TAC Pavement ME User Group – Canadian Climate Trials

Mark Popik, M.Eng., P.Eng., Senior Pavement Engineer, Thurber Engineering Ltd.
Marta Juhasz, P.Eng., Surfacing Standards Specialist, Alberta Transportation
Susanne Chan, MA.Sc., P.Eng., Pavement Design Engineer, MTO MERO
Hugh Donovan, P.Eng., Construction Services Engineer, City of Edmonton
Denis St-Laurent, ing. M.Sc., Service des Chaussées, Ministère des Transports du Québec

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ABSTRACT

In the late 1990s, the National Cooperative Highway Research Program (NCHRP) initiated a project to develop a state-of-the-practice tool for the design of new and rehabilitated pavement structures. The major objective of this NCHRP 1-37A project was to develop a document for adaptation by AASHTO as its new Mechanistic-Empirical Pavement Design Guide (MEPDG) for new and rehabilitated pavement structures. The development of the new AASHTO MEPDG and its supporting software DARWin ME (later re-named to Pavement ME Design), has changed existing pavement design procedures, but would need to be adapted and calibrated for local conditions. In preparation for the release of this new tool, the Pavements and Soils and Materials Standing Committees of the Transportation Association of Canada, initiated a Pool Fund project to provide guidance to Canadian agencies on adaptation and calibration of the MEPDG to Canadian conditions.

Initiated in April of 2004, the project steering committee began by developing a road map that identified short and long term requirements and resources needed to implement the MEPDG in Canada. The calibration process began with the development of a database of historical Canadian climate information for various locations across the country, which has since been included in Pavement ME Design. Other project tasks followed thereafter including a review of traffic inputs and numerous workshops. To further help the project steering committee in determining future project requirements, and to share knowledge in using the design tool, a user group was formed in 2008.

As a way to become more familiar with using the Pavement ME Design program the user group began running trial designs and comparing the variability in results. A flexible pavement design was provided by Manitoba Infrastructure and Transportation that was used as the base design. This base design was modified for various climate stations across Canada, while keeping all other input parameters consistent. Design trials were then completed by changing the season in which the pavement structure was constructed, followed by evaluating the impact of changing asphalt cement grade in the asphalt mixtures. The objective of this paper is to present the results of the trials completed by the TAC Pavement ME user group, and highlight some of the findings of the analysis.

INTRODUCTION

In the late 1990s, the National Cooperative Highway Research Program (NCHRP) initiated a project to develop a state-of-the-practice tool for the design of new and rehabilitated pavement structures. The NCHRP is administered by the Transportation Research Board (TRB) and sponsored by the member departments (ie. individual state departments of transportation) of the American Association of State Highway and Transportation Officials (AASHTO). In cooperation with the Federal Highway Administration (FHWA), the NCHRP was created in 1962 as a means to conduct research in acute problem areas that affect highway planning, design, construction, operation, and maintenance nationwide.

The major objective of the NCHRP 1-37A project was to develop a document for adaptation by AASHTO as its new Mechanistic-Empirical Pavement Design Guide (MEPDG) for new and rehabilitated pavement structures. The development of the new AASHTO MEPDG and its supporting software DARWin ME (later re-named to Pavement ME Design), has changed existing pavement design procedures, but would need to be adapted and calibrated for local conditions [1].

BACKGROUND

In preparation for the release of this new tool, the Pavements Standing Committee and the Soils and Materials Standing Committees of the Transportation Association of Canada (TAC) initiated a Pool Fund project to provide guidance to Canadian agencies on adaptation and calibration of the MEPDG to Canadian conditions. Initiated in April of 2004, the project steering committee (PSC) began by developing a road map that identified short and long term requirements and resources needed to implement the MEPDG in Canada. The calibration process began with the development of a database of historic Canadian climate information available across the country. The climatic information included 190 weather stations from across all ten Canadian provinces and another 33 climate stations from the three Canadian territories. All of these climate stations have since been incorporated into the Pavement ME Design (Pavement ME for short) software by AASHTO.

Other project tasks followed thereafter including a review of traffic inputs and numerous workshops and training sessions. To help the PSC in determining future project requirements, and to share knowledge in using the design tool, a user group was formed in 2008. In August of 2012, members of the TAC Pavement ME User Group (user group) began using the program to run various design trials, as a way to become more familiar with the program. The results of each design trial were shared among the members and discussed at user group meetings.

The initial design trials, as completed by the group, compared the predicted distresses for the same input parameters for various weather stations across the country. A similar exercise was also completed changing the time (and completion) of construction for each of the four seasons. The user group then decided to evaluate the impact different Performance Graded (PG) asphalt cement binders have on predicted distresses.

AKNOWLEDGEMENT

The decision to proceed with preparing and presenting this paper for the 2013 TAC Conference was approved by the TAC Pavement ME User Group members. The material presented in this paper is the property of the user group. An acknowledgement for the content of the presented material goes to all individuals and agencies that participated in running the various design trials. This includes: Marta Juhasz and Kim Edmunds with Alberta Transportation (AT); Hugh Donovan with the City of Edmonton (Edmonton); Alauddin Ahammed with Manitoba Infrastructure Transportation (MIT); Warren Lee with Ministry of Transportation Ontario (MTO); and Julie Roby and Denis St-Laurent with the Ministère des Transports du Québec (MTQ).

A special acknowledgement goes to the previous chair of the TAC Pavement ME User Group Marta Juhasz of Alberta Transportation and the current co-chairs of the TAC Pavement ME User Group, Susanne Chan of MTO and Sherry Sullivan of the Cement Association of Canada.

TAC PAVEMENT ME USER GROUP

The membership of the TAC Pavement ME User Group consists of 36 participants that represent provincial and municipal agencies, industry organizations, consultants, contractors, and academia. The user groups generally hold two face-to-face meetings at the TAC Spring and Fall meetings, with a number of conference calls throughout the year. The intent of these meetings is to provide a forum where users (or interested parties) of the AASHTOWare Pavement ME software can: share their experiences with using the software program; discuss results of the design trials; calibration efforts; or different input parameters used for the analysis.

It is understood by the user group that the high annual licensing fee of the program limits the ability of many agencies to purchase the software. However, as this tool is viewed as the future of pavement designs, membership to the user group remains open to all TAC members.

INITIAL DESIGN TRIALS

During regular discussion at a user group meeting, it was noticed that only a handful of members owned a license for the Pavement ME software, and even fewer members used the program on a regular basis. In an effort to encourage the user group members to begin using the program regularly, a series of design trials were initiated.

The first design trial completed by the group included testing Canadian climate files that are available with the purchase of a workstation license. To ensure that predicted distresses for each station were comparable, the same input file was used for all trial designs. The initial input design file was provided by MIT, which was a flexible pavement of new construction. Each of the agencies that owned a license to the software program completed the design trials in their jurisdictions by only changing the climate stations. As only five agencies participated in this design trial, runs of the remaining climate files were completed by Thurber Engineering Ltd.

Pavement Structure

The design trials were completed for a new flexible pavement, with a 20-year design life. The pavement design for the trial was comprised of a total asphalt thickness of 200 mm, underlain by 200 mm of Granular Base and 500 mm of Granular Subbase. The asphalt surface was separated into two layers with a 50 mm surface mix and a 150 mm thick binder course. Both asphalt mixes were designed to have a unit weight of 2,400 kg/m^3 and in-situ air voids of 5 percent. For the initial trials, the asphalt cement of the surface course was a Performance Graded (PG) 70-40, while a PG 64-34 graded asphalt cement was selected for the lower asphalt mix.

The granular base material was comprised of a crushed stone with a resilient modulus of 207 MPa. The granular subbase material used in the analysis consisted of an A-1-b (AASHTO Soil Classification) material, which consists of a sand and gravel material with a resilient modulus of 172 MPa.

Subgrade Soils

The subgrade soils used in the analysis consisted of highly plastic clay with the soil properties summarized in Table 1.

Table 1. Subgrade Soil Properties.

Characteristic	Soil Property
Percent Passing 4.75 mm	100 %
Percent Passing 2.0 mm	91 %
Percent Passing 75 µm	87 %
Liquid Limit	85 %
Plasticity Index	55 %
Maximum Dry Unit Weight	1,341 kg/m^3
Optimum Moisture Content	29.8 %
Poisson's Ratio	0.35
Coefficient of Lateral Earth Pressure	0.5

The resilient modulus of this subgrade soil was entered as 30 MPa.

Traffic

The traffic analysis for the design trials assumed that the roadway was to contain two-lanes in the design direction, with an 80 percent lane distribution factor for the design lane. An initial two-way Annual Average Daily Truck Traffic (AADTT) of 2,450 was used, with a 50 percent split in truck traffic for the design direction. The operation speed for this roadway was assumed to be 80 km/hr, a compounded growth rate of 2 percent was used, with the truck distribution provided in Table 2.

Table 2. Vehicle Class Distribution.

Vehicle Class	Distribution
Class 4	1.0%
Class 5	4.2%
Class 6	4.1%
Class 7	0.3%
Class 8	3.4%
Class 9	51.4%
Class 10	19.4%
Class 11	1.3%
Class 12	1.2%
Class 13	13.8%

Although the Pavement ME software does not use an ESAL calculation for predicting distresses, the program provides an output text file with an ESAL calculation for comparison purposes with the AASHTO '93 pavement design methodology [2]. The traffic inputs resulted in a calculation of 9.36 million ESALs.

Performance Criteria

The performance verification forms the basis of the acceptance, or rejection, of a trial design evaluated using the Pavement ME software. The design procedure is based on pavement performance, and therefore, the critical levels of pavement distresses that can be tolerated by the agency at the selected level of reliability needs to be specified by the user [3]. The target values used to compare the results of the design trials were the default limits as recommended by AASHTO in the Pavement ME software, and their Manual of Practice [4]. These distress target thresholds values are provided in Table 3.

Table 3. Distress Prediction Target Values.

Predicted Terminal IRI (m/km)	**2.70**
Permanent Deformation - Total Pavement (mm)	**19.00**
AC Bottom-up Fatigue Cracking (%)	**25.00**
AC Thermal Fracture (m/km)	**189.4**
AC top-down Fatigue Cracking (m/km)	**378.8**
Permanent Deformation - AC only (mm)	**6.00**

Software Calibration

Pavement distress prediction models, or transfer functions, are the key components of any M-E design analysis procedure. The accuracy of performance prediction models depend on an effective process of calibration and subsequent validation with independent data sets. All performance models in the Pavement ME software were calibrated on a global level to observed field performance at Long Term Pavement Performance (LTPP) test sections throughout North America [5].

The user group acknowledges that the models (and transfer functions) in Pavement ME software have not been calibrated to Canadian conditions. Calibration is a very involved exercise and the TAC PSC recognized early on that given the variability of truck traffic, climate, materials and construction practices across the country, calibration on a national level was not a feasible undertaking. No Canadian agencies to date have completed calibration and as such the design trials relied on the default global calibration factors that are within the software program.

CANADIAN WEATHER STATIONS

As an initial design trial, those involved ran the provided Manitoba input file for various Canadian weather stations. The general purpose of this trial was two-fold. The main purpose of the runs was to compare the predicted distresses for the various climate stations and compare the results to determine the impact climatic conditions has on a pavement performance. A secondary purpose in running these designs was to ensure that each of the climate files worked in the program.

To keep this initial design trial simple, the original input file was modified by only changing the location of the climate station used in the analysis. The remainder of the design inputs remained unchanged. This allowed for a direct comparison of the predicted distresses for each of the design output results. It should be noted that these design trials were only completed for climate stations across the ten Canadian Provinces. No analyses were attempted for stations in any of the Canadian Territories.

Climate Station Trial Results

For this initial design trial, a total of 125 weather stations were analyzed from across the country. Each of the participants of this trial prepared a summary of their results, which was compiled into one Excel file. The summary of the output file included the climatic information for each weather station, as well as the predicted distresses. Of the 125 design runs, the climate files for Swift River, Saskatchewan and Bathurst, New Brunswick were found to have missing data and errors in attempting to run the design. For presentation in this paper, the successful results for 10 climate stations are provided (in Table 4), which represent the typical climate regions across Canada.

Table 4. Canadian Climate Stations – Trial Result Summary.

	Target Values	**Fredericton, NB**	**Goose Bay, NL**	**Montreal, QC**	**Windsor Airport, ON**	**Winnipeg, MB**	**Uranium City, SK**	**Calgary, AB**	**Cape St. James, BC**	**Vancouver, BC**	**Smith River, BC**
Mean Annual Air Temp. (^{o}C)		5.7	0.4	6.5	9.4	3.1	-3.4	4.6	8.4	10.6	-2.5
Mean Annual Precipitation (mm)		1069.1	942.1	984.3	937.3	528.2	337.9	416.9	1639.1	1159.5	468.1
Number of Wet Days		155.3	186.9	168.4	147.1	127.3	125.7	109.6	243.7	166.9	147.2
Freezing Index (^{o}C-days)		899.8	1787.7	921.6	770.1	2478.3	4134.6	1697.3	18.1	34.3	2739.1
Average Annual No. Freeze-Thaw Cycles:		82.0	61.9	61.2	61.4	72.8	52.9	144.7	11.8	36.7	94.1
Years of Climate Data		21	21	20	20	20	20	20	18	20	15
Distress Prediction Summary											
Predicted Terminal IRI (m/km)	**2.70**	2.70	2.63	**2.72**	**2.75**	2.69	2.63	2.62	2.45	2.58	2.61
Permanent Deformation - Total Pavement (mm)	**19.00**	**20.34**	**17.15**	**21.51**	**23.47**	**21.01**	18.60	**19.17**	14.12	**19.17**	17.25
AC Bottom-up Fatigue Cracking (%)	**25.00**	2.19	1.98	2.27	1.79	1.69	2.09	2.09	1.81	2.09	2.02
AC Thermal Fracture (m/km)	**189.4**	5.2	5.2	5.2	5.2	5.0	9.6	5.2	5.2	5.2	8.2
AC top-down Fatigue Cracking (m/km)	**378.8**	319.3	250.1	342.7	365.4	334.8	298.2	286.7	115.8	276.5	264.1
Permanent Deformation - AC only (mm)	**6.00**	**10.89**	**7.84**	**12.00**	**13.90**	**11.53**	**9.17**	**9.78**	5.07	**9.83**	**7.91**

In reviewing the climate information for the stations, the variability in climate conditions across Canada is noteworthy. Within the ten provinces, the mean annual air temperature varies from as low as -3.4°C (Uranium City, SK) to a high of 10.6°C (Vancouver, BC). This variability extends to Freezing Index (per year) with over 4,100°C-days for Uranium City (SK), while Cape St. James (BC) had only 18°C-days. Some of the driest conditions in Canada are located in the Calgary area with an average of 110 wet-days per year and a mean annual precipitation of 417 mm, while, not surprisingly, the British Columbia coastal region is the wettest in Canada, with Cape St. James experiencing 243 wet-days per year and a mean annual precipitation of 1,640 mm. As expected, the moderate climate areas had the lowest number of freeze-thaw cycles per year, while the Calgary area (with a mean annual air temperature of 4.6°C) undergoes the most freeze-thaw cycles at 145 per year.

Based on the input parameters previously identified, the predicted distresses for each weather station were evaluated against the distress threshold values. In general, most of the climate stations were less than the target values for distresses like: AC Bottom-up Fatigue Cracking; AC Thermal Fracture; and AC top-down Fatigue Cracking. Although most of the climate stations did meet the Terminal IRI target value, a number of climate files were observed to exceed the 2.7 m/km threshold.

The two distress parameters that most climate stations did not meet were the Permanent Deformation – Total Pavement and Permanent Deformation – AC only. Although some of the predicted distresses for the weather stations did meet the rutting threshold for the total pavement structure, practically all of the design outputs failed the 6 mm threshold for rutting in the asphalt surface. The only weather station that met all of the predicted distress target threshold values was Cape St. James (BC). It is recognized that the 6 mm target value for AC permanent deformation is quite stringent and as such most climate stations did not meet this requirement. However, on the whole most climate stations were close to the 19 mm threshold for total permanent deformation. Reviewing the predicted rutting distress with the various climates, it is difficult to draw any correlations. Typically colder climate regions were found to have lower predicted rutting; although some of the moderate climate regions also had lower predicted rutting. The climate station at the Windsor Airport (ON) had one of the highest predicted rutting with the asphalt rutting at 13.9 mm, and a total pavement rutting of 23.5 mm.

In reviewing the summary of the output results, members of the user group noticed some slight discrepancies between the climatic information presented in the output files and the information that is presented in the software climate tab after selecting a weather station. Although the two sets of numbers were close, they did not exactly match. This variability in presented climate information led to many user group members to question the repeatability of results.

VERIFICATION AND VALIDATION

The questions about climate variability and repeatability of results led to some debates between the active participants of the design trials. One of these questions was whether the same input file run on different machines, would generate the same output results. To test this theory, MTQ, AB and Thurber all tried to repeat the results of the initial input file provided by MIT. The comparison in output files from this simple trial resulted with all three parties able to match not only the predicted distresses for the Winnipeg climate station, but also duplicated the annual statistics that are provided in the output report.

This exercise highlights the importance of users running through a verification and validation process between computers using the software, as well as when a new version of the software is installed. Users should ensure that the results they are obtaining have not changed. Of note is that the software download site contains 58 verification and validation files as well as a spreadsheet of expected results for such an exercise.

CONSTRUCTION SEASON VARIABILITY

The user group then continued to build on this success by comparing the results for selected climate stations with modified construction and completion dates for each of the four seasons. For the Winter season, the dates for 'Base Construction', 'Pavement Construction', and 'Traffic Opening' were November (2012), December (2012), and January (2013), respectively. Similarly, for the Spring season, the months were March (2012), April (2012), and May (2012), the Summer season was June (2012), July (2012), and August (2012), while the Fall the months were September (2012), October (2012), and November (2012). As the task to complete these design trials for all of the climate files across Canada would be an overly extensive challenge, only a selected few weather stations representing the various climate regions were selected.

Season Variability Trial Results

A total of 21 weather stations were analyzed varying the construction and completion dates for each of the four seasons. Similar to the first trial, the output files were summarized in a single Excel file. In comparing the results of this limited trial, the user group observed some minor differences in the values presented in the climatic information of the output file; however, these differences were often very slight. Similarly, in comparing the predicted distresses for the various seasons, the variability was often very minor, with little impact to whether the design passed or failed the threshold criteria. Of the 21 weather stations tested, the only location where the construction season made a difference in the pass/fail criteria was The Pas, Manitoba. The results of the analysis at this location are summarized in Table 5.

Table 5. Example of Season Variability

		The Pas, MB			
Season	**Target Values**	**Winter**	**Spring**	**Summer**	**Fall**
Base construction		Nov	Mar	June	Sept
Pavement construction		Dec	Apr	July	Oct
Traffic opening		Jan	May	Aug	Nov
Climate Information					
Mean Annual Air Temp. (^{o}C)		0.62	0.84	1.02	0.93
Mean Annual Precipitation (mm)		440	454	461	444
Number of Wet Days		122.7	122.2	122.4	121.4
Freezing Index (^{o}C-days)		2188	2094	2083	2093
Average Annual No. Freeze-Thaw Cycles:		68.6	70.0	69.3	69.3
Years of Climate Data		20			
Distress Prediction Summary					
Predicted Terminal IRI (m/km)	**2.70**	**2.80**	**2.79**	**2.79**	**2.79**
Permanent Deformation - Total Pavement (mm)	**19.00**	**20.94**	**20.73**	**20.72**	**20.93**
AC Bottom-up Fatigue Cracking (%)	**25.00**	2.27	2.24	2.24	2.25
AC Thermal Fracture (m/km)	**189.4**	**197.3**	188.5	188.6	**189.8**
AC top-down Fatigue Cracking (m/km)	**378.8**	343.6	338.6	337.6	341.4
Permanent Deformation - AC only (mm)	**6.00**	**11.36**	**11.16**	**11.15**	**11.36**

The results of the construction season variability at this location showed a slight increase in the quantity calculated for AC Thermal Fracture when the construction and opening occurred in the fall and winter seasons, as compared to the summer and spring. Although the variability in distress quantity between the four seasons was around 5 percent, the fact that the calculated quantities were all near the threshold value resulted with two seasons exceeded the threshold for thermal cracking, with the other two seasons remained slightly below this threshold value.

PERFORMANCE GRADED ASPHALT CEMENT

To further explore the impact climatic variability has on a flexible pavement structure, the user group decided to continue with a design trial aimed at modifying the type of asphalt cement binder used in the modelled pavement structure. To compare the predicted distresses for Canadian conditions, an additional two weather stations were tested from the southern part of the United States (US).

As the initial design input file used the Superpave Performance Graded (PG) system in the asphalt mix design, the trial continued with using the PG grading system. In the initial design trials, the grades of the asphalt cements included a PG 70-40 binder in the surface course, while a PG 64-34 binder was used for the binder course. For these design trials, the group decided to remove some variability in the results by using the same asphalt cement type for both lifts of asphalt. The different grades of asphalt cement used in this study included: PG64-40; PG64-34; PG58-34; and PG58-28. For consistency purposes, the input files for the initial design trials were modified so that both asphalt layers had a PG70-40 asphalt cement binder.

PG Asphalt Cement Trial Results

A total of 66 Canadian weather stations were used to compare the five different asphalt cement binders. For comparison purposes, weather stations in Phoenix, Arizona (hot & dry climate) and Miami, Florida (hot & wet climate) were used. Due to the large amount of information collected in the summary tables, all of data could not be presented in this paper. However, for discussion purposes, output summaries for Smith River (BC) and Cold Lake (AB) are provided in Table 6, while the output summaries for the US climate stations are provided in Table 7.

The comparison of the test results found that as the PG temperature at the lower end increased (-40°C to -28°C), the predicted AC Thermal Fracture began to exceed the performance criteria value at certain climate stations. In the case of Smith River (BC), the amount of predicted thermal cracking reduced from 609 m/km to 13 m/km as the asphalt cement grade decreased from -34°C to -40°C. Although the quantities of cracking varied, many other weather stations had similar results.

Another interesting observation was found in the comparison of the results for Cold Lake (AB). In this case, the ‘AC Thermal Fracture’ was greatly reduced when reducing the lower temperature grade from -28°C to -34°C; however, an increase in the high temperature grade from 58°C to 64°C (while keeping the lower temperature at -34°C) increased the predicted amount of thermal cracking.

For pavement fatigue cracking, the results showed little fatigue cracking in general (on the order of two percent) except for the US locations that showed higher amounts (five to twelve percent). Fatigue cracking prediction decreased with an increase in the high temperature PG grade (e.g. PG 70-40 had less predicted fatigue cracking than a PG 64-40, a PG 64-34 had less than a PG 58-34). The low temperature PG grade also impacted the fatigue cracking with a decrease in the low temperature grading increasing the fatigue cracking (e.g. PG 64-34 had less predicted fatigue cracking than a PG 64-40).

Table 6. Asphalt Cement Binder Variability – Canadian Weather Stations

		Smith River, BC					**Cold Lake, AB**				
	Target Values	**PG 70-40**	**PG 58-28**	**PG 58-34**	**PG 64-34**	**PG 64-40**	**PG 70-40**	**PG 58-28**	**PG 58-34**	**PG 64-34**	**PG 64-40**
Mean Annual Air Temp. (^{o}C)		-2.54					4.6				
Mean Annual Precipitation (mm)		468.12					416.9				
Number of Wet Days		147.2					109.6				
Freezing Index (^{o}C-days)		2739.13					1697.3				
Average Annual No. Freeze-Thaw Cycles:		94.05					144.7				
Years of Climate Data		15					20				
Distress Prediction Summary											
Predicted Terminal IRI (m/km)	**2.70**	2.61	**2.94**	**2.95**	**2.95**	2.64	2.64	**2.98**	**2.71**	**2.74**	2.67
Permanent Deformation - Total Pavement (mm)	**19.00**	17.49	16.97	17.96	17.13	18.28	**19.42**	**19.23**	**20.33**	**19.15**	**20.50**
AC Bottom-up Fatigue Cracking (%)	**25.00**	2.04	1.99	2.08	2.01	2.12	1.63	1.61	1.70	1.61	1.72
AC Thermal Fracture (m/km)	**189.4**	8.43	**608.6**	**579.5**	**608.6**	12.9	5.0	**608.6**	84.6	**193.5**	5.0
AC top-down Fatigue Cracking (m/km)	**378.8**	275.1	242.4	286.8	254.7	305.2	306.3	289.8	323.4	292.9	333.4
Permanent Deformation - AC only (mm)	**6.00**	**8.11**	**7.66**	**8.52**	**7.80**	**8.80**	**9.99**	**9.83**	**10.82**	**9.76**	**10.97**

Table 7. Asphalt Cement Binder Variability – US Weather Stations

		Phoenix, Arizona					**Miami, Florida**				
	Target Values	**PG 70-40**	**PG 58-28**	**PG 58-34**	**PG 64-34**	**PG 64-40**	**PG 70-40**	**PG 58-28**	**PG 58-34**	**PG 64-34**	**PG 64-40**
Mean Annual Air Temp. (^{o}C)		23.99					27.7				
Mean Annual Precipitation (mm)		168.66					1477.3				
Number of Wet Days		54.8					193.7				
Freezing Index (^{o}C-days)		0					0				
Average Annual No. Freeze-Thaw Cycles:		0					0				
Years of Climate Data		10					10				
Distress Prediction Summary											
Predicted Terminal IRI (m/km)	**2.70**	**2.94**	**3.06**	**3.11**	**2.98**	**3.04**	**2.79**	**2.81**	**2.85**	**2.8**	**2.84**
Permanent Deformation - Total Pavement (mm)	**19.00**	**40.58**	**45.41**	**47.21**	**42.14**	**44.56**	**30.8**	**31.46**	**32.88**	**30.8**	**32.54**
AC Bottom-up Fatigue Cracking (%)	**25.00**	8.02	10.56	12.56	8.78	11.37	5.36	5.82	7.57	5.3	7.48
AC Thermal Fracture (m/km)	**189.4**	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
AC top-down Fatigue Cracking (m/km)	**378.8**	**506.2**	**502.1**	**509.8**	**503.6**	**514.6**	**490.5**	**493.6**	**516.7**	**487.9**	**517.2**
Permanent Deformation - AC only (mm)	**6.00**	**30.34**	**35.03**	**36.73**	**31.86**	**34.14**	**20.6**	**21.3**	**22.59**	**20.68**	**22.26**

For AC rutting, it was surprising that the predicted rutting was generally the same for a given climate station (within 2 mm) regardless of the asphalt cement grade chosen (except for Phoenix AZ). Generally, and as expected, the rutting decreased as the high temperature PG grade increased (e.g. PG 70-40 had less predicted rutting than a PG 64-40, a PG 64-34 had less than a PG 58-34). Perhaps unexpectedly, and as with the fatigue cracking predictions, the low temperature PG grade also appeared to affect the rutting with a PG 64-40 having more predicted rutting than a PG 64-34 (likewise for the PG 58-34 versus PG 58-28).

Another interesting observation was the correlation between predicted 'Terminal IRI' and the predicted 'AC Thermal Fracture'. As expected, pavements with higher quantities of thermal cracking were observed to have a higher IRI value, as compared with pavements with fewer thermal cracks.

The predicted distress for both of the climate stations in the southern US show a clear increase in the amount of asphalt and pavement rutting, as well as top-down fatigue cracking, and the terminal IRI. The soft asphalt cement binders typically used in Canada increased the predicted asphalt rutting by a factor of 4, while the total pavement rutting increased 2.5 times.

CONCLUSIONS

Although the results of the design trials show interesting correlations between predicted distresses and climate conditions, the primary purpose for these trials was to help user group members with software licenses to become more familiar with setting up design input files, and interpreting the results of the analysis. The study also provided an opportunity to compare how certain input parameters influence the predicted distresses. Even though several similar studies have been completed in the US, and the international community, the user group was interested viewing test results for themselves using the Canadian climate files.

Furthermore, in running these design trials, user group members who participated have also begun to understand some of the nuances of the Pavement ME software. Unlike traditional pavement design program, the Pavement ME software is very complex and the results of these trials show the importance of validating and verifying predicted results. The results of these first few trials showed that various models, while giving general trends, will need to be looked at more closely and properly calibrated by each agency individually before fully implementing.

REFERENCES

1. Transportation Association of Canada, Pool Fund Projects – In Progress. Available at http://tac-atc.ca/english/projects/calibration.cfm
2. AASHTO, "Guide For Design of Pavement Structures", 1993.
3. AASHTOWare, "DARWin ME Software Help System – SI Units" Software Help Version 1.0.1, April 2011.
4. AASHTOWare, "Mechanistic-Empirical Pavement Design Guide – A Manual of Practice", Interim Edition, July 2008.
5. AASHTOWare, "Guide for the Local Calibration of the Mechanistic-Empirical Pavement Design Guide", November 2010.