Assessing Climate Change Impact on Asphalt Binder Grade: Selection and its Implications

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Introduction

Objectives

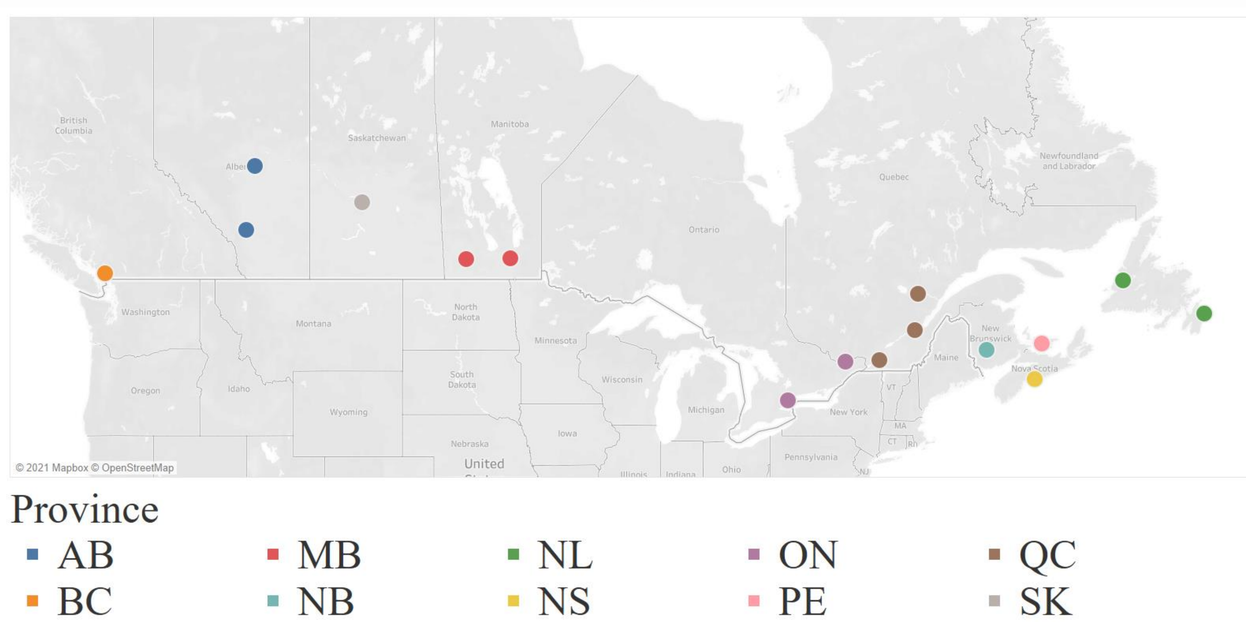
- Quantify the impact of climate change on pavement performance across various climatic regions in Canada.
- Estimate the influence of temperature increase on asphalt binder grade selection.
- To quantify the influence of upgraded binder grade on pavement performance and service life.

Research Outline

This study was carried out in five phases.

1. Collect statistically downscaled climate change models from the pacific Canada climate database.
2. Extract the maximum and minimum temperature data for ten different climate change models.
3. Determine the asphalt binder grade for climate change data.
4. Collect pavement materials, traffic, and structural data from Long-term pavement performance (LTPP) database and Newfoundland Department of Transportation and Works (NL-DTW).
5. Assess the pavement performance for both historical and future climate with the base and upgraded binder grade using AASHTOware Mechanistic-Empirical (ME) Pavement Design.

Test Sites and Climate Change Models:



Test Sites

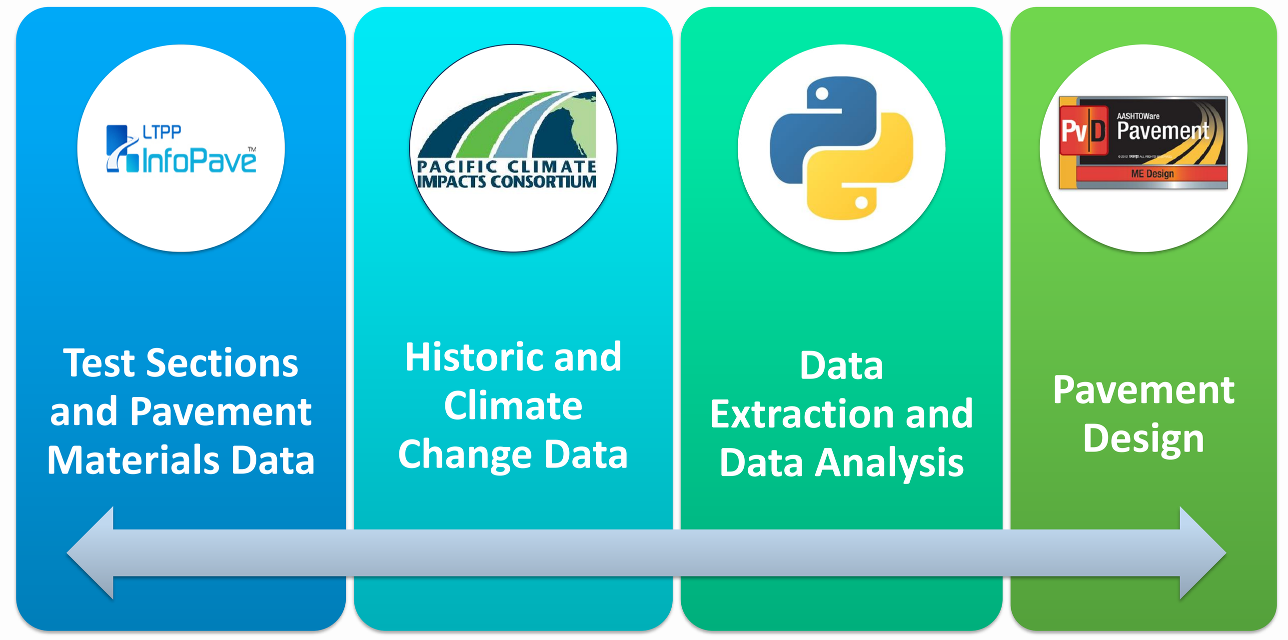
16 test sections: Alberta(2), British Columbia (1), Manitoba(2), New Brunswick(1), Newfoundland(2), Nova Scotia (1), Ontario(2), Prince Edward Island (1), Quebec(3), Saskatchewan(1)

Climate Change Models

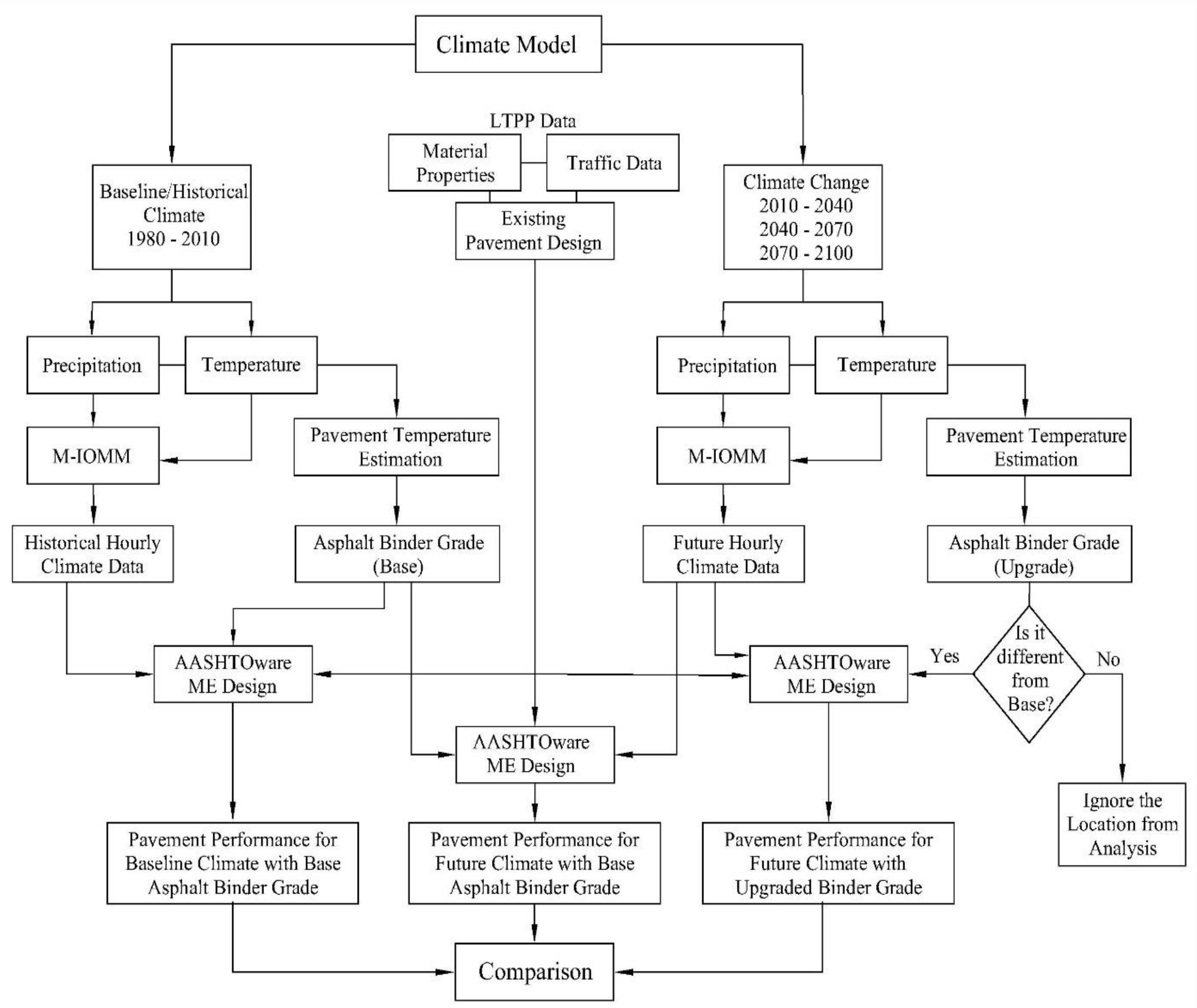
10 Climate change models from pacific climate database (https://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios)

Methodology

Data Collection and Analysis Tools



Methodology



LTPP Pavement Temperature Model

$$T_{P\,max} = 54.325432 + 0.78\ T_{air\,max} - 0.0025\ Lat^2 - 15.41\ \log_{10}(H+25) + z\left(9 + 0.61\sigma^2_{Tair\,max}\right)^{0.5}$$

$$T_{P\,min} = -1.56 + 0.72\ T_{air\,min} - 0.004\ Lat^2 + 6.26\ \log_{10}(H+25) + z\left(4.4 + 0.52\ \sigma^2_{Tair\,min}\right)^{0.5}$$

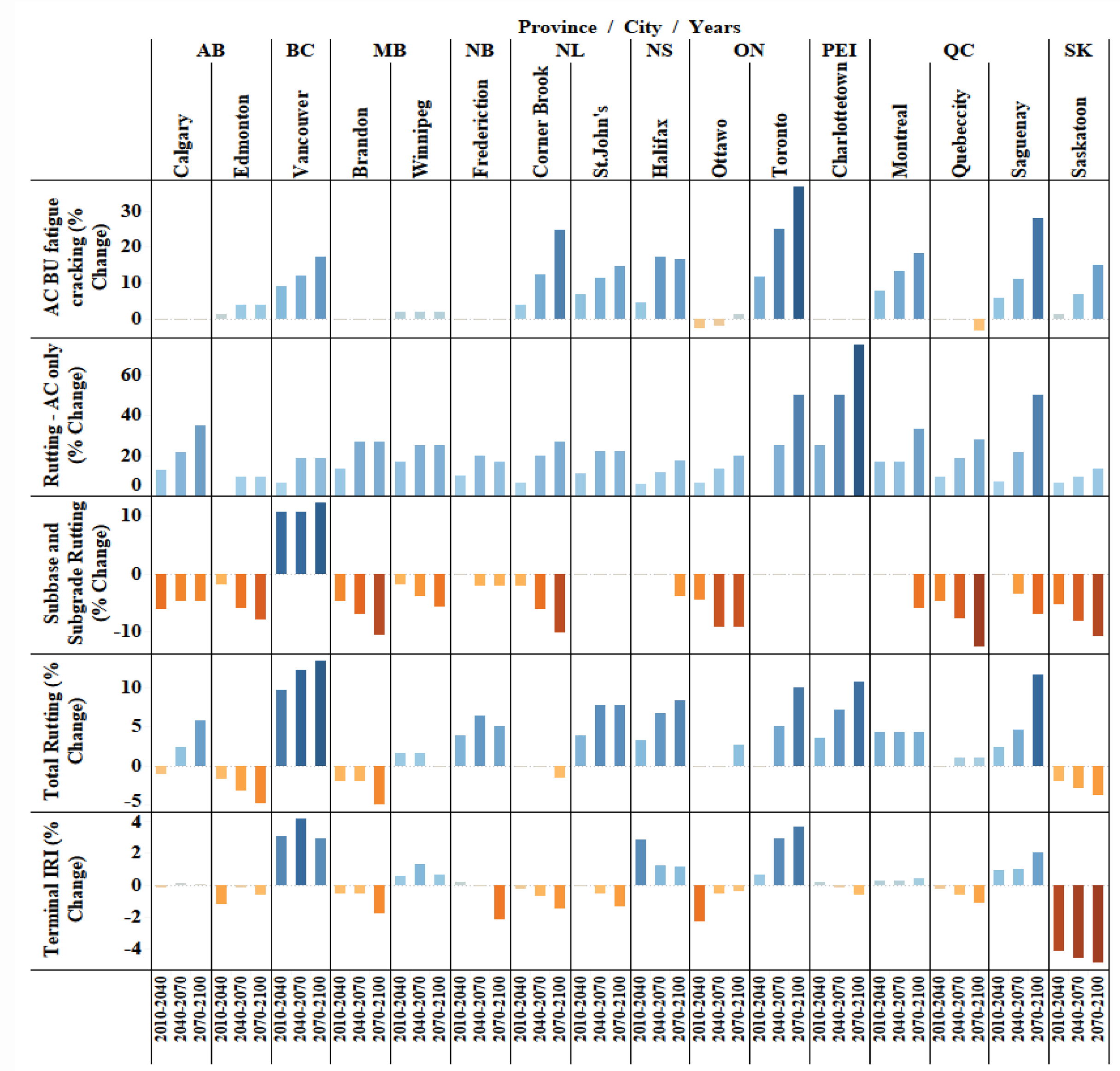
Modified Imposed Offset Morphing Method (M-IOMM)

$$T_{hr} = \left(\frac{T_{pM} - T_{pm}}{T_{hM} - T_{hm}} \times (T_{hD} - T_{hm})\right) + T_{pm}$$

$$P_{hr} = \left(\frac{(P_{dapm} - P_{dahm})}{P_{dahm}} \times p_{hhr}\right) + p_{hhr}$$

Data Analysis and Results

Impact of Climate Change on Pavement Performance



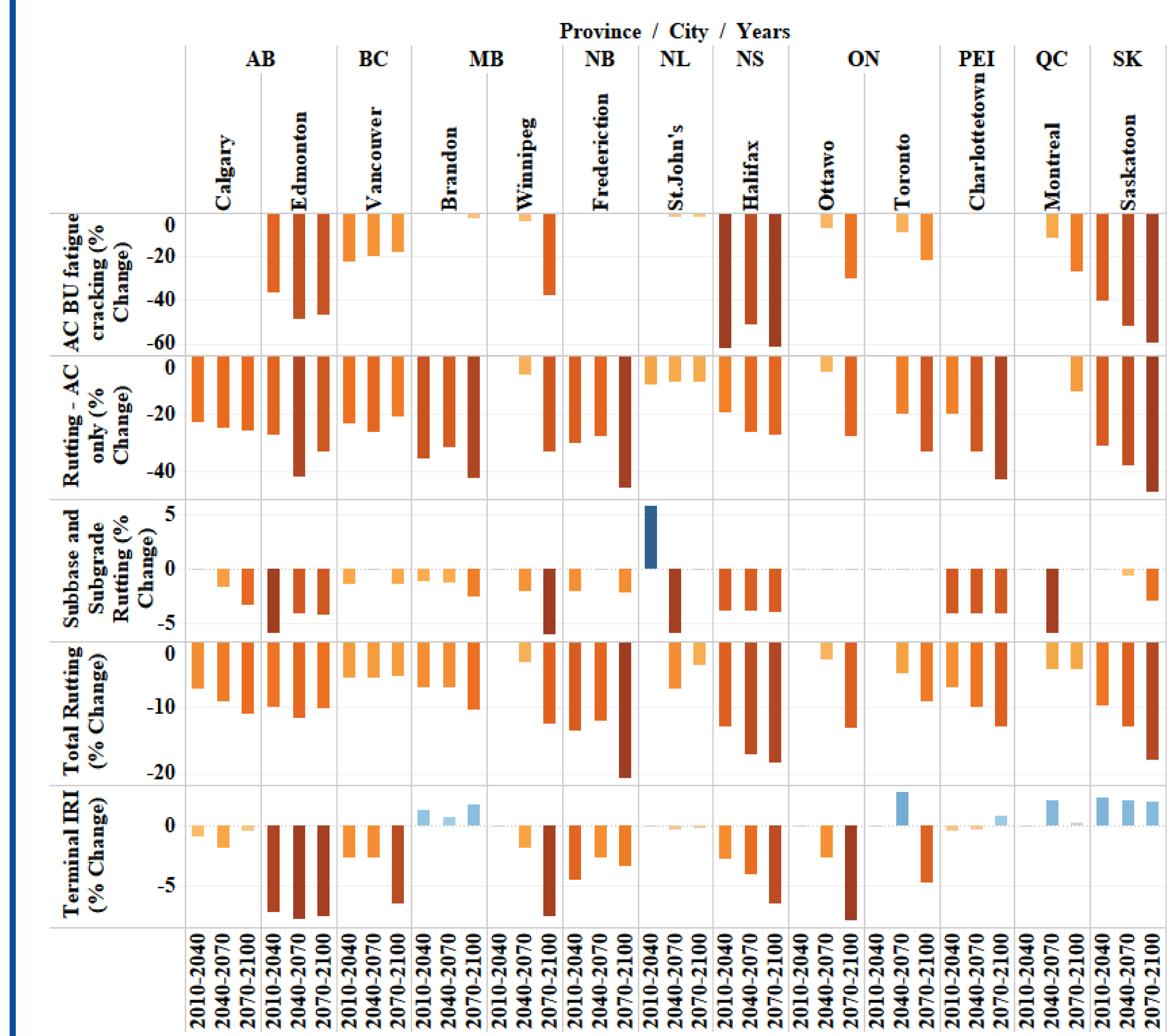
This plot represents the impact of climate change on pavement performance. The bars presented in this plot are the percentage change in performance parameters for future years with respect to baseline/historical climate. For example, in Calgary, the AC rutting is increasing by 13.04% for 2010-2040 when compared to 1980-2010. Similarly, the AC rutting is increasing by 21.74% and 34.78% for 2040-2070 and 2070-2100, respectively wrt. 1980-2010.

Asphalt binder grade for future climate

Province	City	Base Binder 1980-2010	Upgraded Binder 2010-2040	Upgraded Binder 2040-2070	Upgraded Binder 2070-2100
BC	Vancouver	PG 52-16	PG 58-16	PG 58-16	PG 58-10
AB	Calgary	PG 52-40	PG 58-40	PG 58-34	PG 58-28
AB	Edmonton	PG 52-46	PG 58-40	PG 58-40	PG 58-34
SK	Saskatoon	PG 52-52	PG 58-40	PG 58-34	PG 64-34
MB	Brandon	PG 52-46	PG 58-34	PG 58-34	PG 64-28
MB	Winnipeg	PG 58-40	PG 58-40	PG 58-34	PG 64-28
ON	Toronto	PG 58-28	PG 58-28	PG 58-22	PG 64-22
ON	Ottawa	PG 58-34	PG 58-34	PG 58-28	PG 64-28
QC	Montreal	PG 58-34	PG 58-34	PG 58-28	PG 64-22
QC	Quebec City	PG 58-34	PG 58-28	PG 58-28	PG 58-22
QC	Saguenay	PG 58-34	PG 58-34	PG 58-34	PG 58-28
NB	Fredericton	PG 58-34	PG 58-28	PG 58-28	PG 64-22
PEI	Charlottetown	PG 52-34	PG 58-28	PG 58-22	PG 58-16
NS	Halifax	PG 52-28	PG 58-22	PG 58-22	PG 58-16
NL	Corner Brook	PG 52-28	PG 52-28	PG 52-28	PG 52-22
NL	St. John's	PG 52-28	PG 52-22	PG 52-22	PG 58-16

Results

Influence of Upgraded Binder Grade on Performance



This plot represents the influence of upgraded asphalt grade on pavement performance for future climate. The bars presented in this plot are the percentage change in performance parameters for upgraded asphalt grade with respect to base asphalt grade. For example, in Edmonton, the AC BU fatigue cracking is decreasing by 36.60% for 2010-2040 with an upgraded binder (PG 58-40) when compared to the base asphalt (PG 52-46). Similarly, the AC BU fatigue is decreasing by 48.74% and 46.56% for 2040-2070 and 2070-2100, respectively, with the upgraded asphalt wrt base asphalt grade.

Conclusions

- All the locations, except Quebec City, Saguenay, and Corner Brook, need a change in binder grade to adapt to the future climate. All other cities, except Saskatoon and Brandon, need one binder grade increment to adapt to future climate. Only Saskatoon and Brandon need two binder grade increments.

- Permanent deformation in subbase and subgrade is decreasing in 12 out of 16 locations, which might be occurring due to a reduction in freezing index and an increase in temperature.
- Asphalt concrete permanent deformation is increasing at all the location, which might be a resultant of increasing temperature.
- The total permanent deformation is also increasing for 11 out of 16 locations. In these 11 sections, the increase in AC rutting is higher than the subbase and subgrade rutting.

- With the upgrade of asphalt binder grade, a permanent deformation in the AC layer is significantly decreasing, which results in the extended service life of the pavement.
- There is no potential change in the subbase and subgrade permanent deformation. However, there is a slight reduction, which might be a result of the reduced BU fatigue cracking.
- There is a decrease in all the distress, including IRI, for the future climate with the upgraded binder.
- It was noticed that the IRI is reducing due to climate change. Besides, with the upgraded binder, the IRI is further reducing, which results in the extended service life of the pavement.
- Upgrading asphalt binder is a low cost and effective climate change adaptation strategy for Canadian pavements.

Acknowledgements

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