SHOTCRETE OR SCC?

How to select the right repair material?

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Typical Shotcrete or SCC repairs for transportation structures

- Used for vertical or overhead surfaces for thickness greater than 1.5 in (38 mm)

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Shotcrete and SCC repairs

Shotcrete - Definition

Shotcrete — *"Mortar or concrete pneumatically projected at high velocity onto a surface"*

- ACI 506R-05, Guide to Shotcrete

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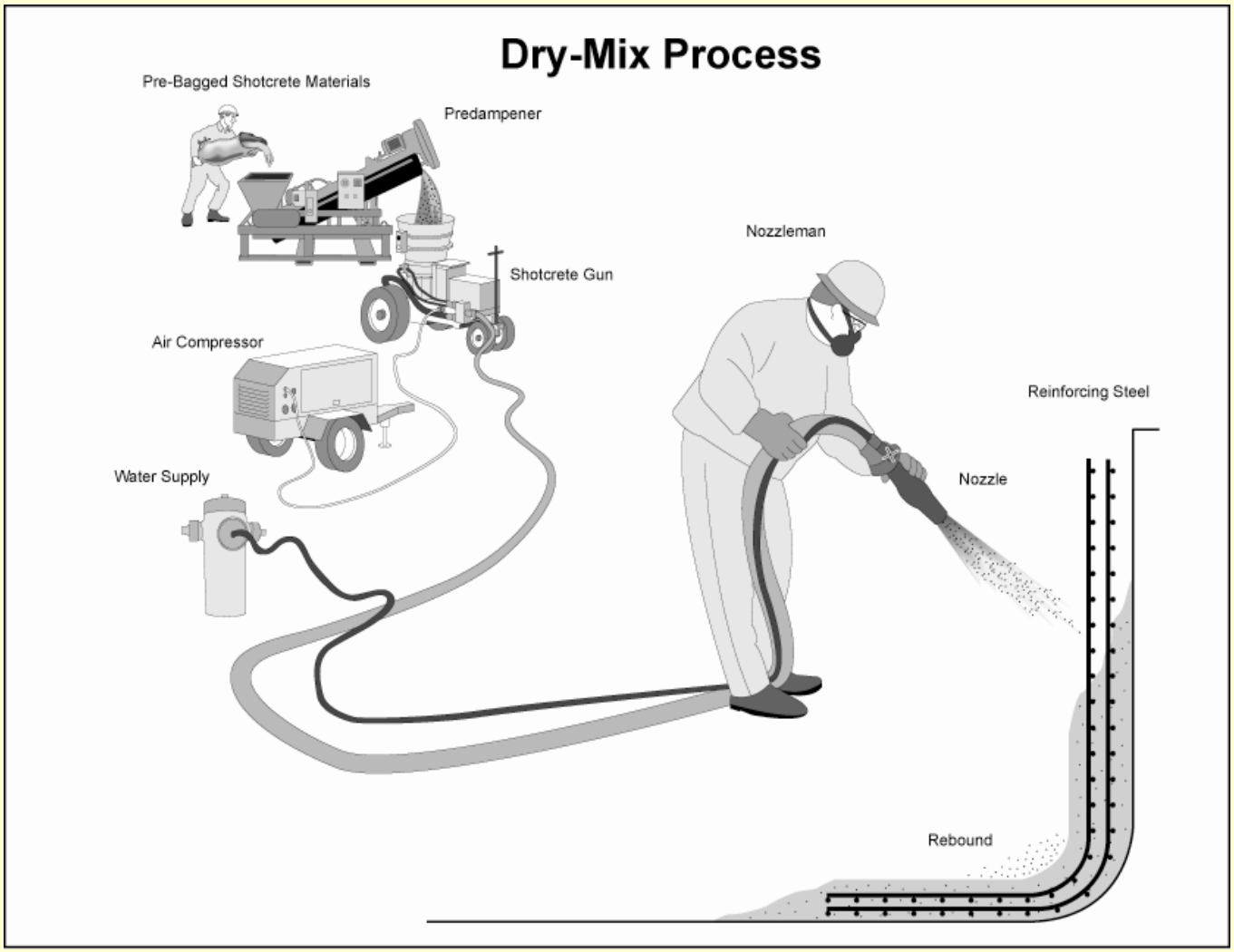
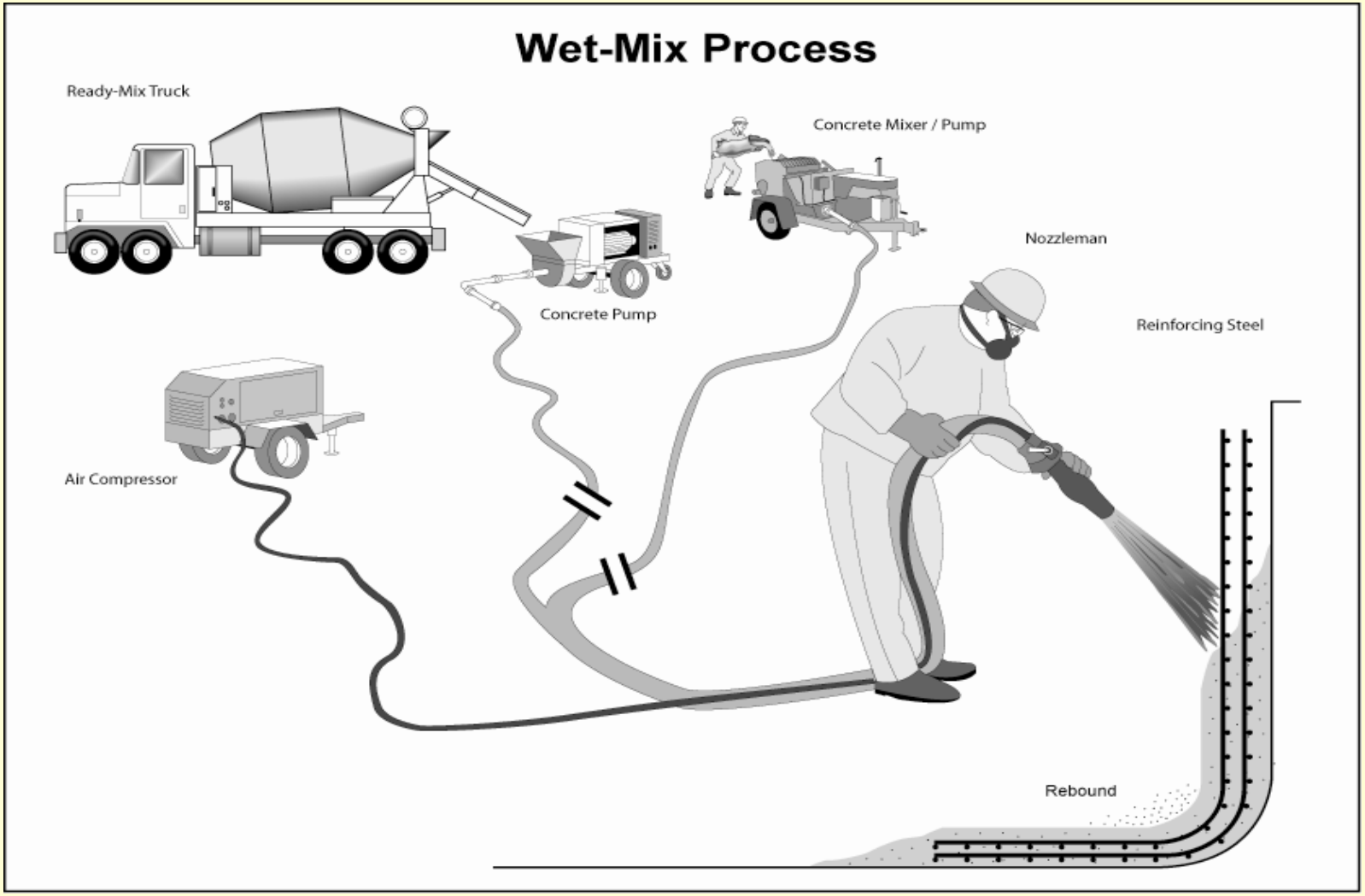
Shotcrete Dry-Mix process



Shotcrete Wet-Mix process



Typical shotcrete mix design parameters

Process	*f'* c *MPa (psi)*	Cement content min. *Kg/m³ (lb/yd³)*		Water/binder max.	Stone content by weight min. 2,5-10 mm (1/8-3/8") *(%)*	Air content *(%)*	Slump *mm (in.)*	Synthetic fibers content min. *kg/m³ (lb/yd³)*	Air void spacing µm (10^{-4}in.)
		Type GUb-SF [1]	Type HE [2]						
Dry-Mix	35 (5076)	450 (760)	460 (775)	~0.40	10	3.5 – 7.0	N/A	0.9 (1.5)	300 (118)
Wet-Mix	35 (5076)	410 (690)	N/A	0.40	25	10 – 15 [3]	100 ± 30 (4 ± 1)	0.9 (1.5)	230 (90)

[1] Hydraulic cement composed of GUb-SF, GUb-F/SF ou GUb-S/SF
[2] Used overhead only
[3] Before pumping

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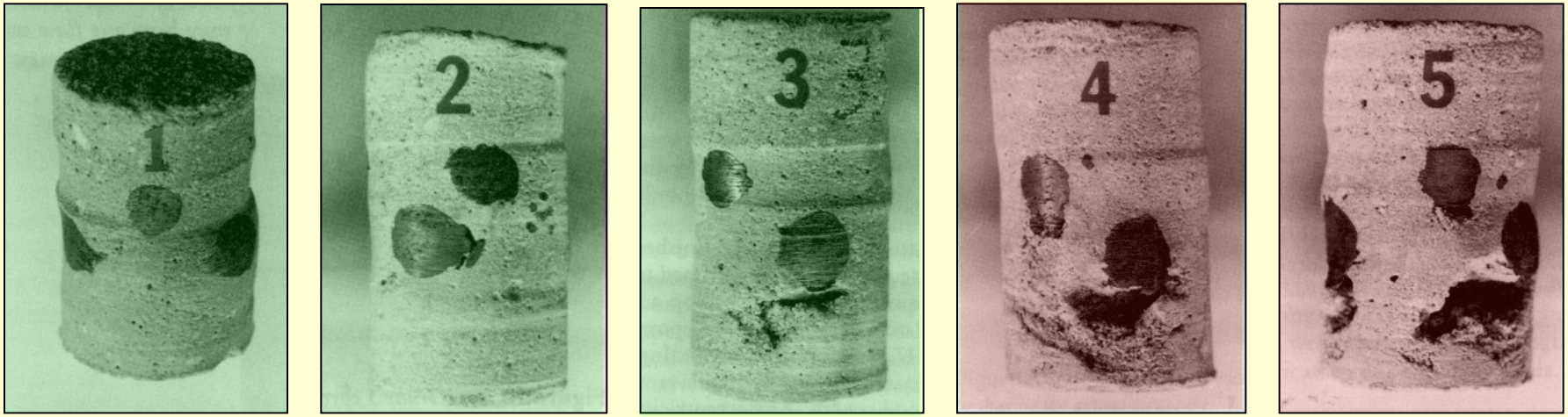
Shotcrete specifications

- Reference guide: ACI 506R-05
- CSA A23.1-09 / A23.3-09
- Transports Québec – *Book VII-Materials 3201 et 3301*

Shotcrete specifications

- ACI C 660 - *Shotcrete Nozzelmen Certification*
  - Valid 5 years ACI / 3 years MTQ



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Surface preparation

- Surface must be clean and free of dirt, oil, grease and any substances that may hinder proper bonding
- Remove all delaminated and unsound concrete and ensure surface adequately is roughened (ICRI- CSP 9 or greater)
- Demolish concrete 1 inch behind any corroded rebar

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Surface preparation (cont.)

- Replace any damaged rebar
- Rebar must be clean and properly fastened
- Sawcut repair perimeter minimum ¾ inch
- Pressure wash surface and maintain wet.
- Remove any excess water

Shotcrete placement

- Nozzle must be perpendicular and about 30 to 48 inch from surface and nozzle moved in a circular motion to ensure proper compaction and rebar encapsulation

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Shotcrete finishing

- Wood trowel finish give a better durability
- A rotating trowel with a high density rubber disk may also be used

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Shotcrete curing

- Vertical surfaces are covered with saturated geotextile and sealed with a polyethylene film to keep surface wet
- Surfaces are maintained humid for 7 days
- Overhead surfaces are curing with a curing agent meeting ASTM C-309

Autoroute 40 Montreal, QC

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Repairs to architectural design of overpass facing

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Shotcrete - Advantages

- Vertical or overhead repairs
- Fast and economical
- Well suited for curved and irregular shaped surfaces
- Requires little or no formwork

Shotcrete – Advantages (cont.)

- Allows for rapid turn-around time
- Possible to have different surface textures.
- Can be used on sites with limited access.
- Excellent durability

Shotcrete - Disavantages

- Very dusty process and rebound increase quantities
- Requires more cleanup
- Rougher surface than SCC or conventional concrete
- Requires certified personnel
- 7 day wet cure required for vertical surfaces

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SCC- Definition

Fresh concrete that can flow around reinforcement and consolidate within formwork under its own weight without vibration and that exhibits no defect due to segregation or bleeding. *- ACI 237*

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SCC - Placement

Photo Transports Québec

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SCC - typical mix design

Mix	*f'* c *MPa* *(psi)*	Cement content min. *Kg/m³* *(lb/yd³)*	Cement	Water/binder max.	Stone mm (in.)	Air content *(%)*	Slump flow *mm* *(in.)*	Air void spacing µm (10^{-4}in.)
XIV-S	35 (5000)	-	GUb-SF GUb-F/SF GUb-S/SF	-	2.5-10 (1/8-3/8")	5 – 9	650 ± 50 (25.5 ± 2)	300 (118)
XIV-R	35[6] (5000)	460 (775)	GUb-F/SF GUb-S/SF	0.35 à 0.40[7]	2.5-10[8] (1/8-3/8")	6 – 9	675 ± 50 (26.5 ± 2)	230 (90)
XIV-C	35[6] (5000)	400 (675) 420 (710)	GUb-SF GUb-F/SF GUb-S/SF	0.45	5-14 (1/5 – ½)	6 – 9	625 ± 50 (24.5 ± 2)	230 (90)

[6] *f* 'c min to 48 hours must be higher than 10 Mpa (1450 psi)

[7] The volumetric ratio of sand/(binder+water+air) must be between 0,6 et 0,8.

[8]The volume of the stone must not exceed 330L/*m³*

- Transports Québec - Tome VII-Matériaux 3101

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SCC - Specifications

- Reference guide: ACI 237R-07
- CSA A23.1-09 / A23.2-09
- Transports Québec - *Book VII-Materials 3101*

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SCC - Avantages

- Overhead and vertical repairs
- Very flowable
- No vibration or consolidation necessary
- Can be pumped or placed by gravity
- Can be placed in heavily reinforced structures, complicated formwork shapes and in difficult to reach and restrained areas
- Excellent bonding, no segregation or bleeding

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SCC – Avantages (cont.)

- Easy to cure
- Ease of placement in limited access areas
- Excellent durability
- Smooth surfaces
- Eliminate honeycombing
- Eliminate surface repairs

SCC - Disadvantages

- Formwork requires more detail
- Stronger and more watertight
- Surface must wet
- Longer setting time and lower initial strengths
- Mix design requires tighter control than conventional concrete to ensure durability

SCC applications

- Vertical or overhead surfaces

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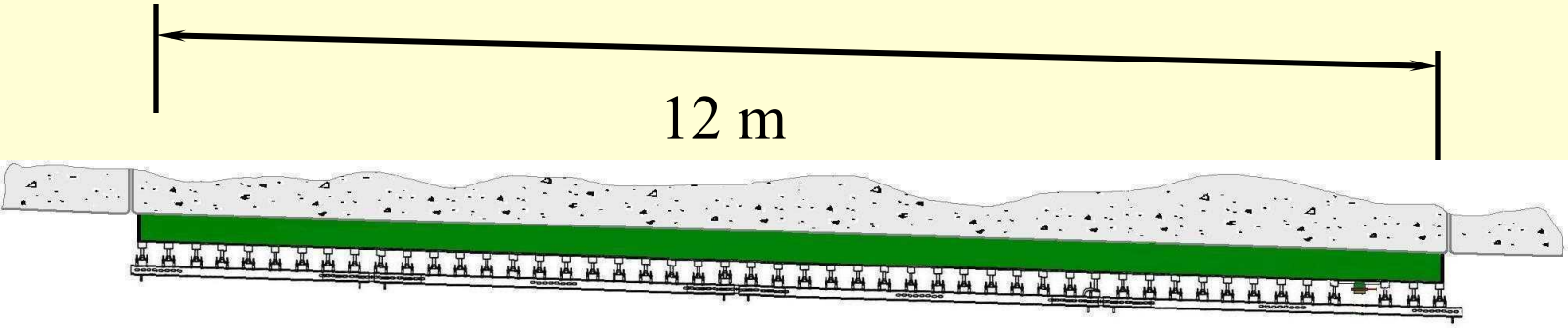
SCC -Tunnel ceiling repairs



Central Station- CN

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Autoroute 13 – 40
AASHTO prestressed beams

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Champlain Bridge
Pier cap and AASHTO beams

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Laviolette Bridge pier repairs

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Notre Dame de Grace Tunnel

- Contract to repair tunnel ceiling
- Restrictions
  - Heavily reinforced thick concrete slab; 48 inches deep
  - Land above tunnel inaccessible
    - ➢No work area available at surface
  - High traffic volume
    - ➢Tunnel designed for 90 000 véhicules in 1967,
    - ➢Over 140 000 véhicules use it daily in 2010
    - ➢Traffic must be maintained during day. Night work required. No shoring possible

Notre Dame de Grace Tunnel

Photo Transports Québec

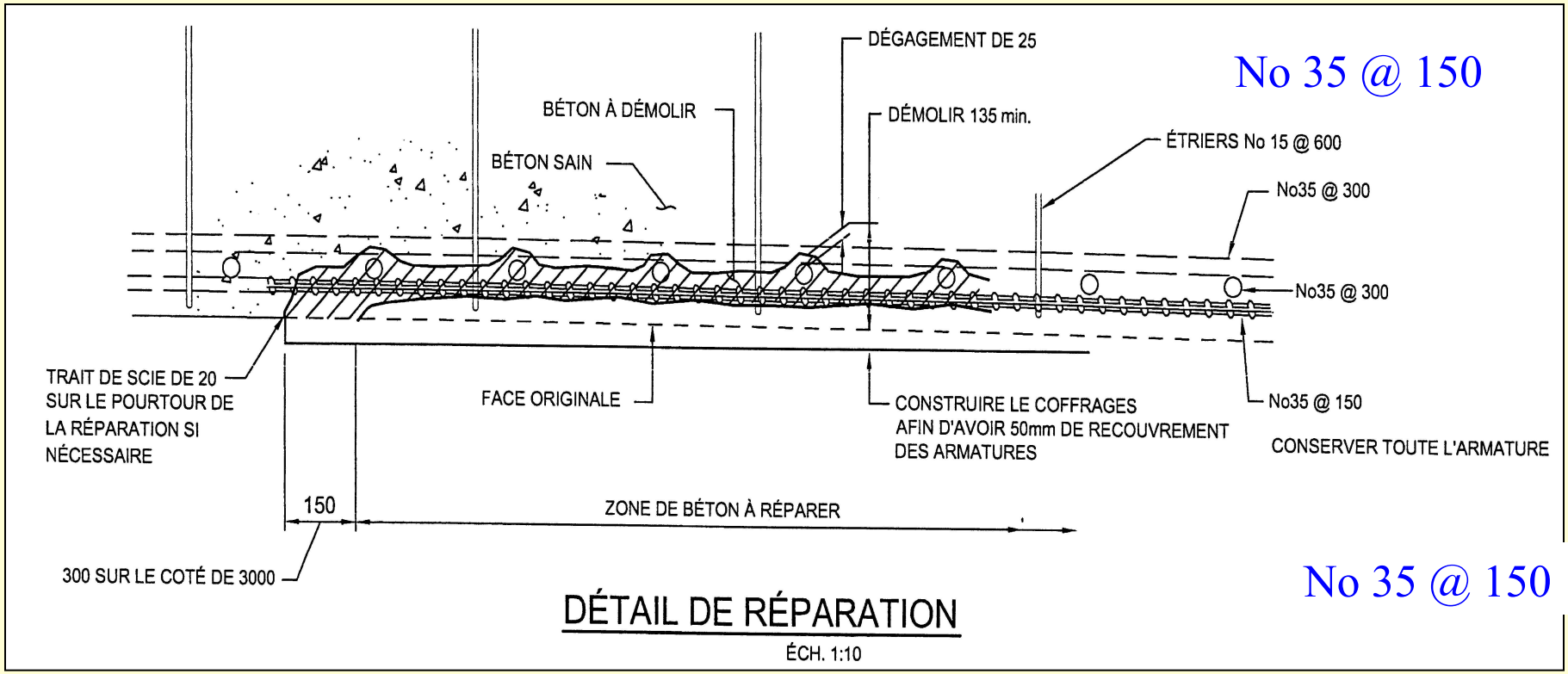
Pre-construction trials

- Two options were studied for the tunnel ceiling repair
  - Shotcrete
  - Self-consolidating concrete

- Two test panels were done in Fall 2002 to select most appropriate repair method and material

Test panels

Test panel: 2m by 6 m (6.7 x 20ft)



-Courtesy Transports Québec

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Test Panels

- Primary observation
  - Conventional demolition behind #11 rebar at 6'' c/c was very difficult
  - Average of 10 to12 hours demolition per test panel

Courtesy Transports Québec

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Test panels

- Second major observation
  - Shotcrete was not well suited for this repair
    - Problem to properly encapsulate closely spaced large diameter rebar
    - Fresh shotcrete fell when traffic re-opened in early

Courtesy Transports Québec

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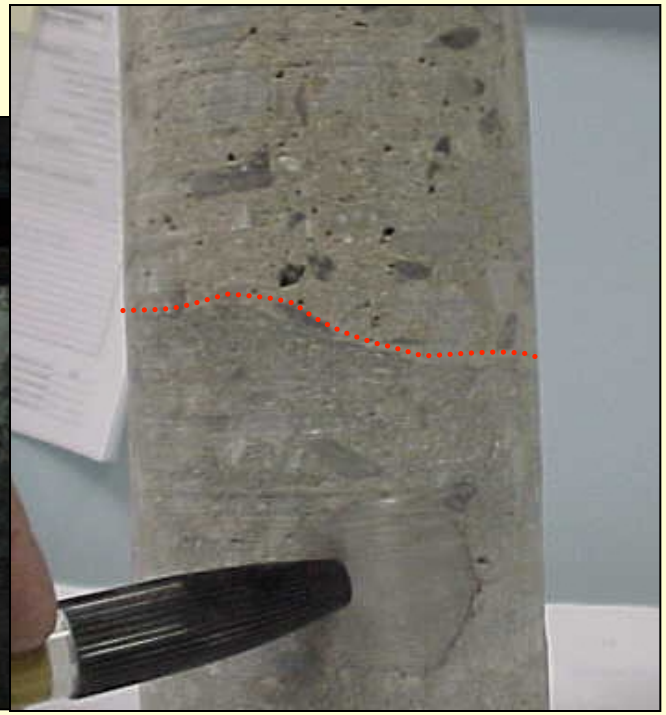
Test panels

- Third major observation
  - SCC repair had excellent results
    - Good bonding to substrate
    - Good encapsulation of large diameter rebar



Photos Transports Québec

Selection Criteria

5 W

WHAT

WHY

WHO

WHERE

WHEN

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WHAT ?

- Scope of work to repair
- Size of project
- Constructability
- Esthetics
- Surface finish and texture
- Geometry

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WHY ?

- Nature of repair
- Cause of repair and remedial measures
- Repair or reconstruction?
- Life cycle analysis
- Emergency repair or permanent solution
- Design or code restrictions
- Validate end use or new use
- Complete solution

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WHO ?

- Who is the owner?
- Is he open to an alternative solution?
- Is the finished product important to him?
- Contractor's know-how
- Does the contractor have the proper shotcrete or formwork expertise to perform the work

WHERE ?

- The environment: Interior or exterior
- If shotcrete, dry or wet shotcrete?
- Durability: freeze-thaw, scaling, chemical resistance, etc…
- Concrete plant and material availability
- Work procedure adapted to environment
- Accessibility to jobsite and work area
- Material supplied by batch plant, mobile mixer or bagged materials

WHEN ?

- Climate and weather considerations
- Jobsite location
- Work performed day, night, weekend
- Shutdown time and allowed work schedule
- Design restrictions

Selection Criteria

- 5 W
- + COST
- + Owner's and engineer's preference and comfort with repair solution

= SELECTION OF REPAIR METHOD AND MATERIAL

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Selection Criteria

CAUTION:

All plans and specifications must be prepared and reviewed by a structural engineer or an appropriate professional experienced in structural concrete repairs

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Questions ?
The more knowledge we share , the more we grow