

Material Testing Specification for Concrete Patching Materials

Government of Alberta

Transportation and Economic Corridors – Technical Standards Branch

B391 – September 1, 2023

Scope: This specification contains approval procedures and requirements necessary for qualifying products for use as concrete patching materials for bridge structures.

1. General

1.1. Introduction

Patching materials are used to repair areas damaged by impact or deterioration. The patch must withstand freeze-thaw cycles, exposure to de-icing salts, extreme temperatures, rapid temperature changes, dynamic and static stresses related to structural conditions and abrasion from traffic and impact loading.

This specification covers the supply of packaged, dry cementitious mortar or concrete materials for the repair of concrete structures. All materials and aggregates must be included as a component of the packaged product and only the mixing liquid and if applicable extension aggregates, as specified by the manufacturer, are to be added in the field. The current edition of all reference documents shall be applied at the time of testing.

1.2. Classification of Patching Materials

Repair location, weather conditions (at the time of placement), and traffic considerations will dictate the type of patching material to be selected. Alberta Transportation classifies concrete patching materials into 5 types as follows:

- (a) **Type NH** - Normal horizontal patches are used to repair areas such as bridge deck potholes or curb top spalls. These products are generally used during the summer when good weather conditions prevail. Traffic shall resume or an overlay shall be placed after approximately three days of curing. The product shall be poured and must be workable to allow for proper finishing and grading.
- (b) **Type OH-V** - Overhead or vertical patches are used to repair areas such as high load damage to precast girders, spalling on the underside of bridge decks, inside face of curbs, pier caps and abutment seats and backwalls. These products are generally used during the summer when good weather conditions prevail. Patching material shall be of a consistency to be applied by troweling rather than pouring.
- (c) **Type LTH** - Low temperature horizontal patches are used to repair areas similar to those described in NH when the ambient temperature is in the range of 0 to 5°C and rising, and generally during the spring and late fall. The product shall be poured and must be workable to allow for proper finishing.
- (d) **Type HEH** - High early horizontal patches are used to repair areas similar to those described in NH. These products are generally used during the summer when good weather conditions prevail and a high early strength is required in order that traffic may be allowed to resume. The product must be poured and workable to allow proper finishing.
- (e) **Type FP** – Form and Pour or Form and Pump patches are used to repair areas similar to those described in OH-V. In addition, it could also be used on vertical surfaces such as walls, columns, and beam sides and bottoms. FP patching materials have high self-compacting properties, high viscosity and low yield, and faster strength development rate which helps restore structural integrity and concrete cover requirement for the damaged element.

2. Approval Procedure

2.1. Arrangements for Testing

The Supplier/Manufacturer shall have their product tested for approval according to the procedures as outlined in this specification. Once reviewed and approved, the product will be included on the Department's Product List.

The tests shall be carried out by an independent laboratory certified to CSA A283 or AASHTO R18 with accompanying accreditation from the Cement and Concrete Reference Laboratory (CCRL) at the supplier's or manufacturer's expense

2.2. Submission Requirements

At minimum, submissions shall contain the following:

- Product name
- Date of manufacturing and product batch/lot number
- Shelf life
- Product bulletins (if available)
- Technical product data sheet (including product description, recommended applications, installation and working temperatures, advantages, limitations, etc.)
- Comprehensive mixing and installation instructions (including requirements for surface preparation, mixing, application, finishing, curing, clean-up, limitations, etc.)
- Material safety data sheet
- Aggregate size
- Quality control test reports (including materials extended with aggregate or extension aggregates used for qualification testing);
- Photographs of packaging and required expiry date markings
- Laboratory test report including all required individual qualifying test results.
- List of Alberta region suppliers

Submissions shall be forwarded by the Supplier/Manufacturer to:

Alberta Transportation
Technical Standards Branch
2nd Floor, Twin Atria Building
4999 - 98 Avenue N.W.
Edmonton, Alberta, T6B 2X3

Attention: Landon Keep, P.Eng.
Bridge Materials Engineer
landon.keep@gov.ab.ca
780-415-1032

Test results will become the property of the Department. The Department reserves the right to publish the test information for public use. Results of testing may be submitted at any time provided all the requirements are met. The Department will update the approval list after a review has been undertaken to ensure that all requirements are satisfied.

2.3. Evaluation

Qualifying test results will be evaluated as per the rating scales shown in Section 3. The individual ratings will be averaged. If the product can be extended with aggregates an additional set of compressive strength tests shall be included in the average score calculation. To be considered for approval, a product must have an average rating of 6.0 or greater with no individual rating being less than 4.0 and only one can be equal to 4.0. The rating difference between individual specimens shall not vary by more than an increment of 1.0 when rated using the scales shown in Section 3.

Patching material must also meet the requirements of Sections 4 & 5.

3. Testing Requirements

3.1. Sample Mixing, Casting, Demolding and Curing

The sample size of each product submitted for testing shall be large enough to allow all specimens to be cast from the same batch. The specimens shall be prepared, mixed, placed and cured according to Manufacturer's directions and the requirements of this specification.

All test specimens shall be prepared using the highest water-to-solids ratio, maximum flow, or most fluid consistency stated on the packaging; and shall remain in the mixing apparatus for the maximum usable working time or pot life specified by the manufacture. The use of accelerators will not be permitted.

3.1.1. Curing and Demolding Instructions

Unless otherwise specified, cure and demold the specimens according to the following instructions until the required testing is to be completed:

- Normal-setting non-polymer-modified materials:
 - Cure in moist cabinet or room at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ Relative Humidity (RH)
 - Remove specimens from the molds at 23 ± 0.5 hours
 - Implement and maintain a wet cure at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $100\% \pm 4\%$ RH until the specimen is 7 days old
 - After 7 days, maintain the specimen at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and RH of $50\% \pm 4\%$ until the remaining tests are conducted
- Normal-setting polymer-modified materials:
 - Specimens shall be covered with polyethylene film (at least 0.1 mm thick) and then stored at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ RH, per ASTM C1439.
 - Remove specimens from the molds at 23 ± 0.5 hours.
 - Implement and maintain a wet cure at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $100\% \pm 4\%$ RH until the specimen is 7 days old
 - After 7 days, maintain the specimen at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and RH of $50\% \pm 4\%$ until the remaining tests are conducted
- Rapid-hardening non-polymer-modified materials*:
 - Cure in moist cabinet or room at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ RH.
 - Remove specimens from molds at 2 ± 0.25 hours after final set.
 - Maintain the specimen at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ RH until the remaining tests are conducted.
- Rapid-hardening polymer-modified materials*:
 - Specimens shall be covered with polyethylene film (at least 0.1 mm thick) and then stored at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ RH, per ASTM C1439.
 - Remove specimens from the molds at 2 ± 0.25 hours after final set.
 - Maintain the specimen at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $50\% \pm 4\%$ RH until the remaining tests are conducted.

* *Rapid-hardening materials are defined as those materials complying with the compressive strength requirements as described in Table 1 of ASTM C928/C928M or materials whose primary binder is in compliance with ASTM C1600/C1600M.*

3.1.2. Curing and Mixing Instructions (LTH Classification)

Mixing liquid and dry LTH packaged material used to make specimens shall be stored at a temperature of 3°C and the tests started only when the mixing liquid and material has achieved a uniform temperature of 3°C throughout. LTH specimens shall be cured at 3°C for the first 24 hours.

3.2. Compressive Strength

Compressive strength testing shall be completed and reported at the following times:

- Type NH, OH-V, and FP: 1, 3, 7, and 28 days after batching
- Type HEH and LTH: 3 hr and 1, 3, 7, and 28 days after batching

Compressive strength testing shall be completed in accordance with CAN/CSA A3004-C2 or ASTM C109 for specimens without coarse aggregate. Compressive strength testing of specimens extended with coarse aggregate shall be tested according to CAN/CSA A23.2-9C or ASTM C39/39M.

Products that can be extended with aggregate (sized 6 to 13 mm in diameter) shall be tested both with and without coarse aggregates for a total of two sets of complete batching, sampling, and testing for compressive strength. The aggregate extension shall be in accordance with the Manufacturer's specifications. Where multiple aggregate extension options are specified, the option resulting in maximum yield shall be used as the coarse aggregate sample. Specifications indicating quality control testing requirements for the extension aggregate must be clearly identified on the product data sheet. Extension aggregates shall meet the requirements of CSA 23.1 or ASTM C33 and be supplied by the supplier/manufacturer to the testing laboratory.

3.2.1. Compressive Strength Rating Scale for Product Classification NH, OH-V and FP (not extended with aggregates)

The following table shows the rating scale for NH, OH-V and FP specimens at 28 days old.

TABLE 1: COMPRESSIVE STRENGTH RATING SCALE FOR TYPE NH, OH-V & FP

Rating	Compressive Strength Range (MPa)
1	< 34.0
2	34.0 to 37.9 or > 84.0
3	38.0 to 39.9 or 80.0 to 83.9
4	38.0 to 39.9 or 80.0 to 83.9
5	40.0 to 41.9 or 76.0 to 79.9
6	42.0 to 43.9 or 72.0 to 75.9
7	44.0 to 45.9 or 68.0 to 71.9
8	46.0 to 47.9 or 64.0 to 67.9
9	48.0 to 49.9 or 60.0 to 63.9
10	50.0 to 59.9

3.2.2. Compressive Strength Rating Scale for Product Classification LTH and HEH (not extended with aggregates)

The following table shows the rating scale for LTH specimens at 24 hours old and HEH specimens at 3 hours old.

TABLE 2: COMPRESSIVE STRENGTH RATING SCALE FOR TYPE LTH (24 HOURS OLD) AND HEH (3 HOURS OLD)

Rating	Compressive Strength Range (MPa)
1	< 14.0
2	14.0 to 15.9
3	16.0 to 17.9
4	18.0 to 19.9
5	20.0 to 21.9
6	22.0 to 23.9
7	24.0 to 25.9
8	26.0 to 27.9
9	28.0 to 29.9
10	> 30.0

3.2.3. Compressive Strength Rating Scale for Product Classification NH, FP, HEH and LTH (extended with aggregates)

The following table shows the rating scale for NH and FP specimens at 28 days old, LTH specimens at 24 hours old, and HEH specimens at 3 hours old that have been extended with aggregate.

TABLE 3: COMPRESSIVE STRENGTH RATING SCALE FOR TYPE NH & FP (28 DAYS OLD), LTH (24 HOURS OLD), AND HEH (3 HOURS OLD) EXTENDED WITH AGGREGATE

Rating	Compressive Strength Range (MPa)
1	< 17.0
2	17.0 to 18.9
3	19.0 to 20.9 or > 70.0
4	21.0 to 22.9 or 66.0 to 69.9
5	23.0 to 24.9 or 62.0 to 65.9
6	25.0 to 26.9 or 58.0 to 61.9
7	27.0 to 28.9 or 54.0 to 57.9
8	29.0 to 30.9 or 50.0 to 53.9
9	31.0 to 33.9 or 46.0 to 49.9
10	33.0 to 45.9

3.3. Direct Tensile Bond Strength

Tensile bond strength shall be carried out as per ASTM C1583, Standard Test Method for Tensile Strength of Concrete Surfaces & the Bond Strength or Tensile Strength of Concrete Repair & Overlay Materials by Direct Tension.

Use an existing concrete substrate of 27.6 to 34.7MPa compressive strength and prepare in accordance with the product manufacturer's surface preparation requirements for the patching material being tested. The minimum concrete surface profile shall be as per the product Manufacturer recommendation. In the absence of a product manufacturer recommendation, the surface shall meet Concrete Surface Profile (CSP) 3, as defined by the International Concrete Repair Institute (ICRI).

The patching material thickness used in the test shall be at the mid-point of recommended thickness range stated on the product data sheet. Thus, the specimens for this test shall only be extended with aggregate if required to achieve the mid-point thickness. The dimensions shall be measured and reported to the nearest 0.5 mm. The extension of any aggregate (if required) should also be clearly reported.

Specimens shall be cured and demolded in accordance with Section 3.1.1 herein. The mixing liquid and dry packaged LTH material shall be stored at a temperature of 3°C and maintained at a uniform temperature of 3°C prior to and during the forming of the specimens. LTH products shall be cured at 3°C for the first 24 hours.

The curing regimen used, age of each specimen, failure mode and average bond strength shall be reported.

3.3.1. Tensile Bond Strength Rating Scale for Product Classification NH, OH-V & FP

The following table shows the rating scale for Type NH, OH-V, and FP specimens 28 days old.

TABLE 4: TENSILE BOND STRENGTH RATING SCALE FOR TYPE NH, OH-V, AND FP (28 DAYS OLD)

Rating	Tensile Bond Strength Range (MPa)
1	< 0.87
2	0.88 to 1.28
3	1.29 to 1.69
4	1.71 to 2.11
5	2.12 to 2.52
6	2.53 to 2.93

7	2.94 to 3.34
8	3.35 to 3.75
9	3.76 to 4.16
10	> 4.16

3.3.2. Tensile Bond Strength Rating Scale for Product Classification LTH & HEH

The following table shows the rating scale for Type LTH specimens at 24 hours of age and Type HEH specimens at 3 hours of age.

TABLE 5: TENSILE BOND STRENGTH RATING SCALE FOR TYPE LTH (24 HOURS OLD) AND HEH (3 HOURS OLD)

Rating	Tensile Bond Strength Range (MPa)
1	< 0.11
2	0.12 to 0.23
3	0.24 to 0.47
4	0.48 to 1.00
5	1.01 to 1.53
6	1.54 to 2.06
7	2.07 to 2.59
8	2.60 to 3.12
9	3.13 to 3.65
10	> 3.65

3.4. Absorption After Immersion

Water absorption shall be determined as follows:

- Cast 2 specimens 150 mm x 150 mm x 50 mm for each product classification and use the average result for rating. Extend product with aggregate only if required to achieve the specified specimen dimensions.
- Cure specimens at 50% R.H. and 23°C (± 2°C) for initial 24 hours (except that LTH products shall be cured at +3°C and 50% R.H. for the first 24-hrs) and then demold. Continue curing at 50% R.H. and 23°C (± 2°C) for a total of 14 days.
- Oven dry specimens at a temperature of 100°C to 110°C for at least 24 hours and until a constant minimum weight is achieved (i.e. the difference between any two successive weights, measured at least 1 hour apart, is less than 0.5% of the lowest weight obtained).
- Allow specimens to cool naturally to a temperature of 20°C to 25°C in a desiccator. Once cooled, weigh and designate this mass as the “oven-dry” mass.
- After completely drying, cooling and determining the “oven-dry” mass, immerse the specimens to a depth of 25 mm in water that is maintained at 21°C ± 2°C for at least 48 hours and until a constant maximum weight is achieved (i.e. the difference between any two successive weights, measured at least 1 hour apart, is less than 0.5% of the largest weight obtained).
- Lightly towel to surface dry, re-weigh, and designate this mass as the saturated surface dry (SSD) mass.
- Calculate absorption percentage as the mass of water absorbed based on the relationship between the oven-dry and SSD mass:

$$\text{Absorption (\%)} = \frac{\text{SSD Mass} - \text{Oven Dry Mass}}{\text{Oven Dry Mass}} \times 100$$

3.4.1. Absorption Rating Scale for All Product Types

The following table shows the rating scale for specimens cured for 14 days.

TABLE 6: ABSORPTION AFTER IMMERSION RATING SCALE FOR ALL PRODUCT CLASSIFICATIONS

Rating	Absorption Range (%)
1	> 10.9
2	9.0 to 10.9
3	7.0 to 8.9
4	6.0 to 6.9
5	5.0 to 5.9
6	4.0 to 4.9
7	3.0 to 3.9
8	2.0 to 2.9
9	1.0 to 1.9
10	< 1.0

3.5. Linear Shrinkage and Moisture Expansion

Linear shrinkage and moisture expansion shall be carried out as per Alberta Transportation BT006, Test Procedure for Measuring Length Change of Bridge Concrete Patching Materials. Testing specimens shall be mixed without any extended aggregates.

Linear shrinkage shall be assessed as per Table 7 below and the maximum moisture expansion shall not exceed the drying shrinkage at 90 days.

3.5.1. Shrinkage Rating Scale for All Product Types

The following table is the rating scale for all specimen types at 28 days of age.

TABLE 7: LINEAR SHRINKAGE RATING SCALE FOR ALL PRODUCT CLASSIFICATIONS

Rating	Linear Shrinkage Range (%)
1	< -0.100
2	-0.060 to -0.100
3	-0.055 to -0.059
4	-0.050 to -0.054
5	-0.045 to -0.049
6	-0.040 to -0.044
7	-0.035 to -0.039
8	-0.030 to -0.034
9	-0.025 to -0.029
10	> -0.025

3.6. Salt Scaling

Salt scale shall be carried out as per ASTM C672, Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals. The following modifications to ASTM C672 shall be incorporated into the testing procedures:

- (a) Proportioning - the patching product shall be prepackaged by the supplier.
- (b) Mixing and testing - machine mix and test according to the applicable provisions of CAN/CSA 23.2-2C.
- (c) Specimen - shall have a 75 mm depth and the dike is to be placed on the under or formed side of the specimen. To ensure all form oil is removed from the formed surface, this surface shall be lightly sandblasted to remove approximately 15 grams of material. Three specimens shall be formed for testing. A brushed concrete surface finish shall be used as the test surface for all specimens.
- (d) Testing shall commence after a curing period of 14 days. For the first 7 days, the specimens shall be kept in moist storage at 100% RH and $23 \pm 2^\circ\text{C}$ (except that LTH products shall be cured at $+3^\circ\text{C}$ and 100% R.H. for the first 24 hours only). For the last 7 days, the specimens shall be kept in a controlled chamber at 50% RH and 23°C ($\pm 2^\circ\text{C}$).
- (e) Salt Solution - the de-icing salt shall consist of sodium chloride and water having a concentration such that each 100 ml of solution contains 3 grams of sodium chloride.
- (f) Mass Loss - Prior to the final visual examination and rating and after each of the 5 cycles, remove the salt solution together with all the flaked off concrete from the surface and place into a watertight container. Tilt the slab into a 500 mm diameter funnel and wash the surface of the specimen with the salt solution. The washing should continue until all loose particles are removed from the concrete. The solution shall then be strained through a filter and the residue dried out in an oven at 105°C to a constant mass. The residue shall be cumulatively weighed after each of the 5 cycles. This residue shall be defined as the loss of mass and expressed in kilograms per square meter of exposed slab area. The loss of mass shall be calculated to the nearest 0.001 kg/m^2 .
- (g) Report - measure and report cumulative weight after every 10 cycles, as kg/m^2 .

Specimens for all product types shall have the mass loss determined every 10 cycles until 50 cycles have been completed.

3.6.1. Salt Rating Scale for All Product Types

The following table shows the rating scale for specimens after 50 cycles.

TABLE 8: MASS LOSS (AFTER 50 CYCLES) RATING SCALE FOR ALL PRODUCT CLASSIFICATIONS

Rating	Mass Loss Range (kg/m^2)
1	> 1.100
2	0.875 to 1.099
3	0.675 to 0.874
4	0.500 to 0.674
5	0.350 to 0.499
6	0.225 to 0.349
7	0.150 to 0.224
8	0.125 to 0.149
9	0.100 to 0.124
10	< 0.100

After 50 cycles of testing, the visual rating of each specimen shall be less than 2 in accordance with ASTM C672.

3.7. Freezing and Thawing Resistance

Freezing and thawing resistance shall be measured in accordance with ASTM C666, Procedure A, Rapid Freezing and Thawing in Water. At 300 cycles of testing, the durability factor calculated to the nearest whole number shall be reported and shall not be less than 80DF.

The relative dynamic modulus of elasticity and length change in percent after 300 cycles of freezing and thawing shall be reported.

3.8. Chloride Resistance

Chloride resistance shall be measured and reported in accordance with ASTM C1543. Specimens shall be prepared and cured in accordance with Section 3.6 and then subjected to 90 days of ponding. Chloride content at the following depths shall not be exceeded after testing.

TABLE 9: CHLORIDE CONTENT PERCENT FOR ALL PRODUCT CLASSIFICATIONS

Sample Depth (mm)	Maximum Chloride Content (%)
13	0.420
25	0.150

3.9. Cracking Potential

Cracking potential of the product, in the neat condition (i.e. not extended with aggregates), shall be assessed in accordance with ASTM C1581

The reporting requirements of ASTM C1581 shall be summarized. The net time to crack, average stress rate, and potential for cracking category shall also be reported in accordance with ASTM C1581.

3.10. Yield and Unit Weight

Yield and unit weight shall be measured in accordance with ASTM C387 using the manufacturer's recommended mixing liquid and amount. Additional yield and unit weight shall be measured and reported for products extended with coarse aggregate.

3.11. Chloride Content

Chloride content shall be carried out in accordance with ASTM C1152. The total chloride content (by mass) should be reported and shall be less than 0.060%.

3.12. Slump Flow (Only for FP Classification)

Slump flow and visual stability index shall be determined in accordance with ASTM C1611.

The slump flow shall be reported after calculation and shall not be less than 500 mm. The Visual Stability Index (VSI) shall also be reported and shall not be greater than 1.

4. Packaging

4.1. Quality and Size

Bags shall be multi-layered with the outer layer of strong paper or equivalent and the inner layers of waterproof material. The maximum weight allowed in a bag is 25 kg. The net weight in each bag shall not vary by more than 2% from that printed on the bag. The volumetric yield shall not vary by more than 2% from that printed on the bag.

4.2. Marking

The following information shall be marked on the outside of each bag:

- (a) Product name
- (b) Manufacturer's name
- (c) Batch number
- (d) Weight of bag
- (e) Date product was manufactured

- (f) Shelf Life
- (g) Yield in cubic metre when mixed with recommended amount of liquid.
- (h) Mix instructions including recommended amount of water or other liquid component or both to be mixed with the package contents.
- (i) The recommended length of mixing time or sequence of mixing time (Or sequence of mixing and resting time in minutes)
- (j) Curing recommendations.
- (k) Photographs of the packaging markings shall also be submitted.

5. Approval and Quality Control

5.1. Approved Product

Products meeting this specification will be considered for approval. The approved products will appear on the Department's Product List accompanied by its type, name, manufacturer and Alberta suppliers/distributors (comprehensive list of Alberta based suppliers to be provided and updated as required by the Manufacturer).

Barring unsatisfactory performance, the approval is valid for 5 years from the date of approval. It will be the responsibility of the Supplier/Manufacturer to retest their product, at their own expense, prior to the end of the 5 year period. The Department will not notify the Supplier/Manufacturer of the expiry date.

Any subsequent change in product formulation or future amendments/changes to the Specification for Concrete Patching Material – B391 will require a retest for re-approval at the Supplier/Manufacturer's expense.

5.2. Quality Control

The Supplier/Manufacturer shall be responsible for quality control of the product. They shall sample and test the material as necessary during production to ensure that all material conforms to these specifications, and is consistent with the sample of material that was tested and approved. When requested by the Department, the Manufacturer will submit the quality control data within 30 days. Any subsequent change in the product will require a requalification at the Supplier's/Manufacturer's expense.

5.3. Right to Reject

The Department reserves the right to reject material, and withdraw the product from the approval list. Failure to pass quality assurance testing will result in removal from the Department's Product List.

The material shall meet or exceed the requirements of all qualifying tests, and shall perform adequately in the field. Unsatisfactory performance, whether short term or long term, will result in removal from the Department's Product List.