Development and Use of Rapid-Setting Self-Consolidating Concrete for Bridge Repairs

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CONCRETE REPAIR SOLUTIONS

Outline

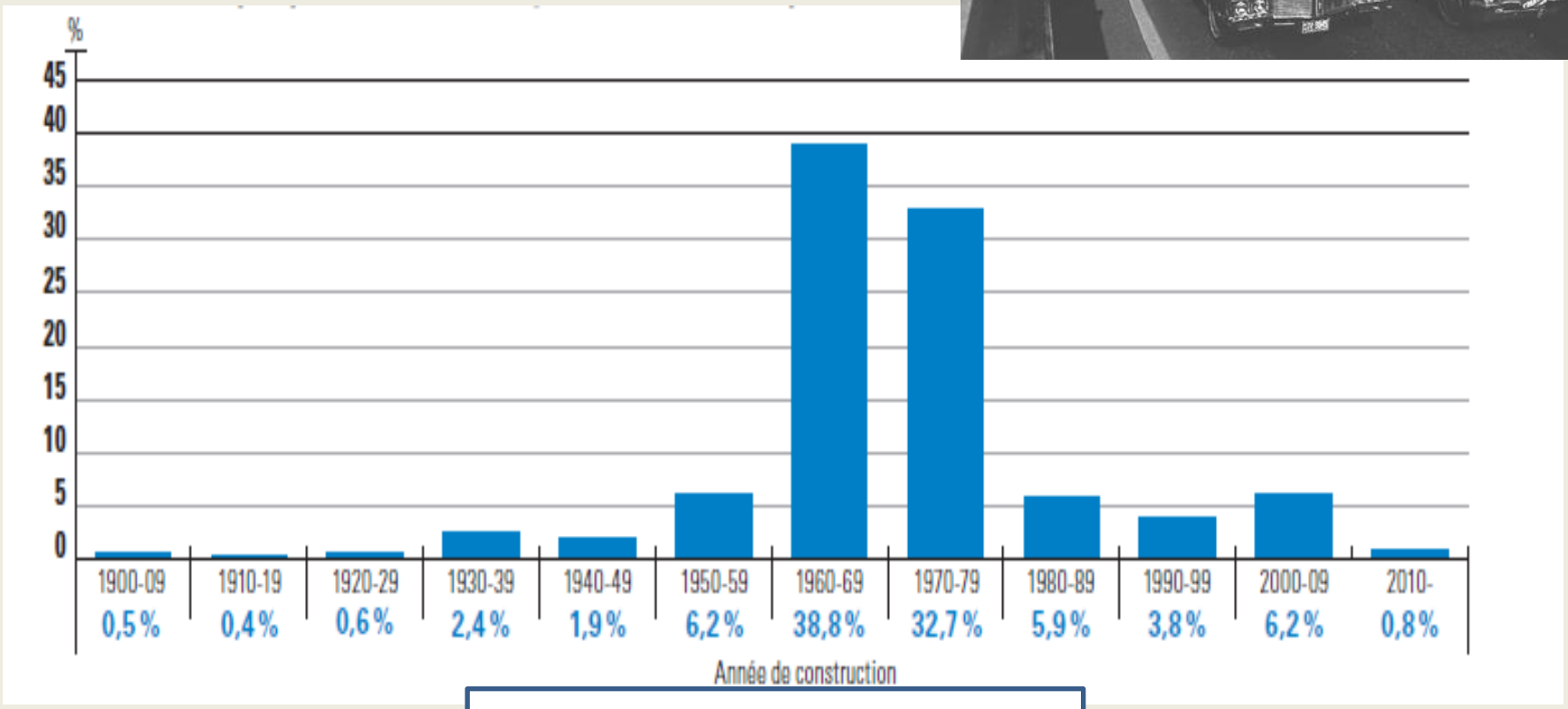
- Introduction
- Background
- Challenges
- Product development
- Applications

Key facts about America's roads and bridges conditions (2008)

- Americans travel over 3 trillion miles per year
- Traffic congestion costs American motorists $78.2 billion a year in wasted time and fuel costs. Americans spend

  4.2 billion hours a year stuck in traffic
- Thirty-three percent of America's major roads are in poor or mediocre condition.
- Twenty-five percent of America's bridges are structurally deficient or functionally obsolete.
- Thirty-six percent of America's major urban highways are congested.
- Vehicle travel on America's highways increased by 41 percent from 1990 to 2006, while new road mileage increased by only 4 percent. The nation's population grew by 20 percent from 1990 to 2006.
- (Source: *TRIP, National transportation research group, Washington DC)*

As in most North-American cities, the highway network in Québec was built mainly during the 1960's and 70's



Source :Transports Quebec

Section II FINANCIAL

The Montreal Star

CHURCHES Pages 13-20

97th Year, No. 271 MONTREAL, SATURDAY, NOVEMBER 20, 1965 PRICE FIFTEEN CENTS

Roads to Nowhere

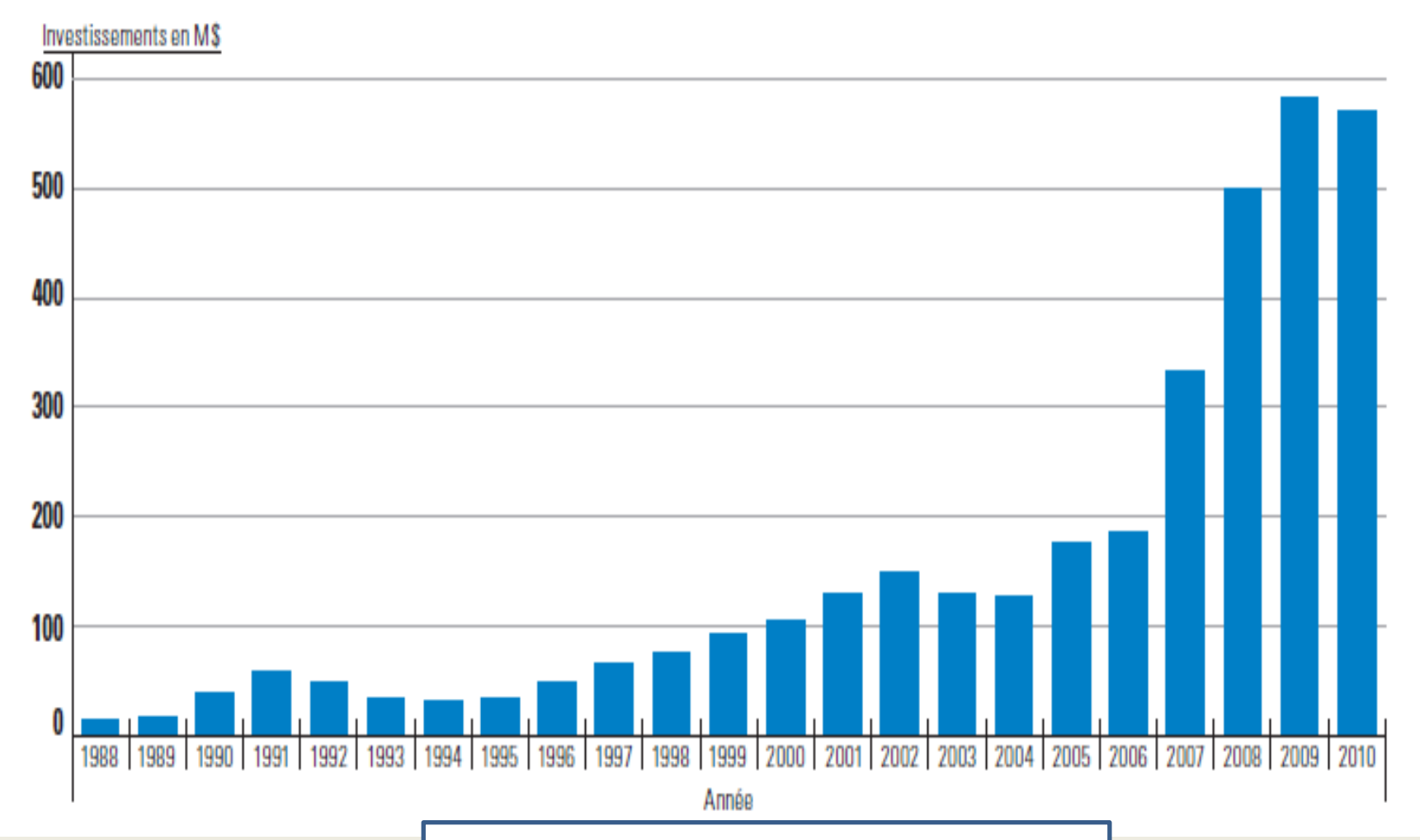
. . . for the time being

By CHARLES LAZARUS

Concrete has played a prominent role in the ability to start and speed the construction of these projects, simply because it is easy to manufacture and more importantly, permanent, versatile, economical and costs little to maintain.

MTQ uses over 800 000 M.T. of salt each year on its roads or approximately 20 M.T./KM *(Source :Transports Quebec)*

Maintenance and repair expenditures



Source :Transports Quebec

CONGESTION INDEX

The Congestion Index compares travel time during non-congested periods (free flow) with travel times in peak hours. The difference is expressed as a percentage increase in travel time, representing the congestion level.

Source: TomTom Congestion Index

City traffic: How slow can you go?

The top 10 most congested North American cities, ranked by overall congestion level, between April and June 2012 were:

1. Los Angeles 34%
2. Vancouver 33%
3. San Francisco 29%
4. Montreal 28%
5. Toronto 27%
6. Washington 26%
7. Seattle 26%
8. New York 25%
9. Chicago 23%
10. Miami 22%

Source: TomTom Congestion Index

Jarry-Querbes Underpass, Montréal QC (2004)

(Courtesy : City of Montréal)

NDG Tunnel completed 2003

Transports Québec SCC specifications

Type	f'_c @ 28 days	Cement content min.	Cement type	W/binder ratio	Coarse aggregate	Air content	Slump-flow	Air-void spacing max.	Chloride perme-ability max.
	MPa (Psi)	**kg/ m³ (lb/ yd³)**			**mm (in.)**	**%**	**mm (in.)**	**µm**	**Coulombs**
XIV-S	35 *(5000)*	-	GUb-SF GUb-F/SF GUb-S/SF	-	2.5 - 10 *(0.1 - 0.4)*	5 - 9	650 ±50 *(26 ± 2)*	300	1500
XIV-R	35 *(5000)*	460 *(775)*	GUb-F/SF GUb-S/SF	0.35 - 0.40	2.5 – 10 *(0.1 - 0.4)*	6 - 9	675 ± 50 *(27 ± 2)*	230	1000
XIV-C	35 *(5000)*	400 *(675)*	GUb-SF GUb-F/SF GUb-S/SF	0.45 max.	5 - 14 *(0.2 – 0.5)*	6 - 9	625 ± 50 *(25 ± 2)*	230	1000

Type *XIV-S* : proprietary bagged material

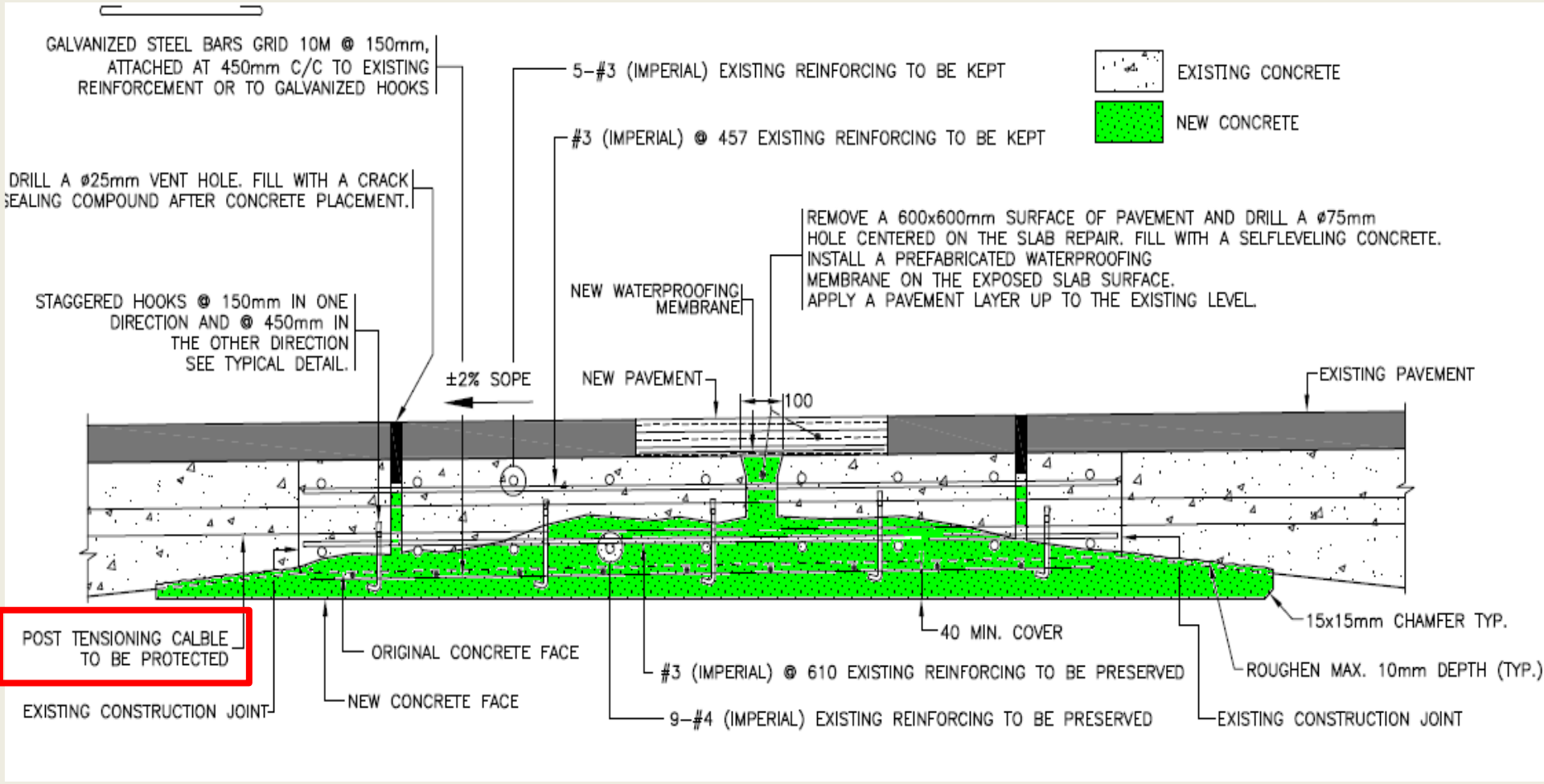
Type *XIV- R*: delivered in Ready-Mix or Mobile Mixer - Repairs

Type *XIV-C* : delivered in Ready-Mix or Mobile Mixer - Construction

- Need to accelerate repairs ?

Champlain Bridge, Montréal QC

Typical repair cross-section

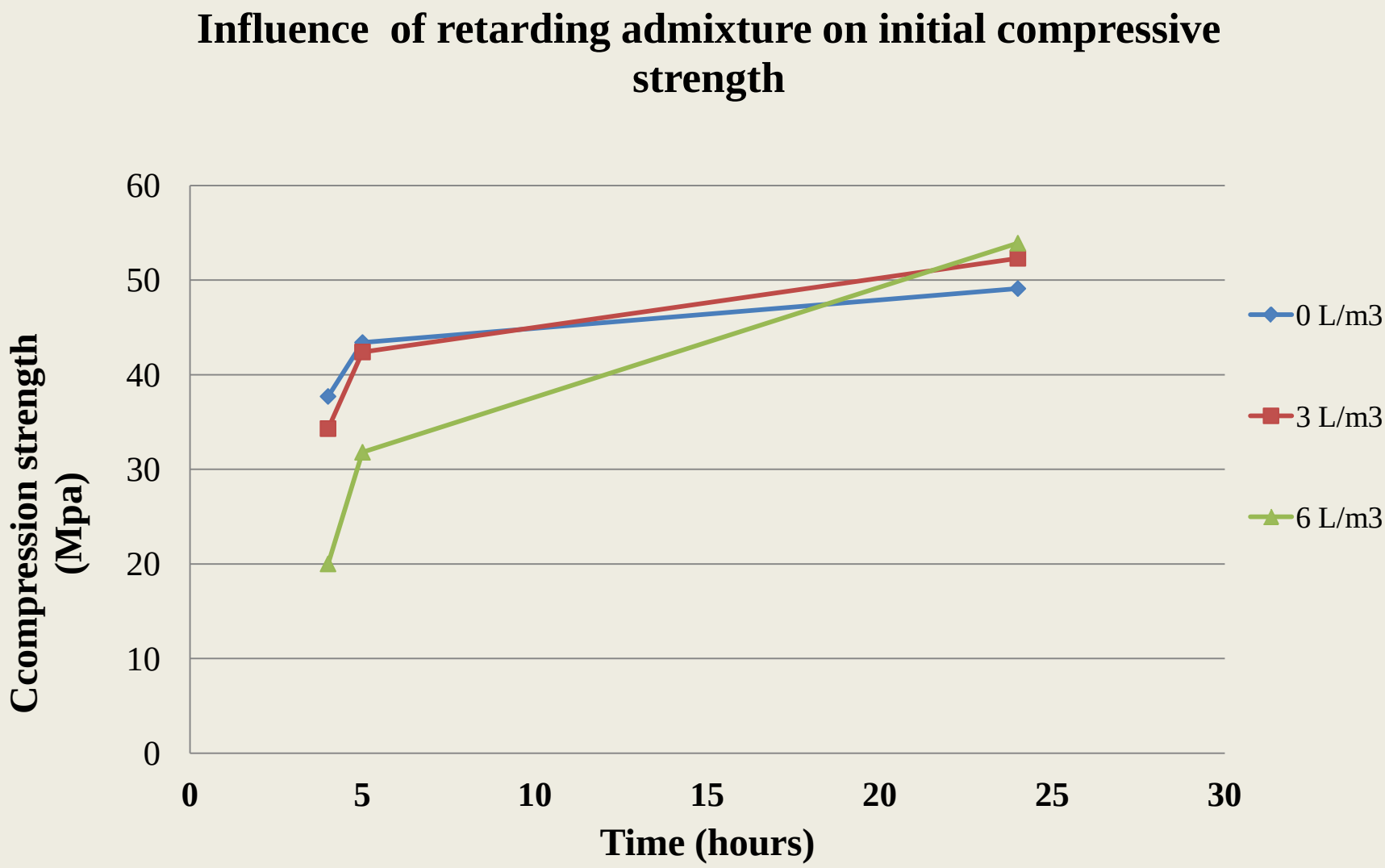


Project specifications

f'_c @ opening to traffic	MPa	*(psi)*	12	*(1740)*
f'_c @ 28 days	MPa	*(psi)*	35	*(5076)*
Ternary cement content	kg/m³	*(lbs/yd³)*	460	*(775)*
W/binder ratio			0.35 - 0.40	
Coarse aggregate size	mm	*(in.)*	2.5 - 10	*(0.2 – 0.4)*
Coarse aggregate volume max.	% (m^3/m^3)	*% (yd^3/yd^3)*	30	*(30)*
Air content	%		6-9	
Slump-flow	mm	*(in.)*	675 ± 50	*(27 ± 2)*
Air-void spacing factor max.	µm	*($in.10^{-3}$)*	230	*(9.3)*
Chloride permeability	Coulombs	Coulombs	1000	*(1000)*

Project restrictions: Working hours

- Traffic closure and works hours:
  - 23:00 to 05:00
- Concrete must have a minimum compressive strength of 12 MPa before opening to traffic at 05:00
- Severe penalties ($$$) for delays to open traffic at 05:00 or low concrete strengths.
- Also free unwanted publicity for the concrete supplier and the contractor on morning traffic reports


Influence of retarding admixture on initial compressive strength
Ccompression strength (Mpa)
60
50
40
30
20
10
0
0
5
10
15
20
25
30
Time (hours)
0 L/m3
3 L/m3
6 L/m3

RS-SCC : Workability test

	Age	Slump-flow		Concrete temperature	
	min	mm	*(in.)*	°C	*(°F)*
Batched at 10h30	-	-	-	-	-
10h35	5	670	*(26)*	27	*(80)*
11h11	41	670	*(26)*	27	*(80)*
11h25	55	590	*(23)*	-	-
11h40	70	190 *	*(7.4)**	30	*(86)*
12:40	140	-	-	52**	*(125)*

** Slump*

***Peak temperature*

RS-SCC :Test results

	Units	Specifications	Trial 1 09/07/13	Trial 2 09/07/14	Actual pour 09/07/15
			BMQ laboratory	*BMQ laboratory*	*Bridge deck*
f'_c [time after water-cement contact]	**Mpa (psi)**	12 *(1740)*	**21.3 [3.5h]** ***(3090)*** **25.1 [4.5h]** ***(3640)***	**26.6 [3h]** ***(3858)*** **28.8 [4h]** ***(4177)***	**35.4 [14.5h]** ***(5134)*** **38.5 [38.5h]** ***(5583)***
f'_c @ 28 days	**Mpa (psi)**	35 *(5076)*	**45.8** ***(6642)***	**45.8** ***(6642)***	**45.4** ***(6584)***
Rapid-setting cement content	**kg/m³ (lbs/yd³)**	460 *(775)*	460 *(775)*	460 *(775)*	460 *(775)*
Water/binder ratio		0.35 - 0.40	0.40	0.40	0.40
Coarse aggregate size	**Mm (in.)**	2.5 - 10 *(0.2 - 0.4)*	2.5 - 10 *(0.2 - 0.4)*	2.5 - 10 *(0.2 - 0.4)*	2.5 - 10 *(0.2 - 0.4)*
Coarse aggregate volume	**m³ (yd³)**	0.30 *(0.40)*	0.28 *(0.40)*	0.28 *(0.40)*	0.28 *(0.40)*
Entrained air content	**%**	6.0 - 9.0	4.6	**7.4**	6.0
Concrete temperature	**°C (°F)**	10 - 30 *(50 -86)*	23 *(73)*	22 *(72)*	26 *(79)*
Slump-flow	**mm (in.)**	675 *(27)*	600 (24)	**700 (28)**	550 (22)
Air void spacing factor	μ	230		**215**	
Durability factor (ASTM 666 Proc.A)	**%**	60	-	**100**	-
Chloride Permeability @ 28 days	Coul	1000		**666**	


ConCreate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RS – SCC


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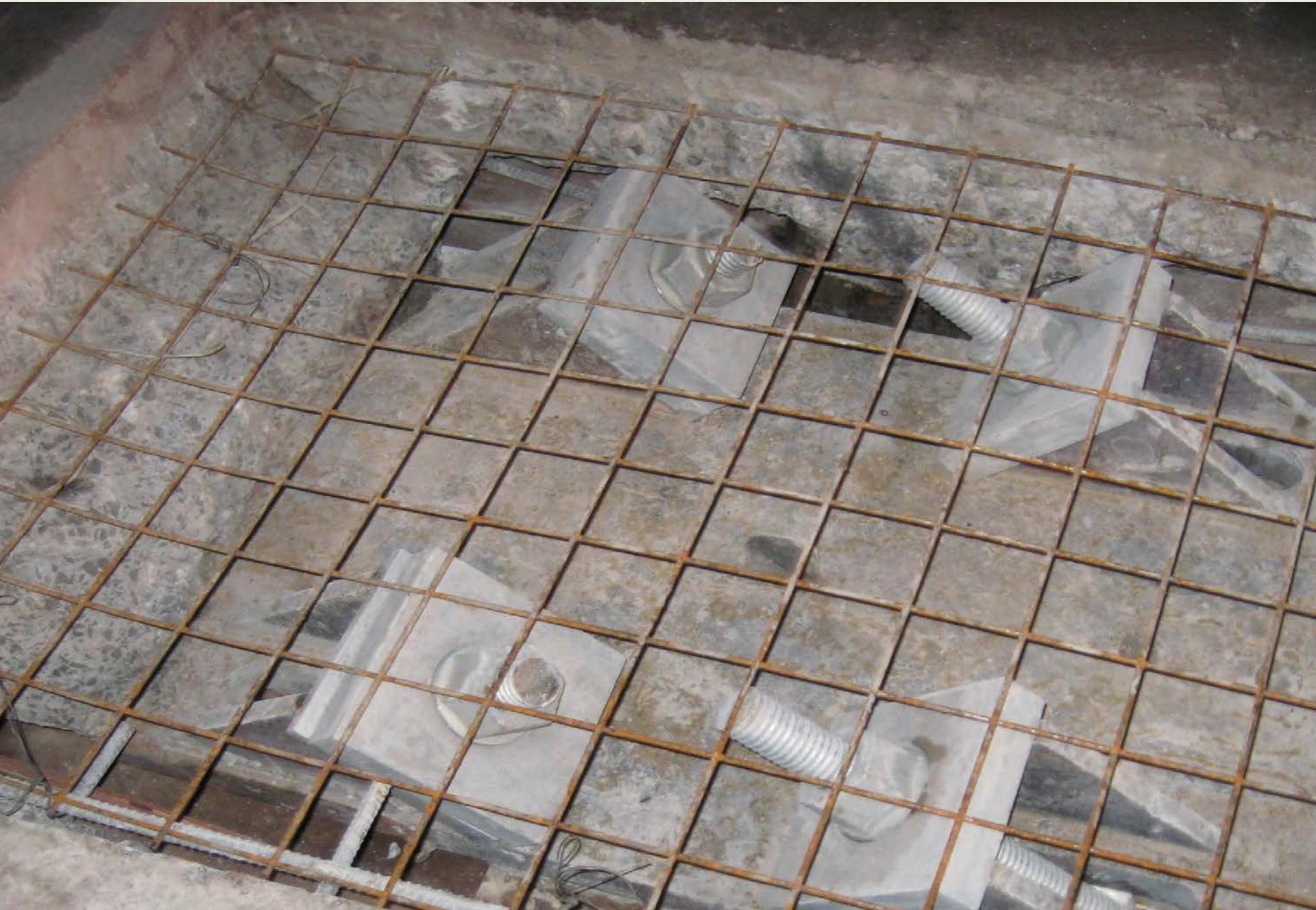

Conclusions

- RS-SCC provides a durable and cost effective solution for the repair and rehahilitation of concrete structures.
- RS-SCC allows quick turn around times for reopening bridges to traffic thus reducing traffic congestion .
- Lower environmental burden with reduced traffic congestion and construction times.

Acknowledgements

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Merci!

Thank you Grazie

Շնորհակալ եմ təşəkkür eskerrik asko eskerrik asko благодаря 谢 谢 謝謝 chokrane xièxie kam sah hamnida tak kiitos märsi aguyjé obrigada obrigado cám ơn .....

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