

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

Jacques Bertrand, Eng.
Ambex Concrete Technologies Inc.

ACI Fall 2012 Convention
October 22, 2012
Sheraton Centre, Toronto ON

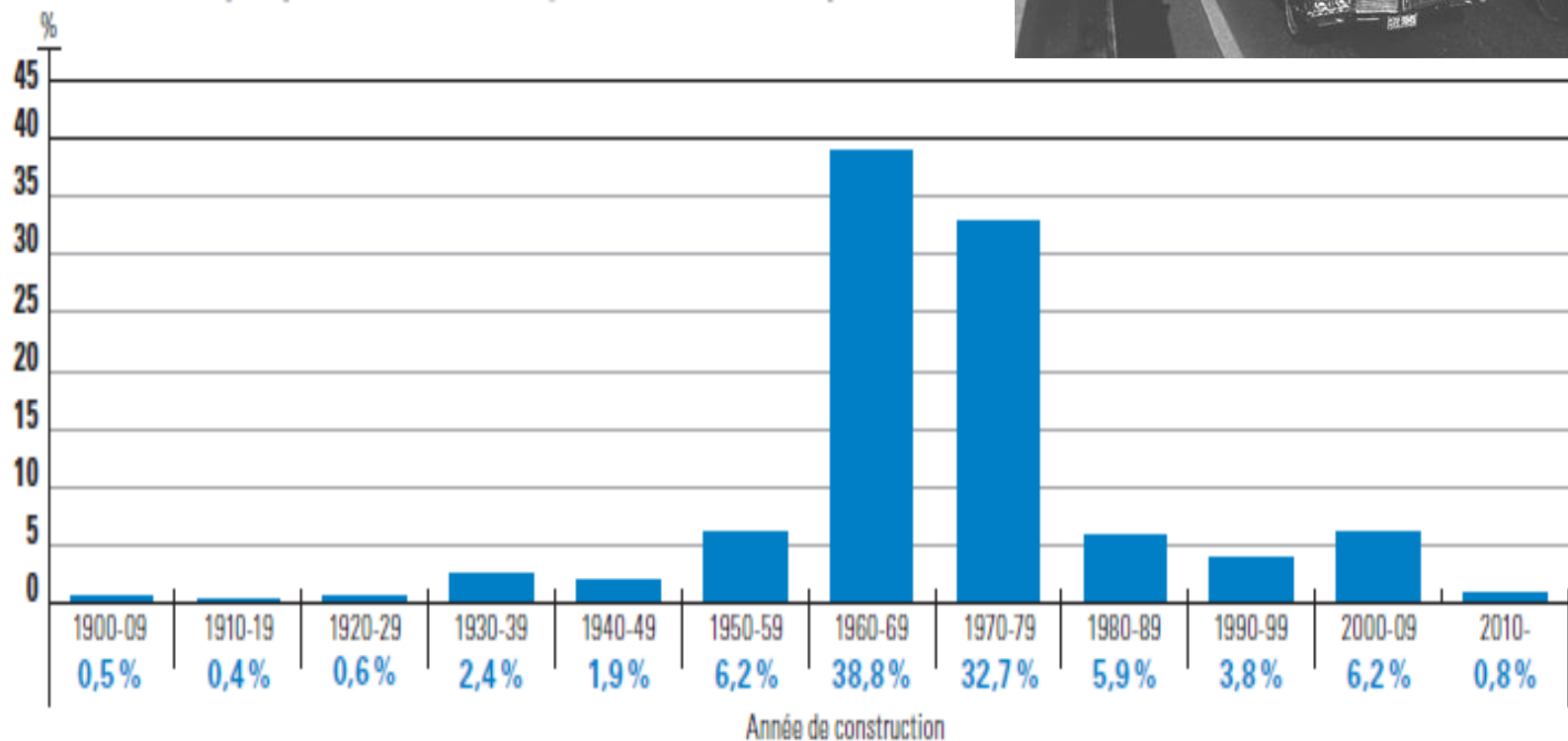
Outline

- 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 Québec

Roads to Nowhere ... for the time being

By CHARLES LAZARUS

Concrete evidence of Montreal's construction boom, is available almost wherever the eye is cast in the metropolitan area; more important, however, is the breakthrough from the strictly functional use of concrete, to an emphasis on aesthetics.

Not everything concrete, of course, can be a thing of pure beauty; but the trend is to do, as much as possible, to go beyond the traditional theme of the past, and infuse the particular projects with a unique style of their own in the use of concrete.

The most dramatic contribution of the trend is to be seen in the bridges, highways and massive interchanges which are blossoming in greater Montreal, as a result of construction of the Trans-Canada Highway and a network of complementary roads and bridges being pushed to completion.

—In the east end, the wide avenue of the grand interchange that will serve Melville Boulevard and Avenue St. Lawrence — the latter artery carrying traffic to and from the Trans-Canada bridge and tunnel crossing of the St. Lawrence to Beauport — already shows a delicate green pattern on the surface of the ramp.

The dynamic road program in the Montreal area has led to a further problem, in recent months, with motorists and their families taking to their vehicles, for an inspection of roads leading to "nowhere."

Nowhere, of course, for the time being; for what the highways are destined about — and fully illustrated by the picture on this page — is that in the months to come, the beautiful highways and interchanges that now terminate sharply high above ground, will soon be extended and completed to reach the...

there has been considerable confusion between "concrete" and "monolithic" — in fact, concrete (in proper) is one of the basic ingredients of concrete, the finished product, which is made up of crushed stone, sand, water and chemical additives.

Montreal's concrete industry is proud of the job it has been called upon to do, in the former metropolitan area which has become the dominant feature of this area's expansion.

Everything, of course, has a general target date of being completed as soon as possible and well in time for Expo.

But how about the future? Will the boom continue?

A prominent spokesman for a large concrete-producing organization, answered this question this way:

"Montreal is now going through the same kind of expansion New York went through 30 years ago. Expo was the catalyst for certain...

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.

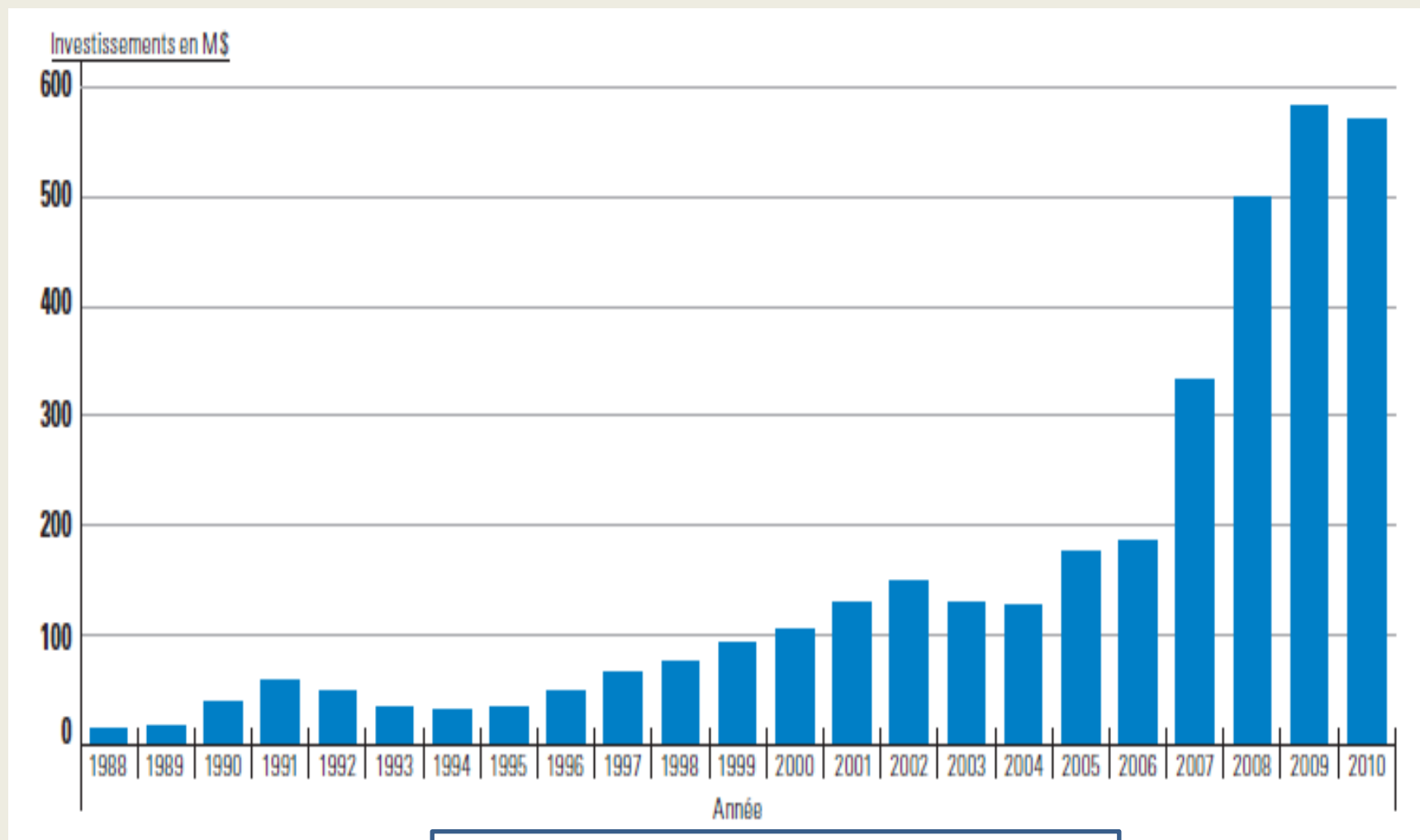




MTQ uses over 800 000 M.T. of salt each year on its roads or
approximately 20 M.T./KM *(Source :Transports Quebec)*



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



1600 M³ SCC

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/ m ³ (lb/ yd ³) | | | 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

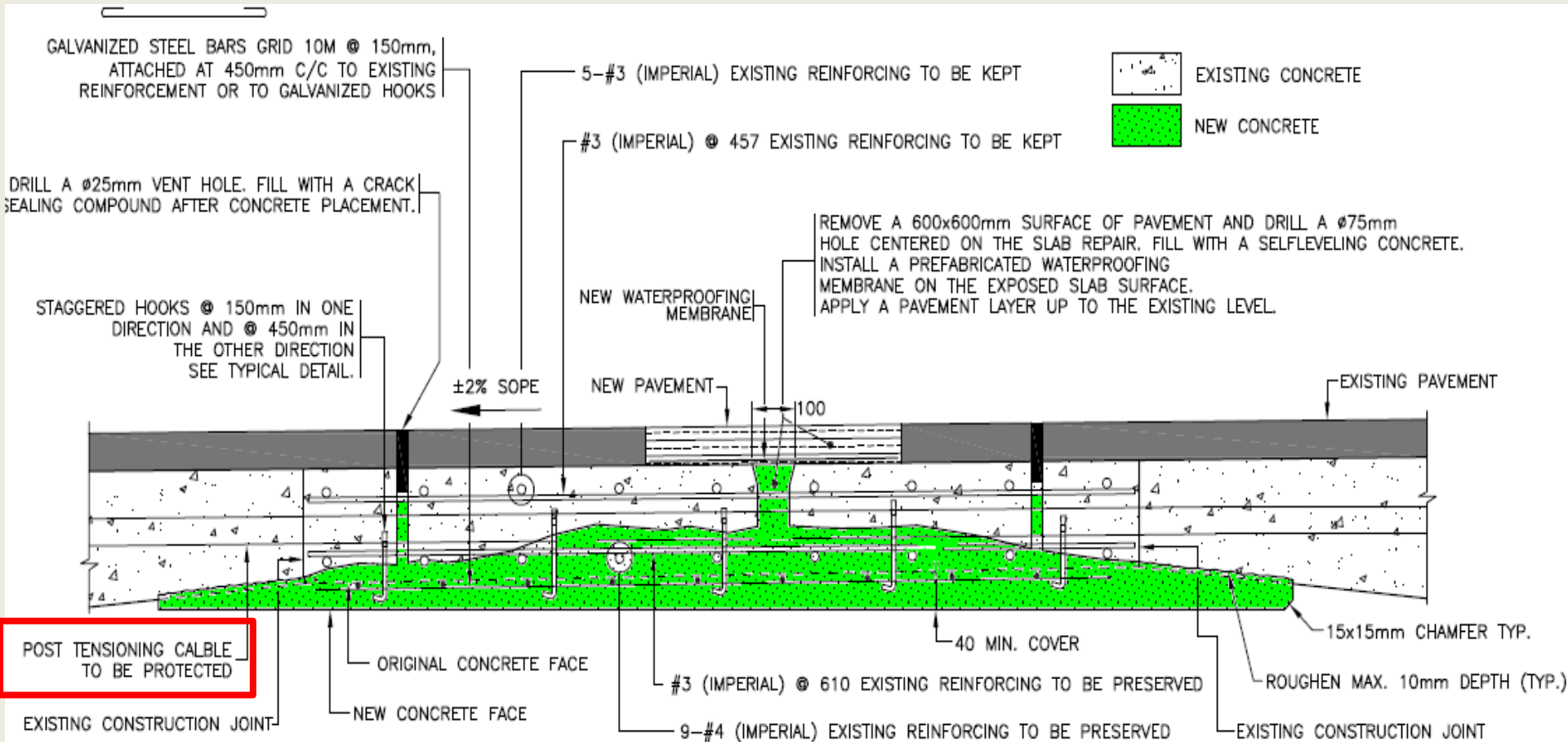
Type *XIV-C* : delivered in Ready-Mix or Mobile Mixer - Construction

- Need to accelerate repairs ?

Champlain Bridge, Montréal QC



Typical repair cross-section



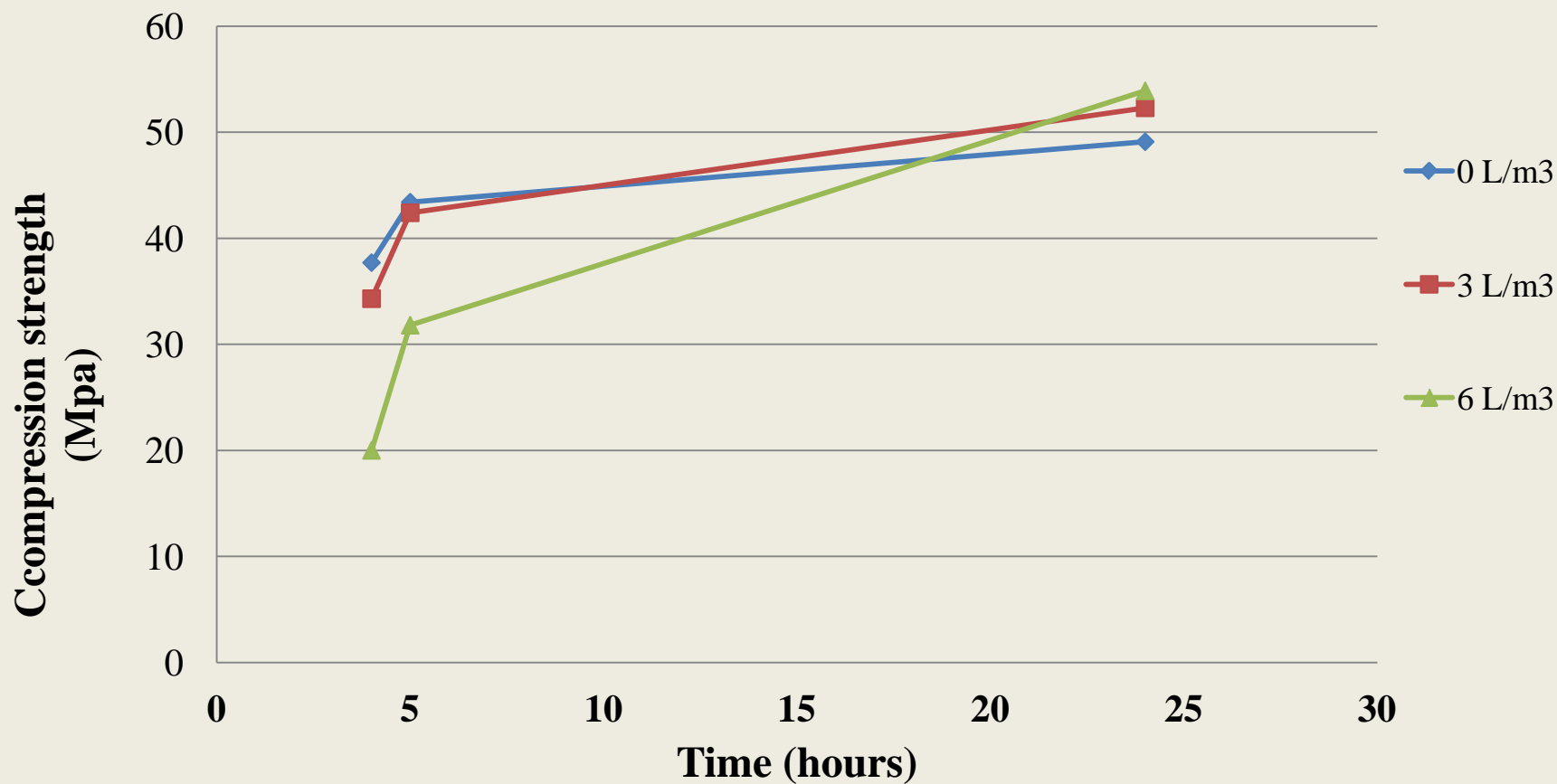
Project specifications

| | | | | |
|---|-------------------------------------|--|-------------|-------------|
| f'_c @ opening to traffic | MPa | (<i>psi</i>) | 12 | (1740) |
| f'_c @ 28 days | MPa | (<i>psi</i>) | 35 | (5076) |
| Ternary cement content | kg/m ³ | (<i>lbs/yd³</i>) | 460 | (775) |
| W/binder ratio | | | 0.35 - 0.40 | |
| Coarse aggregate size | mm | (<i>in.</i>) | 2.5 - 10 | (0.2 – 0.4) |
| Coarse aggregate volume max. | % (m ³ /m ³) | % (<i>yd³/yd³</i>) | 30 | (30) |
| Air content | % | | 6-9 | |
| Slump-flow | mm | (<i>in.</i>) | 675 ± 50 | (27 ± 2) |
| Air-void spacing factor max. | μm | (<i>in.10⁻³</i>) | 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



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 | Specification s | Trial 1 09/07/13 | Trial 2 09/07/14 | Actual pour 09/07/15 |
|--|--------------------|-------------------------|--|--|--|
| | | | <i>BMQ laboratory</i> | <i>BMQ laboratory</i> | <i>Bridge deck</i> |
| 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 | |














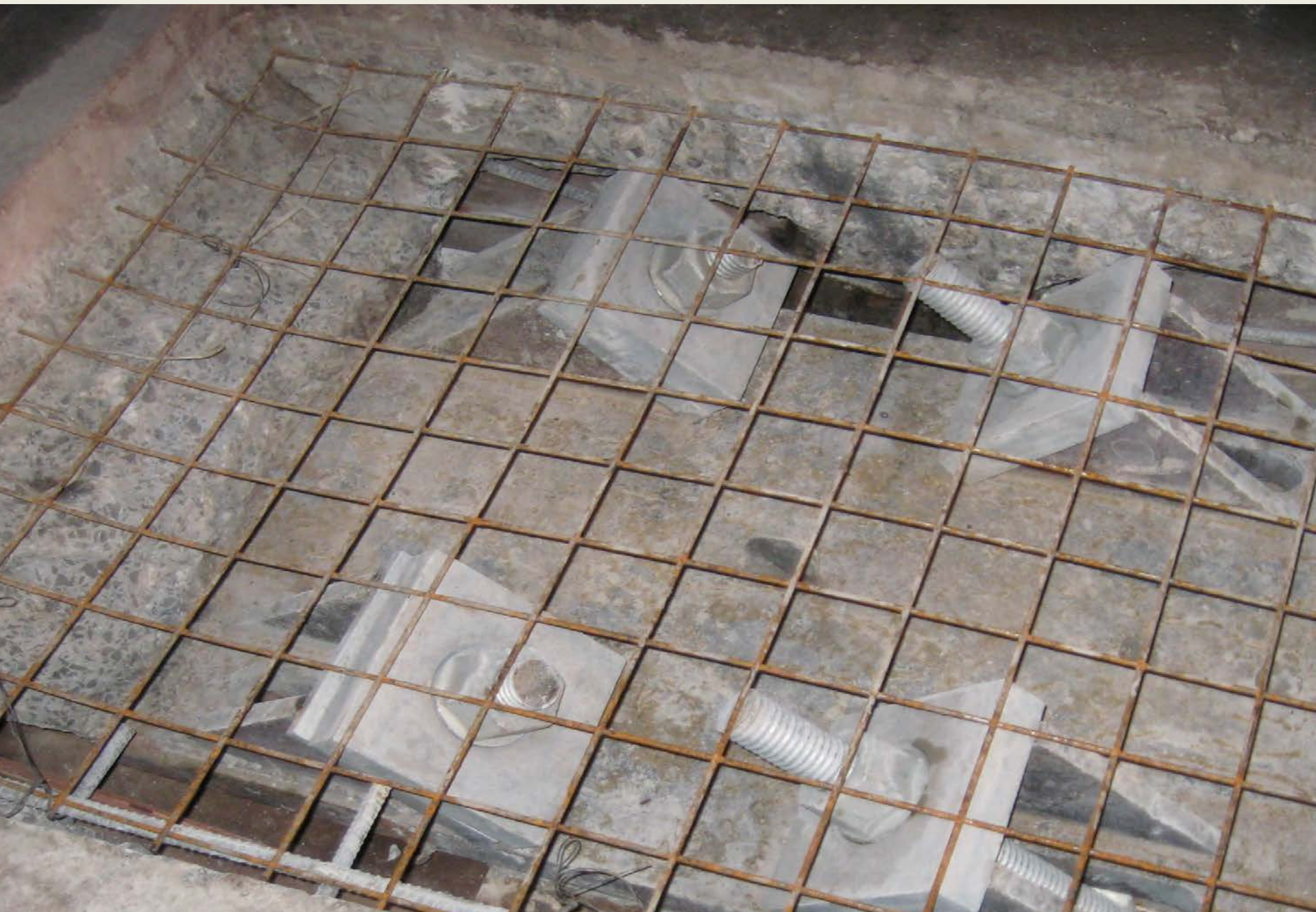
The image shows a construction site for a concrete wall. The wall is made of large, grey concrete panels. A red dashed line outlines a rectangular area on the top left of the wall. A red oval highlights a section of the wall and the scaffolding above it. A red arrow points from the text 'RS - SCC' to the wall. Another red arrow points from the text 'RS - SCC' to the scaffolding. The scaffolding is made of wooden beams and metal pipes. A green hose is hanging from the scaffolding. The ground is covered with dirt and debris. A white plastic bag is on the ground. In the background, there is a body of water and trees.

RS - SCC













Conclusions

- RS-SCC provides a durable and cost effective solution for the repair and rehabilitation 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

- American Concrete Institute
- Québec Ministry of Transport
- Jacques Cartier and Champlain Bridge Authority
- City of Montreal
- Sherbrooke University
- Our clients: Aecon, Construction Concreate, Pomerleau-EBC (JV), EBC Construction, Construction Stellaire, Construction Lomeco, G.T.S. Constriction, Hydro-Québec
- BMQ and Ambex employees whose passion and enthusiasm for concrete have been a source of inspiration to seek and develop innovative concrete products and solutions for the concrete repair industry

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



?

*The more knowledge we share, the more
we grow*