extensive patching, selective cold milling may need to be completed prior to the CIR. The service life of CIR varies depending on existing cracking, remaining cracked pavement, and strength. Reasonable service lives may be 14 to 18 years.

FDR is the recycling of the full depth of the existing asphalt pavement and a portion of the underlying granular base materials by pulverizing with specialized equipment. FDR can be used without stabilizing additives (i.e. pulverization only) however the Department typically requires a bituminous stabilizing additive (either emulsion or foamed asphalt technology). The maximum processing depth is 250 mm, chosen primarily to ensure that compaction can be achieved throughout the entire layer. The depth ratio of ACP to granular materials is ideally of 1:1; however, this often varies based upon project specifics. Supplemental aggregate (Des 2 Class 20 or Class 25) can be incorporated into the FDR process if required to increase the pavement structure. The service life of FDR is considered similar to new construction (i.e. 20 years) if strength requirements for the design ESAL have been met.

Both in-place recycling processes can be considered when the existing asphalt pavement is exhibiting cracking to the extent that the pavement strength is compromised and the future performance of an overlay would also be considered to be compromised. In each process a minimum 50 mm ACP overlay is included. On some low volume roads a double sealcoat may be used in place of an overlay.

A structure coefficient of 0.25 shall be used for FDR when using a stabilizing additive and 0.30 for CIR. A coefficient of 0.14 shall be used for FDR only (i.e. pulverization only).

A more detailed description of various recycling processes, including CIR and FDR, is provided in the following publications:


6. Re-profile milling

Re-profile milling is intended to replace a 20 mm first lift in cases where it will help to eliminate crack-filler related construction issues. The use of milling instead of the first lift material is considered desirable when:

- Width is an issue;
- There is a potential for future recycling and it is desirable to limit the overall pavement thickness;
- Existing cracking exhibits significant spalling that would require shallow treatment;
- There is a benefit to improve crossfall and/or cross-section;
- There is minimum strengthening required.

Re-profile milling is to be controlled to ensure excessive thickness is not removed thus impacting pavement strength. Where more than minimal strengthening is required re-profile milling will not typically be economical.
7. **Mill and Inlay – strength improvement**

Milling of the travel lane can add strength when the existing pavement has deteriorated. An asphalt pavement with extreme severity and extensive fatigue cracking would be considered to have an existing coefficient of about 0.2 or half that of new ACP. The coefficient can be roughly estimated based on a visual assessment of the amount of cracking (see table 5.2 page III-105 of the AASHTO 1993\(^1\) for some guidance) or by assuming some appropriate base coefficient and calculating the effective pavement coefficient based on back-calculated $S_{N_{eff}}$.

8. **Hot In-Place Recycling**

The use of HIR does not need to be evaluated as a specific treatment – where mill and inlay is a potential rehabilitation treatment, HIR can be a tender option (contractor choice). The department has set guidelines for when HIR may not be appropriate based on excessive rutting or stripping issues, mill depths outside practical HIR (i.e. <40mm and >50mm) and traffic volumes greater than 20,000 unless being overlaid. The current special provision should be referred to. The department will provide direction on the need for life cycle adjustments for such option bidding in the special provision.

9. **SGBC**

Pavement designers are advised that the acronym SGBC on department cross-sections refers to 50 mm of ASBC over GBC (e.g. 300 mm SGBC is 50 mm ASBC over 250 mm GBC). The department is in the process of adjusting the cross-sections.

10. **Life Cycle Cost Considerations**

In some cases the selection of specific strategies may result in more interruption to the public due to the number of interventions required over the analysis period. User costs are not well defined nor normally adopted for pavement strategy selection. On higher volume roadways where traffic interruption may be a concern, cost may be assigned to the potential delay. At this time a value of $1/vehicle/km is considered representative of delay costs that result from construction activity. Such delay costs only need to be considered for highways with AADT greater than about 10,000 vpd.

Roadway width is becoming a significant issue for Alberta Transportation and preserving width is a concern on many highways. In some cases pavement design options may preserve width and delay widening. In cases where the next rehabilitation will require grade widening the cost of grade widening delay should be accounted for in the LCCA to compare strategies of different service lives. When comparing strategies that result in different width reductions, the life cycle costs should consider width as a value. For analyzing life cycle costs a value of up to $100/mm/km can be assigned to differentiate the

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value of preserving width when the roadway width is approaching the 3R/4R minimums. (eg: 100 mm overlay reduces width 1 m compared to full depth reclamation and a 50 mm overlay which reduces width 0.5 m – the width premium of up to $50,000/km would be considered in the LCCA).

The department expects to adjust the dollar values above as experience is gained.

**Design Inputs**

11. **Design ESAL Determination**

   The minimum ESAL for any pavement design shall be 30 ESAL/d/d.

   ESAL values contained within the Department’s annual ESAL reports are based on truck factors of 0.881 and 2.073 determined as the provincial average.

   Fully loaded tractor trailer trucks (e.g. semi-trailer and B-train configurations) carrying legal loads can impart 4.5 to about 6.5 ESAL per truck.

   Buses are not generally considered by Alberta Transportation as a source of ESAL, but may be warranted on certain corridors. For example, bus loadings on Hwy 63 north of Fort McMurray must be considered. An appropriate ESAL values for loaded inter-city bus is 3. City buses are not often operated on highways but at seating capacity are approximately 6 ESAL per bus.

   The designer shall evaluate the project for the potential for non-standard (i.e. not average) loadings and adjust the design ESAL appropriately. Examples include areas with gravel resources or logging activity – these may generate many fully or almost fully loaded trucks (and potentially in only one direction) which will change the ESAL determination. Sources of information for such decisions include local Department staff, industry and awareness of industry activities. The longevity of the haul also needs to be considered (e.g. some log or gravel haul may be sporadic and not affect total design ESAL).

   Special consideration also needs to be given for design ESAL along the various high load corridors which typically are subjected to loads that are not captured in the routine ESAL data.

12. **Lane Splits (design lane and secondary lanes)**

   For pavement designs of four lane divided highways 85% of the ESAL shall be assumed to be in the design lane. All other lanes shall be designed to accommodate a minimum of 40% of the ESAL. For greater than 2 lanes per direction the design lane should be designed for 70% of the total ESAL and subsequent lanes shall be designed to accommodate a minimum of 50% of the ESAL. In some cases it may be unclear which lane should be considered the design lane – in such cases all potential design lanes shall be designed to assure they can accommodate 70% of the ESAL.
13. **Reliability (design lane governs)**

The design reliability determined for the mainline design lane applies to all lanes of traffic including any ramps or auxiliary lanes. In the case of interchange ramps the minimum reliability is 90%.

14. **$M_R$ – value to use**

When utilizing back-calculated subgrade modulus from prototype pavements, the average value is estimated for use in the design. Occasionally this indicates a much higher value than would be considered normal and in such cases the 85 percentile value may give a better estimate. A $M_R$ of 30 MPa is a very typical subgrade design value and generally local knowledge is required to utilize higher values for design purposes.

15. **FWD Back-calculation**

Recent work [EBA Seasonal variation; AT FWD Variation (CTAA 2010)] has highlighted the potential variation in back-calculated moduli values using the AASHTO method (but applicable to any method). This variation includes changes in subgrade resilient moduli values through the testing season (trending to stronger in late summer and into the fall months) and the influence of pavement temperature on pavement moduli and the ability to adjust/correct to a standard temperature.

As a result pavement designers must examine FWD data carefully and consider time of testing and pavement temperature into their design decisions. Additional temperature data is now being collected with FWD testing (surface and air) and may now be used, when considered appropriate by the designer, to adjust pavement temperatures based on procedures such as provided by AASHTO and ASTM methodologies. These methods typically require prior temperature records for the area.

Methodologies to better estimate pavement temperatures (to assure the most representative temperature) will be explored/introduced in the future. This will require changes to back-calculation processes to utilize the most appropriate pavement temperatures.

16. **Safety Rest Area**

Safety Rest Areas shall be designed using the following standard sections:

<table>
<thead>
<tr>
<th>ESAL of Through Road (20 year design)</th>
<th>SRA structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACP</td>
</tr>
<tr>
<td>less than 5 Million</td>
<td>200</td>
</tr>
<tr>
<td>5 Million to less than 10 Million</td>
<td>220</td>
</tr>
<tr>
<td>10 million to less than 20 million</td>
<td>230</td>
</tr>
<tr>
<td>20 million or greater</td>
<td>250</td>
</tr>
</tbody>
</table>

Based on assumed $M_R$ of 30 MPa

The mix type for a Safety Rest Area will typically be the same as for the adjoining mainline pavement.
17. Reduced reliability for final stage paving of older pavements

When a final stage surfacing is being designed for a first stage pavement that is 10 years or older, consideration can be given to reducing the reliability of the final stage pavement design. The performance of the existing pavement, road bans, and engineering judgment must be used in these cases.

Design Report Contents

18. Pavement Design Report Requirements

Pavement Design Reports are required to be submitted to the regional sponsor and Technical Standards Branch (Marta Juhasz, Surfacing Design Standards Specialist (marta.juhasz@gov.ab.ca )) at the draft stage for review, comment and direction prior to finalizing. Design reports must be prepared to the following format:

- A one page Executive Summary which summarizes the pertinent background information (e.g. pavement and traffic data), includes a site plan, summarizes the present pavement condition, summarizes the design options, recommendations and provides the B Estimate.
- An Introduction that provides the Project Assignment Description/Limits, Authorization to Proceed, Previous Surfacing Strategy Reports and other applicable reports.
- A review of available information: Existing Pavement Structure/Width, Soils Characteristics, Traffic Volumes and ESALs, FWD Test Data, IRI and Rut measurements.
- All pertinent design inputs.
- A detailed field reconnaissance including:
  - General information such as names of personnel, date, weather condition, and general observations (pavement condition, ride quality, general distresses), locations of junctions of major intersections, bridge, railway, turnouts, etc.,
  - Detailed inspections (generally at least one per uniform segment) identifying items such as environmental/construction/load related distresses, transverse crack counts, locations and lengths of patches, rut measurements, curb locations and height, width measurement and distress severities in accordance with the Pavement Preservation Guidelines.
  - Site photos to illustrate general roadway condition and typical condition of distresses such as cracking.
  - Discussion with Maintenance Contract Inspector or other Operations personnel identifying maintenance/operational pavement related concerns, the type of maintenance work done and the reasons for the maintenance work.
  - Analysis of pavement condition, segmentation, preservation treatment options, evaluation of the inputs and LCCA used to arrive at the design recommendations and the rationale used in selecting the recommended design strategy. The need for and type of pre-overlay treatments should be considered as this can affect the LCCA.
  - Pavement width considerations
  - Selection of base and surfacing materials including ACP mix type and asphalt cement grades.
  - A statement regarding how long the design is valid for (with consideration of the age of the FWD data analyzed – normally no more than 5 years from such testing).
- Typical cross section drawings for the recommended pavement design strategy.
- Graphical presentation of calculated moduli, overlay needs, rut and roughness data/plots, and existing cross sections.
- Recommended surfacing strategy(ies) and basic structural design, including VIS, interchange ramps, etc.
- A ‘B’ type construction estimate / preventative maintenance estimate based on the recommended surfacing strategy and current construction / maintenance costs for the region/area.
- Site plan showing project limits.

Recommended:

Chuck McMillan  Feb 8/13
Director,
Surface Engineering and Aggregates

Approved:

Moh Lali
Executive Director,
Technical Standards Branch