Influence of surface preparation on bonding
(The good , the bad and the ugly)

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INTERNATIONAL CONCRETE REPAIR INSTITUTE

Outline

- Introduction
- What is a good surface preparation?
- Typical Specifications
- BMQ Laboratory test program
- Field results
- Conclusion
- Future perspectives

The Ugly

The Ugly.
Scarified surface uncleaned

More of the Ugly

The Bad
Concrete Impressions
Raked and stamped surface with excessive paste from overfinishing (Circa 2014)

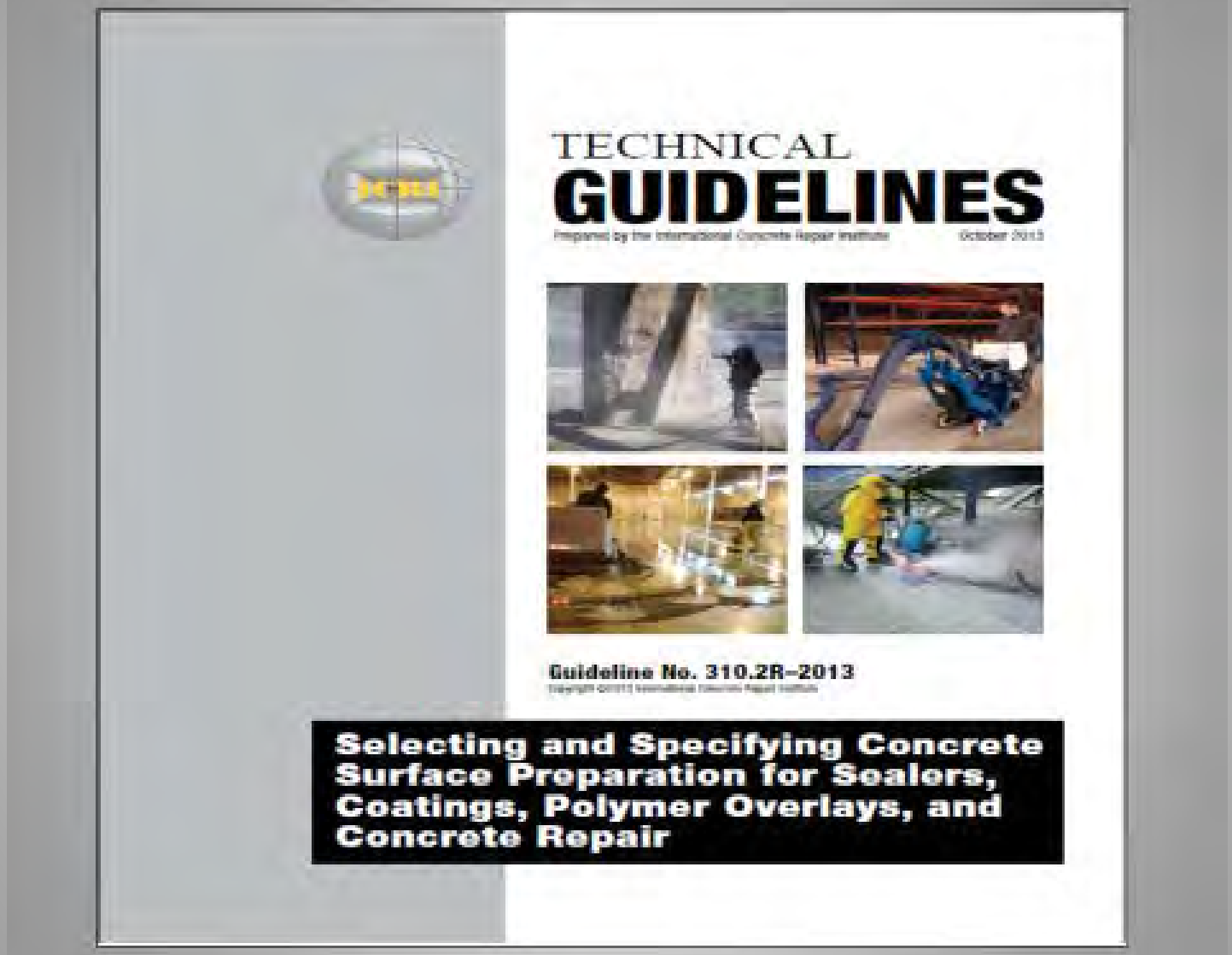
The Bad

Water blasted surface unwashed and uncleaned


Doing it right

A+++

Available tools



Typical procedure for a concrete slab repair

- Remove existing overlay material and expose concrete surfaces.
- Inspect concrete surfaces and determine areas to be repaired and scope of work.
- Remove unsound concrete as required
- Clean surfaces and place repair material
- Validate bonding on repair material to substrate.

CSA A23.1-14

7.8.3.2 Substrate surface preparation

- Sandblast concrete surface to be repaired
- Remove concrete with high pressure water blast.
- Remove concrete by scarification, jackhammering, shotblasting, or grinding.
- Concrete surface must be excavated to sound concrete and clean of any deleterious materials that may affect the bond.
- Ensure surface has an adequate preparation to ensure a proper bond.
- Do not use acid to strip and remove surface materials
- Prepare surface relative to bonding agent specified.
- Water must not bead on concrete surface to be repaired
- The surface profile CSP may be specified according to ICRI 310.2

CSA A23.1-14

7.8.4.2 Substrate Surface Preparation

- Maintain surface wet.
- Remove all free standing water.
- Surface should be SSD
- Mix bonding slurry to a thick consistency
- Spread and brush in bonding slurry on substrate
- Immediately place overlay concrete Do not allow bonding agent to dry
- An epoxy may be used for smooth or rough surfaces.

Specifications reviewed

- ✓CSA 23.1-14
- ✓ ACI 548
- ✓ ACI 562
- ✓ ASTM C1583
- ✓ CSA A23.2-6B
- ✓ ICRI 310.2R-2013
- ✓ ICRI 310.3R-2014
- ✓ ICRI 320.3R-2012

CSA 23.1-14

7.8.6 Bonding

Unless noted otherwise by the designer, the bonding method must ensure a tensile bond strength of at least 0.9 MPA (135 psi) as tested per CSA 23.2-6B

OPSS 930

Transports Ontario

- **930.08.01 Testing - Tensile Bond Strength**

  If failure occurs in the epoxy adhesive and the specified strength of 1.0 MPa has not been reached, the test shall be repeated within 300 mm of the original core location. If a failure occurs fully within the parent concrete, this shall be considered a valid result, unless the Contractor has been directed to leave unsound concrete in place. Retesting is not required when the specified strength of 1.0 MPa has been achieved.

- **930.08.03.02 Tensile Bond Strength**

  For a sublot to be acceptable, the average tensile bond strength of the sublot shall be a minimum of 1.0 MPa. Sublots with average tensile bond strength less than 1.0 MPa and more than or equal to 0.8 MPa shall be accepted with payment reduction.

Special provisions for Latex Modified Concrete Overlays

Transports Ontario

8.02.01.04.01 Acceptance Testing

Tensile bond strength testing shall be according to the clause Testing-Tensile Bond Strength of OPSS 930, except that tensile bond strength of 1.3 MPa shall apply.

ACI

- *ACI 548 Polymers in concrete*
- 1.7 MPa (250 psi) Epoxy mortar to concrete
- *ACI 440 Fiber Reinforced Polymer*
- 1.5 MPa (215 psi) Epoxy to concrete
- These are the only values referenced in ACI documents
- *ACI 562 Concrete Repair Code Requirements*.
- **7.4—Bond**
- **7.4.1 The required bond strength shall be at least 1.5 times**
- greater than the calculated design bond force at the repair
- material to existing concrete interface.
- **7.4.1.1 The measured bond strength shall not be less than**
- the lower of the required bond strength or the tensile strength
- of the existing concrete
- **7.4C—Bond**
- **7.4.1C A low bond strength may not be sufficient to satisfy**
- durability requirements. The International Concrete Repair
- Institute (ICRI) No. 210.3 discusses bond strength in repairs.

TEST CONDITIONS

Substrate preparation		Substrate cleaning		Bonding agent		Repair concrete
	Code		Code		Code	Code
Sandblast CSP3	J	Washed	L	With bonding agent	C	A
Scarification CSP 5	S	Not-washed	NL	Without bonding agent	NC	B
Hydro-demolition CSP 10	H					C
						D

REPAIR CONCRETE

A - STRUCTURAL CONCRETE - MTQ-TYPE VS

B – LATEX MODIFIED CONCRETE-MTQ - TYPE XVI-5

C - LATEX MODIFIED CONCRETE-MTQ - TYPE XVI-15

D - RAPIDSET LATEX MODIFIED CONCRETE- MTQ – TYPE XVI-15

TECHNICAL

GUIDELINES

Prepared by the International Concrete Repair Institute October 2013




Guideline No. 310.2R–2013

Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair

Surface preparation method	Concrete Surface Profile									
	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Detergent scrubbing	■									
Low-pressure water cleaning	■									
Grinding	■	■								
Acid etching	■	■	■							
Needle scaling		■	■	■						
Abrasive blasting		■	■	■	■	■	■			
Shotblasting		■	■	■	■	■	■	■	■	
High- and ultra-high-pressure water jetting			■	■	■	■	■	■	■	■
Scarifying				■	■	■	■			
Surface retarder (1)					■	■	■	■	■	■
Rotomilling						■	■	■	■	
Scabbling							■	■	■	
Handheld concrete breaker							■	■	■	■

(1) Only suitable for freshly placed cementitious materials

ICRI Concrete repair surface profiles

Surface Preparation

Sandblast

Scarification

Hydro-demolition

Formwork and curing

Formwork

Curing of samples

Pullout testing

Pullout anchors

Pullout test

Rupture mode: Substrate (Sample #43)

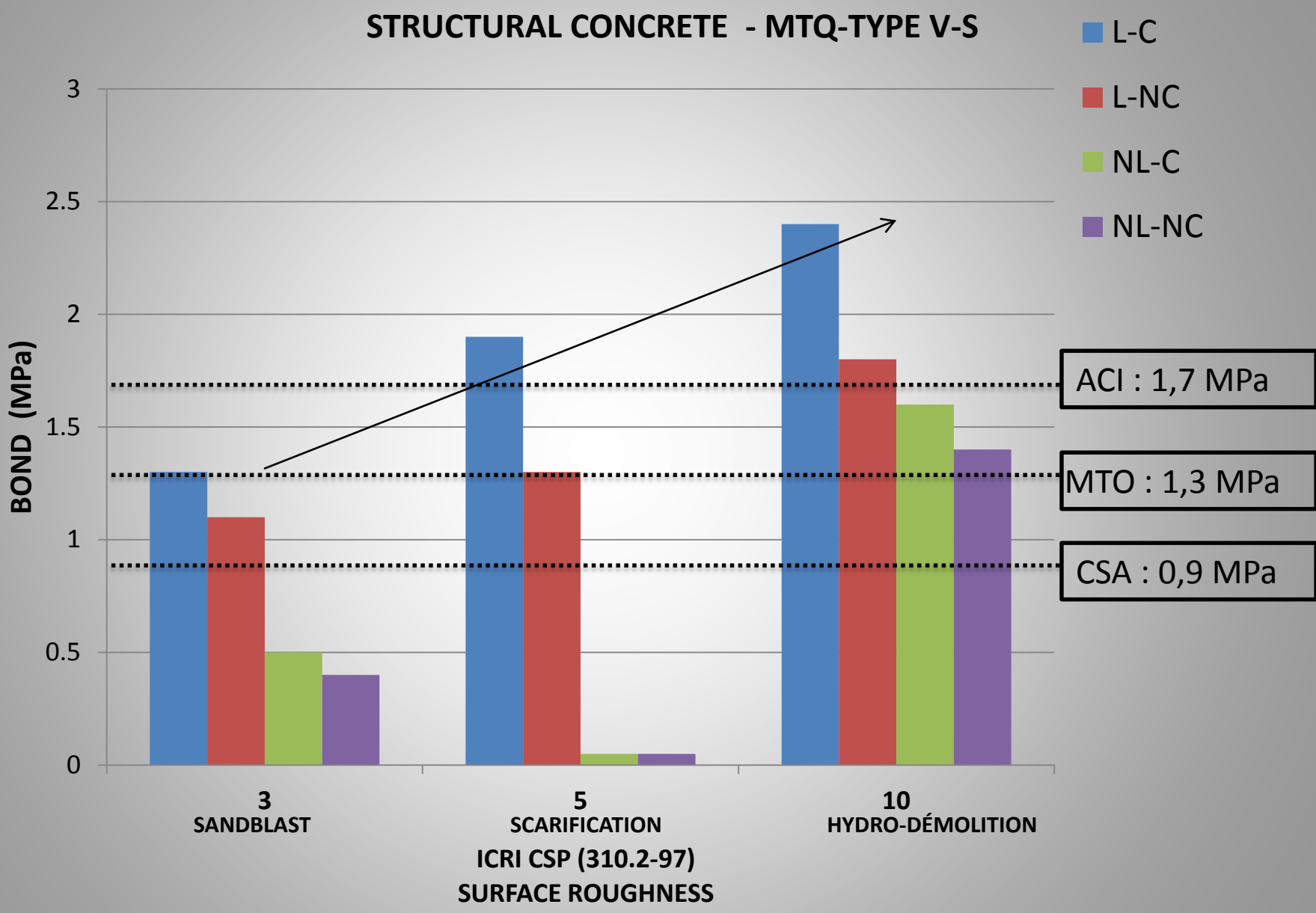
Bond strength : 2,2 MPa

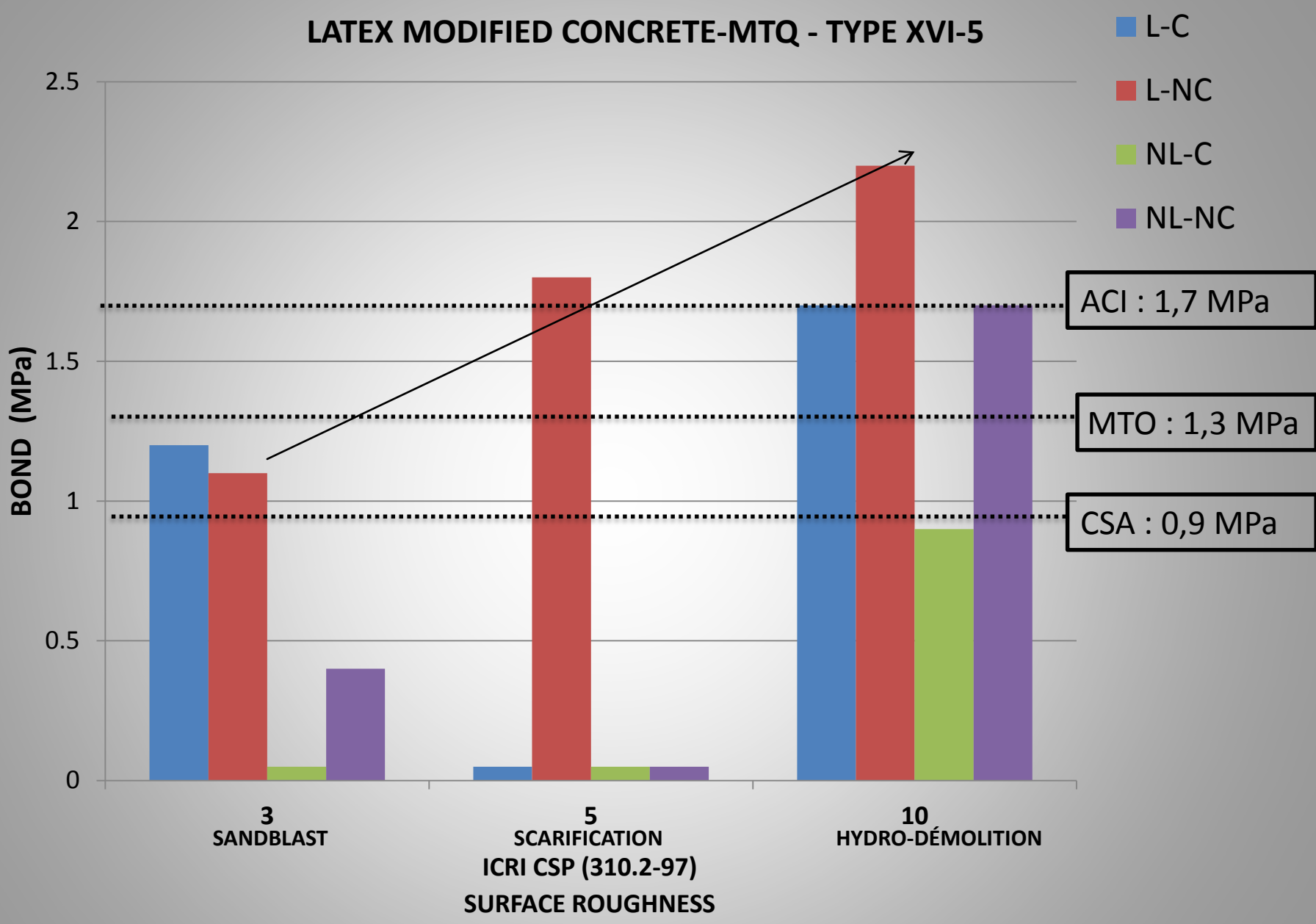
Rupture mode: Interface (Sample #152)

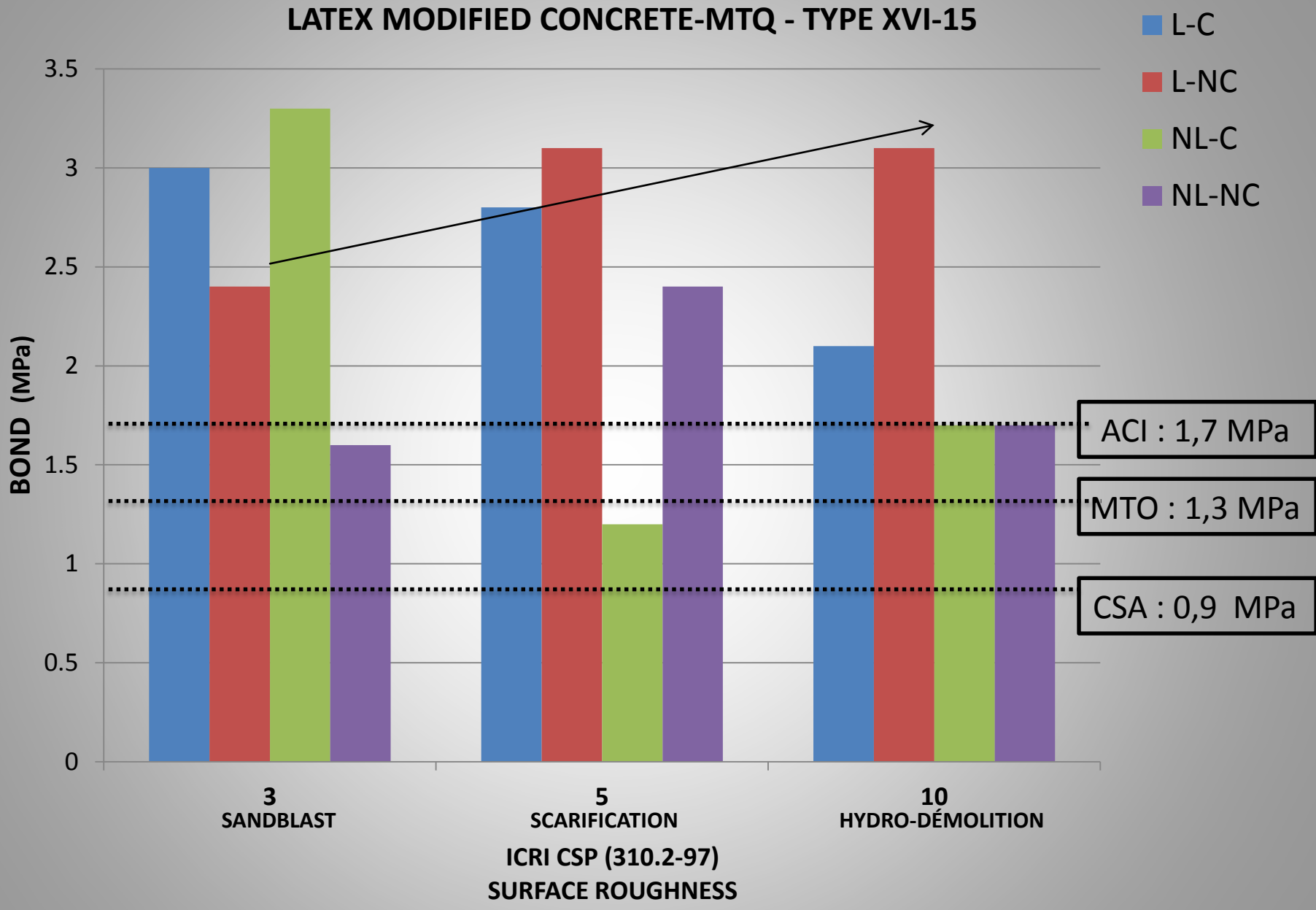
Bond strength : 1,9 MPa

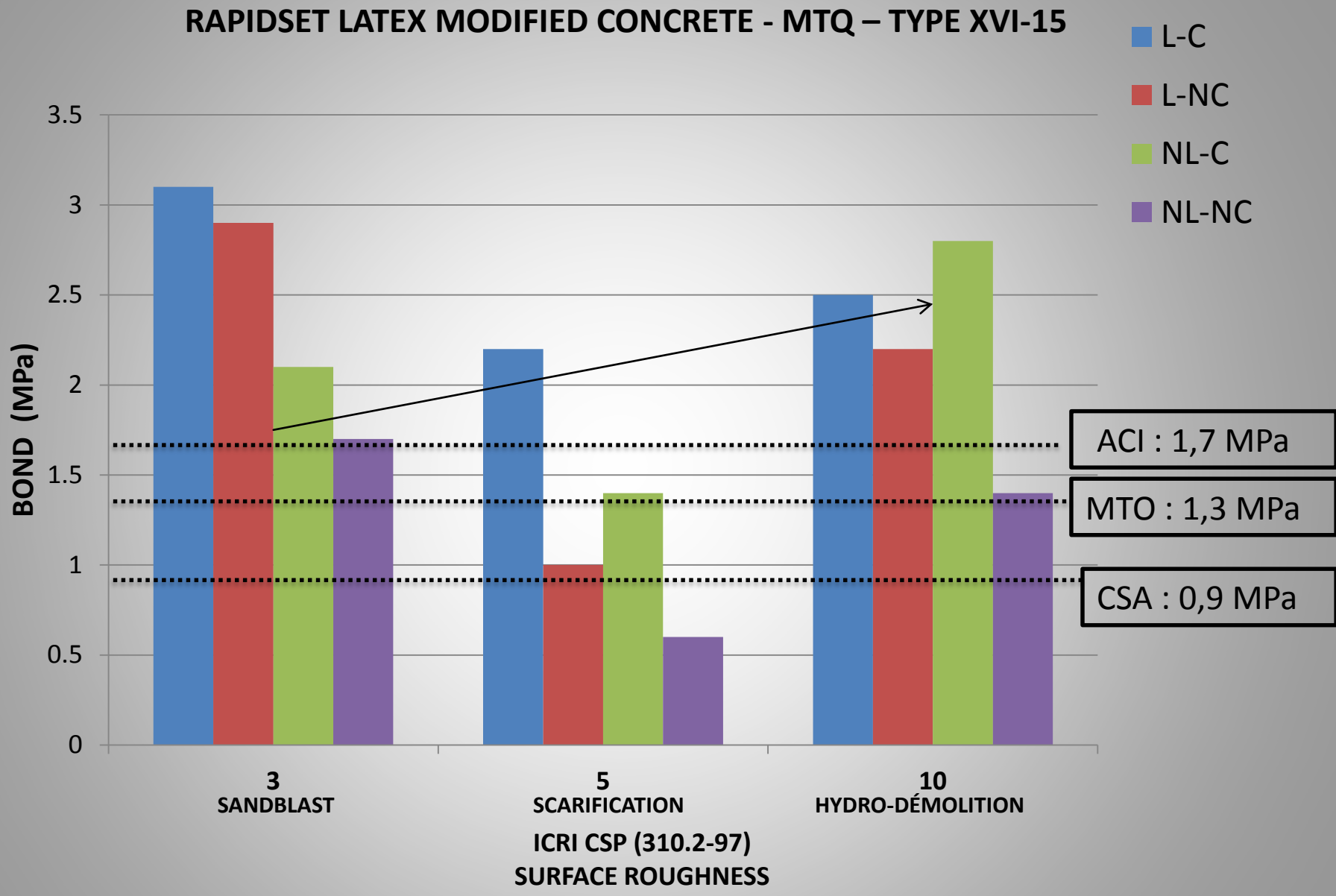
Rupture mode: Repair material (Sample #112)

Bond Strength : 1,8 MPa


STRUCTURAL CONCRETE - MTQ-TYPE V-S
L-C
L-NC
NL-C
NL-NC
BOND (MPa)
3
2.5
2
1.5
1
0.5
0
ACI : 1,7 MPa
MTO : 1,3 MPa
CSA : 0,9 MPa
3
SANDBLAST
5
SCARIFICATION
10
HYDRO-DÉMOLITION
ICRI CSP (310.2-97)
SURFACE ROUGHNESS


LATEX MODIFIED CONCRETE-MTQ - TYPE XVI-5
L-C
L-NC
NL-C
NL-NC
2.5
2
1.5
1
0.5
0
BOND (MPa)
ACI : 1,7 MPa
MTO : 1,3 MPa
CSA : 0,9 MPa
3
SANDBLAST
5
SCARIFICATION
10
HYDRO-DÉMOLITION
ICRI CSP (310.2-97)
SURFACE ROUGHNESS


LATEX MODIFIED CONCRETE-MTQ - TYPE XVI-15
L-C
L-NC
NL-C
NL-NC
BOND (MPa)
3.5
3
2.5
2
1.5
1
0.5
0
ACI : 1,7 MPa
MTO : 1,3 MPa
CSA : 0,9 MPa
3
SANDBLAST
5
SCARIFICATION
10
HYDRO-DÉMOLITION
ICRI CSP (310.2-97)
SURFACE ROUGHNESS


RAPIDSET LATEX MODIFIED CONCRETE - MTQ – TYPE XVI-15
L-C
L-NC
NL-C
NL-NC
BOND (MPa)
3.5
3
2.5
2
1.5
1
0.5
0
ACI : 1,7 MPa
MTO : 1,3 MPa
CSA : 0,9 MPa
3
SANDBLAST
5
SCARIFICATION
10
HYDRO-DÉMOLITION
ICRI CSP (310.2-97)
SURFACE ROUGHNESS

LONG TERM BOND RESULTS

	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
Compression (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 [L (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)
Source	BMQ (QUALITAS)	MTQ	BMQ (LVM)	VTRC	BMQ (LVM)

Field Pullout tests

- Roller compacted concrete slab repair 2012

  RSLMC with no bonding agent on scarified surface CSP 5 - 1.85 MPa

  Break in substrate

  RSLMC with latex bonding slurry on scarified surface CSP 5 - 2.05 MPa

  Break in substrate

Field Pullout Results

- **MTO Batteaux Bridge deck overlay,** Collingwood, ON (10 days)

  Latex modified concrete Type XVI – 15 with latex bonding slurry and scarified surface CSP 6 –

  0.9 MPa Break in substrate

  1.95 MPa Break in repair material
- **MTO Kipling Ave Overpass over Autoroute 401**, Toronto, ON (10 days)

  Latex modified concrete Type XVI –15 with latex bonding slurry and scarified surface CSP 6

  1.73 MPa Break at joint and in substrate (1.2 @ 2.5 MPa)
- **MTO Belfield Ave Overpass,** Toronto, ON (10 days)

  Latex modified concrete Type XVI – 15 with latex bonding slurry and scarified surface CSP 6

  1.7 MPa Break at joint and in repair material

Conclusions

- Bond strength increases as the surface roughness increases
- Surface cleaning after demolition and prior to concreting is ***critical***
- Surface must be SSD
- Bonding slurry is recommended to ensure acceptable bond. Bonding slurry should be vigourously brushed onto substrate.
- Bonding slurry not required for hydro-demolition surfaces.
- Follow rule 53: Do not place latex bonding slurry more than 5 minutes before placing concrete and do not place latex bonding slurry more than 3 meters in front of concrete placement

However…

Latex bonding slurry is not required for a clean well prepared hydro-demolished surface.

Conclusions

- Do 3 pullout tests per condition to reduce variability.
- Use larger surfaces to allow taking more samples when large differences in test results occur.
- Ensure concrete well vibrated

- Adding latex polymer (Styrene-butadene) in concrete increases the bond strength of the repair material to the substrate.

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Future perspectives

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ICRI Concrete Surface Repair Technician Certification Program

- **ACI 562 Repair Code to include provision for use of “ICRI Certified Concrete Surface Repair Technicians" on projects**

- **The Certification Program will go live end of March 2016**

Certified Concrete Surface Repair Technicians will:

- Be qualified to perform pre-placement and post-placement inspections and testing:
  - **Soundings (ASTM D4580)**
  - **Inspecting for Proper Removal of Concrete Including Behind Rebar (ICRI 310.1R)**
  - **Performing Slump of Concrete and Slump Flow of SCC (ASTM C143/C1611)**
  - **Inspecting for Proper Repair Configuration and Surface Preparation (ICRI 310.1R/310.2R)**
  - **Inspecting for Surface Cleanliness of Existing Concrete (Pending ACI 364 TechNote)**
  - **Inspecting for Moisture Condition (Pending ACI 364 TechNote)**
  - **Measuring Rebar Section Loss (Pending ACI 364 TechNote)**
  - **Inspecting for Rebar Cleanliness (ICRI 310.1R)**
  - **Inspecting for Proper Storage, Mixing, Placement of the Repair Material (ICRI 320.3 R)**
  - **Molding Test Cylinders (ASTM C31)**
  - **Setting-up for and Inspecting a Shotcrete Test Panel (ASTM C1140)**
  - **Pull Off Test (ICRI 210.3R–ASTM C1583)**

A final thought

We know what we must do
We just need to do it.

Merci

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- Trochaines

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THE MORE WE SHARE THE MORE WE GROW

(Léonard Nimoy)

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