The Cost Implications of Using Various Flexible Pavement Design Methodologies for Canadian Municipalities

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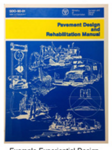
Introduction

- Pavement design methodologies have evolved quite rapidly over the past 30 years
- Adoption of these new techniques has varied significantly by Canadian municipalities
- Current pavement design methodologies used vary from experiential/empirical based design methodologies to more modern mechanistic-empirical based designs



Example Experiential Design
MTO SDO-90

Example Empirical Design
MTO MI-183/AASHTO 93

Example Mechanistic-Empirical
Design DARWin-ME/MEPDG

Summary of Flexible Pavement Design Methods Used in Canada [1]

AGENCY	GENERAL DESIGN METHODS	DESIGN LIFE (years) New/Rehabilitation
BC	AASHTO 93	20/20
AB	AASHTO 93	20/10-20
SK	Shell Method Asphalt Institute	15/15
MB	AASHTO 93/MPEDG CGRA/MEPDG	20/20
ON	AASHTO 93 OPAC Routine (Empirical) Method	Major Highways: 18-22/12-15 Other Projects: 12-15/10-12
QC	AASHTO 93 Chaussee 2	Major Highways: 30/15-30 Other Projects: 25/15-25
NB	AASHTO 93 Rebound Values	20/15
PEI	Asphalt Institute	20/12
NS	AASHTO 93 Correlation Charts	20/15
NL	Standard Sections Used	20/15
Yukon	State of Alaska Design Method	20/12
PWGSC	AASHTO 93	20/12

Study Design

- As pavement design technology has evolved, it has allowed the design of thinner, longer lasting and more reliable pavements
- The objective of the study is to try and quantify the cost benefits of using new design methodologies
- The result will enable municipal engineers to select the most appropriate design method for their district

Design Inputs Required for Each Method

DESIGN INPUT	MTO SDO-90	AASHTO 93 (MTO MI-183)	MEPDG (Calibrated for Ontario)
Pavement Performance	Road Class (King's Highways and Freeways or Secondary Highways)/Region (Northern or Southern Ontario)	Initial Serviceability and Terminal Serviceability	Initial IRI, Terminal IRI
Traffic Characterization	AADT, Truck Percentage	AADT, % Trucks, Lane Distribution Factor, Traffic Growth, Vehicle Classes/Truck Factor, Directional Distribution, Performance Period	AADTT, Lane Distribution Factor, Traffic Growth, Directional Distribution Vehicle Classes (Axle Spectra, Axle Spacing), Traffic Wander (Lane Width, Mean Wheel Location, Standard Deviation), Performance Period
Subgrade Classification	Laboratory Classification (Grain Size Analysis, Plasticity Index)	Laboratory Classification (MTC Classification), Back-calculation from FWD Testing	Laboratory Classification (MTC Classification), Back-calculation from FWD Testing
Pavement Structural Materials Characterization	Granular Base Equivalency	Structural Layer Coefficients	Laboratory Classification (Granular Base/Subbase M_R Testing), Back-calculation from FWD Testing
Reliability	–	Design Reliability, Standard Deviation	Design Reliability Levels
Drainage	Engineering Judgement	Drainage Coefficient	Automatically incorporated into distress prediction
Environment	–	–	AASHTOWare Compatible Local Weather Station
Distress Prediction Modelling	–	–	Default values or adjustments based on calibration factors

Case Examples

- To compare design methods, three different pavement design types were considered
  - low volume local/collector road
  - medium volume arterial road
  - high volume major arterial road
- Common design inputs were used to show how the pavement structural design differ
- The design types represent typical municipal road classes and show the sensitivity of the design methods to different traffic volumes and compositions

Design Notes

- SDO-90 is limited to 130 mm of HMA for traffic > 400 AADTT. A rule of thumb of 30 mm HMA for each x 2 of traffic was used to estimate equivalnet HMA thickness
- For MI-183 and MEPDG designs, the required SSM depth was based on engineering judgement depending on the class of roadway and operating speed
- To simulate the strength gained by adding the SSM in MI-183 designs, the effective subgrade modulus was increased by 1.20 which reduced design SN

Inputs Used For Each Design

	Local	Minor Arterial	Major Arterial
Pavement Performance			
SDO-90	Kings Highway	Kings Highway	Kings Highway
MI-183	4.2/ 2.0	4.4, 2.2	4.5, 2.5
MEPDG	1.0-1.2, 3.3	1.0, 2.7	1.0, 2.3
Traffic			
Analysis Period		12 Years	
Number of Days	260	310	365
AADT	1500	10000	50000
%Trucks	2.0%	7.5%	10.0%
AADTT	30	750	5000
Number of Lanes	2	4	6
Growth %	2.0%	3.0%	4.0%
Lane Distribution Factor	1	0.9	0.6
Directional Distribution	50%	50%	50%
Truck Classes (MI-183)		Table D-2	
Operating Speed	50	60	70
Axle Configuration/Wander		Default	
Axle Spectra		Table 13-16 or use MTO iCorridor	
Axle Spacing		Tandem, 1.45, Tridem, 1.68, Quad, 1.32	
Subgrade Type			
SDO-90		Silty Clay to Clayey Silt (5-75 mm >55%)	
MI-183		40 MPa based on FWD or Table D-8	
MEPDG		40 MPa based on FWD or Table 29-31	
Material Characteristics			
SDO-90		GBE	
MI-183		Table D-9	
MEPDG		Table 22 - 28	
Reliability			
MI-183 (Design Reliability)	80	90	95
MI-183 (Standard Deviation)		0.49	
MEPDG (Reliability)	75	90	95
Drainage			
SDO-90		Engineering Judgement	
MI-183		Drainage Coefficient in Structural Design, Table D-10	
Environment			
MEPDG		Imported Online from Ontario Climate Stations	
Distress Modeling			
MI-183		Pavement Overstressing	
MEPDG		Integrated Default Values, Extensive Study for Local Calibration	

Calculated Pavement Structural Thicknesses for a Local Road

	SDO-90	MTO MI-183	MEPDG
Hot-mix Asphalt	50	70	50
Granular Base	150	100	150
Granular Subbase	450	175	200
Design Value	552 (GBE)	57 (SN)	-

Calculated Pavement Structural Thicknesses for a Major Arterial Road

	SDO-90	MTO MI-183	MEPDG
Hot-mix Asphalt	250	230	250
Granular Base	150	150	150
Granular Subbase	800	420	150
Select Subgrade Material	-	600	600
Design Value	1186 (GBE)	134 (SN)	-

Calculated Pavement Structural Thicknesses for a Minor Arterial Road

	SDO-90	MTO MI-183	MEPDG
Hot-mix Asphalt	160	150	160
Granular Base	150	150	150
Granular Subbase	800	100	150
Select Subgrade Material		450	450
Design Value	1006 (GBE)	101 (SN)	-

Analysis Results

- Initial cost of construction calculated using 2012 cost data
- The mixes specified in the MEPDG designs were also used in the SDO-90 and MI-183 designs to make initial costs comparable
- The costs are based on one lane kilometre of roadway, 3.75 m wide

Difference in Initial Cost of Construction

	SDO-90	MTO MI-183	MEPDG
Local Road	20.2%	3.2%	–
Minor Arterial	16.7%	–	1.3%
Major Arterial	9.5%	–	2.8%

- The lowest cost in each group is shown with a dash while the other costs are shown as a percentage increase compared to the lowest cost

- Both the MI-183 and MEPDG methods provide considerable cost savings over the SDO-90 method
- Greatest savings observed on lower volume roads
- Design HMA thicknesses similar between all methods
- Greatest savings provided by the use of optimized granular materials to mitigate frost heaving while providing required ride quality and service life
- Rule of thumb provided design HMA thickness remarkably similar to those calculated using the MEPDG
- SDO-90 does not model different HMA mixes and a designer may potentially specify mixes that will not perform as those in MEPDG designs and as a result, only very experienced designers are capable of using SDO-90 and MI-183 to produce comparable designs to those created using the MEPDG

Conclusions

- Design HMA thicknesses are very similar for all three design methods
- Optimized material selection results in significant cost savings
- MEPDG designs are more costly to complete and this additional cost must be accounted for when considering using this method
- Experiential and Empirical designs are equivalent to MEPDG designs when completed by very experienced designers
- MEPDG design more readily take into account and can be calibrated for local materials which may result in better designs