AMENDMENTS TO PAVEMENT DESIGN MANUAL

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

March 2017 Amended Sections:
- Long life pavement designs life for urban and interchange areas
- Special considerations for adding lanes (passing lanes, climbing lanes etc)
- Use of Cold In-Place Recycling (CIR) and Full Depth Reclamation (FDR)
- Re-profile milling
- Mill and Inlay
- Hot In-place Recycling (HIR)
- Design ESAL Determination
- Road Bans
- Lane Splits (design lane and secondary lanes)
- SuperPave Design ESAL Threshold and Mix Type Use
- Reliability (design lane governs)
- Subgrade Resilient Modulus (M_r) – value to use
- FWD back-calculation
- Pavement Design Report Requirements

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. Long life pavement designs for urban and interchange areas

Long life pavement designs (which include the concept of Perpetual Pavements) have 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 (e.g. overhead bridge structures, adjoining concrete curb/barrier, etc.) makes it impossible or more costly to raise the elevation of the existing pavement.

For the Department, long life pavements fall into two categories: the full materials design with different mixes at different layers to address cracking and rutting; and the more common application for small sites where the goal is simply to increase the structure for logistics reasons, i.e. at roundabouts, railway crossings, bridge approaches and bridge underpass pavements.

All small site applications shall have an increased pavement structure constructed to provide sufficient structural capacity for a 40 year design period. Within this longer life
design period, milling and replacing surface layers would be the expected future pavement rehabilitation treatment. Such small site applications do not require the use of special mixes (e.g. rich bottom mix). The increased pavement structure in these cases should be achieved by increasing the asphalt concrete pavement (ACP) thickness rather than the base thickness. At bridges (underpasses) the thicker structure should extend 50 m past the bridge crossing and then be tapered over the next 50 m to the normal pavement structure. These areas shall be excluded from the staged paving at the time of initial base/paving new construction projects.

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

Regardless of the design life, engineering judgment is still required to rationalize the recommended pavement structures. The Department’s current pavement design methodology, based on AASHTO 1993, may provide overly conservative pavement structures as design ESALs increase.

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

In some cases the Department 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 (e.g. 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 a wheel path. As required, the existing ACP shall be cut back and removed, and the underlying base removed to provide a consistent and homogeneous pavement structure. The joint shall align with the shoulder-line, the lane edge or between the wheel paths (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 ACP shall be benched (typically a minimum of 0.5 m) into the existing asphalt via milling. In most cases this is detail the Prime Consultant needs to address; however, these requirements shall be identified in the pavement design report. Design cross sections shall show the requirement for benching.

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.

3. 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.
4. **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 recycling of a partial depth of the existing asphalt pavement which is then sized, stabilized and laid down in a continuous operation. CIR treatment depths are typically 80 to 120 mm. It is recommended that a minimum asphalt materials thickness of 50 mm remains below the CIR layer to support equipment; however, leaving additional asphalt materials (i.e. more than 50 mm) also impacts the potential to minimize reflective cracking. Consideration should also be given to the base and subgrade strength in regards to supporting the CIR equipment. Typically, the thickness of the existing asphalt pavement should be less than approximately 200 mm to be considered for CIR treatment. The service life of CIR varies depending on existing cracking, remaining cracked pavement, and strength. Reasonable service lives may be 14 to 18 years.

Pavement designers considering CIR should consider practices from Québec where the ratio of $N_f/f$ should be greater than 2.0, where $N_f$ is the combined thickness of ACP overlay and CIR processed material and $f$ is the thickness of the underlying asphalt materials that are untreated. For example, for a 200 mm thick existing asphalt pavement, CIR treated to 120 mm finished depth, and overlaid with 60 mm ACP, $N_f$ would be 120 mm CIR + 60 mm ACP overlay, and $f$ would be 80 mm of untreated existing asphalt materials, and therefore $N_f/f = 180/80 = 2.25$.

Pavement layer drainage is important for good performance. Because of the higher air voids of the CIR layer, its drainage may be an issue if applied to the driving lanes only. Therefore, CIR treatments shall be designed for the full width of the pavement only.

FDR is the recycling of the full depth of the existing asphalt pavement and a portion of the underlying base materials. FDR can be used without stabilizing additives (i.e. pulverization only); however, the Department typically requires a bituminous stabilizing additive. The maximum finished processing depth is 250 mm, chosen primarily to ensure that compaction can be achieved throughout the entire layer. The thickness ratio of the existing ACP to base is ideally 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 ESALs 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. For each process a minimum 50 mm ACP overlay is required. On some low volume roads a double seal coat may be used instead of an overlay.

Cold milling of the existing pavement prior to in-place recycling can be used to deal with cross-fall deficiencies or variable or increased ACP thicknesses due to patching or other past paving activities. During the detailed design stage the pavement layer thicknesses for
FDH projects are normally checked using Ground Penetrating Radar or coring, particularly if there are questions about ACP thickness or variability.

A structural coefficient of 0.25 shall be used for FDR with 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:

CIR and FDR are both rehabilitation treatments and shall use the reliability levels as defined in Table 10.1 of the Pavement Design Manual.

5. **Re-profile milling**

Re-profile milling is intended to replace a 20 mm first lift in cases where:
- Width is an issue;
- There is a potential for future in-place 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 cross-fall and/or cross section;
- There is minimal strengthening required;
- Where an excess of crack filler is present that could impact paving operation of the first 20 mm lift.

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.

6. **Mill and Inlay**

A mill and inlay 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 approximately 0.2 (i.e. 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 Guide for Design of Pavement Structures* (1993) for some guidance) or by assuming some appropriate base coefficient and calculating the effective pavement coefficient based on back-calculated SN_{eff}. It is recommended that a minimum asphalt materials thickness of 50 mm remains below the milled surface to support equipment.

When the shoulder width is less than 0.5 m, it is considered more practical to mill and replace the full width of the pavement. When designing a mill and inlay, the milling width shall be designed to be just outside the painted shoulder lines. This width will vary depending upon the classification of the highway (e.g. if the lane width is 3.5 m, the milling width shall be 3.6 m).
7. **Hot In-Place Recycling (HIR)**

In the recent past, the use of HIR has not generally been evaluated as a specific rehabilitation treatment. Due to recent advances in HIR technology, the Department has reviewed current design procedures and construction specifications to allow HIR to be used in-lieu of mill and inlay/replace treatments. This is intended to be a Contractor driven option and thus the designer does not need to evaluate HIR as a treatment option.

8. **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.

9. **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 rehabilitation treatment 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 the Department 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 Life Cycle Cost Analysis (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 value of preserving width when the roadway width is approaching the 3R/4R minimums (e.g. 100 mm overlay reduces width by 1 m compared to full depth reclamation and a 50 mm overlay which reduces width 0.5 m – a 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**

10. **Design ESAL Determination**

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

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 averages. Fully loaded tractor trailer trucks (e.g. semi-trailer and B-train configurations) at maximum legal loads can impart 4.5 to about 6.5 ESAL per truck. Buses are not generally considered by the Department 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 a 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 pavement designer shall evaluate the project for the potential for non-standard (i.e. not average) loadings and adjust the design ESALs 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).

Overload ESAL shall also be considered for all highways and this information is available from Technical Standards Branch.

11. Road Bans

The existence of a road ban shall be identified (through discussion with the MCI) and considered on all projects. While there are only a few roads where this is an issue, the existence of a ban is an important consideration particularly if the design intent is to remove the road ban as this may impact the design ESALs for the road.

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. The inner lanes shall be designed to accommodate a minimum of 15% in rural areas to 40% of the ESAL in urban or close to urban areas. In urban environments with greater than 2 lanes per direction, the design lane shall be designed for 70% of the total ESAL and subsequent lanes shall be designed to a minimum of 50% of the ESAL. In rural environments with greater than 2 lanes (e.g. climbing lane), engineering judgment should be used to determine the appropriate lane splits. 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. SuperPave Design ESAL Threshold and Mix Type Use

A fine graded SuperPave mix type shall be specified when the 20 year design ESAL is 30 million or greater. Department SuperPave Specifications are provided in the latest version of the Standard Specifications for Highway Construction, Specification 3.53.

14. 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.

15. Subgrade Resilient Modulus ($M_R$) – value to use

A seasonally adjusted $M_R$ of 30 MPa is a very typical subgrade design value and generally local knowledge is required to utilize higher values for design purposes. Lower values
should be used if the average back-calculated $M_R$ from prototype pavements is lower than 30 MPa.

16. **FWD back-calculation**

DARWin 3.1 was the back-calculation software normally used for the Department. However, this software is no longer supported or available for purchase. As such, alternate software may be used with the agreement/approval of the Department. Output requirements remain the same.

Recent work [EBA Seasonal variation study; Alberta Transportation 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 $M_R$ 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 in 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 may require changes to back-calculation processes to utilize the most appropriate pavement temperatures.

17. **Safety Rest Areas**

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.

18. **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

19. Pavement Design Report Requirements

Pavement Design Reports are required to be submitted to the regional sponsor and Technical Standards Branch (Surfacing Standards Specialist) at the draft stage for review, comment and direction prior to finalizing. Pavement Design Reports must be prepared and shall include the following:

- A one page Executive Summary that summarizes the pertinent background information (e.g. pavement and traffic data), includes a site plan, summarizes the present pavement condition, summarizes the design options, and provides the recommendations and B Cost 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 including addition overload ESALs, FWD Test Data, IRI and Rut measurements.
- All pertinent design inputs.
- A detailed field reconnaissance including:
  - General information such as names of personnel, data, weather condition, and general observations (pavement condition, ride quality, general distresses), locations of junctions of major intersections, bridge, railway, turnouts, etc., as well as a summary of highlights observed during the field reconnaissance.
  - 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 existence of road bans, 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 except for first stage pavements which would normally be no more than 3 years).
- 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 cost estimate.
• Site plan showing project limits.

Recommended:
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Approved:
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