Performance of latex modified bridge decks overlays after 20+ years of service

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Outline

- Definition – Latex Modified Concrete (LMC)
- Historical background of LMC
- Use of LMC in Quebec
- Performance evaluation of 4 LMC bridge deck overlays:
  - Gatineau QC, 1984
  - St-Gilles de Lotbinière QC, 1987
  - Montréal QC, 1991
  - Windsor ON, 1984
- VDOT Report of LMC performance on Lynnhaven Inlet Bridge, in Virginia
- Conclusions

Latex-modified concrete (LMC)

Latex-modified concrete (LMC)

"*Hydraulic cement and aggregates combined at the time of mixing with organic polymers that are dispersed or redispersed in water*."

American Concrete Institute, 548.4 - 11

Historical background

- 3000 BC, Indus Valley: Natural polymer such as albumen and rice paste used for mortar in clay brick walls
- 1923: First patent for a mixture of hydraulic cement and polymer for use in concrete pavement using natural latex
- 1930 -1940: Development of mortars and concretes incorporating natural latex
- 1932: First patent for mixture of hydraulic cement – polymer using synthetic latex
- 1940 - 1960: Development of numerous synthetic polymers

Historical background

- 1960 - 1980: Research on use of polymers in mortars and concretes
- 1956: Use of latex in overlays in USA as protection against chloride ion penetration
- 1969: First utilisation of LMC by VDOT for a bridge deck overlay
- 1975, London England: First conference ‘’International Conference on Polymers in Concrete’’
- 1978: FHWA RD-78-35 Report: “Styrene-Butadiene Latex-Modifiers for Bridge Deck Overlays”
- Today–

  More than 10,000 LMC overlays have been placed in USA

Historical background - Canada

- 1970 - 1980: LMC used in Ontario, MTO
- 1984: Chaudières Bridge, Hull QC. First LMC application for a bridge deck overlay in Québec. Public Works Canada.
- 1985: Transports Québec laboratory evaluation report on LMC
- 1987: First LMC overlay installed by Transports Québec in St-Gilles-de-Lotbinière QC
- 1990: LMC used in remplacement of over 300 expansion joints and slab repairs on elevated portion (9 km) of Metropolitain Blvd, (A40) Montreal QC
- 1992-2005: LMC overlay St-john's Harbor Bridge, St-John's NB
- 2002: First use of Rapidset© LMC in Quebec for expansion joints replacement on Pie IX Bridge, Montreal QC

NORMES BÉTON LATEX MTQ

Transports Québec

NORME

BÉTONS ET PRODUITS CONNEXES

3.1 Bétons

Bétons de masse volumique normale

Tome	
VII	
Chapitre	Norme
3	3101
Page	
5 de 9	
Date	
2011 12 15	

Tableau 3101–2
Caractéristiques des bétons de masse volumique normale pour les ouvrages d'art

Type	Résistance à 28 jours (MPa)	Masse min. liant (kg/m³)	Type de liant[1]	Rapport eau/liant max. ou dans l'intervalle	Gros granulats (mm)	Teneur en air[2] (%)	Affaissement (mm)		Étalement (mm) ±50	L max (µm)	Perméabilité aux ions chlore max. (Coulombs)
							± 30	± 40			
XVI-5	35	390	GUb–SF, GUb–F/SF, GUb–S/SF	0,40	2,5–10	4–8	120	—	—	230	1000
XVI-15	35	390	GU	0,40	2,5–10 5–14	3–7[10]	150	—	—	300	1000

LMC use in QUEBEC

CONCRETE TYPE	UTILISATION	COMPRESSIVE STRENGTH	CURING TIME FOR MEMBRANE INSTALLATION	
15% GU TYPE XVI-15 (1984)	OVERLAYS DECK REPAIRS JOINT REPLACEMENT	15 MPa @ 1 D 25 MPa @ 7 D 35+ MPa @ 28 D	72 HOURS	1 D WET 2 D DRY
15% HE TYPE XVI-15 (1990)	OVERLAYS DECK REPAIRS JOINT REPLACEMENT	20 MPa @ 1 D 30 MPa @ 3 D 35+ MPa @ 7 D 35+ MPa @ 28 D	72 HOURS	1 D WET 2 D DRY
15% RSLMC TYPE XVI-15 (2002)	OVERLAYS DECK REPAIRS JOINT REPLACEMENT	20 MPa @ 3 HR 30+ MPa @ 1 D 35+ MPa @ 7 D 35+ MPa @ 28 D	8 HOURS	4 Hrs WET 4 Hrs DRY
5%TERNARY TYPE XVI-5 (1990)	OVERLAYS DECK REPAIRS REPROFILE DECK	10 MPa @ 1 D 25 MPa @ 7 D 35 + MPa @ 28 D	10 DAYS	7 D WET 3 D DRY

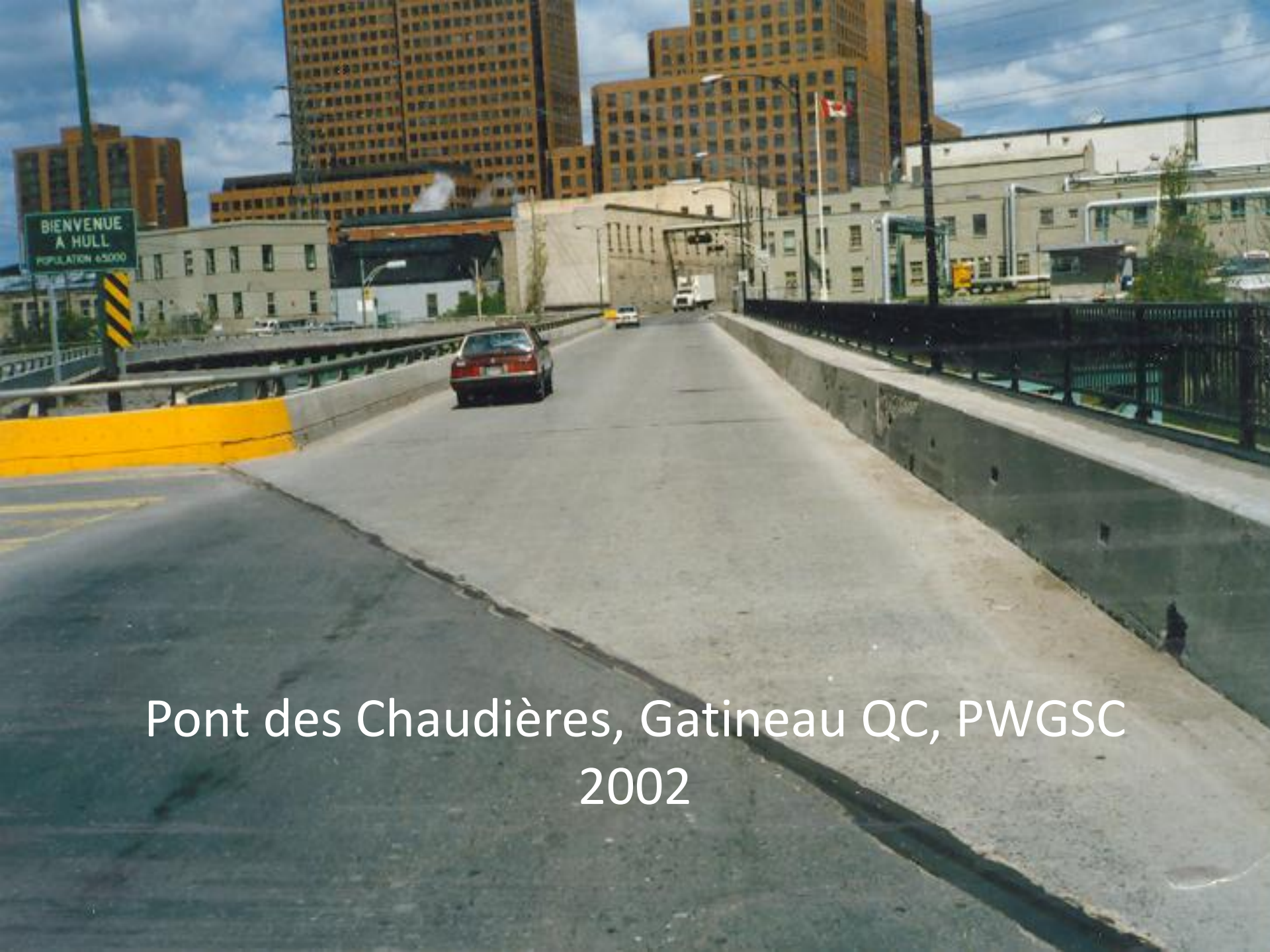
LMC OVERLAYS IN QUÉBEC
(Riding surface)

- Pont des Chaudières, Gatineau QC, 1984, PWGSC GU
- Pont St-Gilles-de-Lotbinière, 1987, MTQ GU
- Pont Île Verte, Laval QC, 1989, City of Laval GU
- Rockland InterchangeA40E/A15N, 1991, MTQ HE
- Pont Édouard Paré, Amos, 2008, MTQ GU
- Turcot Yard Interchange, Ramp E (partial),
- A15S-15S, Montréal, 2010, MTQ GU

LMC OVERLAYS IN QUEBEC

(Riding surface)

- Turcot Yard Interchange, Ramps A, C, D (partial)
  Montréal, 2011, MTQ GU
- Pierre Laporte Bridge, Test section,
  Quebec City, 2011, MTQ RSLMC
- Turcot Yard Interchange, Ramps A, C, D, E, F
  Montreal 2012, MTQ (33,000 M^2) GU
- Bonaventure Expressway, Montreal 2012,
  PJCCI, (6,000 M^2) GU



Pont des Chaudières, Gatineau QC, PWGSC
2002

Pont des Chaudières, Gatineau QC, PWGSC

- 1954: Original construction
  - Asphalt pavement on concrete deck
  - No membrane
- 1984:
  - Remove asphalt pavement
  - Install LMC overlay GU

Pont des Chaudières, Gatineau QC 2009

Compressive strength (MPa) (CSA 23.2-14 C)	LMC overlay	62,2	(25 years)
Air content (%) – Hardened concrete (ASTM C 457)	LMC overlay	2,0	(25 years)
	Original concrete	6,9	(54 years)
Air void spacing factor (µm) (ASTM C 457)	LMC overlay	676	(25 years)
	Original concrete	193	(54 years)
Bonding – Pullout (MPa) (CSA 23.2 - 6 B)	LMC overlay/ original concrete	2,3 1,7	(5 years) (25 years)
Chloride ions penetration (Coulombs) (ASTM C 1202 09)	LMC overlay	172	(25 years)

Source :Béton Mobile du Québec inc. (Qualitas)

DESCRIPTION VISUELLE DES CAROTTES

Dossier	B05634-045
Client	Béton Mobile du Québec inc.
Projet	Essais sur béton de réparation
Endroit	Pont Des Chaudières
Relevé par	Aleksandra Popic, ing. stag. M.Sc.A.
Vérifié par	Jacques Beaulieu ing. M.Sc.A.
Date rapport	2009-11-09

Carotte n°	8
Localisation	Zone non délaminée
Angle de forage	90°
Profondeur (mm)	105-120
Diamètre (mm)	70
Foré par	
Date de carottage	2009-11-04

Épaisseur des matériaux	
Mortier (mm)	
Béton de ciment (mm)	105-120*

Adhérence des matériaux	
Béton réparation / Béton (Oui / Non)	Oui

Caractéristiques du béton	
Diamètre nominal maximal des granulats (mm)	14**
Consolidation (Bonne / Moyenne / Pauvre)	Bonne
Enrobage des granulats (Bon / Moyen / Pauvre)	Bon
Enrobage de l'acier (Bon / Moyen / Pauvre)	
Fissure verticale (longueur, mm)	
Plan de délamination (profondeur, mm)	
Dégradation du béton (profondeur, mm)	
Signe de réactivité alcalis-granulats	

Caractéristiques des barres d'armatures	
Diamètre du premier rang (mm)	
Épaisseur d'enrobage (mm)	
Corrosion (Aucune / Faible / Moyenne / Forte)	
Diamètre du second rang (mm)	
Épaisseur d'enrobage (mm)	
Corrosion (Aucune / Faible / Moyenne / Forte)	

Photographie

Remarques

* L'épaisseur du béton de réparation est de 50 mm.

** La dimension nominale maximale du gros granulat du béton d'origine est de 20 à 28 mm.

L'adhérence du béton d'origine avec le béton de réparation est complète.

À la surface de la carotte les gros granulats sont en relief et le mortier est usé sur une profondeur d'environ 1,5 mm.

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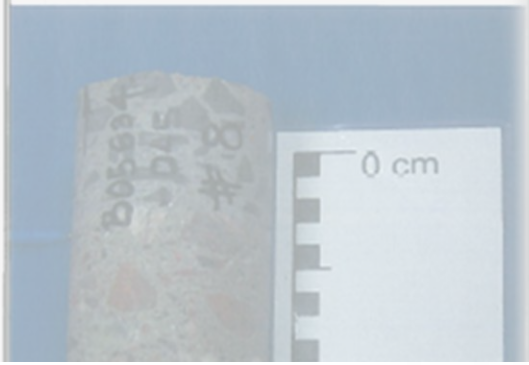
Fissure verticale (longueur, mm)	
Plan de délamination (profondeur, mm)	

Photographie



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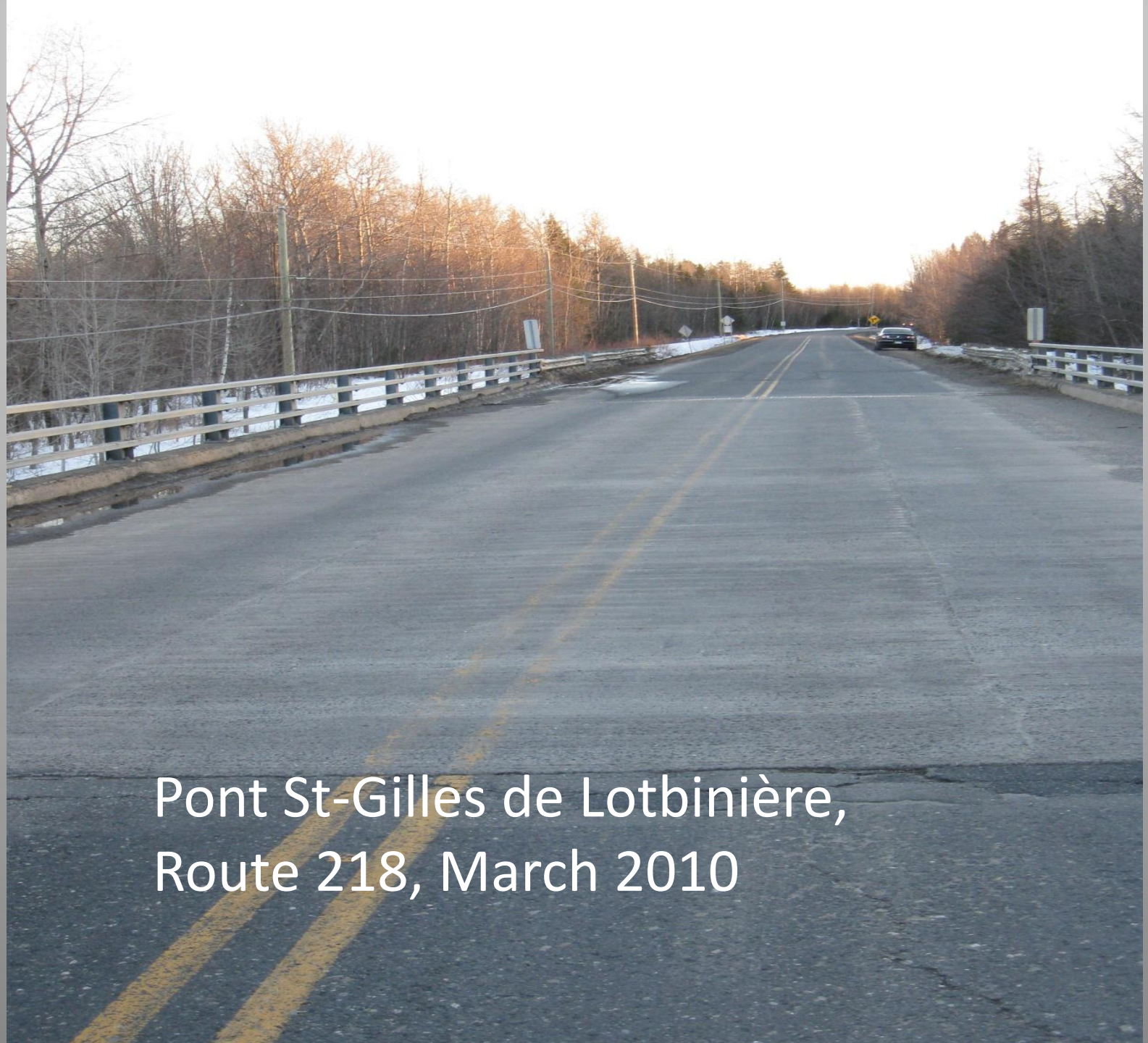
Pont St-Gilles de Lotbinière
Route 218

- 1962: Original construction
  - Simple span with concrete beams
  - Asphalt pavement
- 1987: LMC Overlay
  - Remove asphalt pavement
  - Install LMC overlay (GU)

Pont St-Gilles de Lotbinière

Route 218, July 1987



Pont St-Gilles de Lotbinière,
Route 218, March 2010

Pont St-Gilles de Lotbinière,
Route 218, Mars 2010

St-Gilles de Lotbinière 2010

Compressive strength (MPa) (CSA 23.2-14 C)	LMC overlay	53.9	(23 years)
Air content (%) – Hardened concrete (ASTM C 457)	LMC overlay	7,2	(23 years)
	Original concrete	-	-
Air void spacing factor (µm) (ASTM C 457)	LMC overlay	394	(23 years)
	Original concrete	-	-
Bonding – Pullout (MPa) (CSA 23.2 - 6 B)	LMC overlay/ original concrete	1,3	(23 years)
Chloride ions penetration (Coulombs) (ASTM C 1202 09)	LMC overlay	154	(23 years)
Absorption (%) (ASTM C 642)	LMC overlay	1,00	(23 years)
Permeable voids (%) (ASTM C 642)	LMC overlay	5,00	(23 years)

Metropolitain Blvd, Ramp 40E – 15N, Montréal, QC

- 1956: Construction
  - Deck slab with hollow voids
- 1991: Deck repair
  - Install LMC overlay with HE cement

. Métropolitain Blvd, Ramp 40E – 15N, June 1991, Montréal QC

Metropolitain Blvd, Ramp 40E – 15N, LMC overlay after 20 years service April 2011, Montréal QC

Métropolitain Blvd, Ramp 40E – 15N, Conventionnel concrete deck April 2011, Montréal QC

Montréal 40E-15N 2011			
Compressive strength (MPa) (CSA 23.2-14 C)	LMC overlay	61,8	(20 years)
Air content (%) – Hardened concrete (ASTM C 457)	LMC overlay	5,4	(20 years)
	Original concrete	N/A	N/A
Air void spacing factor (µm) (ASTM C 457)	LMC overlay	224	(20 years)
	Original concrete	-	-
Bonding – Pullout (MPa) (CSA 23.2 - 6 B)	LMC overlay/ original concrete	N/A	N/A
Chloride ions penetration (Coulombs) (ASTM C 1202 09)	LMC overlay	105	(20 years)
Absorption (%) (ASTM C 642)	LMC overlay	0,53	(20 years)
Permeable voids (%) (ASTM C 642)	LMC overlay	1,85	(20 years)

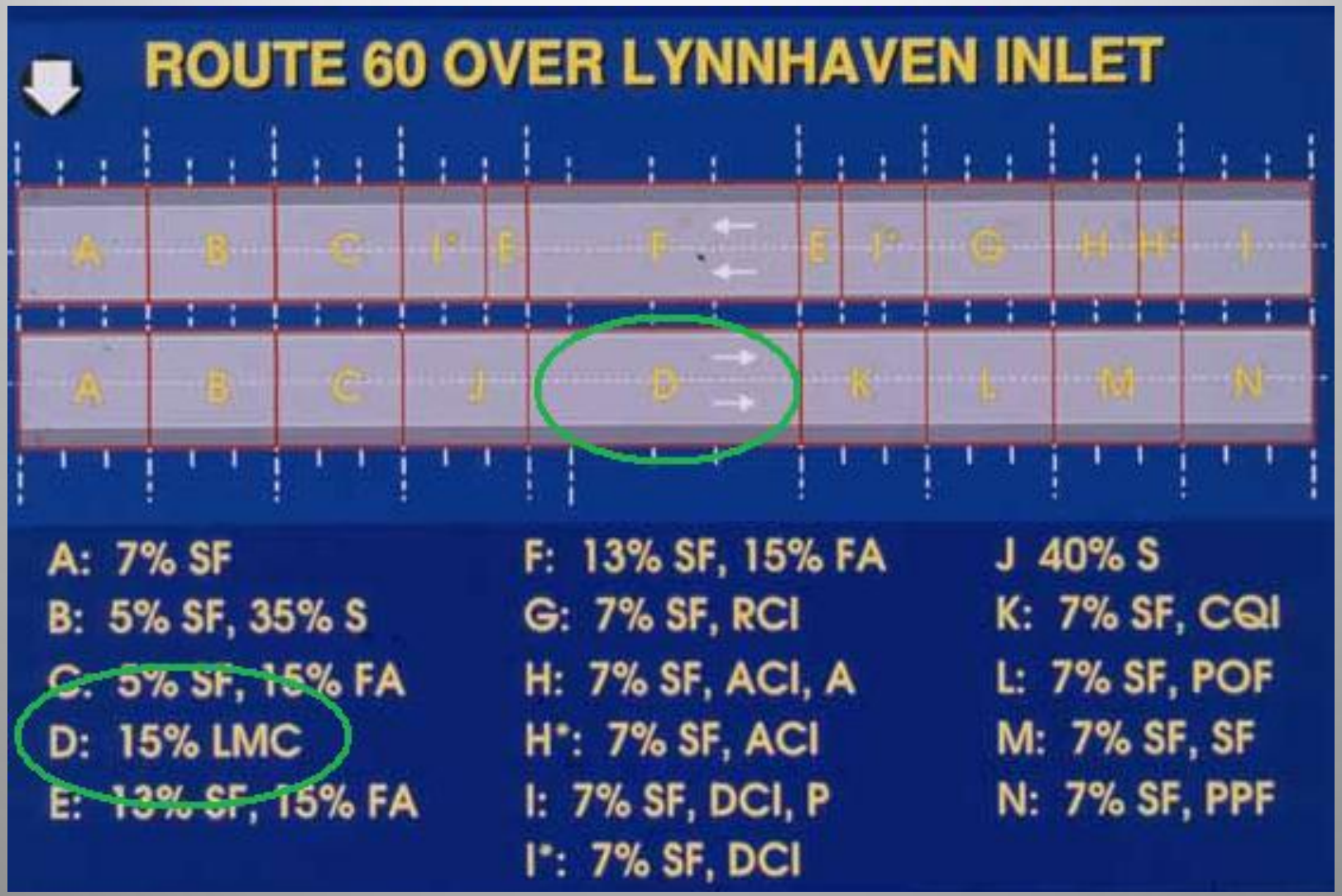
Lynnhaven Bridges

Reference: Michael Sprinkel, Virginia Transportation Research Council

Lynnhaven Inlet VA

- 1996 VDOT:
  - Construction of 16 overlays with high performance concretes
  - Used 13 concrete mixtures on 2 bridges with 28 simple spans on route 60 over Lynnhaven Inlet near Virginia Beach VA
- Project objectives
  - Evaluate and validate over time the performance of concrete overlays for bonding, chloride permeability, chloride content, skid resistance as well as establish a cost comparison for each mixture used
- Field tests and measurements were performed in 1996, 1999 and 2006

Plan View of Alternative Overlays



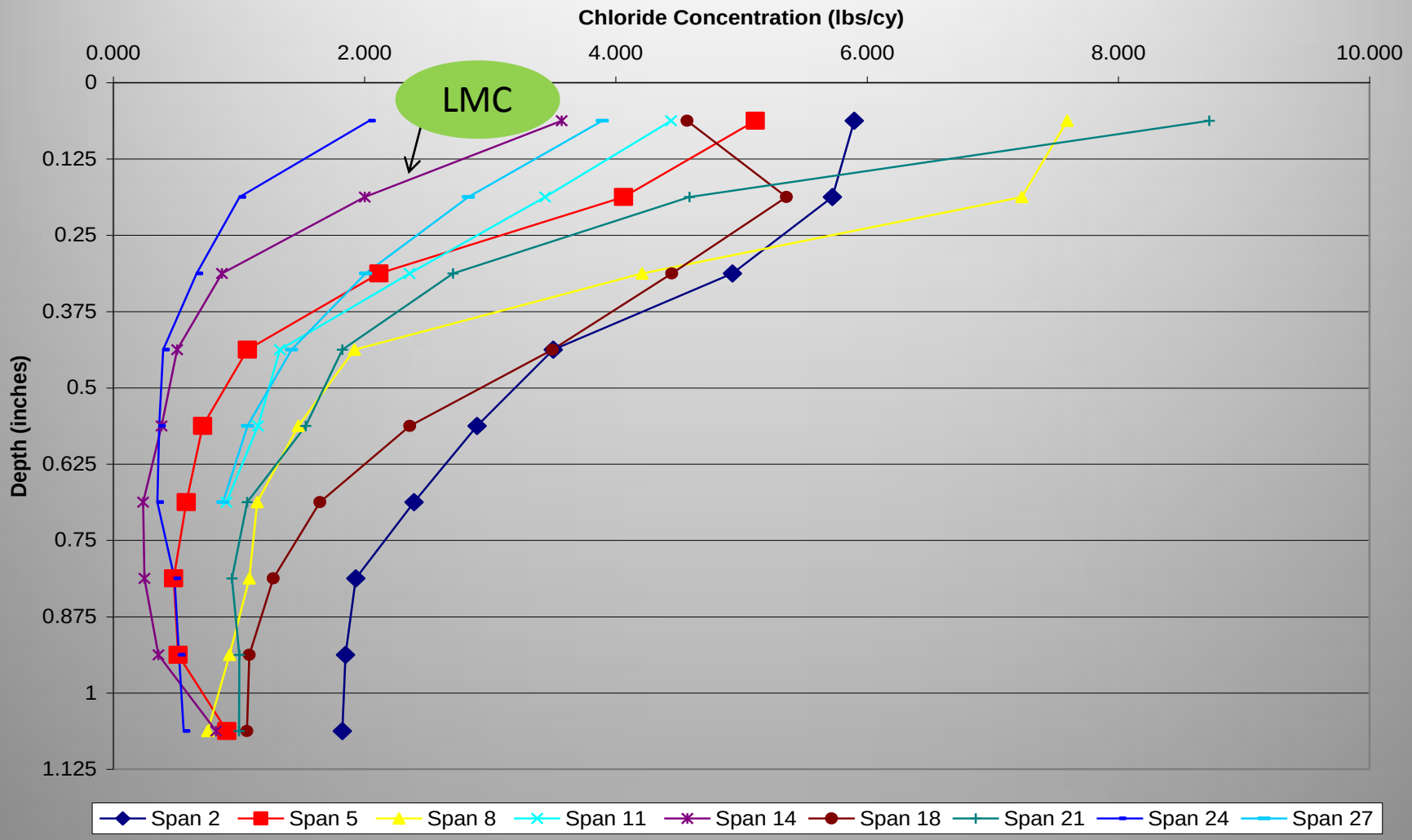
Reference: Michael Sprinkel, Virginia Transportation Research Council

Overlay Protection Rank, Best @ Top

Permeability		Chloride Content		Diffusion Constant	
E2	7%SF	W14	LMC	E14	13%SF, 15%FA
W14	LMC	W24	7%SF, STF	W14	LMC
E11	7%SF, DCI	E5	5%SF, 35%S	E24	7%SF, ACI, A
E14	13%SF, 15%FA	W5	5%SF, 35%S	W21	7%SF, POF
E8	5%SF, 15%FA	E8	5%SF, 15%FA	W24	7%SF, STF
E24	7%SF, ACI, A	E14	13%SF, 15%FA	W5	5%SF, 35%S
E18	7%SF, DCI	E2	7%SF	E5	5%SF, 35%S
E27	7%SF, DCI, P	E24	7%SF, ACI, A	E8	5%SF, 15%FA
E5	5%SF, 35%S	W27	7%SF, PPF	W8	5%SF, 15%FA

Référence: Michael Sprinkel, Virginia Transportation Research Council

Overlay Chloride Ion Profiles, WBL



Reference: Michael Sprinkel, Virginia Transportation Research Council

Route 60 Lynnhaven Inlet VA

Compressive strength (MPa) (ASTM C 39)	LMC overlay	N/A	N/A
Air content (%) – Hardened concrete (ASTM C 457)	LMC overlay	N/A	N/A
Air void spacing factor (µm) (ASTM C 457)	LMC overlay	N/A	N/A
Bonding - Pullout (MPa)	LMC overlay	1,8 2,4 1,9	10 mos 3 yrs 10 yrs
Chloride ions penetration (Coulombs) (ASTM C 1202 09)	LMC overlay	703 333 130	10 mos 3 yrs 10 yrs

Reference: Michael Sprinkel, Virginia Transportation Research Council

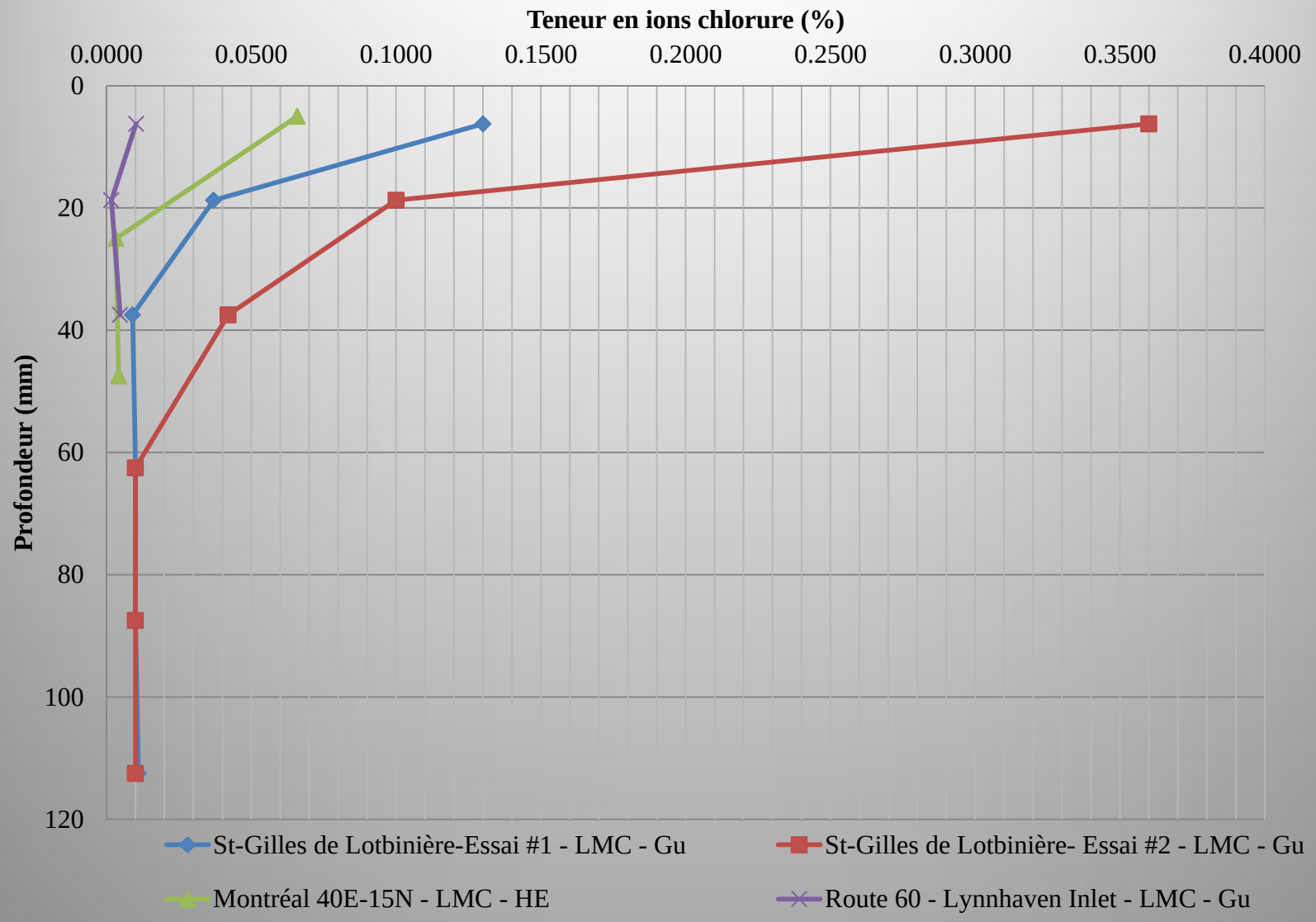
Rankin Street Bridge, Windsor ON 2011

Rankin Street Bridge, Windsor ON 2011			
Compressive strength (MPa) (CSA 23.2-14 C)	LMC overlay	38.8	(27 years)
Air content (%) – Hardened concrete (ASTM C 457)	LMC overlay	2.4	(27 years)
	Original concrete	-	-
Air void spacing factor (μm) (ASTM C 457)	LMC overlay	624	(27 years)
	Original concrete	-	-
Bonding – Pullout (MPa) (CSA 23.2 - 6 B)	LMC overlay/ original concrete	1.31 1.24	(27 years) (27 years)
Chloride ions penetration (Coulombs) (ASTM C 1202 09)	LMC overlay	249	(27 years)
Absorption (%) (ASTM C 642)	LMC overlay	1.2	(27 years)
Permeable voids (%) (ASTM C 642)	LMC overlay	6.7	(27 years)

Summary

	Gatineau QC 2009	St-Gilles de Lotbinière QC 2010	Montreal QC 40E-15N 2011	Route 60 Lynnhaven Inlet VA 1996, 1999, 2006	Rankin Bridge Windsor ON 2011
Compressive strength (MPa) (CSA 23.2-14C)	62,2 (25 yrs)	53,9 (23 yrs)	61,8 (20 yrs)	N/A	38.8 (27 yrs)
Hardened air content (%) (ASTM C 457)	2,0 (25 yrs)	7,2 (23 yrs)	5,4 (20 yrs)	N/A	2.4 (27 yrs)
Air void distribution (µm) (ASTM C 457)	676 (25 yrs)	394 (23 yrs)	224 (20 yrs)	N/A	624 (27 yrs)
Bonding – Pullout (MPa) (CSA 23.2 - 6B)	2,3 (5 yrs) 1,7 (25 yrs)	1,24 (23 yrs)	N/D	1,8 (10 mos) 2,4 (3 yrs) 1,9 (10 yrs)	1.31 (27 yrs) 1.24 (27 yrs)
Chloride ion penetration (Coulombs) (ASTM C 1202)	172 (25 yrs)	154 (23 yrs)	105 (20 yrs)	703 (10 mos) 333 (3 yrs) 130 (10 yrs)	249 (27 yrs)

	Gatineau QC	St-Gilles de Lotbinière QC			Montreal QC 40E-15N		Route 60 Lynnhaven Inlet VA		Rankin Br. Windsor ON	
		Depth (mm)	Test #1 (% m.B)	Test #2 (% m.B)	Depth (mm)	(% m.B)	Depth (mm)	(% m.B)	Depth (MM)	
Chloride content (AASHTO T260)	N/A	0- 12,5 12,5- 25 25- 50 50- 75 75- 100 100- 125	0,1300 0,0370 0,0090 0,0100 0,0100 0,0110	0,3600 0,1000 0,0420 0,0100 0,0100 0,0100	0-10 20-30 45-55	0.0659 0.0033 0.0042	0- 12,5 12,5-25 25- 50	0.1050 0,0210 0,0410	0-10 20-30 40-48	0.20 0.07 0.11
Absorption (%) (ASTM C 642)	N/A	1,0			0,53		N/D		1.2	
Perméable voids (%) (ASTM C 642)	N/A	5,3			1,85		N/D		6.7	
Source	BMQ (QUALITAS)	MTQ			BMQ (LVM)		VTRC		BMQ (LVM)	


Teneur en ions chlorure (%)
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
0.3000
0.3500
0.4000
Profondeur (mm)
0
20
40
60
80
100
120
St-Gilles de Lotbinière-Essai #1 - LMC - Gu
St-Gilles de Lotbinière- Essai #2 - LMC - Gu
Montréal 40E-15N - LMC - HE
Route 60 - Lynnhaven Inlet - LMC - Gu

Conclusions

- Solution for sustainable repairs for bridge overlays
- Can extend the useful life of a bridge deck for 25 years or more
- Economical et environmentally friendly for long term solutions
- Excellent resistance to chloride ion penetration,freeze-thaw durability, scaling
- Excellent bonding of LMC to concrete substrate

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- Qualitas
- LVM
- BMQ personnel

Questions?

The more knowledge we share, the more we grow

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