



CONCRETE REPAIR GUIDE

for Concrete Bridge Components

MINISTRY OF FORESTS, LANDS & NATURAL RESOURCE OPERATIONS

JULY 1ST, 2017



TABLE OF CONTENTS

Table of Contents	II
Table of Figures	III
1.0 Purpose.....	1
2.0 Repair Prescription.....	2
Initial Inspection.....	2
Work Site Preparation.....	3
Surface Preparation	4
Damaged Concrete Removal	4
Reinforcing Steel Repair and Rust Removal.....	6
Formwork Preparation	7
Bonding Agent Application	8
Grout Patch Placement	9
Cold Weather Grout Procedures.....	12
Hot Weather Grout Procedures	13
Finishing Work.....	14
Ballast Wall Gap	14
3.0 Site Management	15
Traffic Control.....	15
Documentation	15
4.0 Resources	16

TABLE OF FIGURES

Figure 1: Ministry Standard 2” test cylinders.	2
Figure 2: Example of a collection system for containing debris and waste for the work site. This could be improved by using a larger tarp to better ensure all debris is captured.....	3
Figure 3: Site preparation in progress – removal of damaged concrete on top of ballast wall and end deck panel. Note saw cut square edges.	4
Figure 4: Mechanical removal of damaged concrete with a chipping hammer.....	4
Figure 5: Ready for formwork. Exposed rebar after damaged concrete removal; note saw cut square edges.....	4
Figure 6: Wire Brushes. Left to right: a) Knotted b) Partial-knotted c) Crimped	6
Figure 7: Formwork placed, subsequent to removal of damaged concrete, to contain grout for ballast wall and deck panel repair.	7
Figure 8: Formwork on underside of deck panel removed showing grout patch inadequately tamped along the edge of the formwork; see Figure 7 for additional repair.....	11
Figure 9: Makeshift tent used with a Tiger Torch to provide heat in cold temperatures to improve grout curing conditions for the repair site. This method is known as `hoarding`.....	12
Figure 10: Example of damp burlap sacks being used to keep grout sample cylinders cool and moist.....	13
Figure 11: Additional grout patch being placed into bottom of a deck panel, adjacent to a ballast wall, to fill voids from initial unconsolidated repair work to obtain original deck dimensions.....	14
Figure 12: Paraseal sealant placed at gap between ballast wall and concrete deck subsequent to concrete repair works.	14

AUTHORS

Beatrice Collier-Pandya
Jacqueline Pigeon
Daniel Chadwick
George Hill

EDITOR

George Hill

PUBLICATION

Ministry of Forests, Lands and Natural Resource Operations © 2017
Timber Operations, Pricing and First Nations Division, Engineering Branch
Chief Engineering Group
July 1st, 2017

1.0 PURPOSE

This document provides a general procedure for concrete bridge component repair as a guideline for Professional Engineers prescribing repair works and workers performing repairs to Ministry concrete bridge components. This document describes recommended procedures and materials.

For all ministry bridges with concrete damage, a professional engineer shall provide a repair prescription including procedures. The Professional Engineer overseeing site repairs is responsible for quality control and for the Ministry's Quality Assurance Program for all aspects of the concreting operations, including the sampling and testing of grout or concrete and constituent materials; the methods for producing and handling the constituent materials; the batching, mixing, handling, transporting, placing, consolidating, finishing, curing of grout or concrete; and, all necessary quality control and verification testing of the fresh and hardened grout or concrete.

Professional Engineers prescribing repairs may reference this document and supplement their repair directions based on site-specific conditions of the damages to be addressed. Repairs specified, should include addressing all delaminated, deteriorated, contaminated and unsound concrete.

Procedures provided here are intended to address relatively minor damages, where primary structural concrete elements have sustained peripheral damage, which would not cause imminent structural failure of the bridge. Examples of minor damages include bridge barrier connections and ballast wall damages. More significant repairs are those where primary structural components have been damaged and where there is a concern for structural capacity of the bridge. Examples would include severe damage to a concrete girder or deck panel directly impacting capacity of a bridge. Such damage will require more significant evaluation and a refined Professional Engineer prescription, which may draw on the content of this document to address.

NOTES:

This procedure references specific products. Target Traffic Patch grout is specified for its high strength, fast set characteristics. Alternate equivalents may be used as pre-approved by the Professional Engineer responsible for overseeing repairs.

These procedures do not prescribe sandblasting to clean the damaged area.

Safe work practices are expected to be implemented including, but not limited to, traffic control and safety equipment/gear. Appropriate practices shall be implemented, such as suitable measures to capture and contain debris and grout, to minimize impacts to the environment.

2.0 REPAIR PRESCRIPTION

INITIAL INSPECTION

The Professional Engineer responsible for overseeing site repairs shall carry out a detailed inspection of the deck surface for patch material, delaminated, deteriorated and contaminated concrete. This may include surveying, sounding or the use of a chain drag (or approved alternate method) to identify areas of delaminated and deteriorated concrete.

The affected site is to be marked by the Professional Engineer before workers are to begin repair works.

The Engineer should provide site-specific written instructions for the repairs including specifications for procedures and materials.

Concrete areas to be repaired shall include all identified areas of delaminated, deteriorated, contaminated and unsound concrete.

Depending on the nature and significance of the repairs, the Engineer may specify taking of grout samples during the repair works to test and confirm for adequate compressive strength prior to placing the repaired components into service.



Figure 1: Ministry Standard 2” test cylinders.

WORK SITE PREPARATION

The site-specific repair procedure must incorporate suitable collection systems that will capture and minimize debris escape and any potential damage/contamination of the surrounding environment during repairs. Systems may include laying or hanging geotextile, placing a debris collection box below the repair area, or, creating barriers to contain debris around the work site.

A preliminary site cleanup shall be undertaken to remove any dirt, dust, organic debris, ponded water, on top of or around the areas to be repaired, that may negatively impact the environment or impede repairs.



Figure 2: Example of a collection system for containing debris and waste for the work site. This could be improved by using a larger tarp to better ensure all debris is captured.

NOTES ON PRESSURE WASHING

The use of any tools or pressure washing techniques will discontinue if the Engineer deems them to be causing damage to the host concrete, reinforcing steel, or any other part of the structure or the environment.

Pressure washing shall always travel away from the repair site and be captured by a collection system for keeping all waste material away from the equipment, preventing the waste material from re-hydrating on the previously cleaned surface, and, for disposal in accordance with all applicable environmental regulations. See Figure 2 as an example.

NOTES ON COMPRESSED AIR

If compressed air blasting is employed, proper line filters and dryers, which remove all oil and water from the air, shall be used. Compressed air shall be periodically tested for presence of these contaminants. A suitable protection system must be employed to contain debris moved as a result of using compressed air.

SURFACE PREPARATION

DAMAGED CONCRETE REMOVAL



Figure 3: Site preparation in progress – removal of damaged concrete on top of ballast wall and end deck panel. Note saw cut square edges.



Figure 4: Mechanical removal of damaged concrete with a chipping hammer



Figure 5: Ready for formwork. Exposed rebar after damaged concrete removal; note saw cut square edges.

Surface preparation is essential to successful repairs. Areas of patch material, delaminated, deteriorated, contaminated and unsound concrete shall be removed to sound concrete, creating a clean, solid surface for grout to adhere.

The removal of unacceptable concrete for repair shall be completed by mechanical and hydraulic methods.

STEP 1: CLEAN WORK AREA

- » If repair is against the ballast wall, remove dirt from the top of the ballast wall, exposing concrete (Figure 3) before beginning the mechanical repair.
- » Remove loose material and loose concrete using a pressure washer. If a pressure washer is not available, using water and brushes or compressed air may also be appropriate. See Notes on Pressure Washing and Notes on Compressed Air on page 3 for further details with these two methods.

STEP 2: CUT REPAIR AREA BOUNDARY

- » Mark out the repair boundaries and saw cut along the edge to create “clean” edges with a slight ~15 degree angle undercut (to help with retention) at a minimum of 12mm deep to the original surface (Figure 5). Take care not to damage existing reinforcing steel and rebar that may be within the boundary.

STEP 3: CHIP AWAY CONCRETE WITHIN REPAIR AREA

- » Remove damaged and loose concrete within the repair boundaries using a chipping hammer while maintaining square edges (Figure 4). Feathered repair edges are to be avoided as they increase susceptibility to subsequent damage.
- » If the open repair area extends more than 100mm under the deck, it is suggested that more chipping occurs to create more working room to allow for easier placement of the repair materials.
- » If rebar parallel to the prepared repair face is exposed, these bars must be fully exposed to allow for adequate surface bonding of the repair grout (minimum 25 mm cover).

REINFORCING STEEL REPAIR AND RUST REMOVAL

Reinforcing steel in the area of repair should be assessed for damage.

DAMAGED REBAR REPAIR

If existing rebar is observed to be bent, damaged or broken causing structural weakness, the Professional Engineer shall provide a specific prescription based on the extent of the damage.

NOTE ON REPAIR AUTHORIZATION

Rebar is not to be bent or manipulated, spliced or replaced without the direction of the Professional Engineer.

RUST REMOVAL

Reinforcing steel rust and corrosion can negatively impact the longevity of repairs. Excessive rust should be dealt with as part of the repair and the following recommendations considered:

- » Concrete and rust on exposed rebar is to be removed to minimize the risk of future corrosion and to increase bond strength with the grout.
- » Remove as much surface rust as possible using a drill mounted hand-held steel wire brush wheel.
- » If the rebar is more than 20% corroded an engineer must determine the requirement for new rebar to be potential spliced in.

Knotted (Figure 6a) or partial-knotted (Figure 6b) wire brushes are recommended for heavy rust removal. A crimped-wire brush (Figure 6c) may be used for moderate to low rust removal.



Figure 6: Wire Brushes. Left to right: a) Knotted b) Partial-knotted c) Crimped

FORMWORK PREPARATION

Once damaged concrete has been removed and reinforcing steel cleaned and treated, formwork can be installed to form the facings for the repair.

STEP 1: CLEAN WORK AREA

Prior to placing of formwork and grout, all sound concrete surfaces at or around the repair shall be cleaned to remove loose materials, dust, slurry, oil, and other contaminants detrimental to the bond, host concrete and grout. This can be accomplished through a number of possible methods:

- » brush with water
- » power washer
- » compressed air

See Notes on Pressure Washing and Notes on Compressed Air on page 3 for further details with these two methods.

STEP 2: PLACE FORMWORK

Place formwork (typically plywood) onto the repair area ensuring the dimensions of the concrete element being repaired are maintained (Figure 7).

NOTES ON FORMWORK TEMPERATURE

When temperatures exceed 25°C, saturate the forms in addition to saturating the surface of concrete. Allow the concrete to reach the surface dry condition. By saturating the form the concrete is prevented from drying too quickly which in turn can result in the concrete cracking.



*Figure 7:
Formwork placed,
subsequent to
removal of
damaged concrete,
to contain grout for
ballast wall and
deck panel repair.*

BONDING AGENT APPLICATION

Prior to placing the grout patch, a bonding agent should be applied to improve bond quality between the concrete and grout surfaces.

CAUTIONARY NOTES

Do not use bonding agent with set accelerated mortars

» E.g. **SikaTop 123 PLUS Winter Grade**.

Do not allow bonding agents to freeze.

Do not apply bonding agents in temperatures below 4°C.

Do not thin bonding agents with solvents.

Prepare the bonding agent in accordance with manufacturer specifications.

Good adhesion can be obtained without a bonding agent; however the bond strength will be weaker than when a bonding agent is used.

ACCEPTABLE PRODUCTS

MOTI APPROVED PRODUCTS

The Ministry of Transportation and Infrastructure lists manufactures of concrete admixtures as submitting independent ASTM testing results meeting ASTM test requirements. These may be used in concrete mix designs in complying with Ministry Specifications. For further information see the most up to date

[Recognized Products List](#).

EPoxy BONDING AGENT	ASTM C881	MOTI CODE	LINK
Sikadur 32 Hi-Mod Epoxy Bonding	I-II-V/B-C/2	(Code 081)	(Spec Sheet)
BASF MasterEmaco ADH 1090 RS	I-II/B-C/2	(Code 438)	(Spec Sheet)

LATEX BONDING AGENT	TYPE	MOTI CODE	LINK
Target Polymer	PVAn	(Code 935)	(Spec Sheet)
Starpatch Acrylic 900X	Acrylic	(Code 301)	(Spec Sheet)
Dayton Superior Acrylic J40	Acrylic	(Code 578)	(Spec Sheet)

The ASTM C881 code listed above is formatted as Type/Class/Grade. PVAn is short for Polyvinyl Acetate Latex (non-re-emulsifiable). For further details on selecting a Bonding Agent, read Noel P. Mailvaganam’s “Effective Use of Bonding Agents” published in 2011 by the Institute for Research in Construction ([direct link](#)).

OTHER PRODUCTS

Other products may be used with the consent of the engineer:

» **SikaTop Armatem 110 EpoCem** [\(Spec Sheet\)](#)

TYPICAL BONDING AGENT APPLICATION PROCEDURE

The manufacture’s specifications should always be considered for preparing and applying a bonding agent. Revisions to the manufacture’s specifications shall not be permitted without the explicit consent of the engineer. The following list shows the procedure of a typical bonding agent for reference only:

- » Substrate must be clean and sound. It may be dry or damp, but it should be free of standing water.
- » Pre-stir each component and proportion equal parts by volume of component A and B into a clean pail. Mix thoroughly for 3 minutes with a paddle at low speed until blend is a uniform colour.
- » Apply by brush, broom, roller or spray. Pay close attention to working time and ensure to place while the bonding agent is tacky. If the product becomes glossy and loses tackiness, remove any surface contaminants and recoat with a new mix.

GROUT PATCH PLACEMENT

STEP 1: GROUT SELECTION

Select the appropriate grout, or another approved equivalent. The table below shows three possible grouts that could be used. These are just three of the many acceptable grouts listed in the [MOTI recognized products list](#).

Product	Code [†]	Working Time	Recommended Bonding Agent	Limitations
Target Traffic Patch Coarse <i>(Spec Sheet)</i>	705 (pg. 70)	20 min.	Target Polymer Bonding Agent	For use on areas greater than 25mm (1 inch) thick
Target Traffic Patch Fine <i>(Spec Sheet)</i>	706 (pg. 70)			For use on areas less than 25mm (1 inch) thick
SikaTop 123 PLUS <i>(Spec Sheet)</i>	1133 (pg. 70)	15 min.	Sika Armatec 110 EpoCem	For overhead applications. 1/8 inch minimum thickness, 1½ inch maximum thickness.
Target V/O Repair Mortar <i>(Spec Sheet)</i>	#N/A	15-20 min.	None	For vertical and overhead surfaces. Do not add more water than recommended.

[†] BC.MOTI Recognized Product List Code

GROUT EXPIRATION

Grout greater than 6 months past the manufacture date shall not be used.

STEP 2: GROUT MIXING

Mix the grout following manufacturer's specifications. Saturate the repair area with water and then allow the concrete to come to a surface dry condition just before placing the grout. If using a bonding agent, bring the repair area to a surface dry condition before applying the bonding agent and immediately apply the grout on top of the bonding agents.

For Target Traffic Patch:

- » DO NOT exceed 3.3 liters (3.5 US quarts) of liquid per 25 kg (55 lb) of fine mix, or 3.0 liters (3.2 US quarts) per 25 kg (55 lb) of coarse mix.
- » Water and mix temperatures, and the temperature of the surface to which the mix is to be applied, should be not less than 3°C (37°F) and not more than 30°C (86°F).
- » Material should be mixed until thoroughly blended and the required consistency has been obtained. Grout should be mixed using a high-torque drill equipped with a mixing paddle at **low speeds**.

Grout must be properly handled, stored and mixed as provided for in the manufacturer's specifications. Workers shall record the method used for mixing the grout.

STEP 3: GROUT PLACEMENT

Place the mixed material as rapidly as possible and consolidate well to eliminate voids. Work the mix into the prepared concrete surface to ensure bonding over the full area and complete coverage.

- » If the material begins to thicken or set before placing, discard the remaining material, do not add more water.
- » Tamping and rodding is preferred over using a vibrator as vibrating can cause separation of the grout.
- » It is preferable to observe the grout to just begin to bleed out the edges of the formwork than to be unsure if grout has reached the formwork edges (Figure 8).

NOTE ON GROUT BLEEDING

If you are grout bleeding, exercise caution to ensure the formwork does not drastically separate at the joints. Relief holes may be drilled to ensure the formwork remains to the original dimensions and joints remain intact.



Figure 8: Formwork on underside of deck panel removed showing grout patch inadequately tamped along the edge of the formwork; see Figure 7 for additional repair.

STEP 4: FINISHING

Once the grout has partially set, complete the surface finish using any conventional finishing technique (broom or trowel) to match the existing finish.

For all temperatures, allow for a minimum of 24 hours for the grout to set and attain or exceed a compressive strength of 25 MPa. The Professional Engineer responsible for the repair should provide an indication when and/or provide additional measures to protect the repair sites for placing the bridge back into service.

Based on anticipated ambient temperature during the day of the repair, as well as 24 hours prior to the repair, cold and hot weather practices may be required as specified by the Professional Engineer responsible for prescribing the repairs.

COLD WEATHER GROUT PROCEDURES

When temperatures are below or anticipated to potentially drop below 5°C, cold weather procedures should be implemented. The heat of hydration of most grouts is not sufficient to keep itself from freezing in sub-zero temperatures particularly if the concrete deck panels or slabs are cold to start.

- » Ensure grout is protected from freezing and maintain curing conditions to ensure sufficient strength and durability
- » The components' temperature should be kept above freezing for a minimum of 24 hours subsequent to grout placement.
- » Pre-warm the dry mix grout and components being grouted to above 10°C. If the grout is not preheated, it will dramatically reduce the temperature of the heated water when mixed.
- » Use warm water (20°C) in mixing the grout.
- » The temperature during the initial 24 hours of cure time should be maintained above 10°C by wrapping the structure in tarps and heating from beneath the structure using suitable heat sources. Ensure heat source is directed away from any components or flammable elements. Various types of tarps and covers have been used including plastic sheeting, construction tarps, lumber wrap and non-woven geotextile. The wrapping would encapsulate the repair area and drape below the bridge to capture the rising heat (Figure 11).
- » Provide sufficient labour to minimize the time required to place and finish the grouting process, to minimize the handling time of the grout and resulting heat loss.



Figure 9: Makeshift tent used with a Tiger Torch to provide heat in cold temperatures to improve grout curing conditions for the repair site. This method is known as 'hoarding'.

HOT WEATHER GROUT PROCEDURES

Hot weather practices should be followed for temperatures above 25°C. High temperatures cause water to evaporate from the surface of the grout at a much faster rate, causing grout to stiffen more quickly thereby increasing the chances of cracking and the likelihood for a reduced final strength.

- » Store the grout in a cool dry location prior to mixing.
- » Use ice water when mixing. Ice should be shaved or crushed and is to be completely melted before mixing to ensure the proper volume is measured.
- » Mix grout in conformance with the manufacturers specifications.
- » Ensure there is enough labour in order to minimize the time required to place and complete the grouting process.
- » Prior to placing grout, moisten the repair area and the formwork.
- » Place damp burlap bags over and cover the repair area with plastic sheeting to keep the placed grout moist (Figure 10). During the initial cure time, periodically re-wet the burlap (re-wet more frequently with higher ambient temperatures).
- » In extreme heat, consider completing the repair in the early morning or evening when ambient temperatures are cooler.



Figure 10: Example of damp burlap sacks being used to keep grout sample cylinders cool and moist.

FINISHING WORK

The Professional Engineer responsible for overseeing the repairs will provide guidance on whether grout samples are to be taken during the repair procedures for the purposes of testing prior to approving the repaired areas for traffic. Where grout samples are taken, refer to the MFR [MRT Bridge Field Grouting Sampling Procedure](#).

- » Remove formwork once set. Ensure panel dimensions are as per drawing. Detail as required.
- » When formwork is removed, re-grout any areas of honey combing that did not form to the mold (Figure 11).



Figure 11: Additional grout patch being placed into bottom of a deck panel, adjacent to a ballast wall, to fill voids from initial unconsolidated repair work to obtain original deck dimensions

BALLAST WALL GAP

If the repair is beside the ballast wall, place foam at the bottom of the gap between the ballast wall and deck panel and place Paraseal level with the top of deck panel and ballast wall (Figure 12)



Figure 12: Paraseal sealant placed at gap between ballast wall and concrete deck subsequent to concrete repair works.

3.0 SITE MANAGEMENT

TRAFFIC CONTROL

When a repair is being completed, traffic control must be considered. The following list shows instructions for traffic control:

- » Ensure appropriate measures given the level of traffic to provide adequate warning and control for approaching vehicles to ensure the safety of personnel working on the repair.
- » If repair work allows for traffic to continue travelling over deck, mark off new grout with cones or other approved barriers.
- » If repair work has been completed on the deck beside the ballast wall, create a temporary ramp with plywood to allow light traffic to continue travelling over the bridge.
- » If repair work is large and traffic cannot be diverted around it, cease all traffic flow for a minimum of 24 hours or until compressive strength reaches 25MPa. If possible, provide an alternative route (place detour signs).

DOCUMENTATION

The Professional Engineer responsible for overseeing the repairs will produce appropriate documentation prescribing the repairs and a statement of construction conformance that the repairs were completed consistent with the prescription. Relevant documents shall be placed on the appropriate bridge records.

4.0 RESOURCES

The following links are listed in the order they appeared in the document. All links are current as of this documents publication date.

[MOTI Recognized Products List](http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/recognized-products-list/recognized_products_list.pdf)

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/recognized-products-list/recognized_products_list.pdf

[Target Polymer Bonding Agent Spec Sheet](http://www.targetproducts.com/UserContent/SpecSheets/polymer.pdf)

<http://www.targetproducts.com/UserContent/SpecSheets/polymer.pdf>

[Sikadur 32 Hi-Mod Spec Sheet](https://can.sika.com/dms/getdocument.get/cd5fe4e0-8856-316b-ad15-977759759c48/Sikadur32HiMod_pds.pdf)

https://can.sika.com/dms/getdocument.get/cd5fe4e0-8856-316b-ad15-977759759c48/Sikadur32HiMod_pds.pdf

[BASF MasterEmaco ADH 1090 RS Spec Sheet](https://assets.master-builders-solutions.basf.com/Shared%20Documents/EB%20Construction%20Chemicals%20-%20US/Construction%20Systems/Data%20Guides/MasterEmaco/basf-masteremaco-adh-1090-rs-tds.pdf)

<https://assets.master-builders-solutions.basf.com/Shared%20Documents/EB%20Construction%20Chemicals%20-%20US/Construction%20Systems/Data%20Guides/MasterEmaco/basf-masteremaco-adh-1090-rs-tds.pdf>

[Starpatch Acrylic 900X Spec Sheet](http://www.starpatchconcrete.com/dat/files/27_specSheet_PDS Bonding 900X.pdf)

http://www.starpatchconcrete.com/dat/files/27_specSheet_PDS Bonding 900X.pdf

[Dayton Superior Acrylic Bonding Agent J40 Spec Sheet](http://daytonsuperior.com/docs/default-source/tech-data-sheets/acrylic_bonding_agent_j40.pdf?sfvrsn=16)

http://daytonsuperior.com/docs/default-source/tech-data-sheets/acrylic_bonding_agent_j40.pdf?sfvrsn=16

[SikaTop Armatec 110 EpoCem Spec Sheet](https://can.sika.com/dms/getdocument.get/67a7d195-812d-36d1-b718-884a31c8e76d/SikaTopArmatec110EpoCem_pds.pdf)

https://can.sika.com/dms/getdocument.get/67a7d195-812d-36d1-b718-884a31c8e76d/SikaTopArmatec110EpoCem_pds.pdf

[Target Traffic Patch Coarse Spec Sheet](http://www.targetproducts.com/UserContent/SpecSheets/trafficpatch.pdf)

<http://www.targetproducts.com/UserContent/SpecSheets/trafficpatch.pdf>

[Target Traffic Patch Fine Spec Sheet](http://www.targetproducts.com/UserContent/SpecSheets/trafficpatch.pdf)

<http://www.targetproducts.com/UserContent/SpecSheets/trafficpatch.pdf>

[SikaTop 123 Plus Spec Sheet](https://can.sika.com/dms/getdocument.get/78030fdd-b7f1-3858-8f62-cc7f46df60e2/SikaTop123plus_pds.pdf)

https://can.sika.com/dms/getdocument.get/78030fdd-b7f1-3858-8f62-cc7f46df60e2/SikaTop123plus_pds.pdf

[Target Vertical Overhead \(V/O\) Structural Repair Mortar](http://www.targetproducts.com/UserContent/SpecSheets/VerticalOHRRepairMortar.pdf)

<http://www.targetproducts.com/UserContent/SpecSheets/VerticalOHRRepairMortar.pdf>

[“Effective Use of Bonding Agents” Noel P. Mailvaganam](https://www.nrc-cnrc.gc.ca/ctu-sc/files/doc/ctu-sc/ctu-n11_eng.pdf)

https://www.nrc-cnrc.gc.ca/ctu-sc/files/doc/ctu-sc/ctu-n11_eng.pdf

[2016 Standard Specifications for Highway Construction Volume 1](http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-specifications/volume_1_ss2016.pdf)

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-specifications/volume_1_ss2016.pdf

[2016 Standard Specifications for Highway Construction Volume 2](http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-specifications/volume_2_ss2016.pdf)

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/highway-specifications/volume_2_ss2016.pdf

[MRT Bridge Field Grouting Sampling Procedure.](http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/resource-roads/groutsampleproceduresec2016.pdf)

<http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/resource-roads/groutsampleproceduresec2016.pdf>